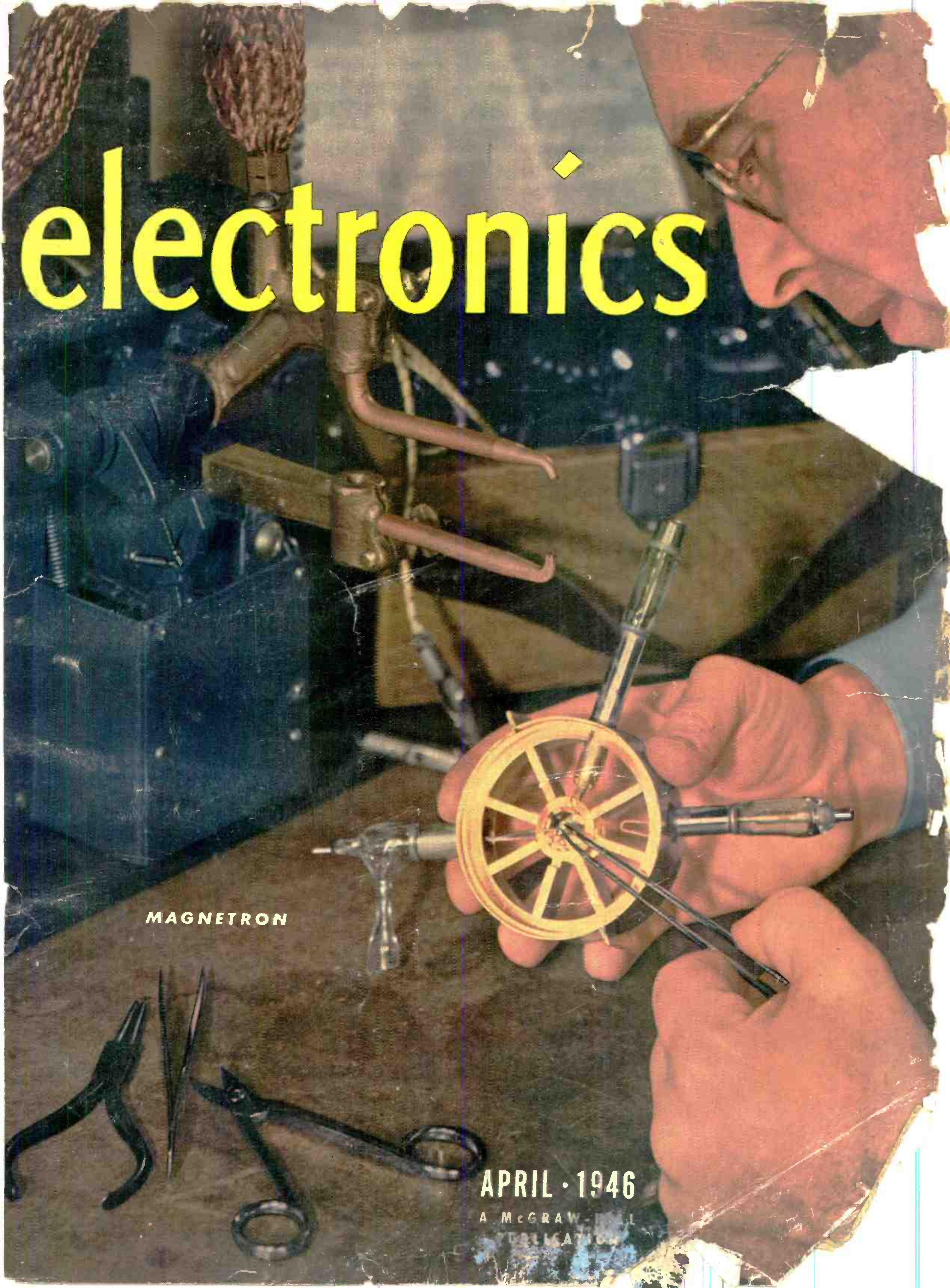
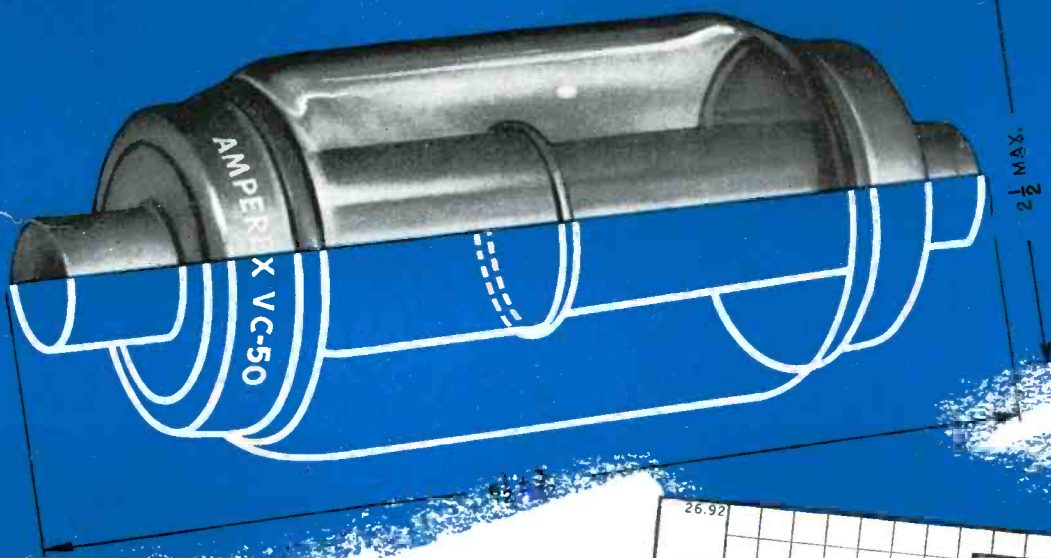

electronics
MAGNETRON
APRIL · 1946

New Vacuum Condenser Cuts Frequency Drift

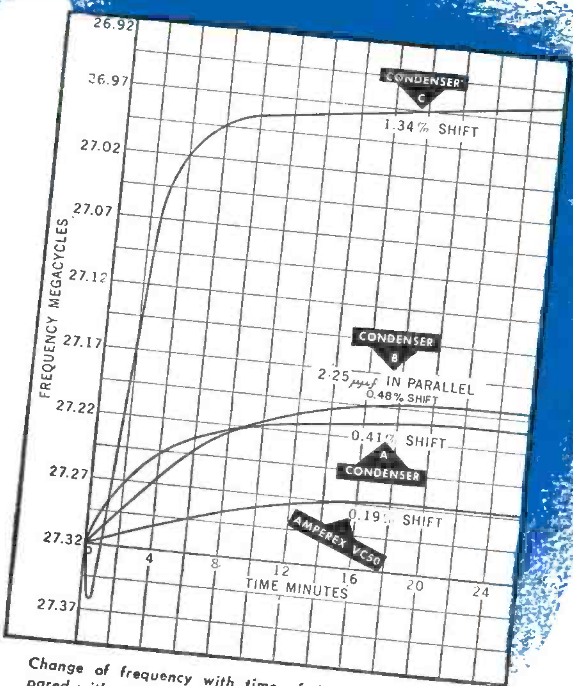


GENERAL CHARACTERISTICS
Capacitance....50 uuf ±2% • Maximum Peak Voltage....30,000
Maximum RMS Current....65 Amps at 10 Mc. • 40 Amps at 60 Mc.

Higher current handling ability and lower I^2R losses in reduced space simplify equipment design — meets new FCC frequency stability regulations for industrial and electro-medical oscillators using Amperex-developed circuits

Design and manufacturing techniques evolved for high power copper anode tubes were successfully brought to bear in developing the unusual qualities of the Amperex VC50 Vacuum Condenser. This unique all-copper construction with large area seals, no welds and increased mechanical ruggedness insures efficient and economical operation.

READY FOR YOU: Detailed technical rating and data sheets.



Change of frequency with time of Amperex VC50 compared with condensers of three other leading manufacturers in a typical piece of industrial equipment operating at 27.32 MC with a 50 uuf vacuum tank condenser and 2000 V.D.C. plate supply under no-load conditions.

POWER TUBE SPECIALISTS SINCE 1925

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ELECTRO-MEDICAL
SPECIAL PURPOSE

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AMPEREX

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electronics

A McGRAW-HILL PUBLICATION

APRIL • 1946

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Unit shown is actual size. 6V6 tube shown for comparison only.

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From Your Distributor

Ultra Compact High Fidelity Audio Units

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A-11	Low impedance mike, pickup, or line to 1 or 2 grids	50, 200, 500 ohms	50,000 ohms	50-10,000 multiple alloy shield for extremely low hum pickup	13.90
A-12	Low impedance mike, pickup, or multiple line to push pull grids	50, 125, 200, 250, 333, 500 ohms	80,000 ohms overall in two sections	30-20,000	12.75
A-18	Single plate to two grids	8,000 to 15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio overall	30-20,000	11.60
A-24	Single plate to multiple line	8,000 to 15,000 ohms	50, 125, 200, 250, 333, 500 ohms	30-20,000	12.75
A-25	Single plate to multiple line 8 MA unbalanced D.C.	8,000 to 15,000 ohms	50, 125, 200, 250, 333, 500 ohms	50-12,000	11.60
A-26	Push pull low level plates to multiple line	8,000 to 15,000 ohms each side	50, 125, 200, 250, 333, 500 ohms	30-20,000	12.75
A-30	Audio choke, 300 henrys @ 2 MA 6000 ohms D.C., 75 henrys @ 4 MA 1500 ohms D.C., inductance with no D.C. 450 henrys				8.70

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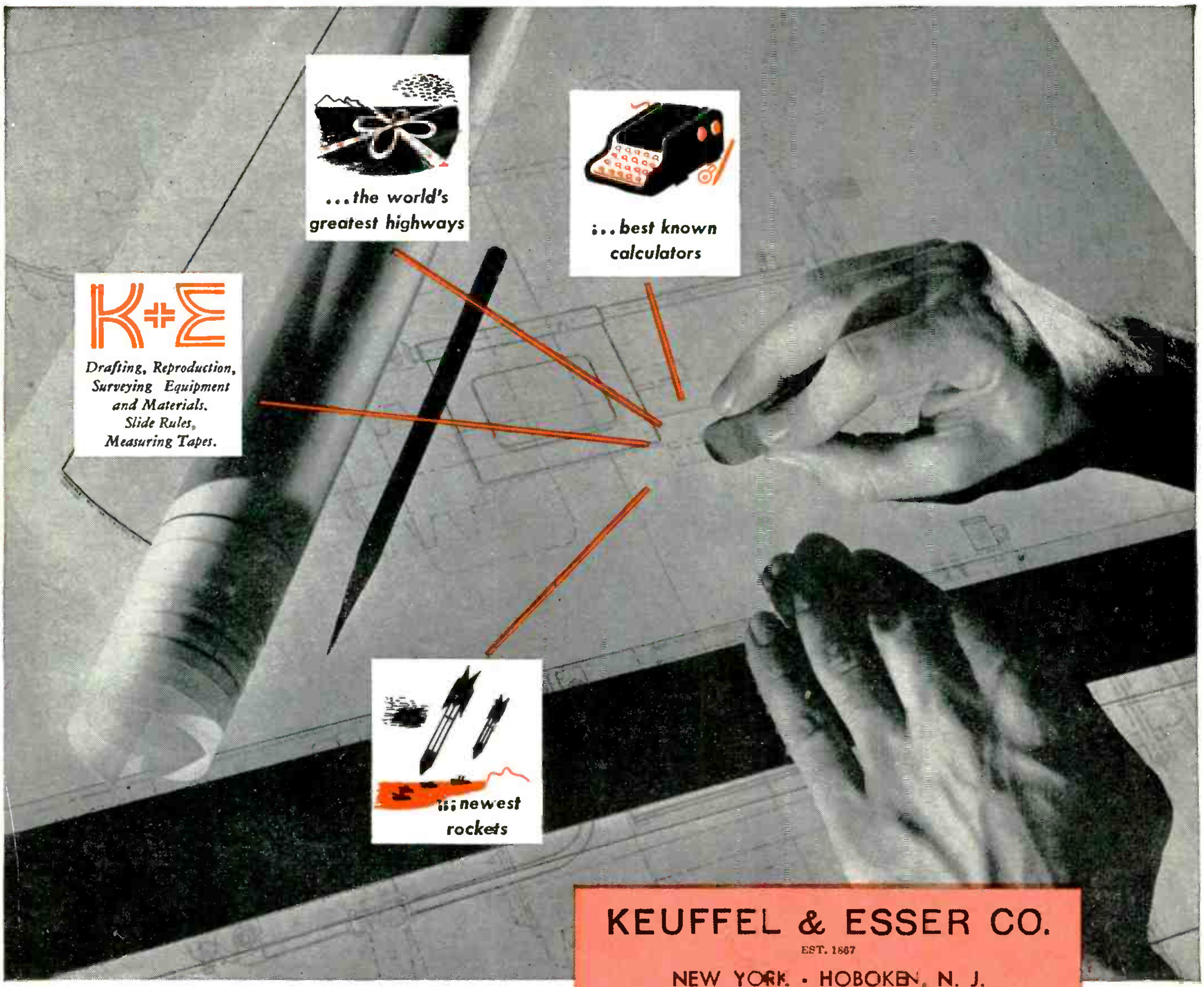

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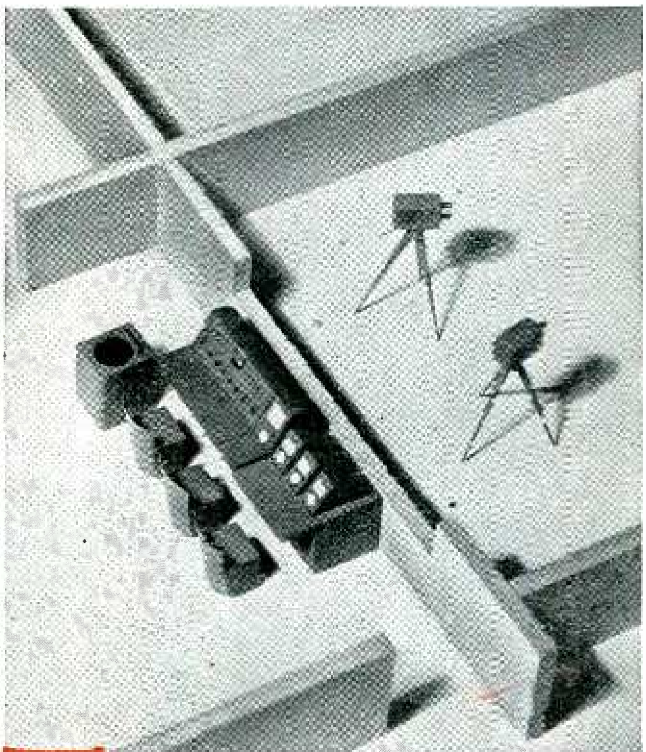

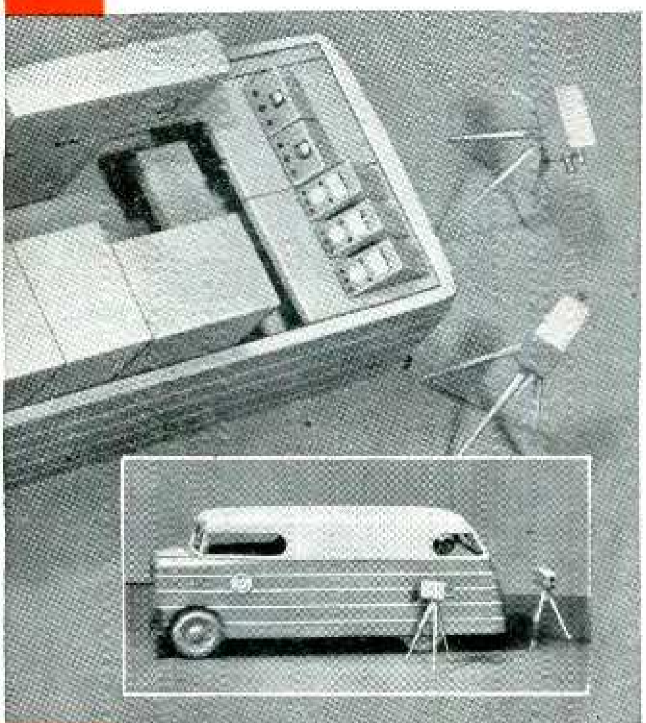

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IF YOU PLAN to start a television station on a modest scale, you will find this equipment a real money-saver. With it you can enjoy the economies of using already prepared program material such as, baseball games, boxing and concerts—which do not require expensive rehearsals and where lighting is seldom a problem. And you can use it in place of *fixed studio equipment* until you want to expand your station facilities.

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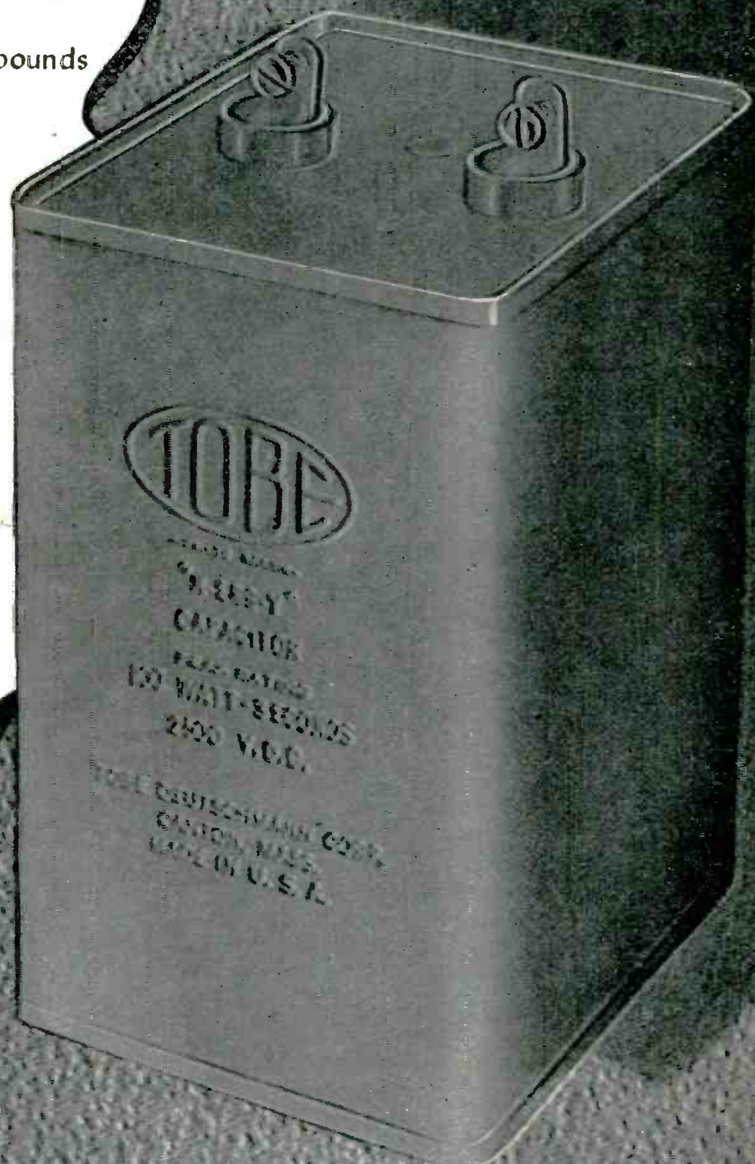

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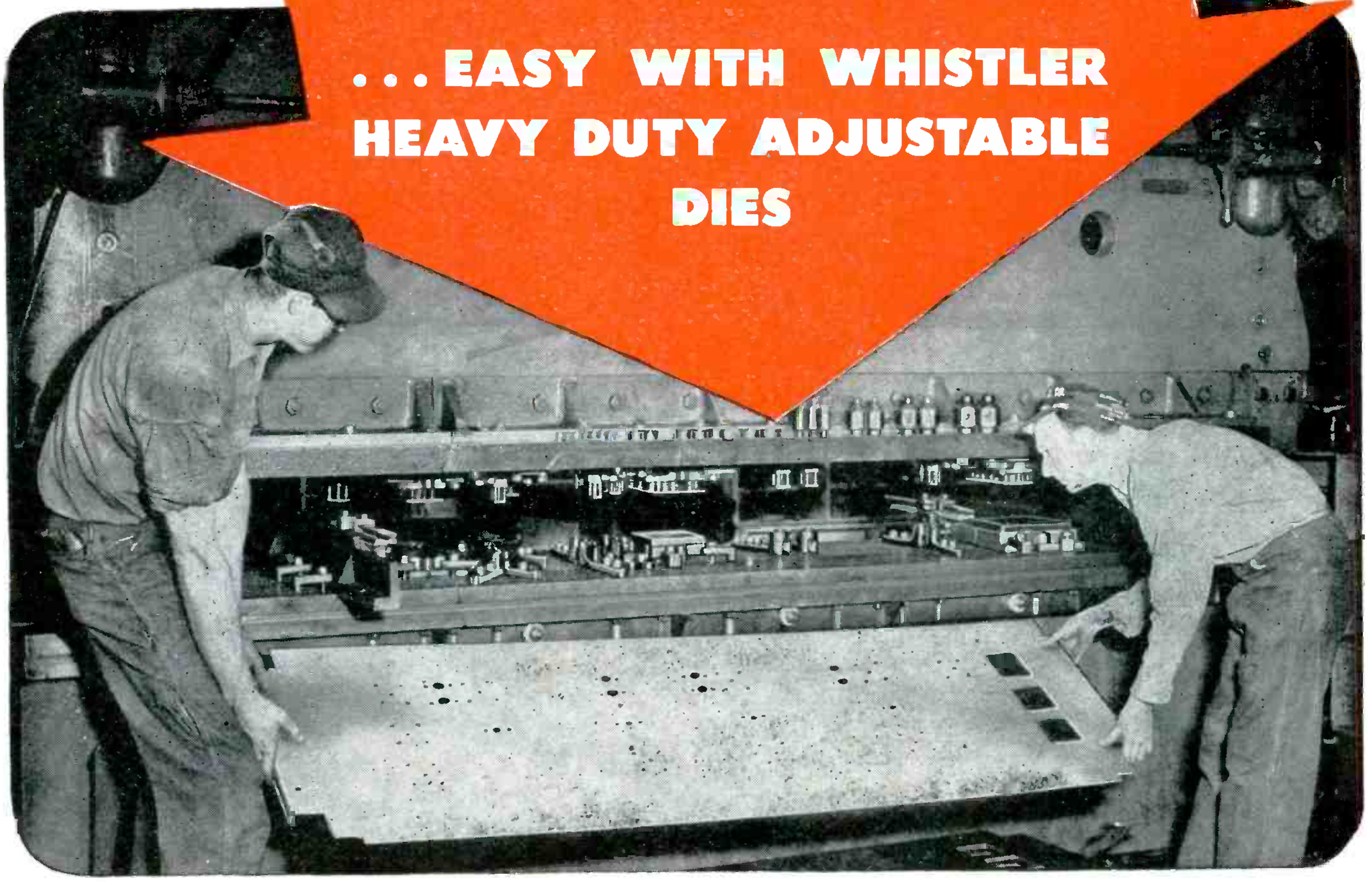

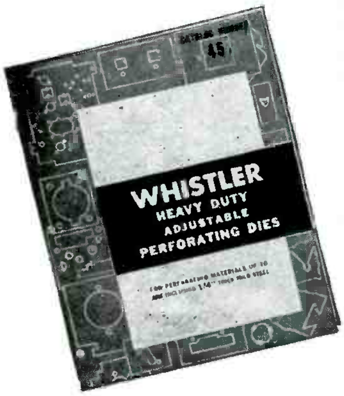

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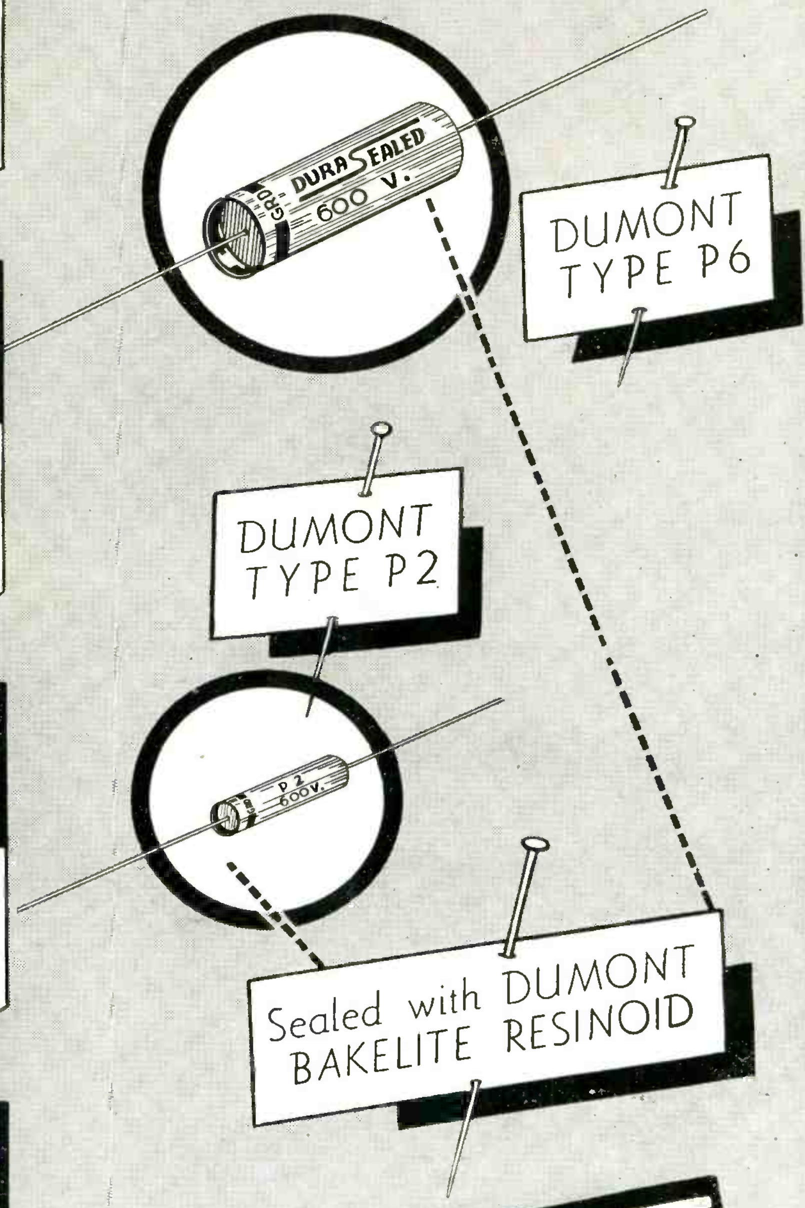
Used in the manufacture of these condensers . . . thus assuring long life and High Surge Rating to these units.



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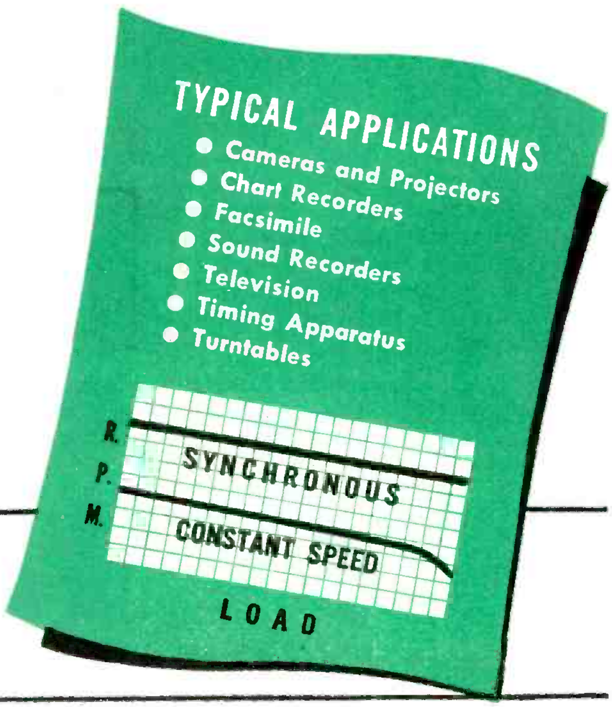

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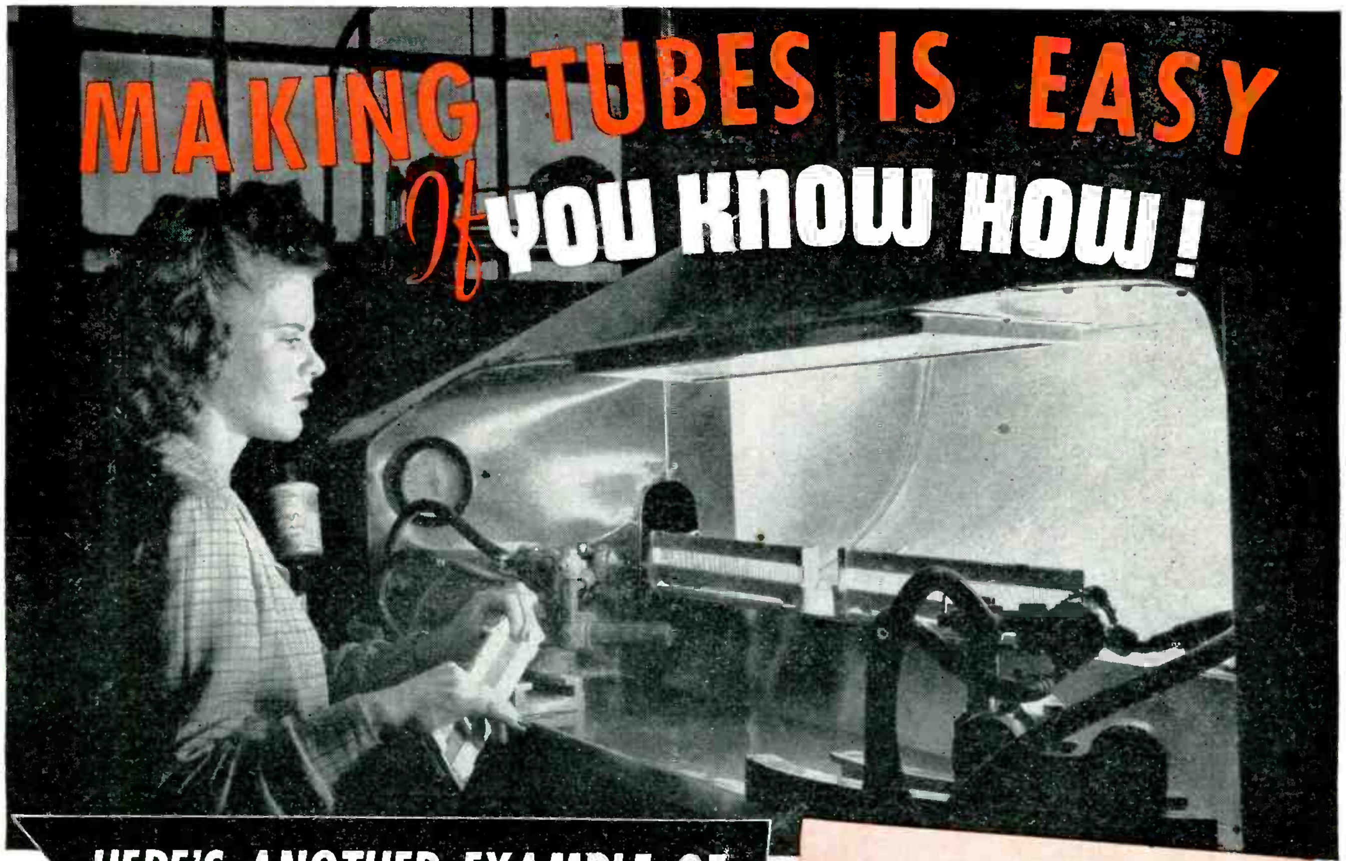
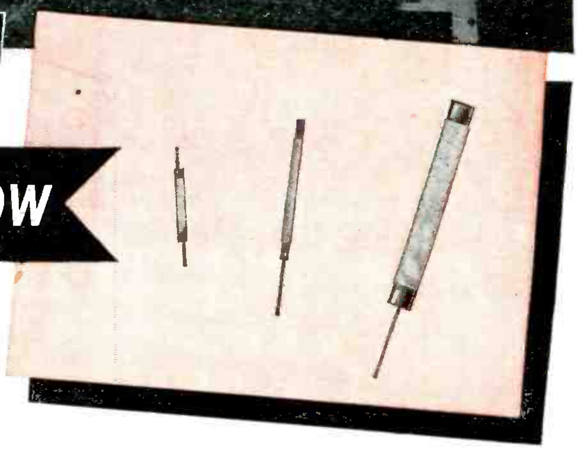


HERE'S ANOTHER EXAMPLE OF UNMATCHED HYTRON KNOW-HOW



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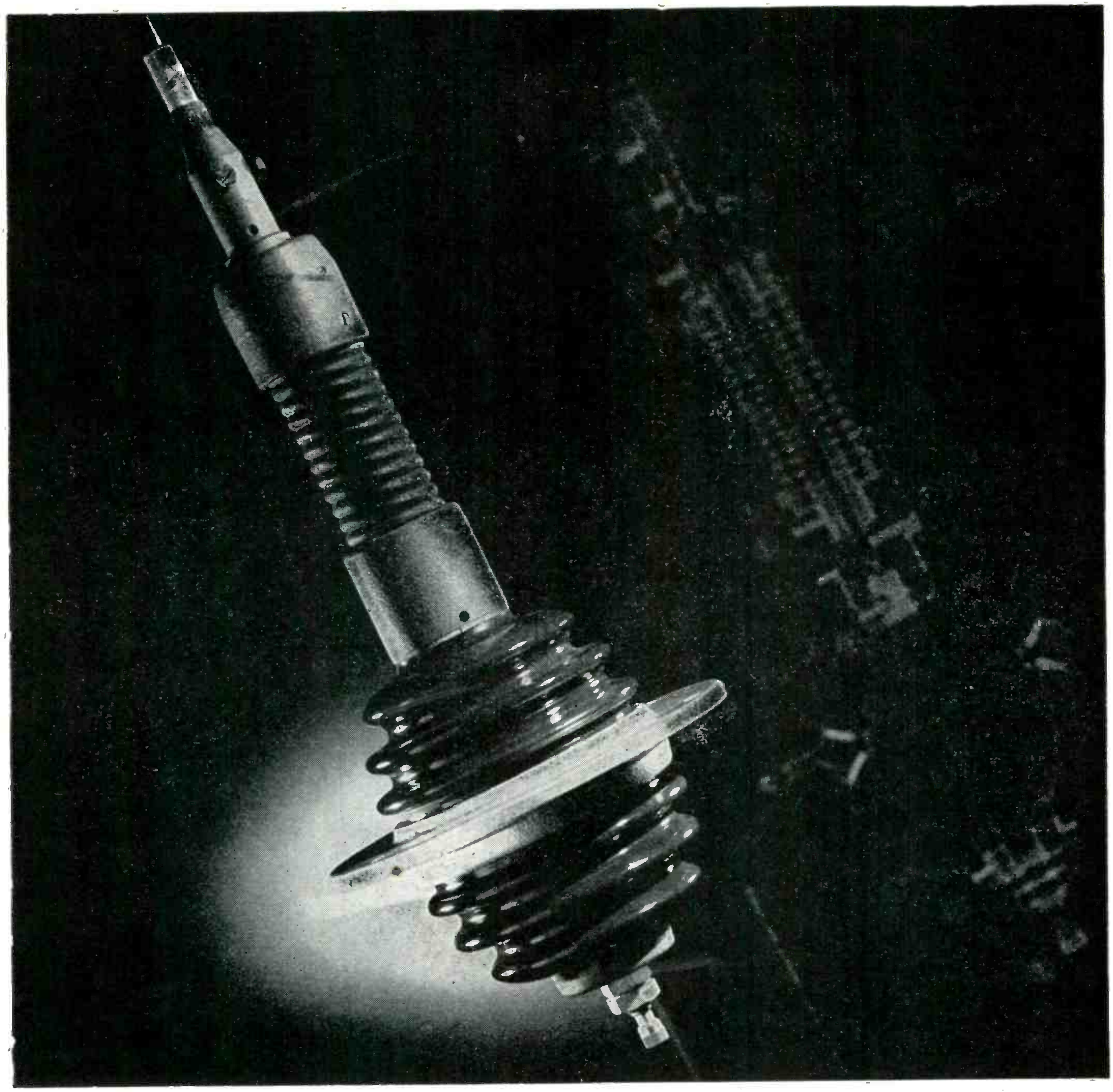

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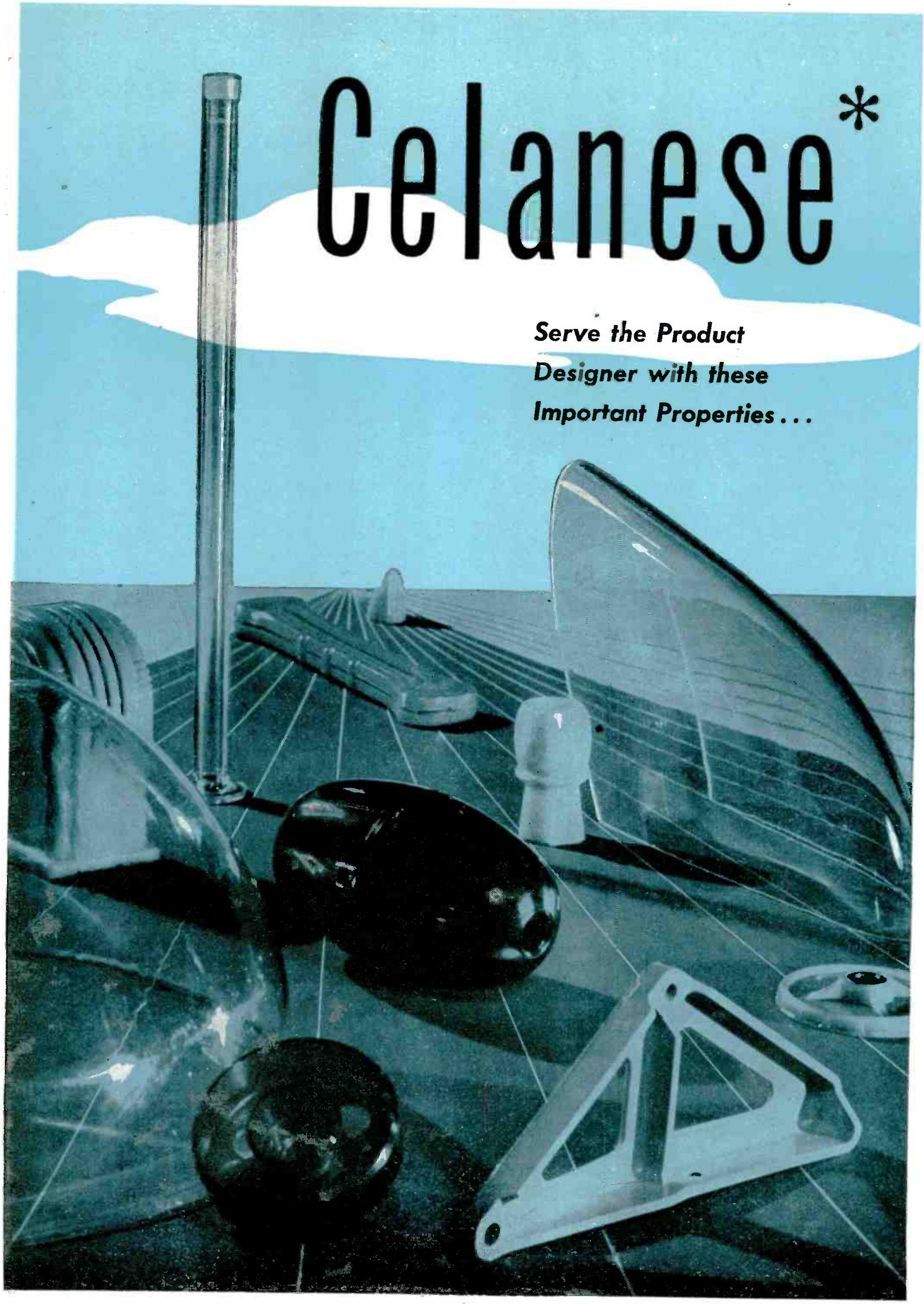
Lapp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Designer with these
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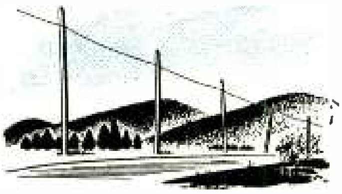
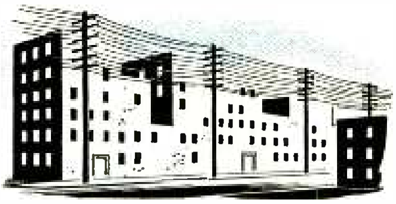
Why

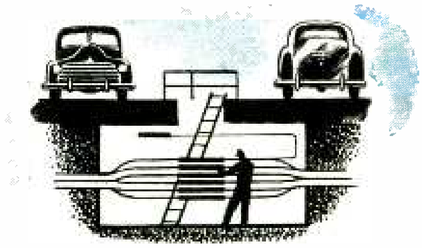
this team is a leader in VHF



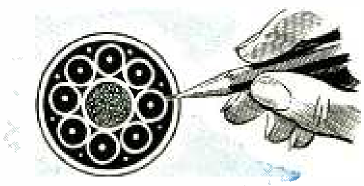
1. *First voice circuits were single iron wires with ground return Frequency limitations, noise and high losses soon ruled them out.*



2. *Big improvement was the all wire circuit—a pair of wires to a message. Later came carrier which stepped up frequency and permitted several messages per circuit*



3. *Lead covered cable compressed many wire circuits into small space—took wires off city streets. But losses are prohibitive at very high frequencies.*



4. *Coaxial cable—a single wire strung in a pencil size tube—extended the usable frequency band up to millions of cycles per second and today carries hundreds of messages per circuit, or the wide bands needed for television.*

transmission

Back in 1933, Bell scientists established an historic first when they transmitted very high frequency radio waves for hundreds of feet along hollow pipes called wave guides. For them it was another forward step in their long research to make communication circuits carry higher frequencies, broader bands and more messages per circuit.

Continuing Research showed the way

From the days of the single open wire line—through all-metallic circuits, phantoming, cable, carrier systems and coaxials—up to today's wave guides, every improvement has been the result of continuous fundamental study.

When Bell Laboratories started work on wave guides, there was no immediate application for the microwaves they guided. But the scientists foresaw that *some day* wave guides would be needed—so they kept on working until they had developed the wave guide into a practical device.

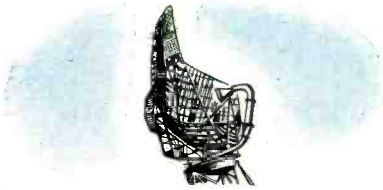
With the war came radar—and the problem of conducting microwave frequencies. Bell Laboratories had the answer—wave guides—without which radar at the higher frequencies would have been impractical.

What this means to YOU

Year after year, Bell Laboratories have continued to develop methods for handling higher and higher frequencies. Year after year Western Electric has provided equipment putting these scientific advances to work. This team has become the natural leader in the field.

When your requirement dictates the use of VHF—in mobile communications, broadcasting, or point-to-point radio telephony—depend on Western Electric to supply the latest and best equipment for your needs.

5. Wave guides, fundamentally different in transmission principle, channel energy as radio waves through pipes; vary in size from several inches to under 1 cm.; become smaller as frequency rises.



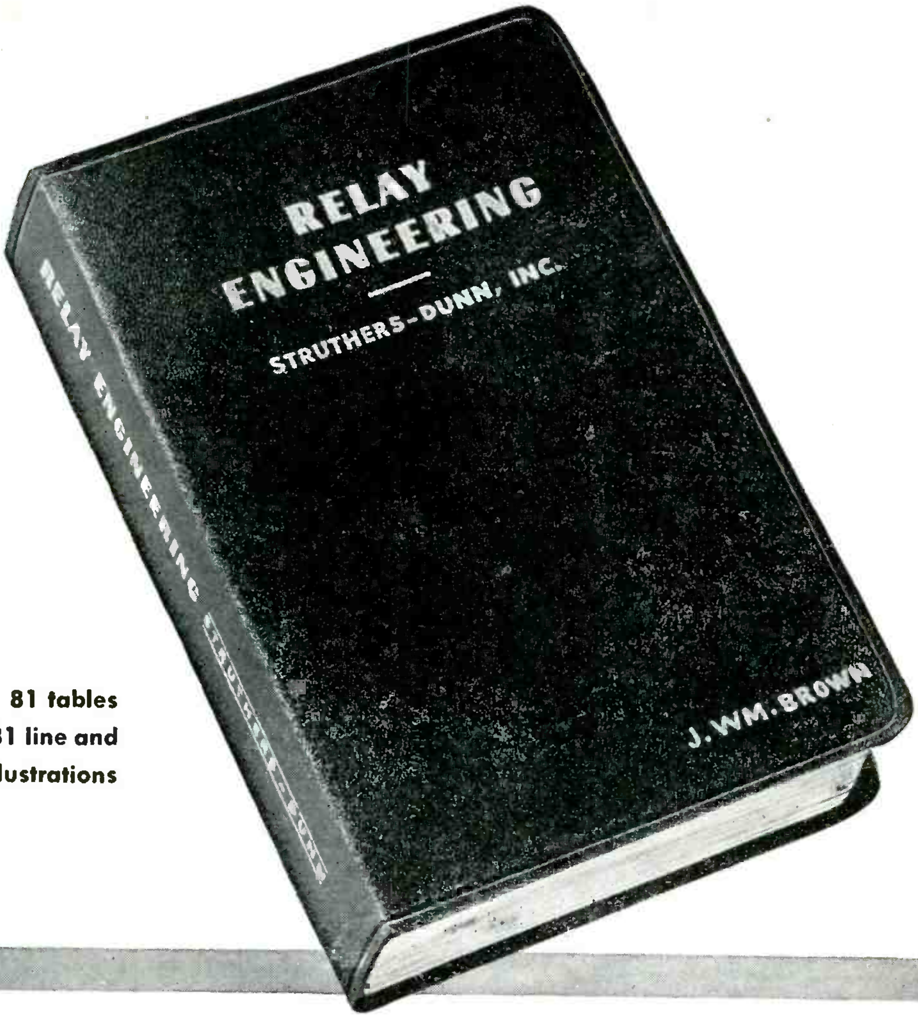
6. Late model radar wave guides, similar to that used to feed the antenna above, can carry 3½ cm. waves at more than eight billion cps. Experimental guides for still shorter waves are being tested.

BELL TELEPHONE LABORATORIES

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

Western Electric

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



150,000 words • 81 tables
863 diagrams • 181 line and
89 photographic illustrations

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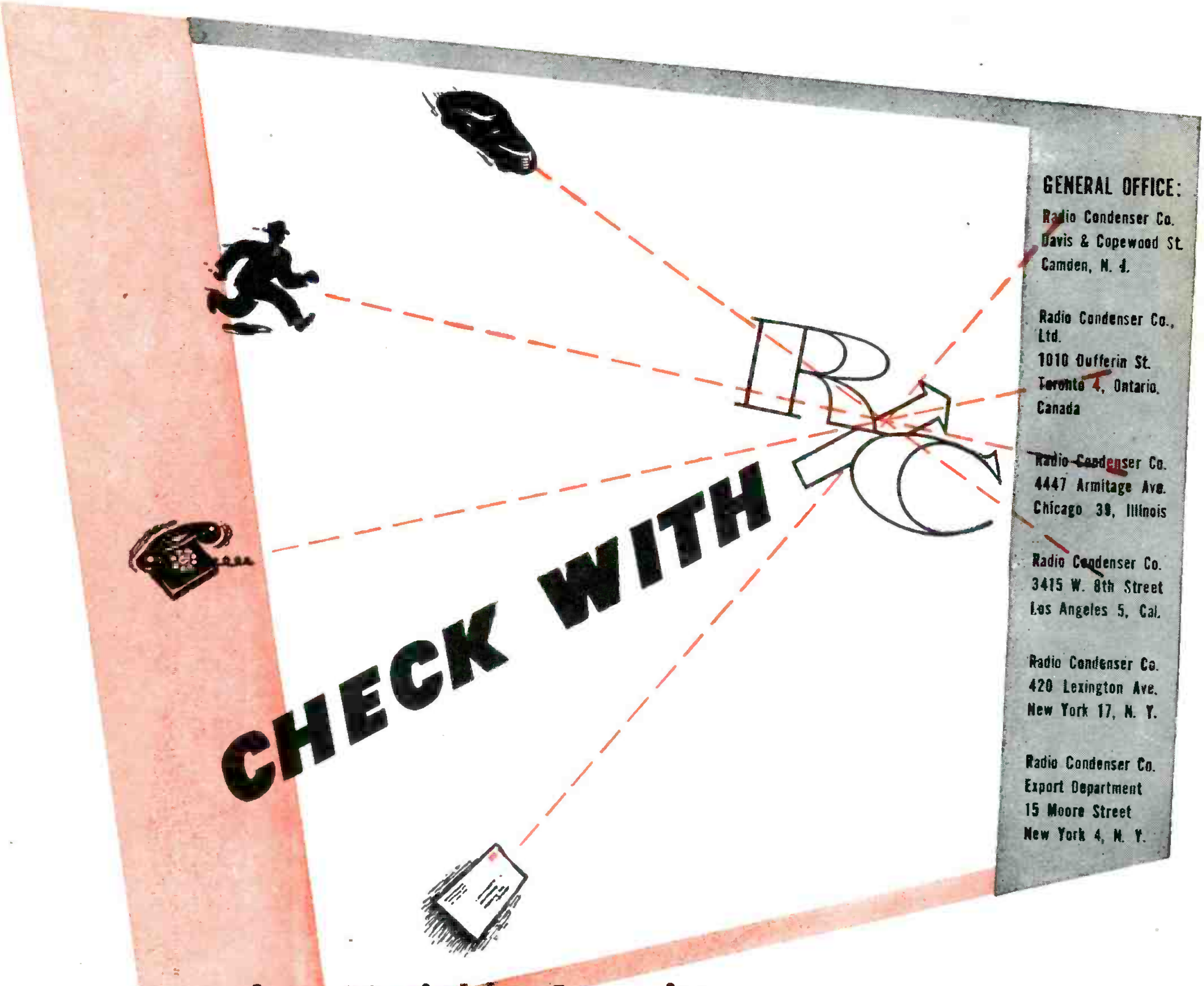
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

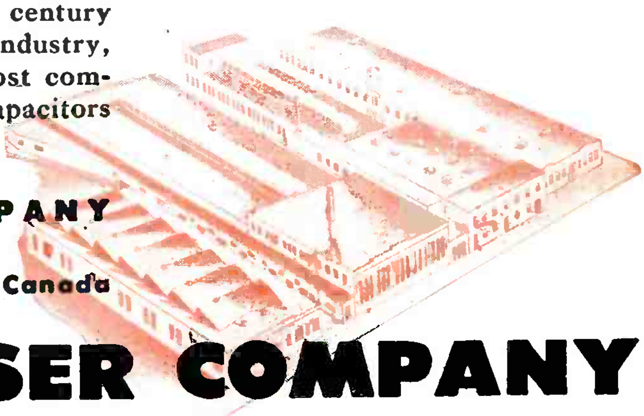


. . . when Variable Capacitor KNOW-HOW makes a difference!

We design and build ONLY variable capacitors and mechanical tuning devices.

This factor, more than any other, has contributed to the high degree of R/C specialized knowledge in the field of variable capacitor design and manufacture.

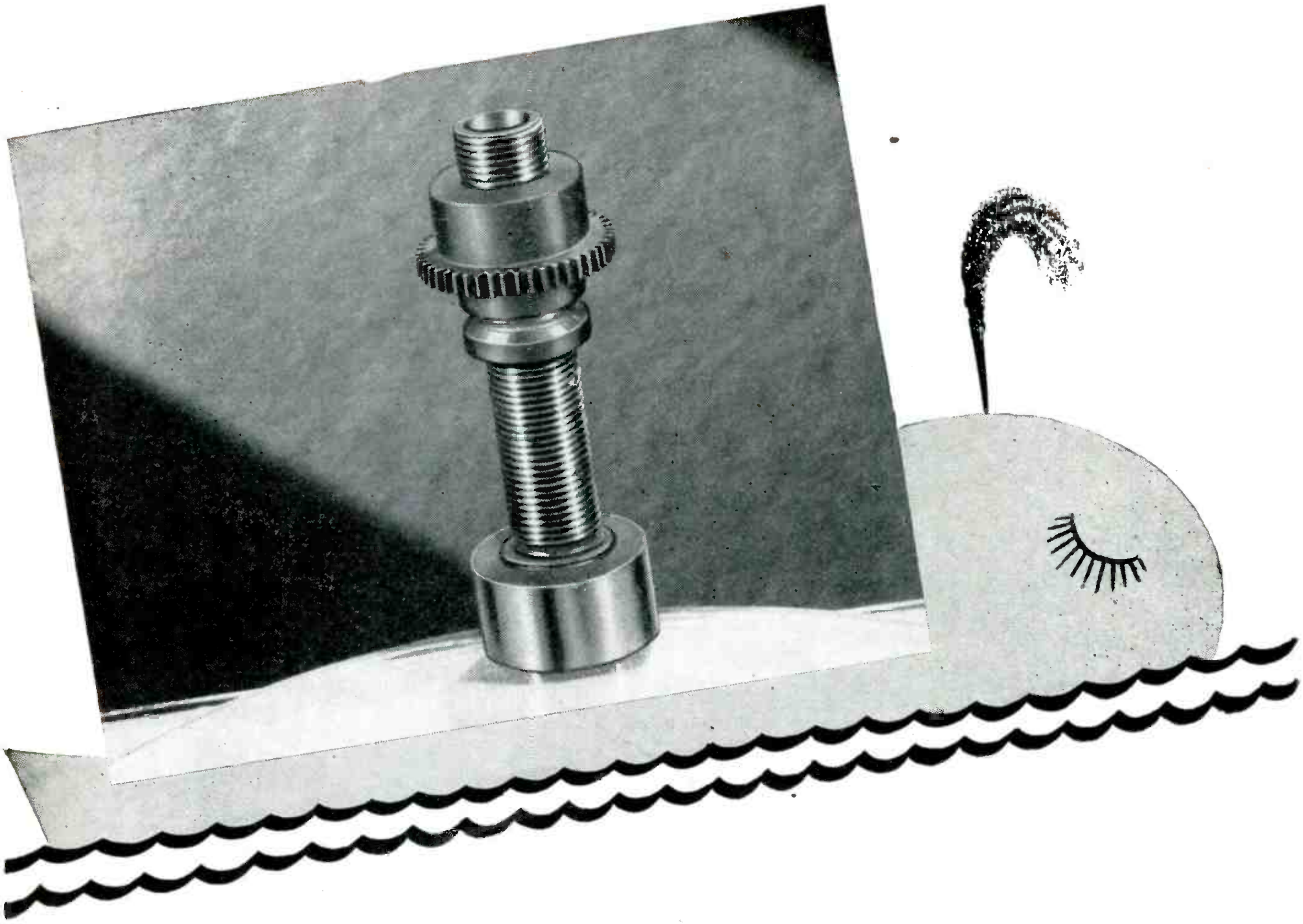
With a history of almost a quarter of a century as suppliers to the set manufacturing industry, Radio Condenser Company offers the most complete engineering background in variable capacitors and mechanical tuning devices.



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

RADIO CONDENSER COMPANY

SUPPLIERS TO SET MANUFACTURERS ONLY



There's a WHALE of a difference in GEARS by — — —

FRACTIONAL HORSEPOWER GEARING

GS

The quantity production of GS custom-made small gears has been developed we believe, to a degree of *uniform* excellence unapproached in the history of the industry! The most extreme precision characterizes every operation. If you must achieve the utmost in smooth, dependable, economical performance, ask a GS engineer about the fractional horsepower gears you need. We can apply to *your* problem, all the skill, the experience, the exclusive methods and machinery developed thru a quarter century of specialization in the manufacture of *better* small gears.

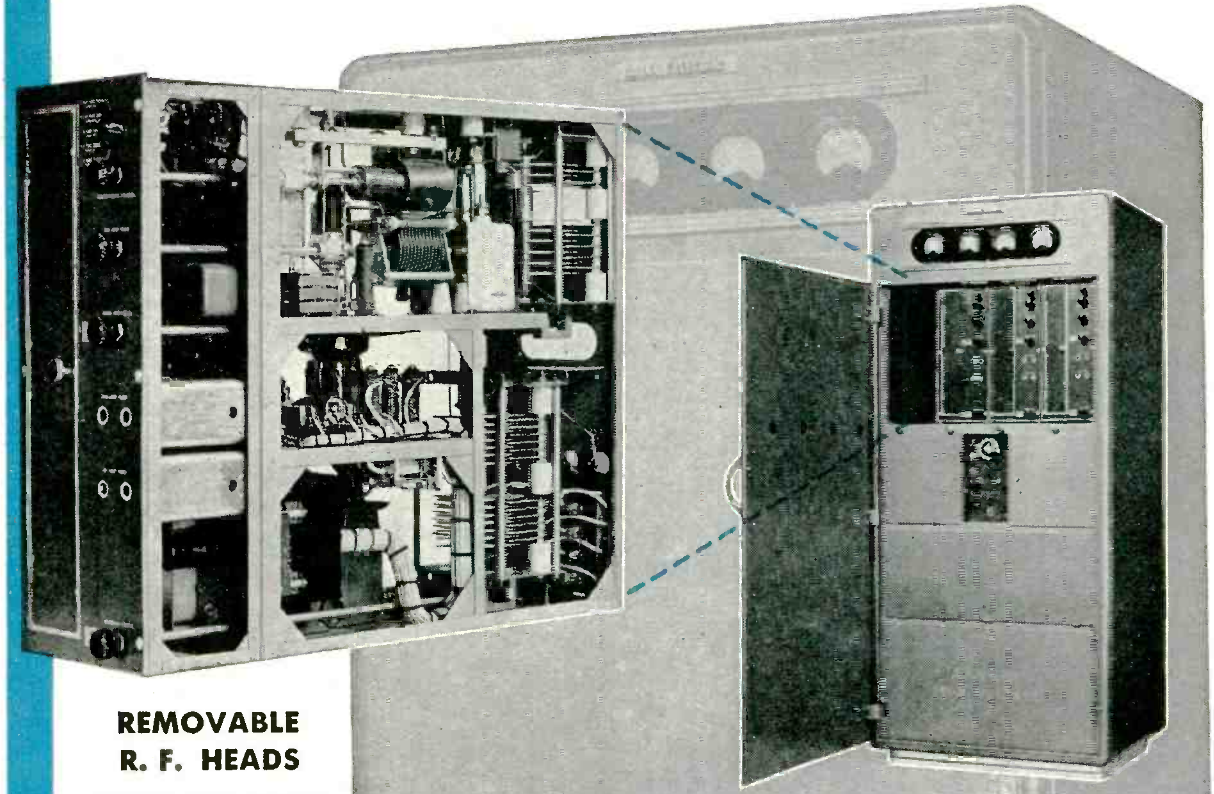
GEAR Specialties

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

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

Wilcox Type 99A Transmitter



REMOVABLE R. F. HEADS

All radio frequency circuits are included in the 2—20 Mc. R.F. head shown above. All connections to the transmitter cabinet are by means of plugs and receptacles.

A medium power transmitter, designed particularly for aeronautical service. Equally adaptable to other fixed services. Check these features for their application to your communication problems:

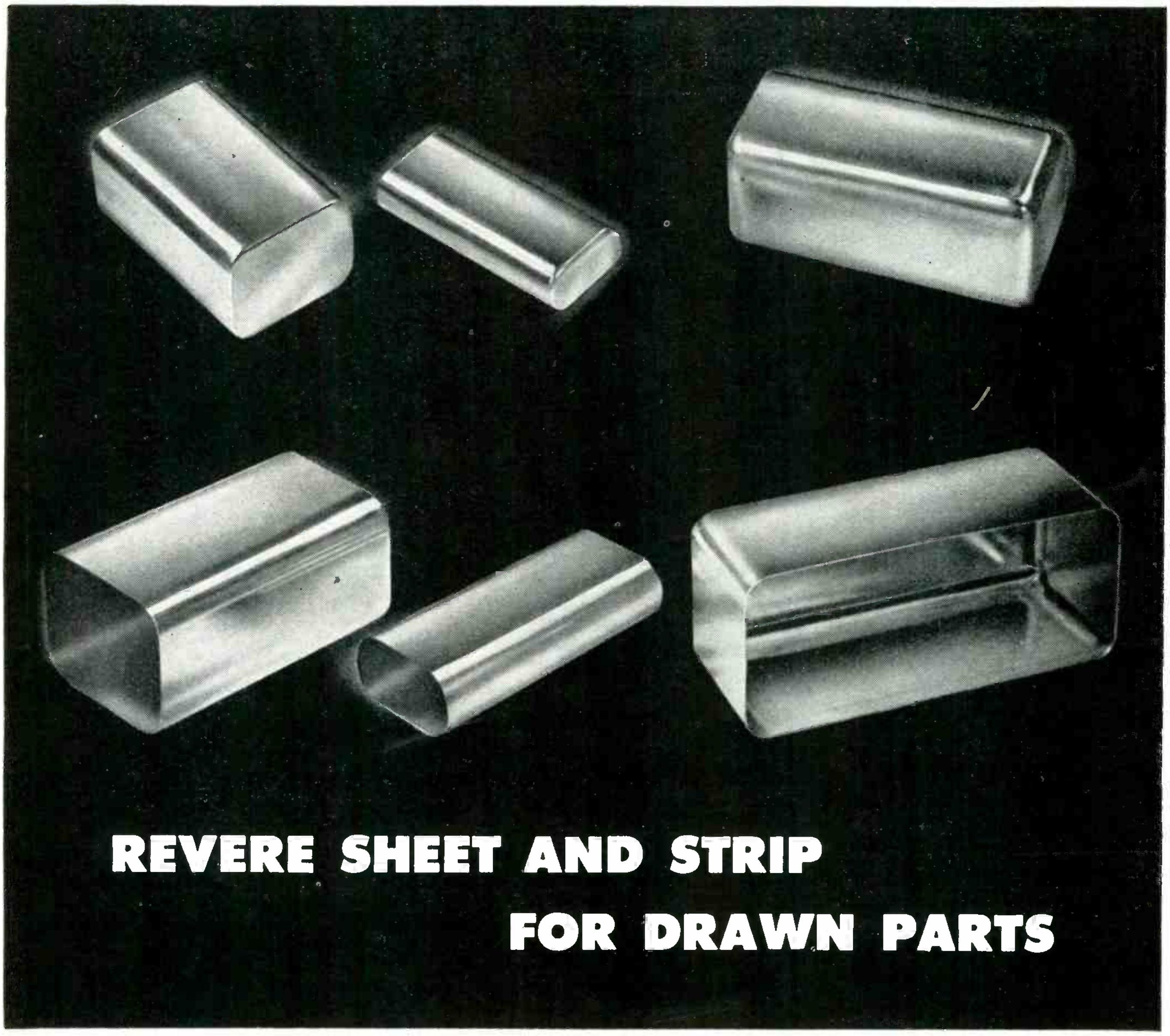
- ★ Four transmitting channels, in the following frequency ranges:
  125—525 Kc. Low Frequency.
  2— 20 Mc. High Frequency.
  100—160 Mc. Very High Frequency.
  Other frequencies by special order.
- ★ Simultaneous channel operation in following maximum combinations:
  3 Channels telegraph.
  2 Channels telephone.
  1 Channel telephone, 2 Channels telegraph.
- ★ Complete remote control by a single telephone pair per operator.
- ★ 400 Watt plus carrier power.
- ★ Low first cost. Removable radio frequency heads are your protection against frequency obsolesence.
- ★ Reliability backed by two years of engineering research, one year of actual field operation.
- ★ Available with all-steel, or wood pre-fabricated transmitter house complete with primary power, antenna, and ventilation fittings.
- ★ Not a "post-war plan," but a field-tested transmitter now in production.

An inquiry on your letterhead outlining your requirements will bring you complete data.

WILCOX ELECTRIC COMPANY, INC.

Manufacturers of Radio Equipment

Fourteenth and Chestnut Kansas City, Missouri



FOR all products to be made by drawing, stamping and similar sheet metal operations, Revere sheet and strip of copper or brass offer maximum ease of fabrication. Not only are these metals naturally ductile, but they benefit further from the metallurgical skill which Revere has gained in 145 years of experience.

In composition, mechanical properties, grain size, dimensions and finish, you will find Revere metals highly uniform. They enable you to set up economical production methods and adhere to them. They can help you produce better products at faster production rates, with less scrap and fewer rejects.

Revere copper, brass and bronze lend themselves readily to the widest variety of finishing operations—polishing, lacquering, electro-plating. With these superior materials it is easy to make radio shields and similar products beautiful as well as serviceable.

That is why wise buyers place their orders with Revere for such mill products as—*Copper and Copper Alloys:* Sheet and Plate, Rolls and Strip, Rod and Bar, Tube and Pipe, Extruded Shapes, Forgings—*Aluminum Alloys:* Tubing, Extruded Shapes, Forgings—*Magnesium Alloys:* Sheet and Plate, Rod and Bar, Tubing, Extruded Shapes, Forgings—*Steel:* Electric Welded Steel Tube. We solicit your orders for these materials.

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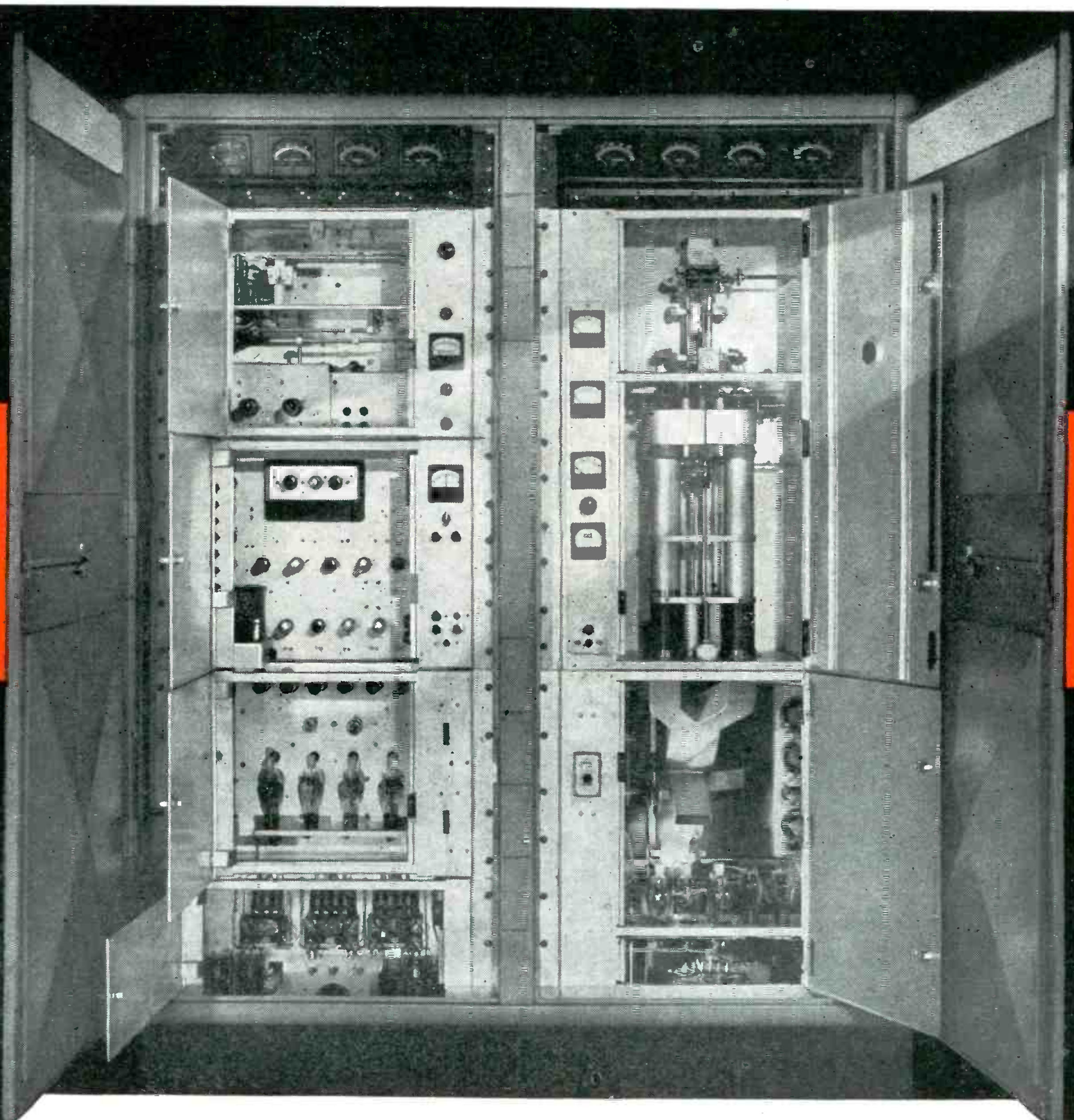
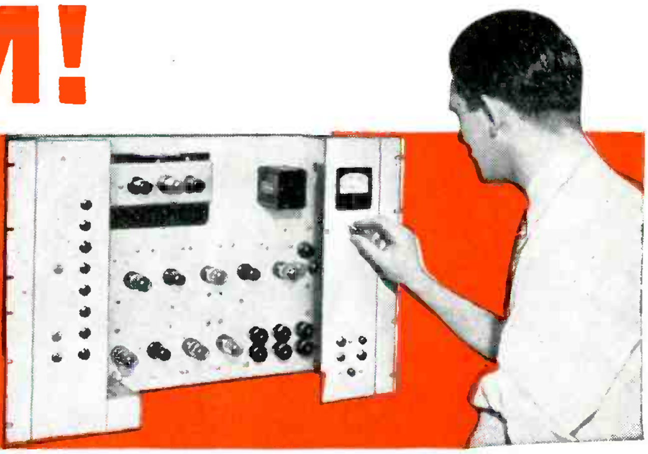
Sales Offices in principal cities, distributors everywhere

Listen to *Exploring the Unknown* on the Mutual Network every Sunday evening, 9 to 9:30 p.m., EST.



HERE'S THE BIG NEWS IN FM!

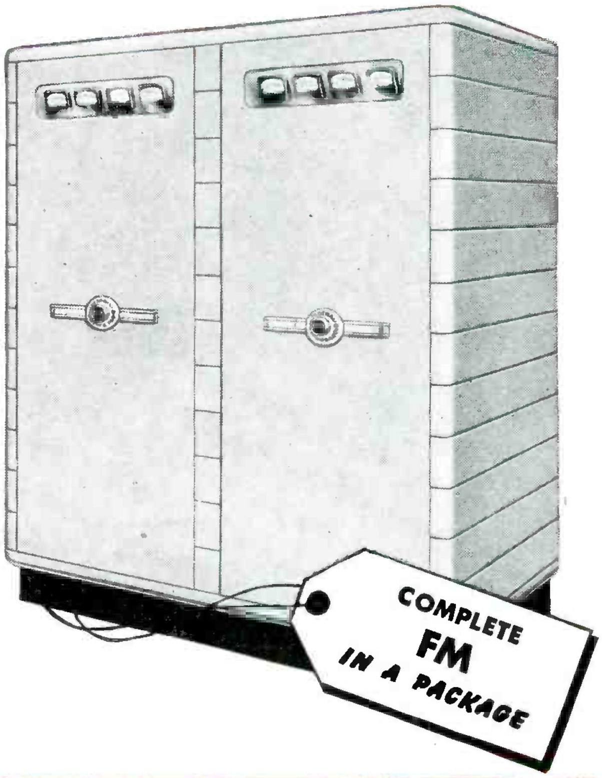
...it's FEDERAL's new "FREQUEMATIC"* MODULATOR



1—3—10 and 50 KILOWATT FM RADIO EQUIPMENT

The "FREQUEMATIC" Modulator takes its place as part of the complete "package" of FM broadcasting equipment offered by Federal. From one source, you get every piece of broadcasting gear to set up operation *now*... from studio equipment to transmitting tower... all precision-engineered, all matched, all of highest quality. No more piecemeal assembly of components, and uncertainties of divided responsibility. Federal assumes full responsibility for delivery and *installation* of a complete FM Broadcasting System. For complete details, write: Federal Telephone and Radio Corporation, Newark 1, New Jersey.

*Trade Mark



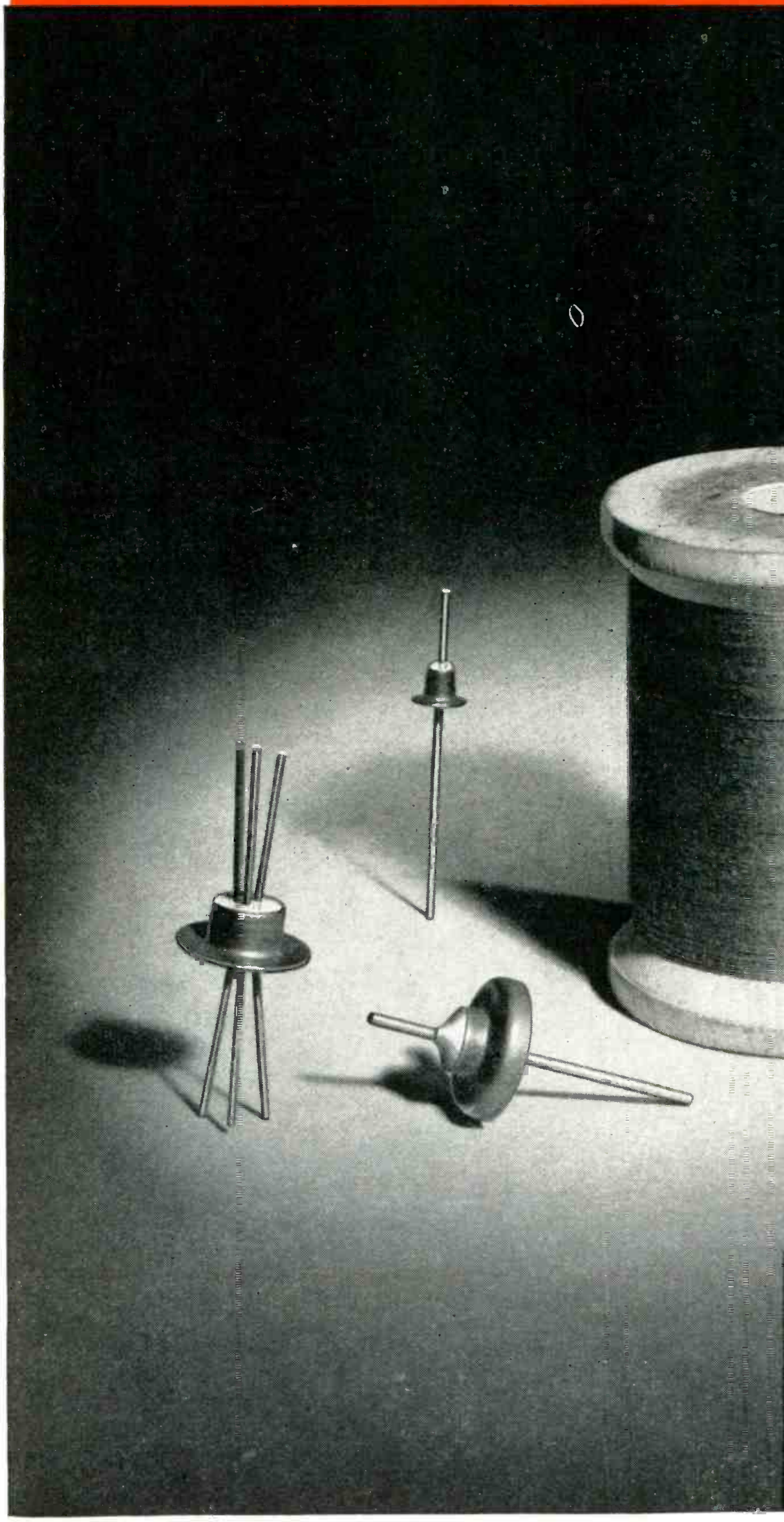
Telephone and Radio Corporation

Newark 1, New Jersey

Export Distributor:
International Standard Electric Corporation

AN IT&T ASSOCIATE

HOW TO SEW UP A WALKIE-



CORNING
means
Research in Glass

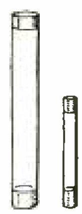
TALKIE SALE!

ONE thing we've learned during the war—almost every small electronic device should be able to work anywhere under any climatic condition. People are going to expect their personal walkie-talkies, plane radios, hearing aids, etc., to be as tough and durable as the stuff the industry developed for the armed forces. The more punishment they take, the better they'll sell.

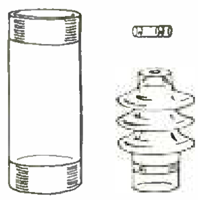
And that's where these funny-looking little eyelet terminals may be able to do you a lot of good. They're used to carry one or more leads into very small openings. The wires pass through tiny glass beads surrounded by metal collars, which you can solder into place in the twinkling of an eye. They form permanent hermetic seals, resist surface contamination, thermal shock and weathering. They have high mechanical strength and are chemically stable. All standard items are readily produced in quantity.

These Eyelet Terminals are another example of the breadth and versatility of Corning's line of electronic products. Some of them are pictured below with a brief description. Maybe they'll point to a possible solution for a problem that's been bothering you. If so, write, wire or phone The Electronic Sales Department, E-4, Technical Products Division, Corning Glass Works, Corning, New York. One of our engineers will be calling on you in record time to help solve your difficulties.

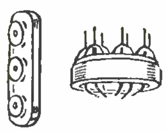
NOTE—*The metallized Tubes and Bushings, Headers and Coil Forms below are all made by the famous Corning Metallizing Process. Can be soldered into place to form true and permanent hermetic seals. Impervious to dust, moisture and corrosion.*



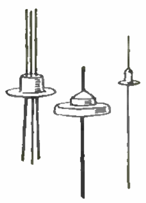
Metallized Tubes *for resistors, capacitors, etc. 20 standard sizes ½" x 2" to 1¼" x 10". Mass-produced for immediate shipment.*



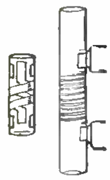
Metallized Bushings. *Tubes in 10 standard sizes, 5/16" x 25/32" to 1" x 4 7/32" in mass production for immediate shipment.*



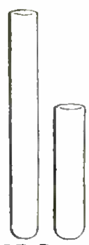
Headers — *The best way to get a large number of leads in a small space for assembly in one operation.*



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



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



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

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

Electronic Glassware

TRADE MARK VYCOR REG. U.S. PAT. OFF.

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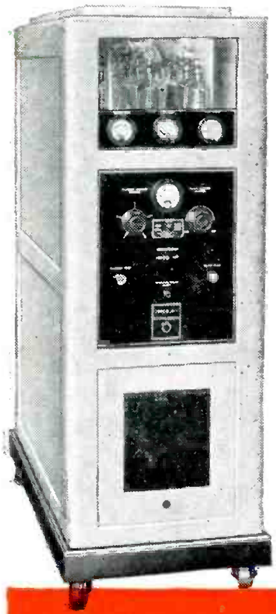
ELECTRONIC BRAZING UNIT with 24 Station INDEXING Work Carrier

Delivers 5 Complete Assemblies Per Minute



HERE'S a striking example of how Scientific Electric Engineers increased brazing production output by designing a special automatic machine to operate in conjunction with Electronic heating.

A manufacturer of weather-proof control box covers was already using electronic heat to speed up production in the brazing operation involved. But greater production was urgently needed. Each assembly was being inserted and removed from a single heater coil . . . one at a time.

To increase output Scientific Electric engineers designed this compact circular, 24 station indexing work carrier which operates from the 18 KW electronic generator at the left.

The operator merely loads the stations as they come around empty. Heat is applied by three water-cooled induction coils under three of the work positions. The coils are followed by the vertically operating ejecting mechanism and a complete assembly is ejected from the carrier each 12 seconds.

The carrier, which is operated by a small motor can be applied to any of our electronic generators depending upon the heat input requirements of the work to be handled. Normal output of the unit illustrated is at 200 to 600 kc.

Workpiece output up to 20 per minute can be obtained and carriers, custom tailored to your requirements, can be delivered within 30 days. Send us your requirements today.

Scientific Electric Electronic Heaters are made in these power sizes... and a range of frequencies up to 300 Megacycles depending upon power requirements.

3 KW	18 KW
5 KW	25 KW
7½ KW	40 KW
8 KW	60 KW
10 KW	80 KW
12½ KW	100 KW
15 KW	250 KW

Scientific Electric

Division of

"S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

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Vacuum Tube and Spark Gap Converters Since 1921

hallicrafters *new Model* S-40

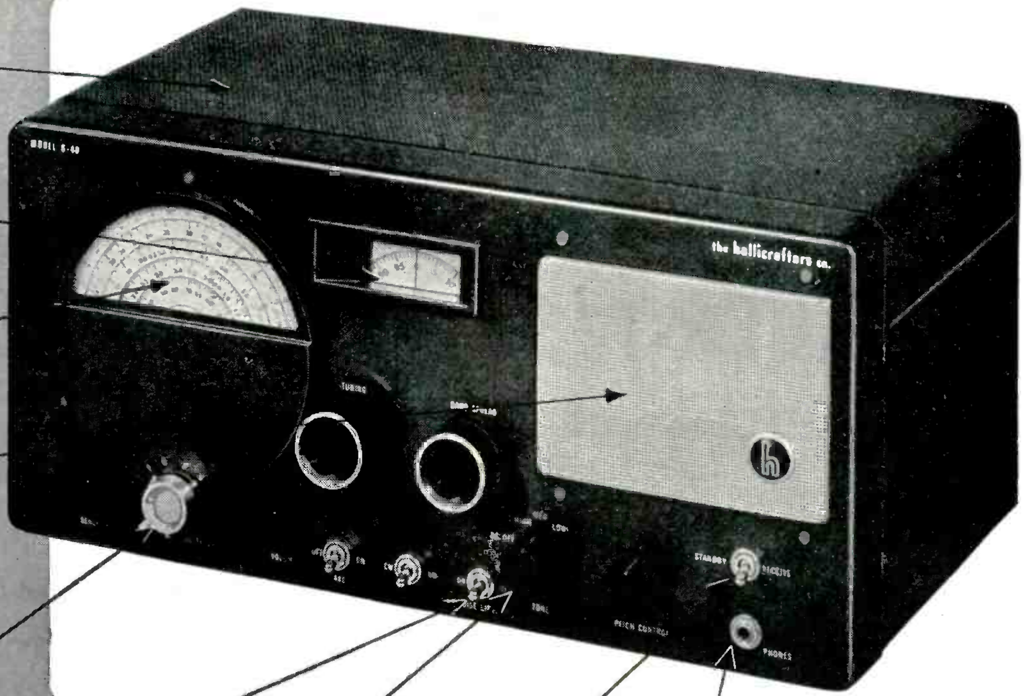
New beauty and perfect ventilation in the perforated steel top

Separate electrical bandspread with inertia flywheel tuning.

Tuning range from 540 kc to 42 Mc continuous in four bands

Self-contained, shock mounted, permanent magnet dynamic speaker

All controls logically grouped for easiest operation. Normal position for broadcast reception marked in red, making possible general use by whole family.



Automatic noise limiter

3-position tone control

Standby receive switch

Phone jack

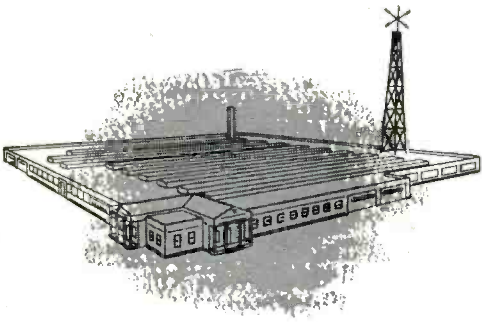
(APPROXIMATELY)

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

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

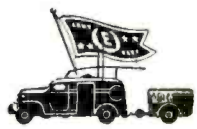
INSIDE STUFF: Beneath the sleek exterior of the S-40 is a beautifully engineered chassis. One stage of tuned radio frequency amplification, the S-40 uses a type 6SA7 tube as converter mixer for best signal to noise ratio. RF coils are of the permeability adjusted "micro-set" type identical with those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

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



hallicrafters RADIO

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



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

FOR SAFE, ECONOMICAL, AUTOMATIC

Power Control at All Times...

GET ADLAKE PLUNGER-TYPE RELAYS!

HERE'S WHY Adlake Plunger-Type Mercury Relays assure safe, economical, automatic power control under any condition:

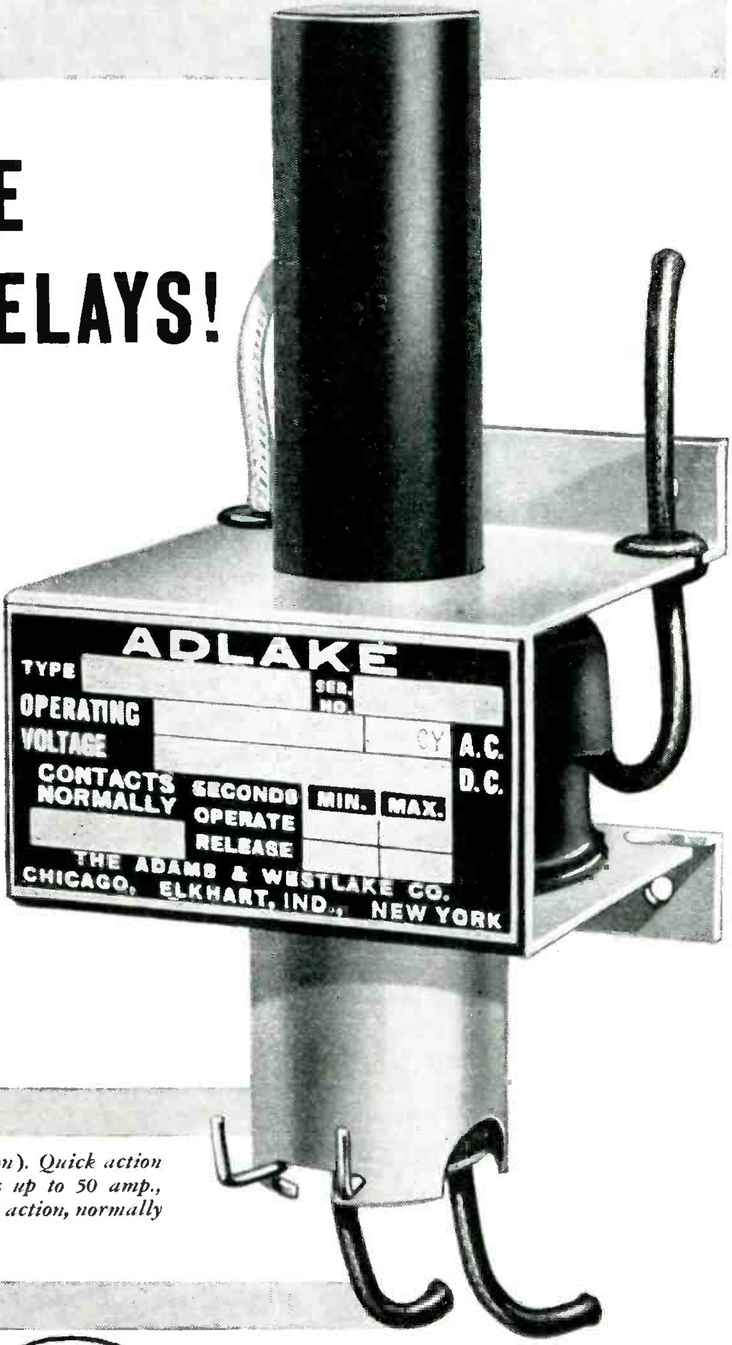
All contact mechanism is *hermetically sealed* in armored glass or metal cylinders so dirt, dust, moisture or oxidation can't possibly interfere with operation.

Liquid metal mercury is *positive* in action, chatterless, silent, impervious to burning, pitting or sticking.

They're absolutely *safe*, and since they're hermetically sealed, Adlakes perform without servicing or maintenance—no periodic cleaning of contacts needed.

And Adlakes are *dependable*—simple in design and principle, no complicated parts to wear out or get out of order!

There's an Adlake Relay for every need. May we suggest the type best suited for yours? Write today for free bulletin.



Model 1040 (for A. C. operation). Quick action available with contact ratings up to 50 amp., A. C. Either quick or time delay action, normally open or closed.

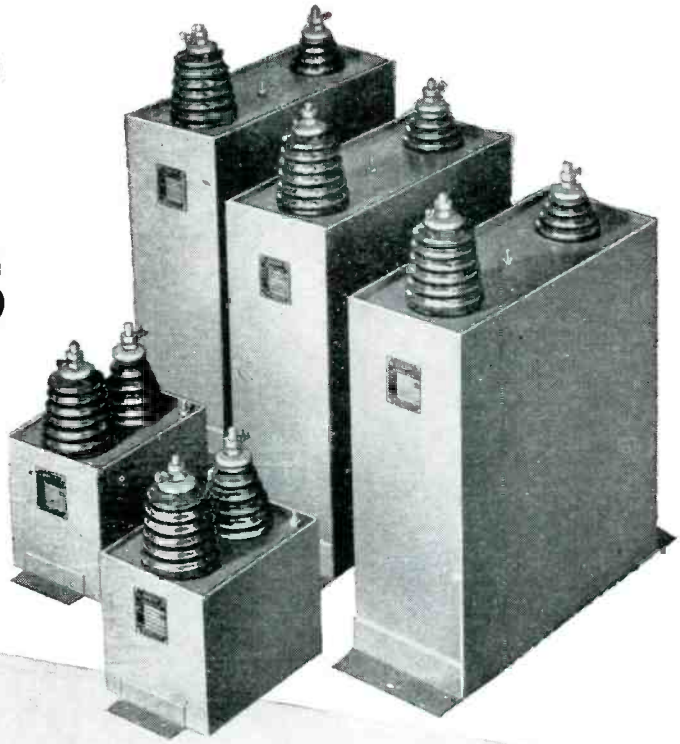
Adlake TRADE MARK

THE ADAMS & WESTLAKE COMPANY

ESTABLISHED IN 1857 — **ELKHART, INDIANA** — NEW YORK · CHICAGO

Manufacturers of Adlake Hermetically Sealed Mercury Relays for Timing, Load and Control Circuits

Special
CAPACITORS
... engineered by AEROVOX



Aerovox Series 20 Hyvol impregnated and filled capacitors in ratings up to 50,000 v. in hermetically sealed welded steel cases.

Aerovox Series 26 stack-mounting Hyvol impregnated and filled capacitors in ratings up to 150,000 v. Laminated bakelite cases. Cast-aluminum terminal ends.

● For those extra-severe-service applications on the largest capacitors, as well as others, Aerovox units have the extra stamina that makes them last. Decades of specialization provide an experience background second to none in solving all kinds of capacitor problems; unexcelled production facilities assure QUALITY as well as quantity.

Aerovox capacitors are liberally engineered for their individual applications. Special multi-layer capacitor tissues . . . long-life, non-inflammable Hyvol impregnant and fill . . . constant filtration and testing of impregnant as regular production routine . . . thorough evacuation and impregnation . . . positive hermetic sealing—these facts of Aerovox craftsmanship spell long, trouble-free service.

Aerovox capacitors in daily use speak for themselves. No finer capacitors are built. Aerovox engineers stand ready to meet your most severe requirements.

Submit your capacitor problem. The tougher the better! Write for literature.

AEROVOX capacitors

FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

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

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CHECK THESE FEATURES...

—features that emphasize the versatility of

The DUMONT TYPE 247 OSCILLOGRAPH

all these features *plus*...

exceptionally fine quality . . . well planned mechanical design . . . and completely dependable electrical performance . . . all of which make the DuMont Type 247 Cathode-Ray Oscillograph the logical choice for all applications that require a measuring instrument of fine accuracy.

★ *WRITE FOR DESCRIPTIVE LITERATURE*

1 AUTOMATIC BEAM CONTROL FOR PHOTOGRAPHIC PURPOSES

Permits high-contrast photographic recordings by holding the spot brightness at zero until the transient under study is initiated – then the spot is automatically raised to full brilliance.

2 EXTENDED TIME BASE RANGE 0.5 to 50,000 C. P. S.

A compensated circuit assures a linear sweep at all operating frequencies. The single sweep operates over a range corresponding to 0.5 to 10,000 c.p.s. The sweep is initiated by the controlling signal.

3 VERTICAL AMPLIFIER RESPONSE UNIFORM—2 to 200,000 C. P. S.

The response curve does not exhibit a positive slope above 1,000 c.p.s., thus assuring a linear phase-frequency relationship for the amplifier.

4 HORIZONTAL AMPLIFIER MAY BE USED AS A D-C AMPLIFIER

This amplifier is direct-coupled throughout, with the exception of an input capacitor which can be shorted out by operating a front-panel switch.

5 3,000-VOLT ACCELERATING POTENTIAL PROVIDES BRIGHTER CRT PATTERN

Sufficient brilliance for all but the highest writing rates without using special equipment.

DUMONT *Precision Electronics & Television*

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

INDEPENDENT INVESTIGATOR FINDS

Sonotone uses Phillips Screws to reduce case breakage 90%

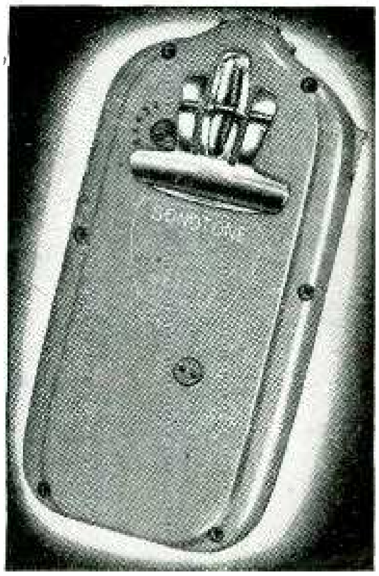
This investigator from James O. Peck Co., industrial research authorities, is visiting a number of representative plants to get authentic FACTS on assembly savings.

GET HIS FACT FILLED REPORTS ... GET THE COMPLETE STORY

Every driver skid eliminated saves $1.35 reclaiming costs!

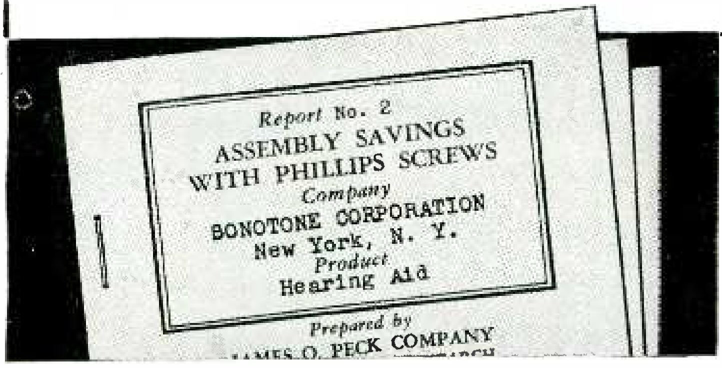
SONOTONE CORPORATION uses Phillips Screws because they lower costs and improve the product . . . the same simple but all-important reason why thousands of other successful manufacturers use them.

TO GET THE FACTS, to determine the actual savings, the investigator studied Sonotone's assembly methods, asked the same questions you would ask. He was told that, with slotted screws, breakage of the fine, hard plastic case of the Sonotone hearing aid would be ten times greater than with Phillips screws. Reclaiming, which involves not only the cost of a new case half, but also the cost of disassembly, reassembly and careful matching up of case halves, amounted to $1.35 per unit. The burr-free, ornamental Phillips recess is another reason why Sonotone chose Phillips Screws. Read the complete, revealing story in the Sonotone report.



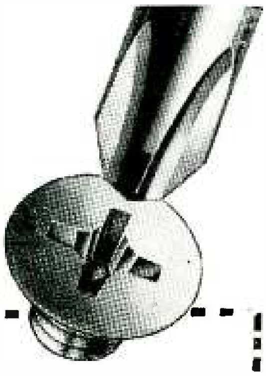
THE ASSEMBLY STUDIES cover all types of products—metal, plastics, wood—show how the many Phillips Screw advantages add up big savings you can make in your assemblies.

THE REPORTS now ready—and more to come—comprise a practical manual of modern assembly methods, never-before-printed information, inside facts you'd pay good money to get,—and it's yours, now, FREE!



PACKED WITH IDEAS FOR SAVINGS IN YOUR ASSEMBLIES!

Whatever you make you'll find how all assemblers licked problems like your own. Get these reports. The coupon will bring those ready now, and the rest as they are issued. Fill it in and mail it—TODAY!



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

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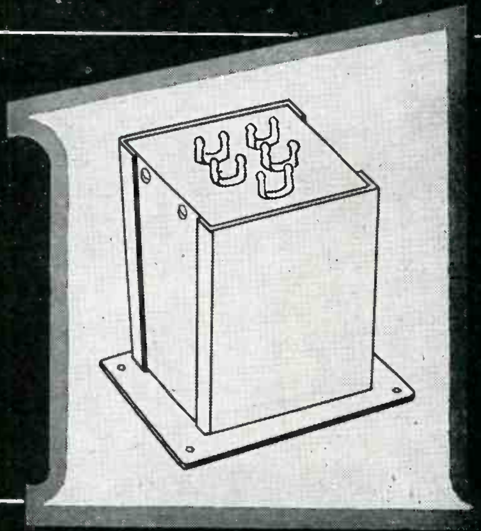

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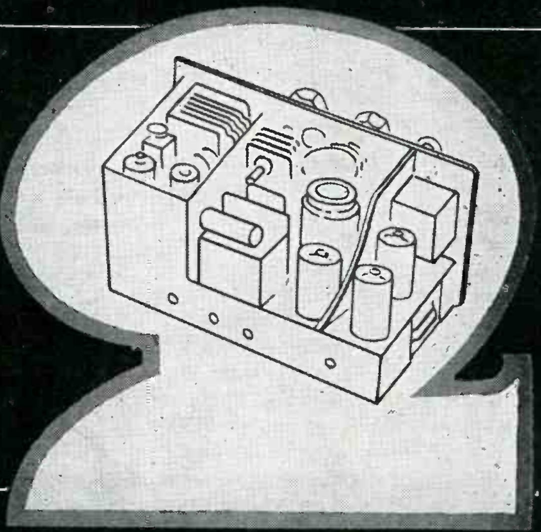

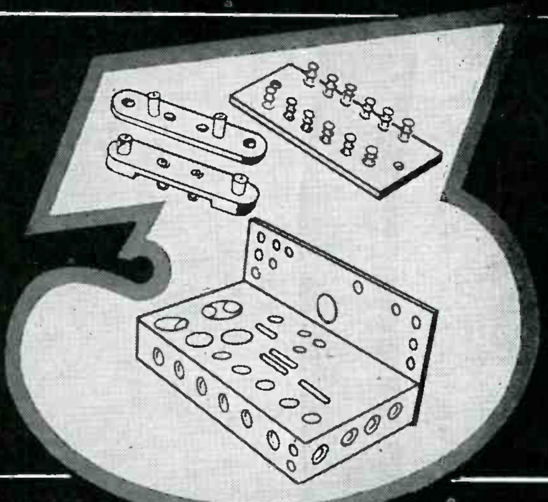

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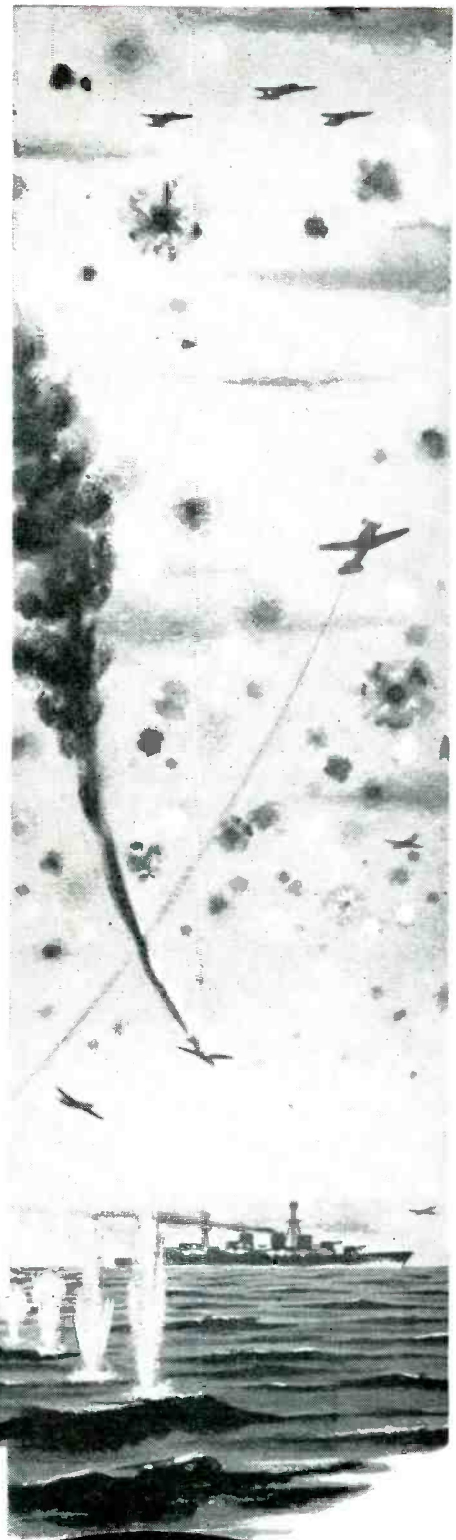

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Standardized

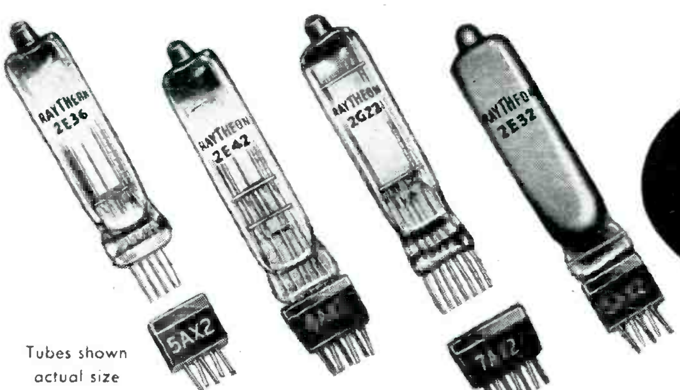
SUB-MINIATURE TUBES

**FIRST DEVELOPED TO BE SHOT FROM GUNS—
NOW DESIGNED FOR RADIO RECEIVER USE**

In October, 1940, Raytheon was the first tube manufacturer to take an NDRC contract to develop tubes for the Proximity Fuze project. In March, 1941, these tubes were successfully shot from guns and the Fuze project was established as being practical and effective. Late in 1941 Raytheon contributed a basically improved type of filament suspension which has since been employed in all vacuum tubes for the V T Fuze.

Since V T Fuzes could be used but once, the tubes were soldered in directly. This method is uneconomical for radio applications. With this in mind, Raytheon then developed a plug-in feature and low-loss socket which allows all the space-saving which characterizes these tubes. Today there are four basic types in the Raytheon line of sub-miniature tubes—all specifically designed for low-voltage radio receiver applications. Standard sockets are available permitting easy tube replacement and low cost chassis assembly operations.

These tubes have been standardized and registered with RMA. The day of pocket superheterodyne receivers for police patrol, fire-fighting, railroad operation and sport and entertainment reception is here, *now*. For long life, rugged construction, low assembly and maintenance costs—with user acceptance assured—use Raytheon Standard Sub-Miniature tubes. Technical data sheets available on request.



Tubes shown actual size

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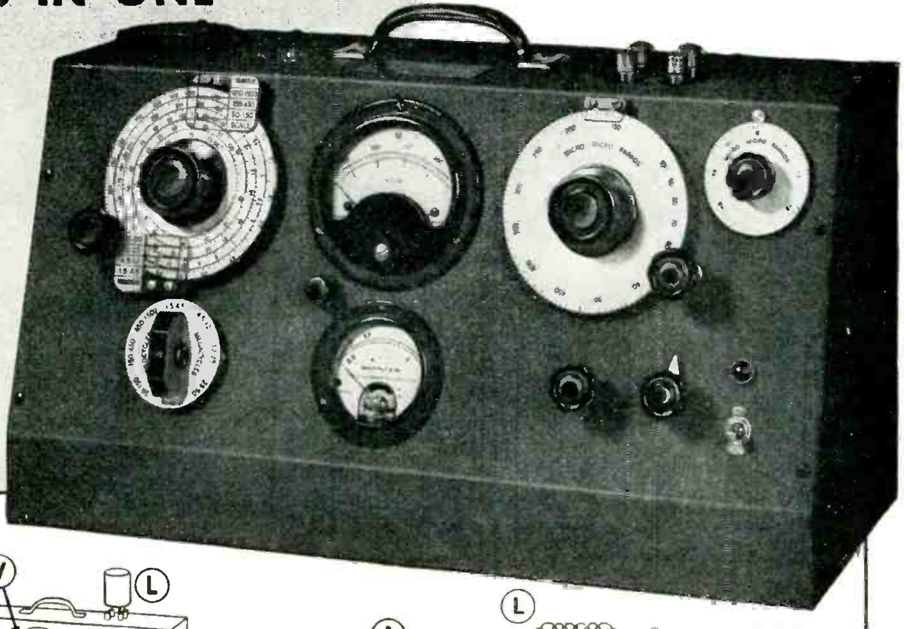
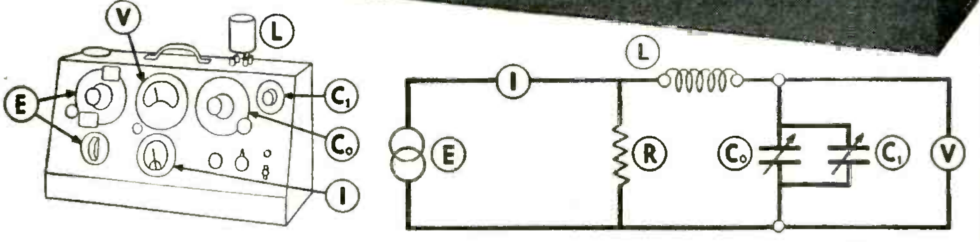
The Q METER

TYPE 160-A



A dependable test and measuring instrument that should be included in your new equipment plans.



SIMPLIFIED LAYOUT AND SCHEMATIC OF THE 160-A Q-METER

For many years the Q-Meter has been an outstanding contribution to the field of radio frequency measuring equipment. It is an indispensible instrument to engineers, manufacturers, research laboratories and to the whole radio and electronics industry. Because of its simplicity and ease of operation, it replaces many costly pieces of apparatus with which the radio laboratory is customarily equipped. More than one radio engineer has told us that "The Q-Meter is the most valuable instrument that we have in our laboratory".

A FEW USES OF THE 160-A-Q-METER

- Q and inductance measurement of coils.
- Q and capacitance measurement of capacitors.
- Dielectric and power factor measurements of ceramics, plastics and other insulating materials.
- Measurement of circuit losses.
- Interelectrode capacitance measurements.
- Measurement of input impedance of vacuum tubes.
- Measurement of high frequency cable characteristics.
- Measurement of characteristics of small antennae.
- Measurement of coefficient of coupling of R.F. Transformers.
- Measurement of transmission line characteristics.
- The measurement of frequency with negligible loading on circuit under test (50 kc.—75 mc.).

Write for catalog and supplement.

THE BASIC METHOD OF MEASUREMENT EMPLOYED IN THE 160-A Q-METER

An 8 range R.F. oscillator (E) supplies a heavy current (I) to an extremely low resistance load (R), the value of which is accurately known. The calibrated voltage thus developed across the load resistance (R) is coupled to a series circuit consisting of the inductance under test (L) and a calibrated variable air capacitor (C_0), having a vernier section (C_1). When this series circuit is tuned to resonance by means of the capacitor ($C_0 + C_1$), the "Q" of the inductance under test is indicated directly by the vacuum tube voltmeter (V). Variations of this basic method of measurement are used to measure inductance, capacitance and resistance.

SPECIFICATIONS

Oscillator Frequency Range: 50 kc. to 75 mc. in 8 ranges.

Oscillator Frequency Accuracy: $\pm$ 1%, 50 kc. — 50 mc.
$\pm$ 3%, 50 mc. — 75 mc.

Q Measurement Range: Directly calibrated in Q, 20–250: "Multiply-Q-By" Meter (I) calibrated in tenths from x1 to x2, and also at x2.5; extending Q range to 625.

Q Measurement Accuracy: Approximately 5% for direct reading measurement, for frequencies up to 30 mc. Accuracy less at higher frequencies.

Capacitance Calibration Range: Main capacitor section (C_0) 30–450 mmf accuracy 1% or 1 mmf whichever is greater. Vernier capacitor section (C_1) +3 mmf, zero, —3 mmf, calibrated in 0.1 mmf steps. Accuracy $\pm$ 0.1 mmf.

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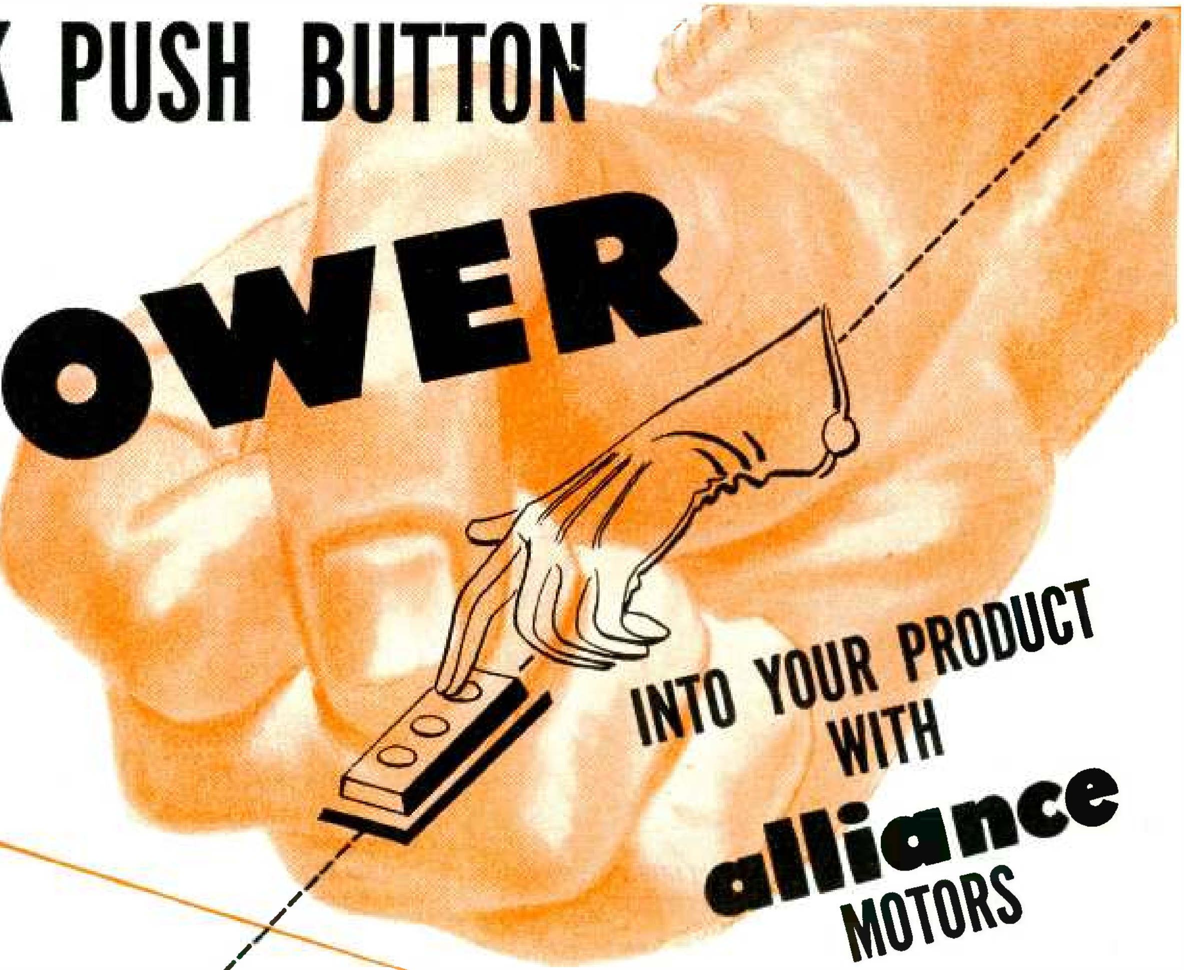

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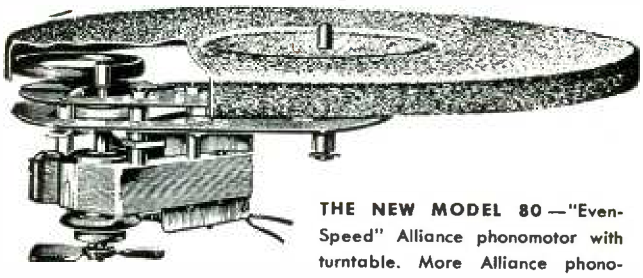

THE NEW MODEL 80—"Even-Speed" Alliance phonomotor with turntable. More Alliance phonomotors are used in the radio industry than any other kind.

Alliance Powr-Pakt Motors are manufactured in shaded pole induction and split phase resistor types. Frequencies range from 40 to 60 cycles, voltages from 24 to 250 and power ratings from less than 1–300th on up to 1–20th horsepower.

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Hook up your electronic, electrical and radio controls with Alliance Powr-Pakt Motors! They'll increase the flexibility and usefulness of any mechanical process.

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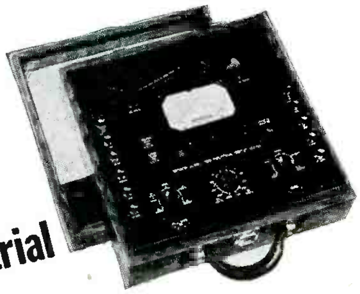
provides the simplest, quickest means for determining circuit conditions, loads taken by motors and other electrical equipment — all during normal operation without circuit interruption. The clamping jaws are simply placed over the conductor or bus, and current reading taken.



★ **the complete industrial CIRCUIT TESTER** (Model 785)

27 meters in one — with selected AC and DC voltage, current, and resistance ranges. With DC voltage sensitivity of 20,000 ohms per volt, it is ideal for testing photo-cell and sensitive relay circuits, alarm systems, electronic equipment etc., as well as small motors and controls, lighting circuits, etc. Can be used with current transformers and voltage multipliers.

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direct-reading, pocket size meter calibrated to measure light values in foot-candles, and in "seeing tasks". Equipped with the WESTON VISCOR filter, it measures all light values direct, without correction factors. Models for other requirements.

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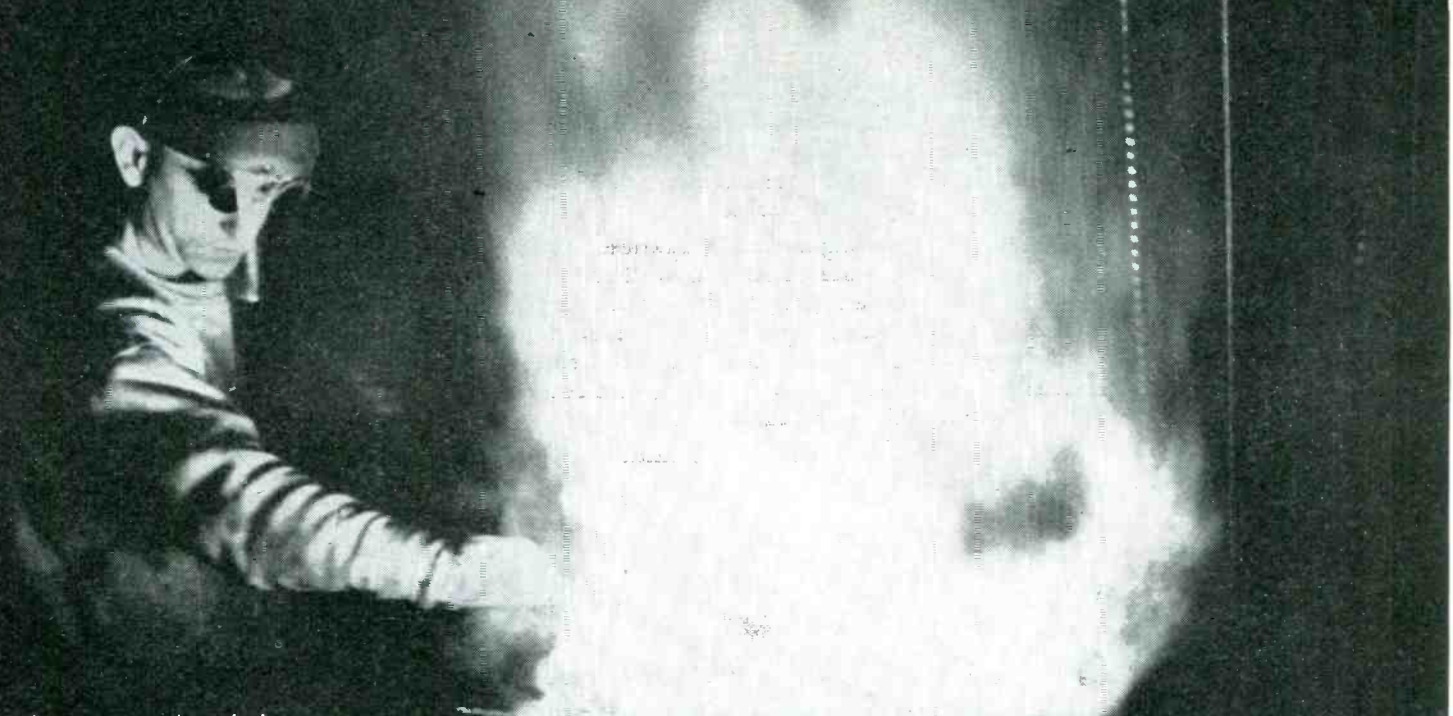

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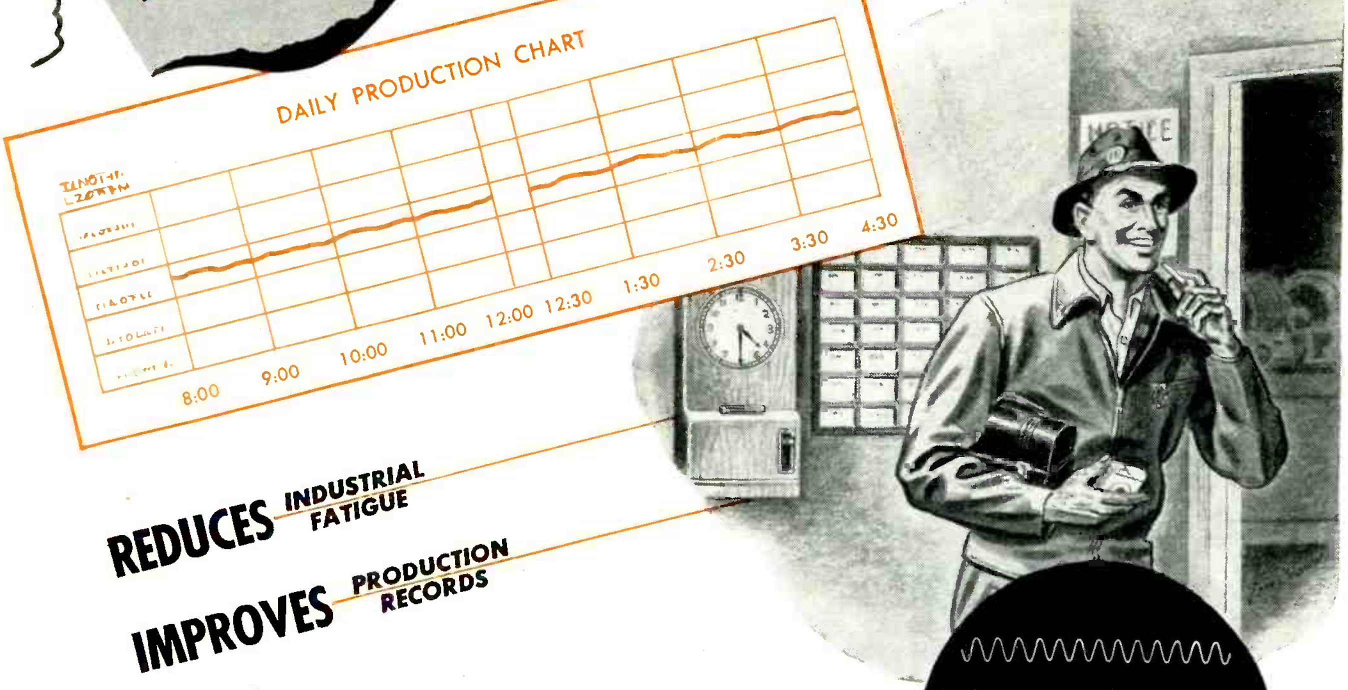

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"Vibration nerves" are a chief cause of industrial fatigue, with all its attendant troubles: employees who are tired before lunchtime; supercritical foremen and quickly resentful workers; confusion; lowered production; increased absenteeism and labor turnover; all cutting deep into company profits.

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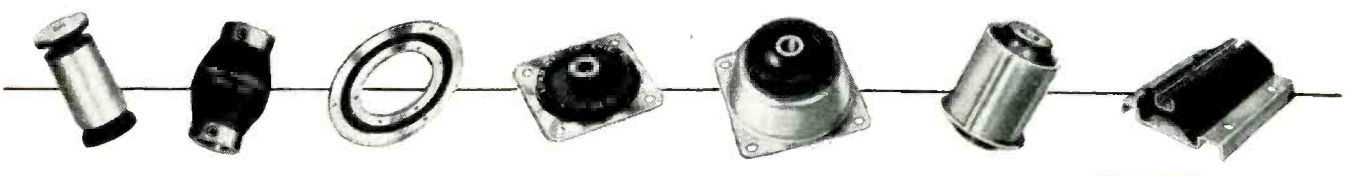
When you come to Lord, you are coming straight to Vibration Control Headquarters.

Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.



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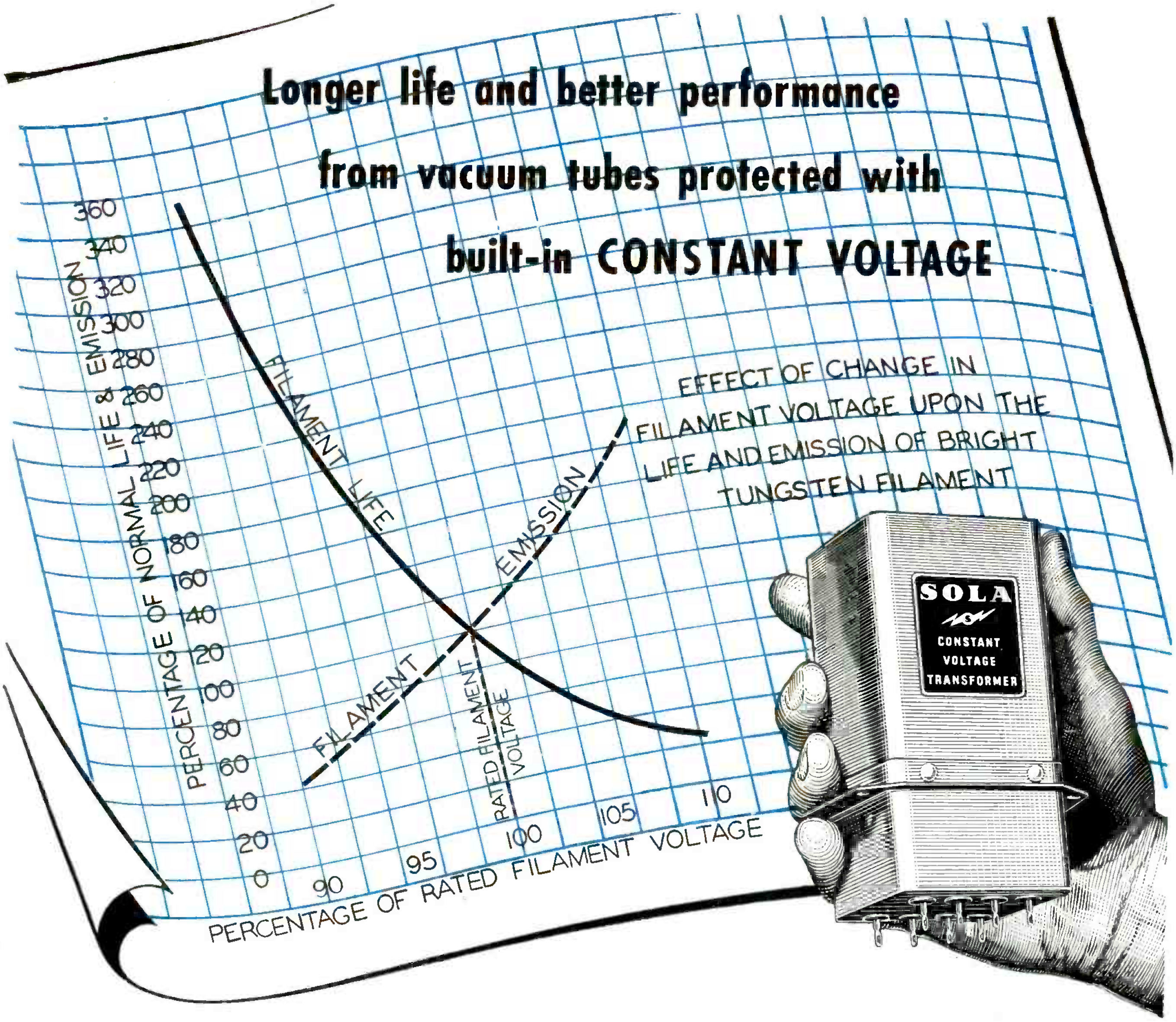

A 5% over-voltage will reduce the life of a tungsten filament by 50%.

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Commercial line voltages today may vary as much as ± 20%.

With a SOLA Constant Voltage Transformer as a built-in component of your equipment, these line voltage variations can be ignored. No need to depend upon operator adjustments. No need to worry about operator forgetfulness. You can depend on it — the right voltage is *always* there.

Vacuum tubes protected by SOLA Constant Voltage Filament Transformers require no starting resistors or high reactance transformers. Filaments are automatically and positively protected against damaging inrush currents. Tube life is noticeably prolonged.

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Standard units are available in capacities from 10 VA to 15 KVA either for the operation of equipment now in use or as built-in units. Where special problems confront the designer, consultation with SOLA engineers may provide a positive and economical solution.

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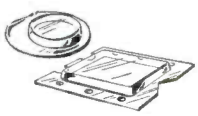
Radio Dial windows are a Printloid specialty, and we have made millions for the country's largest radio manufacturers. Printloid has worked for every industry, producing finished products as well as sub-assemblies.



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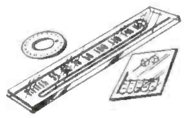

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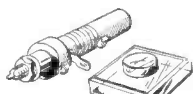

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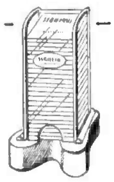
Printloid experts work to your specifications or execute your original designs. Displays have been created for leading national advertisers. Our engineers invite you to consult them on your problems.



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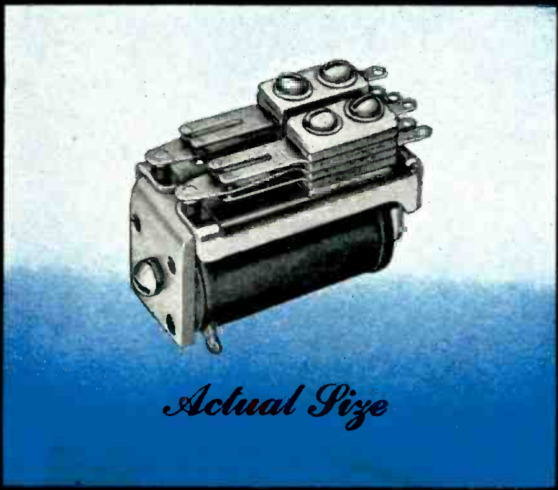

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Weight 1¾ oz.

Windings up to 6000 ohms

Operating voltages up to 85 volts DC, wattage 1.25 to .3

Contact arrangements in all variations of forms A-B-C to maximum of 12 springs

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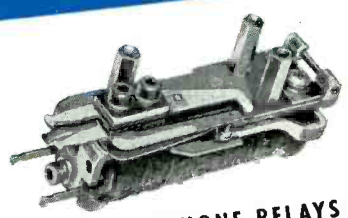

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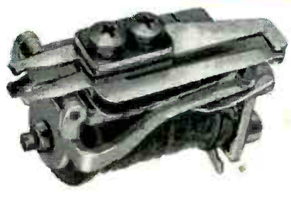
4" long. Operating voltages up to 220 volts DC—time delay—palladium contacts carry 175 watts—up to 24 springs.



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Designed for such power circuits as motor starting up to 1 hp., heater loads up to 20 amperes, or any control circuit requiring fast, positive switching. Contact arrangements up to DPDT.

● Build P & B standard relays into your design and take advantage of the low cost, quick delivery, that mass production offers. Forward your specifications today for price and delivery estimates. Large quantities of standard parts are stocked for quick assembly. Write for 1946 catalog illustrating a full line of "Standard Relays." Most types are carried in stock by your local electronics parts jobber.

