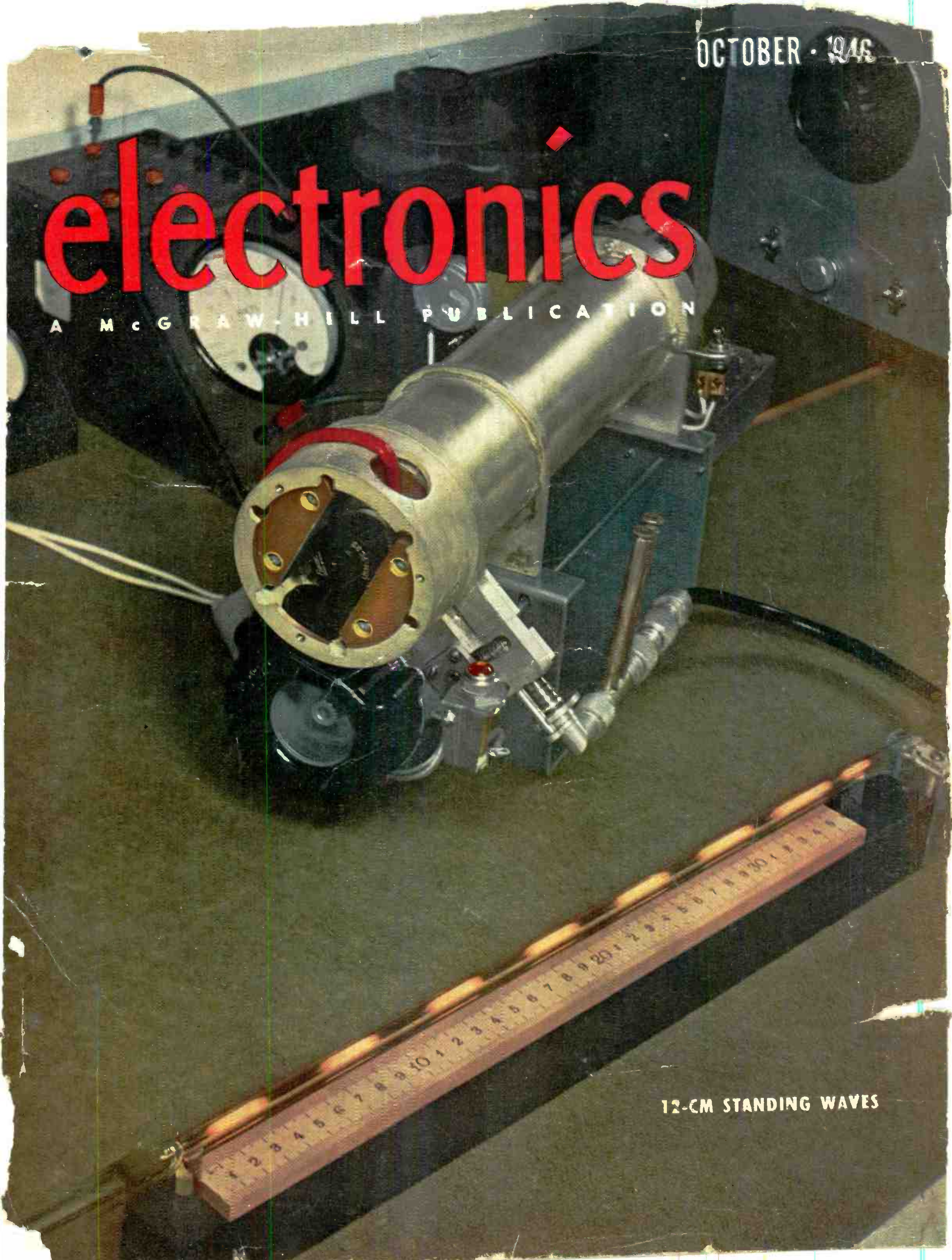
OCTOBER · 1946
electronics
A McGRAW-HILL PUBLICATION
12-CM STANDING WAVES

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electronics

A McGRAW-HILL PUBLICATION

OCTOBER • 1946

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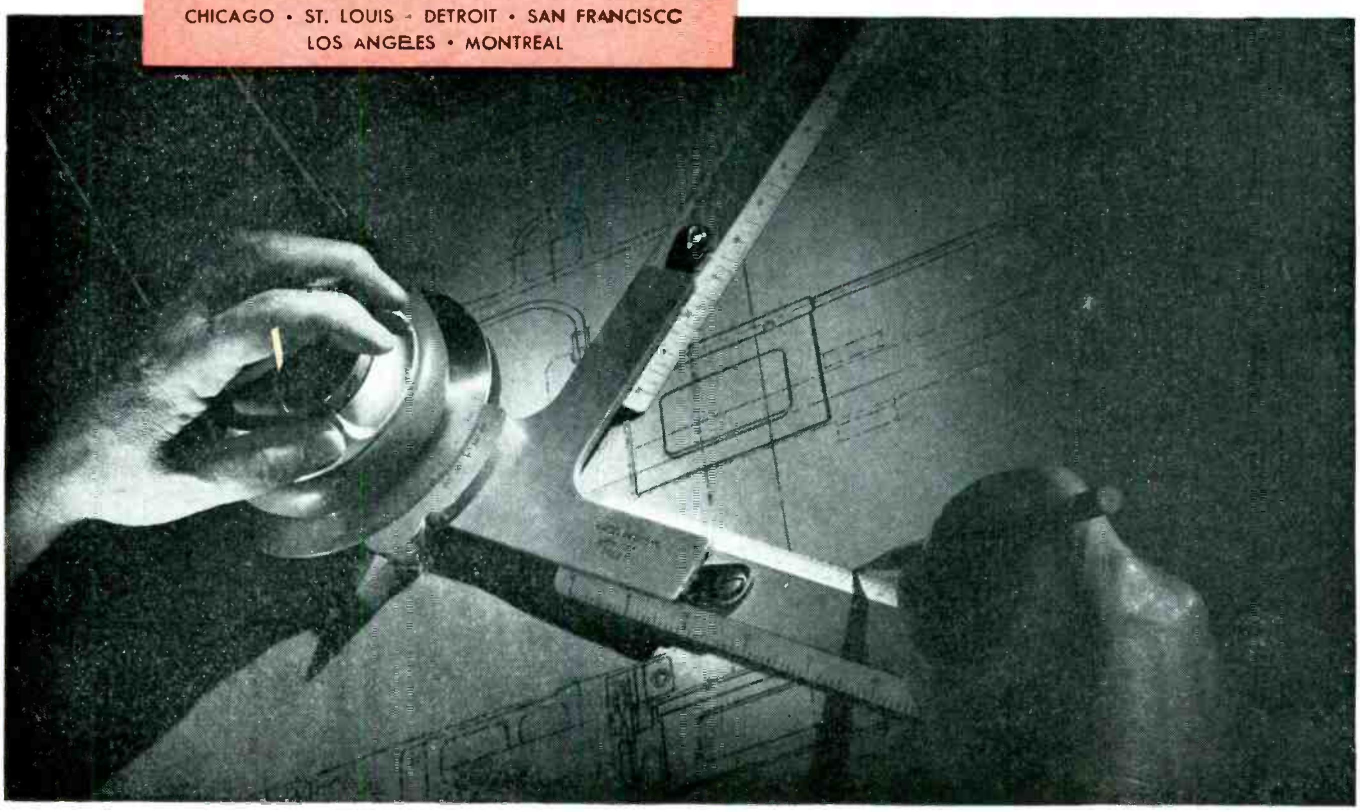

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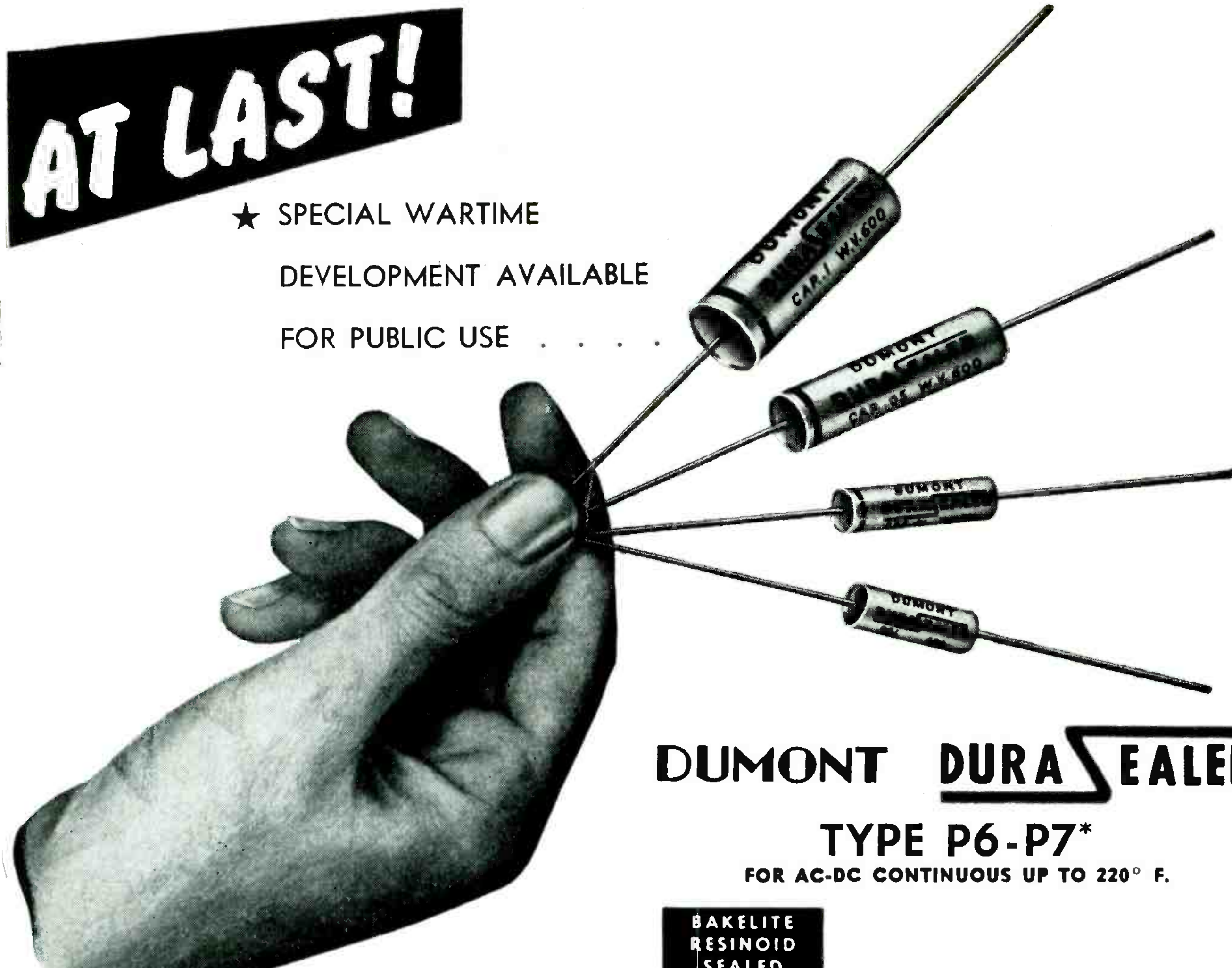

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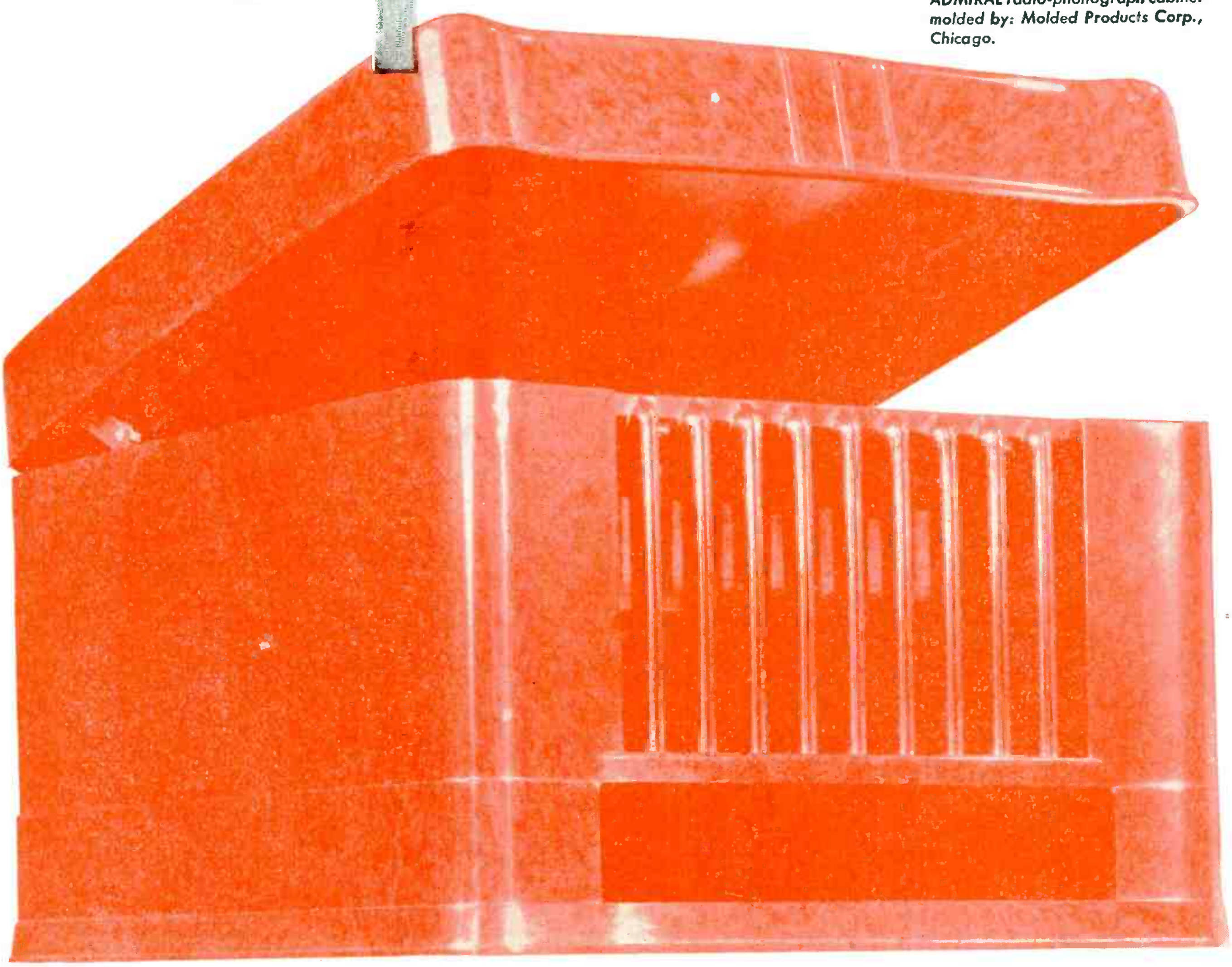
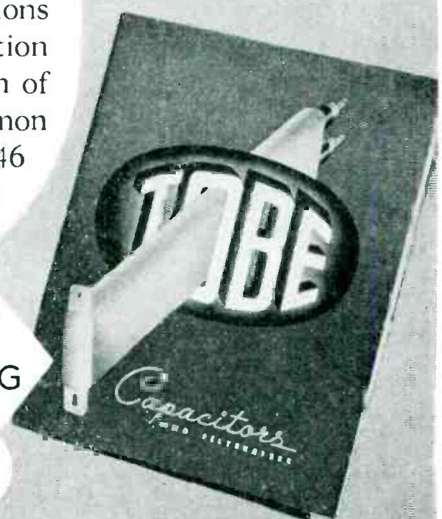


FACTS about *Capacitors*

This Handbook

gives 40 pages of dimensions, housings, terminal structures, mounting provisions, and electrical ratings, as well as performance characteristics of capacitors for diversified applications in the production of electrical apparatus. The Filterette section offers detailed data and specific recommendations for selection of approved units to quell radio noise from more than 80 common electrical devices which create troublesome interference. The 1946 TOBE Catalog represents a real effort to satisfy the current needs of electronics engineers with a lucid, concise collection of data on capacitors.



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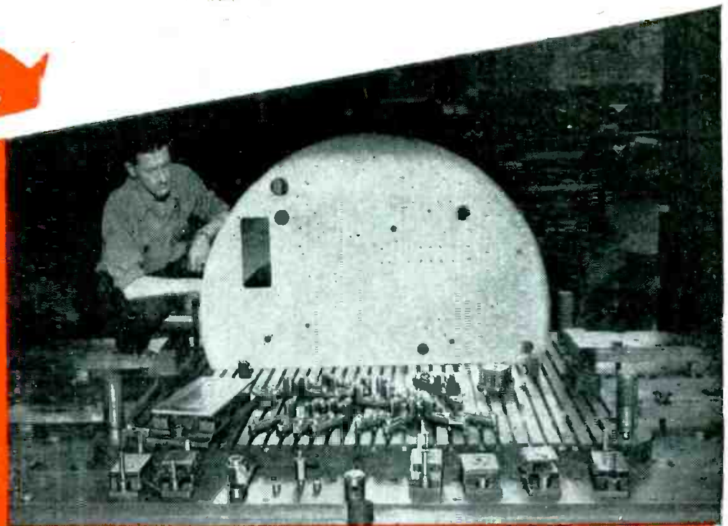

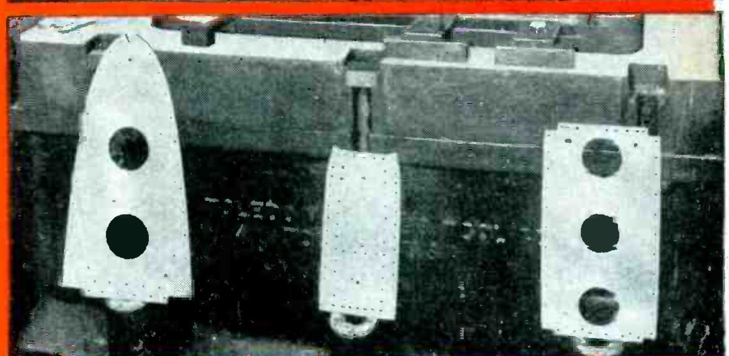

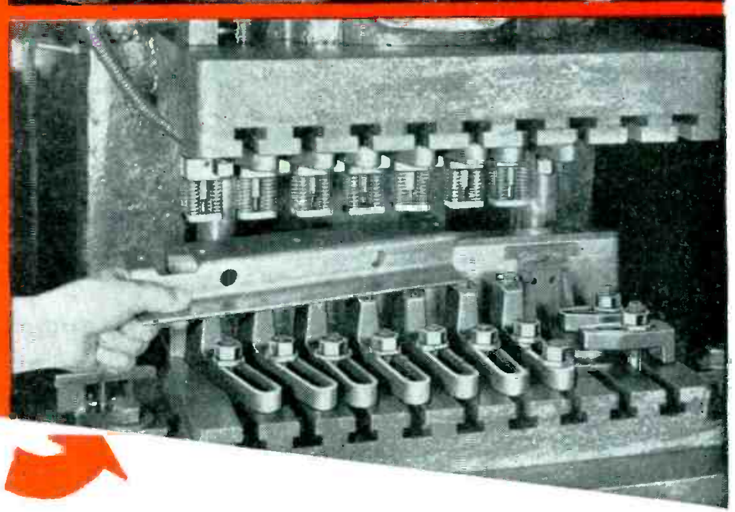

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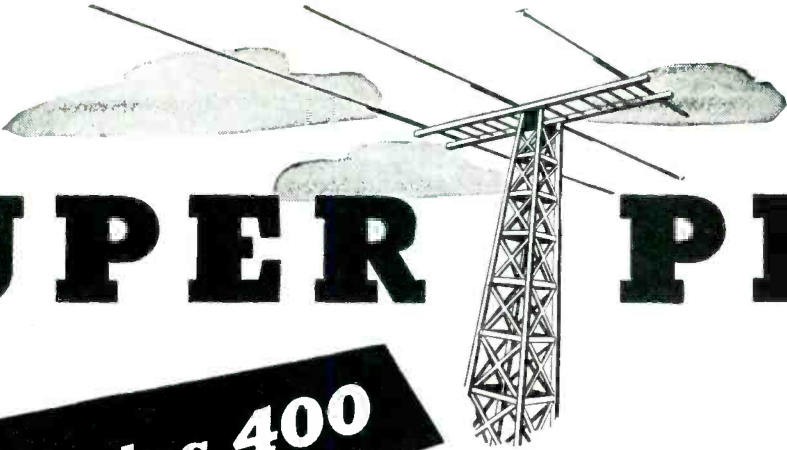

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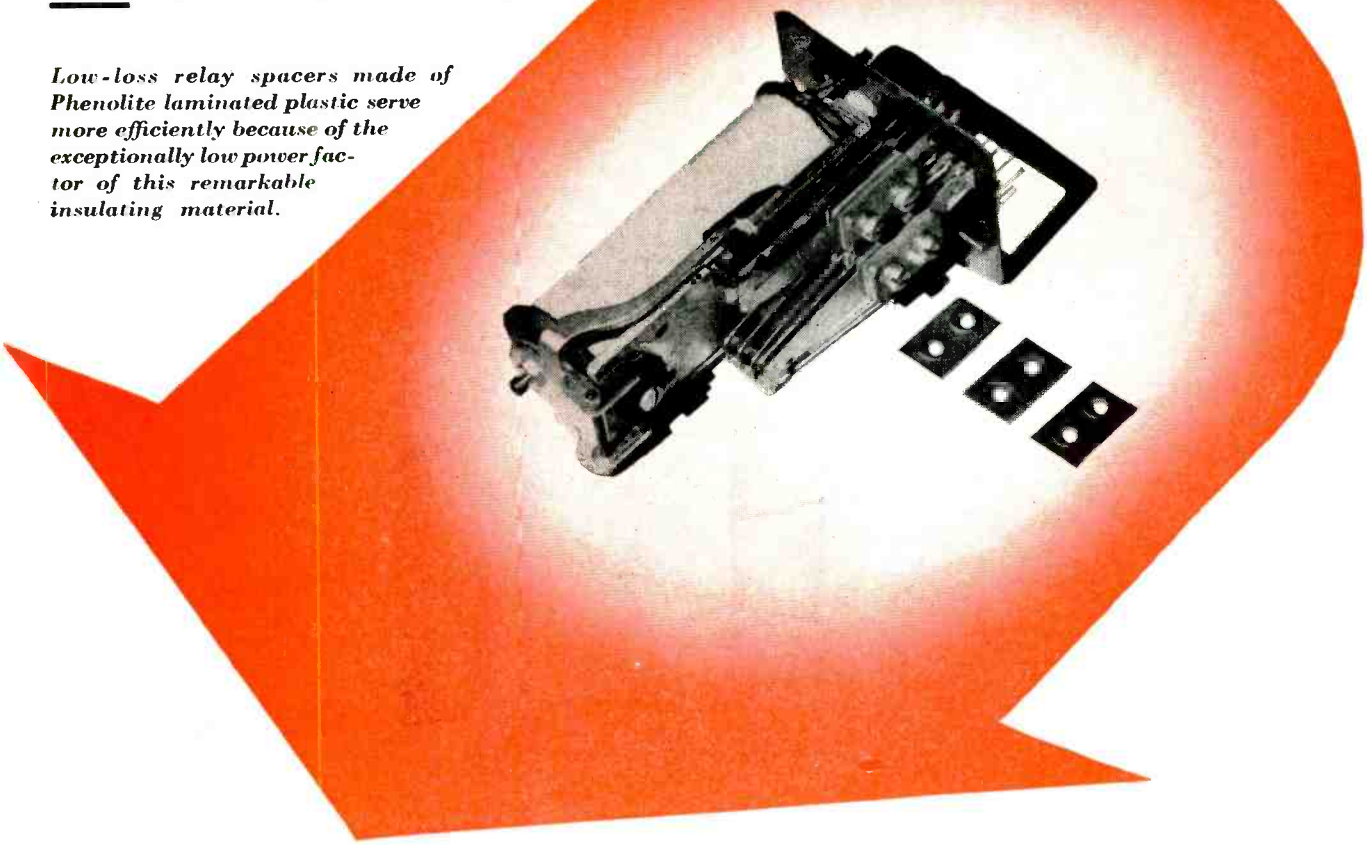

For electrical applications, you're assured of reduced losses and improved performance with Phenolite laminated plastic. Especially suitable for insulation in both high and low voltage applications, it possesses a low power factor at high frequencies, and has an unusually low moisture absorption. Its electrical properties change but very little, even when exposed to high humidity over long periods.

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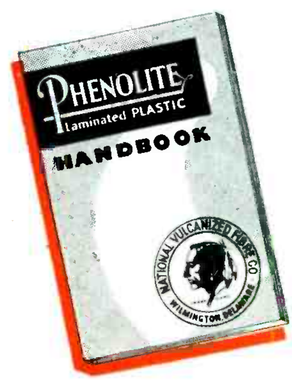

PHENOLITE laminated plastic is available in sheets, rods and tubes in sizes and grades to suit your requirements. Write for valuable illustrated handbook outlining specifications and uses. It's FREE, of course.

Phenolite's rare *combination* of properties—physical, mechanical and chemical—makes it broadly adaptable for efficient, economical use in *many* industries. Light in weight (about half that of aluminum), it is exceptionally resilient and high in impact strength . . . is resistant to abrasion . . . possesses good machinability . . . resists heat and moisture . . . and is not affected by solvents and oils.

There are many ways in which this versatile material can serve efficiently and economically in your products or plant equipment. For complete information, write to —

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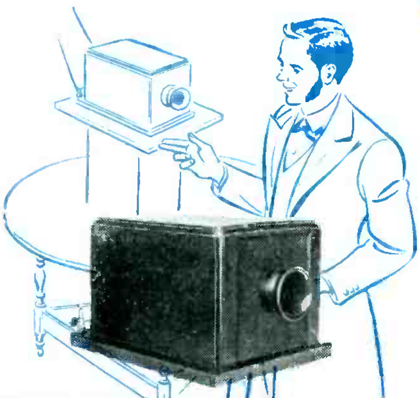
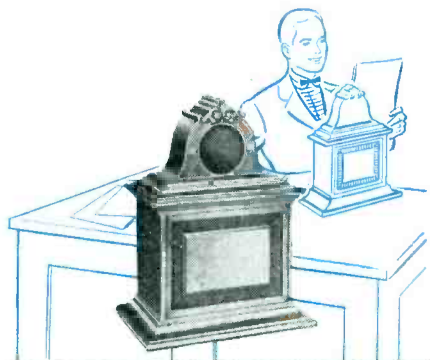
Why this team sets the



1877: Grand-daddy of all microphones was Alexander Graham Bell's box telephone, into which Thomas A. Watson shouted and sang in the first intercity demonstrations of the infant art of telephony.

1920: Telephone scientists developed the first successful commercial mike—the double carbon button air-dampec type. Used first in public address systems, it later became the early symbol of broadcasting.

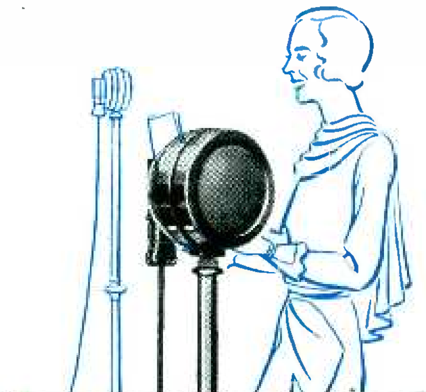


1921: The condensor microphone, designed by Bell Laboratories for sound measurement in 1916, entered the public address and broadcasting fields. It provided a wide frequency range and reduced distortion.

1937: The Western Electric "Machine Gun" mike does for sound pick-up what the telephoto lens does for photography. Sharply directional, this microphone makes sound "close-ups" at unusually long range.

1938: Cardioid directional microphone, with ribbon and dynamic elements, was the first mike ever to combine 3 pick-up patterns in one instrument. The later 639B, with 6 patterns, is also one of the finest all-purpose mikes ever made.

pace in Microphone Development



1931: Bell Telephone Laboratories developed the Western Electric moving coil or dynamic microphone. The first of its kind, it was rugged, noiseless, compact, and needed no polarizing energy. Many are still in use.

1935: The first non-directional mike — the famous Western Electric 8-Ball, designed by Bell Laboratories. Small, spherical, it provided top quality single mike pick-up of speech or music from every direction.

1936: Directional with slide-on baffle, non-directional without it, the Western Electric Salt Shaker gave highest quality pick-up at new low cost. Widely used in studios and remotes as well as in high quality sound distribution.

1946: No larger in diameter than a quarter, the 640 Double-A condenser mike (shown with associated amplifier) is ideal for single mike high fidelity pick-ups. It was originally designed as a laboratory test instrument.

What is a microphone? Fundamentally it's a device which converts sound into electrical energy—just what Bell's original telephone did for the first time away back in the seventies.

Today's Western Electric mikes—the Salt Shaker, Cardioid and 640 Double-A—are a far cry from the first crude, close-talking telephone transmitter. But they're its direct descendants.

Year after year, Bell Telephone scientists—through continuing research—have developed finer and finer telephones and microphones.

Year after year, Western Electric has manufactured these instruments, building quality into each one.

Together these teammates have been responsible for almost every important advance in microphone development.

Whether you want a single mike, a complete broadcasting station, or radio telephone equipment for use on land, at sea or in the air, here's the point to remember:

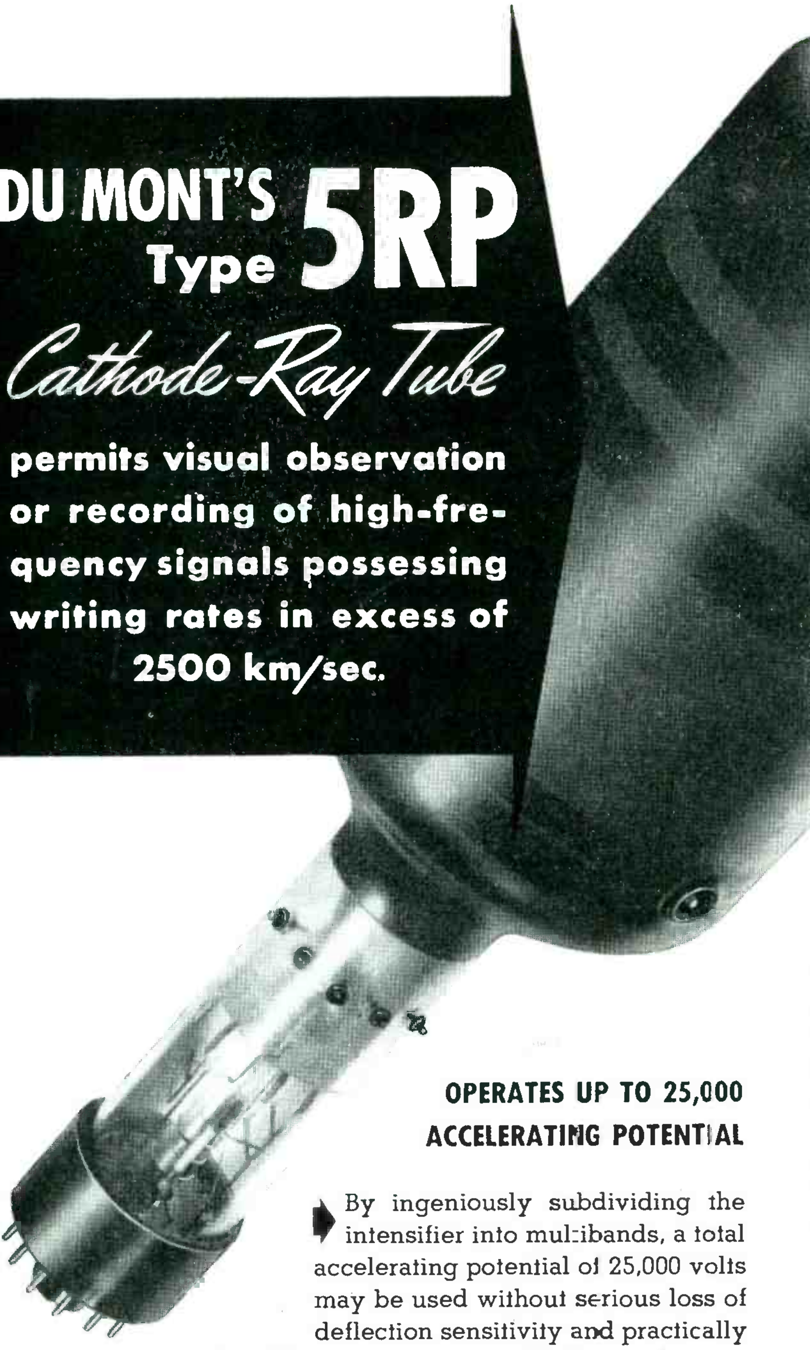
If Bell Telephone Laboratories designed it and Western Electric made it, you can be sure there's nothing finer.

BELL TELEPHONE LABORATORIES

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

Western Electric

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



DU MONT'S Type 5RP

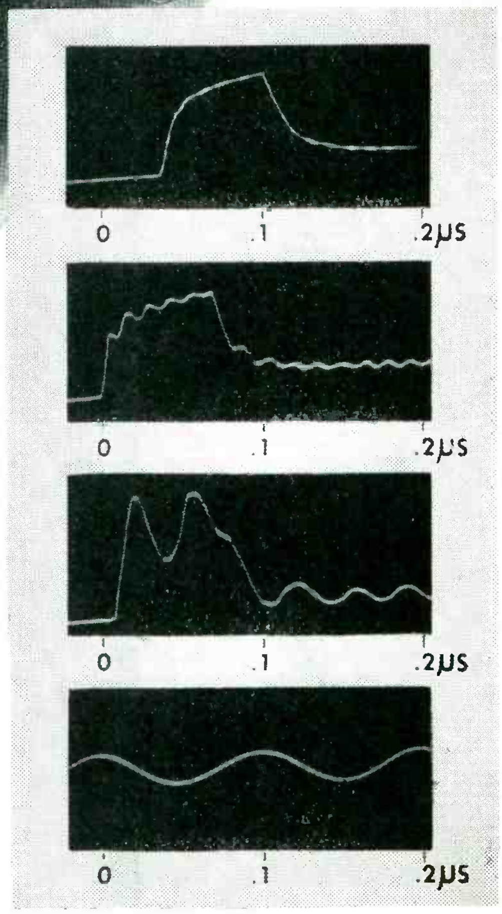
Cathode-Ray Tube

permits visual observation or recording of high-frequency signals possessing writing rates in excess of 2500 km/sec.

OPERATES UP TO 25,000 ACCELERATING POTENTIAL

By ingeniously subdividing the intensifier into multibands, a total accelerating potential of 25,000 volts may be used without serious loss of deflection sensitivity and practically no distortion with Eb3/EB2 ratios as high as 10. Thus, adequate brilliance is provided for signals which ordinarily could not be seen or recorded on a conventional cathode-ray tube. A low-capacitance deflection system, with leads brought out through the neck of the tube, makes the 5RP particularly useful for high-frequency applications.

Write for descriptive literature.



Typical high-speed single-transient recordings with 5RP at 18,000 volts accelerating potential. (Courtesy of Prof. M. Newman, Institute of Technology, University of Minnesota.)

DUMONT *Precision Electronics & Television*

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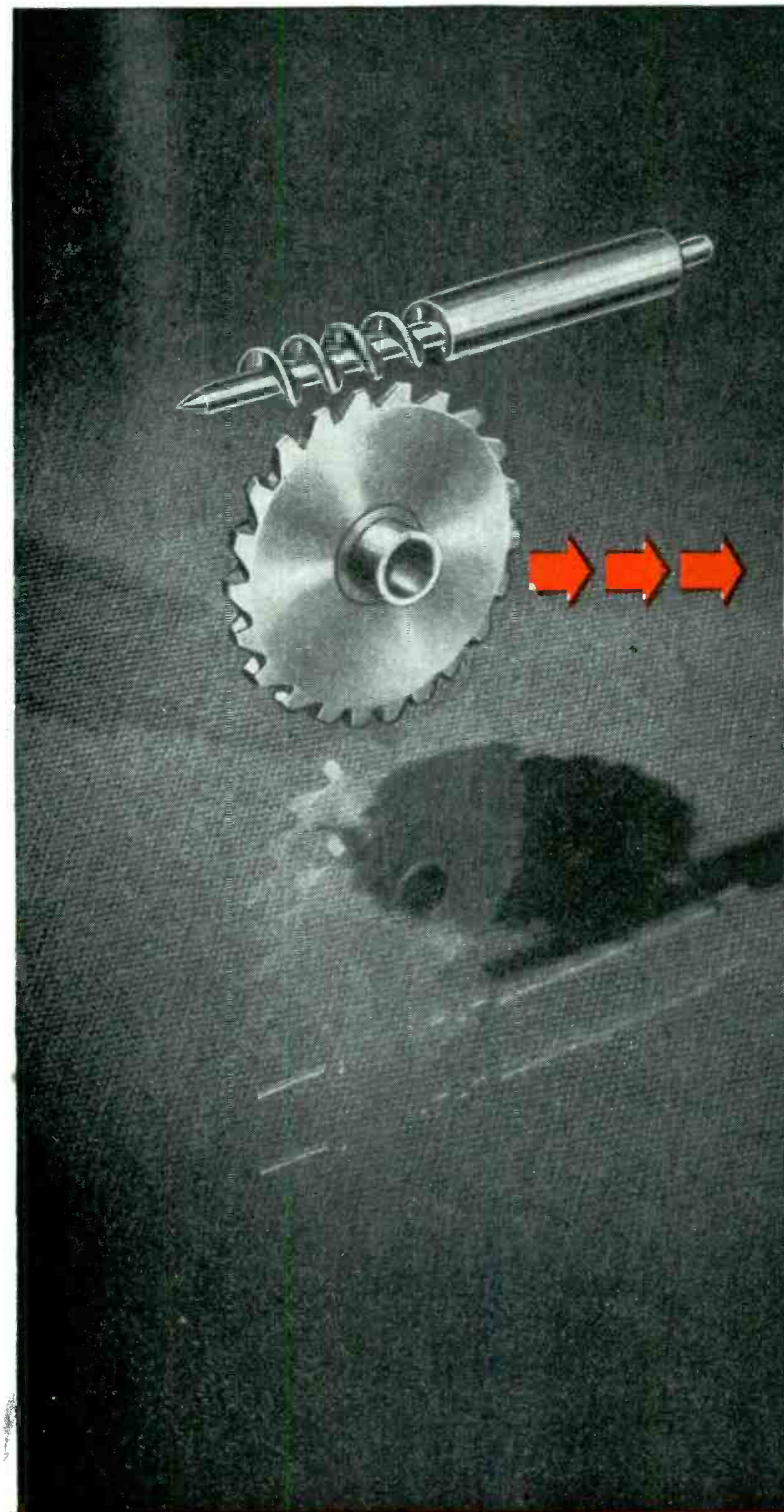

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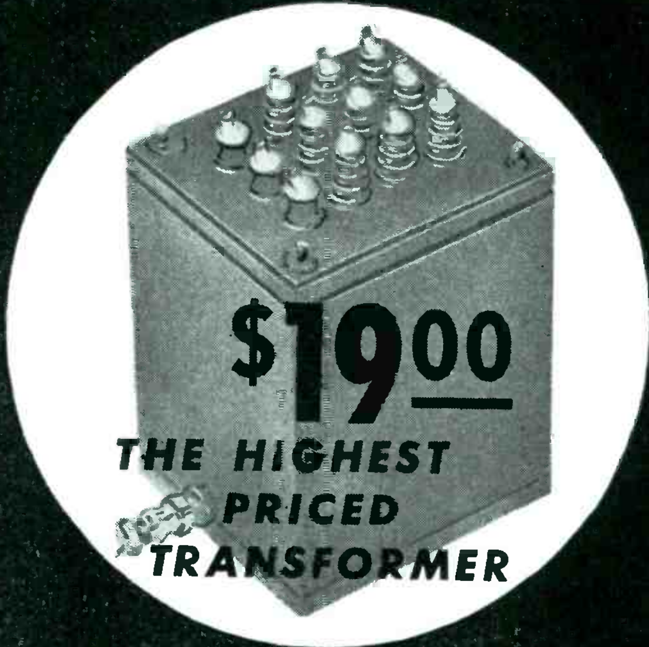

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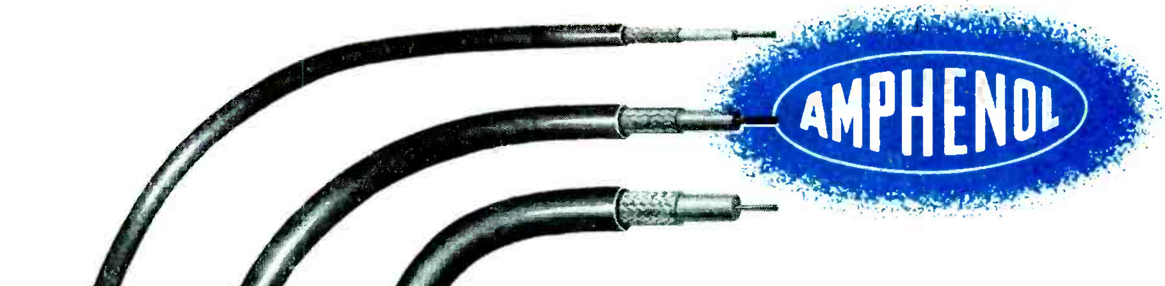


Microphone Cables

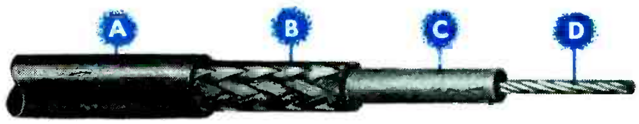
Low Capacitance • Flexible Plastic Jackets

Amphenol engineers announce a new line of four microphone cables in three sizes and two kinds of plastic jackets. All are of unusually low capacitance for their small diameter. They are designed for use by P.A. system installers and service men and for manufacturers of sound equipment, photoelectric devices, home recorders and the complete range of similar applications—as well as for regular studio type installations.