Potter & Brumfield SALES CO., 549 West Washington Blvd., Chicago 6, Ill.

EXPORT DEPARTMENT, 2020 ENGINEERING BUILDING, CHICAGO 6, U. S. A.

RAYTHEON'S NEW STUDIO CONSOLE

For AM or FM

Easily Controls Two Studios, Announcer's Booth and Fourteen Permanently Wired Remote Lines

COMPLETE high-fidelity speech-input facilities for the modern station; this single compact unit contains all the control, amplifying and monitoring equipment. Any combination of studios, remote lines or turntables may be broadcast and auditioned simultaneously through the two high quality main amplifier channels. On-coming programs may be cued and the volume pre-set while on the air.

Its modern functional beauty in two-tone metallic tan will blend with other equipment and yet add a definite air of quality and distinction to your studio. Sloping front panel combines maximum visibility of controls with ease of operation. Sloping top panel gives operator an unobstructed view into the studio.

Engineered for dependability and built of finest quality components throughout. Telephone-type lever action, 3 position key switches assure trouble-free operation and *eliminate nineteen controls*. This simplified switching reduces operational errors. All controls are standard, simple and positive—easy to operate.

Inquire! The low price of this Raytheon Console will amaze you. The first orders are now being delivered. Write to:

RAYTHEON MANUFACTURING COMPANY
Broadcast Equipment Division
7517 N. Clark Street, Chicago 26, Illinois

Devoted to Research and Manufacture for the Broadcasting Industry

Compare THESE OUTSTANDING FEATURES WITH ANY OTHER CONSOLE

1. **Seven** built-in pre-amplifiers—*more than any other console*—making possible 5 microphones and 2 turntables, or 7 microphones, on the air simultaneously.
2. **Nine** mixer positions—*more than any other console*—leading to 5 microphones, two turntables, one remote line and one network line.
3. **Fourteen** remote lines—*more than any other console*—may be wired in permanently.
4. **Telephone-Type** lever-action key switches used throughout—most dependable, trouble-free switches available. No push buttons.
5. **Frequency Response** 2 DB from 30 to 15,000 cycles. Ideal speech input system for either AM or FM.
6. **Distortion** less than 1%, from 50 to 10,000 cycles.
7. **Noise Level** minus 65 DB's or better. Airplane-type four-way rubber shock mounting eliminates outside noise and operational "clicks."
8. **All FCC Requirements** for FM transmission are met.
9. **Dual Power Supply** provides standby circuit instantly available for emergency use.
10. **Power Supply** designed for mounting on desk, wall or relay rack.
11. **Instant Access** to all wiring and components. Top hinged panel opens at a touch. Entire cabinet tilts back on sturdy full-length rear hinge.

RAYTHEON

Excellence in Electronics

Ends your search for a versatile
HARD AS DIAMOND **CERAMIC**

Conjured up in the crystal ball lies the answer to your radio frequency insulation and industrial ceramic problems. Consult with us on the possibilities of using STEATITE . . . the material of the future . . . TODAY.

Centralab

Division of GLOBE-UNION INC., Milwaukee

PRODUCERS OF

Ceramic Trimmers
Bulletin 695

Ceramic High Voltage Capacitors
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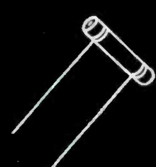
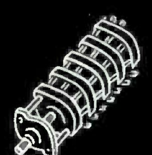
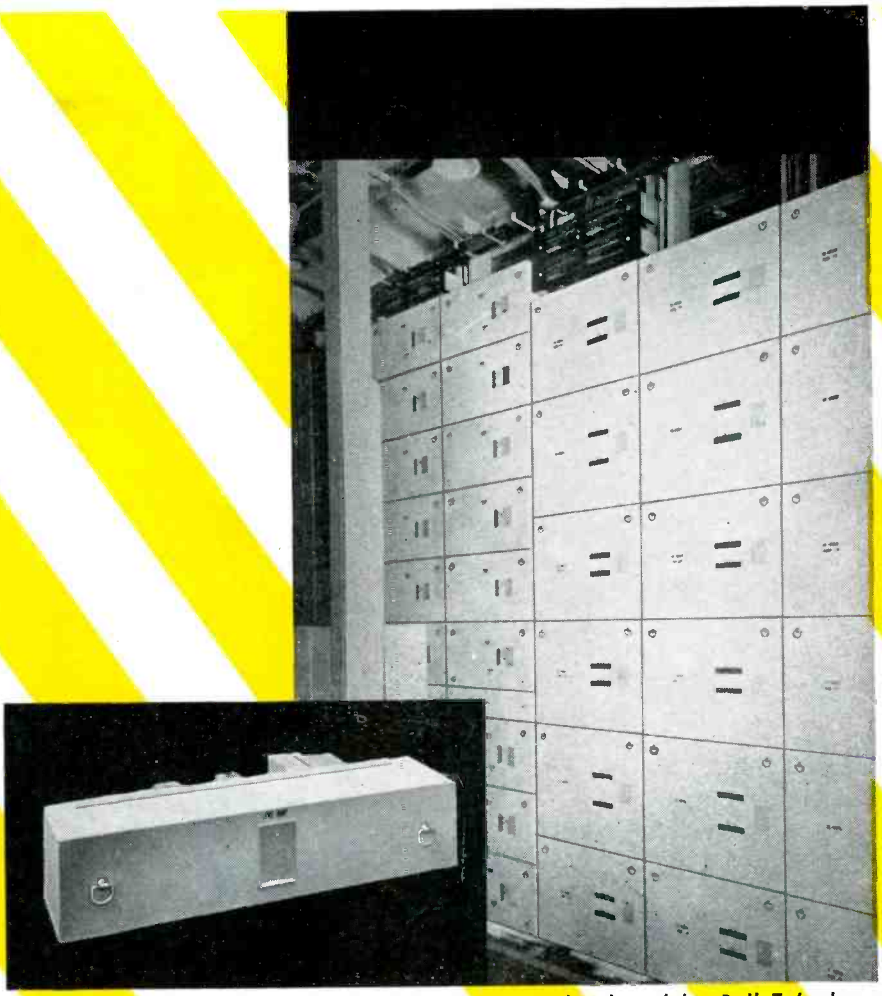
Variable Resistors
Bulletin 697



Tubular Ceramic Capacitors
Bulletins 630 and 586



Selector Switches
Bulletin 722



Toll Systems Broad Band Carrier Telephone, as developed by Bell Telephone Laboratories, must be readily accessible for inspection and maintenance. Close-up of Line Amplifier used in multi-channel Carrier Telephone Systems, showing ring type Dzus fasteners, which permit quick removal of telephone equipment covers.

DZUS* FOR ACCESSIBILITY
Saves time and money

The rapid, positive-action of these fasteners speeds up accessibility to vital parts and thus reduces inspection and maintenance time and cost. It is easy to install on any hinged or removable part. The Dzus spring and stud are permanently attached—no parts to get loose or lost. For speedy, dependable fasteners—always specify Dzus spiral cam fasteners. Dzus Fastener Co., Inc., Babylon, New York. In Canada: Railway and Power Engineering Corp., Ltd.

SEND for a copy of the new Dzus brochure. More and more manufacturers in all fields of industry are adopting Dzus spiral cam fasteners because of their outstanding advantages.

**The word Dzus is the registered trade mark of the Dzus Fastener Co., Inc.*

Why are Carbonyl Iron Powders better?

In illustration, note regularity of pattern. This is due to uniform shape, density, size, and purity of each particle.

These factors account for high "Q" value—the combination of maximum magnetic permeability and minimum power loss. This is why carbonyl iron powders are better.

The following text gives a brief, complete outline of G.A.F. Carbonyl Iron Powders for those desiring more information.

G.A.F. Carbonyl Iron Powders are obtained by thermal decomposition of iron penta-carbonyl. There are five different grades in production, which are designated as "L," "C," "E," "TH," and "SF" Powder. Each of these five types of iron powder is obtained by special process methods and has its special field of application.

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

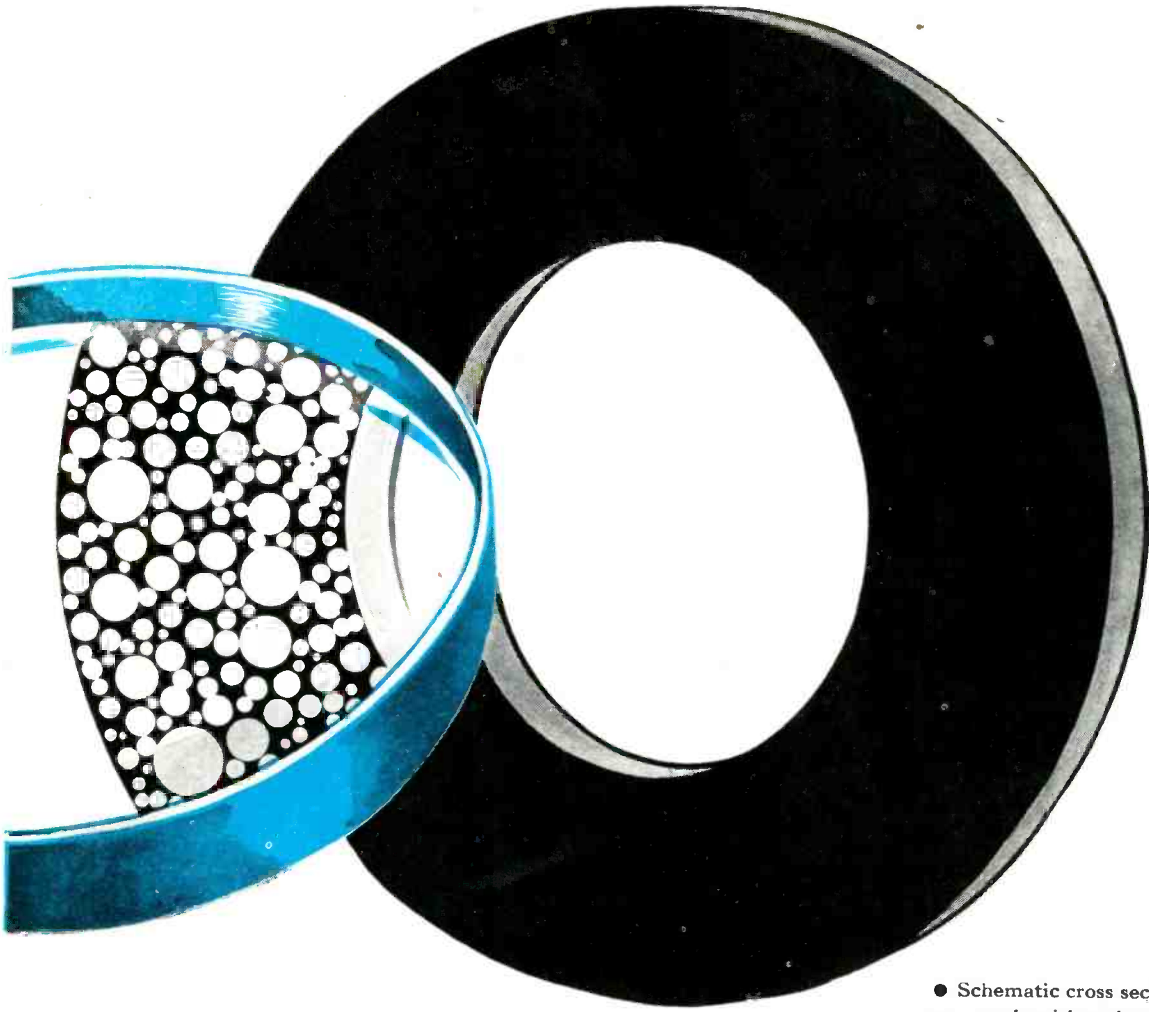
The chemical analysis, the weight-average particle size, the "tap density," and the apparent density are given in the following table for the five different grades:

TABLE 1

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

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

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



● Schematic cross section of powdered iron core made with carbonyl iron powder.

Table 2 below gives relative Q values (quality factors) and effective permeabilities for the different grades of carbonyl iron powder. The values given in the table are derived from measurements on straight cylindrical cores placed in simple solenoidal coils. Although the data were not obtained at optimum conditions, the Q values as expressed in percentage of the best core give an indication of the useful frequency ranges for the different powder grades.

TABLE 2

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

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

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

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

G.A.F. CARBONYL IRON POWDERS

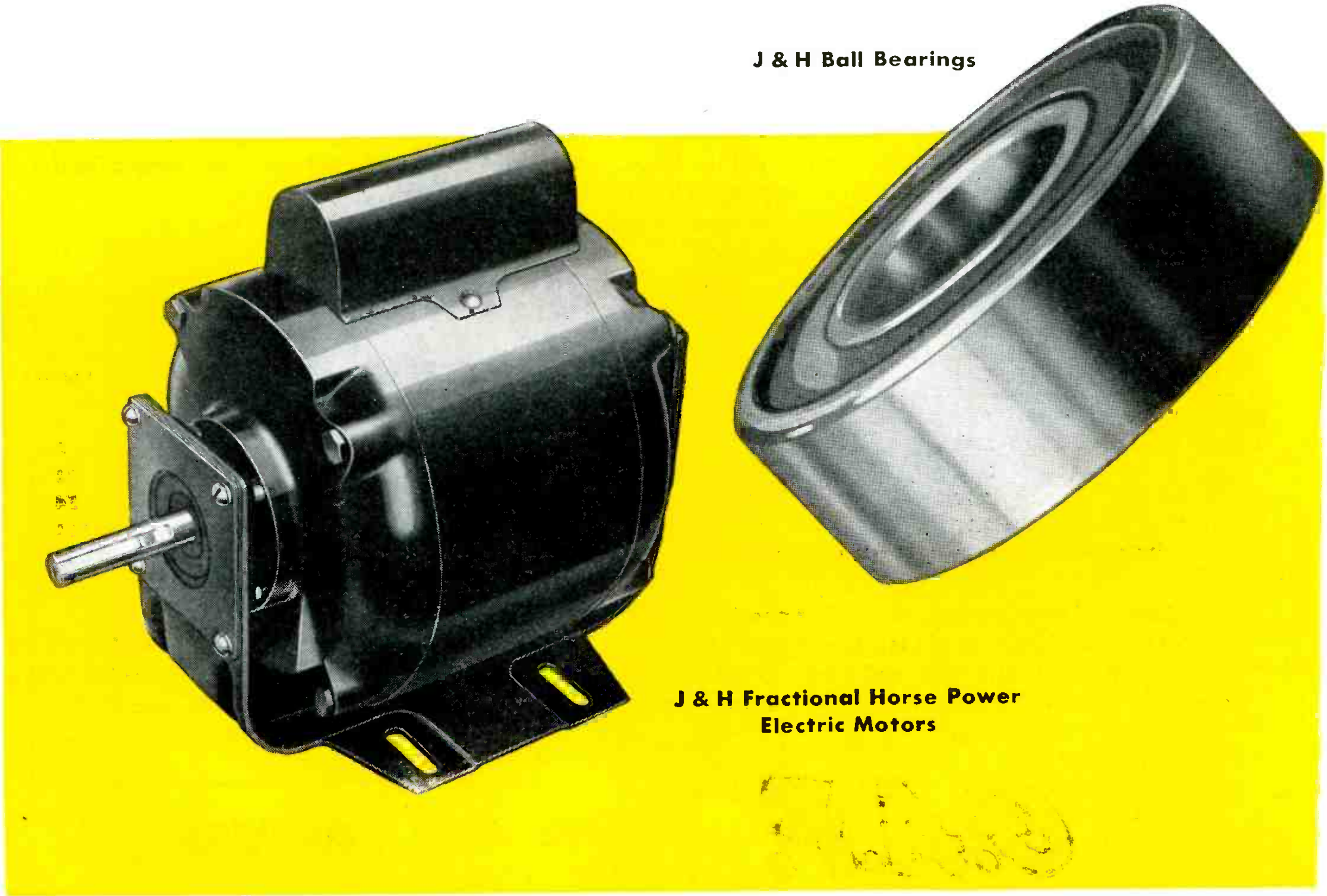
What's Jack & Heintz doing?

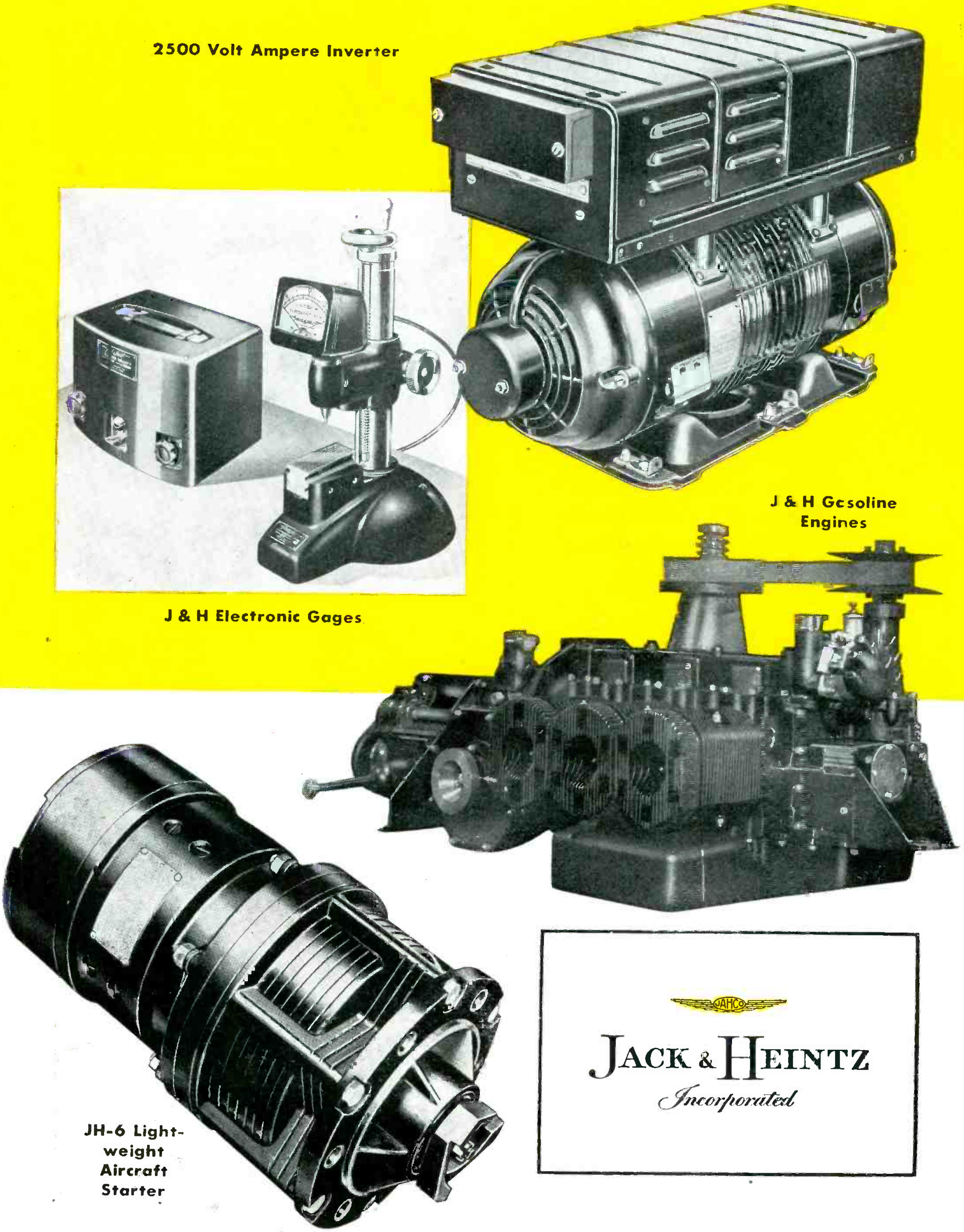
Busy manufacturing the things you see on this page. All (except the engine, which is still under test) are pouring off our production lines—lines that the war proved can turn out precision products in mass-production speed and quantity.

During the war Jack & Heintz made many of the most delicate instruments our Air Forces used—and had to make them in larger quantity and less time than had ever before been possible. And Jack & Heintz did it.

This skill-in-quantity, this precision-in-volume, is now being applied to the products shown here, and will be used to manufacture others soon.

Our pledge to peacetime customers is the same as our pledge to the Air Force—every product bearing our name will be made with the same skill and care as the products on which lives depended—and depended safely—in the war. Jack & Heintz, Inc., Cleveland, Ohio.





2500 Volt Ampere Inverter

J & H Electronic Gages

J & H Gasoline Engines

JH-6 Lightweight Aircraft Starter

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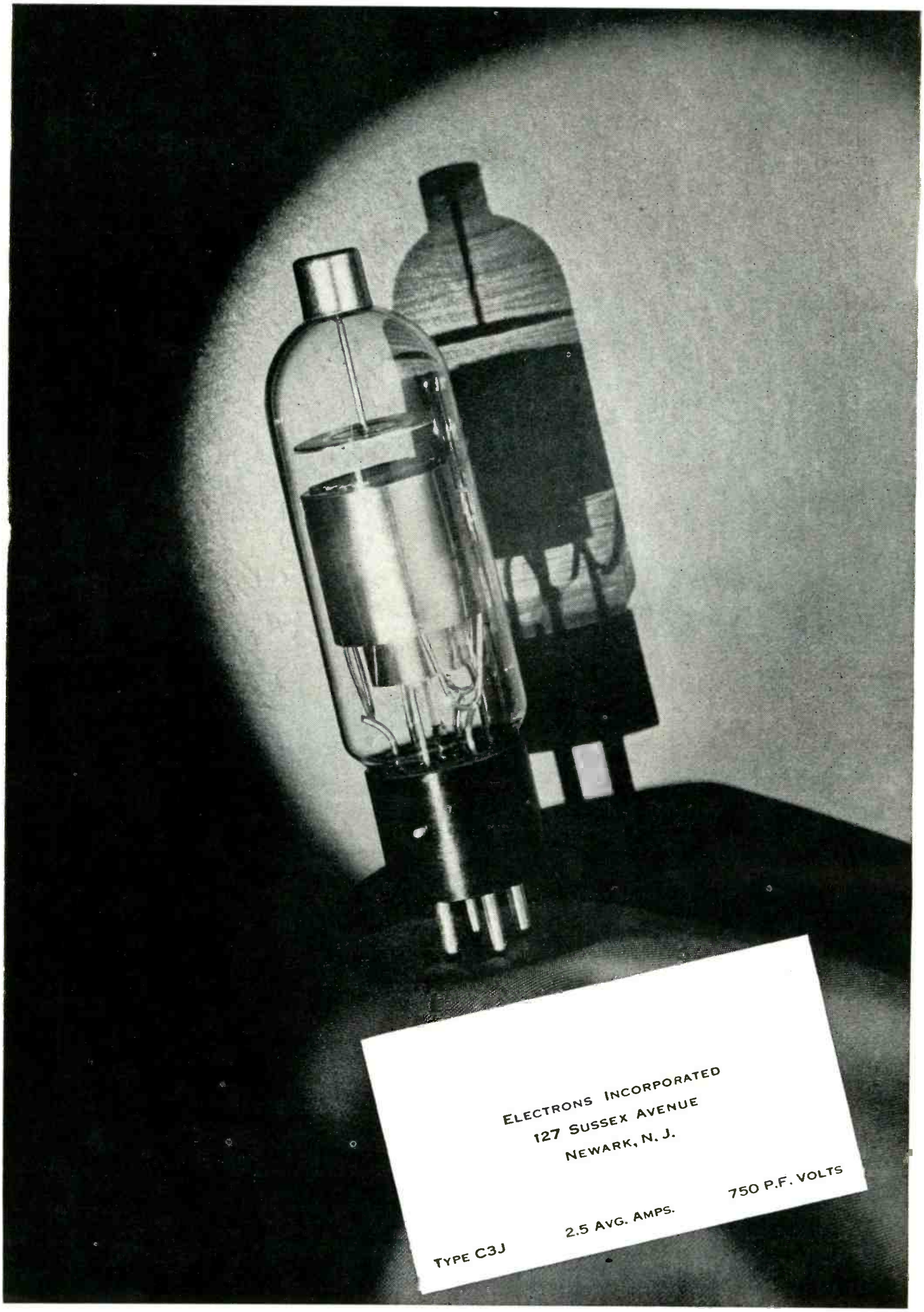
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127 SUSSEX AVENUE
NEWARK, N. J.
TYPE C3J
2.5 AVG. AMPS.
750 P.F. VOLTS


NEW ECONOMY, LIGHT WEIGHT, SERVICE
WHATEVER YOUR LINE!
THIS POWER CABLE was installed in an unfavorable situation. Part of it runs adjacent to high pressure steam lines. Part lies in sump water containing cresylic acid waste. The cable itself is a 300,000 CM power cable used on 4,160 volt Delta, 3 phase, 60 cycle – 300 ampere average service. It is cycled periodically from a no load condition to full load. Replacing a heavy cable sheathed with paper and lead, in July, 1944, the new conductor is insulated with polyethylene, a plastic so light it floats in water. Only 6/64-inch thick, this insulation has remarkable low loss electrical characteristics, an extremely low water vapor transmission coefficient, and exceptional resistance to water and chemicals. It is tough and impact resistant; inherently flexible and extensible; has a wide temperature working range.
Polyethylene insulation should rapidly supplant many older types – yield longer service and bring freedom from many causes of failure. Engineers, designers, and manufacturers will find, too, that the unique properties of this new plastic will bring economy and improved characteristics to an almost limitless line of products. Polyethylene resins can be molded as well as extruded; calendered onto cloth and paper; made into monofilaments, flexible sheets and film.
Write Department 18-P for Booklet V-2, "Polyethylene Resins." Experimental samples of this new plastic are also available upon request.
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Unit of
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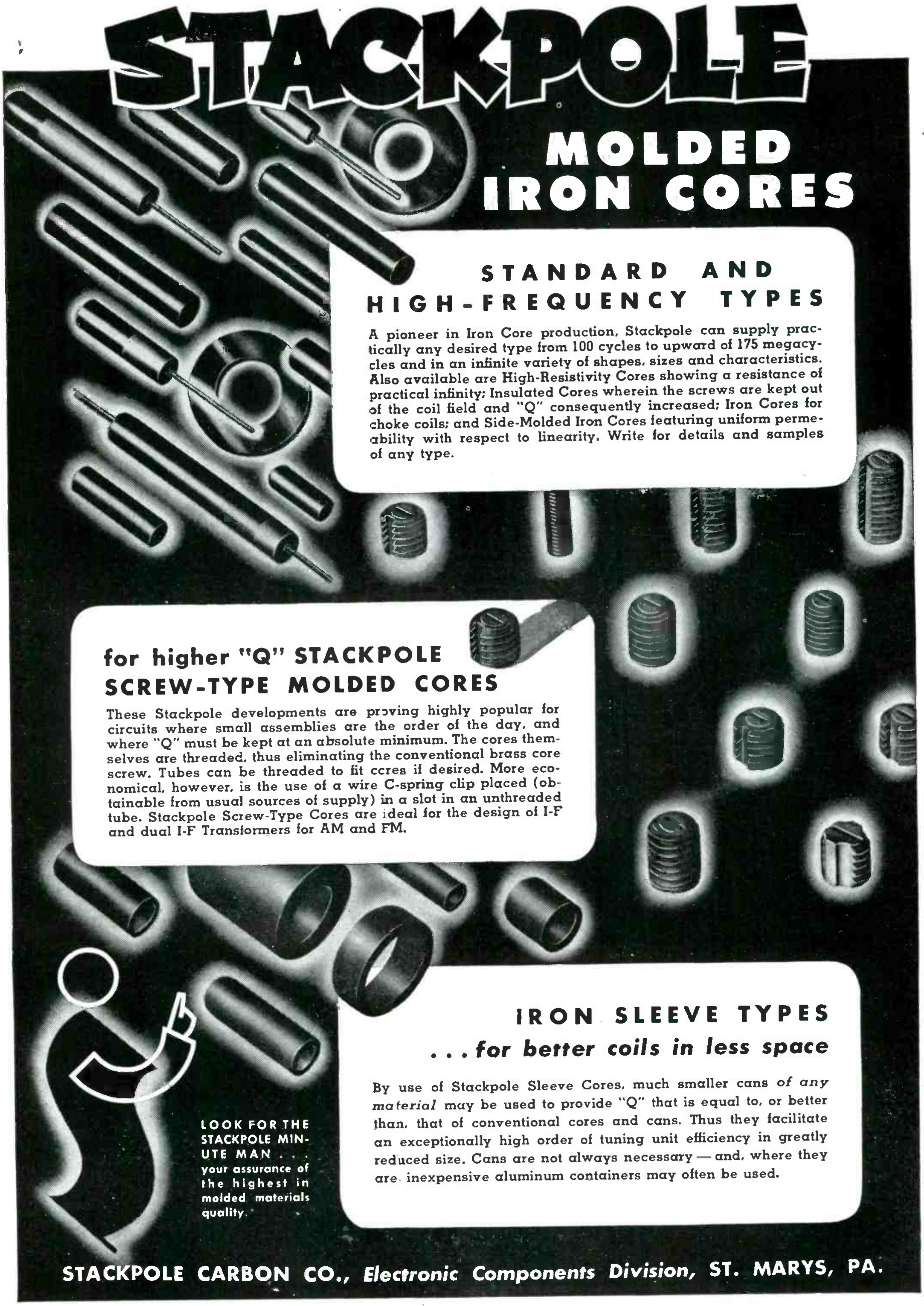
UCC
30 E. 42ND ST., NEW YORK 17, N.Y.
POLYETHYLENE


STACKPOLE
MOLDED IRON CORES
STANDARD AND HIGH-FREQUENCY TYPES
A pioneer in Iron Core production, Stackpole can supply practically any desired type from 100 cycles to upward of 175 megacycles and in an infinite variety of shapes, sizes and characteristics. Also available are High-Resistivity Cores showing a resistance of practical infinity; Insulated Cores wherein the screws are kept out of the coil field and "Q" consequently increased; Iron Cores for choke coils; and Side-Molded Iron Cores featuring uniform permeability with respect to linearity. Write for details and samples of any type.
for higher "Q" STACKPOLE SCREW-TYPE MOLDED CORES
These Stackpole developments are proving highly popular for circuits where small assemblies are the order of the day, and where "Q" must be kept at an absolute minimum. The cores themselves are threaded, thus eliminating the conventional brass core screw. Tubes can be threaded to fit cores if desired. More economical, however, is the use of a wire C-spring clip placed (obtainable from usual sources of supply) in a slot in an unthreaded tube. Stackpole Screw-Type Cores are ideal for the design of I-F and dual I-F Transformers for AM and FM.
IRON SLEEVE TYPES
. . . for better coils in less space
By use of Stackpole Sleeve Cores, much smaller cans of any material may be used to provide "Q" that is equal to, or better than, that of conventional cores and cans. Thus they facilitate an exceptionally high order of tuning unit efficiency in greatly reduced size. Cans are not always necessary — and, where they are, inexpensive aluminum containers may often be used.
LOOK FOR THE STACKPOLE MINUTE MAN . . . your assurance of the highest in molded materials quality.
STACKPOLE CARBON CO., Electronic Components Division, ST. MARYS, PA.

LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

DOUBLE SENSITIVITY D. C. VOLT RANGES
0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A. C. VOLT RANGES
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM-MEGOHMS
0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)
0-10 megohms (60,000 ohms center scale)

DIRECT READING OUTPUT LEVEL DECIBEL RANGES
−30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D. C. MILLIAMPERES
0-1-10-100-1000 Milliamperes, at 250 M.V.

D. C. AMPERES
0-10 Amperes, at 250 M.V.

OUTPUT READINGS
Condenser in series with A.C. Volts for output readings.

ATTRACTIVE COMPACT CASE
Size: 2½" x 5½" x 6". A readily portable, completely insulated, black, molded case, with strap handle. A suitable black, leather carrying case (No. 629) also available, with strap handle.

LONG 5" SCALE ARC
For greater reading accuracy on the Triplett RED ● DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

Write for descriptive folder giving full technical details

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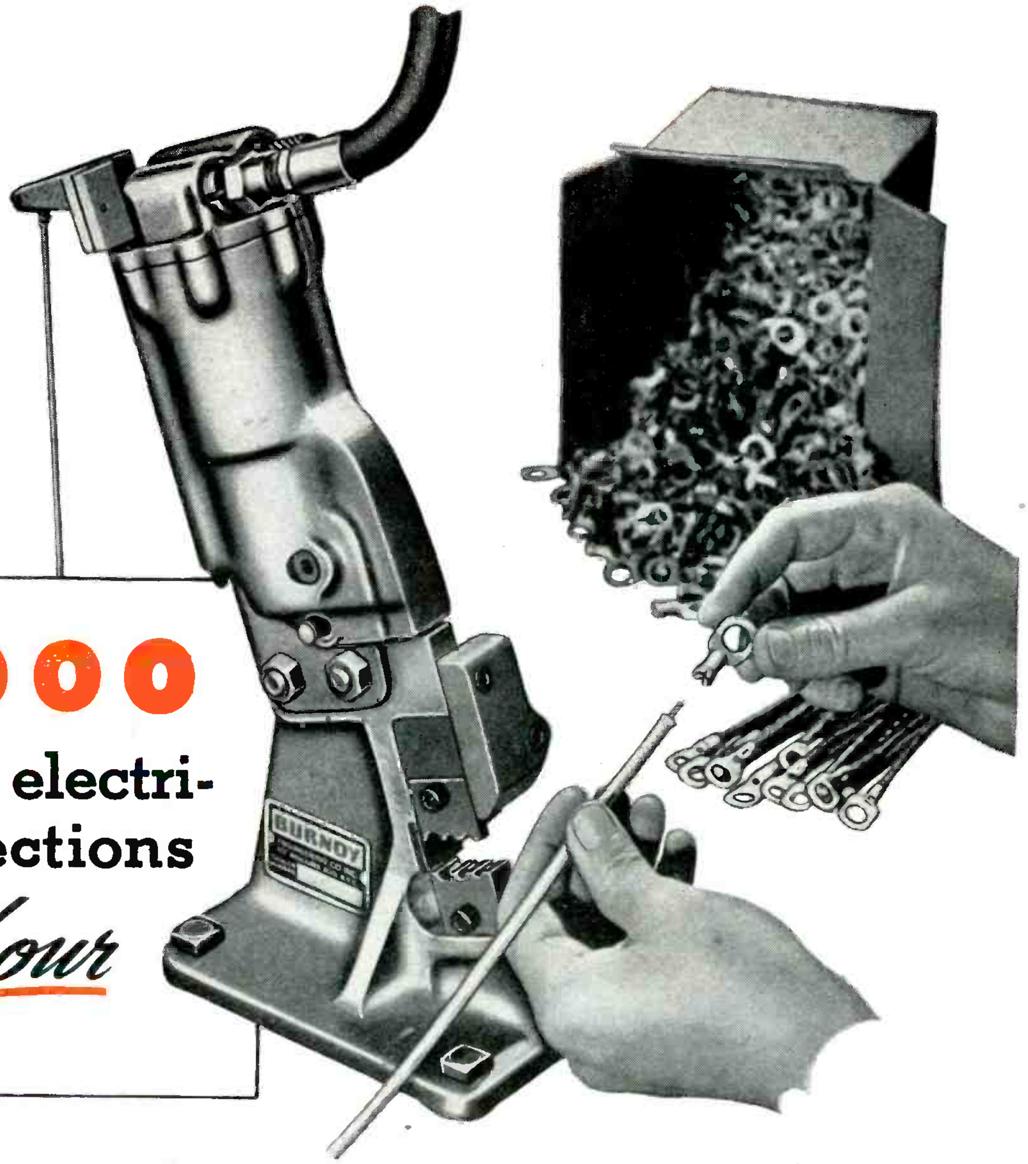
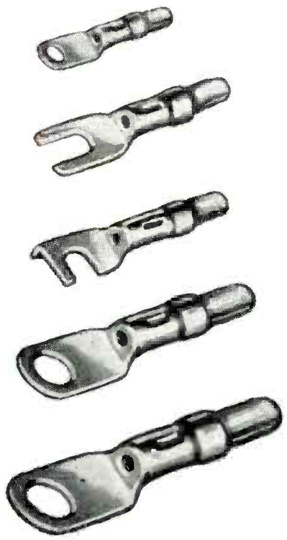
STANDARDS ARE SET BY TRIPLETT

Triplett
ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

up to **1000** solderless electrical connections *per hour*





Burndy HYPRESS

(Pneumatic Foot Operation)

Make your own cost comparison. With this new Burndy No. Y10NCP HYPRESS one operator can attach up to 1000 Burndy HYDENT connectors per hour! *Compare for efficiency too,* remembering that the HYDENT connector is of one-piece pure copper construction, and that each connection is uniform in mechanical strength and electrical efficiency. For complete information write for the HYDENT catalog. Burndy Engineering Co., Inc., 107-L Bruckner Blvd., New York 54, N. Y.

BURNDY ENGINEERING COMPANY, INC.

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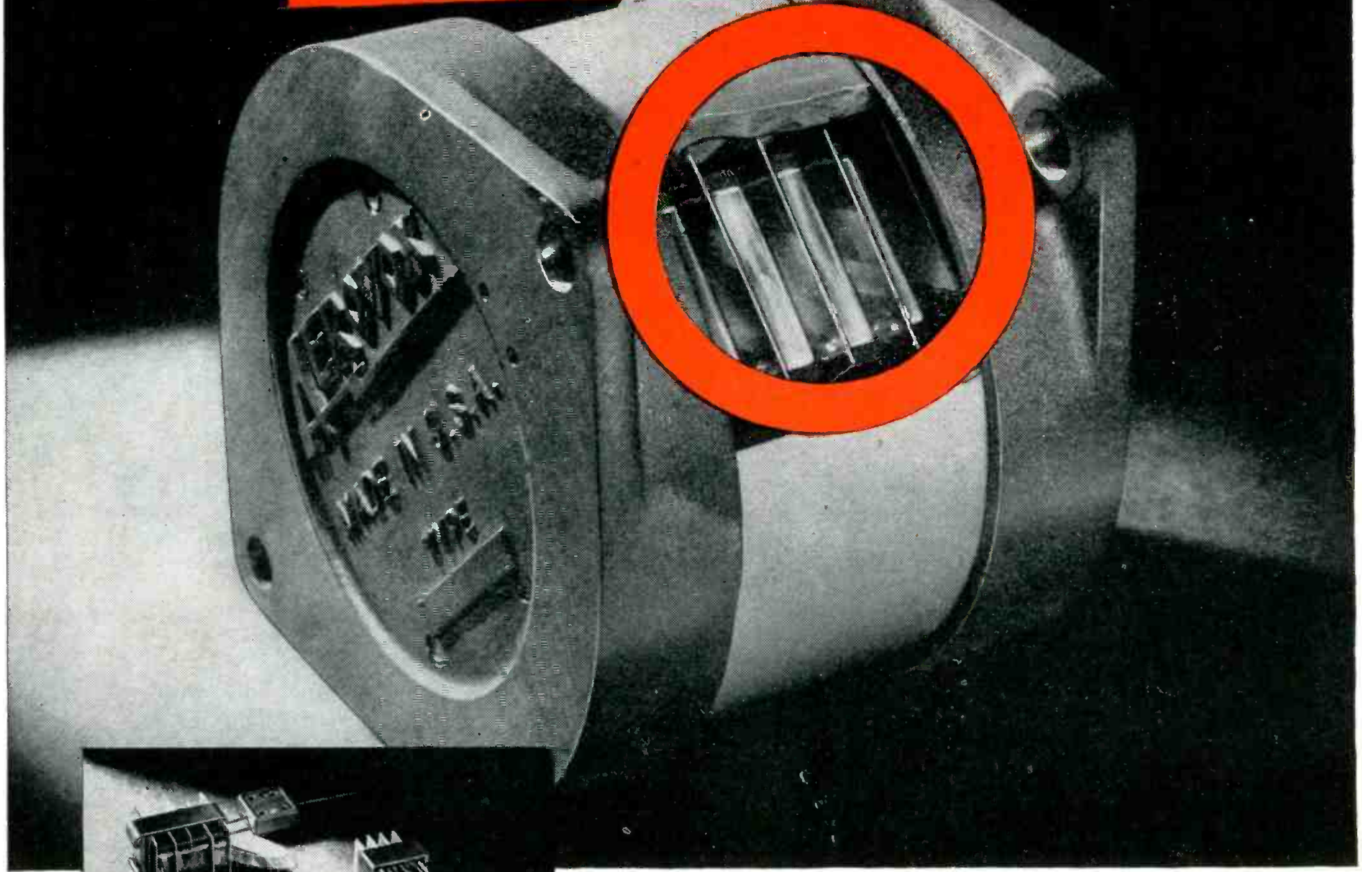
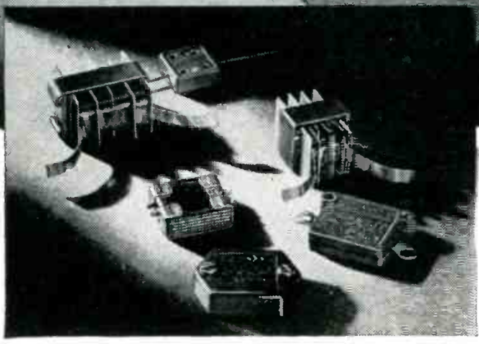
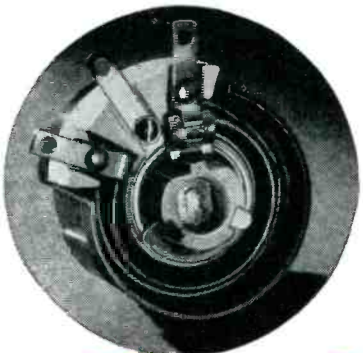
Sealed-In ELECTRICAL





(*Top*) Aerovox Type 1970 Capacitor cutaway to show sections formed of alternate layers of Mica and foil. Also shown (*left*) are Aerovox Types 1467, 1455 and 1650, before and after molding or potting. Clear and slightly stained sheet mica is employed because it is free of all cracks, waves and buckles, providing an even insulating surface with strong, uniform dielectric characteristics.



For this metallic rheostat, the DeJur Amsco Corporation required a thin, flexible insulating material that would not break down under temperatures up to 300° F. Micanite tubing was slit and inserted between resistance element and metal case. Complete electrical and thermal insulation was provided.

MUNSELL MICA

MICANITE Built-Up Mica

LAMICOID Laminated Plastics

EMPIRE Varnished Cloths and Tapes

MICo Insulating Specialties

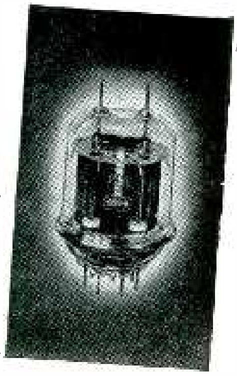
INSULATION CAN BE DEPENDABLE

That's why the Aerovox Corporation specifies Mica for many of its molded, ceramic cased and other type capacitors. Mica seldom breaks down. Under almost any conditions Mica's dielectric strength, uniform dielectric constant and unusual capacitance stability provide dependable sealed-in insulation. Its inherently low dielectric loss and temperature coefficient are additional safeguards to maintain product quality and longevity. And Mica's chemical stability and natural resistance to heat permit its use in the most humid climates.

All of Mica's durable physical and electrical qualities are available to you in two basic forms—as sheet mica or as Micanite (thin Mica splittings bonded together into tubes or sheets). Either form is supplied pre-fabricated to your specifications. Consult our engineers with your next insulation problem. Their long experience with every type of insulating material assures you of an unbiased recommendation. Mica Insulator Company sales offices and distributors are conveniently located throughout the United States.

PROPERTIES OF SHEET MICA

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



In processing, the RCA 829 transmitting tube is subjected to temperatures much higher than encountered in normal service in order to release unwanted gases. Because clear sheet mica is free of gaseous inclusions of its own and can withstand much higher temperatures, it was specified for the combined functions of grid and plate spacer and insulator.

EUGENE MUNSELL DIVISION OF

MICA *Insulator* COMPANY

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

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Gentlemen:

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( ) Enclose price list.
( ) Please have your application engineer see me when in my vicinity.

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Ex-G.I. Seeks Job

Can you use this finger-size 10 kw Triode?

Doubtless there are many electronic experimenters and designers working in the intermediate micro-wave range with need for just such a triode. Designed and built by National Union for advanced radar installations, this N. U. 3C37 should prove a "natural" for engineers concerned with instruments for aircraft, navigation, railroads, communication relay transmission and many related applications. Here is the only tube of its kind—a newcomer to electronics, yet an experienced veteran proved under the most rigorous service conditions. There are electronic jobs it can do better than they have ever before been done—problems it can solve for the first time. Why not write us about the N. U. 3C37? Or come to our laboratories and talk it over with a National Union engineer.

Qualifications of the N. U. 3C37

- Delivers 10 KW peak RF power output at frequencies as high as 1150 megacycles.
- Anode and grid dissipation capabilities are adequate to enable the tube to withstand large momentary overloads without damage or distortion of electrical characteristics.
- Internal and external surfaces are silver plated to minimize skin resistance and RF losses.
- Specially constructed radiator greatly reduces RF losses. Permits operation at duty cycles of 1% with air-blast cooling.
- Anode radiator of silver plated copper efficiently transfers heat to any resonator of which it becomes a part.
- Negligible frequency drift due to cylindrical construction and closely controlled mechanical tolerances.
- Maximum mechanical strength.

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RADIO AND ELECTRON TUBES

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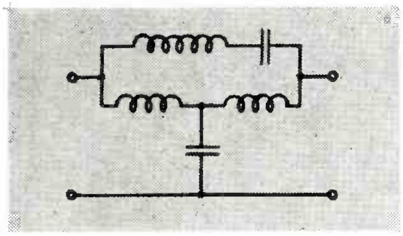

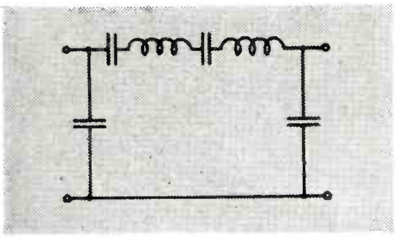

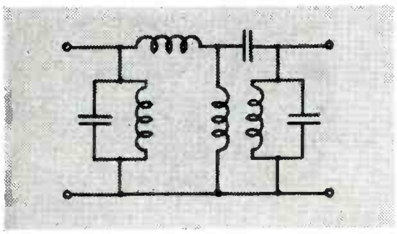

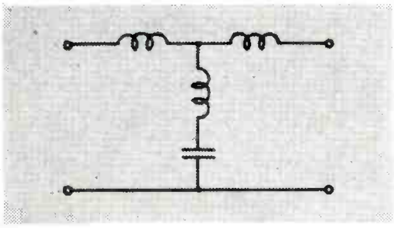

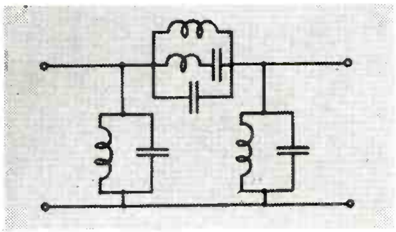

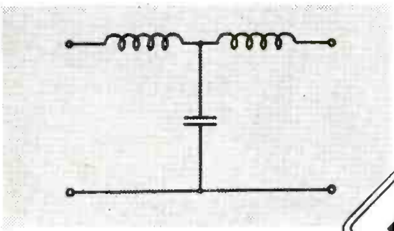

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ELECTRIC WAVE FILTERS

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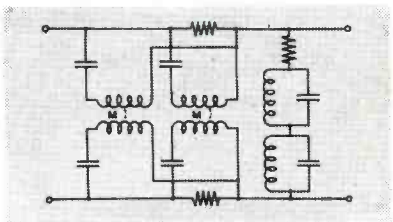
Kenyon's **always progressive engineering staff has created a wide range of *Special Design Laminations* employing practical application of the very latest steel alloys. As a result, efficient, low cost and compact space saving equipment are all now available.**

Because standard transformer cases are not usually suitably shaped for *Filter* Components, Kenyon's engineers have developed a wide range of special designs guaranteed to deliver maximum efficiency.

Diligent research has given Kenyon's engineers a vast and an intimate knowledge of filters and filter components. As your advisors, these experts can usually recommend minor changes in specifications that allow major saving in COST, EFFICIENCY or SIZE — or all three.

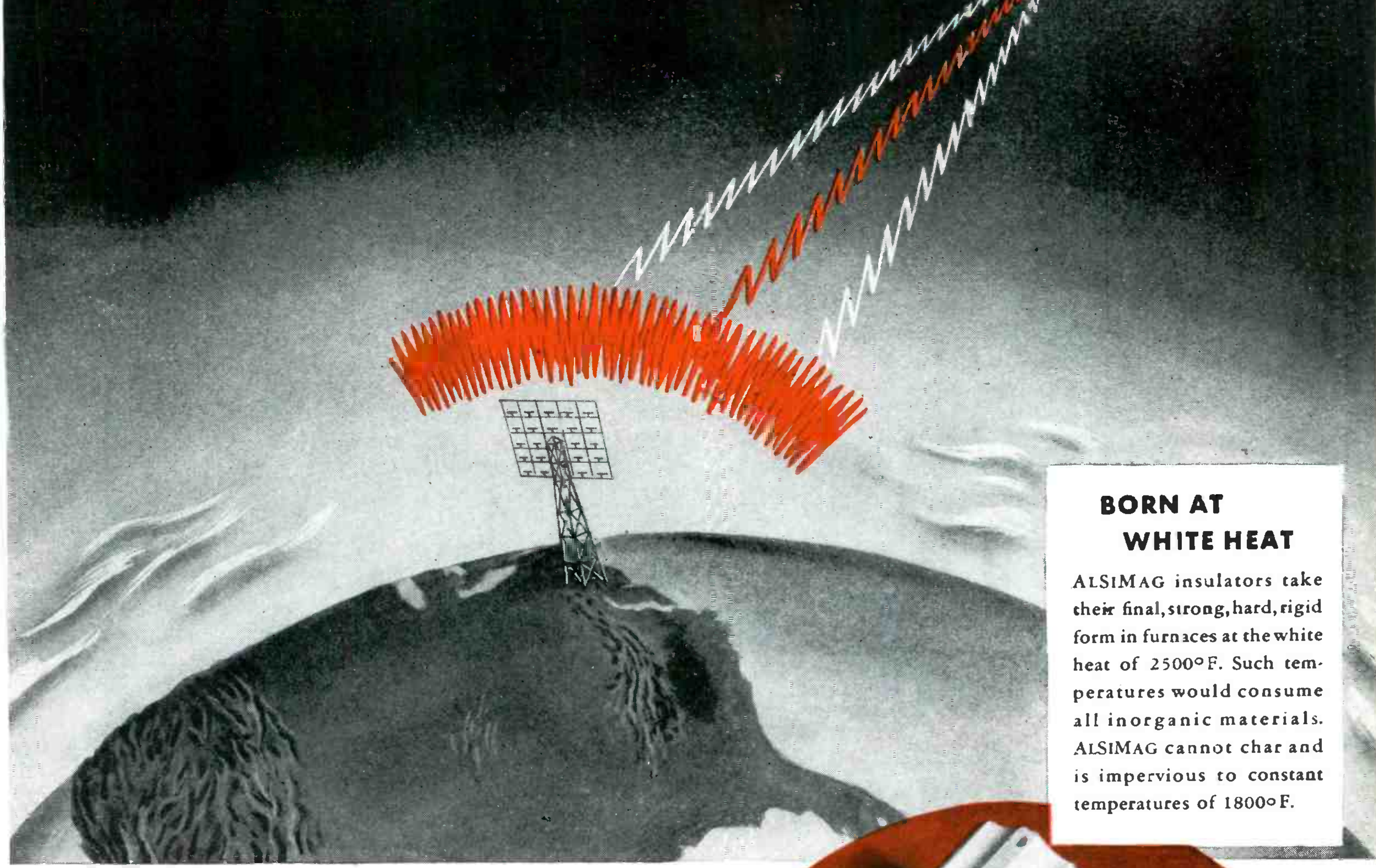


Inquiries Invited

THE MARK OF EXCELLENCE

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK, U. S. A.

MAN HITS MOON



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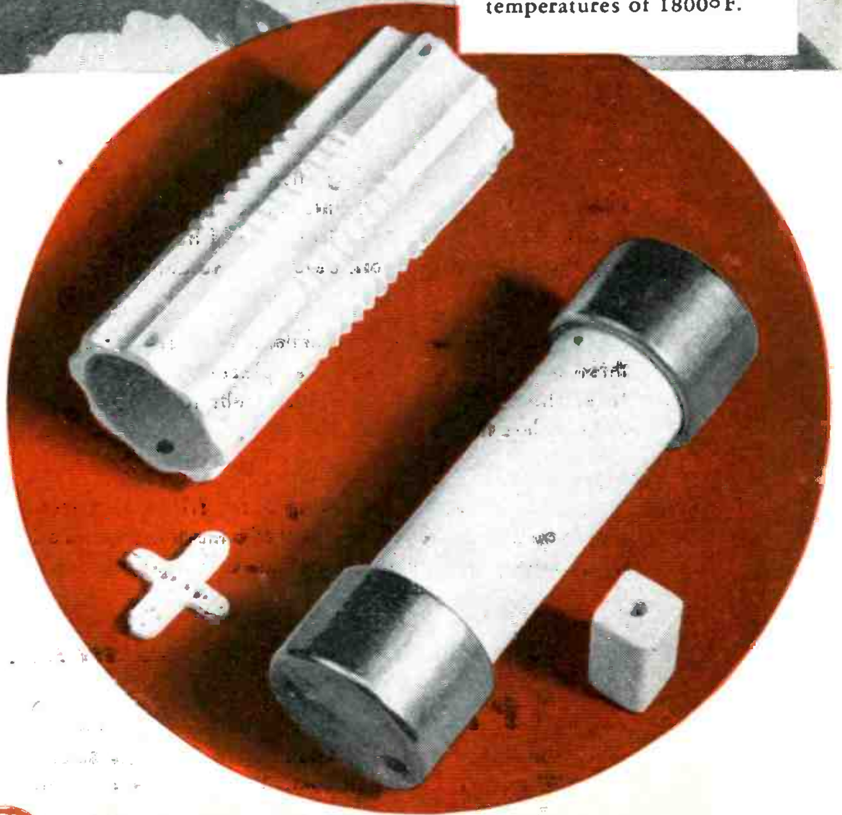
ALSIMAG insulators take their final, strong, hard, rigid form in furnaces at the white heat of 2500° F. Such temperatures would consume all inorganic materials. ALSIMAG cannot char and is impervious to constant temperatures of 1800° F.



THE radar experiment which resulted in the first contact with the moon is still another revelation of the brilliant advances made in electronics during the war.

The high standards of radio, radar and other war equipment for controls and communications, which called for extensive use of ALSIMAG Steatite Ceramics, will be carried forward into many peacetime products of QUALITY.

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ARMY E NAVY

Original Award July 27, 1942
Second Award February 13, 1943
Third Award September 25, 1943
7, 1944

ALSIMAG

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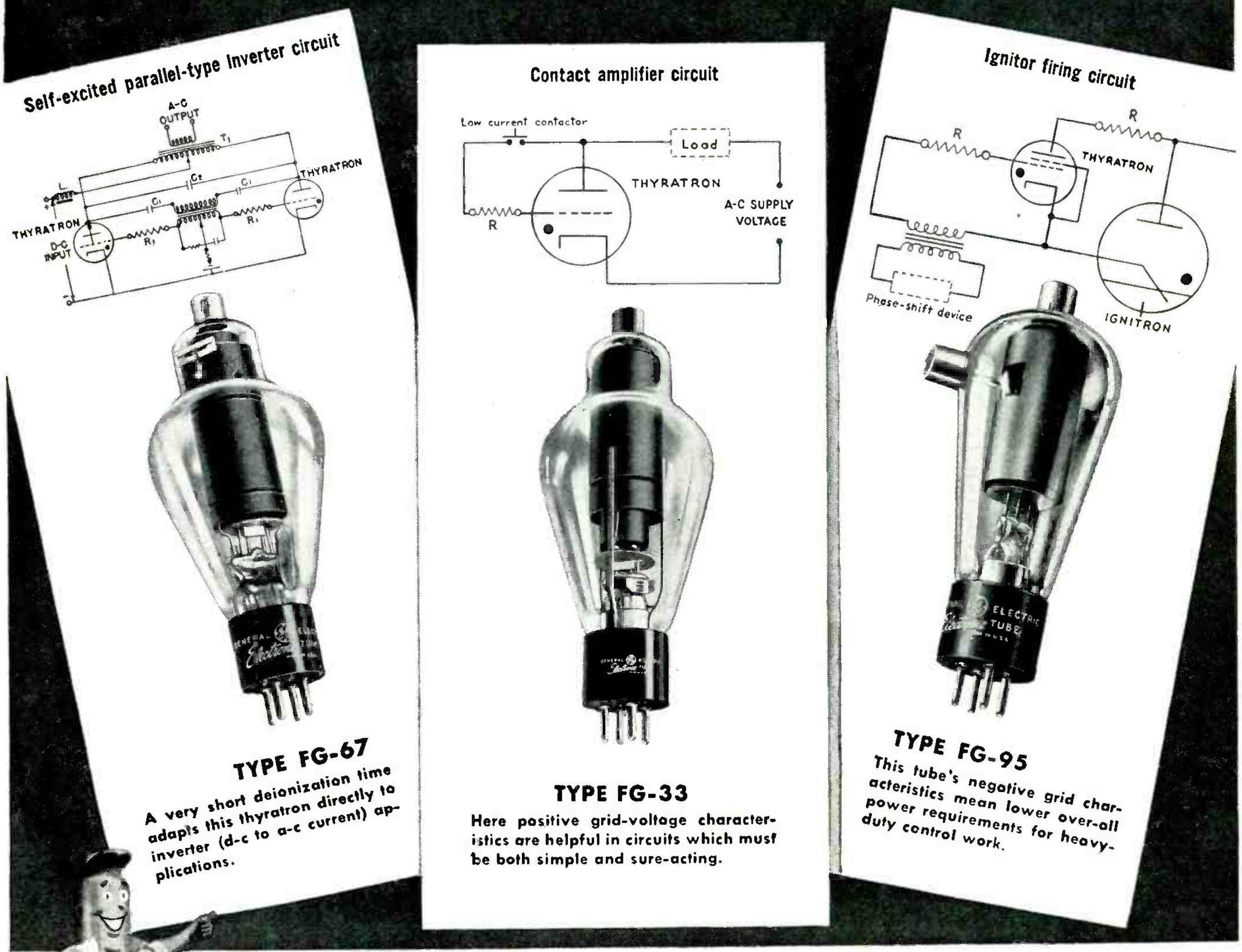
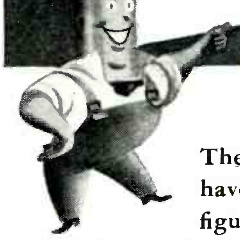
EACH OF THESE G-E THYRATRONS

does a specific job well!





The three G-E thyratrons shown here have similar ratings. Voltage and current figures are alike: for anode, peak voltage 1,000 v, peak current 15 amp, avg current 2.5 amp (except that the FG-95, when used for ignitor firing, is rated at 30 amp peak and 0.5 amp avg).

Yet . . . each tube is "tailor-made" for a different electronic requirement and type of circuit, meeting the needs of that circuit as no other thyratron can do!

General Electric—which built thyratrons *first,* which today builds *the most* thyratrons—can supply control or other tubes to *do the job right* in any type of electronic equipment now on your drawing-board. Furthermore—by reason of branch, distributor, and dealer stocks in hundreds of cities—G. E. can assure spot service on replacement tubes for users of your equipment!

Toward these ends, G-E tube engineers are ready to work closely with you. Contact your nearest G-E office, or write *Electronics Department, General Electric Company, Schenectady 5, New York.*

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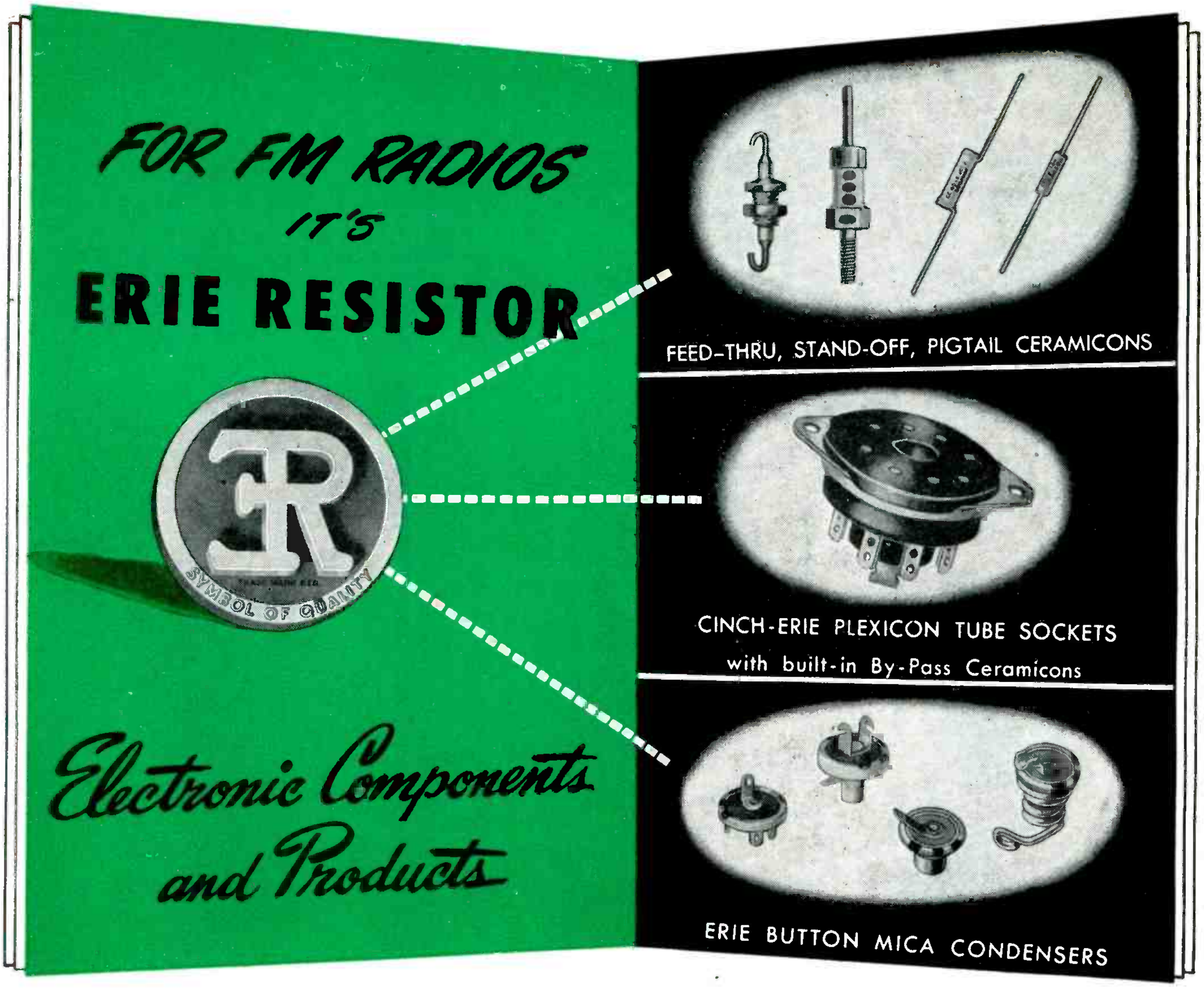


Due to the high operating frequencies of FM, many electrical and mechanical characteristics not ordinarily considered in condensers, become of paramount importance. The most important of these is low inductance, both in leads and in the basic construction of the condensers themselves.

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

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

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

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

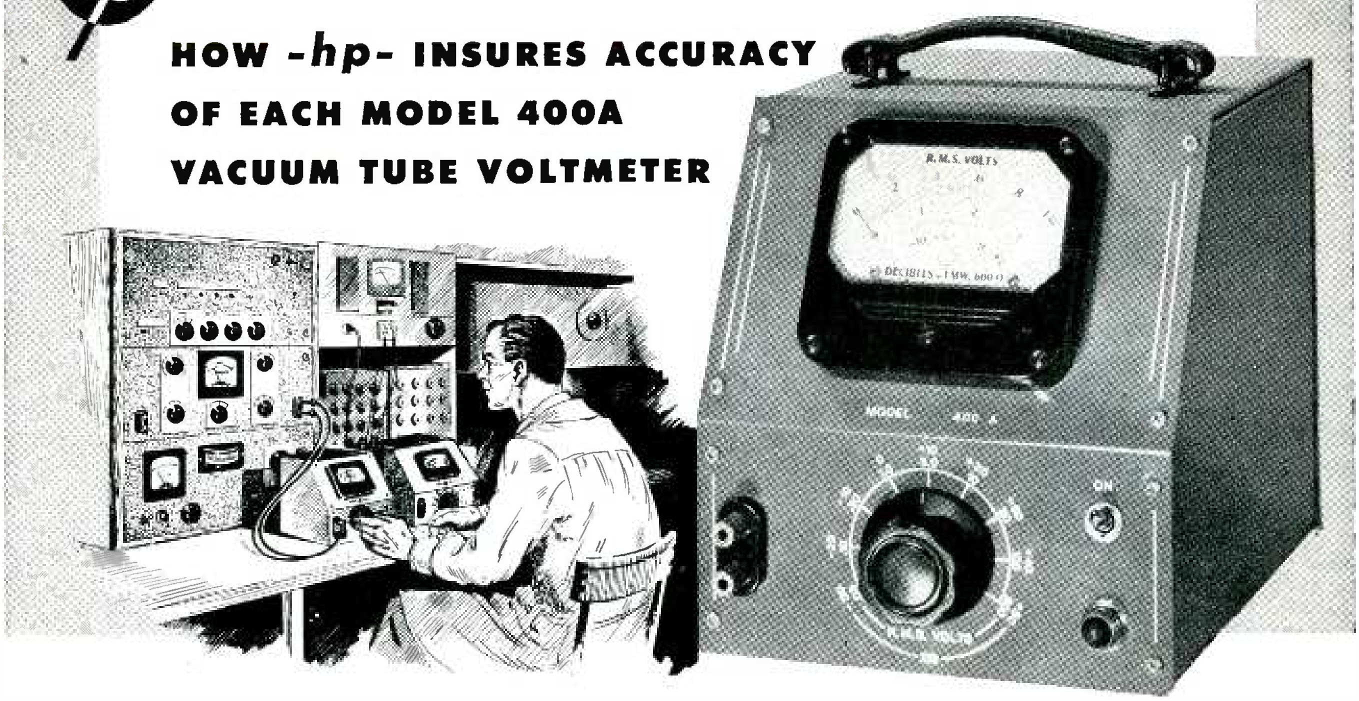
Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND . . . TORONTO, CANADA

LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

HOW -*hp*- INSURES ACCURACY OF EACH MODEL 400A VACUUM TUBE VOLTMETER



The accuracy of -*hp*- instruments begins with the engineers' blueprints, but it does not stop there. Precision assembly, individual hand calibration for each instrument, and pre-calibration tests over the entire range of the instrument are your assurance that speed and accuracy will be maintained under all operating conditions.

UNIQUE VOLTAGE GENERATOR

Take the -*hp*- Model 400A Vacuum Tube Voltmeter for example. This measuring instrument is unusually versatile, because of its wide frequency range, wide voltage range, and high order of accuracy. For adequate production tests of the 400A, it was necessary to develop known voltages ranging from 3 millivolts to 300 volts, at frequencies from 10 cycles to 1,000,000 cycles. HP engineers solved the problem by building a unique voltage generator which would function as a test set by generating known voltages over the entire range of the Model 400A. Circuits were devised to develop 160 different combinations of voltages and frequencies, each a separate calibration point for the 400A. Each of these voltages is related to the other with an accuracy of better than ½%. The absolute magnitude of each voltage is held to better than ±1%. This voltage is compared regularly with standard laboratory instruments of high accuracy. The voltages which are developed are sinusoidal so that no error in calibration is introduced by poor wave form.

DEPENDABLE ACCURACY

Because of this careful checking and rechecking, you can depend on the operating efficiency and accuracy of the Model 400A Vacuum Tube Voltmeter for many measuring jobs, including measuring voltages in the audio, supersonic, and lower rf regions; amplifier gain; network response; output level; hum level; power circuit, high frequency, video, and carrier current voltages; capacity; and coil figure of merit. An outstanding feature of the -*hp*- Model 400A is that voltage indication is proportional to average value of the full wave.

For complete data on the Model 400A, and on other -*hp*- laboratory instruments, write today to Hewlett-Packard Company.

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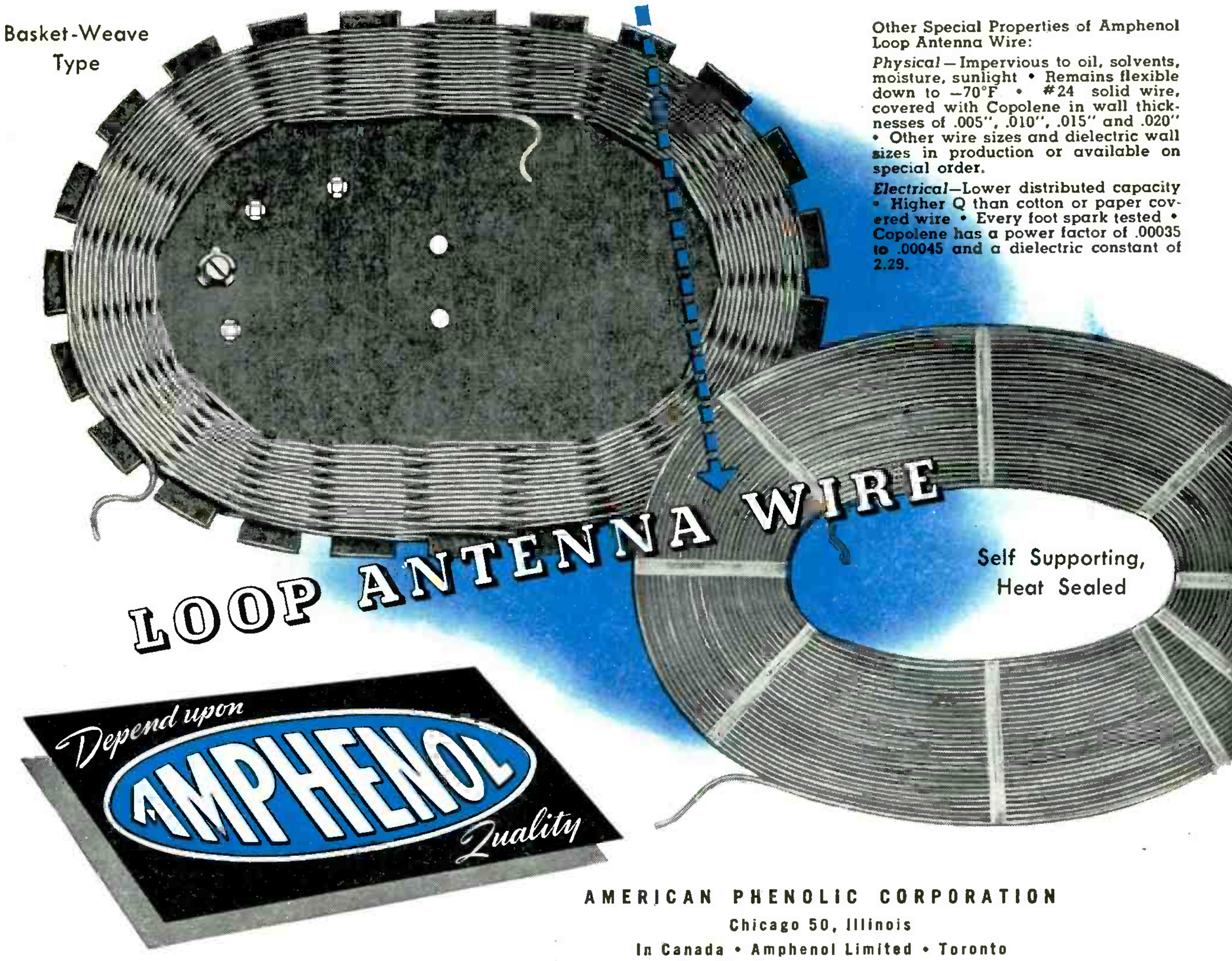
One of the latest Amphenol developments is a loop antenna wire insulated with low-loss Copolene. The production advantages and the electrical superiorities of this wire are many, and the cost compares favorably with that of conventional wire commonly used for the purpose.

The Copolene dielectric acts as a flux during soldering operations—no stripping is necessary. It remains flexible and is easily wound on coil-winding equipment. Best of all, it can be heat-treated for self-supporting coils and the finished coils may be heat-sealed to mounting boards—no cementing or stitching required. Copolene insulation is non-hygroscopic—saves labor and cost of impregnation with lacquer or waxes.

Radio set manufacturers and coil winders have found it profitable to take advantage of this new wire. Write today for complete information.



Other Special Properties of Amphenol Loop Antenna Wire:

Physical—Impervious to oil, solvents, moisture, sunlight • Remains flexible down to −70°F • #24 solid wire, covered with Copolene in wall thicknesses of .005", .010", .015" and .020" • Other wire sizes and dielectric wall sizes in production or available on special order.

Electrical—Lower distributed capacity • Higher Q than cotton or paper covered wire • Every foot spark tested • Copolene has a power factor of .00035 to .00045 and a dielectric constant of 2.29.

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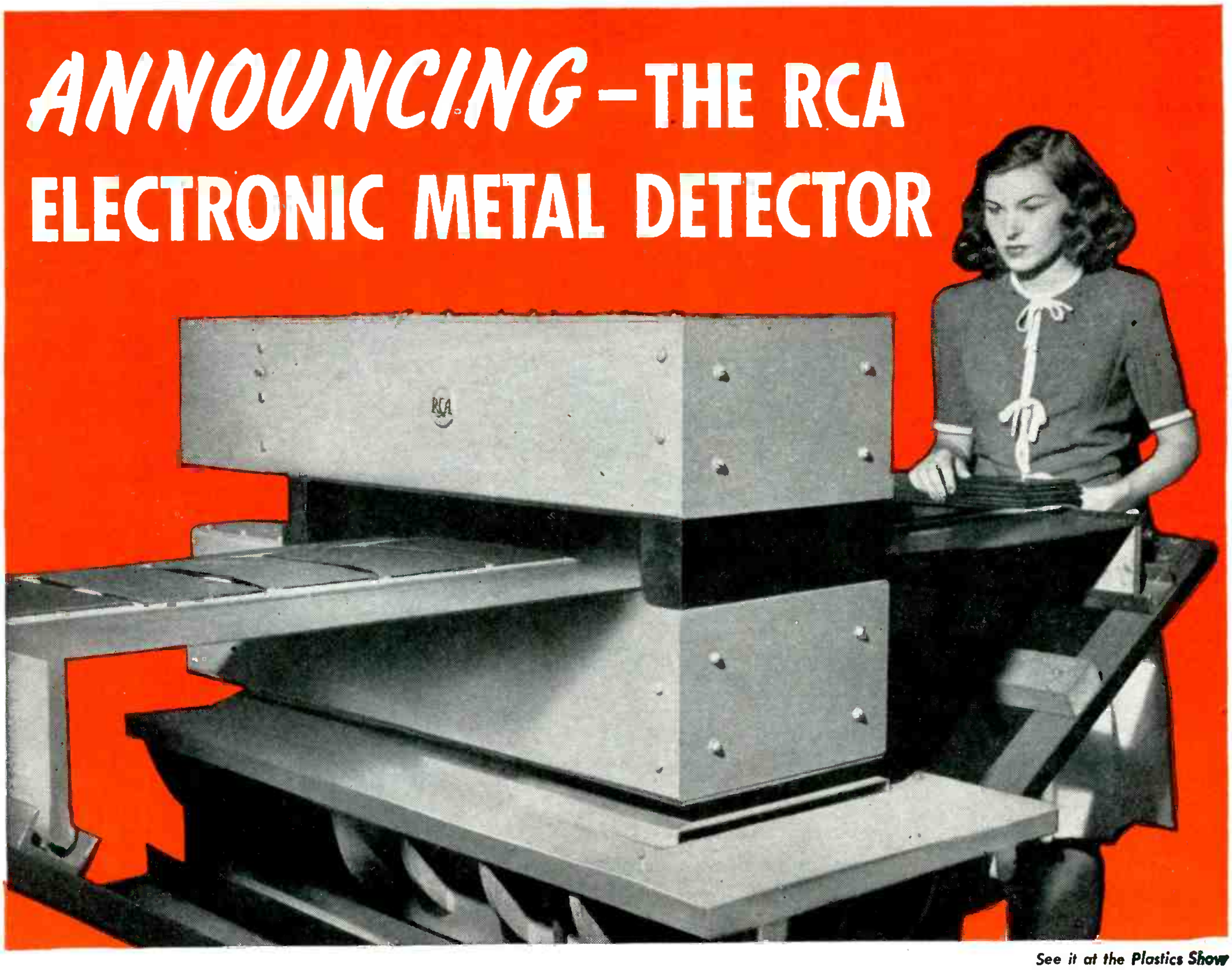


See it at the Plastics Show

. . . Protects product quality, prevents machinery damage

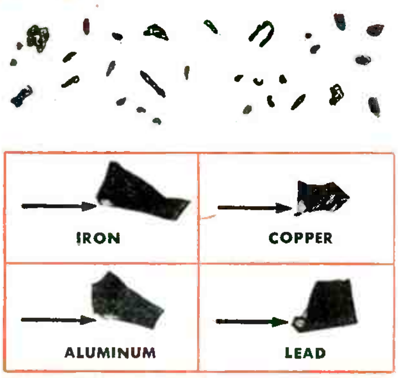
This new unit provides a quick, sure way to detect metal particles, of any kind, in non-metallic materials.

The product being inspected—such as plastic preforms—is conveyed by belt or other means through the inspection aperture.

Here it is screened by a high-frequency electromagnetic field and, if metal is present, causes a reaction which is detected by an electron-tube amplifier. This, in turn, triggers a bell or lamp and the faulty product is automatically rejected and/or marked.

Small, as well as large pieces of metal, are detected even when deeply embedded in the material. Discrimination can be adjusted to fit conditions. Operation is rapid—conveyor speeds up to 600 feet a minute are possible without loss of efficiency. It is easy to operate. Operating costs are low—uses only 140 watts. Installation is easy—"all-in-one" construction simplifies wiring, saves space. Available in 4-, 7-, and 12-inch aperture heights to meet varying product requirements.

You will find that this RCA electronic metal detector will quickly pay for itself by preventing machinery damage, reducing lost production time, and increasing customer good-will. Write for new bulletin *today.* Radio Corporation of America, Dept. 30-D, Electronic Apparatus Section, Camden, N. J.



Detects every type of metal and alloy—These metal particles were detected in plastic preforms by an RCA electronic metal detector.

ELECTRONIC EQUIPMENT

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.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YESTERDAY
This generator cutout (replacement) for the automotive industry was the original product of R-B-M in 1921. Soon other automotive electrical control devices were added.
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Heavy Duty Toggle Switch
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Heavy Duty Starter Button
Magnetic Starting Solenoid
TODAY
R-B-M has grown steadily through the years, building an enviable reputation as a leading manufacturer of manual and magnetic controls for a wide variety of applications that are known for their sound engineering, good construction and reliable performance.
A. C. Magnetic Relay
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Standard Duty Push Button
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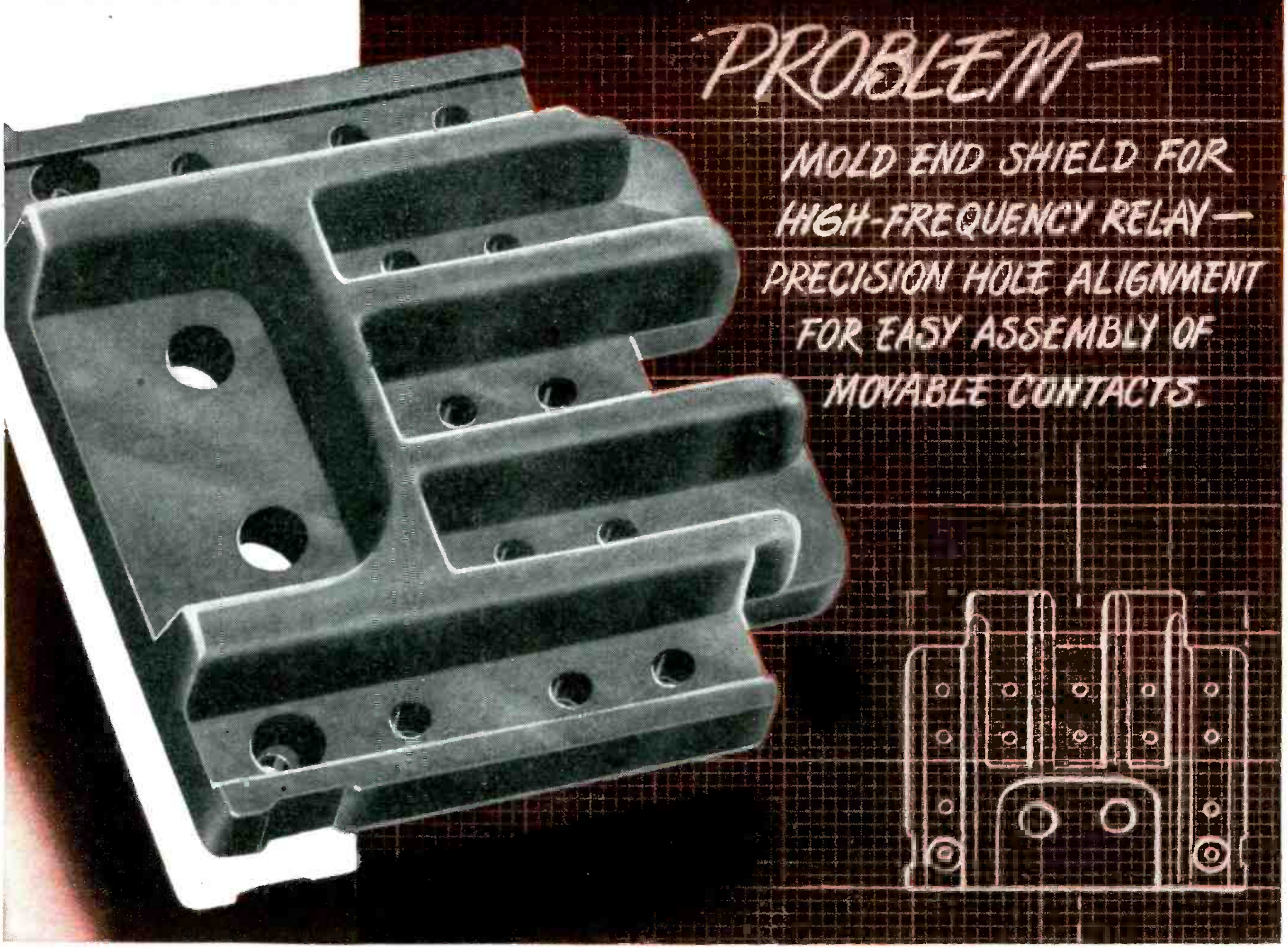
MANUAL AND MAGNETIC ELECTRIC CONTROLS—FOR AUTOMOTIVE, INDUSTRIAL, COMMUNICATION AND ELECTRONIC USE

DESIGNED AND ENGINEERED AT NO. 1 PLASTICS AVENUE



G-E mycalex lines up another high-frequency job

● A sensitive high-frequency relay that operates under high temperatures needed an end shield. This plate had to be made of low-loss insulating material . . . flat . . . and with accurate hole "line-up" for the assembly of many electrical contacts.

This problem was solved at No. 1 Plastics Avenue by new techniques in molding G-E mycalex—compound of glass and powdered mica with a unique combination of properties.

Note the sixteen holes—they are molded into this rigid material. And the part, as it comes from the mold, is *finished* with all tolerances satisfactory for trouble-free mass assembly methods. Why not find out more about G-E mycalex and the techniques which have been developed for molding it?

SEND FOR YOUR OWN COPY. A new bulletin on G-E mycalex is just off the press. A helpful design handbook, it contains complete and up-to-date information for solving your high-frequency insulation problems with G-E mycalex—a hard gray-colored, stonelike material with a unique combination of properties. Find out about new grades of G-E mycalex and new G-E mycalex molding techniques which make wider and more economical applications now possible. Fill in the coupon and mail it today.

GENERAL ELECTRIC

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MYCALEX

PLASTICS DIVISIONS (S-9), GENERAL ELECTRIC COMPANY
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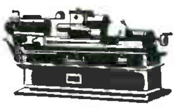
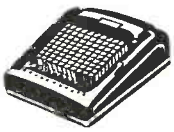
Deadening these disturbing, and oft-times destructive, impulses is accomplished with minimum computation . . . and with no design changes! Total area of pads is determined by weight to be supported. (A loading of 50 lbs. per sq. inch gives a deflection of 1/16 in. per pad thickness.)

Though simple in construction, its operating principle is unusual. Two accurately ribbed layers of resilient, long-lived, oil-resisting synthetic rubber are cemented together so that ribs are mutually perpendicular. Flexibility is thus combined with stability in *all* directions. The ratio of vertical to horizontal spring rate is small, for efficient absorption of both vertical and side-thrusting impulses!

Net result: unusual noise reduction, increased physical comfort, minimum disturbance effects. Added to which is the elimination of anchoring requirements . . . MB Pads stop "creeping" machines in their tracks.





Versatile, adaptable MB Pads have unlimited uses. They can be applied between automotive frame and body for cushioned comfort . . . to textile machines . . . to punch presses, lathes, and other machine tools . . . even to business machines.

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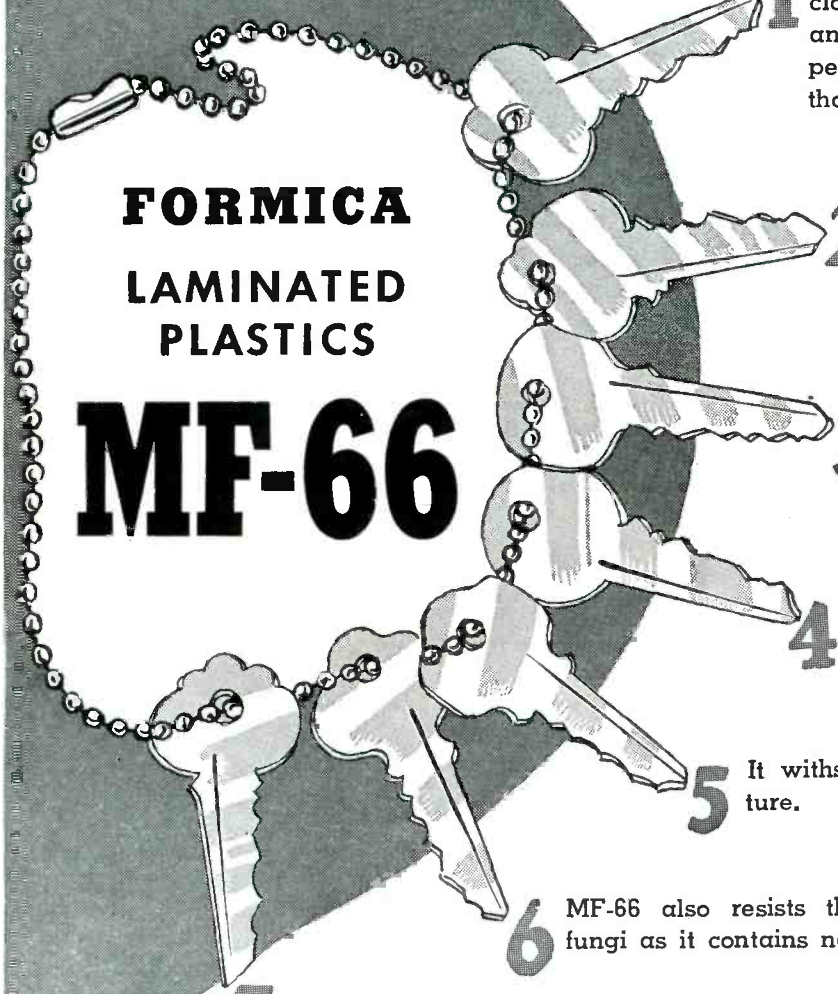
The Seven Keys to BETTER PROPERTIES!

This new insulating material with the resins and glass base developed for many war applications presents many advantages.



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MF-66

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3 It withstands vibration that is so often present where airplanes, ships, and ground installations are concerned.

4 MF-66 dimensions are stable under changes of humidity.

5 It withstands changes of temperature.

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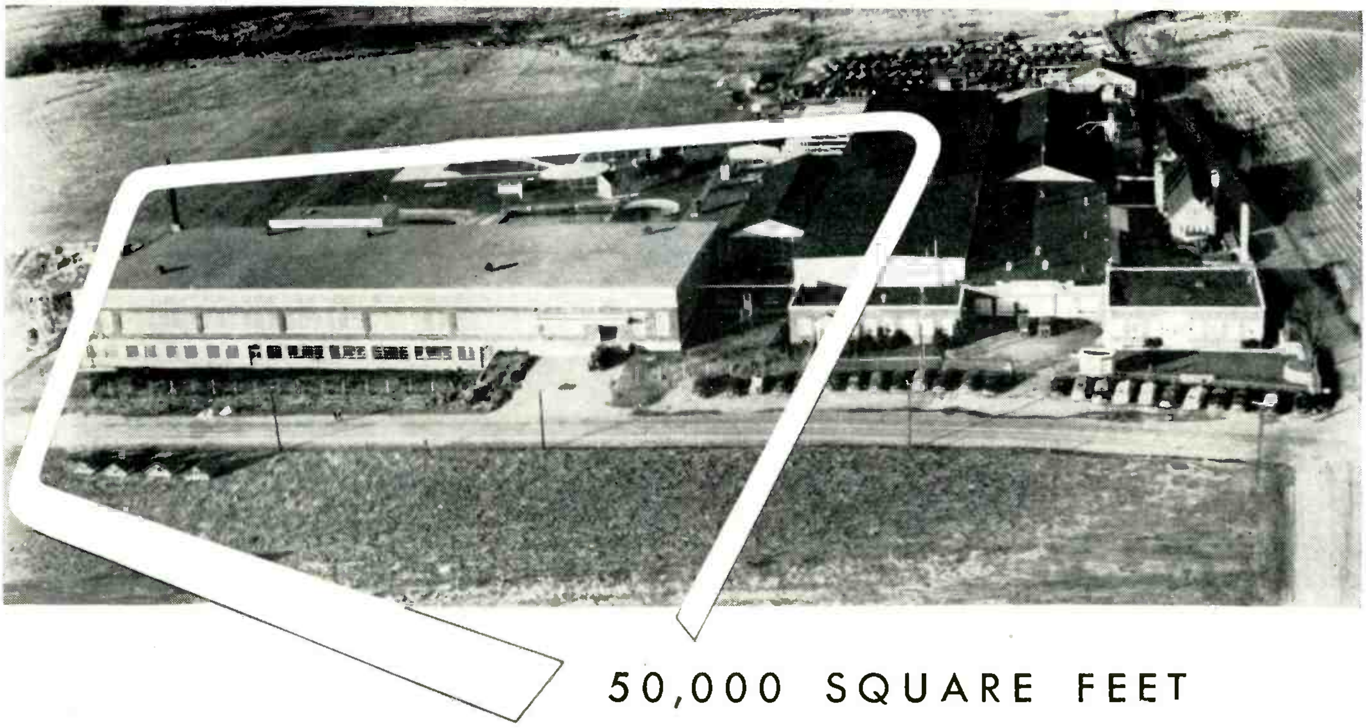

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Production experience is joined with the most modern equipment, to supply you with Superior tubing.

The size range is still ⅝″ OD down to the smallest.

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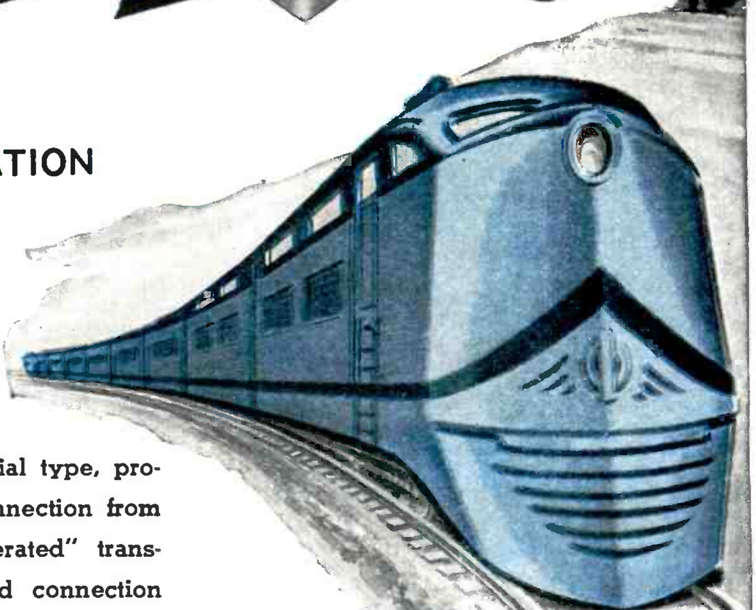

A compactly designed relay of co-axial type, providing for the transfer of antenna connection from "normal" receiving position to "operated" transmitting position, with receiver-ground connection when transmitting. Equipped with regular co-axial type cable fittings and designed especially for use in applications where impedance matching, and standing-wave ratio are of primary importance.

Complete details of our new co-axial relays and the many other relays in the Price line are given in our catalog. Write for it today.

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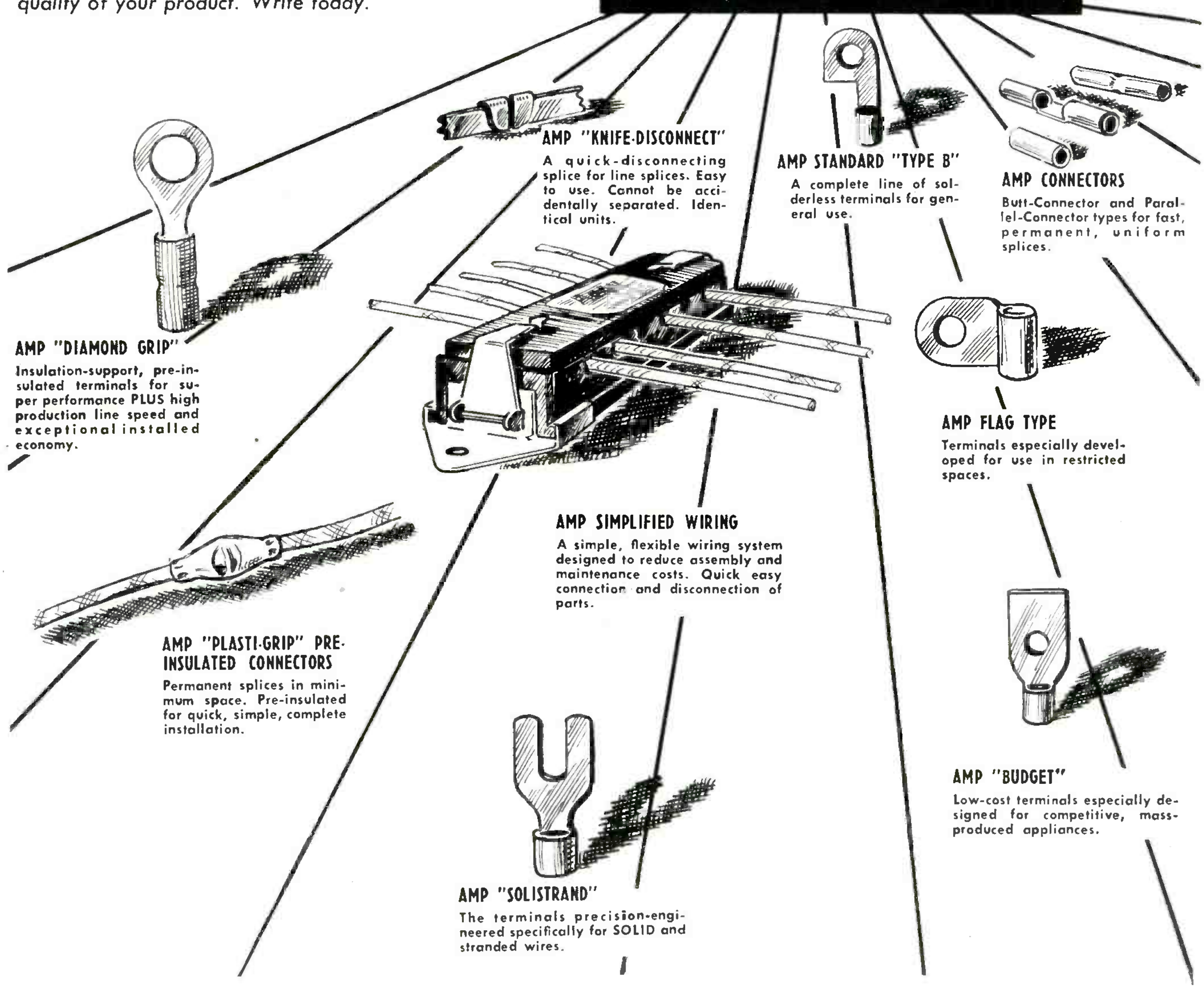
Whatever your wiring problem, AMP has the answer. AMP engineers have pioneered the major developments in solderless wiring. They are specialists. Their knowledge and experience are yours for the asking. Let them show you how AMP Solderless Wiring Devices can *speed up your production, reduce your costs, improve the quality of your product. Write today.*

An AMP Solderless Connection FOR EVERY PURPOSE

AMP TERMINALS

for
- *Super Performance*
- *General Purpose Uses*
- *Low Cost Competition*



Any of these types of AMP terminals are available in a wide range of wire sizes, stud sizes, and tongue shapes.

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LOAN TO BRITAIN

... Investment in World Economic Unity

CONGRESS should give swift and confident approval to the proposed loan to Great Britain.

Few other issues of foreign policy in the present troubled world lend themselves to such clear appraisal of where our National interest lies.

In simplest terms, the question is whether we should extend to Great Britain a credit of $3¾ billions (plus $650 millions in payment for lend-lease balances) in return for her promise to repay principal with interest over a fifty year period starting at the end of 1951, and her pledge to give the fullest possible support to the kind of world trading system which it is the declared policy of both the United States and the United Nations Organization to promote.

We Can Afford to Make It

The sum we hazard is not inconsiderable, but financial risks have meaning only when related to resources. The line of credit provided by the loan will amount, at most, to a claim on 2/5 of 1 per cent of our gross output for the five to six year period over which it may be used. The interest rate charged, while moderate, is higher than our Treasury is paying upon current borrowings. The risk entailed is well within our resources as a creditor. In the considered judgment of the American and British technical experts who thrashed through the intricate accounting for three painful months, the amount and terms offered will suffice to allow Britain, under rigid austerity, to relax her system of foreign trade restrictions, and to expand exports sufficiently to pay her debt commitments.

Against the considered risks of extending the loan, there must be weighed the certain costs of refusing it. Without the loan, Britain has no recourse but to maintain and extend the system of bloc trading which she adopted under stress of world depression and world war. If that is the route Britain follows, she will carry with her a large part of the sterling area countries — all British Commonwealth and Empire countries (except Newfoundland and Canada) plus Egypt, Iraq, and Iceland—and many of the nations with which the United Kingdom has payment agreements (Argentina, Bolivia, Brazil, Chile, Paraguay, Peru, Uruguay, Belgium, Czechoslovakia, Denmark, Finland, France, Netherlands, Norway, Portugal, Spain, Sweden, and Turkey).

Altogether, the United Kingdom's orbit accounts for more than half of the world's imports and exports combined. It likewise is crucial to the trade of the United States. In the years immediately preceding the war, the sterling area and payment-agreement countries provided just under one-half of both the import and export trade of this country.

Russia, of course, will continue to conduct her foreign commerce exclusively upon a state-trading basis. Before the war, the Soviet Union transacted only a little more than 1 per cent of foreign trade business, but its future sphere of influence will be large—conceivably embracing as much as 30 per cent of total international trade.

We Cannot Afford to Refuse It

If the weight of British influence in foreign trade is thrown toward the Russian pattern rather than toward ours, it is apparent that bloc trading, with all of is supporting devices—bilateral deals, exchange controls, import and export quotas, subsidies, currency manipulations and the like —will be the prevailing pattern for foreign transactions.

In self-protection, the United States would have no alternative but to conform to the dominant pattern. We should be forced to form our own bloc, and to enter into active economic warfare in bidding for trade concessions against the offers of our rivals. How well we would do this is problematical. To the game we would bring the largest economic potential in the world. But our handicaps would be equally impressive.

First, under a system in which political and economic motivations are inextricably fused, a democratic nation, and particularly one with a tradition of freedom in its domestic enterprise, would operate at a great disadvantage. We should inevitably be driven toward more and more government control of our entire economy.

Second, with a pattern of foreign trade in which our exports habitually are greater than our imports, our bargaining position in international trade is much weaker than our over-all economic strength would suggest. Under state-controlled trading we should still find it difficult to compete successfully without resort to loans, and under these conditions our loans would be supporting a system alien to our choice and interest.

Third, under a regimented system which made economic decisions subservient to political considerations, it is virtually certain that the volume of world trade would shrink. That was the clear experience of the nineteen-thirties. Thus, the standard of living in the United States would suffer in common with all others, and we would be forced into a particularly drastic curtailment of certain war-expanded segments of our economy, at the very time when a large portion of the world is most in need of the products they can produce.

Weighing the Alternative Costs

In the years immediately ahead it is certain that from two-thirds to three-quarters of all international trade will be transacted either in pounds or dollars. If both circuits are linked in a determined effort to restore competitive world markets, to which buyers and sellers alike have access without discrimination, that will be the dominant system of foreign trade. If the sterling group with its satellites organizes a closed grid, our exclusive effort cannot preserve the trade pattern that we believe offers most to us and to the world.

No one can accurately measure the costs to the United States of refusing the loan and accepting the consequences. But unquestionably they would dwarf to insignificance the sum risked in the proposed credit. We would lose through the shrinkage of our trade, through the wrench of violent readjustments in our production patterns, and eventually through the curtailment of our over-all output below what it would be under an open rather than a closed system. We would lose heavily in economic liberty under a procedure that can be followed with success only by a close regimentation of production as well as trade.

Most of all, we would lose in prestige, through demonstrating that we are still unprepared to exercise a world leadership to which our giant stature as the possessor of almost half of the world's economic capacity entitles us. Once again we would be exhibiting to the world political feet of clay supporting an economic frame of heroic proportions.

It Is Far from a "Soft" Bargain

There has been some disposition in this country to regard the loan to Britain as a somewhat "soft" and generally unprecedented transaction that smacks of charity. This is the sheerest nonsense.

In the first place, the kind of economic system we want has never functioned and cannot operate now without a lender. For many decades prior to World War I Great Britain filled the creditor role. In 1913 her foreign investments totaled $19 billions, and she not only made such transactions pay, but they proved her salvation through two grim wars. Her credits helped in the industrial development of a large segment of the world, including the United States. Of all the nations in the world, only the United States can assume now the mantle which Britain no longer can support.

In the second place, the terms of our proposed loan to the United Kingdom are far from easy. Britain put a substantially greater proportion of her relatively meager resources into the war than we did, and dissipated a large share of her foreign holdings in the process while accumulating an outside debt of crushing magnitude. On a per capita basis her internal debt is greater than ours. Many Britons feel that our proposed loan is too small, and its terms too rigorous. If the amount proves to be inadequate, we shall have to consider supplemental aid at a later date. But the majority believe that the present offer gives a fighting chance to restore the system of world trade that we and they both want, and upon which the World Bank, the Monetary Fund, and the International Trade Organization under United Nations aegis are based. It is certain that without our loan all of this will go by the board.

In the third place, our proposed loan is far from being without precedent. Canada, which is linked by far closer economic ties to us than to the Empire, already has provided for a loan to Britain of $1,200,000,000. This amounts to almost a third of what we propose to lend, although Canada's population is less than 10 per cent, and her income is little more than 5 per cent of ours.

Shall the United States Lead or Follow?

The way to exercise leadership is to lead. Nothing could be more futile than to go half way toward establishing the economic order for which we stand, and then withhold the crucial measure that will make it work. Failure to approve the loan to Britain will be a clear default of leadership. Failure to approve it promptly will dissipate its effectiveness.

It has been officially stated that the British loan is a unique case that will establish no precedents for further credits to other nations. It is exceptional in its importance to our aim. But if the United States expects to make its economic program the dominant one for world trade, it must continue to exercise the creditor function without which that program cannot persist.

The most that we should ask is that future loan transactions be scrutinized as was this one to see that they offer comparable security and comparable return in support of the program for which we stand.

For the loan to Britain, it can be said that never before has one nation had an opportunity to gain so much at so little risk as has the United States in this uniquely decisive case.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 46TH OF A SERIES

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NEW NON-EMITTING GRID!

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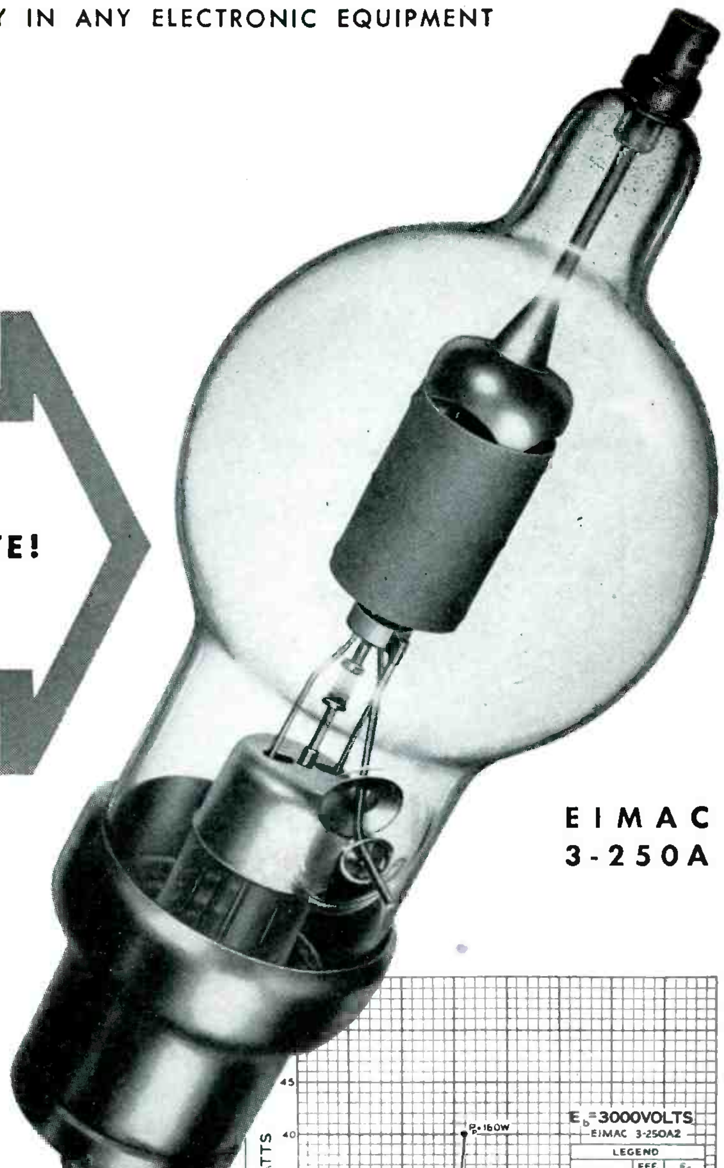

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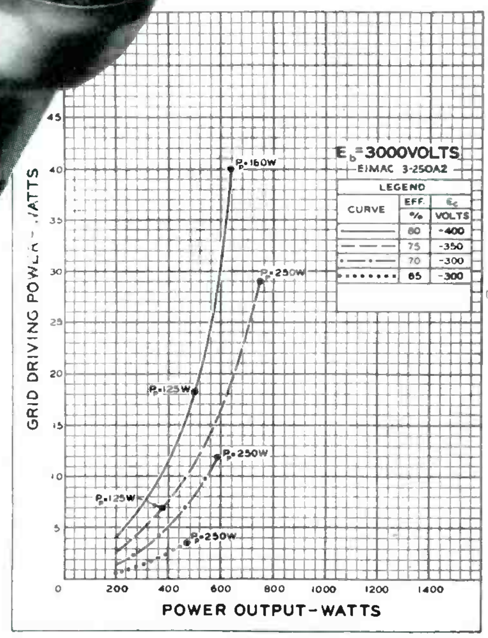

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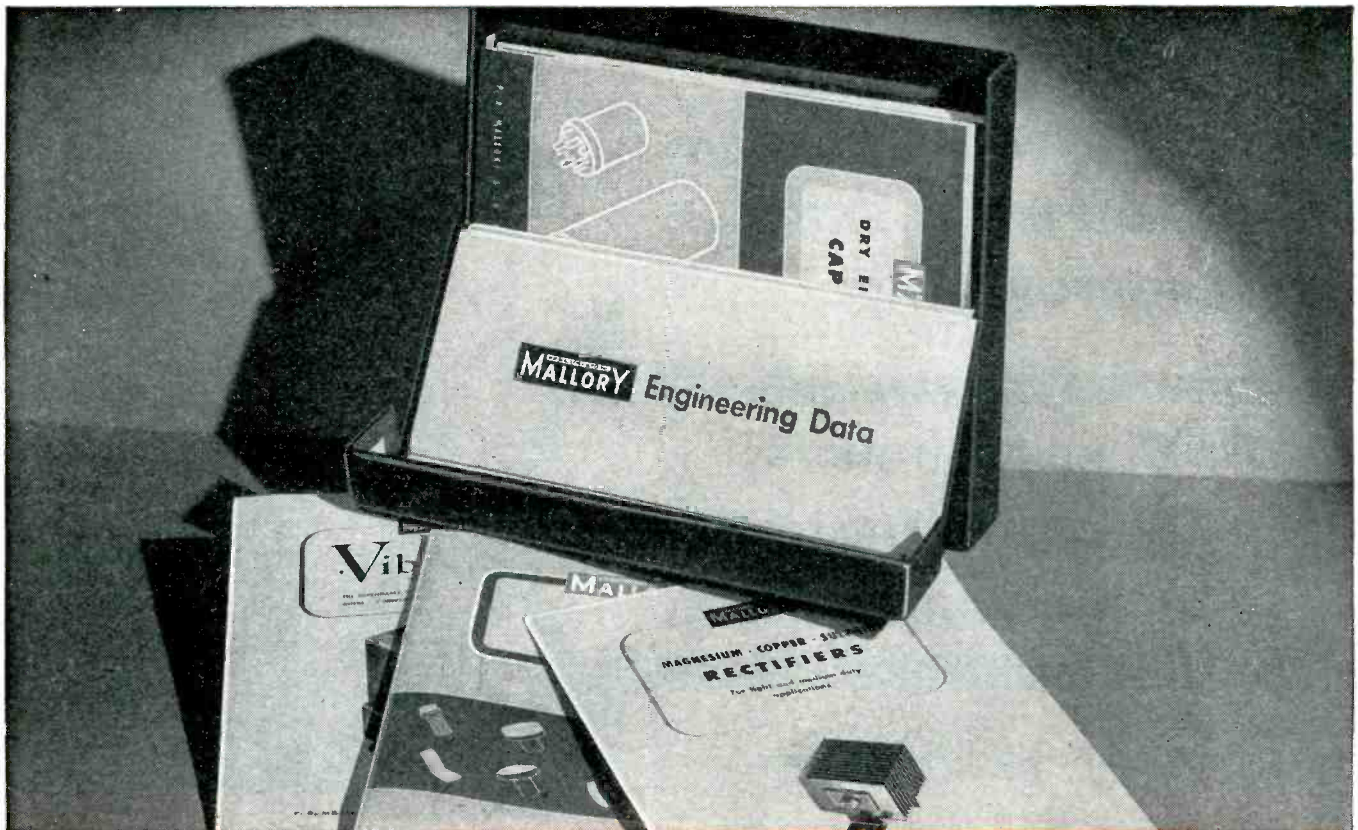

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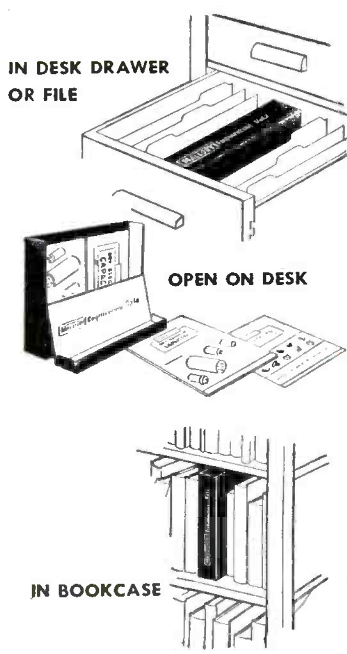

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CROSS TALK

► **LORAN** . . . Arrival in New York Harbor of MS Gripsholm, the well-known Swedish-American luxury liner, with the first commercial installation of loran brightens the hope that this and other wartime developments will soon find their way into peacetime applications. As our readers know, loran is an electronic—and elegant—method of finding one's location on the face of the earth by determining accurately the time required for signals to reach the particular spot from two or more sets of transmitters whose position is accurately known.

This new aid to navigation does not measure the direction of arrival of the signals as do ordinary direction-finding systems. Like radar it does its important job by measuring the small but finite time nature requires for transmitting radio energy through space.

Without doubt passenger ships will carry loran and radar. The latter enables the ship master to see where he is in the dark or in fog, particularly with respect to nearby objects. The combination of loran for long-range and radar for short-range position-finding should prove to be marvelous steps toward complete safety at sea.

Whether cargo vessels will carry loran or radar may turn out to be another story. Insurance rates on ships at sea take into account aids to safety, and if there are no other charges than the purchase and ordinary maintenance of the equipment, the decreased insurance will pay for the new equipment. On the other hand, if an operator is required, then the additional navigation aids represented by loran or radar will add considerable overhead to the cost of running the ship.

In a highly competitive business like cargo shipping, fixed charges must be kept low. Wide adoption of radar or loran by cargo vessels—unless ordered by government—will hinge on the matter of whether extra operating personnel will be required. If the equipment can be operated by deck officers, or by an existing radio operator, and if no additional help is needed, then these new aids to navigation will find their place in ships at sea as they have in ships of the sky.

► **RESEARCH** . . . Recently a very large American manufacturer found that 10,000 stockholders expressed interest in company research while only 95 wanted to know more about company finances. Such a circumstance can only be a result of the war.

This is all to the good. Only by continuing research can standards of living in peace and success in war be sure. The disturbing factor, however, is the constant stream of researchers who pass through this editorial office who say "my company is cutting down on research—where can I find a job?"

What's the matter with the electronics industry? Is it losing its nerve?

► **FIRE** . . . So far the horizon shows no electronic device, except radio, which can be sold to the average American home. All such gimmicks proposed to date are either too expensive, are not necessary or are just plain silly.

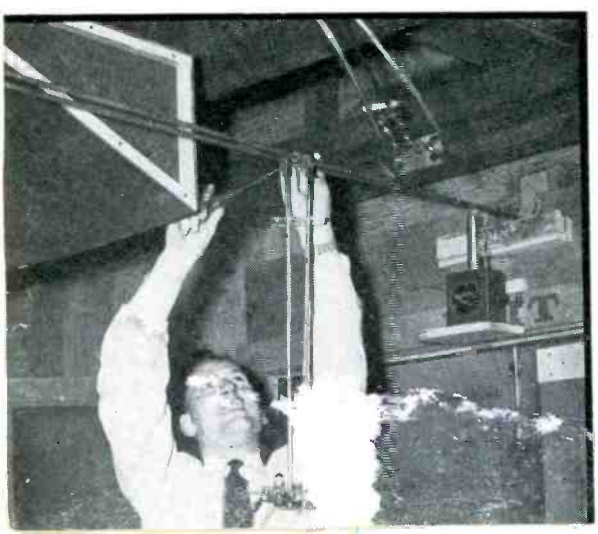
The Christmastime Hartford fire in which aged inmates of a hospital lost their lives, the daily radio and newspaper reports of disastrous fires in which lives and farmer's stock are lost, indicate that some device, electronic or not, which would accurately and cheaply and surely give an alarm within one's own precincts of the approach of fire could be sold in untold millions to American home owners.

► **CROSSROADS** . . . At the request of the Navy Department, Donald G. Fink, Executive Editor of ELECTRONICS, has been granted a leave of absence for the period of the atom bomb tests in the Pacific to be associated with Captain Christian L. Engelman, Electronics Coordinating Officer of the project. Mr. Fink will leave some time around the first of April for Bikini Atoll, returning to his desk early in the Fall.

Dr. Harold D. Webb (right) adjusts the auxiliary tuning crystal in the lunar receiver while E. K. Stodola looks on. Behind Stodola is the nine-inch type-A indicator which records the echoes

Lt. Colonel John H. DeWitt, Jr., in charge of the project, at the power supply controls of the transmitter, a modified version of the SCR-271 early-warning radar used at Pearl Harbor. DeWitt is former chief engineer of WSM

The author, Jack Mofenson, adjusts the position of the waveform-monitoring stub. Over this transmission line traveled the 3-kw transmitted pulse and the millionth of a billionth of a watt echo



RADAR ECHOES

THE RECENT EXPERIMENTS performed by the Signal Corps Engineering Laboratories in receiving radar echoes from the moon have aroused much comment from engineers, astronomers and others engaged in technical pursuits. Although the scientific aspects of sending radio-frequency signals through the ionosphere are certainly of importance, the work done on the project is better classified as an engineering achievement. As yet, no long-term systematic observations have been made. This article is confined, therefore, to a discussion of the technical characteristics and general description of the equipment employed.

Briefly, the experiment consisted of transmitting quarter-second pulses of radio-frequency energy at 111.5 mc every four seconds in the direction of the moon, and detecting echo signals approximately 2.5 seconds after transmission. Display of the detected signals was audible as well as visible. Technically, the experiment utilized well-established radar techniques, but with radically different constants throughout the system. Considerations of pulse width, receiver bandwidth, transmitter power and the precise frequency of the returned signal due to Doppler effect, were such that careful attention had to be given to the design of the overall equipment.

After preliminary calculations were made concerning transmitter power, the reflectivity coefficient of the target, and receiver noise figure, it was apparent that receiving radar echoes from the moon was technically possible. Under the direction of Lt. Col. John H. DeWitt, a project called "project Diana" was set up in September 1945 to develop a radar system capable of transmitting r-f pulses to the moon, and detecting echoes more than 2 seconds later. Prior to entering the Signal Corps, Colonel DeWitt, who at that time was chief engineer of Radio Station WSM in Nashville, Tenn., designed and constructed transmitting and receiving equipment for the purpose of receiving echoes from the moon. This equipment employed substantially similar transmitter power and frequency to that used by the Signal Corps, but the attempt was a failure due to insufficient sensitivity in the receiver. Colonel DeWitt's appreciation of the problem and personal supervision were the driving forces that made the present experiment successful. Assisting Lt, Colonel DeWitt were: E. K. Stodola, Dr. Harold D. Webb, Herbert P. Kauffman and the writer, all of Evans Signal Laboratory. Credit is also due the members of the Antenna and Mechanical Design Group, Research Section, Theoretical Studies Group and others.

The practical implications of radar contact with the moon are numerous. During the war the Germans used the V2 Rocket which climbed some 70 miles above the earth, and the future holds the unhappy prospect of missiles going far higher than this. The matter of transmission of radio signals to great distances above the earth for detection and control of such weapons becomes a problem of military importance. Further, the use of a reflector far beyond the earth for radio waves makes possible direct measurement of the ability of radio waves to penetrate the ionosphere. A more complete investigation in this direction is indicated. The possibility of using the moon as the reflector for a part-time long-distance point-to-point

electronics WAR REPORT

By JACK MOFENSON
Evans Signal Laboratory
Belmar, N. J.

FROM THE MOON

Detailed description of the techniques underlying the first recorded radio transmission through outer space. Calculations show that the maximum range of Signal Corps radar on lunar target exceeds one million miles

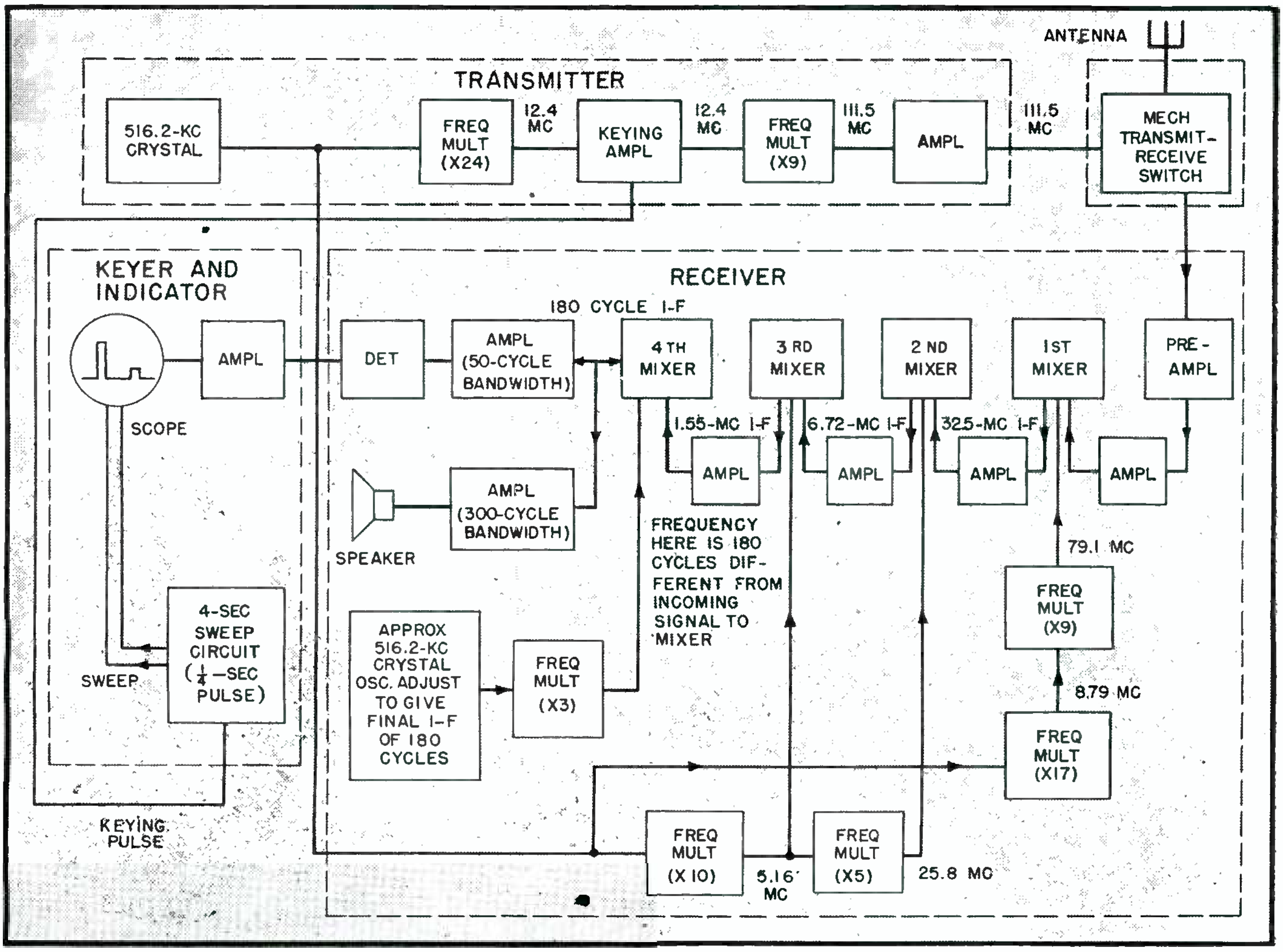


FIG. 1—Block diagram showing the essential elements of the system. Transmitter and receiver are controlled by the same crystal, permitting stable tuning of the narrow-band receiver relative to transmitter frequency

communication system is also being considered, as well as using the moon as a target to measure field-strength patterns.

Determination of Requirements

Several of the constants which determine the maximum distance at which a radar set can detect targets are peak transmitter power, radio-frequency of the transmitted signal, duration of the signal, receiver noise figure, and target echoing area. These constants, among others, are concisely summarized in what has been called the free-space radar equation.

$$r = \sqrt[4]{\frac{P_t A_o G_o \sigma}{P_r (4\pi)^2}} \qquad (1)$$

This equation has already been derived in ELECTRONICS[1]. In this equation, r is the radar range at which a signal may be detected, P_t is the transmitter power during the pulse,

Herbert Kaufman adjusts the bias on the high-level multiplying stages of the transmitter. Kaufman and the four others shown were the personnel of "project Diana"

G_t the transmitting antenna power gain, A_r the absorption area of the receiving antenna, σ the effective echoing area of the target, and P_r the power of a barely discernible signal, on the same basis as P_t. The power gain due to ground reflections (not considered in the free-space equation) at maximum effectiveness increases the range of the system by a factor of 2. This is equivalent to a power gain of 12 db.

In the case of a target as large as the moon (2160 miles diameter), calculations showed that in order to receive an echo from the whole hemisphere of the moon at once a pulse width greater than 0.02 seconds was required. This set a lower limit on the transmitter pulse width which corresponds to an optimum bandwidth of 50 cps for the receiver. These requirements eliminate, for the present, the use of the microwave frequencies, because of considerations of pulse length.

Propagation studies indicated that electromagnetic waves at a frequency of 110 mc were capable of penetrating the ionosphere, and because of availability of equipment, a radar set operating at 111.5 mc was chosen for the experiment. The peak power available in this transmitter was equivalent to 3000 watts for P_t using a 0.25-second pulse. The transmitter had the added advantage of being crystal controlled, deriving its final radio frequency after a series of frequency multiplications from a 516.2-kc crystal oscillator. The receiver associated with the transmitter was of the multi-mixer type (quadruple superheterodyne) capable of beating down radio-frequency signals to a final intermediate frequency of 180 cycles per second. Such an arrangement permitted use of an extremely narrow pass band, 57 cps, thus making the receiver highly selective and limiting the noise to a very low value. The extremely narrow-band receiver was an advantage, also, because it permitted tuning the receiver to the exact radio frequency of the returned echo. The importance of this can best be realized by considering the fact that due to the relative velocities of the earth and the moon, the returned signal may differ from the transmitted signal by as much as 300 cycles, due to the Doppler frequency shift. In using a highly selective receiver whose final mixer is tuned to receive the precalculated frequency of an echo return from the moon, the receiver rejects any signal returned at any other frequency.

To reduce the noise contribution of the receiver, a high-gain, low-noise-figure pre-amplifier was connected between the antenna and the receiver proper. The minimum perceptible received power was P_r readily calculated from the formula for noise figure.

$$\overline{NF} = \frac{E^2/4R}{KTB} \qquad (2)$$

In this formula $E^2/4R$ is the maximum available signal power at the receiver input terminals in watts, where E is the signal voltage at the antenna terminals, and R is the effective impedance in ohms. KTB is the maximum available noise power at the receiver input, where K is Boltzman's constant, 1.37×10^{-23} joules per degree Kelvin, T is the temperature in degrees Kelvin, chosen at 300 degrees, and B is the noise bandwidth of the receiver in cycles per second. For this receiver B is 57. For a one-to-one ratio Eq. 3 gives signal-power to noise-power of

$$P_r = \frac{E^2}{4R} = \overline{NF}\,KTB \qquad (3)$$

1.48×10^{-18} watts, taking the effective noise figure of the receiver as 7 db.

The best antenna available at this frequency was a 32-dipole array utilized by the SCR-271 early-warning radar. Two of these arrays were secured side by side and mounted on a 100-foot tower. Calculations show that the array had a power gain of 152 times that of a single halfwave dipole antenna. Since the effective gain of a single dipole is 1.64 times that of an isotropic radiator, the value of G_t is given as 1.64×152 or 250.

The absorption area A_r of the re-

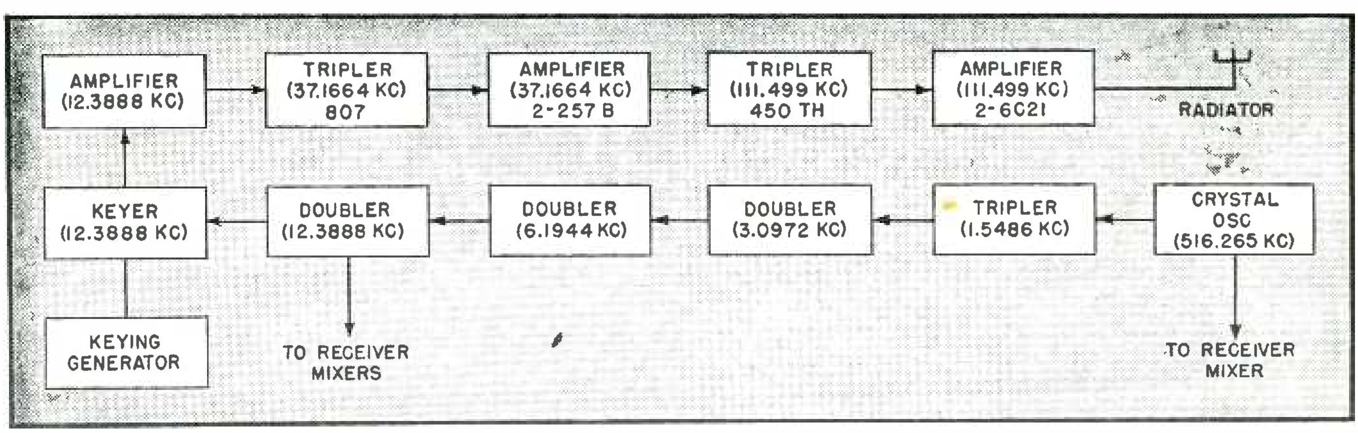


FIG. 2—Block diagram of the transmitter proper. This arrangement is a part of equipment designed for another purpose by E. H. Armstrong, adapted by the Signal Corps for the lunar studies

ceiving antenna is calculated from

$$A_e = \frac{G_o \lambda^2}{4\pi} \tag{4}$$

Substituting the value of G_o previously given, A_e = 522.1 × 10^{-7} square miles.