These cables are small in diameter, light in weight and the durable plastic jackets remain flexible down to —40°. Standard microphone connectors and cord protectors may be used with any type. Amphenol cable numbers 21-120, 21-138 and 21-146 have black vinyl jackets. Style 21-147 is the same as 21-138 except it has a polyethylene jacket.

The vinyl type jacket is recommended for heavy use in auditoriums, outdoors and other places where long lengths are required and where crowds of people may be walking over the cable. Polyethylene (21-147) is suitable for home and cocktail lounge applications, where the cord may remain in one position for many days, because the material is chemically inert and has no effect on varnishes. See table below for complete electrical and physical specifications.

	21-120	21-138	21-146	21-147
A	.242″ diam. Black Vinyl	.195″ diam. Black Vinyl	.155″ diam. Black Vinyl	.195″ diam. Black Polyethylene
B	#34 AWG. COPPER 65% COVERAGE	#34 TINNED COPPER 65% COVERAGE	#36 TINNED COPPER 65% COVERAGE	#34 TINNED COPPER 65% COVERAGE
C	POLYETHYLENE .175″ diam.	POLYETHYLENE .116″ diam.	POLYETHYLENE .080″ diam.	POLYETHYLENE .116″ diam.
D	7 STRANDS #30 WIRE	7 STRANDS #30 WIRE	7 STRANDS #30 WIRE	7 STRANDS #30 WIRE
CAPACITANCE PER FOOT	20 mmf	25 mmf	35 mmf	25 mmf



Microphone Connectors

Amphenol manufactures a complete line of microphone connectors, receptacles and jacks. Connectors are available in straight, right angle and feed-through styles. Receptacles are of single hole and mounting plate types—grounded or insulated.

Write for complete information.

AMERICAN PHENOLIC CORPORATION

CHICAGO 50, ILLINOIS
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AN Adlake Mercury Relay can always be depended on, whether it's in burglar alarms or any of hundreds of other uses.

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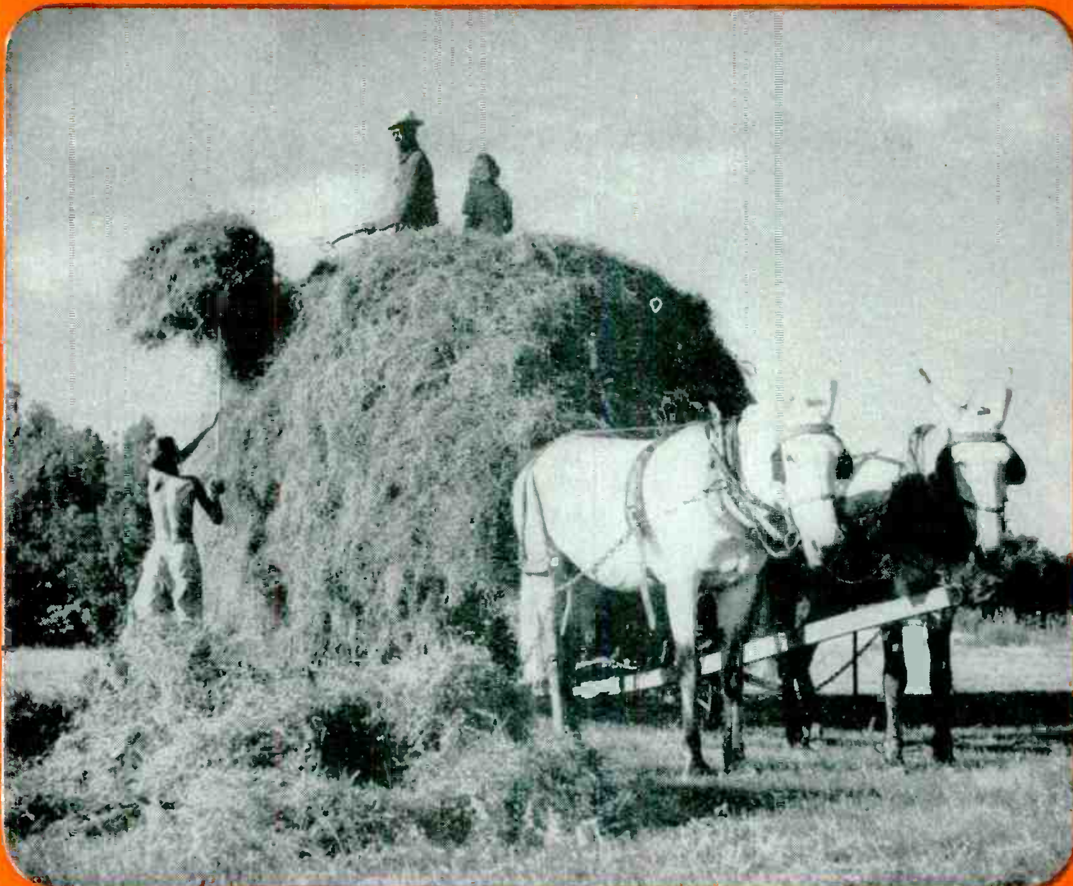

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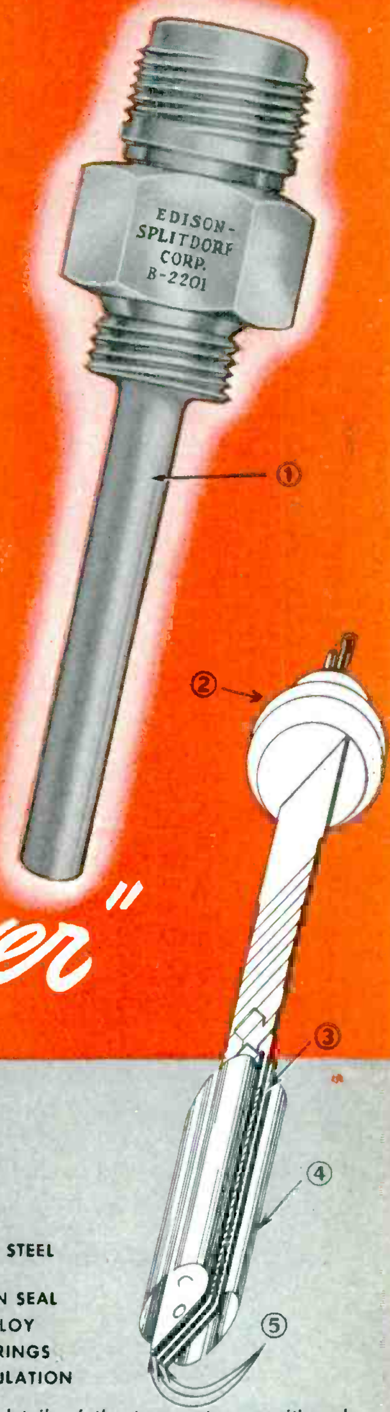


Sure Cure for Hay "Fever"

With This New Electrical Resistance Thermometer

WATCH that hay! When it runs a temperature it may ignite and burn down the barn. That's spontaneous combustion and to prevent it an extremely sensitive Electrical Resistance Thermometer Bulb, developed by Edison-Splitdorf Corporation, is used to detect temperature changes.

Not only does this wonder bulb detect overheating in hay mows; it also determines ground and air temperatures in greenhouses — reports temperature changes in the bearings of power station generators, railroad cars, vital spots of airplanes, chemical reactions, hospital rooms and even in patients undergoing operations. Its uses are unlimited and it will measure temperatures ranging from −200° F to 600° F in solids, liquids and gases. Time constant is less than 2 seconds.

The heart of this bulb is a resistance element wound with a wire having a Temperature Coefficient of Resistance of .00636 per degree C. A change of 1° C produces a .39 ohms change in the unit which in turn produces a corresponding change in the current flowing through the recording meter.

Although this type thermometer has been used in industry for many years it was never successfully developed for volume production because of a lack of an adequate supply of a resistance wire with a stable T. C.

Spurred by the urgency of the war, Driver-Harris Metallurgists working with Edison Engineers speedily developed D-H 99 Alloy to meet this need. It is a resistance wire having a stable T. C. of .00636 per degree C when drawn to .002" diameter and available in large quantities with dependably uniform properties from spool to spool.

Today Driver-Harris manufactures over 80 electrical *heat and corrosion-resistant* alloys. If, like Edison-Splitdorf, the alloy wire you need has not been developed, tell us about it. We've solved many difficult metallurgical problems in 47 years.

1. STAINLESS STEEL BULB
2. PORCELAIN SEAL
3. D-H 99 ALLOY
4. SILVER SPRINGS
5. MICA INSULATION

Construction details of the temperature sensitive element which is hermetically sealed into the stainless steel bulb of the Edison-Splitdorf Electrical Resistance Thermometer. Made for the Foxboro Company and other instrument manufacturers.

D H — SPECIAL PURPOSE ALLOYS SINCE 1899

Driver-Harris
COMPANY

Exclusive Manufacturers of Nichrome

HARRISON, N. J.

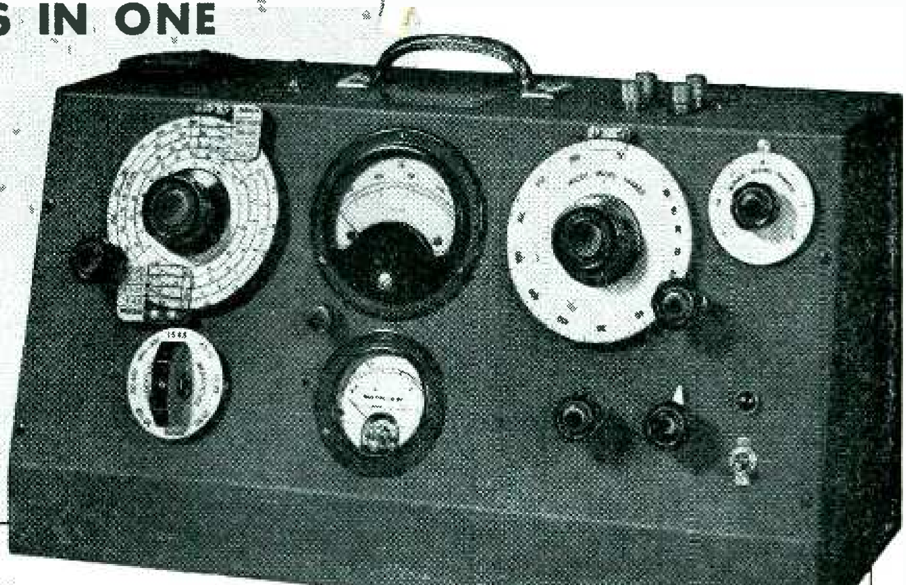
BRANCHES: Chicago • Detroit • Cleveland
Los Angeles • San Francisco • Seattle

The B. GREENING WIRE COMPANY, LTD.
Hamilton, Ontario, Canada

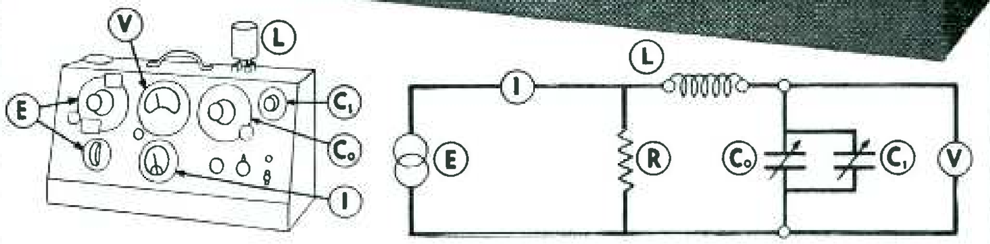
MANY FEATURES IN ONE INSTRUMENT!

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: **± 1%, 50 kc. — 50 mc.**
± 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 ± 0.1 mmf.**

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

BRC

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

Measures Amount of Solder Ejected

Micrometer Control is an exclusive Eject-O-Matic feature. The micrometer wheel, conveniently located in the handle of the Ejecto-O-Matic, provides accurate control of the amount of solder ejected—from 1/16 to 3/8 inch lengths. You can set the wheel to eject a fixed amount of solder and if, during the course of a job, more or less solder is required, a touch of the micrometer wheel instantly changes the amount ejected. This means neat, uniform joints—faster production.

The Eject-O-Matic is now available in 50 and 75 watt models. 100 and 150 watt models will be in production as soon as materials become available.

Model 19-S *(illustrated)* with base—retails at $18.95

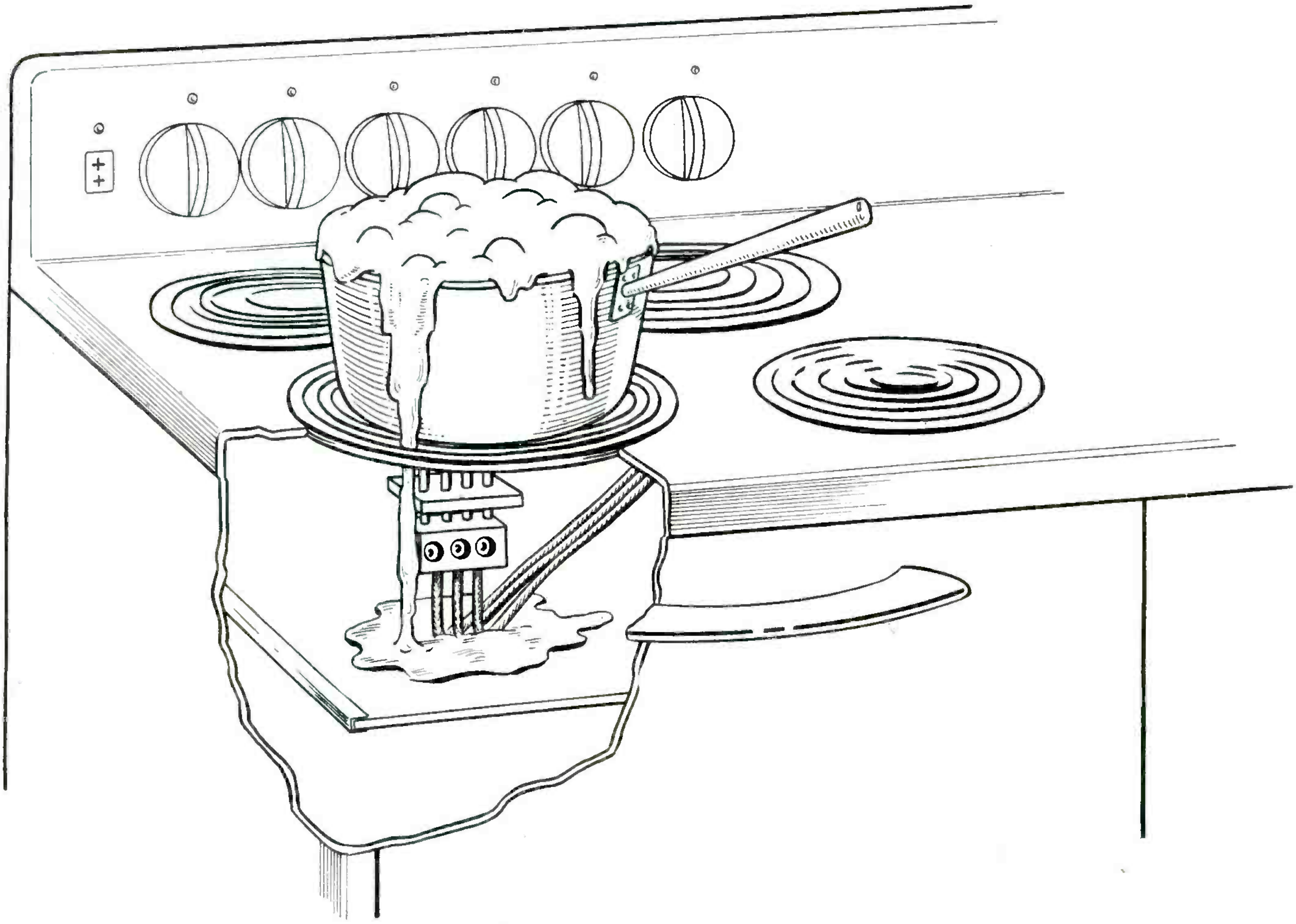
MORE POINTS OF SUPERIORITY

1. Automatic Feed
2. Anti-fatigue Balance—Light Weight
3. Automatic Retracting Feature— Prevents Melting of Excess Solder
4. Drop-forged, Multi-Clad, Non-corrosive Tip
5. Cooling Vanes Dissipate Excess Heat
6. Safety, Utility Base

Individually packed. Shipping wt. per carton of 12 units, approx. 42 lbs.
Send for literature

AUTOMATIC-FEED SOLDERING TOOL
EJECT-O-MATIC
HOUSES · MEASURES · EJECTS THE SOLDER

MULTI-PRODUCTS TOOL COMPANY, 123 SUSSEX AVENUE, NEWARK 4, NEW JERSEY



Here is the report of a leading public service company telling what can happen to wire insulation in electrical equipment . . . and how they cut their service calls in half with BH Non-Fraying Fiberglas Sleeving.

"The majority of our service calls are for the repair of unit leads which have dropped down into the drip pan and have either shorted out or grounded out. That's why we require an insulation that is non-absorbent and will not break even when saturated with grease or moisture. BH Fiberglas Sleeving meets this specification and will not deteriorate even in direct contact with heat units. Our men like BH Fiberglas Sleeving because it's non-fraying, doesn't fuzz out."

Write for samples of BH Fiberglas Sleeving. Test it in your own plant, in your own product—under actual service conditions. Learn why America's leading manufacturers of home appliances, radios and industrial equipment have standardized on BH insulation in their plans for post-war production.

BENTLEY, HARRIS MFG. CO., CONSHOHOCKEN, PA.

BH *Fiberglas** SLEEVINGS

*BH Non-Fraying Fiberglas Sleevings are made by an exclusive Bentley, Harris process (U. S. Pat. No. 2393530). "Fiberglas" is Reg. TM of Owens-Corning Fiberglas Corp.

USE COUPON NOW

Bentley, Harris Mfg. Co., Dept. E-3, Conshohocken, Pa.

I am interested in BH Non-Fraying Fiberglas Sleeving for __________ (product)

operating at temperatures of ____°F. at ____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleeving stays flexible as string, will not crack or split when bent.

NAME __________ COMPANY __________

ADDRESS __________

Send samples and prices on other BH Products as follows:

- ☐ Magneto Varnished Tubing Grade "A"
- ☐ Flexible Varnished Tubing Grade "B"
- ☐ Saturated Sleeving Grade C-1
- ☐ Saturated Sleeving Grade C-2
- ☐ Saturated Sleeving Grade C-3

NEW... BEST!

H-f power tube for FM with
RING-SEAL CONTACTS

- Tube can be installed or replaced in a few seconds
- Greater area of ring-seal contacts increases h-f circuit efficiency
- Superior electrical characteristics include (a) minimum inductance
  (b) no neutralization required
  (c) extremely low driving power
- A pair of GL-7D21's easily will handle output for a 3-kw FM transmitter

TRANSMITTER designers will welcome the new GL-7D21, most modern, most *practical* of FM power tubes. Ring-seal contacts—an important General Electric development—mean fast tube installation or replacement (therefore less time off the air) while providing generous terminal-contact areas. . . . Electrically, Type GL-7D21 is equally advanced. There is complete internal shielding of the 4 electrodes, and provision for a r-f ground plane makes possible external shielding as well. . . . The tube is designed with minimum internal inductance. Low grid-to-plate capacitance eliminates need for neutralization. Plate ratings (see right) give the GL-7D21 an output sufficiently large so that a pair will more than meet the needs of a 3-kw FM transmitter—with only 120 w driving power (for 2 tubes) required!... G-E tube engineers will be glad to assist you in applying this modern, compact, highly efficient tube to your latest FM circuit. See your nearest G-E office, or write to the *Electronics Department, General Electric Company, Schenectady 5, New York.*

TYPE GL-7D21

Sketch shows how easily a GL-7D21 can be plugged in. The concentric ring-seal design provides ample contact-surface for all terminals.

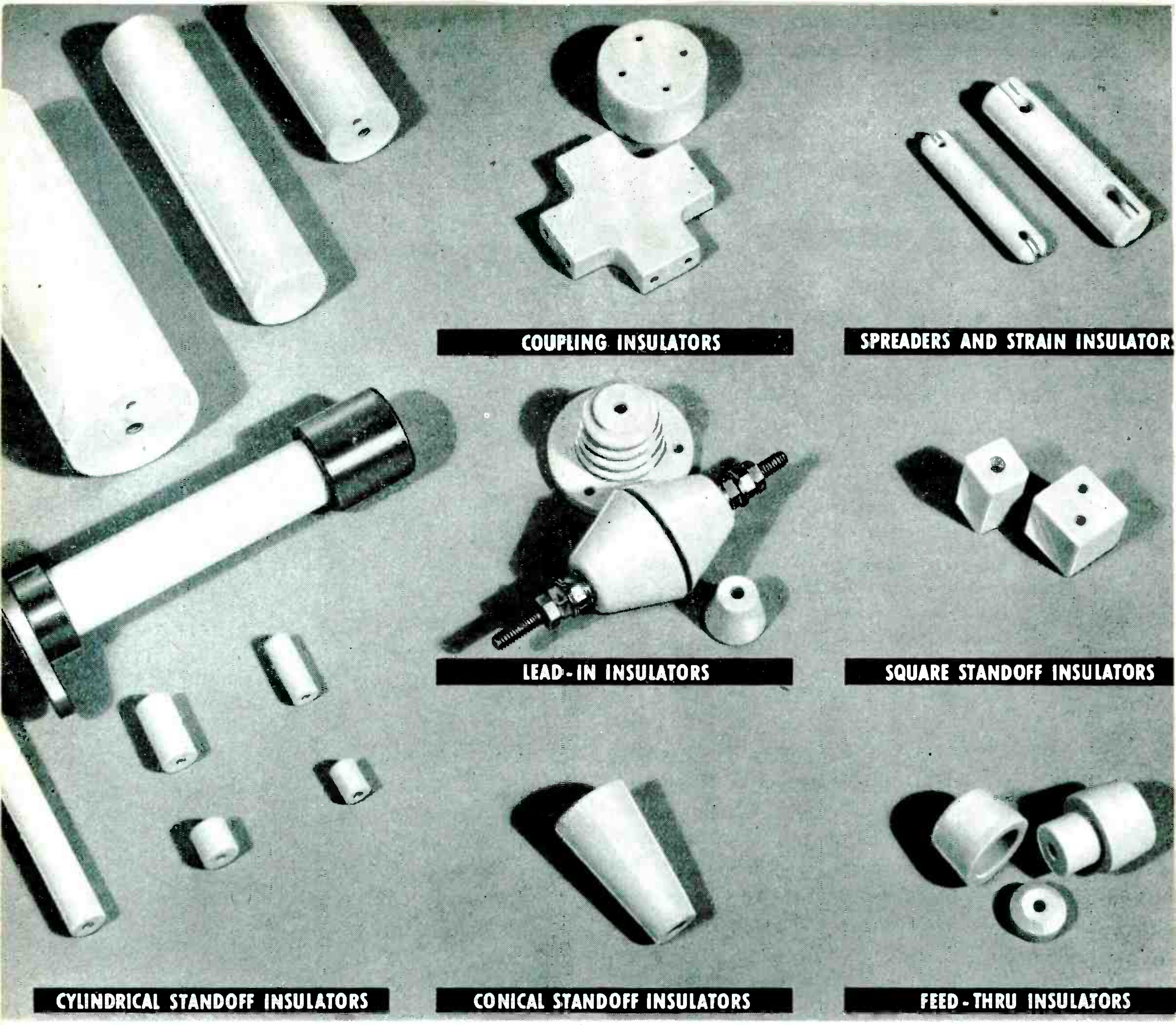
RATINGS OF TYPE GL-7D21

Filament voltage	6.3 v
Filament current	30 amp
Frequency in megacycles at max ratings	110
Type of cooling	forced-air
Max plate ratings, Class C telegraphy:	
voltage	4,000 v
current	1 amp
input	3,000 w
dissipation	1,200 w

GENERAL ELECTRIC

161-E7-8850

FIRST AND GREATEST NAME IN ELECTRONICS



IMMEDIATE DELIVERY FROM STOCK

ON MOST SIZES AND TYPES OF STANDARD INSULATORS

These insulators are the types most frequently used in radio and other high frequency applications. They are made of AlSiMag 196. They are in keeping with the trend toward standardization and interchangeability. American Lava Corporation has worked for more than a year toward building stocks to the point where its pre-war service on these standard insulators could be resumed. Now volume deliveries can be made immediately on almost the entire range of these standard insulators. Write for Bulletin 143 which gives complete data.

AlSiMag technical ceramics made to customer's specifications are our principal products. Our engineering staff will be glad to review and make recommendations on your designs.

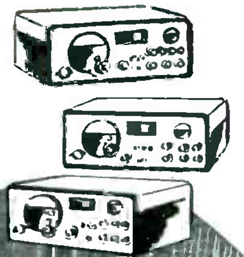
Bulletin 143 illustrates, lists and gives dimensional data on standard insulators available from stock. Copy on request.

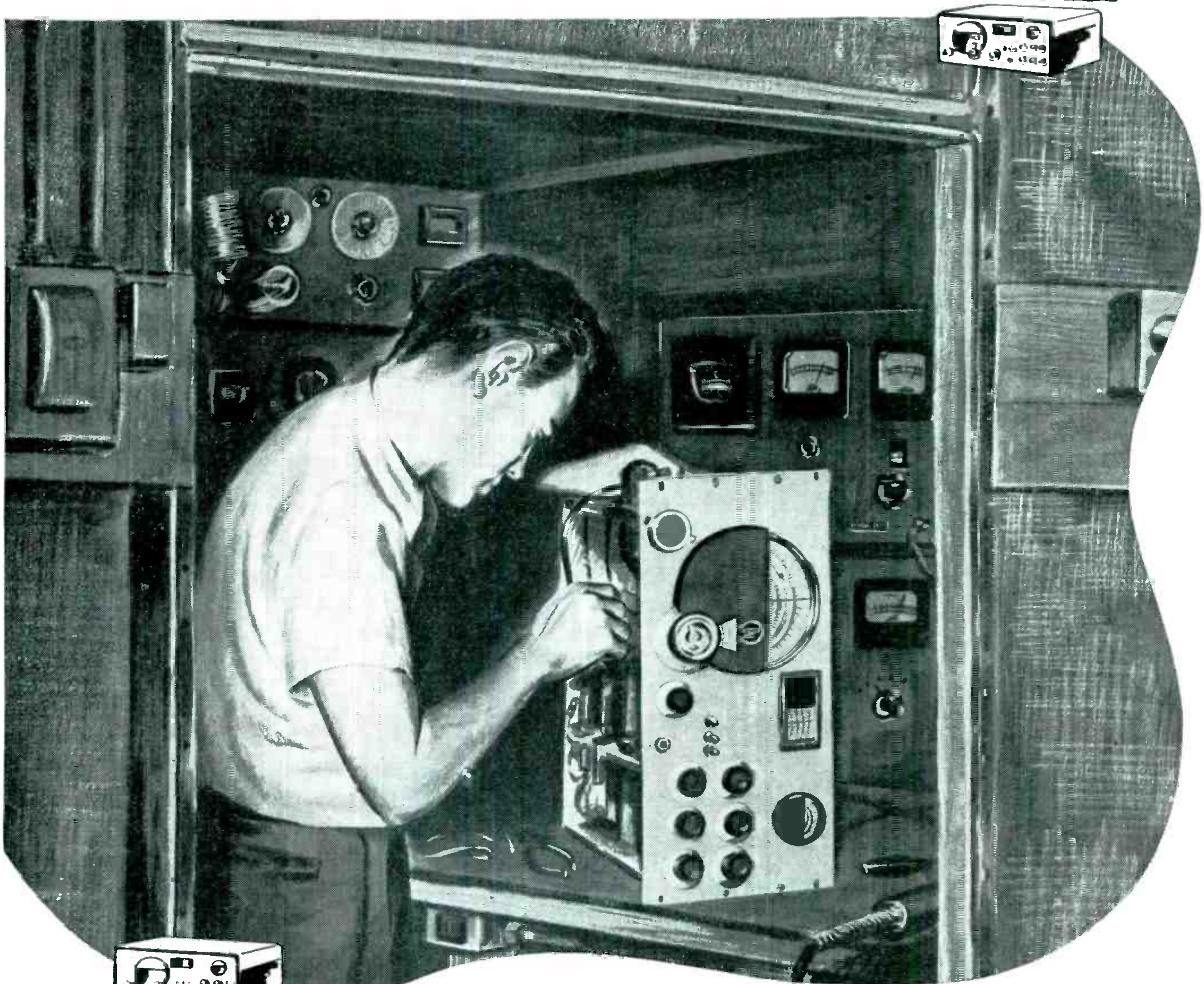
ALSIMAG

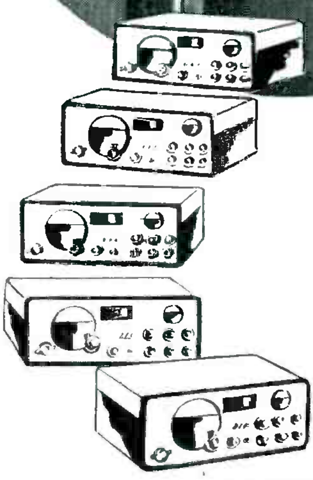
AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE
44TH YEAR OF CERAMIC LEADERSHIP

ENGINEERING SERVICE OFFICES:
ST. LOUIS, Mo., 1123 Washington Ave., Tel: Garfield 4959 • NEWARK, N. J., 671 Broad Street, Tel: Mitchell 2-8159
CAMBRIDGE, Mass., 38-B Brattle St., Tel: Kirkland 4498 • CHICAGO, 9 S. Clinton St., Tel: Central 1721
SAN FRANCISCO, 163 Second St., Tel: Douglas 2464 • LOS ANGELES, 324 N. San Pedro St., Tel: Mutual 9076

The first hundred sets are the hardest . . .







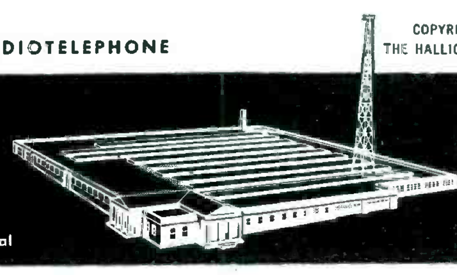
YOU can take it from Hallicrafters: the first hundred radio sets of any new model are the hardest. Hallicrafters is completing a run of 100 of the new Model SX-42. This extraordinary set has been more than a year in the making and behind it are more than 20 years intensive experience in the manufacture of high frequency communications equipment. The first 100 SX-42's have been checked, re-checked in a thousand and one testing operations. Because the set covers from 540 kc to 110 Mc *continuously* in six bands it must be as delicately balanced and precisely aligned as an expensive watch. One out of every five persons on the SX-42 assembly line is an inspector, watchdog over the strictest Hallicrafters standards. The first 100 SX-42's are now being placed in the hands of radio technicians, engineers, amateurs all over the world. These qualified critics will submit to Hallicrafters detailed reports. This final field testing of this great new receiver will bring the SX-42 one step closer to reality for you. Watch for the SX-42, wait for the SX-42 . . . the radio man's radio . . . the radio that's remembered by the veteran . . . preferred by the amateur. . .

BUILDERS OF *Skyfone* AVIATION RADIOTELEPHONE

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



Don't Just Buy...Ask!

"Micro Switch" is not a generic term classifying a certain type of small switch.

"Micro Switch" is the identifying mark of a very extensive line of precision snap-action switch products which can be designed and built to meet certain specific applications.

Therefore when it is advantageous for you to employ precision snap-action switching do not just *buy* a "Micro Switch." Ask us for our suggestions, guidance and assistance in supplying you with the Micro Switch snap-action principle in the form that will most exactly meet your requirements.

There is no one "Micro Switch" but there are 3365 combinations of electrical characteristics, actuators and housings available to you in which the Micro Switch snap-action principle can be best employed for your particular purpose.

However, to give you that principle in the combination most correct for your purpose we have to know your problem. *Your* problem, *plus* our solution equals *the* answer to your requirements.

Many people think of the "MICRO" precision switch as a small plastic enclosed single switch. It is much more than this. It is our interpretation of your problem, and the application of the Micro Switch snap-action principle in a certain type of housing, with a certain type of actuator, with just the right pretravel and overtravel of the plunger; the correct operating force, and the proper movement differential to your product—a combination of all those factors that will best perform the function for which it was intended.

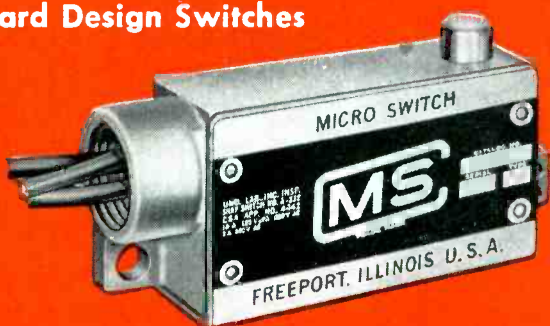
Illustrated below are five standard forms of housings in which the Micro Switch snap-action principle is generally employed. The captions underneath these illustrations tell the wide variety of combinations in which each can be supplied. Also illustrated are three special designs which further indicate the broad opportunity which exists for the application of the Micro Switch snap-action principle. Switches that will meet most requirements are available in the five standard housings shown. *Samples are not available in the special designs illustrated.*

The opposite page tells you how, too, can secure information as to the correct application of the Micro Switch principle to your product.

Standard Design Switches

"V3" Switches
Offer 6 Combinations

Basic Switches
Offer 2,385 Combinations



"LN" Switches
Offer 305 Combinations

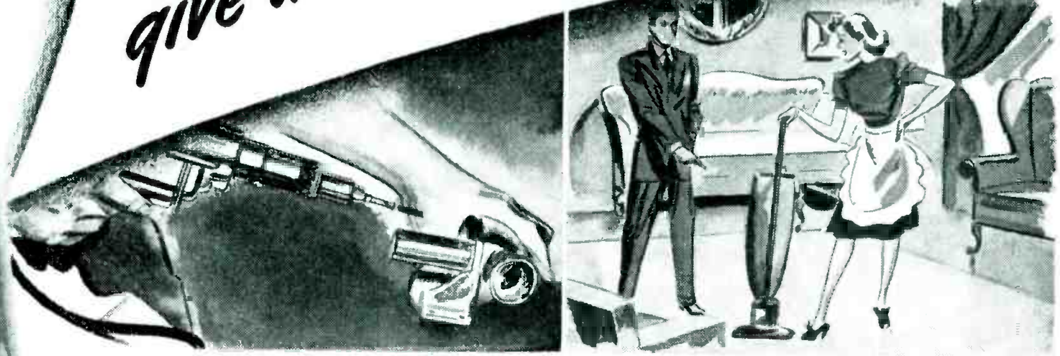
Die Cast Switches
Offer 637 Combinations

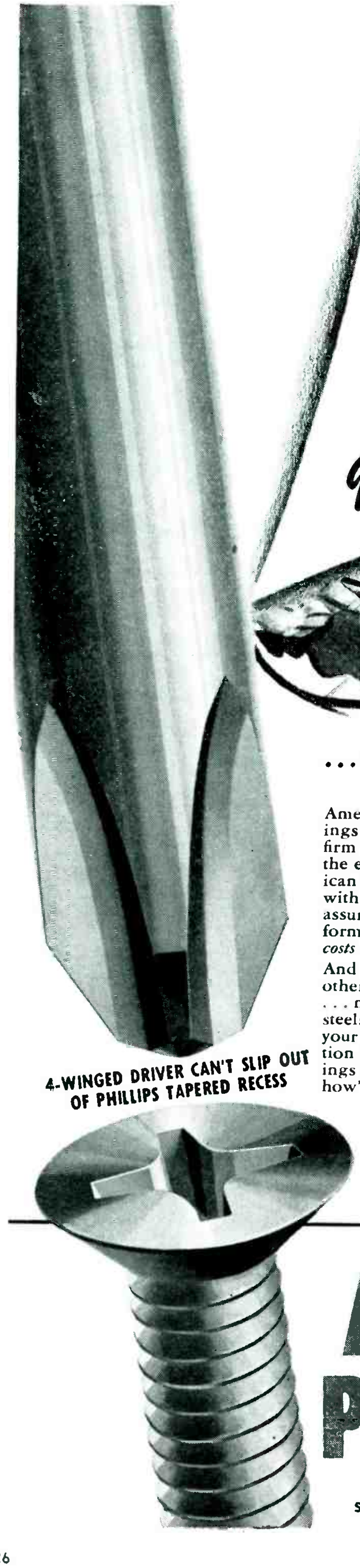
Explosion Proof Switches
Offer 32 Combinations

Special Designs

THIS TRADEMARK MS IDENTIFIES PRECISION SNAP-ACTION

AMERICAN PHILLIPS SCREWS give all these savings:–





...in *your* hands

American Phillips Screws begin your savings with *speed of handling* . . . which means firm fit of the 4-winged Phillips Driver into the engineered, tapered recess. And American Phillips Screws build up your savings with *automatic straight-driving accuracy.* assured by the fact that screw and driver form one single, straight-line unit. *Assembly costs drop 50%.*

And American tops your savings above all others by its special knowledge of metals . . . not only brass, and bronze, but stainless steels, monel, aluminum, everdur. Bring your fastening problems to the "Information Center," and get extra, engineered savings from the greater metallurgical "know-how" of American Phillips engineers.

...in *your customers'* hands

American Phillips Screws are more than sales promotion . . . *they are sales protection.* For products assembled with these good-looking, vibration-resistant fastenings are the products that *last.*

Users don't have to leave a vac (or any other Phillips-assembled product) idle because a "screw is loose somewhere." American Phillips Screws hug up tight and flush . . . and stay there for the life of the product.

If *you* use American Phillips Screws in *your* product, merchandise them for all they're worth—*and they're worth plenty!*

If you aren't using them . . . add them now to *your* sales promotion program.