The remaining constant to be determined before solving Eq. 1 is σ the effective echoing area of the target. Calculations of the reflectivity coefficient made by Walter McAfee of the Theoretical Studies Group, assuming zero conductivity and a dielectric constant of six for the moon, resulted in the figure 0.1766. The effective echoing area is this figure multiplied by the projected area of the moon, $\pi d^2/4$ where d is the lunar diameter. This gave an effective echoing area of 0.1766 $(2160)^2$ (3.1416)/4 or 647,000 square miles.

Substitution of these values in the free-space radar equation gave a maximum range of 573,500 miles and indicated that the effective range of the equipment chosen was more than twice that needed to receive echoes from the moon. By adding the power gain due to ground reflection, a further excess of power of 12 db or a range of 1,140,000 miles was indicated, which meant that according to calculations, the received signal should be about 20 db above thermal noise. This calculation of the signal strength of the returned echo checked closely with observations, and indicated that no appreciable attenuation occurs in free space.

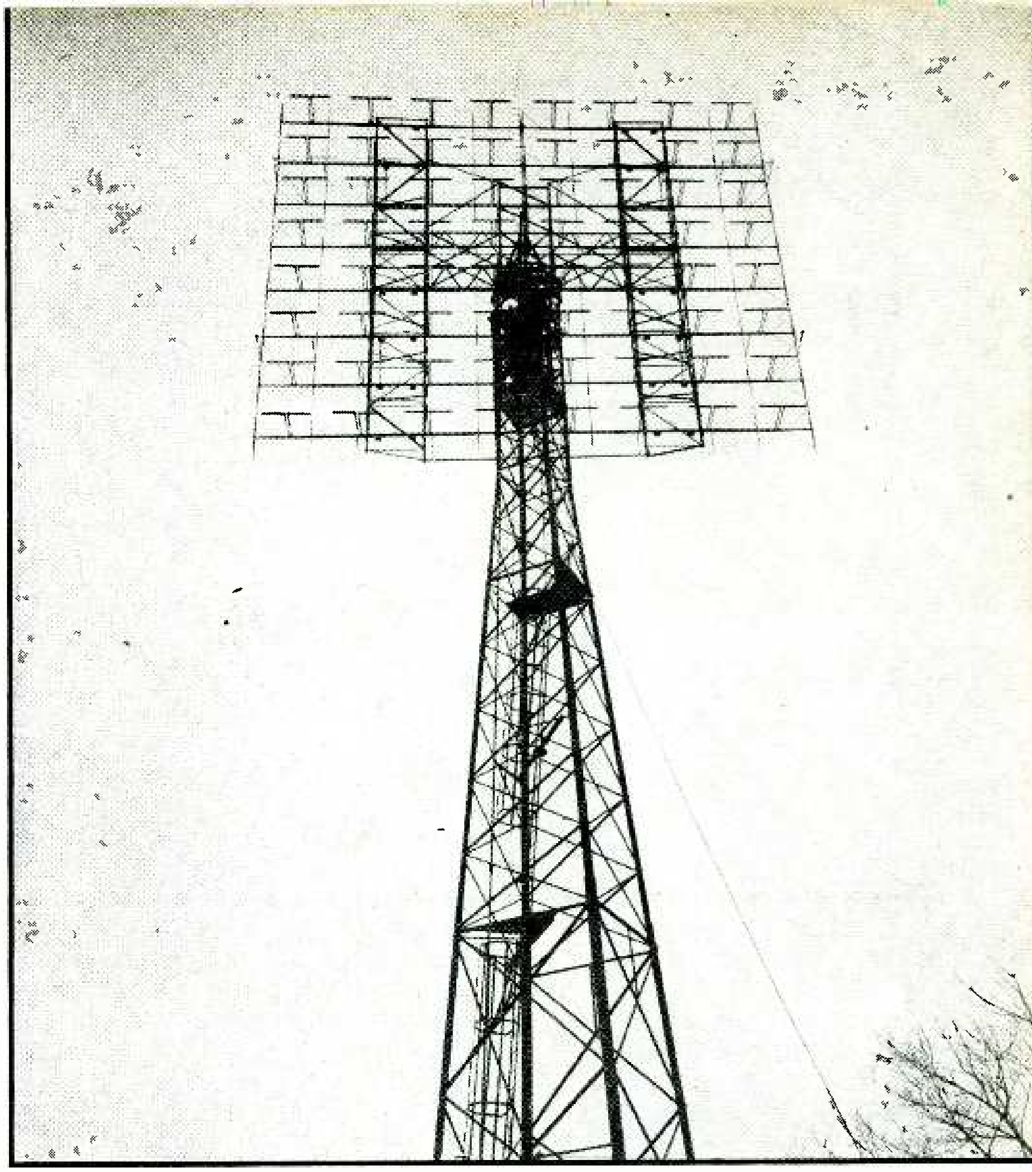


FIG. 3—The radiator consists of two standard SCR-271 "mattresses" mounted side by side, 64 dipoles in all. This 40-foot-square array is supported on a 100-foot tower, can look at the moon only at moonrise and moonset

Transmitter

Once the determination of constants was completed, the choice of available radar sets was made. Since no attempt was made to design major components specifically for this experiment, the selection of receiver and transmitter was made from equipment on hand. A crystal-controlled radar transmitter and receiver designed by Major E. H. Armstrong for another purpose were selected since they met the requirements of power and bandwidth. A block diagram of the complete transmitting, receiving and indicating system is shown in Fig. 1.

The transmitter is crystal controlled, deriving its final radio frequency of 111.5 mc after a series of frequency multiplications from a fundamental crystal oscillator frequency of 516.2 kc. Keying is accomplished by causing a low-level multiplier stage to conduct by driving its cathode negative for the duration of the transmitted pulse. In the initial setup, keying was performed mechanically by a relay, but this has since been replaced by an electronic keyer with the pulse width controllable between 0.02 to 0.2 seconds. A block diagram of the transmitter is shown in Fig. 2.

From the diagram it is apparent that the transmitter is of a conventional type. The output is fed over a 250-ohm open-wire transmission line to the antenna array. The antenna contains 64 dipoles horizontally polarized. The effective power gain of the array is 250, or 24 db.

The antenna, shown in Fig. 3, is mounted on a steel tower 100 feet high and is controllable in azimuth only. No provision has been made to incline the antenna in elevation. Because of this restriction, the times of observation using the present equipment were necessarily limited to moonrise and moonset. That this condition of observation is the worst possible (due to the long path through the atmosphere and the consequent possibility of trapped radiation) has been recognized. But it was impractical to procure an array of the equatorial type. Aside from propagation deficiencies, a far more serious limitation was the fact that observations were limited to two short periods daily.

The beam width of the array is approximately 15 deg at the half-power points, with the first three lobes spaced approximately 3 deg in elevation. Since the diameter of the moon subtends roughly one half degree of arc, most of the power transmitted does not illuminate the target, which constitutes a serious waste of power. The rate of rise of the moon along its ecliptic is 1 degree of arc every

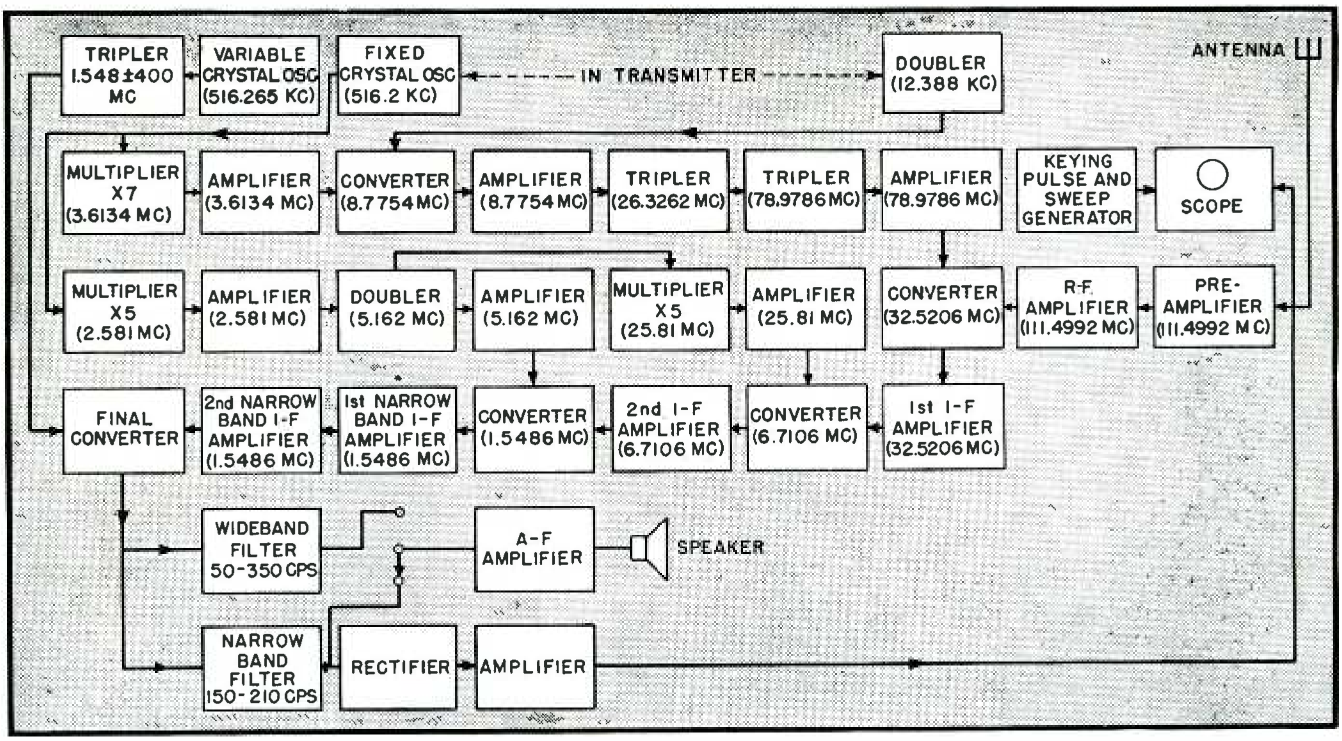


FIG. 4—Block diagram of receiver, a quadruple superheterodyne. Four mixers, controlled from transmitter crystal, keep receiver in tune, beat signal down to 180-cps i-f frequency. Visual as well as aural indications are provided

4 minutes, which allowed roughly 40 minutes of observation as the moon intercepted the first three lobes of the antenna. Bending effects due to long transmission path through the ionosphere undoubtedly exist, but no precise measurement of this effect has yet been made.

Receiving System

The receiving system is sufficiently different from conventional design to warrant a more complete description. A block diagram is shown in Fig. 4. The entire receiver is frequency controlled, and contains four mixer stages which heterodyne the radio-frequency signal to a final intermediate frequency of 180 cps. Since the first three injection frequency voltages as well as the final radio frequency are derived from multiples of a common crystal oscillator, a high degree of frequency stability is achieved in the system. This high degree of stability is essential to permit tuning the highly selective receiver to the frequency of the echo signal. This tuning is accomplished in the final heterodyne stage.

In tuning it is necessary to take account of the change in frequency of the returned signal which results from variations in the relative velocity of the moon with respect to the earth. The frequency of the returning echo may differ from the transmitted frequency by as much as 300 cycles per second, since the relative velocities of the earth and moon vary from about +900 mph at moonrise to −900 mph at moonset. At the frequency of the transmitter, a relative velocity of 3 miles per hour between antenna and target causes a shift of approximately 1 cycle per second in the received signal. This frequency shift, due to relative velocities of the transmitting antenna and target, is present in all radar echoes from moving targets, but is undetected in conventional receivers because the bandwidth of the normal receiver is many times greater than the frequency shift. In the Diana receiver, a bandwidth of 57 cps is achieved in the final i-f stages. It is therefore necessary to predetermine the Doppler frequency shift for the particular observation being made, and to select the proper crystal for the final heterodyne mixer. To achieve the high degree of accuracy required in the final mixer, provision is made to modify the frequency of the crystal-controlled oscillator by means of a screwdriver control which varies the air gap above the crystal. Final adjustment of the oscillator is made by beating the crystal oscillator output against a secondary frequency standard source, and observing the output on a monitoring oscilloscope.

The output of the final heterodyne mixer is fed into two channels, one audio, the other video. The audio channel is simply a power amplifier stage with the output connected to a loud speaker. The video output channel is fed into a second detector to recover the envelope of the 180 cps intermediate-frequency signal, and then is amplified by a high-gain video amplifier and connected directly to the vertical deflecting plates of a nine-inch cathode-ray tube. The horizontal deflection is a linear 4-second type-A sweep. The visible output is the characteristic low-frequency noise pattern representing a 57-cycle bandwidth centered at 180 cycles. A sudden upward departure from the base line occurs when an echo signal is received from the moon. This is shown clearly in Fig. 5. The audible signal is random noise of 57-cycle bandwidth, superimposed on a fixed-frequency note, at the intermediate frequency of 180 cycles, when the echo is received.

As stated previously, tuning of the receiver is accomplished in the final mixer. The injection signal frequency must be calculated for each observation to take into account the relative velocity of target and antenna due to both the rotational velocity of the earth and the orbital velocity of the moon. These data, together with azimuth angle and time, are calculated daily from information given by the Nautical Almanac and Ephemeris. The detection of the frequency due to Doppler shift is made with a high degree of accuracy by the selective receiver. This in itself is corroboration that the echo signal is from the moon. Also, the echo interval of 2.4 seconds admits of no other explanation.

The pre-amplifier of the receiver consists of a three-stage tuned r-f amplifier employing two grounded-grid stages (6J4) followed by a 6SH7 tuned amplifier at the transmitter frequency. The overall gain of the pre-amplifier alone is 30 db with an overall noise figure of 3.5 db and a bandwidth of 1 mc. The electrical design of the first two stages was suggested by a development of Dr. F. B. Llewellyn. A simplified schematic of the first two stages is shown in Fig. 6. The use of concentric tubing inductances for the tuned circuits provides automatic r-f filtering on the direct-current and filament leads. The pre-amplifier was designed originally as an improvement kit for the SCR-271 radar, and like the transmitter and receiver, was chosen for the Diana experiment because it satisfied one of the requirements, that of a very low noise figure receiver. A tuned impedance-matching transformer is used between the receiver and transmission line to convert the 250-ohm balanced input to the 50-ohm unbalanced input of the pre-amplifier.

The transmit-receive switching system (t/r box) employed in the original experiment was a set of two

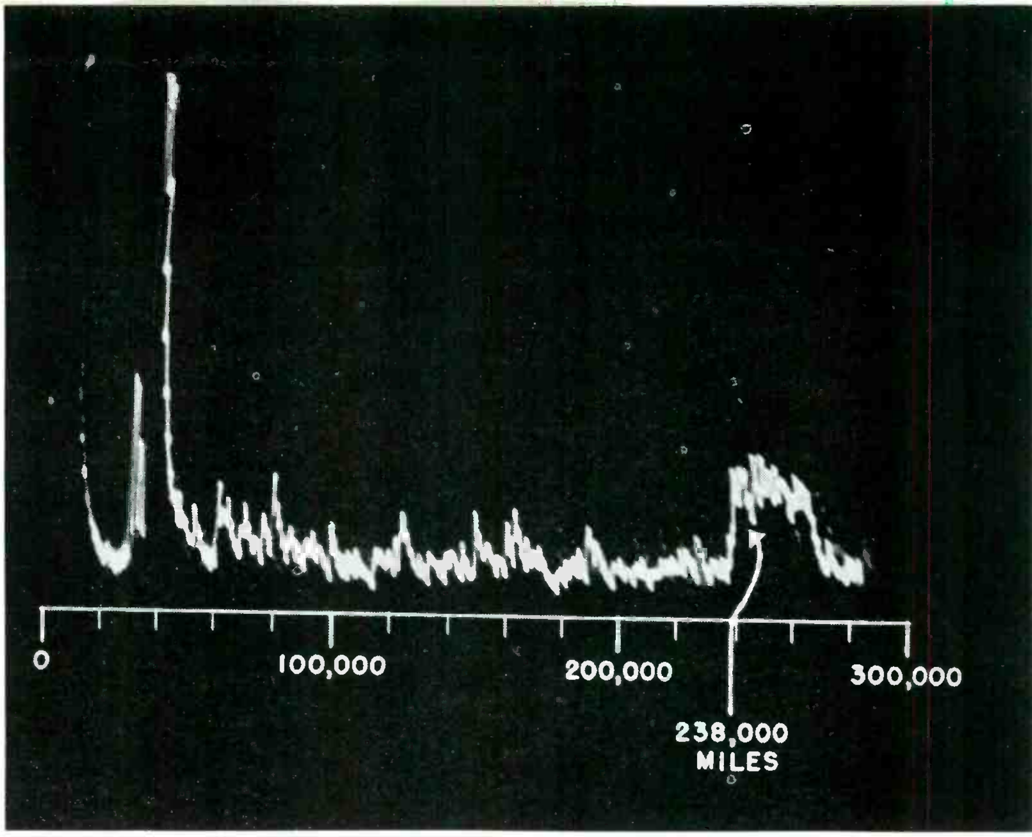


FIG. 5—Most widely published cathode-ray trace in history, this type-A presentation shows amplitude of moon echo about three times peak noise. Taken at moonrise, January 22, 1946. The relative velocity of moon and earth was 682 miles per hour, requiring a 227-cps shift in tuning to allow for Doppler effect. Signal-to-noise ratios as high as 20 db have been recorded

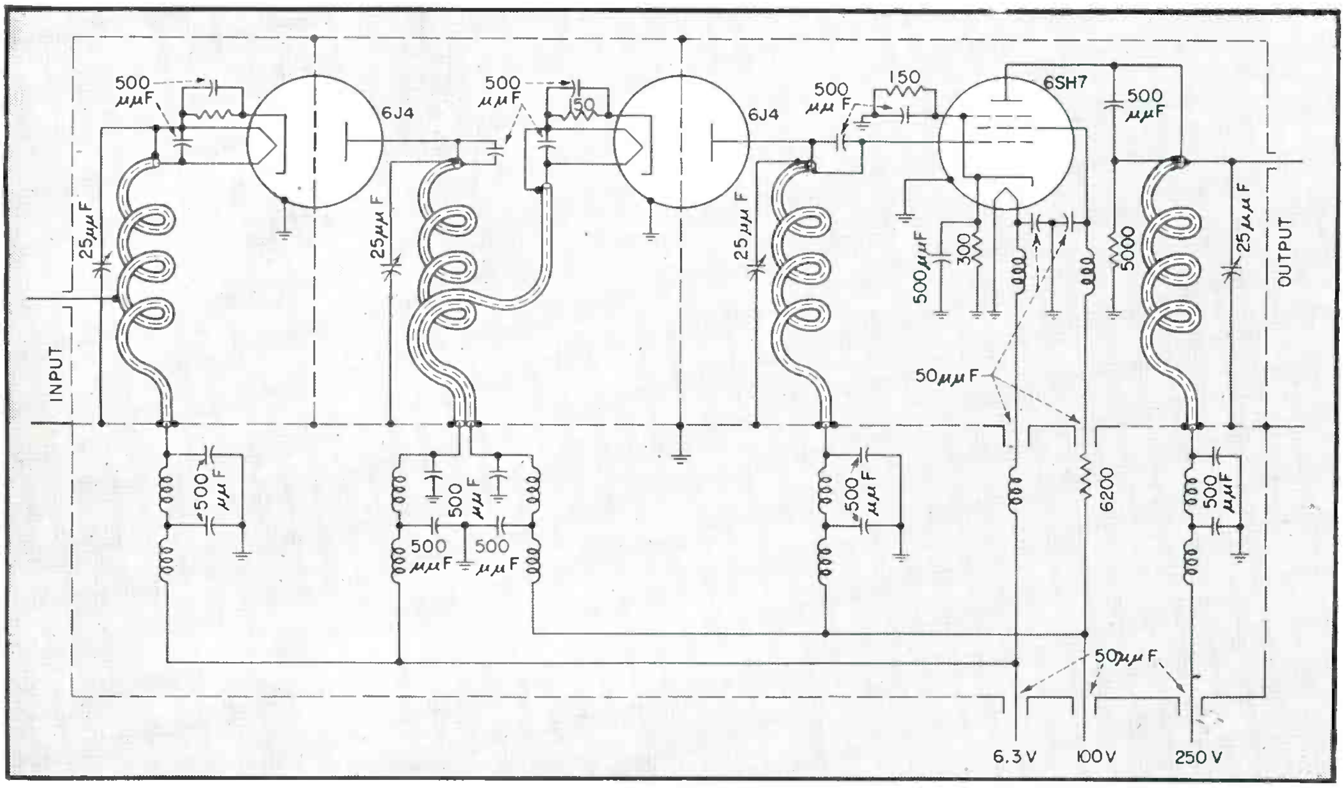


FIG. 6—Secret of success was low-noise pre-amplifier, a grounded-grid circuit based on a design by F. B. Llewellyn. Coaxial leads inside coils exclude r-f from d-c circuits

mechanically-operated shorting bars on the transmission line, operating from a multivibrator-controlled relay during the transmitted pulse interval of 0.25 sec. One of the shorting bars serves to short out the receiver input during transmission, and the other shorts out the transmitter during reception.

Keyer and Indicator

The visual indicator used is a nine-inch electrostatic cathode-ray tube, 9EP7, with a long-persistence screen. The electron beam is caused to scan the width of the tube, synchronously with the transmitted pulse, in 4 seconds, forming a linear time base. The persistence of the tube is long enough to retain the pattern for at least two sweeps. The circuit employed to generate this sweep is a direct-coupled transitron sawtooth oscillator, described below. A pulse equivalent in time to the keying pulse is also generated by this circuit and is applied to the cathode of a low-level multiplier stage of the transmitter, causing it to conduct for the pulse duration and to drive the subsequent multipliers.

The time-base generator consists essentially of a high-gain pentode amplifier with capacitance coupling between plate and grid. The schematic is shown in Fig. 7. The capacitance coupled path includes a cathode follower stage, the left hand section of V_2. For the duration of the conduction cycle, the anode voltage of the pentode V_1 drops and capacitor C_1 begins to discharge through the tube. As the voltage on the plate drops the current flow in C_1 drives the grid negative, tending to cut off the plate current. A condition of dynamic equilibrium then exists with the plate voltage dropping at a linear rate determined by R_1 and C_1 and the grid being maintained at a constant voltage, since each decrement in plate voltage causes a corresponding drop on the grid which keeps the grid signal and hence the output of the tube substantially constant. The time constant of R_1 C_1 is chosen to cause C_1 to become fully discharged during the cycle.

When the plate voltage drops to the point where electrons from the cathode can no longer flow to it, an increase in screen current occurs which rapidly decreases the screen voltage and correspondingly decreases the suppressor voltage. This action, which is cumulative, has the effect of suddenly cutting off the anode current. This causes the cathode current to be retarded by the suppressor grid and made to flow to the screen. A negative pulse appears at the screen, and C_1 begins to charge through the cathode follower until a point is reached where the plate begins to draw current and the oscillator is recycled. The screen returns to its original voltage, and the plate voltage begins to fall. By suitable choice of R_1 and C_1 a range of from about 0.1 to 3 cps is obtained.

Keying-voltage signals are derived from the differentiated output of the negative pulse appearing on the screen of the oscillator. This is used to trigger a multivibrator whose time constant is controllable by a variable 5 meg resistor, varying the output pulse width from 0.02 to 0.25 seconds.

The addition of the cathode follower stage V_2 was made to shorten the charge time of C_1 by causing it to charge through the grid cathode space of the cathode follower. This reduces the return trace time. Tube V_3 serves as a degenerative phase-inverting amplifier to secure push-pull sweep voltage.

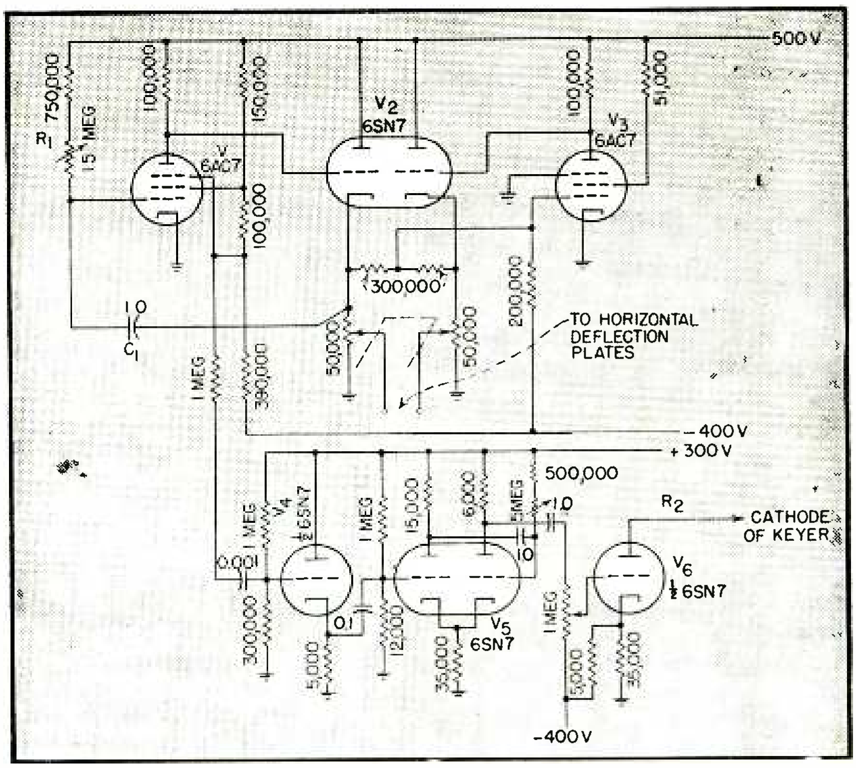


FIG. 7—Linear deflection circuit of type-A indicator, which sweeps spot across screen in up to ten seconds. Basic circuit is transitron oscillator. Sweep and keyer are controlled by the cathode-coupled flip-flop circuit at bottom of diagram

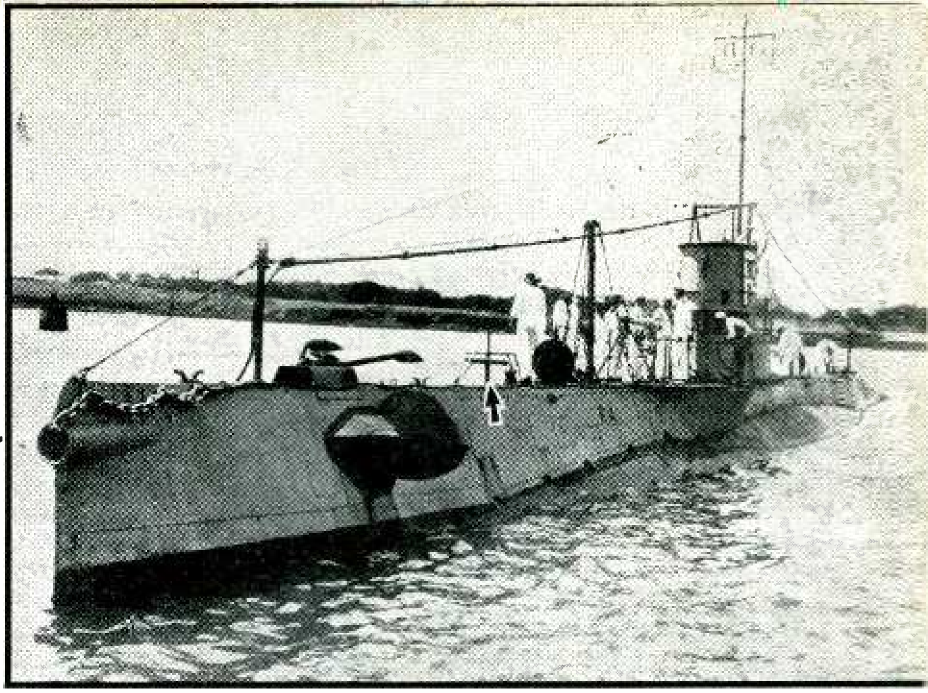
The keyer multivibrator is a conventional cathode-coupled flip-flop circuit with the initiating trigger applied as a positive pulse on the grid of the normally non-conducting section. A positive pulse varying in width from 0.02 to 0.25 seconds is obtained at the plate of the other section. This signal is applied to a normally cut off pentode whose load impedance is the cathode of the 12.388 mc amplifier stage in the transmitter. For the duration of this applied signal, the plate of the amplifier is driven negative, taking the cathode of the keying tube down with it, thus causing it to conduct.

The first echoes from the moon were received at moonrise on January 10, 1946. The indication was of the audible type in the form of a 180-cycle beat note occurring 2.5 seconds after transmission.

Although numerous observations have been made, both at moonrise and moonset, echo returns do not occur after every transmission. Further measurements are needed before precise scientific conclusions can be drawn.

Reference

(1) The Radar Equation, ELECTRONICS, p. 92, April 1945.



USS R-4 submarine, with arrow pointing to JP hydrophone installed topside (U. S. Navy photo)

SONAR FOR SUBMARINES

Technical details of sonar equipment used on submarines for underwater listening, including description of supersonic converter circuit, construction of highly directive line-type magnetostriction hydrophone, and analysis of transmission characteristics of sea water

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WITH the declassification by the Navy of JP sonar equipment, it is possible for the first time to describe a complete underwater sound system, including the advanced form of magnetostriction hydrophone that became the standard transducer in submarine listening devices. The JP sonar was developed in cooperation with the Navy by Columbia University, Division of War Research, under NDRC Section 6 at the U. S. Navy Underwater Sound Laboratory at New London, Connecticut.

The success of underwater sound devices became increasingly important to the American war effort with the launching of the German submarine campaign against our coastal shipping in 1942. While playing an important role in the defeat of the U boat, American sonic gear also performed outstandingly against the Japanese. The JP sonar carried a large share of the burden of underwater listening during the war, and constituted a major advance in the development of American underwater sound gear.

Much of the developmental work in the field of underwater sound went into sonic ranging devices which project a signal into the water and obtain information of various kinds from the echo. Such ranging devices are of fundamental importance, but a listening device has a complementary importance and a number of advantages as a warning instrument. It gives warning of the presence of a surface vessel at greater ranges than from an echo ranging device, which suffers from the doubled distance the signal must travel and the far from efficient reflection by the target.

The operator of a listening device gets information about the outside world by identification of sounds which is lacking when echo ranging is employed. Furthermore, the tactical and psychological advantages of actually being able to hear the enemy were found early in the war to be of great importance to the commander of a submerged submarine.

electronics WAR REPORT

Underwater Listening Problems

The most important sound produced in the water by a moving vessel, either on the surface or submerged, is usually the result of cavitation at the propeller. The resulting underwater sound wave is highly complex and has frequency components throughout the sonic and into the supersonic spectrum. The acoustic pressure produced in the water at 1,000 yards by the propeller of a typical ship moving at medium speed is plotted in Fig. 1 for frequencies between 100 and 10,000 cycles.

Other noises produced in the water by a vessel include the vibration of the engines or other machinery and impact-type noises such as the banging of chains or other gear. Speed-reducing gears and pumps are especially noisy. Some types of bearings may have a periodic squeak, and the hull of the ship may cause cavitation in the water at high speeds. These types of noises will in general be carried through the water as waves of complex frequency distribution, with both sonic and supersonic components.

Although exact analysis of the transmission characteristics of sea water is difficult, there are two main effects that influence the range of a sound in sea water. The first is the expected inverse-square-law reduction in energy caused by the spreading of the wave; the other is an absorption effect due to the mechanical resistance of the water. The latter effect, for signals below about 5 kc, adds approximately 2 db of attenuation per 1,000 yards to that due to spreading. Above 5 kc, the attenuation from absorption increases rapidly. At 100 kc, the absorption amounts to approximately 20 db per 1,000 yards. This transmission characteristic makes it certain that at relatively long ranges an underwater sound will consist predominantly of low-frequency energy.

Ambient water noise is a never-absent factor that vitally affects the range and effectiveness of underwater listening devices. The noise level varies with different states of sea agitation and with other factors, but under most representative conditions has an energy distribution that falls off rapidly in the higher frequencies. The falling characteristic of the noise with frequency usually gives high signal frequencies a better signal-to-noise ratio at close ranges, but at long ranges the attenuation of the signal at high frequencies tends to cancel this advantage. The frequency at which the signal first becomes recognizable when closing range may be anywhere in the spectrum, but is most often in the 500 to 2,000-cps range.

Equipment Requirements

It will be seen from the above that a searching device must be capable of responding to signal frequencies anywhere in the sonic and well into the supersonic range. Rugged electromechanical transducers for such a range are essential. The transducers must operate under water, at static pressures as high as 250 lb per square inch, and in addition are subject to dynamic pressures arising from depth charges and the motion of the submarine through the water. The problem of matching the transducer impedance to that of the water is of an unfamiliar order of dimensions, as the mechanical impedance of water is many times that of air.

Additional design factors arise from the combination of the listening and tracking functions with searching in the JP sonar. For the listening function it is desirable that the operator be able to hear the signal through a system having controllable characteristics over the audible band. If the aural character of the signal is emphasized by filtering, experienced operators can identify different types of vessels by their sound. Many operators became so experienced in the interpretation of sonic signals that they could in some cases tell whether a ship was loaded or unloaded, when it made a sharp turn in the water, etc.

For the tracking function, the system should, of course, be as directive in its response as possible.

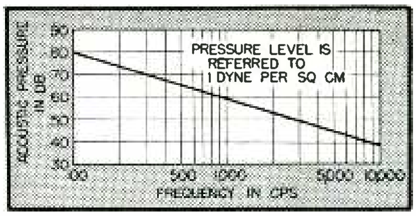


FIG. 1—Acoustic pressure in water due to propeller of freighter 1,000 yards away

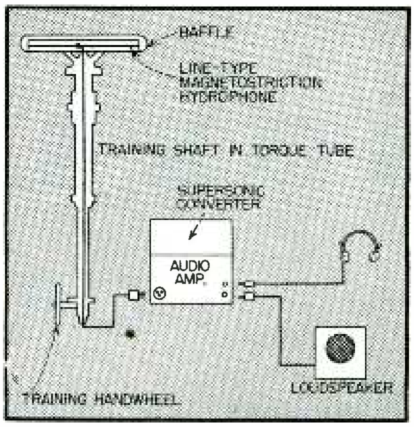


FIG. 2—Drawing of JP sonar listening equipment

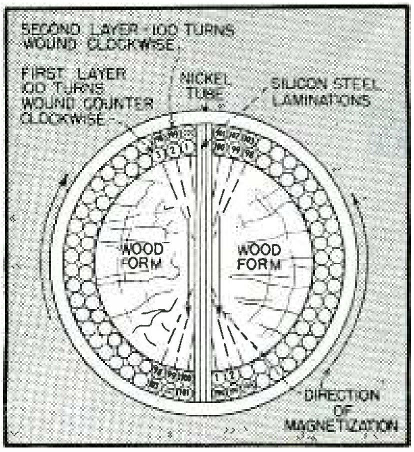


FIG. 3—Cross-section view of line-type magnetostriction hydrophone

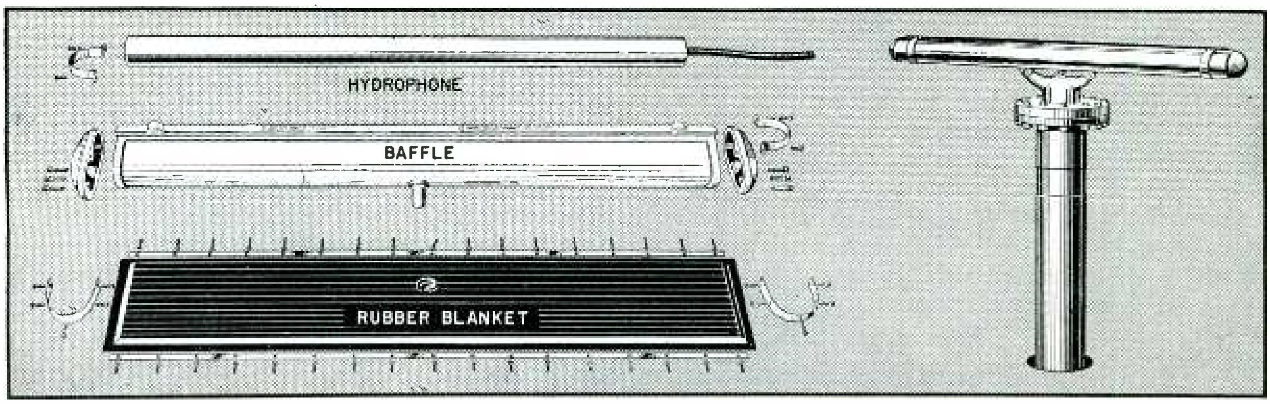


FIG. 4—Magnetostriction hydrophone, disassembled at left and assembled at right for topside mounting on a submarine

The JP equipments met the above requirements through the development of the line type of magnetostriction hydrophone and specialized electronic equipment to function with it. The complete equipment, shown in block form in Fig. 2, consists of the hydrophone mounted at the top of a training shaft which extends through the topside of the submarine, the training gear for revolving the hydrophone and indicating its tracking position to the operator, the listening amplifier for raising the signal level and bringing it under the operator's control, and the supersonic converter for heterodyning signals in the supersonic spectrum down to audibility.

To search or track in the sonic range, or to listen directly to a signal for the aural character, the hydrophone is fed directly into the listening amplifier, with the supersonic converter cut out of the system. When searching for supersonic signals or tracking on the higher components of any signal, the converter is cut into the system between the hydrophone and the listening amplifier.

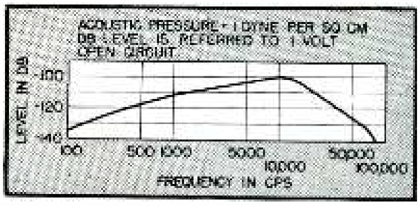


FIG. 5—Frequency response of hydrophone

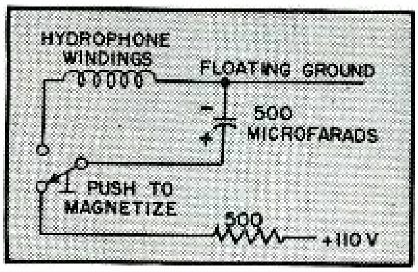


FIG. 6—Circuit for remagnetizing nickel tube of magnetostriction hydrophone

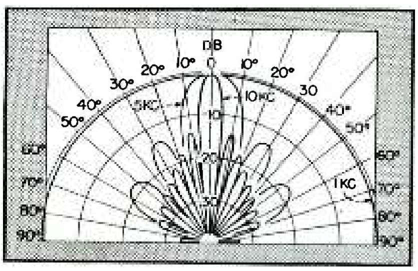


FIG. 7—Directivity pattern of hydrophone at three different frequencies

Earlier types of hydrophones were of piston construction, using a multiplicity of magnetized nickel tubes placed parallel to each other and fastened perpendicularly to a diaphragm in contact with the water. This performs well in certain applications, but when greatly increased directivity is demanded of the system, the physical dimensions of the piston hydrophone make it unwieldy. Interference between successive wave fronts at close bearing angles, which is the basis of the directivity of a typical underwater sound transducer, cannot be achieved in the sonic range with a circular diaphragm of practical dimensions.

Magnetostriction Hydrophone Design

The line type of hydrophone overcame this difficulty by using a single magnetized element, a nickel tube 3 feet long and 2 inches in diameter. The tube itself acts as a diaphragm to receive energy from the water. The coil is wound on a soft wood and silicon steel core and is entirely enclosed in the tube, as shown in the cross-sectional view of Fig. 3. In back of the tube and supporting it in the horizontal position is the baffle, a bronze casting of streamlined cross-section which is covered with a rubber blanket to absorb sound reaching the hydrophone from the rear. The hydrophone tube, the baffle, the rubber blanket, and various fittings disassembled are shown in Fig. 4 along with the complete assembly as mounted at the top of the training shaft.

Hydrophone Characteristics

The nickel tube is magnetized before use and the instrument operates on the residual magnetism. Deformation of the tube by acoustic energy in the water produces a corresponding variation in the magnetic field, which is carried through the coil by the transverse steel core.

Figure 5 shows the sensitivity and frequency response of the JP hydrophone, in decibels below one volt at the open-circuit terminals, with a constant acoustic pressure of one dyne per square centimeter. The rising character of the response between 100 and 10,000 cycles is desirable to equalize the reverse characteristic of underwater signals at long ranges. The response in the supersonic range is necessary to make the system completely flexible as a tracking and searching device.

The residual magnetism in the tube gradually falls off in use, and may be materially reduced by the shock of depth-charge explosions or other underwater disturbances. The remagnetizing circuit shown in Fig. 6 is therefore provided in the amplifier for remagnetizing the tube. The 500-microfarad capacitor is maintained in a charged condition across the 110-volt d-c power line, and a pushbutton switch allows the capacitor to be discharged through the hydrophone coil.

The directivity pattern of the JP hydrophone is shown in Fig. 7 for single frequencies of 1, 5 and 10 kc. At 1 kc, with a wavelength of nearly five feet, there is no useful directive effect, while at 10 kc the response falls off nearly to zero at about 5 degrees either side of zero bearing. The first secondary lobe in the pattern is about 13 db below the zero-bearing

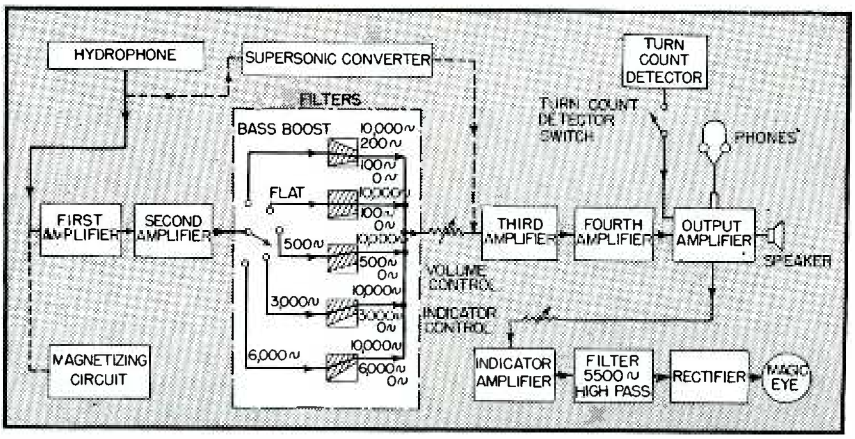


FIG. 8—Block diagram of JP sonic listening gear

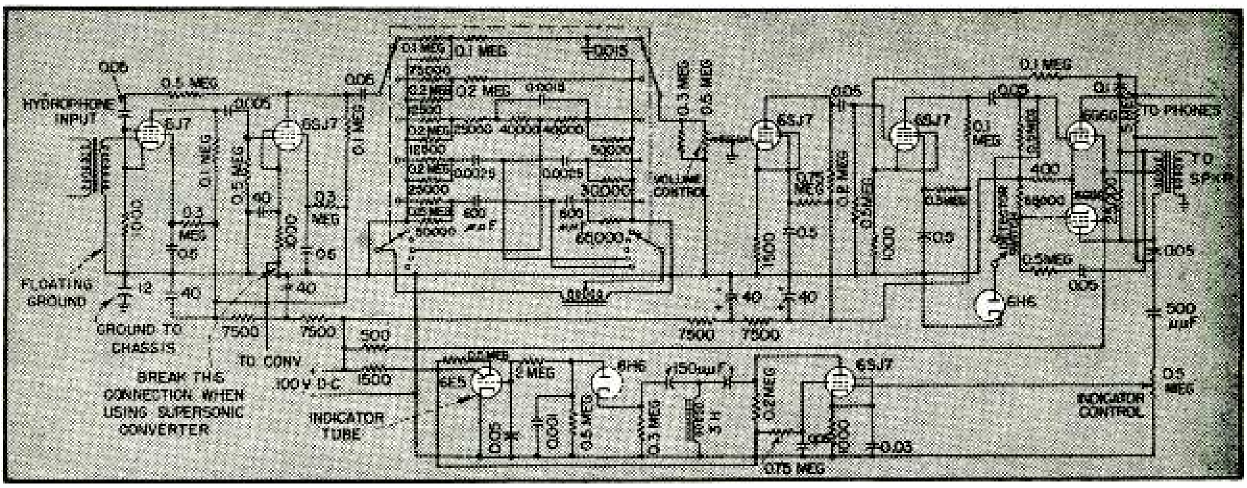


FIG. 9—Circuit diagram of a-f amplifier for models JP-2 and JP-3 sonar equipment

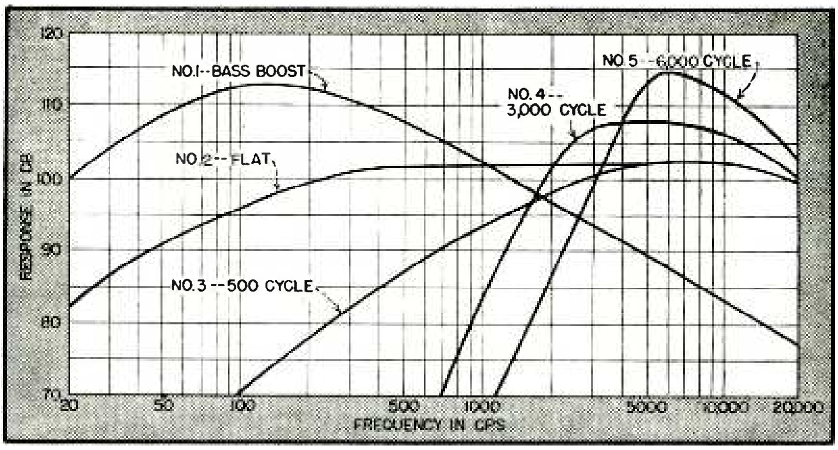


FIG. 10—Response of a-f amplifier at the five filter-switch settings

response. As the signal frequency rises into the supersonic spectrum the directive pattern shows even sharper peaks, which indicates the reason for the emphasis on the high frequencies in the tracking function.

Actual listening employs a band of frequencies which minimizes the prominence of the secondary lobes of the directivity pattern.

The line hydrophone has a solid directive pattern of the pancake type, as opposed to the bowling-pin pattern of the piston hydrophone. The difference can be visualized by revolving the 10-kc pattern of Fig. 7 first around the horizontal reference line as an axis to form the pancake pattern, and then around the vertical center-line to form the bowling-pin pattern. The pancake pattern is considered superior for searching purposes because it gives equal response to signals in a plane normal to the hydrophone axis, no matter what the vertical angle of elevation. This ignores the effect of the baffle, which reduces the response from the rear and thus allows the operator to place the signal in the forward arc of the pancake pattern.

Amplifier Circuit

The hydrophone output is brought down through the training shaft to the listening amplifier. A block diagram of the amplifier is shown in Fig. 8 and the complete schematic in Fig. 9. It is in the main a resistance-coupled five-stage arrangement of conventional design, using pentodes throughout. Two separate feedback loops are used to stabilize gain and reduce noise, one over the first two stages and one over the last two.

The electrical sensitivity of the system, measured from the output of the hydrophone, is approximately 10^{-8} volt. With a hydrophone of the JP type and overall amplifier sensitivity of the order of 0.01 microvolt, the system has a sensitivity margin of about 20 db over that required to raise the water noise to audibility under average conditions. Further increases in sensitivity have not been found of value in listening systems of the JP type, as the water noise is at present the limiting factor on the range of the system.

Testing of large groups of operators has shown that for a signal to be recognized through the noise, the signal level must be about equal to the noise level over a band of frequencies somewhere in the audible spectrum. The width of such a band which will just make the signal discernible, known as the critical bandwidth, varies somewhat with the position of the band in the spectrum. With strongly periodic signals, experienced operators can sometimes pick out a signal as much as 10 db below the noise level.

To reduce the noise level and make the system most effective at the point in the spectrum where the signal-to-noise ratio happens to be most favorable, the amplifier incorporates a variable equalizer between the second and third stages. The characteristic response for each of the five filter positions is shown in Fig. 10. The bass-boost or No. 1 position aids in identifying noises with a predominant low-frequency character, such as banging chains, machinery vibration, etc, and is useful at long ranges. The unequalized position is No. 2, and No. 3, 4 and 5 cut in high-pass filters with progressively higher cut-off points. The latter positions are most useful at relatively close ranges, when the falling characteristic of the noise with frequency can be used to advantage.

Limiting the response to the 3,000 or 6,000-cycle-and-up range will often eliminate the major part of the noise energy, which lies in the lower frequencies, and will permit the operator to pick out signals that would otherwise be completely masked. Naturally, reducing the bandwidth also reduces the noise level by some factor independent of differential frequency effects.

Normal listening was with high-quality headphones so sounds would be as near the original as possible.

The indicator channel, with an amplifier stage and a high-pass filter cutting off at 5,500 cycles, is used to give the operator a sharp visual indication of zero bearing on the target. Restriction of the response of the tuning eye tube to signals above 5,500 cycles is necessary to obtain a sharply directional response.

The output stage includes a diode which can be thrown in with a switch to shunt the grid circuit, with the plate of the diode connected directly to the grid and the cathode of the diode connected to ground. The resulting clipping action on positive signal peaks provides a strong band of harmonics which will often make a periodic signal stand out clearly from the noise. This simple distortion-supplying device is most often used to get a clear count on the propeller beat of another vessel, hence the name turn-count detector.

Supersonic Converter

The supersonic converter is shown in block form in Fig. 11 and the complete schematic in Fig. 12. It contains five 6SJ7 pentodes, one as an amplifier and two each as oscillators and mixers. The first conversion uses a local oscillator frequency tunable over the range of 102 to 154 kc, so that any signal in the 8 to 65 kc input range of the instrument will produce a difference frequency between 89 and 94 kc. The second local oscillator is tuned to 94 kc, so that the final difference frequency will be in the audible band below 5 kc. The various filters restrict the response of the system to the desired range.

The oscillator voltages from the electron-coupled oscillators are injected at the suppressor grids of the mixers. A three-step volume control at the grid of the first mixer provides a long, short, and medium range, with 20 db of attenuation between each step. The audio output of the converter is − 4 db over the range of 500 to 5,000 cycles. The converter gives the system as a whole 18 db more gain at supersonic frequencies than the listening amplifier alone has at 1,000 cycles.

With the hydrophone output fed into the supersonic converter and the converter output connected into the listening amplifier at the grid of the third stage, the operator can search for signals in the supersonic range, or use the higher components of any signal for greater tracking accuracy. Switching is provided so that the converter can be instantly connected into the listening system. An operator experienced in the use of the converter can determine the bearing of a signal, under favorable conditions, with an accuracy of better than 1.5 degrees.

The flexibility of the JP sonar and its ability to bring the actual sound of the signal into the submarine, together with its range and high accuracy of tracking, made it a major contribution to the success of American submarines during the war.

Important contributions to the success of the JP sonic apparatus were made by H. C. Williams, J. W. Horton, T. E. Shea, F. P. Herrnfeld, W. B. Snow, D. P. Loye, R. Chapman, R. H. Griffin, M. T. Rodger, and the late A. L. Thuras.

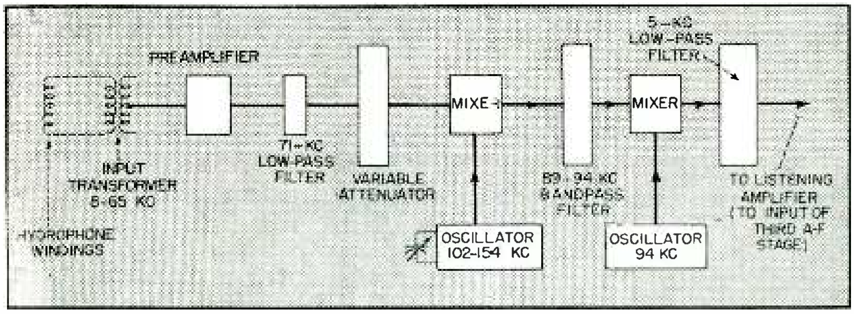
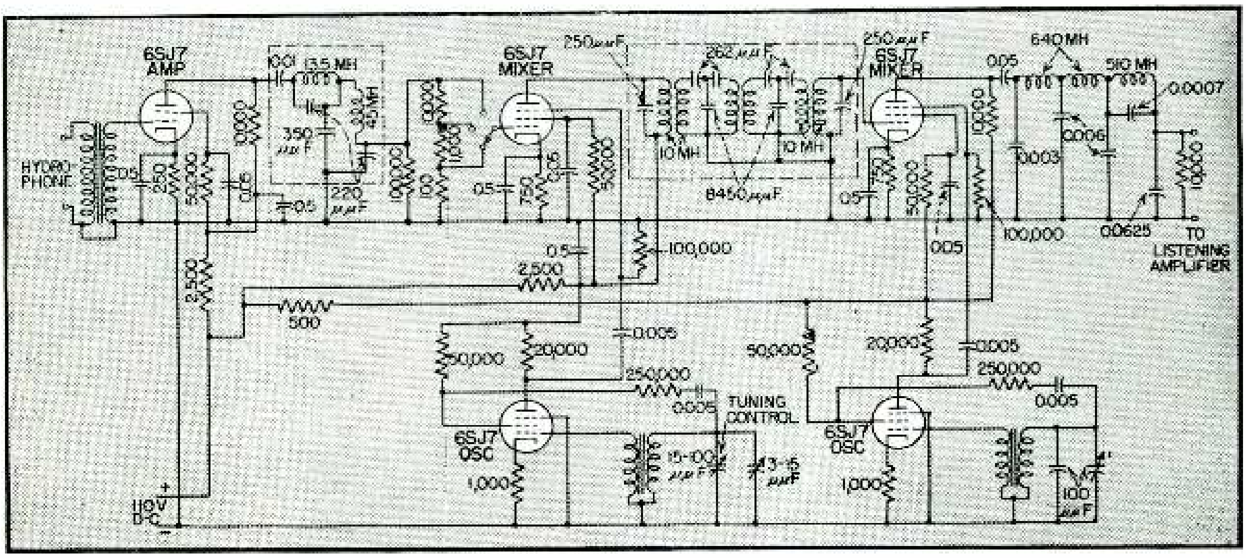


FIG. 11—Block diagram of supersonic converter used to heterodyne supersonic signals in the range from 8 to 65 kc down to the audible band below 5,000 cycles

FIG. 12 (below)—Circuit diagram of supersonic converter



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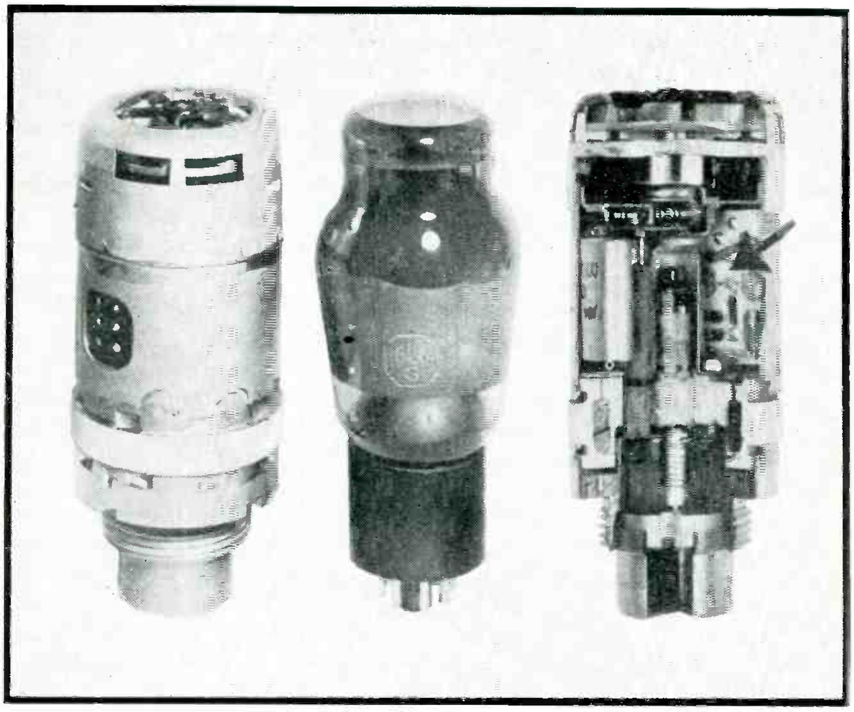
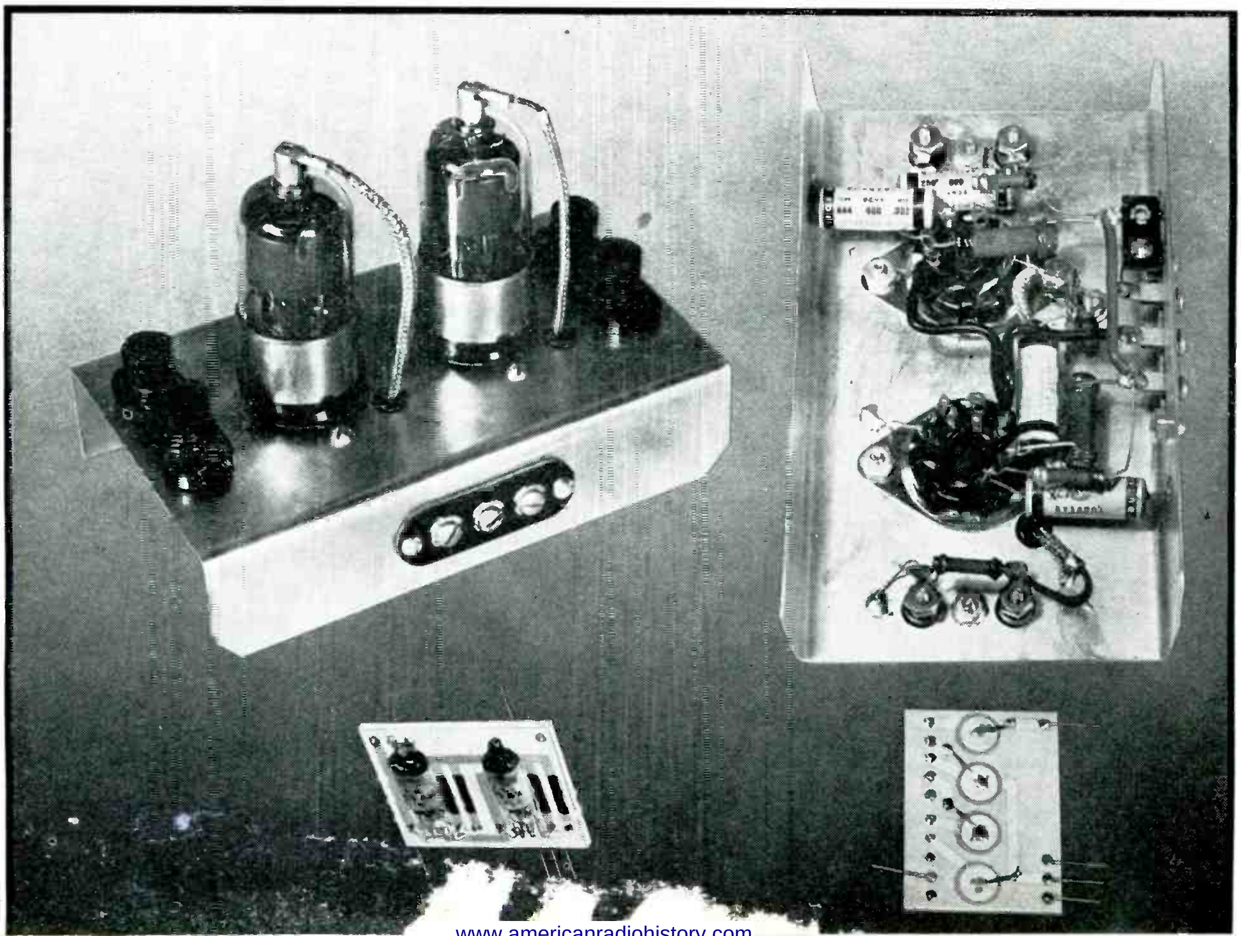


FIG. 1—Comparison of tiniest mortar VT fuze with standard 6L6G radio tube, and cross-section of fuze. Arrow points to printed ceramic electronic control circuit

THE development of the tiny generator-powered radio proximity fuze for the U. S. Army's mortar shells resulted in several new processes and techniques which promise to do much in reducing size and improving efficiency of many types of electronic devices. Outstanding among these is perfection of a method of printing wiring and certain components on a ceramic surface.

The diminutive size of the mortar fuze may be realized from Fig. 1, in which it is shown alongside a 6L6G radio tube. The cross-section view shows a portion of an electronic control circuit constructed according to the new principle. Completely self-contained with radio transmitter-receiver, control circuits, safety devices and a turbo-generator power supply, the fuze was designed to withstand a set-back force of 10,000 times that of gravity. The limited space requirements for the control circuit, coupled with the necessity of rugged-

FIG. 2—Top and bottom views of two-stage amplifier constructed according to present practice and (below) by new printed ceramic technique developed for use with subminiature tubes



Electronic Circuits

First details of new technique for printing wiring directly on a steatite chassis block with silver solution by a silk screen process, then spraying on resistors through masks. This method makes possible the mass production of ultracompact amplifiers and radio sets

ness in design, led to the adoption of the printed ceramic method.

With the resumption of peacetime activity, the new circuit wiring process promises to have wide use in such applications as pocket radios, personal telephones, miniature hearing aids, meteorological instruments, and miscellaneous electronic control circuits. A typical example of its use is seen in Fig. 2, in which a two-stage audio amplifier constructed on this principle is compared with one made according to present table-model radio practice.

Essentially the process consists of the following four techniques: (1) Printing or stencilling the circuit wiring (using silver paint) onto a suitable chassis or base material, such as a plate of steatite; (2) Spraying the resistors in the form of a carbon and resin mixture, onto the plate through positioning masks that locate them between appropriate silvered end tabs; (3) Attaching small disc-type capacitors, consisting of a high-dielectric-constant ceramic with both faces silvered, directly to the silvered wiring on the plate; (4) Soldering other components such as tubes into appropriately located and silvered holes in the ceramic. Used with the newly developed subminiature tubes, the electronic circuit assembly made possible by this process is extremely compact.

Figure 3 shows the circuit and the

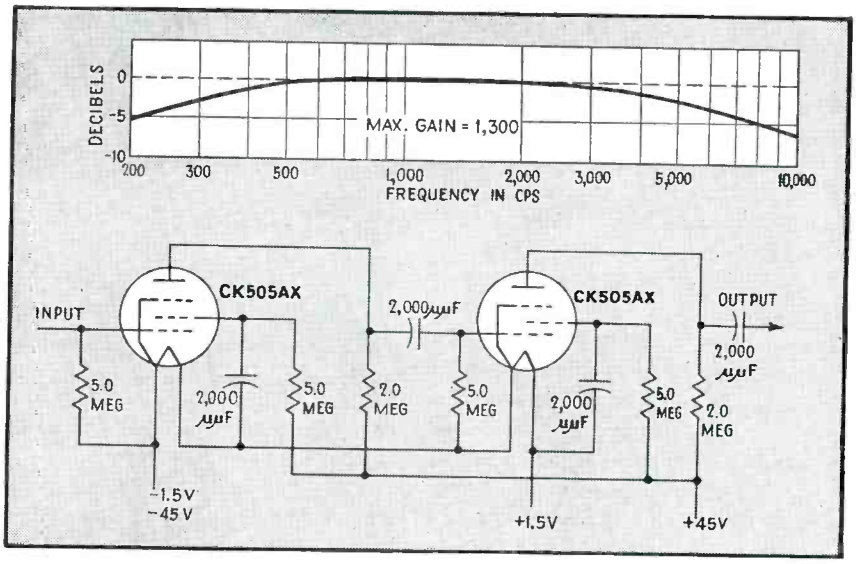
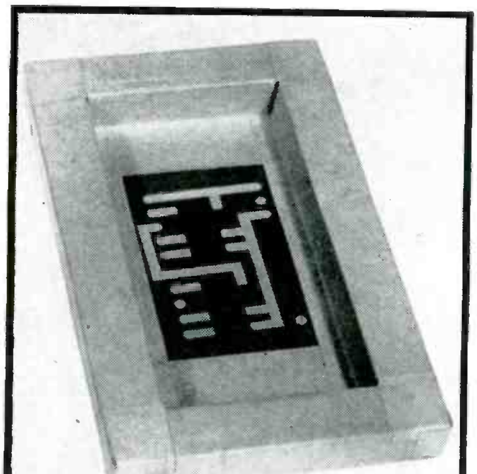
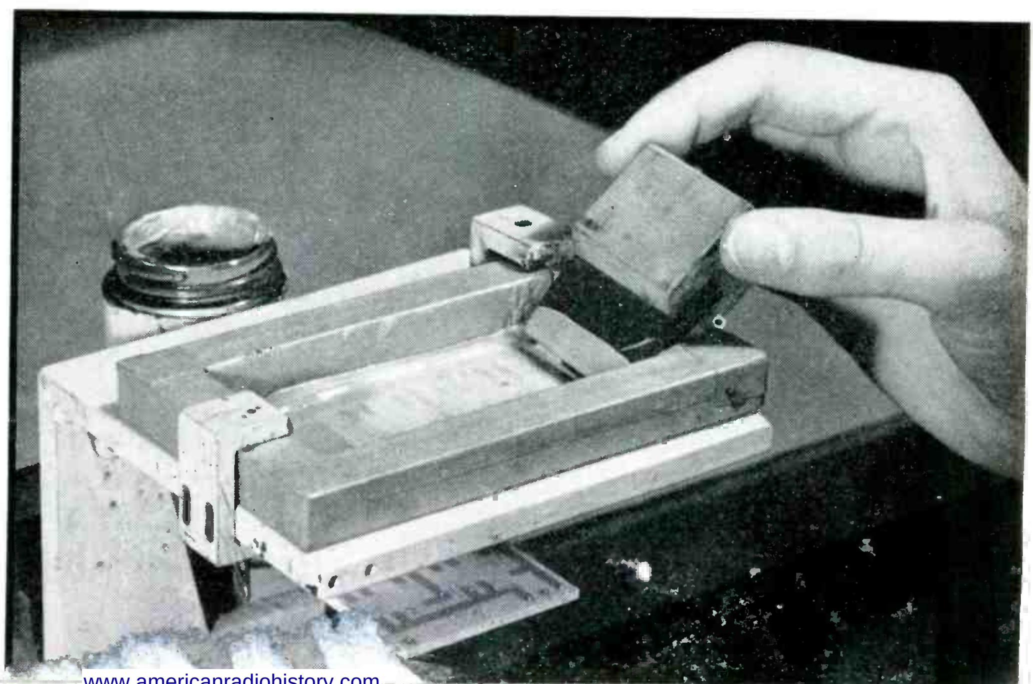


FIG. 3—Circuit and response characteristics of two-stage audio amplifier used as example illustrating the advantages of the printed ceramic technique





Silk screen (above) mounted ready for use, and jig (right) for holding screen and steatite plate during printing. Design has just been printed on the plate by forcing silver solution through the screen with a neoprene bar, and the printed plate has been lowered out of contact with the screen gain-frequency characteristic for the printed amplifier of Fig. 2. The response is identical to that of ordinary circuits. This is to be expected, as basically the components of this circuit are resistors, capacitors, and tubes just as in the standard circuits.

Although an audio circuit is described, the method is adaptable to high as well as low frequencies. In fact, the reduced size of the components and assembly allows very efficient ultrahigh-frequency circuits to be constructed in a limited amount of space. At very high and ultrahigh-frequencies small circular or rectangular spiraled coils may be printed flat on the ceramic surface in the same fashion as the wiring leads, using silver paint. It is possible to obtain Q values of 150 to 200 and even higher if desired.

The method is adaptable also to attenuators, filters, corrective networks and, in general, any low-power electric circuit. In circuits requiring the use of tubes, subminiature tubes now on the market are ideal. These inch-size tubes, which played a principal part in the development of proximity fuzes, are not only small but rugged and efficient. Filament drain is exceedingly low. Typical characteristics of Raytheon subminiature tubes as used in printed electronic circuits are shown in Table I.

Soldering of subminiature tube leads to a printed ceramic chassis. Ceramic capacitor discs in foreground are also soldered to the steatite

Although the compactness of the method was the most important factor in its application to the VT fuse, other equally important and desirable characteristics are the uniformity of finished assemblies both in appearance and performance, high production speed, and ease of circuit checking. Uniformity is obtained since each circuit is an exact reproduction of the master pattern. High production speed is obtained by the screening and spraying operations, which combine in a few fast mechanical operations the former operations of cutting wires to length and soldering wires and resistors into place.

Because of its two-dimensional nature and the open method of construction, circuits constructed by this new process lend themselves to rapid circuit tracing and repair. Faulty components such as resistors and capacitors which are on the chassis can be repaired, if desired, by soldering a conventional component of equivalent value across each faulty part and opening the circuit leading to the fault.

Details of Construction

Six stages in the evolution of the printed ceramic circuit are portrayed in Fig. 4. The base material most commonly used is steatite, a hard, dense, porcelain-like ceramic material. Like porcelain, steatite is

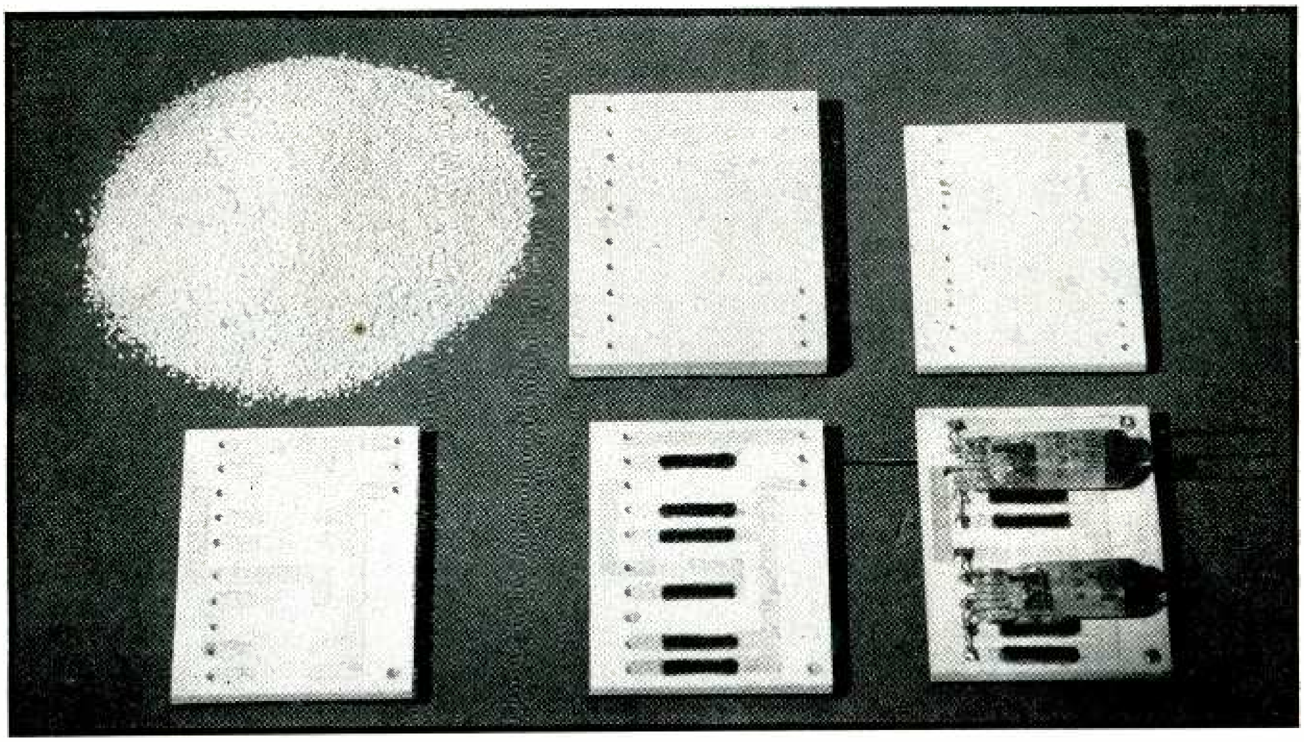


FIG. 4—Evolution of a printed electronic circuit, showing the amount of powder needed to press one steatite plate, the pressed but unfired plate, the fired plate (showing shrinkage), circuit wiring applied through silk screen and fired on, resistors sprayed on, and the final assembled unit

formed by various methods of extruding, pressing, or casting to a predetermined larger size and then dried and fired at almost white-heat temperatures to shrink and vitrify it to its final form.

Preparatory to fabricating to shape, the carefully selected and ground talc is thoroughly mixed with small percentages of clays, fluxes, and organic binders in large muller mixers. Water is added and the batch is worked to a uniformly plastic condition.

The pieces are pressed to the desired form by either a dry or wet press process. The dry press method, which lends itself to more rapid and automatic pressing, is used whenever possible. However, the more complex pieces are of necessity wet-pressed to obtain satisfactory flow of materials to the various parts of the mold. Material is prepared for pressing by disintegrating a wet batch into small granular particles by use of high-speed hammer mills. For wet pressing it is used in this form and pressed in molds at pressures of one-half to two tons per square inch. For dry pressing, the granulated material is dried and screened for use and pressed in molds at pressures between five and ten tons per sq in.

TABLE I. Typical Characteristics of Subminiature Tubes Used in Printed Electronic Circuits

Electrical Characteristics	CK-505AX Pentode Voltage Amplifier Type	CK-503AX Pentode Output Type	2E 31 2E 32 Pentode Shielded R-F Type	2E 41 2E 42 Diode-Pentode	2G 21 2G 22 Triode-Heptode	CK-509AX Triode Voltage Amplifier Type
Filament voltage in d-c volts	0.625	1.25	1.25	1.25	1.25	0.625
Filament current in ma	30	45	50	30	50	30
Plate voltage in volts	30	45	22.5	22.5	22.5	45
Screen voltage in volts	30	45	22.5	22.5	22.5	—
Control grid voltage* in volts	0	−4.5	0	0	0	0
Peak a-f grid voltage in volts	—	4.5	—	—	—	—
Transconductance in μmhos	175	500	500	400	60 (Gc)	160
Plate resistance in megohms	1	0.12	0.35	0.25	0.5**	0.15
Plate current in ma	0.15	1.25	0.35	0.4	0.2	0.15
Screen current in ma	0.05	0.4	0.3	0.15	0.3	—
Load resistance in megohms	1	0.03	—	—	—	1
Screen resistance in megohms	3	0	—	—	—	—
Power output in milliwatts	—	25	—	—	—	—
Voltage gain	35	—	—	—	—	16
Distortion, percent	—	10	—	—	—	—
Max. grid-plate capacitance in $\mu\mu$f	—	—	0.018	0.10	0.065***	—
Oscillator plate voltage in volts	—	—	—	—	22.5	—
Oscillator plate current in ma	—	—	—	—	1.0	—

*With 5-meg grid res. connected to F. **Approx. conversion plate res. ***Signal grid to mixer plate capacitance.

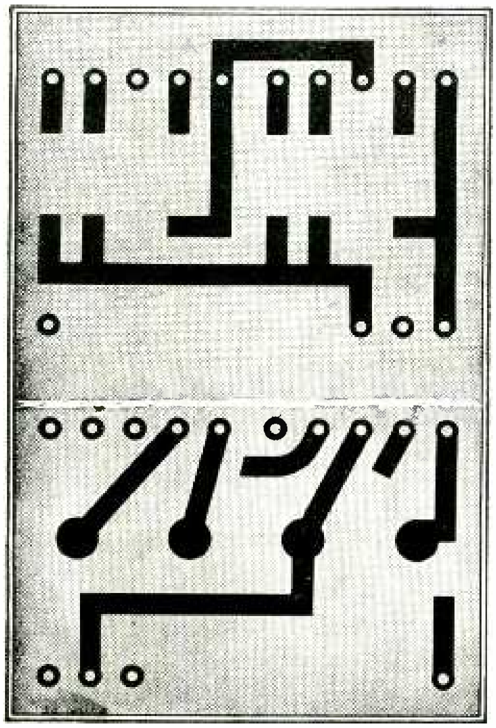


FIG. 5—Front and back patterns for wiring of printed amplifier

The pieces thus formed are sprayed or dipped with glass-forming materials on any surface which is to be glazed, and fired through continuous tunnel kilns to temperatures approximating 2400 degrees F. After this treatment they are no longer soft and easily machinable, but have a hardness approaching that of sapphire. In certain instances where more exacting dimensional requirements have to be met than can be held by careful control of the fabrication processes, those dimensions are wet ground to exact size on large carborundum discs or diamond wheels.

Application of Silver Wiring

The leads between components are applied by a process in which the silver is intimately bonded to the ceramic. The silver is in the form of a paint or paste. Very finely divided metallic silver or silver oxide is uniformly dispersed in a suitable vehicle, and the consistency is adjusted with solvents to meet requirements for the specific type of application. The degree of bonding or adherence of the fired silver to the ceramic surface is largely dependent on the surface condition of the ceramic before application of the silver paint or paste. Therefore, the ceramic surface must be free of dust, dirt, grease, or other contaminants.

The method most commonly used for circuit reproduction is a screening process in which the silver paint is dispersed through the open mesh of a silk or metal screen arranged as a mask to define the circuit. This makes it possible to print circuits of any degree of complexity. Complicated designs can be held to very close tolerances. The deposited or printed film thickness is very uniform and little silver paint is wasted.

For best results a genuine Swiss silk is used for the screen. The mesh size of the silk is dependent on the fineness of design desired and the characteristics of the paint vehicle. The silk is stretched tightly on a wooden frame and coated with a material, such as gelatin or polyvinyl alcohol, which is capable of becoming photosensitive when sensitized with potassium dichromate. A photographic positive is held tightly against the sensitized silk screen and exposed to light. The portions of the sensitized coating exposed to light become insoluble in water. Those portions which are not exposed to light are water soluble and wash out. The parts that wash out form the design of the pattern to be printed. Front and back patterns for the wiring of the amplifier of Fig. 2 are shown in Fig. 5.

The next step is to place the paste on one end of the top surface of the screen. The ceramic to be painted is brought into contact with the opposite or bottom surface of the screen. A neoprene bar is moved across the top surface of the silk, forcing the silver paint ahead and through the open mesh of the screen pattern. The paint forced through the open mesh is deposited on the ceramic plate in a design which conforms identically to that of the screen pattern.

After applying the silver to the ceramic, the parts are placed in a furnace and heated to a temperature between 1300 and 1500 F. This temperature removes the vehicle and solvents, and intimately bonds the silver to the ceramic. Properly fired silver has the dull metallic appearance of typical silver color and will adhere to the ceramic surface with a tensile strength of approximately 3000 pounds per square inch.

Resistoring

The process of resistoring involves the application of an accurately controlled amount of resistance paint to the ceramic surface. The paint consists of a conducting material, a filler or inert material, and a vehicle or binder. By varying the quantities of these ingredients, paints covering a resistance range from 3 ohms to 200 megohms may be obtained. Other dedesired electrical and physical characteristics, including good adhesion to the ceramic surface, are also obtained by the proper formulation of the three components.

The paint is applied by a spray process. The size and position of the resistors are governed by suitable masks which have good adhesion to the ceramic surface. After air drying, the masks are removed and the paint is cured in an oven at 300° F for several hours to produce stable resistors. A special resin coating is applied to the resistors to protect

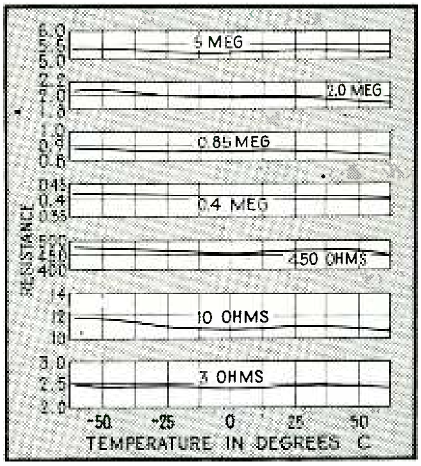


FIG. 6—Effect of temperature on sprayed resistors

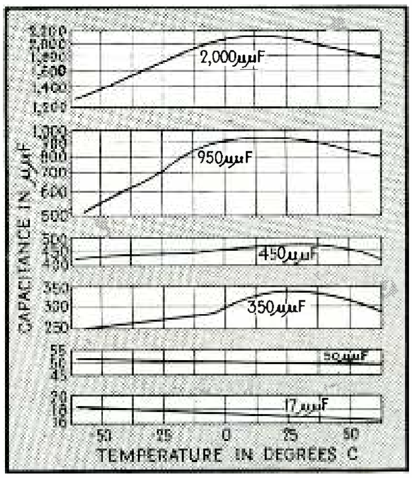


FIG. 7—Effect of temperature on ceramic disc capacitors employing titanates as dielectrics

them against humidity and other effects.

Resistance stability with time, under load or under extreme humidity conditions, is good. When exposed for 100 hours in 95 percent relative humidity at 110 F, the average resistance change was minus 10 percent for values in the range of 5 ohms to 10 megohms. This was not a permanent change, as the original values were obtained on suitable drying.

Ceramic Disc Capacitors

The ceramic disc capacitors are molded from high-dielectric-constant mixtures of titanates. Capacitance is controlled by the mix, the thickness of the disc, and the area of the silvering on the faces. Dielectric constants of 40, 100, 1000, and 2000 are used for capacitors ranging in value from 6.5 to 2000 $\mu\mu$f. These capacitors are from ⅛ inch to ⅜ inch in diameter and 20 to 40 mils thick. Higher dielectric constant materials than described have been used, but these are still in the experimental stage.

Soldering to Metallized Ceramic

External leads, such as tube leads or leads from separate resistor or capacitor components, may be soldered to the silver wiring on the plate, providing a solder having about 2 percent silver, to saturate against further absorption of silver, is used. The ceramic disc capacitors are soldered to the plate with a low-temperature bismuth solder. The low-temperature solder minimizes the possibility of fracturing the ceramic during soldering.

Effects of Temperature

Variations in resistance and capacitance values with temperature for several common values of components are shown in Fig. 6 and 7. The performance is comparable to that of standard components. Improvements in techniques to be expected with wide use of the process make probable even superior performance to that obtainable with ordinary type components.

Conclusions

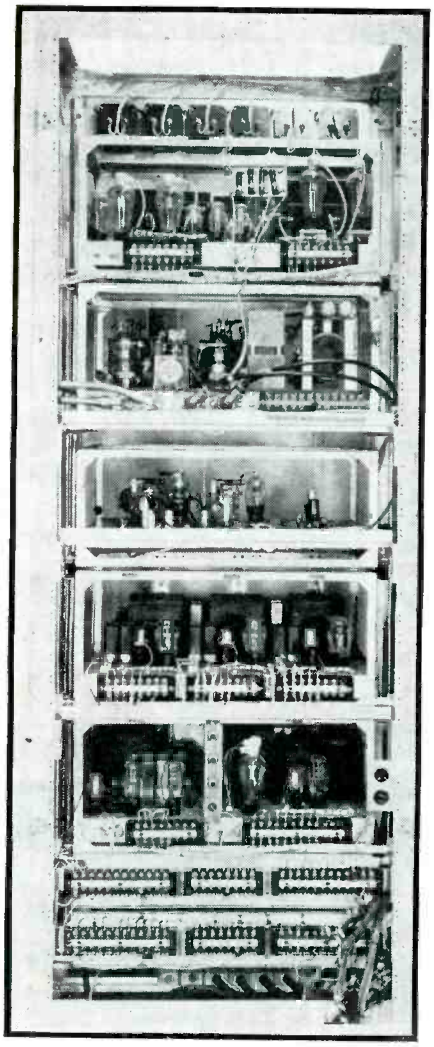
In addition to the advantages delineated above, other features of this method of manufacture are apparent. Amplifier, filter, or other control circuit assemblies may be printed on small ceramic blocks and plugged into a main chassis. Replacements can then be made in the same manner as a tube is now changed. Furthermore, any tampering with a circuit by inexperienced personnel is immediately apparent. Although ordinary resistors or capacitors may be soldered across the printed components, the change is clearly visible.

This article is based on work carried out jointly by the Centralab Division of Globe Union Inc. and the Ordnance Development Division of the National Bureau of Standards under the direction of Harry Diamond. The work was accomplished under development contracts with Division 4, N.D.R.C. under Dr. Alexander Ellett, leading to production contracts by the Army Ordnance Department.

COLOR TELEVISION On Ultra High Frequencies

Color images broadcast on 490 mc in recent CBS demonstrations show great improvement over 1940 tests. New system uses 10-mc video band to carry 525-line signal, transmits sound by f-m bursts interspersed with the video information

After an interlude of five years occasioned by the war, the Columbia Broadcasting System has resumed development of the color television system last demonstrated to the press in September 1940. Several radical departures have been introduced in the latest version of the system, aimed primarily at improving the detail of the images, and secondarily at improving the color quality. The method of introducing the color to the signal remains the same. A mechanically-driven color wheel, composed of trichromatic filter segments, rotates before the camera and a similar wheel rotates synchronously in front of the picture tube in the receiver. This method of transmission was reported[1, 2] in ELECTRONICS and elsewhere in 1940 and 1942.



Rear view of the modulator. Video stages occupy second and third racks from top. Remaining racks are power supplies

The color images in the present system are scanned in 525 lines, interlaced 2-to-1, and the interlaced fields are scanned at a rate of 120 per second. Each field is scanned and reproduced in succession through a different primary color in the filter wheel. The three colors are thus presented to the viewer in 1/40th of a second. The persistence of vision extends for a longer period than this, so the three colors fuse in the mind of the observer and a multicolored reproduction results.

The principal shortcomings of the images in 1940 were low definition, 343 lines compared with 525 lines in the standard black-and-white images, and occasional difficulties in the rendition of certain colors, particularly the dark shades. Both definition and color have been considerably improved in the equipment recently demonstrated to the press. Details of the new equipment were described before the IRE Winter convention

Front view of transmitter. The large size is required to provide sufficient r-f and video stages to reach 1-kw peak output modulated over 10-mc band

by Messrs. Goldmark, Reeves, Schlesinger, Serrell, and Lyman of the CBS Engineering Staff.

Changes to Improve Definition

To improve the definition of the images, Dr. Goldmark and his staff elected to increase the number of lines to 525, the value now used in black-and-white systems. Since twice as many pictures are transmitted per second in the color system as in the monochrome system, the bandwidth required is twice as great for the same number of lines. The maximum video frequency in the black-and-white system is about 4 mc, so the corresponding figure for color would be 8 mc. The figure adopted for the CBS system is 10 mc, an increase which improves the resolution in the horizontal dimension relative to the standard black-and-white picture.

When 10 mc is adopted as the maximum video frequency, space cannot be found for r-f sidebands in the vhf television band (54 to 216 mc). For this reason, among others, CBS decided to enter the uhf experimental television band (480 to 920 mc). The channel proposed for use, shown in Fig. 1, is similar in form to the vhf standard, i.e. vestigial sideband transmission and reception. The transmitter carrier is set at 485 mc, and the sidebands extend from 480 to 496 mc, or 16 mc overall. The receiver i-f bandpass characteristic attenuates the transmitter carrier by 50 percent and thus restores equal amplitude to all video frequencies at the output of the receiver second detector. All this is identical to present black-and-white practice except that the radio frequencies are roughly 2 to 10 times higher and the bandwidth is 2 to 3 times wider.

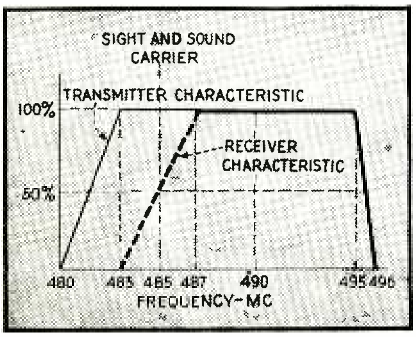


FIG. 1—Proposed uhf channel, employing vestigial sideband transmission over a 16-mc band. Sight and sound signals are transmitted on the same carrier

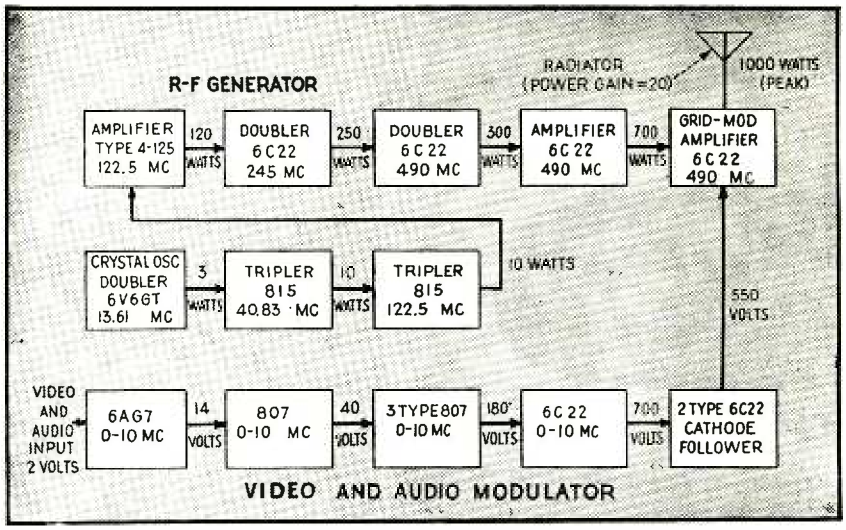
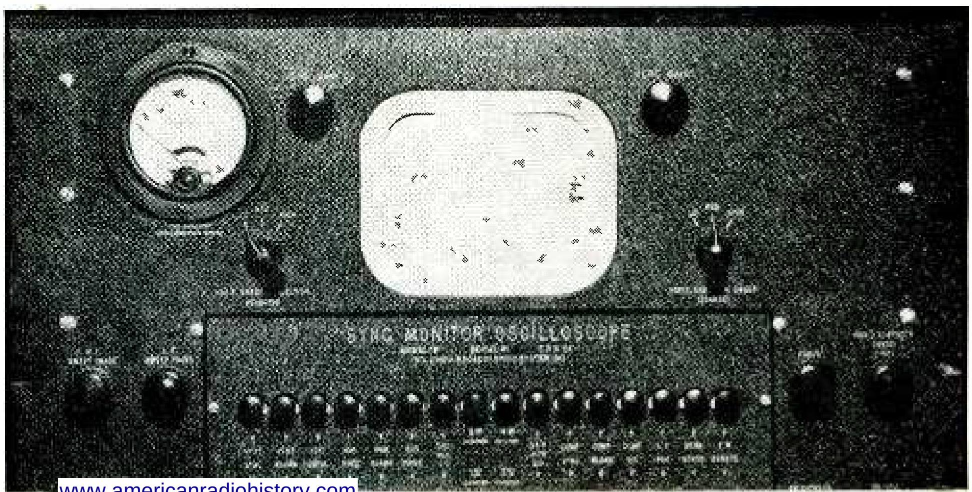


FIG. 2—Block diagram of the transmitter, showing frequency and power transformations and voltage gains in the modulator. The 6C22 r-f tube is a water-cooled disk-seal type

The sideband filter required to remove the lower sideband has not yet been completed by CBS, so double sideband operation was used during the demonstrations. To keep within the band, the carrier was set at 490 mc and the sidebands extended 10 mc either side. The additional sideband energy radiated in the lower sideband, relative to the characteristic in Fig. 1, has no effect on the receiver operation which remains as shown, with the 50 percent level shifted to 490 mc.

To design a transmitter capable of radiating substantial power at this frequency, while being modulated over a 10-mc bandwidth was a task of large magnitude. The transmitter was designed and built by the Federal Telephone and Radio Corp., using as its essential component a water-cooled disk-seal triode, type 6C22. The transmitter meets the specification with a power output of 1 kilowatt peak or 600 watts average. The block diagram is shown in Fig. 2. The r-f chain consists of eight stages, a crystal tritet, two triplers and two doublers with three linear amplifiers, interspersed as shown. The last four stages, including the final grid modulated amplifier use the new tube. The frequency and power transformations of each stage are shown.

The video modulating chain uses five stages, each conductively coupled so that all frequencies from d-c to 10 mc are passed with constant amplitude and time delay. The voltage gains attainable over this band are not large, ranging from 3 to 7 times depending on the tube type used. The video couplings are of the compensated filter type, both four-terminal and two-terminal networks being used. A 2-volt peak to peak input video signal is capable of modulating the final amplifier to its peak output of one kilowatt.



Synchronization monitor for keeping tabs on complex waveforms throughout video system. Thirty-two pushbuttons permit rapid selection of various signals

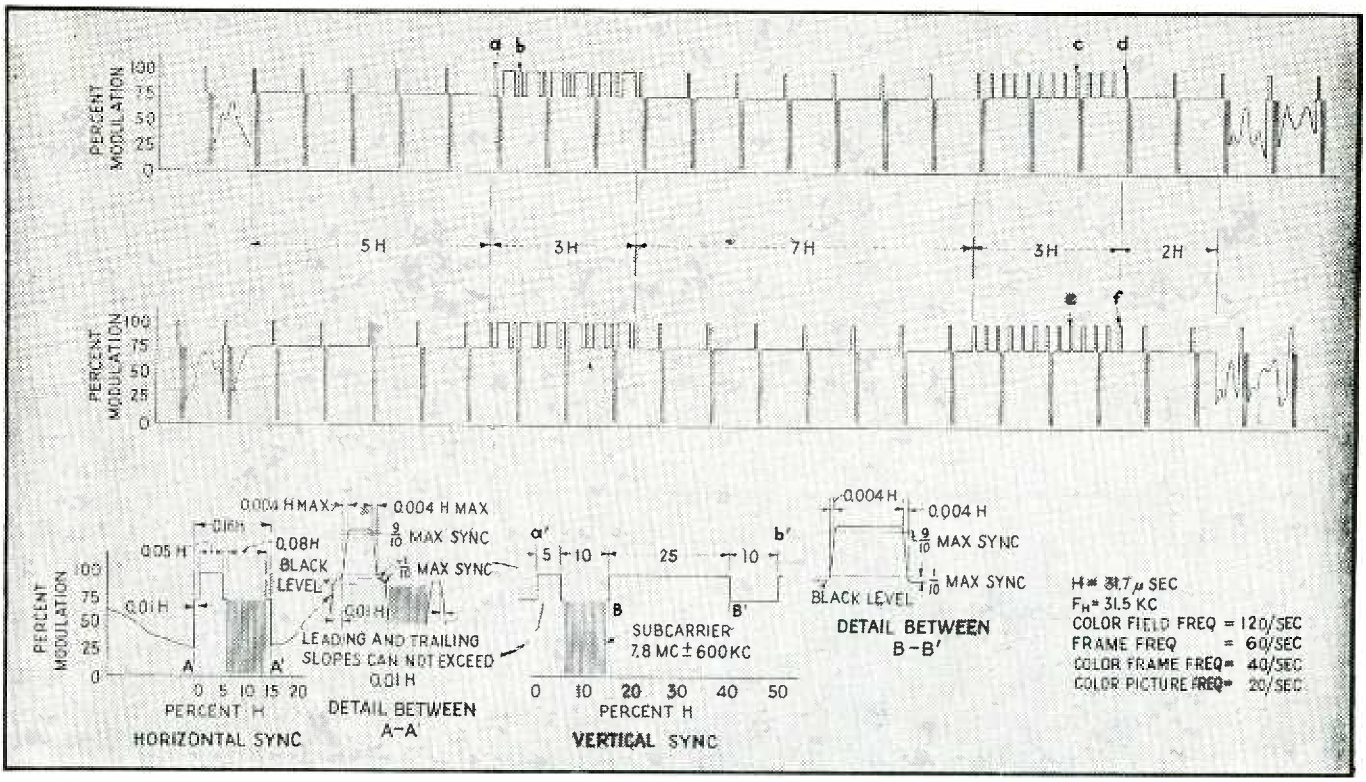


FIG. 3—Video waveform used in the CBS system. The sound is transmitted by an 8-mc subcarrier radiated during the horizontal retrace time. Color pulses are inserted to synchronize the color wheel

The power output of the transmitter is multiplied 20 times by the radiator. The radiation pattern is highly directional in the vertical plane, produced by a slotted waveguide structure which compresses the radiated signal into a vertical angle of 6 degrees, while delivering a signal of substantially constant magnitude over the 360 degrees of the horizon. To compress the beam to 6 degrees requires a radiator surface about 10 wave-lengths long. Fortunately this is not impractical at 490 mc. The antenna consists of two waveguide panels, each 18.5 feet high and 2 feet wide. These panels are mounted on the north and south faces of the Chrysler Building in New York and the beam is so oriented in elevation that the field strength at ground level is theoretically constant at all points out to the horizon. The horizontal pattern of each antenna panel extends theoretically over 180 degrees. The actual horizontal coverage has not yet been investigated, but it is expected that only a slight loss in gain is experienced in the east and west directions. Each panel has a power gain of 40, the transmitter power being split between the two, resulting in an effective radiated power of 20 kilowatts.

Sight and Sound on Same Carrier

The numerical constants employed in scanning make possible the transmission of the sound signal and the picture signal on the same carrier. Since the 525-line picture is completely scanned (two fields) in 1/60th of a second, the line scanning frequency is 525 × 60 = 31,500 cps. It has been appreciated for some time that the inactive time during the re-

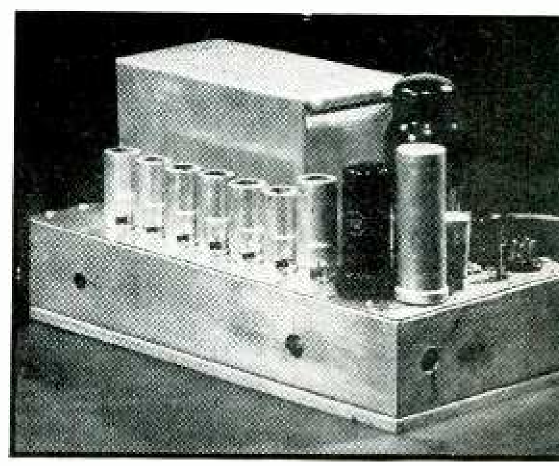
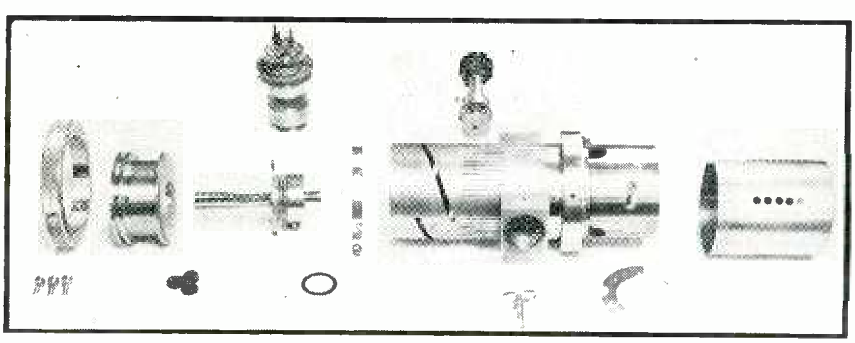


FIG. 4—R-f and video signal components of the receiver. A crystal mixer and six i-f stages (at left of center) are used, and 8-microvolt sensitivity is achieved



Exploded view of the coaxial final amplifier of the transmitter. Type 6C22 amplifier tube is at top left

trace of the scanning line might be used for transmitting the sound on the picture carrier. But the maximum audio frequency which can be transmitted without serious distortion in such a system is limited to not more than one half the line-scanning frequency. In practice, distortionless transmission can be achieved up to a value of about one-third the scanning frequency, or in this case 31,500/3 = 10,500 cps. This is high enough to permit faithful sound transmission, but is not as high as the 15-kc limit specified for black-and-white sound.

The video waveform, showing the relative position of sound, video and synchronization signals, is shown in Fig. 3. This diagram is not unlike the standard video waveform of the vhf black-and-white system, except for the numerical constants and the insertion of the sound. Negative transmission is employed, that is, upward modulation produces black. In the region above the black level standard horizontal synchronization pulses are sent to synchronize each line. At the conclusion of each field, the vertical sync pulse is transmitted. This differs from the black-and-white standard in that no preparatory pulses are used, but the serrated form used in black-and-white (interspersed long pulses and double-frequency line pulses) is retained.

Below the black level, the camera signal is sent in the normal manner. Immediately following each horizontal sync pulse, while the scanning spot is retracing, a burst of 7.8-mc sine-wave signal is inserted, extended over the full amplitude of the black-to-white region, and lasting for eight percent of the horizontal scanning time. The 7.8-mc bursts constitute a discontinuous subcarrier which is frequency modulated by the sound signal. At the receiver the subcarrier bursts are selected from the video wave in a 7.8-mc tuned circuit and passed through an f-m discriminator which recovers the audio frequencies. The audio signal contains distortion products, due to the discontinuous nature of the carrier, extending from 15,000 cps upward. These are eliminated by a low-pass filter in the receiver which removes all audio signals above 10 kc. The extension of the audio subcarrier into the picture signal region would brighten the cathode-ray beam during the retrace time, unless means are provided to prevent it. Local blanking signals are generated in the receiver to depress the cathode-ray beam during the retrace time.

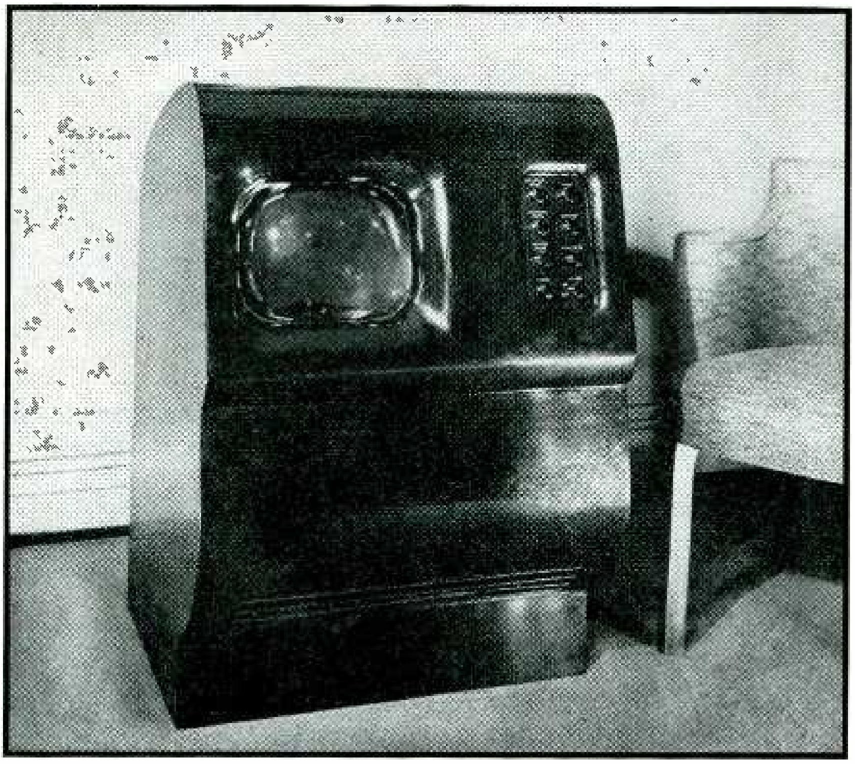


FIG. 5—The direct-viewing receiver demonstrated to the press. The screen of the 10-inch tube is magnified to 12-inch size. The shock-mounted color-wheel drive makes virtually no noise

The two basic advantages of the sound-on-sight system are: (1) one transmitter is required and (2) the receiver tuning is not critical. The receiver also is simpler in that no separate sound i-f amplifier is required, but this advantage is offset by the necessity of providing a low pass audio filter and local blanking circuits to remove the sound bursts from the picture.

The video waveform (Fig. 3) shows the color pulses which are used to synchronize the color wheel of the receiver. These consist of three additional horizontal sync pulses inserted during each of three successive fields (shown as c-d and e-f in the diagram).

The Receivers

Two receivers were demonstrated to the press, a direct-viewing type employing a 10-inch picture tube and magnifier, and a projection set using a Schmitt optical system to produce a 17 by 22-inch picture. The radio and video-frequency components, identical in the two sets, are shown in Fig. 4. The head end of the receiver is a silicon crystal mixer (no preamplification is used), which is continuously tunable over the band from 480 to 920 mc. The tuning element is an extensible transmission line of unusual design. Ganged to the tuning control is a tunable r-f filter which rejects images and reduces the noise spectrum. The local oscillator is a 6F4 acorn triode. The i-f amplifier consists of six stages, type 6AK5, operated at 105 mc and coupled by single-tuned circuits, tuned to three staggered frequencies. The sensitivity is such that the noise level (about 8 microvolts) is reached at full gain. This is an extremely low noise figure, considering that the overall i-f bandwidth is 12 mc. Two video frequency amplifiers are used, terminating in a 6AG7 tetrode.

In the direct-viewing set, Fig. 5, a 22-inch color wheel covers the face of the 10-inch tube. The filter segments have substantially the same shape as those used in 1940,[1,2] but the filter materials themselves are somewhat different. Standardized color distributions, designated as Wratten numbers 61 (green) 47 (blue) and 26 (red) are used. One form of filter developed by Kodak is produced on an acetate base, coated with the colored gelatine and protected by lacquer. Segments of this material are riveted to a wheel made of transparent plastic. Another filter is a true plastic, developed by Monsanto, the color extending throughout the material. Sheets of this substance are inserted between two transparent discs, in the form of a sandwich.

One cause of occasional flicker in the 1940 images has been eliminated by rigid standardization of the optical transmission of the filter elements. The wheel consists of six segments, two of each color. If the two segments in a given color (particularly green, since this color contributes directly to the luminosity of the image) do not have the same transmission within a few percent, a 20-cycle flicker may be visible in areas having the same color as the filter segment. The manufacturers of the filter materials are able to meet the close tolerances required. The phosphor (of neutral white color) used in the cathode-ray tube has also been standardized by two manufacturers (Sylvania and General Electric). The phosphor is of the aluminum-backed type which increases the brightness and contrast of the image. The direct viewing receiver employs a magnifying lens to increase the apparent size of the image from 10 inches to 12 inches. Since this is a moderate degree of magnification, the angle over which the image is visible extends to about 30 degrees each side of the magnifier axis.

The filter wheel displays an average transmission of about 14 percent. Since 86 percent of the light is absorbed, the phosphor image must be very bright. An accelerating voltage of 8000 is used, obtained from a "flyback" power supply which employs the high voltage generated across the scanning coils during the horizontal retrace periods.

The color-wheel is driven by a 1750-rpm induction motor, synchronized by a type 6SN7 synchronization

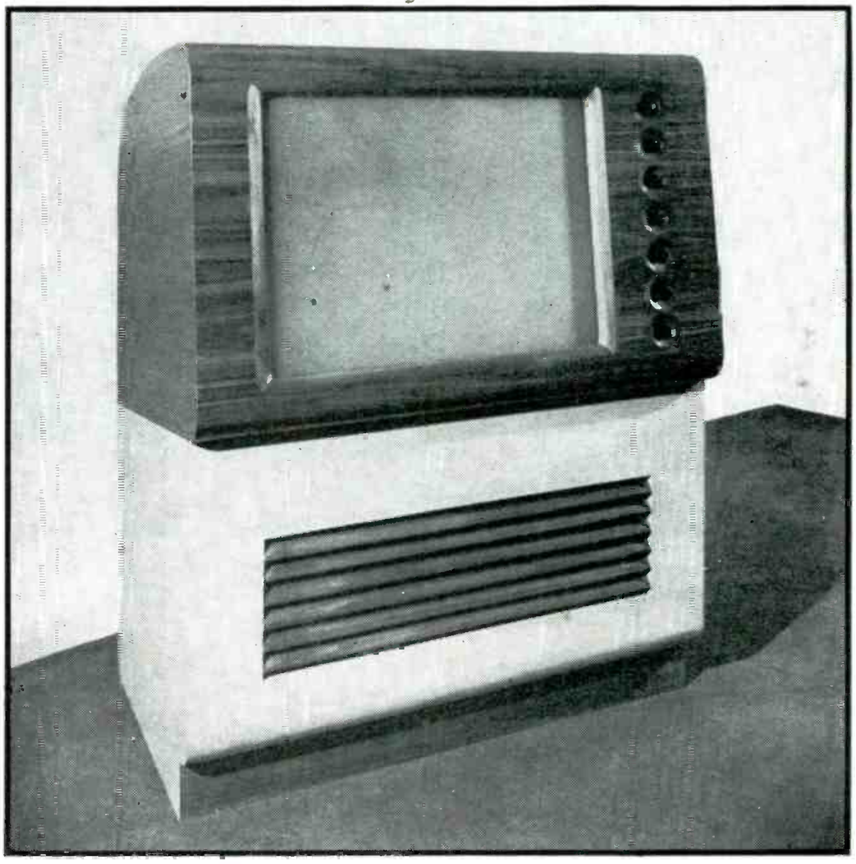
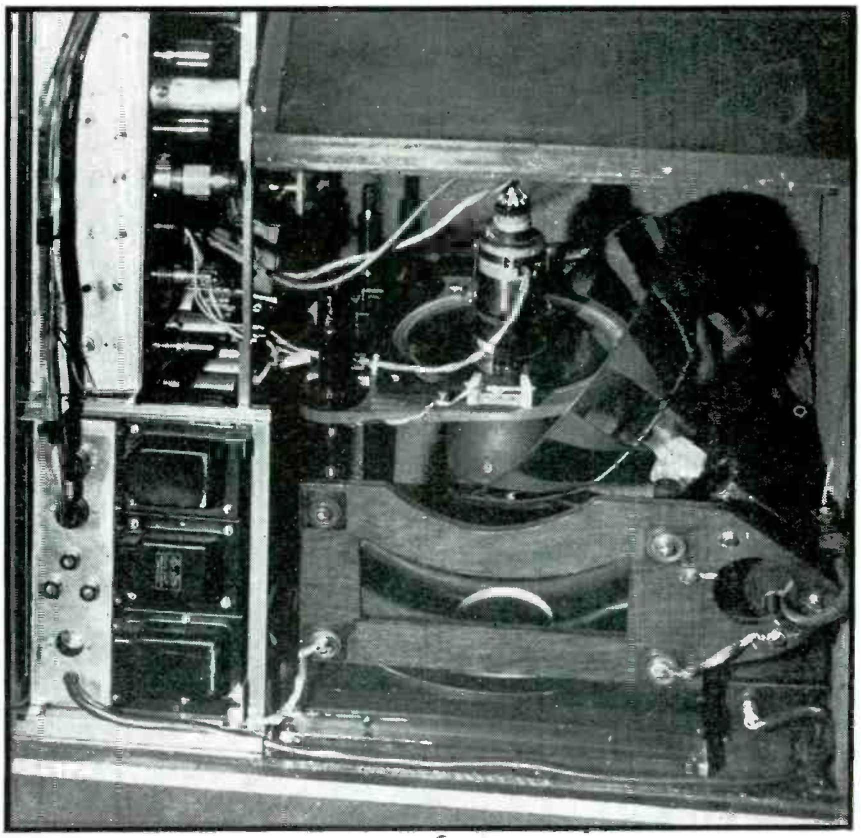


FIG. 8—Front view of projection receiver, which produces a 17 by 22-inch picture through a Schmitt optical system

FIG. 7—Rear view of projection set. The cup-shaped color wheel is shown at right of projection tube, above the spherical mirror



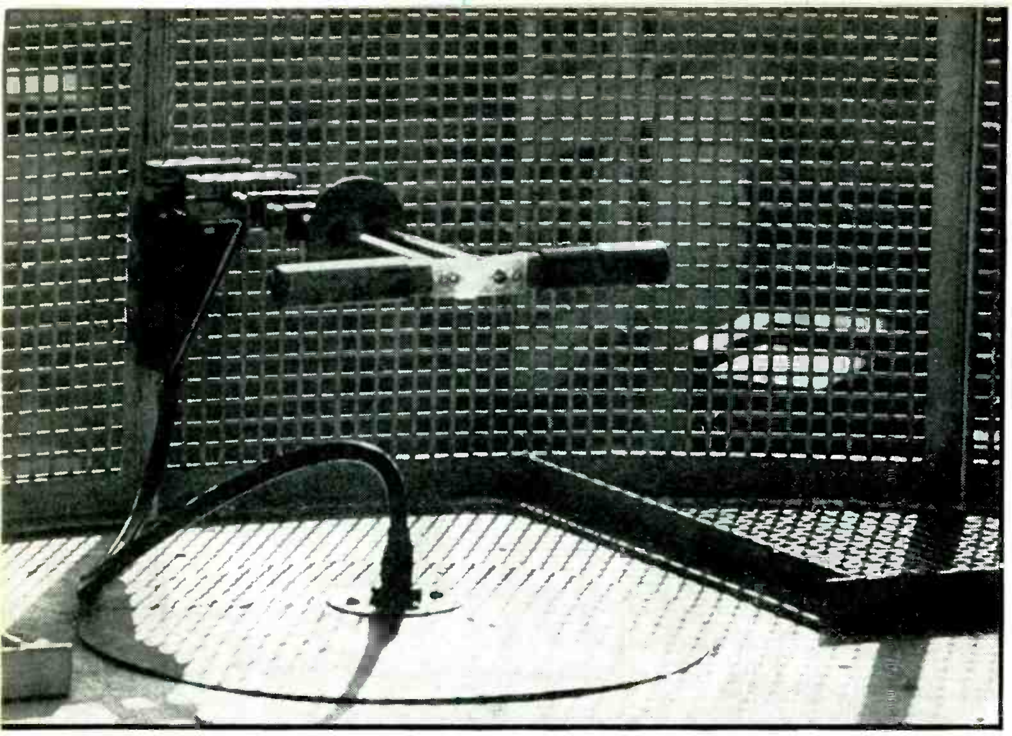


FIG. 8—The receiving antenna consists of a dipole and a 6-by-2 foot parabolic reflector which can be steered by remote control. The fifteen-degree beam width eliminates ghosts from reflected signals

stage which compares the incoming pulses with locally generated ones and thereby controls the speed and phase of the disc. A phase compensation circuit is used to maintain the instantaneous position of the wheel within a few degrees of the correct value as it rotates. This permits full utilization of the area of the filter segments. Since the color wheel synchronization is obtained from the video waveform, the phasing of the color segments is automatically selected (that is, a given color automatically appears before the receiver tube when that color is present before the camera at the transmitter).

Since the fundamental color recurrence rate of the system is 120 per second, which is twice that of the power frequency of 60 cps, precautions must be taken to shield the picture tube from a-c fields, and to avoid power supply ripple in certain critical circuits, particularly the scanning generator output tubes. Such filtering is not required in all scanning tubes, however, and its cost is moderate. The picture tube shield is of the permalloy type.

The projection receiver, Fig. 6 and 7, employs a 5-inch projection tube which faces downward toward the spherical mirror of the Schmitt optical system, where the image is reflected through a molded cast-plastic correction lens. The color sequence is introduced by a modified wheel in the form of a cup, mounted to the side of the picture tube. The filter segments rotate directly under the face of the projection tube. To conserve light, the blue filter used has twice the optical transmission of the filter used in the direct-viewing receiver, and as a consequence the color gamut is somewhat reduced in the projection set. The projection color wheel rotates at 600 rpm and contains 12 segments, four of each color.

In a high definition picture ghost images must be minimized, and this is particularly important when color is transmitted. To avoid ghosts from reflected signals (which may also affect the quality of the f-m burst sound transmission) a directive receiver aerial is considered essential for use in built-up city districts.

Receiving Antenna

The antenna used in the demonstrations is a single dipole, Fig. 8, mounted at the focus of a parabolic reflector of perforated metal, 6 feet wide and 2 feet high. The beam width is about 15 degrees in azimuth. The structure is motor driven in azimuth. Direction can be shown on a chart by a remote control through a selsyn indicator system. Excellent ghost-free reception was obtained on direct line to the transmitter as well as by reflected signals from the Empire State building and other tall buildings in the vicinity. No difficulty was experienced in avoiding reflections, although ghosts were visible when the beam was turned so that it faced the wall of the CBS building.

Camera and Pick-up Equipment

At present the CBS equipment is limited to pickup from 16-mm color

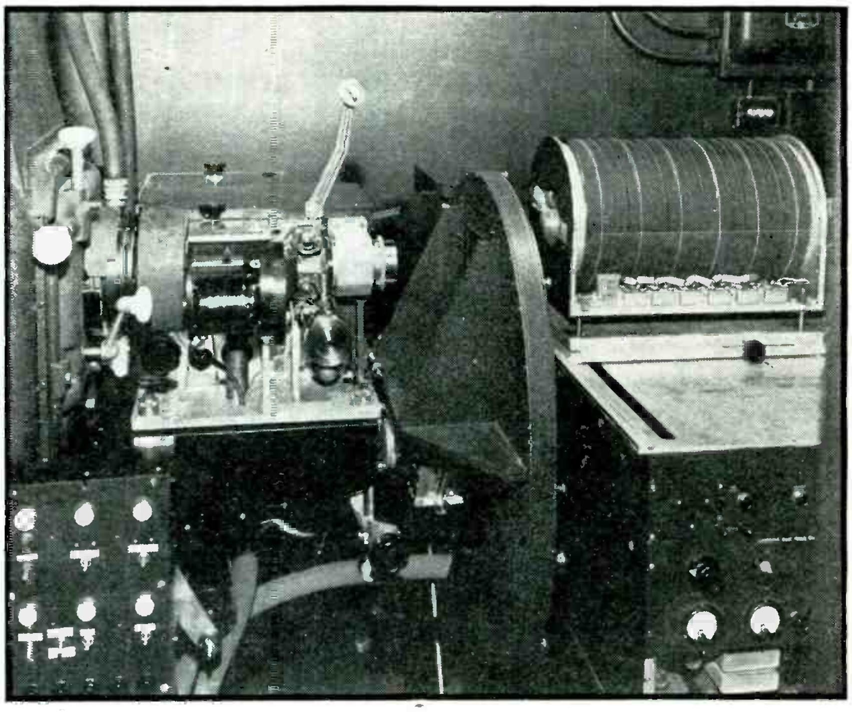


FIG. 9—Camera pick-up equipment for 16-mm film and 35-mm slides. The continuous-motion projector and color wheel are at the left, selector lens disc at center, image dissector in cylindrical housing at right

film and 35-mm color slides. Work is in progress on a direct pickup camera which is expected to be ready for demonstration in May. The film camera tube is an image dissector, a tube ideally suited because it has no storage and hence does not carry over stored charge on the unscanned interlaced lines from one color segment to the next. The tube has low sensitivity, however, and requires correspondingly great illumination—too great to permit direct pickup. The direct equipment will employ an orthicon storage-type tube. The film images are scanned in a continuous-motion projector by passage through five stationary lens elements. A selector disc permitting light to pass through one lens at a time, Fig. 9, introduces a shift in the optical axis to counterbalance the motion of the film.

A block diagram of the pickup and associated sync equipment is shown in Fig. 10. The signal output from the dissector, after passage through the video preamplifier, is passed to a video amplifier and gamma control. The latter is a non-linear amplifier which compensates for the curvature in the dynamic transfer characteristic of the remainder of the system, including the receiver picture tube. After passage through this gamma control amplifier, the signal has such a form that the light output in the receiver picture tube is a linear function of the light input to the dissector tube, that is, the gamma is unity. This is a new departure which has greatly improved the ability of the system to render dark shades, as well as to maintain color balance over a wide range of illumination. The gamma control has the property of maintaining a fixed output amplitude regardless of changes in the curvature introduced. The gamma control is applied simultaneously to all three colors. A separate gamma characteristic for each color, introduced in sequence, has theoretical advantages but has not proved necessary in practice.

After emerging from the gamma control the camera signal is mixed with the other portions of the video waveform (sync and sound f-m bursts in accordance with Fig. 3. Monitoring facilities are provided at the outputs of the sync generator (waveforms viewed), the gamma control (image viewed in black and white), and the mixer amplifier (image viewed in color). The relative amplitudes of the camera signals produced in the three colors are varied by the color mixer. This is an improved version of the color mixing equipment used in 1940. The 1940 mixer employed 20 tubes and occupied three chassis of equipment. The new mixer is purely mechanical in operation and occupies less space than a 6-inch cube. The image pickup, synchronization and sound-on-sight equipment is now being produced, following CBS designs, by the Westinghouse Electric Corp.

The system just described transmits excellent color pictures. The intrinsic definition of the pictures is better than the 525-line black-and-white pictures by virtue of the more than proportionally wide band used and, of course, the apparent definition is greatly enhanced by the color contrasts present in the image. From this standpoint the images are perhaps the best television pictures yet produced. Further work, to investigate the coverage properties of the uhf signal and to develop direct pickup equipment of equally high quality, has been undertaken by the CBS group and will be reported in these pages as soon as the results are available.—D. G. F.

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(1) Color Television Demonstrated by CBS Engineers, ELECTRONICS, p 32, Oct. 1940.

(2) Goldmark, Dyer, Piore and Hollywood, Color Television, Part I, Proc. IRE p 162, Apr. 1942.

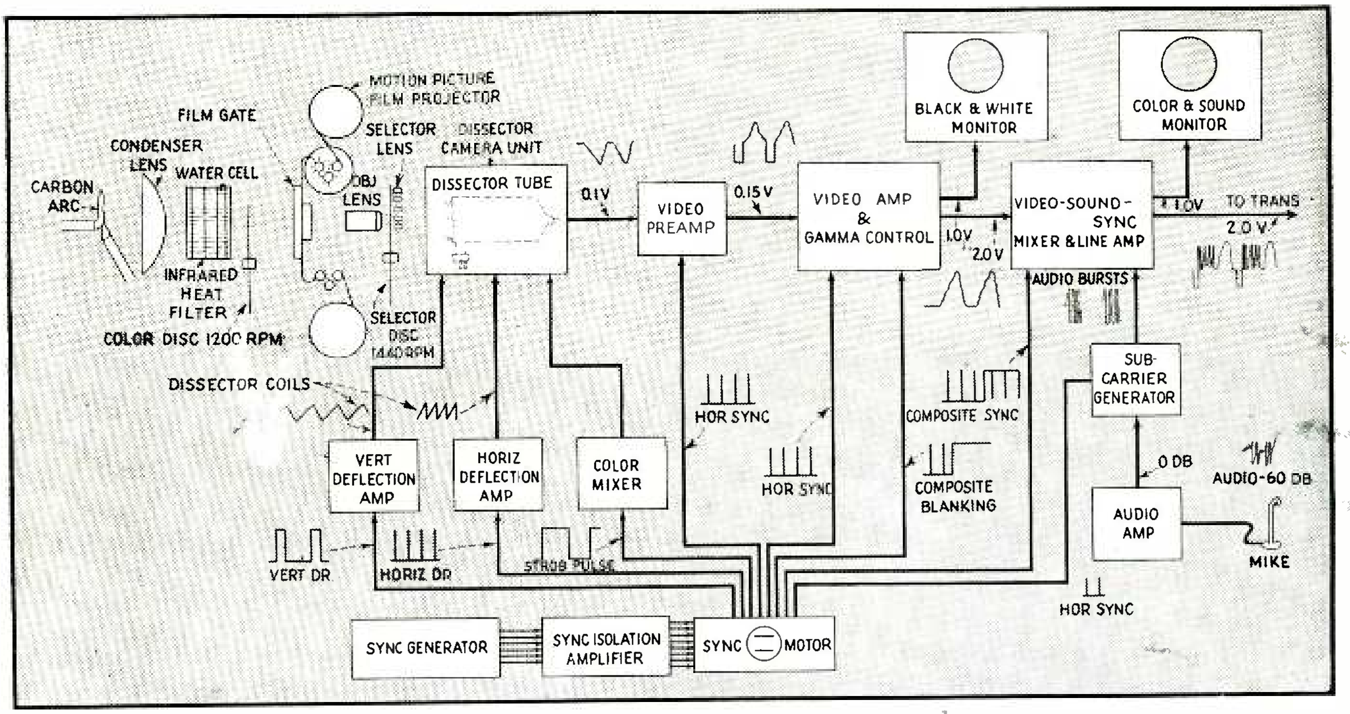

FIG. 10—Block diagram of pickup, sync and sound-on-sight equipment

ULTRASONIC

Design of r-f generator and quartz crystal radiator providing ultrasonic mechanical energy for disintegration of bacterial cells and other unique physical and chemical effects. The frequencies involved range as high as 500 megacycles

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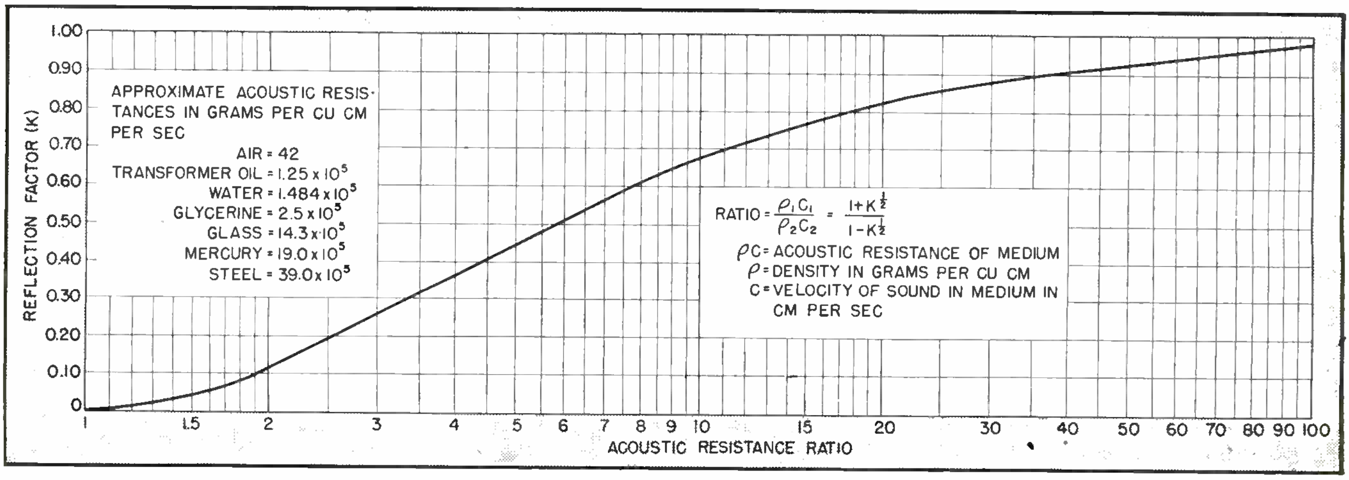


FIG. 1—Chart giving percent reflection (K × 100) at interface of two media having different acoustic resistances

The term "ultrasonics" is applied to super audible sound waves which can be generated in liquids and solids over a frequency range of 30 kc to as high as 500 mc. The unique physical and chemical effects produced by intense sound fields at these frequencies are finding wide applications in many fields of investigation. As an example, in the field of biochemistry ultrasonic energy has been successfully employed by the authors in the disintegration of bacterial cells, permitting a detailed study of their enzyme system.[1, 2] This paper presents a consideration of the problems encountered in the design and construction of ultrasonic laboratory equipment.

The basic element of the piezo type ultrasonic generator consists of an X-cut quartz plate vibrating in the longitudinal or thickness mode, acoustically loaded by immersion in a liquid media and excited at mechanical resonance in order to achieve an appreciable ultrasonic output. The circular plate usually employed has diameters as large as 10 cm, the thickness of course being determined by the resonant frequency desired.

Ultrasonic intensities generated will vary directly with the acoustic resistance of the surrounding medium and with the square of the applied voltage and operating frequency. However, the latter two factors cannot be increased indefinitely to achieve greater outputs. The maximum voltage that can be applied is determined by the breakdown point of the crystal and its associated supports. Furthermore, vibration does not occur uniformly over the surface of the quartz plate, and if excited too vigorously the elastic limits of certain sections of it may be exceeded even though other areas are relatively motionless. Crystal fragility and liability to voltage breakdown increase at higher frequencies due to diminishing thickness, and hence operation at high intensities is usually confined to frequencies below one megacycle.

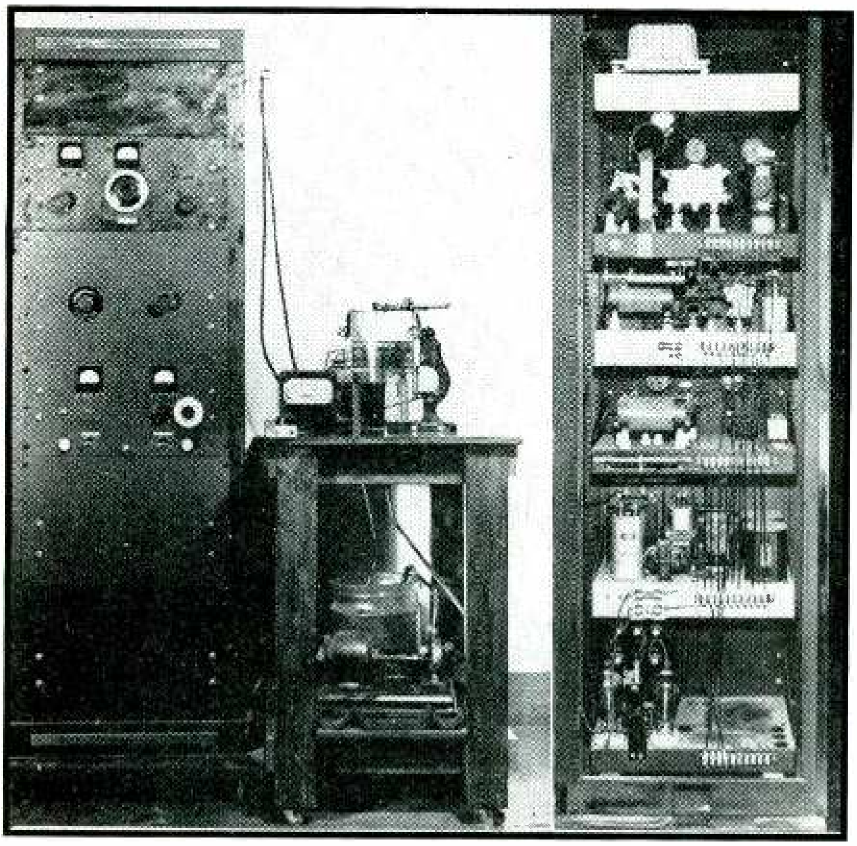
Efficiency Criteria

These limitations on the exciting power make it essential that the efficiency of the acoustical system be as high as possible. The four criteria for such a system are as follows:

(1) Damping of the quartz radiator due to its support must be avoided. This is accomplished by securing the crystal at points of low

Height of fountain of liquid thrown up from surface of medium during ultrasonic exposure is criterion of ultrasonic intensity

GENERATOR



Radio-frequency generator connected to quartz radiator immersed in oil in glass container on table. Cooling system for oil is on shelf under table. Microscope stand is being used as rack and pinion for adjusting height of fluid-filled flask in oil. Output power is over 500 watts in operating range of from 150 to 1000 kc. At right is a rear view of the ultrasonic generator

motion either about its periphery or in the middle of the thickness dimension, the nodal point for an X-cut crystal.

(2) Reflections between objects to be immersed in the sound field and the conducting medium should be minimized. These will occur when the sound crosses a junction of two media having unequal acoustic resistances.[3] From the approximate acoustic resistances given on the reflection chart in Fig. 1 it may be seen that the reflection loss for a glass container immersed in an oil medium would be about 70 percent (K = 0.7 for an acoustic resistance ratio of 11), and between any medium and air close to 100 percent. Thin sections of material interposed in the sound path will cause a minimum of attenuation if they are an integral number of wavelengths thick.

(3) The acoustic loading on the radiator should be concentrated on one surface only. This requires that the other be coupled to a medium of very high or low acoustic resistance to provide a maximum of reflection. In practice, one surface is coupled to the liquid medium and the other is exposed to air, concentrating the radiation in one direction.

(4) In order to obtain large intensities coupled with a minimum of reflections, a medium having the highest acoustic resistance consistent with good dielectric properties is selected. A transformer oil, such as Wemco C produced by the Westinghouse Electric Corp., has proven to be one of the most suitable.

Fortunately, dispersion of the radiated energy does not introduce much loss since the radiation from a circular plane source is confined to a highly directional beam when the radio of radiator radius to the wavelength is large. Further concentration may be obtained by using a spherically curved plate of large curvature which develops very high intensities at its focal point. In addition, recent investigation has shown that slightly curved crystals, while not producing a marked focussing effect, provide intensities at all distances from the radiator which are superior to those obtainable from either a flat or focussed radiator.[4]

Design of Crystal Holder

With these requirements in mind, the crystal holder sketched in Fig. 2 was developed. It consists of a quartz crystal sandwiched between two brass rings that are held together by

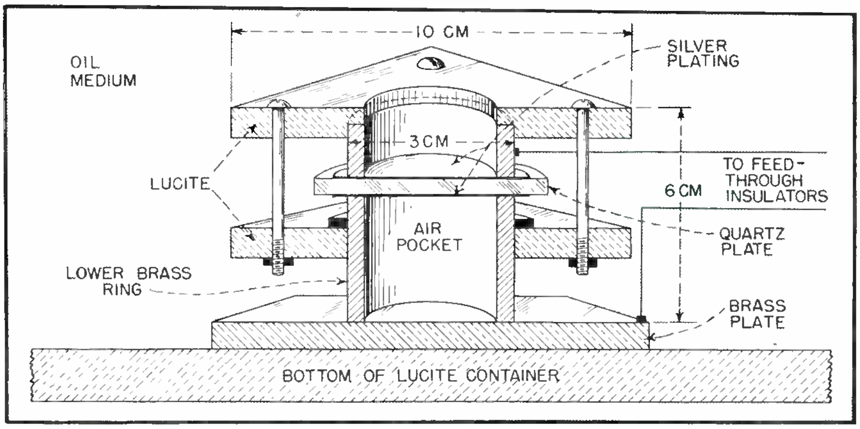


FIG. 2—Construction of quartz radiator designed for immersion in oil

This work was supported by a grant from the John and Mary R. Markle Foundation, administered by Dr. D. E. Green of the Department of Medicine, College of Physicians and Surgeons, Columbia University.

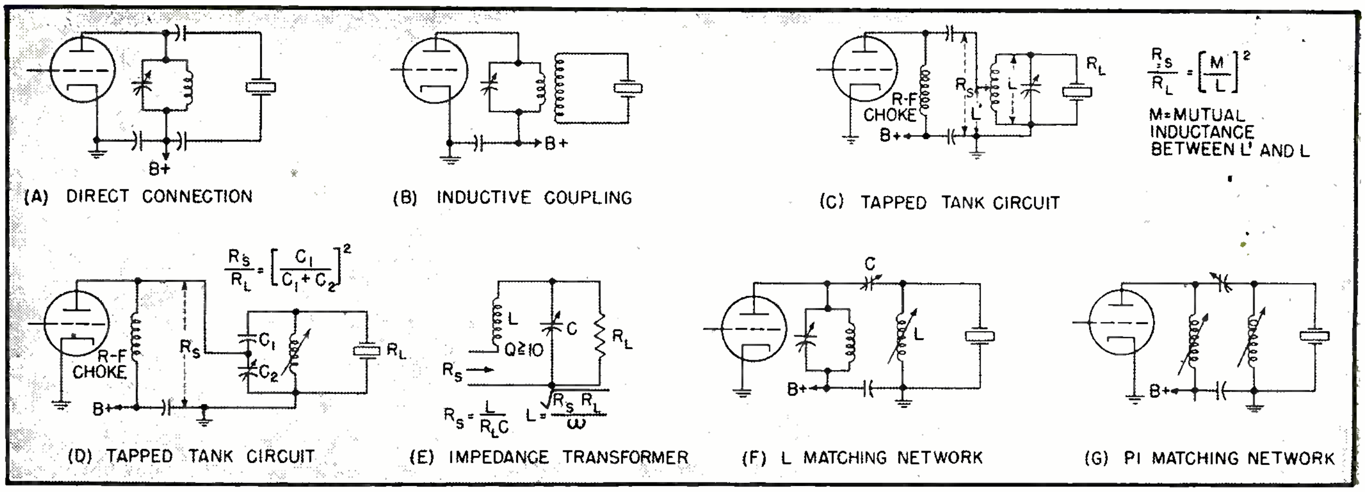


FIG. 3—Coupling circuits suitable for matching the output of an r-f generator to a quartz radiator

a Lucite press device which permits changes in contact pressure of the brass electrodes on the quartz surfaces. Although it leads to some damping, this arrangement has the advantage that breakdown of the insulating medium is eliminated completely. With other types of holders which were constructed and tested, voltage breakdown of the transformer oil resulted in immediate and irreparable damage to the surfaces of the quartz crystal.

The surface of the quartz crystal is silver-plated routinely every six months by Brashear's method. It was found that a silver-plated surface is superior to a surface of aluminum or silver foil cemented or spattered onto the quartz surfaces. To increase the voltage breakdown path, the upper and lower plating is not carried out to the extreme edge of the crystal. Lucite is used exclusively in the mounting and in the oil chamber as insulation against high voltage.

The crystal holder is completely immersed in transformer oil which serves at once as insulation medium, conducting medium for ultrasound, and circulating fluid for the cooling system. The oil is circulated continuously by a centrifugal pump from the ultrasound apparatus through a copper coil surrounded by an ice-water mixture. Much heat is formed during operation and efficient cooling is necessary to prevent the temperature from rising above 30 C in the bacterial suspension.

When the crystal holder is immersed in the oil bath, the lower brass ring electrode automatically forms an air pocket, which almost completely reflects the sound waves at the lower side of the quartz plate. The reflected waves come automatically into the right phase with those radiated upwards and increase their energy, hence the total damping of the crystal becomes less, owing to the decrease in the radiation decrement.

In the design of the radio-frequency sources used to excite ultrasonic generators, it has heretofore been the trend to increase the power output capabilities of the equipment in order to increase ultrasonic outputs. The futility of this is evident when it is realized that only an increase in applied voltage is necessary to accomplish this. The actual power consumption of any crystal radiator will rarely exceed 250 watts and will usually be much less.

Ultrasonic Power Output

The input impedance at resonance of a quartz radiator is mainly resistive and is the equivalent of a load of 10,000 to 250,000 ohms shunted by a capacitance of as much as 100 $\mu\mu$f. Developing large voltages across such an impedance is simply a problem in impedance matching. The resistive load which the usual class-C amplifier must see across its tank circuit ranges from 500 to 10,000 ohms depending on its operating conditions, and these values will determine the matching ratios to be used in the network coupling the r-f generator to the crystal.

It is interesting to note that any reflection of sound back to the quartz radiator alters the electrical impedance of the radiator in a manner similar to that in which the impedance of a discontinuous transmission line varies with length. The input impedance is therefore a minimum when the reflection path is an odd number of quarter wavelengths long. Total reflection may also cause a shift in the quartz resonant frequency by as much as 20 percent and consequently is to be avoided.[5]

Coupling Circuits

In Fig. 3 are shown various coupling circuits suitable for matching purposes.

In Fig. 3A the crystal is connected directly across the tank circuit of the r-f generator and the excitation is limited to the peak voltage developed across the tank. In Fig. 3B, an inductive coupling circuit is shown but it has proven to be relatively inefficient and subject to breakdowns.

In Fig. 3C and 3D, a tapped tank circuit is utilized, the final amplifier being connected across only a portion of either branch. A further extension of this idea is the parallel resonant impedance transformer in Fig. 3E, where L is equal to $(R_sR_L)^{\frac{1}{2}}/\omega$. If the circuit Q is greater than 10, a small load R_s will be presented to a generator looking into either branch of the circuit when a large load R_L is shunted across it. This action is identical to that of the L matching network in Fig. 3F.

Probably the best arrangement is the use of a pi network as shown in Fig. 3G, which will provide the most exact impedance match and will obviate the use of a tank circuit.

Voltages developed across matching components will increase as the square root of the impedance level, and hence special care must be taken in insulating these components. Sharp edges and corners will cause undue concentrations of electrostatic flux which are likely to result in corona and frequent breakdowns. The design of inductive elements should take into consideration not only the potential gradients existing across the windings and forms but also the amount of dissipation the coil forms must accommodate.

R-F Generator Circuit

The requirements of the r-f generator used to excite these radiators are similar to those of the usual radio transmitter, except that provisions for the use of both a crystal-controlled and a stabilized, calibrated variable-frequency exciter should be included. Operating frequencies may cover a wider range than usual but continuous frequency coverage is not absolutely essential. Additional refinements might also include a variable power output control and an automatic timing device to facilitate accurate ultrasonic time exposures.

The circuit of a generator designed and constructed to excite a quartz radiator is shown in Fig. 4. It employs beam-power tetrodes to eliminate neutralization, and the final amplifier consists of type 813 tubes operating in push-pull parallel. The generator has an operating range of from 150 to 1000 kc, obtained by switching plate circuit inductors. When fully loaded, it will deliver over 500 watts output. In operation, all metallic objects associated with the equipment are grounded to prevent accidental burning of the operator by induced potentials.

Simple oscillator circuits may also be employed as generators. A suitable oscillator circuit for this purpose, similar to those used as high-voltage supplies for cathode-ray tubes, is shown in Fig. 5.[6] The secondary, L_2, is tuned to the operating frequency by the distributed capacitance shunting it, and for low power loss is of very high impedance. To obtain a stable tuning characteristic, feedback for the grid circuit is obtained solely from L_2. To improve the generator regulation, the coupling between L_1 and L_2 is made at least twenty times greater than is critical.

For those tempted to experiment, it should be noted that the high damping of the quartz plate used as a radiator makes it impossible to employ this plate to establish the frequency of the generator.

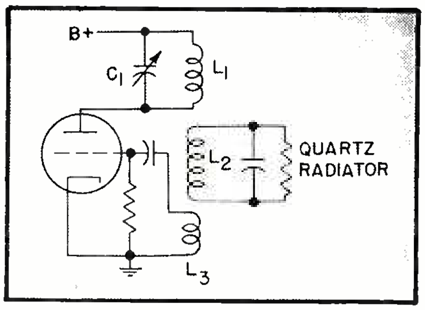


FIG. 5—Self-excited oscillator circuit suitable for driving a quartz radiator

Typical Application

One application of the ultrasonic generator to the problems of enzymology will be described briefly. A thin suspension of bacteria is placed in a flask and immersed in the medium by a rack and pinion device. The flask is then adjusted to a critical distance from the radiator determined by the peak in the height of the cone of fluid thrown up within the flask by the radiation pressure of the ultrasound. After a ten-minute exposure to ensure satisfactory disintegration, the material is spun down in the high-speed head of a refrigerated International Centrifuge at 20,000 rpm. In five minutes all cellular debris as well as intact cells will have been centrifuged down, and the supernatant fluid, usually turbid and light amber in appearance, is carefully decanted into a chilled container for analysis.

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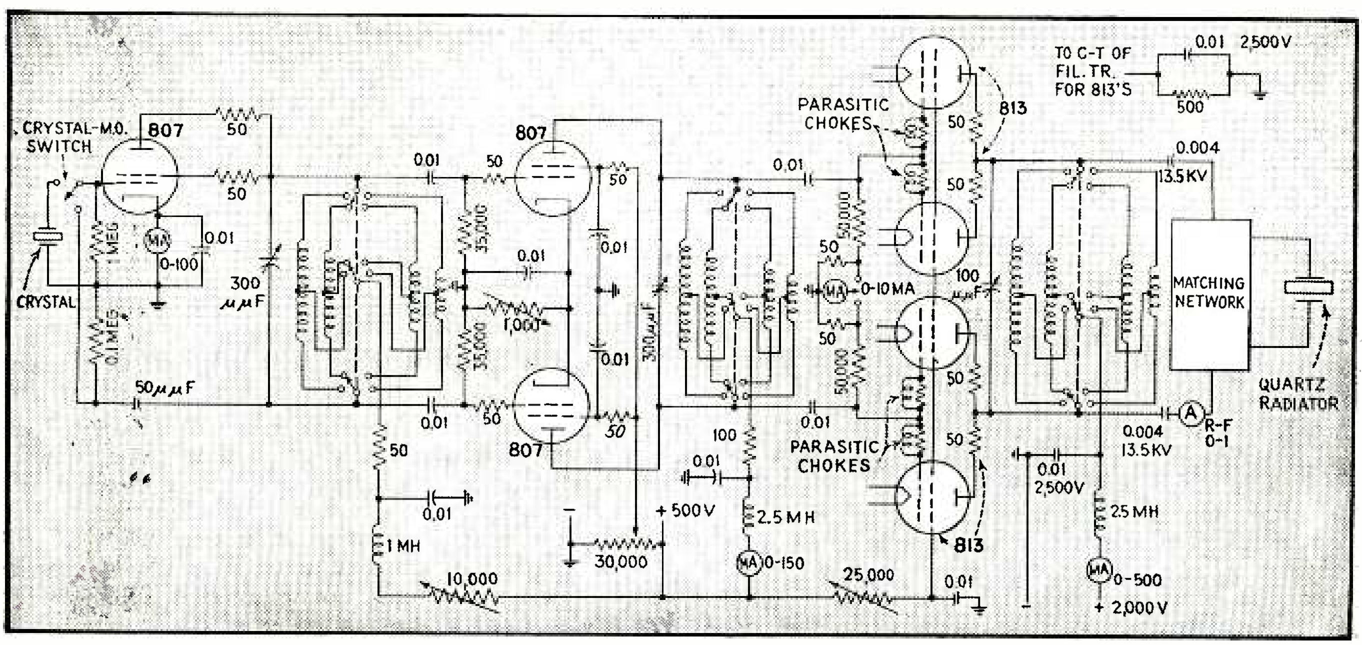

FIG. 4—Circuit of r-f generator used to excite an ultrasonic quartz radiator

AFC for R-F HEATING

Automatic correction of frequency shift under varying load is accomplished by an electric motor that tunes the heating oscillator back to the desired frequency. Discriminator and search circuits actuate relays to control motor rotation

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IN PROCESSING MATERIAL by means of radio-frequency energy, it is desirable to accurately control the heating oscillator frequency. Most oscillators used for induction and dielectric heating have poor frequency stability as compared to oscillators used for communication purposes. This is because they are much more heavily loaded, and the characteristics of the load change considerably during the heating cycle.

Some manufacturers have made an attempt to shield their oscillators to eliminate interference to communication services. However, with conditions met in field installations, excessive radiation can easily occur at the work-handling point, even though the oscillator itself has been properly shielded, unless extreme precautions are taken in shielding the work circuit as well.[1]

The Federal Communications Commission, to reduce interference to other services by industrial electronic equipment, has assigned definite frequency bands for use by industry. The tentative proposed frequency stability requirement is ± 0.05 percent.[2] Obviously, it will not be practicable to maintain such stability with a self-excited type of generator without some means of frequency correction.

Amplifiers for Low Power

One possible solution to the problem is to employ broadcast transmitter design methods utilizing a crystal or small stabilized oscillator with amplifiers following it until the necessary power required to drive the final amplifier is obtained. In the case of generators of low output (1 to 10 kw), this method would be relatively inexpensive, although the added size and cost would be considerably greater than that of present heating oscillators. For higher-powered generators (10 to 200 kw), this method would add many complications and increase the cost tremendously over that of a simple oscillator of corresponding power output.

With the rapid development of frequency-modulation technique in the past few years, many automatic frequency control devices have been developed to maintain accurate oscillator frequency. Extremely accurate frequency control has been obtained by the use of reactance tubes or similar devices connected across the oscillator tank circuit.[3] Unfortunately, it is not very practical to utilize such correction means for high-power oscillators because of the large power requirements of the reactance tube and associated circuits. In addition, it is difficult to correct for the large frequency variations encountered in induction and dielectric heating oscillators because of the limited range of reactance variation obtainable with such devices.

It is possible to obtain heating oscillator frequency stability in the order of ± 0.05 percent by mechanical means. If a portion of the oscillator circuit inductance, capacitance, or transmission line length, can be varied by means of a motor, a system such as that shown in block diagram form in Fig. 1 may be used.

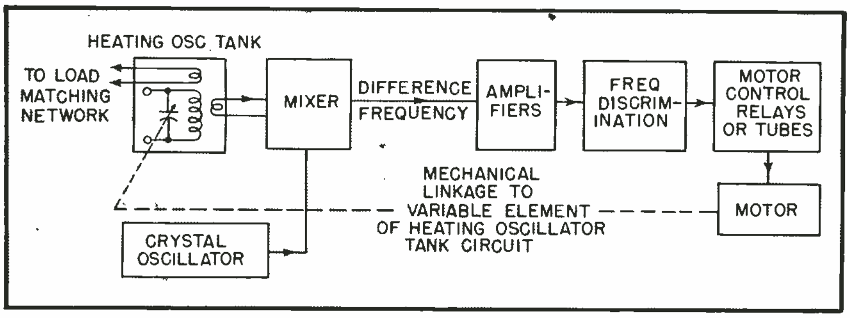
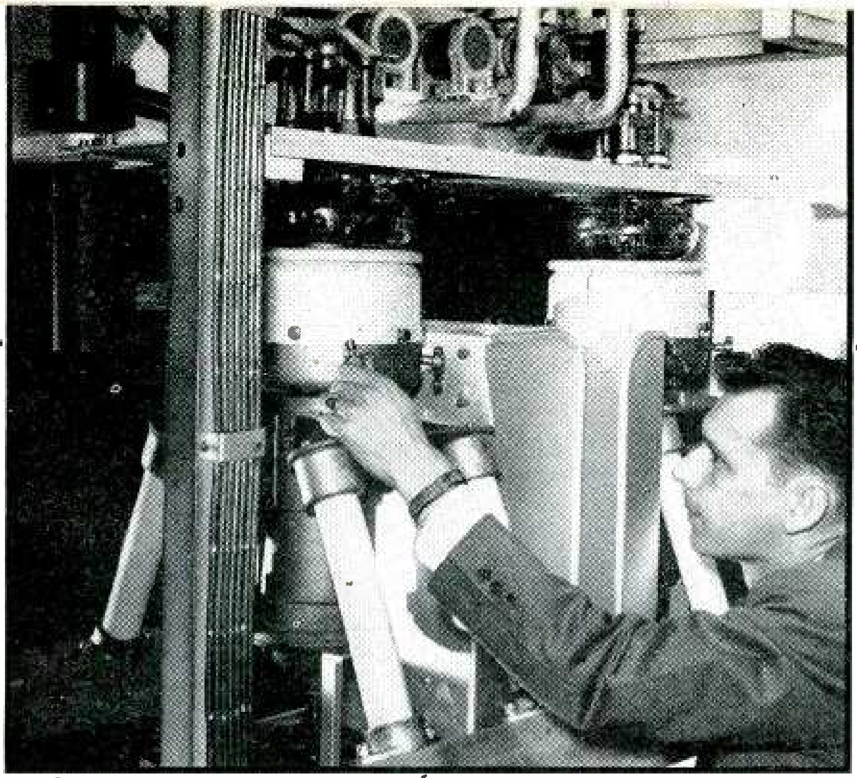


FIG. 1—Essential stages of the afc system for an electronic heating generator. A frequency stability on the order of $\pm$ 0.05 percent is obtained

Tuning Correction

The output from a crystal oscillator which may operate at a desired heating oscillator frequency[4] or at some fixed frequency above or below the desired heating oscillator frequency[5] is fed into a mixer stage along with some voltage picked up from the heating oscillator. The output circuit of the mixer stage is designed to pass the difference frequency between the two oscillators. After suitable amplification, this voltage is applied to a diode discriminator which may be of the Seeley or Crosby type. If the crystal oscillator frequency is made the desired



Automatic frequency control is employed on this 100-kw Westinghouse oscillator for electronic heating

heating oscillator frequency, the *RC* or audio-frequency transformer type of frequency discrimination may be used.

The discriminator output is used to control electromagnetic relays, thyratrons or vacuum tubes which in turn control the motor attached to the variable element of the heating oscillator tank circuit.

Motor Tuning Control

If the heating oscillator is on frequency, the resultant discriminator output voltage will be zero so that the control circuit will permit the motor to be at rest. If the heating oscillator frequency drifts higher or lower than mean frequency, the discriminator resultant output will assume a polarity such as to drive the motor in the proper direction to return the oscillator to its proper frequency.

No detailed circuit for the conversion of difference frequency between heating oscillator and desired frequency to direct current is shown because the form which such a circuit takes depends upon the point in the frequency spectrum where the master oscillator operates and the accuracy of correction desired. However, the conversion of the discriminator output to mechanical motion of the variable element of the heating oscillator tank circuit is relatively independent of the oscillator frequency. One possible control system for this purpose is shown.

Figure 2 is a simplified diagram of a method for motor control which will function properly with certain limitations. The d-c voltage output from the discriminator is connected to the control grids of V_1 and V_2. In the plate circuits of these tubes polarized relay coils are connected in such a manner that if the plate current of V_1 exceeds that of V_2 by a certain amount, contact K_1A will close. If the plate current of V_2 exceeds that of V_1 by the same amount, contact K_1A' will close. Then if the discriminator is arranged so that point 1 is negative with respect to ground and point 2 is positive for a heating-oscillator frequency greater than the desired frequency, V_2 will draw more plate current than V_1, causing relay contact K_1A' to close.

When K_1A' closes, it shorts out the coil of relay coil K_2 so that its contact K_2A opens and K_2B closes. This completes the circuit through the motor armature, causing current to flow from point B to point A.

The motor will rotate to vary the heating-oscillator tank circuit in the proper direction to lower its frequency until the proper frequency is reached when the voltage between points 1 and 2 are equal, at which time K_1A' opens, stopping the motor. Obviously, for a heating-oscillator frequency less than the proper frequency, the tank circuit will be varied in the opposite direction to make the necessary correction. The limitations of the circuit are imposed by the bandwidth of the discriminator employed and the sensitivity of the polarized relay.

Limitations of Discriminator

Figure 3 shows a typical plate current characteristic for V_1 and V_2. If the discriminator characteristic is so shaped as to cause the polarized relay to operate at points 1 and 2, then it will again center at points 3 and 4 where the difference currents

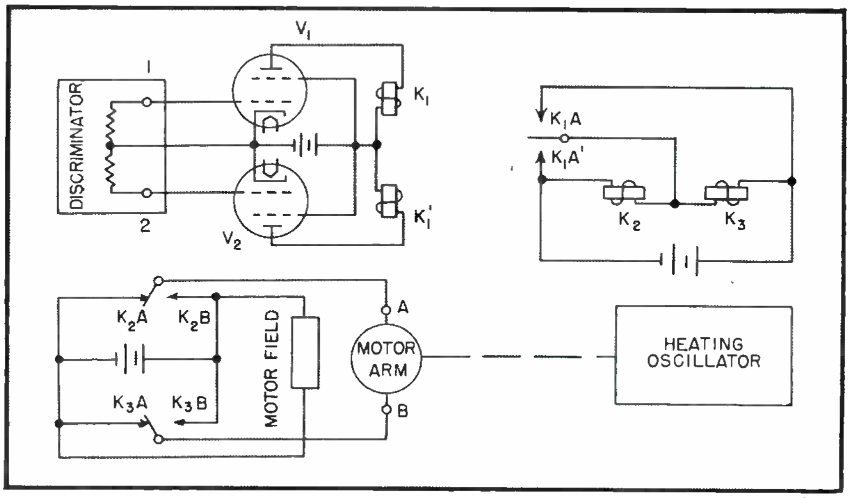


FIG. 2—Control circuit for converting the discriminator output into mechanical motion of the tuning element of the heating oscillator

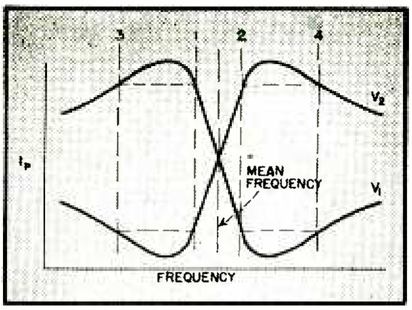
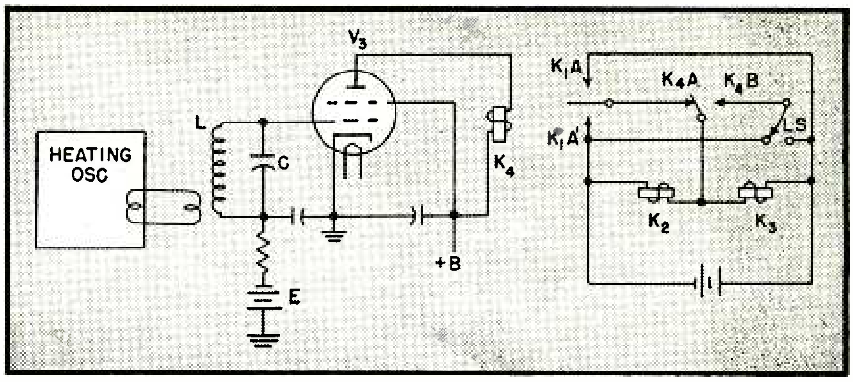


FIG. 3—Plate current characteristics of tubes V_1 and V_2 of Fig. 2. Points 1 and 2 determine the correction accuracy and points 3 and 4 indicate the effective bandwidth of the discriminator

FIG. 4—Search circuit for maintaining the frequency within the desired limits at the start of a new heating cycle



are the same as at points 1 and 2. Unfortunately, the closer the points 1 and 2 are brought together by steepening the slope of the plate current crossover curves to get better accuracy of frequency correction the more rapidly do the plate currents approach one another off resonance.

Search Circuit Operation

With the relatively large frequency change encountered in radio-frequency generators during heat treatment of materials, the oscillator frequency may be outside the limits of points 3 or 4 at the start of a new heating cycle, so that no correction can take place. In order to make certain that this condition cannot occur, a further refinement of the circuit shown in Fig. 2 is usually necessary. A search circuit such as is shown in Fig. 4 can be made to cause the variable element in the heating-oscillator tank circuit to rotate, even though the frequency is outside the limits of points 3 and 4, until it is brought within these limits. The discriminator will then take over to center the frequency.

Some r-f voltage from the heating oscillator is coupled to an *LC* circuit tuned to the proper oscillator frequency. This circuit is connected to the grid of a pentode used as a detector, with the search relay K_4 connected in its plate circuit. The Q of this circuit and the bias voltage *E* are so adjusted that K_4 will close just before point 1 is reached for one direction of frequency connection and just before point 2 is reached in the opposite direction of frequency correction.

The adjustments will also cause K_4 to open just before points 3 and 4 are reached when the frequency departs from the mean frequency. Contacts K_4A and K_4B, along with limit switch *LS*, will then cause the motor to operate even though the frequency of the heating oscillator is outside the discriminator effective range until the frequency is brought within this range. When that occurs, they will relinquish control to the polarized relay K_1, which will perform the same function as before.

Other Methods

The frequency of the heating oscillator may be outside the desired limits of correction for an appreciable time at the beginning of a heat cycle. It may therefore be desirable to automatically return the variable portion of the tank circuit to the proper starting point after the completion of a heat cycle for applications where the heating procedure is not a continuous process. This can be done automatically by additional relay contact arrangements.

There are many other possible arrangements of relays, thyratrons and vacuum tubes which have been devised for other applications[6] and can be used to accomplish motor control for frequency correction. In any of these systems the problem of hunting arises, and may be overcome by the same methods employed for other motor control devices. In general, the higher the sensitivity desired the more difficult it becomes to overcome hunting unless the electrical and mechanical inertia of the system can be kept low.

Unfortunately, for large power oscillators the variable element will be bulky with inherent high inertia. For such cases, braking or motor-plugging schemes[7] may be employed to prevent motor overshoot. Such schemes apply reverse current to the motor armature momentarily of such magnitude as to overcome all inertia at the instant when it is desired to stop the motor. Many feedback systems[8] and motor-braking systems developed for other applications may also be helpful here.

Systems of the type discussed above for frequency correction can be made employing small receiving-type tubes and components whose overall size and cost will be much less than the oscillator-amplifier type of design. For small oscillators from 1 to 10 kw output it may be more economical to employ broadcast transmitter design technique for accurate frequency control. For larger units, the above system is much more economical in both space and cost.

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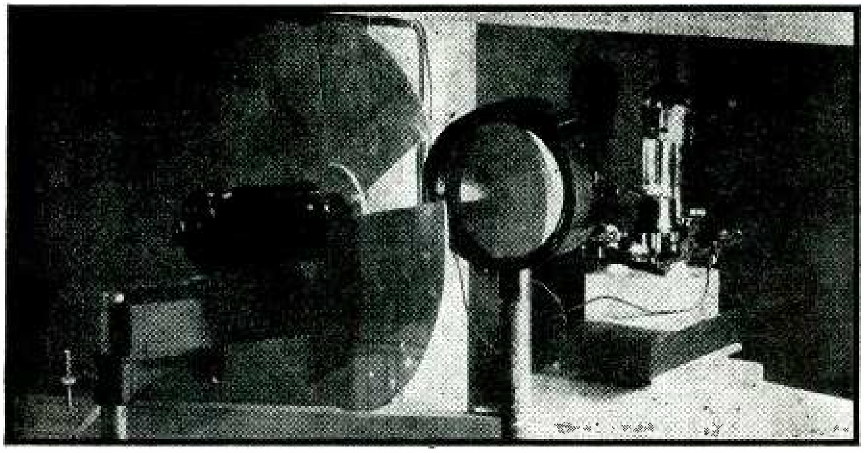

Rotating sector and photo unit arrangement, as used in a grating spectrograph, shown with the electrostatic shield removed

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SPECTROGRAPH EXPOSURE CONTROL

Semi-automatic device employing a phototube and a grid-glow tube permits duplicate exposures to be made on photographic plates despite variations in the arc source. Other applications are indicated

IN RECENT YEARS the spectrograph has evolved from a small optical instrument with little dispersive power to a massive structure having dispersive powers of the order of 1.0 angstrom per millimeter or less.

The necessity for some device whereby duplicate exposures on photographic plates may be obtained naturally arises, especially in quantitative spectrographic analysis. A need for such a device is readily grasped when one observes the image of the arc or spark source on the slit of the spectrograph wandering from side to side, changing in intensity and even failing.

The types of spectrographs in use are generally of the grating or quartz-prism types and both can be adapted for use with a semi-automatic integrating exposure control developed by the author. In particular, the grating spectrograph lends itself readily to an integrating method of recording the light energy developed. The apparatus described herein was designed to operate with a grating spectrograph having a dispersive power of 2.6 angstroms per millimeter, employing a grating of 30,000 lines per inch and having a radius of curvature of 21 feet. Using a simple photocell, it automatically determines the end point of photographic exposures and further application of such a device to other measurements, such as solar radiation,

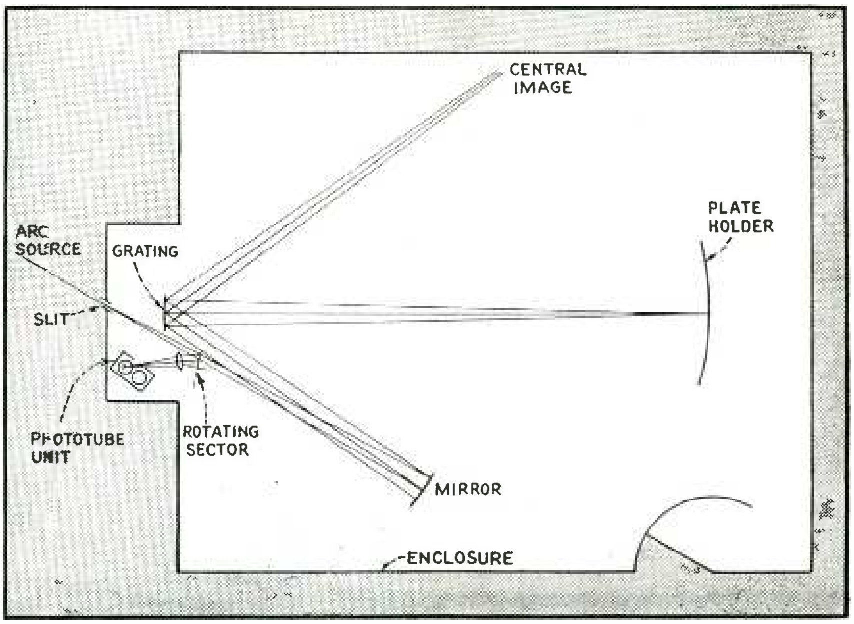

FIG. 1—Simplified diagram of a grating spectrograph equipped with an exposure-control photo unit

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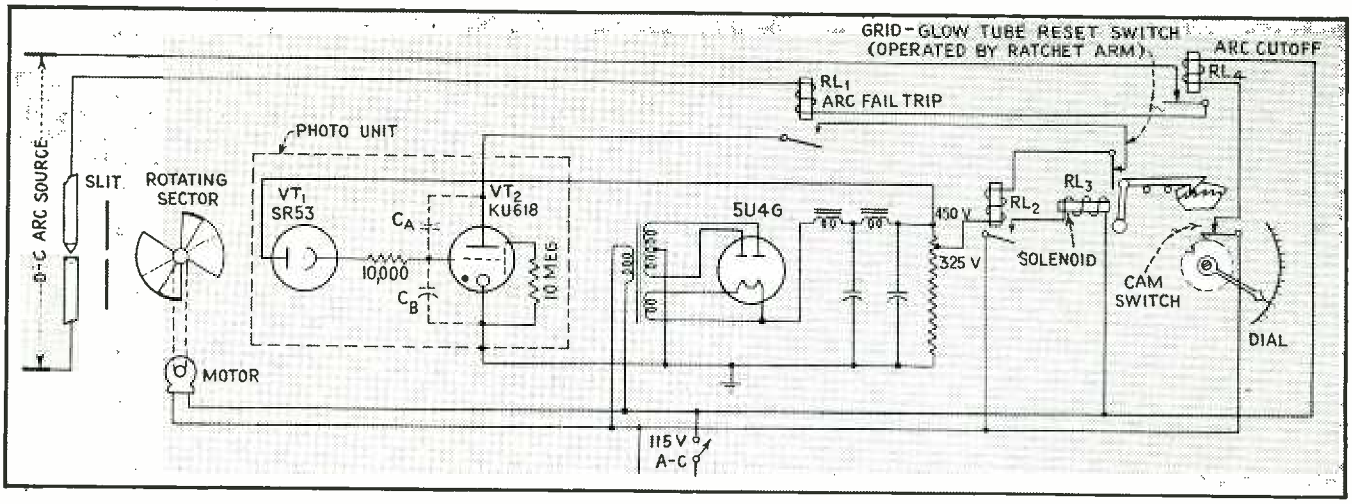


FIG. 2—Complete circuit diagram of the spectrograph exposure control device

visible and invisible, will be apparent. The use of the device to measure the intensity of spectral lines in spectroscopy is also possible.

The Apparatus

Figure 1 shows the relative locations of the various parts of a grating spectrograph. The phototube unit is located near the slit of the spectrograph, within the spectrograph enclosure. Light from the arc source passes through the slit to the mirror and then to the grating, forming spectrum lines on the plate holder and giving a central image.

In this particular application the incident light received by the phototube is reflected from the surface of a polished aluminum rotating sector located between the slit and the mirror within the spectrograph enclosure. The sector is adjustable for long or short exposures, dependent upon the nature of the analysis. Thus the light received by the phototube will be actually only a cross section of that exposing the photographic plate. If the sector is rotated at a reasonable speed (about 900 rpm) the light received by the phototube will be representative of that received by the spectrograph plate.

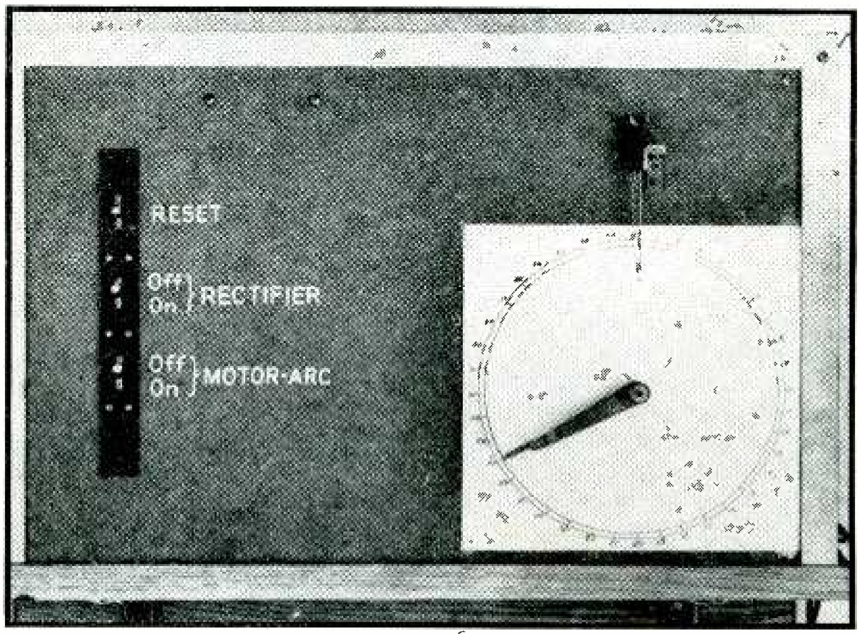
As shown in Figure 2, the photo unit consists of two tubes VT_1 and VT_2, a phototube and a cold-cathode grid-glow tube. The grid-glow tube operates as an integrating-device actuator.

Details of Operation

In operation, the phototube converts the incident light into electrical energy and charges a capacitor, C_B, at a rate proportional to the intensity of the incident radiation, at the same time discharging C_A. Capacitors C_A and C_B are the partial capacitances of VT_1 and VT_2. At a particular grid potential predetermined by the voltage on the plate of VT_2, the grid-glow tube fires, registering one integrated interval, and reestablishes the system to its initial conditions. This process is repeated many times for a complete exposure, thus giving an integrated result. The accuracy is dependent partially upon the size of the increments. The dial setting determines the number of these increments. A ratchet wheel having many teeth is employed to position the dial, sums up the increments and thus becomes the integrator.

The overall unit contains a rectifier to supply the necessary d-c voltages for the phototube and the grid-glow tube. The sample to be analyzed is placed in the cavity of the lower arc electrode (pure carbon) and an arc is established between the two electrodes. This causes relay RL_1 to operate, completing the circuit to the grid-glow tube. Relay RL_1 insures inoperation of the indicator should the arc fail. Reestablishment of the arc restores operation. This provision also permits the exposure to be interrupted if desired without appreciable error due to slight leakages that may exist.

After each successive charge-up of capacitance C_B, VT_2 fires, causing the relay RL_2 to operate, actuating sole-



Front panel of power supply, relay and ratchet unit, showing the indicator dial noid RL_3 which ratches the dial one increment and resets the grid-glow tube by opening its plate circuit for an instant by means of the switch located near the solenoid arm. After many such cycles of operation are completed a cam-switch opens and releases the arc cutoff relay RL_4, thus interrupting the arc circuit. This arc cutoff relay extinguishes the arc when the desired exposure or end point is obtained. The desired length of exposure is determined by the position of the cam switch, which is preset by moving the indicator arm about the indicator scale. Once the arc is established for any setting of the dial, the operation is automatic.

Certain precautions must be taken to eliminate as far as possible any leakage paths present across the phototube leads. Removal of the base from the phototube and the grid-glow tube is recommended. The photounit must be mounted on a base of good dielectric material. If mounted compactly, surrounded by some form of electrostatic shielding and properly grounded, a portable arrangement will be obtained with only three interconnecting leads to the recording unit. In humid climates, operation of the phototube unit under a desiccator might be required.

Performance

It is reasonable to expect some variation in the sensitivity of the phototube cathode surface to the wavelength of incident light and to area of surface. However, for any given analysis, especially in samples having the unknown material in percentages of the order ½ to 5 percent, the energy distribution is rather constant. Furthermore the cathode surface exposed for different spectrograms is practically constant. Losses due to absorption in the air are likewise similar for each sample. These errors, although they represent inaccuracies so far as quantitative measure of the incident light is concerned, do not represent errors in obtaining duplication of results for any complete analysis.

Figure 3 is an exposed spectrograph plate showing five successive copper spectrograms. Each of these exposures was made by the integrating exposure control from unweighed electrodes of copper. There was an actual variation in exposure time of over three to one when taking the five spectrograms. This large variation in exposure time was due to deliberate motion of the arc, causing the image of the arc to wander on and off the slit. Examination of this plate shows the uniformity of results obtained by this equipment.

Further sensitivity can be obtained by employing a C7022B electron-multiplier phototube. Some preliminary data has been obtained using this tube at the central image, thus eliminating lens systems and reflections from a rotating sector. The results indicate that a sensitivity of at least ten times that obtained with the apparatus described can be obtained. Certain difficulties were encountered, the greatest of these being variation of the sensitivity of the portion of the phototube surface employed.

The author acknowledges the assistance of H. D. Ussery, Dr. F. B. Haynes, and other members of the Physics Department of the Virginia Polytechnic Institute, whose cooperation made possible this development.

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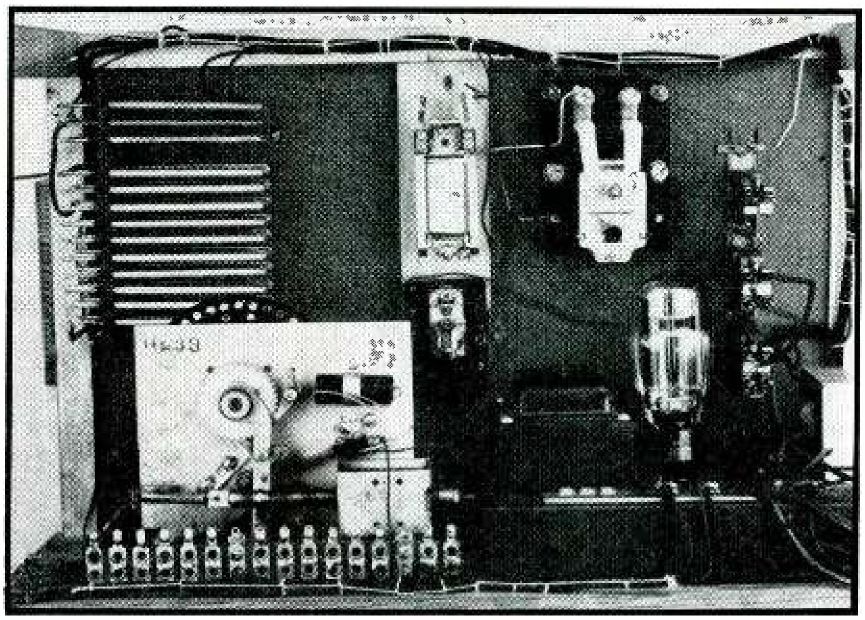

Spectrograph exposure control power supply, relay and ratchet unit, seen from the back

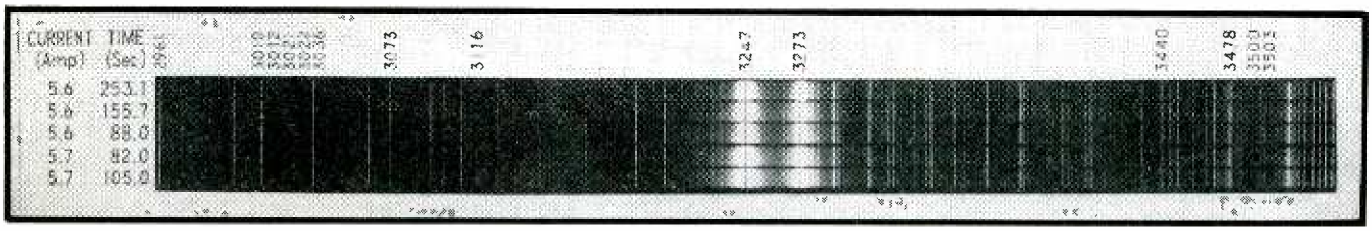

FIG. 3—Exposed plate showing, from top to bottom, five successive exposures under the varying arc and time conditions indicated at the left

Vibration and MOBILE

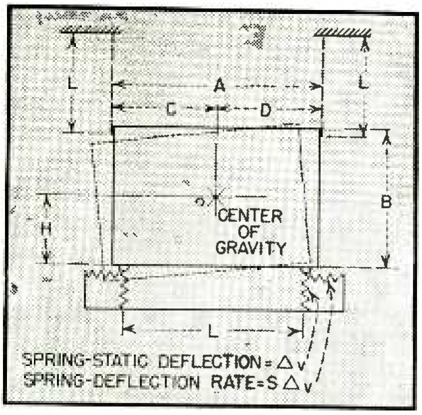

FIG. 1—The solid lines show the usual method of mounting electronic equipment to isolate vibration and reduce shock. The vertical dashed lines show the location of wires used in the experimental determination of radius of gyration

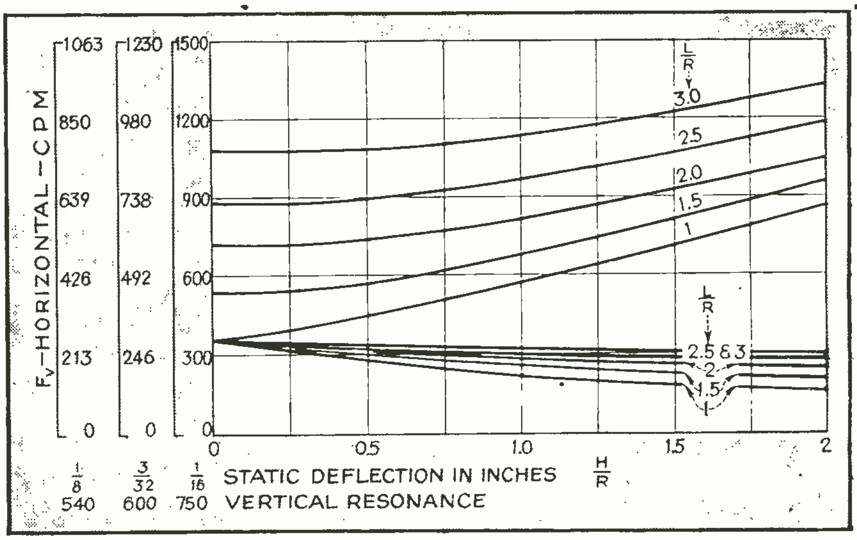

FIG. 2—Resonance diagram for use in applying shock and vibration mounts with horizontal stiffness equal to one-quarter the vertical stiffness. R = radius of gyration ≅ 1/5 (case height and case width). H = vertical distance-mounts to center of gravity. L = mount spacing

VIBRATION FATIGUE TESTS of commercial and military aircraft radios are standard practice in the industry, and the accepted requirements have been covered by government specifications. However, improved types of vibration isolators[1] are now commercially available for aircraft and new applications of radio equipment are presenting shock and vibration conditions of an entirely different nature. Proper application of the new vibration isolators and tests of equipment for services other than aircraft require the application of some theory not previously used, as well as a few additional methods of using vibration test equipment.

The tests indicate such things as possible interference due to relative movements of parts under vibration; their points of resonance; the swinging of connecting wires; crystallization of or weakness at soldered terminals; fasteners that loosen; strength of brackets, especially at bends; welded joints subject to shock and vibration; and mount problems.

We use two types of vibration tests in conjunction with design. The first test is a check of the mechanical design of the unit itself. The complete unshockmounted unit is subjected to vibration over the expected or specified frequency range, and carefully observed with a Strobotac for any resonant vibratory motion of components, panels, etc. The vibration is applied successively in three mutually perpendicular directions by a machine made by L. A. B. Corporation of Summit, N. J.

Vibratory displacements of 0.005 inch are sufficient to produce easily observable motion in any members resonant in the usually specified test range of 600 to 3600 cycles per minute. If there is vibration in service at the resonant frequency of any member, even amplitudes so small that they can barely be felt are sufficient to cause fatigue failure of unmounted equipment resonant at an exciting frequency. If vibration-isolating mounts are used, component resonance must be well above (3 or more times) mount resonance.

Two Tests

The structural strength of radio chassis and brackets is usually empirically determined by the designer, who is normally primarily influenced by such considerations as weight, electrical performance and ease of servicing. Increased competitive emphasis on these factors requires more highly stressed structural members and increases the probability of resonance at frequencies present in service. No readily usable design data on resonance of structural members is available, and "beefing up" of members found by test to be resonant is the usual procedure. An example of this first test is illustrated by a flightweight receiver designed for use in light personal planes where absolute minimum weight is essential.

Communications equipment designed for services which subject the equipment to shock or vibration is almost invariably shockmounted. Whether the mounts are primarily intended to absorb shock, or are both to absorb shock and to isolate vibration, there is the same design problem. This is because the usual form of shockmount is essentially a rubber spring and if only its shock-absorbing qualities are considered by the designer the mount in many actual cases will amplify barely noticeable vibration up to destructive amplitudes. Tube failure complaints from the field are a good indication of vibration amplification in service, if

Shock Testing of EQUIPMENT

Proper application of newly developed vibration isolators to mobile communications equipment requires techniques not previously employed. Methods of testing shockmounts in three mutually perpendicular directions are given, along with data on resonant conditions

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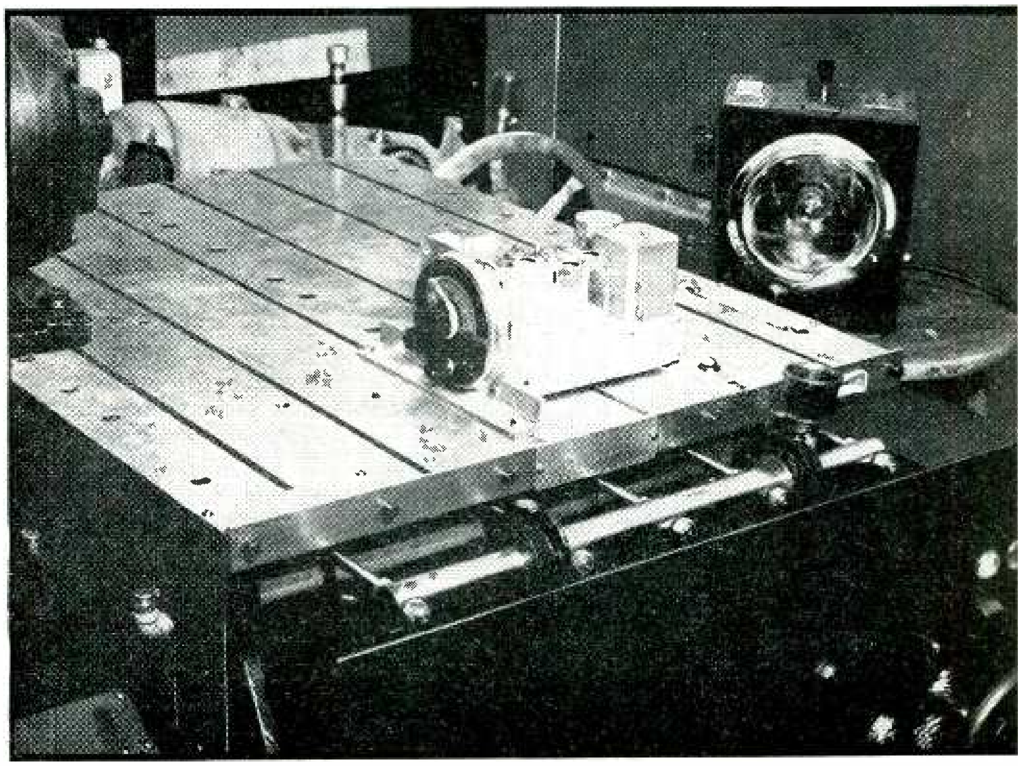


Personal aircraft receiver and radio compass mounted for mechanical resonance test

it is known that shock conditions are not the probable cause. The second vibration test is to secure data on the vibration isolation efficiency of the shockmount.

Directions of Resonant Frequencies

In most applications, the greatest shock forces are in a vertical direction, and in the past it was customary to apply the test vibration only in this direction. The current practice, however, is to test in three mutually perpendicular directions, since the direction of vibration in service is dependent on the nature of the equipments support and the structure between the cause of vibration and the equipment. The usual result in field tests is to find some components vibrating in all directions. Since most communications equipment is for general application, it must be assumed for test purposes that all directions of vibration are equally important.

The widely distributed formulas for calculation of isolation efficiency of mounts assume that the equipment will only have a lineal vibratory motion and no tendency to rotate. This is true only so long as the unit is on mounts loaded to equal deflections and located in a plane passing through the center of gravity of the unit. For obvious reasons, however, the most widely used layout places all the mounts between the unit and the supporting surface, and the equipment is free to tip as well as to move lineally. In such cases the mounted unit has one vertical resonant frequency, two resonant frequencies about a fore and aft horizontal axis, and two about a sidewise horizontal axis. These occur one above and one below the single horizontal resonant frequency which would be secured if the unit did not tip.

With many of the mount designs applied in the past to usual radio designs this higher resonant frequency is at or near the speed of internal combustion engines, and is very undesirable. There is a sixth resonant frequency—torsional about a vertical axis—but this has no significance in most applications.

A formula useful for computing these torsional modes of resonance is given below. Its derivation is similar to that of the formula for use without tipping and is based on the classic equation $F = MA$. Equal mounts, equally loaded and symmetrically placed with respect to the center of gravity, are assumed, but for practical purposes negligible error is introduced by using the average of four slightly different static deflections such as are usual in an actual design. The vertical resonant frequency in cps is computed by the usual formula $f_v = 3.1\sqrt{1\Delta_v}$.

resonant frequencies (cps)

$$= 2.21\sqrt{B \pm \sqrt{B^2 - 4C}}$$

$$\text{where } B = \frac{S\,L/2\,(2 + H^2 + R^2)}{\Delta_v\,SR^2}$$

$$\text{and } C = \frac{L^2/2}{\Delta_v^2\,SR^2}$$

L = Distance between mounts
H = Height of equipment's center of gravity above plane of mounts
R = Radius of gyration of the equipment
Δ_v = Static deflection of mounts
S = Horizontal to vertical softness ratio of mounts

These relations are illustrated in Fig. 1 which shows a schematic drawing of the usual method of mounting electronic equipment. It also shows the location of supports used in experimentally determining radius of gyration as referred to below.

Radius of Gyration

If any accuracy is to be secured with this formula—or any other formula—the static deflection and softness ratio must be secured under the actual load conditions. Most mount load deflection curves are nonlineal and the slopes at the point of actual loading must be used, rather than total measured deflections. Radius of gyration can be rather laboriously computed by handbook formulas, or can be approximated ($\frac{1}{3}$ of $A + B$ in the sketch is an average value from measurements on a number of aircraft radios), but is best actually measured by use of a bifilar pendulum. For the latter, the formula is as follows (T is the period in seconds; other dimensions show in the sketch and are expressed in inches.)

$$R = 3.14\;T\sqrt{CD/L}$$

In applying the resonance formula, the designer usually finds the height and radius of gyration fixed by other considerations. Mounts with suitable static deflection and horizontal softness ratio can be selected, however. Deflection of $\frac{1}{16}$ to $\frac{1}{8}$ inch and softness ratios of 3 to 5 are about the values required for general aircraft application (no resonance above 15 cps) and approximately these values are now commercially available. Graphs similar to that shown in Fig. 2 (for a mount in use by Bendix) can then eliminate the need of successive approximations in finding the greatest spacing which will not exceed the maximum allowable frequency. (The maximum permissible spacing should be used to minimize shock forces on the mounts.)

The improvement in performance which can be secured from use of mounts with suitable horizontal softness is illustrated by the photographs of Fig. 3 and the performance curves of Fig. 4. The unit shown conforms to standard $\frac{1}{2}$ ATR case dimensions. Mounts of the same type and rating were used in both cases, but a simple adapter was added in one case to increase horizontal softness.

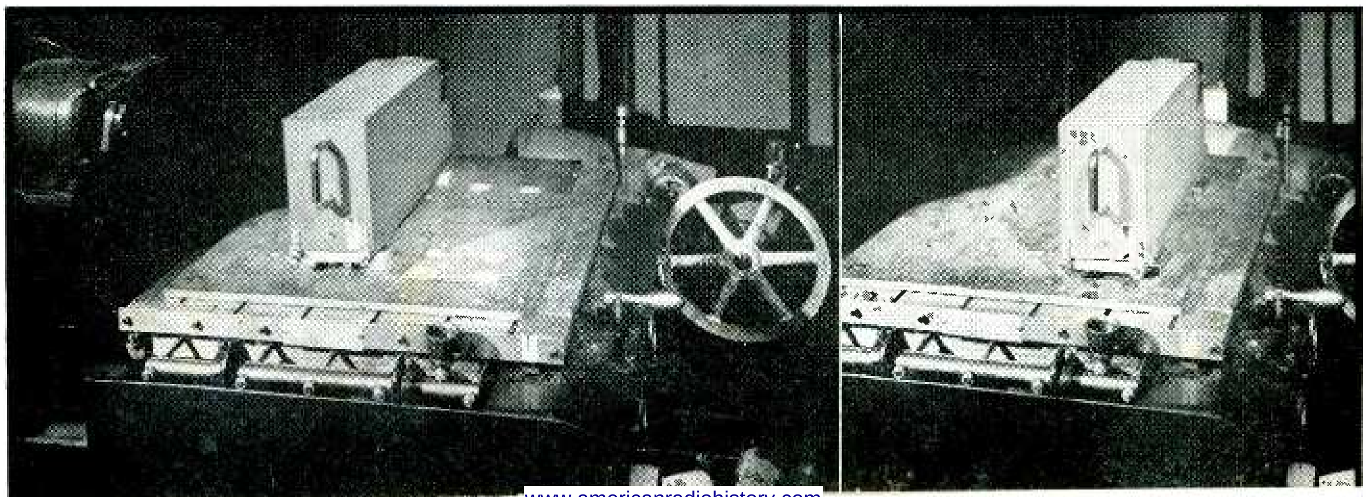
Vertical isolation at 1500 and 2100 cpm with the standard mounts is not as great as would theoretically be expected, but is typical of many installations. Unequal loading of the mounts results in slight torsional impulses which have an appreciable effect at the torsional resonance frequency. The performance in the operating range of the horizontally soft mounts under vertical vibration is improved by the elimination of these slight peaks, even though the load is no more evenly distributed.

Shock Fatigue Tests

The vibration test table may also be used for shock fatigue testing if such a test is warranted by the requirements of the application. For such an application electronic equipment is normally shock-mounted on rubber. The mounts effectively isolate against large impact shock forces caused by rapid small displacements, such as are caused by metal-to-metal contact or by the vibration of structural members induced by impact forces. No effective isolation, however, can be secured from accelerative forces without exceeding reasonable space limitations, and if these forces are large and numerous in service, fatigue failure should be investigated. This requires test forces equal to or greater than those which may be expected in service, at frequencies near the resonant frequency of the mounted equipment. This frequency is dictated by the fact that accelerative forces in service will cause rapidly decaying vibration of the unit at its resonant frequency, regardless of the speed with which the force is applied.

In service, large accelerative shock forces normally will deflect mounts past their lineal range. In test, to secure large forces at low frequencies, the displacements must also be large enough to cause deflection past the lineal range. It is then no longer possible to treat the mount as a simple spring with one resonant frequency, such as is generally assumed for vibration isolation calculations.

FIG. 3—Bendix interphone amplifiers whose geometrical proportions (½ ATR, CAA designation) present the most difficult vibration isolation problem of the standard equipment cases. The unit on the left is mounted on conventional vertical shear-type mountings and the unit at right is mounted on identical rubber elements with an additional rubber part to produce isolation of horizontal vibration. The test table in both cases is vibrating at a speed of 2100 rpm, with a total excursion of 1/64 inch in the left-right direction. The photographic definition of the equipment shown at the right illustrates the improvement



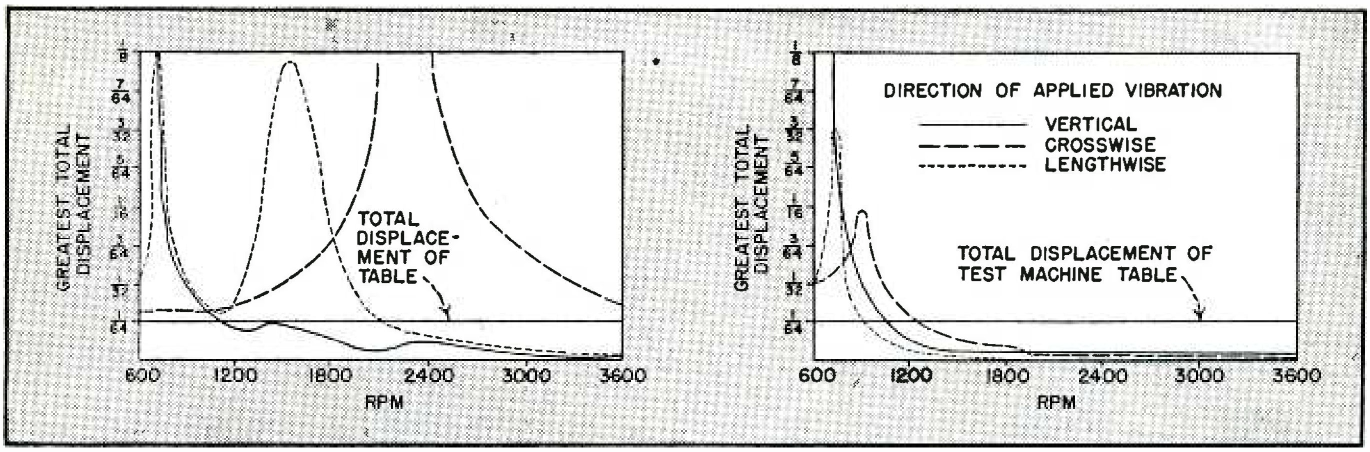


FIG. 4—Overall vibration performance at various engine speeds and in three mutually perpendicular directions is shown on these graphs for the two units of Fig. 3. In the graph on the right, effective isolation is secured in the normal operating range of aircraft engines. The graph on the left shows that conventional mounts actually magnify vibration at these speeds

A load mounted on a spring whose modulus is constant for small deflections but which increases with increasing large deflections has a range of resonant frequencies, rather than a single resonant frequency. If the frequency of an adequate disturbing force is increased past the resonant frequency of the lineal deflection, the spring deflects further into the nonlineal range of the spring. The greater force speeds up the motion and resonant motion of the load continues at frequencies above the lineal resonant frequency.

This motion continues as frequency is increased until the friction loss in the mount equals the energy input of the disturbing force, when the motion subsides to movements in the lineal range whose magnitude can be computed by the simple spring formula.

Such resonance carry-over is of course highly undesirable in service, but can easily be—and always is—avoided by making the linear deflection range of the spring materially greater than the vibratory displacements which will be encountered in service. The phenomenon is important, however, when testing at large amplitudes and low frequencies. Knowing the stress-strain relation of the mount, it is possible to compute the approximate deflection for resonance at frequencies above linear resonance. A method for doing this is given in Den Hartog's "Mechanical Vibration," but the method is laborious and the results inaccurate because of the comparatively large effect of internal friction in such cases. For most purposes it is sufficient merely to be familiar with this type of resonance, and frequency displacement curves at various exciting displacements for a case of this type are shown in Fig. 5.

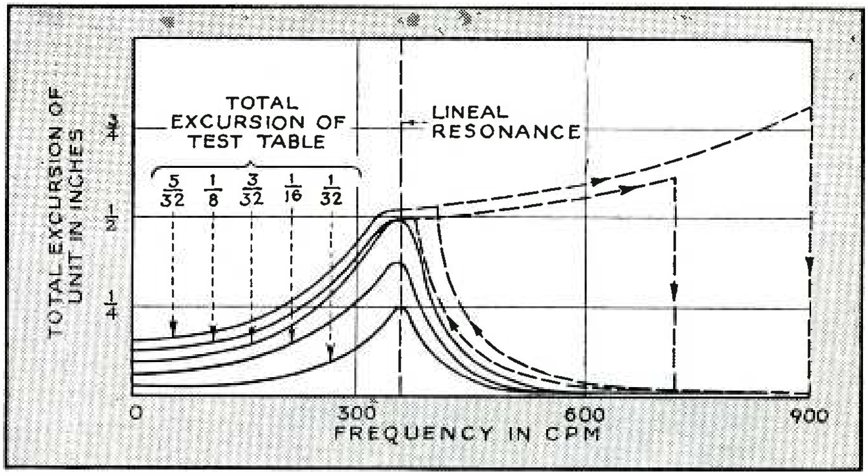


FIG. 5—Vibration isolation and magnification of an effectively lineal vibration isolator and a nonlineal shock absorbing bumper. At amplitudes of vibrations such as would be reasonably encountered in service, there is a single resonant frequency. At larger amplitudes, there is a range of frequencies above this at which resonance continues due to the combined effect of lineal and nonlineal characteristics

Other Equipment

To use resonance carry-over for test purposes it is also necessary to measure the forces. Since the movement is not simple harmonic motion, the usual G meters reading rms voltage are not suitable. A pressure-sensitive pickup from such a device feeding a recorder of suitable frequency response must be used so that the peak voltage generated by the pickup can be measured rather than the rms value.

With such a device, forces of large definite magnitudes near linear resonance frequency can be obtained with practically any type of mount. Curves showing the forces generated by the simple harmonic motion of a test table, and the forces in a unit vibrating resonantly with a complex harmonic motion are shown.

The equipment from which the curves were secured is the Bendix railroad model MRT-1 communications transmitter-receiver. The test subjects the unit to forces of the magnitude of those encountered in severe service conditions such as are encountered in switch-engine installations and freight service in mountainous regions.

Reference

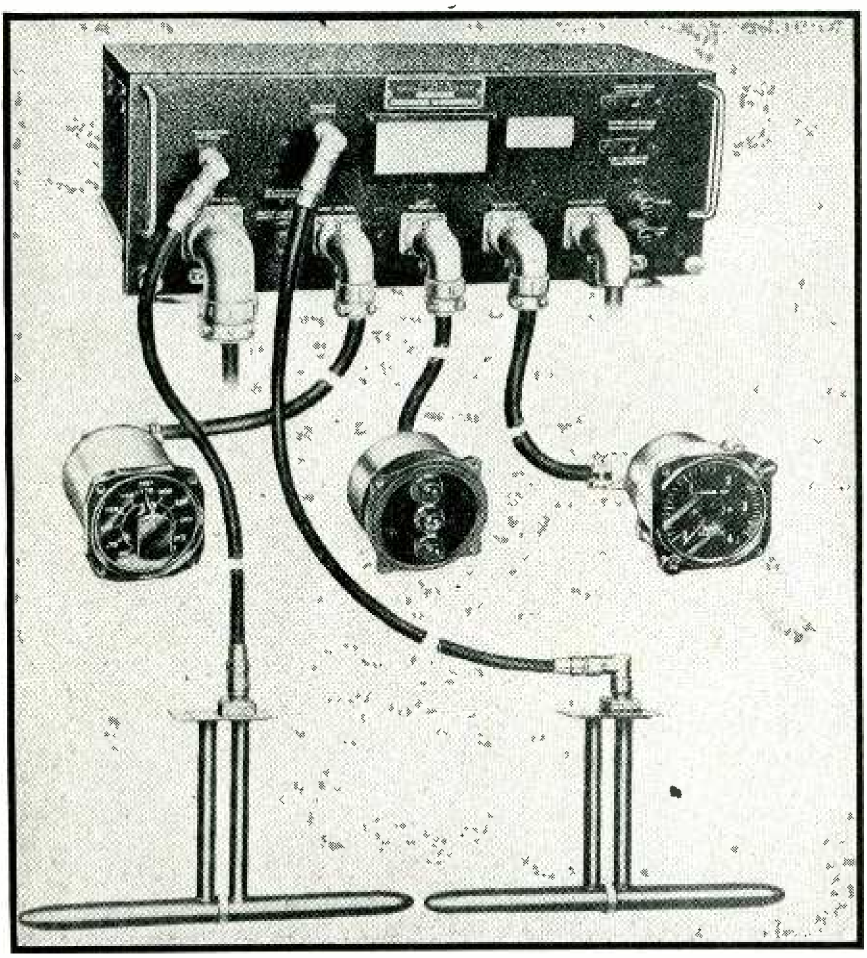
(1) Vibration Control for Electronic Products, ELECTRONICS, p 134, September 1945.

F-M Radar Altimeter

Frequency-modulated signals from the APN-1 equipment are directed earthward from an aircraft, and the beat note between transmitted and received signals is measured to obtain an indication of altitude, accurate to a few feet above the earth

IN 1938 United Airlines demonstrated to the press a radio altimeter which had been developed by the Bell Telephone Laboratories, and which revealed the height of an aircraft above the terrain by timing a reflected radio wave. The word radar had not then been invented, and the principle employed by the altimeter was different from that of the pulse-type radars which were then being developed in great secrecy. No technical information was revealed at the time, but the general principle of operation was described in several publications[1,2]. Shortly thereafter censorship was imposed on further information.

A detailed description of an f-m radar altimeter may now be given, following the recent declassification of the model AN/APN-1 altimeter. This altimeter was installed on over 100,000 Army and Navy aircraft during the war. The APN-1, operating on the same principles as the equipment demonstrated before the war, was designed for production by the RCA group at Camden. The altimeter is one of two widely used in wartime aviation (the other uses the reflected pulse principle). It is expected to be installed on commercial aircraft following recent type approval by the Civil Aeronautics Authority.

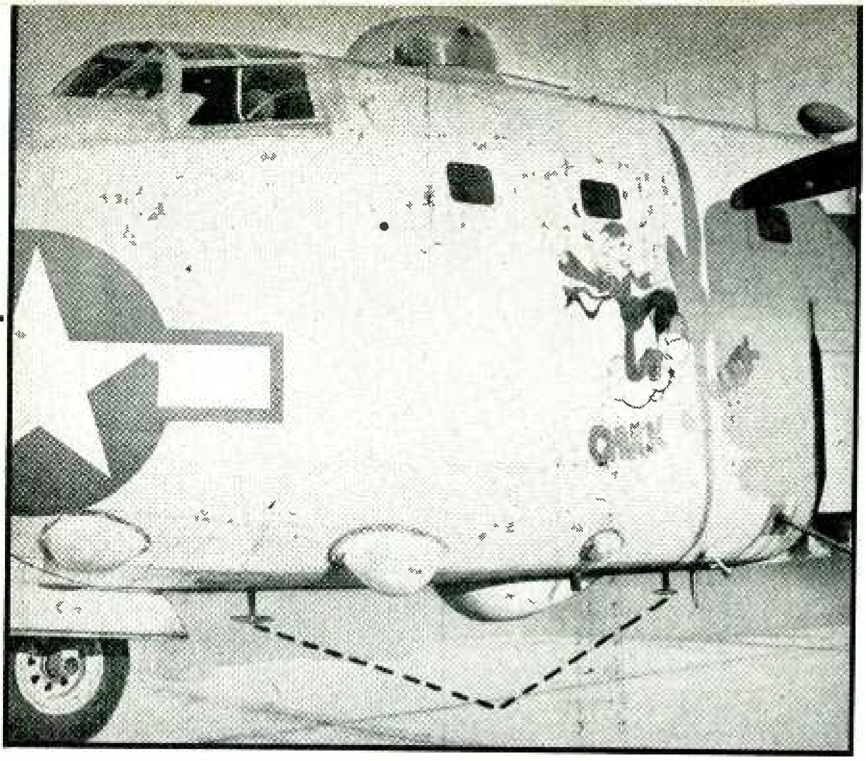


Type AVQ-6 f-m radar altimeter, version of the APN-1 equipment approved by CAA for commercial use

Principle of F-M Radar

Frequency-modulation radar determines the distance to a reflecting surface (in this case the ground beneath the plane) by measuring the frequency shift between transmitted and reflected waves. While the wave is traveling to the surface and back, the transmitter frequency is changing under the influence of the frequency modulation. When the reflected wave arrives back at the transmitter, its frequency is slightly different from that then being transmitted. The transmitted and reflected signals are combined in a detector and the frequency difference between them developed as a beat note. This frequency difference becomes larger as the distance to the reflecting surface becomes greater. The altitude is indicated by converting the beat frequency into a distance indication.

The advantage of this method lies in its ability to measure very short distances, down to a few feet. The minimum detection distance in the pulse method is limited by the length of the pulse. Even if a pulse as short as 0.2 microsecond is used, the minimum range is one hundred feet. Pulse radar thus cannot indicate altitude during landings when the height of the aircraft above ground must be accurately indicated from a few hundred feet down to zero. For indicating higher altitudes, the pulse method is useful and has in fact been employed in a high-altitude instrument.



Lubber-line installation of radar altimeter dipoles below the fuselage of a Navy Consolidated Privateer (PB4Y-2). The radomes house antennas for radar countermeasures

One disadvantage of the f-m principle is the fact that an altimeter designed for low-altitude indication cannot indicate very high altitudes without lowering the deviation of the frequency modulation. Hence, two scales are required to cover all operational altitudes and in early equipments there was a chance of human error in reading the correct scale. Later versions of the equipment provided against this type of error.

The quantitative relationships which govern the design of an f-m radar altimeter may be derived from Fig. 1. At the top of the figure, the frequencies of the transmitted and received waves are plotted as functions of time. The solid line represents the transmitted frequency, which is modulated by the linear triangular waveform. The total deviation of the frequency modulation (the peak-to-peak value of the modulation envelope) is indicated as ΔC megacycles. In the APN-1 equipment, the center frequency is 440 mc, and the deviation is plus or minus 20 mc ($\Delta C = 40$ mc) on the low-altitude range.

The dashed line in Fig. 1 represents the received signal. This signal is, of course, frequency-modulated by the same envelope since the signal preserves its form during reflection, but the received signal is displaced in time by the reflected interval, which is equal to $2h/c$ where h is the height of the aircraft above the terrain in feet and c is the velocity of radio wave propagation in feet per second. As a consequence of this time displacement, a corresponding frequency displacement occurs, indicated by the vertical separation Δf between the solid and dashed lines.

The relationship between the altitude h and the frequency difference Δf, can be found by comparing similar triangles in the figure. The height of the triangular waveform is ΔC and half its base is $1/(2f_m)$, where f_m is the frequency of the modulation envelope. The ratio of the height to half the base is $2\Delta C f_m$ and this is equal to the frequency difference divided by the time difference:

$$2\Delta C f_m = \frac{\Delta f}{2h/c} \qquad (1)$$

where ΔC, f_m, and Δf are all measured in cps. The relationship between frequency difference and height is then found by rearranging Eq. 1

$$\frac{\Delta f}{h} = \frac{4\Delta C f_m}{c} \qquad (2)$$

It will be noted that the sensitivity of the indication, in cps frequency difference per foot, can be increased by employing a wide frequency deviation or a high modulation frequency, or both. In the APN-1 equipment, ΔC is 40 mc, f_m is 120 cps, and c is 984×10^6 feet per second, and hence $\Delta f/h$ is 19 cps per foot of altitude.

It thus appears that audio frequencies up to 7,600 cps are developed in the beat note between transmitted and received signals, provided that heights not greater than 400 feet are encountered. For higher altitudes, up to 4,000 feet, a lower frequency deviation $\Delta C = 4$ mc is introduced and the beat frequency is thereby reduced to 1.9 cps per foot. The maximum beat frequency developed is then the same ($4000 \times 1.9 = 7{,}600$ cps).

A minor aberration occurs during the period between reversal of the

electronics WAR REPORT

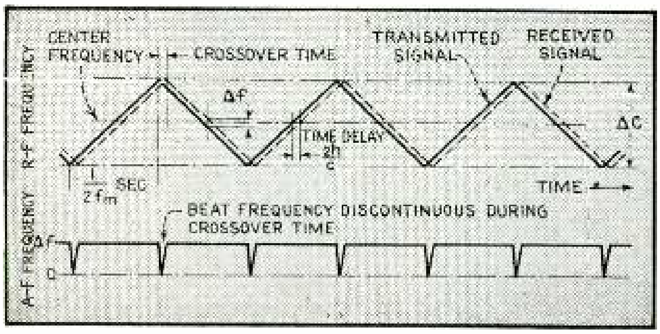


FIG. 1—Time and frequency relationships when a triangular modulation envelope is employed in an f-m radar system. Transmitted and received signals combine to give a-f beat note

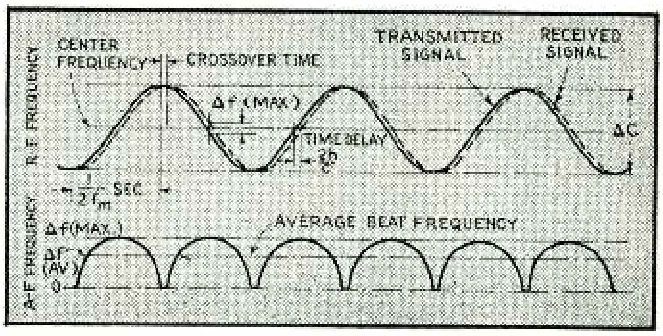


FIG. 2—Time and frequency relationships when the modulation envelope is sinusoidal. The average beat note corresponds to the constant beat of the triangular case (Fig. 1)

transmitted frequency deviation and the corresponding reversal in the received wave, as shown in Fig. 1. The transmitted frequency, at the center of this period, falls to a value equal to the received signal, which is then still increasing. At this instant, therefore, the beat note is zero. During this crossover interval the beat frequency is variable, dropping to zero at the center. However, the duration of the crossover interval is only 20 microseconds, at the maximum altitude of 4,000 feet, compared with 42,500 microseconds, the half period of the modulation envelope. Consequently the crossover effect is negligible.

In practice it is not convenient to modulate the frequency with a triangular envelope, and a sinusoidal envelope is substituted. The situation is then that shown in Fig. 2. The frequency difference is no longer a constant between crossovers, but varies in the manner shown, from zero at the crossover to a maximum which occurs when the transmitted frequency is passing through its center value. By circuits described later, the average beat frequency is measured and this value corresponds with that produced by triangular modulation. Equation 2 may be used to predict the average beat frequency Δf when sinusoidal modulation is used.

In installing the equipment in an aircraft, care must be taken to equalize residual delays between the transmitting and receiving inputs to the beat-note detector. The distance between the inputs is not zero when the wheels of the aircraft are on the ground, but is equal to the sum of the cable lengths between detector and the two radiators, plus the physical reflection distance (amounting to a few feet) between radiators and the ground midway between them. This residual altitude error is removed in calibrating the instrument.

A final error may appear when the aircraft is flying over very smooth terrain such as a runway or smooth water. Under these conditions, the indicated beat frequency shifts back and forth by an amount equivalent to about six feet when the actual altitude changes by six inches (one quarter wavelength at 440 mc). When the terrain contains a rough surface (projections higher than six inches) the shift is averaged out and the indicated altitude is the correct value. The shifting altitude (known as fixed error) may be quickly recognized, and the correct altitude is the intermediate value between the limits of the shift.

General Layout of APN-1 Equipment

A block diagram of the essential elements of the APN-1 altimeter is shown in Fig. 3. A transformer-coupled audio oscillator operating at 120 cps drives the modulator unit. This is a mechanical modulator resembling the voice-coil assembly of a dynamic loudspeaker. The moving element of the modulator drives one plate of a balanced capacitor in the transmitter tank circuit, thus producing a frequency-modulated output. Two amplitudes of drive are available, one for 40 mc total deviation (low-altitude scale), the other for the reduced deviation of 4 mc (high-altitude scale).

The transmitter itself is a line-controlled push-pull oscillator employing two types 955 acorn triodes. The transmitter produces a power output of about 100 milliwatts at a center frequency of 440 mc. Part of the transmitted signal is passed to a dipole transmitting antenna, mounted under one wing of the aircraft. Another portion of the signal is injected

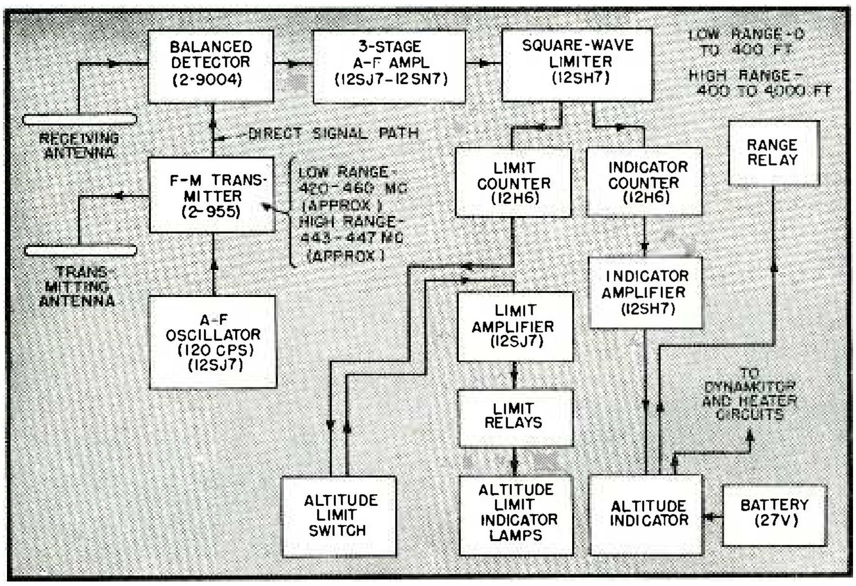


FIG. 3—Block diagram of the APN-1 altimeter. The beat note is clipped and its average frequency measured in the counter circuits

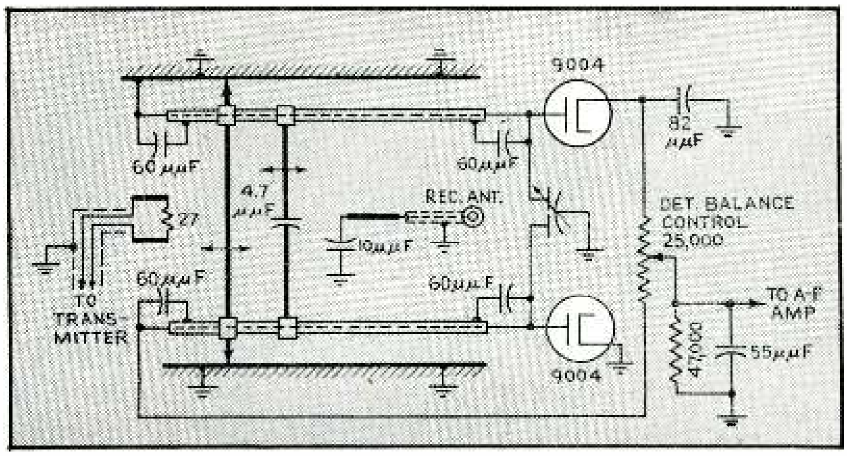


FIG. 4—Balanced diode detector. The circuit arrangement is insensitive to amplitude modulation which may arise due to passage of the f-m signal through the resonances of the circuit elements

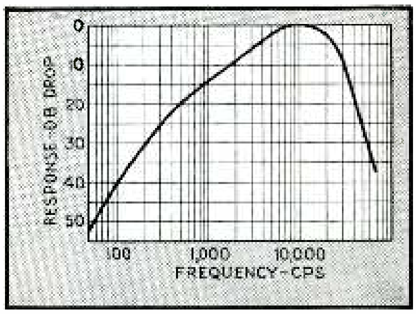


FIG. 5—Frequency characteristic of the three-stage audio amplifier which discriminates against low-frequency components

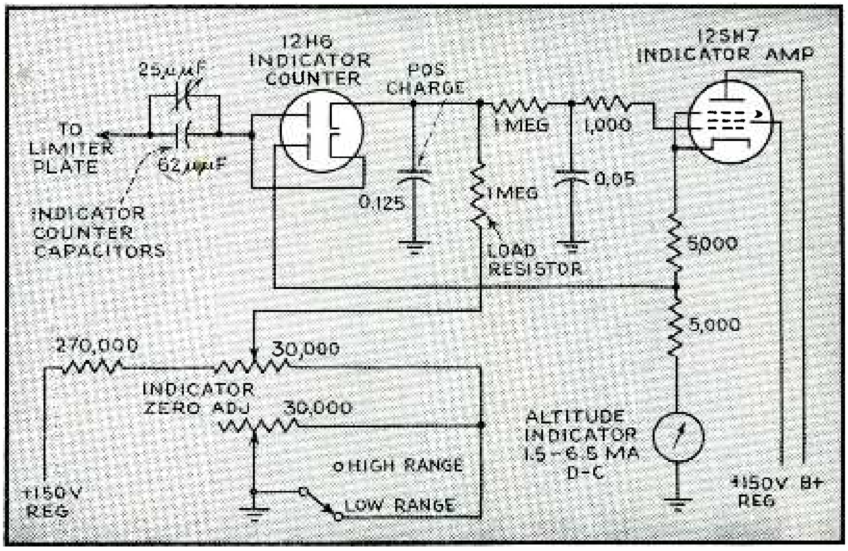


FIG. 6—Double-diode counter circuit, which develops a positive d-c voltage proportional to the beat note frequency

directly into the receiver detector.

The head end of the receiver is a balanced push-pull detector employing two type 9004 acorn diodes. The balanced detector mixes the received and transmitted signals. These signals are applied respectively in push-push and push-pull, an arrangement which avoids mutual coupling between the two signals. The push-push connection is a rod centrally located between two conductors of the detector tuned circuit, and the push-pull connection is a coupling loop. The detector circuit is balanced against amplitude-modulated signals and hence discriminates against amplitude variations introduced by the passage of the f-m signals through the resonant regions of the tuned circuits and antennas. The details of the detector are shown in Fig. 4.

The audio-frequency output (beat note) of the detector is passed to a three-stage audio amplifier which has the frequency response characteristic shown in Fig. 5. The low-frequency components are attenuated, since the amplitude modulation due to resonant effects is at a maximum at the modulation frequency (120 cps) and its lower harmonics. The gain characteristic also equalizes the amplitude of the beat note as a function of height, since the received signal is strongest when the aircraft is near the ground and the beat note has its lowest values. The a-f gain continues to increase above 7,600 cps, the maximum beat-note frequency. The high amplifier output drives the altitude indicator off scale when the altitude exceeds 400 and 4,000 feet, respectively, on the low and high altitude scale. The frequency charactertistic shown is obtained by the use of degenerative feedback. The amplifier is shock-mounted and is shielded against stray r-f pickup from other equipment.

The audio-frequency output of the amplifier is converted into a corresponding direct-current signal for altitude indication. This signal also actuates limit relays to indicate deviations from an assigned altitude or to control the automatic pilot. The conversion process begins in a limiter stage which converts the sinusoidal beat output (varying in frequency in accordance with Fig. 2) into a rectangular wave of about 135 volts peak-to-peak amplitude. The purpose of this limiter is to remove amplitude variations which may persist and to provide sharp leading edges which may be counted in determining the average frequency of the beat note. The limiter stage, an over-driven amplifier, limits the positive peaks by grid current and the negative peaks by grid voltage cutoff.

The output of the limiter stage is passed to two counter stages, which determine the average frequency of the beat note by counting the rectangular waves. The first counter operates the altitude indicator. This circuit, Fig. 6, consists of a double diode. One section of the diode passes the positive half-cycles of the limiter output, charging a capacitor and load resistor in shunt. The resistance and capacitance values are so chosen that the charge on the capacitor leaks off through the resistor at a rate approximating the conduction of charge through the diode. Hence when the positive rectangular waves arrive at a more rapid rate (higher beat note), the direct voltage across the capacitor tends to increase, and vice versa. This voltage is passed through a low-pass *RC* filter which averages the direct voltage and applies it to the grid of the output amplifier tube. A milliammeter in the cathode of the latter tube registers, over a range of 5 milliamperes, the average value of the direct voltage on the grid. This meter is calibrated directly in feet, 0 to 400 and 400 to 4,000. The scale shown is switched synchronously with the switch which controls the total deviation of the transmitted signal, so it is not possible to misread the scale.

A part of the voltage across the cathode resistance is fed back to the other section of the diode in the counter circuit. This diode passes the negative halves of the limiter output to ground, and this discharges the coupling capacitor, leaving it ready to receive the ensuing positive half. The feedback from the output amplifier biases the diode and improves the linearity of the indication.

A similar counter circuit is employed to actuate the limit relays. In this case, however, the polarity of the diodes is reversed, and a negative voltage is developed across the load. The amplitude of this voltage is substantially proportional to the frequency of the limiter output and hence to the altitude.

The counter voltage is passed to

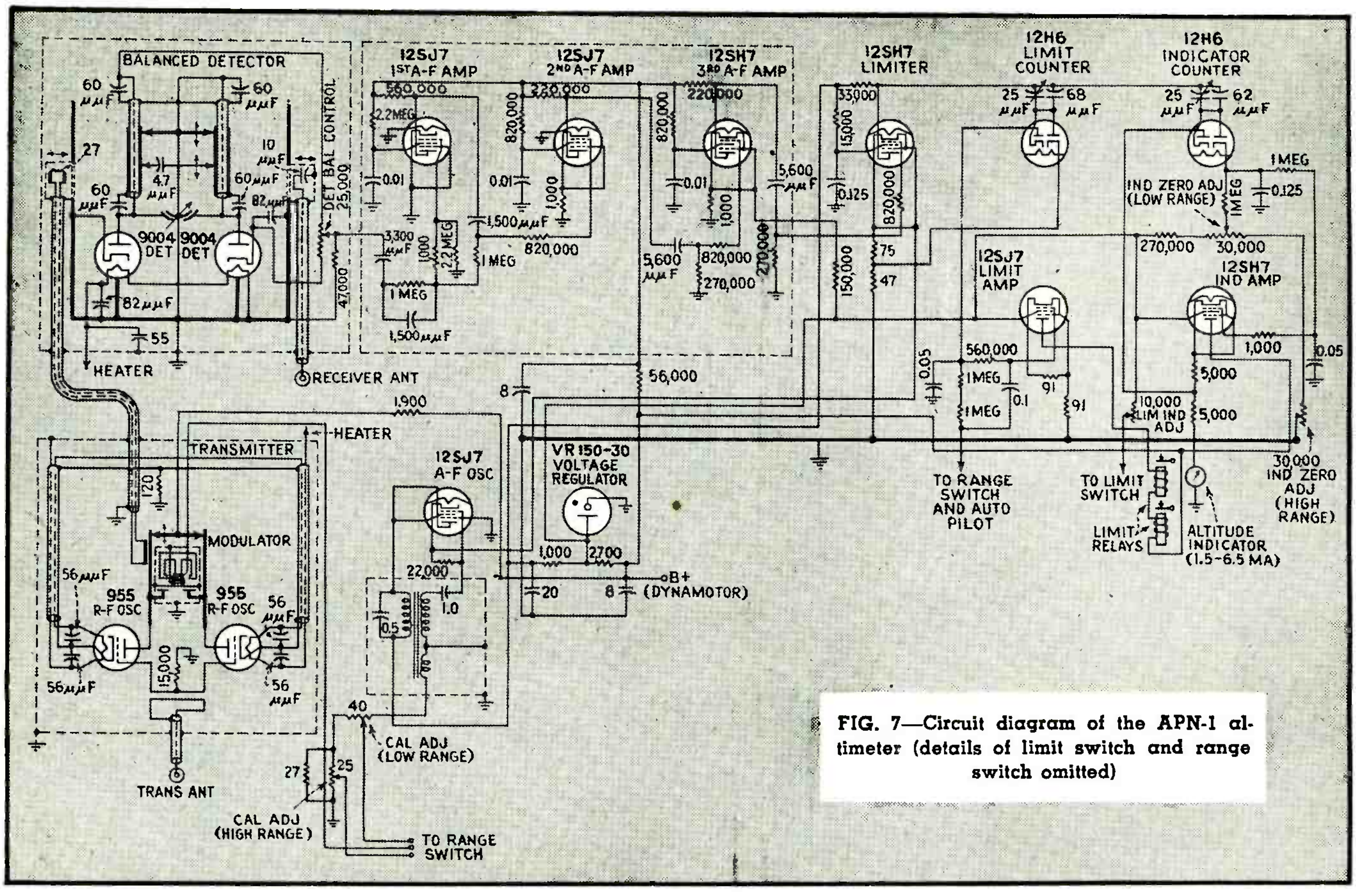


FIG. 7—Circuit diagram of the APN-1 altimeter (details of limit switch and range switch omitted)

the grid of a self-biased pentode stage. Relays in the plate circuit of this tube are actuated when the plate current exceeds certain limits. These limits are set by the operator, who adjusts a potentiometer which applies bias to the amplifier stage. This potentiometer is marked in feet and is set at the altitude at which it is desired to fly. The relays remain in their normal positions if the plane remains within 10 feet of the selected altitude. If the altitude deviates further than this, the counter circuit depresses or elevates the bias by an amount sufficient to operate the corresponding relay. Three lamps are controlled by these relays. One, white in color, lights when the relays are in normal position (altitude within 10 feet of the preset value). A red lamp lights when the altitude falls below the lower limit, and a green lamp when the altitude exceeds the upper limit. Corresponding voltage impulses are available to control the automatic pilot so as to correct altitude changes.

Physical Appearance

Three indicating units appear on the instrument panel of the aircraft, or at some other convenient point in the pilot's compartment. They are the altitude limit control, the indicating lamps, and the indicator dial. The on-off switch and range switch are provided directly on the face of the indicator. The total weight of the equipment is about 25 pounds, installed, and it consumes about 2.5 amperes at 27.5 volts d-c.

The accuracy is better than plus or minus five percent of the indicated altitude above terrain, plus or minus the six-foot uncertainty previously mentioned. On the high range, the fixed error is plus or minus 60 feet.

The two dipole antennas are installed so that the direct transfer of energy from one to the other is minimized. Usually the antennas are placed under the wings on either side of the metal fuselage. The antenna pattern, when the reflecting surface of the aircraft is taken into account, is a broad cardioid which illuminates the terrain below over a wide area. The f-m altimeter cannot be relied upon to detect obstacles dead ahead, although it will indicate rising ground and thus give advance warning of high ground ahead.

The power supply includes a dynamotor for plate and screen voltages, regulated by a gaseous regulator (type VR 150-30). The filaments of the tubes are connected in series parallel across the 27-volt supply. The complete circuit of the APN-1 altimeter is given in Fig. 7.

A model of the APN-1 has been approved by the Civil Aeronautics Authority for use in commercial aircraft. This equipment incorporates an automatic frequency response control in the audio amplifier. At low altitudes when no high frequencies are present except those due to noise, it is advantageous to reduce the high-frequency gain. Conversely, at high altitudes, high-frequency gain is required to amplify the weak beat note.

The editors wish to express thanks to Russell Newhouse of the Bell Telephone Laboratories and H. J. Markley of the RCA Service Company, for information on which this article is based.—D.G.F.

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High Speed Oscillograph

Oscillograph for transient measurements has rapid writing speeds, in excess of 50 centimeters per microsecond. Simultaneous viewing of cathode-ray tube screen by recording camera and operator facilitates positioning and focusing the trace between measurements

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HIGH WRITING SPEED oscillography capable of recording transient voltage or current wave shapes has become an indispensable tool of high-voltage engineering. That section of high-voltage engineering which deals with the behavior of circuits or apparatus under transient conditions requires laboratory equipment capable of producing and recording surge voltages and currents measured in kilovolts and kiloamperes, with time scales measured in microseconds. The transients to be studied are generally produced by the discharge of a number of capacitors in series and the recording is done by some form of cathode-ray oscillograph.

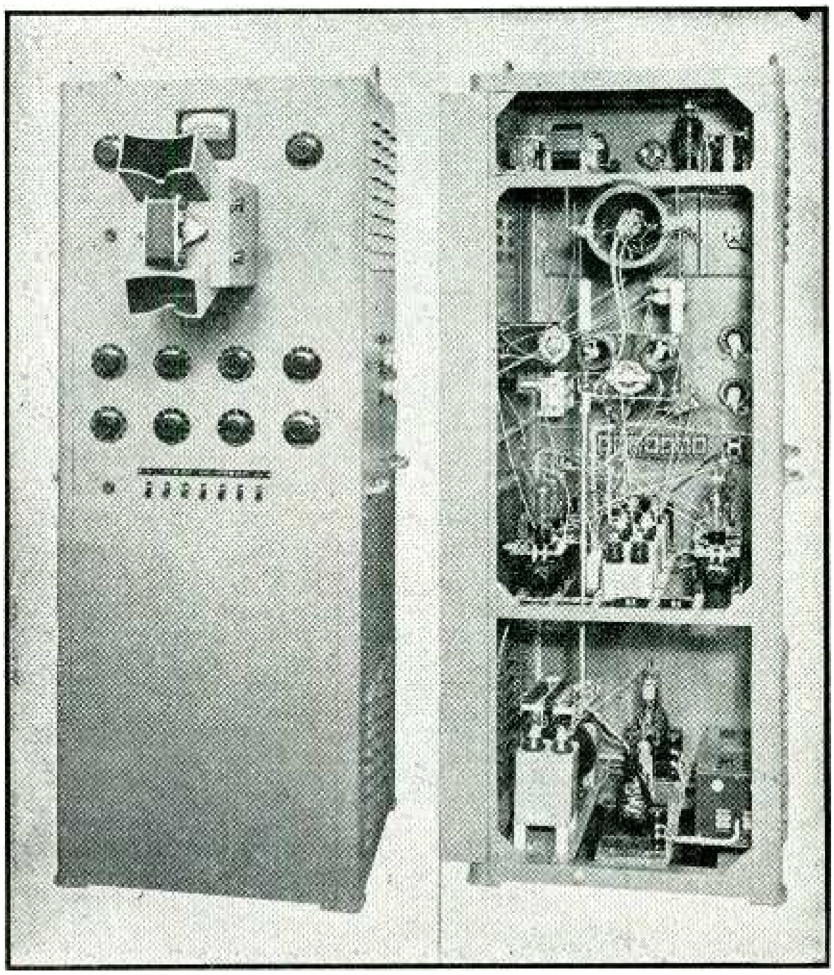
Oscillograph Features

Based on experience gained in operating several types of oscillographs in which the film was inserted in the vacuum chamber of the cold cathode, cathode-ray tube and the compartment vacuum pumped after each loading, an oscillograph was designed around a hot cathode, sealed off, cathode-ray tube (see Kuehni, H. P. and Ramo, Simon, A New High Speed Cathode Ray Oscillograph, *Electrical Engineering*, June 1937, p. 721, disc. 1401). Changes were made in this oscillograph as experience and special requirements suggested.

The features of the resulting oscillograph suit it to rapid recording of high-speed transients. The single, sealed off, cathode-ray tube eliminates delays of releasing and repumping the vacuum and the problems associated with the pumps. A small camera for photographically recording the transients portrayed on the screen and giving records about 20 to 25 percent of screen size is mounted in front of the tube. New rolls of film can be quickly inserted.

Other oscillographs have been built containing two or three cathode-ray tubes with rotating or moving film cameras, and with cameras taking full-size pictures. Optical systems can be designed to have separate cameras for the multi-tube types or, by means of mirrors, three tubes may be covered by one camera.

The cathode-ray tube is mounted horizontally in a magnetic shield



Cabinet houses magnetically shielded cathode-ray tube, sweep generator, and high-voltage power supply. Voltage regulator at bottom prevents interference from power line fluctuation. Operator can view screen during tests from a standing or sitting position

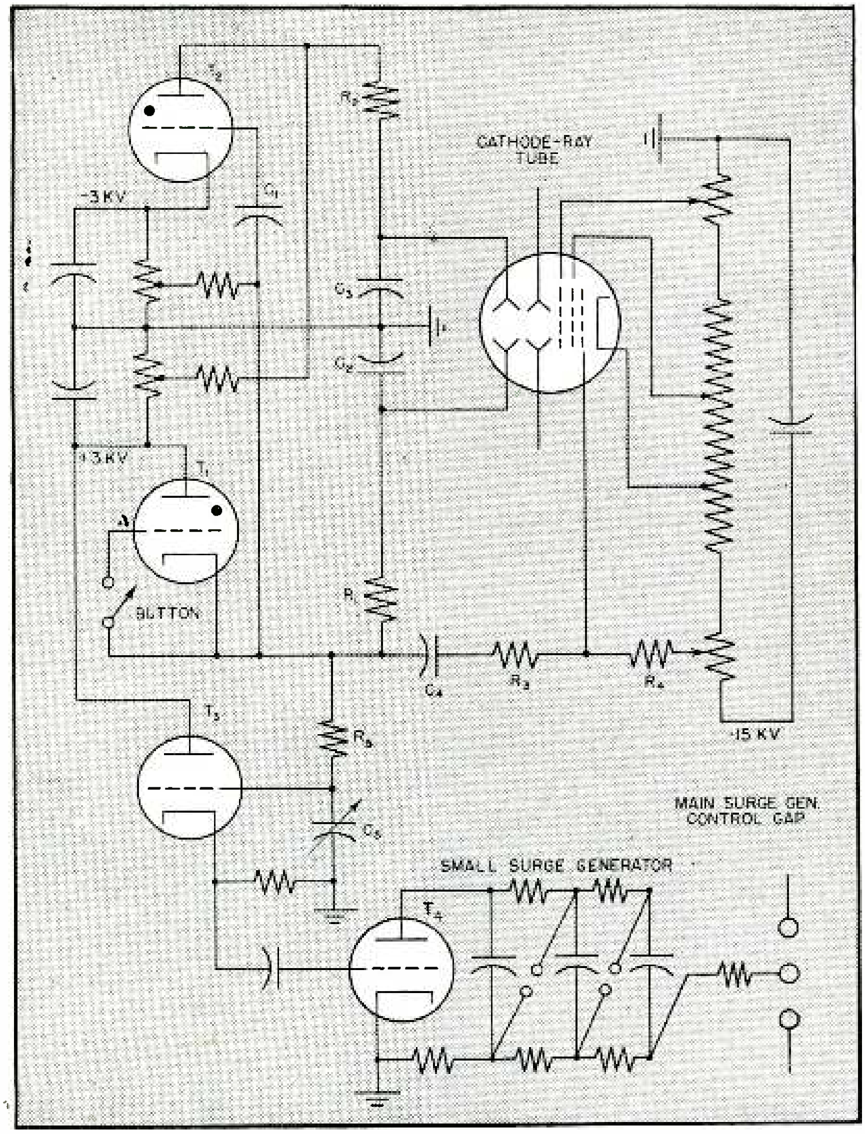


FIG. 1—Sweep generator can either trigger or be triggered by transient under observation

near the top at a level most convenient for visual observation. The camera holder has two eyepieces, one above the camera for observation from a standing position, and one below for operation from a sitting position. Image focusing and continuous visual checking of performance can thus be made without delay or interruption. The size of the steel cabinet, two feet square and five and a third feet high, permits building a desk or table around it for more convenient operation. Power and deflection terminals are on the right side. A door at the back gives easy access to all parts.

At the top right is the timing wave oscillator, giving frequencies of 10, 50, 500, and 5,000 kc at several hundred volts. At the upper left is the d-c, deflection calibration circuit having a single-wave rectifier and a range of 0–1,000 volts. Below the cathode-ray tube are the sweep and beam control circuits shown in Fig. 1. Rectifier and bias arrangements have been omitted for simplicity. The balanced, thyratron-operated time axis generator gives sweeps ranging from one to 2000 microseconds duration. In the bottom is the 15-kv voltage doubler cathode d-c supply, a resistance divider for obtaining potentials for other tube elements, and a constant voltage transformer to insure accuracy despite fluctuating line voltage.

Figure 2 shows a series of oscillograms taken for plotting the volt-time breakdown curve of a 20-inch rod gap. Time axis and deflection calibrations are also given. This figure illustrates the sort of surge test records which can be obtained. The oscillograms were taken about as fast as the surge generator adjustments were made. The fastest writing speed shown in these records is some 20 centimeters per microsecond. For inclusion in reports these records can be enlarged to suitable size. For tabulating test data and measuring voltage and time values it is most convenient to project the negatives on ruled graph paper.

Oscillograms

Figure 3 shows a record of the flashover of a transformer bushing on the front of the wave. The oscillation after breakdown required a writing speed of about 50 centimeters per microsecond. However, this writing speed is by no means the available maximum. This record was taken with a one to one $f/3$ lens and those in Fig. 2 with an $f/2$ lens. In the course of our laboratory work, writing speeds of several meters per microsecond have been required and easily obtained with an $f/1.5$ lens. Such performance is not unusual and does not require additional skill on the part of the operator.

Sweep Tripping

In the above application the tripping of the surge generator was controlled by the sweep circuit of the oscillograph. Another problem frequently encountered is that of recording a surge whose time of occurrence cannot be controlled. The same sweep circuit used for surge generator work may be used in this connection because it can be tripped and the beam established on the screen with a loss of only 0.2 to 0.3 microseconds. This tripping may be repeated as often as sixty times a second if repeated surges are required. In most cases the loss of 0.2 microsecond is unimportant. Where necessary, this loss can be regained by connecting a delay cable between the surge point and the deflection plates.

The repeating characteristic of the sweep circuit makes possible studies of such varied phenomenon as high-frequency vibrations, lightning or switching surges, and ignition circuit transients. In the latter case the deflection plates may be connected to one spark plug and every spark wave shape observed on the screen. Then the effect of various operating conditions can be quickly determined. Records are taken either by snapshot exposure of the stationary film camera or by using a moving film camera.

An application which has lately become important is the measurement of short time intervals either on a single or repeating basis. A deflection voltage of 100 volts is ample for indicating a point along the time axis, and therefore microsecond intervals between phenomenon in one or more circuits can be conveniently measured.

Typical Application

In Fig. 1 is a diagram of the oscillograph as used with a surge generator. The operation is as follows: pushing the button fires the positive sweep thyratron T_1, raising its cathode from about −1500 volts to +3000 volts. This change of voltage has four functions: (1) it immediately trips the negative sweep tube T_2 through coupling capacitor C_1; (2) it provides half the sweep voltage by charging C_2 through R_1, the other negative half being provided by C_3 charging through R_2; (3) it establishes the cathode-ray beam by reducing the negative bias on the cathode-ray tube control grid through the circuit C_4, R_3, R_4; (4) it fires the time-delay thyratron T_3 at some time later depending on resistance R_5 and capacitance C_5.

The firing of thyratron T_3 immediately causes the large thyratron T_4 to fire, thereby tripping the small surge generator. The small surge generator has an output of about 70 kv which is enough for tripping the control gap of the main surge generator. The complete tripping is accomplished with such precision that no variation is visually noticeable in the position of the surge on the screen even on the one-microsecond sweep. For such precision the gaps of both the tripping and the main generator have to be preionized either with ultraviolet light or with corona.

With the sweep already established and in motion, the surge is applied to the vertical plates where it can be observed and simultaneously recorded photographically. Several hundred such records may easily be obtained in an eight-hour day, assuming normal time to prepare each test point.

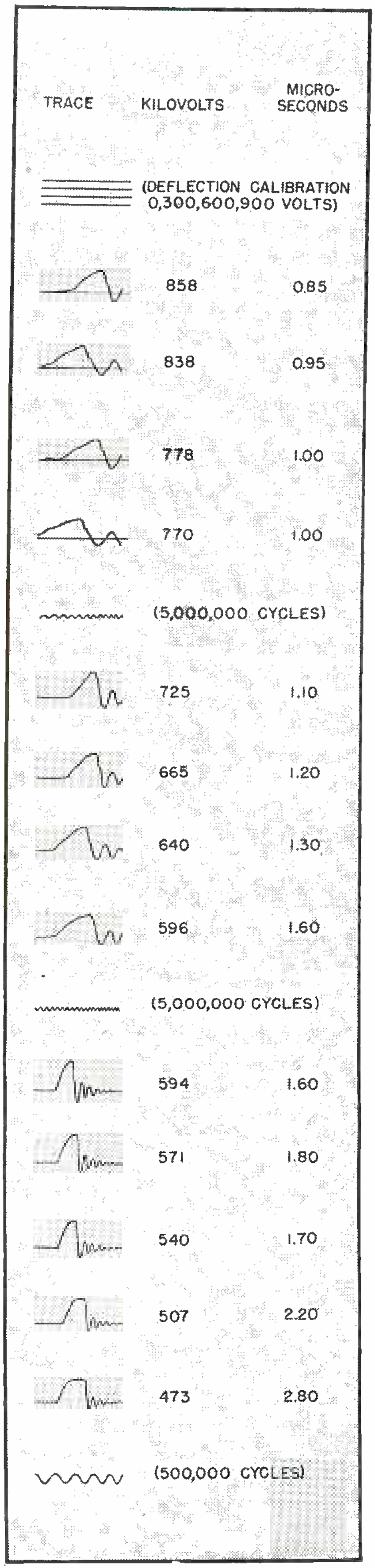


FIG. 2—Series of test oscillograms

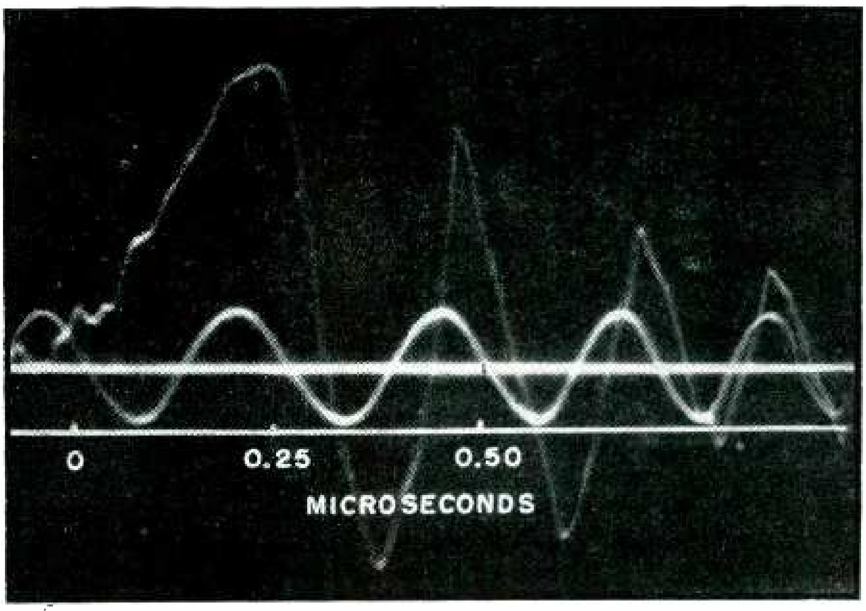


FIG. 3—Record of high-voltage transformer flashover

Grounded-Grid Power

Radio-frequency power amplifiers using grounded-grid circuits operate at higher frequencies and can handle wider bandwidths than capacitance-neutralized grounded-cathode circuits. These advantages suit the grounded-grid circuit to television, f-m, and industrial uses

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POWER AMPLIFICATION at high frequencies has always been a difficult technical problem. As the frequency is increased, the problems become more difficult. A number of these problems can be alleviated by a novel circuit which, undoubtedly, is destined to be used widely in the high-frequency field. This circuit is often called the grounded-grid circuit, and while it is not new it has not until recently received the attention it deserves. The purpose of this article is to call attention to this circuit, point out its advantages and characteristics, and show how such a circuit is designed.

There are three practical ways of utilizing a triode as an amplifier. The most common way is to apply the input signal between grid and filament terminals and take output from plate and filament. A second way is to apply input to grid and plate and take output from filament and plate. This type of amplifier is known as a cathode follower. The third way is to apply input to grid and filament and take output from plate and grid. There is no generally accepted name for this type of amplifier. It has been variously called grounded-grid amplifier, inverted amplifier, and common grid circuit because the grid is common to the input and output circuits. According to this terminology, the normal amplifier would be called a common cathode circuit, and the cathode follower would be a common plate circuit. In this article, the designation grounded-grid will be employed since it has been used fairly widely.

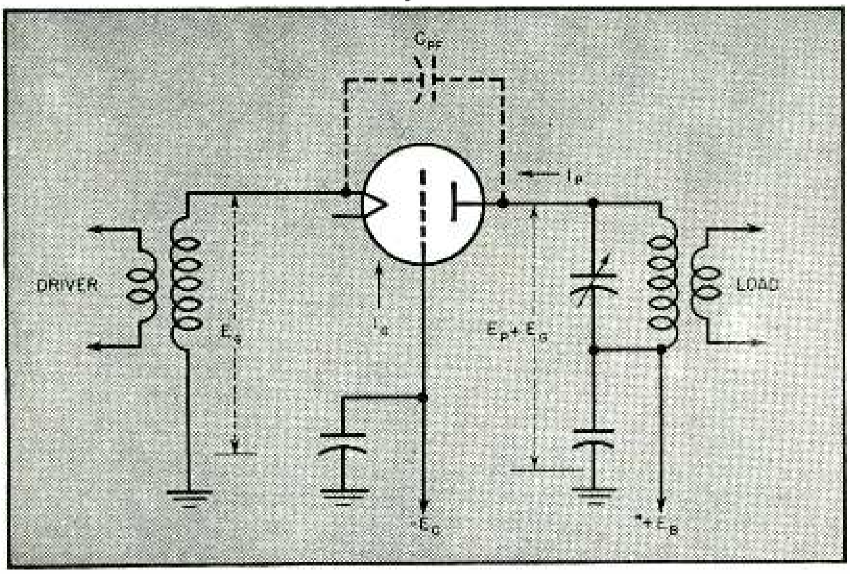


FIG. 1—Circuit and parameters of grounded-grid r-f power amplifier

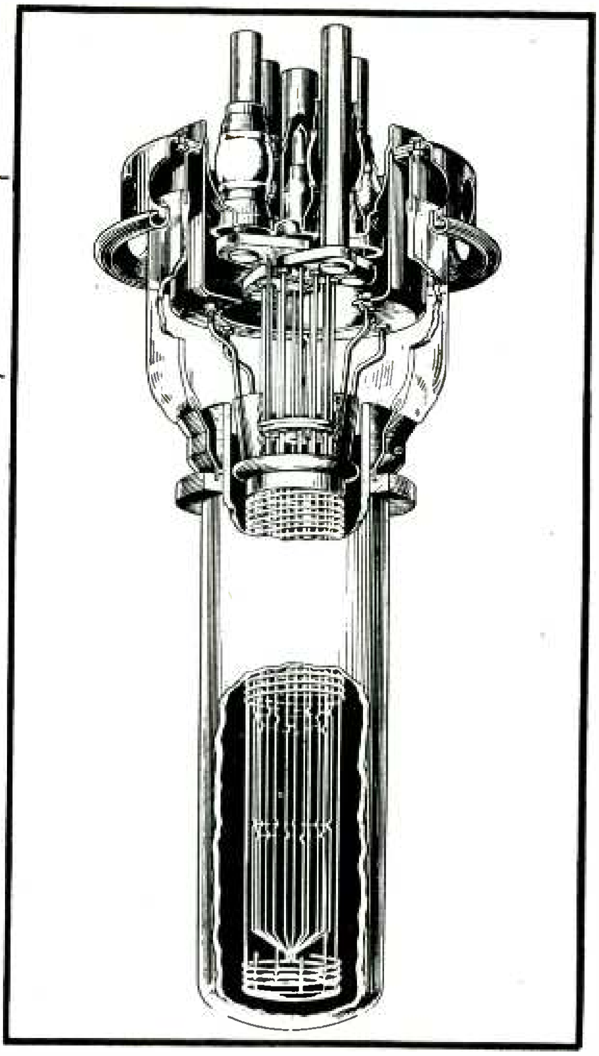
Problems of Tube Design

Consider a normal triode circuit with input applied between grid and filament and a tuned output circuit between plate and filament. The filament is grounded. It is well known that such an amplifier will oscillate by itself at some undesired frequency because of feedback through the grid-plate capacitance of the tube. The cure for this difficulty is neutralization. However, as the frequency is increased, neutralization becomes increasingly difficult to handle. Because feedback is caused by capacitance between grid and plate and because any external neutralizing circuit is isolated from the internal capacitance by the inductances of grid and plate leads, the frequency band over which the tube can be neutralized becomes narrower and narrower with increasing frequency and finally vanishes altogether. Another undesirable effect is that capacitance neutralization serves to increase the input and output capacitances of the amplifier. For example a push-pull cross-neutralized amplifier has an output capacitance per tube equal to the plate-filament capacitance of the tube plus twice the grid-plate capacitance. This resultant high capacitance narrows the r-f bandwidth that can be handled or it may reduce the efficiency of the amplifier because of excessive circulating kilovoltamperes.

Tetrodes and pentodes were developed to overcome the foregoing

Amplifiers

FIG. 2—Cut-away view showing method of extending grid cylinder to complete the shielding between filament and plate circuits in a triode especially designed for grounded-grid circuits



difficulties. In these types of tubes, the screen and suppressor shield the control grid from the plate so that the feedback capacitance is low enough to make neutralization unnecessary. However, as the frequency is increased, self-oscillation may occur if the screen and suppressor leads have appreciable inductance. Then, these grids cannot be held effectively at r-f ground potential and, as a result, feed-through may occur. Twin tubes such as the RCA-829B were designed to overcome this difficulty. In a twin tube designed for push-pull operation, screen grids and cathodes can be intimately connected within the tube so that practically no inductance is present between these electrodes. Tubes of this design give excellent performance. The only difficulty is that tube cost for a twin-pentode tends to be high compared to the cost of triodes or triodes for equivalent power output capability.

Circuit Characteristics

The grounded-grid circuit is a way of using a triode which reduces the possibility of self-oscillation without the need for neutralization. Figure 1 shows a grounded-grid amplifier circuit, in which the control grid acts as shield between plate and cathode to reduce feedback capacitance C_{PF}. Thus, the control grid performs one function of a screen grid in a tetrode.

A second characteristic of the grounded-grid circuit is that the driver tube and output tube act in series to supply the load. In Fig. 1, the driver produces an r-f voltage E_G across the input terminals of the output tube. The latter has an r-f voltage E_P across its plate and cathode. These voltages are 180 degrees out of phase with respect to the cathode so that the r-f voltage from plate to grid and also across the output circuit is $E_P + E_G$. If I_P is the fundamental component of plate current 180 degrees out of phase with E_P, and I_G is the fundamental component of grid current in phase with E_G, the following relations then hold

Power delivered to load circuit = $(E_P + E_G)I_P$

Power delivered by output tube = E_PI_P

Driver power transferred to load circuit = E_GI_P

Power delivered by driver circuit = $E_G(I_P + I_G)$

Power absorbed by output tube = E_GI_G

It is apparent from these relationships that driver tube and output tube act in series to supply the load circuit. Power output, therefore, is higher than would be expected and the conventional efficiency, based on the input to the output tube, is unusually high.

The foregoing discussion brings out a third characteristic. The driving power of a grounded-grid amplifier is higher than when the same tube is used in a normal triode circuit and may be three to ten times greater. However, this increased power is not lost; it is merely transferred to the plate circuit and appears as output, as explained above.

Tubes for Grounded-Grid Circuits

A fourth characteristic is lower output capacitance. In a grounded-grid circuit, output capacitance is approximately C_{GP}, whereas in a normal capacitance-neutralized amplifier the output capacitance is more than twice this value. This fact is most important at high frequencies because lower output capacitance results in increased r-f bandwidth-handling capabilities and in lower circulating kva in the output circuits.

All of the foregoing characteristics are advantageous with the exception of the increased driving power. The latter is a disadvantage because it may require more or bigger amplifier stages in the transmitter design. Because a pentode or beam tetrode does not have this disadvantage, the field of application of grounded-grid amplifiers is at frequencies at which pentodes are not available for the desired power, or where the cost of pentodes is greater than the cost of additional driving stages required by the grounded-grid circuit. Present indications are that the frequency and power boundaries are about as follows

Power in Kw	*Frequency in Mc*
0.1	300
25	30
100	10

For the stated power, the grounded-grid circuit becomes desirable at a frequency above that listed.

Most of the characteristics which make a triode desirable in a normal circuit also make it desirable in a grounded-grid circuit. However, there are some additional requirements for a good grounded-grid tube. It has been stated above that the grid and its associated external ground plane should act as a screen between anode and cathode and their respective circuits. Therefore, the tube should be so designed that the anode and cathode connections are on opposite sides of the grid connection. For example, a tube which has an external anode with the grid terminal insulated from one end and the filament terminal insulated from the other end is not at all suited for grounded-grid operation. On the other hand, a tube such as the 9C21 illustrated in Fig. 2 is ideally suited for grounded-grid operation because the grid terminal is a large metal flange which can be connected to a metal shield separating the anode circuit from the cathode circuit. In addition, the grid support of the 9C21 has very low inductance and, therefore, meets the second requirement for a good grounded-grid triode.

Let it be required to design a grounded-grid stage utilizing one 9C21 triode. The tube will be used in the circuit shown in Fig. 1. The manufacturer's data show the following typical operating conditions for normal grounded-cathode circuits

D-c plate voltage = 17,000 v
D-c grid voltage = —1,600 v
Peak r-f grid voltage = 2,200 v
D-c plate current = 7.9 amp
D-c grid current = 0.9 amp
Driving power = 1,800 w
Power output = 100 kw

Amplifier Design

It is first necessary to obtain the r-f plate voltage swing E_p. This can be estimated from the fact that in a properly excited class-C amplifier, the plate voltage will swing down to the value of the peak positive grid voltage. Because the value of the latter is equal to 2,200 minus 1,600 volts, or 600 volts, E_p is $2^{-\frac{1}{2}}(17{,}000-600) = 11{,}600$ volts rms.

Next, the fundamental components of plate current and of grid current must be obtained using the power output and driving power values given above

$$I_p = \frac{100{,}000}{11{,}600} = 8.63 \text{ amperes}$$

and

$$I_g = \frac{1{,}800\sqrt{2}}{2{,}200} = 1.16 \text{ amp.}$$

The output power and the driving

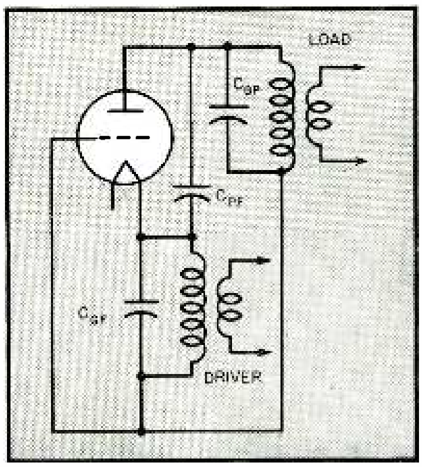


FIG. 3—Rearrangement of circuit of Fig. 1 shows that the grounded-grid amplifier is similar to the Colpitts oscillator

power of the grounded-grid stage can now be calculated from the relations given earlier. We obtain

$$\text{Power output} = (E_p + E_g)\, I_p$$

$$= \left(11{,}600 + \frac{2200}{\sqrt{2}}\right) 8.63 = 113 \text{ kw.}$$

$$\text{Driving power} = E_g(I_p + I_g)$$

$$= \frac{2200}{\sqrt{2}}\,(8.63 + 1.16) = 15.2 \text{ kw.}$$

It is possible to change the power output to some extent by varying the grid bias and the grid swing. For example, if the bias should be changed from −1,600 to −2,000 volts and the grid swing by a like amount, i.e., to 2,600 volts, the power output would be 116 kilowatts.

A grounded-grid amplifier stage can go into self-oscillation, particularly at high frequencies, because of feedback from plate to cathode through the plate-filament capacitance. This action is more easily understood if the amplifier stage is redrawn as a Colpitts oscillator circuit, as shown in Fig. 3. Because we are dealing with the worst conditions, inductive tuning only is assumed. The output circuit must be inductive at the oscillation frequency, as the following analysis proves.

Conditions for Oscillation

It is well known that circuit reactance between filament and grid must be capacitative and, furthermore, should be at least one-fifth the reactance between plate and filament. This reactance will produce an excitation ratio, that is, a ratio of plate swing to grid swing, of five. In any good grounded-grid tube, the plate-filament capacitance will be so low that its ratio to the grid-filament capacitance will be much less than one-fifth. Thus, to produce oscillation, the input circuit must be inductive so as to reduce the effective capacitance between grid and filament to a value about five times that of the plate-filament capacitance. With tuned input circuits, this condition can easily be fulfilled. Let it be assumed that this condition is exactly fulfilled.

The total tank circuit capacitance is then

$$C_T = C_{PF} + \frac{5\, C_{GP}\, C_{PF}}{C_{GP} + 5\, C_{PF}}$$

In the case of 9C21, this capacitance would be

$$C_T = 1.8 + \frac{48 \times 5 \times 1.8}{48 + 5 \times 1.8} = 9.4\ \mu\mu\text{f}$$

Thus for this 100-kw tube, the tank capacitance for parasitic oscillation is only 9.4 $\mu\mu$f, a value which is quite small. This capacitance will

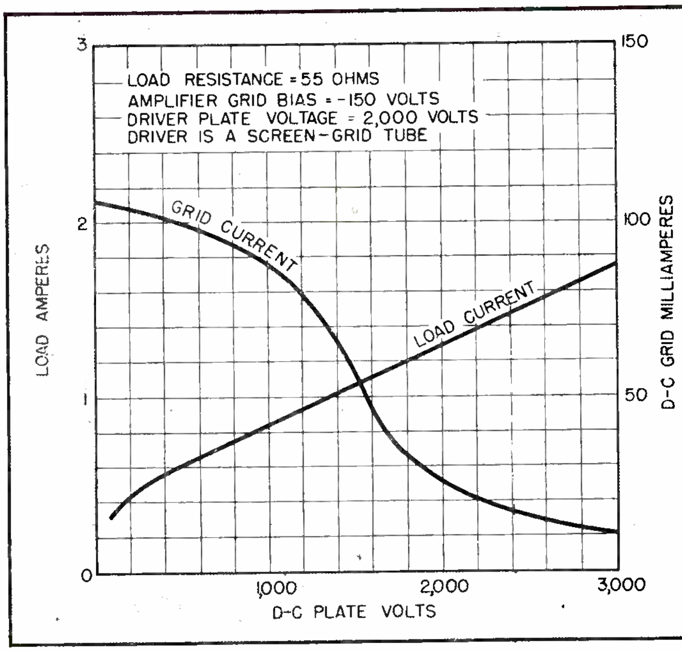


FIG. 4—Plate modulation characteristic of grounded-grid r-f amplifier

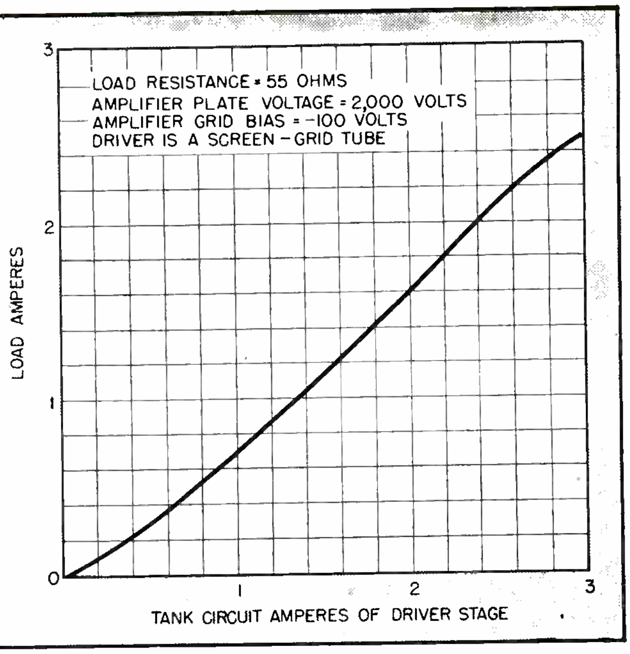


FIG. 5—Class-B power amplification characteristic of grounded-grid circuit

store only appreciable amounts of power at high frequencies. Assume operation at a frequency of 20 mc. The reactance of C_T is then 850 ohms. If the tube is operated at 12 kilovolts with a plate swing of 11.6 kilovolts, the reactive power is $(11,600/2)^2/850 = 80$ kilovoltamperes.