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

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

AMERICAN PHILLIPS *Screws*

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

SOLD THROUGH INDUSTRIAL SUPPLY DISTRIBUTORS


CRL
Centralab
CERAMIC
TUBULAR CAPACITORS
. . . from the ceramic which houses the capacitor to the silver paint and copper plating, every part of these capacitors is completely fabricated by CENTRALAB.
. . . no wonder that all Centralab Tubular capacitors hold such fine tolerances.
Always Specify Centralab.
CRL
Centralab
Division of GLOBE-UNION INC., Milwaukee
PRODUCERS OF
Ceramic Trimmers
Bulletin 695
Ceramic High Voltage Capacitors
Bulletin 814
Variable Resistors
Bulletin 697
Tubular Ceramic
Capacitors
Bulletins 630 and 586
Selector Switches
Bulletin 722

FOR IMMEDIATE DELIVERY

The Model 15-BL RCA electronic power generator.

The work unit for the Model 15-BL.

The Model 2-BL RCA electronic power generator. Separate work unit on top can be located anywhere within a 25-ft. radius of generator.

RCA Electronic Induction Heating Equipment

Separate work units permit convenient arrangement of equipment

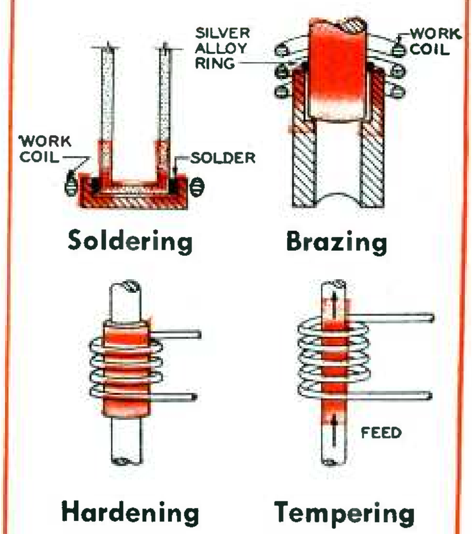
With this immediately available equipment you can begin at once to realize the advantages of electronic heat—simplify tough jobs, cut cost, reduce rejects, speed production.

The larger equipment will help you speed brazing and many hardening jobs. The 2-BL unit is "a natural" for smaller jobs such as soldering condenser cans, terminals, radiator valves, watch cases, etc.

In each case the work unit is separate from the generator and can be mounted right next to the assembly line; the generator can be placed as much as 25 feet away, out of the working area. For the larger unit, a kit of components can be furnished in lieu of the work unit, for direct mounting on conveyors or other mechanized setups. Many other exclusive RCA features contribute to ease of operation, accessibility, low maintenance, and safety.

Installation supervision and initial operator training is provided at no extra cost to you. A contract is available for complete service and maintenance by RCA.

An indication from you of your requirements will assure immediate shipment of this hard-to-get equipment. Write: Dept. 30-J, Electronic Apparatus Section, Radio Corporation of America, Camden, New Jersey.



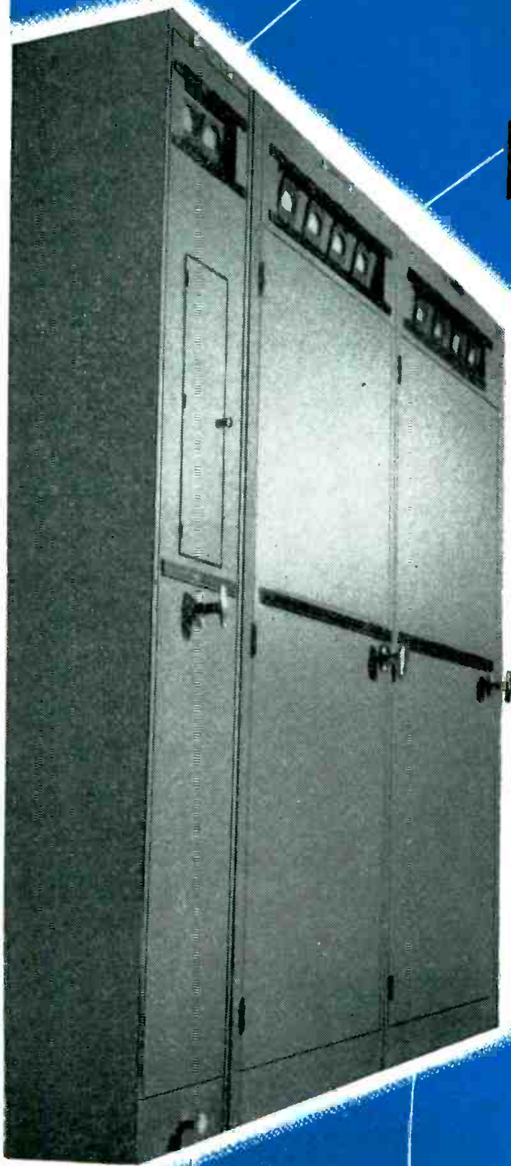
ELECTRONIC HEATING

RADIO CORPORATION of AMERICA

ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: R C A VICTOR Company Limited, Montreal

INFORMATION PLEASE!



Radio communication is as vital to the airways as rails are to the railroads. For high performance, dependability, and easy maintenance, WILCOX radio equipment has earned the confidence of airline personnel throughout the world. Solve your communication problems with Wilcox.

Check the Wilcox 2500 Watt 96C Transmitter For:

1. PERFORMANCE—Transmitter units combine with modulator and rectifier to give either simultaneous transmission on a number of frequencies, or the selection of an individual frequency best suited to the immediate communication problem. Complete remote control.

2. DEPENDABILITY—Research, engineering, and testing combined with highest quality materials result in a rugged product capable of sustained operation through all conditions of temperature, humidity, and weather.

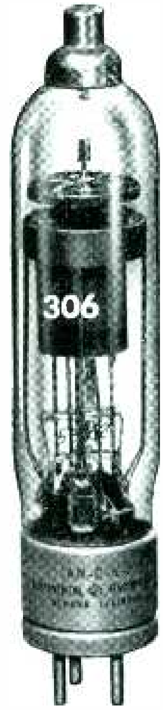
3. MAINTENANCE—All controls and components are completely accessible. Plugs and receptacles or clips make every major section readily removable. Fuses, power and telephone line terminals are located on convenient panels.

4. SAFETY—The disconnect switch at base of transmitter cuts off all voltage and grounds components so unit can be serviced without affecting operation of adjacent channels.

A request on your letterhead will bring complete information

Wilcox Electric Company, Inc.
KANSAS CITY, MISSOURI

Tubes are . . . CHARACTERS!



AMATEUR

BROADCAST

INDUSTRIAL ELECTRONIC

123-209

124-212

122-244

Handle them with Johnson Sockets

SOCKET—	BASE OR TYPICAL TUBE
123-209 123-210	Med 4 Pin Bayonet
123-211	Standard Jumbo 4 Pin
123-216	Giant 5 Pin Bayonet
124-212 124-213 124-214 124-215	833 A 152TL 1500th 204A
120-267 120-277B	9000 series Miniature
121-235 121-245 121-265	Acorn
122-101 122-217 122-224 122-225 122-226 122-227 122-228 122-234 122-237 122-244	829 Small 7 Pin 4 Pin 5 Pin 6 Pin 7 Pin Med. Octal RK72 7 Pin Large Super Jumbo (Industrial No. 412 Base
122-247 122-248 122-275 124-220	826 826 Giant 5 Pin 899R

There are many types in the tube family. Like humans they differ in appearance and performance. Each makes individual demands on its socket. A JOHNSON socket accomodates the 4-250A where provision for adequate heat dissapation is a major requirement. JOHNSON designed the first ceramic socket for miniature tubes where the socket must hold the small pins firmly and still accomodate minor variations without fracturing the envelope.

JOHNSON has achieved unusual prominence through skill in engineering both ceramics and metal to meet these demands. Experienced electronic engineers recognize and provide for tube and circuit requirements. Confidence, cooperation and assistance on the part of tube manufacturers explain the more complete line, and why JOHNSON is the only manufacturer producing some types.

When you need sockets look to JOHNSON. The price is usually no more, frequently less.

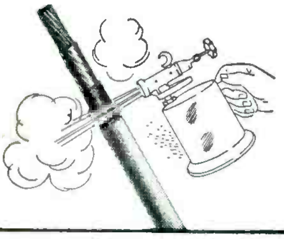
For more information write Dept. D

JOHNSON

a famous name in Radio

E. F. JOHNSON CO. WASECA, MINN.

1 WON'T BURN OR SUPPORT FLAME



SIX REASONS WHY ROCKBESTOS WIRES AND CABLES

Give Your Products

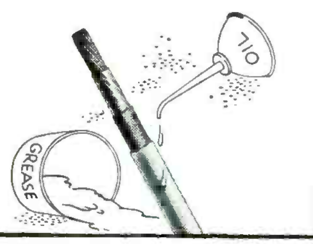
Performance Protection

Longer Life

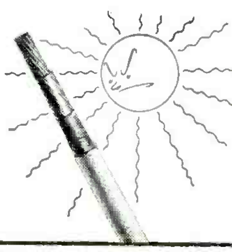
and Added Sales Appeal

2 PERMANENTLY AGE RESISTANT

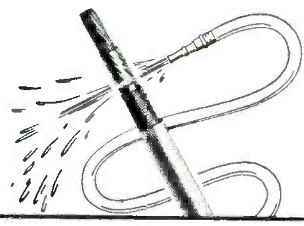
3 OIL AND GREASE RESISTANT



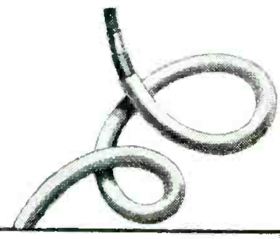
4 RESISTS HEAT AND OXIDATION



5 MOISTURE RESISTANT



6 REMAINS FLEXIBLE



Offer "Immediate Delivery" today and you can sell electrical products in quantity regardless of quality. But will they stay sold . . . or will dissatisfied customers run up your operating costs with demands for replacements, repairs or servicing?

There's no substitute for quality when performance has to sell your product and keep it sold. And where wire is concerned you can guard against future trouble and build a reputation that will increase sales by wiring with *permanently insulated* Rockbestos wires, cables and cords. They are built to outlast your product . . . insulated with heat, flame and age resistant impregnated asbestos to eliminate failures caused by overloads, high ambient temperatures and hard usage under severe operating conditions.

Let Rockbestos *permanently insulated* wires help guarantee the performance of whatever you make . . . aircraft, buses, cranes, electronic calculators and controls, locomotives, motors, radio transmitters, ranges and hundreds of others. For recommendations or a catalog write to:

ROCKBESTOS PRODUCTS CORPORATION
440 Nicoll St., New Haven 4, Conn.

ROCKBESTOS
The Wire with Permanent Insulation

A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos to protect performance and give lasting service.

ROCKBESTOS FIREWALL HOOKUP WIRE

This heat, flame and moisture resistant wire, insulated with high dielectric tapes and impregnated felted asbestos and covered with color-coded, lacquered glass braid, has a maximum operating temperature of 125° C. Ideal for radios, television, amplifiers, calculators or small motor, coil, dynamotor and transformer leads. No. 22 to 4AWG in 1000 volt rating — No. 12, 14 and 16 AWG in 3,000 volt, also in twisted pair, tripled, shielded and multi-conductor constructions.

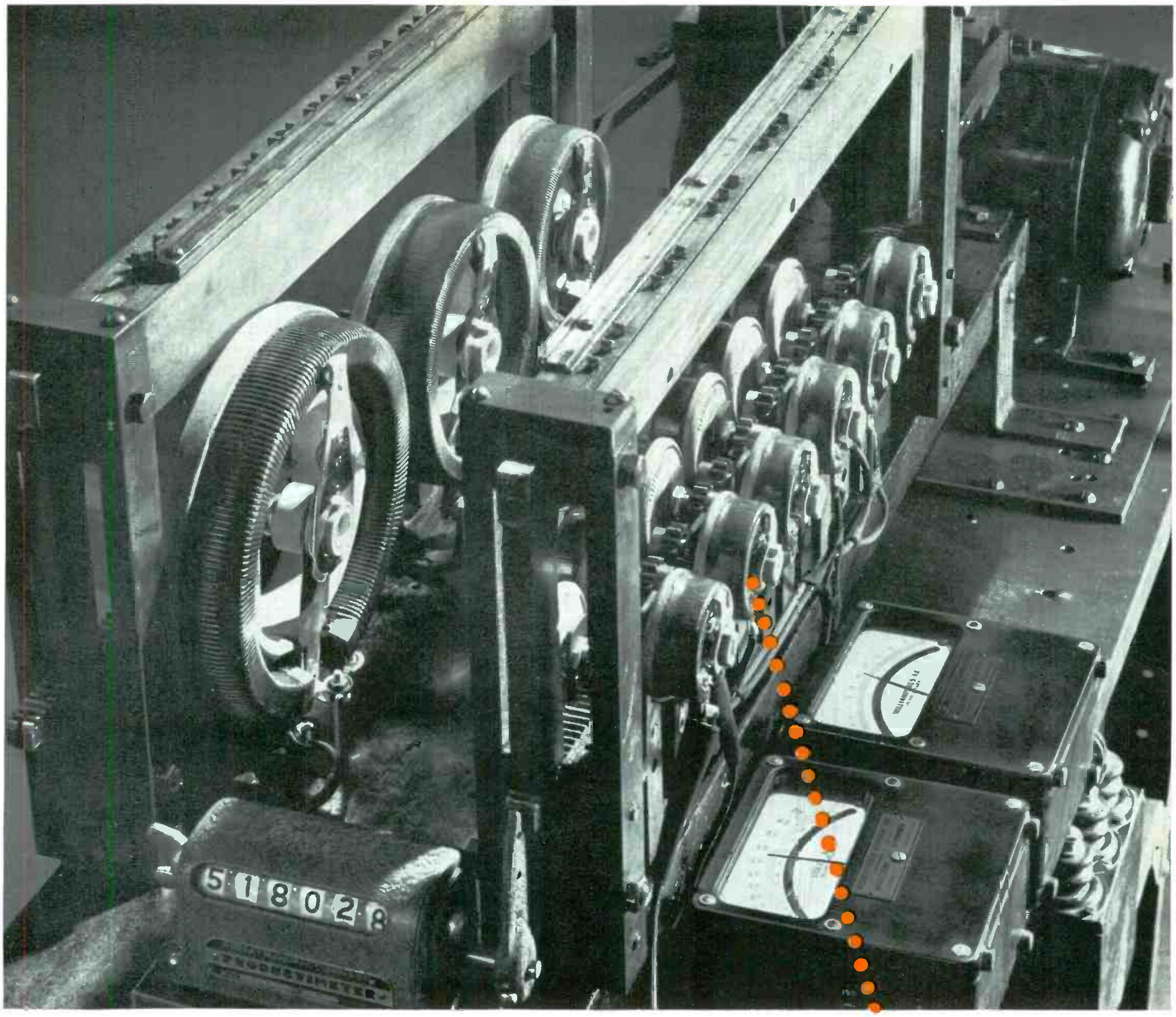
ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for low voltage intercommunications, signal and temperature control systems. Its asbestos insulation and steel armor assure trouble-free circuits. Sizes No. 14 to 18 AWG in two to five conductors with .0125", or .025" — or (for 115 volt service) .031" impregnated asbestos insulation.

ROCKBESTOS A.V.C. MOTOR LEAD CABLE

Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads and high ambient temperatures. Insulated with impregnated felted asbestos and varnished cambric, and covered with a heavy asbestos braid, it is heat-proof and resistant to oil, grease, moisture and flame. Sizes 18 AWG to 1,000,000 CM.

NEW YORK BUFFALO CLEVELAND CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.



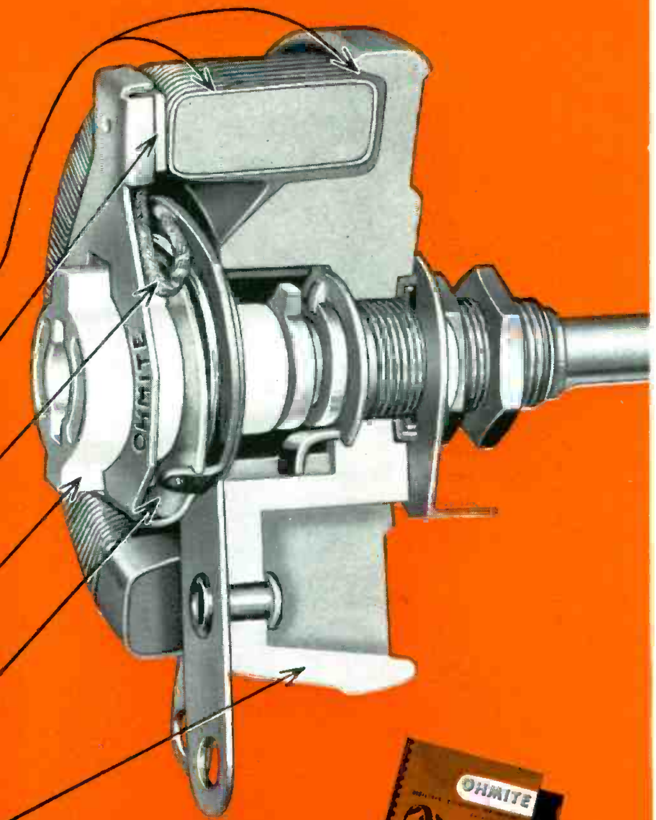
Crowding Years of Rheostat Life ...into a Few Hours

Back and forth . . . back and forth . . . twenty times a minute for days and weeks . . . these Ohmite rheostats are rotated continuously under full electrical load. It's Ohmite's way of condensing a lifetime of grueling rheostat service into a few days, in order to make sure that Ohmite rheostats will stand up under the toughest service conditions. Every new Ohmite rheostat development is pre-tested in this manner on a specially-designed, rotation life testing machine in the Ohmite laboratories before it is released for production. That's just one more reason why you can depend upon Ohmite rheostats for years of unfailing, trouble-free life.

Be Right with... OHMITE

RHEOSTATS • RESISTORS • TAP SWITCHES

Here's why you get YEARS OF UNFAILING OPERATION with OHMITE Rheostats



Ohmite rheostats are engineered to give long, trouble-free service and unmatched smoothness of action. Following are a few of the features that make possible their outstanding performance:

- **VITREOUS ENAMEL BOND**—Core and base are bonded together by vitreous enamel into one integral unit. Each turn of wire is also permanently locked in place by vitreous enamel.
- **METAL GRAPHITE BRUSH**—Perfect contact with negligible wear on the wire is insured by the metal-graphite contact brush (varied to fit the current and resistance) and the large, flat contact surface.
- **LARGE PIGTAIL SHUNT**—Current is carried directly to the slip-ring by a pigtail shunt of ample size, assuring an uninterrupted connection at all times. Large slip-ring minimizes mechanical wear.
- **INSULATED SHAFT AND BUSHING**—High strength ceramic hub insulates the shaft and bushing from all live parts. Underwriters' Laboratories listed models are available.
- **UNIFORM CONTACT PRESSURE**—Tempered steel contact arm forms a long steel spring which assures uniform contact pressure. Universal joint action of the brush maintains "flush-floating" contact.
- **ALL CERAMIC AND METAL CONSTRUCTION**—Ohmite rheostats have a ceramic core, base, and driving hub. There is only ceramic and metal in their construction—nothing to char, burn, shrink, or deteriorate. They are designed for long, trouble-free life.

OHMITE MANUFACTURING COMPANY
4817 Flournoy Street, Chicago 44, Illinois

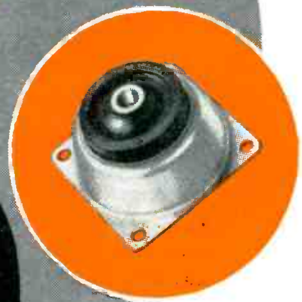
Write on company letterhead for Catalog and Engineering Manual No. 40.

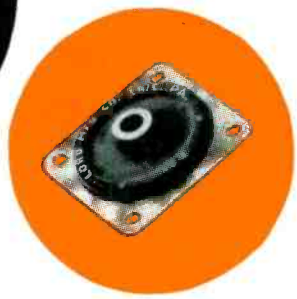
Vibration

LOWERS WORKERS' MORALE
SHORTENS MACHINE LIFE
INCREASES REJECTS
CUTS YOUR PROFITS

Control it with

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS





"VIBRATION nerves" are not the only cause of industrial fatigue, but they are a sure cause . . . and controllable, because vibration is controllable. Lord, pioneer in vibration control, has made better working conditions for hundreds of manufacturers, with consequent improved morale, increased output, and lowered employee turnover.

Machines, as well as men, are vulnerable to the destructive forces of vibration. Vibration control improves the quality of the machine's output, lowers maintenance cost, and greatly extends its useful life.

Vibration control is a necessary preliminary to quality control. Better workers and smoothly functioning machines are reflected immediately in the inspector's report of fewer rejects. It all points up to the prime objective of all industrial effort—increased profits.

Lord-engineered vibration control in your plant is a small investment with large and far-reaching returns. Write for Bulletin 104.

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

IT TAKES BONDED RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

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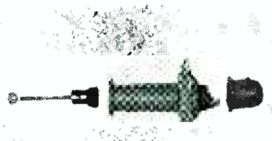
CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

AIRCRAFT RADAR SCANNER TYPE AN/APS-6

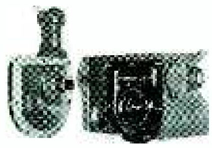


APS 6 AIR PUMP

The Dalmo-Victor designed air pump is a slow-speed, single-action piston pump, which requires no extra power source. Air is delivered to rear joint of the antenna wave guide, and will maintain a pressure of 10 pounds per square inch gauge at all altitudes up to 30,000′ above sea level against an air leakage of 4 cubic inches of free air per minute.

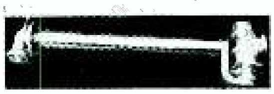
FEED HORN

This feed is a pressurized X-Band rear feed horn for circular paraboloids. The electrical features include high gain, low VSWR, and external tuning adjustment. The mechanical features include 100 per cent pressure tight sealing, light weight, few parts, and ease of fabrication and assembly.



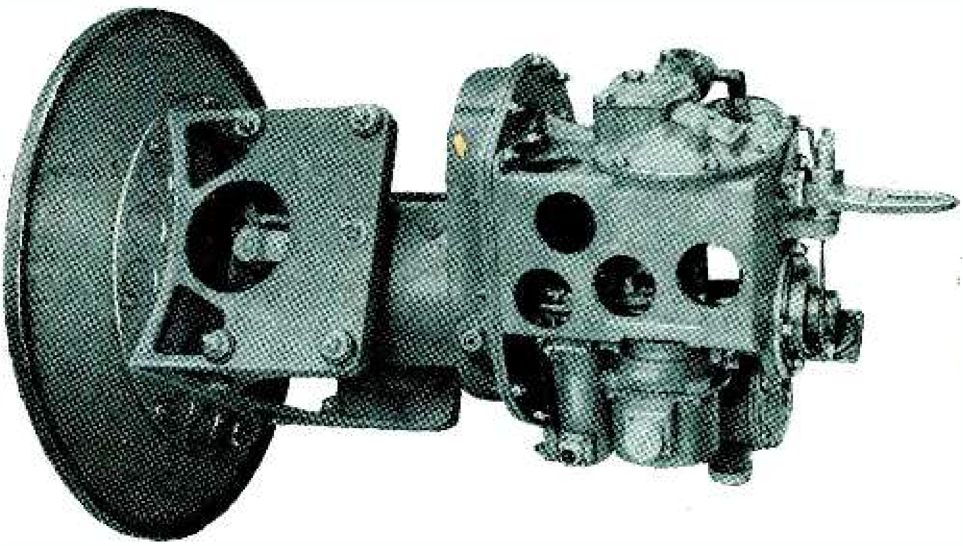
MAIN GEAR HOUSING

The AN/APS-6 Antenna is a high-speed spiral type of scanner driven at 1200 r.p.m. through enclosed helical gearing, and simultaneous nod motion is introduced by means of a crank reciprocated rack and pinion mechanism to imoart a nod motion of ± 60° at a rate of 15 complete nod cycles per minute.



APS 6 WAVEGUIDE ASSEMBLY

The waveguide components of the AN/APS-6 Antenna consist of rear joint, spindle, oscillating joint and antenna feed horn. Waveguide components are pressurizable and use externally adjustable button tuning.



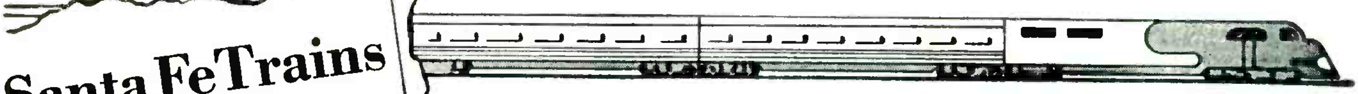
At the close of hostilities Dalmo-Victor was producing and delivering nearly 90% of the night fighter Radar Antenna-Scanners used by the U. S. Navy. We had developed the top quality product in this field.

Our "know-how" is ready for commercial and research development purposes, our engineering and electronic research staff is intact, our manufacturing and testing facilities are ample. We solicit inquiries from electronic engineers, aircraft companies — from all who may be properly interested.

DALMO VICTOR

SAN CARLOS, CALIFORNIA

All aboard... to music!



Santa Fe Trains To Get Radio, Music Systems

In announcing forthcoming installation of musical wire reproducers, radio and public address systems on their passenger trains, Fred G. Gurley, president of the Atchison, Topeka, and Santa Fe Railway, yesterday disclosed that individual outlets will be placed in sleeping cars.

Each roomette, bedroom, compartment, and drawing room will be equipped with push-button selector, a loud speaker, and volume control, so that occupants may have their choice of radio or wire-reproduced popular or semi-classical music, Mr. Gurley stated. A pilot lamp, lighting automatically when the announcement system is in use, will be installed so that passengers may turn the system on if they so desire.

As a forerunner of this innovation, wire reproducing units providing programs of various types of music, will be placed on the Santa Fe dining car 1450 when it goes into transcontinental service on March 10. As soon as equipment and labor are available, the railroad president declared, similar installations will be made on both new and old dining cars, as well as sleeping, chair, and club-lounge cars.

Speakers will be placed in the ceiling of these cars to provide an even distribution of low-level sound throughout the car. The volume will be set at an advantageous point for both the listener and conversationalist, it was stated.

Farnsworth Television and Radio Corporation of Fort Wayne, Indiana, designed the over-all integrated system.

Reprinted from the Chicago Journal of Commerce, March 4, 1946.

New Program Distribution Systems Make Rail Travel More Pleasant; Will Increase Passenger Traffic!

Systems Produced by Pioneers in Quality Sound Reproduction, Communications and Television.

Music now brings its magic to the railway passenger—and gives railroads another tool with which to sell travel by rail!

In announcing the first modern electronic program distribution systems for railroads, the Farnsworth Television & Radio Corporation takes a logical step forward. Known for its superlative phonograph-radios, including The Capehart, for its pioneering in the fields of tonal reproduction, television and other forms of electronics, Farnsworth now extends its engineering knowledge and manufacturing skill to the field of passenger entertainment.

These new systems will meet the varying tastes of passengers and the specific operating conditions of individual roads. Based upon the knowledge secured from railroad-conducted surveys, the most complete Farnsworth system provides four channels for individual selection: one for classical and one for popular music; a third for radio programs; and a fourth for train announcements and travel talks. More simplified Farnsworth Systems are also available.

Farnsworth engineering has met and overcome the problems peculiar to pleasing sound reproduction in passenger cars, including the need for uniform, low-level distribution and automatic compensation for varying ambient noise levels.

With these comprehensive, flexible systems, railroads can now provide passengers with the same standard of entertainment and comfort they expect in their own homes. Farnsworth Television & Radio Corporation, Fort Wayne 1, Indiana.

Farnsworth

MAKERS OF

THE CAPEHART • THE PANAMUSE BY CAPEHART

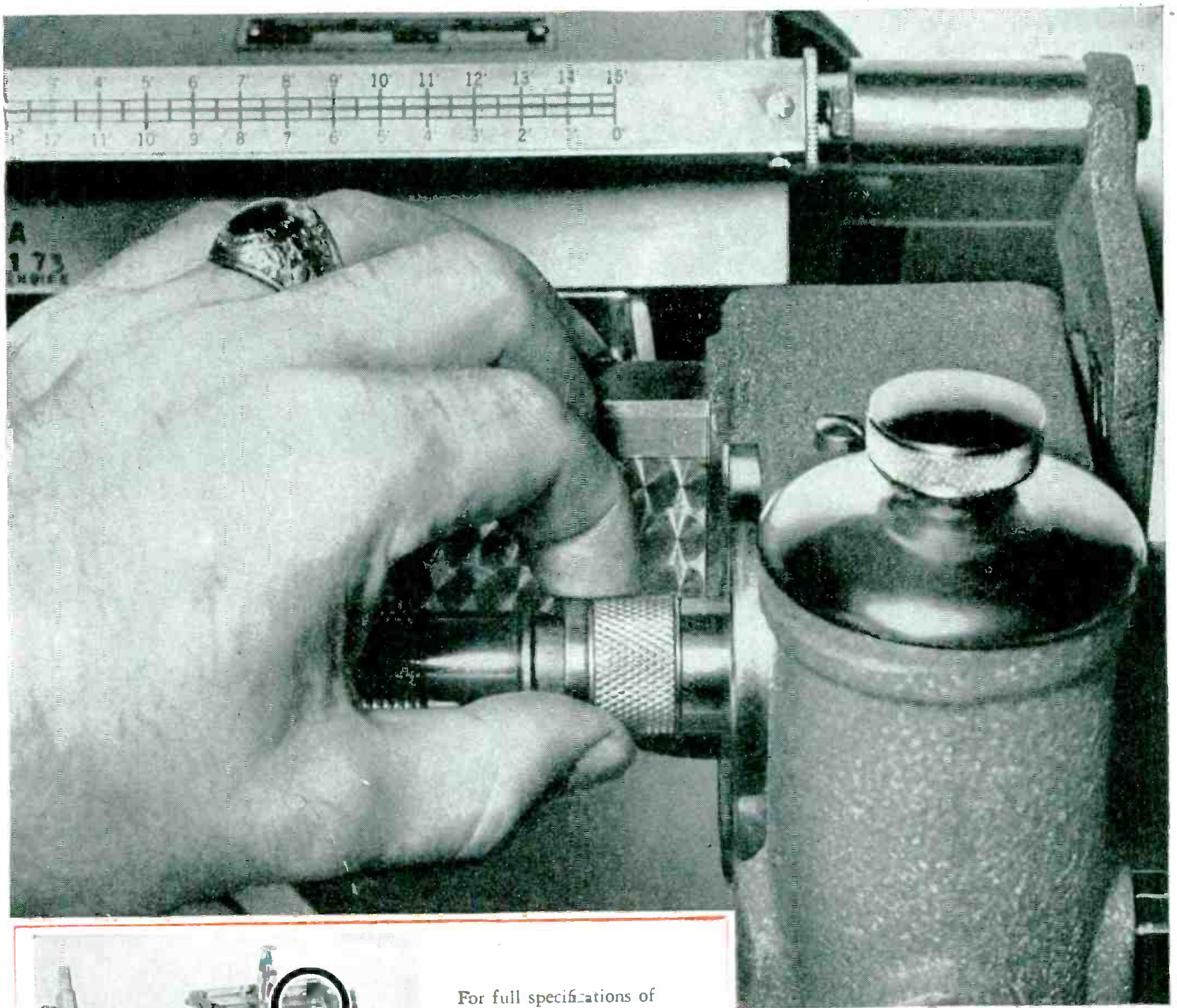
Other Products Include: Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • The Farnsworth Phonograph-Radio

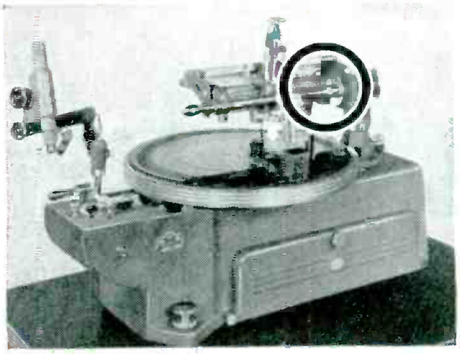
Where there is Horsepower... *There is Wire*

The earth . . . like a busy caterpillar . . . spun round itself a cocoon of copper wire.

And from that chrysalis there hatched a brood of flying horsepower that brought a new civilization . . . brought dignity to drudges . . . power to the weak—a new joy in living to almost everyone.

Each day finds new fields of progress . . . new services to man . . . each with its peculiar *need* for wire, to generate . . . to direct . . . to harness . . . to control . . . and to utilize its particular breed of horsepower. These special wire requirements are met with ten thousand different engineering achievements by the wiremakers—such as Belden.





every time we do this stunt—

A Manufacturer Cuts His Production Costs!

Bending over backwards for our customers is part of C-D's service. Actually though, designing a special type capacitor may not be so strenuous a job for us. Not because your capacitor problem is a breeze. It simply comes easier to us, than to most other manufacturers, to bend ourselves to specialized tasks.

For, in the course of designing and manufacturing over 1/4 of a million different types of capacitors, our engineers have gathered a wealth of information, experience, or call it "know-how" that speeds the solution to every problem they handle. And the sooner your requirements are met . . . the more perfect the design — the greater are your savings. Typically, of the many problems C-D engineers have successfully licked are the capacitor types shown below.

If your plans call for anything in capacitors, consult with our engineers. Catalog of standard types available on request.

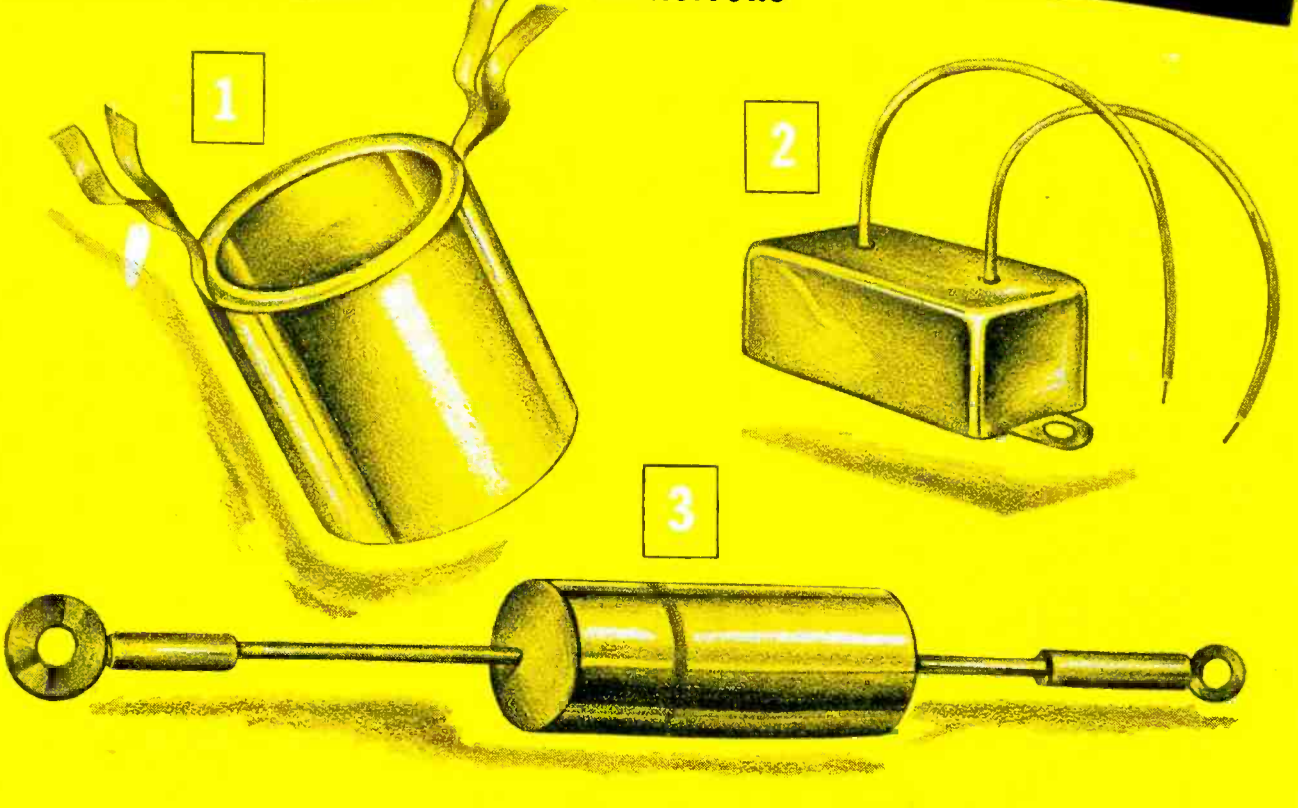
Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. Five other plants in New Bedford, Providence, Worcester and Brookline.

CORNELL-DUBILIER
world's largest manufacturer of
CAPACITORS

MICA • DYKANOL • PAPER • ELECTROLYTIC CAPACITORS

CORNELL-DUBILIER CAPACITORS

A FEW OF C-D's MADE-TO-ORDER CAPACITORS



CAPACITOR #1. This capacitor unit was designed for a manufacturer of motors. Mounts directly on motor shaft.

CAPACITOR #2. Designed for spark suppressor applications in home appliance equipment. An inexpensive dependable unit for competitively priced mixers, juicers, grinders, etc.

CAPACITOR #3. Standard paper tubular capacitor adapted for automobile ammeter, oil pump, radio noise filter applications, etc.

MAILED FREE *on request!*

At last! Industries' *new* and *revolutionary heating process* explained in a language understandable to everyone. In fifteen minutes reading time, you will gain a complete basic knowledge of Electronic Heating. This important handbook discusses all the essential facts you have to know in considering the application of Electronic Heating to your own manufacturing methods.

It contains a brief record of the historical background and development of the process — explains the principle of its operation — describes the two chief methods and fields of application and lists many proved present-day uses.

Let us send you a complimentary copy at once. Fill in the coupon or write on your company letterhead.

Manufacturers of Vacuum Tube and Spark Gap Converters since 1921

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

107 Monroe Street **Garfield, New Jersey**

USE THIS COUPON FOR CONVENIENCE

SCIENTIFIC ELECTRIC
107 Monroe Street, Garfield, N. J.

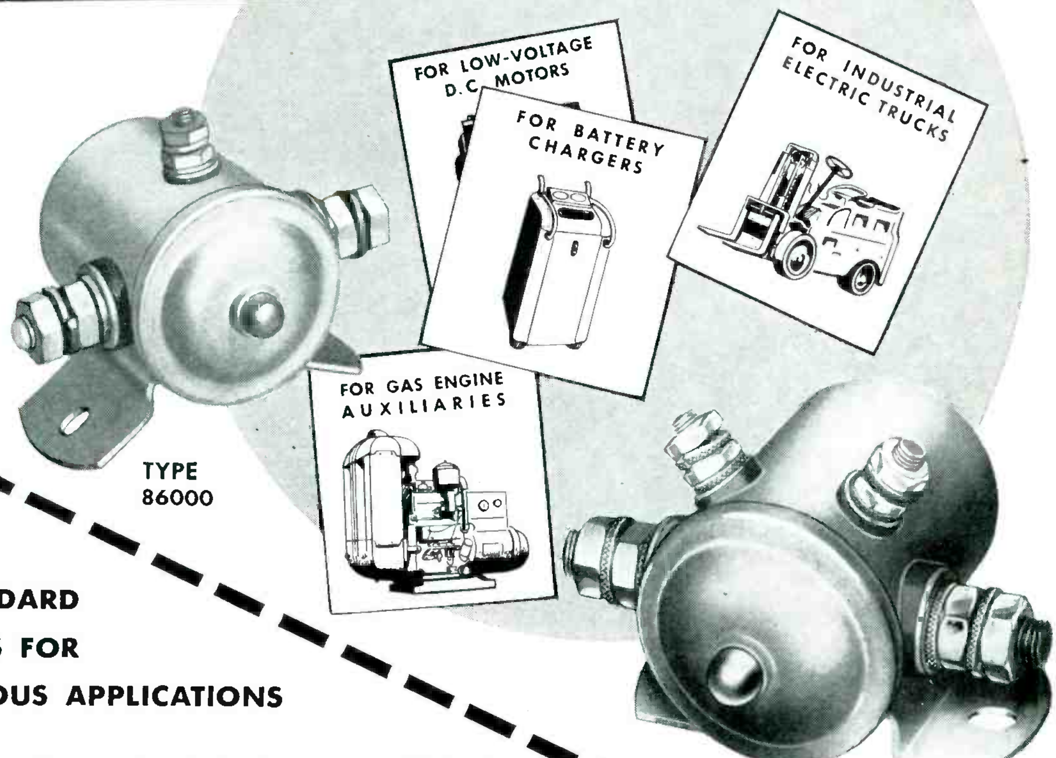
Please rush my complimentary copy of *The ABC of Electronic Heating* today to:

Name.. Title..............

Company Address..

City.. State..............

TIME-TESTED • PERFORMANCE-PROVED
SOLENOIDS



STANDARD TYPES FOR VARIOUS APPLICATIONS

TYPE 87000

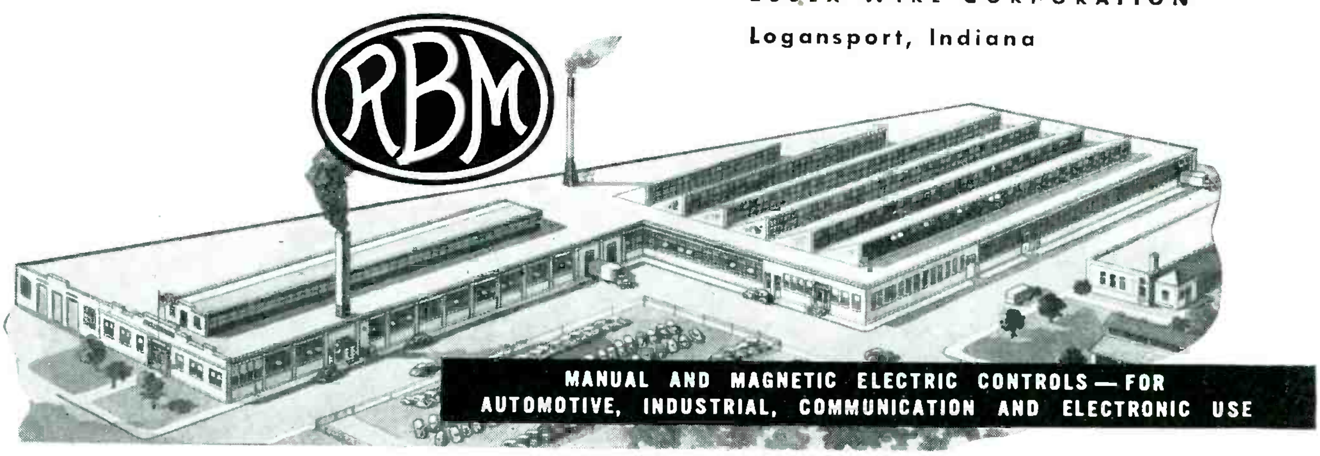
In the past 20 years, hundreds of thousands of R-B-M low voltage D.C. Solenoid Contactors have been giving efficient daily performance as gasoline engine starting contactors—battery charging contactors—low voltage D.C. motor controls—auxiliary contactors for industrial electrical trucks—and on mobile and stationary gasoline engine driven apparatus of all kinds.

R-B-M Solenoid Contactors can be furnished with insulated coil terminals or with one insulated coil terminal; the other coil lead may be grounded or connected to the line terminal. All types can be supplied with either flat or curved mounting bracket.

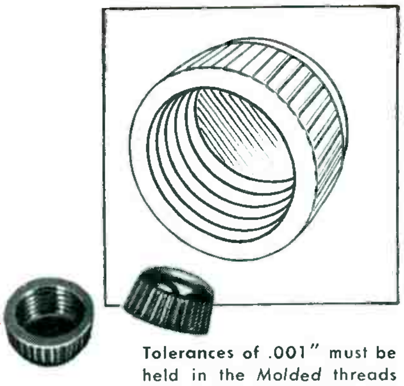
Contacts are single pole, normally open, double break rated at 100 amperes continuous inductive load; or 300 amperes in-rush at 6 volts D.C. and at 50 amperes continuous inductive load or in-rush at 32 volts D.C. Copper contacts are standard, though special alloys are available. Coils are available from 6 to 32 volts D.C. continuous or intermittent duty.

For further information, write for Bulletin 520. Address Dept. A.

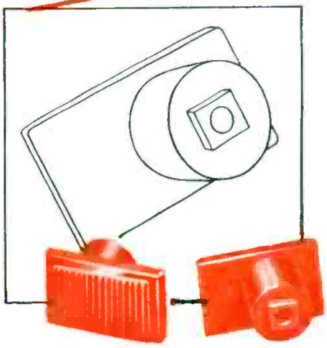
R-B-M DIVISION
ESSEX WIRE CORPORATION
Logansport, Indiana



THE SMALLEST PARTS ARE OFTEN THE TOUGHEST

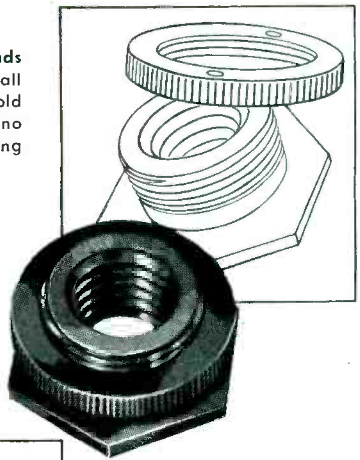


Tolerances of .001" must be held in the *Molded threads of this piece, whose inside diameter is only 5/16 inch.*



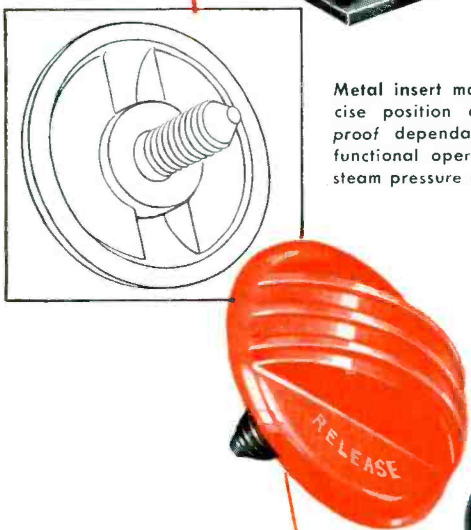
Clean-cut design that adds eye appeal is demanded for this radio push button.

Internal and External threads molded into this bushing call for the most exacting mold making. After molding, no thread cutting or machining is needed.

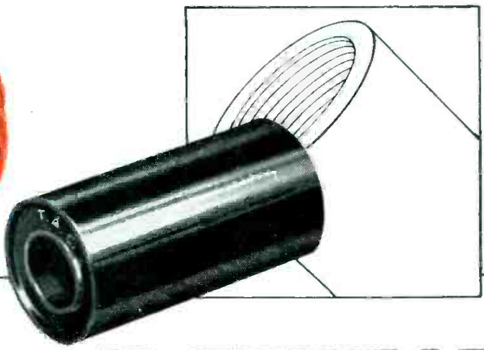


Although the large custom molded pieces attract more attention, we never overlook the importance of the small ones. So no matter whether the part is large or small, whether the requirements simple or complicated, HI-EFF precision workmanship goes into every phase of its production . . . engineering, designing, mold making, molding and finishing. Each of these functions is directed by our own staff of specialists, each handled in our own two modern production plants.

It will pay you to get the facts about HI-EFF facilities when planning molded parts—large or small—for your product. Your inquiry will receive our prompt and expert attention. Taylor Manufacturing Co., 3078 W. Meineke Ave., Milwaukee 10, Wisconsin.



Metal insert molded in precise position assures *fool-proof* dependability in the functional operation of this steam pressure release knob.



High Speed Finishing of this compression molded piece is accomplished by a specially designed machine to do 4 finishing jobs in one operation. *Volume production and low cost is the result.*

TAYLOR OF MILWAUKEE

CUSTOM MOLDERS OF HI-EFF PLASTIC AND RUBBER PARTS

EASTERN AIR DEVICES, INC.

Announces the Opening of their

SPECIAL DESIGN DIVISION

for Fractional H.P. Motors and other Control Components

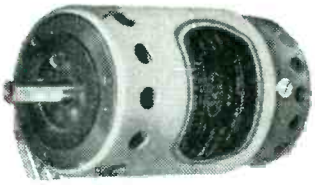
SPECIAL DESIGN
EAD
DIVISION

This department was specifically created to handle problems necessitating "Special Design" control devices.

We are particularly interested in non-catalog, non-standard types of high frequency fractional h.p. motors and other devices, such as special solenoids, tachometer generators and small generators of the permanent magnet type. Consult our "Special Design Division" with your unusual or knotty control problems. Our experienced, creative personnel will originate special devices with or without specifications.

SPECIAL DESIGN
EAD
DIVISION

A FEW SPECIAL MOTORS



J-31 MOTOR
115 volts, 400 cycles. 1/00 to 1/25 H.P. Wt. 15 oz. Designed for Airborne Power and Servo use.

J-36 GENERATOR
Tachometer Generator with Permanent Magnet Field. 2 volts per 100 R.P.M. 1% linearity. Designed for Remote Gunfire Control.

J-61-D MOTOR
Switching Motor, 5 oz. in. thru 45° rotation. 115 volts. 60 cycles. Insensitive to shock. Replaced solenoid on Submarine Radar switching problem.

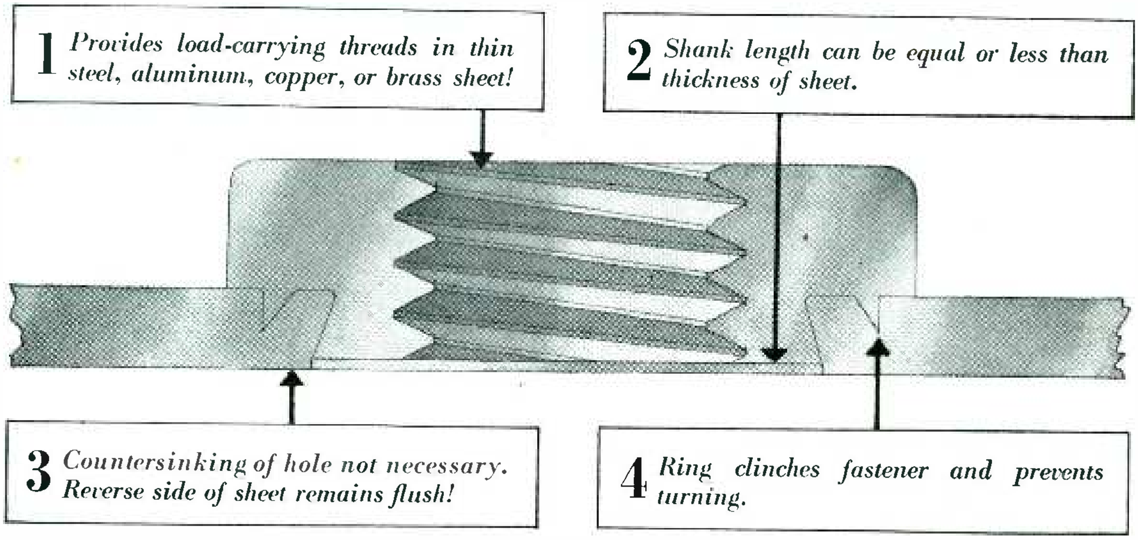
EASTERN AIR DEVICES, INC.

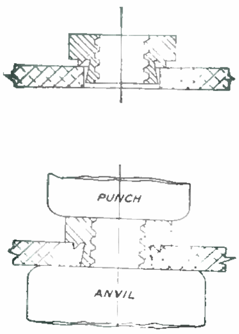
130 FLATBUSH AVENUE, BROOKLYN 17, N. Y.

NEW!

Self-Clinching Fastener

PROVIDES LOAD-CARRYING THREADS IN THIN STEEL, ALUMINUM, COPPER OR BRASS SHEET!





PEM Self-Clinching Fasteners solve assembly problems involving steel, aluminum, copper, or brass sheet. Because no special tools are required, PEM Self-Clinching Fasteners save time, labor, and weight; mean faster, more simplified clinching. For complete information, write to *Penn Engineering and Manufacturing Corporation, Doylestown, Pennsylvania.*

IT'S THIS EASY!

Punch straight hole, insert fastener in sheet, and apply pressure to head of fastener.

Enlarged to show detail. Available in thread sizes #2-56, #4-40, #6-32, #8-32, #10-32, and #10-24.

PEM

PENN ENGINEERING & MANUFACTURING CORP., DOYLESTOWN, PA.

COMPLETE AUDIO FACILITIES WITH

Only 2 Types of AMPLIFIERS VACUUM TUBES

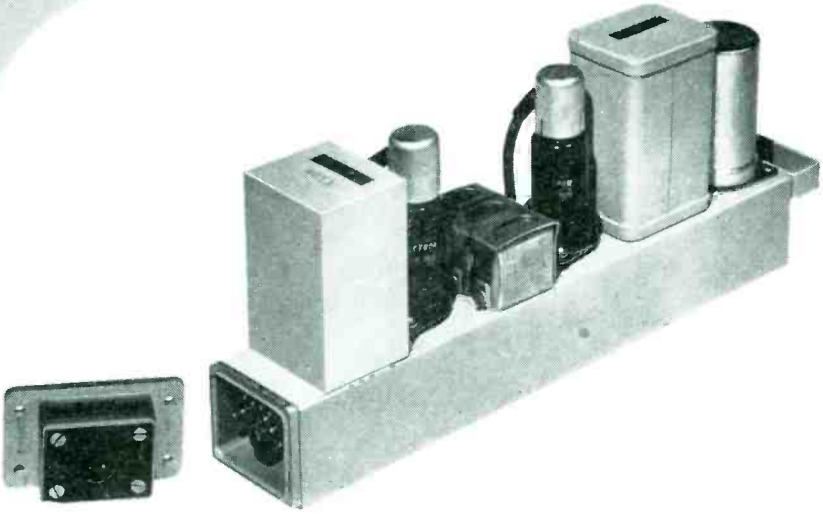
. . . AND ALL PLUG-IN

The Langevin Types 116-A and 117-A Plug-in Amplifiers were developed in collaboration with the General Engineering Department of the Columbia Broadcasting System.

We believe these amplifiers fulfill the desire of many broadcast engineers to simplify their audio facilities. With only these two types of amplifiers even the largest system can be fabricated. Further—in the interest of simplicity—only two types of tubes are required in the operation of both these units (the accompanying power supply uses a selenium rectifier). A replaced amplifier can be serviced when convenient at a test bench, with the aid of a simple service unit designed for that purpose.

Many lessons learned during the War have been incorporated in these amplifiers: They are simple, compact, rugged and of high quality; they are replaceable in a matter of seconds WITHOUT THE USE OF TOOLS; they are designed for easy servicing. And they can be either rack or console mounted; fittings are available. These units are connected into the circuit by means of a plug especially designed for them by Cannon—employing gold plated contacts and a shielded TWIN-AX input connection.

A COMPLETE SYSTEM USING THESE AMPLIFIERS WILL BE BETTER IN ALL RESPECTS THAN THE F.C.C. RECOMMENDATIONS FOR FM.

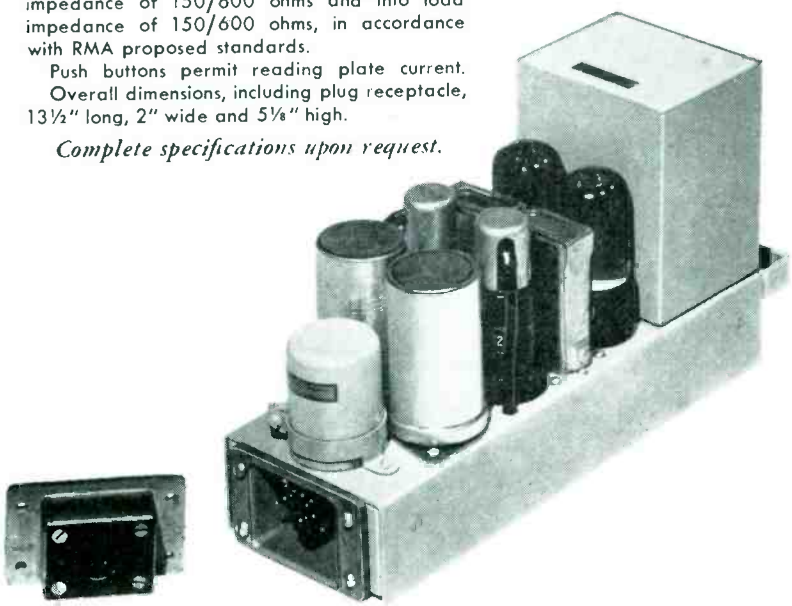


The Type 116-A has been designed for use as a microphone preliminary and as a booster amplifier—gain 36 db. Operates from source impedance of 150/600 ohms and into load impedance of 150/600 ohms, in accordance with RMA proposed standards.

Push buttons permit reading plate current.

Overall dimensions, including plug receptacle, 13½" long, 2" wide and 5⅛" high.

Complete specifications upon request.



The Type 117-A has been designed as a program or monitor amplifier—gain 55 db. Operates from source impedance of 150/600 ohms and into load impedance of 150/600 ohms, in accordance with RMA proposed standards.

Push buttons permit reading plate current.

Overall dimensions, including plug receptacle, 11" long, 3¼" wide and 5½" high.

Complete specifications upon request.

The Langevin Company

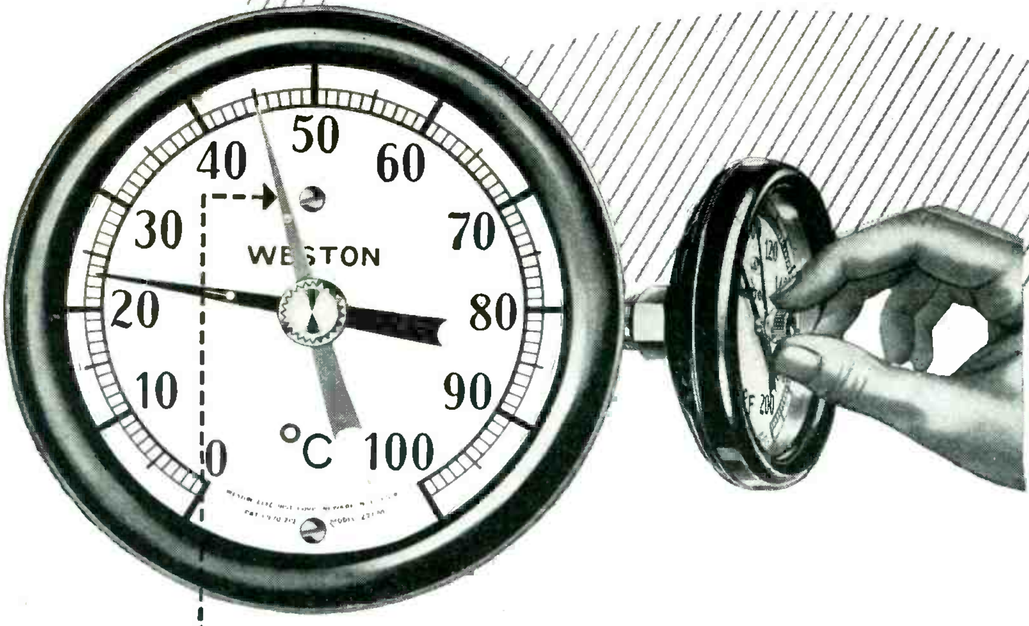
INCORPORATED

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

NEW all metal WESTON

MAXIMUM-MINIMUM Thermometer



RED INDEX shows the highest or lowest temperature reached!

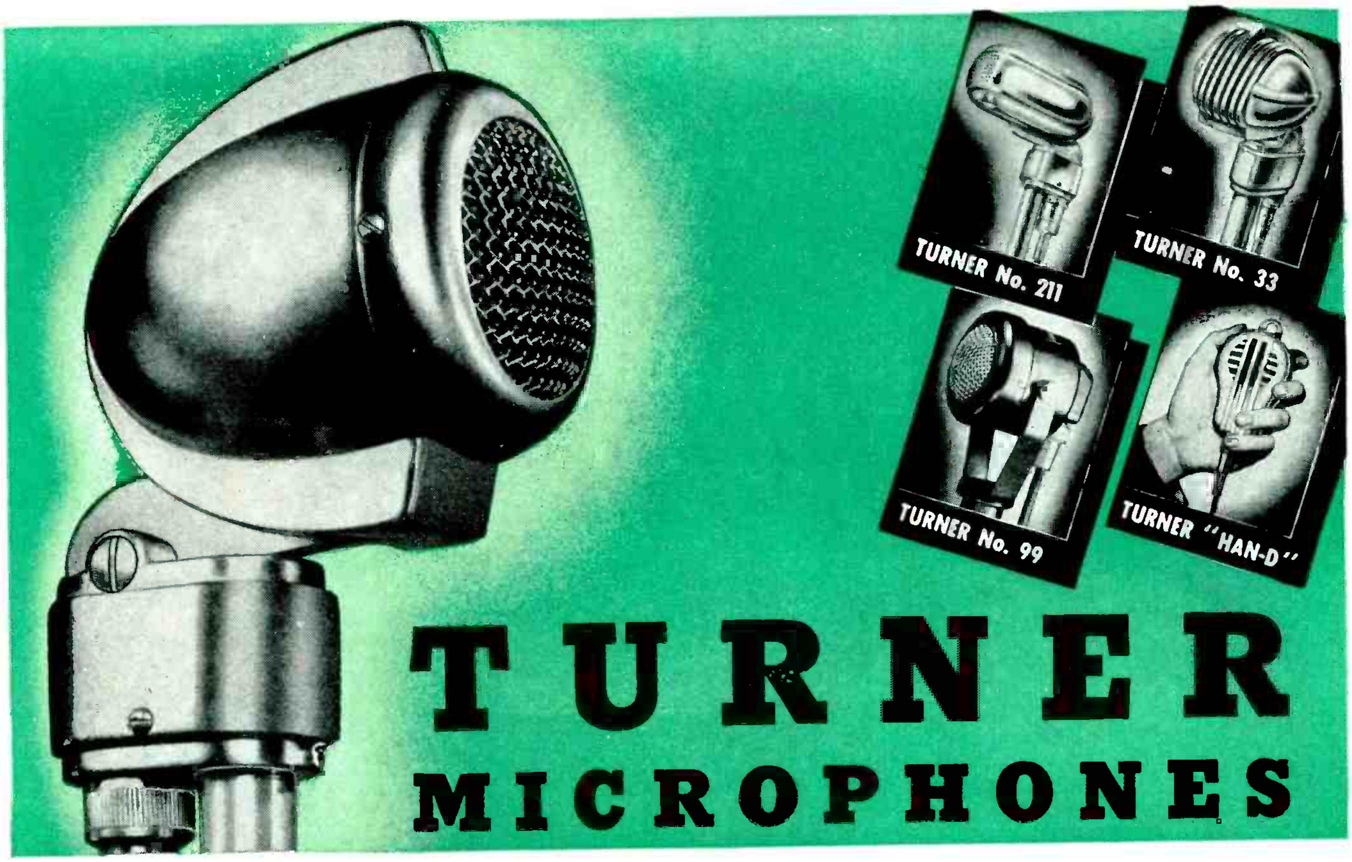
Simply swing the red index to the low side of the temperature pointer, and the index will move to the *lowest temperature reached*, and *remain there* until manually reset. For *highest temperature* record, simply swing the red index around to the high side of the pointer.

The index movement in no way impairs the guaranteed high accuracy of the WESTON Thermometer.

Thus the WESTON Maximum-Minimum Thermometer provides, at only slightly above ordinary thermometer prices, a means of obtaining high or low temperature records on equipment or processes where these extreme temperatures are critical. Ideal for transformers, sterilizers, ovens, chemical equipment, food processing, etc. For complete information, consult your nearest WESTON representative. WESTON ELECTRICAL INSTRUMENT CORPORATION, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston Instruments

ALBANY • ATLANTA • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • JACKSONVILLE • KNOXVILLE • LOS ANGELES • MERIDEN • MINNEAPOLIS • NEWARK NEW ORLEANS • NEW YORK • PHILADELPHIA • PHOENIX • PITTSBURGH • ROCHESTER • SAN FRANCISCO • SEATTLE • ST. LOUIS • SYRACUSE • IN CANADA, NORTHERN ELECTRIC CO., LTD., POWERLITE DEVICES, LTD.



A *CERTIFIED* UNIT FOR EVERY JOB

Whatever your need for accurate reproduction of voice, music or sound, there is a Turner Microphone especially adapted to your requirements. The complete Turner Line of precision units includes both crystal and dynamic microphones for every communications purpose.

Engineered to faithfully reproduce desired sound without distortions, every unit is tested and *Certified* before leaving the factory assuring dependable performance under severe operating conditions. For utmost in performance plus modern, eye appealing style, Turn to Turner.

Call in your Turner Microphone Representative to help you select the right unit for the job

Turner Microphone Representatives are thoroughly qualified in every field of microphone application. This experience is at your service. Call in your nearest Turner Representative.

He will be glad to study your electronic communications problems and recommend the Turner unit which will assure maximum results from your equipment.

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Cleveland 15, Ohio

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905 17th Street N. E., Cedar Rapids, Iowa

MICROPHONES LICENSED UNDER U. S. PATENTS OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY, AND WESTERN ELECTRIC COMPANY, INCORPORATED

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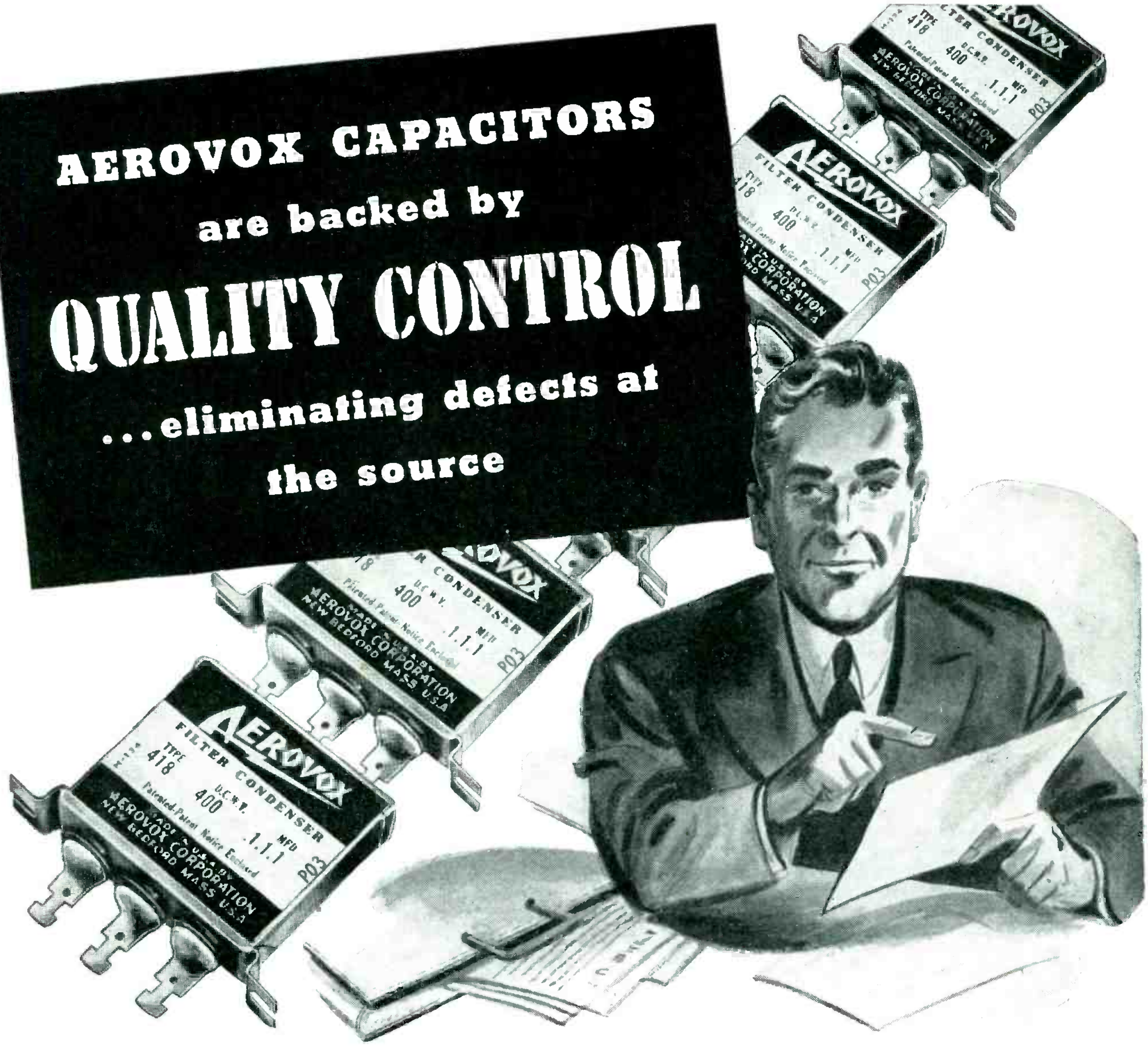
TURN TO TURNER FOR THE FINEST IN ELECTRONIC EQUIPMENT

AEROVOX CAPACITORS are backed by QUALITY CONTROL ...eliminating defects at the source



• When that Aerovox sales engineer takes your order, he releases the chain reaction of QUALITY CONTROL.

First, he has studied your particular application. From long and specialized experience, he knows circuits, constants, components. He is backed by an engineering staff second to none. So he sells only *that type capacitor* that can render the most service at least cost.

At the Aerovox plant that order reacts all the way back to raw materials. Aerovox maintains a complete process average of all its vendors. Incoming materials are critically inspected. For example: over 12,000 chemical tests are made each month!

Then there are quality control checks at every step in production. Defective materials or workmanship just can't get by. Defective units are simply not produced.

Finally, the Aerovox Quality Control Department plots daily test data to determine that the process is in control at all times. When any part of the process is out of control, production stops; the situation is investigated and corrected. Thus, the possibility of any defectives screening through is lessened more than ever before. You have utmost assurance that these capacitors are thoroughly dependable.

• • •

Yes indeed, Aerovox QUALITY CONTROL is your gain quite as well as ours.

• Let us apply QUALITY CONTROL to your capacitance problems and needs!

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FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

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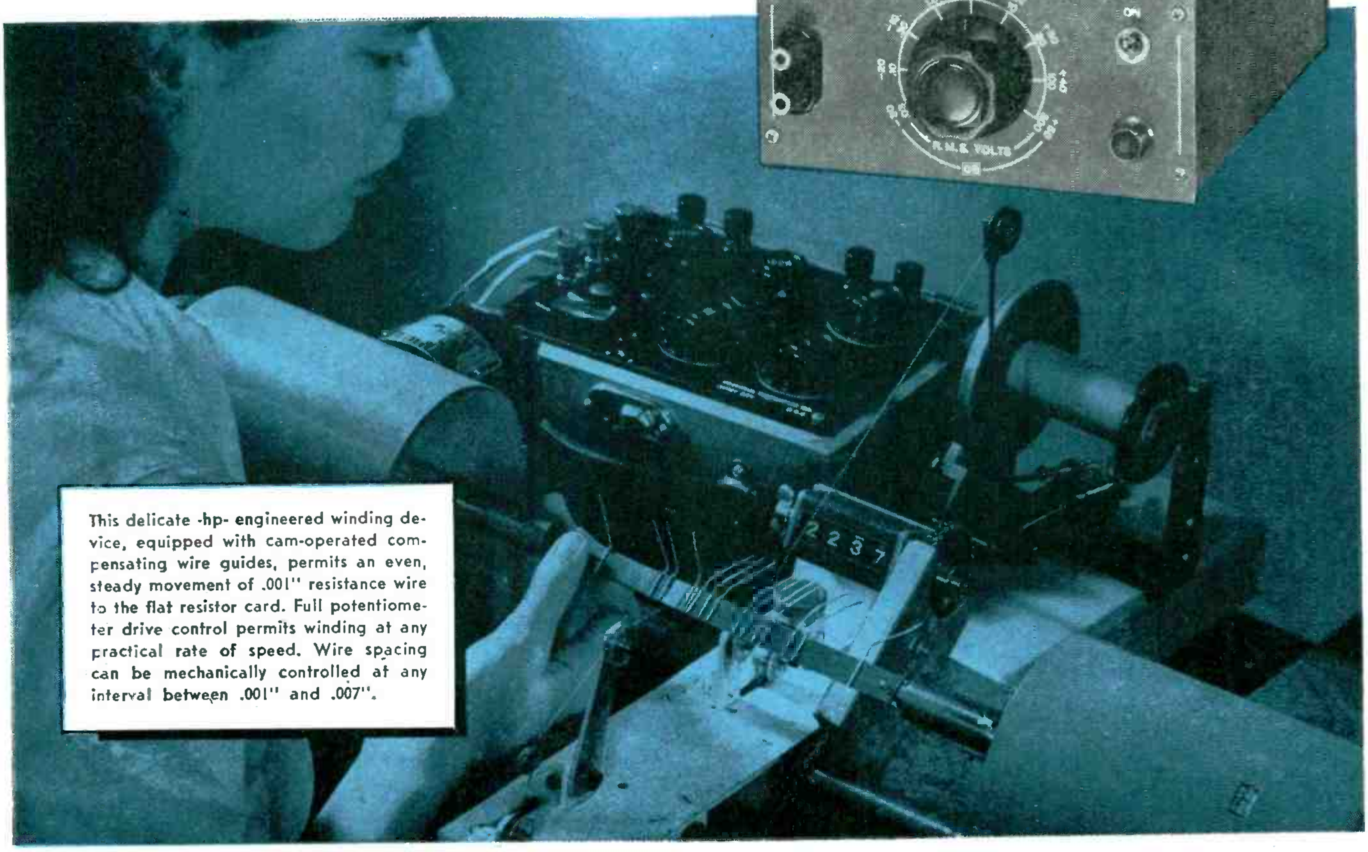
LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

Dependability and Uniformity of Accuracy Assured in the -*hp*- 400A Vacuum Tube Voltmeter



This delicate -hp- engineered winding device, equipped with cam-operated compensating wire guides, permits an even, steady movement of .001" resistance wire to the flat resistor card. Full potentiometer drive control permits winding at any practical rate of speed. Wire spacing can be mechanically controlled at any interval between .001" and .007".

Flat resistor voltage dividers for the -*hp*- 400A Voltmeter are precision-wound by machine. This development by -*hp*- engineers makes possible the construction of more precisely uniform instruments —more economically, more quickly.

The -*hp*- 400A Voltmeter long ago set a high standard of accuracy in measurements ranging from .005 volts to 300 volts, at frequencies from 10 cps to 1 megacycle. There are no troublesome adjustments to make during measurement, and normally no special precautions against overloads are needed.

The meter of the -*hp*- 400A has scales for both voltage and decibel calibrations; and a handy range knob permits instantaneous range selection in 10 db steps. The instrument itself is light, rugged, and compact for easy portability.

Write today for complete details and price of this precision-built, general purpose voltmeter.

HEWLETT-PACKARD COMPANY

1293A PAGE MILL ROAD, PALO ALTO, CALIFORNIA

Vacuum Tube Voltmeters • Audio Signal Generators
Audio Frequency Oscillators • Noise and Distortion Analyzers
Wave Analyzers • Frequency Meters • Square Wave Generators
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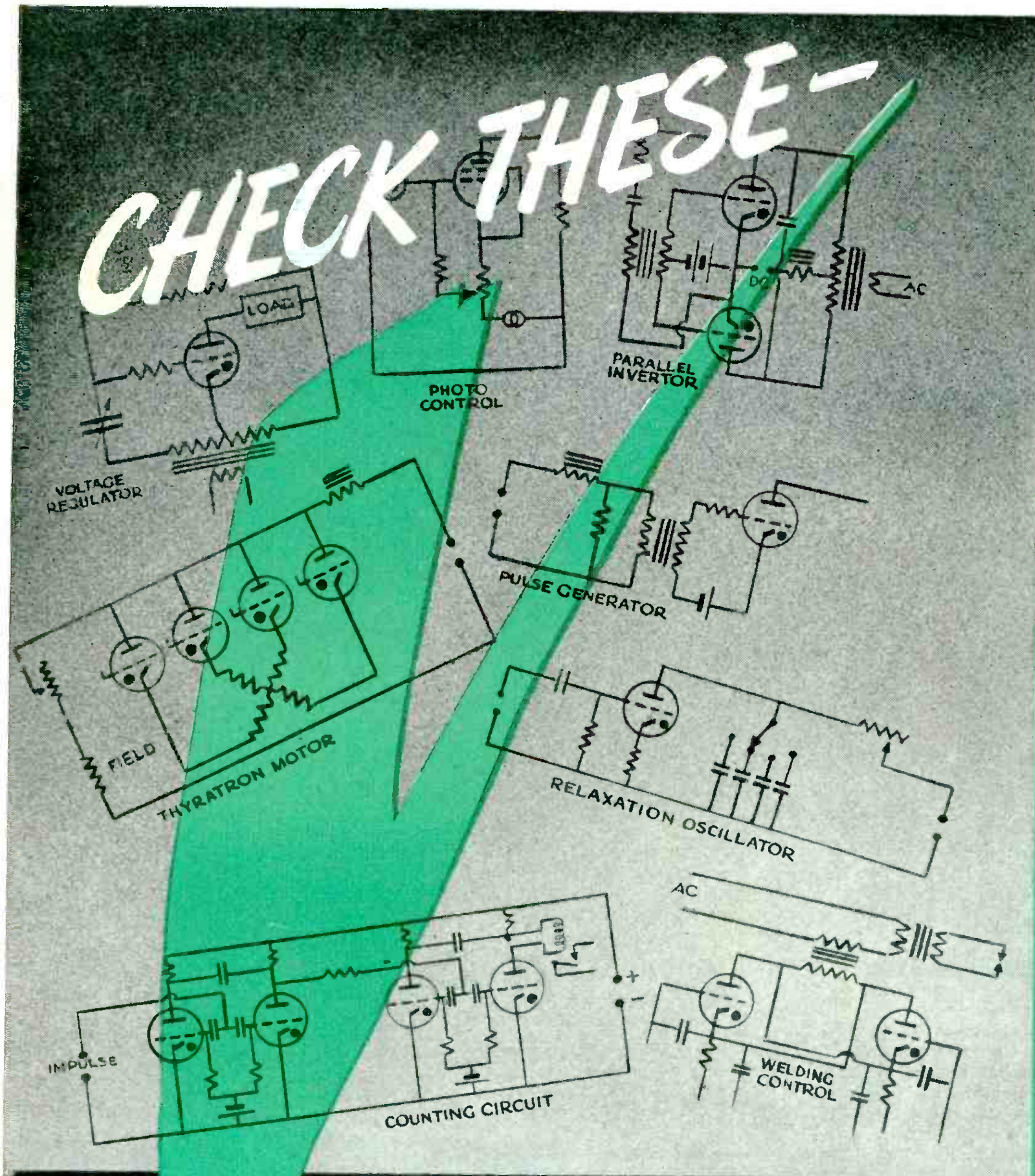

CHATHAM THYRATRONS

for control problem solutions

CHATHAM Thyratrons solve difficult control problems with a degree of accuracy and dependability unequalled by manual or ordinary mechanical control devices. Typically, the five CHATHAM Thyratrons illustrated provide precision performance in most industrial applications including counting, sorting, timing, measuring, pulsing, process control, voltage regulation, current conversion, etc. These tubes, and many other rectifiers currently in wide demand for industry and communications, can now be supplied by CHATHAM on short notice . . . in any quantity. For complete details—technical data, information, or collaboration in applying Thyratrons to your equipment or machinery—call or write today

CHATHAM ELECTRONICS

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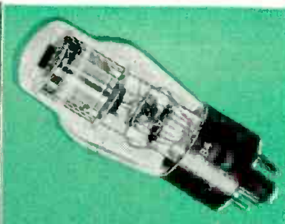
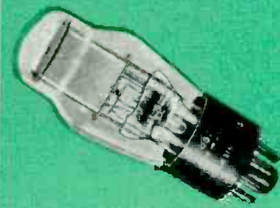


884 GRID CONTROLLED ARGON RECTIFIER AND OSCILLATOR

Peak inverse and peak forward voltage	300 volts
Peak plate current	300 Ma
Average plate current	75 Ma
Average plate current (oscillator)	2 Ma
Filament voltage	6.3 volts



2050 GRID CONTROLLED XENON RECTIFIER

Peak inverse voltage	1300 volts
Peak plate current	500 Ma
Average plate current	100 Ma
Filament voltage	6.3 volts
Filament current	6 amps

17 GRID CONTROLLED MERCURY VAPOR RECTIFIER

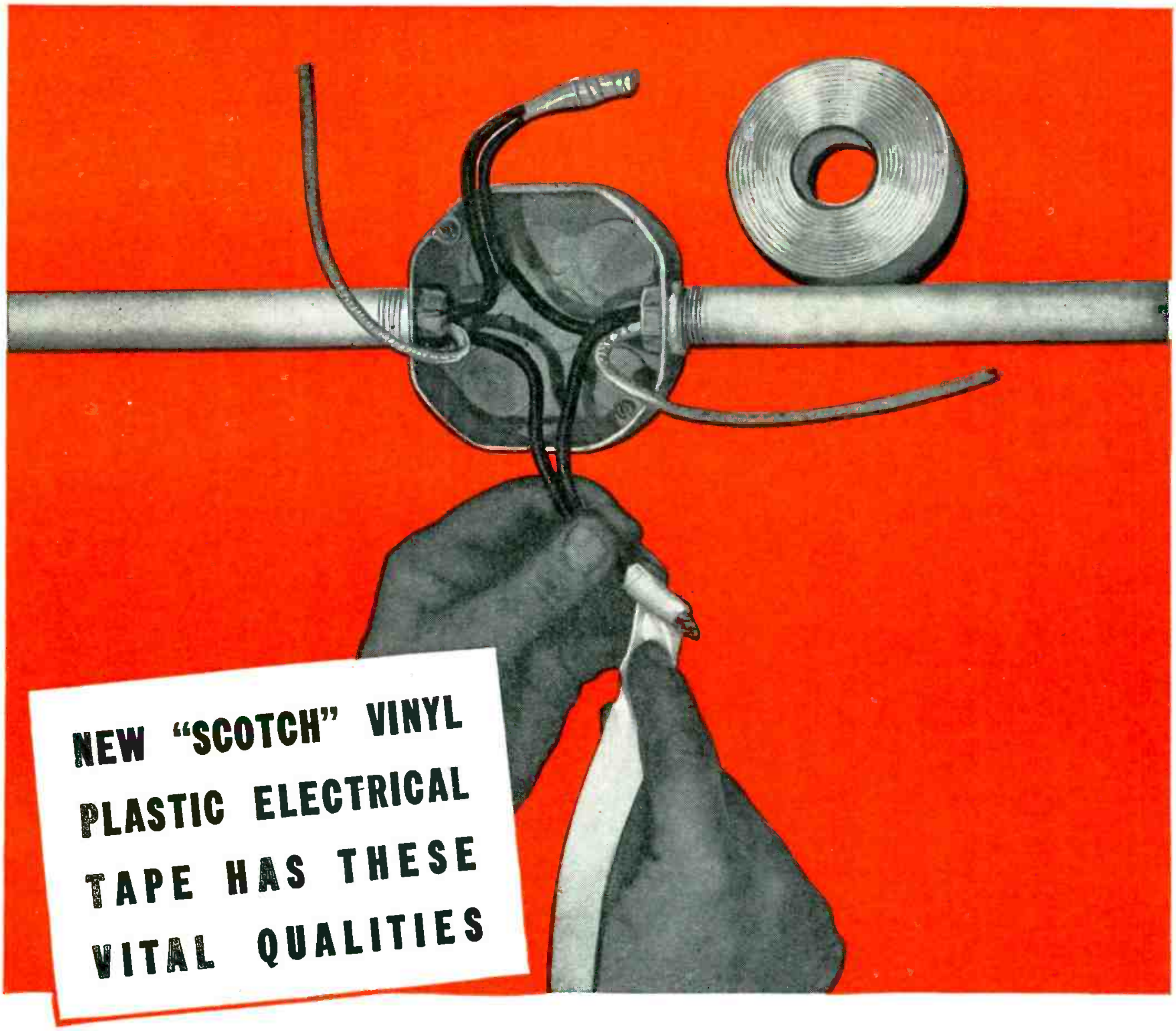
Peak inverse voltage	5000 volts
Peak plate current	2.0 amps
Average plate current	.5 amps
Filament voltage	2.5 volts
Filament current	5.0 amps

2021 GRID CONTROLLED XENON RECTIFIER

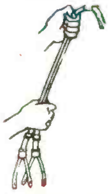
Peak inverse voltage	1300 volts
Peak plate current	500 Ma
Load current	100 Ma
Filament voltage	6.3 volts
Filament current	6 amps

2A4G GRID CONTROLLER ARGON RECTIFIER

Peak inverse voltage	200 volts
Peak plate current	1.25 amps
Average plate current	100 Ma
Filament voltage	2.5 volts
Filament current	2.5 amps

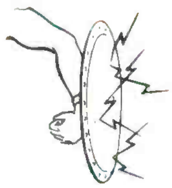


S-T-R-E-T-C-H



enables it to mould snugly to irregular surfaces.