We also know that oscillator stability necessitates an operating Q of at least 12. Therefore, in the above case, the circuit could be loaded to 6.7 kw. If all the circuit losses, including driving power and any power delivered to the load, are less than 6.7 kw, the tube will oscillate with certain adjustments of the input and output circuits. If we assume that the normal output circuit loss is five percent of 100 kw, or 5 kw, this value plus the driving power and the normal load coupled to the tube would be sufficient to make the amplifier stable at the assumed frequency.

Modulation Characteristics

When plate modulation of only a grounded-grid amplifier stage is attempted, a characteristic such as illustrated in Fig. 4 is obtained. It will first be noted that grid current varies widely with plate voltage. As the plate voltage increases, the plate current also increases and causes an increasing load on the driver stage. Due to the regulation of the latter, driving voltage decreases and with it grid current. This decrease of grid current is quite large and is characteristic of this type of amplifier.

Over quite a range of plate voltage, the output current is linear with plate voltage as in the case of conventional class C amplifiers. However, at low voltages load current departs from linearity and will not be zero until negative values of plate voltage are reached. This phenomenon is due to the fact that r-f driving voltage and d-c plate supply voltage are in series as shown in Fig. 1. As a result the plate not only has a d-c supply voltage but also simultaneously an r-f supply voltage. Therefore, the plate current and the load current do not drop to zero until a value of negative plate voltage equal to the value of the peak driving voltage is reached. Accordingly, the resultant characteristic of modulating only a grounded-grid stage shows distortion unless one is satisfied with partial modulation. To obtain a modulation characteristic which will permit 100-percent modulation, it would be necessary to modulate simultaneously one or more successive stages.

The above problem is of little practical consequence because amplitude modulation is rarely used at the high frequencies for which the grounded-grid circuit is particularly applicable. The problem does not exist for such services as frequency-modulation, television and industrial power.

When a grounded-grid amplifier is used as a linear, class-B r-f amplifier, quite satisfactory results are obtained, as shown in Fig. 5. Such an amplifier could be used to amplify television signals.

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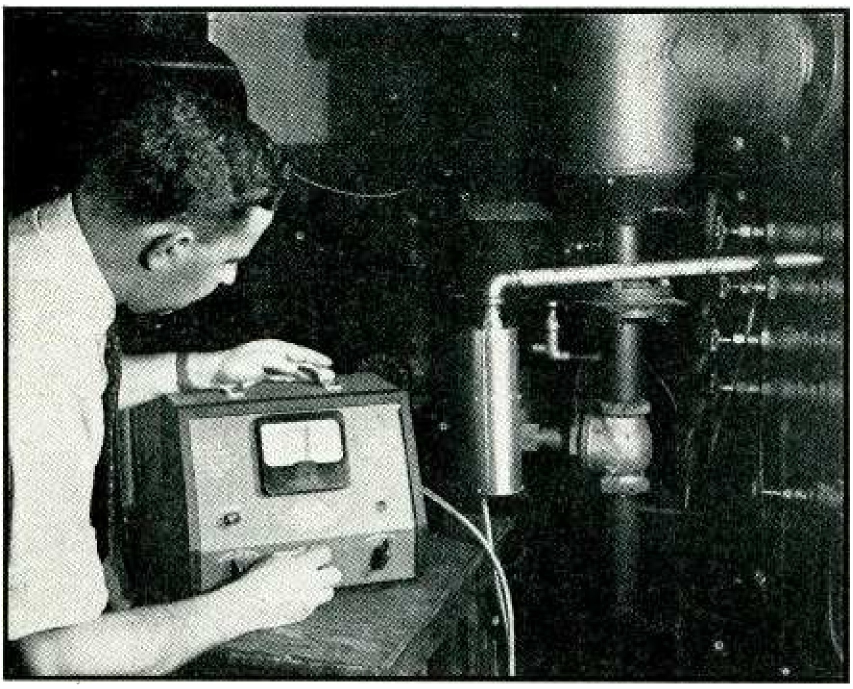
Radium-Type Vacuum

Gas molecules are ionized by alpha particles from a pellet of radium, in linear relation to gas pressure, and the resulting ion current is collected and measured with a special high-gain d-c amplifier using an acorn tube and having up to 10^{12} ohms input resistance



Alphatron radium-type vacuum gage in use on an industrial high-vacuum furnace, registering a gas pressure of 6 mm during pumpdown. The polished metal cylinder attached to the pipe at the right contains the ionization chamber (upper section) and the probe amplifier stage

PRESSURE measurements in the interval between one micron and ten millimeters are required in a number of industrial processes, some of which are indicated on the chart in Fig. 1. The chart also portrays the intervals covered by conventional gages[1] in comparison with the range of a radium-source ion gage described in this article. **By utilizing the ionization effect of emanations from a small, permanent radium source, this gage gives indications of gas pressures accurately, directly, and continuously in the in-between range covered only by the unwieldy and fragile McLeod gages.**

Since the ionization effect is produced by the constant flow of alpha particles from a sealed radium source, there is no filament to burn out and no filament current to set and maintain. Furthermore, the gage cannot be damaged by exposure to atmospheric pressure. It is ruggedly constructed of all-metal parts not subject to breakage. There is no degassing to be done when the gage is turned on, and the absence of mercury vapor eliminates one of the common contaminators of vacuum systems.

The use of the ionization effect in the high-pressure range avoids the lag in readings common to gages utilizing the principle of thermal radiation and gives instantaneous response to pressure changes. Within the three standard ranges no complicated calibration curves are required for different gases, there being a linear reaction to pressure. Gases other than air can be measured merely by applying a multiplying factor to meter readings.

Since air and water vapor give so nearly equal ionization currents, the instrument is ideal for all vacuum applications involving mixtures of these two gases, as in dehydration equipment. If the gage is set to read total pressure of a 50-50 mixture of air and water vapor, it will be accurate within approximately 7.5 percent for all mixture ratios.

At pressures above about 25 mm the recombination of ions produced in the chamber becomes appreciable and linearity is lost, although the gage may be calibrated for pressures up to and beyond atmospheric, as shown in Fig. 2.

Throughout its linear range, when used with the amplifier to be described, the gage measures pressures with three scales of sensitivities: 0-100 microns, 0-1 millimeter, and 0-10 millimeters. Normally the combination of gage and amplifier is calibrated for air pressures, while other gas pressures are determined by the use of conversion factors; however, the scales may be set to read directly for other atmospheres where this is desired. Figure 3 shows the relative response for the ordinary gases encountered. It will be seen that the high relative response to acetone vapor lends itself admirably to the acetone technique of leak detection on kinetic vacuum systems.

Theory of Operation

Alpha particles emitted by a radium source collide with gas molecules in the ion chamber, producing approximately 33 ion pairs per cm of path length per mm air pressure, per alpha particle.[2,3] By the action of an electric field strong enough to effect saturation currents, these ions

Gage

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are collected at a rate dependent upon their production, and thus constitute a minute current whose magnitude is a linear function of pressure. Since the alpha activity of a radium source in equilibrium with its immediate decay products is constant for all practical purposes, it only becomes necessary to measure these currents in order to evaluate pressures.

Some 10^7 alpha particles per second are ejected into the ion chamber from the 200-microgram radium source used. With a mean path length of 5.5 cm in the ion chamber, it is predictable that approximately 2×10^{-10} amp of ionization current is to be realized per millimeter of air pressure. Since the recombination of ions is a function of collection field strength and molecular mean free path, an increasing fraction of the ions produced will be lost in this manner and at some high pressure the deviation from linearity will become detectable for any one set of gage conditions. This point is at 25 mm, for the present design, and no further increase is necessary here for this is well within the operating region of simpler pressure gages.

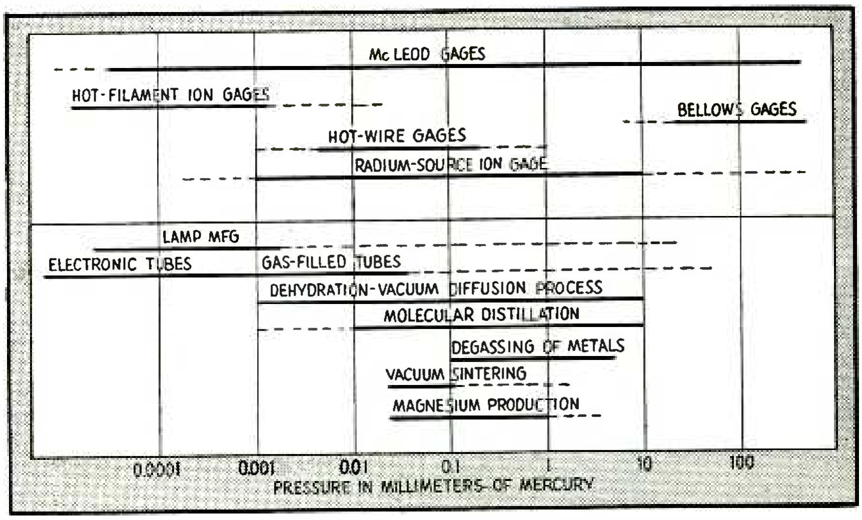


FIG. 1—Pressure ranges of vacuum gages and processes. Solid lines indicate definite regions of operation, while dash-dash lines represent regions that are questionable or to which special gages may extend

D-C Amplifier Circuit

The essential features of the radium-type vacuum gage are illustrated in Fig. 4, and include the following: (1) the vacuum chamber, a brass shell with suitable vacuum-tight insulators and provision for making connection to a vacuum system; (2) the radium source, containing approximately 200 micrograms of radium, sealed to prevent radon loss, and in equilibrium with its immediate decay products; (3) ion collector electrodes, with a plate electrode being used to produce an electric field for ion collection, and a grid essentially at ground potential to minimize the effect of electrical leakage across the input insulator; (4) a suitable means of measuring

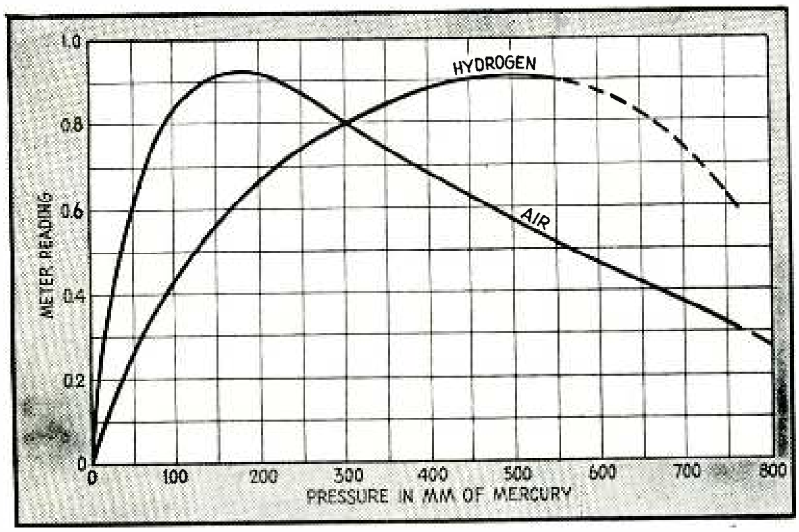


FIG. 2—Calibration curves for extended range of radium-type vacuum gage, indicating possibility of measuring air pressures well over atmospheric if operator knows whether he is above or below the 175-mm peak of the calibration curve. Range setting IV on the instrument is used for these higher-pressure measurements. A separate calibration curve must be prepared for each gas, using a McLeod or bellows gage as a standard

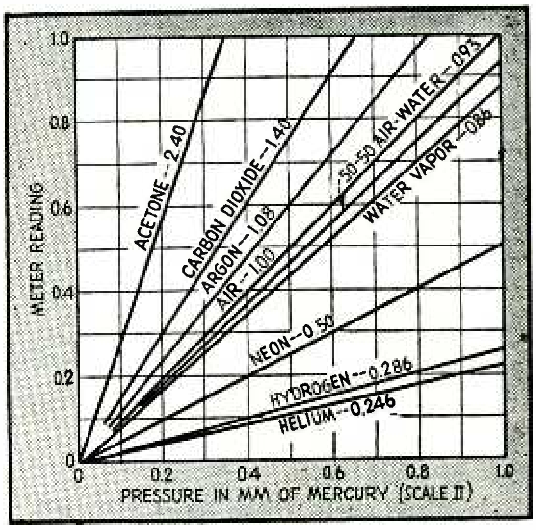


FIG. 3—Calibration curves showing linear performance of gage over its three normal ranges. For scale I, multiply abscissa values by 10; for scale III, multiply abscissa values by 100 and read as microns of mercury. Values on curves give relative response

the minute ion current produced.

The high-gain d-c amplifier devised by Shepard Roberts[4] lends itself admirably to the job at hand. The basic circuit is given in Fig. 5. Once the cathode bias (E_C) has been adjusted with no input current I_I so that the battery voltage is equaled by the cathode resistor drop E_2 in the second stage, there will be no output current I_0 indicated by the meter. Now, if a minute input current I_I flows through R_I a signal voltage E_I is developed. This signal voltage is opposed by the output voltage E_0, so that the net change of bias on VT_1 is $\Delta E_G = E_I - E_0$. If μ is the overall gain of the circuit, $\mu\Delta E_G = E_0 = \mu(E_I - E_0)$. From this, $E_I = E_0(1 + 1/\mu)$.

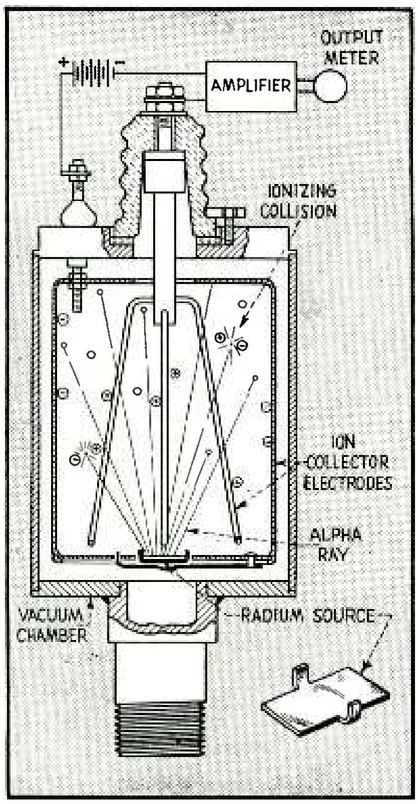


FIG. 4—Cross-section of ion chamber, showing location of radioactive source and collector electrodes

If the gain μ be made large, the factor $1/\mu$ may be neglected without sensibly affecting the relationship. Then $E_I = E_0$, or $I_IR_I = I_0R_0$. Rearranging gives $I_I = I_0R_0/R_I$; in other words, the calibration (current amplification) is a matter of resistor ratios only and is independent of widely changing tube characteristics so long as the gain remains high. At the same time the potential of the input grid with respect to ground is changed only by E_I/μ, thus minimizing the effect of electrical leakage across any insulator in the input circuit.

If a 200-microampere meter is used to indicate I_0, it is possible with resistor ratios of 10^7 to measure 2×10^{-11} ampere at full-scale deflections. This is the order of ion currents realized from the gage at 100 microns of air pressure.

Experimental and Production Models

Originally the Roberts circuit was tried with a 6C6-6K5 tube lineup and found satisfactory for gage operation at 0-1 mm and 0-10 mm sensitivities. In this version a single 1,000-megohm input resistor was used in conjunction with switchable 1,000 and 10,000-ohm output resistors. The amplifier then operated on 0.2 and 2.0 volts of signal.

To obtain a third scale by using a 100,000-ohm output resistor would require 20 signal volts on the same basis and since the battery is only 22½ volts, this means of attaining an additional range is not satisfactory.

By the same token one cannot go in the other direction to operate on a 0.02-volt signal. For a 0.2-volt signal and a μ of 100, we obtain $\Delta E_G = E_I/\mu = 0.2/100 = 2$ millivolts for full-scale deflection. Hence for one-percent scale deflection only 20 microvolts of ΔE_G are required. This was found by experience to be the lower limit that gave stable operation, free from zero-setting drift and sporadic fluctuation. Even though the zero setting may drift, the current amplification is unaffected, and I_I is determined by simply resetting and then reading. Zero is reset by disconnecting the input and adjusting E_C for zero I_0.

No attempt was made to measure the inherent grid current of the 6C6 first stage since it was possible to use the amplifier after adjusting the value of heater voltage to approximate the circuit values given in Roberts' article. By using a value of 2×10^{11} ohms for R_1, the amplifier was pressed to its limit.

In the production model, the first stage of the amplifier was located at

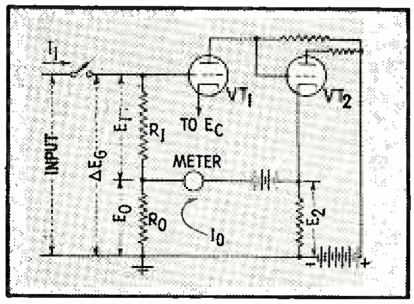


FIG. 5—Basic d-c amplifier circuit

the end of a cable in a probe assembly, since it was considered inadvisable to attempt piping the minute ionization currents from the gage to the amplifier. The need for three ranges of sensitivity (0-100 microns; 0-1 mm; 0-10 mm) dictated that some means of switching the input resistors be provided so that the entire blind spot in the pressure spectrum could be adequately covered. This was first effected by a switch on the probe, but later a relay was added to make all operations remotely controlled.

Acorn Tubes Is Used

The production model uses a type 954 acorn tube in place of the 6C6. The simplicity of the amplifier depends upon realizing comparatively high voltage gain in the first stage. The second stage is degenerative about 3 to 1, and the overall gain must be kept up to negate the $1/\mu$ factor.

Acorns have been used before in electrometer circuits,[5] but the signal has always been applied to the suppressor grid to keep the inherent signal grid current low, and consequently the gain has been approximately unity. Conceivably, two additional stages (to get the proper feedback phase relationship) could be added to attain the required μ, but this becomes somewhat complicated because of the need for batteries between stages.

Screen Grid Voltage

It was discovered that the signal could be applied to the control grid on the 954 and still obtain a low inherent grid current with appreciable gain ($g_m = 90$) if a proper value of screen voltage were chosen. A family of curves is given in Fig. 6 showing

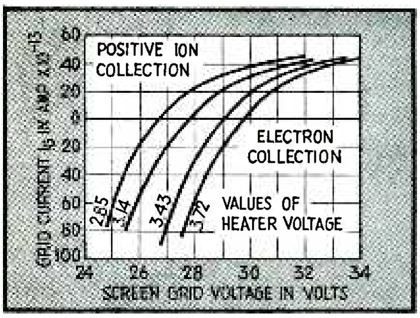


FIG. 6—Operating characteristics of tube

the relation between screen voltage and grid current at various values of heater voltage. At low values the grid current is due to electron collection, while at higher values positive ion collection predominates.

To measure these minute grid currents, the amplifier was adjusted to operate at full-scale deflection with 0.2 volt E_I, so that with a 10^{10}-ohm input resistor each microampere of output current represented 10^{-13} ampere of I_I. By adjusting E_C with a 10^{8}-ohm input resistor for zero I_O and then switching to 10^{10} ohms input, any deflection noted will be due to the grid current I_G developing a signal across this higher R_I, and I_G may be evaluated directly. For each value of heater voltage there is a value of screen voltage that will balance positive ion and electron collection, so that essentially zero grid current exists. This screen voltage is made adjustable to compensate for tube to tube variations, and is set by a searching method so that no deflection is noted when switching between 10^{8} and 10^{10}-ohm input values.

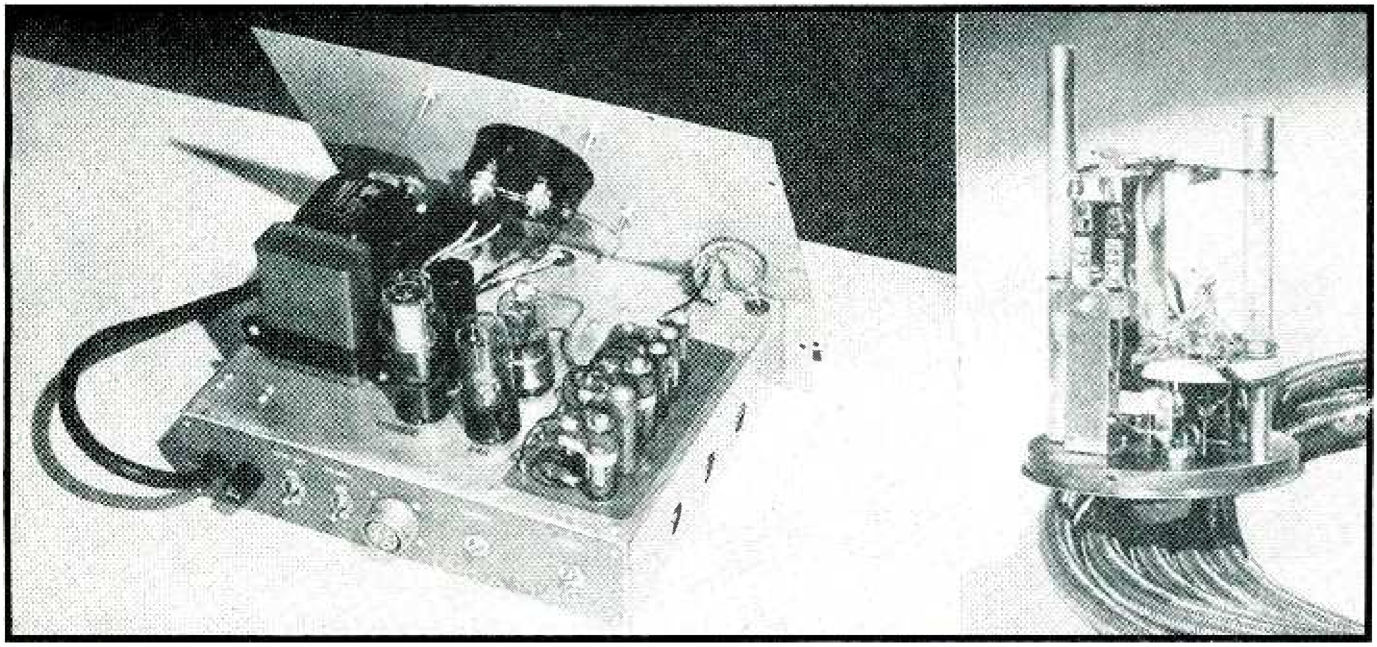
Controlling Zero Drift

It is not beyond the realm of possibility to regulate the three variables —cathode bias voltage, screen grid voltage, and heater voltage—to such a degree that zero drift becomes negligible. On the basis of measurements, the arbitrary operating value of 3.7 volts a-c was chosen for the heater voltage. By operating the 954 under the above conditions it was possible to improve the amplifier characteristics over that experienced with the 6C6. At the same time the advantage of a smaller physical dimension was gained so that all the components necessary to complete remote control could be incorporated in a compact probe assembly. Furthermore, I_G was held low by only partially temperature-limiting the emission, and therefore the warm-up time was materially reduced. The 6C6 required operating at full 6.3 volts to start, with later reduction to operating values to run; otherwise, the amplifier would drift for hours before temperature equilibrium was established. With the 954, the amplifier on highest sensitivity is ready to operate after just one minute of warm-up and will drift only 5 percent of full scale to its final equilibrium in the next five minutes.

Two relays and two high-value resistors complete the major components of the probe assembly. The upper relay mechanism operates to disconnect and ground the ion current input to the tube grid so that the amplifier may be zero balanced. The lower relay serves to connect the low side of the 10^{8}-ohm resistor to the 10^{10}-ohm resistor, thus changing the value of R_I. This low end of the 10^{8}-ohm resistor must be held above ground by at least 10^{12} ohms when in the open position so that the 10^{10}-ohm resistor will not be appreciably changed in its value by shunting. Therefore, this end is left floating, with no supporting insulator.

Control Panel

A ten-wire cable connects this probe assembly to the control panel, as shown in Fig. 7. In this unit are located the power supply, controls, second stage, battery, and output meter. The four-inch meter is a 200-microampere movement with ap-



Rear view of chassis of control unit for gage, and closeup of 954 amplifier stage, located in probe head along with two glass-encased high-value resistors (98 and 10,820 megohms here), and two switching relays. This unit fits under the ionization chamber

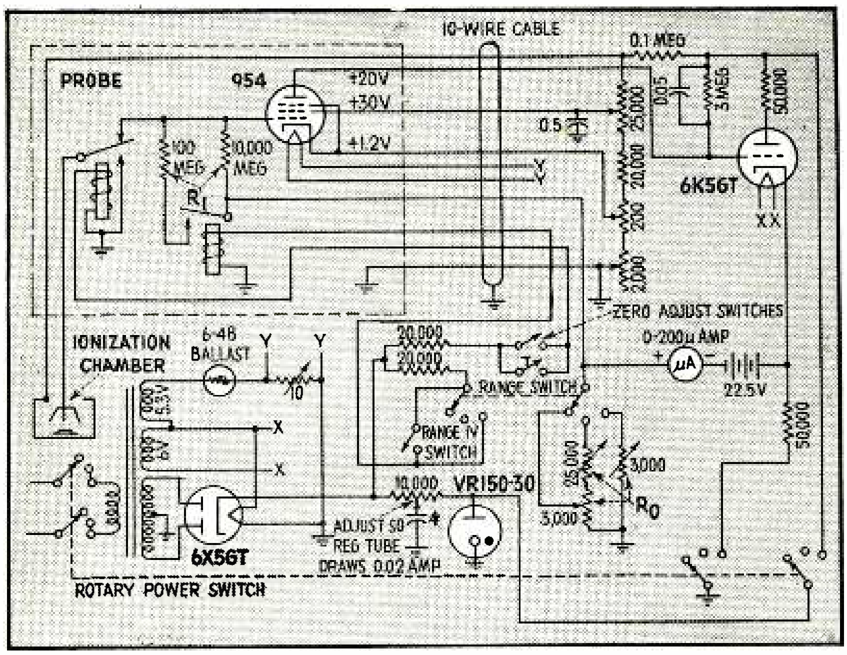


FIG. 7—Circuit diagram of type 510 Alphatron radium-type vacuum gage

proximately 300 ohms impedance, calibrated 0-1 mm with one hundred divisions so that the instrument may be adjusted to read pressures directly. Since the battery drain under the worst conditions can only be 400 microamperes, the life in this application is practically shelf life. Regulated d-c power is supplied to the amplifier.

Sufficient control of the partially limited emission in the first stage is obtained by an ordinary current regulator tube. To accomplish this two filament windings are connected to give 11.3 volts a-c and this is fed to the 6-4B regulator. The regulator is then loaded with a ten-ohm resistor to provide the operating value of heater supply to the 954. In use, a properly operating regulator overcompensates slightly for changes in line voltages so that the net zero shift is only one to two percent on the highest-sensitivity scale, in a direction opposite to that of a line voltage change of ten volts.

Complete Circuit

The 6K5 second stage was retained unchanged with the exception of the addition of a 0.05-μf capacitor. This serves to remove the ghost flutter of the output meter needle on highest sensitivity. The complete circuit is given in Fig. 7.

Three controls and a pushbutton are provided on the front panel. A rotary power switch permits warm-up before operation and insures that the battery is disconnected in the off position. A pushbutton operates the ion disconnect relay in the probe so that the amplifier may be zero-adjusted by the control provided. Sensitivity ratios of 10 to 1 and 100 to 1 are obtainable with the final control on the front panel. When set to range I (10 mm full scale), this control operates the switching relay to connect a 10^8-ohm input resistor in the 954 grid and simultaneously selects a 3000-ohm adjustable R_o. On range II and III (1.0 and 0.1 mm full scale) the value of R_I is 10^{10} ohms, while 25,000-ohm and 3,000-ohm potentiometers respectively are used for R_o. These variables are necessary to allow for manufacturing tolerances in R_1 and in the radium sources. They are adjusted under operating conditions to read the gage ion current as air pressure directly.

TABLE 1. OPERATING VALUES

Switch Pos.	III	II	I	IV
Range in mm	0–0.1	0–1	0–10	....
Mult Factor	$\times 0.1$	$\times 1$	$\times 10$	....
R_I	10^{10}	10^{10}	10^8	10^8
R_O	10^3	10^4	10^3	10^4
Current in amp	10^7	10^6	10^6	10^4
I_I full scale	2×10^{-11}	2×10^{-10}	2×10^{-9}	2×10^{-8}

In Table I are shown the approximate operating conditions for use with the present design ion chambers. The fourth range is not provided as such, but it is obtainable by using the R_o value for range II with a value of 10^8 ohms for R_I. A switch on the rear of the chassis operates the switching relay for this function, and is also used while adjusting for the proper value of screen grid voltage. Under these conditions the calibration approximates the curve in Fig. 2.

Another switch in the rear operates the disconnect relay, making it unnecessary to hold the zero-set pushbutton depressed during adjustment procedures. Finally, two more controls, a coarse zero adjustment and a screen grid voltage adjustment, complete this entirely flexible amplifier.

As an illustration of amplifier stability, a production model was picked at random, balanced for zero I_o, and calibrated with a gage for the three pressure ranges. This combination was used continuously under all pressure and line conditions for one month, during which time the net change in I_o was 2×10^{-13} ampere, or enough to give only one division of deflection between ranges. The maximum deviation was three divisions of deflection on highest sensitivity.

Applications

With this new and useful gage as a tool it has become possible to gain important knowledge in the field of industrial high vacuum. Applications include large-scale bulk dehydration, in one phase of which it has already become indispensable. New and interesting applications for this instrument or a modification thereof are being encountered each day, and it is felt that here is not only a pressure gage for a difficult pressure interval but also a fundamental tool to be used on the gas molecule.

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TRANSIENT Delay Line

Design criteria for a pulse-delay network useful in radar, television, or test oscilloscope work. With highest frequency component of the transient known, a simple, graphical solution is possible for required values of inductance and capacitance

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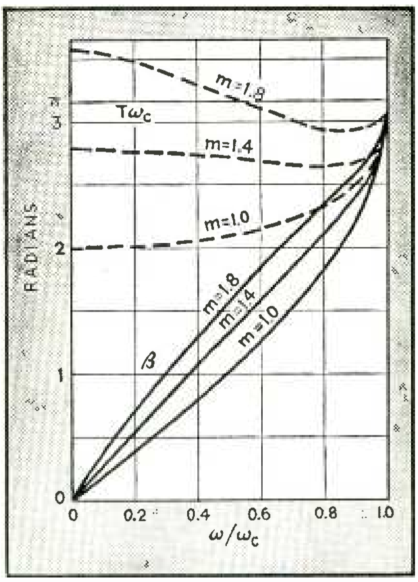


FIG. 1—Phase-shift characteristics for one section are shown by the solid lines. The dashed lines show how the slopes vary as the cutoff frequency is approached, expressed in terms of $T\omega_c$

When designing special electronic equipment, it is often necessary to provide some method of delaying or storing electrical information for a given length of time. If this memory time is in the order of microseconds, an electrical network with special characteristics can be designed and constructed quite easily. Except for a small amount of attenuation, the signals applied to the network input will be faithfully reproduced at the output after the required time has elapsed.

Effect of *m* on Phase Shift

By choosing the correct value of m in an m-derived low-pass filter, it is possible to obtain a phase-shift characteristic that is fairly linear with frequency for almost the entire pass band. If a transient signal is passed through this filter, it will be delayed in time by an amount equal to $\beta/2\pi f$ where β is the phase shift in radians at a frequency f. No phase distortion will occur if the phase characteristic of the filter is linear up to the highest frequency included in the transient signal. By placing sections of these filters in cascade any desired delay can be obtained.

The effect of m on the phase-shift characteristic of one section is shown by the solid-line curves in Fig. 1. β is plotted against ω/ω_c for various values of m. The broken-line curves in Fig. 1 show how the slopes of the solid-line curves vary with ω/ω_c. The ordinate is expressed in terms of $T\omega_c$. Because $\beta = \omega T$, this also equals $\beta/(\omega/\omega_c)$. We see that when m equals 1.4, the phase shift is fairly linear up to 95 percent of the cutoff frequency, and the average value for $T\omega_c$ can be taken from the curve as 2.73. $T\omega_c$ will never vary more than $\pm$ 2.93 percent from this value for frequencies below 95 percent of cutoff.

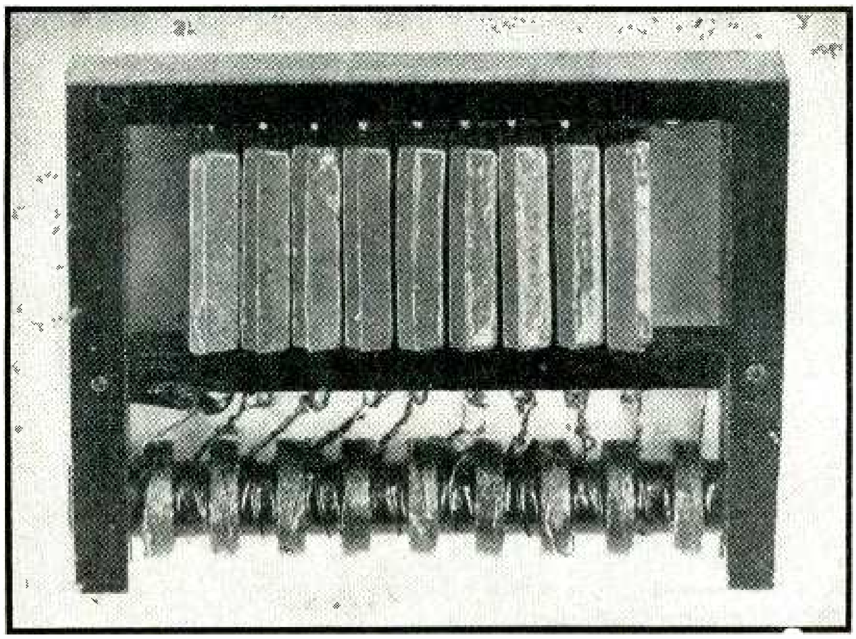
Figure 2A shows a T section of an m-derived low-pass filter. Substituting a value of 1.4 for m, we get

$$L'_1 = mL_k/2 = 0.7L_k \quad (1)$$

$$L'_2 = \frac{(1-m^2)}{4m} L_k = -L_k/5.6 \quad (2)$$

$$C' = mC_k = 1.4C_k \quad (3)$$

We can see that L'_2 is negative. This negative value of L'_2 can be obtained by using the network shown in Fig. 2B. The network with mutual inductances is equivalent to the net-



An experimental delay unit of nine sections. Characteristic impedance is 500 ohms. There is a total delay of 1.5 microseconds for a transient having a maximum frequency component of 2.5 mc. The unit is illustrated about twice normal size work of 2C. Therefore

$$\left(\frac{1-m^2}{4m}\right) L_k = -M \qquad (4)$$

$$mL_k/2 = L/2 + M \qquad (5)$$

$$mC_k = C \qquad (6)$$

Substituting Eq. 4 in Eq. 5 we get

$$L = mL_k + \left(\frac{1-m^2}{2m}\right) L_k = \left(\frac{m^2+1}{2m}\right) L_k \qquad (7)$$

Letting $T\omega_c = 2.73$ which is the value we previously determined from Fig. 1, then

$$T = \frac{2.73}{w_c} \qquad (8)$$

or
$$f_c = \frac{2.73}{2\pi T} = \frac{0.435}{T} \qquad (8a)$$

Cutoff Frequency

This derivation shows that T is inversely proportional to the cutoff frequency. Referring to Fig. 2C, the cutoff frequency of an m-derived filter is

$$f_c = \frac{1}{\pi\sqrt{(L+2M)\,C + 4C\,(-M)}}$$

Since k (coefficent of coupling) $= M/L$

then
$$f_c = \frac{1}{\pi\sqrt{(LC+2kL)\,C + 4\,C\,(-kL)}}$$

$$= \frac{1}{\pi\sqrt{(LC+2kL)\,C - 4kLC}}$$

$$= \frac{1}{\pi\sqrt{CL\,(1-2K)}} \qquad (9)$$

or
$$\omega_c = \frac{2}{\sqrt{CL\,(1-2k)}} \qquad (9a)$$

Substituting Eq. 9a in Eq. 8, we get

$$T = 1.36\sqrt{CL\,(1-2k)} \text{ when } m = 1.4 \qquad (10)$$

With the use of Eq. 10 the time delay of an m-derived filter, when $m = 1.4$, can be calculated.

Terminating the Filter

So that no reflections will occur, it is necessary to terminate the filter correctly. Assuming the filter consists of pure reactances, then the terminating resistance,

$$R_0 = \sqrt{L_k/C_k} \qquad (11)$$

Substituting Eq. 6 and 7 in Eq. 11

$$R_0 = \sqrt{\frac{L\,\dfrac{(2m)}{(m^2+1)}}{C/m}} = \sqrt{\frac{L\,(2m^2)}{C\,(m^2+1)}} \qquad (12)$$

Since $k = M/L$, then from Eq. 4 and 7

$$k = \frac{\dfrac{(m^2+1)}{(4m)}\,L_k}{\dfrac{(m_2+1)}{(2m)}\,L_k} = \frac{m^2-1}{2\,(m^2+1)} \qquad (13)$$

or

$$2k\,(m^2+1) = m^2 - 1$$

$$2km^2 + 2k = m^2 - 1 \qquad (14)$$

and

$$m^2 = \frac{1+2k}{1-2k} \qquad (14a)$$

Substituting in Eq. 12, we get

$$R_0 = \sqrt{\frac{L\,(1+2k)}{C}} \qquad (15)$$

Substituting the value of 1.4 for m in Eq. 14a, we see that $k = 1/6$.

The chart shown in Fig. 3 is based on Eq. 10 and 15 which, when reduced to their simplest form, are

$$\left.\begin{aligned} T &= 1.11\sqrt{LC} \\ R_0 &= 1.15\sqrt{L/C} \end{aligned}\right\} \text{ when } m = 1.4 \qquad \begin{aligned}(16)\\(17)\end{aligned}$$

Use of Chart

Knowing the delay time for one T section and the terminating resistance, the correct inductance and capacitance for the filter can be determined from the chart. As many sections as desired may be added in cascade to give any time delay desired. The total delay will be T times the number of sections.

It must be remembered that the chart is fairly accurate only if it is used for frequencies below 95 percent of cutoff.

Using Eq. 8, we see that

$$f_{max} = \frac{0.435 \times 0.95}{T} = \frac{0.41}{T} \qquad (18)$$

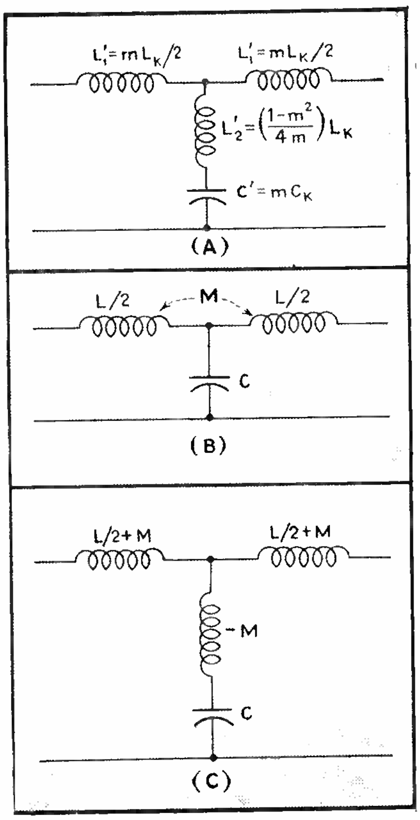


FIG. 2—Development of a T section of an m-derived low-pass filter. (A) The value of L'_2 is shown to be negative and is obtained in practice by the circuit of (B). (C) demonstrates the derivation of the cutoff frequency

Suppose we have a transient signal which we want to delay one microsecond. We want the impedance of the network to be 1,000 ohms. Also, the highest frequency contained in the transient signal is one mc. What will be the constants of the network?

Example

Knowing f_{max}, we first determine the maximum delay T per section realizable.

$$f_{max} = \frac{0.41}{T} \text{ or } T = \frac{0.41}{1 \times 10^6} = 0.41 \times 10^{-6} \text{ sec}$$

The number of sections will be the total time divided by T, or $10^{-6}/(0.41 \times 10^{-6}) = 2.44$.

Therefore, three sections are the minimum to be used. With three sections we will have $(10^{-6}/3) = 0.33 \times 10^{-6}$ seconds delay per section. From the chart we can determine L and C. We see that $L = 260\mu$h and $C = 340$ $\mu\mu$f. Therefore, the networks will have the constants shown in Fig. 4, when $k = 1/6$.

Design Considerations

The following are practical problems that must be taken into consideration when constructing a delay filter:

(1) Providing small attenuation.

(2) Obtaining the correct coefficient of coupling.

(3) Preventing reflections.

The attenuation of the network depends upon the Q of the capacitors and inductors. Usually the loss due to the capacitors is negligible and can be neglected. The attenuation for frequencies lower than 95 percent of cutoff is approximately equal to $\omega T/2Q_L$ nepers, where T is the delay time in seconds. Q_L can be increased in several different ways. The size of the wire used for winding inductors can be large. However, this will increase the physical size of the filter and hence increase stray capacitance between coils. If the frequencies involved are in the order of 100 kc to 4 mc, the use of litz wire will help to increase Q_L. Also, Q_L can be increased by using powdered-iron cores.

The coefficient of coupling can be controlled by varying the spacing between adjacent coils. The spacing should be adjusted so that the coefficient of coupling is equal to 0.16.

Unless the network is terminated in its characteristic impedance or a

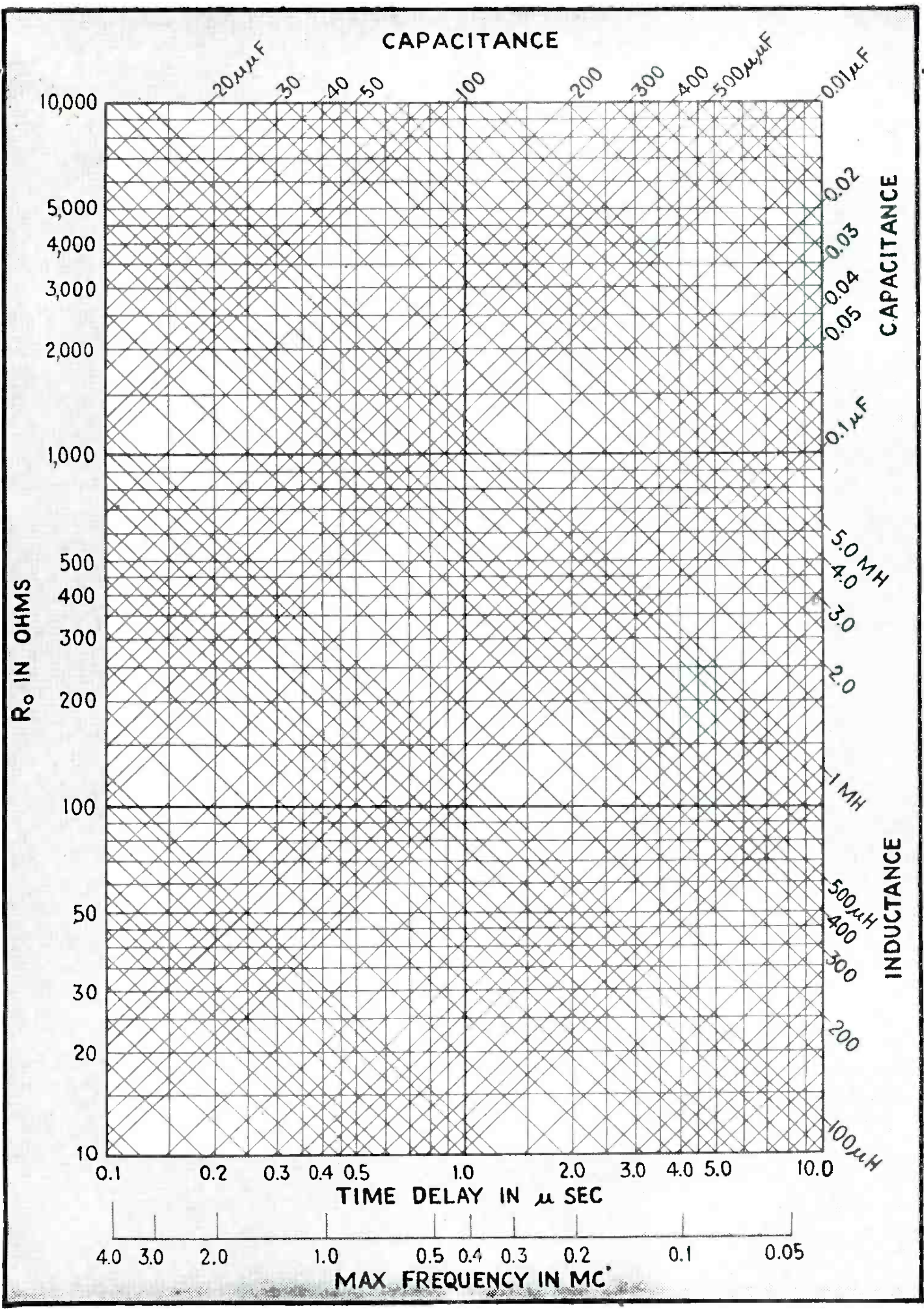


FIG. 3—Chart used in determining the value of inductance and capacitance of the filter when time delay T and terminating resistance R_o are known, accurate only when used for frequency below 90 percent of cutoff

close approximation to it, echoes or reflections will occur when transient signals are inserted. Usually when several sections are used in cascade, a sufficiently good termination will be obtained when both ends of the network are terminated with capacitors equal to $C/2$. However, if a more perfect termination is desired, a half-π section where $m = 0.6$ can be used.

It is good design practice to try to use a network as low in impedance as possible. This reduces the size of the inductors and hence reduces the stray capacitance between coils and permits an increase in the Q of the coil, in turn producing less phase distortion and less attenuation.

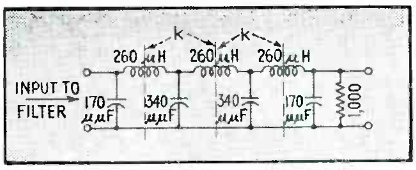


FIG. 4—Three T sections form a filter network to delay a transient signal 10 microseconds. Impedance of the network is 1,000 ohms and the highest frequency contained in the transient is 1 mc

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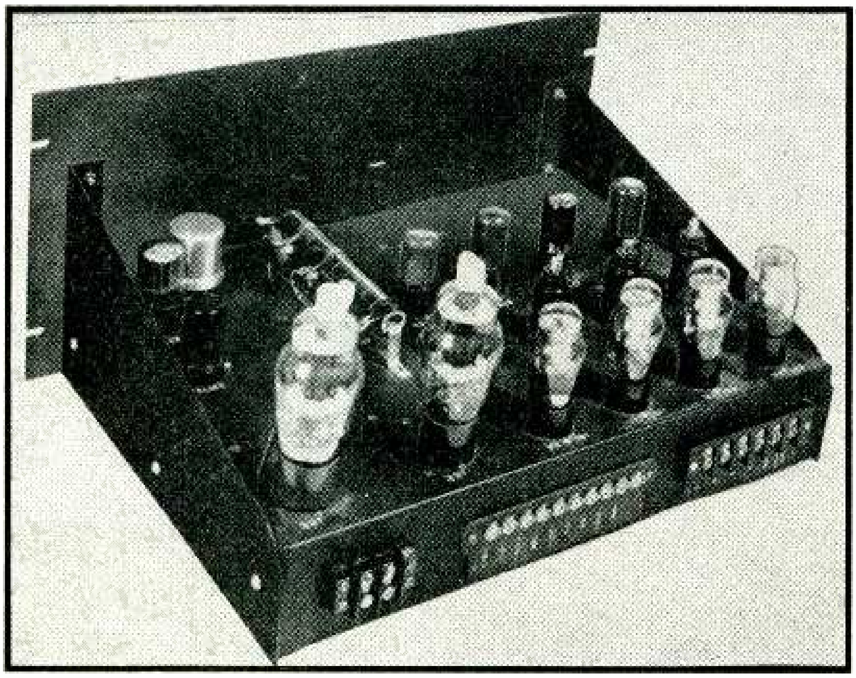
FOUR-CHANNEL



Top chassis view of the four-channel electronic switch, showing the ring-counter and gate-amplifier tubes at the right and the crystal-oscillator trigger circuit tubes near the front panel. The wide-band amplifier tubes are type 807

By N. A. MOERMAN

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THE cathode-ray oscilloscope has in recent years become an indispensable tool for the research worker and the engineer. The value of this equipment and, concurrently, the reason for its success can be attributed almost wholly to its inherent versatility, a factor that is being constantly enhanced by the development of auxiliary circuits and modified cathode-ray tube types.

One application of considerable importance in research work is multiple-channel cathode-ray oscilloscope recording which has become invaluable for the simultaneous study of several interrelated phenomena of transient character. The most satisfactory method that has been employed for this purpose up to the present time has been photographic recording of the traces of several cathode-ray tubes. The obvious disadvantage of this type of system, however, is the increase in complexity and bulk of the equipment as the number of recording channels is increased.

In an effort to circumvent or minimize this disadvantage, there have been two developments of interest, the multiple-beam cathode-ray tube and the electronic switch.

An electronic switch[1, 2, 3] is a device that enables simultaneous observation of two separate phenomena with the aid of the cathode-ray oscilloscope. This is accomplished by alternately connecting the respective circuits under study to the input of the cathode-ray oscilloscope by electronic means.

This device, as supplied commercially, is valuable for a number of specific applications, but has several disadvantages for general use:

(1) Only steady-state or recurrent phenomena can be observed since reliance is placed upon persistence of vision or still photography for proper interpretation.

(2) The frequencies of the waveforms under study must be related to each other by some integral multiple.

(3) Transient phenomena can neither be viewed nor recorded satisfactorily because of the low switching frequency normally employed and the use of capacitance-coupled amplifiers.

(4) The number of circuits that may be switched is normally limited to two, although by interconnecting several units this limitation can be overcome.

Requirements of a Four-Channel Recorder

The need for a four-channel recording system imposed a unique

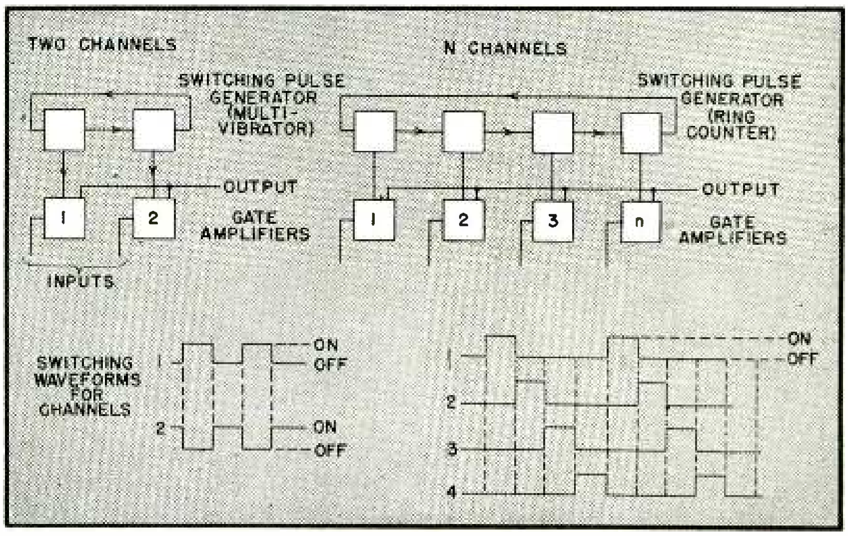


FIG. 1—Block diagram and type of waveform for a standard electronic switch and the four-channel switch described in text. The ring counter circuit can be developed for n channels as indicated

ELECTRONIC SWITCH

An electronic switch permits display of four or more transients at once on a conventional cathode-ray oscilloscope screen. A crystal-controlled ring counter triggers the gate amplifiers which switch and mix signals supplied to a wide-band amplifier in the equipment

requirement on the design of an electronic switch, as indicated in Fig. 1. In a conventional two-channel electronic switch, a multivibrator supplies the required square-wave switching pulses which alternately bias to cut off the respective gate amplifiers. The common plate connection between these amplifiers provides the point at which the composite signal is applied to the oscilloscope. On the other hand, the n-channel electronic switch contains n generators which supply switching pulses consecutively to gate amplifiers 1 to n, this cycle of operation being continuously repeated. The duration of each switching pulse must obviously be $1/n$ times the period for each cycle of operation.

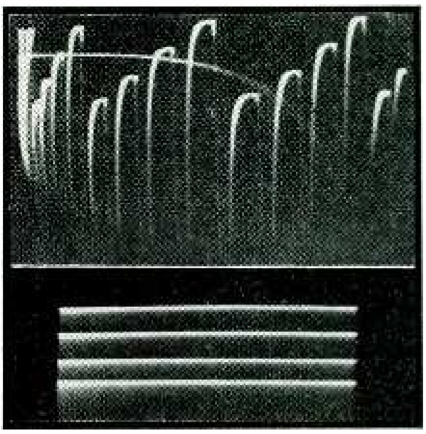
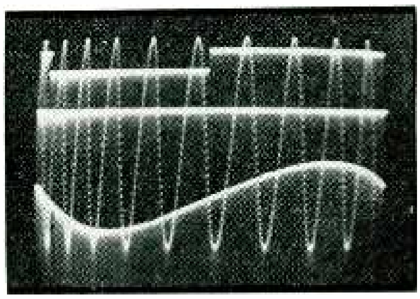


FIG. 2—Composite four-channel waveform on expanded time scale (above). Interval between pulses is 1/100,000 sec. Below are phase relations among the switching pulses of the four-channel switch, shown with a slower sweep frequency

FIG. 3—Oscilloscope traces resulting when three different signals were introduced through the four-channel switch. Top trace presents a 60-cps square wave and the bottom a 60-cps sine wave. No signal was applied to the second-trace input. A 600-cps sine wave of large amplitude superimposes the third trace upon the others. The spacing of the dots is controlled by the crystal oscillator and allows precise determination of the slope of waveforms



Ring Counter

The requirements for a switching pulse generator have been conveniently satisfied by the use of an electronic ring counter. By means of this system it becomes theoretically possible to devise an electronic switch for an infinite number of channels. Practical considerations have restricted our application to four channels.

An electronic ring counter may be defined as a series of square-wave generating circuits (of the Eccles-Jordan type[4]) so arranged that only one circuit of the series is in the on position at any instant. Trigger pulses applied simultaneously to all the circuits pass this condition consecutively to each square-wave generator, the cycle of operation continuing as long as the trigger pulses are applied.

The on position of a pulse-generating circuit is that state of the circuit from which a positive switching pulse is obtained. A succession of trigger pulses applied to the counter ring results in positive switching pulses being supplied consecutively by circuits 1 to n. This cycle of operation is continuously repeated. Since all gate amplifiers are normally biased beyond cutoff, the function of these positive switching pulses becomes that of turning on the respective gate amplifiers. Any one of the gate circuits is brought into the conducting state for a period of $1/n$ times the switching cycle and is off during the remaining part of the cycle.

The phase relations between the switching pulses for a four-channel electronic switch are shown in Fig. 1. The composite waveform is again derived from the common plate connection between gate amplifiers. Oscillograms of the actual waveforms obtained are reproduced in Fig. 2.

At this point it may appear that considerable resolution of the waveforms under study will be lost because of the relatively short period during which any channel is active. This would be of some concern if the switching rate were comparable to or less than the frequencies contained in the waveforms under study. This apparent difficulty is largely overcome by making the switching rate as high as possible. In the apparatus described a switching rate of 25,000 cycles is employed.

The degree of resolution actually obtained with the four-channel electronic switch is shown in Figs. 3, 4, and 5.

Design Criteria

The chassis contains all the essential elements for the operation of the four-channel electronic switch with the exception of power supplies and the necessary preamplifiers. These elements are (1) the trigger pulse source, (2) the switching-pulse generator (ring counter), (3) the gate amplifiers, and (4) the output amplifier. They are described in detail below.

For proper operation of the ring counter a source of trigger pulses of the proper frequency and shape is required. A pulse frequency of 100 kc which yields a switching

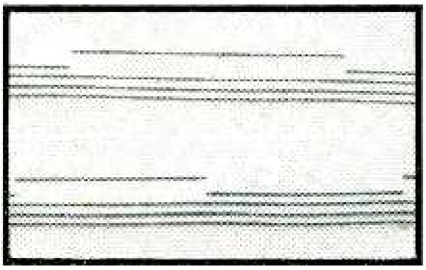


FIG. 4—A 60-cps square wave (top line) recorded with a revolving-drum type camera at a speed of 285 inches per sec (above) and 195 inches per sec (below)

rate of 25,000 cycles was chosen.

In the complete four-channel switch circuit in Fig. 6, one half of tube V_2 (6SN7) is connected with associated components to form a Pierce oscillator. The other half of V_2 serves as a square-wave amplifier.

Circuit Details

Differentiation of the 100-kc square waves is accomplished by the RC combination composed of R_4 and C_2. Of the positive and negative pulses resulting, only the positive pulses are amplified by tube V_1, which is biased to cutoff. Negative pulses appearing at the plate of V_1 have the desired characteristics noted above. These are applied to a common bus for injection into the ring-counter and gate-amplifier.

The switching-pulse generator (ring counter) is composed of four 6SN7 tubes connected in standard Eccles-Jordan square-wave circuits with the addition of inductance, L_1, in each plate circuit. The inductance is placed in that side of the circuit from which the positive switching pulse is derived. A considerable improvement in the squareness of the switching pulse results without adversely affecting normal operation of the circuits.

Square-wave Generator Circuit

An Eccles-Jordan circuit (sometimes called a flip-flop circuit) has two stable states such that for either state one grid is at cutoff and the other at zero, so that one tube is off while the other conducts. Of those grids in the ring counter that are connected to the source of trigger pulses only one grid is zero at any instant. This grid is associated with the circuit that is on. The trigger pulse operates on this grid and flops the circuit to its other stable state (off). During this transition the positive rise in voltage at the left-hand plate is applied through C_1 to the cutoff-biased grid of the succeeding circuit, which is then turned on. The next trigger pulse operates on this circuit, which is then flopped to the off position as in the case of the preceding circuit. In this way, a positive switching pulse is generated at the right-hand plate of each circuit during the sequence off-on-off.

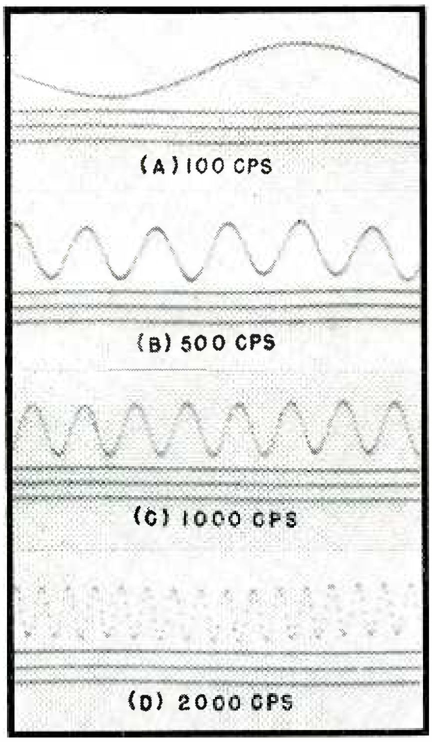


FIG. 5—Photographic recordings of signals fed to a commercial oscilloscope through the four-channel switch, only one channel of which is used here. A high degree of resolution is possible well above commercial power frequencies

It will be noted in the schematic diagram that pushbutton switch S_3 has been inserted between the two legs of the square-wave circuits, one of which is connected in reverse order. This provides a front-panel control for initiating the proper sequence of operation for the counting ring after applying power.

Switching the Pulses

The gate amplifiers serve the twofold purpose of switching and then mixing the signals applied to their respective inputs. For this function the type 6L7 tube was selected.

At the outset, it was felt that the inner control grid of the 6L7 would be the logical point for introducing the switching pulse since cathode current cutoff could then be assured. This arrangement was tried and found to be unworkable because of the distortion introduced by applying the useful signal to the second control grid. The functions of the two control grids were then reversed and a great improvement in the operation noted. The disadvantage to this mode of operation, however, is the incomplete cathode-current cutoff, requiring isolation of the screen-voltage supplies to insure minimum coupling.

Variable resistor R_1 in the cathode circuit provides a means for orienting the trace on the cathode-ray tube with respect to the other traces. When it is desired to observe less than the four available traces, switch S_2 is thrown. This introduces a large resistor (R_2) into the cathode circuit, which then deflects the respective trace off the screen.

For added flexibility, provisions are made for restoring normal single-trace operation. This may be desired where high-frequency recording and good resolution are required, and is made possible by operating switch S_1. This shunts the trigger pulses to ground through C_3 and removes the bias on the operating 6L7 tube by connecting its second control grid to cathode.

Wide-Band Amplifier

It was evident early in the development of the apparatus that amplification of the composite signal would present some difficulty. The problem involved is that of amplifying unidirectional square-wave pulses of approximately 75 volts amplitude. These pulses are modulated by as much as 25 per cent. Capacitance coupling could not be used because of the transient d-c amplification requirement. Furthermore, it was found to introduce interchannel coupling.

The output-amplifier circuit finally evolved is shown in the schematic diagram. Triode-connected 807 tubes in push-pull were selected because of their large signal-handling capabilities coupled with low distortion. An excessively large common cathode resistor (R_3) is employed which serves two important functions: The cathode substantially follows the grid, thereby absorbing the large d-c potential at the 6L7 plates and miminizing undesirable grid loading due to the direct connection. Phase inversion is also conveniently provided.

The grid voltage of the phase-inverter tube is established at a point on a voltage divider from B+ to ground and permits orientation of the composite signal on the cathode-ray screen.

There is linear response over the useful portion (about four-fifths) of the cathode-ray tube screen. Contributing to this is the high value of plate voltage (650 volts) applied to the 807 amplifiers.

Recording

For the recording medium, use is made of a DuMont type 5LP5 cathode-ray tube (blue screen) operating at maximum voltage in order to attain maximum spot intensity. A revolving-drum type camera using a single strip of oscillograph recording paper (Eastman No. 697, 4 x 60 inches) is employed with an *f* 2.3 (three-inch focal length) lens to provide a one-to-one image.

Records taken with this apparatus are illustrated in Fig. 4 and 5. The cathode-ray tube voltages were, in this case, only three-quarters of the maximum value. These records demonstrate the degree of resolution and recording intensity that may be obtained.

Interpretation of Records

It may appear disadvantageous that the steeply sloping portions of recorded transients are defined by a series of dots. This characteristic, however, may be used to advantage where it is desired to obtain quantitative values for these slopes. For this purpose the oscillator has been crystal-controlled, thereby accurately fixing the time between successive dots. The slope measurement then becomes that of simply measuring the vertical distance between successive dots and dividing by 1/25,000 sec. There is an increase in precision attainable in this way as contrasted to the normal method, by which the horizontal component of steep slopes must be determined.

Acknowledgement

This work was done while the author was employed at the Instrumentation Laboratory, Laboratory Services OR & DC, Aberdeen Proving Ground, Md.

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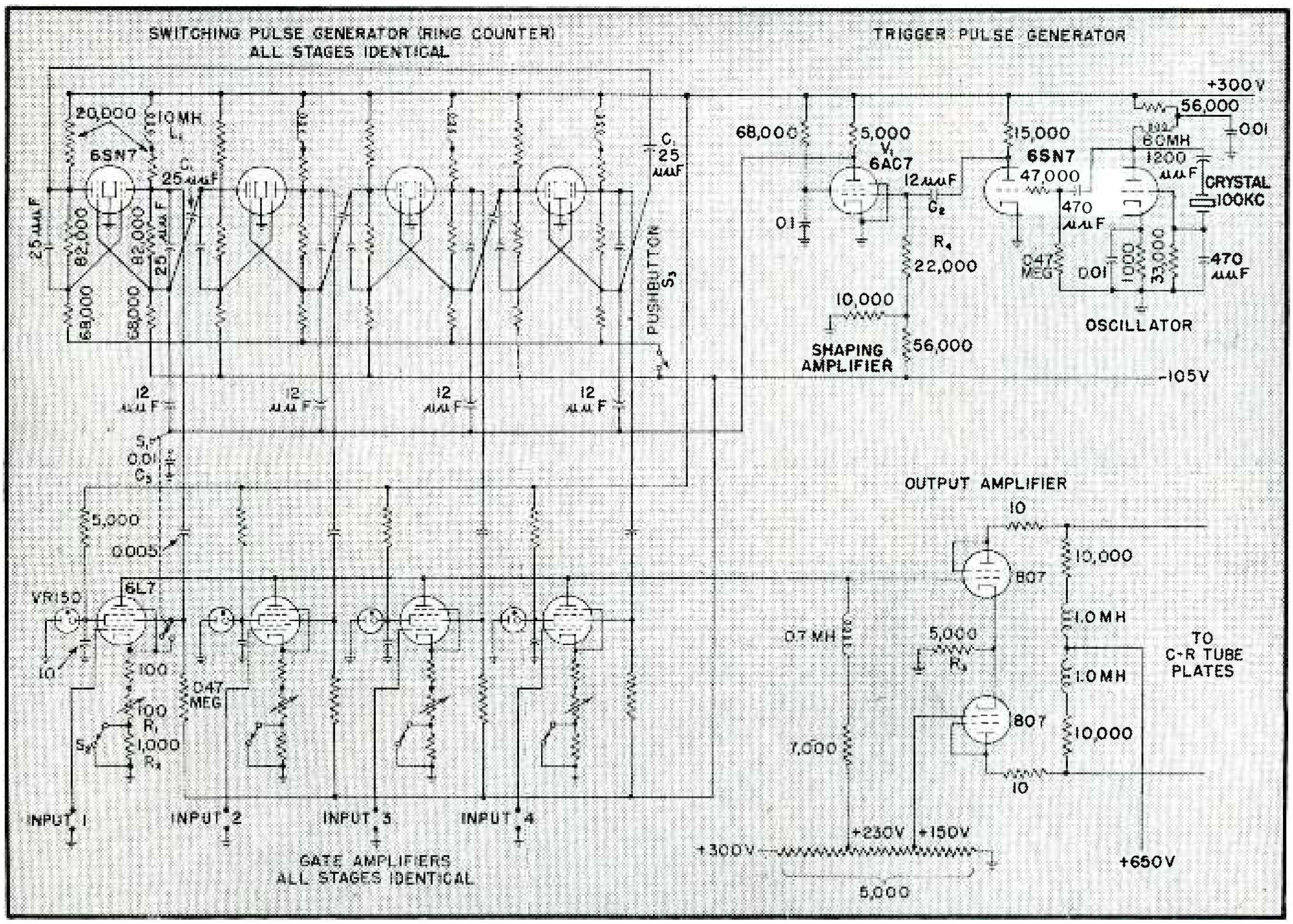
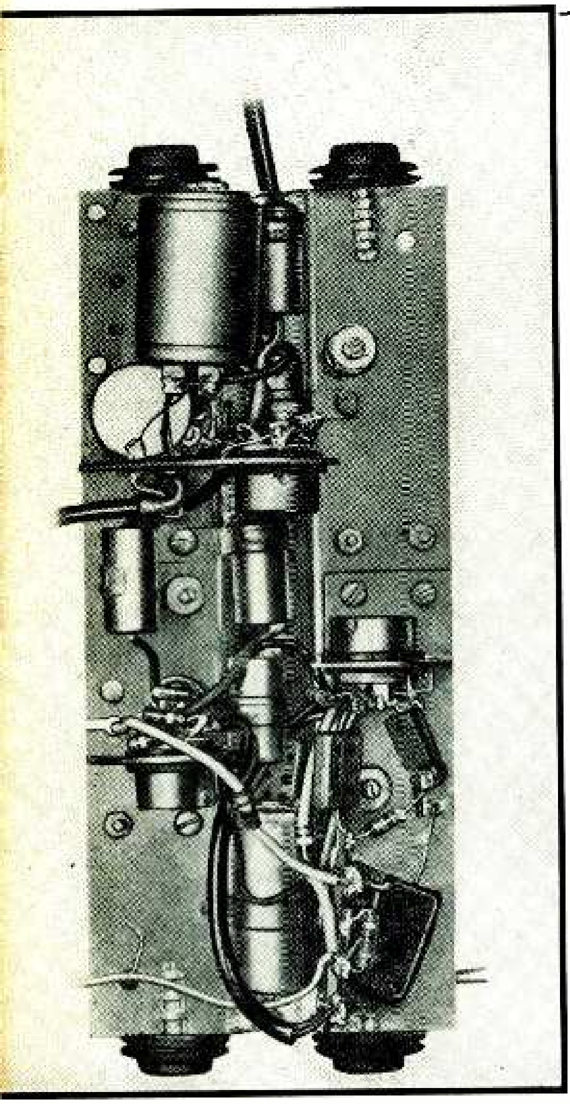


FIG. 6—Schematic circuit diagram of the four-channel electronic switch, showing the crystal-controlled trigger pulse source and output amplifier in detail. Conventional power supplies are not built into the electronic switch unit

THE SONOBUOY

Expendable radio transmitter, modulated by signals from an underwater magnetostriction hydrophone, revealed the presence of submerged submarines to patrol ships and planes



Radio transmitter inclosed in the buoy is compactly assembled. Rubber grommets provide shock mountings for many of the components. Although the equipment is expendable, it must give dependable operation during its few hours of life

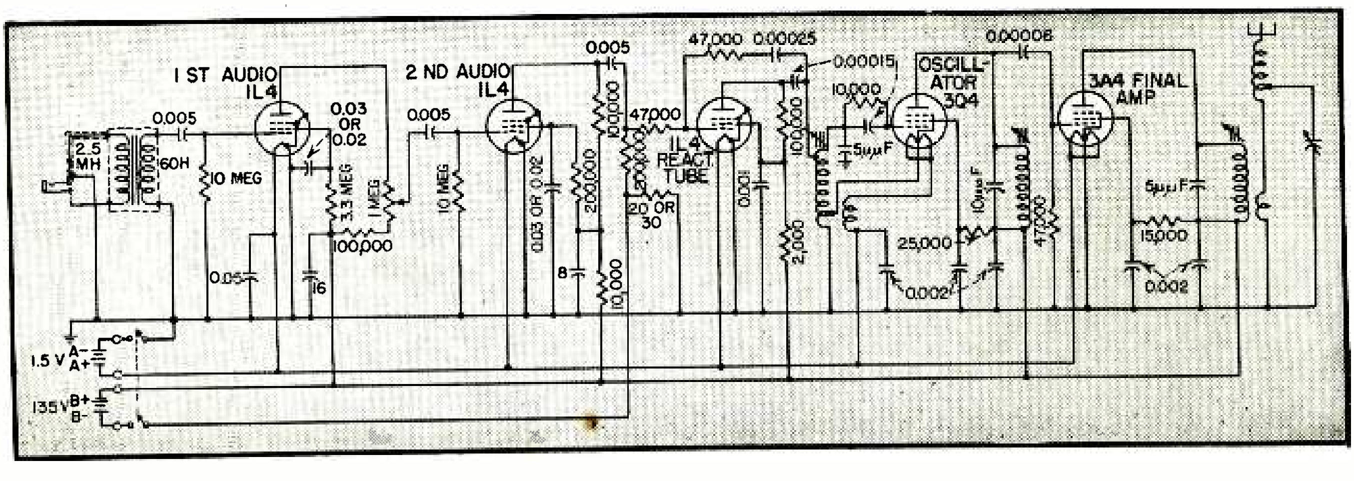
THROUGHOUT THE GREATER PART of the war, the German submarine-menace was great. As is now well known, radar was highly effective in locating U-boats which had surfaced and microwave radar could even detect a submarine's periscope as it just cleared the surface. For underwater detection of enemy submarines, destroyers and DE boats used sonar. However, both radar and sonar required that a signal be sent from the searching plane or ship. Thus the searcher revealed his presence, thereby warning the enemy to take evasive action. The sonobuoy enabled searching planes and ships to locate enemy submarines without revealing their own position.

Tactical Operation

The sonobuoy contains an underwater microphone or hydrophone. This hydrophone picks up underwater sounds, such as propeller noises, from submarines. The pickup range depends upon the state of the sea, and the speed, depth and type of the submarine. Range varies between several hundred and several thousand yards. After amplification the signal from the hydrophone frequency-modulates a low-powered radio transmitter. The transmitted signal is received by patrol craft. In this ingenious manner a radio operator on or above the sea hears sounds beneath the surface of the water. The sonobuoy thus combines the underwater detecting abilities of sonar and the range of radio.

In locating submarines the radio operator of a patrolling airplane throws out a 13½ pound sonobuoy, first pulling out the 39 inch telescopic antenna, an action which also connects the batteries to the circuits. The navigator records the buoy's sea position. A 24 inch muslin parachute opens to break the buoy's fall and to assure that it strikes the sea in an upright position gently enough not to damage or appreciably detune the radio circuits. The buoy's striking

Input transformer and two-stage, resistance-capacitance coupled amplifier provide high voltage gain in audio circuit. By using reactance-tube frequency modulation, negligible modulating power is needed. Reactance tube frequency-modulates the oscillator in its grid tank. Second harmonic from oscillator is coupled into power-amplifier-doubler which feeds the quarter-wave whip antenna



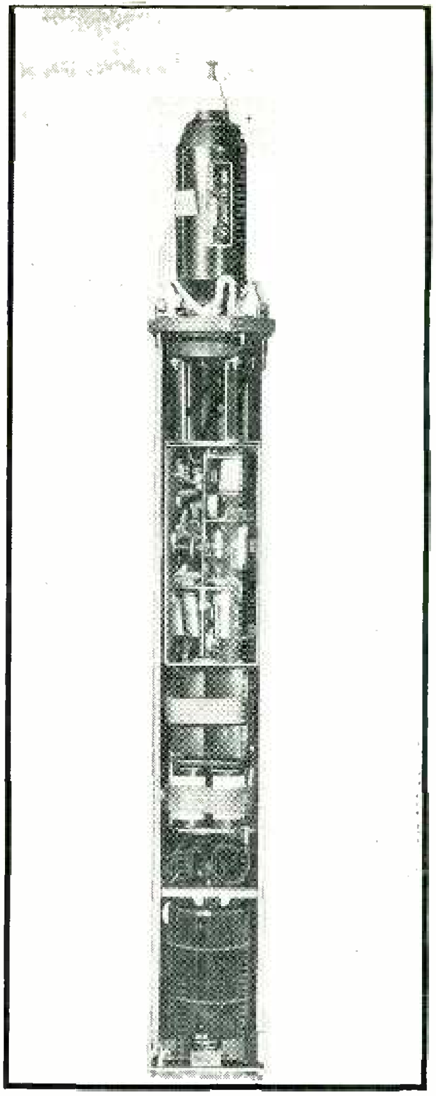
electronics WAR REPORT

the water releases the hydrophone, which unreels itself to a depth of 20 ft. A bag of dye spreads a colored blot on the sea so that the patrol plane can more readily spot the buoy position.

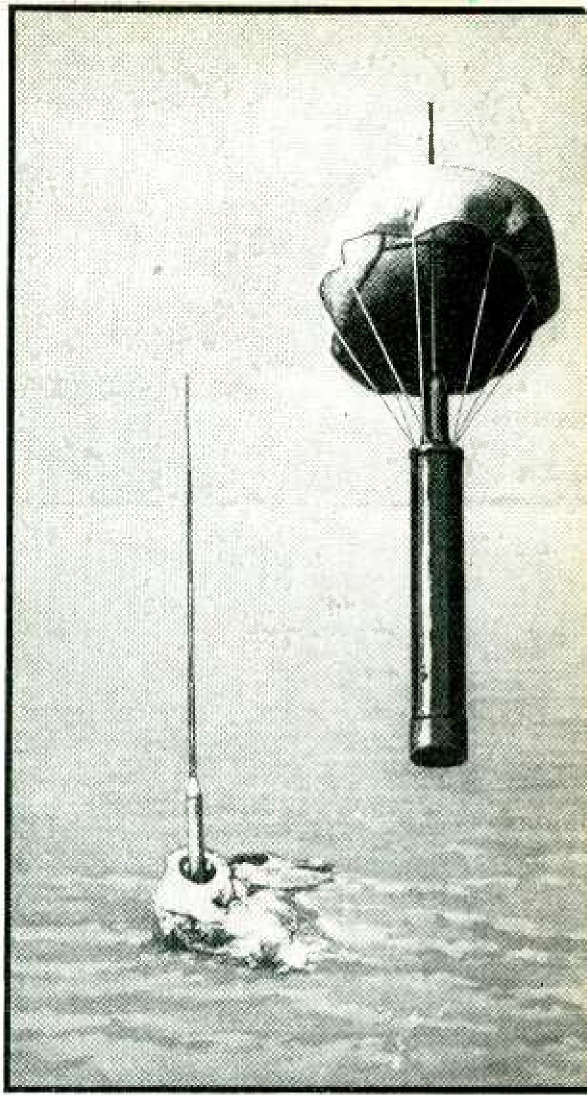
Several sonobuoys may be dropped in a "spread". Frequencies of the buoys in such a spread differ by 0.8 megacycle. Color coding of the buoys and on the dial of the ship's sonobuoy receiver correspond, so that the radio operator can quickly tune in and identify any buoy in the spread.

By listening over the radio the operator can tell, from the relative loudnesses of signals from buoys, near which buoy the submarine is lurking, or in which direction it is moving. While a submarine is under attack the operator hears the explosions and even sounds of the submarine breaking up when the attack is successful. Recordings of these sounds are evidence of a kill.

A soluble carbowax plug in the buoyant, watertight sonobuoy case dissolves in a few hours, and the expendable transmitter sinks, thereby preventing the enemy from recovering it. Power supply batteries were designed to have such a life that they are about exhausted when the buoy floods and sinks.



On striking the water a sensitive button in the bottom of the 4¾ by 40-inch sonobuoy releases the hydrophone downward on a cable. Batteries, turned on when the buoy is launched, supply power during the four hours of operation



Sonobuoy is thrown from patrol plane. Parachute (right lowers it into the water (left). Underwater microphone picks up submarine sounds which are relayed by the radio transmitter in the buoy to the patrol plane or a ship

Circuits

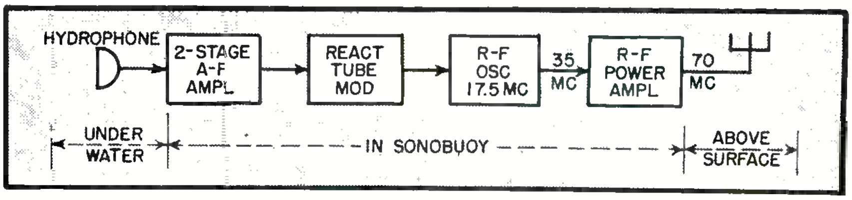
The hydrophone used in the sonobuoy consists of a waterproof-wire winding on a magnetized-nickel cylinder. Sound waves produce electrical voltages by magnetostriction. Approximately three microvolts of audio signal is fed by a high-ratio stepup transformer to a two stage amplifier which is flat from 200 to 10,000 cps and down about 12 db at 200 cps.

A reactance tube frequency-modulates the tank of the electron-coupled Hartley oscillator. The oscillator operates in the vicinity of 18 megacycles, with the plate tuned to the second harmonic. In the r-f amplifier this frequency is again doubled. The transmitter signal is thus in the 70 megacycle range, and has a 75 kilocycle maximum deviation. The antenna is a vertical quarter-wave whip. An insulator holds the antenna base just above the surface of the sea.

The radiated power, about a tenth of a watt, is sufficient for line-of-sight transmission. Depending on how high the receiving antenna is, a ship can receive a sonobuoy signal from about six nautical miles away. An airplane flying at 5,000 feet can receive signals from 40 to 50 nautical miles away. Automatic frequency control in the receiver, working from unbalance in the discriminator output, follows random drifts of the sonobuoy transmitter center frequency.

Development

Research and development engineering was carried out at the Underwater Sound Laboratory of Columbia University at New London, Conn. under National Defense Research Committee contract. Production engineering and manufacture were done by Emerson Radio and Phonograph Co., and Freed Radio Corp. The navy used hundreds of sonobuoys in both Atlantic and Pacific waters.—K. H.



Sonobuoy, shown here in block-diagram form, is a complete, compact f-m transmitter

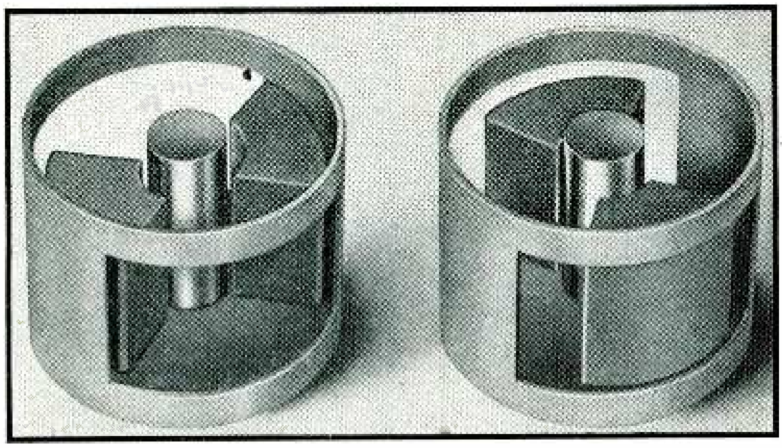


FIG. 1—Basic form of coaxial butterfly circuit. High-frequency setting is shown at left, low-frequency setting at right

Coaxial

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In spite of the large increase in production and use of high-frequency equipment during the war, simple and convenient laboratory apparatus such as variable oscillators and standard-signal generators, for frequencies above 500 megacycles, have not progressed commensurably. Much equipment has been built and used at frequencies well above 500 megacycles, but most of it has been for special purposes and is not suitable for general laboratory use.

During the emergency period, when speed was essential, it proved much quicker and easier to build a series of fixed-frequency test oscillators for specified frequencies and uses than to build multiple-purpose wide-range variable oscillators.

While fixed-frequency or limited-range oscillators were being used as an expedient, development work was continued on wide-range variable oscillators. This paper is a report on one such development, using the type 2C43 lighthouse tube. The oscillators developed have a single tuning control, wide tuning ranges, good output, and no sliding contacts.

Original Butterfly Circuit

Simple negative-grid triode oscillators using a single tuned circuit between grid and plate can be made to operate at frequencies approaching the resonant frequency of the tube if the tube has properly proportioned grid-cathode and plate-cathode capacitances. A compact tuning unit such as the butterfly circuit[1] is connected with a minimum of lead inductance between grid and plate, while feedback to sustain oscillation is determined by the effective grid-cathode and plate-cathode capacitances.

Because of the low ratio of plate-cathode to grid-cathode capacitance of the disc-seal or lighthouse tubes, efforts to use these in simple oscillator circuits were not successful above 700 megacycles. However, of the available high-frequency triodes, the lighthouse tube seems to have power ratings best suited for use in laboratory oscillators, when maximum frequency and good output are required. Although this tube does not work well in the simple oscillators using a single tuned circuit, it will oscillate to higher frequencies than other available tubes, with good efficiency, when used in oscillators employing multiple tuned circuits.

Coaxial Version

To build a tuning unit to fit the lighthouse tube in a convenient manner, a much different mechanical structure from the original butterfly circuit was required. Since the tube was designed for use in coaxial-line resonators, it seemed desirable to try to build variable oscillators using elements of coaxial lines as resonant circuits. The resulting tuning unit has become known as the coaxial butterfly.

Figure 1 illustrates the basic form of the coaxial butterfly tuning unit, showing the high-frequency position of the rotor at the left and the low-frequency position at the right. This unit consists of a coaxial line shorted at one end and open at the other. The outer conductor is not a full cylinder, but has two 105-degree sections cut away. Rotating between inner and outer conductors are two 75-degree sectors which vary the frequency.

In operation the tube is connected across the open end of the line and acts as a capacitive load foreshortening the line. The length of the line at resonance is much less than a quarter-wavelength because of this loading. As the two rotor sectors are rotated, the characteristic impedance of the line is varied. This means that the amount of foreshortening caused by the tube grid-plate capacitance changes, and hence the resonant frequency is varied.

Figure 2 shows a basic unit equip-

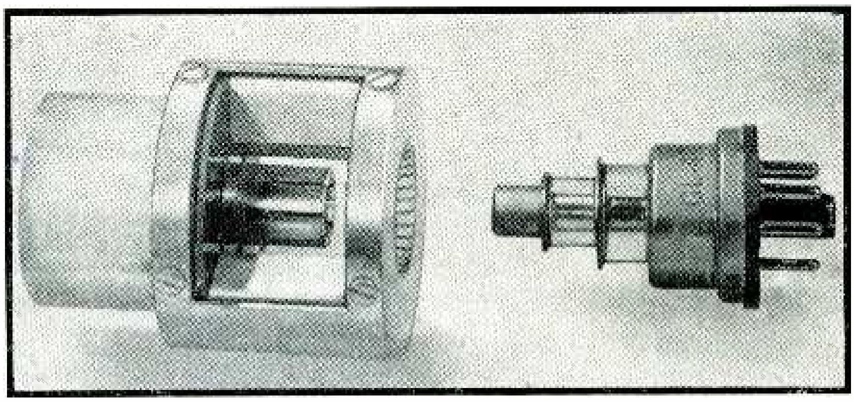

FIG. 2—Coaxial butterfly unit, designed to make plate and grid connections automatically when pushed over the lighthouse tube

Butterfly Circuits

Coaxial versions designed to fit over the type 2C43 lighthouse tube serve as wide-range uhf signal generators suitable for general laboratory use in the range from 500 to 1,600 megacycles. A single control varies feedback and frequency for either c-w or pulsed operation

ped with terminals for connection to the plate and grid of the lighthouse tube. In addition to the loading caused by the tube grid-plate capacitance, there is some capacitance added across the open end of the line by the rotor segments.

Frequency-Capacitance Chart

To get a better understanding of these tuning units, the plot shown in Fig. 3 was made. Values of loading capacitance required for a line of unit cm length are plotted versus frequency for a range of Z_0 from 10 to 500 ohms.

Besides showing that there is not much to be gained in frequency range by making the loading capacitance larger than the tube grid-plate capacitance, the chart can be used as a means of finding the resonant frequency for a line of known impedance Z_0, known length, and a given loading capacitance, or to obtain the proper loading capacitance for a desired frequency with a line of given Z_0 and length.

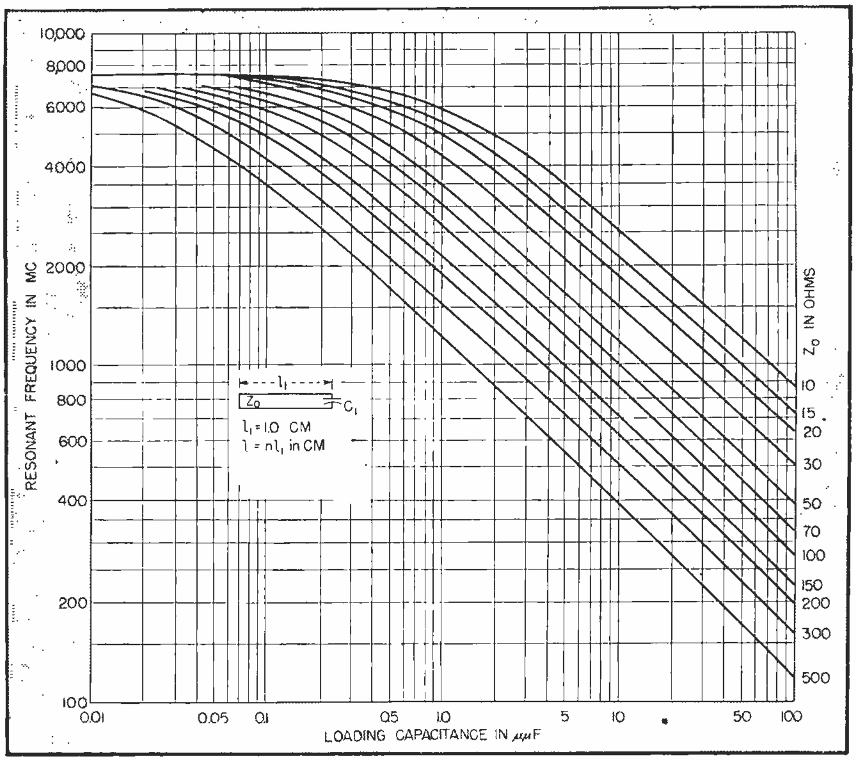

FIG. 3—Calculated curves of resonant frequency as a function of loading capacitance and Z_0 for a line of unit cm length. For a line n cm long, multiply capacitance scale values by n and divide frequency scale values by n before using chart

The chart has proved very useful in designing some of the coaxial tuning units. For example, with the dimensions and spacings that are considered practical in these tuned circuits, Z_0 can be varied from about 30 ohms to 150 ohms. If we make the tuned circuit 2 cm long, what frequency range should we get if the total effective loading capacitance is 4$\mu\mu$f This makes $n = 2$; the chart is adapted for this line length by multiplying capacitance scale values by 2. The original 2-$\mu\mu$f line on the chart now represents 4 $\mu\mu$f, the value at hand, and the frequency values obtained will be divided by 2. For $Z_0 =$ 150 ohms the frequency then is 1,600/2, and is 3,200/2 at $Z_0 = 30$ ohms, giving a frequency range of 800 to 1,600 megacycles for the unit.

Figure 4 shows the rotor construction which has given the widest frequency ranges. The two full metal rings at the ends not only make a stronger and more easily supported rotor than is shown in the basic units, but serve to keep the lumped inductance at the ends of the line at a minimum so that it is possible to take advantage of most of the change in Z_0 caused by the rotor segments.

Wide Frequency Ranges

The most effective means for getting wide frequency ranges has been to reduce all spacings between the rotor and the fixed portions of the tuned circuit. This decreases the effective Z_0 when the rotor is meshed with the outer conductor. In addition, the effective loading capacitance is increased. At low frequencies, Z_0 is unchanged, and the resonant frequency is reduced. At high-frequency settings the resonant frequency is increased because the decrease in Z_0 has greater effect than the increase in loading capacitance.

Stator Design

The stator or outer conductor of the line can be altered or shaped to provide a desirable law of frequency variation. While this lowers the top frequency for a given unit, the consequent reduction in the low-frequency limit produces an increased frequency range. Figure 5 illustrates one possibility. Here a 1,000-1,300 megacycle oscillator was designed for beat operation with a fixed 1,000-mc oscillator. A logarithmic variation of beat frequency was desired between 10 and 300 megacycles. Curve A shows the variation obtained before shaping, with most of the frequency change occurring in the relatively small region where the rotor segments are just beginning to pass under the outer conductor. Curve B shows the results of shaping the stator as indicated in sketch B, and curve C shows the final curve obtained with the outer conductor shaped in the manner shown in sketch C. It will be noted that rotation has been reduced from 90 degrees to slightly less than 70 degrees.

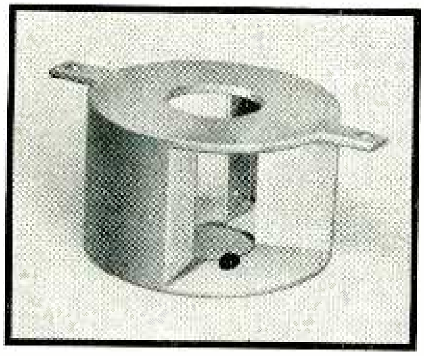

FIG. 4—Coaxial butterfly rotor construction which has given widest frequency ranges in uhf oscillators

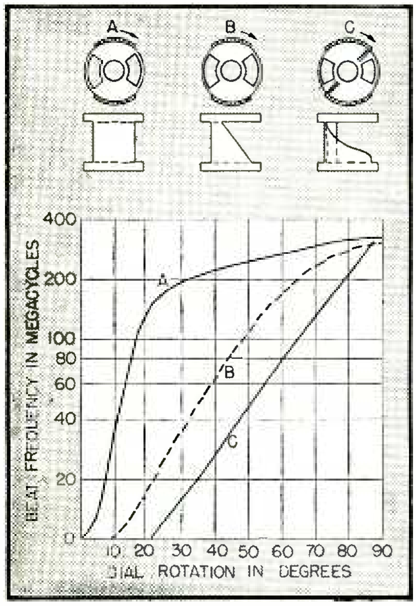

FIG. 5—Example of frequency variation versus dial rotation that is possible with coaxial butterfly units. Curves A, B, and C apply when stator or outer conductor of unit is shaped as in sketches A, B, and C respectively

The Q obtained with a coaxial butterfly circuit is low when compared with that obtained in coaxial tuners of optimum dimensions. Measurements on a tuning unit with a range of 620-1,350 megacycles indicate that the Q is about 350 at the low frequency and about 200 at 1,000 megacycles.

Feedback Circuits

The basic feedback circuit used with coaxial butterfly oscillators is shown in Fig. 6. The coaxial butterfly unit supplies a high resonant impedance between grid and plate of the tube. The outer cylinder, with tube and tuned circuit forming part of the inner conductor, makes up a coaxial resonator between grid and cathode of the tube. The fields of the two circuits are linked through the openings of the coaxial butterfly. Proper feedback for oscillation is obtained by adjusting the two disc-shaped plungers within the outer cylinder.

In addition to the frequency-determining rotor, this system requires two adjustable elements which have multiple sliding contacts. This circuit can be simplified if the plungers are properly located for the highest oscillator frequency and feedback for lower frequencies is maintained by adding capacitance C_F between a point on the tuning unit and a point on the outer chamber.

Sliding contacts can be eliminated if this capacitance is added, as shown in Fig. 7, by a series of adjustable metal fingers (a) which mesh successively with a tab on a ring (d) which is carried by the rotor. While multiple tuning elements are required, a variable oscillator with a single tuning control is the result. Oscillators with capacitive feedback adjustments such as this work satisfactorily over frequency ranges of about 1.6 to 1. Coaxial butterfly tuning units can be conveniently built to cover ranges of 2 to 1.

To make use of ranges available for grid-plate tuning units, an additional element to the feedback circuit was found necessary. This addition, shown in Fig. 8, consists of added grid-cathode capacitance produced by a series of adjustable fingers (b) mounted on the cathode stub which mesh successively with the shoe (c) mounted on the feedback ring (d).

As will be demonstrated, the feedback circuits outlined affect the coupling between the grid-plate tuning unit and the grid-cathode resonant circuit as well as keep the grid-cathode circuit properly tuned. Variations in coupling are caused by the relation of the feedback fingers (a) to the openings in the coaxial butterfly unit. For this reason, and because the coupling varies with the rotor position, some amount of experimenting and compromising is required before a continuously variable oscillator with a frequency range of 2 to 1 can be obtained. The final result, however, is an oscillator that has a wide tuning range, good efficiency, a single tuning control, and no sliding contacts.

Steps in the development of oscillators using the coaxial butterfly cir-

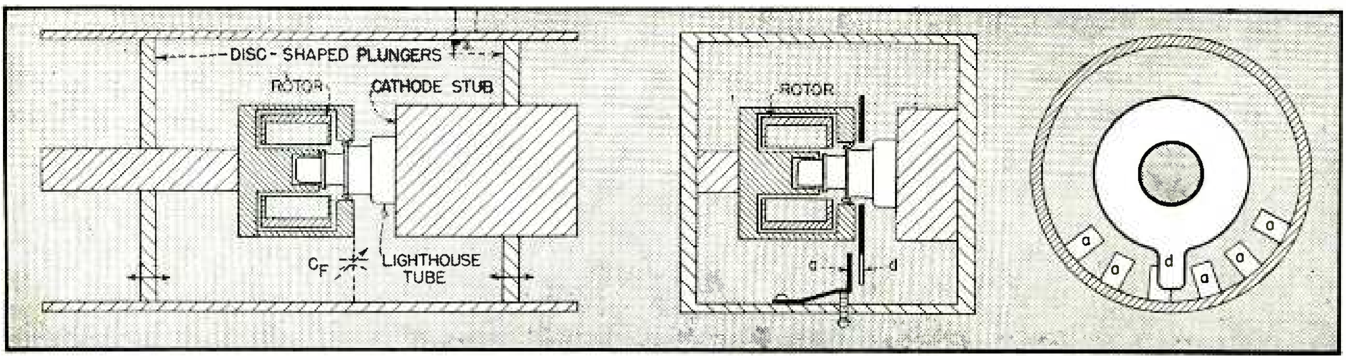

FIG. 6—Basic feedback circuit used with coaxial butterfly oscillators described in this article

FIG. 7—Cross-section and end views of oscillator, showing C_F of Fig. 6 added to eliminate sliding contacts

cuit have been outlined. Operating characteristics and descriptions of some of these oscillators follow.

The first oscillators developed using the coaxial butterfly unit were for use in a beat-frequency oscillator having a fixed 1,000-mc oscillator beating with a variable 1,000 to 3,000-mc oscillator to produce an output frequency of 10 to 300 mc.

Beat-Frequency Oscillator

The beat-frequency oscillator was suggested as a means for obtaining pulses with extremely short rise time at low frequencies where conventional oscillators do not have sufficiently rapid starting or buildup time. The fixed oscillator was to operate as either a c-w oscillator or a pulsed oscillator.

Pulsing requires more than the usual feedback to obtain the short rise time, and early experiments using the sliding end discs for feedback adjustment showed that a change in feedback was required if the oscillator was to be shifted from c-w operation to pulsed operation. It was noted that the change was accomplished by keeping the length of the outer cylinder constant and moving the tuning unit with respect to the end discs.

It was also found that the results could be duplicated by using the capacitive-type feedback. To reduce drift, the two oscillators were kept as much alike as possible. Outer chamber dimensions were kept the same. Adjustable capacitive-type feedback was retained for the fixed oscillator to obtain the required change in feedback, and the fixed oscillator grid-plate tuning unit was built as a coaxial butterfly with the rotor omitted.

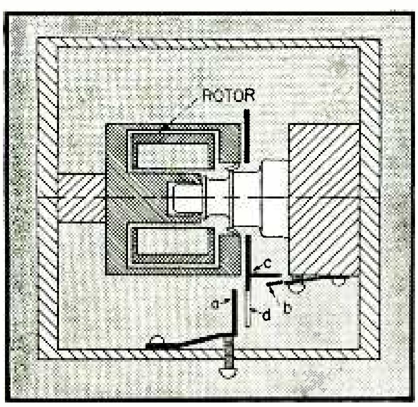

FIG. 8—Feedback circuit for wide-range coaxial butterfly oscillator, with no sliding contacts

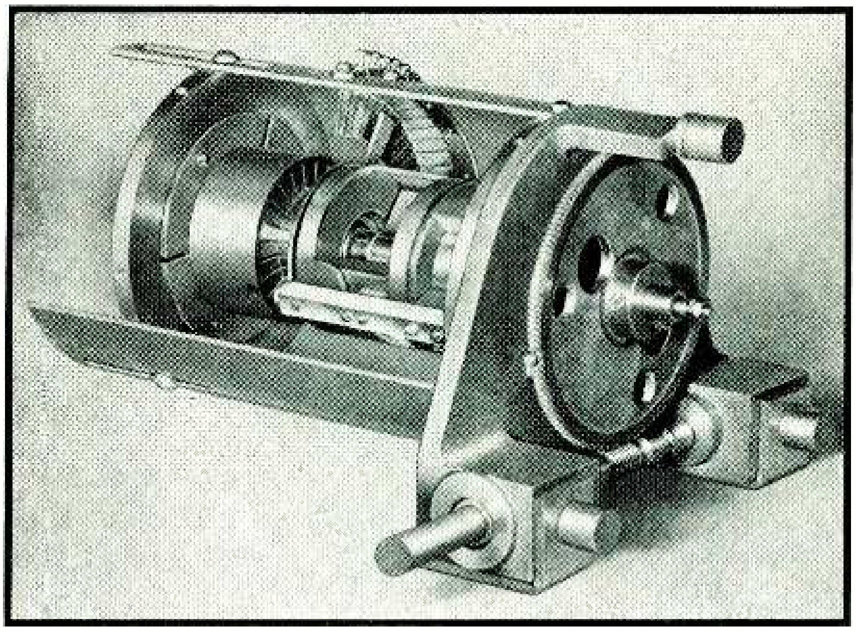

FIG. 10—Coaxial butterfly oscillator for 1,000 to 1,300 megacycles

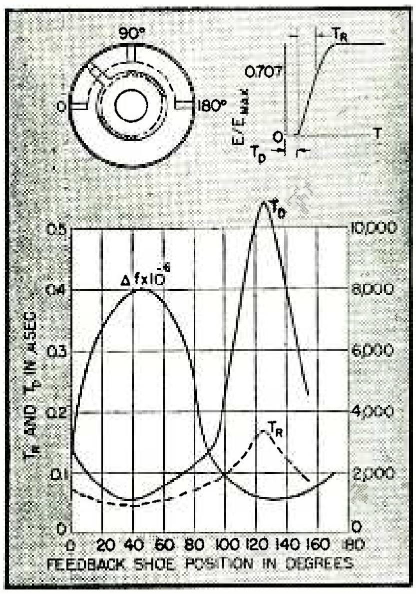

FIG. 9—Variations in oscillator stability and buildup time as a function of feedback capacitance location with respect to openings in the coaxial butterfly unit

Oscillator Buildup Time

Figure 9 demonstrates rather clearly that the capacitive adjustment does more than keep the grid-cathode chamber properly tuned. By shifting the point at which the capacitance is produced, frequency stability and oscillator starting or buildup time are markedly modified. As indicated by the upper right-hand sketch, the oscillator buildup time has been broken up, for convenience, into two components, which have been called T_D and T_R (delay time and rise time). Good stability required for c-w operation results when the capacitance is produced in line with the solid portion of the tuning unit, while rapid rise time and short delay time required for pulsed operation result when the capacitance is produced in line with the opening of the tuning unit.

As a pulsed oscillator, delay time was reduced to about 0.05 microsecond and the rise time was reduced to less than 0.05 microsecond. Many things was tried in an effort to improve the rise time of the oscillator under pulsed conditions. Loading the oscillator in an effort to reduce the Q of the tuned circuit was one device that was effective. The effect was not noticeable, however, until feedback had been adjusted for optimum pulse shape.

As a means to pulse the oscillator, a relatively low-power negative pulse was produced across the cathode resistor. This method was simple, worked very well, and did not require the high power that would be needed for plate pulsing.

As a c-w oscillator, the stability factor or frequency change in parts per million caused by a 30-percent change in plate voltage was reduced to 1,000. Power output of 1.7 watts with an efficiency of 30 percent was obtained with 250 volts on the plate. While operation is possible for all positions of the feedback capacitance, stability is poor when feedback

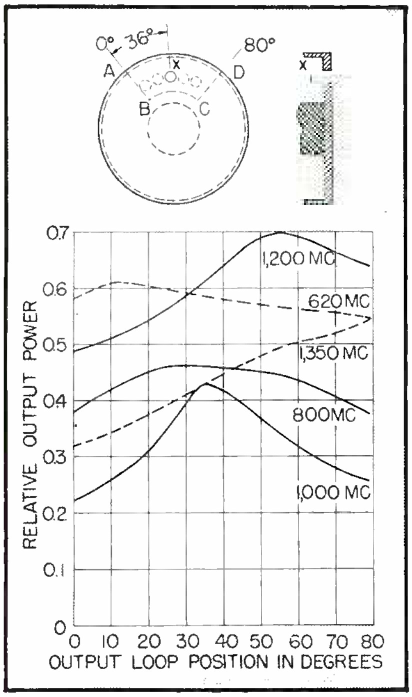

FIG. 11—Oscillator output as a function of output loop location with respect to active feedback fingers

is optimum for pulsing, and oscillator rise time is bad when feedback is optimum for c-w operation.

Variable Oscillator

Power output of an experimental model of the 1,000-1,300 megacycle variable oscillator for use in the beat-frequency oscillator varied from 0.3 watt to 0.7 watt with a plate voltage of 250 volts, while efficiency varied from 6 percent to 15 percent. A sizeable loss of power output and efficiency is the price paid for variable-frequency operation.

Figure 10 is a cutaway view of the variable oscillator which was evolved. This oscillator has a single tuning control and no sliding contacts. The structure which supports and drives the rotor segments also supports and drives the feedback ring past the adjustable fingers. The outer conductor of the coaxial butterfly is shaped to produce the desired frequency distribution, and the contour of one of the sections can be seen in the photograph.

Wide-Range Oscillator

After completing work on the beat-frequency oscillator, it was decided to try to make an oscillator having a wide range that would be suitable for laboratory use. As has already been pointed out, ranges could be made much wider than were required for the beat-frequency oscillator. Experiments showed that because of the space required by the outboard drive for the rotor, the maximum frequency for which the outer resonant circuit could be adjusted was about 1,350 mc. To get as wide a range as possible for experiments, the lower frequency was reduced. The final frequency range obtained with this oscillator was 620 to 1,340 mc. This range was again obtained with a single tuning control, with no sliding contacts.

Position of Coupling Loop

Location of an output coupling loop for this oscillator was determined experimentally. It was first roughly determined that maximum output could be obtained if the loop were located in the end disc of the outer chamber, opposite the adjustable feedback fingers.

Figure 11 illustrates the method used to locate the optimum position for the loop. At several frequencies throughout the range the oscillator end disc was rotated so that loop X was moved through the arc subtended by the feedback fingers (area ABCD). By this means it was discovered that maximum output for any frequency was obtained when the output loop was opposite the acting feedback finger. The fixed loop position which will give best output over the frequency range is then at 36 degrees, or opposite the 1,000-mc active feedback finger.

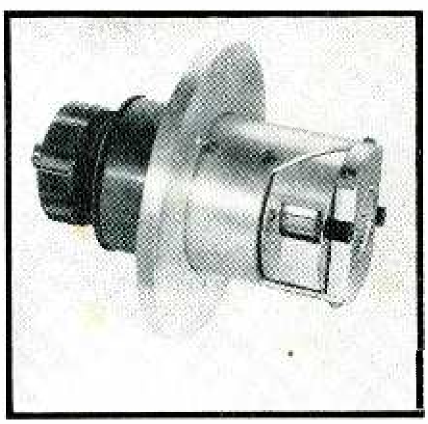

FIG. 12—Coaxial butterfly tuning unit for 800-1,600 megacycles. Tuning knob is at left, and controls the position of the rotor. The lighthouse tube is inserted in the recess at the right end of the unit

Power output obtained over the frequency range varies between 0.15 and 0.30 watt. Here again increased frequency range is gained with a reduction in power output.

Getting Higher Frequencies

To extend the useful range of these oscillators to higher frequencies, a coaxial butterfly tuning unit for a range of 800 to 1,600 mc has been built and is shown in Fig. 12. Its actual frequency range with the type 2C43 tube is 770 to 1,650 mc. This tuning unit features a more compact and simple rotor support and drive than was used on previous models. Portions of the plate end or short-circuited end of the line have been cut away to allow the rotor supports to turn. Also, portions of the grid-end disc have been sliced off to make way for the supports which hold the feedback ring to the rotor. Other mechanical changes have simplified the assembly of the unit appreciably. Oscillations have been obtained over the frequency range of this unit with about the same vigor as are obtained from the lower-frequency unit. Tests have not been completed on this oscillator, but it is hoped that a mechanically simplified feedback circuit can be devised.

Conclusions

The oscillators described in this paper, while not of the more desirable single tuned circuit type depending upon the tube electrode capacitances for feedback, do operate with a single tuning control and are somewhat more efficient. Sliding contacts have been eliminated and wide ranges have been maintained. The oscillators have high enough output to be used as laboratory oscillators or in standard-signal generators.

New tubes may soon make these circuits obsolete, but for the present they are useful and their performance is comparable to that of oscillators operating at much lower frequencies. It is hoped that the information presented here, when added to other bits of information, will make for a better understanding of ultrahigh-frequency triode oscillators.

Reference

(1) Karplus, Eduard, Wide-Range Tuned Circuits and Oscillators for High Frequencies, *Proc. IRE*, p 426–441, July, 1945.

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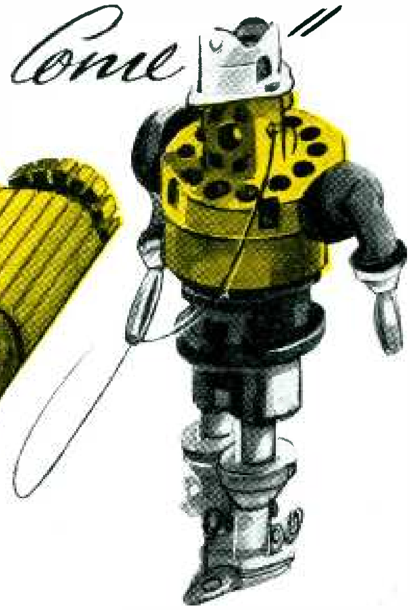

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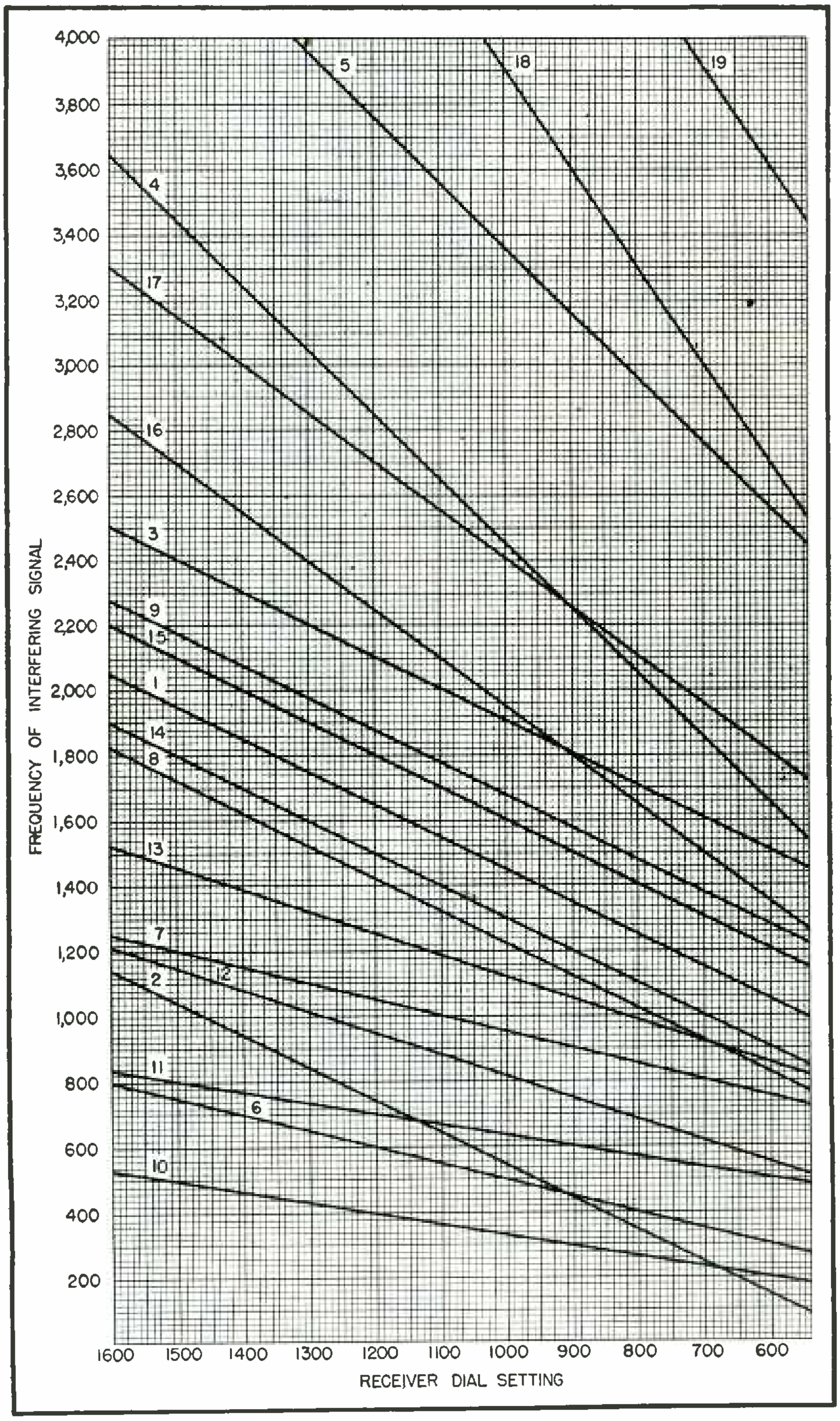
Beat-Frequency INTERFERENCE CHART

By DON BARTON
New York, N. Y.

INTERFERENCE may be present in the output of superheterodyne radio receivers if their input circuits are not selective enough to reject all but the desired incoming signal. These spurious responses will be the result of the combining of the oscillator frequency and/or its harmonics with the fundamental or harmonics of strong stations radiating a frequency differing from that to which the tuned input circuit of the converter is adjusted.



The accompanying chart plots 19 different combinations of signal and oscillator frequencies that can produce interference in a receiver using the RMA standard i-f of 455 kc. The curves are computed from formulas given previously in ELECTRONICS.[1]

The following examples illustrate several different types of interference. At 660 kc, a vertical line drawn on the chart will intersect all of the curves. Perpendiculars from these points of intersection to the left will give the interfering signal frequency. Thus one objectionable point is determined to be 220 kc from curve 10. A long-wave signal other than that of the i-f may consequently be present in the output of the receiver due to the local oscillator beating with the third harmonic of the interfering signal to produce 455 kc.

The intersection of the 660-kc line with curve 1 indicates an interfering signal of 1115 kc. Although no station operates on this frequency, audible beats would be produced by reaction with either or both the 1110-kc or 1120-kc carriers 5000 cycles away.

Curve number 4 shows that police calls may be received while curves 18 and 19 show that amateur signals can also beat at the same time. By using the formula numbered to correspond to the curve intersected,[1] the exact frequency of the interfering signal can be computed and the audio frequency of the whistle determined, assuming that the station producing the interference is on its assigned wavelength.

REFERENCE

(1) Adams, J. J., Receiver Interference Chart, ELECTRONICS, p 43, Feb. 1941.

INDUSTRIAL CONTROL

Fifty-foot Lightbeam Controls Rotating Mandrel 164
Radar Increases Safety of Night Boat 164
R-F Heating in Bakery Industry 166
Electronic Contactors for Control Applications 186

Fifty-foot Lightbeam Controls Rotating Mandrel

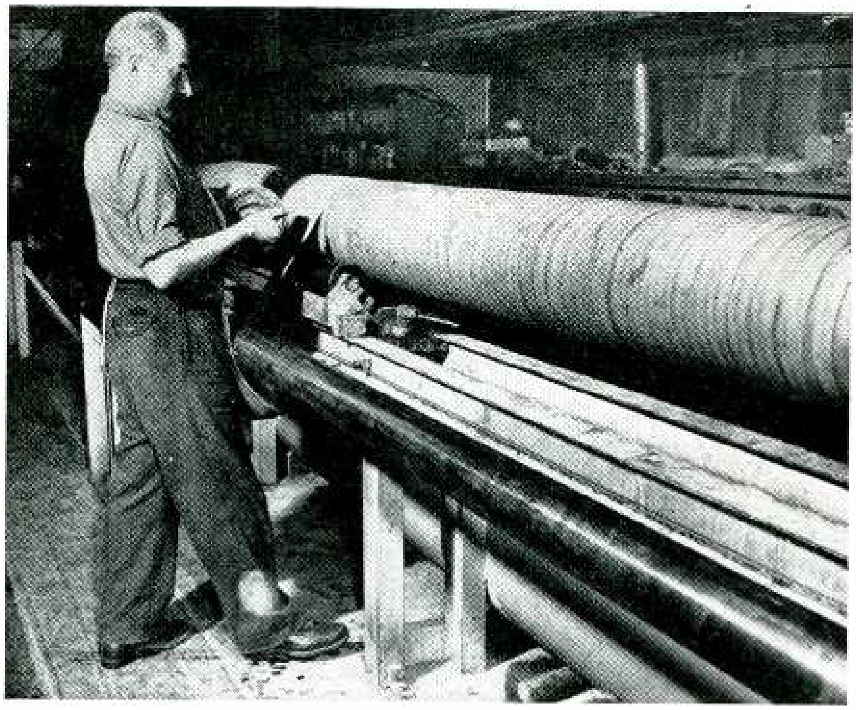
IN MAKING heavy hose at the Hewitt Rubber Corporation in Buffalo, N. Y., part of the process involves wrapping material on a huge 50-foot rotating mandrel, this being the standard length of finished rubber hose. This is done just prior to vulcanization and is an important step in the making of quality hose.

Until recently, the driven chuck which rotates the mandrel was controlled by the operator stepping on a wire cable which was stretched the full 50-foot length or by signaling the operator of the chuck by a nod of his head whenever the machine was to be started or stopped. This signal was sometimes not seen or the response to it was slow, and the wrapper could then be caught in the machine.

Recently, photoelectric equipment was installed about 12 inches above the floor. The light beam is thrown the entire 50-foot length and the machine is stopped instantly when the operator kicks either foot forward and so interrupts the beam. This may be done effectively at any point along the machine. A telescopic lens of 32-inch focal length focuses the beam to the phototube.

When first installed, the beam both started and stopped the machine, but to start the machine a wire cable is now stretched the length of the machine. This is placed close to the wrapping bar and operated by a pull of the finger of either operator.

Besides providing greater safety to the operator, the floor is left clear of any gear that might impair the travel of the operator, who now controls the machine with a minimum of effort and so may pay full attention to his work.



This fifty-foot mandrel on a large hose-wrapping machine is stopped by the operator when he moves his foot forward and interrupts a lightbeam that extends the full length of the machine

Radar Increases Safety of Night Boat

REGULAR NIGHT sailings of the commercial passenger-carrying night boat, *City of Richmond*, will benefit from an installation of radar equipment for navigation now being made by Westinghouse. The ship plies between Baltimore and Norfolk for the Old Bay Line, which plans to add more radar units to other ships of its fleet.

The installation is of the continuous plan-position-indicator type that provides a continuous picture of ship traffic and shoreline conditions from 100 yards to 32 miles distant in three ranges 2, 8 and 32 miles radius. The equipment uses a 7-inch cathode-ray tube mounted in a small cabinet convenient to the watch officer's station on the bridge.

Westinghouse engineers mount the antenna for laboratory tests of marine radar equipment for the Old Bay Line's Baltimore-Norfolk night boat, *City of Richmond*. The antenna will rotate under a mushroom-like protective cover atop pedestal to be located on the wheelhouse roof

The installation is in two major parts: the antenna, mounted under a large mushroom-like plastic dome atop a 5½-foot pedestal on the wheelhouse roof, with the modulator, preamplifier and other r-f components in the weatherproof base of the ped-

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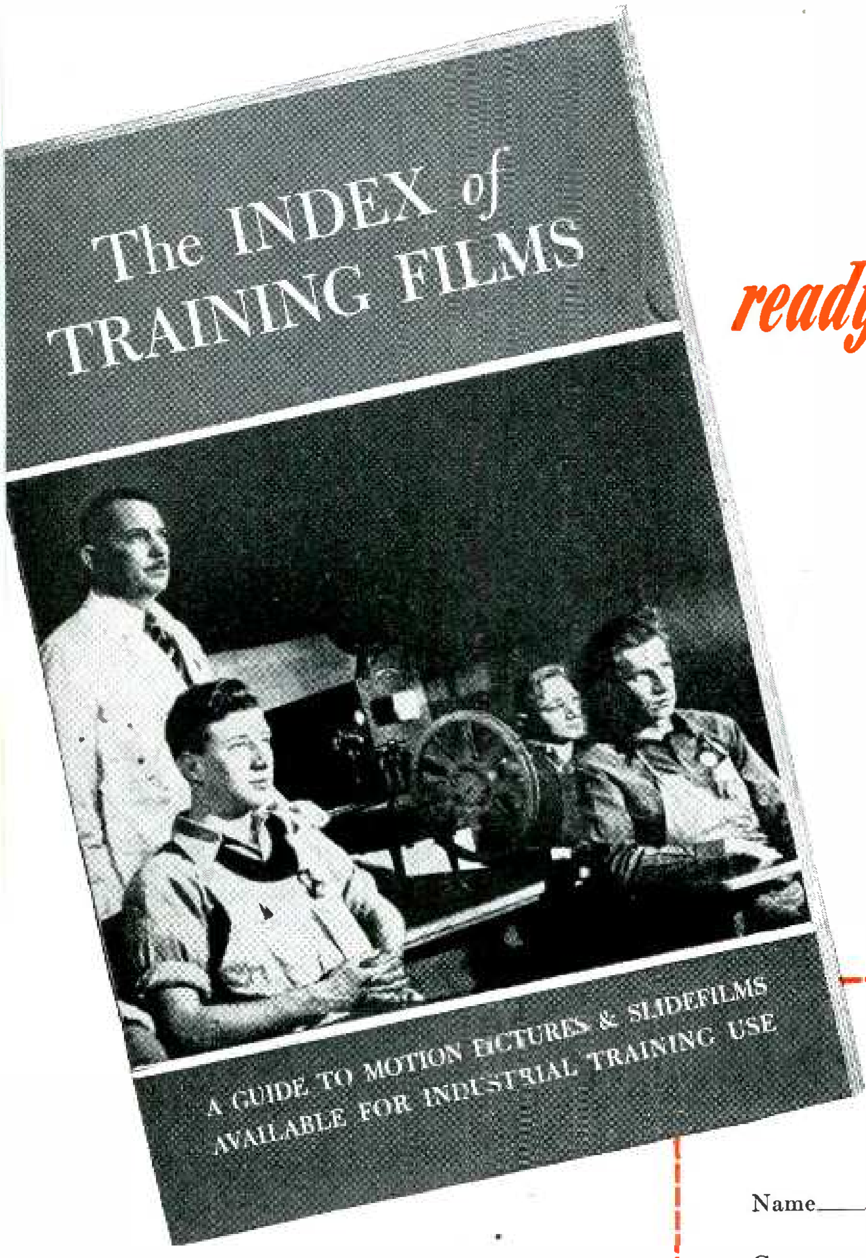

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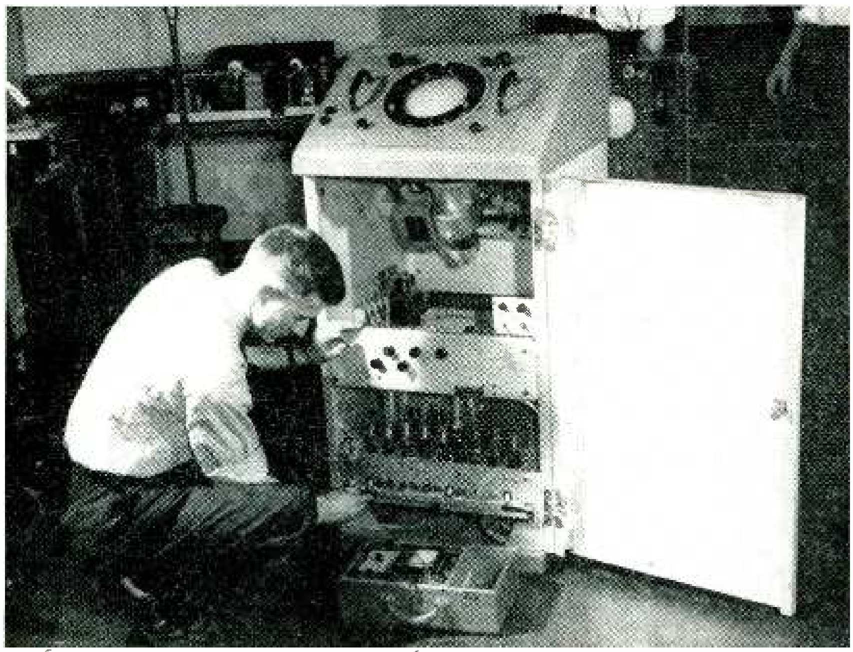


Westinghouse engineer Lynn Ulman checks receiver-indicator of the first major installation for use on long-distance passenger-carrying marine service. The seven-inch ppi scope of this receiver-indicator console will be located on the bridge

estal, and the receiver-indicator console, a cabinet two feet square and 48 inches high located on the bridge. Power is provided by a below-decks rotary converter operating on the ship's d-c line.

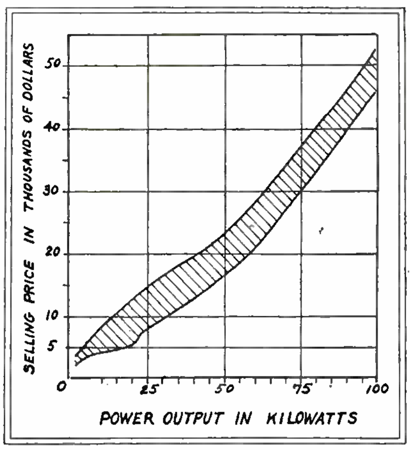
Although the antenna is designed to provide a full 360-degree horizontal sweep, because of its location on the wheelhouse roof the stack will obstruct its scan for about nine degrees dead astern. If complete coverage astern is needed, it will be necessary to elevate the antenna. Operation is in the frequency band from 9,320 to 9,430 megacycles.

R-F Heating in Bakery Industry

THAT ELECTRONIC HEATING has been successfully applied to food products for dehydration, cooking, melting, roasting, deinfestation, baking, defrosting, and mold inhibition was announced at an annual meeting of bakers in Chicago by V. W. Sherman, president of Sherman Industrial Electronics Co., who copyrighted the talk. It was stated that certain applications are feasible only under special circumstances and that others are dubious and should not yet be recommended for development. He described some applications that have been repeatedly tested and possess both practicability and economic soundness.

Defrosting

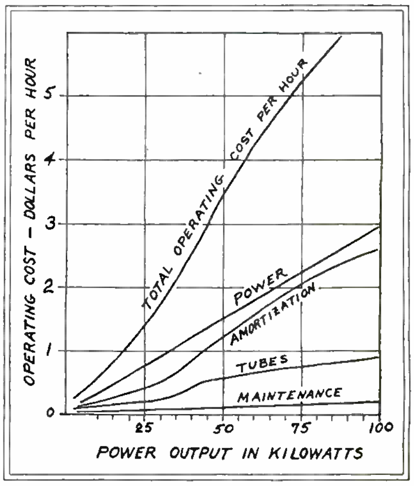
Thirty-pound cartons of perishable fruits like strawberries have been defrosted with electronic heat in a matter of minutes, in contrast to the four hours in warm water or the one to seven days presently required at room temperature. Smaller two-pound cakes of frozen food were defrosted in less than one minute. Five-pound blocks of frozen eggs were defrosted in less than three minutes.



For a given power output, the selling price of an h-f generator increases as the output frequency required by the job becomes higher. Dielectric heaters for bakery and food work require a frequency in the order of 13 to 30 mc. Small units range $750 to $1,000 per kw and larger sizes about $400 to $500 per kw of output

All these jobs were accomplished with only three kw of 13-megacycle electronic heat. Based on this work, a 25-kw electronic defroster was designed to handle barrels of frozen food at the rate of 750 to 1000 lb per hour depending upon initial temperature. To bakers, candy and ice cream makers electronic defrosting means a saving of time, space, and handling and also the reduction of spoilage and the retention of fresh flavor. From the health standpoint, electronic defrosting insures an exceptionally low bacteria count in eggs and similar products due to the speed of the process, which reduced drastically the time food was exposed to the atmosphere.