R-E-S-I-S-T-A-N-C-E

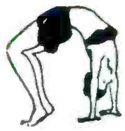


withstands flame, water, oils, acid, alkalis and corrosive chemicals.

T-H-I-N-N-E-S-S

only .007 inch thick, but has a 10,000 volt breakdown.

F-L-E-X-I-B-I-L-I-T-Y



remains flexible even at low temperatures.

WRITE FOR A FREE SAMPLE TO TRY IN YOUR OWN WORK.

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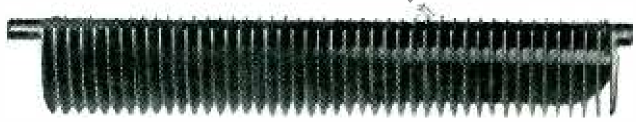
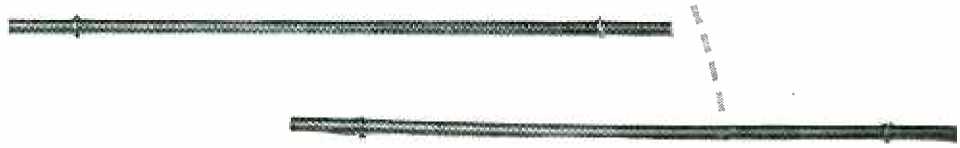
SCOTCH BRAND *Electrical* **TAPE**

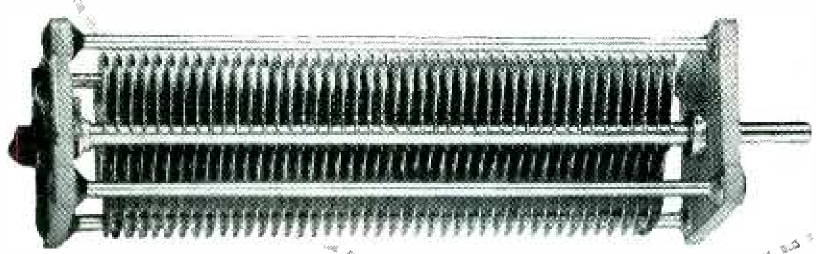
Made in U.S.A. by MINNESOTA MINING & MFG. CO. St. Paul 6, Minn.
THE 3M COMPANY



Brass for



variable condensers



. . . see REVERE

THE rods, shafts and plates of these variable condensers were made of brass furnished by Revere. We are especially proud of this because orders received for metal for this important purpose reflect our ability to hold gauges to the exceedingly close tolerances that are necessary in order to permit rapid manufacture of uniform units. Thus the critical distances between rotors and stators are maintained on a production basis. Brass is also highly desirable because of its low "creep" or drift with temperature changes, its strength and rigidity, and the ease with which it can be machined, stamped, soldered and plated if necessary.

In addition to various types of brass and bronze, Revere also offers Electrolytic Copper, Free-Cutting Copper, O.F.H.C. Copper, and other copper and copper alloys of special interest to the electronic industry. These may be had in the usual mill forms of bar and rod, sheet and strip, tube and pipe, and extruded shapes. When you do development work the question is sure to arise as to which material is best, and which form most economical to work. We have assisted a number of electronic manufacturers solve perplexing problems, and will be glad to work with you through the Revere Technical Advisory Service.

REVERE

COPPER AND BRASS INCORPORATED

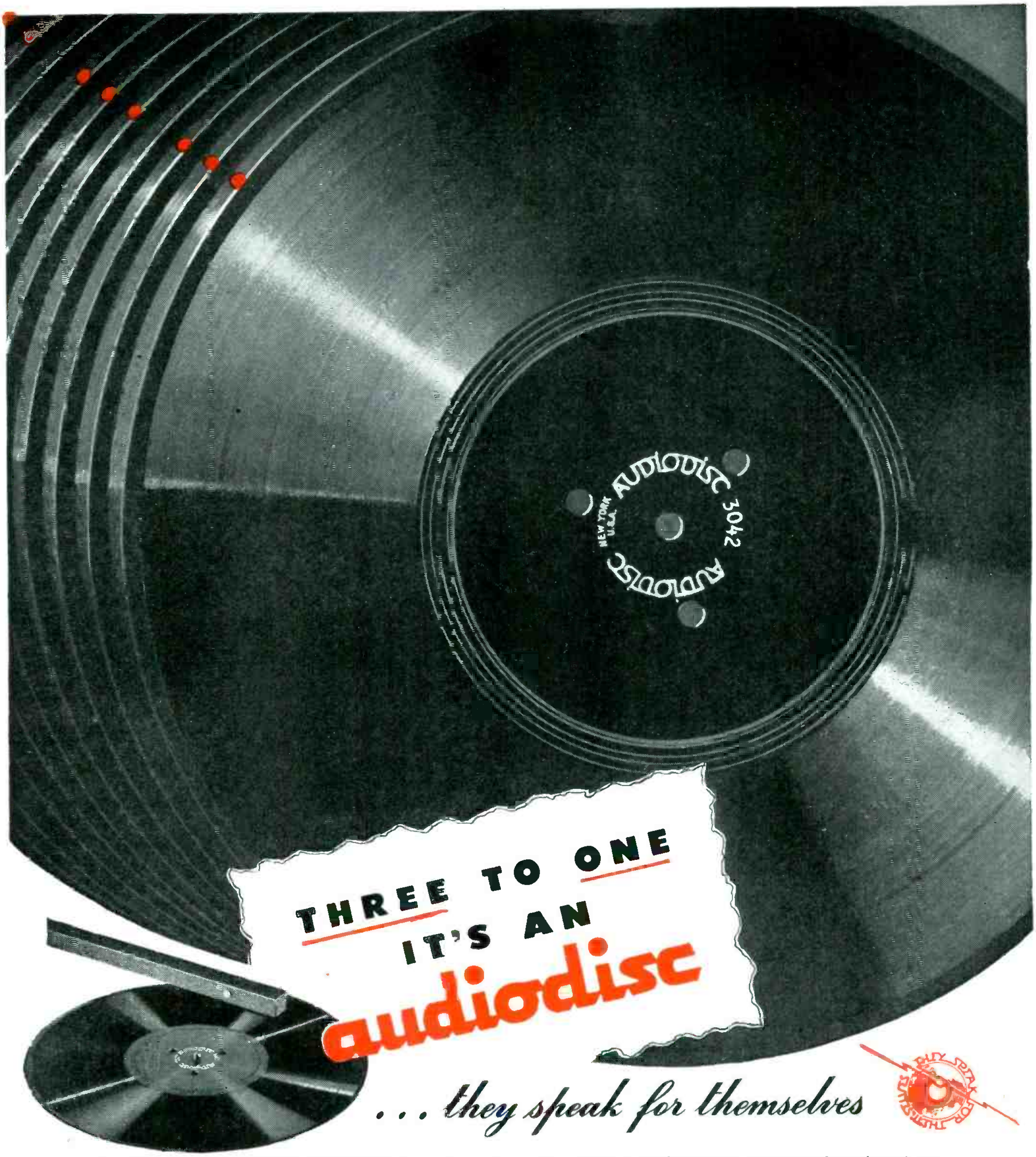
Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

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

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.



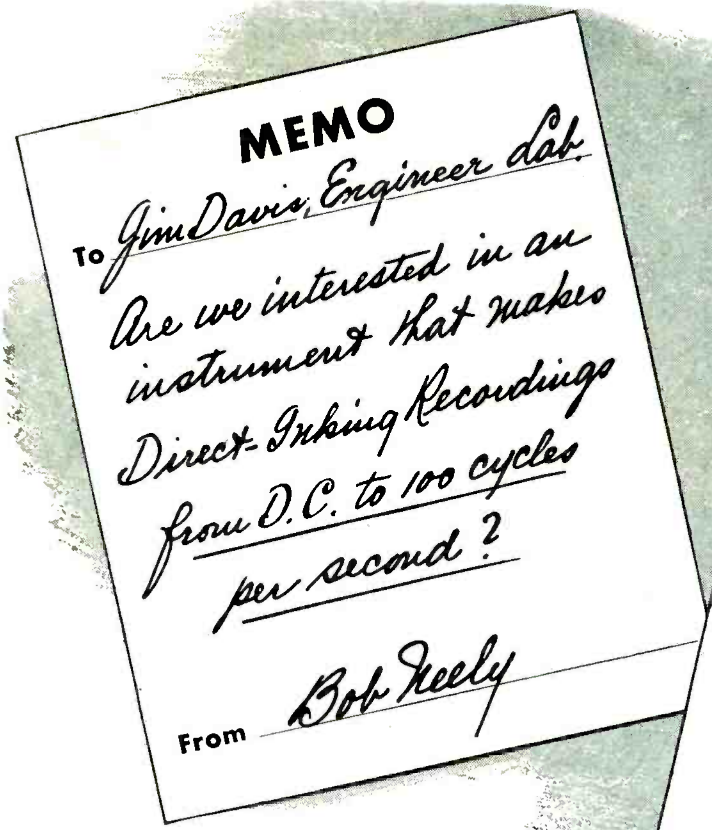
IN THE BROADCASTING STATIONS throughout the nation, when a live program is recorded for broadcast — when an off-the-air program is recorded for rebroadcast—when recordings are made for clients or for rehearsal and audition purposes — when recordings are made for reference files — in fact when any recording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

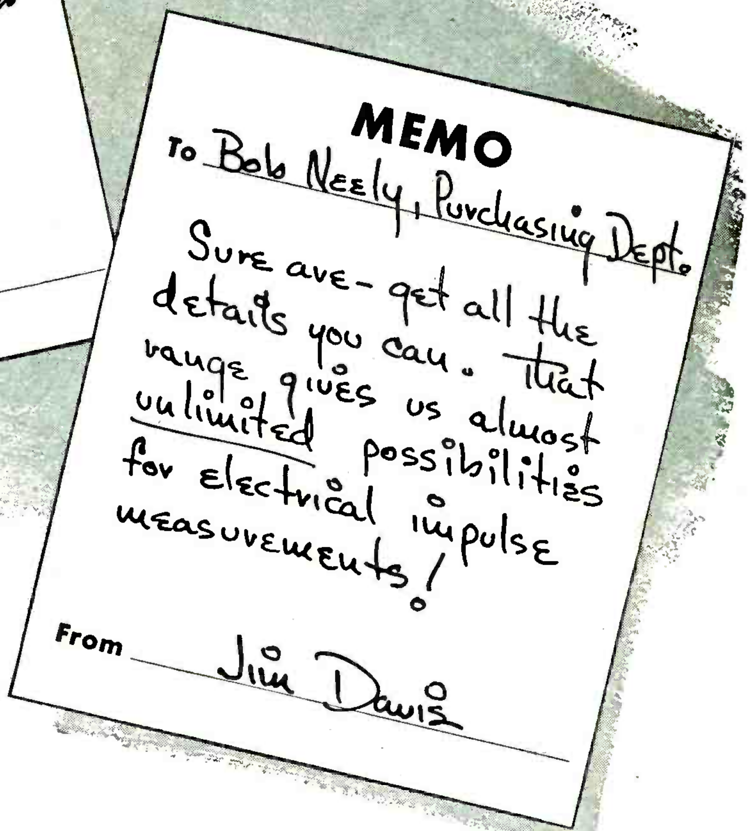
This outstanding preference for Audiodiscs has been recently confirmed by a double-check survey covering 400 radio stations. Approximately half these stations were called upon and reported the actual number of discs used—Audiodiscs and others. The remainder reported by letter stating the proportion of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

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

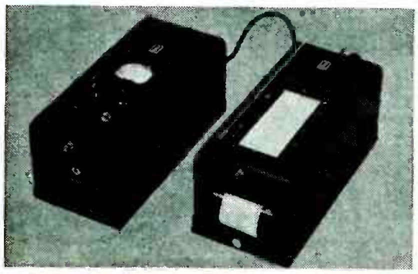
Audiodiscs are manufactured in the U.S.A. under Exclusive License from La Societé des Vernis Pyrolac—France.

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

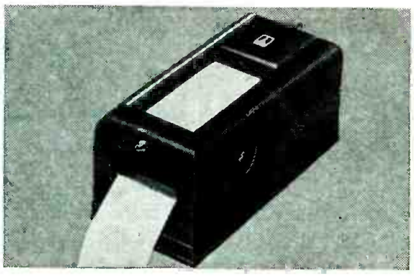




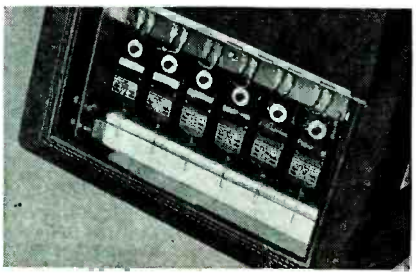
Brush Magnetic Oscillographs may be used for making detailed recordings of electrical impulses for an almost limitless number of applications. The Magnetic Pen Motor is capable of recording a D.C. signal. Used with the BL-905 amplifier, the frequency range is from .2 to 100 cycles per second. Recordings are direct, instantaneous, ink-on-paper graphs. Can be used for recording strains, pressures, vibrations, temperatures, light intensity and countless other phenomena. Write today for detailed bulletin.



Brush Single-Channel Magnetic Oscillograph with amplifier. Especially suited for counting, temperature recording, surface analysis—and similar applications.



Brush Double-Channel Magnetic Oscillographs for use where two simultaneous recordings are desired—as in synchronizing problems.



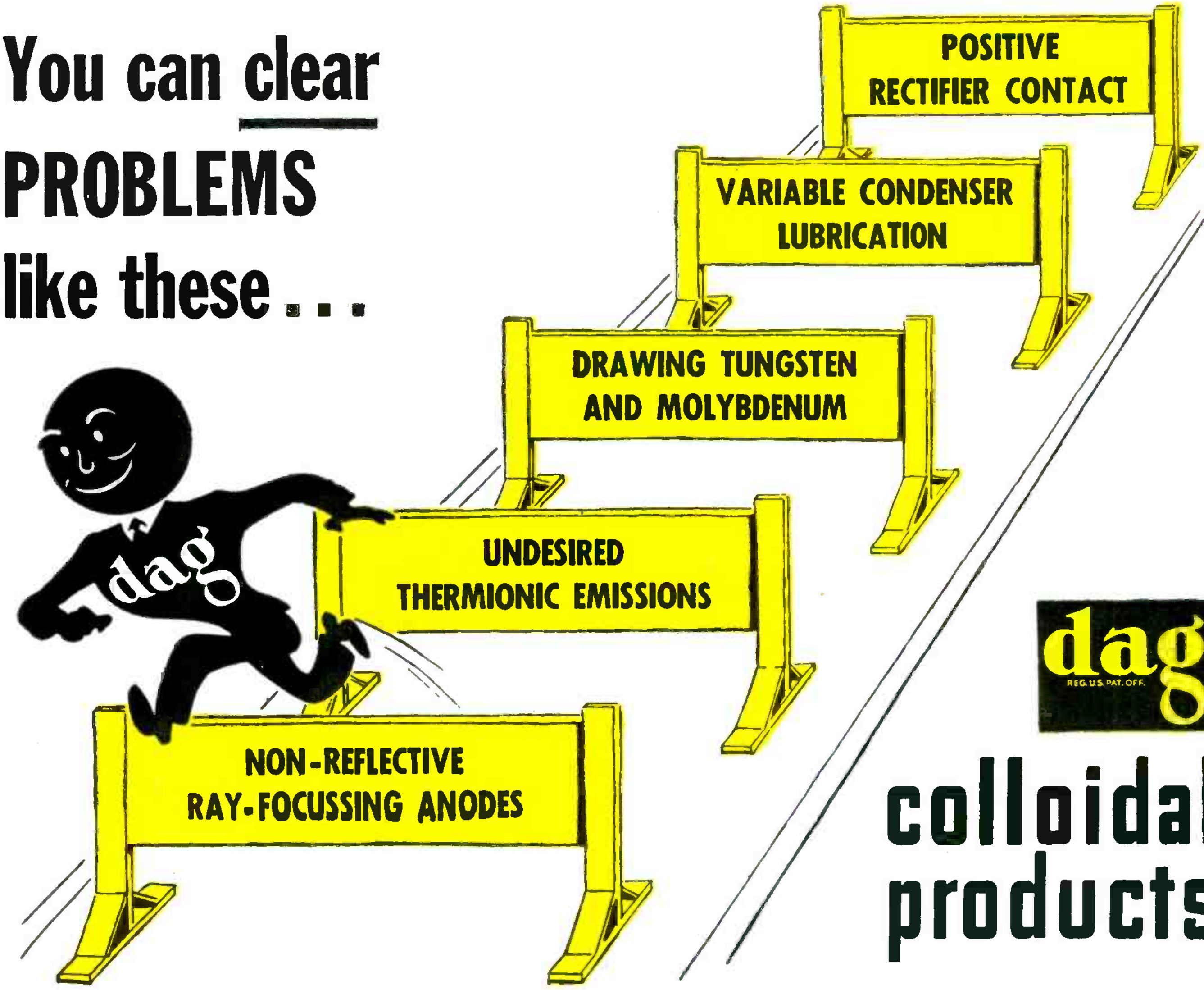
Brush Six-Channel Magnetic Oscillograph. Excellent for strain-gauge recordings and similar multiple applications.

THE BRUSH DEVELOPMENT CO.

3405 Perkins Avenue, Cleveland 14, Ohio

Canadian Representatives: A. C. Wickman, (Canada) Ltd., P. O. Box 9, Station N, Toronto 14

You can clear PROBLEMS like these . . .



dag REG. U.S. PAT. OFF.

colloidal products

Newly developed "**dag**" dispersions and newly discovered applications for colloidal graphite make it possible for you to clear more obstacles to efficient production than ever before.

The free booklets listed below include information on *all* of these recent developments, industry by industry, process by process.

Attention is directed especially to Bulletin No. 460, an up-to-the-minute, comprehensive story of "**dag**" colloidal graphite dispersions and their relation to modern industry.

To augment your ready reference library with these valuable aids to fast modern production, clip the coupon below.

ACHESON COLLOIDS CORPORATION, Port Huron, Michigan

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

- **460** A data and reference booklet regarding "**dag**" colloidal graphite dispersions and their applications. 16 pages profusely illustrated. ☐
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- **423** Facts about "**dag**" colloidal graphite as a HIGH TEMPERATURE LUBRICANT. ☐
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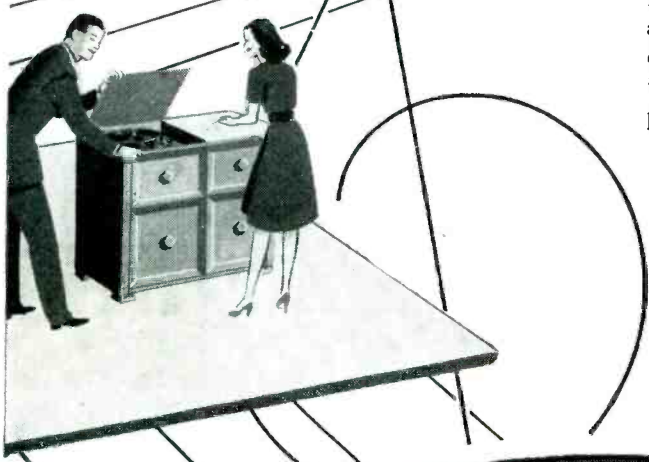
OUR PRESENT OIL SUPPLIER IS__________

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

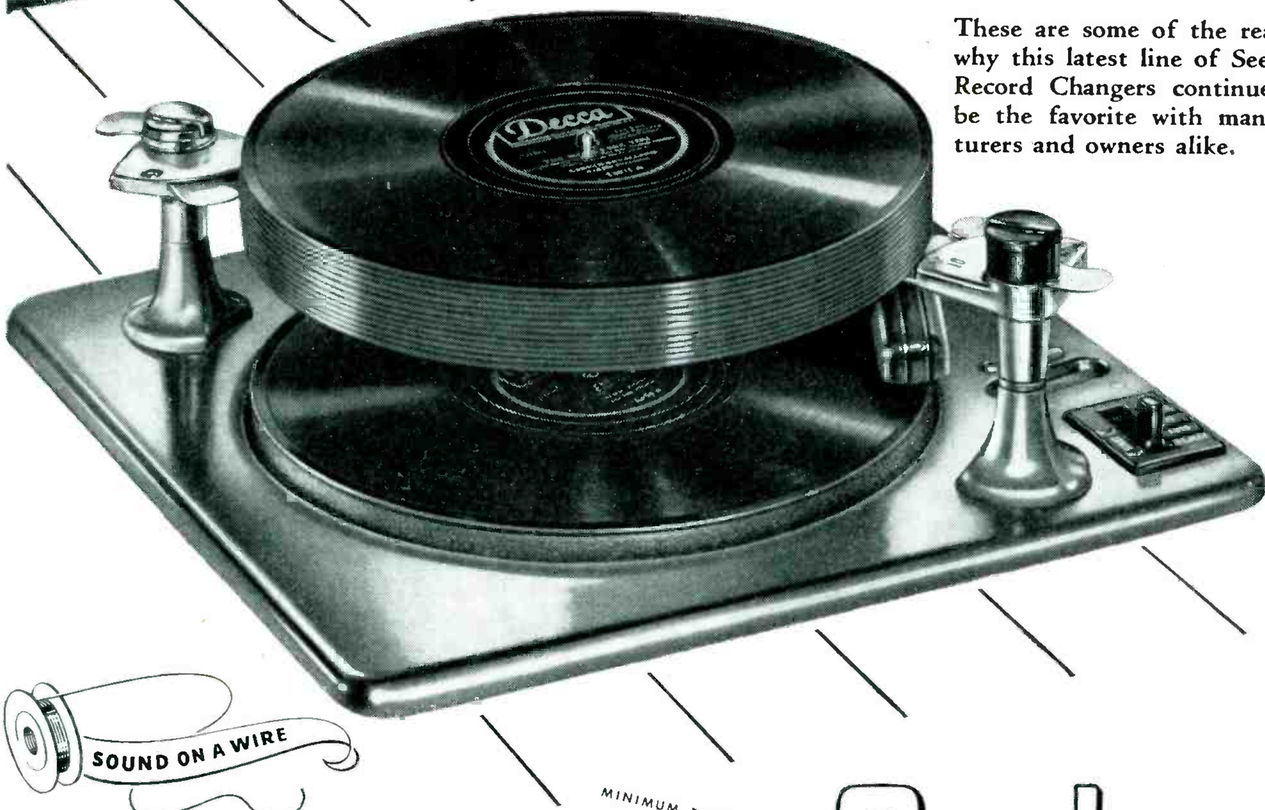
LOOK TO SEEBURG CHANGERS FOR TROUBLE-FREE OPERATION . . . BETTER PERFORMANCE



Phonograph manufacturers know that the success as well as the popularity of the instruments they manufacture depend in no small measure on the record changer they use. This is why so many of the leading producers of phonographs look to Seeburg for these mechanisms.

- The multiple posts of Seeburg changers hold records flat and prevent wear on spindle holes.
- The quiet mechanism moves records into place with minimum time between changes.
- The featherweight crystal pickup reproduces subtle harmonies and prevents wear on records.
- The strong, quiet motor brings the turntable up to speed and holds that speed constant.

These are some of the reasons why this latest line of Seeburg Record Changers continues to be the favorite with manufacturers and owners alike.



The new Seeburg Wire Recorder *— a brand-new development — permits perfect home recording of speeches, plays, radio programs. Single control knob simplifies operation.*

RADIO MANUFACTURERS *— provision must be made in your circuits to accommodate the* Seeburg Wire Recorder. *We invite inquiries.*

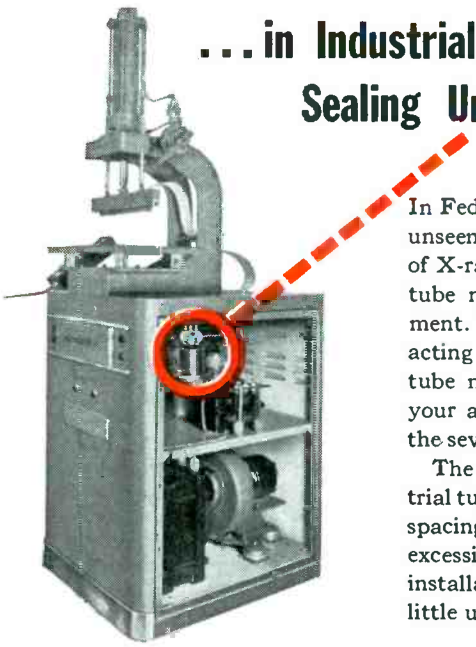
MINIMUM FRICTION
SILENT
LONG LIFE
CONSTANT SPEED
TROUBLE-FREE OPERATION

Seeburg

RECORD CHANGERS ★ WIRE RECORDERS

J. P. SEEBURG CORPORATION
1500 N. DAYTON ST. • CHICAGO, 22

... in Industrial Electronic Equipment like this 2½-KW Dielectric Sealing Unit made by the RADIO RECEPTOR CO. INC., N. Y. C.



In Federal Power Tubes, there can be no unseen flaws — because the searching eye of X-ray tells the "inside story" of *every* tube not once, but *twice*, before shipment. This test, together with other exacting requirements, means that each tube must be perfect in every detail — your assurance of longer tube life under the severe conditions of industrial service.

The 7C25, like all of Federal's industrial tubes, is built to take a beating. Wide spacing of internal elements fortify against excessive vibration. Flexible leads simplify installation and reduce strains. And very little unshielded glass is used, minimizing the possibility of breakage in handling or in service.

For complete information, write to Dept. L313.

DATA FOR 7C25 TUBE

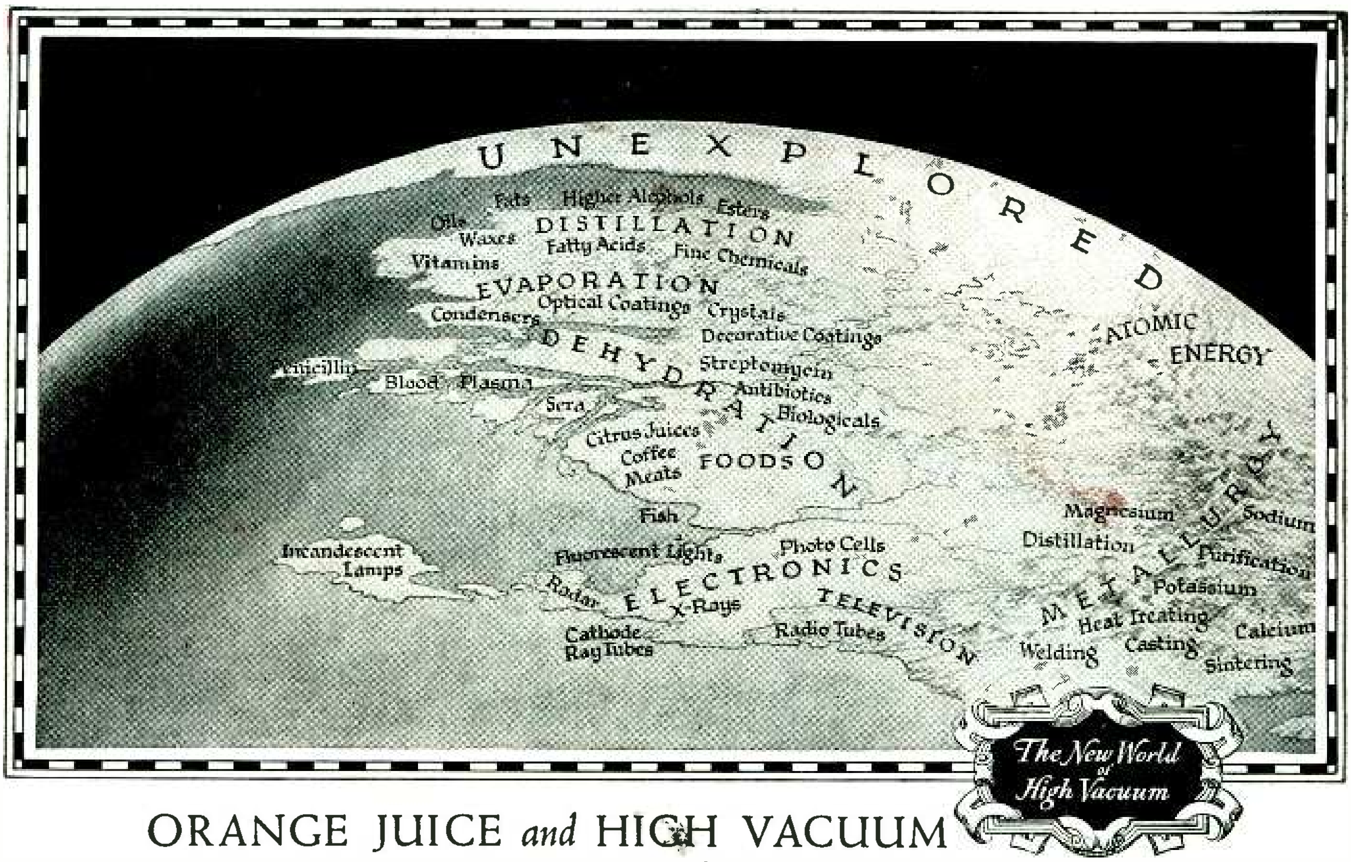
Filament Voltage	11.0 volts
Filament Current	27.5 amp.
Maximum Ratings for Maximum Frequency of 50 Mc	
DC Plate Voltage	4500 volts
DC Plate Current	1.25 amp.
Plate Dissipation	2500 watts
Overall Height	App. 7 inches
Maximum Diameter	3½ inches
Type of cooling	Forced Air

Federal Telephone and Radio Corporation

In Canada:—Federal Electric Manufacturing Company, Ltd. Montreal.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y. C.

An IT&T Associate — Federal Telephone & Radio FTR

Newark 4, New Jersey



ORANGE JUICE *and* HIGH VACUUM

High Vacuum offers to industry a vast new area, virtually unexplored. No one knows its extent or its resources. No one can say what opportunities are there for your industry. No one can tell you, but National Research Corporation can help you find out as it has helped many others. It can furnish the technology and equipment as it did for the Dehydration of Orange Juice.

For generations men have tried to concentrate the fresh juice of tree-ripened oranges so that it could be sent all over the world. If orange juice could thus be freed from the limitations inherent in the shipment of fresh fruit, the benefits, to American families, to restaurants and hospitals, to the growers and to the millions all over the world who have never tasted it, would be enormous.

But all methods of canning, concentration, dehydration and refrigeration led to discouraging results.

Before the war, we at National Research Corporation believed that orange juice could be dried successfully at low pressures, but we had more important work — magnesium production, penicillin desiccation, lens coating. At the request of the Army we turned, in 1944, to the vacuum dehydration of orange juice on a large scale.

The results were gratifying, and in March, 1945, we put in operation a pilot plant in Plymouth, Florida, taking its raw material from the nearby juicing plant of the Plymouth Citrus Growers' Association. Here the fresh juice was dried to a powder having a moisture content of less than 1 per cent.

By the summer of 1945, the success of this operation led to the organization of Vacuum Foods Corporation with exclusive license to operate processes developed for the citrus field. Under the engineering supervision of National Research Corporation, a plant with a capacity of *20,000 gallons of juice per day* was designed and built at Plymouth, Florida.

During processing, fresh strained juice undergoes a series of operations under High Vacuum, one of which produces at low temperature a concentrate with no loss of flavor or vitamin content. A portion of this is canned and, reconstituted by the addition of water, is now being served as fresh juice in leading hotels in New York and Chicago and by principal air lines.

The remaining concentrate is reduced to powder in drying chambers under a pressure between one hundred thousandth and one millionth that of normal atmosphere.

Neither juice nor concentrate is subjected to high temperature during processing, but in this high vacuum, moisture passes off readily with the barest minimum of Vitamin C or flavor loss. The powder is then packed in sealed cans, a four-pound shipment of which equals in juice a 90-pound crate of oranges.

Today, by the magic of high vacuum, the old ambition is realized and pure, fresh, tree-ripe orange juice, in concentrate and powder form is giving the benefit and pleasure of citrus fruit to the world.

We at National Research Corporation would like to put high vacuum to work for you. We are fully prepared to help you with both laboratory-scale and full-size plant equipment involving its industrial applications.

VACUUM ENGINEERING DIVISION, National Research Corporation, Boston 15, Massachusetts.

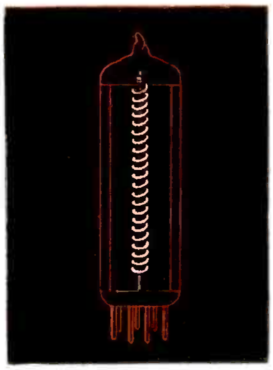
We engineer Plant installations and manufacture High Vacuum Gauges, Valves, Seals, Diffusion Pumps, Stills, Furnaces, Coating Equipment and Dehydration Equipment.

HIGH VACUUM FOR INDUSTRY

NATIONAL RESEARCH CORPORATION

VACUUM ENGINEERING DIVISION

a good thing in a small package



CALLITE'S coiled coil heater

in National Union's miniature rectifier tube

National Union Radio Corporation's miniature N.U. 117Z3 was designed for battery plus line-powered midget radios. With a maximum seated height of 2⅜", this tube required a filament that would deliver the same amount of heating power to the cathode that was heretofore attainable only in larger envelopes.

Callite supplied this vital ingredient with a special 1.3 milligram tungsten wire heater. Wound on a .004 molybdenum mandrel for 800 turns per inch, the coil was then rewound on a .030 steel mandrel and skip turned every 68 t.p.i. Result: a highly efficient coiled coil heater for this miniature tube with high emission properties equal in performance to larger envelope tubes.

Cooperation in designing exact metallurgical components for radio and electrical devices means more than just willingness. 26 years of engineering and production know-how have given us a wealth of show-how, too. Call on Callite for your standard or special requirements and benefit by our wide experience and flexibility. Callite Tungsten Corporation, 551 39th Street, Union City, N. J. Branch offices: Chicago, Cleveland.

CALLITE TUNGSTEN CORPORATION CT

Callite

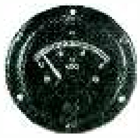
TUBE COMPONENTS

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

MADE TO ORDER

FOR AIRCRAFT PANELBOARDS

MB PRECISION MINIATURE METERS



THERMOCOUPLE THERMOMETERS

For Example . . .

Accurate to within $\pm 2\%$, MB instruments also have the sensitivity for use with thermocouples. 20 millivolt drop produces full deflection in instruments compensated for copper temperature error; uncompensated—only 12½ millivolts. You can get them with square or round, anodized aluminum housings, plain or luminous scales—all built for long, hard usage.

HAIRLINE ACCURACY, minimum size and weight, electrically adapted for a specific job . . . that's what you can be sure of with MB miniatures . . . instruments truly "made to order" for aircraft! Plan on their design advantages . . . and their dependability . . . for fuel gages, cylinder head thermometers, oil temperature and pressure gages, and others.

These efficient meters are designed for the required calibrations and special performance characteristics, and compensated for error-producing temperature changes . . . for use wherever quantities can be measured electrically. Not only do they offer unfailing accuracy, but they also help you *cut panel space and weight requirements to the bone.*

MB instruments are built to high standards, of only top-quality materials. Let an MB engineer show you how easily and economically the 1-inch and 1½-inch models can be applied to your own designs. Write for details.

THE MB MANUFACTURING COMPANY, INC.
331 East Street, New Haven 11, Conn.

INSTRUMENT DIVISION

MINIATURE ELECTRICAL INSTRUMENTS FOR ANY PURPOSE

LITTLE COMPONENT*

HUGE SUCCESS

. . . THANKS TO

MYCALEX

THE "PERFECT" LOW LOSS INSULATION

The problem was to mold insulating material of exceptionally low loss factor and high dielectric strength into a closely integrated bond with a metal insert of high conductivity. The difficulty was acute, for both materials had to have virtually the same coefficient of expansion in order to insure an efficient electrical and mechanical seal. High resistance to arcing in the insulator was also imperative. It had to be moisture-proof and heat-resistant.

MYCALEX 410 (Molded Mycalex) proved to be the only solution after many other insulators had been tested and rejected . . . because MYCALEX has the ideal combination of electrical and mechanical properties for today's high frequency applications.

Have you a problem involving the sealing of highest type insulation with metal? Are your specifications particularly exacting? More than 25 years of leadership in solving the toughest high frequency insulating problems make MYCALEX a "natural" to solve yours. Our engineers will be pleased to cooperate.

*PANEL JACK

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

MYCALEX CORPORATION OF AMERICA

"Owners of 'MYCALEX' Patents"

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THIS NEW VARNISHED INSULATING MATERIAL

TURBOTUF

PROVIDES MOISTURE RESISTANCE

THERMOPLASTIC INSULATED WIRE:
TURBOTHERM wire features high dielectric properties and resistance to heat and other destructive elements. Nos. 18 to 30 stranded and solid conductor.

FLEXIBLE VARNISHED TUBING:
TURBOTUF tubings in two top grades—Magneto and Radio grade available in standard sizes from No. 24 (.020″ ID) to No. 1 (1.000″ ID).

SATURATED SLEEVING:
TURBOTUF Sleeving—an all-purpose insulation for the lower dielectric ranges—in standard sizes from No. 20 (.034″ ID) to No. ½ (.500″ ID).

FIBROUS GLASS TUBING:
TURBO Glass Fibre Tubing possesses superior electrical and physical characteristics—supplied in sizes from No. 20 (.034″ ID) to No. ⅜ (.375″ ID).

EXTRUDED PLASTIC TUBING:
A smooth wall plastic tubing with notable resistance to severe low temperatures and subsequent embrittlement.

TURBOTUF sheds water almost as well as a duck's back!

No matter how superior its other advantages, an electrical insulating material must possess a low moisture-absorption factor to maintain its insulating quality. Absorption of water by an insulator not only nullifies its dielectric value, but also subjects it to excessively rapid deterioration through electro-chemical action, rot, mildew and other destructive elements.

New TURBOTUF fabricating methods, employing an exclusive TURBO varnish impregnant, thoroughly saturates the fabric "all-the-way-through." This impervious varnish coating not only closes the interstices of the fabric against moisture, but is itself inherently resistant to water. Excellent dielectric properties combined with resistance against destructive elements and mechanical strain provide features which are desirable for most electrical applications.

Other TURBO products, include fibrous glass tubing, extruded plastic tubing, thermoplastic insulated wire, identification markers and mica specialties. Write for the helpful TURBO Sample Board with actual mounted specimens.

REMEMBER.. IF IT'S TURBO ..IT SAFEGUARDS!

WILLIAM BRAND & COMPANY

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CODE WORD ● JERAD

Jensen
Fine Acoustic Equipment

MANUFACTURING CO.
6601 SOUTH LARAMIE AVE.
CHICAGO ILLINOIS

"ALL THE JENSEN SPEAKERS YOU WANT"

During the war...when we were building and shipping thousands of loud speakers every week for the Armed Services...we would have staked our last dollar on our ability to continue our large-scale production when the war was over. We would have promised our customers eagerly, "You'll have all the JENSEN speakers you want when the war ends." Little did we know then that the postwar period would be so difficult.

There's no use reminding you that strikes and shortages of material have resulted in a scarcity of steel and copper wire and all of the parts needed for making loud speakers. Nor can we console ourselves with the thought that other manufacturers are in the same boat. We know our customers need merchandise and we're truly sorry that our production is a trickle instead of a flood; that our deliveries are slow; that our new products are not yet in full production. Some day soon materials will become more plentiful and our production will catch up with our backlog.

Then we can truthfully and honestly promise...and deliver..."all the JENSEN speakers you want."

Now all we can tell our customers is, "We appreciate your patience."

Thomas A. White
President

The Name Insures the Quality

5 MONOGRAPHS AVAILABLE

1. Loud Speaker Frequency-Response Measurements
2. Impedance Matching and Power Distribution
3. Frequency Range in Music Reproduction
4. The Effective Reproduction of Speech
5. Horn Type Loud Speakers

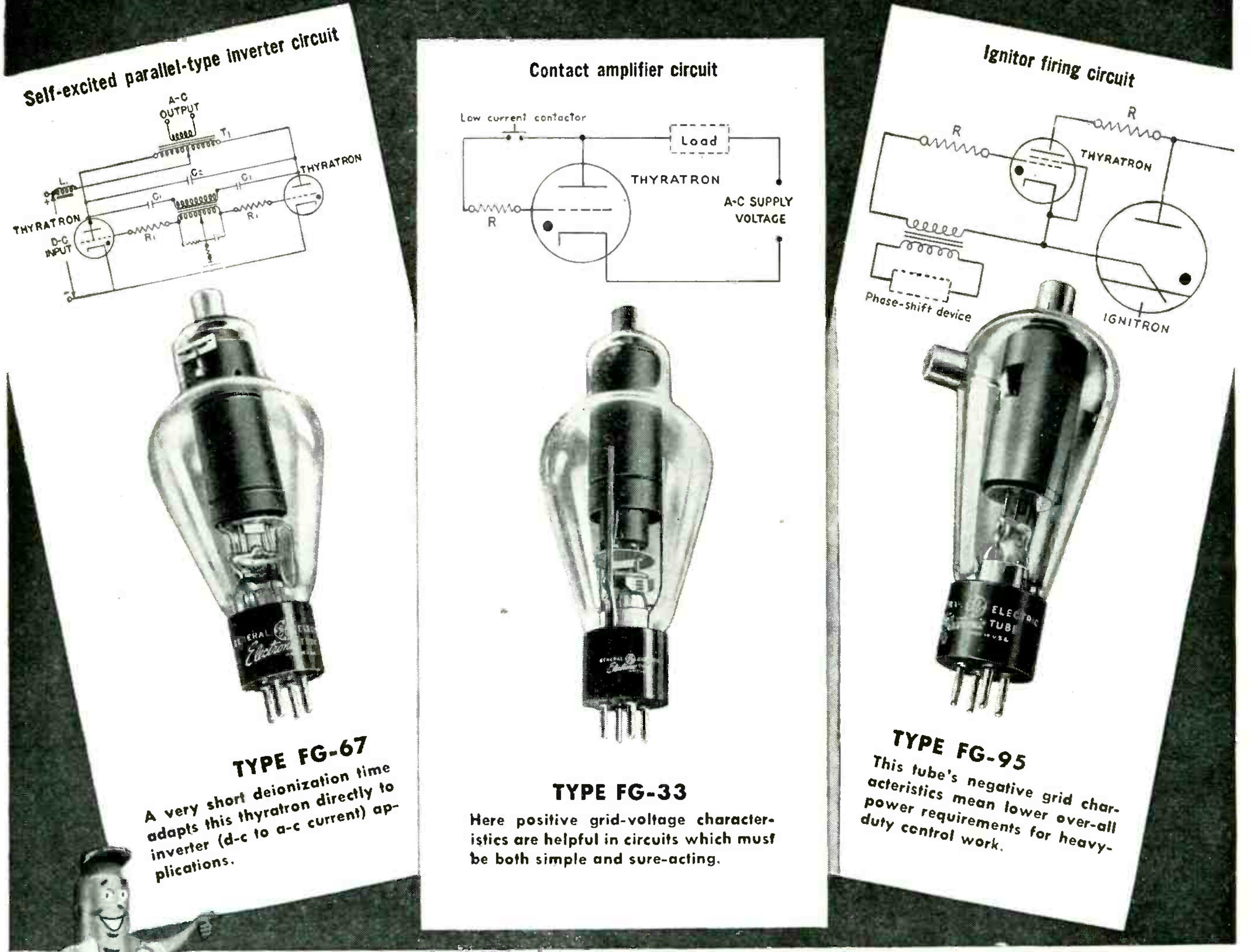
25c Each

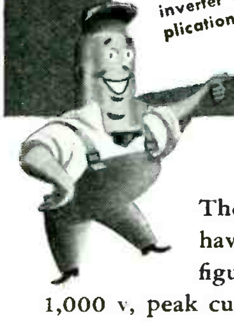
If you haven't yet procured these five valuable technical booklets, order now—either from your dealer or direct—at 25c each.

JENSEN MANUFACTURING COMPANY · 6607 South Laramie Avenue, Chicago 38, Illinois
IN CANADA · J. R. LONGSTAFFE, LTD., 11 KING STREET, WEST, TORONTO

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.*

GENERAL ELECTRIC

162-E4-8850

FIRST AND GREATEST NAME IN ELECTRONICS

THE POWER YOU want is

POWR-PAKT MOTORS

Alliance Powr-Pakt Motors will open and close valves, switches, operate toys and motion displays, actuate parts in business and vending machines, and can be used as component power sources in electronic control systems.

The Model 80 Phonomotor has been the outstanding favorite of manufacturers and jobbers who want a power source that's smooth, quiet, and time-tested. This is the No. 1 motor for driving turntables and record changers!

For original equipment and replacement, the leading radio manufacturers and jobbers of radio parts *rely* on Alliance Phonomotors and Powr-Pakt Motors to drive their turntables, record changers, recording and tuning devices.

Alliance Motors are mass produced, precision built, and low in cost. Besides Phonomotors, Alliance makes a wide range of small motors designed to meet the special demands of small loads. Write!

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

STUPAKOFF HERMETIC SEALS

meet exacting demands of

MODERN ELECTRONIC DEVELOPMENTS

Stupakoff Kovar*-glass seals provide permanently vacuum and pressure tight, insulated electrical lead-ins on products which must be sealed from the atmosphere, even under the most adverse climatic conditions.

Metal-glass terminals are available, or can be made in shapes and sizes to suit your needs . . . with single or multiple, hollow or solid electrodes.

Kovar alloy is also available in the form of sheet, rod, wire, tubing and special shapes for the manufacturers of electronic tubes and others who have their own glass working facilities.

A line from you as to your sealing problems will enable us to make specific recommendations and supply the applicable literature.

*Reg. U. S. Pat. Off.

Trade Mark No. 337962

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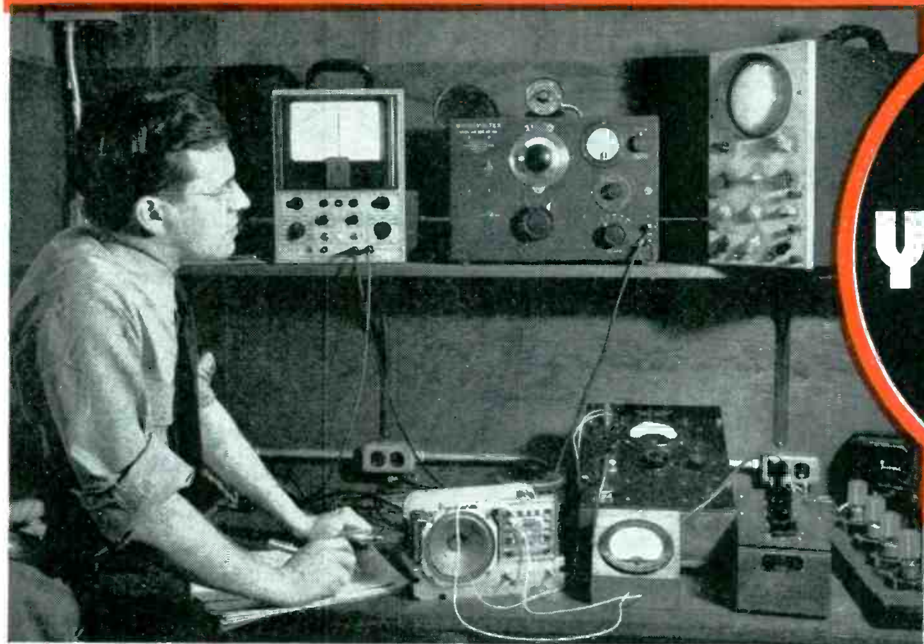
EXPORT DEPARTMENT 13 E. 40TH ST., NEW YORK 16, N. Y. CABLE ADDRESS ARLAB ALL CODES

MAKING TUBES IS EASY...



If YOU KNOW HOW!

Hytron commercial engineer makes precision measurements of 50L6GT performance in many typical radio receivers. He then compiles weighted averages of tube characteristics selected to be correlated for functional testing.

Out of the commercial engineer's investigations grows this functional production tester. Combined functional and standardized tests are quicker. Operator can be even more accurate, and you are assured of more uniform performance.

FUNCTIONAL TESTING..

Another HYTRON EXTRA!

You may have discovered that a tube rigidly inspected by standardized testing procedures (JAN, RMA, IRE) still may not perform satisfactorily in your equipment. Ordinary control of basic characteristics may not be enough. Functional dynamic tests—selected and correlated to simulate performance in typical equipment applications—may have to be added.

Simple analogy explains why. Testing of fundamental tube characteristics is like inspection of individual components of multi-ganged tuned circuits. When the tuner is assembled or the tube connected into a circuit, coils and condensers or tube characteristics may not combine properly. Individual variations within tolerances may be in opposition. Operational tests are the only positive checks.

Hytron commercial engineers, therefore, developed functional testers like the illustrated 50L6GT production test kit—essentially a customary equipment circuit. Whether or not a part of the standardized tests, 50L6GT characteristics related to power sensitivity and output are simultaneously checked for smooth dynamic interaction. This comprehensive functional test automatically includes additional minor tests—pertinent but usually omitted from production testing. Hum itself is also measured, because no basic characteristic test controls it adequately.

Functional testing is another Hytron extra. Based on painstakingly acquired know-how, it is often the best and easiest way to assure you of uniform, reliable tube performance in your equipment.

SPECIALISTS IN RADIO RECEIVING TUBES SINCE 1921

HYTRON RADIO TUBES

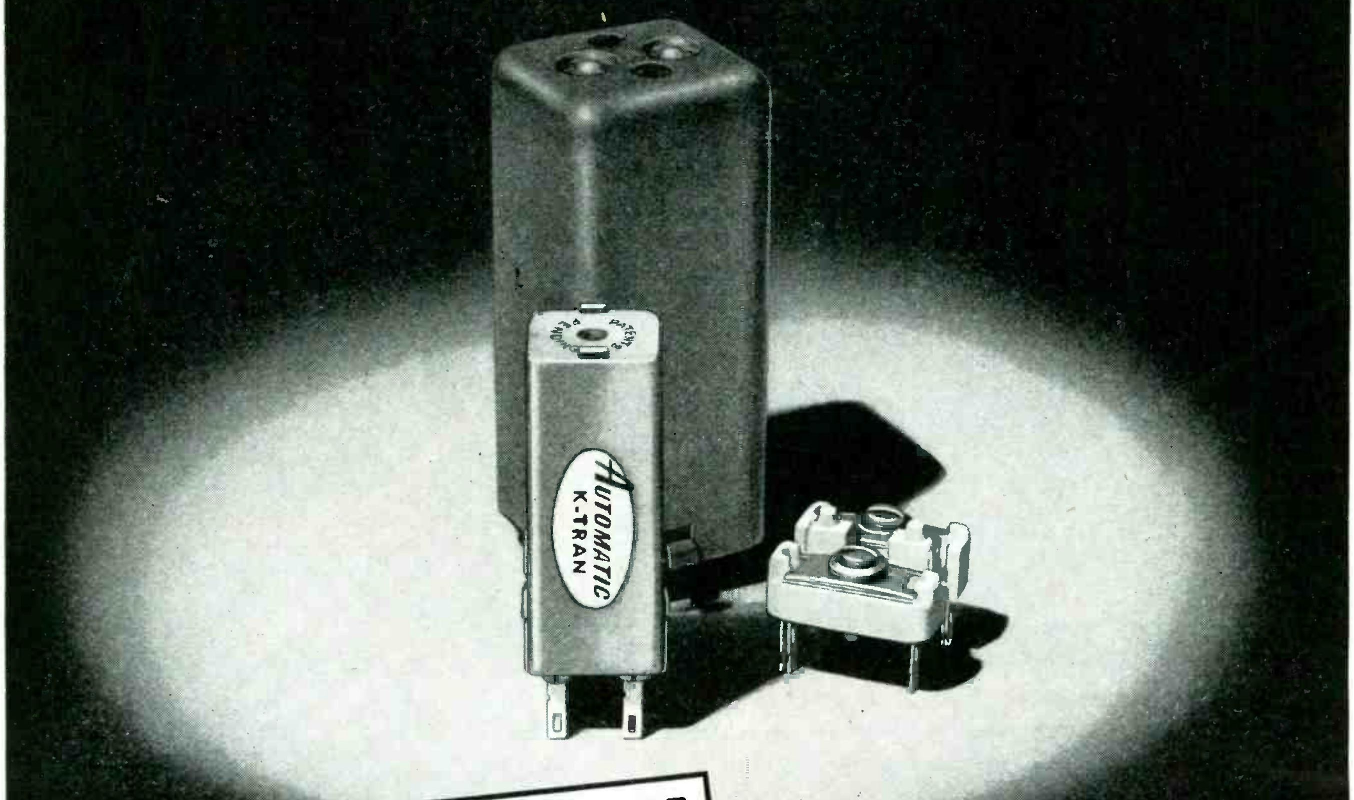
HYTRON

RADIO AND ELECTRONICS CORP.

ARMY NAVY E

MAIN OFFICE: SALEM, MASSACHUSETTS

USE STANDARD PARTS — SAVE TIME AND MONEY



TRANSITION

The K-TRAN has been acclaimed as an outstanding development in I. F. Transformer design.

The K-TRAN is now being used by many manufacturers in newly designed receivers. The small size and high performance of the K-TRAN makes possible the use of a few standardized K-TRANS throughout a complete line of chasses, simplifying purchasing, stocking, and design problems tremendously.

Our production of old-style I. F. Transformers for existing designs will continue.

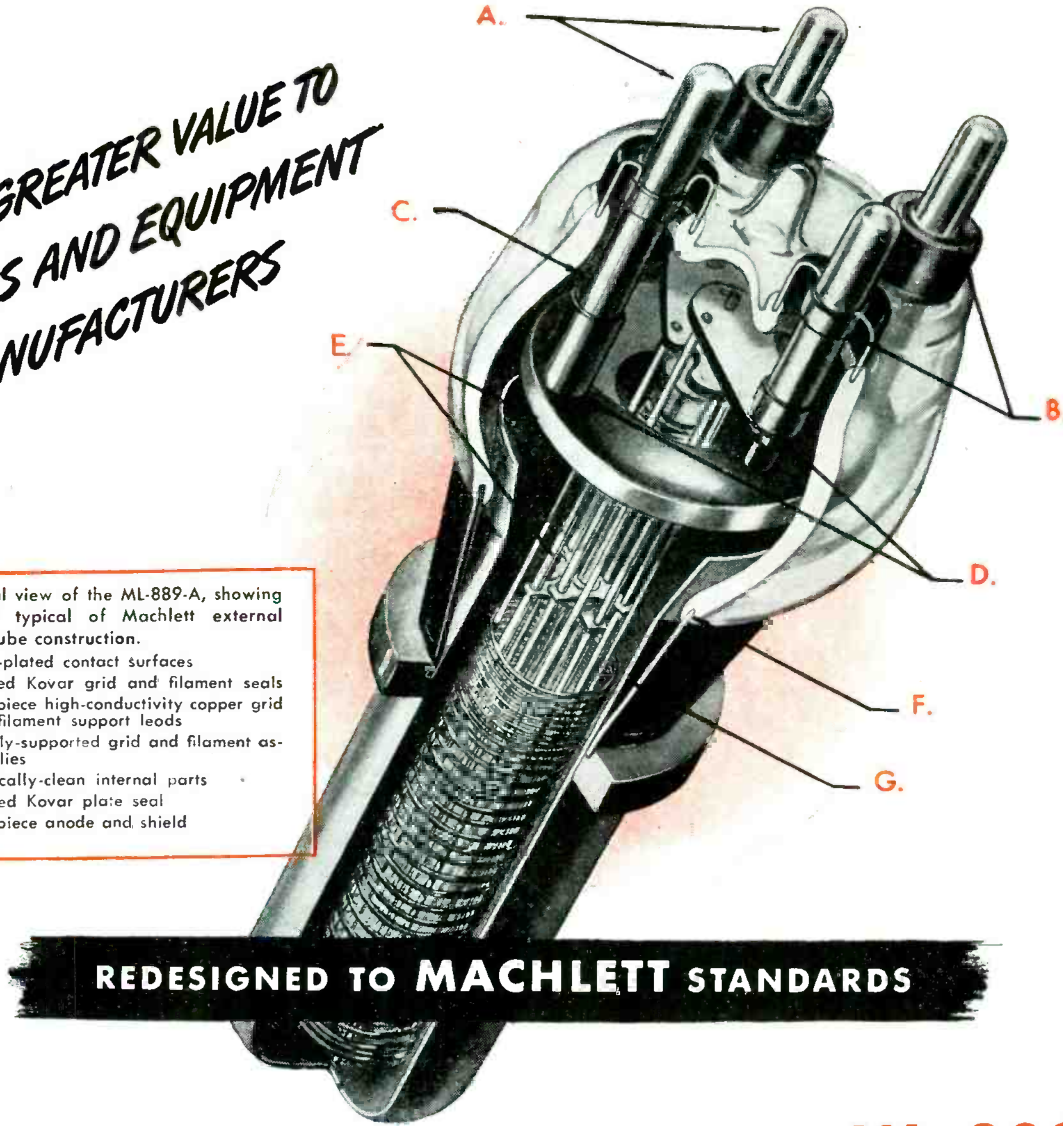
AUTOMATIC *MICA TRIMMER CONDENSERS are still the standard of the industry.*

AUTOMATIC MANUFACTURING
C O R P O R A T I O N

MASS PRODUCTION COILS & MICA TRIMMER CONDENSERS

900 PASSAIC AVE. EAST NEWARK, N. J.

FOR GREATER VALUE TO USERS AND EQUIPMENT MANUFACTURERS



Sectional view of the ML-889-A, showing features typical of Machlett external anode tube construction.

A. Gold-plated contact surfaces
B. Rugged Kovar grid and filament seals
C. One-piece high-conductivity copper grid and filament support leads
D. Rigidly-supported grid and filament assemblies
E. Surgically-clean internal parts
F. Rugged Kovar plate seal
G. One-piece anode and shield

REDESIGNED TO MACHLETT STANDARDS

For better performance and longer life! ML-889A

HERE, in the ML-889A and ML-889RA, is another outstanding example of Machlett's ability to apply to the design and manufacture of high-power triodes its unique skills acquired through a half-century of electron tube production . . . a half-century of leadership in producing the most critical and exacting of all electron tubes. This background and resulting know-how are effectively reflected in the design and construction of all Machlett external anode tubes. Note, for instance, these features of the ML-892 and ML-892R:

1. Heavy Kovar sections for grid and plate seals, instead of feather-edge copper. Result . . . greatly increased mechanical strength.

2. Grid assembly supported by heavy Kovar cup, for strength and stable inter-element spacing.

3. Filament assembly greatly strengthened to increase life and preserve correct spacing.

4. All internal parts processed by special Machlett techniques which prevent contamination by foreign particles, assuring permanent outgassing.

5. Tube pumped by unique Machlett continuous, straight-line, high-voltage process, assuring same high standards maintained in Machlett high-voltage X-ray tubes.

• • •

For complete details of this greatly improved tube, write Machlett Laboratories, Inc., Springdale, Connecticut.

GENERAL CHARACTERISTICS

	ML-892	ML-892-R
Filament Voltage	22	22 volts
Filament Current	60	60 amps.
Amplification Factor	50	50
Maximum frequency for full power	1.6	1.6 mc.
Capacity grid to plate	27	30 uuf
Capacity grid to filament	18	18 uuf
Capacity plate to filament	2	2 uuf
Cooling	Water 3 to 8 G.P.M.	Air 400-700 C.F.M.

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES

ITS 49 YEARS OF ELECTRON TUBE EXPERIENCE

MITCHELL-RAND *has* VARNISHED TUBINGS

of fiberglas and staple fiber cotton yarn for every electrical insulation requirement.

M-R THE ELECTRICAL INSULATION HEADQUARTERS FOR 57 YEARS.

M-R Fiberglas (inorganic) Varnished Tubings are made in four grades: Standard; Double Saturated; Triple Strength and Impregnated.

STANDARD

STANDARD GRADE has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED

DOUBLE SATURATED has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH

TRIPLE STRENGTH is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED

IMPREGNATED is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*

MIRAC • HYGRADE

FOR USERS OF COTTON YARN VARNISHED TUBINGS The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life. *Write For Samples.*

FREE FOR THE ASKING
Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drill sizes, etc.

HEADQUARTERS THE ELECTRICAL INSULATION MR FOR 57 YEARS

MITCHELL-RAND INSULATION COMPANY, INC.

51 MURRAY STREET | ***COrtlandt 7-9264*** | **NEW YORK 7, N.Y.**

A PARTIAL LIST OF M-R PRODUCTS

- Fiberglas Varnished Tape and Cloth
- Insulating Papers and Twines
- Cable Filling and Pothead Compounds
- Friction Tape and Splice
- Transformer Compounds
- Fiberglas Saturated Sleeving, Varnished Tubing
- Asbestos Sleeving and Tape
- Varnished Cambric Cloth and Tape
- Mica Plate, Tape, Paper, Cloth, Tubing
- Fiberglas Braided Sleeving
- Cotton Tapes, Webbings and Sleevings
- Impregnated Varnish Tubing
- Insulating Varnishes of all types
- Extruded Plastic Tubing

PUNCTURE PROOF

LAPP GAS-FILLED CONDENSER OFFERS NON-DETERIORATING, UNIFORM PERFORMANCE

The dielectric of the Lapp condenser is an inert gas, non-deteriorating and puncture proof. After years of service, the condenser retains the same margin of security it had when installed in the circuit. Also, it offers lower loss than solid-dielectric units, with corresponding economy of power. Not needing to "warm up," it provides constant capacitance under temperature variation. Variable, adjustable and fixed capacitance units are available, in current ratings up to 500 amperes R.M.S., and voltage ratings up to 60 Kv peak. Fixed units have been made with capacitance up to 60,000 mmf., variable and adjustable units up to 16,000 mmf.

Lapp

LAPP INSULATOR COMPANY, INC., LE ROY, NEW YORK

Super

NON-INDUCTIVE RESISTORS

FOR HIGH R-F USES

Sprague Koolohm type SIF super non-inductive resistors have solved many serious problems in high-frequency radar and communications work involving dummy loads and dummy antennae, line terminations, rhombic antenna phasing resistors, and others—wherever there is need for power wire-wound resistors having extremely small phase angles.

These SIF units are made in seven types, with power rating from 15 to 150 watts. Typical maximum phase angle values, measured at 3MC are as follows:

5 ohms to 26 ohms . . . 20°
27 ohms to 99 ohms . . . 12°
100 ohms and higher . . . 6°

For complete details write for the new catalog of Sprague Koolohm wire-wound resistors for every requirement.

A Large Government Laboratory Reports:

"Preliminary measurements on the Sample No. 878, Type 120SIF resistors have indicated that these resistors should fulfill the requirements of the intended service. Over a frequency range from 6 to 15 Mc and with six units connected in parallel the impedance (R±JX) varied from 49+J4.3 to 51+J6.3. At a frequency of 10 Mc and with each unit measured singly, the resistance of six units varied from 295 to 306.5 ohms and the reactance varied from 0 to −4.2 ohms. The higher reactance obtained for the parallel arrangement is partially due to the necessary connecting buss bars."

SPRAGUE ELECTRIC COMPANY

RESISTOR DIVISION NORTH ADAMS, MASS.

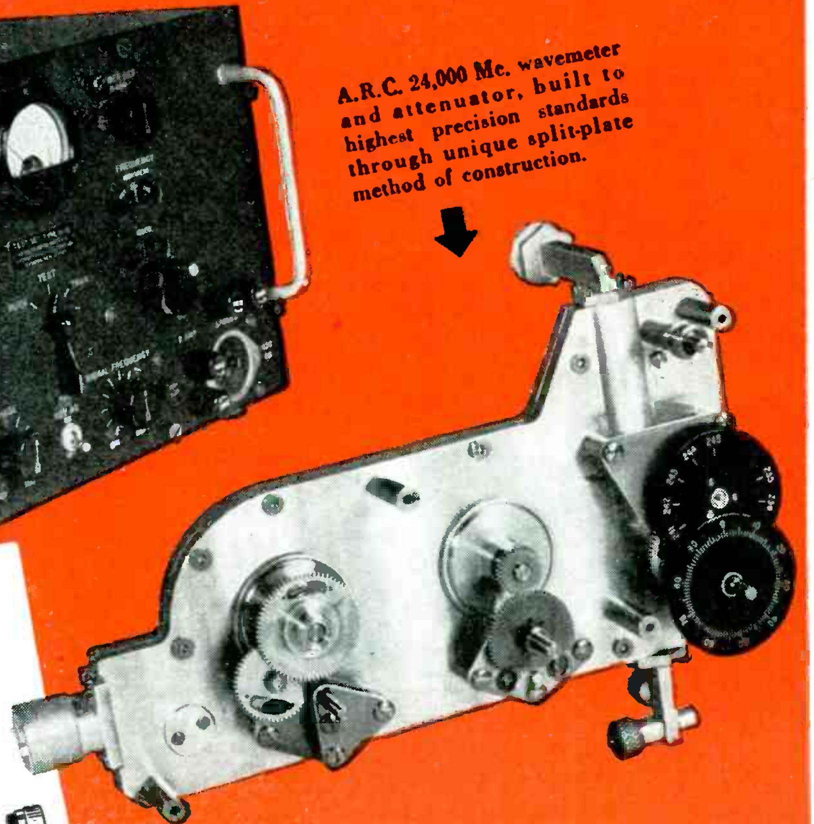
SPRAGUE KOOLOHM RESISTORS

Reg. U. S. Pat. Off.

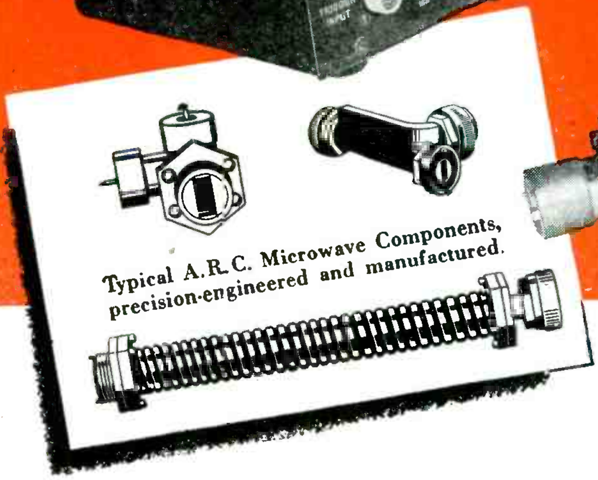
WIRE-WOUND POWER TYPES • BOBBIN TYPES • METER MULTIPLIERS • MEGOMAX, ETC.

Now Available!

MICROWAVE TEST AND MEASUREMENT EQUIPMENT BY ARC



A.R.C. 24,000 Mc. wavemeter and attenuator, built to highest precision standards through unique split-plate method of construction.



Typical A.R.C. Microwave Components, precision-engineered and manufactured.

Recently released from Army-Navy classification, this equipment, formerly known as the TS-223/AP, is now being produced by Aircraft Radio Corporation as the A.R.C. Test Set, Type H-10.

This highly specialized test equipment is used primarily for the measurement of radar receiver sensitivity, frequency and band width; and transmitter power and frequency, in the 24,000 Mc. band. Other field or laboratory measurements possible with this equipment include testing of type 2K50 r-f oscillator tubes and measurement of radar receiver recovery time.

The heart of the A.R.C. Test Set, the 24,000 Mc. wavemeter and attenuator, is available separately, if desired.

For full information on A.R.C. microwave accessories and component parts, write

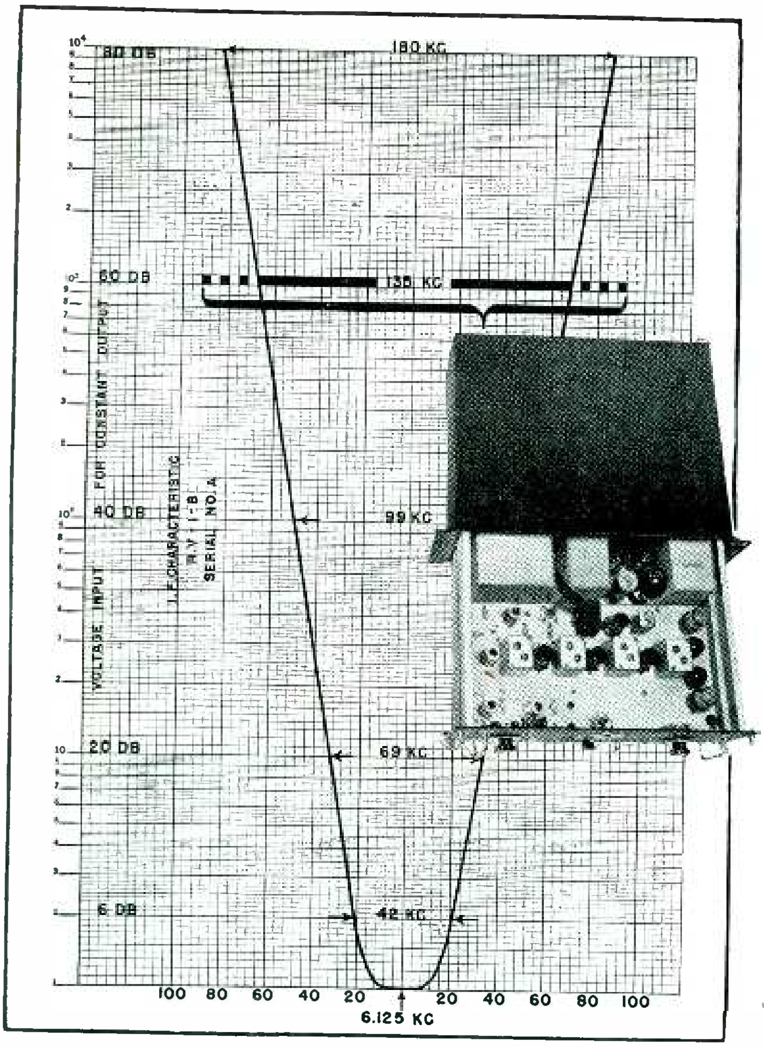
NOW AVAILABLE: free, illustrated catalog of A.R.C. Radio and Electronic Component Parts and Accessories

Contractors since 1929 to the Army and the Navy

AIRCRAFT RADIO CORPORATION
BOONTON, NEW JERSEY

ARC

Communication Supts. . . . . . . Radio Engineers . . . . .



ACTUAL SELECTIVITY CURVE RECEIVER RV-1-B
(installed in airline communication system)

HERE IS RECEIVER PERFORMANCE

which meets ultimate airline requirements

NOW!

Ultimate airline standards for VHF communications require a channel separation of 100 kc. Here is a crystal controlled, single frequency receiver which will meet that requirement TODAY.

Note the outstanding features of the RV-1-B receiver in the box at the left.

Typical of performance attained by Radio Receptor equipment is the high selectivity of receiver RV-1-B for airlines and airports. Engineering and building radio equipment for superior operating characteristics have been primary functions at Radio Receptor since 1922. Reflected in every Radio Receptor product is this background of consistent superiority and the refusal to compromise with quality where lives and property are at stake.

Radio Receptor experience takes in the entire field of radio communications equipment and radio navigational aids for airports and airlines — fields like LaGuardia, Washington National and others, airlines such as American Overseas and others. Radio Receptor designers and technicians are ready to apply this experience to your equipment specification and installation problems.

Write today on your letterhead for full information on Radio Receptor equipment. Address Dept. C-4.

NOTE these outstanding features

FREQUENCY RANGE: 100 to 162 mc.

AUDIO OUTPUT: 1 watt undistorted.

SENSITIVITY: Signal-to-noise ratio better than 2:1 (6 db) for a 2 microvolt signal modulated 30%.

IMAGE RATIO: Better than 1000:1 (60 db) at 130 mc.

A.V.C. ACTION: Amplified A.V.C. audio output changes less than 4 db for signal inputs between 10 and 100,000 microvolts.

PEAK NOISE LIMITER: Impulse noise automatically clipped to 3 db (approx.) Over 100% modulation for carriers of 10 microvolts or more.

CARRIER OPERATED AUDIO CHANNEL: Audio channel is normally cut off. A received carrier of approximately 2 microvolts or more turns it on. Special "Snap action" circuit insures clear open or shut condition.

HEIGHT: 5¼" Standard Rack Mounting.

Peak performance obtained with only 140 volt plate supply—can be operated locally or remotely.

Unit slides out of dust cover on ball bearings, and can be inverted while operating for easy, accessible servicing.

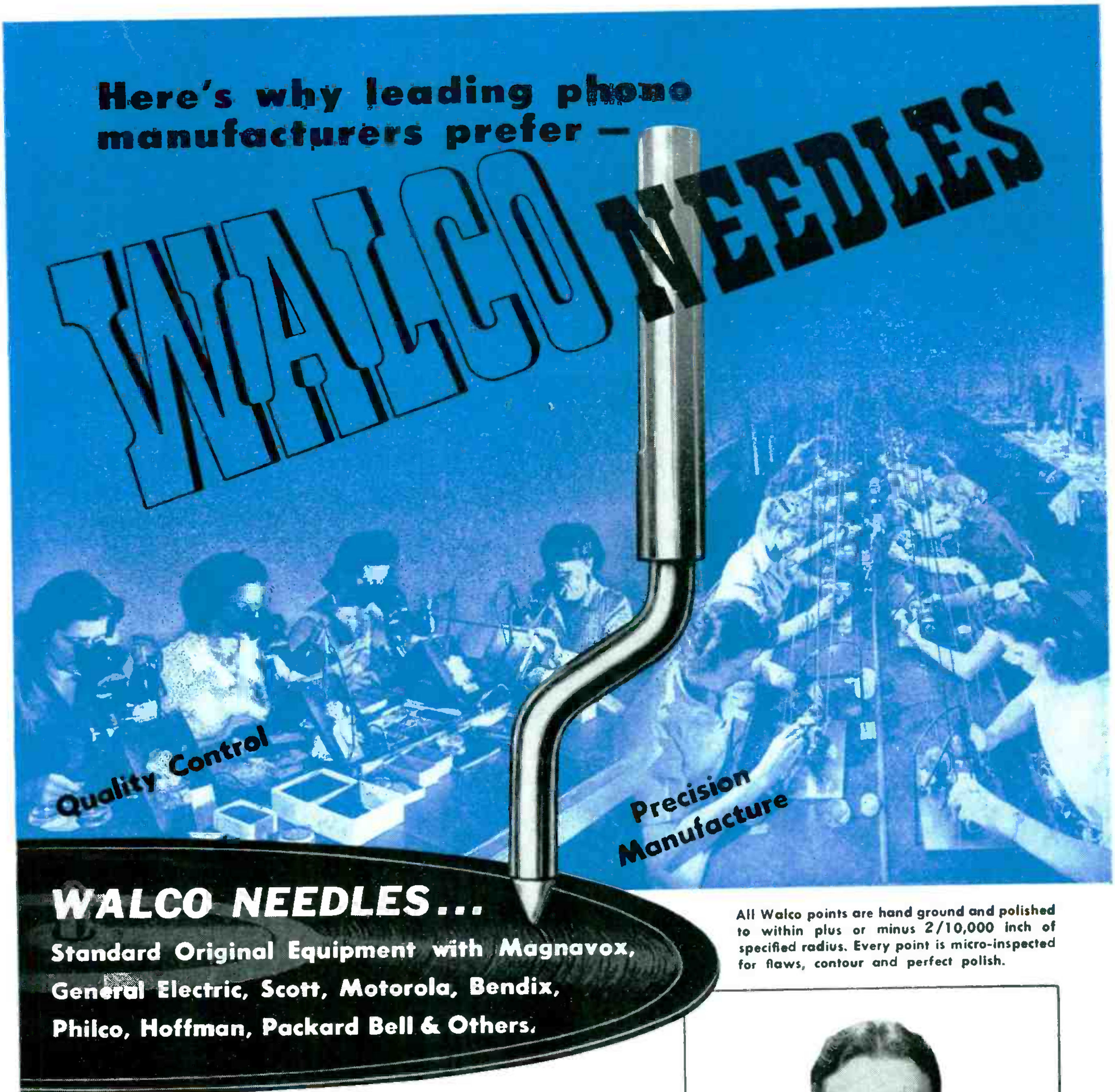
1899

Communications Division

RADIO RECEPTOR COMPANY, INC.