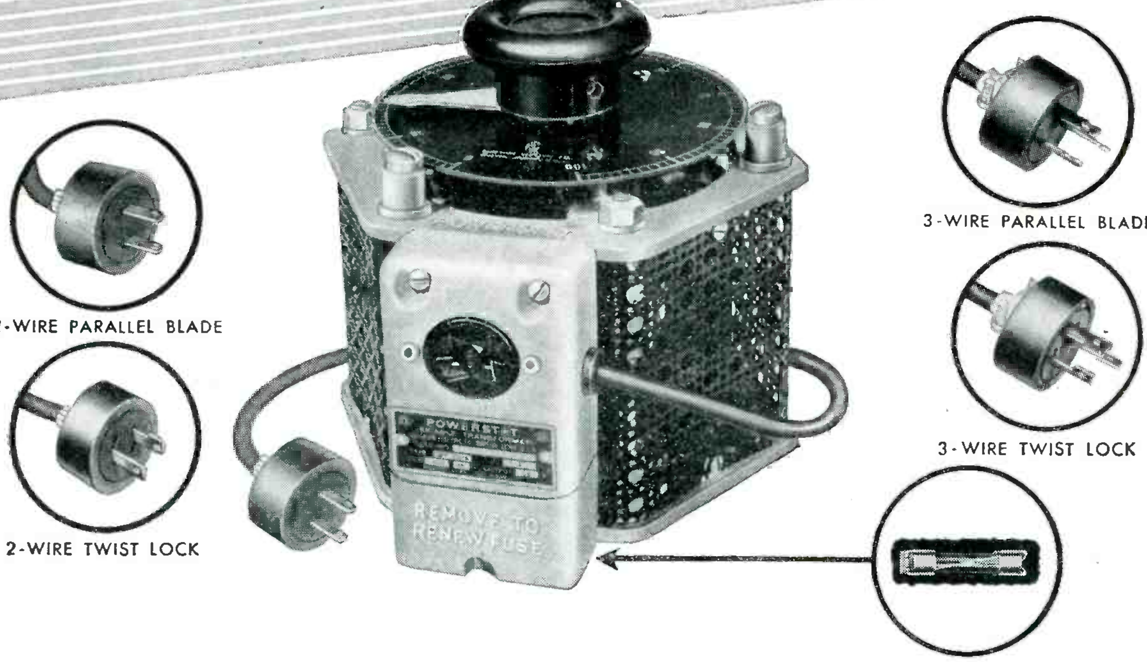
A large bakery may require the defrosting of 10,000 pounds of product per day. Many ice cream manufacturers use 40 to 50 barrels of frozen fruit a day. Defrosting times ranging from 45 minutes to two hours cover practical requests for equipment performance at this time and a 30 to 40-minute treatment time is recommended to reduce power and cost, yet insure low bacteria count.



Operating cost for electronic heaters up to 100 kw. The curves are based on one make only and do not necessarily apply to all makes

The special defrosting of bread frozen to retain its freshness over a period of two weeks has been successfully done with electronic heat. The appearance and taste of the product were stated by bakery men to be equivalent to that of the fresh product. Other successful defrosting ap-

NEW Versatile Connections



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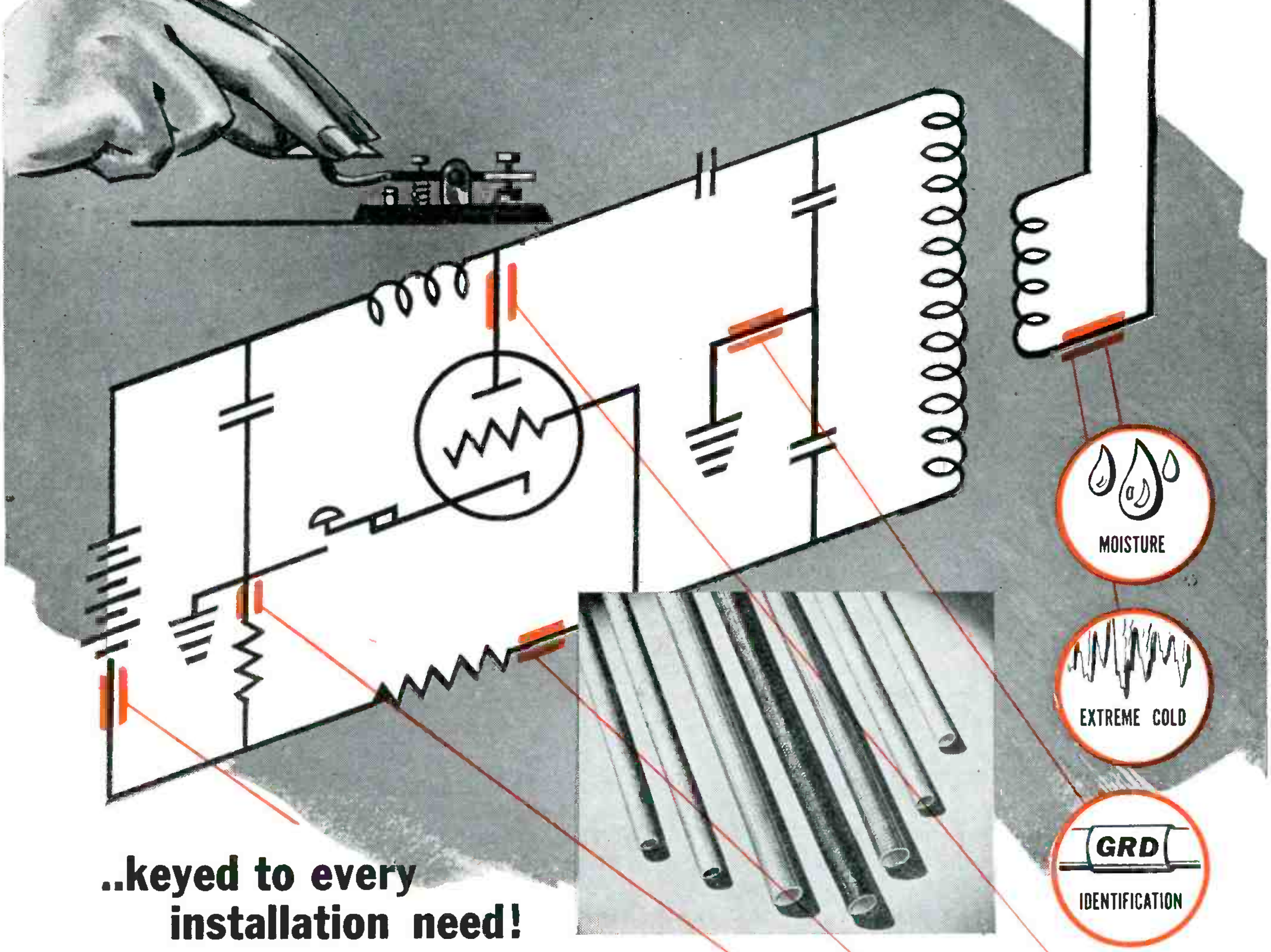

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plications have included eggs (40 lb/hr/kw), chickens (30 lb/hr/kw), and a wide variety of packaged frozen foods.

Another application somewhat related to defrosting is the warming through of dough to promote rising. A reduction of shortening required is said to be made possible by the rapid and substantially uniform warming experienced with electronic heating.

Cooking and Baking

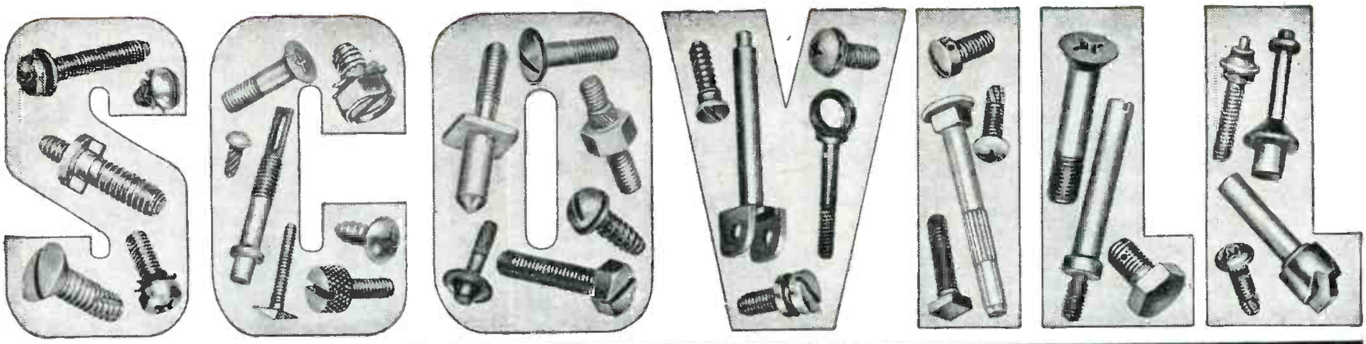
With only three kilowatts or less of electronic heat, heavy cookies $\frac{3}{8}$ inch thick by 3 inches in diameter have been baked in 75 seconds. Fruit cake has been baked in glass dishes. Homogeneous foods such as meat loaf, diced vegetables, cored apples and many meal and flour products have been readily cooked. A five-pound leg of lamb was roasted perfectly in 30 minutes, gravy and all. This would have taken 2 to 3 hours in an ordinary oven.

Cooking or baking is an art that requires more than time and temperature. The application of electronic heat to such an art will require cooperative development. For example, the electronically baked cookie had no brown crust, and its surface color was much the same as its interior. Crusting could be readily added as a finishing operation using infrared lamps or electric strip heaters. In either case, the overall baking time would be definitely reduced but such necessary changes in baking technique must be decided by trial.

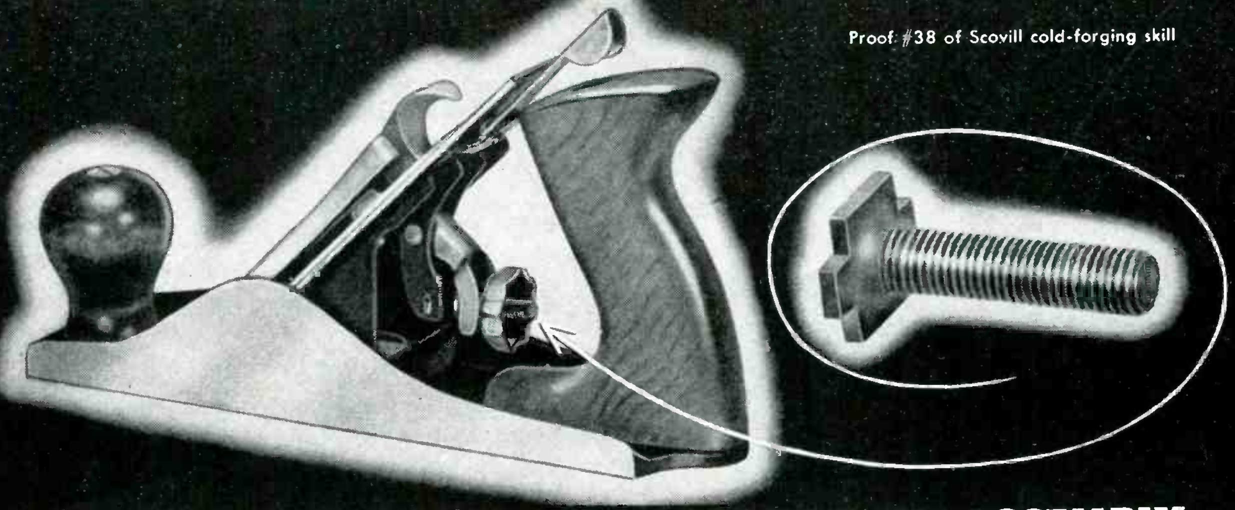
Melting

Chocolate, cocoa mixtures, sugar in several forms, starches, and other products can be melted with electronic heat. The rapid and substantially uniform heat was of real advantage. In certain cases special fixture design was required because of the product's tendency to foam. This was the case with dextrose and with lump sugar. Sugar syrup does not foam, nor does chocolate, nor starch which rapidly reduced to a jelly-like mass with electronic heat. When the product to be heated has both lumps and powder, the lumps may be expected to heat about twice as fast as the powder.

Mold inhibition is an excellent application and has produced positive



Proof #38 of Scovill cold-forging skill



ANOTHER CASE WHERE SPECIAL DESIGN CUT ASSEMBLY TIME, AND SCOVILL COLD-FORGING CUT COSTS

The part above is but one of many instances wherein Scovill cold-forging skill and equipment helped customers get better fastenings (frequently at substantial savings over other production methods).

If your product is in the Design stage that is the best place to call in Scovill experts for special, cold-forged fastenings that will reduce assembly time and do a better job on the Job. Scovill cold-forging skill and equipment may not only make such special designs practical but also bring important savings over other production methods.

If your fastenings are already in production Scovill cold-forging may well produce them better for less.

In any event it will pay you to discuss your problem with Scovill. No cost or obligation, of course.

● ***Call Scovill on these standard fastenings for production efficiency... Phillips Recessed Head Screws... Type F Self-Tapping Screws... Washer-Screw Assemblies***

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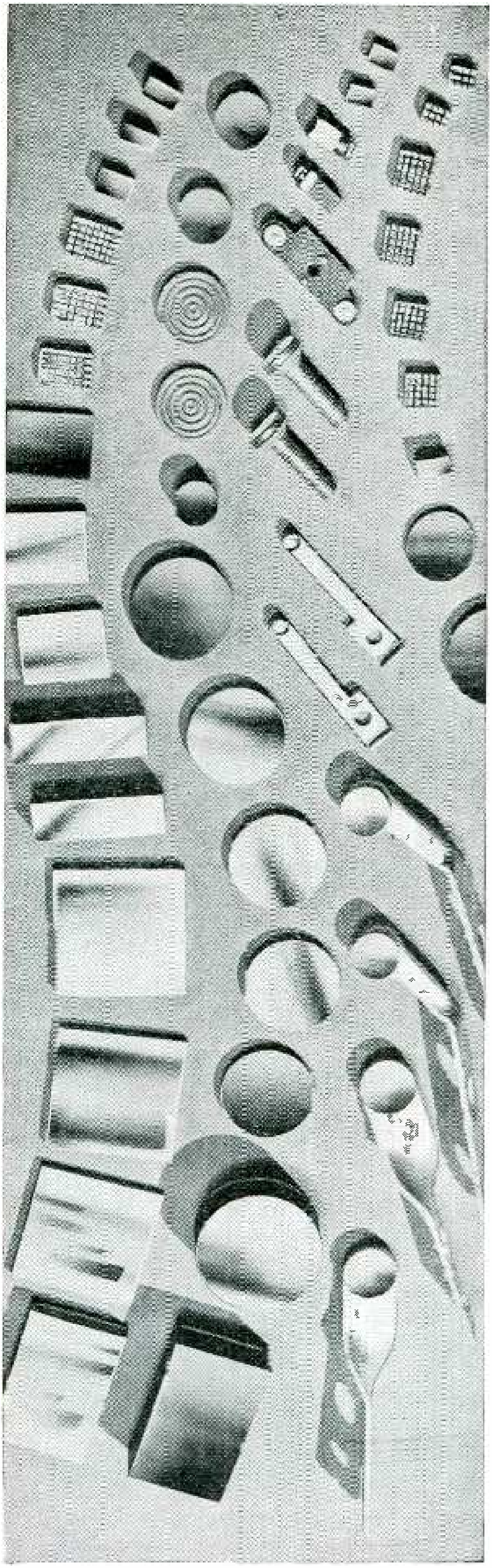
ANOTHER WILCO DEVELOPMENT



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PROPERTIES AND CHARACTERISTICS—WILCOLOY Silver Tungsten, Copper Tungsten, Silver Graphite, Silver Molybdenum and other WILCOLOY contact materials assure a degree of longevity, and thermal and electrical properties not possible to materials previously used in applications subject to severe current interruptions.

These Sintered Powder Metal Contacts offer a choice of properties including ductility, hardness, density, freedom from sticking, low metal transfer, high conductivity and arc-resistance. They perform uniformly and dependably in heavy duty circuit breakers, both air and oil relays, aircraft units, motor brushes, commutator segments, fuse replacement units and other specialized applications.

CONSULT OUR ENGINEERING DEPARTMENT—Write our Engineering Department for help in developing the proper application of WILCO materials to your products.

SEND FOR WILCO BLUE BOOK—The Blue Book contains descriptions of most WILCOLOY Sintered Powder Metal Contacts and other WILCO products. Send for FREE copy today.

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Platinum
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Alloys
Sintered Powder Metal

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SILVER CLAD STEEL—

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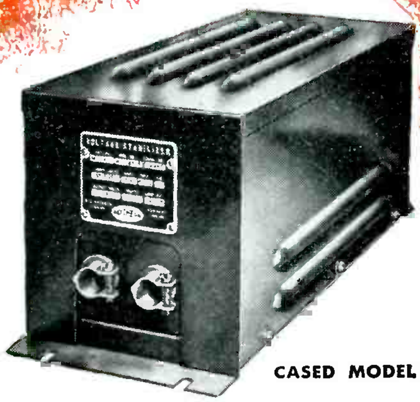
of Varying Power Supply



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Raytheon Voltage Stabilizers

DELIVER OUTPUT VOLTAGE CONSTANT TO ±½%

FLUCTUATION of line voltage need not impair the performance of your electrical equipment. Such variations are easily corrected with magnetic-type, entirely automatic Raytheon Voltage Stabilizers.

Positive control is gained. Power supply is stabilized to ±½%. Reliability and accuracy of performance are effectively improved, *and at low cost.*

Investigate. Determine how positive control of line voltage can benefit your equipment. Our Bulletin DL-48-537 gives the detailed story. Write for it today.

Get These Principal Operating Advantages:

- **Control of output voltage to within ±½% of 115 or 230 V.**
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RAYTHEON

RAYTHEON MANUFACTURING COMPANY
Industrial Electronics Division, Waltham 54, Mass.

Excellence in Electronics

results. Whole wheat bread, Boston brown bread, and white bread so treated remained mold-free for over two weeks. An untreated control loaf showed mold before the end of the second day. The protective treatment was given directly after wrapping and sealing the loaf in cellophane. Electronic heat developed the temperature of 140 F uniformly throughout the loaf in a matter of seconds. The small amount of moisture condensed on the inside of the cellophane wrapper during heating was quickly reabsorbed by the loaf during the cooling-off period. The treated product suffered no change of texture or taste.

Other Food Applications

Carmelizing, dehydrating, deinfesting, popping, and sterilizing have been done. Work in the food field has covered a long list of products ranging alphabetically from apples to yeast and including birdseed, candy, cereal, cinnamon, corn, eclairs, gelatin, licorice, malt, meats, muffins, nuts, potatoes, spices, and starch.

Figures 1, 2, and 3 show how white flour, a prepared biscuit mix, and a

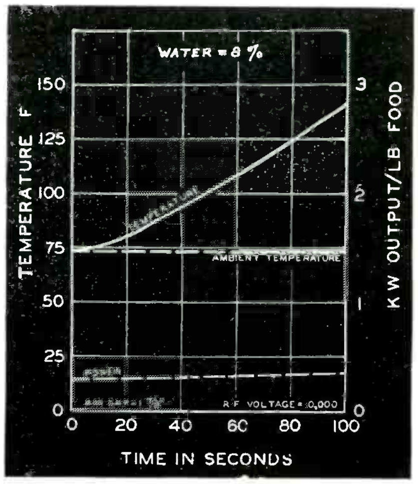
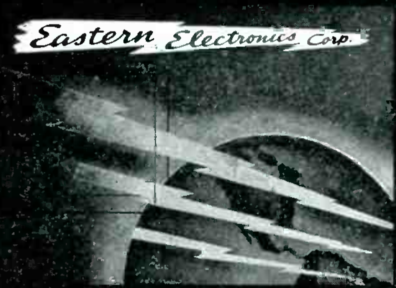


Fig. 1—Electronic heating of white flour

ginger bread mix, respectively, responded to electronic heating which was applied as a protection against infestation. Although each food responded in a somewhat individual manner it may be noted that if the power had been adjusted to exactly one kilowatt in each case, then the 75-degree temperature rise would have been accomplished in substantially the same time (40 to 45 seconds) for each one-pound sample. In



- **PRECISION WIRE WOUND RESISTORS**
- **WHEATSTONE BRIDGES**
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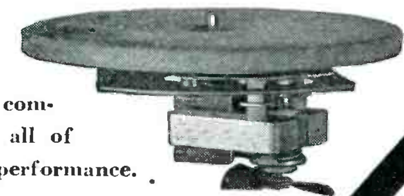
PHONOGRAPH TURNTABLE UNIT The need at this time for large quantities of phonograph turntable assemblies has prompted us to quickly design and tool up for the immediate production of this item. Engineers will find this compact turntable meeting all of their requirements for performance.



PERFORMANCE: — Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

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RELIABILITY: — The motor is fan-cooled and will operate continuously with an exceptionally low temperature rise. All bearings are of ample size and are provided with self-lubricating features.

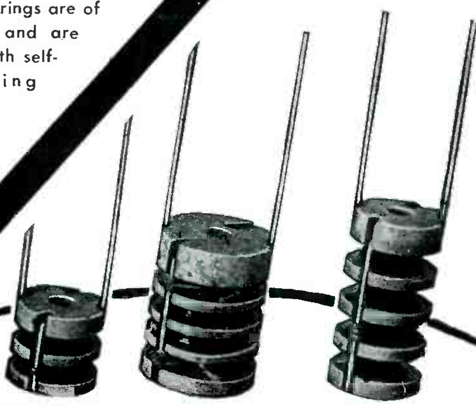
Type C
Maximum resistance 500,000 ohms.

Type A
Maximum resistance 1,000,000 ohms.

Type B
Maximum resistance 1,000,000 ohms.

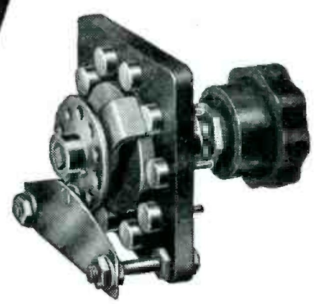
Type XM
Instrument resistance shunt .1 ohms or lower. 25 watts.

We will make special resistors to any value or tolerance.



Type C Type A Type B

★ ★ ★



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Designed for use where low contact resistance and mechanical sturdiness is required. Its construction insures long wear with low contact resistance of less than .001 ohm. May be arranged to have several sections to obtain multi-polar switching.

Well suited for precision test instruments; shunt ammeters, thermo-couple types, Wheatstone Bridges, and similar devices.

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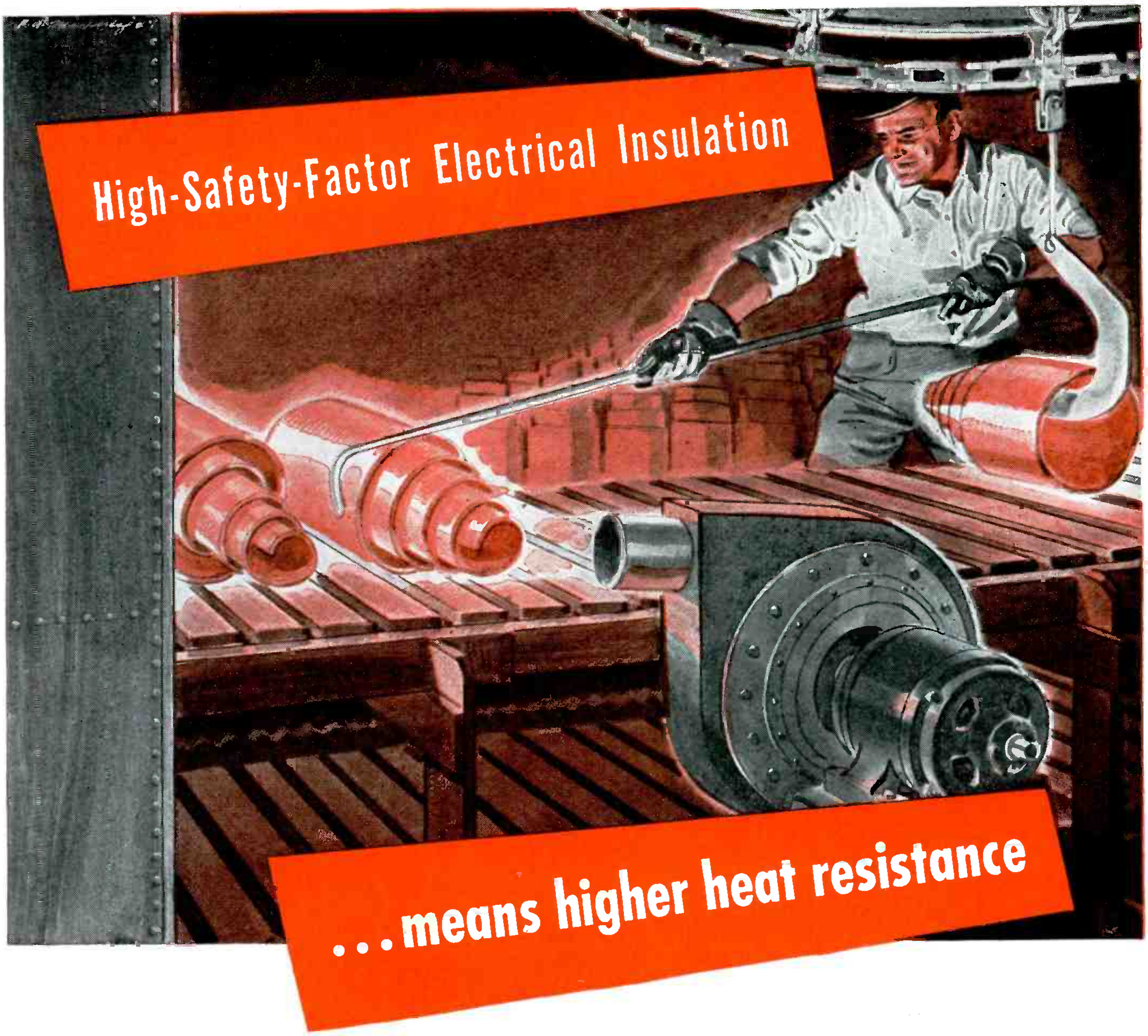

Heat is a limiting factor in design, as designers and manufacturers of electrical equipment know. It's an obstacle to maximum operating efficiency and is a prime source of trouble for the user of the equipment.

As a base for impregnating varnishes of all types, including those specifically developed for high temperature applications, Fiberglas Electrical Insulation Materials provide the fully tested solution to many high-heat problems. Furthermore, it provides a means of overcoming many other conditions which are the major sources of insulation failure—such as moisture, corrosive vapors or acids, and overload.

In addition to unmatched mechanical and electrical advantages, Fiberglas Electrical Insulations can help give your product extremely valuable merchandising features and sales influence.

The full line of Fiberglas Electrical Insulation Materials can help you solve a heat problem—help increase the operating efficiency of your products—reduce maintenance requirements or provide a potent sales advantage.

Get complete information—write for a copy of "Are your motors a good insurance risk?" The name of the Distributors serving your locality will also be furnished if you desire. Owens-Corning Fiberglas Corp., 1860 Nicholas Bldg., Toledo 1, Ohio. Branch Offices in Principal Cities.

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Electrical Insulation Materials

a commercial installation, where radiation and fixtures losses are negligible compared to energy in the product, almost double this heating rate per pound would be experienced for each kilowatt of applied energy.

For the bakery the following are felt to offer the most immediate value: an electronic baker for baking thick cookies either completely or at least during the early stages so as

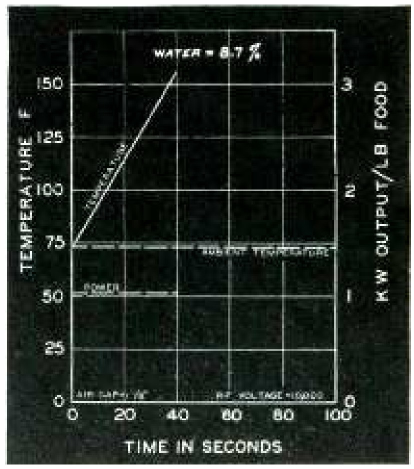


Fig. 2—Electronic heating of prepared biscuit mix

to strike through and initiate heating of the core, an electronic mold inhibiter for packaged goods, and an electronic defroster for frozen fruits and eggs.

Popular Misconceptions

To make use of electronic heat today, the following ideas must be discarded as either downright fanciful or at least of no proven basis.

(1) That for each material there

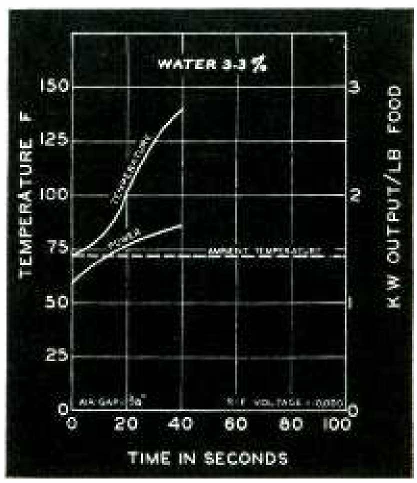


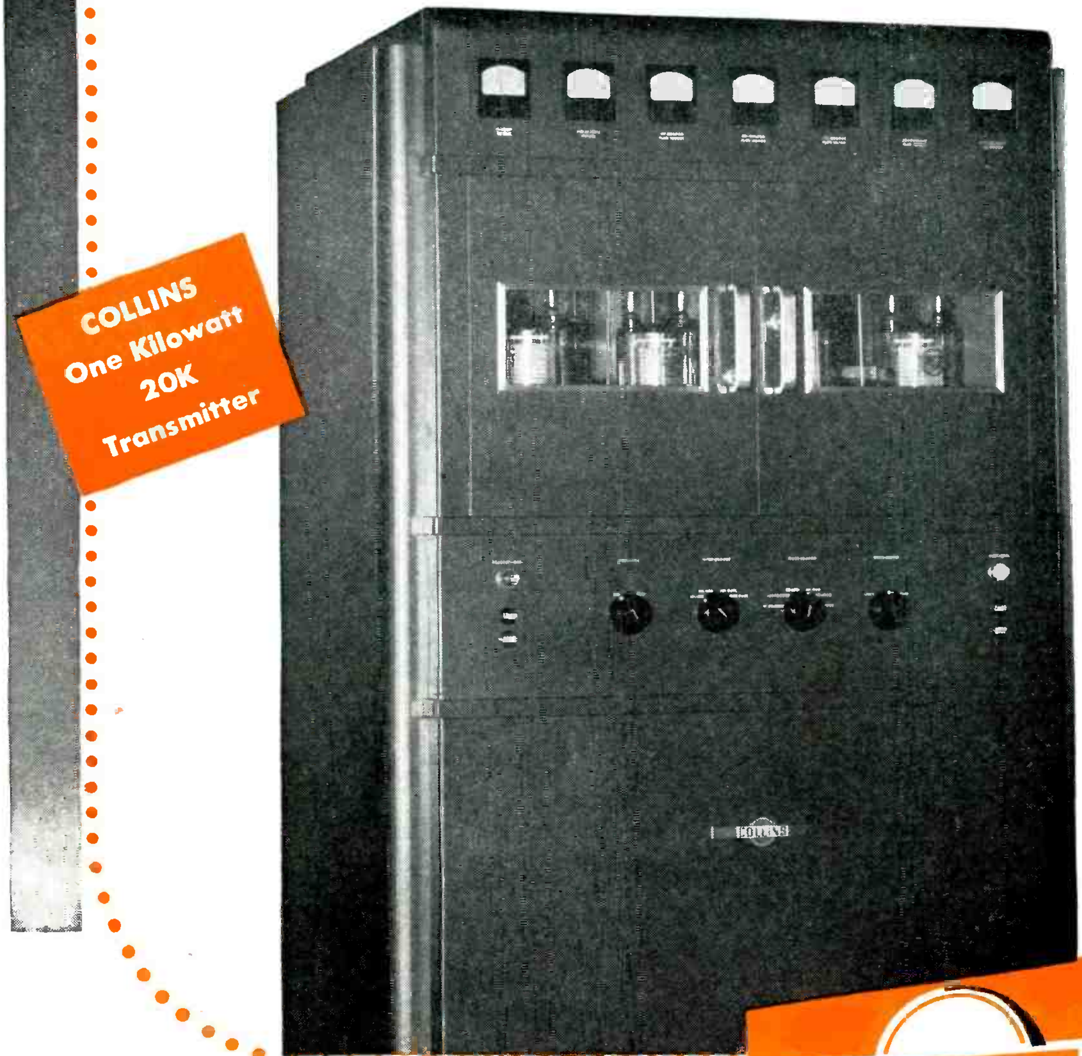
Fig. 3—Electronic heating of gingerbread mix

More output per dollar input!

The highly-efficient output network of the Collins 20K AM broadcast transmitter contributes materially to its high operating economy and reliability. Efficient transfer of power from final amplifier to antenna calls for less power input, and therefore less power dissipation in circuit elements. Lower operating cost, greater dependability, and longer component life are the results of ingenious coordination of circuit design, components, and tubes.

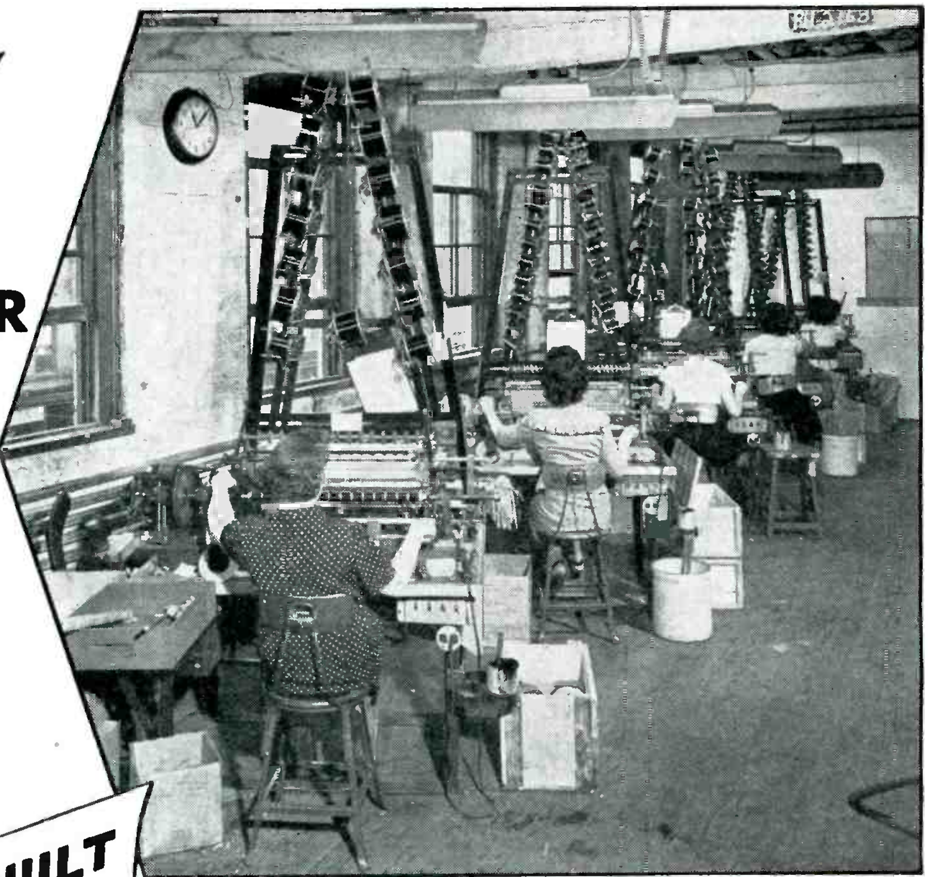
Audio frequency distortion, noise level, and audio frequency response are within FCC high fidelity requirements. Stabilized feedback constantly safeguards these excellent performance characteristics under widely varying operating conditions.

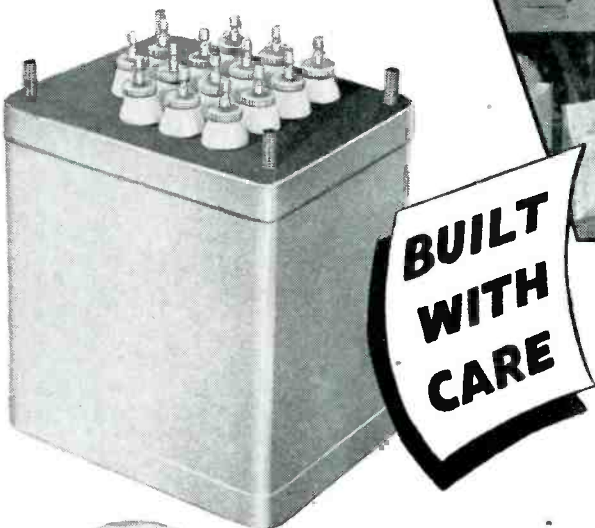
Complete metering and motor tuning provide control over all circuits. Power change-over from 1000 watts to 500 watts is instantaneous. Write for further information. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.



FOR BROADCAST QUALITY, IT'S . . . . COLLINS

Every AmerTran Transformer *is* BUILT WITH CARE





Advantages of multiple coil winding

Coil winding is an important phase of AmerTran Transformer construction. Use is made of high speed multiple winding machines (some of AmerTran design) capable of producing many coils at a time with exceptional uniformity. Care enters the picture in the precise control with which such elements as number of turns, tightness of layers and wire tension are maintained. Tight coils have fewer and smaller air pockets, and greater heat-conducting capacity. AmerTran coil winding methods add up to close conformity to specifications, uniformly excellent characteristics, and usually a consumer saving for a specific type and quality of transformer.

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Audio Transformers and Reactors. Modulation Transformers (to 500 KVA). Hermetically sealed Transformers. Plate and Filament Transformers. Filter Reactors. Wave Filters. High Voltage Rectifiers. Microphone and Interstage Transformers. Transtat A. C. Voltage Regulators. Other Electronic and Industrial Transformers.

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is one special frequency which produces super results not possible at a frequency slightly different.

(2) That higher frequency will always give better results.

(3) That there is something magic about a Btu of electronic heat.

(4) That electronically heated material escapes the conventional laws of thermo-dynamics, chemistry, etc, and that nothing limits the maximum speed of electronic heat.

(5) That dielectric fields, as such, have germicidal power.

(6) That electronic heaters have some mysterious effect upon persons.

The special-frequency fallacy seems logical until one runs tests on food

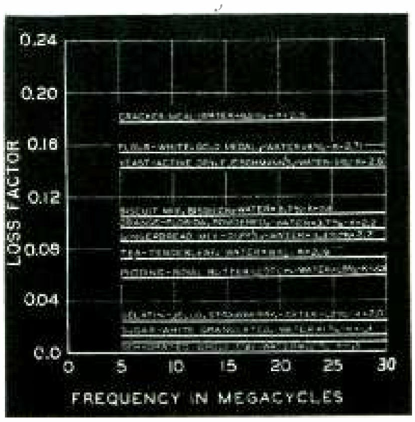

Fig. 4—The electrical loss factor of food is practically constant over a wide frequency range

after food as represented in Fig. 4. Over the usable frequency range, we have no magic frequency and could use almost any practical value as long as it is effective and does not require too high a voltage across the product. In spite of exceptions in the chemical field, it may be stated that thus far no magic frequency has basis for recognition in the heating of food products.

Use of a higher frequency sounds progressive but it gives better results only if lower work voltages are essential or if some unusual circumstance exists.

Electronic heater fields have neither germicidal power nor human sterilization power. They are merely capable of producing heat in a faster and more effective manner. The heat so created may be more advantageously located but it behaves exactly

for any type of application

BLILEY has the crystals

To name all the engineers who "consult Bliley first" on frequency control problems would make a mighty impressive list.

They know from experience that Bliley engineers are always working in advance of the industry's requirements, and that the right crystal for their particular application will be available without undue delay.

That is why Bliley acid etched* crystals persistently show up wherever important developments are taking place in the communications field —and go with those developments to all parts of the globe.

Your products, too, will benefit if you make it a habit to "consult Bliley first" on frequency control problems. There's over 15 years of quartz crystal engineering experience at your beck and call.

* *Acid etching quartz crystals to frequency is a patented Bliley process.*

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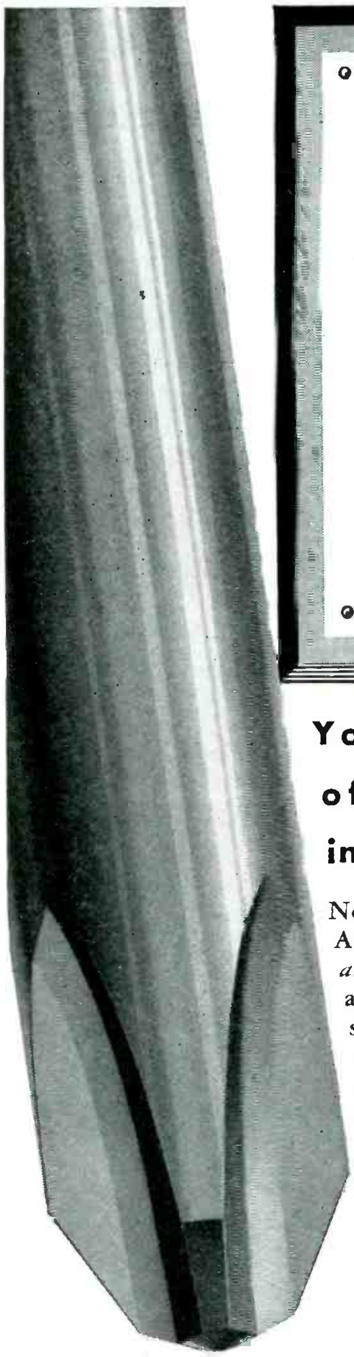

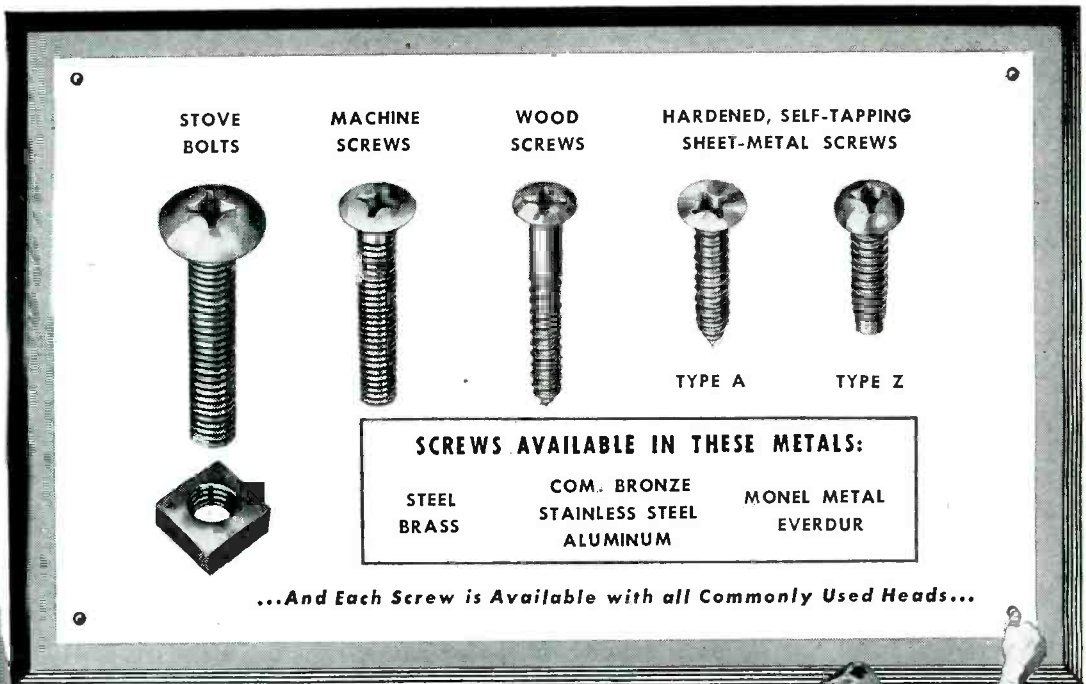

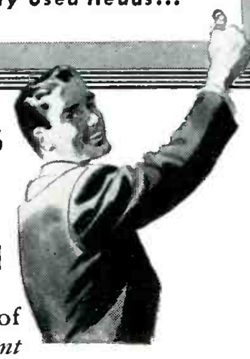

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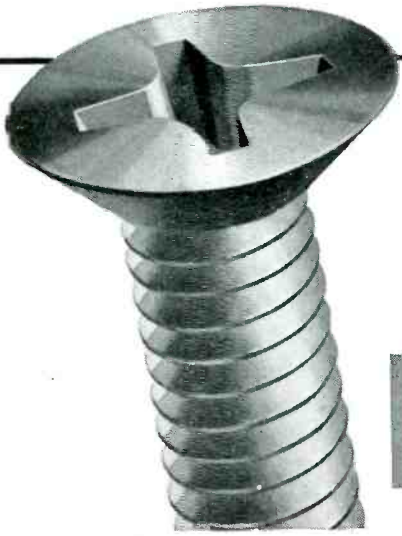

You've got Thousands to Gain—and Nothing to Lose

WHEN YOU CHANGE TO:

AMERICAN PHILLIPS *Screws*

like a Btu from any other heat source.

In other fields we may reasonably expect to see electronic defrosters developed for commercial kitchens and for frozen food stores.

Electronic cookers for special restaurant and domestic use are practical but still expensive and additional development is indicated. The heating fixture and work mechanization requires job engineering in every case and since the job will decide what the electronic heater must be capable of doing, it necessarily follows that the purchase of equipment for an industrial application should be based upon the recommendation of experienced industrial electronic engineers.

Operating Costs

The maintenance problem is confined to routine inspection and the replacement of tubes (average life 2,000 hours). Service cost records, based on several hundred r-f generators ranging in output from three to 75 kw and located throughout the East and Middle West, have indicated an average annual maintenance cost approximately five percent of the purchase price of the generator.

The total of all elements of operating cost rarely exceeds 10 cents per hour per kw of output. A three-kw output unit costs about 30 cents per hour to operate whereas a 25-kw output unit can be operated for only $1.30 per hour, which is less than six cents per hour per kw of output.

These figures take into consideration an overall electrical efficiency of 50 percent, conservative tube life of 2000 hours, equipment life of ten 2400-hour work-years (300 days × 8 hours), and annual maintenance cost equal to 5 percent of purchase price.

• • •

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INDUSTRIAL MACHINE and process operations provide a wide field for application of electronic relays and, since their construction presents no appreciable problem, new designs

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★ **25 Millivolts AC Full Scale**
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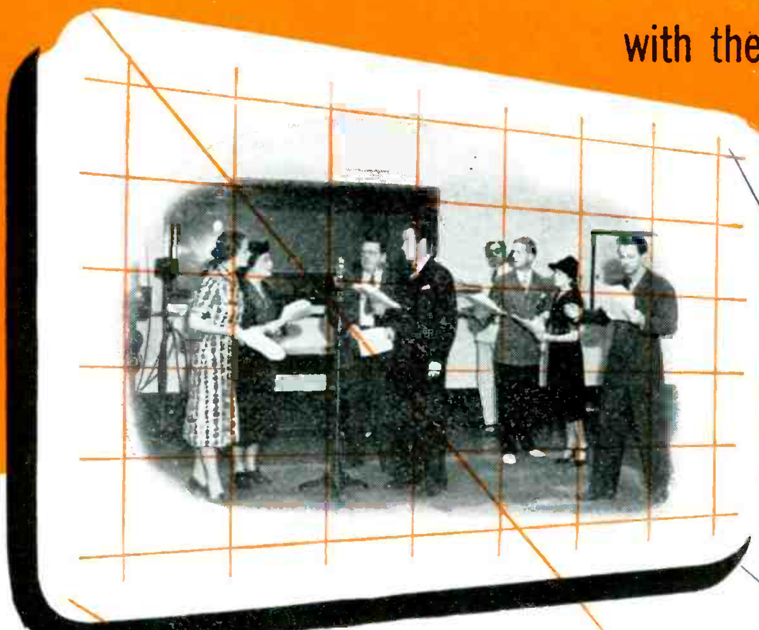

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Vacuum Tube Voltmeter
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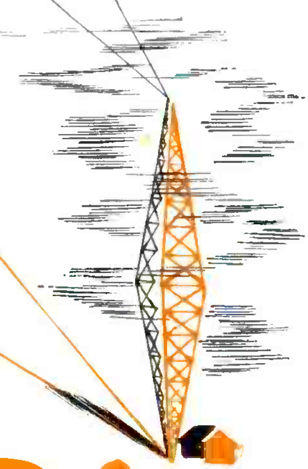
Amplifier

RANGES:

A. C. VOLTS: 0 — .025 — .1 — .25 (with amplifier) — 2.5 — 10 — 25 — 100 — 250 — 1000
D. C. VOLTS: 0 — 2.5 — 10 — 25 — 100 — 250 — 1000
D. C. CURRENT: 0 — 2.5 — 10 — 25 — 100 — 250 — 1000 Ma.
OHMS: .1 ohm to 1000 megohms
A. C. FREQUENCY RANGE: 10-5000 cps. (with amplifier) — 50 cps. to 700 megacycles
ACCURACY: 2% on full scale — D. C. volt, ohm and current; 2%, 50 cps to 50 megacycles, A. C. volt; 5% accuracy entire A. C. frequency range



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MODEL 451, complete with Amplifier Model 101 weighs 20 lbs.; Size: 10¾" x 9" x 8".

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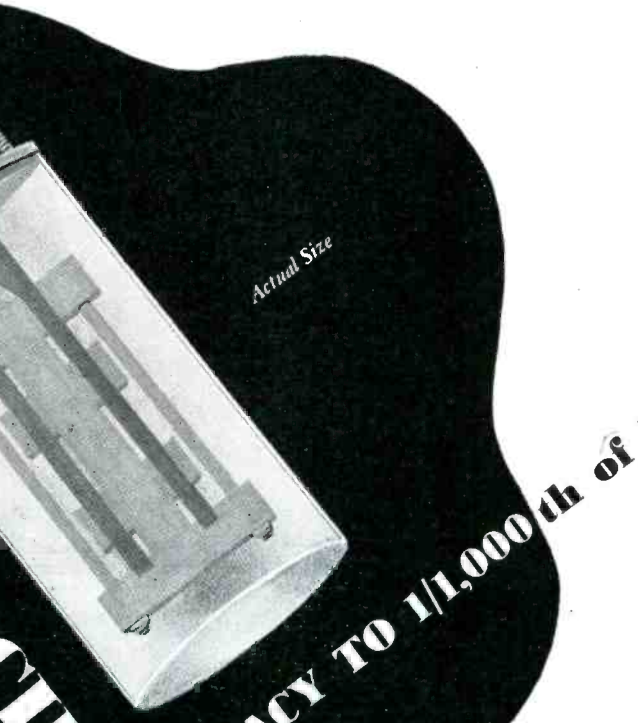
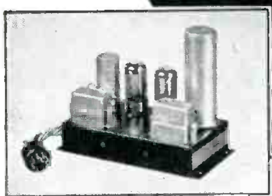
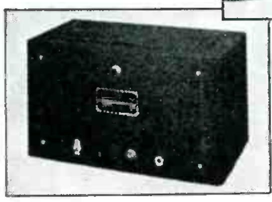
ACCURACY TO 1/1,000th of 1%







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(60 cycle) for use with external power supply

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Records time intervals with resolution to .001 second

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These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

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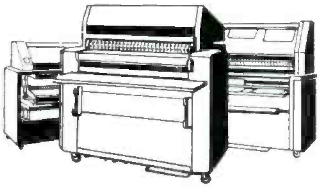

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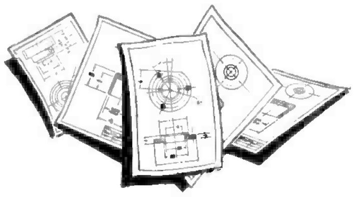

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are appearing frequently. Basically, however, these electronic relays may be divided into three main groups: the vacuum-tube type, the cold-cathode type, and the hot-cathode type.

Vacuum-tube Type

Figure 1 shows a fundamental circuit for this type of unit. Tube V_1, usually a medium-mu triode such as the 6J5, is biased to, or near, cutoff by the bias supply B_2. In this condition, little or no current flows through the plate-cathode circuit.

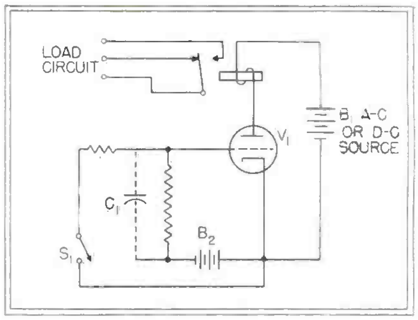


Fig. 1—Circuit of electronic relay using a vacuum tube. Addition of capacitor C_1 provides delayed action

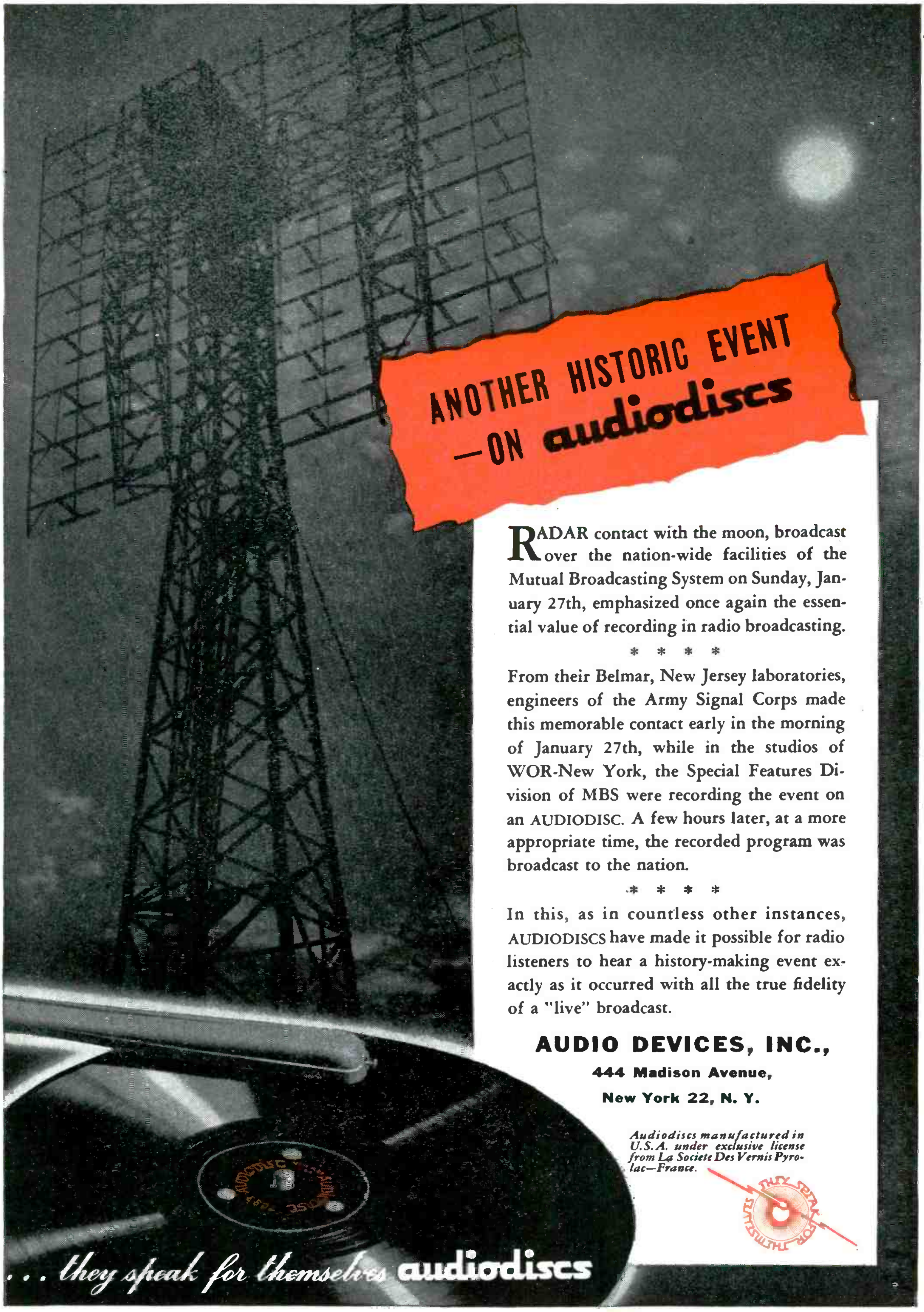
When the control contacts S_1 are closed, the grid of the tube is connected directly to the cathode. This reduces the bias on the tube to zero and a current of between six and ten milliamperes flows through the relay and pulls it in.

The current-multiplying effect of such a circuit is large. With a bias voltage of -10 volts and a grid resistor of two megohms, the maximum current that can flow through the control contacts S_1 will be five microamperes.

The contacts on the relay can be easily designed to handle a single or dual three-ampere inductive circuit. This gives in effect a current amplification of 3/0.000005 or 600,000. For noninductive circuits, the relay contacts can be rated at a higher current capacity and the amplifying factor may run as high as two or three million.

If the contacts S_1 form a high resistance when they are in the closed position, the bias will be only partially removed from the grid of the tube and the plate current will not rise to its full value. This may cause the relay action to be erratic and prevent snap action.

This type of electronic relay has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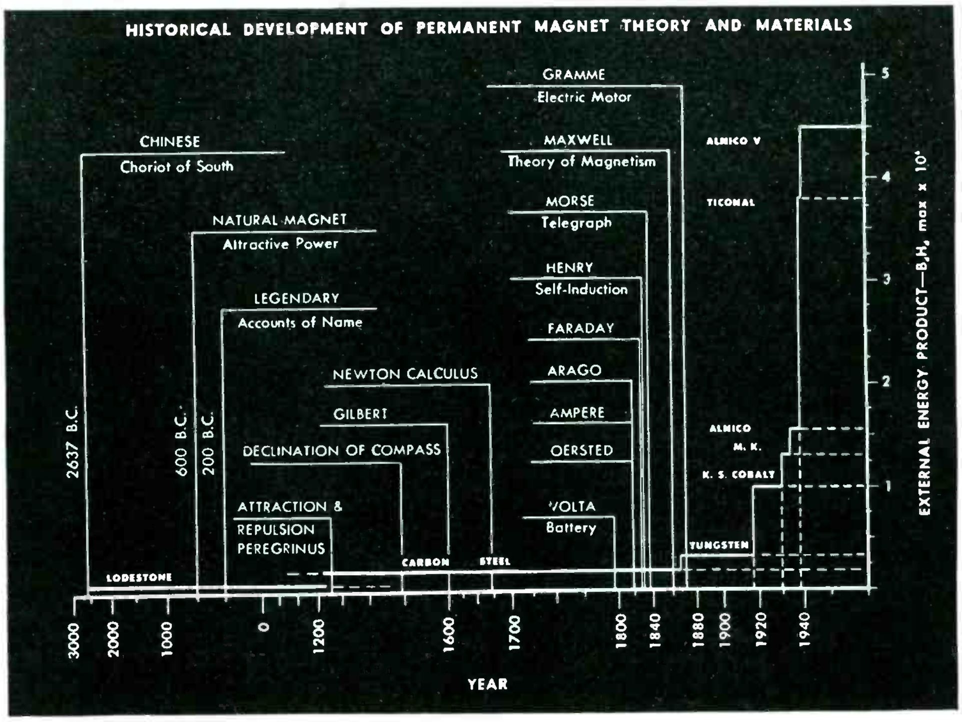

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Filament Voltage	None: Cold Cathode

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- Sound on film
- Oscillograph timing markers
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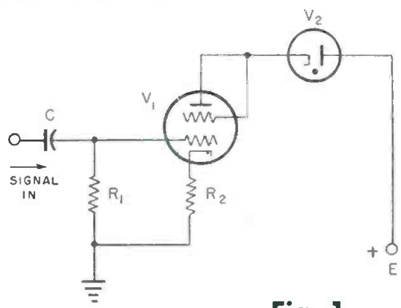
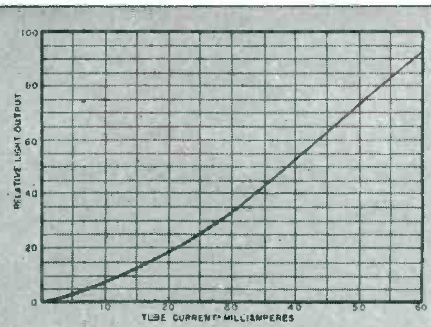
The Sylvania Glow Modulator Tube 1B59/1130B



E	+300 volts d-c
C	0.05 microfarad
R_1	0.5 megohm
R_2	675 ohms
V_1	6L6G
V_2	1B59/1130B

Fig. 1



Relationship between light output and current in the 1B59/1130B

Fig. 2

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MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS time-delay action. Since the bias cidcuit of the tube must be direct current to obtain proper operation, resistive and capacitive components can be added to delay the action of the grid and therefore, of the relay. A suitable capacitor connected as C_1 in Fig. 1 will serve this purpose. The relay then will not respond to very rapid changes in contacts S_1 and for this reason, contact chattering can be minimized and suitable time delays for certain applications can be introduced.

Cold-cathode Tube

Figure 2 illustrates the fundamental circuit given in tube manuals for a radio-frequency-controlled relay. Tube V_1 could be an OA4G cold-cathode gas triode, or a similar tube. Resistors R_1 and R_2 are proportioned

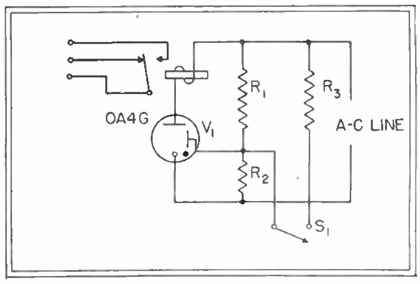

Fig. 2—Conventional relay circuit for a filamentless cold-cathode tube

so that the igniter electrode will normally be maintained below its firing potential. The control contacts S_1, when closed, raise the igniter potential by means of paralleling resistor R_3 and fire the tube. A relay current of twenty-five milliamperes is usually maximum for this type of tube.

As soon as the control contacts are opened, the igniter is returned to its original potential and the tube will cease firing on the first a-c supply cycle that makes the anode of the tube negative to the cathode. In all relay circuits where a-c is used and the tube acts as a half-wave rectifier, the relay is subjected to half-wave pulses and must either be a fully shaded pole a-c type or must be paralleled with a suitable filter capacitor to smooth out the half-wave pulses and prevent chattering.

Assuming a 115-volt, rms, a-c supply for the circuit shown in Fig. 2, the peak anode-cathode voltage would be 154 peak volts and the igniter

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General Characteristics — ML889A	
Filament Voltage	11 volts
Filament Current	125 amperes
Amplification Factor	21
Maximum Frequency for Full Power	50 mc.
Capacity, Grid to Plate	17.8 uuf.
Capacity, Grid to Filament	19.5 uuf.
Capacity, Plate to Filament	2.5 uuf.
Cooling	Water
Water	3-6 gals/min.
Air (ML889RA)	15 cfm.

At reduced power, may be operated at frequencies as high as 150 megacycles.

The ML889A and ML889RA are outstanding examples of Machlett's ability to apply its time-tested and advanced techniques to tubes of standard design with resulting improvement in construction, performance and life. They incorporate the "know-how" that has made Machlett electron tubes demonstrably superior since 1897. Consider these advanced features that give you better tubes with longer and more uniform performance:

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5. One piece copper anode and shield assure uniform internal surface, permit maximum accuracy of assembly, provide complete shielding of anode seal and reduce difficult-to-outgas inter-faces normally found in tubes of this type.

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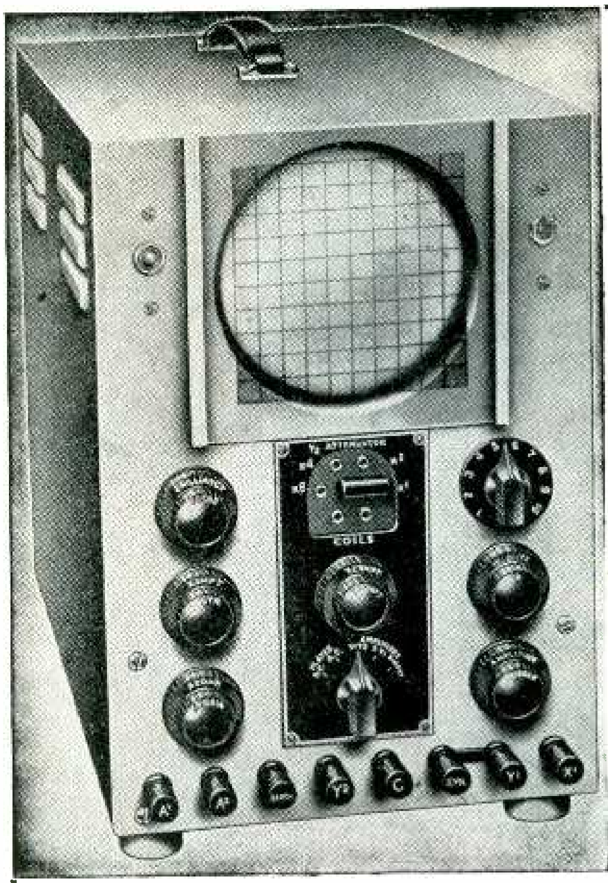

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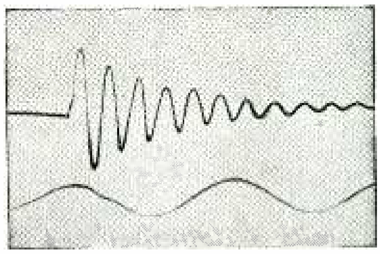

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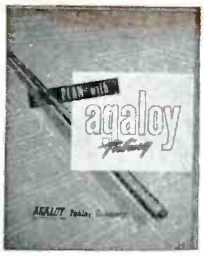

Send for your copy "Plan with Agaloy Tubing" electrode should be maintained at approximately 60 peak volts to prevent firing. To insure ignition for run-of-the-mill tubes, this potential should be raised to 90 peak volts when control contacts S_1 are closed. If R_1 is 150,000 ohms and R_2 is 100,000 ohms, the additional current required through R_2 to raise the igniter to the firing potential of 90 peak volts will be 90 − 60 volts/100,000 ohms, or 0.0003 ampere. This additional current would be obtained through resistor R_3 and would have to pass through control contacts S_1.

Limitations

Increasing the values of resistors R_1 and R_2 would reduce the control current requirements proportionally, but their values cannot be made too large because the igniter current required to fire the tube is appreciable (approximately 100 microamperes), and an excessive voltage drop through R_1, when the tube fired, would cause unstable operation. To supply the 0.0003-ampere control current, R_3 would require a value of 413,333 ohms.

The cold-cathode circuit is simple to construct and, if the tubes used are reasonably uniform, will give satisfactory results for most applications. This circuit has certain disadvantages, such as the necessity for handling rather high potentials in the control circuit, and the limitation of the relay current to 25 milliamperes.

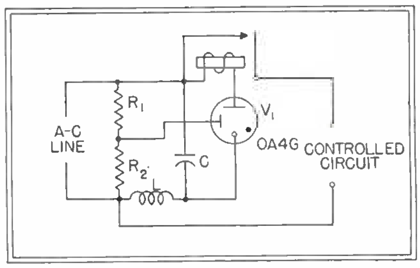

Fig. 3—Actuation by a specific carrier frequency is provided by adding a tuned circuit to Fig. 2

The relay circuit shown in Fig. 3, is an interesting application of the cold-cathode tube to r-f carrier relay service. This circuit is similar to Fig. 2 except that a high-Q tuned r-f circuit (LC) is inserted as shown. When no r-f is present, the igniter is maintained below its firing potential by the voltage divider $R_1 - R_2$; if an

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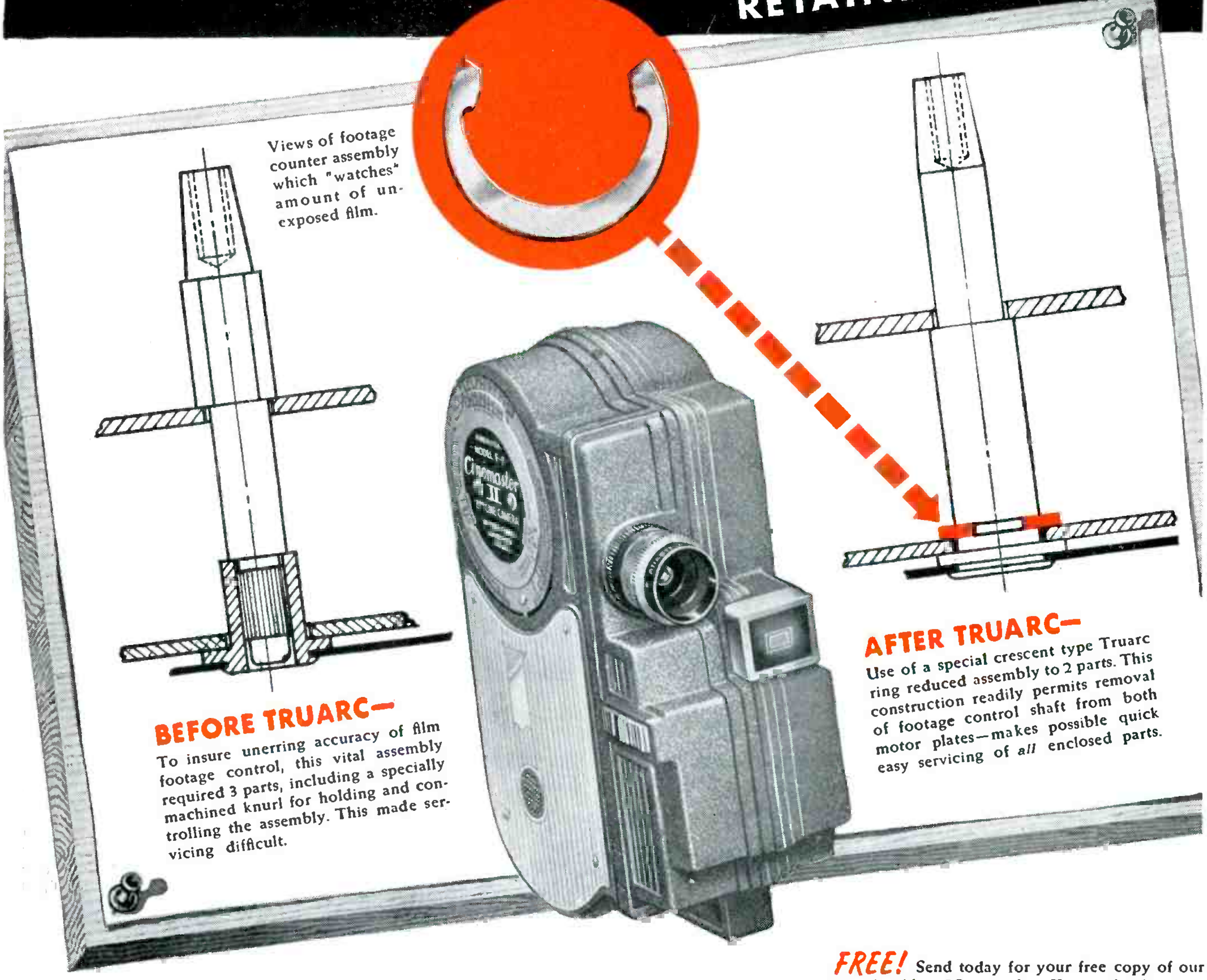

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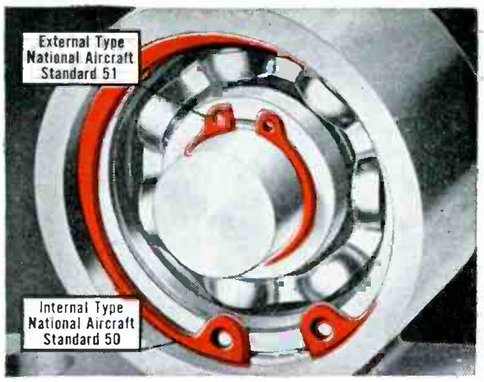

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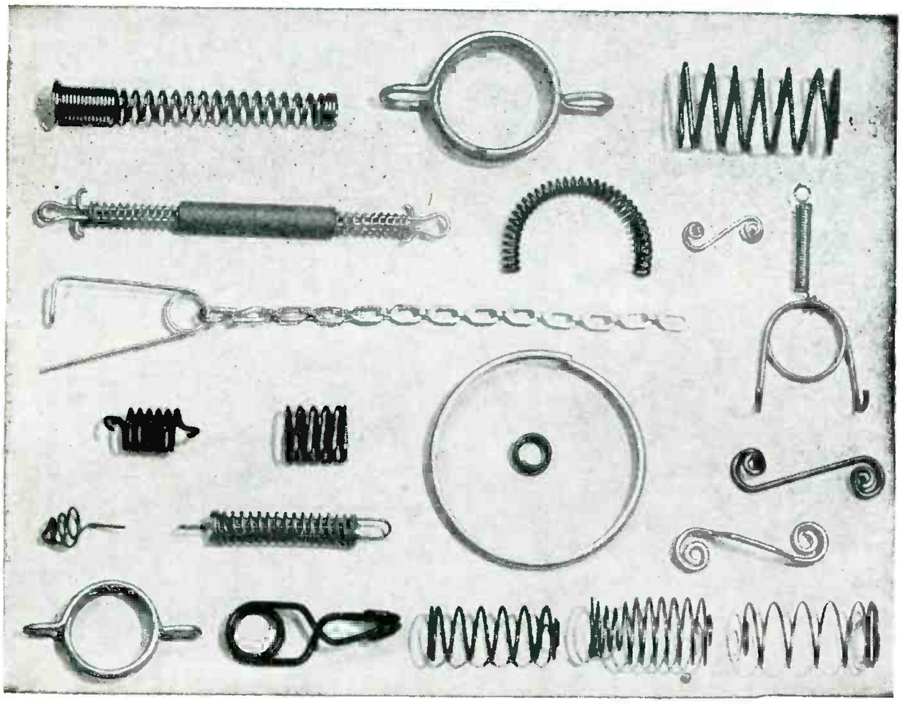
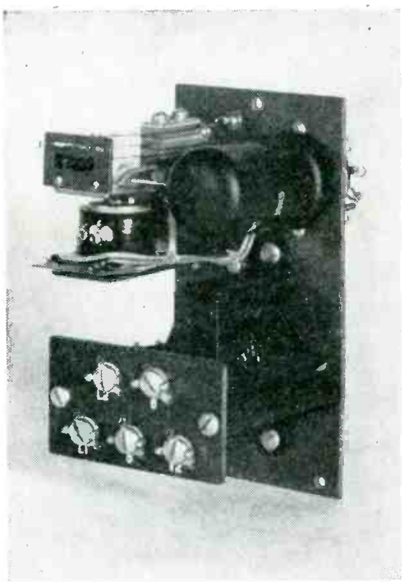


r-f carrier of the proper frequency appears across the line terminals, an r-f voltage will appear across L and supplement the existing igniter cathode potential sufficiently to fire the tube.

Hot-cathode Type

If the cold-cathode triode is replaced by a hot-cathode thyratron, the control circuit voltage may be reduced to a few volts. This is often important because when it is desired to use very light moving contacts, the contact potential must be kept at a minimum to prevent the electrostatic forces present from causing contact chattering. In addition, the current available for relay operation is practically unlimited, with 100 milliamperes as a normal value for the smaller thyratrons.



This electronic contactor is employed in a temperature control system that requires snap-acting spdt contacts carrying 12 amperes of noninductive a-c and which are actuated by an impulse of two microamperes

Figure 4 shows a typical circuit using a GL502A thyratron. The maximum relay current for this tube is 100 milliamperes. Bias is supplied to the grid by the 6.3-volt filament transformer T_1, and prevents the tube from firing. When control contacts S_1 are closed, the grid is returned to the cathode, the bias is removed, and the tube will fire.

The rms current flowing through the control contacts is given by the expression 6.3 volts/$(R_1 + R_2)$. If we assign a value of two megohms to

$R_1 + R_2$, the control current will be $6.3/2 \times 10^6$ or 3.15 microamperes. Even lower currents are possible under certain conditions.

Resistor R_1 is placed in series with the grid to prevent any possible damage to this element due to the accidental connecting of a large external voltage source to contacts S_1. A value of 50,000 ohms is usually adequate.

Capacitor C_1, shown in dotted lines, may be connected across R_2 to improve the phasing of the circuit and enhance its snap-acting quali-

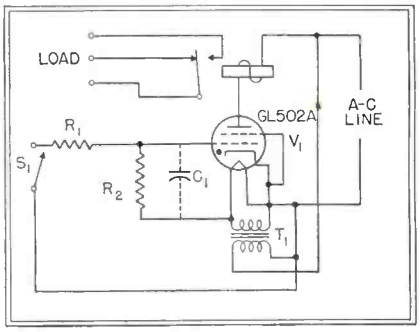


Fig. 4—At low control voltages, a hot-cathode thyratron permits the use of light-weight contacts

ties. The addition of C_1, although its value is usually quite small, will increase the control current requirements slightly. A capacitance value of 0.001 μf in parallel with a two-megohm value of R_2 would permit a control current of 3.9 microamperes to flow if the bias supply has a potential of 6.3 volts.

The circuit shown in Fig. 4 has one disadvantage. If its installation is not properly supervised, a short-circuit or high grid potential may result. This difficulty results from the fact that one of the control contacts is connected directly to the supply line and if the other one becomes grounded, trouble may result. To avoid this difficulty, a transformer-isolated unit, such as that shown in Fig. 5, may be used.

The 100-milliampere relay current capability of the GL502-A is usually sufficient, but it should be kept in mind that larger tubes handling amperes may be used without difficulty. For instance, the RCA 3D22 can be substituted in the circuit given in Fig. 4, without appreciably increasing the control current

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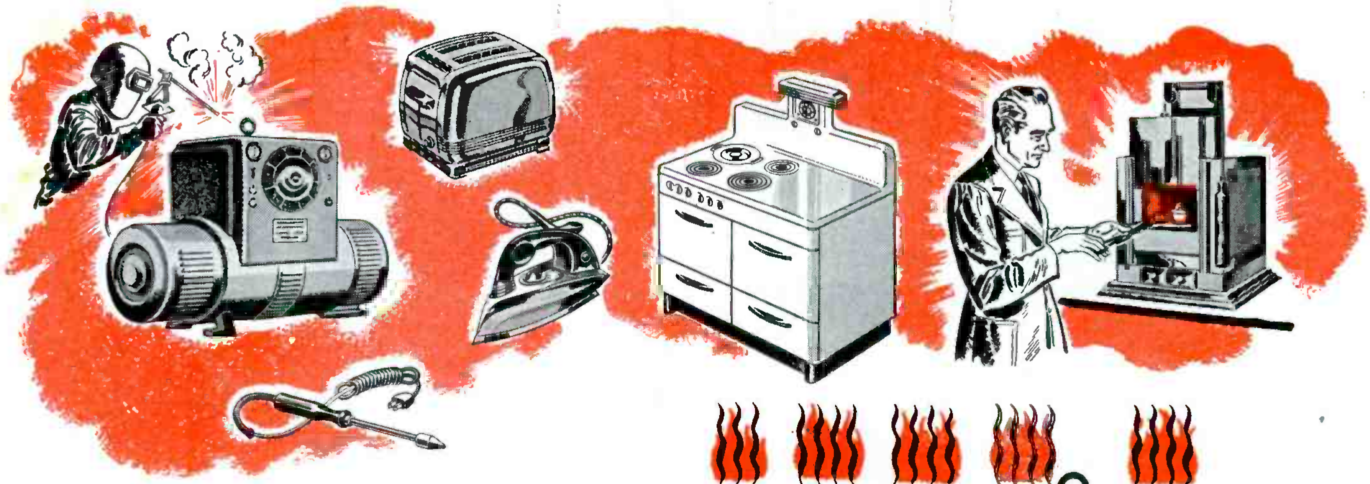

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Motor Control

Another use to which the thyratron circuit is well suited is the direct operation of a motor from contacts carrying microamperes without the use of intermediate electromechanical relays. A direct-current motor can be connected in the anode circuit of tube V_1 in Fig. 4. However, the operation of an a-c two-phase motor requires certain changes. Figure 6 shows a circuit which is adapted to

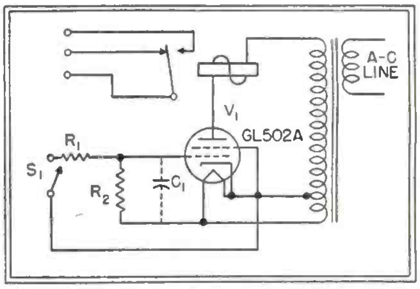

Fig. 5—To prevent grounding one or both control contacts, an isolation transformer can be used

this type of operation. The motor shown is a two-phase, capacitor-type unit and provides reversing operation from a single pair of control contacts, S_1. The operation is such that when the contacts are open, the motor will rotate in one direction and when they are closed, the motor will rotate in the opposite direction.

Tubes V_1 and V_2 are both biased from the 6.3-volt filament circuit and the grid of V_2 is raised to firing potential by coupling capacitor C_3, which is supplied with line potential whenever V_1 is dormant. When contacts S_1 are open, V_1 is dormant and V_2 fires; when the control contacts

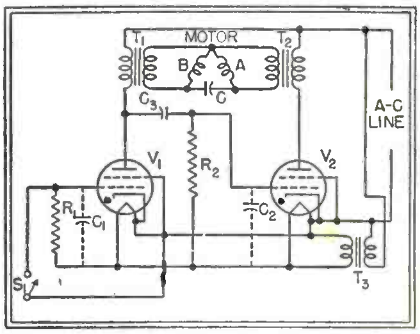

Fig. 6—With this circuit, one pair of control contacts permits reversing a two-phase motor

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Electroneering is our business

THE RAULAND CORPORATION • CHICAGO 41, ILLINOIS are closed, V_1 fires and reduces the potential supplying coupling capacitor C_3 to a value which is nearly zero. This removes the firing voltages from the grid of V_2 and it becomes dormant.

The motor is supplied by transformers T_1 and T_2, alternately. When V_2 fires, transformer T_2 feeds an alternating current to motor winding *A*. Winding *B* is supplied through phase-shift capacitor *C* and a rotating field results which drives the motor. Some efficiency is lost due to the shunting effect of transformer T_1 on motor winding *B*, but the motor operation is satisfactory for most purposes. When V_1 fires, the operation is reversed and transformer T_1 supplies power. Since the input to transformers T_1 and T_2 is half-wave, the addition of some filter capacitance (not shown in the diagram) to the circuit will serve to improve the wave form of the current reaching the motor.

Although any of the three basic relay circuits discussed will be found satisfactory for many operations, the hot-cathode thyratron offers the most promise in the control field since it combines high sensitivity, snap action and large current capacity.

• • •

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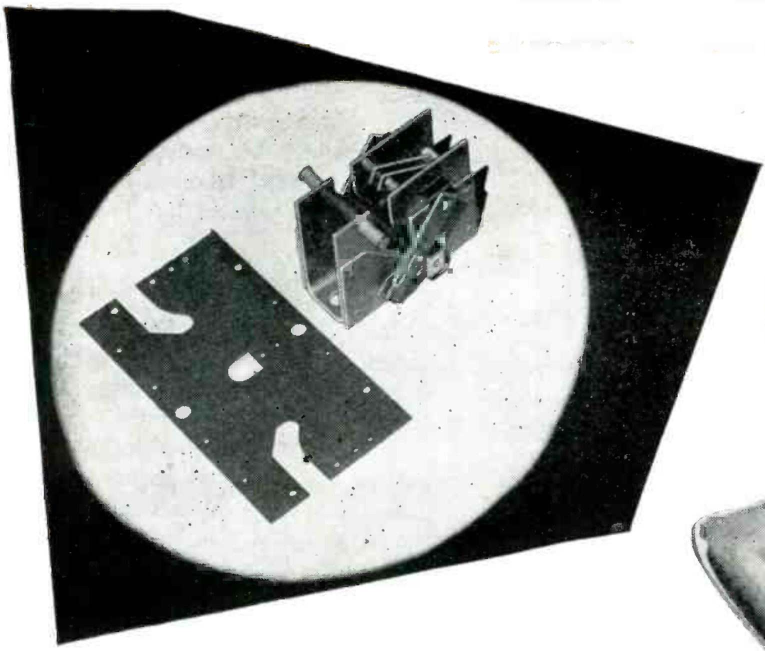

Shapely

Post-Formed Phenolite chassis for high voltage circuit breaker. All holes and cut-outs are punched in the flat blank (*foreground*) before post-forming in channel shape. Use of Phenolite chassis in place of metal eliminates insulation of each separate part of assembly.

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TUBES AT WORK

Video and Audio on One Carrier 208
Simple Converter Circuit for New F-M Band 212
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More on Spherics, Storm Detector 224

Video and Audio on One Carrier

A NEW television system in which sound and vision can be transmitted from a single transmitter occupying a normal band space has been developed by the British firm of Pye Radio Ltd.

The best method of understanding the new system is to consider the old system used by the BBC before the war, in which the picture was broken up into 405 lines and 25 pictures per second were transmitted. Typical lines are shown as *AB*, *CD*, *EF* in Fig. 1 and the tonal value along the line is expressed as the height of the waveform. During the periods *BC*, *DE*, etc, the electron beam in the camera is returning to start another line.

The time required to scan a line under this arrangement is 90 microseconds and at the end of the line the leading edge of the synchronizing pulse triggers the time-base in the receiver and suppresses the flyback, which occupies 10 microseconds. This obviously means that for 10 percent of the total transmission time the transmitter is idle. Actually it is the flyback which demands the greater part of the 10 microseconds, not the synchronizing pulse.

In the Videosonic system, this idle period is utilized to transmit the sound program and it is done by inserting a pulse into the 10-microsecond period and arranging that the width of the pulse is a measure of the audio modulation. At their maximum, the pulses occupy five microseconds and they narrow down to one microsecond at audio troughs. The mean width is three microseconds. Figure 2 illustrates this point and at the line-scanning frequency of the present system, 10,125 pulses per second are transmitted.

At the receiver end, separation is easy and depends on the pulse amplitude being greater than the maximum video amplitude. If the former is considered as 100 percent of the r-f carrier, the greatest video amplitude corresponding to a peak "white" is about 75 percent. All that is necessary then is to incorporate in the receiver simple limiting circuits which will only pass signals whose amplitude is greater than peak "white" signals. In practice the ratio of 75 to 100 percent has been found ample.

Advantages

There is no mutual interference between the sound and vision signals since the pulse corresponding to the former is absent during the scanning period. A new method of blacking out the flyback must be used but no difficulties have arisen in this direction.

The advantages of the new system are:

(1) The sound transmitter can be dispensed with.

(2) The received sound signal is more free from noise than under the

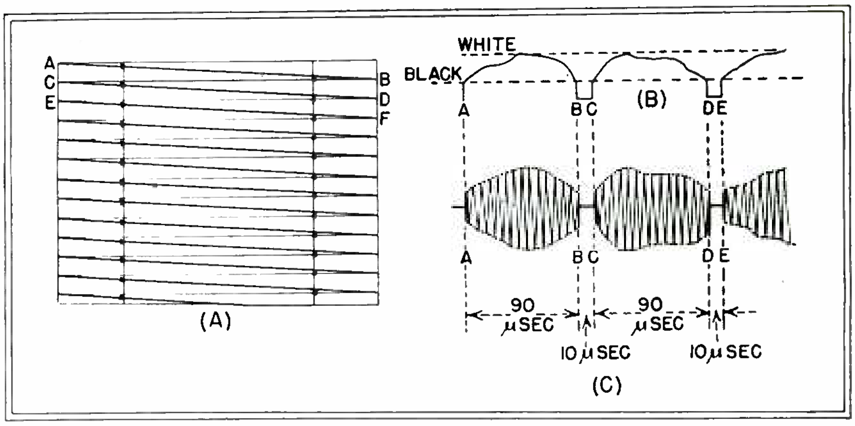

Fig. 1—The method of scanning a television picture is shown at (A). The resulting video waveform is shown at (B) and the radio-frequency waveform at (C)

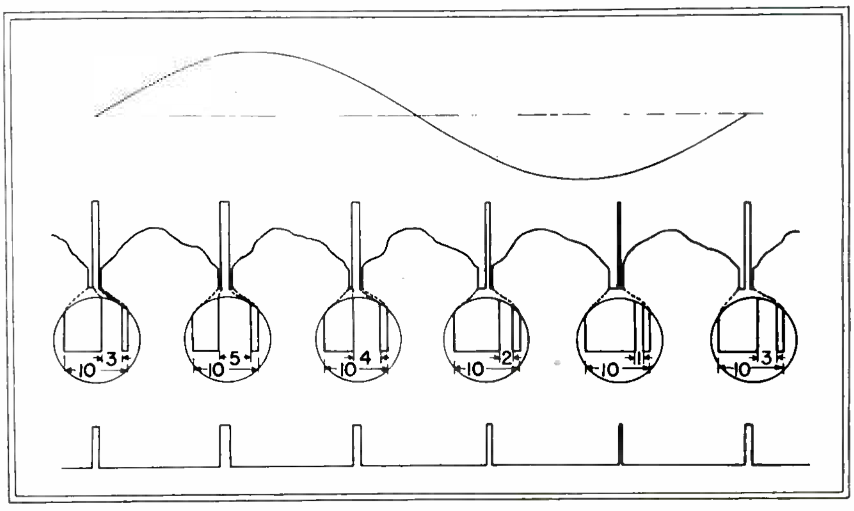

Fig. 2—Method of inserting a sine-wave sound pulse in the flyback periods *BC*, *DE* of Fig. 1 so that the width of the pulse varies with the sound to be transmitted. At the receiver, the pulses at the bottom are separated from the video and passed through a low-pass filter that feeds the loudspeaker

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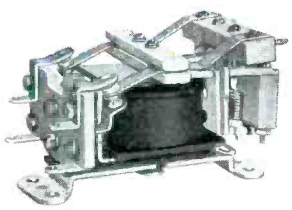
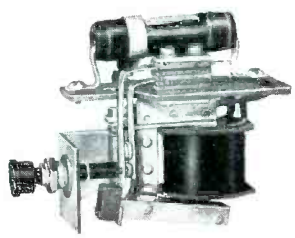
Let us furnish cost-free information about the complete Guardian line of Radio Relays, also all Telephone Type Relays including the small Midget; and a special Switch used on push-to-talk circuits.


Series 165-A Relay


Series X-100 Relay

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older system. Theoretical investigations have shown that it would be equivalent to increasing the transmitter power 100 times.

(3) The old difficulty of routing the sound and vision signals at the receiver vanishes.

(4) No ether space is occupied by the sound transmitter.

(5) The steady level of the sound pulses makes compensation for fading easier.

(6) The receiving antenna could be made more efficient since it would only have to operate on a single frequency band.

The chief disadvantage of the system is coupled with the existing 405-line transmission. At present, as the line frequency is 10,125, the audio frequency limit would be about 5,000 cycles—an undesirable figure since British listeners have been accustomed to transmitters with a practically flat response between 30 and at least 10,000 cycles. To achieve an upper audio limit of 10,000 cycles the number of lines would have to be increased to 1,000 which would give a line pulse frequency of 25,000.

One advantage of the pulse insertion scheme is that it would be quite easy to incorporate additional pulses corresponding to stereophonic sound, or for color work.

Figure 3 is an oscillogram of the Videosonic waveform during the 10-microsecond period. The sound pulse having a mean duration of three microseconds is shown extending downwards. Figure 4 is a photograph taken on a special receiver to show the variable sound-width pulses occurring during the flyback periods. These pulses build up a white band of variable width reminiscent of the

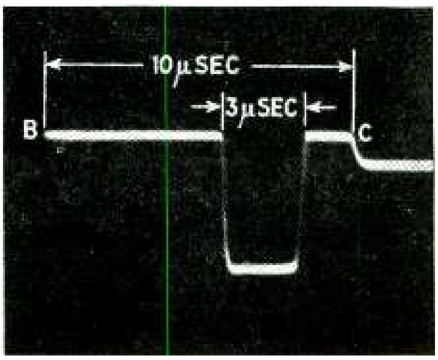

Fig. 3—The waveform during the 10-microsecond period as it appears on an oscilloscope

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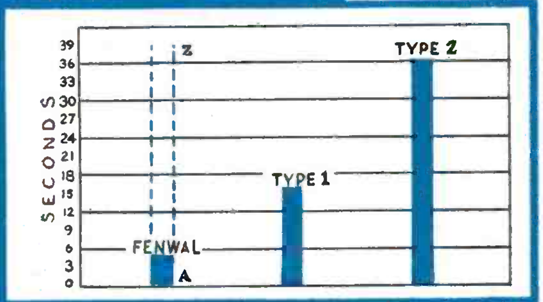
Chart shows the time interval required for a Fenwal Thermoswitch to change 10°F. when subjected to a 20° change in temperature. Compare this performance with that of Type 1 and Type 2 thermostats. Proper application can modify this response time to any value desired, from A to Z.

RESPONSE TIME CHART



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11.—Minimum size
12.—Tamper-proof and sealed
13.—Uniform sensitivity over adjustable temperature range
14.—Readily installed

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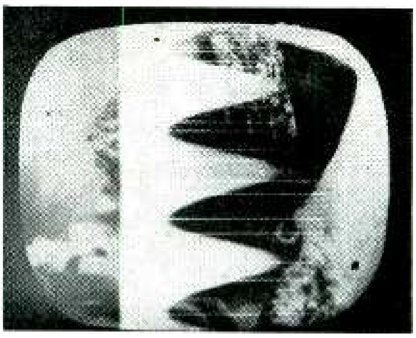


Fig. 4—Photo of the screen of a special receiver showing the variable sound-width pulses during the flyback period

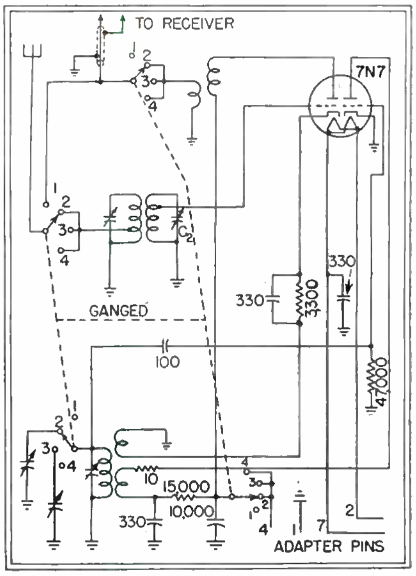
sound track on motion picture film.

Two racks of the equipment contain the sound waveform generator and the mixer units. The function of these is to produce pulses at the correct instant having a width dependent on the audio waveform to be transmitted and then to mix these pulses into the vision waveform. These two racks would take the place of the sound transmitter at the television station, with the addition of high-power audio amplifiers.

• • •

Simple Converter Circuit for New F-M Band

THE FINAL CIRCUIT of the Hallicrafters converter for tuning to the new f-m band is shown in the diagram. The unit employs a double-triode



Complete circuit of the Hallicrafters f-m converter. All capacitor values are indicated in micromicrofarads

3 LEADERS *in internal curing* INSULATING VARNISHES

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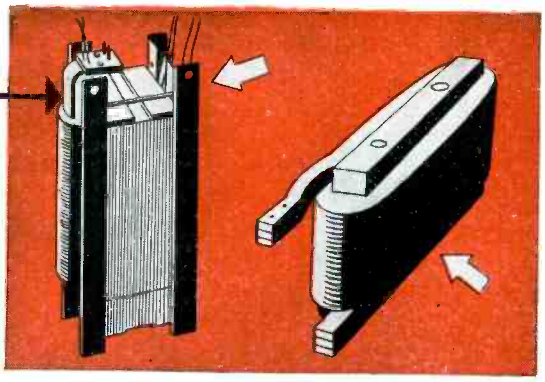

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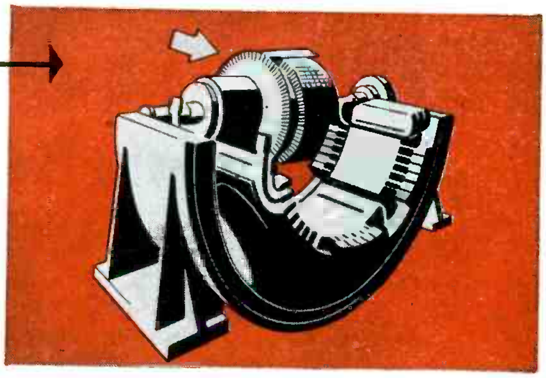

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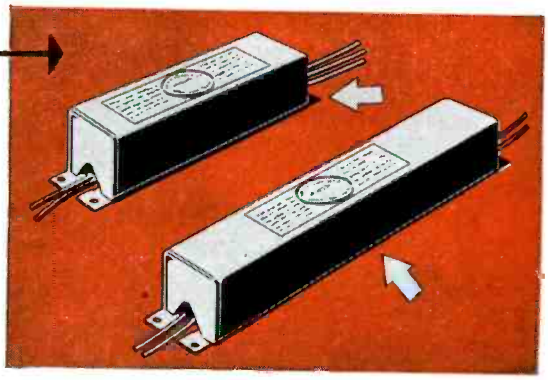

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IRVINGTON *Varnish and Insulator Company*

Irvington 11, New Jersey, U.S.A.

7N7 for mixer and oscillator to form a double superheterodyne when connected to a prewar f-m receiver.

When placed on position 1, the four-gang switch permits operation of the receiver on other frequencies by feeding the antenna directly to the receiver antenna terminal. When set to positions 2, 3, and 4, the switch connects trimmer capacitors into the tuned circuits for covering frequency ranges of 84 to 93, 93 to 102, and 102 to 111 megacycles respectively. All tuning over each range is done by means of the regular tuning dial of the receiver.

Power for the converter is obtained from one of the power amplifier sockets in the receiver by an adapter that fits under the tube.

• • •

Frequency Stabilization at 450 Mc

By Peter B. Myers
National Bureau of Standards
Washington, D. C.

Due to the recent FCC allocations and the growing interest in the very high radio frequencies, the matter of constant frequencies at vhf becomes increasingly important. Crystal control is required for greatest constancy but quartz plates above about 30 mc are still impractical and involve delicate hand finishing.

At the present time, higher constant frequencies are generally obtained by electrical harmonic generators working off standard low-frequency crystals. Above about 100 mc, the number of harmonic generators and auxiliary pieces of equipment becomes excessive and other means of frequency control are needed. The mechanical harmonics of a quartz plate may however be utilized; for example, using the fifth mechanical harmonic of a 30-mc plate, the fundamental oscillation would be 150 mc and one stage of electrical harmonic generation (tripling) would produce standard crystal-controlled frequencies of 450 mc.

Used Harmonic Crystal

Mechanical harmonics may be excited in specially prepared AT or BT cut crystals, in which odd harmonics

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Zirmet Benefits Both Tube Manufacturer and Tube User

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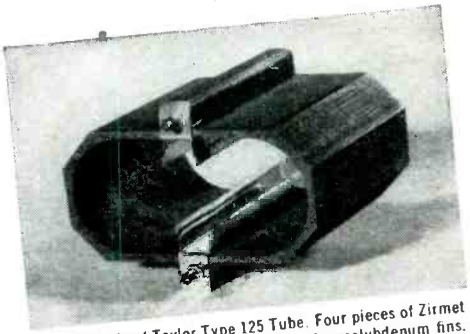
"The application of the Zirconium Metal to the fins of the T-125 means that we are able to cut our pumping time by about thirty per cent, and the gettering action while the tube is actually in operation, is very good.

"The type T-125 tube is widely used in diathermy at frequencies up to 70 MC, and of course, in Amateur Radio operation at the present time, at 28 to 30 MC. We feel that the Metal is most effective in obtaining a higher order of vacuum in this particular application. It is well worth the small added expense."

Taylor Type 125 Tube for diathermy and radio applications.



Carbon Anode of Taylor Type 125 Tube. Four pieces of Zirmet 1/16" x 1 1/2" x .005" are welded to the molybdenum fins.

Zirmet is literally "what the doctor ordered" and may prove equally effective for you.

Many Advantages for Tube Maker and User

If you are a tube manufacturer, the use of Zirmet as a continuous getter means less pumping time, better vacuum, less shrinkage, clean tubes, and, naturally, satisfied customers. If you are a tube user, you can count on better emission and longer life when you buy a tube containing Zirmet the *continuous getter*.

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up to the 23rd have been excited. A limiting factor is the optical flatness of the crystal. Mason and Fair found that the Q of the crystal increases in general with higher mechanical harmonics.[1] Special circuit arrangements are needed for harmonic oscillations above the seventh.

In recent experiments, the fifth mechanical harmonic of a 10-mc crystal was employed, followed by two electrical triplers, to reach 450 mc. Push-pull triplers incorporating midget tubes were used throughout. The oscillator tube was a 6C4 as were the tubes of the first tripler. Since the 6C4 was not found to be suitable for use at 450 mc, two type 6F4 were used in the final stage.

The output proved to be as stable as that obtained at the crystal's fundamental frequency. The generally accepted figure of 0.0025 percent as the maximum deviation in frequency of a crystal in the absence of regulation of any kind would limit the drift to 11 kilocycles at 450 megacycles. A two-hour test of the apparatus with a regulated power supply showed a maximum drift of 1.1 kilocycle at 450 megacycles, amounting to a frequency variation of ±0.00025 percent or 2.5 parts in a million.

The crystal temperature coefficient was the same for the overtones as for the fundamental. The power output of the crystal oscillator used was less at each higher overtone, but the power was ample at 50 mc to drive a buffer amplifier.

The writer acknowledges his indebtedness to W. D. George and M. C. Selby of the Radio Laboratory of the National Bureau of Standards, where the experimental work was carried out; and his obligation to the Optical Division of the Bureau for the preparation of 10-mc quartz crystals with optically flat and parallel faces.

REFERENCE

(1) Mason, W. P., and Fair, I. E., A New Direct Crystal-controlled Oscillator, Bell Telephone System Monograph B-1363.

• • •

Radio Design Data Presented in Chicago

ASPECTS OF f-m receiver design, receiver response trends, and intermodulation effects in audio systems were

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TRANSFORMERS

among the subjects covered by ten technical papers delivered at the Chicago Engineering Conference, sponsored by the Chicago Section of IRE. Held early in February, the meeting was attended by more than 500 radio engineers.

Details of f-m receiver design were discussed by Frank C. Gow of RCA Laboratories, who pointed out that series tuning in preselector stages is more effective than parallel tuning and that common coupling can be minimized by efficient design of the r-f circuits and by grounding the stator of the converter tuning capacitor.

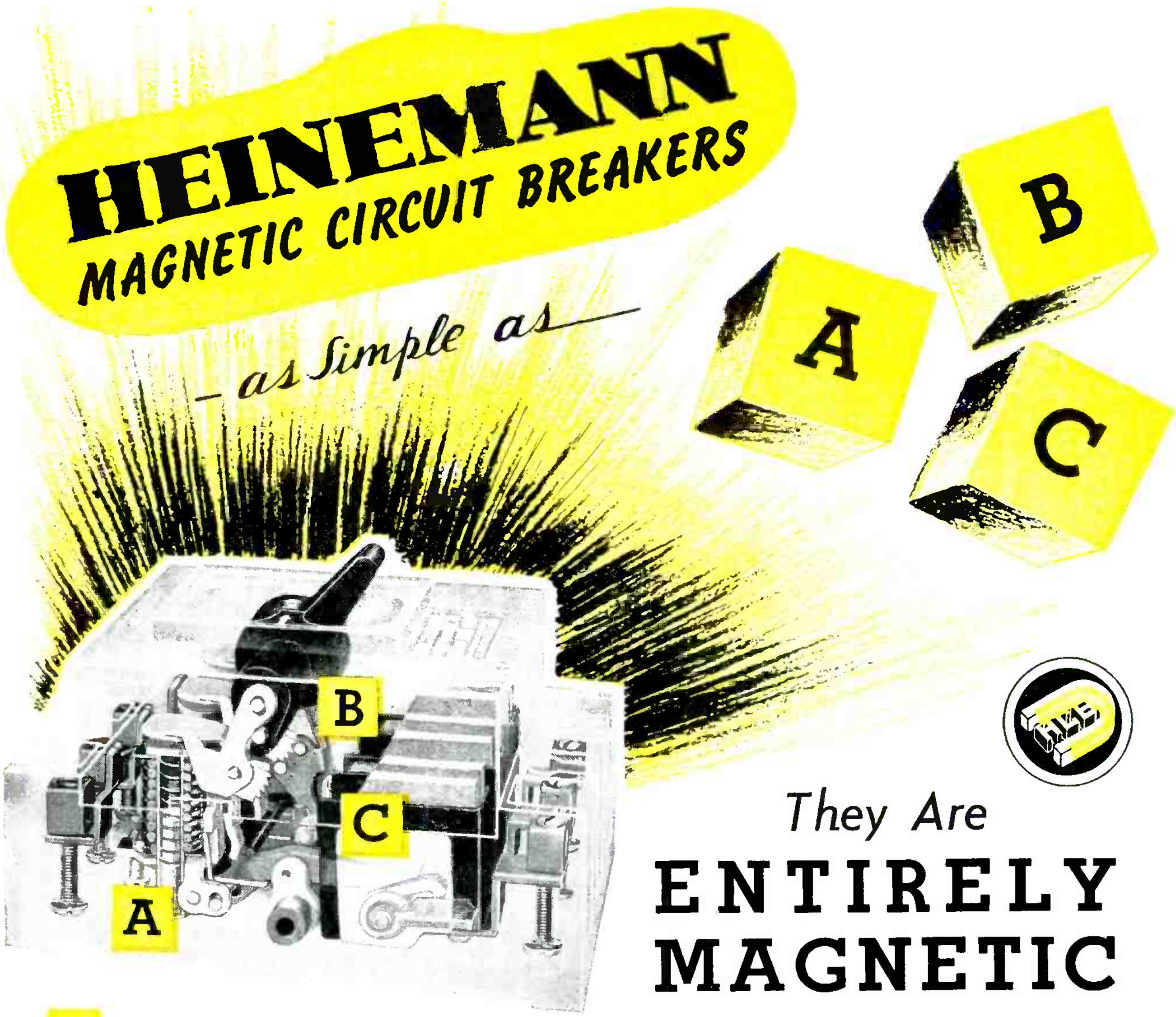
Oscillator efficiency and stability can be obtained with four methods of conversion: a pentagrid using inner grid injection, pentagrid using outer grid injection, separate oscillator and mixer, and dual triode oscillator-converters. Greater stability can be obtained by using second harmonic conversion, although conversion transconductance is lower. If oscillation occurs, it can be cured by biasing the converter grid. Outer-grid injection results in more efficient, stable operation. For good operation, a 16-μv signal in the antenna is sufficient.

High frequency triode mixers are characterized by low input conductance but inductance is sometimes inserted in the plate lead to form a series-resonant circuit to increase grid input resistance. Triode mixers have lower noise level than pentodes.

In the design of the i-f amplifier, stability is the first consideration, with selectivity next. Effects of input loading on the selectivity of avc stages can be reduced by using high-C tuning circuits and adding degeneration by omitting bypass capacitors from bias resistors.

Audio Quality

The new FCC standards on good engineering practices concerning f-m broadcasting specify an a-f bandwidth of from 50 to 15,000 cycles in a manner which includes a minimum of distortion and unpleasant effects. Such specifications make necessary radical changes in audio frequency design, measuring techniques and concepts, according to J. K. Hilliard of Altec Lansing Corp. All elements of distortion must be reduced to a low degree, otherwise results of ex-



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This latch mechanism operates with the least amount of friction and greatest speed of any latch known. It performs two functions, opening the breaker with the least mechanical delay, and opening it independently of handle operation. It functions only under overload or short circuit conditions.

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This blowout adds speed to the arc interruption. Individual arcing chambers carefuly insulated from each other have magnetic blowout contacts mounted in them. As the value of the current to be interrupted increases, the quenching effect becomes greater, due to the intensified magnetic blowout field.

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tending frequency range will produce quality which is less pleasing than that obtained with a limited bandwidth.

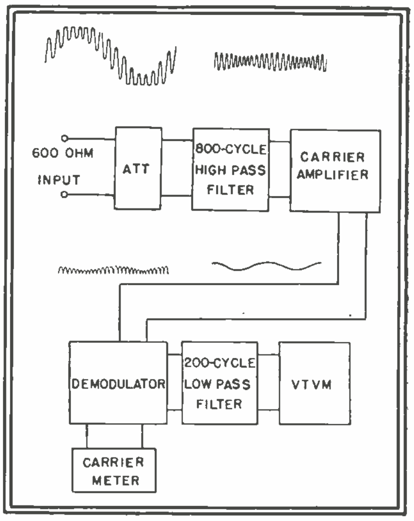
Distortions may be in frequency and amplitude, and may be due to hum and noise or caused by interaction of complex frequencies or intermodulation. To meet the FCC requirements, an amplifier should have a total hum and noise at least 66 db below the full modulation or overload point. It should have a reserve sine-wave carrying capacity at least six db beyond full modulation.

There should be no significant difference in frequency response of the amplifier between runs made with oscillator and oscilloscope at maximum operating level, a level of 30 db below that point, and 60 db below maximum level. For direct transmission, six percent intermodulation should not be exceeded in the frequency band, and if the signal is be recorded and rerecorded or is to be transmitted through a network of amplifiers, it is desirable that intermodulation products be held below four percent.

Test Technique

Intermodulation tests consist of transmitting simultaneously two known frequencies through equipment under test and then measuring the degree of interaction and distortion of the two by determining the amount of new frequencies generated. First and second harmonics of intermodulation and ripple components are usually present.

The test method uses two oscilla-



Block diagram of intermodulation analyzer

MN-62A

MN-60A

THE NEW NA-1 AIRCRAFT NAVIGATIONAL SYSTEM

Latest addition to the already famous Bendix Radio Compass Line

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The MN-62A Radio Compass Receiver is designed for operation with r.f. transmission lines up to 30 feet in length, for flexibility in location of loop and sense antenna. All receiver and loop control circuits are included in a single case. The receiver operates from a primary power supply of 115 V., 400 cycles a.c. and 28 V. d.c.

The MN-60A Iron Core Loop—Small, streamlined, is ideal for highspeed craft. It increases payload of aircraft by reducing air-drag.

All functions of the NA-1 System are controlled with the type MN-63A Remote Control Unit, or with custom-built controls designed for specific overall systems and types of airplanes. Bendix Radio specializes in the design of such consolidated control assemblies.

Bearing indicators are available in several types and sizes for either a single or dual compass system.

All components of the NA-1 System are built to the same rigid specifications that have made Bendix the Greatest Name in Aircraft Radio. They bear CAA type certification for scheduled airline operation.

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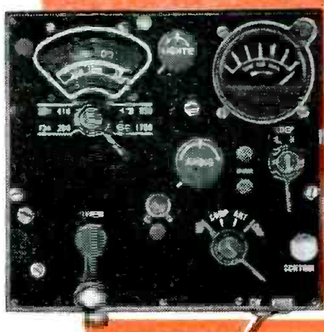

MN-63A

MN-37

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tors, one having low frequency output of 40-60-100 cps and the other with frequencies of 1,000-7,000-12,000 cps combined in a hybrid coil and fed through an attenuator to the equipment under test.

A block diagram of the intermodulation analyzer is shown. The input attenuator can dissipate 50 watts and is adjustable over a 90-db range in one-db steps. The output of the equipment under test consists of a low-frequency signal with a high-frequency signal superimposed plus harmonics of the original tones and intermodulation distortion.

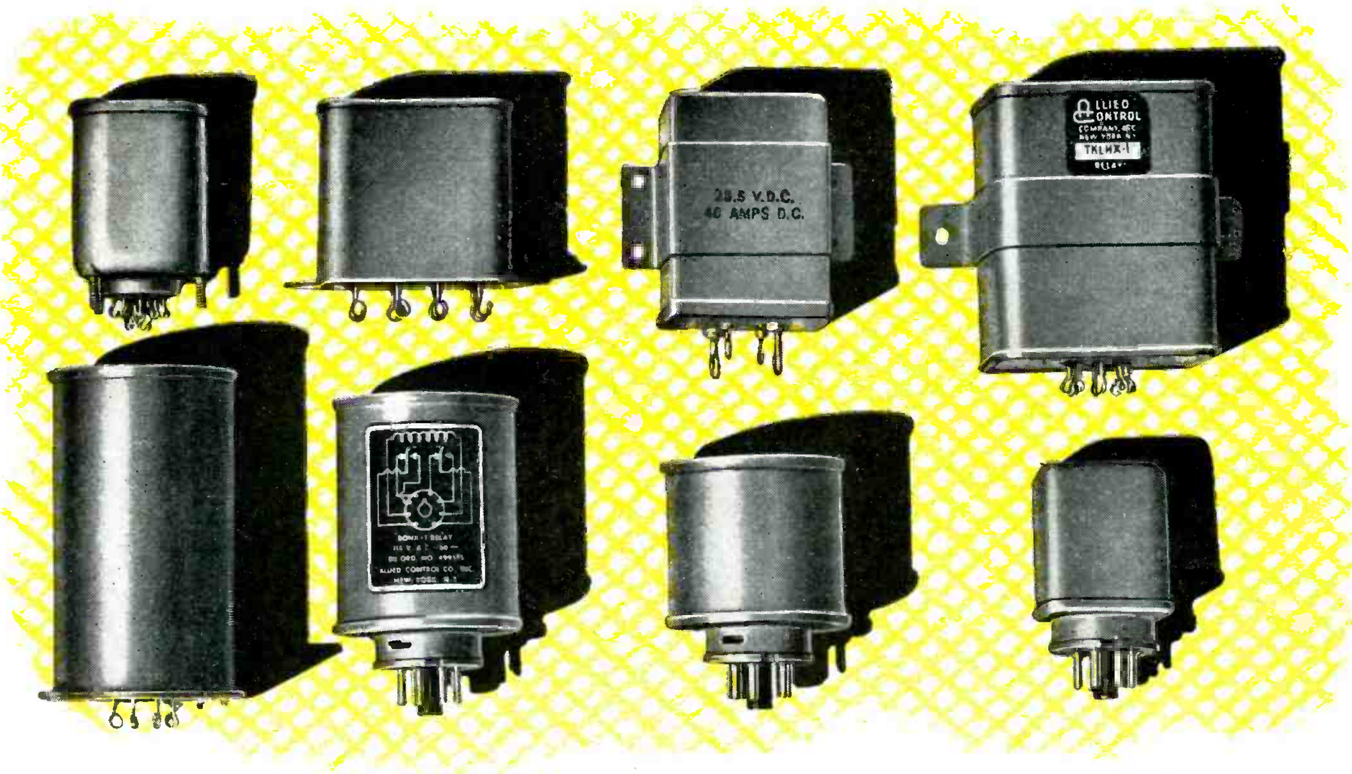
To measure the intermodulation, the original low-frequency component must be removed. This is done in the 800-cycle filter following the attenuator. The filter output, a carrier and its resultant side bands, is then amplified and demodulated. A 200-cycle low-pass filter removes the carrier and transmits only the ripple components up to 200 cycles. The 200-cycle cutoff was set to admit at least second harmonics for all original low frequencies, more being accepted for the 40 and 60-cycle tones.

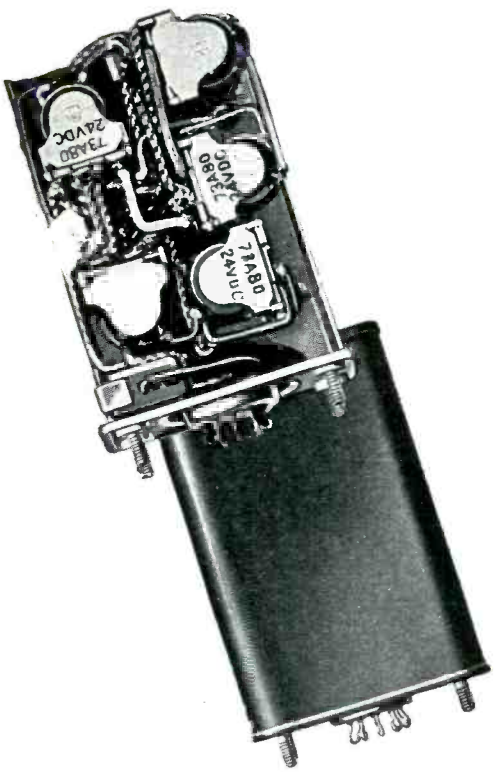
The ability of an amplifier system to transmit the low frequencies that occur simultaneously with the higher frequencies of speech and music is very important. Without such carrying capacity, extreme distortion may result. Transformers and other devices which change their impedance at low frequencies are a major cause of such distortion. All types of systems show the least distortion near the middle portion of the transmission band. For this reason, test frequencies were chosen near the outer portions of the band.

Practical Aspects of High Fidelity

That too much emphasis is placed on frequency response and not enough on entertainment value of reproduction was stressed by Hugh S. Knowles of Jensen Radio Manufacturing Co. He stated that high-fidelity sets produced in 1935 were capable of reproducing frequencies up to 7,000 cycles, which is far above the average today. Receivers produced in 1937 covered the range from 40 to 4,000 cycles and those produced in 1941, 70 to 3,500 or 4,000 cycles.

Chinn and Eisenberg specify wide-range reproduction as 30 to 10,000





DIVERSITY OF DESIGN *plus* IN ALLIED's HERMETICALLY-SEALED RELAYS

These relays are designed to fit your specific applications and to fill your special requirements completely, but this is not all.

When you specify "Allied" you are sure to get a unit that is completely engineered as a sealed relay — not just equipment built around older types. Moreover these sealed relays are produced completely, from start to finish, in Allied plants, by one organization, under coordinated standards.

These products have back of them a wealth of pioneering experience in the sealing of relays to protect them from dirt, moisture and many foreign substances or to prevent tampering or accidental damage to the working parts. This experience is today expressed in a completely organized sealed-relay division, using the most modern techniques and equipment including a specially designed sealing room where air temperature, humidity and cleanliness are scientifically controlled.

There is wide diversity of design in Allied sealed relays. But of far greater importance are the benefits of experience, complete engineering, and modern manufacturing by one organization. Before you specify be sure to get all the facts about Allied relays.

The photo above shows a cut-away view and completed assembly of Allied type TKHX-26 sealed relay with ten soldered terminals individually color marked.

ALLIED CONTROL COMPANY, INC.

AL-102J

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

cycles, medium from 50 to 8,000 cycles and narrow range from 100 to 4,500 cycles. The narrow range is wider than that of most production models of today. Surveys have shown that a band between the narrow and medium ranges is preferred by the public.

Response curves commonly shown as indicative of performance often lead to incorrect conclusions since the curves are dependent on location of the microphone and loudspeaker even in rooms that may be built to a given set of specifications. The loudspeaker output should go up at high frequencies to sound best to the ear. Subharmonic distortion is sometimes introduced to aid reproduction. Distortion from intermodulation varies greatly with frequency and may affect entertainment value of wide-range systems. The speaker felt that the entertainment value of a two-channel system reproducing frequencies up to 3,500 cycles is better than a one-channel system with 15,000 cycle response and that a spread-source effect in reproducing music is desirable even though it cuts articulation efficiency.

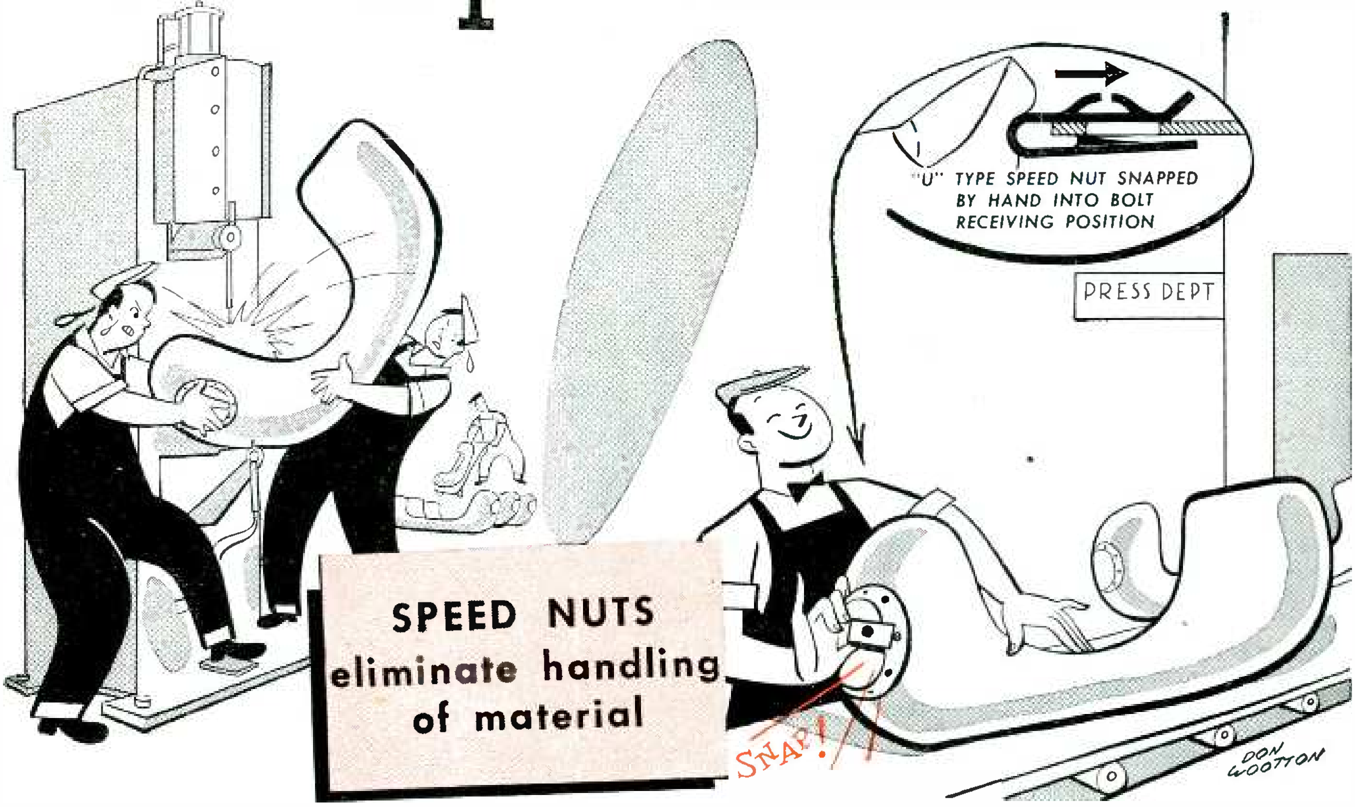
• • •

More on Spherics, Storm Detector

FURTHER TECHNICAL details of the spherics detector for locating distant storm centers (ELECTRONICS, Feb. 1946, p 212) have been disclosed by the Office of the Chief Signal Officer. The equipment enables weather forecasters to plot storms across thousands of miles of ocean by detection of static electricity in thunderstorms, cloud masses, or rainfall.

Experience proved that the spherics technique was not as effective in tropical climates as in more temperate regions. It was also found that nocturnal observations were significantly less accurate than those made in the daytime. And due to the comparatively low frequency of the spheric impulses (7 to 10 kilocycles), deflection of the ground wave causes a considerable factor of error, especially in coastal locations. Another element of error is introduced when the direction finders pick up low-frequency communication transmis-

Why do it the hard way ?
Just snap on a SPEED NUT !



A SPEED NUT CASE HISTORY

One car builder used four welding machines to attach cage nuts on fender stampings for head lamp assembly. Three men were needed for each machine . . . one hauled stampings from the press department and two more wrestled the stampings and located them in fixtures on the welder. Because of all this handling, stampings were frequently damaged. And after painting, threads had to be re-tapped.

Changing to self-retaining Speed Nuts radically reduced the costs of this operation! Two men now do this work on a conveyor and quickly snap the Speed Nuts into place by hand. We will be glad to give you complete details of this case history on request.

* * *

In Canada: Wallace Barnes Co., Ltd., Hamilton, Ontario
In England: Simmonds Aerocessories, Ltd., London
In France: Aerocessoires Simmonds, S.A., Paris
In Australia: Simmonds Aerocessories, Pty. Ltd., Melbourne

Time was when the only way to fasten a nut in place for blind location assembly was to weld, rivet or clinch a cage nut over the bolt hole. This anchored the nut . . . but man, what a job it was!

Changing to Speed Nuts really simplifies this type of operation! Effort is reduced to a fraction — hands freed for more productive work. Welding machines eliminated. Less floor space needed. And, there is less handling and easier final assembly. You get all this *plus* a better finished product because the spring tension lock of Tinnerman Speed Nuts *prevents vibration loosening.*

There are many types of self-retaining Speed Nuts . . . all designed to drastically reduce the cost of blind location fastening. Let us show you how they can be used on your product to effect really worth-while savings. Send in your assembly details today!

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Speed Nuts*
PATENTED
MORE THAN 3000 SHAPES AND SIZES

*Trade Mark Reg. U. S. Pat. Off.

FASTEST THING IN FASTENINGS

sions simultaneously with spheric impulses.

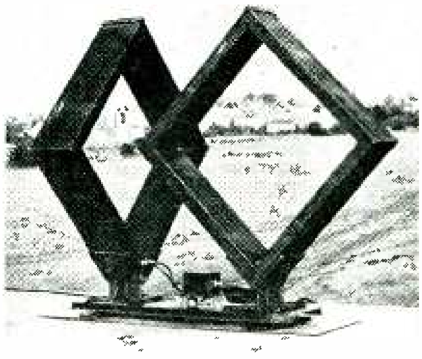
As used by the Signal Corps, each spherics set weighs about 450 pounds and costs about $5000. The frequency range of the latest model is 3.6 to 17.5 kilocycles.

Fixed Loop Antennas

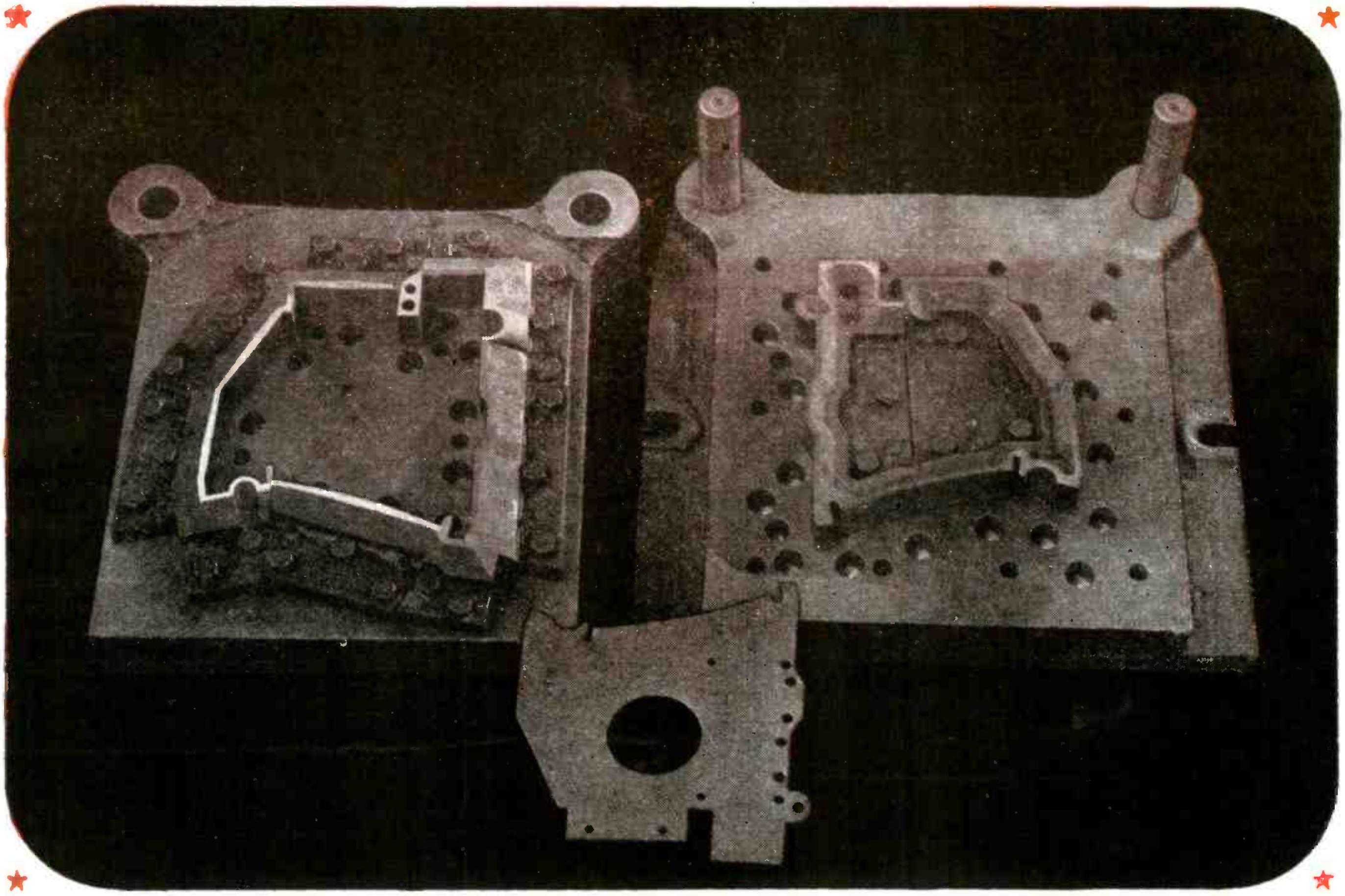
Most radio direction finders are designed to detect continuous-wave signals which are sufficiently enduring in time to permit the determination of direction by rotation of an antenna. The detection of spherics obviously poses greater problems, and the static direction finder is engineered with two separate antennas which do not rotate. The two loop antennas are erected at right angles to each other so that the plane of one is perpendicular to the north-south direction and the plane of the other is perpendicular to the east-west direction.

Each antenna consists of 400 turns of wire wound inside a waterproof aluminum shield. The output voltage of each loop is coupled to identical but separate high-gain amplifiers, which are designed to produce identical output voltages in response to equal stimuli. The output voltages of the amplifiers in turn are coupled to the deflection plates of the oscilloscope.