SINCE 1922 IN RADIO AND ELECTRONICS

251 West 19th Street — New York 11, N. Y.



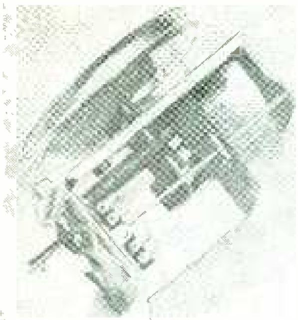
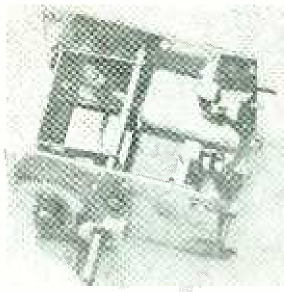
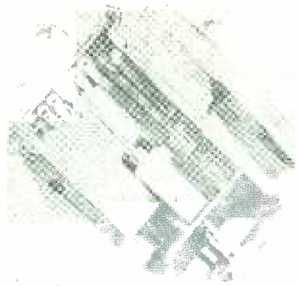
All Walco points are hand ground and polished to within plus or minus 2/10,000 inch of specified radius. Every point is micro-inspected for flaws, contour and perfect polish.

COMPLETE FACILITIES for the manufacture of sapphire and metal points to any specifications include the smallest Swiss screw and stamping machines, microscopic grinding and finishing. Strict quality control throughout.

NEEDLES FOR SPECIAL SETTINGS can be made from your blueprints. The WALCO engineering staff will gladly work with you on individual problems—your inquiries are invited. WALCO needles are a product of ELECTROVOX COMPANY, INC., NEWARK 2, NEW JERSEY.

MR. ROY DALLY
chief engineer, heads the WALCO research staff. A recognized authority on phono needle and pick-up design, and author of many authoritative papers on the subject, he is available to help solve manufacturers' problems.

The Choice of Leading Phono Manufacturers—
—Scientifically Designed for Music at its Best!

PERMEABILITY TUNING

Aladdin
REG. U.S. PAT. OFF.

PIONEERS
ORIGINATORS

A New Contribution

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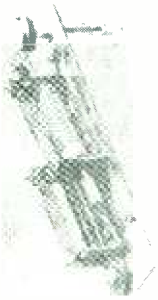


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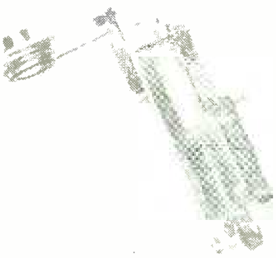

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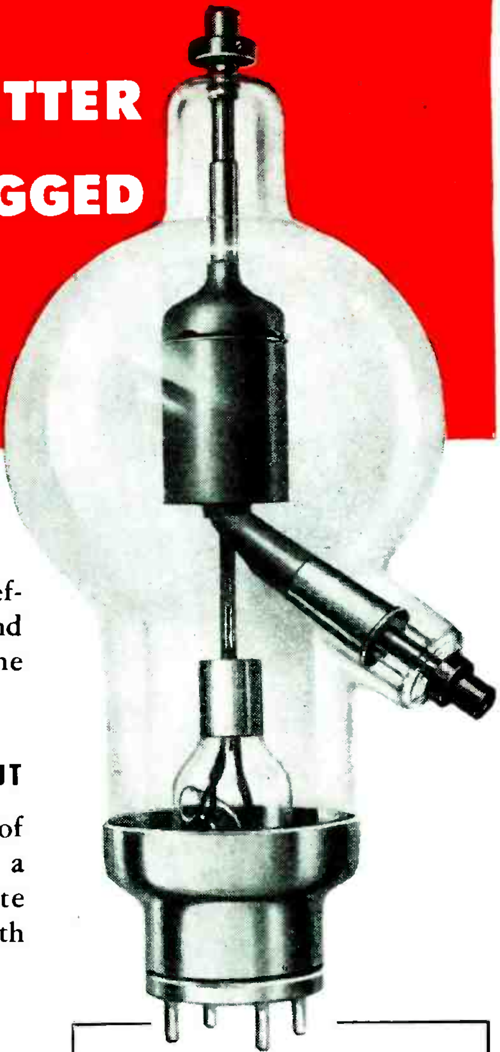
IT'S TOUGH TO FIND A BETTER TRIODE THAN THE BIG, RUGGED

EIMAC 750TL



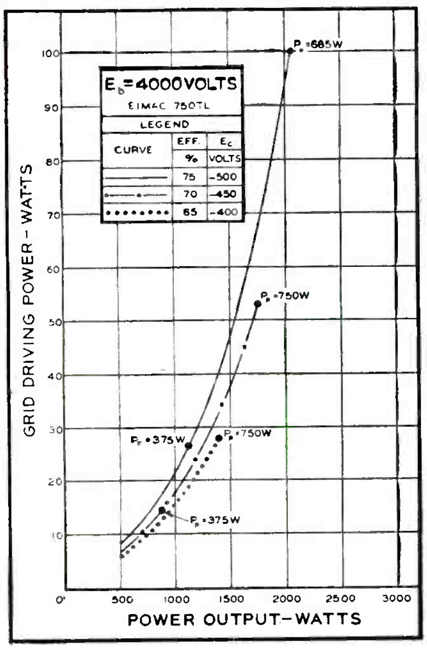
VERSATILE MEDIUM-MU TRIODE

The Eimac 750TL is a medium-mu triode designed for high efficiency operation whether used as a modulator, oscillator or amplifier. This is an unusually versatile tube capable of many kilowatts of output.

Successful high frequency operation of this triode is assured by unusually low interelectrode capacitances, heavy leads, and a big tough cathode.

The chart below shows power-gain characteristics of the 750TL.

As a Class-C amplifier, the Eimac 750TL will provide plate power output of 1750 watts with 4000 volts on the plate and only 53 watts driving power.



At frequencies below 40 mc, or as a Class-B modulator, the 750TL operates at high plate efficiencies, thus permitting r-f and a-f outputs of many times the plate dissipation rating.

3½ KILOWATT AUDIO OUTPUT

As Class-B modulators, a pair of Eimac 750TL's will produce a typical maximum-signal plate power output of 3500 watts, with only 30 watts grid drive.

THESE ARE RUGGED TUBES

These big, powerful 750TL's are built for long, trouble-free service for a wide variety of uses. Many Eimac 750TL's installed months and years ago are still going quietly and efficiently about their business. Why not ask Eimac today for a price and data sheet giving full details of this versatile triode. Naturally, there is no obligation. Eitel-McCullough, Inc., 1298E San Mateo Ave., San Bruno, Calif. Export Agents: Frazar and Hansen, 301 Clay St., San Francisco 11, Calif., U. S. A.

GENERAL CHARACTERISTICS

Eimac 750TL

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	21.0 amperes
Amplification Factor (Average)	15
Direct Interelectrode Capacitances (Average)	
Grid-Plate	5.8 μμfd
Grid-Filament	8.5 μμfd
Plate-Filament	1.2 μμfd
Transconductance (I_B=1.0 amp., E_B=5000, E_C=—100)	3500 μmhos
Frequency for Maximum Ratings	40 Mc
Base	Special 4 Pin No. 5003B
Basing	RMA type 4BD
Maximum Overall Dimensions:	
Length	17.0 inches
Diameter	7.125 inches
Net Weight	2.75 pounds
Shipping Weight (Average)	8.0 pounds

Follow the Leaders to

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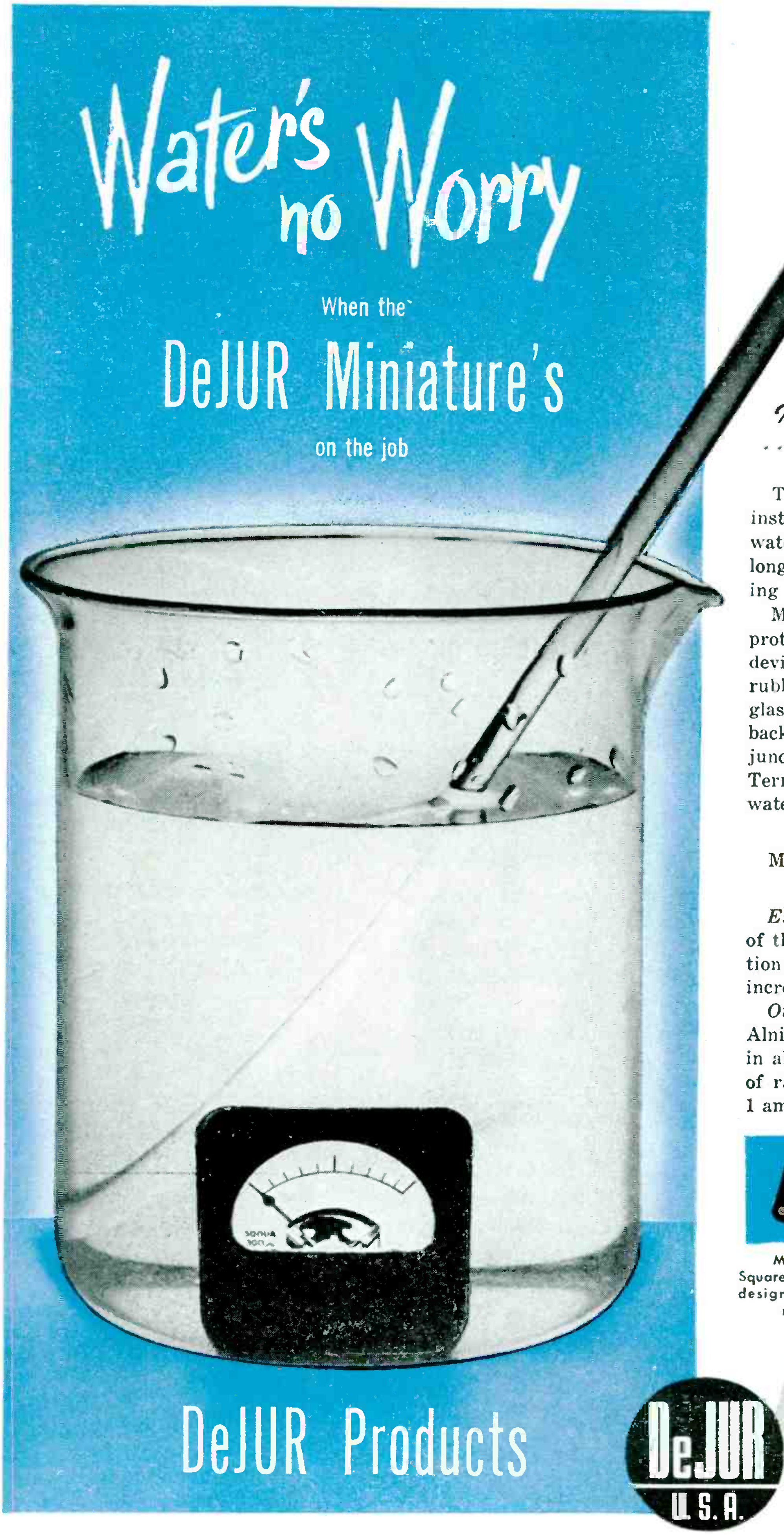

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MODEL 112
Square plastic case is designed for screw-mounting.

MODEL 120
Smallest ring-mounted meter available. Metal case.

Their Mechanical Perfection Protects Their Electrical Performance

A FREE ECONOMY IS WORTH FIGHTING FOR

BUSINESS must take the initiative if the price decontrol machinery, set up by Congress, is to be effective. The present price control law is far more than a set of instructions to the administrators of OPA; it is a challenge to business to be aggressive in speeding decontrol decisions and in persuading the Price Decontrol Board to adopt a strong stand for return to a free economy.

Thus far business has not met this challenge. *Two months after the passage of the new price law not a single application for decontrol of a major product had been filed by an industry advisory committee.* This is due in part to the red tape controlling such applications. Nonetheless, a continuation of such inactivity on the part of business can well result in perpetuating price control far beyond the time either the present law or sensible economic policy require.

It was the clear intent of Congress to hasten our return to a free economy. In the legislation continuing the general control of prices, Congress formally declared its purpose to have it "terminated as rapidly as possible."

To accomplish this, the House originally approved a formula which would have made decontrol mandatory when production had attained a prescribed level. The automatic decontrol provision was dropped before the bill was finally passed, partly because of the uncertain effects of strikes on production. But Congress did not mean to return the timing and extent of decontrol to the administrative discretion of OPA.

On the contrary, to assure having price control "terminated as rapidly as possible," Congress created a Price Decontrol Board and gave it power to overrule OPA when the board finds price control should be removed. Moreover, it gave to industry the right and the responsibility to seek decontrol. Also, in a further effort to speed up the decontrol process, it placed narrow limits on the time allowed for board decisions.

Congress had compelling economic reasons for doing its legislative best to speed up decontrol.

1. It is by all odds the best way to eliminate the bottlenecks in production and the black markets which have plagued the country since V-J Day.

   Rigid price ceilings promote shortages of badly needed commodities by discouraging their production. Such shortages both upset the flow of production and promote black markets. At present a considerable part of American industry is stymied by shortage of critical parts and materials. Price control is much to blame.

2. There must be flexibility of prices if a round of new wage adjustments, which may be forced on industry early in 1947, is to be negotiated without grave risks of seriously curtailing production.

   When, under the leadership of the national administration, the first post V-J Day round of wage adjustments was made, price ceilings were held rigid while wages were boosted. The result was a series of price-wage squeezes which upset production. They would have been disastrous if we had not been in a sellers' market, created by a tremendous accumulation of wartime shortages. In 1947, however, many industries will be in a buyers' market. It must be possible, therefore, to have wage increases reflected promptly in price adjustments if we are to avoid a repetition of the costly post V-J Day round of strikes, which often had price control as the key issue.

3. Rapid decontrol is necessary to maintain a high level of employment and production.

   Almost five years of price control inevitably twisted the factors of production and distribution far out of the equilibrium which would prevail in a free economy to which it is the clear purpose of the nation to return. Unless the return to a free economy is facilitated by a speedy and orderly decontrol, the jolt of an abrupt return to competition can be expected to upset employment and production seriously.

It's Up To Business

To encourage speed and boldness in decontrol, Congress provided for the reimposition of control over any prices which, after being released, might get out of hand. The dangers of this sort are chronically exaggerated. During the 25-day period in July when there was no price control the Civilian Production Administration found that "manufacturers of finished industrial and consumer products have generally exhibited commendable restraint in increasing prices no more than increased costs."

All of this endeavor to speed up decontrol and expand its scope is likely to be futile, however, unless business furnishes the driving power for the machinery Congress provided. OPA certainly will not do it. Neither can the Decontrol Board be expected to go out and drum up cases.

The necessity for vigorous action by business in pressing for decontrol is increased by the fact that the general legislative standards to guide decisions by the Decontrol Board are vague. They must be clarified and sharpened by decisions in specific cases.

The main principle to guide the decontrol of non-agricultural products is that price ceilings shall be removed when supply is in approximate balance with demand. But what precisely does that mean? The meaning will become clear only through Decontrol Board decisions.

The same is true of the principle which makes automatic decontrol of a non-agricultural commodity contingent on whether or not it "is important to business costs or living costs." Business must press cases which will give specific meaning to those vague terms if decontrol is to get on apace.

Cards Are Stacked

At present the government has the cards pretty well stacked against rapid decontrol.

First, the key members of the staff of the Price Decontrol Board are holdovers from the Bowles regime which emphasized the importance of carrying on price control rather than speed in getting rid of it.

Second, in exercising his authority to prescribe regulations to govern petitions for decontrol, the OPA administrator has required excessively complicated statistical and economic data. Manufacturers who are sure they can convince any fair-minded board of the desirability of decontrolling certain of their products assert that they are blocked by statistical entanglements.

Third, OPA has discouraged business from moving immediately under one section of the law to speed decontrol. This section provides that products "not important in relation to business or living costs" may be freed from price ceilings immediately and must be freed by December 31, 1946, unles OPA specifically finds they are important to these costs. Instead of making it possible for business to move under this section now, OPA has issued rules which have the effect of blocking such a course until the end of the year.

In the light of obstacles such as these, it is not surprising that the record of decontrol to date is not impressive.

Decontrol Record

Since June 30 there has been a drop from about 70% to about 60% in the total value of products under price control. But most of the drop has been accounted for by food products, which Congress took the lead in decontrolling, and by industrial machinery which was being decontrolled when Congress acted. By far the larger part of manufactured consumer goods remains under control.

This, however, is no time for business to be discouraged. Rather, business should accept the obstacles put in its way as a challenge and work harder than ever for speedy decontrol.

The case for decontrol should not be stated in narrow technical terms. It should be based on grounds of broad public policy, and should demonstrate how a speedy return to a free economy can hasten the full release of the nation's productive power.

For example, there should be very clear demonstrations of how, in far too many cases, rigid price ceilings— (1) discourage production of key parts and materials by making such production relatively unprofitable, (2) create shortages of key parts and materials which tie up broad ranges of production or result in piling up lopsided inventories of partially completed goods, and (3) thus cut away the foundations of a stable economy and the prospects of steadily sustained employment.

There should be equally full demonstrations of the well known sequence from shortages to unrealistic price ceilings to black markets. Meat prices are rolled back, but the meat is rolled under the counter.

A free economy is worth fighting for. Liberty is preserved only by the constant struggle of those who believe in it. Neither the interests of the nation in a strong and well-balanced economy nor the interests of business itself will be served by drifting at this time. Now is the time for business to lead a strong offensive for speedy elimination of price control.

James H. McGraw, Jr.

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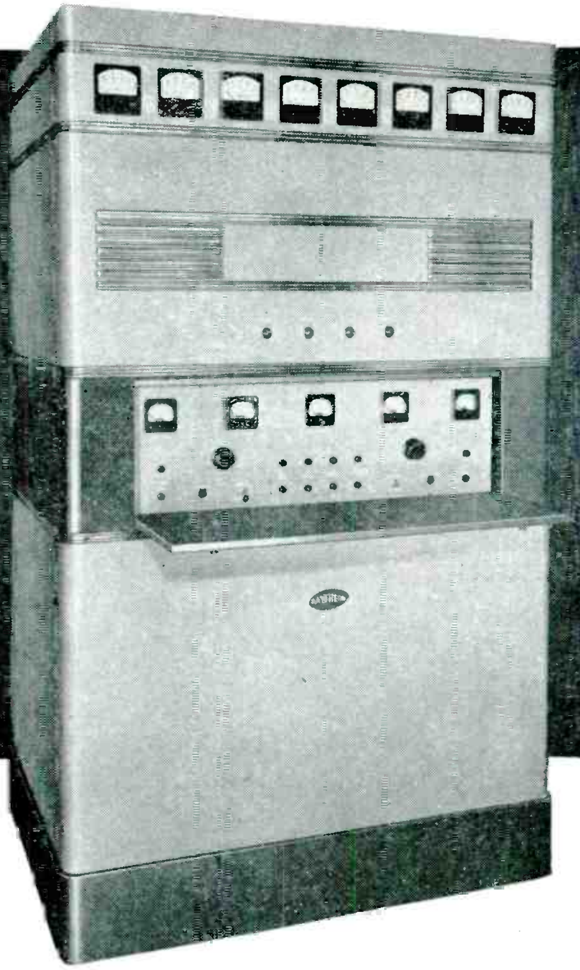
THIS IS THE 51st OF A SERIES

IF IT'S 1000 WATTS YOU WANT



...STUDY THIS NEW, ADVANCED RAYTHEON AM TRANSMITTER

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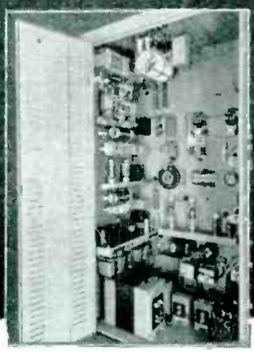

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This Raytheon transmitter commands attention of 1000 Watt station owners and engineers. Before *you* decide on a transmitter, write or wire for our fully illustrated specification bulletin. *Prompt deliveries can be made.*

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

1 **Simplified, More Efficient Circuits**—A high level modulation system eliminates necessity of complicated and critical adjustment of linear amplifiers and minimizes harmonic distortion. Tube cost low, power consumption considerably lower.

2 **Greater Dependability**—Modern components, operated at well below their maximum ratings, and simplified circuit design reduce failures to minimum. Designed to withstand overloads—fully resistant to excessive temperatures, high humidity. Performance not impaired by ordinary line voltage fluctuation.

3 **High Fidelity Signal**—Modern triode type tubes used in all audio stages have an inherently lower distortion level. Specially designed audio transformers reduce distortion still further. The feedback circuit also improves signal quality but is not essential in this simplified circuit.

4 **Push-Pull Final Amplifier**—A Push-Pull R F final amplifier materially decreases harmonic distortion. Parasitic oscillation in this stage is eliminated and suppressors are not needed.

5 **Easy to Operate**—Only two stages, the R F Drive Amplifier and Power Amplifier, have to be tuned. A Video type amplifier eliminates complicated tuning of the Buffer stage.

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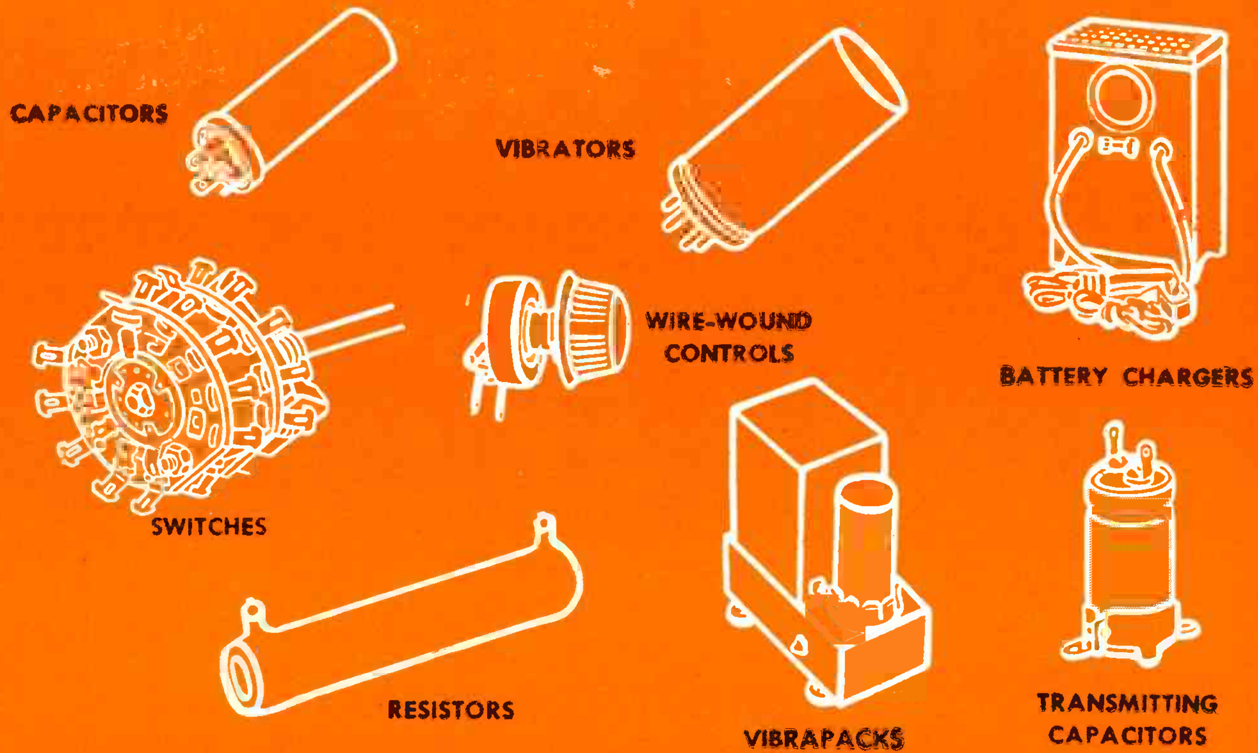

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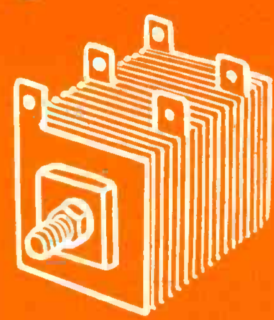

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CROSS TALK

► **NBS** . . . Electronics is an industry which has grown up in the United States largely within the last decade. Scientific principles responsible for its genesis and growth were derived principally from physics, chemistry, mathematics, electrical engineering and radio engineering. It was only natural for the National Bureau of Standards to play an important role in the early years of this new field, particularly in developing fundamental and derived standards of measurements and numerical data. Such work was readily carried out by Bureau units already in existence.

The industry expanded rapidly during the war. New knowledge had to be developed quickly and without thorough digestion. Many new avenues of application were tentatively opened up and much new research of a basic nature was indicated. Now that wartime urgency has ceased, the Bureau of Standards, through a full fledged electronics unit, could once more perform very valuable services.

Lest industry wonder why a government department should be involved in work that industry may properly call its own, one example will suffice to point out that there are many jobs a disinterested agency working for everyone could best do: Up to very recently the only types of electric power used in American industry have been direct current and power at a frequency of 60 cycles or thereabouts. An accelerating trend is evident, however, in the use of power at all manner of frequencies, including frequencies that can be generated only by electron tubes. Thus competition for frequencies may easily arise between the communication companies and those making and using high frequency power for non-communication purposes. This clash of interest has already led to other difficulties regarding interference created by therapeutic apparatus.

Much data is needed by all branches of the industry on such matters as the amount of shielding needed to eliminate interference to one service by another, on the matter of the proper frequencies to use, on the matter of necessary standards of performance. If the dielectric properties of all materials at all frequencies were known, engineering and usage could proceed much more efficiently. Collection of such data is probably beyond the capabilities of any industrial company, but the information is necessary.

The Bureau of Standards could easily find a hundred jobs which would produce data of great value to the electronics manufacturer and user. An industry such as electronics, founded on scientific principles, needs a constant source of supply of basic data and an agency to call upon when unbiased technical opinion is needed, especially where such opinion is backed up by physical or electrical measurements.

It is hoped that the near post-war years will find the National Bureau of Standards in such a position.

► **SCRAP** . . . While it may be difficult to realize that America must again awaken to the need for steel scrap, such is the fact.

Steel is needed to produce houses, machinery, automobiles, refrigerators, radios and all the other things that form the backbone of our high standard of living. Scrap makes up fifty percent of the charge in open-hearth furnaces, from which by far the greatest proportion of all steel comes. During the coal strike, a larger proportion of scrap than normal was used because there was no coal to make pig iron. Further strikes in consuming and fabricating industries, from which a large part of the scrap normally comes, held back the return of scrap to the furnaces. In recent months as many as 25 to 30 open hearth furnaces have been idle for lack of scrap.

Much usable scrap is lying dormant in industrial plants, warehouses, yards and out-of-the way places, scrap that is urgently needed, scrap that must be moved to market in order that steel can move into all those manufactured products which industry is anxious to make and consumers so anxious to buy.

WEATHER

Although a new radio direction-finding receiver is gradually replacing radar for measuring wind velocities by tracking radiosonde balloons through clouds and darkness, seven microwave radar units are now in regular storm detection service

By HERBERT B. BROOKS Lieutenant, Air Weather Service
Evans Signal Laboratory
Belmar, New Jersey

THE RAPID GROWTH of commercial flying along about 1930 stimulated upper air measurement and study, and the military needs of World War II threw weather forecasters and air crew members into a close association that discouraged mysticism on the part of either. Forecasts are still based on rules and experience, but the rules extend to the stratosphere.

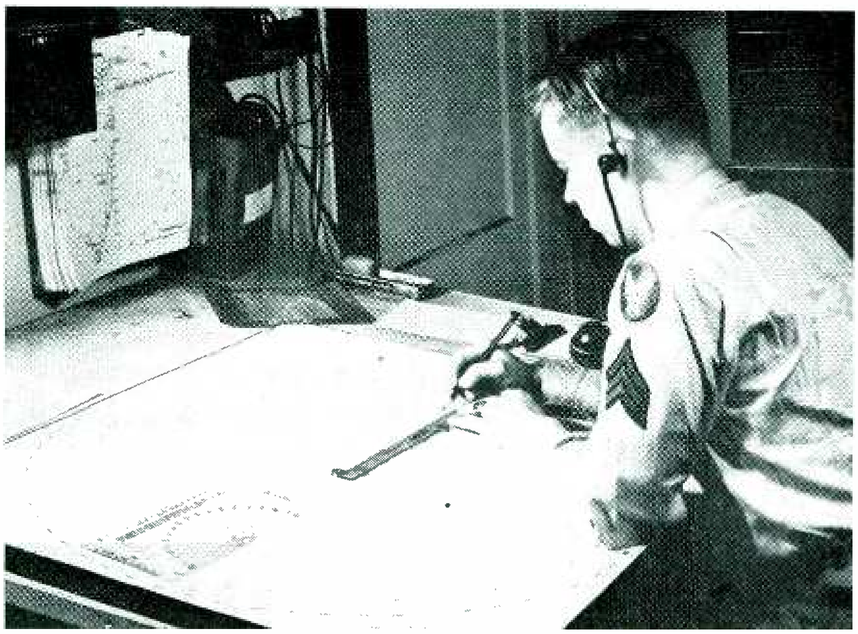
Having finished their war training job, many university meteorology departments are encouraging theoretical and applied research. Weather forecasting should soon become a much more exact science.

Wind Finding

For several decades the winds aloft have been measured by observing with a theodolite the motion of free balloons inflated with hydrogen or helium, as shown in Fig. 1. The present network of a few hundred pilot balloon stations distributed over North America is almost dense enough for complete knowledge of the wind field in clear weather, up to the stratosphere. But bad weather is more important than good weather, and a pilot balloon (pibal) run ends when the balloon enters a cloud. Using radio direction-finding (rdf) and position-finding (radar) techniques developed for combat, the weather services now measure winds to higher altitude and with greater accuracy in nearly any kind of weather.

The first radio wind (rawin) flights were made in 1923 and 1924 by Signal Corps personnel at McCook field, using a small balloon-borne spark transmitter. By 1928 a vacuum-tube system on a wavelength of 125 meters had been tested at Fort Monmouth, New Jersey. Signals from these transmitters were received on azimuth-finders using loop antennas[1]. Japan was reported to have used an improved version of the vacuum-tube system in World War II.

FIG. 1 — Conventional theodolite, and weather balloon just before release. With optical tracking, a run ends when the balloon enters the clouds

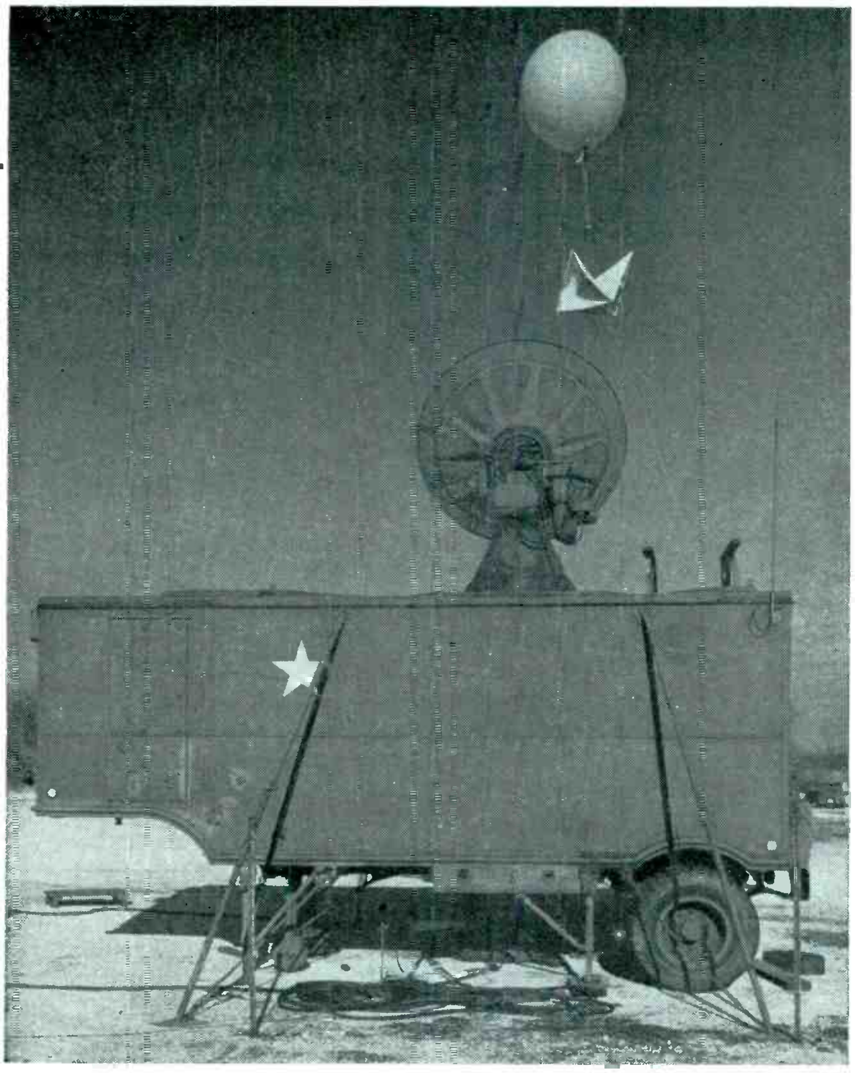


Plotting the horizontal track of an ascending weather balloon from radar indications

In 1937 a 100-foot wire borne aloft by a meteorological balloon was tracked by radar at Fort Monmouth.

To permit wind measurement to great heights in cloudy weather, a dipole reflector target such as the one illustrated in Fig. 2 was developed for use with the SCR-268 radar,[2] and pibal plotting equipment and methods were suitably modified. In 1943 the Signal Corps trained 35 Air Weather Service officers for six weeks in the theory

FORECASTING



Two operators and this 11-cm radar can track a weather balloon through clouds and darkness to 100,000 yards range if the balloon carries a gable target like that shown aloft here

and operation of the equipment. These officers were instrumental in developing electronic weather techniques, usually in cooperation with other services such as the antiaircraft artillery.

Wind measurements made with the SCR-268 are similar in accuracy to those made with theodolites (azimuth and elevation angles to the nearest 0.1 degree). The tracking accuracy of the set is about one degree in angle and 200 yards in range. Elevation angle readings become erratic below 17 degrees due to ground reflection of the wide beam. Four operators are required for manual tracking and for reading and recording the data.

The pioneer microwave ground radar was the SCR-545. The designers felt that the narrow beam characteristic of microwave systems would cause difficulty in searching for and picking up targets, so they provided a 200-megacycle system for search and approximate location in addition to the 11-cm accurate tracking system. Three operators are required to get on the target; the set then tracks automatically in azimuth, elevation angle, and range. A few SCR-545 sets were used for rawins while this radar was still in service, but were soon replaced by the SCR-584.[3] The SCR-584 operates on 11 cm only and is lighter and more compact than the SCR-545. Operating controls and maintenance adjustments are easily accessible to a two-operator team. Automatic angle tracking and aided (manual) range tracking are provided.

In 1943 Major Joseph O. Fletcher and Captain J. E. Nastronero studied radar at the Radiation Laboratory of the Massachusetts Institute of Technology. They learned the advantages of the corner reflector for microwaves and the theory of microwave scattering by rain-drops, predicted many years ago but first demonstrated during World War II, probably in 1942.

The Antiaircraft Artillery used a four-cornered flat-top corner target made of paper-backed foil supported on light wooden sticks, which was borne aloft by a balloon for collimation (alignment) purposes. The Signal Corps Engineering Laboratories and the Air Weather Service designed a slightly larger reflector with one of the four corners

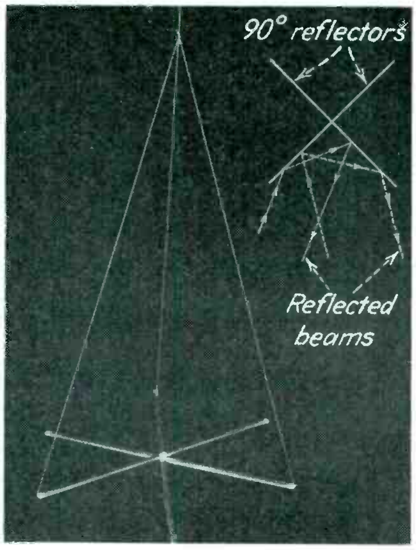


FIG. 2—Dipole target for 200-mc radar, and diagram showing how a target reflects incident beams back to their source

opening downward; it was found that the gable form gave a higher ascent rate. This gable target has been tracked to 100,000 yards range.

The SCR-658 radio direction-finding receiver shown in Fig. 3 went into production in 1944, and soon became standard for use in the Air Weather Service. It is simpler, cheaper, and lighter than the SCR-584, partly because it contains no transmitter, is not inclosed in a van, and does not track automatically. The ground equipment measures azimuth and elevation angle, and the transmitter signals its height by means of a baroswitch. The transmitter is now combined with radiosonde elements, which signal the air temperature and humidity on the flight.

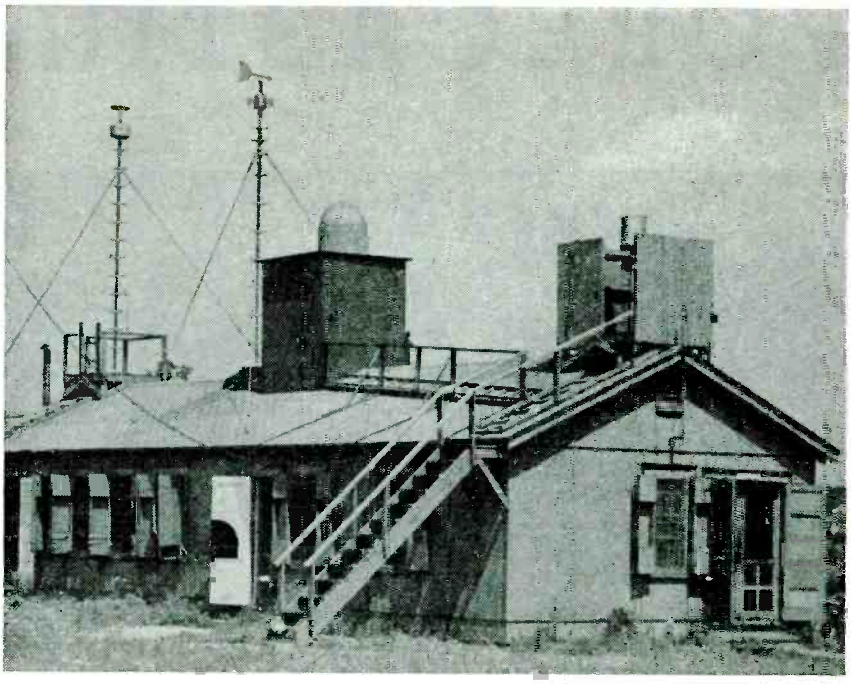
The technique of radar wind-finding found quick acceptance, impeded only by diversion of equipment to more urgent uses. This was because radar offered a better means of doing an old job which had become indispensable to meteorology.

Storm Detection

Although radar is rapidly replacing the theodolite in measuring winds aloft, such is not the case with radar storm detection. The tool is new, and the job is still being studied and recognized.