When the loops are mounted at right angles to each other, signals arriving along the ground produce in each loop a voltage whose value is determined by the strength and angle of approach of each received signal. Since the two loops are identical in construction, their output voltages are identical in wave shape



Loop antennas of the direction-finder system for locating distant storms

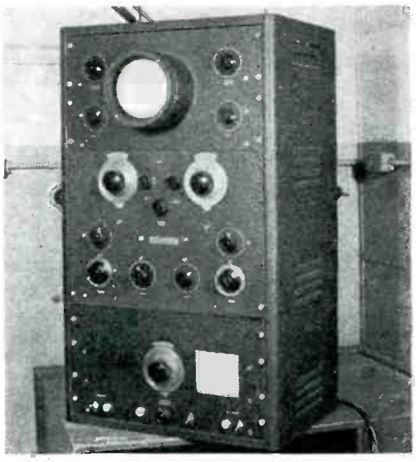


HOW TO *Cut Costs and "Corners"* ON YOUR BLANKING DIES

and phase, and are equal in magnitude for signals arriving from angles of 45, 135, 225, and 315 degrees.

The output voltages of the two loops are amplified to the point where they are strong enough to deflect the oscilloscope electron beam. The output voltage of the north-south loop amplifier is applied to the vertical plates and theoutput voltage of the east-west loop amplifier is applied to the horizontal plates.

In view of the brief duration of the oscilloscope flashes, a certain element of error is inherent in the instantaneous visual reading of the directional bearings. The Signal Corps is attempting to overcome this problem by developing auxiliary photographic equipment which records the oscilloscope indications on 35-mm film. This equipment includes a motion picture camera through which the film is drawn continuously at a speed of one to five inches per second, and a continuous action developer which automatically processes and dries the exposed film received directly from the camera. The film is then projected upon a viewing screen.



Electronic equipment of the static direction finder. Only half of the cathode-ray tube is calibrated since the individual direction finders provide data with 180-degree ambiguity

The camera action is synchronized at all stations of the spherics network by a radio timing unit which produces timing pulses, accurate to within 1 part in 50,000. This auxiliary photographic equipment is still in the laboratory stage.

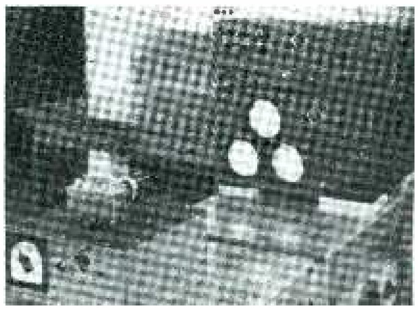
the IRE Winter Technical Meeting engineers of Westinghouse Electric Corp. described high speed x-ray equipment capable of recording impact pressure waves.)

Measurements

In addition to instruments and measurements largely concerned with testing electrical machinery, three papers pertaining to electronic circuits were presented. In the first, prepared by engineers of the Leeds and Northrup Co., electronically balanced recorders having high input impedances and balancing time in the order of seconds were described. These recorders were developed for use with thermocouples and phototubes. Vacuum tubes within the recorders provide signal amplification, others control the balancing motors.

An automatic oscillograph with a memory was described by A. M. Zarem, California Institute of Technology, Pasadena, Calif. The oscillograph consists essentially of a long-persistance screen, cathode-ray tube. The unit was designed to record randomly occurring transients.

The cathode-ray tube is normally in constant operation. The time base is operating; the signal is applied. When a transient occurs in the system being monitored, the transient is immediately drawn on the tube screen. The transient also blanks the beam preventing masking of the transient by later steady state signals and trips a camera focused on the screen. The transient trace is photographed before it decays. The system can reset itself in preparation for the next transient once the initial transient trace has been photographed. The beam blanking is removed, the film moved to the next frame, and the camera reset.



Automatic oscillograph records transients whenever one occurs

Servomechanism problems can be studied by electrical analogy methods described by Westinghouse engineers. The principle of the technique is to represent all mechanical properties such as time lag, inertia, stiffness, and friction by their electrical analogies. The electrical analogies are wired into the servo control circuit. Oscilloscopic observations at essential points in the circuit indicate system behavior. By this method, servomechanisms can be quickly studied and the effects on stability and speed of response of the parameters determined. The paper is specifically concerned with angular position servomechanisms.

Atomic Power

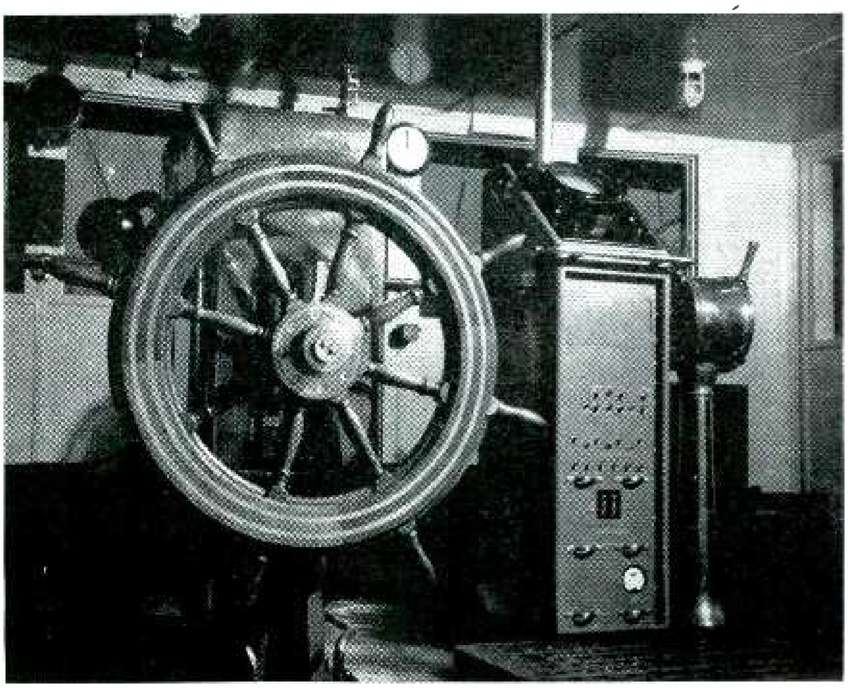
Generation of electric power from atomic fission promises to be the greatest directly constructive social benefit of atomic power. However, engineering difficulties which must be overcome before this application is economically feasible will require years of experience with this new energy source.

In an address before the Institute, J. R. Dunning, Columbia University, New York City, explained that, because of the necessarily thick shielding to confine harmful radiation within the atomic boiler, power plants would be too heavy for all but stationary locations although the reduced bunker requirements might enable atomic prime movers to be carried on the largest battle ships giving them a virtually unlimited range. Reactions within atomic boilers are self regulating; any desired temperature can be produced and maintained.

During his lecture Dr. Dunning demonstrated detection and recording of actual atom splitting, and showed that water acts to decelerate neutrons to their resonant velocity, thereby increasing their effectiveness in splitting atoms.

Addressing a combined meeting of the AIEE with the IRE, L. R. Groves, Maj. Gen. in charge of the Manhattan Project, said that the expense of developing the atomic bomb was only slightly greater than a week of modern warfare. Because of the uncertainty of obtaining usable results, the tactical command proceeded on the assumption that the atomic bomb would not be available. The atomic bomb project used 90,000 electron tubes.

During the AIEE symposium on nuclear energy at which K. K. Darrow, Bell Telephone Labs., Inc., C. G. Suits, General Electric Co., J. A. Hutcheson, Westinghouse Electric Corp., and P. W. Swain, McGraw-Hill Publishing Co., spoke, it was pointed out that present high cost of producing nuclear energy prohibits its im-



Simplified to the extent that one man in the pilot house can operate it, war developed radar opens new frontiers in maritime safety and independence from weather

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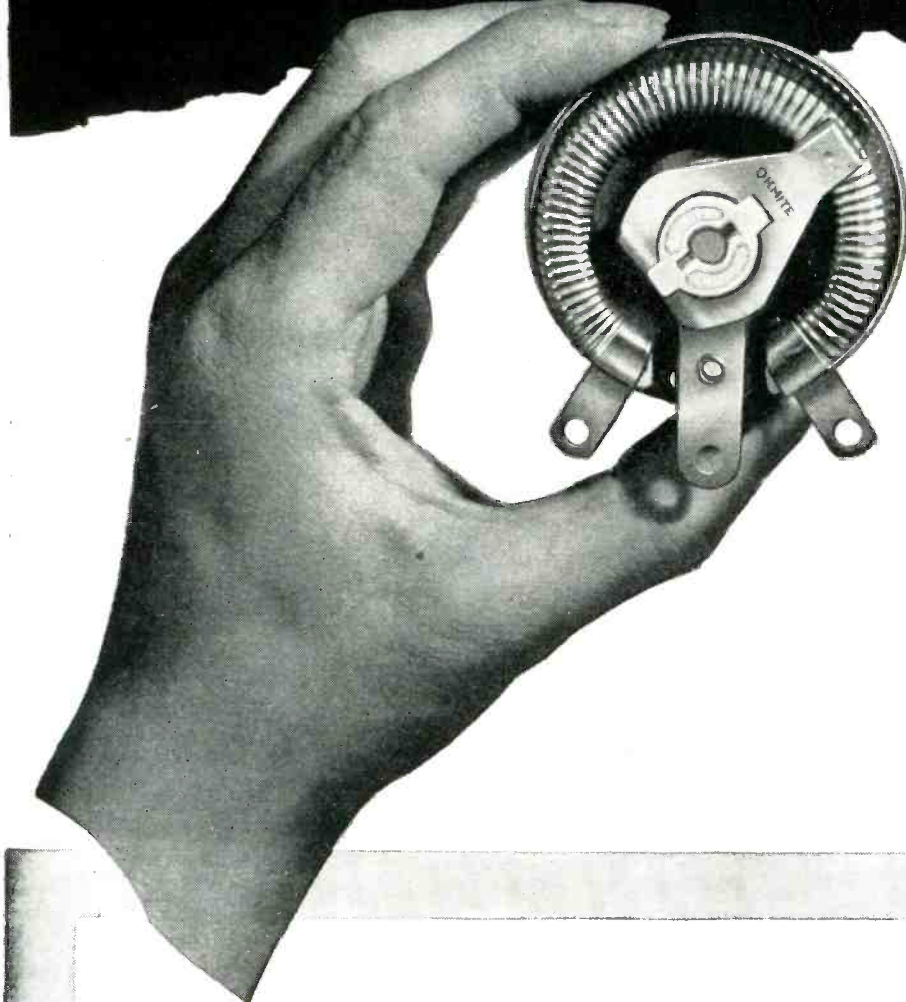
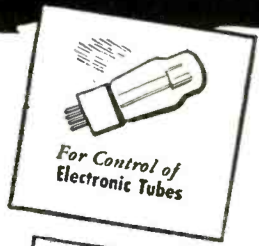
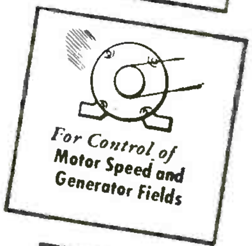
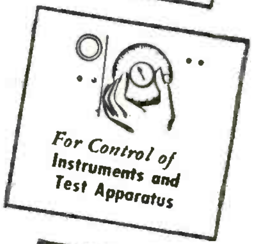
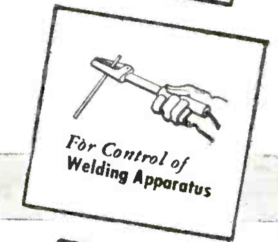
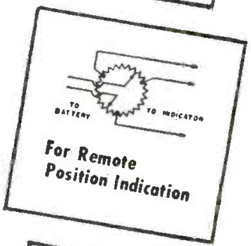



For Control of Electronic Tubes

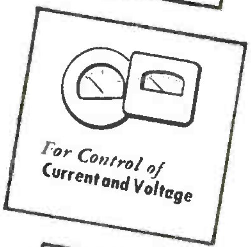

For Control of Motor Speed and Generator Fields

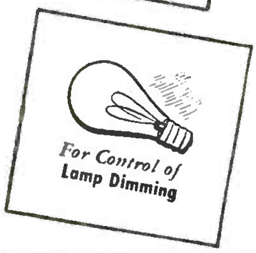

For Control of Instruments and Test Apparatus


For Control of Welding Apparatus



For Remote Position Indication


For Control of Current and Voltage


For Control of Lamp Dimming

Time-proved Design! Widest Range of Sizes!

You get these advantages: (1) Ohmite experience with countless rheostat applications. (2) Service-proved Ohmite features that assure permanently smooth, close control. (3) Extensive range of sizes and types for easy, economical selection of the best unit for every application.

There are ten wattage sizes ranging from 25 to 1000 watts—from 1⁹⁄₁₆″ diameter to 12″ diameter—in uniform or tapered winding—in single or tandem units—in regular or special designs. Stock models from 25 to 500 watts, in many resistance values.

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Write on company letterhead for this helpful guide in the selection and application of rheostats, resistors, tap switches, chokes and attenuators.

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THE ELECTRON ART

AIEE Winter Convention

SPECIFIC INFORMATION on new frontiers initiated or given impetus by technical advances during the war was presented before approximately 2,000 engineers attending the 1946 AIEE Winter Convention held January 21-25 at the Engineering Societies Building, New York City. Of particular interest to ELECTRONICS readers were the sessions on communications, sound recording, industrial tube applications, and radar. Beginning on page 236 abstracts of the more informative papers are presented.

Electronic applications were mentioned in nearly all sessions. Although major portions of these sessions dealt specifically with electrical engineering, such as hydroelectric systems, power transmission and machine tool process drives, electronic techniques were mentioned in the sessions on excitation systems, industrial power applications, and instruments and measurements.

Power Generation

Electronic excitation systems for large a-c generators were described and principles of design and performance characteristics presented by Westinghouse engineers. These exciters provide reliable, continuous service, good generator regulation, and quick generator recovery from load switching and system shorts. Circuits using thyratrons can be designed so that tubes can be replaced without interrupting service.

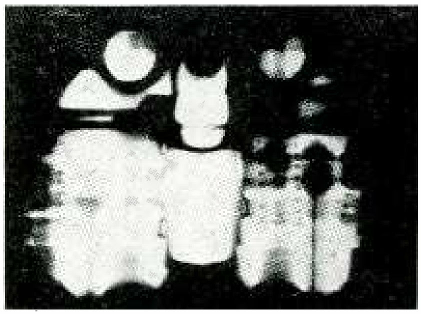
Essentially these electronic exciters are rectifiers for supplying the d-c fields of generators. This particular design feature is a means of maintaining d-c excitation despite generator output voltage and current variations, especially during shorts. Besides the obvious method of operating from an auxiliary generator, the output of the exciter can be stabilized over wide ranges of main generator output either by compensating series transformers, firing angle control, or electronic regulation.

Power Applications

Industrial power applications utilizing electronics include induction heating and radiography. During this session, H. F. Storm of Allis-Chalmers Mfg. Co., Milwaukee, Wis., derived a graph of centimeters penetration for long, cylindrical charges heated by induction. The graph covers the frequency range from one cycle to one hundred megacycles and resistivities from one to one-thousand micro-ohms per centimeter.

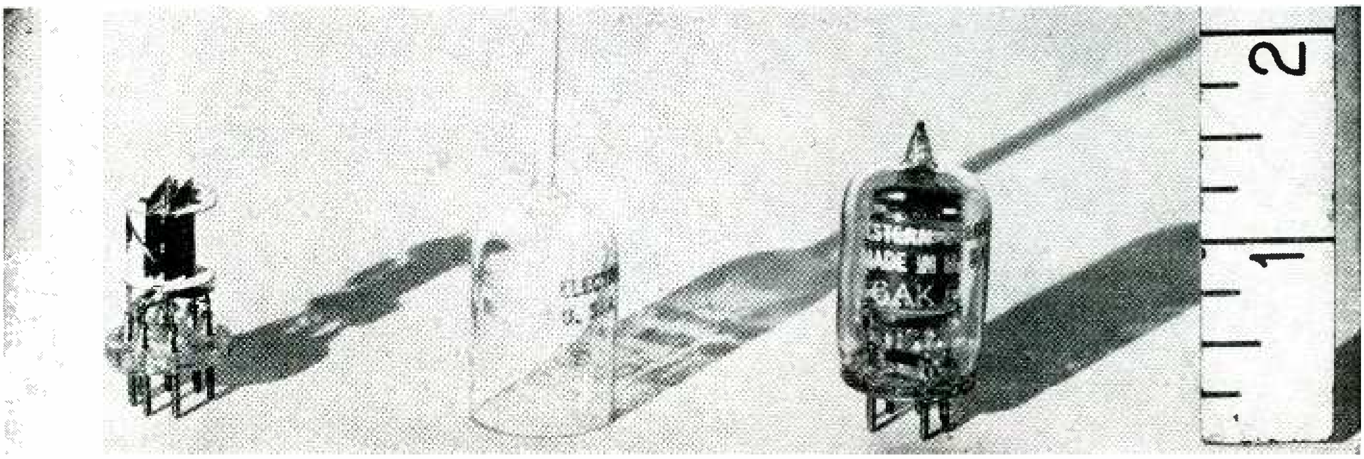
X-rays produced by electrons magnetically accelerated in the Betatron have higher penetration than those currently produced by direct potential acceleration. Thicker sections of metals can be more quickly radiographed by these x-rays than by lower energy rays.

How the Betatron has been developed from a laboratory instrument into an industrial tool was related in a paper prepared by J. P. Girard of Allis-Chalmers Mfg. Co., Milwaukee, Wis., and G. D. Adams, University of Illinois, Urbana, Ill. Tests indicate that, like steel, most metals have a region of minimum absorption in the vicinity of twenty-million electron volt x-rays. Therefore the Betatron is designed to work in this range. Sections having wide variations in thickness can be radiographed. The small spot size of the Betatron x-ray source approximates the ideal point source, making possible enlargement of the specimen on the radiograph by simply increasing the specimen to film distance.



Radiograph of Ford Model T motor made from Betatron produced x-rays

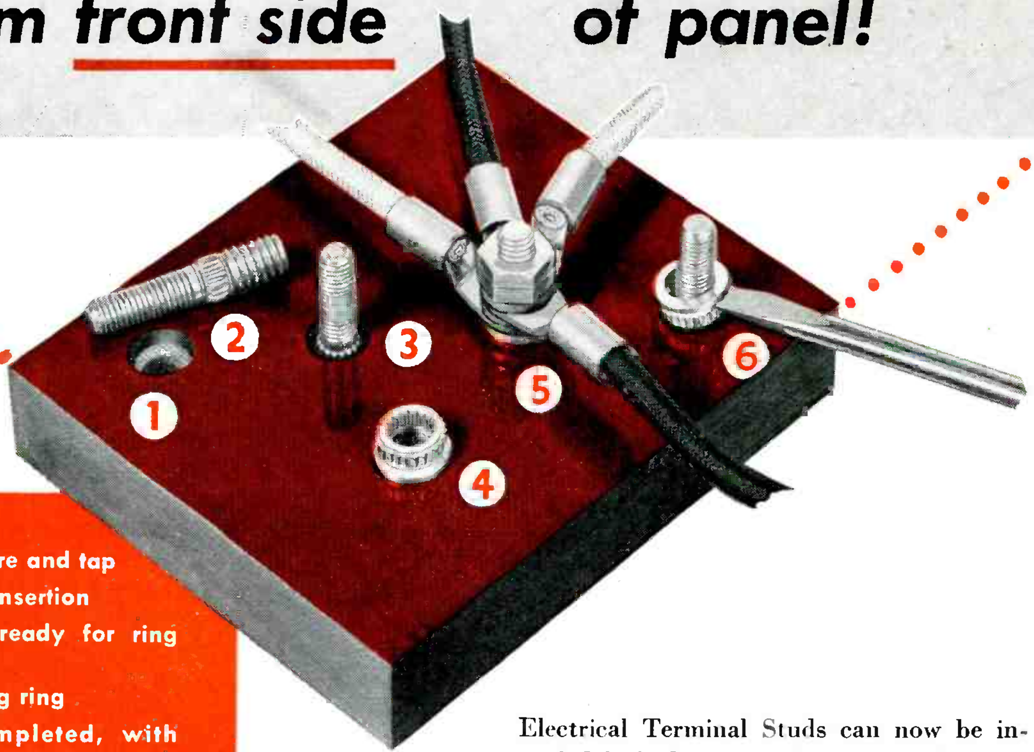
Other projected applications of the Betatron include medical therapy and nuclear research. (News comes from General Electric Co. that engineers of their x-ray laboratory are developing a Betatron x-ray generator. At



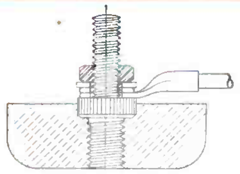
Miniature pentode developed for war time radar and having high figure of merit opens new frontier in such wide band systems as television and pulse modulation

KOSÁN ELECTRICAL TERMINAL STUDS

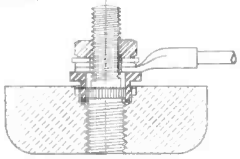
Installed . . . Locked in . . . Replaced from front side of panel!



1. Drill, counterbore and tap
2. Stud ready for insertion
3. Stud inserted, ready for ring installation
4. Terminal locking ring
5. Assembly completed, with terminals
6. Terminal locking ring removed



Molded-In Type. Terminal Stud molded solidly in panel, can be removed by simple means and replaced with two-piece type without damage to material or disturbance of other terminals.



Two-Piece Type. Panel drilled, counterbored and tapped, terminal stud inserted and locked with ring. Quick and easy removal may be effected as indicated. (No. 6 above)

Electrical Terminal Studs can now be installed, locked-in and replaced from the front side of the panel. This development is possible because of the Rosán Terminal Locking Ring which not only locks the stud firmly in the material, but allows the terminals to be tightly fastened without rotation.

The Rosán Terminal Stud may be molded into the panel, or casily installed after forming. It can be just as easily removed by prying under the flange at the top of the ring, without disturbing other studs or terminals.

Send for samples and full information on this time and moneysaving fastening system.

(Patents issued and pending, U. S. A. and foreign countries)

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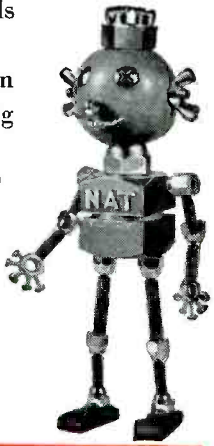
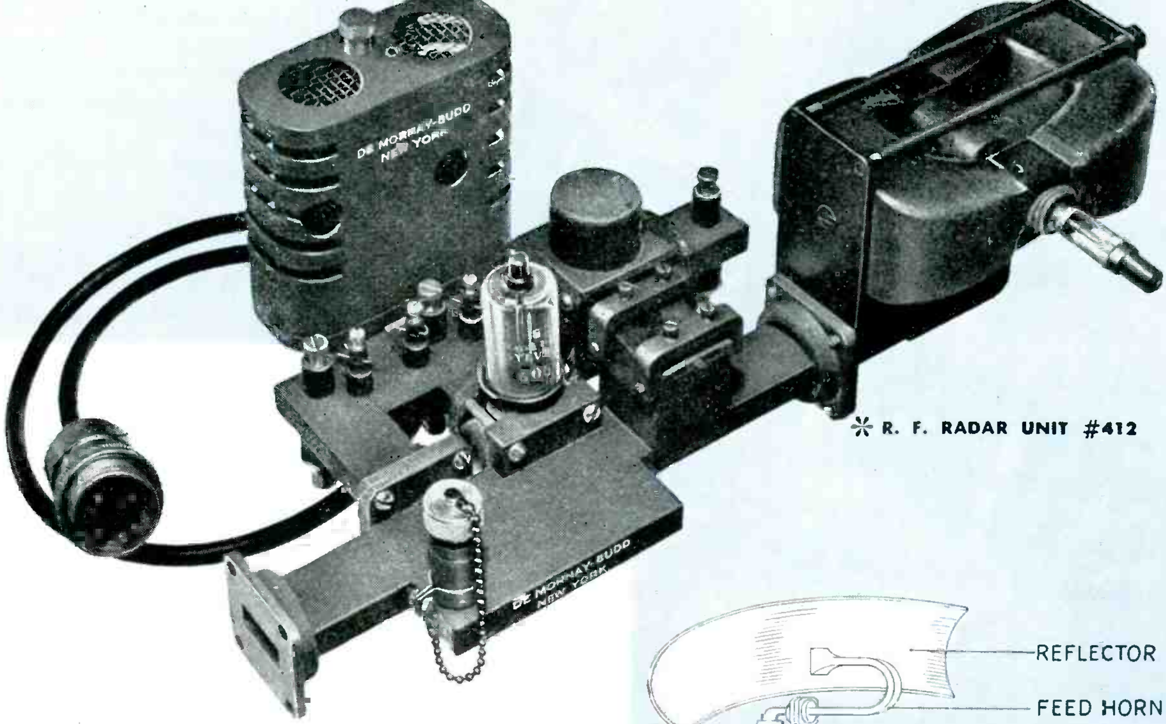
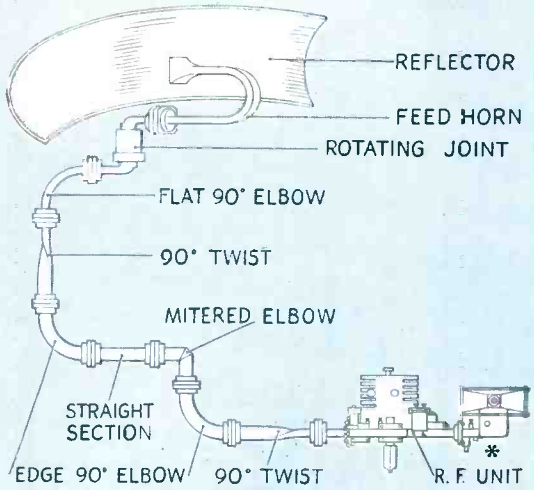


THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

PACKAGED R. F. RADAR ASSEMBLY ELIMINATES DESIGN HEADACHES



✲ R. F. RADAR UNIT #412



R. F. Radar unit #412 (indicated by asterisk) used in conjunction with standard DeMornay-Budd transmission line components.

The DeMornay-Budd packaged R. F. Unit provides a complete R. F. assembly for microwave radar. It is now possible to obtain as standard items all the microwave R. F. components necessary in the fabrication of a complete radar—DeMornay-Budd Standard Transmission Line Components plus packaged R. F. Unit.

The R. F. Radar Unit is delivered complete and ready to operate. It is wired and contains all the necessary tubes and crystals. The unit uses a packaged magnetron capable of delivering 20 kw., peak power, at 9375 mc. Two type 2K25 local oscillator tubes are provided, one for receiver and A.F.C. and the other for beacon operation. A type 1B35 A-T-R tube, a type 1B24 T-R tube and the necessary type 1N21 crystals are included in the assembly. A 20 db. directional coupler permits accurate measurements to be made at any time with a maximum of convenience and safety.

Since the use of radar beacons is contemplated in the near future, the unit has been designed with a beacon cavity and crystal mount. The unit can be supplied without the beacon cavity and crystal mount and beacon local oscillator, and a termination supplied in their place so that it becomes a simple matter to convert to beacon operation when necessary.

We offer complete laboratory research facilities and have available such production test equipment as: Standing Wave Detectors, Calibrated Attenuators, Slug Tuners, Power Supplies, Square Wave Modulators, in addition to transmission line components shown in diagram above. Write for information or catalog.

DE MORNAY BUDD

EQUIPMENT FOR 97% OF ALL RADAR SETS

DE MORNAY-BUDD, INC.
475 GRAND CONCOURSE, NEW YORK, N. Y.

mediate constructive use. In areas where other fuels are scarce, such as Australia, atomic energy will first be harnessed for power generation. Based on present knowledge, small power units for automobiles, homes, and airplanes are not feasible. To support long-range development, much fundamental research in nuclear physics is necessary. The development of the atomic bomb exhausted our surplus of fundamental knowledge. The only new fact learned was the discovery of nuclear fission in 1939. Fission, distinguished from radioactivity, occurs in sereval relatively abundant elements making nuclear energy marginally economically available.

Most solid fuel consumed in this country produces low pressure, low temperature industrial steam. It is in this field rather than in power generation that atomic energy can best be applied. The limiting economic factor in electric power is transmission. Nuclear energy is most usable in large power generating stations; therefore it is not an immediate competitor for coal because of the technical difficulties and high initial cost of electrical power distribution.

Of particular importance are the applications of nuclear fission in the fields of medicine, chemistry, and for penetrating further into fundamental knowledge of matter from which other sciences can build.

Demonstrations

Displays of wartime developments and field trips to plants indicated new frontiers in a tangible form. Greatest interest was shown in a dial radiophone for automobiles demonstrated by engineers of the Fred M. Link Corp., New York. Operation is on the experimental 152-162-mc band. Dialing on a standard Western Electric dial phone selectively calls other cars or a tie-in station to line subscribers. Communication over the f-m radio link was maintained between engineers at the DuMont Laboratories on Madison Ave. and a moving car.

Awards

The Edison Medal, awarded annually to the individual contributing most significantly to economic and

dependable power generation and transmission, was presented for 1945 to Philip Sporn, American Gas & Electric Corp., by W. E. Wickenden, president, on behalf of the AIEE. W. H. Harrison, American Telephone & Telegraph Co., received the Hoover Medal for 1945. This medal, awarded by the national civil, mining, mechanical, and electrical engineering societies, takes its name from its first medalist, and is given to a fellow engineer for distinguished public service. S. F. Voorhees, New York architect, made the award on behalf of the participating societies at a combined meeting of the AIEE with the IRE.

Communication

Electronic Regeneration of Teleprinter Signals

By H. F. WILDER
Western Union Telegraph Co.
New York, N. Y.

DIFFERENCES in transmission velocities over wire lines of the harmonic components of rectangular teleprinter pulses and presence of noise result in deterioration of the signal after transmission over long distances. To restore the sharpness of the impulses and provide a gate to noise, a regeneration repeater is introduced in the line.

To accomplish the function of a signal regenerator electronically, a timing gate is used. The arrival of the start signal in the series of impulses of a teleprinter character trips a relay which sends an impulse down a lumped, timing network. The progression of this timing impulse down the relay line activates a tube at the times there should be polarity reversals of the signal. Thus this tube only accepts signal reversals at the instants they should occur. In this way the signal is restored to its original sharpness, and noise is rejected.

Tunable Rejection Filter

By R. C. TAYLOR
Western Union Telegraph Co.
New York, N. Y.

IN COMMUNICATIONS it is frequently necessary to reject a narrow frequency band. To do this a bridge is used; each arm is resonant at the

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"An asset in which the Nickel Plate Road takes great pride is the high standard of service which it renders to the shipping public. With its record for outstanding performance during the war years back of it, the Nickel Plate is looking forward to the utilization of new technological developments, such as radio and teletype, in order to attain still higher standards of service and usefulness."

President,
The New York, Chicago & St. Louis R.R. Co.

To fulfill completely its promise of increased rail efficiency, railroad radio equipment must be so designed that individual system units, such as transmitters, receivers, power supplies, and remote control units, will be readily accessible for inspection and quickly removable for service, replacement, or relocation.

Realizing the importance of these requirements, the Farnsworth Mobile Communications Division has engineered its railway communications equipment on the bases of *standardized design* and *unitized construction.*

Practical results from the application of these two engineering principles include the facts that—

(1) The basic components of Farnsworth systems, whether of space-radiating or inductive type, are *separate units,* which can be *quickly disassociated* from a system, either for maintenance or relocation.

(2) The same receiver, transmitter, or remote control unit is usable for wayside, mobile, or relay installations, thus providing *complete interchangeability* of basic equipment throughout any Farnsworth communications system.

(3) *Space-radio and inductive type* Farnsworth *units can be interchanged,* whether a part of mobile or stationary installations, and can be *readily utilized in combination* to meet varying railway operating conditions and requirements.

These are a few of the many engineering features incorporated in Farnsworth railway communications equipments to guarantee *maximum availability and flexibility with simplified, low-cost maintenance.* Farnsworth Television & Radio Corporation, Dept. E-4, Fort Wayne 1, Indiana.

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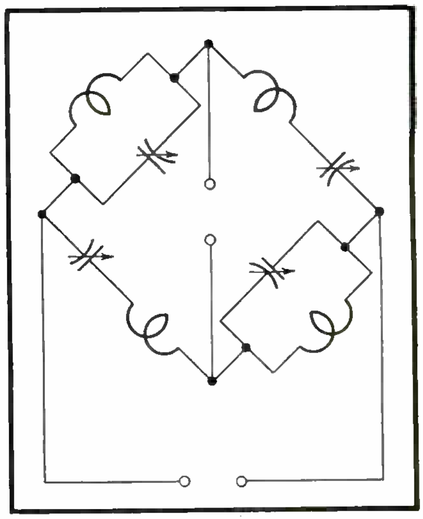
rejection frequency and the resonant dissipations in the arms are equal, therefore the bridge is balanced and does not pass that frequency.

An analysis made of the filter using circle diagrams shows that the



Basic Wheatstone bridge rejection filter eliminates pilot frequencies from carrier communication and telemetering circuits

Q of the inductors determines the narrowness of the rejection band. Two rejection filters in tandem tuned to slightly different frequencies can be used to reject a wider band than one alone. This practice preserves the sharpness of the rejection band.

Inertia Throat Microphones

By L. G. PACENT
Pacent Engineering Corp.
New York, N. Y.

and E. H. GREIBACH
Sonotone Corp.
Elmsford, N. Y.

COMMUNICATION from such noisy locations as airplanes and machine shops can be made using throat microphones. These units pick up the vibrations of the larynx transmitted directly through the throat walls rather than the atmospheric vibrations. Thus they respond to speaking but are relatively insensitive to air-borne noise.

The throat vibrations of speech are weak in overtones. To compensate for this, a rapidly rising response characteristic is required of the magnetic inertia microphone. This requirement necessitates setting the resonant frequency in the

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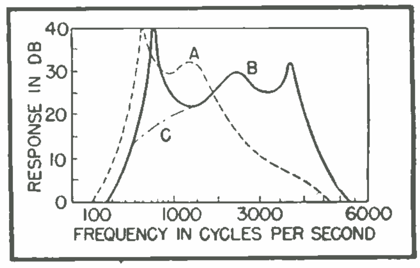
vicinity of three to four kilocycles. Although so high a resonant frequency improves intelligibility of the microphone signal, it decreases the output. For sound powered com-



Curves A and B show response for single and double resonant units respectively, curve C shows effect of damping the double resonant microphone to improve quality

munication systems, high output from the microphone is necessary. This requirement can be met by introducing a second resonant frequency in the vicinity of one kilocycle.

Objective Testing of Throat Microphones

By E. H. GREIBACH

Sonotone Corp. Elmsford, N. Y.

LABORATORY TESTING of throat microphones and bone conduction earphones requires a counterpart of the human organ under study. In both cases the transmission characteristic of the skin layer enters into the unit, therefore a single unit can be used in testing either element. The artificial throat is essentially a dynamic loudspeaker, but has masses, springs, and pads to produce the required impedance vs frequency characteristic. Viscoloid pads have given a fair approach to the loss component of the skin, but it is difficult to simulate both skin stiffness and resistance by even a combination of pads.

In operation the driving coil is fed from a resistance-capacitance network to produce uniform velocity of the testing platform over the frequency range. The filter-pad is placed on the platform and then the throat microphone. In this way the microphone sees a simulation of the impedance looking through the skin into the throat. By driving the plat-

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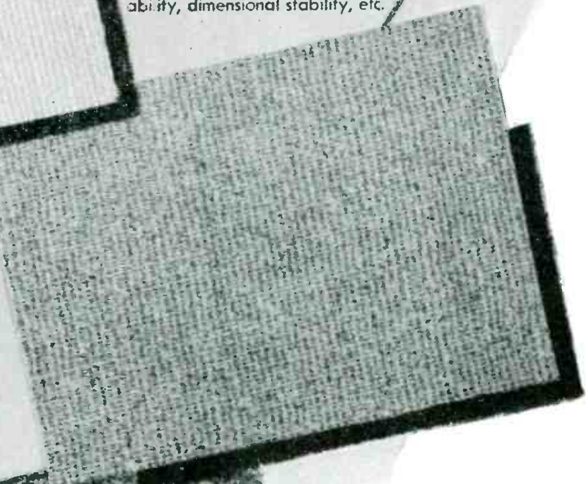
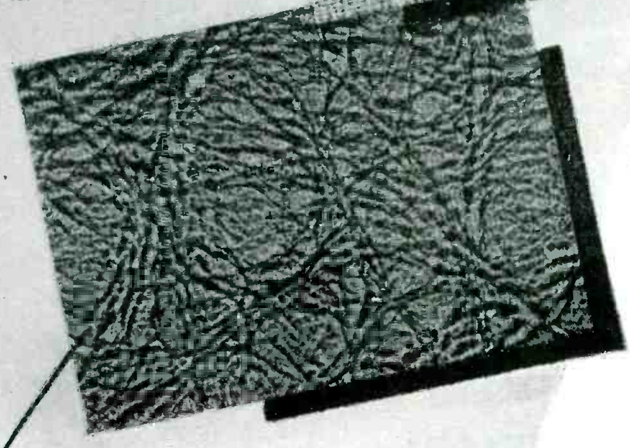


impregnated

Interthread treatment with various newer plastics to give bulk strength, stiffness, transparency, resistance to moisture, mildew, heat, cold, chemical actions, etc., retaining cloth surface appearance.



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Surface treatment on a cloth structure to meet a great variety of functional and decorative uses.

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THE HOLLISTON MILLS, INC., NORWOOD, MASSACHUSETTS form with a receiver and measuring the current generated in the driving coil the unit can be used as an artificial mastoid.

Sound Recording

Wire Recording

By D. W. PUGSLEY
General Electric Co.
Schenectady, N. Y.

POSSIBLE USES of wire recording include that for the home, commercial and public announcements at broadcast stations, pocket recorders, and recording in such vibrating locations as cars, trains, and aircraft. The long, continuous records which can be made recommend wire for recording telephone conversations, air and rail traffic messages, and recording for students, the blind, and the sick.

At the present stage of the art, satisfactory frequency response can be obtained at two feet per minute, with a 40-db dynamic range, and three percent total harmonic distortion. Recording, splicing, dubbing, and erasing are easy. Noise is 40 db below signal; there is freedom from interference from external vibration. Records can be played back many times, require small storage space, and are not easily damaged.

However, driving the record and loading the magazine are difficult. The blank is expensive. Because of the difficult and lengthy production of recordings on wire commercially produced recordings in quantity are unlikely.

Wire Recorder Head Design

By T. H. LONG
C. G. Conn, Ltd.
Elkhart, Ind.

TESTS ON HEADS through which the magnetic wire runs in a groove showed that the accumulation of magnetic mud in the gap lowered the response to 5,000 cps by 15 db at a wire speed of two feet per second. Low frequencies were less effected. Also lifting of the wire slightly from the bottom of the groove reduced the output 3 db at 5,000 cps, although it did not affect the low frequency output. In addition to these practical defects, there is the theoretical magnetic defect that flux penetration is less for a curved surface than for a flat one.

An improved head design was de-

Announcement

Federated Metals Division, American Smelting and Refining Company, is happy to announce that as of February 1, 1946, it has completed arrangements with the Gardiner Metal Company of Chicago to produce and market the entire line of Gardiner *extruded* solder.

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As a result of this arrangement, Federated's capacity to produce extruded solders has been broadened. This means a further improvement in service for Federated customers. The combined facilities and experience make available to extruded solder users everywhere, a fund of knowledge and quality of service second to none. These advantages, plus precise metallurgical control, assure buyers of uniform, high quality extruded solders.

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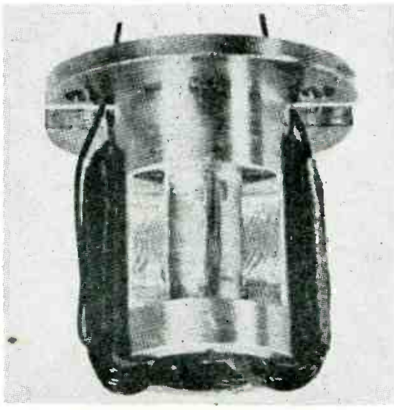
veloped after observing that the playback response was 8 db higher when the wire was running across the top of the lamination than when it was at the bottom of the groove. The new head with either open or closed winding duplicates the performance of conventional closed winding types if stainless steel wire having a coercive force of about 175 oersteds and usual retentivity is used.

By lengthening the gap to about half an inch, level winding can be used. The record is played back and forth along the gap, distributing wear and helping to keep the surface clean. It was found desirable to fill the gap with hardened beryllium copper to prevent undercutting of the gap material and eventual shunting of the gap by magnetic mud.



Experimental model of open head. Level winding technique, ease of cleaning, and greater high frequency response are obtained

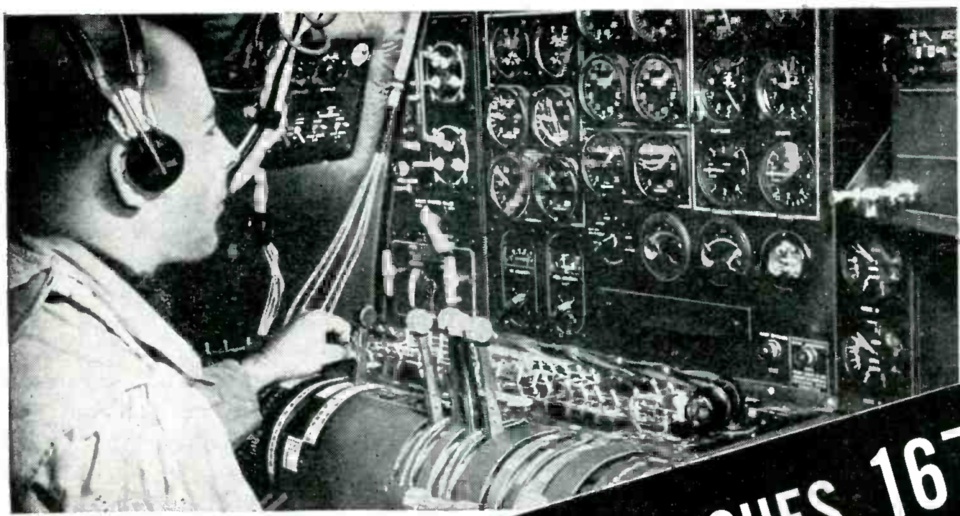
B-H Tracer

By T. H. Long and G. D. McMullen
C. G. Conn, Ltd.
Elkhart, Ind.

Magnetoscope measurements show that variations of coercive force over the length of record wire are sufficient to produce several decibels variation in the low-frequency playback. Changes in wire tension were observed to produce appreciable instantaneous changes in coercive force and retentivity.

The instrument used for these measurements consisted of a magnetizing coil capable of 1,500 ampere turns per inch, although some wires will require more than 2,500 ampere turns per inch for saturation. A balance coil was used to exclude the

No electrical equipment can be any better than its insulation



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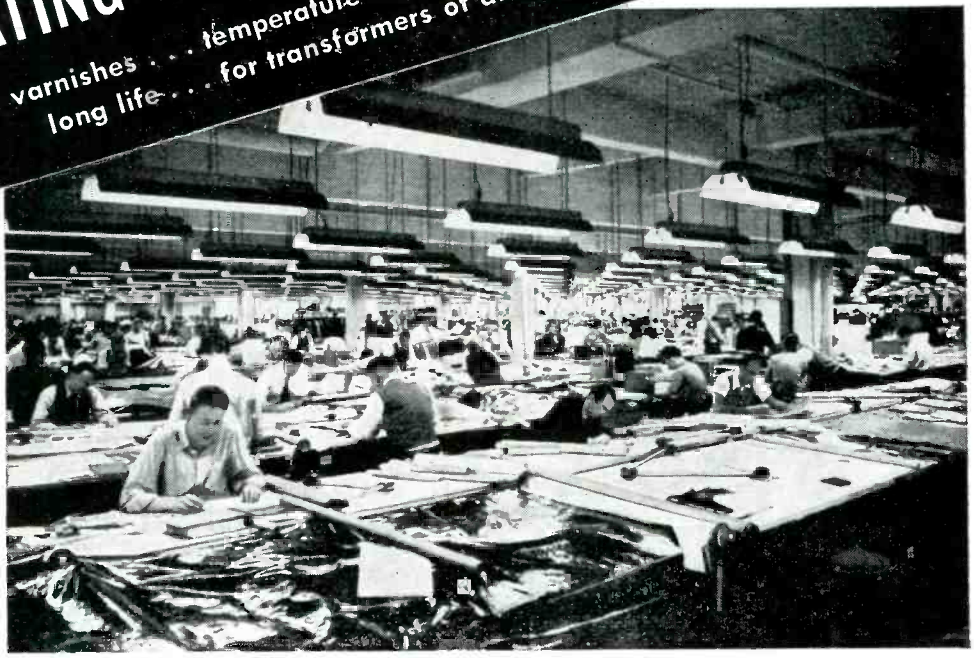

. . . and the same varnish can protect a fluorescent ballast with long-lived, heat-resisting insulation.

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influence of air flux from the measurements. The detector coil was centered in the magnetizing coil where nearly uniform flux can be expected.

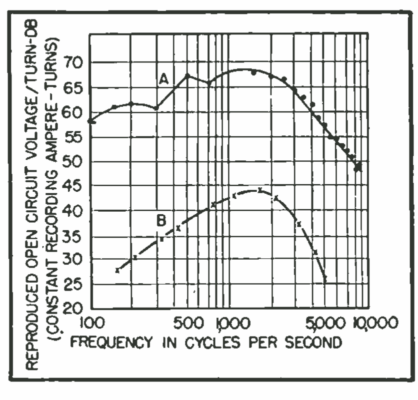
A magnetizing frequency of 200 cps was used. The amplifier was designed to have wide frequency response and negligible phase shift because of the necessity of reproducing the irregular B-H curve. The time constant of the integrating circuit was 100 times the half period of the fundamental frequency. Hum bucking as well as complete filtering was necessary in the power supply to eliminate power frequency disturbances in the trace. The B-H curve was reproduced on a conventional oscilloscope.

Magnetic Tape Signal and Noise

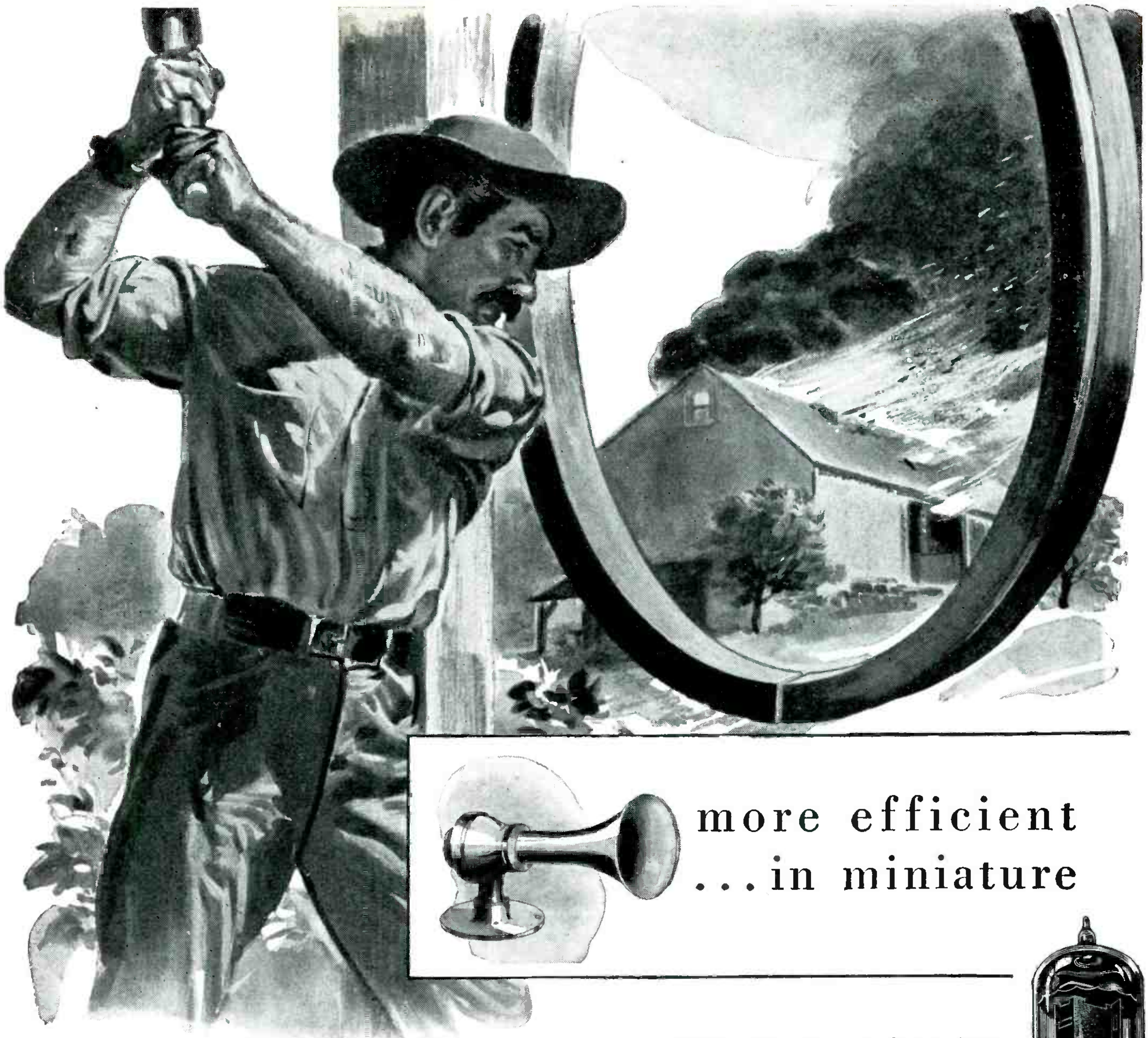
By D. E. WOOLDRIDGE
Bell Telephone Labs., Inc.
New York, N. Y.

THEORETICAL ANALYSIS of perpendicular recording on tape, made to determine what properties of tape and associated magnetic elements affect noise and signal output levels, indicate methods of decreasing noise and increasing signal.

Although magnetic theory is still insufficient to correlate tape noise with any measurable magnetic property, it can be said in general that noise is less in demagnetized tape than in saturated tape. High signal to noise level should be produced by tapes having high coercive forces. To meet this requirement, vicalloy tape having a coercive force of 200 to



Using vicalloy tape perpendicularly magnetized and offset pole pieces, the characteristic of curve A was obtained. Curve B shows characteristic of old unit for comparison



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ACTUAL SIZE

At the press of a button, the modern fire siren screams its warning for miles. In contrast, it took a husky man to strike an iron tire hard enough, with a heavy sledge, to sound an alarm even over a comparatively small area. Greater efficiency in miniature is as evident in the fire alarm as it is in the Electronic Tube.

TUNG-SOL Miniature Tubes are more impervious to the effects of shock and vibration as they are constructed with smaller, lighter parts. The glass button base has better dielectric properties than the old style bases. Lower lead inductance, lower inter-element capacities, and higher mutual conductance are characteristics of TUNG-SOL Miniatures that assure superior performance in high frequency currents. The advantages of smaller lighter tubes in over-all set design needs no amplification.

The TUNG-SOL engineers who developed TUNG-SOL Miniatures are at the service of radio set and other electronic equipment manufacturers. They will be glad to aid in using Miniatures to the best advantage, by advice as to circuits and tube selection. Of course such consultation is held in strictest confidence.

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250, five times that of earlier tapes, was developed.

Output signal level is limited largely by a region of high reluctance in the pole piece tips. The best material for the pole pieces is already available, molybdenum permalloy. By using wider pole pieces (0.041 inch by 0.040 inch), offset so that the leading edge of one is opposite the following edge of the other, a self-supporting head requiring fewer turns to saturate the tape and giving greater output was obtained. A-c bias is both quieter and capable of giving higher level, high quality recordings than other forms of bias.

Combining these improvements, high quality recordings equalized from 100 to 8,000 cps with a useful volume range of 50 db at a tape speed of 16 ips were obtained.

Phonograph Reproducer Design

By W. S. BACHMAN
General Electric Co.
Bridgeport, Conn.

STRAINED WIRE resistance reproducer design is carried out. The techniques of analyzing the mechanical components are applicable to other reproducer types. Because the output voltage of the polarized strained wire is proportional to its displacement, this type of reproducer is useful in measuring recorded frequency characteristics. A variable reluctance reproducer having low mechanical impedance by virtue of its small moving mass is designed. Both types of reproducer have the supporting arm resonance damped by the suspension compliance.

Studying Disk Performance

By H. E. ROYS
RCA Victor Division
Indianapolis, Ind.

TOOLS AND TESTS for measuring performance, primarily of lacquer recordings and pressings, have been advanced to assure improvements in record fidelity. Cutting force can readily be measured by replacing the permanent magnet field of a cutting head by an a-c field, reorientating the armature assembly to respond to tangential rather than radial forces, and feeding the armature coil output to a meter. Measurements using such a technique indicate the self-regulating effect of a free head

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While the present day Ward Leonard Plate Type Rheostats have been modernized, made even smoother in action and offer many more steps of control in smaller diameters, they are still built on a rigid steel plate foundation.

With the wide range of types and sizes of Ward Leonard Rheostats you will find the one to meet your requirements—from the smallest electronic to the largest industrial application. Send for Rheostat Bulletins today.

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against a head controlled by an advance ball. The self-regulating action of the floating head tends to maintain a constant recorded signal level. Effects of lacquer hardness, turntable drive, and cutter bounce can also be determined.

Intermodulation measurements of distortion, which give closer correlation with listener tests than harmonic distortion measurements, show the effects of tip radius and processing of pressings. These tests are easier to apply than harmonic tests because shifting of phase and frequency caused by turntable flutter do not affect the results.

Sound Recording in Business

By L. D. NORTON
Dictaphone Corp.
Bridgeport, Conn.

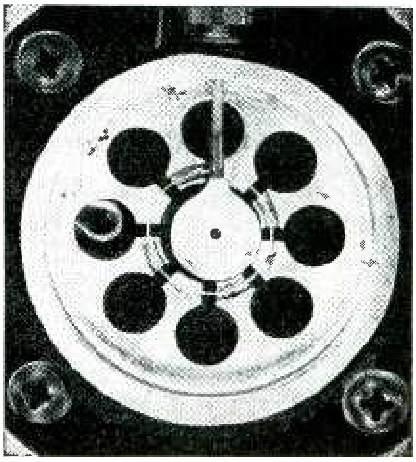
IMPROVEMENTS in electrical recording and reproducing techniques, plus the additional facilities available if dictaphones can be connected to electrical speech channels, make electrical dictaphones feasible. To compete with the acoustic instrument of proven reliability and simplicity, electrical dictaphones must be equally simple and reliable in operation. From a critical examination of requirements for business recorders standards were proposed.

Industrial Electronics

Development of Magnetrons

By W. C. BROWN
Raytheon Mfg. Co.
Waltham, Mass.

EARLY LABORATORY magnetrons operated at relatively low frequencies, at low efficiencies, and delivered low



Looking into the cavities of a 300 kw magnetron, cover removed

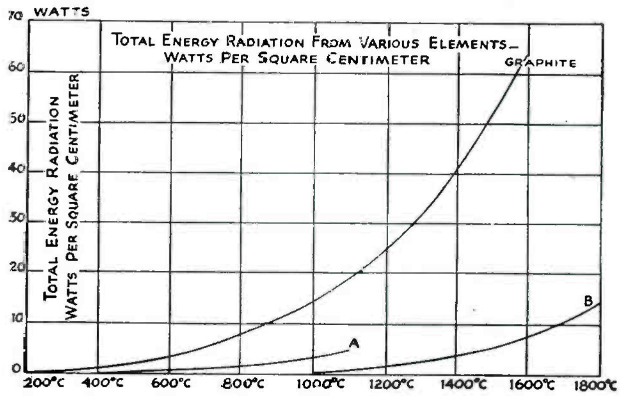
ONE OF the big advantages of using graphite for anodes is the high thermal emissivity of this remarkable material. Because "National" graphite is almost an ideal black body, it is a nearly perfect heat radiator. In fact, no other anode material even approaches "National" graphite in this respect.

This means that anodes of "National" graphite will operate at lower temperatures for a given amount of energy dissipated. Thus, *all* tube parts will operate at a lower temperature, resulting in less distortion and more uniform tube characteristics.

In addition to this important property, here are others that, combined, make "National" graphite a most valuable anode material: High electrical and thermal conductivity, low electron emission, extremely low thermal expansion, and no melting point! Furthermore, graphite can be machined into intricate shapes to very close tolerances.

The full story on the possibilities of graphite for your anodes may be had by getting in touch with National Carbon Company, Inc.

This graph shows the total energy radiation from graphite and other anode materials in watts per sq. cm.



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power. Recent, rapid development of magnetrons has resulted in tubes delivering megawatts in the 3,000 megacycle range at efficiencies up to fifty percent. In the 10,000-mc range, up to 300 kw are developed.

Except for the power supply, the magnetron is a complete transmitter within itself. Development of the packaged magnetron, which has an attached permanent magnet, has reduced bulk and weight of the magnetron to the point where it is a simple, reliable tool for electronic engineers.

Hydrogen Thyratron

By H. H. HEINS
Sylvania Electric Products, Inc. Emporium, Pa.

PULSE TECHNIQUES used in navigational equipment such as radar, loran, and shoran, and in communication systems of the pulse modulation types require rapid, high power pulsing. The hydrogen, cold-cathode thyratron was designed to supply the high peak currents and voltages necessary. Because of the short deionization time of hydrogen, rapid switching rates are possible. Electrical characteristics are little changed by a wide variation of temperature.

The hydrogen thyratron can be used for switching capacitor discharge type welding circuits, and in place of spark gaps in induction-heating equipment.

Dielectric Heating

Bp I. E. MOUROMTSEFF
Westinghouse Electric Corp. Bloomfield, N. J.

LABORATORY TESTS indicate that dielectric heating can be used for disinfecting grain in bulk, sterilizing packaged cereals, making safety glass, gluing wood laminations and shoe soles, and curing textile fibers. It has proven useful in drying enamel insulation on wire, and rolls of paper. Medical doctors have found dielectric heating advantageous in treating common colds and some other ailments, although the effects can be duplicated by other forms of heat treatment. Despite the technical possibility of these applications, initial costs of dielectric heating installations are prohibitive at present.

Dielectric heating depends on the presence of permanent molecular di-

RADIO TRANSMITTERS
by Press Wireless

Radio Transmitter
Model T50CF-1

This modern, 50-kilowatt, 4 to 21 megacycle radio transmitter is actually two transmitters in one. The entire unit may be used as a 50kw transmitter for on-off CW or frequency-shift keying with an FS keyer and may be modulated by a high-level Class-B modulator. Complete controls and an individual power supply for the exciter and driver stage provide a medium-power r-f carrier of 3-kilowatts on CW or FS—separate and independent of the power amplifier section. The separate controls and high-voltage power supply for the PA make this section available as an independent Class-C final amplifier unit for use with a suitable double-sideband Class-B modulator-driver. The PA section may be adjusted for operation as a Class-B linear amplifier when used with a suppressed-carrier exciter or other r-f driver source.

DESIGNED for CW or FS operation, this equipment with companion Modulator Model TM 50-1 will transmit MODUPLEX* where AM and FS signal intelligence appear simultaneously on the same carrier.

MODEL T50CF-1 provides protection throughout for personnel and equipment by elaborate interlocking and automatic recycling control circuits. An automatic-shutdown feature cuts off the transmitter after a preset interval if the external (remote) keying line is idle.

Press Wireless will deliver this high quality transmitter and others of 2,500, 5,000, or 20,000 watts with associated equipment within five months from the receipt of your order.

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poles in the material to be heated. The choice of frequency depends chiefly upon the ease of load matching and avoidance of standing waves in the work. The wavelength should not exceed one sixteenth the greatest dimension of the work. Dielectric constants of most materials decrease but little with increasing frequency, whereas power factors change variously. Changes of power factor during heating are the greatest load-matching complication.

High powers required for dielectric heating are available. The resnatron and magnetron extend these powers into the centimeter range.

Testing with Pulses

By H. W. Lord
Research Laboratory
General Electric Co.
Schenectady, N. Y.

ADVANTAGES of high-potential testing of motors and transformers using surges or pulses are that (1) winding stresses are similar to those due to switching surges during operation, (2) high voltages are obtainable from small equipment, and (3) shock from the pulse voltage is less dangerous than from other high voltage test equipment.

Improved surge testors can be built using techniques originally developed for radar such as hydrogen thyratrons, pulse forming networks, and pulse transformers. By using a shielded pulse transformer balanced to ground, the bulky, motor driven, synchronous switch commonly used in high voltage test sets is eliminated. In addition, fault display on the oscilloscope screen is made simpler and more sensitive, because a bridge circuit giving zero voltage at balance can be used instead of direct comparison of two high voltages.

A laboratory surge tester suitable for testing fractional horsepower motors and radio transformers was demonstrated.

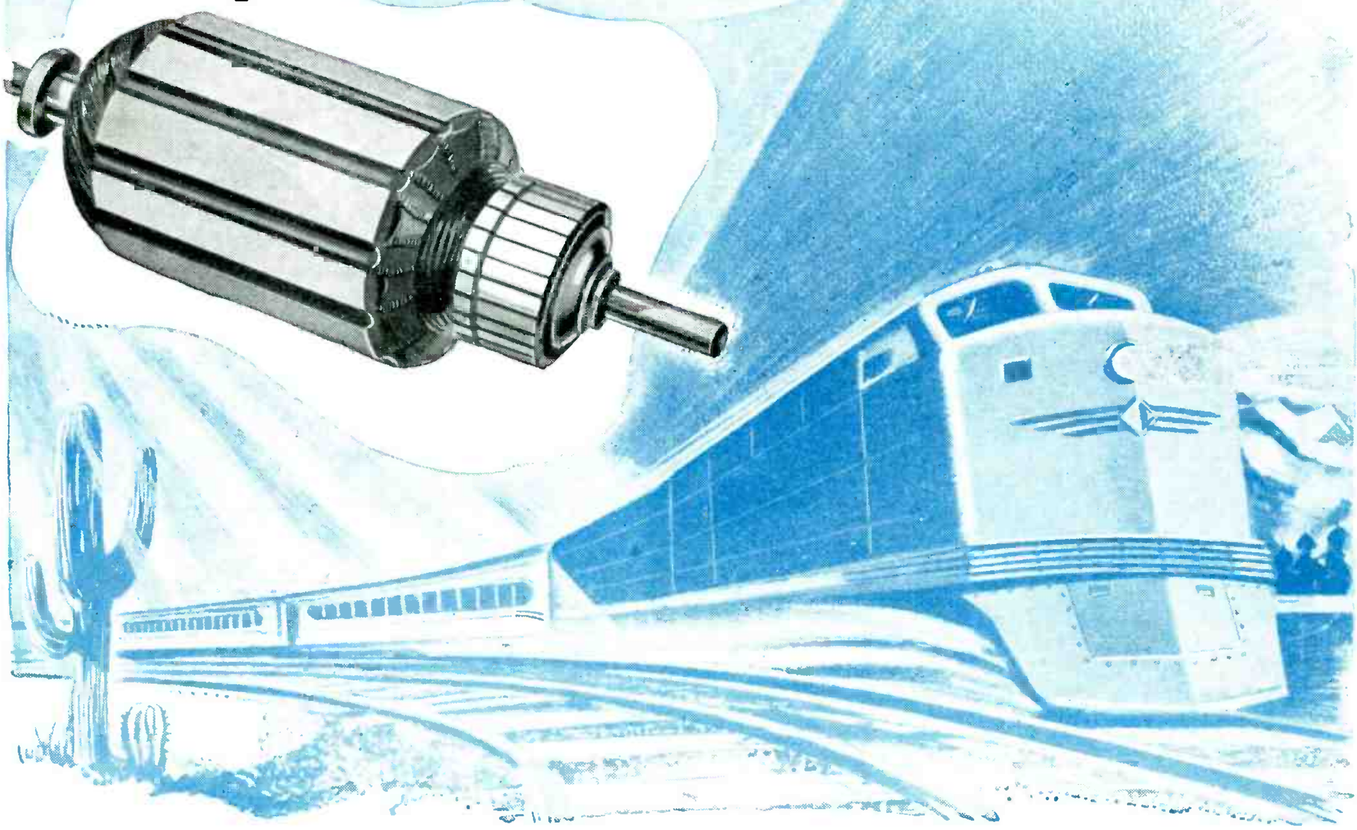
Radar

Radar Systems Considerations

By D. A. Quarles
Bell Telephone Laboratories, Inc.
New York, N. Y.

RADAR DESIGN has quickly passed into specialists' field. There has been full interchange of technical information

Specify C-D MICABOND



The power that drives a Diesel Locomotive is Electricity! Electricity generated by huge Diesel Driven Generators . . . generators that depend on C-D MICABOND insulation to stand the high heat and vibration of continuous operation. The small armature illustrated separately is used in your automobile generator . . . it too must give long-dependable service . . . furthermore it must also be economical to produce so it is built on a fast moving assembly line. Accuracy in dimensions is essential in both these uses of C-D MICABOND insulating rings and segments . . . first to insure unfailing service; secondly to facilitate fast economical assembly.

C-D MICABOND is Mica in usable forms. MICA splittings bonded together in sheets and tubes from which segments, rings and other shapes are readily and accurately fabricated. Into every shipment of C-D MICABOND goes a half century of C-D "know-how" . . . your assurance that C-D MICABOND is engineered to do the job for which it is specified.

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DILECTO—Thermosetting Laminates.

CELORON—A Molded Phenolic.

DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.

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The NON-Metallics

DIAMOND Vulcanized FIBRE

VULCOID—Resin Impregnated Vulcanized Fibre.

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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

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Bulletin GF gives Comprehensive Data on all C-D Products. Individual Catalogs are also Available.

Continental · Diamond C-D Engineered Dielectrics

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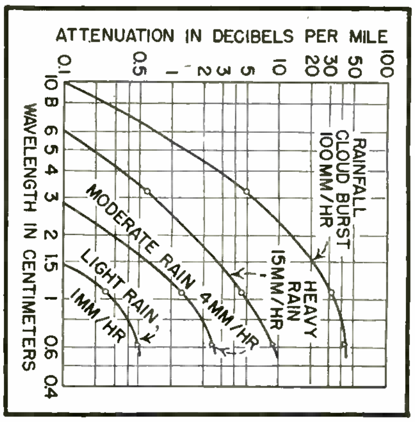
Continental-Diamond FIBRE COMPANY

Established 1895..Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE between workers both here and in England so that each has used the building blocks of the other. In designing radar, the antenna is the essential element. Used both for transmission and reception, it provides the required illumination pattern which can be specially directed into narrow, fan shaped, or other contoured beams depending upon the intended use of the system.

Angular resolution and range discrimination are limited by a volume of confusion, the cross section of which is determined by beam cross section and whose depth is determined by pulse length. To obtain a



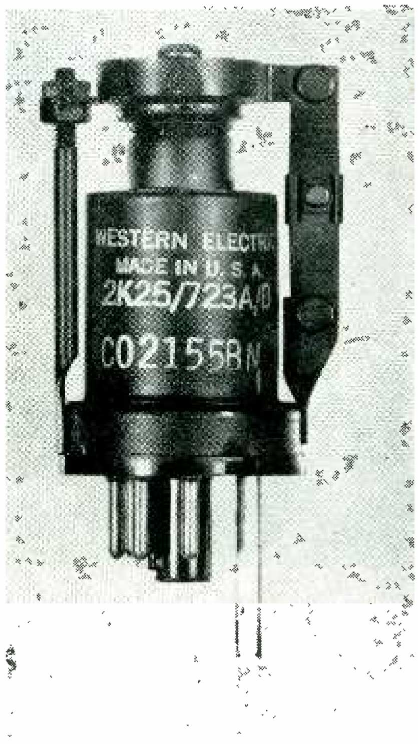
Moisture absorption of radio waves in the centimeter region is appreciable, also absorption bands from molecules (not shown) are encountered at these short wavelengths

narrow beam, high frequencies are necessary in limiting the antenna to physically realizable dimensions. Since the beginning of the war radar has advanced from one meter to one centimeter. Pulses have also become shorter. The figure of confusion has been reduced to about one fifth its earlier volume. However, as shown in the accompanying figure, moisture absorption of these short waves appears to limit the useful radio spectrum at the high frequency end. The spectrum seems to have been explored and is rapidly being conquered and settled.

Production of pulses is done commonly by electronically shorting a storage transmission line by such means as the hydrogen thyratron. The produced pulse is coupled to the r-f tube, usually a magnetron delivering megawatts of instantaneous output to the antenna. Where revolving antennas are used, discontinuities that vary with angular posi-

tion tend to pull the magnetron frequency. The impedance irregularity is increased by long transmission paths, thus careful design is required.

The receiver, protected during transmitter operation by a gas filled, TR duplexer tube, receives the reflected pulse. The first design problem is to maintain frequency tracking with the transmitter. Beating oscillators are used. In the microwave range, single cavity, reflex, velocity-modulated tubes are common. Their frequencies are



Reflex, velocity modulation, beating oscillator shown full size

stabilized by either controlling the repeller voltage or thermally tuning the cavity. Crystal detectors whose noise closely approximates their theoretical resistance over the spectrum are used as converters in preference to vacuum tubes whose noise factors increase with frequency.

Although early practice was to design the narrowest i-f band consistent with pulse width, experience has indicated that, although noise increases with bandwidth, the increased resolution of the amplified pulse and smaller grain size of the noise from wideband channels gives a clearer picture. Bandwidths up to

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The precision-built DeJur 1½" Meters are doing a man-sized job on many applications where space must be conserved.

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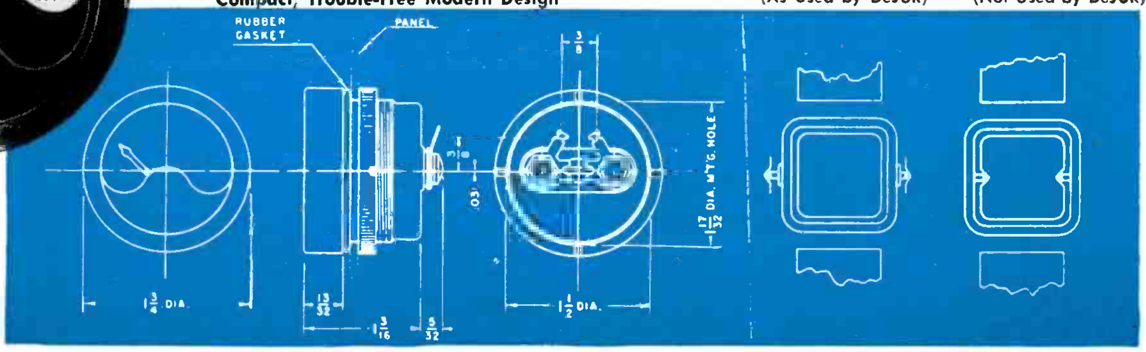

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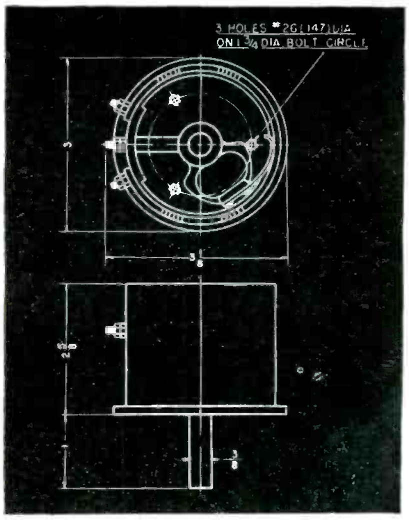

Send details of your requirements to DeJur. Our engineers will gladly advise the correct instrument to meet your needs.

in a wide line of models for many electronic and general electrical applications. They are electrically and mechanically engineered to meet the precise requirements of electrical manufacturers.

The 11 Watt Model 275 (illustrated) is typical of DeJur Potentiometers. Rugged yet light in weight, it is built to give outstanding service under the most severe operating conditions.

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DeJUR-AMSCO CORPORATION

LONG ISLAND CITY 1, N. Y.

AMMETERS . . . VOLTMETERS . . . POTENTIOMETERS ten megacycles at either 30 or 60 megacycles are used.

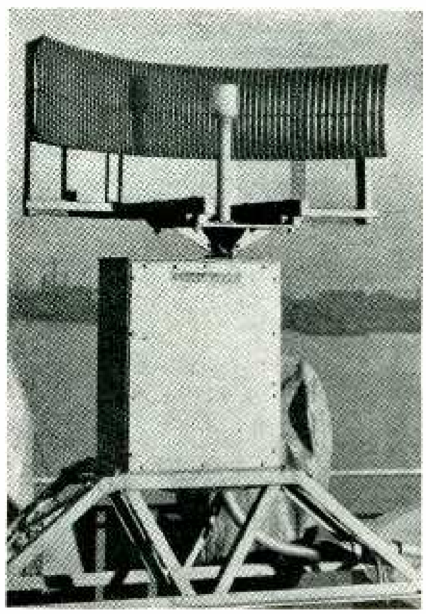
The results are displayed by methods now familiar to all. Cathode-ray focusing by permanent magnets instead of electromagnetic focusing is used, thereby reducing power supply requirements and stabilizing the focus. Techniques are much like those of television with the addition of means to expand portions of the display and to distinguish between fixed and moving objects.

In military applications for precise target location, lobe switching and conical scanning combined with servo tracking are used. Computing systems use the tracking motion to anticipate future target positions. The art has been adequately treated elsewhere.

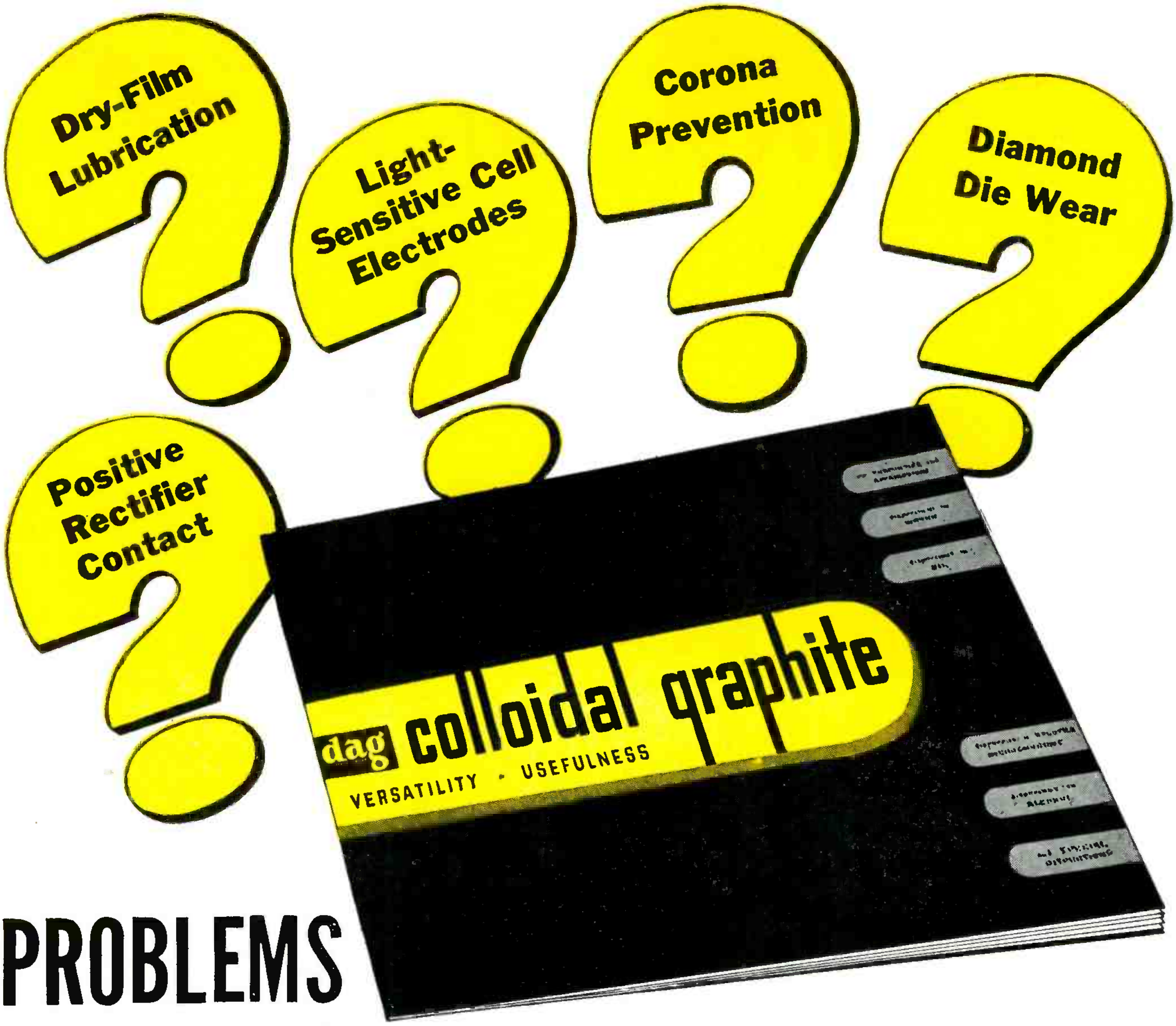
Marine Radar for Peacetime Use

By L. H. LYNN and O. H. WINN
General Electric Corp.
Schenectady, N. Y.

EXPERIMENTS ON A Great Lakes ore boat using a modified military shipborne search radar indicated the increased navigational safety and saving of shipping time especially during periods of low visibility. However, the merchantman can not economically carry the large, highly trained personnel required to operate military radar. Therefore a simpli-



Antenna pedestal houses r-f circuits and scanning mechanism of the simplified maritime radar



PROBLEMS
(MAYBE YOURS)
HAVE ANSWERS (MAYBE OURS) ...

if you know where to look!

Special problems of lubrication, parting, coating and impregnation are all about us in the electronics field. Those emphasized above are just a few—typical of the "lesser" vexations with "major" consequences.

Our first job is to *spot* such problems. Our second is to *solve* them.

To help do both, Acheson Colloids Corporation has just published a new 16-page treatise on the *versatility* and the *usefulness* of that unique material with so many unique properties—**"dag"** colloidal graphite. It gives properties and applications. It contains dozens of illustrations and columns of data. It covers dispersions in water, oil, volatile hydrocarbons, glycerine, alcohol, resins, waxes and other carriers.

Send for it. It may open your eyes—both to *problems* which are costing you money, and to their *answers*.

JMLco A-D1

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan

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

fied unit has been developed for merchant marine use.

Because of the simplicity of interpreting the indications, a plan position type indicator is used. Controls are reduced to those necessary to adjust the instrument, select range, and take bearing. Others are available only for installation and service adjustment. The equipment is housed in two units, one in the pilot house, the other at the antenna location. A motor-generator supplies power from the ship's mains.

Airborne Radar for Navigation and Obstacle Detection

By R. C. JENSEN and R. A ARNETT
General Electric Co.
Schenectady, N. Y.

PUBLICITY RECENTLY given radar by newspapers and technical magazines has caught the public imagination. Stimulated by aviation accidents, people have proposed radar for navigation and obstacle detection by aircraft. However limitations to present radar restrict its application.

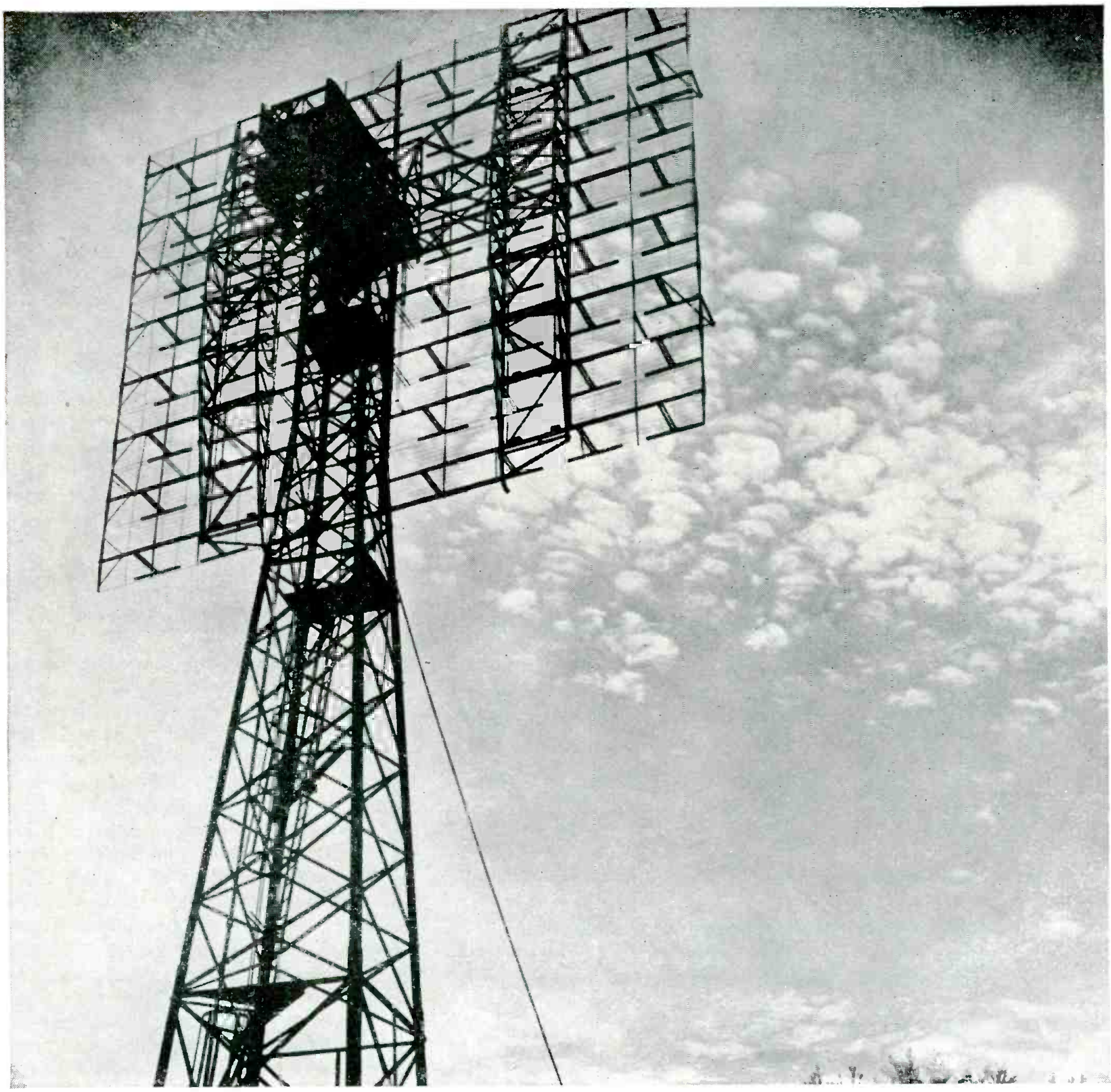
For observing the ground, as in military applications for bombing, the optimum radiation pattern is one for which the intensity reaching the ground follows the squared cosecant of the angle from the beam axis. However, the display from such a pattern fails to indicate relative heights of objects. Other beams can be used, each with its particular inadequacies.

Sharp beams are necessary to provide adequate resolution of objects. The navigational necessity of scanning a wide area with a narrow beam cannot yet be solved within the carrying capacity of the plane. Before the equivalent three dimensional resolution and range accuracy that is now possible for plan position radar can be achieved with lightweight airborne equipment, many electrical and mechanical engineering problems are to be overcome.

Shoran Precision Radar

By STUART W. SEELEY
Radio Corp. of America
New York, N. Y.

FOR NAVIGATION at short range, shoran is more accurate than loran. Used initially to guide bombers and reconnaissance planes over Europe,



TO THE MOON AND BACK ...VIA BLAW-KNOX

Because we have been a confidential advisor to the Army Signal Corps since long before World War II it was only natural that Blaw-Knox should, in a special way, participate in the sensational earth-to-moon contact . . . The 100 ft. tower, which carries this double 64 dipole antenna, is a Blaw-Knox product.

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OF BLAW-KNOX COMPANY
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VERTICAL RADIATORS
FM & TELEVISION TOWERS

Seven Blaw-Knox plants have been awarded the Army-Navy "E", and have regularly received renewal stars for continued high achievement in the production of war materiel.

shoran can provide precise navigational fixes close to the base stations. The principle of operation is that of measuring the interval between transmission of a pulse by the plane and the return of echoes from fixed reradiation stations. There is no signal coordination between stations. The fixed transmitters are triggered by the pulse radiated from the plane. By determining the roundtrip transmission interval between each of two stations, the navigator locates his position in systems of circular coordinates with the fixed stations as centers. Pulse transmitting equipment, receivers, and timing circuits are similar to those of other pulse signaling equipment.

Microwave Testing

By E. I. GREEN, H. J. FISHER and J. G. FERGUSON
Bell Telephone Labs., Inc. New York, N. Y.

TECHNIQUES AND FACILITIES developed for microwave radar testing are applicable in the r-f range from 500 to 25,000 mc, and at intermediate frequencies for communication by pulse, frequency, and amplitude modulation from both audio and video signals. In addition to checking circuit and system operation common to communication and radar, radar testing also includes measuring the accuracy of the indicated target location. Equipment of the types familiar at lower frequencies have been developed.

In the uhf range, coaxial r-f circuits are used; in the shf band, wave guides are used. Standard signal generators have high frequency stability, can be tuned over an appreciable frequency range, incorporate attenuator pads and power measuring circuits (usually calibrated in dbm, that is db from a milliwatt reference level), and f-m sweeps and pulse modulation.

Either coaxial or wave guide wavemeters are common, although a combination of the two called transition wavemeters, are also used. Coaxial resonators are such that only the coaxial mode ($TM_{0,0,n}$) can exist. Cylindrical cavities excited in their dominant mode ($TE_{1,1,n}$) to avoid spurious resonances from other modes, although for higher selectivity the circular electric mode ($TE_{0,1,n}$) can be used. For variable

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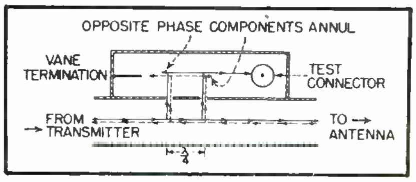
frequency cavities, the TE modes are preferred because of their zero current at the inner walls, thus simplifying design of moving contacts.

Power measurements for signal generator outputs, detecting resonance of wavemeters, and measuring transmitter output, and circuit gains and attenuations are all basically the same. Crystal rectifiers, necessitating protection from overloads and stubbing to provide d-c returns from the indicating instrument, and thermistors, platinum wires or thermocouples, placed directly in the field to be measured, are used. These latter, being sensitive to temperature, require care in use.

Standing wave ratios, indicative of impedance mismatch, can be measured in several ways. A traveling probe in the coaxial line or wave guide can directly detect the standing wave. The standing wave can be made to move past a fixed probe by changing the electrical length of a section of a wave guide by squeezing it, or the reflected energy from a mismatch can be separated from the incident energy by a hybrid T.

Another method of measuring standing wave ratio, also used to separate transmitter and receiver power within a radar antenna feeder, is the directional couple. Because of the quarter-wave spacing of the two pickup probes, energy passing in one direction cancels itself within the directional couple and energy from the other direction reinforces itself. In this way energy reflected either from a target or from an impedance discontinuity can be measured.



Directional couple for measuring energy passing in only one direction in a wave guide can be used for detecting impedance mismatches

Wideband amplifiers and high speed, linear sweeps have been developed for oscilloscopes. Accurate timing circuits, triggering circuits, and pulse generators carry accuracies to better than plus or minus two hundredths of a microsecond.

What Do You Want in a Relay?.. CLARE Will "Custom-Build" It ...Exactly

● Clare puts the designer in the driver's seat. Clare Relays permit a flexibility of plan unheard of with ordinary relays.

The secret? There isn't any. It's just that Clare "custom-building" makes it possible for you . . . with the utmost economy . . . to have a relay exactly suited to your specific requirements.

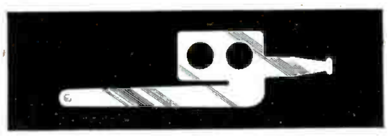
Clare doesn't design and manufacture a new relay for you from the ground up. There would be no economy for you in that. Clare "custom-building" selects the proper combination of Clare features for the job and includes them in a standard basic frame that is ideal for the requirement at hand.

Clare "custom-building" is a method of construction. It permits a wide range of contact ratings . . . five different contact forms or any combination of them . . . either flat or hemispherical contacts which may be of rare metals or special alloys . . . coil windings to match the circuit and application.

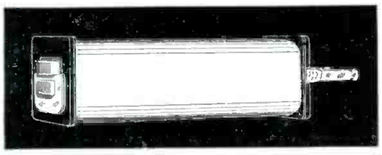
Clare Relays are built for applications where precise performance, long life and dependability are prime requisites. Thousands of users attest to the value of Clare Relays and the Clare "custom-built" principle.

To "custom-build" a relay for you Clare engineers must know all the facts surrounding the requirements. Clare has sales engineers in all principal cities to show you how Clare "Custom-Built" Multiple Contact Relays are the effective answer to modern design problems.

Send for the new Clare Engineering Data Book with its full information on the full line of Clare Relays and allied control apparatus. Address: C. P. Clare & Company, 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY.

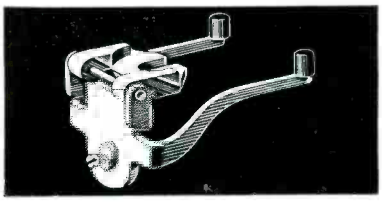


Contacts are welded to nickel silver springs by a special process. May be of precious metals or alloys in 12 different standard or special types and sizes.



Coil core of a.c. relays is of thin laminations of silicon steel, riveted together. This reduces hysteresis and eddy current losses, gives large amount of power with small heat losses.

High voltage spring pile-up insulators of special heat-treated Bakelite. Have minimum cold flow properties, low moisture absorption content. Permit punching without cracks or checks.



Double arm armature assembly with stainless steel shaft, operating in a marine brass yoke. Heelpiece, core and armature assembly of magnetic metal.

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

NEW PRODUCTS

New materials, new components, new assemblies; new measuring equipment; new technical bulletins, and new catalogs

1

Noise and Field Intensity Meter

STODDARD AIRCRAFT RADIO CO., 6644 Santa Monica Boulevard, Hollywood 38, Calif., is now releasing the Model NMA-4 noise and field intensity meter heretofore available only to the Navy.

It is useful in locating and indicating in microvolts, the amplitude of noise causing disturbance to radio reception in aircraft, and in other receiver locations; in determining the effectiveness of filtering and shielding electrical apparatus which produces radio noise at ultra-high frequencies; for indicating and recording in microvolts per meter the field intensity of a-m, f-m and television transmitters.

The r-f amplifier, mixer and oscillator circuits use butterflies which vary capacitance and inductance simultaneously, offering noiseless tuning from 100-400 mc.

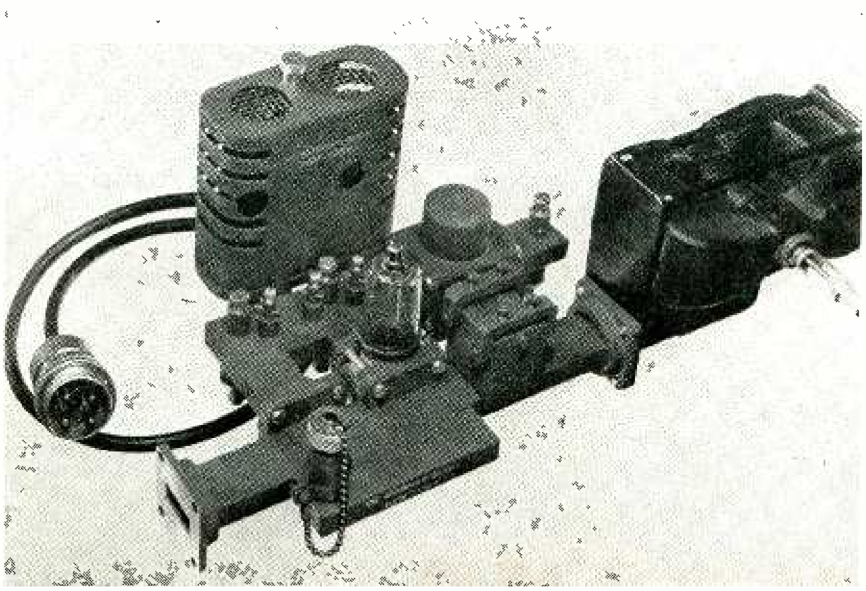
These circuits maintain a high degree of stability and nearly constant value of resonant impedance which provides for substantially uniform calibration. Stability of calibration is affected by shot noise developed in the plate circuit of the r-f amplifier.

The voltage range is 1 to 100,000 microvolts. The field intensity range is 5 to 100,000 microvolts per meter. Performance and construction specifications are in accordance with acceptable government requirements. Designed for portable or laboratory use at 105-125 v a-c, the unit is $15\frac{3}{16}$ in. high, $21\frac{1}{2}$ in. wide, $14\frac{9}{16}$ in. deep. Weight is 56 lb. Accessories are provided for various types of measurements.

2

Packaged Magnetron Oscillator for Radar

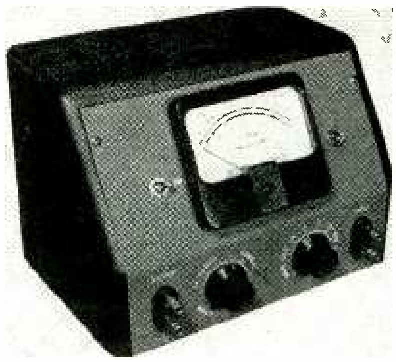
DE MORNAY BUDD, 475 Grand Concourse, New York 51, N. Y., has available in its line of microwave equipment a packaged r-f radar unit. The magnetron oscillator is capable of delivering 20 kw peak power at 9,375 mc. Two local oscillators, two t-r tubes, crystals, and a narrow-band directional coupler for measurements are included, as well as a beacon cavity and crystal mount for future beacon use.



3

Amplifier-Voltmeter

INSTRUMENT ELECTRONICS, 253-21 Northern Boulevard, Little Neck, L. I., N. Y. The Model 45 logarithmic voltmeter has an accuracy of ±2 percent over its range from 0.0005 to 500 v at frequencies from 7 cps to

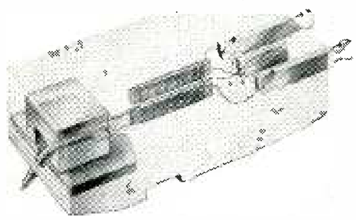


1.6 mc. It is useful in vibration studies, audio measurements and in broadcast and carrier frequency communications work. Power consumption is 30 w from a 117-v, 60-cps line. The table model is $7\frac{1}{2} \times 8\frac{3}{4} \times 10\frac{1}{2}$ in. and the price is $185.

4

Vibrating Reed Pickup

FRANK RIEBER, INC., 11916 West Pico Blvd., Los Angeles 34, Calif. The Caltron lateral reproducer is a generator operating by virtue of a vibrating reed moving in a magnetic field. Designed particularly for reproduction of commercial pressings, the pickup is housed and mounted in

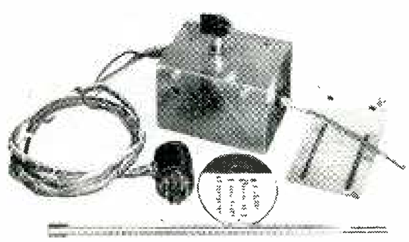


such a way as to be mechanically interchangeable with most crystal pickup cartridges. The hum-bucking coil is seen above the pickup coil in the phantom drawing.

5

Frequency Converter

THE HALLICRAFTERS CO., Chicago 16, Ill., provides a means of converting f-m broadcast receivers now tuning between 42 and 50 mc for reception



of signals on the new band, 88 to 108 mc, in the CN-1 kit. The new circuit components are mounted in a box 6 x 4 x 4 in. which weighs 7 lb. The price is $15.

6

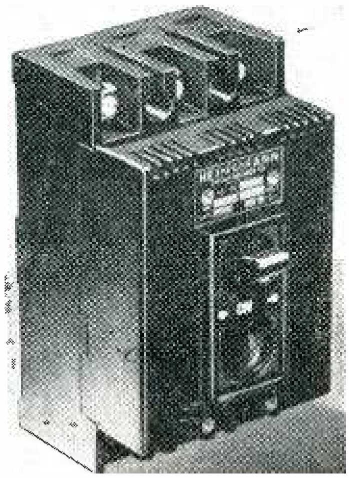
Heavy Turntable

ROBINSON RECORDING LABORATORIES, 35 South Ninth St., Philadelphia 7, Pa., is now manufacturing a new, heavy, belt-drive turntable equipped with a lever shift from 78 to 33⅓ rpm. The chassis bed plate is 20 x 24 in. and mounts in an opening 19 x 23 in. It can be supplied without pickup for $295. Console is $75 extra.

7

Circuit Breaker

HEINEMANN CIRCUIT BREAKER CO., 97 Plum St., Trenton, N. J., is now manufacturing a three-pole breaker which opens all circuits when an



overload occurs in any one leg. It is designed for 120/230 v a-c or 250 v d-c use at 50 amp maximum. Overall dimensions are $5\frac{1}{4}$x$2\frac{11}{16}$x3 in.

8

Vacuum Relay

MONITOR CONTROLLER CO., Baltimore 2, Md. is manufacturing a spst vacuum relay which operates on 35 ma at 120 v d-c and will make or break a d-c circuit carrying 2 amp at 5,000 v. The Type RC 9972 sells for $47.

9

Communications Receiver

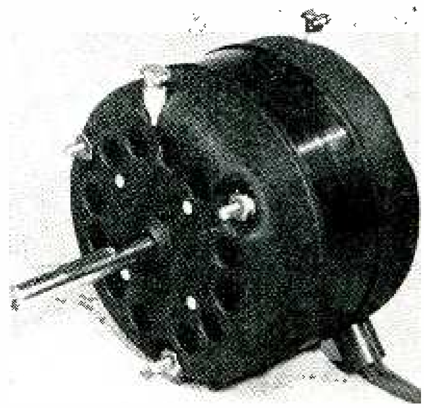
THE HAMMARLUND MFG. CO., 460 W. 34th St., New York 1, N. Y., is once again manufacturing a Super-Pro

receiver for civilian use. The new Series 400 model operates either between 0.54 and 30 mc or 1.25 and 40 mc with five amateur bands spread substantially over the dial of the latter (SP-400-SX) model. The receiver is equipped with crystal filter, avc, noise limiter, S meter, and has a built-in power supply.

10

Shaded-Pole Motor

ALLIANCE MANUFACTURING CO., Alliance, Ohio, has designed a 1/30 hp shaded-pole motor which will operate

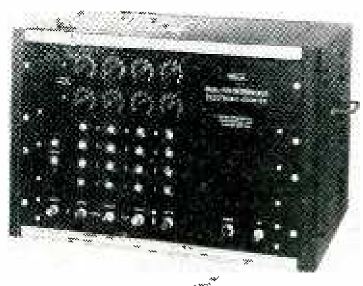


fans or do intermittent duty in other services. It has a 4½ in. outside diameter and operates at 50 or 60 cps on voltages of 220 or less.

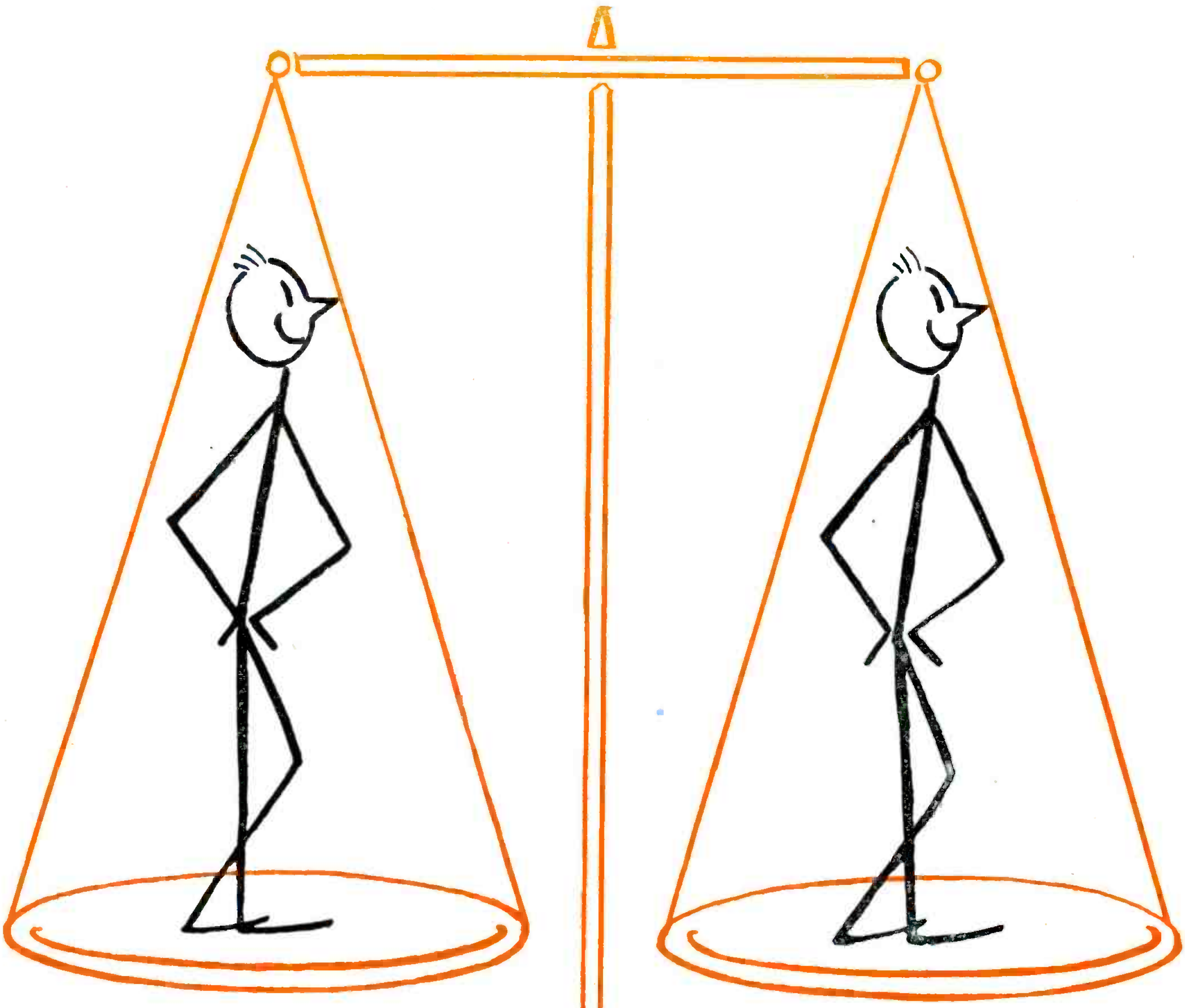
11

Industrial Counter

POTTER INSTRUMENT CO., 136-56 Roosevelt Ave., Flushing, N. Y. The dual predetermined electronic counter is proving valuable in such in-



dustrial tasks as the counting and packaging of small items. Employing four-tube counter decade circuits



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Even through the war years, when conditions were difficult, we were able to maintain the uniformity of our thin gauge papers for important military equipment. We continue this ability for you for peace time products, including capacitors, coils, transformers and other insulating purposes, requiring thin gauge papers. Our grades range in thickness from .00025″ to .004″ with extremely low tolerance limits. Specify Schweitzer for thin gauge paper.

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arranged to give two independent predetermining channels, any number from 0 to 10,000 may be set up by manipulating rotary switches. Operating power is from 110 v 60 cps lines.

12

Sound Projector

ATLAS SOUND CORP., 1449 39th St., Brooklyn 18, N. Y. The Atlas HU-15 weather-proof loudspeaker can be positioned for optimum coverage in

any direction and then locked in place. Voice coil impedance is 8 ohms, input power 12 w. Bell diameter is 8½ in. as is the overall depth. It weighs 6 lb and lists for $30.

13

Precision Resistors

RESISTANCE PRODUCTS CO., 140 South Second St., Harrisburg, Pa. have begun to market a new line of wire-wound precision resistors designed to meet the requirements of JAN specification R-93, RB10 through RB14. The non-inductive windings

are made on steatite forms, covered with an electrical varnish and baked. Tolerances are normally ±1 percent but resistors within ±0.1 percent can be furnished on order. Mounting is by means of a 6-32 machine screw through the center hole. The largest unit with a resistance of 2.75 meg is ⅞ by 2$\frac{1}{16}$ in. exclusive of lugs.

14

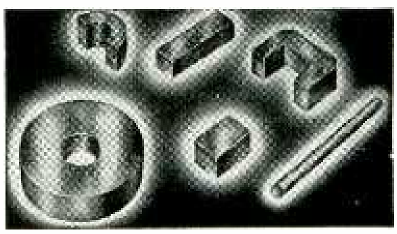
Wire Stripping

FAIRCHILD CAMERA & INSTRUMENT CORP., Jamaica, N. Y., is now licensing the use of its chemical solution for quickly and harmlessly stripping all modern types of synthetic covered wires, no matter how small. After nearly two years of use, it has been found non-toxic to the worker and in no way chemically harmful to the product.

15

Alnico II Components

STACKPOLE CARBON CO., St. Marys, Penna., announces a line of sintered



Alnico II parts and an engineering service for production of special components.

16

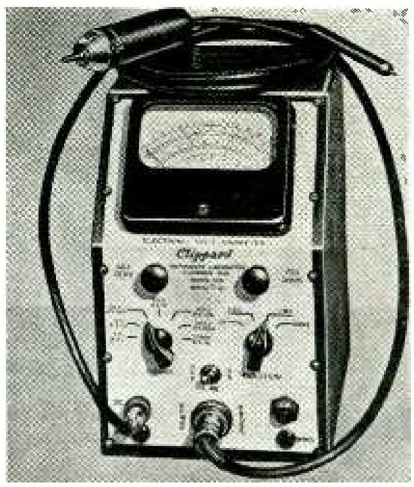
V-t Volt-Ohmmeter

CLIPPARD INSTRUMENT LABORATORY, 1440 Chase Ave., Cincinnati 23, Ohio, is now producing the Model 406 electronic volt-ohmmeter.

A-c potentials are measured by means of a small-diameter high-impedance pen-type dual-diode probe on a 36-in. detachable shielded cable. A convenient ground terminal near the end of the probe provides minimum lead length for maximum accuracy of a-c measurements in all frequency ranges.

Full-scale sensitivity of 0-1, 0-3, 0-10, 0-30, 0-100, 0-300 and 0-1,000 a-c and d-c; 0-1,000 megohms in seven ranges with ample overlap to eliminate guess work and a db scale of —20 to +51 is provided on a large square-faced D'Arsonval type meter of 200 microamp sensitivity. The instrument is housed in an oak case with folding leather carrying handle. Detachable 36-in. d-c probe, ground cable, ohms probe and fused power supply cable are also standard equipment.

Input impedance of the meter is less than 7 $\mu\mu$f, 7 megohms a-c, 28



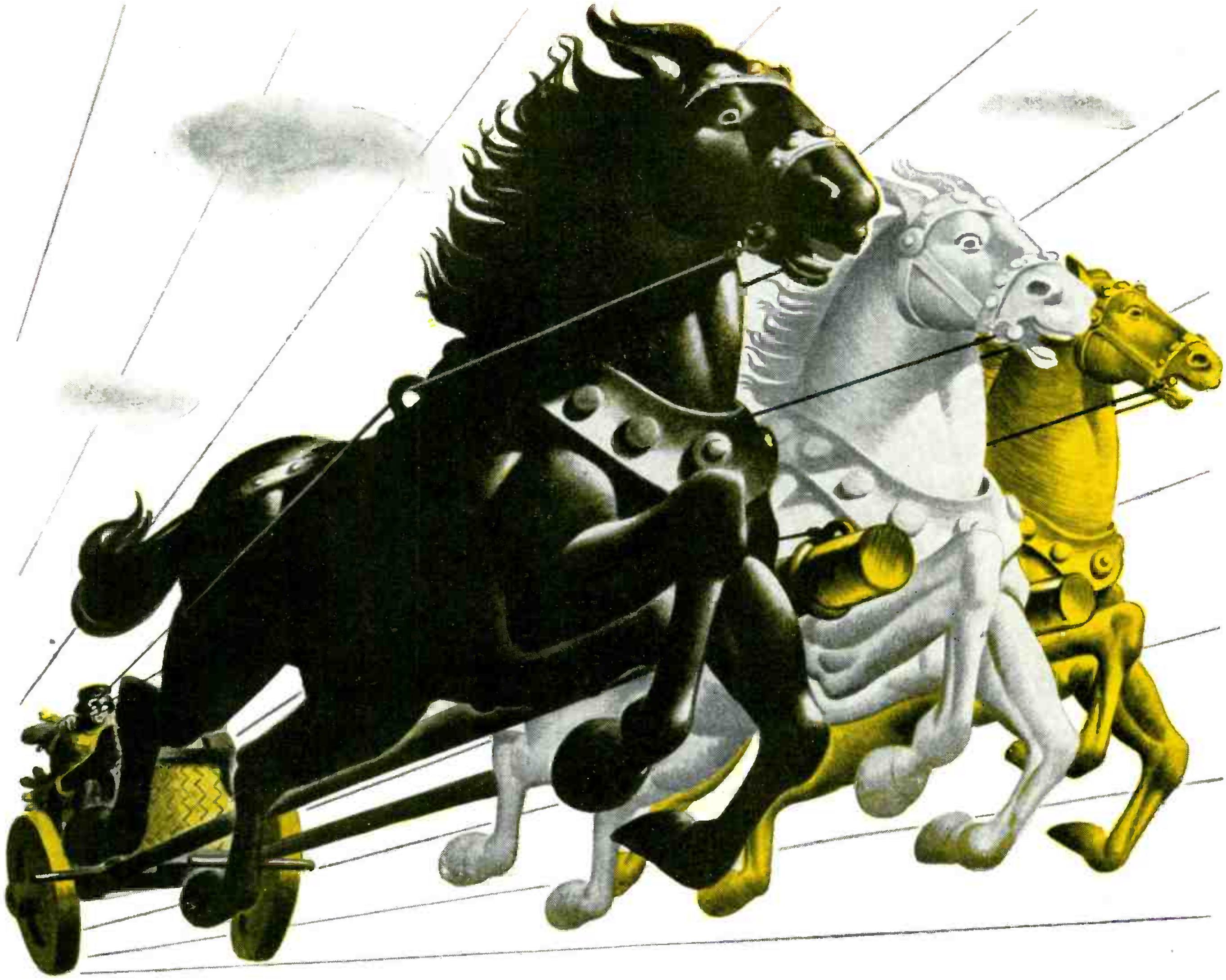
megohms d-c, assuring accuracy of readings through all ranges with minimum circuit disturbances.

Tube complement consists of one 6X5GT rectifier, and two 6SN7GT dual-purpose tubes chassis-mounted and one 6AL5 dual diode in shielded probe. The instrument is calibrated to 2 percent accuracy in all ranges with 5 percent accuracy guaranteed in the field.

17

Decade Inductors

NEW YORK TRANSFORMER CO., 62 William St., New York 5, N. Y. is manufacturing a series of inductance decades for use in bridge and low-level filter circuits. They range from the Model 211, 0.11 henry in steps



Where There is Horsepower . . .

THERE IS WIRE

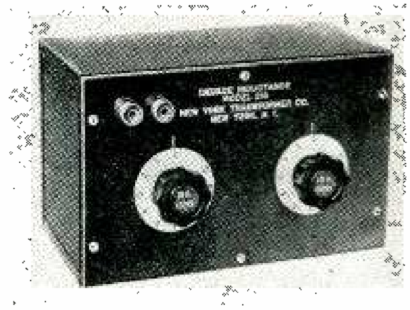
Coal . . . Water . . . Oil . . . these are our sources of power. Our early use of each of them was crude and localized and wasteful—before the time of electrical wire.

Now, wire harnesses horsepower. Wire traps it at its birth—even bringing about its generation. Wire packages power and brings it into our homes. Wire transforms power into a thousand different characters. Wire focuses—diffuses—interrupts—intensifies—splits—graduates power; transmuting one energy to many other forms: to heat—to light—to sound—or back again to whirling motion. Wire guides and controls power and makes it universally useful.

The use of horsepower is a many-sided science, now that wire is here. Each specialized application has its specialized wire counterpart. The development of these wires is in itself a scientific undertaking . . . a challenge . . . an achievement . . . a source of pride for the wiremakers among whom a pioneering leader is Belden Manufacturing Company.

Belden

WIREMAKER FOR INDUSTRY



of 0.001 h to Model 214 with a total of 110 h in steps of 1.0 h. The former has a Q of about 43 at 4,000 cps, dropping to 15 at 400 and 15,000 cps. The latter has its maximum Q at about 200 cps.

18

Ionization Lamp

AMGLO CORPORATION, 4234 N. Lincoln Ave., Chicago, Ill. produces a lamp which gives light produced by the direct ionization of inert gas when a concentrated electron stream

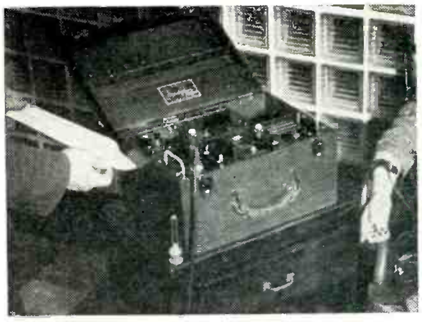
is directed through a closely wound spiral having an open end. When used as a photoflash lamp, it is said to produce a light one hundred times brighter than the sun for 1/10,000 second.

19

Electrocardiograph

ELECTRONIC CORPORATION OF AMERICA, 45 West 18th St., New York 11, N. Y. The Cardiotron makes it possible to record on paper the minutest heart action or variation. Speed of the recording tape can be varied in order to expand or compress the graph. An amplifier magnifies heart


SIMPSON ELECTRIC CO. CHICAGO, ILL.

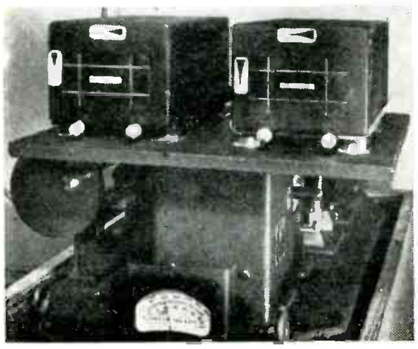


action 14,000 times. The equipment is portable, housed in a case 15¾ x 11½ x 9¼. It weighs 34 lb. Built to operate on 115 v a-c, it can be used on d-c,. if provided with a converter.

20

Shock Mount

ROBINSON AVIATION INC., Teterboro, N. J. announces a new type of antivibration mounting unit which includes a damping system, a snubbing system and electrical bonding. Three



standard sizes are available for loads varying from ½ to 45 lb. The illustration shows the effect of a vibrating test stand on two units, the one to the left mounted on conventional shear-type unit.

21

Production Heater

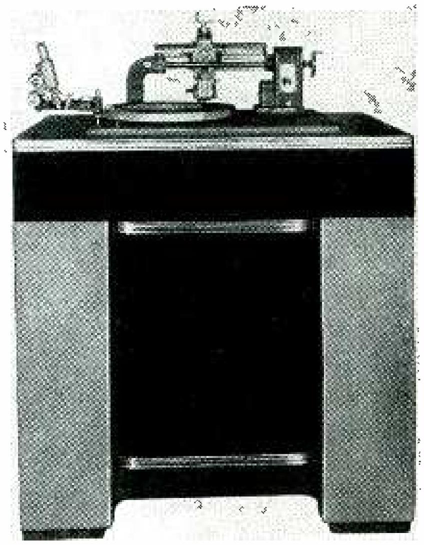
MARION ELECTRICAL INSTRUMENT Co., Manchester, N. H. The bench-type induction heater now in pro-

duction is useful for small-parts industrial soldering. Work coils for the most common types of job can be made up without involved calculations or need for retuning. The equipment is contained in a cabinet $15\frac{3}{4} \times 21\frac{1}{2} \times 15$ in. and weighs 150 lb. It operates from a 115-v 60-cps line, drawing 775 w. The price is $360.

22

Recording Turntable

PRESTO RECORDING CORP., 242 W. 55th St., New York 19, N. Y. The new 14-A turntable for commercial use is directly gear-driven at either 78.26 or 33.33 rpm. Mechanical vibration is minimized by the use of mas-



sive parts and care in damping. The motor, gear box and transmission shaft, for example, are mounted on a separate base, the whole assembly weighing 160 lb. The cutting head mounting can be used for either vertical or lateral recording at any one of five pitches.

23

R-f Voltmeter

BALLANTINE LABORATORIES, INC., Boonton, N. J. The Model 300 electronic voltmeter can be used from 30 cps to 5.5 mc with accuracies ranging between 3 and 5 percent. The voltage range is from 0.001 to 1 v in three decade ranges and is extended to 10 and 100 v by multipliers. Input impedance is equal to a resis-

the new electronics BUYERS' GUIDE

Contents were determined by questionnairing a cross-section of the many types of people who will use the Guide. They indicated the information they want, need and use, suggested important listing breakdowns and were enthusiastic about its vital usefulness. That's why we KNOW the Guide will be read . . . it's being "tailored to known needs".

Listings will provide authentic, easy-to-find buying reference. All items will be indexed with classifications broken down where necessary for complete clarification to quickly answer the question, "Who makes it and where can I buy it?" Advertisers' names and page numbers will be flagged in bold type as the source of necessary data on which to base purchases or make direct inquiry.

Advertising space used in the Buyers' Guide should come out of Catalog Budgets. It is the year-round opportunity to promote ALL your products, NOT JUST ONE. Expose them all to the buyers who will use this Guide. Purchases will be based on the data your ads contain, and *remember* advertisers' names and page numbers will be flagged to secure immediate attention. Use the Guide as your Salesman-In-Print to reach, daily, the buying readership assured this valuable engineers' data book. You can't afford to miss it!

A SEPARATE ISSUE COMING JUNE 1946

A NEW PLAN has been adapted for the 1946 Buyers' Guide. For the Subscriber; it will be an additional, bonus issue of ELECTRONICS containing news and vital information of year-round value, plus the most authentic, comprehensive listing of products ever attempted. For the Advertiser; its twelve-month usefulness assures complete readership by the largest buying audience ever assembled.

CLOSING DATES

Copy to prepare: All details must be in our New York office not later than March 15th. *Copy to set:* April 1st, no proofs April 10th. *Complete Plates:* May 1st. Rates and detailed information can be obtained from the ELECTRONICS representative in your territory, or send for the 12 page descriptive folder illustrated below.

ABC **electronics** ABP

330 West 42nd St. • Established 1930 • New York 18, N. Y.

A McGRAW-HILL PUBLICATION

tance of 1 meg shunted by a capacitance of 9 μμf. Seven tubes are used. The self-contained power supply operates on 110-120 v 50-60 cps. The meter is 5 x 6¼ x 11⅛ in and weighs 10 lb.

24

Mike Stand

UNIVERSAL MICROPHONE CO., Inglewood, Cal., is producing a new type A31 microphone desk stand with a die-cast base and wooden handle

which is demountable. The microphone is attached to a threaded brass ferrule at the top of the handle. The stand lists at $3.

25

R-F Contactors

MONITOR CONTROLLER CO., Baltimore 2, Md. The r-f contactors, Types RC 5710 through RC 5780 operate on 220 v 60 cps and carry up to 2-mc circuits with currents as high as 15 amp and voltages to 10,000. Prices run from about $42 to $59 for various contact arrangements. The Type RC

7680 transfer switch can be used at 1 mc and carries 75 amp at 15 kv. It measures 12 x 14 x 15 in. The Type RC 5980 can be used at 30 mc, carrying 30 amp and 3,500 v. It is 5 x 8 x 13½ in.

26

A-m Transmitter

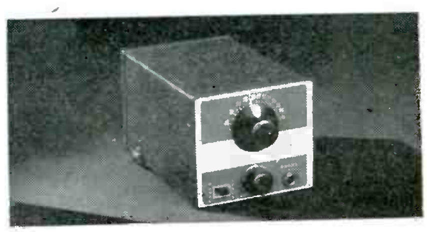
RAYTHEON MANUFACTURING CO., 60 E. 42nd St., New York 17, N. Y. The first item of broadcast equipment in a contemplated series is a 250 w a-m transmitter with a flat frequency response from 30 to 10,000 cps. Low-

power stages are tuned by a low-speed, motor-operated clutch mechanism. The final amplifier has a broad frequency response and does not require care in tuning. Air-cooled triodes are used throughout.

27

Aircraft Range Receiver

MAGUIRE INDUSTRIES, INC., 500 5th Ave., New York 18, N. Y. The first item in a line of aircraft radio equipment to be manufactured by this company is the Model ARR-1 range receiver to cover the 190-420 kc frequency band. A filter can be switched in during the reception of voice an-



G-E LAMINATED PLASTICS
FABRICATED TO YOUR SPECIFICATIONS

YOU GET ACCURATELY FINISHED PARTS MADE OF THE RIGHT MATERIAL READY FOR THE JOB

G-E Textolite sheets, tubes and rods are fabricated in an almost unlimited variety of sizes and shapes, and the General Electric Company has the necessary equipment to do this rapidly and economically—lathes, saws, shears, punches, hobs and mills . . . . even specially designed machinery to speed up and lower the cost on large production runs.

And because there are over 50 grades of G-E Textolite to select from, each having an individual combination of properties—electrical, mechanical, chemical, thermal—you get a grade that fits your needs.

Correctly machined and made of the right material for your application, you can be assured that when G-E Textolite fabricated parts reach you they will do the job.

Let us know your requirements. Write to Section S-2, General Electric Co., Plastics Divisions, One Plastics Ave., Pittsfield, Mass.

G-E Textolite tubing is shown being threaded to exacting mechanical and electrical specifications for radio coil forms.

G-E TEXTOLITE IS SUPPLIED IN THE FOLLOWING FORMS:

Sheets, Tubes, and Rods	Molded Laminated Parts
Fabricated Parts	Post-Formed Laminates
Nameplates	Translucent Laminates
Low-Pressure Molded Parts	

CD-46-E2

"everything in Plastics"

GENERAL ELECTRIC

nouncements. Operated entirely by dry batteries, the set weighs a little over $3\frac{1}{2}$ lb and measures $4\frac{1}{8} \times 4\frac{1}{2} \times 6\frac{3}{4}$ in. Without batteries or headphones it sells for $29.

28

Aircraft Radio

BENDIX RADIO, Baltimore 4, Md. The PATR-10 is a five-channel vhf transmitter combined with a range and broadcast receiver and is designed for the private flier. The transmitter section is crystal controlled,

using only 131.9 and 131.7 mc at this time. The addition of a loop antenna will allow using the receiver unit as an aural-null direction finder. Powered by a 12- or 24-volt battery, the equipment consumes 42 w. It measures 5 x 7 x 7 in. and weighs 7 lb.

29

Flash Capacitor

TOBE DEUTSCHMANN CORP., Canton, Mass. The "N-Erg-Y" capacitor has a storage capacity of 100 watt-seconds at a peak rating of 2,500 v d-c and has been designed for portable flash units. Instantaneous currents

ANSONIA BUILT A GREAT NEW FLEXIBLE CABLE FOR NAVY RADAR

For use on radar and gunfire control, the Navy needed a specialized high frequency cable. It had to feature:

(1) flexibility
(2) extreme low dielectric loss factors
(3) serviceability under extreme weather conditions.

WANTED—High Frequency Transmission Problems, for M-I-29 . . . a new flexible cable featuring extremely low loss and high conductance. For use where coaxial characteristics are required in a flexible cable.

In cooperation with Navy Engineering, Ansonia helped develop a cable answering these requirements — M-I-29—available now, to you!

To the Navy this cable represented high fidelity radar images and dependable service under severe operating conditions. To you, it may mean clearer television, truer FM radio tone or the solution of a problem in transmitting ultra high frequency power with low loss, since it approaches coaxial cable in dielectric qualities yet is completely flexible.

Insulated with ANKOSEAL thermoplastic insulation, M-I-29 can be engineered and supplied to meet special dielectric characteristics and operating conditions. "Yankee Ingenuity" displayed in the creation of this cable is ready now to help make it meet your particular needs.

This is one of a complete line of *job-engineered* cables made by Ansonia. For details on this or other cables, write Dept. AL The Ansonia Electrical Company, Ansonia, Conn.

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA CONNECTICUT

ARMY E NAVY

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

Makers of the famous Noma Lights—the greatest name in decorative lighting. Manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

as great as 1,250 amp are possible for more than 10,000 charge-discharge cycles. The steel housing measures $6\frac{1}{2}$ x $4\frac{5}{8}$ x $3\frac{3}{4}$ in. and the unit weighs $6\frac{1}{4}$ lb.

30

Hydrogen Thyratrons

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. The Type 4C35 and 5C22 hydrogen thyratrons now available for communications and industrial applications are designed to include low deionization time, rapid switching

rates, high peak currents, high plate voltages, moderate trigger requirements and operation at zero bias. The tube illustrated has the following characteristics: heater, 6.3 v, 9.6 amp; peak anode, 16 kv, 325 amp; average anode d-c current, 200 ma; bulb size, T-20; overall length, 10 in.

31

Breaker Switch

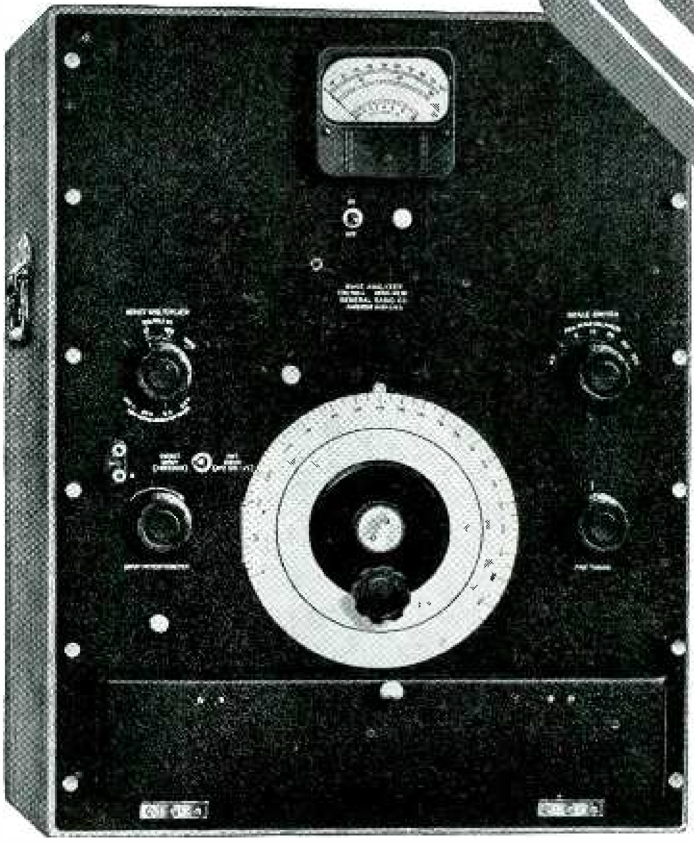
AIREON MFG. CORP., Kansas City, Kansas, has designed a series of circuit breaker switches for protection of circuits drawing 15 to 35 amp, suitable for a-c or d-c use. The units can be furnished in water-tight and explosion-resisting enclosures.

32

F-m Broadcast Transmitter

RADIO ENGINEERING LABORATORIES, INC., 35-54 Thirty-Sixth St., Long Island 1, N. Y. recently exhibited a 1 kw f-m broadcast transmitter designated the Model 518-DL. The interior of the power amplifier cham-

for Measuring Complex Waveforms



THIS analyzer offers the simplest, most accurate and most direct method of measuring the amplitude and frequency of the components of any complex electrical waveform.

It is ideally suited to hundreds of harmonic-distortion measurements on such equipment as any type of audio apparatus; broadcast receivers and transmitters; telephone and public address systems, oscillators, amplifiers and other vacuum-tube circuits; hum measurements in a-c operated communication equipment; harmonic studies of electric power systems and electric machinery; induction studies on telephone lines.

In its essentials this analyzer consists of a heterodyne-type vacuum-tube voltmeter with a highly selective filter using three quartz crystals. At only 60 cycles from resonance the attenuation is down by 75 decibels, yet tuning is very easy by virtue of the 4-cycle flat top characteristic at resonance. Standards for both voltage and frequency are built into the analyzer and can be used to check its calibration at any time.

The frequency range is 20 to 16,000 cycles and the voltage range 300 microvolts to 300 volts full scale. The instrument is completely a-c operated and has no pickup from external magnetic fields.

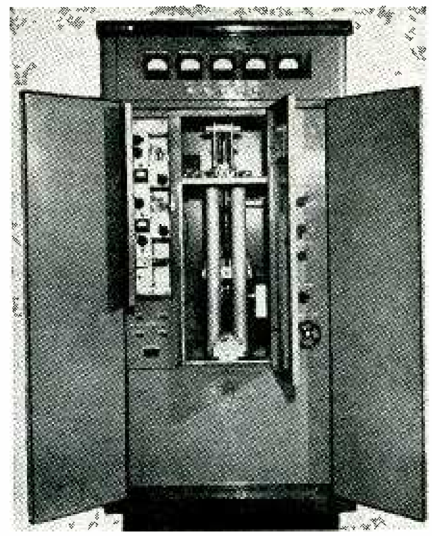
TYPE 736-A WAVE ANALYZER $640.00

WRITE FOR COMPLETE DATA

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 1000 N. Seward St., Los Angeles 38



ber is shown in the illustration. The Armstrong dual-channel modulator is at the left and the power and control section to the right. The equipment is designed for operation on the new 88-108 mc band.

33

Miniature Meters

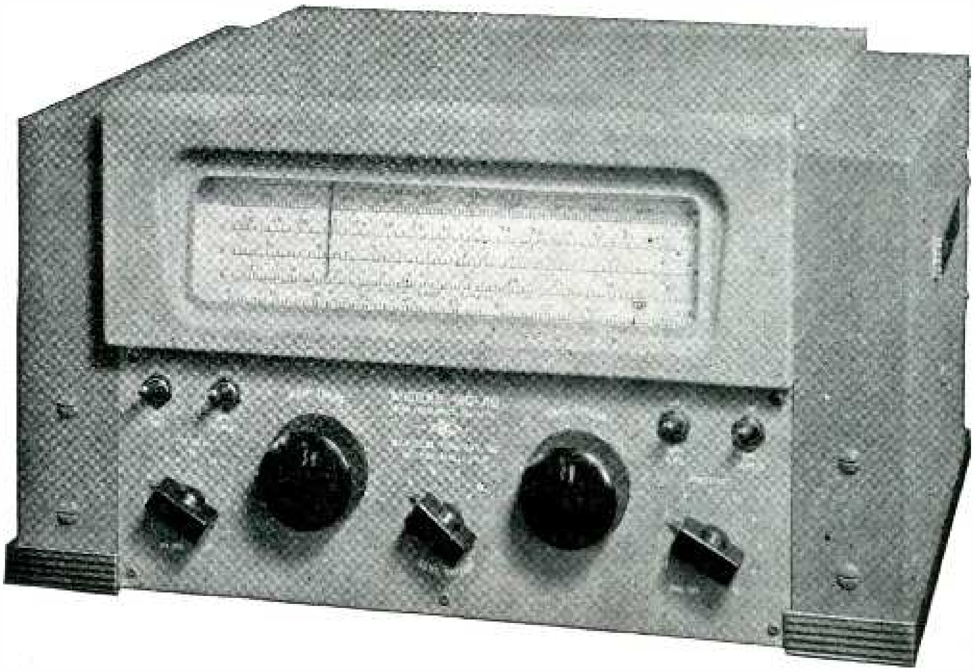
THE MB MANUFACTURING CO., INC., 331 State St., New Haven 11, Conn., has available two series of small meters; the No. 102 mounts through a 1-in. hole and the No. 152 through

a $1\frac{1}{2}$-in. opening. These meters are sealed, have an accuracy of 2 percent of full-scale deflection at any point and embody the features found in larger meters of the same general type.

34

Metal Sorter

CONTROL EQUIPMENT CO., 547 Brushton Ave., Pittsburgh 21, Pa. The apparatus used for determining the composition of various metals operates on the principle of a voltage



THE NC-46

The new National NC-46 Receiver is a fine performer at a moderate price. Ten tubes in an advanced superheterodyne circuit provide excellent sensitivity throughout the receiver's range from 550 KC to 30 MC. Circuit features include an amplified and delayed AVC, series valve noise limiter with automatic threshold control, CW oscillator and separate RF and AF gain controls. The push-pull output provides 3 watts power, and the AC-DC power supply is self-contained.

ARMY E NAVY

ARMY E NAVY

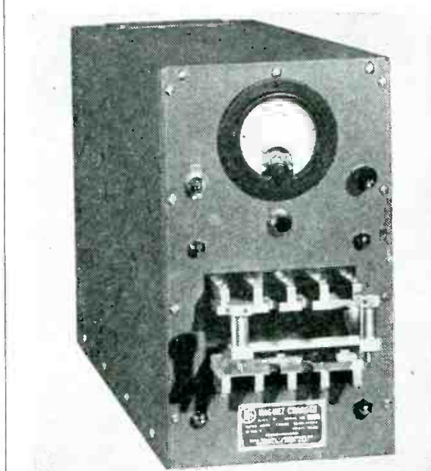
NATIONAL COMPANY, INC., MALDEN, MASS.

being generated when dissimilar metals are rubbed together. Reference standards are compared with unknowns and determinations are made at the rate of 30 a minute in production. There is no destruction of finished parts. The sorter requires less than 100 watts at 115 or 230 v, 25 to 60 cps. It weighs approximately 30 lb.

35

Magnet Charger

RADIO FREQUENCY LABORATORIES, INC., Boonton, N. J. The first commercial version of an instrument magnet charger developed during the war is now coming on the market. Useful on production lines or in repair shops, it operates by the sudden discharge of a capacitor through a



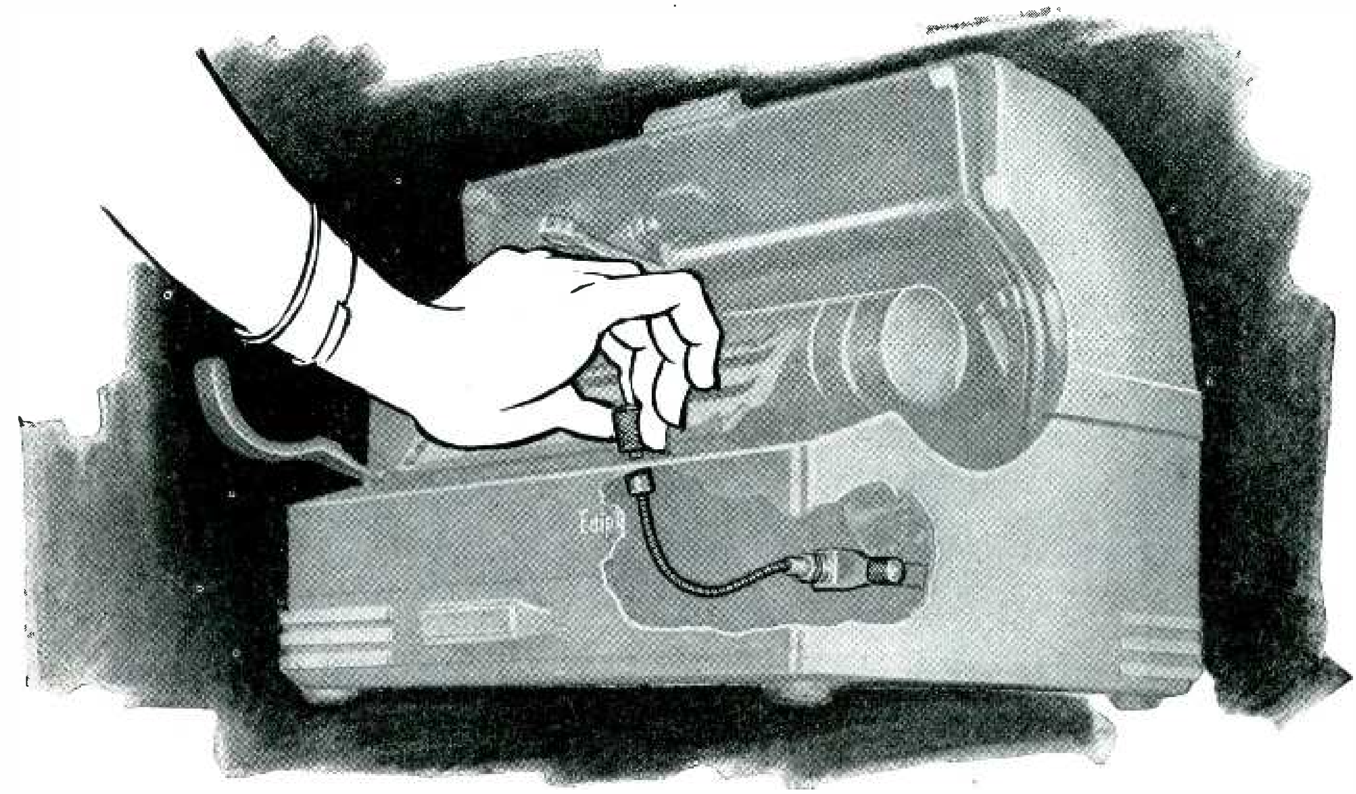
current transformer. A pushbutton control fires an ignitron-type tube to discharge the capacitor. Secondary currents exceed 15,000 peak amp. There are no exposed high-voltage terminals. The unit measures 7 x 13 x 17 in. and weighs 75 lb. It operates from 100-120 v, 50-60 cps lines, consuming 25 w. Price is $490 f.o.b.

36

Production Counter

THE AUTOTRON CO., Danville, Ill. The Shadowcount will count up to 1,000 items a minute by means of the interruption of a light beam received by a photoelectric tube. Parts drop through a chute past the light beam and need not necessarily be spaced in order to resolve the num-

FINGER TIP CONTROL



with S.S.WHITE FLEXIBLE SHAFTS

Finger tip control of cylinder speed for regulating voice pitch is provided by means of an S.S.White Remote Control flexible shaft in the Edison Miracle Secretarial Ediphone. Although the shaft makes a 90° bend in a short radius, a quick, sensitive adjustment of the flyball governor is made by the typist with a minimum effort of thumb and finger tips on the knurled knob. In the words of the chief engineer, "this application provides a smooth range of speed control with facility of adjustment equal to that of a micrometer."

Where smooth, accurate control is needed in electronic and related equipment, an S.S.White Remote Control flexible shaft is a simple, easily applied way to get it. It will pay every engineer to be familiar with the wide range and scope of S.S.White flexible shaft applications.

FREE HANDBOOK FOR ENGINEERS

Full details of S.S.White Flexible Shafts and their application are contained in the 256-page Flexible Shaft Handbook. A free copy will be sent to any engineer who writes for it on his business letterhead and indicates his position.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

ARMY E NAVY

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

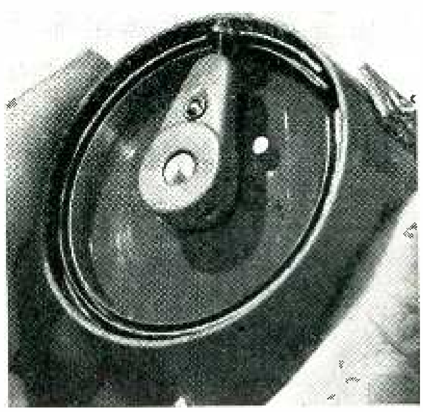
One of America's AAAA Industrial Enterprises

ber of objects. Several types and accessories are available to convert the basic counting mechanism to special tasks. The cabinet size, not including hoppers or other external feeding apparatus, is 10 x 12 x 9 in.

37

Mixer Control

CINEMA ENGINEERING Co., 1510 W. Verdugo Ave., Burbank, Calif., has designed a new mixer control which is said to reduce contact noise to a low order. It uses a wedge-shaped



roller riding on a plastic arm to make contact between the resistance wire and a metal track. Models No. 3182 and 1047 ladder-type attenuators are provided with this mechanical improvement.

38

Exposure Control

SIDWARD PRODUCTS Co., 261 Broadway, New York 7, N. Y., produces an integrating light intensity control weighing 6 lb which measures exposures from ⅕ sec to 45 min. The

They wanted a metal to pull an *Electronic Trigger*

In developing the Proximity Fuse, *Problem One* was to design a 5-tube radio transmitter and receiver small enough to fit into a shell nose. *Problem Two* was to engineer the unit to withstand physical shocks and strains never before encountered.

There was the smashing impact of the initial discharge. There was an accelerating force greater than 15,000 times gravity. There was the terrific centrifugal force imparted by barrel rifling.

Yet . . . aside from size, the tiny tubes that formed the "brains" of the fuse did not differ much from those used in home radios.

As in conventional tubes, most had elements of Nickel.

The low gas content of Nickel meant easy evacuation and no impairment of vacuum during use. *(An important feature with so little surface area available for "getter" action.)*

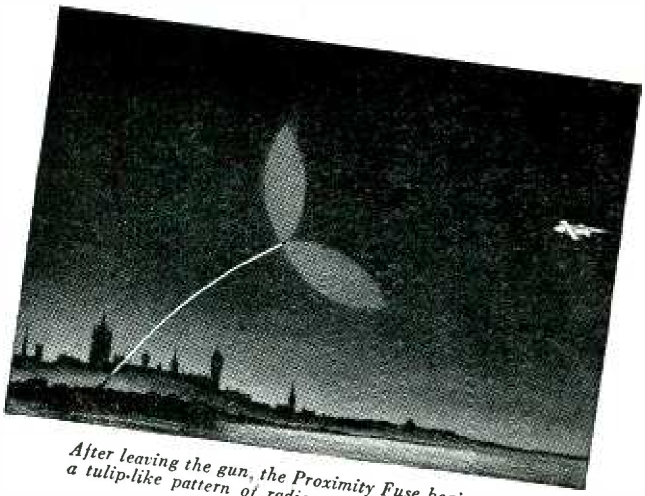
In addition, Nickel could resist deterioration in fabrication and withstand high evacuation temperatures without distortion.

Moreover, Nickel supplied all the required electronic and electrical properties.

Finally, and of very great importance, Nickel could be worked in the extremely small sizes needed.

When you have a metal selection problem, investigate Nickel and high-Nickel alloys. They are workable metals offering a hard-to-find combination of properties for electronic applications. Write for the new "Inco Nickel Alloys for Electronic Uses" which gives you the data you want on the composition and characteristics of 13 Nickel alloys to solve electronic problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



After leaving the gun, the Proximity Fuse begins to send out a tulip-like pattern of radio waves.

As target enters wave field, the waves are reflected back to the fuse where they release the electronic detonating trigger.

Photo courtesy of Sylvania Electric Products, Inc.

Here's *one of the tiny tubes for the radio in the Proximity Fuse. In most of the tubes used, all elements are made of pure Nickel. Some tubes, depending upon design, use Nickel-molybdenum alloys in addition to Nickel.*

Nickel

NICKEL INCO ALLOYS MONEL* • "K" MONEL* • "S" MONEL* • "R" MONEL* • "KR" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*

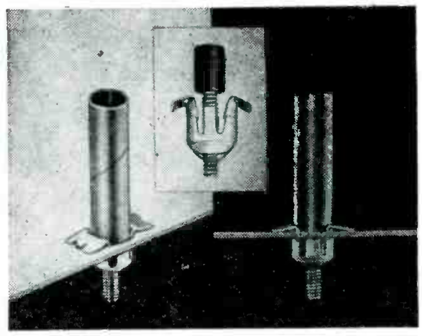
*Reg. U. S. Pat. Off.

unit can also be made to actuate a camera shutter. Twenty watts of power at 115 v 60 cps is required to operate the equipment which measures $8 \times 8 \times 8$ in. The phototube housing is $1\frac{1}{2} \times 1\frac{1}{2} \times 4$ in.

39

Coil Mounting

TINNERMAN PRODUCTS, INC., 2106 Fulton Road, Cleveland 13, Ohio, has just announced a new secure mounting for coil forms in radio chassis

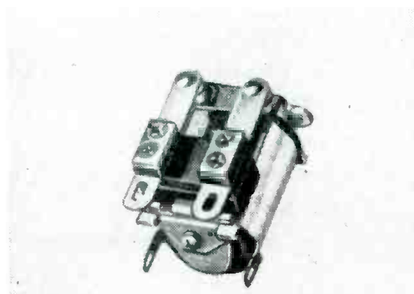


assemblies. The fasteners are available for mounting $\frac{9}{32}$ and $\frac{3}{8}$ in. forms to panels of various thicknesses. Samples are available.

40

Control Relay

ALLIED CONTROL CO., INC., 2 East End Ave., New York 21, N. Y. The type CR relay is light in weight but has contacts capable of carrying 15



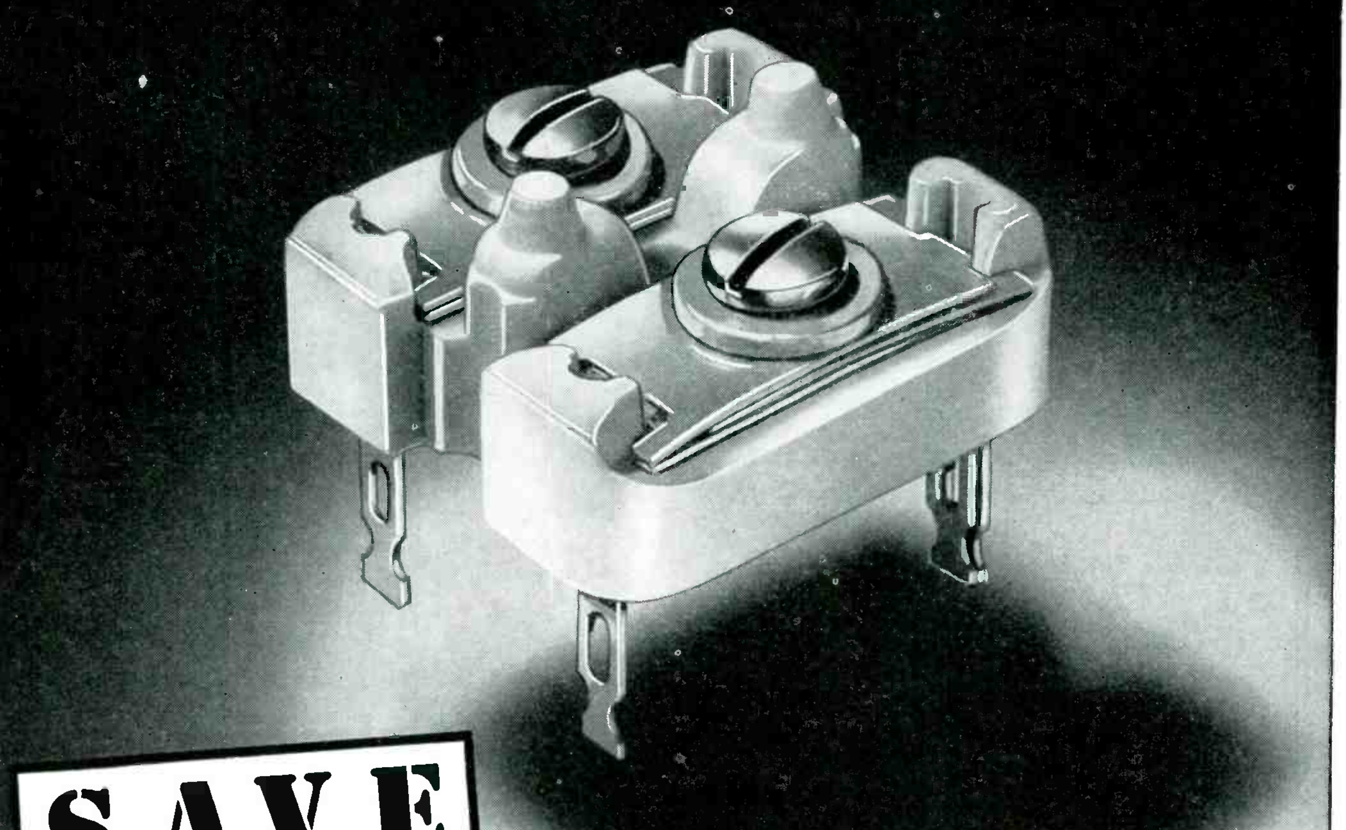
amp at 24 v d-c or 110 v a-c, non-inductive. The single-pole unit is $1\frac{33}{64} \times 1\frac{8}{32} \times 1\frac{25}{32}$ in. and weighs 3 oz. A variety of contact combinations is available.

41

Miniature Transformers

UNITED TRANSFORMER CORP., 150 Varick St., New York 13, N. Y. Now

USE STANDARD PARTS—SAVE TIME AND MONEY



SAVE

For many years
Automatic has manufactured
Coils and Trimmers for manufacturers.

Our mass-production methods
will save you money and headaches.

Order your Coils and Trimmers from
people who "know how".

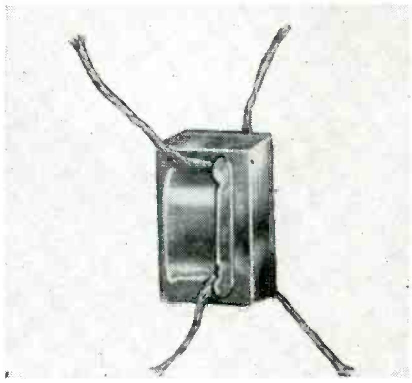
ARMY E NAVY

AUTOMATIC MANUFACTURING CORPORATION

MASS PRODUCTION COILS & MICA TRIMMER CONDENSERS

900 PASSAIC AVE. EAST NEWARK, N. J.

available is a new series of Sub-Ouncer transformers so far used only in military equipment. Coils are uniform layer-wound of Formex wire on a molded nylon bobbin. Re-

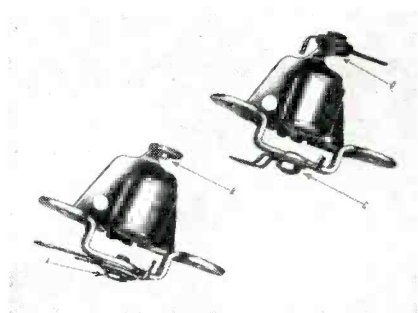


sponse of standard types is within ±3 db from 200 to 5,000 cps. The five types available immediately measure $\frac{9}{16}$ x $\frac{5}{8}$ x $\frac{7}{8}$ in. and weigh $\frac{1}{3}$ oz.

42

Jewel Bearing

Marion Electrical Instrument Co., Manchester, N. H., has developed a new jewel-bearing assembly for D'Arsonval instruments. It con-



sists of a metalized boro-silicate glass V jewel which is induction-soldered into position to replace the conventional screw setting and jewels. The new, simplified assembly is shown at the left.

43

Conductivity Cell

Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J. The type CEL-F wand-type cell can be safely immersed in a vat or tank and withdrawn after the reading is

Always Reliable—All Ways!

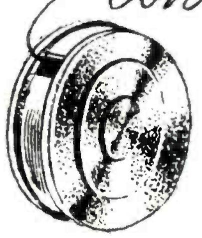
SEEBURG RECORD CHANGERS

MINIMUM FRICTION • • SILENT • CONSTANT SPEED
LONG LIFE • TROUBLE-FREE OPERATION

RELIABILITY of operation is the prime requisite of a good record changer. New and more efficient features have been added to the complete line of SEEBURG RECORD CHANGERS . . . but only after these features were given exhaustive laboratory and field tests . . . for RELIABILITY is the quality that is built into all SEEBURG RECORD CHANGERS. Years of trouble-free operation in actual use is the best proof that SEEBURG RECORD CHANGERS are Always Reliable—All Ways!

SEEBURG *Wire* RECORDER

An Electronic Engineering Achievement



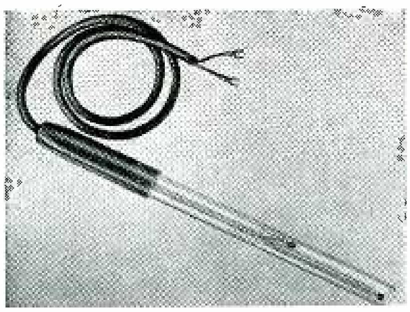
The SEEBURG WIRE RECORDER is a revolutionary new recording and reproducing instrument. The versatility of the SEEBURG WIRE RECORDER readily lends itself to practical uses in the commercial, legal and entertainment fields. One simple control knob operates the SEEBURG WIRE RECORDER to record and reproduce speeches, plays, meetings, music, radio programs, etc. There are no needles or discs used.

IT WILL BE NECESSARY... for radio manufacturers to make provisions in their circuits to accommodate the SEEBURG WIRE RECORDER. We therefore invite prompt inquiries from interested radio manufacturers.

Seeburg

DEPENDABLE MECHANISMS **1946**

J. P. SEEBURG CORP. • CHICAGO



determined from an associated conductivity bridge. It takes the form of a Pyrex wand measuring approximately 1 in. outside diameter by 20 in. long.

44

Cardioid Mike

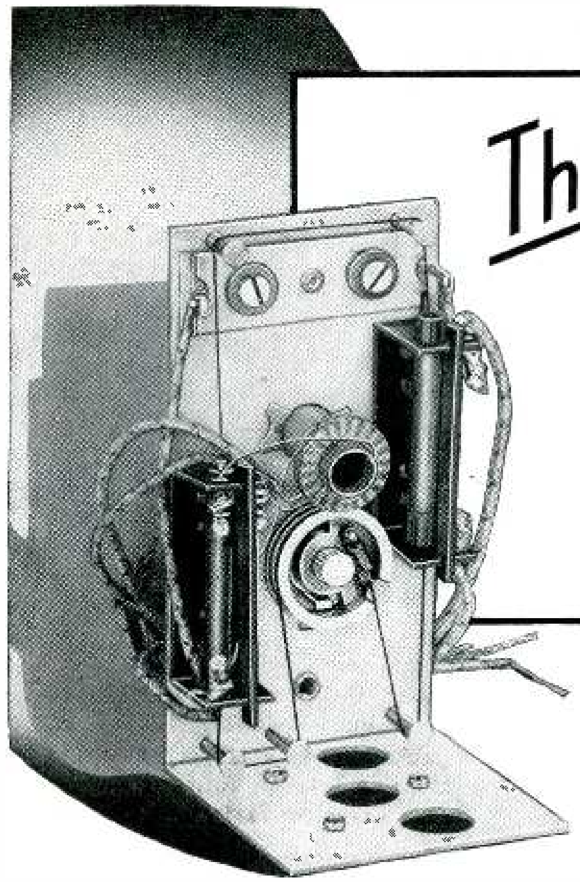
ELECTRO-VOICE, INC., 1239 South Bend Ave., South Bend 24, Ind. The Model 950 Cardax microphone has a dual frequency-response selector and an on-off switch. Its cardioid re-

sponse allows greater gain to the loudspeakers of a public address system without feedback. Equipped with a built-in connector, 5/8 in.-27 thread and 20-ft cable, the new mike lists at $37.

Literature

45

Dry Plate Rectifiers. Selenium Corp. of America, 1719 West Pico Blvd., Los Angeles 15, Calif. Catalog B presents a fairly complete sketch of selenium rectifiers from the discovery of the basic metal in 1817 up to a summary of new developments on page 34. The pages between are full of circuits, specifi-



The RADACOR TUNER

● Typical example of Micro-Ferrocart's precision-engineering is the Radacor Model T11 Tuner shown here. Sturdily constructed, simply designed, this highly efficient component was evolved to help solve your present-day problems of procurement and engineering.

● If you are interested in this newest of Micro-Ferrocart components, or if you contemplate the manufacture of any product that involves electronic or mechanical powder metallurgy, why not write to us today. The engineering skill that has created for Micro-Ferrocart its reputation for "quality in production" is at your service.

ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART PRODUCTS DIVISION

MAGUIRE INDUSTRIES, INC., 375 FAIRFIELD AVE., STAMFORD, CONN.

cations, and descriptions of uses to which cataloged items can be put.

46

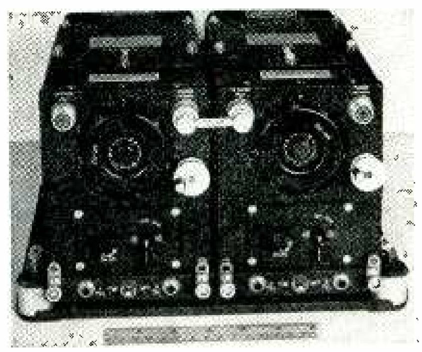
News Digest. General Electric Co., Schenectady, N. Y., publishes a quarterly News Digest reporting activities and developments in the company; not a technical publication.

47

Nickel. International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. List A contains an index of current papers on the uses and properties of metals, including one of interest to the ceramic industry.

48

Components. Aircraft Radio Corporation, Boonton, N. J. In addition to preliminary data on microwave components and aircraft communications equipment, bulletins are available covering fasteners, multi-con-



tact plugs and receptacles, switches, d-c relays, sealed capacitors, chokes and transformers and variable air capacitors suitable for transmitting or receiving equipment.

49

Direction Finders. Sperry Gyroscope Co., Inc., Great Neck, N. Y. Publication 15-43 describes an aircraft radio direction finder, listing specifications and tests taken by CAA approved methods.

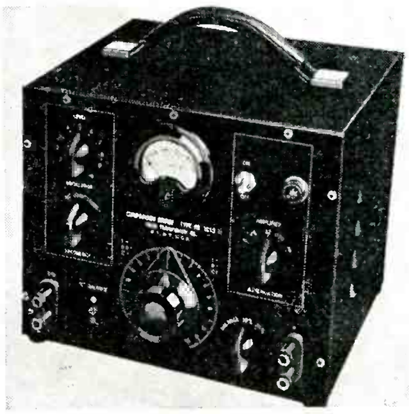
50

Nomographs. Federal Telephone and Radio Corp., Newark 1, N. J. A folder containing technical data in the form of single sheets will be found useful to engineers interested in determining such information as

the attenuation in square wave guides, power dissipated in water-cooled devices, and paint requirements for various shaped pieces.

51

Limit Bridge. Freed Transformer Co., 72 Spring St., New York 12, N. Y., has a brochure available for the



new No. 1010 comparison and limit bridge useful in production testing of components. The instrument sells for $150.

52

Temperature Control. H-B Instrument Co., 2519 N. Broad St., Philadelphia 32, Pa. Catalog No. 14 contains 16 pages of illustrations and details of temperature control for ovens, heating baths and refrigerants.

53

Ceramic Capacitors. Electrical Reactance Corp., Franklinvile, N. Y., has just published a bulletin to describe, according to JAN specifications, its line of type CN capacitors with parallel leads.

54

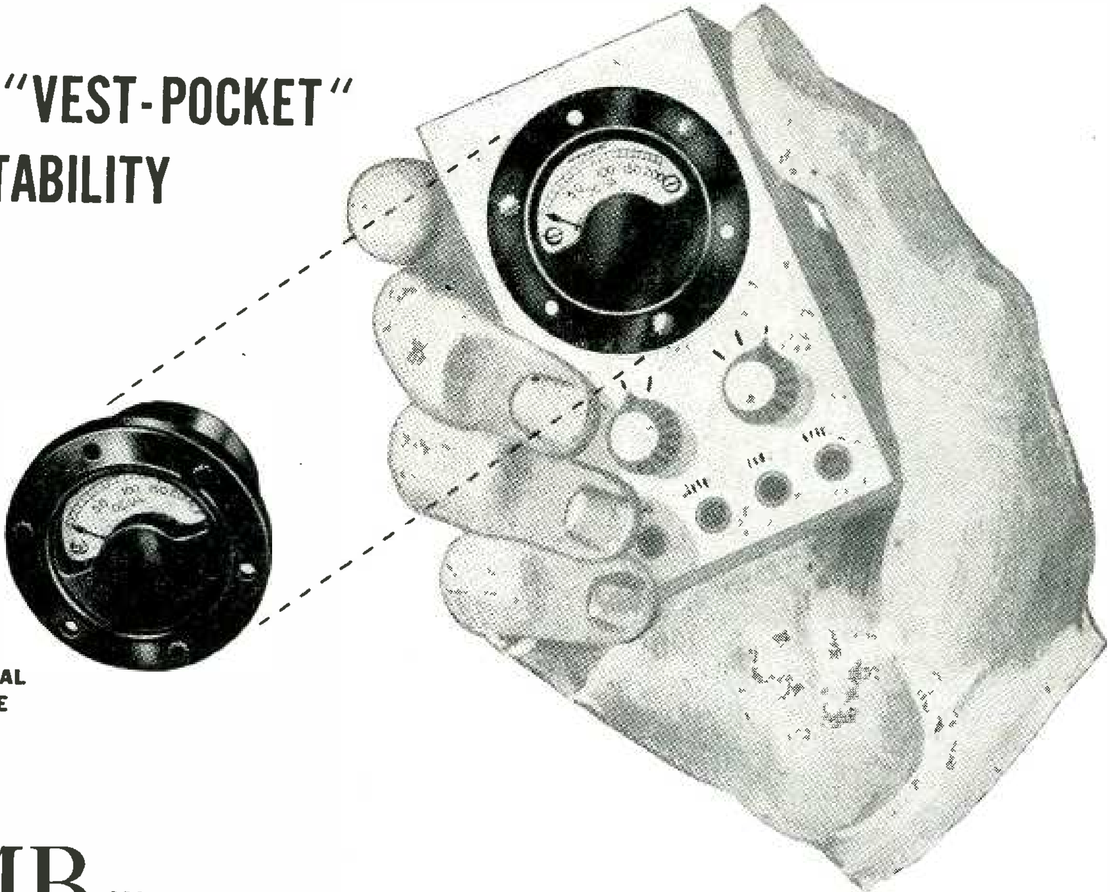
Marine Electronic Equipment. General Electric Co., Schenectady 5, N. Y., will send a non-technical 16-page buletin about electronic aids to navigation to anyone interested in depth finders, direction finders or radar-type lookout.

55

Antennas. Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y., has published its 1946

MINIMUM SIZE IN METERS

..."FOR "VEST-POCKET" PORTABILITY



MB MINIATURES HAVE A 1-INCH MOUNTING DIAMETER

A *big* fact to remember, when designing portable products for compactness, is this: *MB precision meters are the smallest made today.* Their use in many testing devices adds "carrying-convenience"... an influential sales factor.

It's one good reason for putting MB miniatures to work in equipment like photographic exposure meters, electrical tachometers, and other important instruments. In the many unusual applications for which MB meters are now being specified—pocket voltmeters to test hearing aid or flashgun batteries, for example—the equipment takes no more space than a matchbox or watch.

But, in addition to unmatched size, MB instruments offer precision performance. Response is fast . . . and accurate to the ±2% AWS specification, giving reliable readings on the well-defined scales. Damping characteristics are excellent. The lightweight moving element, in anodized aluminum housing, resists damage from shock and vibration . . . assures long, dependable service life. In short, MB meters can be used in both precision industrial testers and those for consumer use with equal advantage.

Write for information on the complete line of MB 1-inch and 1½-inch meters. These models, available in both round and square shapes, are adaptable to many special purposes. An MB engineer will be glad to work out the details with you.

THE MB MANUFACTURING COMPANY, INC.
331 East Street, New Haven 11, Conn.

INSTRUMENT DIVISION

MINIATURE ELECTRICAL METERS FOR ANY PURPOSE antenna catalog including information on f-m and television, autoradio antennas and a complete line of parts.

56

Electronic Education. General Electric Co., Thompson Road Plant, Syracuse, N. Y. is distributing booklet EBR-28 which describes the role of electronics in education. A list of publications bearing on this subject is included.

57

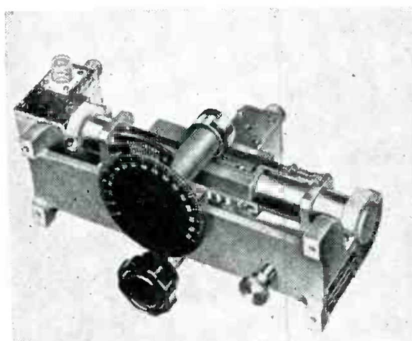
Research Organization. Polytechnic Research & Development Co., Inc., 66 Court St., Brooklyn 2, N. Y., has a brochure describing the services it intends to make available to industry in the field of applied physics. The organization is an outgrowth of P. I. B. Products, Inc.

58

Tubes. Eithel-McCullough, Inc., San Bruno, Cal. has available a nontechnical booklet picturing its line of tubes, vacuum pumps and vacuum capacitors together with a price list.

59

Microwave Apparatus. Sperry Gyroscope Co., Inc., Great Neck, N. Y. A new catalog in three parts pictures some of the latest equipment available for civilian use in the



microwave region of the radio spectrum. Microwave measurements, klystrons and wave-guide components are included. The Model 127 30-mc variable attenuator is illustrated.

60

Tube Characteristics. Sylvania Electric Products Inc., Emporium, Pa. Characteristics of radio tubes,

FOR TROUBLE-FREE WIRE PERFORMANCE

125 Permanently Insulated ROCKBESTOS Wires, Cables and Cords

From the three basic designs illustrated Rockbestos has developed a complete line of 125 failure resisting wires, cables and cords, a few of which are described. All have the same performance guaranteeing characteristics detailed below. Write for information, samples.

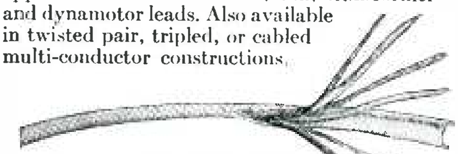
Rockbestos Permanent Insulation Insures Long-Lived Service

1. A tough impregnated asbestos braid, resistant to heat, flame, moisture, oil, grease, alkalies and corrosive fumes.
2. Felted asbestos insulation impregnated with heat, flame and moisture resistant compounds will not dry out with age, burn, or bake brittle under high temperatures.
3. Lubricated varnished cambric for high dielectric strength and added moisture resistance — protected from heat, flame and oxidation by felted asbestos walls.
4. Impregnated asbestos insulation that withstands heat of overloads and aging and won't become brittle, crack, rot or burn.
5. Conductors are perfectly centered in helically applied non-flowing insulation and will always remain so.

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

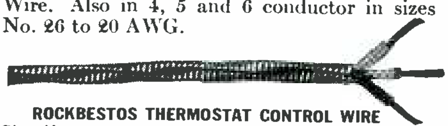
Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt insulated with high dielectric synthetic tape, impregnated felted asbestos and covered with color coded lacquered glass braid.

Originally designed to meet the demand of airborne radio equipment manufacturers for a flame and heat resistant wire and widely used since in ground, marine and mobile communications systems, electronic devices and apparatus. Operating temperature range 125° C. to minus 50° C. Ideal for wiring harnesses in compact apparatus and small motor, coil, transformer and dynamotor leads. Also available in twisted pair, tripled, or cabled multi-conductor constructions.



ROCKBESTOS FIREWALL MULTI-CONDUCTOR INSTRUMENT CABLE

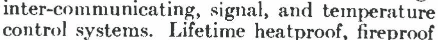
This unusually small, light weight, high-dielectric No. 26 AWG three conductor cable, with individuals insulated like our hookup wire, was designed for use where space is at a premium and dependable performance is essential. Made to a nominal diameter of .125″ it is smaller than a No. 14 AWG Hookup Wire. Also in 4, 5 and 6 conductor in sizes No. 26 to 20 AWG.



ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125″, or .025″ or (for 115 volt service) .031″ of impregnated felted asbestos insulation and steel armor.

A multi-conductor control wire for low voltage inter-communicating, signal, and temperature control systems. Lifetime heatproof, fireproof insulation and rugged steel armor give trouble-proof circuits.



ROCKBESTOS A.V.C. 600 VOLT SWITCHBOARD WIRE

(National Electrical Code, Type AVB)

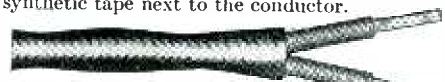
Sizes No. 18 to No. 4/0 AWG with varnished cambric and impregnated asbestos insulation and gray, black, white or colored flameproof braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A.V.C. Hinge Cable and Switchboard Bus Cable have same fireproof and heatproof characteristics.

ROCKBESTOS ALL-ASBESTOS LEAD WIRE

Sizes No. 8 to 30 AWG solid or stranded copper, monel or nickel conductors insulated with .031″ or .040″ of impregnated felted asbestos in black, white or colors.

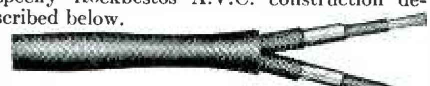
Resistant to heat, flame, oil and grease this wire won't dry out, crack, flow, swell or rot. For higher dielectric strength and moisture resistance specify Type CA Lead Wire with synthetic tape next to the conductor.



ROCKBESTOS ALL-ASBESTOS 600 VOLT FLEXIBLE CORD

Sizes No. 10 to 18 AWG with two or three conductors insulated with impregnated felted asbestos and covered with asbestos braid.

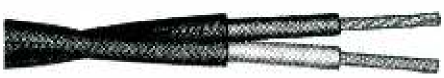
This heavy duty heat-resisting flexible cord is ideal for leads on instruments and apparatus that develop heat in operation or may be used in hot locations. For moisture resistant type specify Rockbestos A.V.C. construction described below.



ROCKBESTOS A.V.C. 600 VOLT FLEXIBLE CORD

Sizes No. 10 to 18 AWG with two or three conductors insulated with impregnated felted asbestos, varnished cambric, felted asbestos covered with heavy impregnated asbestos braid.

For applications such as mentioned above in which heavy duty, high-dielectric, heat and moisture resistant flexible cord is required we recommend this construction with individual conductors insulated exactly like Rockbestos A.V.C. Motor Lead Cable.



ROCKBESTOS 300 VOLT HEAT RESISTING DUPLEX FLEXIBLE CORD

(Underwriters' Type AFPD)

Sizes No. 10 to 18 AWG stranded plain copper conductors insulated with impregnated felted asbestos, polarized, twisted together and covered with a cotton braid.

This heat-resisting flexible cord made of two Type AF fixture wires covered with braid is approved by the Underwriters' Laboratories for fixture wiring. Also recommended for apparatus leads where moisture resistance is not required.

SHIELDED ROCKBESTOS FIREWALL HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating and 12, 14 and 16 AWG in 3000 volt insulated with synthetic tape and impregnated felted asbestos, covered with color-coded lacquered glass braid, and shielded with a tinned copper braid.

High in dielectric strength and resistance to heat, flame, moisture, oil, grease, gasoline and cleaning fluids like unshielded Rockbestos Firewall Hookup Wire, this construction protects performance in radio equipment and communications systems. 1000 volt type also made in twisted pair, tripled and various multi-conductor constructions.

ROCKBESTOS APPARATUS HEATING CABLE

No. 19 AWG nickel-chromium resistance wire insulated with .040″ of impregnated felted asbestos and covered with 4/64″ waterproof lead sheath.

Manufacturers of devices requiring the controlled distribution of a mild heat can use this pliable cable to advantage. It can be easily bent and formed to fit in or around irregular shaped objects to put heat where you want it.

ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAD CABLE

(National Electrical Code, Type AVA)

Size 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.

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.

ROCKBESTOS ASBESTOS INSULATED MAGNET WIRE

Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and coil treatment requirements. Designed for Class B windings, the insulation is non-checking and not affected by heat or aging.

WON'T bake brittle, bloom, burn or rot— RESIST heat, moisture, oil, grease and fumes

ROCKBESTOS PRODUCTS CORP.
434 NICOLL STREET, NEW HAVEN 4, CONN.

ROCKBESTOS

The Wire with Permanent Insulation

cataloged in both numerical and alphabetical order, are given in an 18-page booklet recently published.

61

Mobile Radiophone Service. American Telephone and Telegraph Co., 195 Broadway, New York 7, N. Y., is issuing two booklets describing a proposed mobile service and one type of mobile equipment.

62

Measurement Equipment. Boonton Radio Corp., Boonton, N. J., has just issued a supplement to its Catalog C covering precision signal generators, a mica tester and a spark coil test set.

63

Mica Ceramic Insulation. Electronic Mechanics, Inc., 70 Clifton Boulevard, Clifton, N. J. Bulletin No. 104 gives suggestions for use of Mykroy insulating material in the fabrication of sockets and terminal supports.

64

Radio Teletype. Globe Wireless Ltd., Chrysler Bldg., New York 17, N. Y., has a non-technical booklet describing applications and operation of the Radiotype system.

65

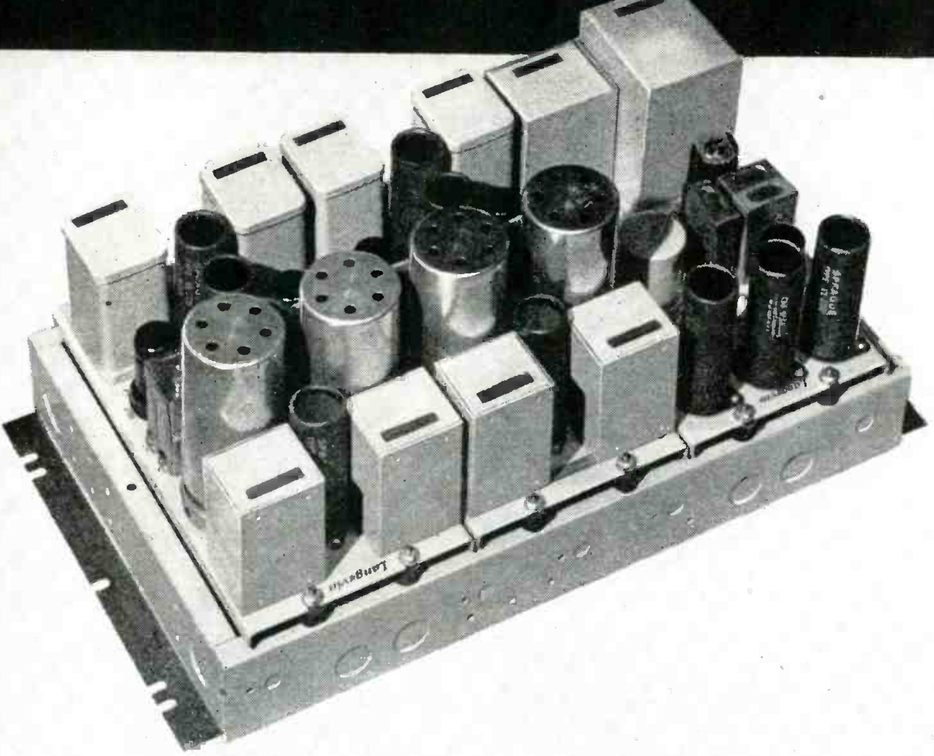
Induction Heating. Lepel High Frequency Laboratories Inc., 39 W. 60th St., New York 23, N. Y. A 31-page booklet illustrates the manifold uses of induction heating in the industrial field. Soldering, brazing and gear hardening are all possible on the same equipment with a proper choice of work coil for the individual job.

66

Small Switches. Mu-Switch Corp., Inc., Canton, Mass. has evolved an interesting catalog with split pages making it easy to refer to the various switch types and at the same time thumb through a secondary cataloging of their characteristics. There are more than 19 pages of photographs, specifications and prices.

STUDIO AMPLIFIERS

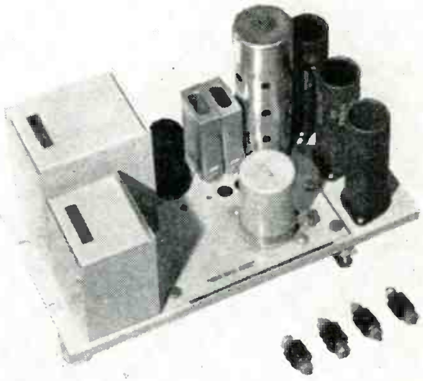
Engineered for High Quality Performance and Dependable Service



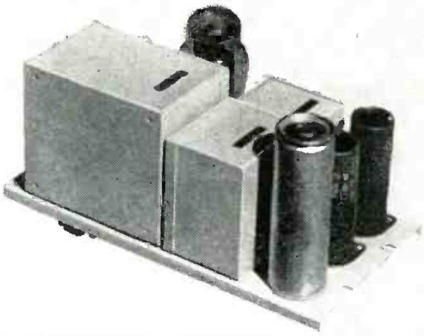
AT LEFT: Two Langevin Type 111-A Dual Pre-Amplifiers and one Langevin Type 102-A Amplifier on a Type 3-A Mounting Frame. This unit provides four pre-amplifiers and one line amplifier, or three pre-amplifiers, one booster amplifier and one line amplifier, all occupying 10½ in. of rack mounting space. An external power supply, the Langevin 201-B Rectifier, as shown below, is required. The Type 3-A Mounting Frame can be housed in a Type 201-A Cabinet, for wall mounting, if desired.

Langevin Audio Transmission Facilities are designed and built to have the extended frequency response, noise and distortion levels required in the F.C.C. Regulations for FM transmission.

In complying with these regulations too much emphasis cannot be placed on the quality of the transformers that are a part of the audio system. Noise, for instance, is largely associated with the input transformers—distortion, with the output transformers—and frequency response with both. Therefore, the transformers in Langevin equipment are manufactured by us—and are held to a specified tolerance—so that frequency response, noise and distortion levels of the entire system are well within requirements.



The Type 106-A Amplifier is a two-stage, fixed medium gain, low noise pre-amplifier, or booster amplifier, for use in high-quality speech input systems. The Type 106-A can be mounted on one-third of the space available on a Type 3-A Mounting Frame in combination with two Type 111-A Pre-Amplifiers, or in any similar combination.



The Type 201-B Rectifier supplies plate and filament power for the Langevin Types 102, 106, 111 and similar amplifiers from a 105-125 volt, 50-60 cycle AC source. The ripple voltage of the 201-B Rectifier is 0.04% at full power output 75MA and 0.02% at a drain of 30 milliamperes.

"Worthy of an Engineer's Careful Consideration"

The Langevin Company
INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK
37 W. 65 St., 23

SAN FRANCISCO
1050 Howard St., 3

LOS ANGELES
1000 N. Seward St., 38

NEWS OF THE INDUSTRY

Reports on German industry; CAA vhf radio; Lanac; telediffusion in Sweden; guided missile project; wireless television camera; RMA Spring Meeting

War Department Unveils 18,000-tube Robot Calculator

VIRTUAL ELIMINATION of computing time in the solution of mathematical problems is just one of the amazing achievements of the Eniac, an 18,000-tube electronic computer revealed Feb. 15 by the War Department. For problems ranging from prediction of electron paths of nuclear physics to the trajectories of guided missiles and the orbits of planets in cosmic space, this world's largest and most intricate electronic device provides on a printed sheet in a few hours, with up to six carbons, numerical tables that have heretofore required as many as 100 man-years of computed time.

The Eniac (Electronic Numerical Integrator and Computer) was designed and constructed for the Army Ordnance Department at the Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia to break a mathematical bottleneck in computing lengthy and complicated firing and bombing tables for vital ordnance equipment.

Ballistic Applications

For each angle of elevation at which an artillery piece is fired, a different trajectory has to be calculated, embracing such factors as muzzle velocities, powder temperatures, projectile weight, range, time of flight, point of fall, and atmospheric conditions. In addition, such matters as ballistic coefficient and drag function must be taken into account. It takes a skilled computer about three days to compute one such trajectory with the aid of an ordinary desk calculating machine. After the trajectories are calculated, the angles of elevation for many different ranges, using varying conditions of muzzle velocity, density of air, wind, etc. are computed. This part of the work usually takes about three months by a large staff of trained computers. The Eniac will do both sections of the job in from one to two days.

Industrial Uses

The new robot calculator will solve equally complex peacetime problems in electronics, electrical engineering, aerodynamics and scientific weather prediction. In industry, it is believed that better, more scientific design will now be possible as a result of the new machine's ability to handle hundreds of different factors in one computation. Much lengthy and costly design experimentation, often involving the construction of a series of expensive models, a common practice in airplane design, might also be eliminated. Such trial-and-error methods would not suffice to deal with complex phenomena arising, for instance, from the blast of an atomic bomb.

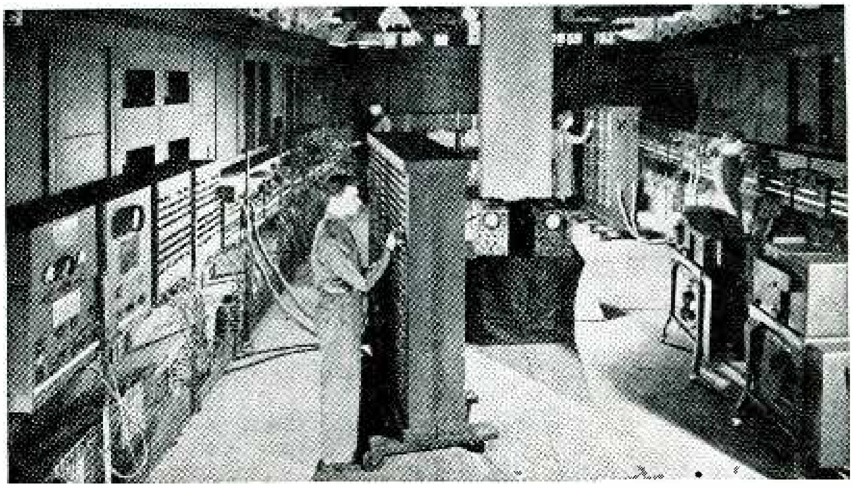
General Details

The original idea for the Eniac was that of Dr. John W. Mauchly, of the Moore School faculty. Captain Herman Goldstine, mathematician and ballistic expert for Army Ordnance, enthusiastically promoted development of the Eniac.

Administrative supervision of the project was assumed by Dr. J. G. Brainerd of the Moore School, and J. Presper Eckert, Jr. took charge of the technical and engineering activities.

The Eniac is a digital or discrete variable computing machine, as opposed to continuous variable types such as differential analyzers. If used to complete capacity, the Eniac will carry out in five minutes more than ten million additions or subtractions of ten-figure numbers. The machine performs a single addition in 1/5000th of a second and can do a number of distinct additions simultaneously.

The Eniac occupies a room 30 by 50 feet in size, weighs 30 tons, and has 100 feet of panels arranged in a large U, with 16 of the panels on each leg and 8 panels on the end. Power consumption is 150 kw, of which 45 kw goes to a bank of 28 power supplies that provides the 88 d-c voltages required.



Setting up the Eniac for a problem takes far more time than is required for the machine to punch out the answers on the IBM machines at the right. Power supply panels are across the open end of the U, behind the camera used in taking this photograph

Operating Procedure

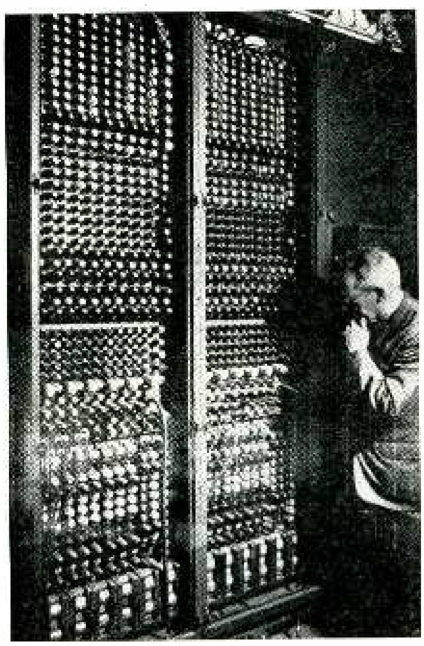
The general method of handling a problem is as follows: First, the scientist must write down mathematical equations that express the phenomena involved. Second, he must break down the mathematical formulation into a sequence of additions, subtractions, multiplications, divisions, square rootings and transfers from

unit to unit of the Eniac. Finally, program switches must be set, numbers must be put into the function table memory by setting the switches, and connections must be established between units of the Eniac for the communication of programming and numerical information.

There are three basic elements in the Eniac: arithmetic elements, memory elements and control elements. There is also magnitude discrimination, which partakes of both arithmetic and control characteristics and consists of comparing the size of two numbers. On the basis of such comparison, the machine determines which of two computational courses is to be followed.

Arithmetic Elements

The arithmetic elements include 20 accumulators, 1 multiplier and 1 combination divider and square rooter. The accumulators provide means for storing numbers computed in the course of a problem, and also permit addition or subtraction of a second number to or from the stored number. The accumulators



Rear view of two of the accumulator racks of the Eniac. In the upper portion, each vertical row of 28 tubes is mounted on a separate plug-in chassis that can be removed quickly and replaced with a spare unit in case of trouble. In the lower group, banks of 12 tubes are removable. The entire machine is constructed in this manner, and trouble can be isolated to the defective chassis simply by running a selected test problem through and comparing the result with a correct solution kept on file for this purpose

New reference guide for Capacitors

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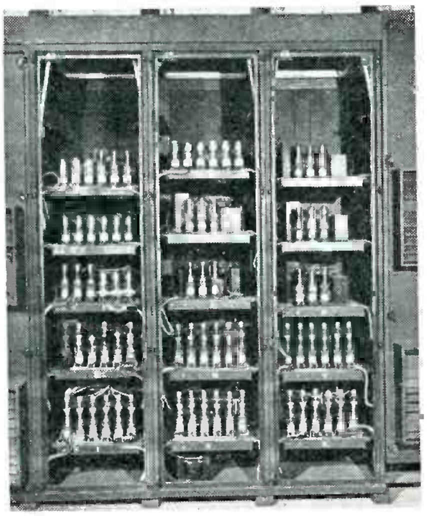
MAGNAVOX HAS SERVED THE RADIO INDUSTRY FOR OVER 35 YEARS are capable of performing these operations on numbers having as many as ten decimal digits, and indicate the associated plus or minus sign. The multiplier can find the product of two decimal numbers, each having as many as ten digits. The combination divider and square rooter can find the quotient of two nine-digit decimal numbers or the square root of a nine-digit decimal number.

Memory Elements

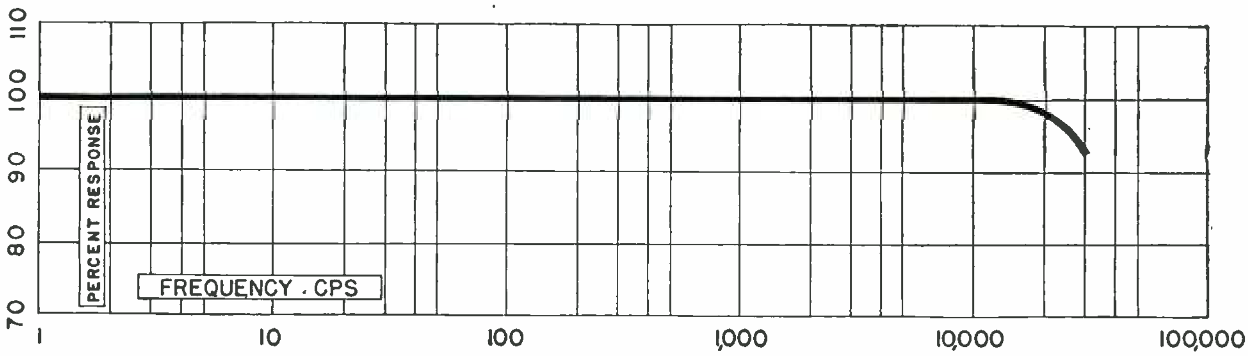
Memory elements of the machine include internal memory devices, of limited capacity, and external memory devices in the form of punched cards having unlimited capacity. Communication between the internal and external memory takes place at speeds which are set by the mechanical punch card devices.

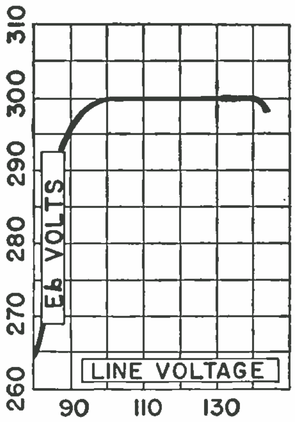
Internal memory can be further subdivided in three ways. First, there are accumulators for numerical data calculated in the course of the computation and which must be available for other portions of the

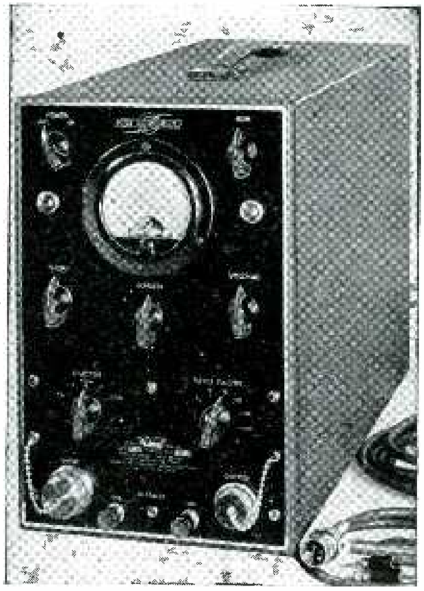


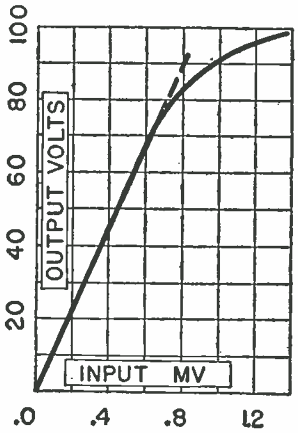
Three of the power supply panels of the Eniac. Xenon-filled 4B24, 4B25 and C6J gaseous rectifier tubes, operating with red-hot plates, provide the 88 d-c voltages required by the robot calculator

computation. Second, empirical data known before the machine is started can be remembered by setting switches on the function tables. Third, there is a memory for instructions. This causes transfer between the various memory and arithmetic units and causes the arithmetic units to perform desired operations on the numbers. Setting of program switches permits program input signals to be received in one or more units, thus causing the unit or units









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to function within themselves and, on the completion of this internal functioning, to emit program output signals to cause other units to function. The master programmer coordinates this kind of memory function for the entire machine.

Control Elements

The control elements include the initiating unit, concerned mainly with starting and stopping the Eniac, and the cycling unit which generates the fundamental signals. The cycling unit contains an oscillator which generates electrical pulses at the rate of 100,000 per second and can do one basic operation every 20th pulse or a total of 5,000 additions, subtractions, multiplications or divisions per second.

When all controls have been set and cards have been punched for the external memory section, the cards are dropped into the IBM reader section and a starting button is pressed. If the machine is operated at full speed, the numbered neon lights on the panels blink 5,000 times per second and the entire panel appears to give one quick glow before the lights settle down at the final answer. Generally, however, the machine must be slowed down to the rate at which answer cards can be punched mechanically. The punched cards are then run through an IBM machine that prints the answers automatically on a sheet of paper.

Though a calculator can carry out numerous logical operations, it cannot do creative thinking. The mathematician, physicist or engineer is still needed—in fact, more than ever, to analyze the problem mathematically and set up the sequence of operations in the machine. It is expected, however, that machines of this type will bring a greater mathematics consciousness to engineering and production.

Army Seeks Technicians

To CIVILIANS skilled in the maintenance and repair of radio, radar, telephone, and electric power equipment, and willing to replace enlisted technicians now stationed in the Philippines, Japan, and Korea, the Signal Corps is offering attractive jobs. The appointments, for a minimum of one year with transportation furnished both ways, carry salaries

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German Technical Data

WEEKLY BIBLIOGRAPHIES of both technical and nontechnical reports on scientific and industrial information, mostly obtained in Germany and German-occupied countries, are being made available at the Government Printing Office for a nominal price. The lists also will contain titles of reports on U. S. Government-sponsored research (ORSD, Army and Navy), although only a comparatively few have been released to date.

The reports listed in the weekly bibliographies are grouped according to subject matter, serial number, price and length, with a brief description of report content. Materials, manufacturing processes, products, developmental work, and other scientific and technical matters are discussed in the reports.

Approximately 2,000 reports have been listed previously by the Office of the Publication Board, Department of Commerce. This same listing will be duplicated by the Government Printing Office in its weekly bibliographies until such time as the listing reaches the same point as OPB's lists. Then OPB will devote its full time to checking the various reports, having them photostated or microfilmed and sent to various government repositories in Washington. Complete reports should be ordered from OPB.

The Superintendent of Documents will accept $10.00 as approximate payment for a yearly subscription to the weekly bibliographies and will notify subscribers if additional remittance is required. Single copies may be purchased at varying prices. The first bibliography is priced at 15¢. Orders for these weekly lists should be accompanied by check, CML

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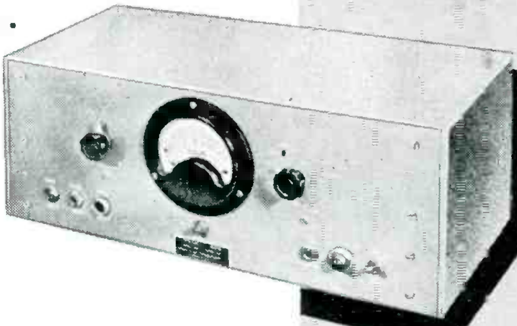

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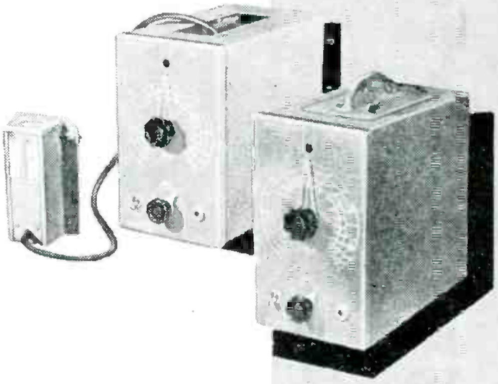

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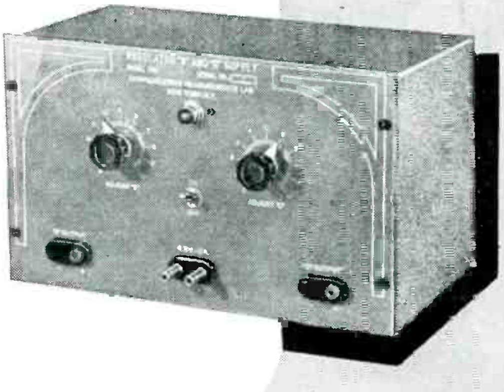

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Among the mimeographed reports on electronic subjects that can now be ordered from Office of the Publication Board, Department of Commerce, Washington, D. C., are the following:

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CAA Promises Gradual Change to VHF Facilities

THE CHANGE FROM low frequency to very high frequency radio for aircraft communications and signals will be gradual, all existing equipment will continue in use and retain its value, and there will be an interim period in which both vhf and low-frequency equipment will be in use, according to T. P. Wright, Administrator of Civil Aeronautics. Eventually, after a matter of several years, all communications along the airways and all signals for radio navigation will be in the vhf bands, which will be better in all respects than that in use today. In particular, they will be beyond the static belt.

Today, the private flier transmits to CAA ground stations on 3,105 kc and listens to traffic control towers on 278 kc. This equipment represents thousands of dollars investment, and will not be disturbed. The CAA will continue to operate these services on these frequencies. In addition, the existing low-frequency ranges will be available for use by the private flier, since his receiver covers the 200-400 kc band.

Anticipating the crowding of radio

channels by the 400,000 to 500,000 airplanes predicted within the next 10 years, the CAA has made plans for eventual and complete change to vhf equipment. Already, transmitters are installed on the ground which can be used by planes fitted with vhf equipment. This equipment gives better results, and also relieves the 3,105-kc band which, in congested areas, is already crowded.

Radio manufacturers plan to build a five-channel transmitter covering the 131-mc band. Originally, only two frequencies will be covered in this transmitter, 131.9 kc for communication from plane to traffic tower, and 131.7 kc from plane to airways station. Later, as these channels become crowded, three other channels can be made operative by the simple addition to the transmitter of one crystal for each one.

On the ground, vhf transmitters for talking to planes will be in the 118-mc band. Transmitters already are installed at CAA towers, and are being used to communicate with planes in congested areas in order to relieve the low-frequency tower channels. At CAA airway stations, there will be transmitters on 111.1 mc.

An important advantage in the use of vhf is that 90 channels are available for aviation compared to 60 at low frequency, and these channels can be repeated more often within continental United States without interference. As far as the average pilot is concerned, however, vhf will be most welcomed for its freedom from static, a fault of the low-frequency transmission that makes it uncomfortable, uncertain, and sometimes dangerous.

New Range Beacons

The whole airway range system of the country is to be converted to vhf. The two-course aural and visual vhf range has been developed to the point where it is now installed on certain airways in the country, and plans have been completed for putting it in on all airways.

Engineers found that conversion of the aural-visual range to the omni-directional range employed the same equipment and was relatively inexpensive to do. Thus, in the middle of the vhf program, the plan has been modified to include omni-directional ranges. This type of range simplifies flying for the private flier, either on or off the airways, and still

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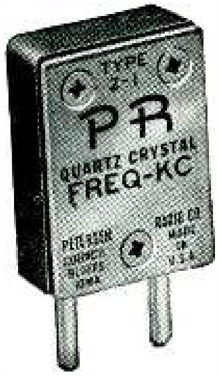

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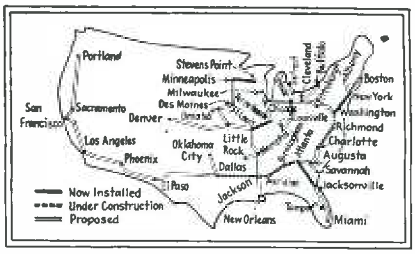
Blind Landing Systems

Instrument landing equipment is being installed by the CAA at nearly 100 airports throughout the country. This is the three-element system developed by the CAA, consisting of the localizer, glide path and marker beacon. Although the Army and Navy did remarkable things with radar in instrument landing during the war, the pilots of the airlines, the technical men of the airlines and CAA radio engineers all agree that considerable development work will be required before radar is safely applicable to commercial use.

Of the three elements of the CAA landing system, 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 of the line to define the course along the runway, has been improved by using phase comparison instead of amplitude comparison. Now the course is defined by comparing the phase of two 60-cycle signals. This change has resulted in a considerable simplification of the equipment required in the transmitter on the ground, and

COAXIAL CABLE PROGRAM



Status of AT&T coast-to-coast coaxial network. Some sections will be radio relay within the next few years. About 700 miles of coaxial toll cables were placed in 1945, and some 2,100 miles is scheduled for 1946. The recently completed New York-Washington link has already been used successfully for television programs

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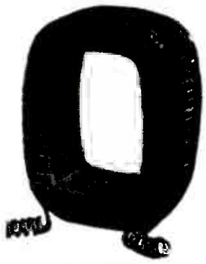
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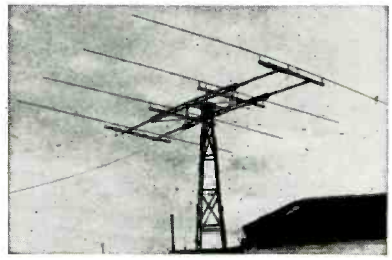

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a lightening and simplification of the airborne receiver. A straight-line glide path has been developed as an additional improvement of the landing system.

The CAA is cooperating with the Army in service testing of its automatic instrument landing system. In this, the indications of the cross-pointer instrument by which the system is flown are connected to a standard automatic pilot, and the airplane is flown to the point of contact with the ground without human hands on the controls.

Telediffusion in Sweden

By LEONARD SILK

McGraw-Hill World News
Stockholm, Sweden

A FIGHT is in progress here between supporters of telediffusion or wired wireless and technical experts favoring frequency modulation as the solution of Sweden's broadcasting difficulties. Telediffusion is being considered not because mountains make reception in valleys poor, but because of the great distances to the relatively few wireless transmitters which it has been possible to install in Sweden owing to the lack of wavelengths, and perhaps even more important, because of the severe electrical interferences in many areas here.

People living along the railroad tracks in Sweden find it impossible to use their radios at certain hours during the day, since the Swedish railroads are largely electrically-powered. Besides disturbances from high-tension power lines and contact wires for the railways, there are those from electric plants in factories, hospitals, and office buildings. Those listeners are worse off who are resident in certain districts of Värmland, Dalsland, Bohuslän, Smaland and certain communities along the railways. In almost every case, these are not mountainous areas. In the North, however, some interference is experienced from ionospheric disturbances.

According to an over-all estimate made by the Radio Bureau of the Telegraph Administration, even if existing broadcasting stations had been expanded to the fullest possible extent, about 600,000 subscribers to the broadcasting network could not get satisfactory reception. This figure is fantastically large, since the

total number of radio licensees in Sweden is 1,840,000.

Another great complaint of Swedish listeners is lack of variety in their radio diet. At present only one program is broadcast simultaneously for all of Sweden. The Broadcasting Committee's ambition is to provide three programs simultaneously.

VHF F-M Broadcasting

In searching for solutions, the Committee discovered that no new wavelengths can be obtained for Sweden in the long-wave, medium-wave and short-wave bands. There are, however, possibilities in the vhf bands, in which f-m is being considered. It would be possible here with about 150 vhf transmitters at an establishment cost of about $6,800,000 to reach about 75 percent of the present number of license holders. This method permits transmission of two programs at once. Main objection to the solution through f-m is that present radio receiving sets cannot be used for reception of f-m. Capital invested in receiving sets has been estimated at an amount ranging between $60,000,000 and $270,000,000.

Carrier Broadcast System

The second solution (which has the support of the Committee) is using high-frequency wired wireless by which radio programs would be distributed along available telephone lines. It would thus be possible to avoid difficulties that arise due to lack of wavelengths in radio transmission, and three or four programs could be transmitted on each line. Broadcasts would be piped from Stockholm to booster stations and thence to private houses (or, in small villages, to one house which would serve as feeder for others).

It is possible to transmit programs by carrier via electric power mains, but the plant then becomes technically complicated and expensive. Something similar was tried in Germany under Hitler but for a different reason—to keep internal propaganda truly internal, and perhaps to avoid broadcast transmissions going off the air in case of air raids.

The Committee considered use of telephone lines to be preferable, especially since transmission can take place without breach of telephone secrecy. Listeners will not have to buy new and expensive receiving sets. Also, special mass-produced wired wireless receiving sets would be a great deal cheaper both to buy and operate than present sets.

Sweden would continue to broadcast one of its three programs on the air and would pipe that program plus two others through the wires. Major criticisms to the scheme are that a nondemocratic government could do terrible things with such a tight internal system and that it would take so long to complete (20 years). Proponents reply that the scheme could be effected immediately to give those with phone lines a variety of programs, that it is essential to get going with some scheme, and that new phone lines which must be laid are important and useful in any case.

The Committee has made additional suggestions and given prices for other means of improving Swedish broadcasting. For extension of the wireless station grid: $5,000,000. For installation of two short-wave transmitters (to beam programs to Swedes abroad): $2,400,000. For building of a Broadcasting House (huge studios) in Stockholm, on which construction will probably start this summer: $12,500,000. For wired wireless to listeners unable to get fully satisfactory reception: $42,000,000. For wired wireless to all listeners in order to provide several simultaneous programs: $94,000,000.

Lanac for Aviation

A NEW WARBORN SYSTEM for protection and navigation of aircraft while in flight has been announced by Hazeltine Electronics Corporation. It is called Lanac, abbreviation for Laminar Air Navigation and Anti-Collision system.

The basic concept of the system, developed by Knox McIlwain of the Hazeltine organization, rests upon the fact that commercial and private aircraft while in flight are restricted to certain laminae or air strata and that it is essential for these planes to know what obstacles are present in their respective strata of operation. The system makes it possible: (1) to prevent collisions between planes in the air or between planes and mountains, high buildings, or other fixed obstacles; (2) to identify individual planes while in flight as to airline and flight number; (3) to furnish direction and other data directly to the pilot without the assis-

tance of a ground crew; (4) to increase the traffic-handling capacity of airways and airports; (5) to increase the safety of transoceanic and other flights far distant from ground stations; (6) to give automatic navigational aid to pilots while flying so that the possibility of lost planes is reduced to a minimum; (7) to give airports and ground check stations continuous data on the location as well as the identity of all planes.

If the Lanac system is officially adopted, every airplane will be equipped with a challenger and a replier—radar sending and receiving sets controlled by barometric devices so as to be responsive only at the altitudes for which they are set. The challenger sends out a constant series of challenges which are automatically picked up by the repliers of other planes in the same air stratum. Upon receipt of such signals, the replier automatically transmits a reply so that the presence of another plane in the same stratum is instantly known and collision can be avoided. When ascending or descending, the pilot can temporarily change the barometric range of his challenger to investigate the air layers he is approaching. Through barometric selection, a plane in normal operation is advised only of obstacles in its own stratum of flight and is not confused by a multiplicity of signals from other strata.

Mountains, high buildings, and other fixed obstacles can be equipped with permanent repliers which will be responsive to challenges transmitted by any planes flying at a dangerous altitude.

Plane identification is obtained by varying the characteristics of the reply signals transmitted by the replier of each plane, so as to reproduce in Morse code the letter designation of each individual plane. This information can be picked up by other planes and by ground stations.

For navigational purposes the pilot of a Lanac-equipped plane will be able to challenge navigational beacons on the ground and receive their replies, each so coded as to be readily identifiable. By means of these navigational fixes the pilot can establish his exact position and determine his ground speed. The plan envisages the establishment of these navigational beacons at strategic points.

The Lanac system is already in an

advanced stage of practical development since the whole system is based upon scientific developments worked out during the war. It is estimated that the complete equipment, including challenger, replier, and all accessories for airplane use, will weigh approximately 200 pounds and require a space, exclusive of antenna blisters, of about 4.8 cu ft.

Instrument approach can be governed by an additional position on the control switch by means of which an oscilloscope can be made to show the horizontal and vertical position of the plane with respect to a true glide-path, together with the amount of heading into the wind required to resist any existing cross-wind. The desired glide angle is obtained semiautomatically by the mere setting of a switch, after which the pilot needs only to keep certain pips in alignment on his oscilloscope.

AAF Guided Missiles Group

THE FUNCTIONS OF THE First Experimental Guided Missiles Group, established this year by the Army Air Forces with headquarters at Elgin Field, Florida, and commanded by Colonel H. T. Alness, will be development of tactics and techniques of guided missile operations, training of personnel, development of organizational and equipment requirements of the group, and demonstration of guided missiles in the AAF program.

Personnel for the group, to be composed of 715 enlisted men and 130 officers, will consist almost entirely of highly trained specialists. The men are being selected for their knowledge of radar, television, infrared, aerodynamics, control systems, and other scientific devices connected with guided missiles.

The group will not participate in origination or technical developments of guided missiles, but will develop their tactical use and determine the best methods of employing them in combat.

Guided Missile Projects

Several missiles have already been developed and are now ready for tactical experiments. The Azon bomb, a standard 1,000-pound bomb with a radio-controlled tail that can be steered to the left or right on receipt of radio signals from the plane drop-

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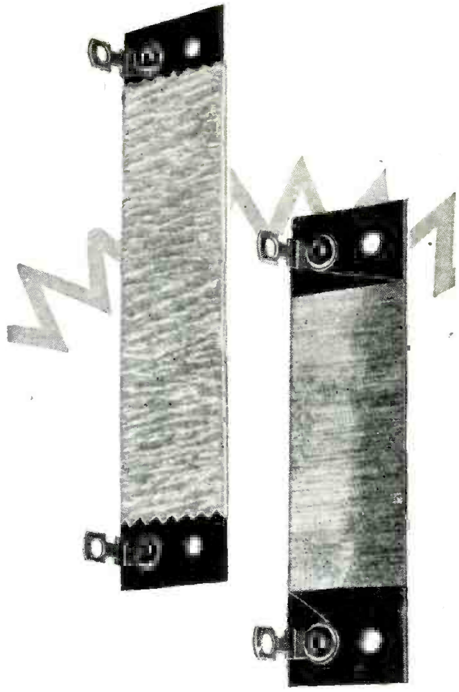

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★ Just turn those tight-tolerance resistor requirements of yours over to CLAROSTAT, just as other instrument-makers have been doing for years past.

Remember, CLAROSTAT specialists offer over two decades of winding experience, outstanding skill, and exclusive winding facilities. They wind all wire sizes even down to .0009" dia. Windings as fine as 600 to 700 turns per inch, on bakelite, ceramic or other material, flat or round. Also string windings in fibre glass and cord.

★ Submit your problem . . .

Solving your resistance and control problems is our business. Call on us for engineering collaboration, specifications, quotations.

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ping it, proved highly successful against bridges in India and Burma. One bridge was destroyed for each four sorties, a greatly increased efficiency percentage over ordinary bombs. A further development, completed just before the end of the war, was the Razon bomb, controllable in both azimuth and range.

Other guided missile projects include Felix, a bomb attracted to heat, and the Roc, a standard 1,000-pound bomb equipped with television to scan the target and relay vital information back to the aircraft.

Although the only fully developed American guided missiles at the present time are air-to-ground types dropped from an aircraft, extensive plans have been made for the development of ground-to-air and ground-to-ground missiles. The German V-2 rocket is an example of ground-to-ground missiles.

Further possibilities of guided missile development include retrievable missiles for reconnaissance, automatic photographic sorties, and other similar long-distance missions.

Wireless Television Camera

PEACETIME BENEFITS FROM wartime development of a television-guided bomb were described by Farnsworth Television & Radio Corp. A portable camera-transmitter unit, built originally to help bombardiers steer their missiles directly to the target, has proved adaptable to on-the-spot television news pickups. The camera is light enough to be carried in an ordinary large-sized suitcase and can be operated by battery if a power line is not available.

A main transmitter beams out synchronizing signals to lock in the signals of the portable camera-transmitter, which then sends its composite signal back to the main transmitter for broadcasting. The present range from which this signal can reach the main transmitter is about 15 miles.

The AAF high-angle television bombing technique was in its final stages when the war ended last August. The camera-transmitter unit, an 18-inch diameter cylinder having a depth of 15 inches, was shock-mounted in the nose of a 1000-pound bomb. Also in the bomb was a radio receiving unit which controlled a small gyroscopic mechanism in the tail section. After the bomb fell

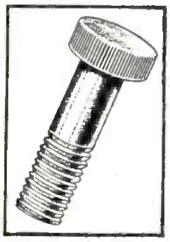
SAY MODERN METHODS SLASH SCREW COSTS 86%

KEENE, N. H. (Special)—Modern methods applied to screw manufacture were cited today as responsible for the incredible saving of 86% in screw costs for a customer of the New England Screw Company of this city. Figures show that the customer was paying $3.75 a thousand for screws from another source and that New England Screw furnished the same product for only 53c.

The customer first approached New England Screw when they became dissatisfied with deliveries and service from another manufacturer. Already far behind in production, they had little hope of catching up, much less of saving any money.

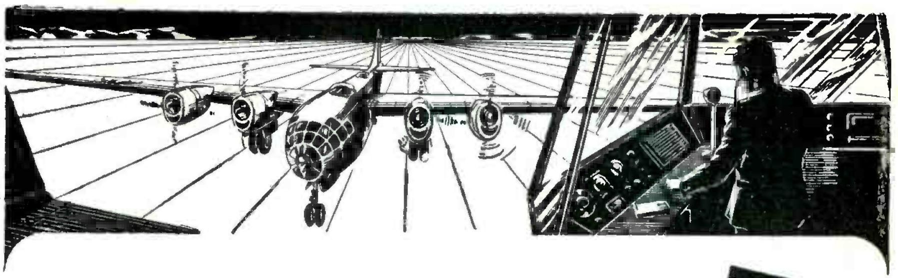
"Our delivery schedules had to be set so high," recalled the president of New England Screw, "they didn't dream we could maintain them. But we did! And saved them 86% in the bargain!"

One of the many special screws made by this firm is shown in the illustration at the left. New England Screw has been making standard and special screws and headed shanks for over 50 years, and their modern manufacturing methods are described in an interesting catalog which will be sent to any company requesting it. Engineers of any manufacturer using screws or headed shanks are invited to consult with their Engineering Department which will gladly co-operate.



NEW ENGLAND SCREW CO.

KEENE, NEW HAMPSHIRE



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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?

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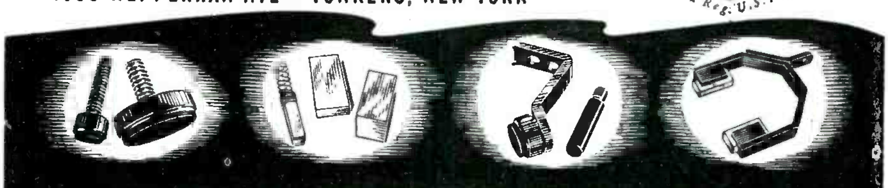

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Soldering Heat in 5 Seconds

Wherever you have a soldered joint in radio, electrical or electronic repair and service work, the Speed Iron will do the job faster and better.

The transformer principle gives high heat—in 5 seconds—after you press the trigger switch. Convenient to hold with a pistol grip handle, the compact dimensions of this new soldering tool permit you to get close to the joint. The copper loop soldering tip permits working in tight spots. The heat is produced by the high current flowing through the soldering tip—permitting direct and fast transfer to the soldered connection.

If you want to save time on soldering jobs with a tool that is ready to use in 5 seconds, get a Speed Iron today. See your radio parts distributor or write direct.

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

WELLER MFG. CO.

515 NORTHAMPTON STREET, EASTON, PA.

through the bay doors, the eye in its nose began to scan the terrain below, picking out roadways, bridges, buildings and even moving automobiles. The directional transmitting antenna in the rear sprayed this signal back toward the plane in a 90-degree cone.

In the plane, the bombardier picked out the target on a 5-by-7-inch monitoring screen, and guided the bomb in both azimuth and elevation by radio so as to keep the image of the target under the crosshairs.

RMA Changes Resistor Standards

IN RMA STANDARD M4-215, the markings for tolerance of fixed composition resistors have been expanded as follows:

Brown	Plus or minus 1%
Red	Plus or minus 2%
Orange	Plus or minus 3%
Yellow	Plus or minus 4%
Gold	Plus or minus 5%
Silver	Plus or minus 10%
No Color	Plus or minus 20%

The use of green for 5 percent was opposed, so as not to have two different ways of indicating the same tolerance.

In Standard M4-216, the exterior body color of insulated resistors may now be any color other than black. The preferred color is natural tan. The exterior body color of uninsulated resistors shall be black, except that in the case of unnisulated resistors with radial leads the exterior body color may be white if the resistors are color-coded in accordance with Standard M4-214B, or may be that of the color code of the first significant figure of the resistance value if resistors are color-coded in accordance with Standard M4-214A.

RMA Spring Meeting

IN TWO TECHNICAL sessions starting at 9:00 a.m. on Monday, April 29 and Tuesday April 30, 1946, eight technical papers will be presented at the Spring Meeting of the Engineering Department of Radio Manufacturers Association, to be held at the Hotel Penn-Harris, Harrisburg, Pa. At a dinner Tuesday evening R. C. Cosgrove, RMA president, will be toastmaster and W. R. G. Baker, director of the RMA Engineering Department, will speak on "The transmitter Engineer and the Electronics Industry."

The following papers are scheduled

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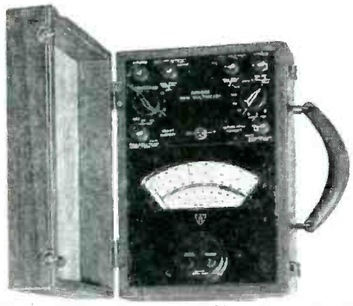

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A Combination AC. Multimeter and DC Multimeter

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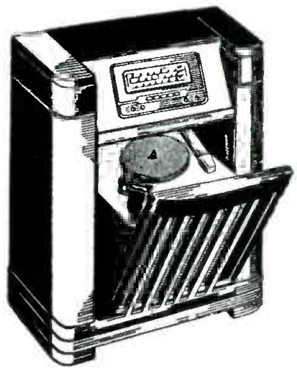

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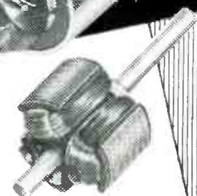

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for the technical program:

April 29: Broadcast Transmitter Design as Detemined by Market Survey, by M. R. Briggs of Westinghouse; A 5-kw Television Tube—Design and Application, by R. B. Ayer and C. D. Kentner of RCA; A Proposed Method of Rating Microphones and Loudspeakers for Systems Use, by F. Rumanow of Bell Labs; Railway Communication, by A. V. Dasburgh of General Railway Signal Co. and E. W. Kenefake of GE.

April 30: The Hydrogen Thyratron, by H. Heins of Sylvania; Mobile Communications Range Tests, by D. E. Noble of Galvin; The Use of Intermodulation Tests in Designing and Selecting High Quality Audio Channels, by J. K. Hilliard of Altec Lansing Corp.; Navar System of Radio Navigation and Air Traffic Control, by H. Busignes and P. Adams of Federal Telephone & Radio Corp.

MEETINGS TO COME

APRIL 1; IRE-AIEE Atomic Engineering Lecture Series (members $1 per lecture; nonmembers $1.50); Mass Analysis and Isotope Separation, by J. A. Hipple of Westinghouse; 7 p.m. at Engineering Societies Building, 33 W. 39th St., New York City.

APRIL 8; IRE-AIEE; Measuring Instruments for Atomic Engineering (see April 1 data).

APRIL 10; AIEE; Applications of Servomechanisms, by S. J. Mikina; 7 p.m. at 301 Pupin Hall, Columbia University.

APRIL 15; IRE-AIEE; Medical and Industrial Applications of Atomic Physics, by R. D. Evans of MIT (see April 1 data).

APRIL 25-30; INTERNATIONAL LIGHTING EXPOSITION; Stevens Hotel, Chicago.

APRIL 29-30; RMA SPRING MEETING; Hotel Penn-Harris, Harrisburg, Pa.; chairman V. M. Graham, P.O. Box 750, Williamsport, Pa.; eight technical papers to be presented.

MAY 13-16; RADIO PARTS AND ELECTRONIC EQUIPMENT TRADE SHOW; Stevens Hotel, Chicago; inquiries to 221 N. LaSalle St., Chicago; special train for radio industry personnel leaves Grand Central Station, New York City at 4:15 p.m. May 12—

make reservations with Perry Saftler, 53 Park Place, New York.

MAY 15-17; NEW ENGLAND ELECTRICAL TRADE SHOW; Exhibition Hall, Boston, Mass.

MAY 20-25; NATIONAL MARITIME EXPOSITION; Grand Central Palace, New York City; inquiries to headquarters at 17 Battery Place.

JUNE 20-23; SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION; annual meeting, Jefferson Hotel, St. Louis, Mo.

BUSINESS NEWS

GENERAL ELECTRIC Co. has set up a new industrial engineering division, to be known as the Power Electronics Division and headed by L. W. Morton.

GRIGSBY-ALLISON CO., INC., Arlington Heights, Ill., organized in late 1945 by R. J. Grigsby and K. C. Allison, will produce radio switches, tuners, and other electrical and mechanical devices in a new plant now nearing completion.

L. S. BRACH MFG. CO. celebrates its 40th anniversary by moving into its recently purchased three-story building in Newark, where they will concentrate on development and increased production of a diversified line of antennas while continuing to manufacture private-brand radio and electrical products.

PRECISION SPECIALTIES, Los Angeles, has started operation of a new radio-electronics section. Among the first products will be several models of home radios.

U. S. TELEVISION MFG. CORP. has moved to new quarters at 3 West 61st St., New York City, where they are planning for a production schedule of over 5,000 finished radios per week. Manufacture of television sets is scheduled to begin in the spring.

GENERAL INSTRUMENT CORP., Elizabeth, N. J., is installing a 1½-mile conveyor system and will soon have a total of 3,400 workers as compared to 1,100 on V-J day.

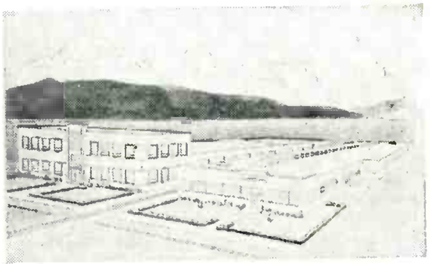
AUDIO PRODUCTS CO., Burbank, Calif., has established an electronic application division to produce various types of electronic controls.

CINCH MFG. CORP., Chicago, wholly owned subsidiary of United Carr Fastener Corp., has purchased the assets of Howard B. Jones Co., and will continue production of Jones

products under a new management, with Howard B. Jones being retained in a consultant capacity.

Paul Godley Co., Upper Montclair, N. J., has moved its radio engineering laboratories to Great Notch, N. J., in a tranquil, close-to-nature setting at The Notch in the Watchung Mountains.

Acme Electric & Mfg. Co. has a new and modern plant nearing completion at Cuba, N. Y. that will more than double its transformer



Cuba, N. Y. manufacturing facilities of Acme Electric & Mfg. Co. Noisebreaking walls will separate punch press departments from assembly lines

manufacturing facilities. One entire section will be devoted to research on transformer design and performance.

Technology Instrument Corp. has been established in Waltham, Mass. by H. H. Scott, R. W. Searle, and L. E. Packard, all formerly with General Radio Co. The new firm will develop and manufacture electronic and laboratory equipment. Mr. Scott, who will serve as president, was responsible for development of General Radio's present line of sound and vibration measuring equipment, f-m and broadcast station monitoring equipment, and other r-f and a-f instruments.

RCA Victor Division has leased a plant in Chicago solely for the fabrication and assembly of auto radios, with peak employment of approximately 700 workers scheduled for June 1.

The Electrodyne Co., Boston, was formed recently to provide research and development service in electromechanics, vacuum-tube applications, and optics, as well as manufacture of electronic equipment. Bertram Wellman is president, Elek J. Ludvigh, II, is director of research, and B. J. Kaplan and Leslie G. Rathbun, Jr., are vice-presidents.

Illinois Institute of Technology will make available to sponsoring or-

HOW TO *Speed up Production*

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Here's a typical installation of Sta-Warm compound melting equipment, employing heated hose for dispensing.

From a rectangular tank built to user's own specifications for capacity and proportions, and equipped with variable thermostat control, melted potting compound is dispensed into transformers through a 10 ft. Sta-Warm flexible metallic hose. The hose itself is electrically heated to maintain proper temperature of the compound until it reaches its destination. A separately controlled thermostat on the hose line further guarantees that the compound will neither burn (and carbonize) or freeze (and solidify) before leaving the nozzle.

The tank only, the hose only, or both as a complete working unit may be ordered as required to fit into your compound melting and dispensing set-up to speed up production without adding extra man-hours.

Why not inquire for full details and prices today by writing fully to Dept. D?

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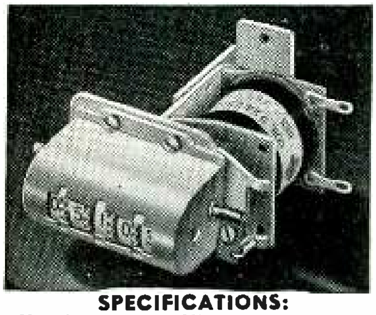

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Manual counter type M1. Non-electrical but otherwise exactly as described. Complete with lever. Each: $1.75. Electric counter. Non-reset, type NR1, exactly as shown and described. $4.10 each for 115 volts, 60 cycles. Other voltages from 6 to 220 are 75c extra. Convenient mounting bracket, 26c. Reset electric counter, type R1 (not shown), soon available. 5 digits. Heavy duty. Resets with twist of fingers. Torque motor type, suitable also for electronic circuits. Standard voltages 6 to 220. Net each: $14.50.

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A G&G HiSpeed ELECTRO-COUNTER, registers up to 40,000 counts an hour . . . it records with consistent accuracy up to 600 times a minute!

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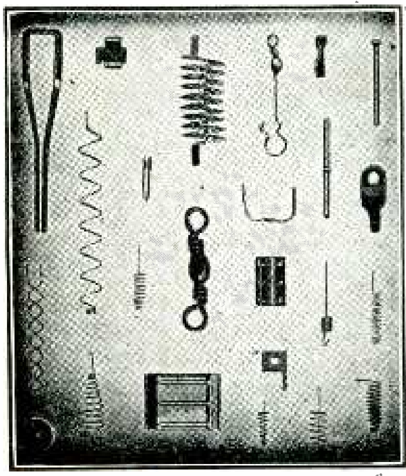

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Filaments, anodes, supports, springs, etc. for electronic tubes. Small wire and flat metal formed parts to your prints for your assemblies. LUXON fishing tackle accessories, double pointed pins, fine sizes wire straightened. Inquiries will receive prompt attention.

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STAFF of 181 12th YEAR

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PERSONNEL

ALEXANDER NORDEN, for many years vice-president of L. S. Brach Mfg. Co., has been elected president of Interstate Mfg. Corp., Newark, N. J.

CHARLES JEFFERS has returned to his post as technical director of WOAI, San Antonio, after three years service with OWI where he served as chief of the Engineering Division, Communications Facilities Overseas Branch.

WILLIAM F. FRANKART, formerly assistant chief engineer of Aireon Mfg. Corp., Kansas City, Kansas, takes over as radio department head at Precision Specialties Co., Los Angeles.

ROGER B. COLTON has retired from the Army after 35 years service and is now associated with the firm of

General Henry H. Arnold (left) presenting Distinguished Service Medal and Legion of Merit to Major General Roger B. Colton in recognition of outstanding wartime services that included developments leading to applications of radar to strategic bombing, fire control, and guided missiles

Colton & Foss, Inc., Washington, D. C., electronic consultants specializing in broadcast, public service communications, radio, and radar development.

ARTHUR H. WULFSBERG has joined the Research Division of Collins Radio Co. Previous work involved design and production of radar and loran equipment at Sylvania Electric Products Inc.

C. R. MADUELL, JR., formerly research physicist for Signal Corps

2 VITAL AIDS

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#JE-12 — (Hardened tool steel insert) or JE-13 (Stainless steel insert) Miniature tube pin straightener to obtain a perfect fit when the tube is placed in the set.

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For Every Purpose

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S12-A

TYPE S8-B—General purpose, laboratory and field, 12 to 24 elements. Permanent film or paper record, 6" to 10" wide, to 200' long. Record speeds from 1/3" to 40" per second, instantly selected by quick changing transmission. Simultaneous viewing and recording. Time coordinate device. Bulletin SP-165.

TYPE S8-C—Identical to S8-B—with 24 to 36 elements. Bulletin SP-165.

TYPE S8-D—Similar to Type S8-B in quality and accuracy. Low cost; automatic features are not included. Bulletin SP-175.

TYPE S12-A—Portable general purpose laboratory and field, 12 elements. Record speeds quickly selected by change gears from ½" to 48" per second. Simultaneous viewing and recording. Bulletin SP-167.

TYPE S14-A—NEW STUDENT OSCILLOGRAPH. Accurate and dependable. General purpose laboratory and field. Ideal for colleges and technical schools. Instant magazine loading. Simultaneous viewing and recording. Bulletin SP-182.

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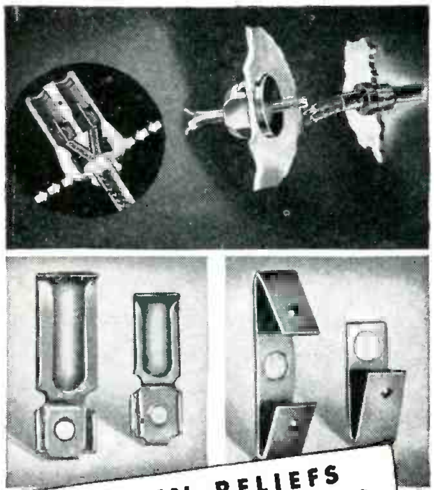

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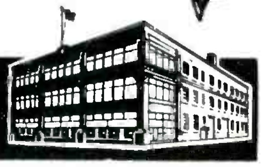

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Engineering Labs, is now consultant physicist and vice-president of Delta Electronic Equipment Co., New Orleans, La.

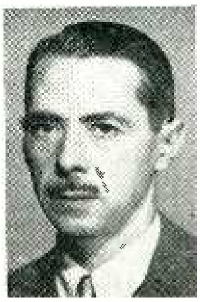
ROBERT H. HOLLISTER has been named service department manager at Collins Radio Co.

MATT J. JELEN, after ten years with Sparks-Worthington Co., has joined U. S. Television Mfg. Corp. as senior engineer in the Radio Division.

ALLEN D. PETTEE has been made chief electrical engineer of General Cable Corp., New York, N. Y.

HOMER HOWARD is now chief engineer of Audio Products Co., Burbank, Calif. He was formerly manager of the Pacific Coast radio division of Lear Aircraft.

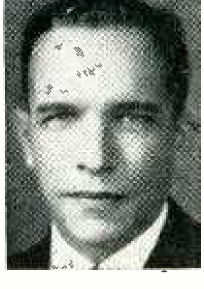

H. Howard


C. M. Wheeler

CARSON M. WHEELER has joined Amperex Electronic Corp., Brooklyn, N. Y., as chief engineer in charge of tube development. For the last ten years he was with Federal Telephone and Radio Corp., serving during the war as assistant to the director of vacuum tube research.

J. D. SCHANTZ received a promotion to assistant manager of the research department at Farnsworth Television & Radio Corp., Fort Wayne, Indiana, having been with this firm and the predecessor company in Philadelphia since 1936.


J. D. Schantz


H. C. Florance

HERBERT C. FLORANCE has been made chief engineer of WGHF, new f-m

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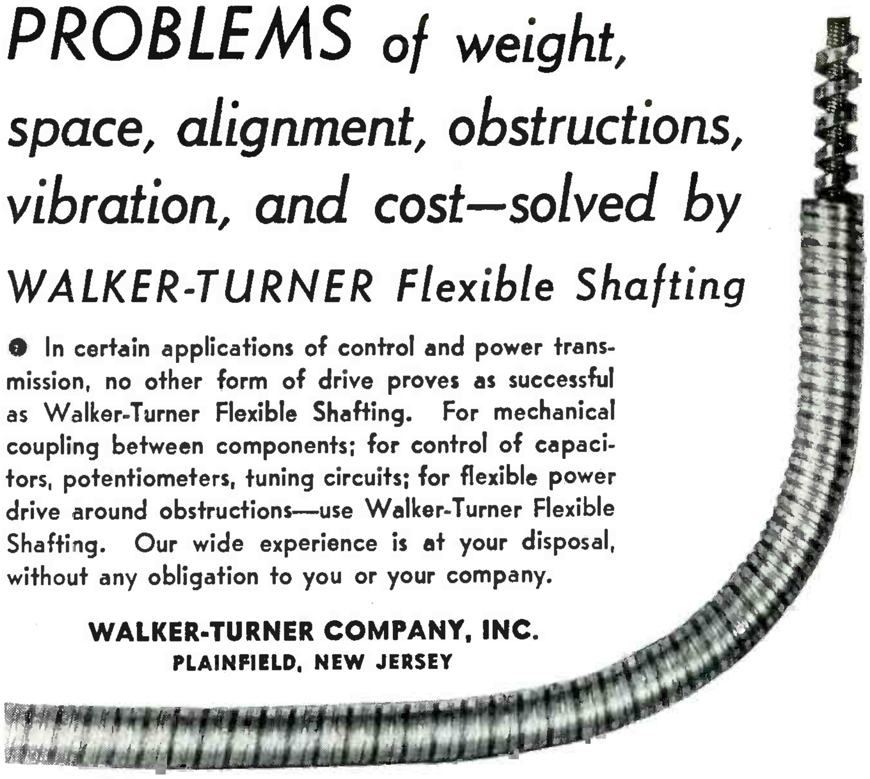

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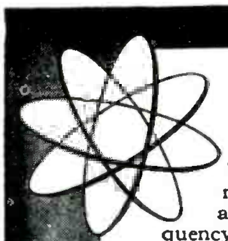

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and facsimile broadcasting station in New York City.

FRANK H. R. POUNSETT, formerly chief engineer of the radio division of Research Enterprises Limited, is now chief engineer of Stromberg-Carlson Co. Limited, Toronto.

GEORGE L. HALLER has been named assistant dean of the School of Chemistry and Physics at Pennsylvania State College. Colonel Haller's work during the war dealt with radio and radar countermeasure equipment, submarine detection from aircraft, and radio and radar control of guided missiles.

SAMUEL GUBIN becomes vice-president in charge of engineering for Spectrum Engineers, Inc., newly organized engineering and consulting firm in Philadelphia. He was formerly with RCA in Camden, where he supervised the microwave beacon group.

CHARLES J. ALBA is radio research engineer at Air Associates, Inc., Los Angeles. He was formerly with Air Track Mfg. Co., College Park, Md. in the same capacity.

NEAL TURNER is now quality control chief at Hallicrafters Co., Chicago.

JOHN J. LIVINGOOD has left the faculty of Harvard University to become assistant director of research at Collins Radio Co., Cedar Rapids, Iowa. He directed developmental work on high power at ultrahigh frequencies at Harvard RRL and worked on cyclotron design and operation.

J. J. Livingood

W. R. Jones

WALTER R. JONES was made chief engineer of the Radio Tube Division at Sylvania Electric Products Inc. He has been with Sylvania 17 years.

THOMAS C. STEPHENS comes to the Research Division of Collins Radio Co. from the University of Iowa where he was an instructor in radio and electrical engineering.

GWILYM A. PRICE becomes president

and chief executive officer of Westinghouse Electric Corp., succeeding George H. Bucher who resigned and is now vice chairman of the board of directors.

AWARDS

SOSTHENES BEHN, president of International Telephone and Telegraph Corp., was awarded the Medal for Merit, highest civilian decoration for wartime service, for fostering extensive research and development which produced radio and telephone equipment used to great advantage by the Army.

FRANK M. FOLSOM, executive vice-president in charge of the RCA Victor Division, Camden, was awarded the Medal for Merit in recognition of outstanding services as Chief of the Procurement Branch of the Navy's office of Procurement and Material.

ARTHUR F. VAN DYCK, assistant to Dr. C. B. Jolliffe at RCA, received the Legion of Merit award for his contributions to the development and

Rear Admiral Monroe Kelly presenting Legion of Merit medal and citation to A. F. Van Dyck

establishment of loran systems in the U. S. Navy. Commander Van Dyck was Officer-in-Charge of Navigational Aids in the Office of the Chief of Naval Operations.

JOHN F. RIDER was presented with the Legion of Merit medal for "exceptional administrative service to the Signal Corps Publication Agency," from which he retired in 1945 as Lieutenant Colonel.

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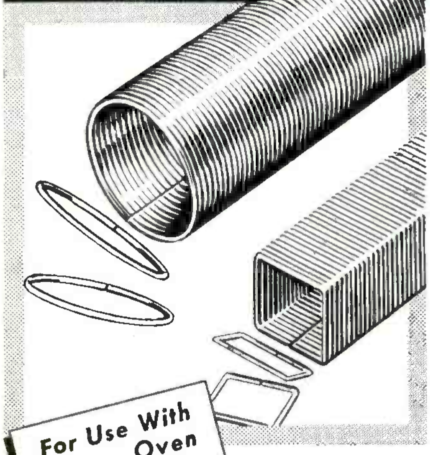

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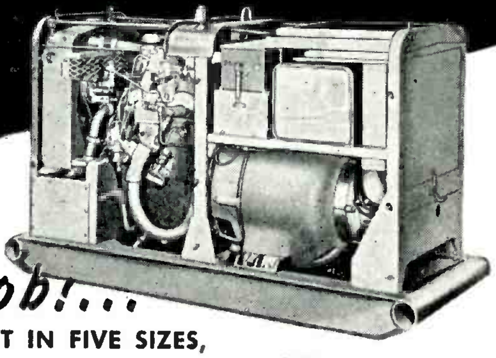

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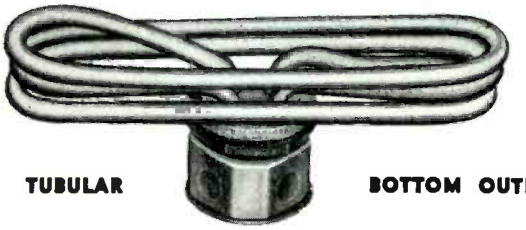

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NEW BOOKS

Fundamental Theory of Servomechanisms

By LEROY A. MACCOLL, *Bell Telephone Laboratories, Inc. D. Van Nostrand Co., Inc., New York, N. Y.*, 1945, 130 *pages*, $2.25.

GENERAL THEORY OF LINEAR, continuously operating servomechanisms is studied by the technique of feedback amplifier design. That is, the characteristics of servomechanisms are analysed by studying their frequency and phase characteristics in the complex frequency plane. Stability is treated in the manner of Nyquist's criterion for feedback amplifiers. As a consequence of this treatment, the approach is more intelligible to communication engineers than that of the purely mathematical analysis of the differentiating and integrating action of the servomechanism so frequently used in studying its transient behavior.

The material, originally circulated within the limits of wartime secrecy, covers simple systems in their steady state, transient behavior of servomechanisms, stability, and accuracy. Based on the equations for servo characteristics, means of stabilizing and controlling accuracy are discussed. The work concludes with treatments of oscillating control, sampling, and on-off servomechanisms. A chapter is devoted to a comparison of the transient analysis and the steady-state approach to servo operation in which the merits of the steady-state method used in this text are demonstrated.—F.R.

• • •

Electronics For Engineers

By JOHN MARKUS AND VIN ZELUFF, *Associate Editors*, ELECTRONICS. *McGraw-Hill Book Company, New York* 18, 1945, 390 *pages*, $6.00.

THIS IS A COLLECTION of articles culled from the pages of ELECTRONICS and written by many different engineering authors. According to the preface the editors of the book ". . . have gone through the complete files of the magazine from the first issue (April, 1930) and from this wealth of technical data have selected 142 articles, reference sheets, charts and graphs that have been in greatest demand for their reference value. All of this material

has been carefully checked, edited and condensed where desirable to put it into the best possible form for presentation in a book."

A need for such a book is almost self-evident, for it is the sad but universal experience of subscribers to monthly technical magazines that the material of the new and oncoming issues tends to bury the previously published material. The reader and user, if he makes any attempt, carries on a losing struggle to retain ready access to the articles which he has specially marked for future reference.

The editors have performed a valuable service by bringing together this collection. Theirs is the responsibility for the selections and omissions of material. In the opinion of the reviewer it is a job well done and does credit to their judgment.

The individual papers are grouped into 27 chapters within a self-explanatory alphabetical index. The typography, arrangement and display are excellent. The material is much too rich and varied to make it possible to indicate more than its general scope as given by the chapter headings, as follows: A-F Impedance-Matching Networks, Antennas, Audio Amplifiers, Audio-Circuit Design, Capacitors, Cathode-Ray Tubes, Coaxial Lines, Electronic Heating, Filters, Industrial Control, Iron-Core Transformers and Chokes, Mathematics, Networks, Oscillators, Permanent Magnets, Pulses, Rectifiers, Relays, R-F Coils and Transformers, R-F Impedance-Matching Networks, R-F Power Amplifiers, Sound, Television, Frequency Modulation and Facsimile, Transmission Lines, Tubes, Tuned Circuits, and Wide-Band Amplifiers.

Here is a volume of practical, useful material, the very stuff out of which the practice of electronic engineering is made. Engineers, designers, teachers, and builders of electronic and communication equipment will find in it suggestions and helps which fellow engineers have through the years devised, constructed and passed on out of their own daily practice and experience.—HENRY E. HARTIG

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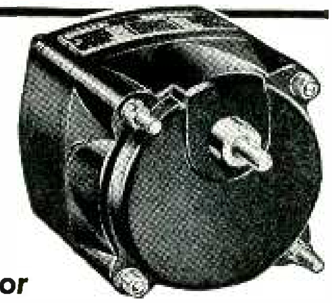

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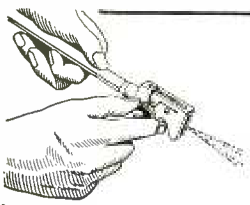
E. C.	1/50 — 1/30	1725	Induction Capacitor	3 21/64″	4½″ to 5¼″
E. U.	1/25 — 1/10	5-10M	Series	3 21/64″	4½″ to 5⅞″
K. S.	1/20 — 1/10	1725	Induction Split Phase	4 13/32″	5½″ to 8¼″
K. C.	1/20 — 1/10	1725	Capacitor Start & Run	4 13/32″	5½″ to 8¼″



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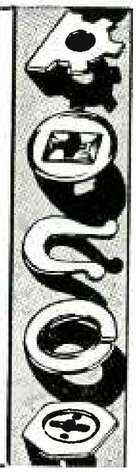

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Appendix: Radar

What are electrons and where do they come from? How does television work? What is the secret of radar, of loran, of BTO? What is a diode? an ignitron? a klystron? a precipitron? How are pictures and facsimile newspapers transmitted over wires or through the ether? How is sound recorded on motion-picture film and on phonograph records? What is the outlook for postwar developments in electronics?

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Spoof

FOR A NUMBER of years now work has been proceeding in order to bring perfection to the crudely conceived idea of a machine that would not only supply inverse reactive current for use in unilateral phase detractors, but would also be capable of automatically synchronizing cardinal grammeters. Such a machine is the "Turbo-Encabulator." Basically, the only new principle involved is that instead of power being generated by the relative motion of conductors and fluxes, it is produced by the modial interaction of magneto-reluctance and capacitive directance.

The original machine had a baseplate of prefabulated amulite, surmounted by a malleable logarithmic casing in such a way that the two spurving bearings were in a direct line with the pentametric fan. The latter consisted simply of six hydrocoptic marzelvanes, so fitted to the ambifacient lunar waneshaft that side fumbling was effectively prevented. The main winding was of the normal lotus-o-delta type placed in panendermic semi-boloid slots in the stator, every seventh conductor being connected by a non-reversible tremie pipe to the differential girdlespring on the "up" end of the grammeters.

Forty-one manestically spaced grouting brushes were arranged to feed into the rotor slip-stream a mixture of high S-value phenylhydrobenzamine and five per cent reminative tetryliodohexamine. Both of these liquids have specific pericosities given by $P = 2.5_n^{6.7}$ where n is the diathetical evolute of retrograde temperature phase disposition and C is Cholmondeley's annular grillage coefficient. Initially, n was measured with the aid of a metapolar refractive pilfrometer (for a description of this ingenious instrument, see L. E. Rum-

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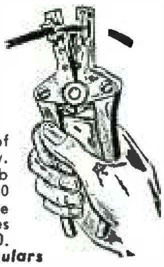

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pelverstein in "Zeitschrift für Elektrotechnistatischs-Donnerblitze" vol. vii), but up to the present date nothing has been found to equal the transcendental hopper dadoscope. (See "Proceedings of the Peruvian Academy of Skatological Sciences" June, 1914.)

Electrical engineers will appreciate the difficulty of nubing together a regurgitative purwell and a supramitive wennel-sprocket. Indeed, this proved to be a stumbling block to further development until, in 1942, it was found that the use of anhydrous nangling pins enabled a kryptonastic bolling shim to the tankered.

The early attempts to construct a sufficiently robust spiral decommutator failed largely because of a lack of appreciation of the large quasi-piestic stresses in the gremlin studs; the latter were specially designed to hold the roffit bars to the spamshaft. When, however, it was discovered that wending could be prevented by a simple addition to the living sockets, almost perfect running was secured.

The operating point is maintained as near as possible to the h.f. rem peak by constantly fromaging the bitumogenous spandrels. This is a distinct advance on the standard nivel-sheave in that no dramcock oil is required after the phase detractors have remissed.

Undoubtedly, the turbo-encabulator has now reached a very high level of technical development. It has been successfully used for operating nofer trunnions. In addition, whenever a barescent skor motion is required, it may be employed in conjunction with a drawn reciprocating dingle arm to reduce sinusoidal depleneration.

EDITOR'S NOTE. The above description of the turbo-encabulator is taken from the *Industrial Bulletin* of Arthur D. Little Company, Cambridge, Mass. Unfortunately no photographs of the device are available at the moment. It is hoped that when military restrictions are loosened a bit and Arthur D. Little engineers are not so busy more data will be published on what seems to be a most important industrial instrument. Despite the lucid description quoted above more information is definitely needed.

JOHN AMBROSE FLEMING, discoverer of the diode, wrote more than 90 important scientific treatises between 1892 and 1934. His 1,700 page book on electromagnetic waves is considered one of the classics of radio literature.

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RADIO COIL Engineer wanted. Must have experience in design, production methods and necessary test equipment for I. F. and R. F. coil production. Reply in strict confidence stating experience and salary. N. Y. metropolitan area. P-136, Electronics, 330 W. 42nd St., New York 18, N. Y.

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(Continued on page 358)

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Additional Employment ads on page 358

for CAMERAS and PROJECTORS

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P-117, Electronics
520 N. Michigan Ave., Chicago 11, Ill.

POSITIONS WANTED

(Continued from page 357)

TECHNICAL EDITOR: Writing—editing Signal Corps Instruction books, technical manuals, inspection manuals 4 yr. Column (with by-line) 5 yr. NY Herald-Tribune. 2 yr. features NY Telegraph. 10 yr. own adv. agency. 12 summers Ringling adv. dept. Ind. Art Sch. LL.M. Mature. PW-139, Electronics, 330 W. 42nd St., New York 18, N. Y.

SALES ENGINEER: M.S. in physics with 2 years instructing experience and 5 years experience in electronic research and design engineering desires position requiring both technical and public contact abilities. Familiar with electronic, power, and mechanical equipment. Single, 30, will go anywhere in states. PW-140, Electronics, 330 W. 42nd St., New York 18, N. Y.

CHEMIST-CHEMICAL Engineer. Two degrees. Five years industrial experience in research, development, sales-service on materials for electrical and electronic application—dielectrics, resistors, high-K capacitors, ceramics. Broad electrical experience, proven ability, excellent references. Desires responsible position in research and development, production, or technical sales. PW-141, Electronics, 330 W. 42nd St., New York 18, N. Y.

SECY. NAVY electronics and civilian airline communications experience, wishes morning and afternoon, $1.50 hr. while attending Columbia University. PW-142, Electronics, 330 W. 42nd St., New York 18, N. Y.

LABORATORY ASSISTANT 25, single, television laboratory, production experience, Army radar training, some college. Connection with progressive expanding firm desired. PW-143, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO ENGINEER: age 26, four years experience design, development, and research radio receivers in marine, radar, direction finding and VHF. Excellent knowledge field intensity measuring equipment. Desires responsible position development and research. At present project engineer with large concern. Location New York City and immediate vicinity. PW-144, Electronics, 330 W. 42nd St., New York 18, N. Y.

SELLING OPPORTUNITY WANTED

SALESMAN CALLING on principal electronics mfgrs. N. J., Md., Penna., wants additional line instruments, parts, components. Will handle on commission basis. RA-145, Electronics, 330 W. 42nd St., New York 18, N. Y.

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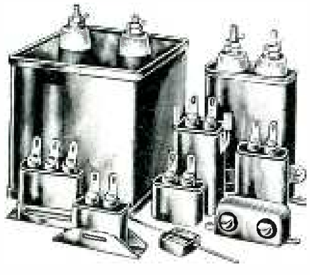

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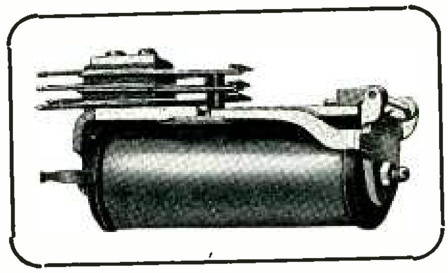

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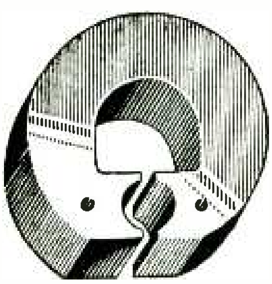

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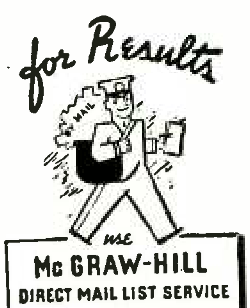

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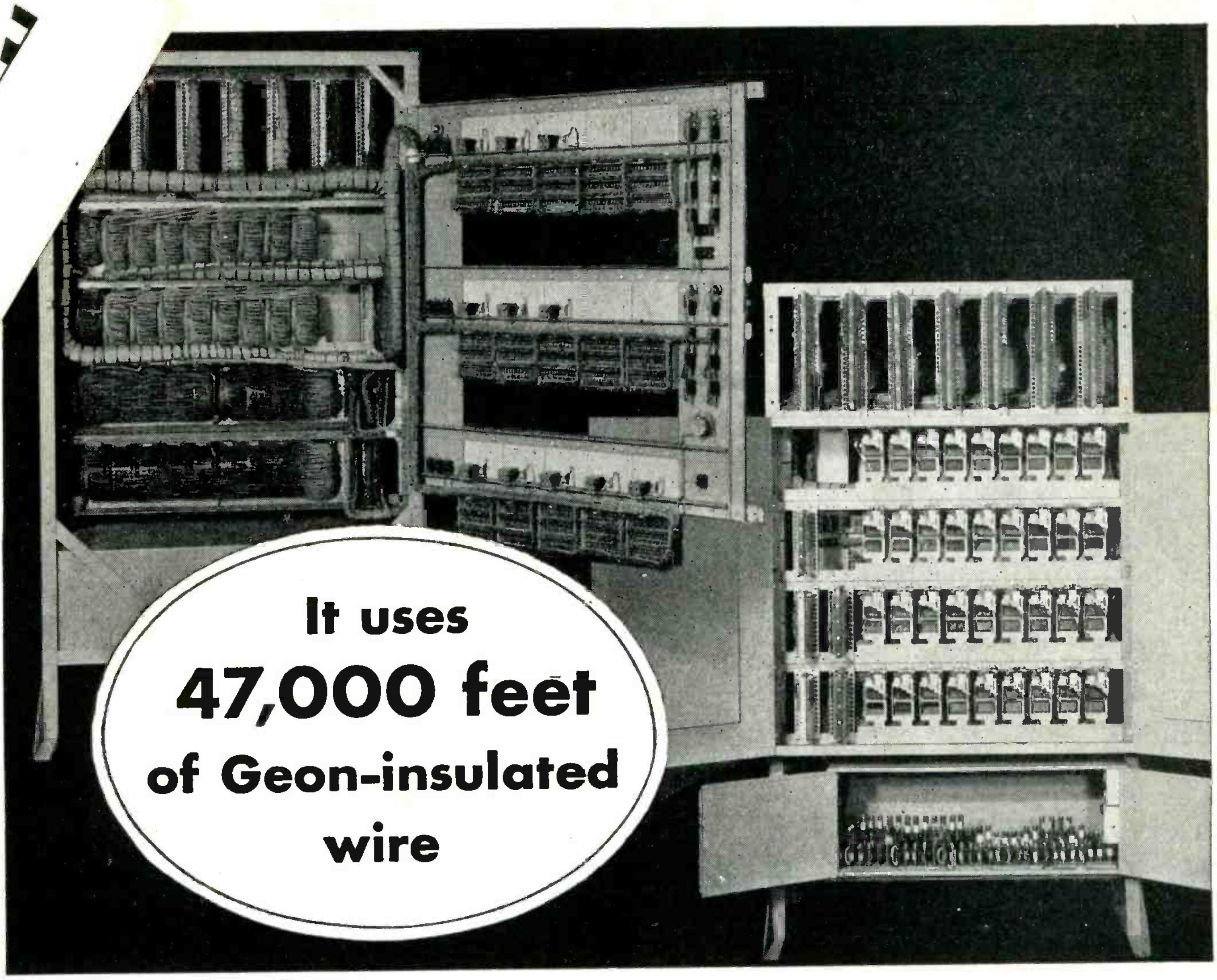

Same type insulation is revolutionizing home and industrial wiring

THESE front and rear views of a Rotary Switch and Relay Bank Rack—that's what Western Union calls it—give some idea of where all the wire goes. But they don't tell why so much Geon-insulated wire is used in machines like these as well as other equally complicated instruments designed and built by Western Union engineers.

Most important, of course, are the excellent electrical properties of insulation made from GEON. They permit a thinner coating of insulation. In instrument wiring that means that the assembly engineer has more room for doing his intricate job. In building wiring it means more conductors per conduit or smaller holes to be drilled.

But insulation made from GEON offers more than this. In all types of wiring it's easier to handle because it's smooth and non-sticky. It's easily identified because of the brilliant, permanent colors. It's highly abrasion resistant—pull it around sharp corners without fear of tearing. It resists water (GEON compounds, of course, are Underwriters approved for TW and other type wires); it resists oil and greases, acids and most other chemicals, sunlight and ozone, flexing, heat and cold, and most other normally destructive factors.

The next time you order wire—for manufacturing, home or industrial wiring—be sure to specify wire insulated with GEON now being made by leading wire and cable manufacturers. Or for more information please write Department F-4, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

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Polyvinyl Materials

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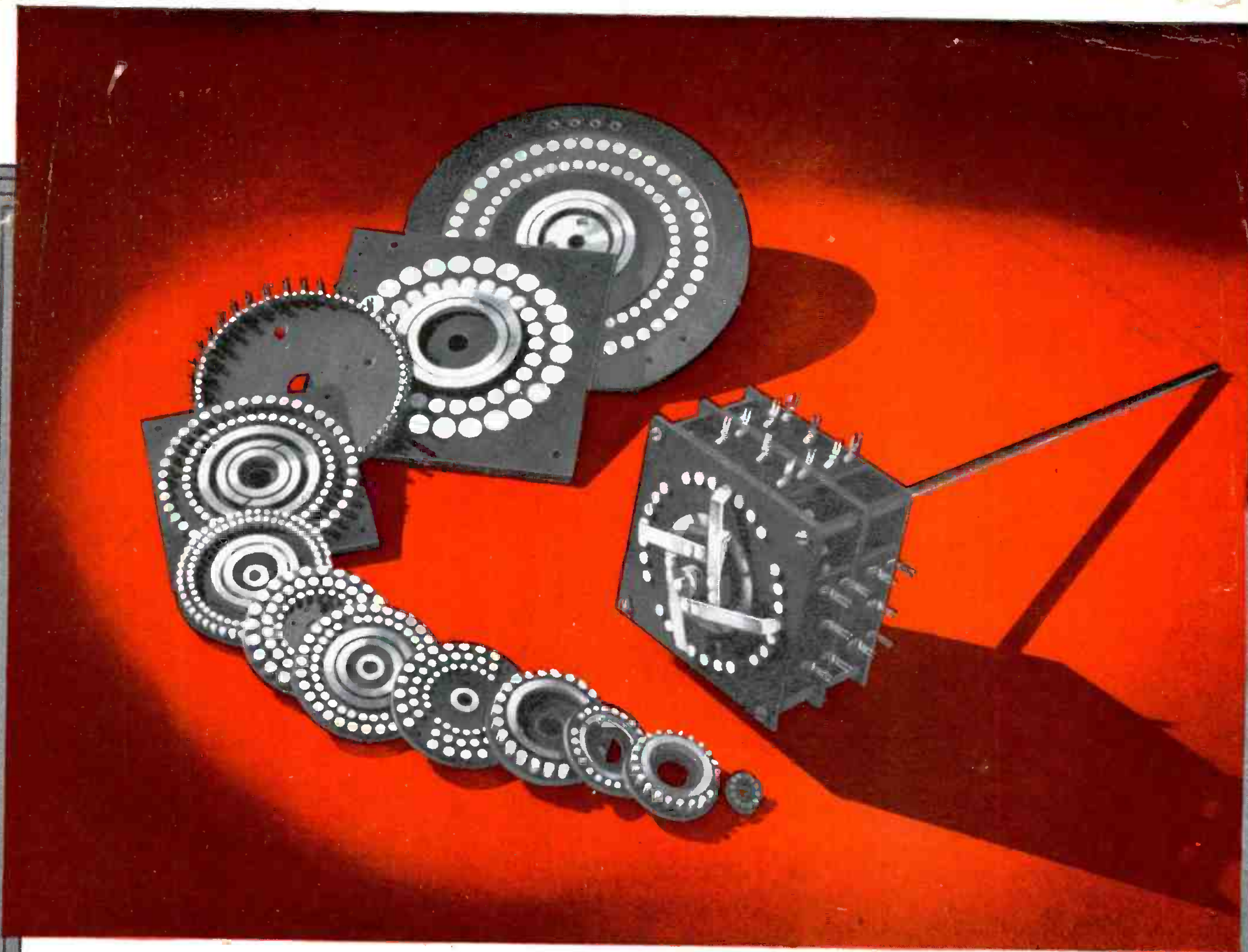

For table-model, console and large-screen television receivers

RCA now has available four new and improved Kinescopes of standardized type that meet practically all television receiver design requirements. These RCA-developed Kinescopes feature higher quality, longer operating life and far greater brilliance and definition than the prewar types. The use of high-volume precision equipment in their manufacture, coupled with RCA's extensive wartime experience in the design and mass production of cathode-ray tubes is reflected in the lower pricing of all four types.

RCA-5TP4: The RCA-5TP4 (5″ face) metallic film Projection Kinescope more than doubles screen brightness of 16″ x 20″ projected pictures. The "mirror-backed" screen also improves picture contrast and detail. Combined with the Reflective Optical System, the 5TP4 permits viewing at higher ambient light levels.

RCA-10BP4: The RCA-10BP4 with its 10-inch face is the star performer of the directly viewed line of Kinescopes. It is characterized by high definition and picture contrast 2 to 3 times greater than prewar types. Deflection and focus are accomplished magnetically. An outside conductive coating, when grounded, serves as a filter capacitor. The new, high-voltage Duodecal 7-pin base is used.

RCA-7DP4: The RCA-7DP4 Directly Viewed Kinescope is a compact tube with a 7″ diameter face particularly adaptable to table-model receivers. It incorporates the same features as the RCA-10BP4 but employs electrostatic focusing and a lower anode potential.

RCA-7GP4: Specifically designed for inexpensive table-model receivers, the 7GP4, also having a 7″ face, has exceptionally high deflection sensitivity, a high-efficiency screen and operates at a relatively low anode potential. Both deflection and focusing are accomplished electrostatically. The low-price and high-performance characteristics of the 7GP4 make it unusually attractive for receiver designs aimed at the mass market. **RCA Tube Application Engineers** are ready to consult with you now on the adaptation of RCA Preferred Type Kinescopes to your television receiver design requirements. If you wish aid in the application of these or other RCA tube types, write RCA, Commercial Engineering Department, Section D-6D, Harrison, N. J.

COMPARATIVE SPECIFICATIONS

	5TP4	10BP4	7DP4	7GP4
Heater Volts	6.3	6.3	6.3	6.3
Heater Amps	0.6	0.6	0.6	0.6
Anode Volts*	27,000	10,000	8,000	4,000
Focus	Electrostatic	Magnetic	Electrostatic	Electrostatic
Deflection	Magnetic	Magnetic	Magnetic	Electrostatic
Deflection Angle	50°	50°	50°	
Raster Size (approx.)	2 3/4″ x 3 5/8	6″ x 8″	4″ x 5 1/2″	4″ x 5 1/2″
Bulb Dia. (max.)	5 1/8″	10 5/8″	7 5/16″	7 1/8″
Length (max.)	12 1/8″	18″	14 7/16″	14 7/8″
Base	Duodecal	Duodecal	Duodecal	Diheptal
Fluorescence	White	White	White	White
Persistence	Medium	Medium	Medium	Medium

*design center maximum value.

The Fountainhead of Modern Tube Development is RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.