Microwave radar indicates the location of rain or other precipitation with great accuracy and resolution. Thunderstorm behavior can be forecast for 15 minutes to several hours using trends indicated by past observations.

Radar has proven especially useful in detecting thunderstorm areas so that airmen can avoid them. Many other groups will soon benefit by accurate short-range shower, lightning, hail, windstorm, and



Radar installation in Army weather station for storm detection. Antenna is in radome on roof near center of building

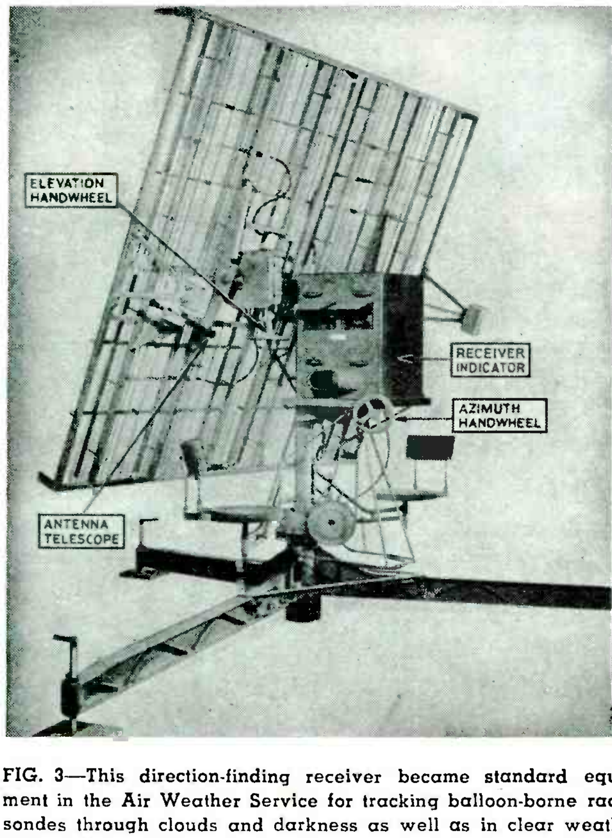


FIG. 3—This direction-finding receiver became standard equipment in the Air Weather Service for tracking balloon-borne radiosondes through clouds and darkness as well as in clear weather

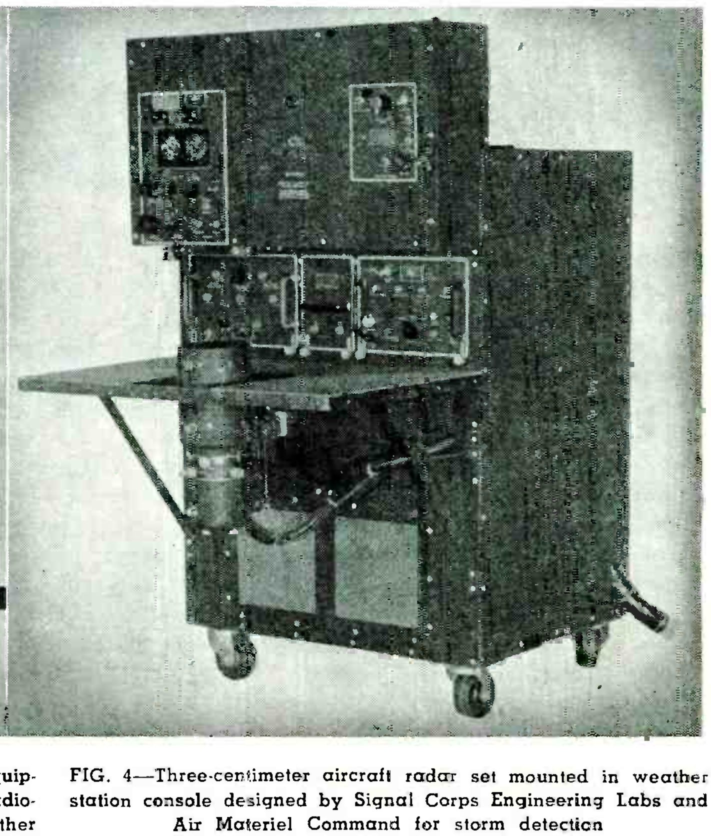


FIG. 4—Three-centimeter aircraft radar set mounted in weather station console designed by Signal Corps Engineering Labs and Air Materiel Command for storm detection

hurricane warnings resulting from radar observations.

The army is conducting basic researches intended to answer the following questions:

(1) What is the effect of various radar parameters on echo strength?

(2) How can a storm echo be interpreted in weather terms?

(3) What is the effect of weather in scattering and absorbing the radar energy?

(4) What is the distribution of drop and ice crystal size and number in various cloud types?

Storm detection on the ground and in the air is expected to play a part in the Army Air Forces' all-weather flying project. Thunderstorms cause hazard and discomfort in flying due to their turbulence, icing, radio interference, and occasional damage to aircraft from direct hits by lightning.

The Weather Bureau, Army, Navy, and National Advisory Committee for Aeronautics are conducting a research project on thunderstorm microstructure near Orlando, Florida. Radar is used for detection, mapping, and surveillance of thunderstorm rain cores, and for taking some of the rawin observations.

The first extensive field test of radar storm detection was in the Panama Canal Zone, where air and sea patrols and well-sited long-range radars kept constant vigil against the attack that never came. Tropical thunderstorms are large and they can be dangerous for blimps and extremely uncomfortable for airplanes. Weather observers were stationed at 10-cm aircraft warning radars, and these observers were allowed to make rareps (rain area reports) over the shoulder of the radar operator, or to operate the set a few minutes out of each hour. This seemed to be a workable compromise between aircraft warning and weather, since tropical thunderstorms move and change comparatively slowly. A fairly elaborate code was used to transmit the location, size, and behavior of these storm areas to the air fields, where they were plotted on local charts.

The most popular storm detection radar is the APQ-13 shown in Fig. 4. This set was designed for installation in aircraft and has a smaller dish and lower power than most of the 10-cm sets which have been used for storm detection, but its 3-cm wavelength gives it greater sensitivity.[4] Microwave power is scattered approximately as the fourth power of the frequency, as in other forms of Rayleigh or small-particle scattering. However, when the radar beam has to penetrate a considerable depth of heavy rain, the optimum wavelength for storm detection increases, as red light penetrates haze better than blue light. Figure 5 illustrates this effect; at 3 cm there is less penetration of the rain cloud and hence the total area of rain does not show.

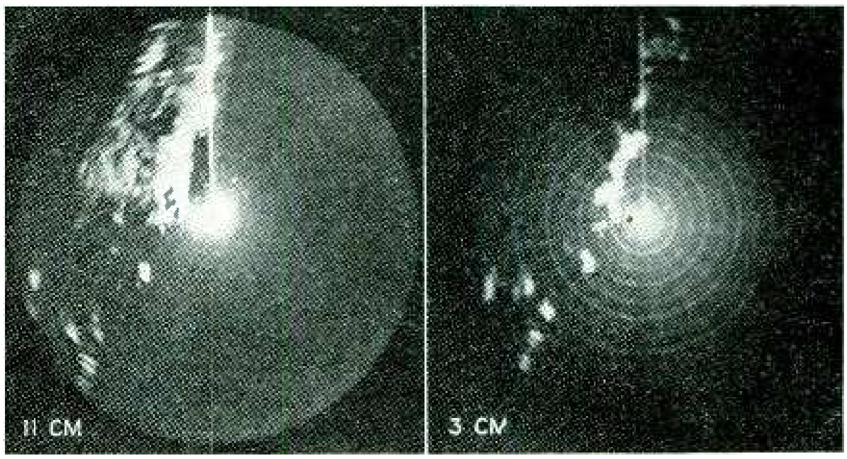


FIG. 5—Summer line squall as it appears on scope of 11-cm radar and 3-cm radar. Range marks are 5 nautical miles apart on both patterns

Rain at the radar station deposits a film of water on the radome (antenna cover). Figure 6 indicates roughly the magnitude of the attenuation in this film, in terms of video signal voltage. Rain was simulated by spraying water on the radome at a known rate.

Since rain echoes have radial depth, the echo power is proportional to the length of the transmitted pulse so long as half the pulse fits within the rain cloud. A slight increase in sensitivity is provided by a longer (2¼ microsecond) pulse in storm detection. This pulse is intended for use with navigational beacons, but it can be used in normal radar search by a simple modification.

Thunderstorm height is important, but height can be measured only on the nearer storms because of the limited angular resolution of the radar and because of the weak signal returned from thunderstorm tops. In measuring height, the beam is tilted up until the echo just disappears. An angle of 1.5 degrees (half the nominal beam width) is subtracted from the tilt meter reading to get the elevation angle.

In the spring of 1946, three SCR-584 radars were still in weather operation. Seven APQ-13 radars have been in regular storm detection service since the summer of 1945, and have contributed to air safety in their vicinity. The Air Weather Service plans to increase this number to 45 in the United States during 1946. Storm observations will probably be available for civilian use.

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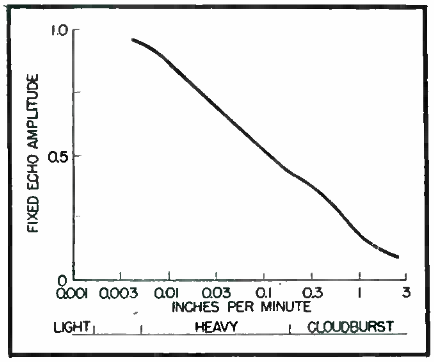
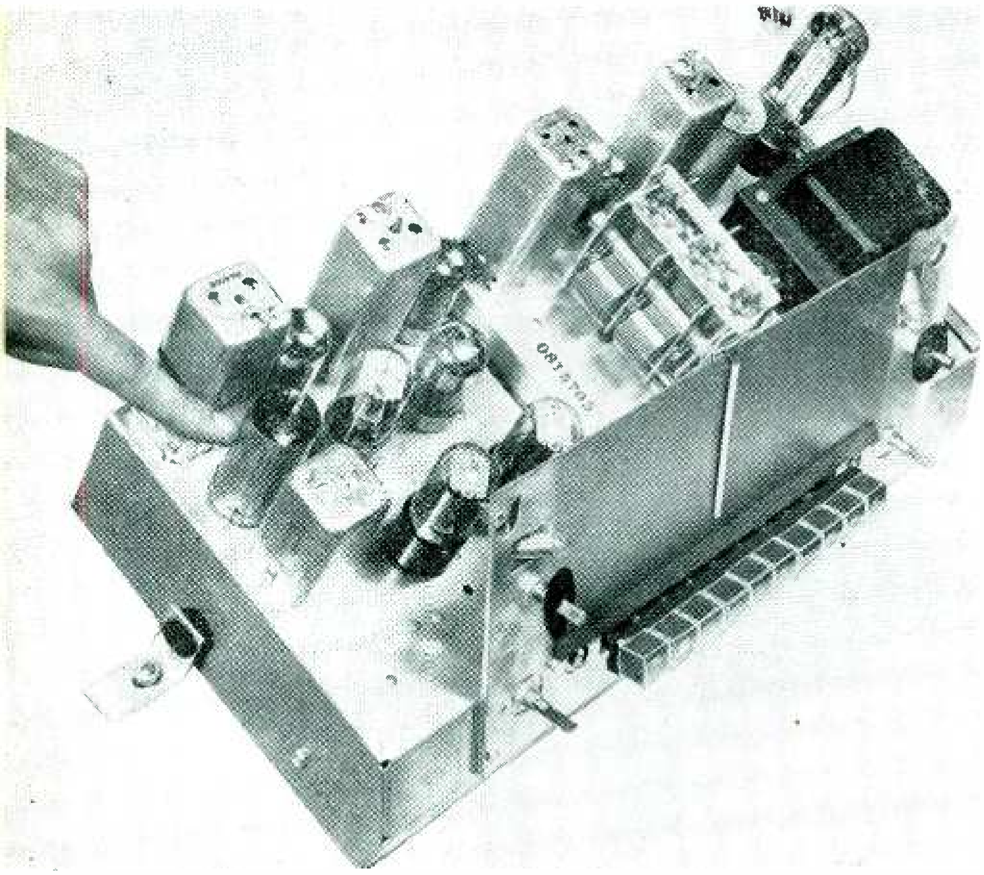


FIG. 6—Attenuation of 3-cm waves for simulated rain falling on radome at various rates

SINGLE-STAGE



Receiver chassis utilizing the new f-m detector. The shield can at extreme left contains the step-down i-f transformer that feeds the FM 1000 tube; the oscillator and quadrature circuits are in the can below the tube

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The art has long had at its command a number of excellent single-stage circuits which very closely approximate the ideal amplitude-modulation detector, so constructed and arranged as to be highly responsive to variations in carrier-wave amplitude but not at all responsive to carrier-frequency deviation. It was concluded that further development of f-m methods and systems was being greatly impeded by the lack of a comparable tool in the frequency-modulation art. Accordingly, efforts were directed to the development of a single-stage frequency-modulation detector, so constructed and arranged as to be highly responsive to carrier-frequency deviation, but not at all responsive to carrier-amplitude variations.

The f-m detector to be described is responsive directly, and solely, to the frequency deviation of the received carrier signal. In practice, the full capabilities of the circuit are efficiently realized by the use of a special heptode tube having high transconductance and sharp cutoff characteristics together with shielding of the grid number 3 from other tube elements.

The minimum i-f input signal required to operate the detector is approximately one-half volt rms for full deviation, the voltage required varying linearly with deviation. The relation between the frequency deviation of the applied carrier wave and the audio output voltage is linear up to the limit of the detector characteristic, where a sharp break occurs. The output for full 75 kilocycle deviation is approximately 20 volts, peak to peak. The response of the circuit to amplitude variation is negligible and, with attention to shielding, is normally 50 to 60 db less than the f-m response.

A circuit diagram of the detector is shown in Fig. 1. The essential parts are the heptode tube and two tuned circuits reactively coupled. The output of the i-f amplifier is applied to one of the two control grids of the heptode, shown as grid 3, and audio is derived from the plate current of the tube.

Fundamental Circuit

One of the two tuned circuits is connected to the first grid of the heptode, while the other is connected to the heptode plate. Both tuned circuits are tuned approximately to the intermediate frequency, and the plate tuned circuit is damped so as to have a bandwidth approximately six times that of the useful deviation band.

The portion of the diagram shown dotted is a neutralizing circuit which may be used to remove the disturbing effects of capacitance coupling from grid 3 to the heptode plate. If the layout of wiring is reasonably good, no neutralizing is needed.

Because of feedback of energy from the electron stream to the input grid, it is desirable to drive the detector from a source of fairly low impedance. Thus a step-down transformer (having an effective turns ratio of about three to one) is ordinarily used at the input.

The first three elements of the tube, together with the tuned circuit *B*, comprise an oscillator. Since the screen is bypassed to ground, oscillator voltage appears on grid 1 and the cathode. The oscillator operates class C, so that the space current through the heptode consists of a series of pulses. It is highly desirable that the pulse

F-M DETECTOR

Operating principles of a circuit that uses a special heptode tube arranged as an oscillator and phase detector. Output at full deviation is twenty volts, peak to peak, and response to amplitude variation is fifty db less than to frequency change

duration be short compared to the time interval between pulses.

Phase Relation

The second control grid (3) of the heptode causes the tube to function as a phase detector. The proportion of a space current pulse reaching the plate of the heptode depends on the potential of this control grid at the instant of arrival of the pulse. This instantaneous control voltage in turn depends on the sum of the bias and the incoming signal voltage, which may add to or subtract from the bias, depending on the phase relation between the oscillator and the incoming i-f signal.

The fundamental component of the resulting plate current is fed back to the oscillator through a tuned phasing circuit, which is reactively coupled to the oscillator tank. The adjustment of this phasing circuit is such that the effect of the feedback is reactive. When this is done, variations in plate current cause pure frequency modulation of the oscillator without any variations of loading to the first order, in other words, without changing the amplitude of the oscillator signal.

The phase of the feedback is unaffected by the incoming signal on the second control grid (grid 3). If the pulses of plate current through the tube are short, the incoming signal can only modify their magnitude, not their phase.

The oscillator circuit is shielded from the direct action of the incoming signal, so that the frequency of the oscillator is determined wholly by its fixed constants and the fundamental component of the heptode plate current. The circuit is so adjusted that, with no input, the oscillation is at center frequency. Provided that the phasing circuit is damped so as to be noncritical with regard to frequency, and so long as the oscillator has a constant amplitude, the variation of frequency as a function of plate current is linear.

Because the plate current consists of a train of pulses, it follows that the mean value of the current over any one cycle is substantially equal to one-half of the peak value of the fundamental component. This is true for any wave form of this type, and it does not depend on the exact shape of the pulse, provided only that the pulses be fairly short compared to the interval between pulses.

Oscillator Locks in Phase

The phase of the incoming signal with respect to the oscillator, by affecting the plate current magnitude, affects the oscillator frequency. This causes the phase relation to change, tending toward an equilibrium phase relation. It follows that the oscillator locks into a nearly fixed phase relation with the incoming signal. The oscillator frequency is consequently the same as that of the signal. But the oscillator frequency is directly proportional to the fundamental component of plate current, which alone governs it, so that this plate-current component must vary linearly with signal frequency deviation.

Finally, from the fact that the mean plate current is proportional to the fundamental component, it can be concluded that the mean plate current varies linearly with the signal frequency.

Put somewhat differently, if the fundamental component of plate current were not directly proportional to signal frequency, then the oscillator would not remain locked in phase with the signal. But it has been noted that there is a strong tendency for the oscillator to seek an equilibrium phase relation with the signal, so that as long as the incoming signal is strong enough to cause the oscillator to lock in,

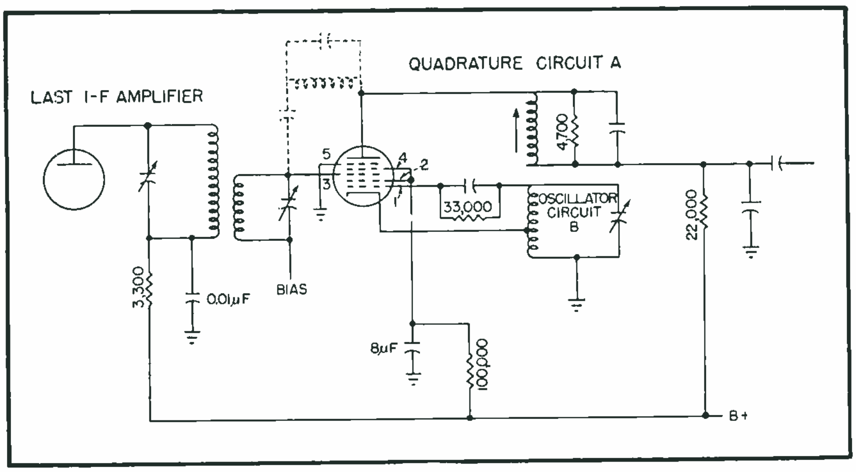

FIG. 1—Basic circuit of the f-m detector

then the plate current must be proportional to signal frequency.

Effect of Signal

If the oscillation frequency of the detector, in the absence of signal, is at the center of the i-f band, and if a signal is applied at this frequency, then the oscillator must adjust itself to be in quadrature with the incoming signal. Only at the instant that the incoming sine wave passes through zero can a pulse of plate current pass through the tube without being either increased or decreased in size by the effect of the signal voltage, which would change the phase back toward quadrature. There are two such instants in each incoming signal cycle but only one corresponds to a stable lock-in condition, the other in effect repelling the pulse in phase until it moves to the stable condition. This situation is shown in Fig. 2A.

The manner in which the size of the plate current pulses vary with the relative phase difference between the oscillator and incoming signal is shown in Fig. 2B and 2C.

If the signal frequency changes to a new value within the i-f band, the phase slowly changes until a new plate current is established, which is consistent with the new frequency. With a large signal, only a very small phase variation between oscillator and signal is required to reach the new equilibrium; with weak signals, the variation of phase is greater. If the signal is too small and the frequency deviation too great, no phase may exist at which the instantaneous grid potential is sufficiently different from the bias potential to produce the required plate current, and the oscillator will fall out of synchronization. The signal strength required to maintain synchronization varies directly with deviation.

If, while the frequency is off center, the amplitude of the incoming signal is varied, the only effect is that the oscillator phase readjusts itself continuously to maintain the plate current demanded by the frequency.

Thus, the circuit functions as a detector with an extremely linear response to frequency modulation

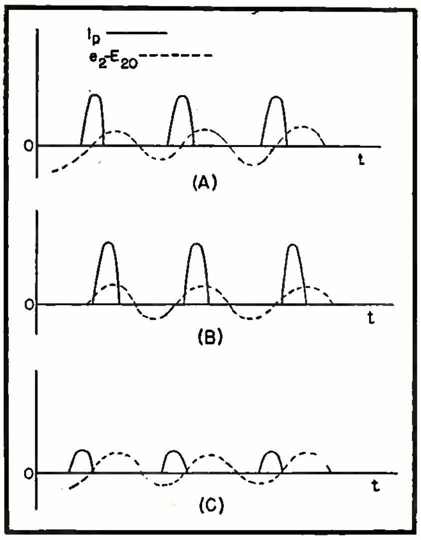

FIG. 2—Variation of plate-current pulse due to phase difference of oscillator and incoming signal

and with no response of the mean plate current to amplitude modulation, provided that the incoming signal is sufficiently large to synchronize the oscillator.

The shape of the plate current vs. frequency characteristic is shown in Fig. 3 for various adjustments of the phasing circuit; in Fig. 3A the circuit is adjusted for quadrature, while Fig. 3B and 3C show the effect of mistuning. It is worthy of note that the correct adjustment does not give the maximum lock-in range for a given input signal. The slightly detuned adjustment of Fig. 3C gives somewhat greater lock-in range.

A-M Response

An extremely small response to amplitude modulation may remain due to the presence of stray coupling between the input signal and the oscillator. This coupling is mainly capacitive and is composed of stray wiring capacity plus interelectrode capacitance from input grid to other tube elements. By special design precautions, the tube interelectrode capacitance has been made very small. In practice, it is essential to adjust the circuit primarily for linearity, relying on correct design and wiring layout to eliminate extraneous effects.

The neutralizing circuit (shown dotted in Fig. 1) consisting of a blocking capacitor in series with a nearly self-resonant choke, can effectively remove the residual response to amplitude modulation when it is uneconomical further to reduce stray capacitance. This has not been found to be noticeably better under field conditions, however, since the unneutralized circuit has negligible amplitude modulation response.

Mathematical Analysis

In exact mathematical analysis, the operation of the complete detector circuit even for steady state conditions is quite complex, involving the algebra of coupled circuits. Hence, the outstanding traits of the arrangement tend to be obscured by details of analysis.

The equivalent circuit shown in Fig. 4 is analytically much more clean cut and over a considerable range of frequency is equivalent to the actual circuit. This is true because, although the actual detector has two tuned circuits instead of one as in Fig. 4, the phasing circuit is very heavily damped, so that its bandwidth is approximately six times that corresponding to the maximum deviation expected. Hence, this circuit reflects a substantially unchanging loading and detuning into the oscillator in the relevant frequency range, while it shifts the plate current feedback phase through 90 degrees.

Using the circuit of Fig. 4, it is easy to show how the circuit ignores amplitude modulation and why its detection characteristic is inherently linear.

The negative conductance reflected by the tube in Fig. 4 across the tuned circuit is $-aI_k/E_1 = G$, where E_1 is the peak voltage across the tuned circuit, a is the effective stepdown turns ratio of the oscillator coil, and I_k is the fundamental component of cathode current, i_k.

It is a good approximation to represent the plate current as a function of i_k and e_2, the instantaneous voltage on the second control grid, by the expression $i_p = i_k F(e_2)$, where $F(e_2)$ is a function shaped somewhat like an integral sign.

The second control grid voltage is made up of the sum of a fixed bias and the sinusoidal incoming signal of magnitude E_2. Then $e_2 = E_{20} + E_{2(t)} \cos(\omega_0 t + \phi_{2(t)})$, where E_2 and

ϕ_2 are functions of t varying slowly with respect to $\cos \omega_0 t$.

$F(e_2)$ may be expanded in a Taylor's series about $e_2 = E_{20}$, and terms beyond the second neglected. This approximation turns out to be rather good because of the fact that in normal operation i_k is zero except for a short time during which e_2 is within a half volt or so of E_{20}.

$$F(e_2) = F(E_{20}) + F'(E_{20})\, E_2 \cos(\omega_0 t + \phi_2)$$

The cathode current pulses occur at the time when the voltage on the first control grid is at a maximum. This voltage is of the form $e_1 = E_1 \cos(\omega_0 t + \phi_{1(t)})$. It maximizes when $\omega_0 t = -\phi_1$, so that the mean effective value of $F(e_2)$ during the occurrence of the current pulse is

$$F(e_2)\Big]_{\omega_0 t = -\phi_1} = F_0 + F' E_2 \cos(\phi_2 - \phi_1),$$

writing, for brevity, F_0 and F' for $F(E_{20})$ and $F'(E_{20})$ respectively.

Then the magnitude of the fundamental component of plate current can be expressed as a function of magnitudes and phases of signal and oscillator voltages as follows:

$$I_p = I_k [F_0 + F' E_2 \cos(\phi_2 - \phi_1)]$$

The above expression specifies the magnitude of I_p. The phase of I_p is substantially in exact opposition to that of the oscillator, due to the normal phase inverting action of the tube and the inability of the incoming signal appreciably to change the timing of the pulses of current.

The quadrature network, Q, represents the effect of the actual phasing circuit. It is here represented as merely applying to the oscillator from a high impedance source a current proportional to I_p but changed in magnitude by a factor H and shifted in phase with respect to the oscillator voltage by an amount θ.

The admittance which this current reflects across the tuned circuit is the ratio of the current to E_1

$$Y = \frac{H \epsilon^{j\theta} I_k [F_0 + F' E_2 \cos(\phi_2 - \phi_1)]}{E_1}$$

The conductance across the tube contributed by the oscillator elements, as noted above, is $G = -aI_k/E_1$. The admittance of the tuned circuit alone is $Y_1 = g_1 + j\omega C_1 + 1/j\omega L_1$. Near resonance this can be represented approximately by $Y_1 = g_1 + j2C(\omega - \omega_1)$, where ω_1 is the resonant frequency of the tuned circuit alone.

For steady oscillation, the total admittance across the tuned circuit must be zero.

$$G + Y + Y_1 = g_1 - \frac{a I_k}{E_1} + H \frac{I_k}{E_1}[F_0 + F' E_2 \cos(\phi_2 - \phi_1)] \cos\theta + j\Big\{2C(\omega - \omega_1) + H \frac{I_k}{E_1}[F_0 + F' E_2 \cos(\phi_2 - \phi_1)] \sin\theta\Big\} = 0$$

or substituting,

$$I_p = I_k [F_0 + F' E_2 \cos(\phi_2 - \phi_1)]$$

$$0 = E_1 g_1 - aI_k + H \cos\theta\, I_p + j\Big\{E_1\, 2C(\omega - \omega_1)\, H \sin\theta\, I_p\Big\}$$

Both real and imaginary parts of this expression must be separately equal to zero. Setting the imaginary part equal to zero gives

$$I_p = \frac{2C\, E_1}{H \sin\theta}(\omega - \omega_1).$$

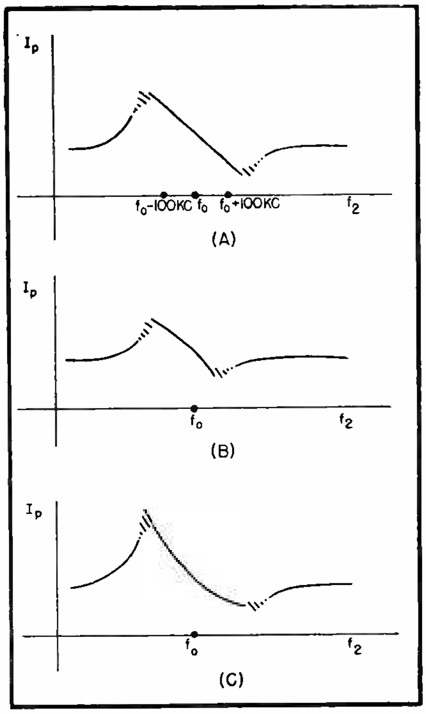

FIG. 3—Adjustment of the phasing circuit produces these curves of plate current plotted against frequency

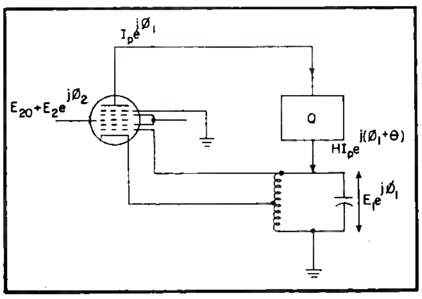

FIG. 4—Circuit of Fig. 1 arranged for mathematical analysis

The equation is important because it dictates that the plate current varies directly with frequency provided E_1 is constant. It also shows that the connection between plate current and frequency does not depend on E_2, again provided E_1 is constant.

Phasing Adjustment

Setting the real part equal to zero gives

$$E_1 g_1 - aI_k + H \cos\theta\, I_p = 0$$

In this equation g_1 and I_k are definite functions of E_1 alone, so that the equation represents a connecting relation between E_1 and I_p. For correct operation, it is desirable for E_1 to be constant and unaffected by I_p. It follows that the correct adjustment of the phasing circuit is that which causes $\cos\theta$ to be zero.

This adjustment can be performed readily by causing I_p to vary by means of an audio voltage applied to the signal input grid and adjusting the phasing circuit for a minimum of audio in the oscillator grid current. Since the phasing circuit has a low Q, the adjustment is not particularly critical.

Carrying on the above approximate mathematical treatment, the effect of stray couplings from the signal input to other parts of the circuit can be evaluated. The general result is that such couplings, if large enough, tend to cause the detector to respond slightly to amplitude modulation.

The effect of the finite duration of the pulses of cathode current can also be treated approximately by a slight extension of the above analysis. It has been found that, if the pulses have a duration of less than one quarter of a cycle, the detector operates for all practical purposes as if the pulses were ideally short. If the current pulses become longer than one third of a cycle, the operation of the circuit becomes more complex, with some residual distortion.

The width of the pulses is controlled by the loading reflected into the oscillator circuit by the phasing circuit. No more coupling to the phasing circuit should be used than enough to give the required deviation sensitivity, excessive coupling causing wide pulses.

Machine-Tool CONTOUR CONTROLLER

Converting stylus position relative to a templet into quadrature signals and mixing these components gives a vector signal indicative of direction and distance stylus has moved. Phase of signal governs motor control to keep tool moving at constant speed around work

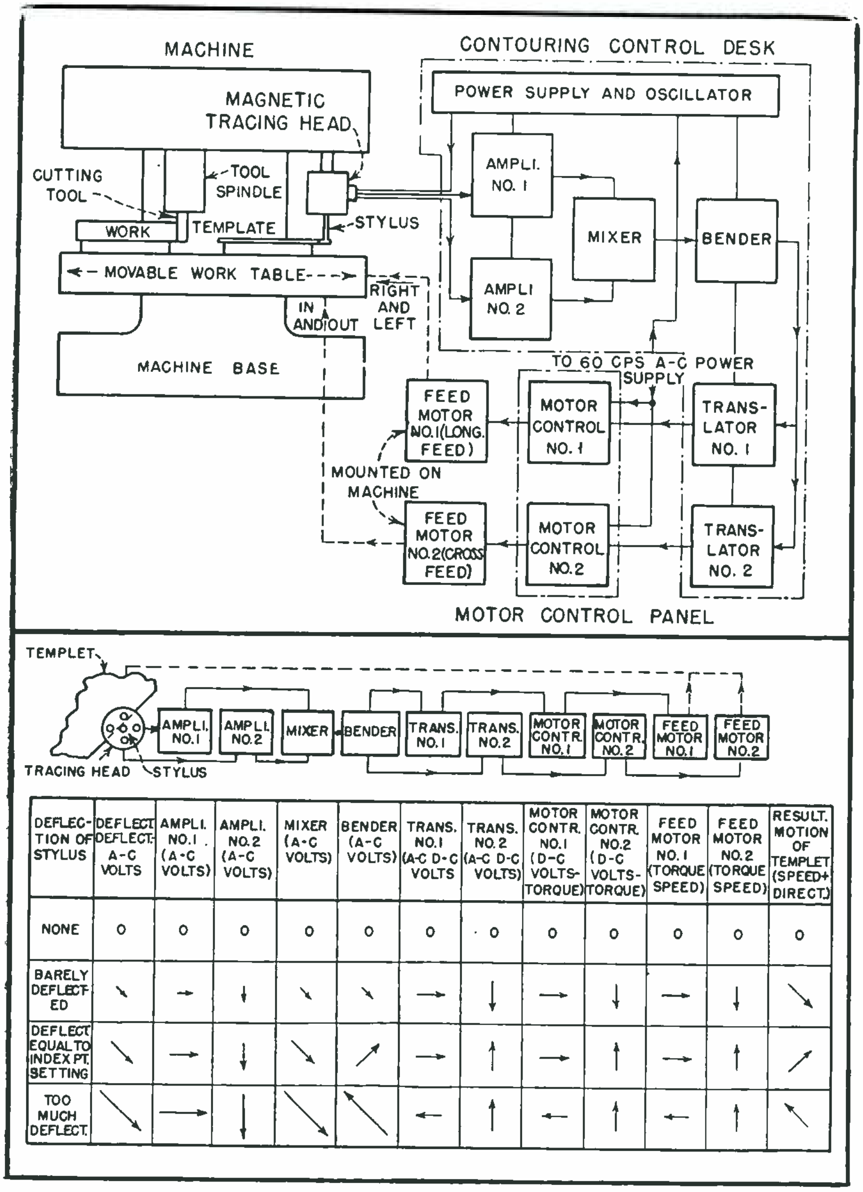

FIG. 1—Components of automatic contouring control shown in operational relationship to each other in the upper diagram. Arrows below, indicate circuit operation, showing that if there is no stylus deflection there will be no machine drive; if there is slight stylus motion, the templet will tend to make more positive contact against the stylus; if the stylus deflection equals the desired index-point setting, the cutter will move parallel to the templet face; and if the stylus is deflected too much, the work and templet will be moved out from the tool and stylus respectively

AUTOMATIC CONTOURING controls simplify machining such odd-shaped work as cams or dies that cannot be machined on a standard machine without excessive labor. The one described here accomplishes its purpose by following and duplicating contours of a master templet or pattern. It gives positioning follow-up that is completely electrical, highly accurate, continuous instead of step by step, drives the tool at constant travel speed, and is flexible in its control of the machine.

In describing the electronic contouring control, description of the motor controller is abbreviated to avoid repetition of other published articles on that and related subjects. In addition, to avoid confusion, the detailed description is limited to the application of contouring to a milling machine and contouring in one plane (in this case, the horizontal plane). If the machine has provision for controlling the vertical feed, it is relatively simple to switch from one of the feeds being controlled (either electrically or mechanically) to the vertical feed, and at the same time re-orient the tracing head. The principle of operation as described will be the same.

Control Components

A complete electronic contouring control equipment comprises the following components:

MACHINE TOOL—A lathe, boring mill, milling machine, etc. that is constructed so that the two feed motors can be connected through proper gearing directly to the corresponding lead screws can be used as the machine tool.

TWO FEED MOTORS—One motor is connected through proper gearing

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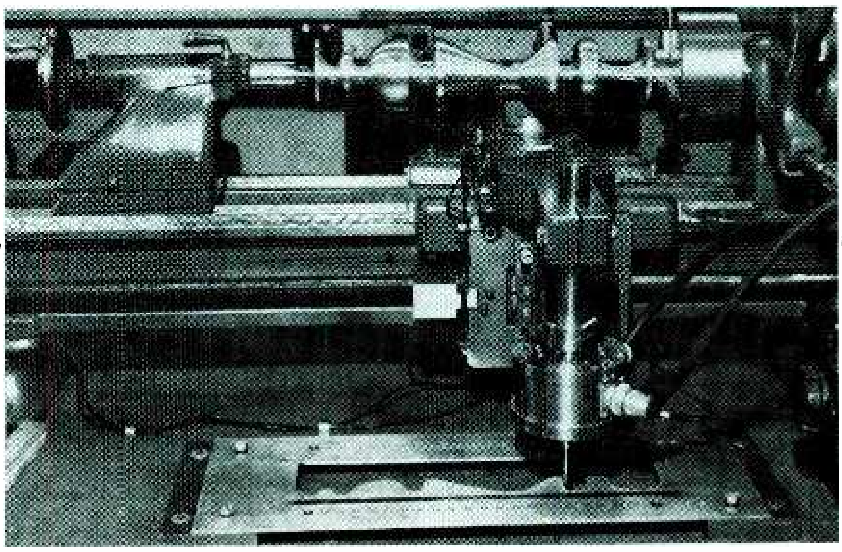


Tracer head of electronic contouring controller mounted on the tool carriage of a lathe

to the cross feed lead screw and the other is connected through proper gearing to the longitudinal feed lead screw. The size of the motors will depend upon the size of the machine. There can be no direct mechanical tie between feeds because it is necessary that they be mutually independent.

MOTOR CONTROL PANEL—A floor-mounted panel contains the electronic controls for both feed motors. It can be set out of the way behind the machine. The size of the thyratron power tubes that control the motors will depend upon the size of the corresponding feed motors.

CONTOURING CONTROL DESK—A bench-board, floor-mounted panel contains the electronic contouring control panels. It should be located for the operator's convenience unless separate push-button stations are used. All necessary operating controls such as push-buttons and potentiometers are located on its sloping top.

MAGNETIC TRACING HEAD—The tracing head is rigidly mounted in proper and fixed location with respect to the cutting tool. It can be fastened to the arbor or set in a cavity in the frame. The stylus must have free access to the edge of the templet, and must be perpendicular to the plane of contouring. The axis of each set of tracer head coils must be parallel to the corresponding feed motion. Force required to deflect the stylus is low, being approximately four ounces for a 0.01 in. deflection, consequently templets of wood or plaster can be used.

TEMPLET AND TEMPLET SUPPORT—The templet is rigidly mounted in proper location with respect to the work, with free access to the tracing head stylus. Either the templet or tracing head should be adjustable relative to the other to simplify initial tool line-up.

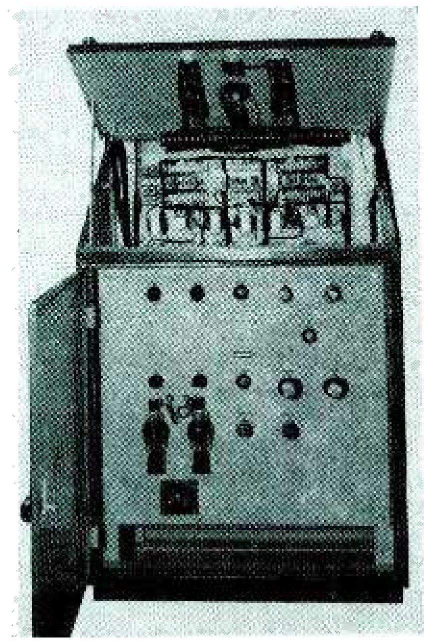
Figure 1 shows schematically how the above components are combined to make up a complete electronic contouring control equipment. The complete equipment operates as a closed-loop control system, or, more specifically, a positioning follow up control system. When the templet is in contact with the stylus, the tracing head, illustrated photographically, generates signals that, after being amplified, mixed, bent, and translated, are fed into the motor control panel. The motor controls in turn control the speed and direction of rotation of the corresponding feed motors to drive the movable table with the templet mounted on it so that the stylus feels along the edge of the templet.

The power supply and oscillator (conventional, therefore not shown in circuits) supplies d-c voltage used in the various circuits, and also a 2,000-cycle a-c voltage from a vacuum tube oscillator and power amplifier. The 2,000-cycle voltage is used for faster speed of response and more efficient use of the variable inductances in the tracing head. The voltage from the power amplifier is fed into a phase-shift bridge, which, by means of a resistor-capacitor combination, provides two output voltages 90 degrees out of phase.

The two output voltages, designated reference and quadrature, are fed to the corresponding translator circuits. In addition, they are stepped down and fed to the corresponding tracing head bridge circuits, of which the two sets of variable inductances in the tracing head are a part (Fig. 2).

Tracing Head Bridge Circuits

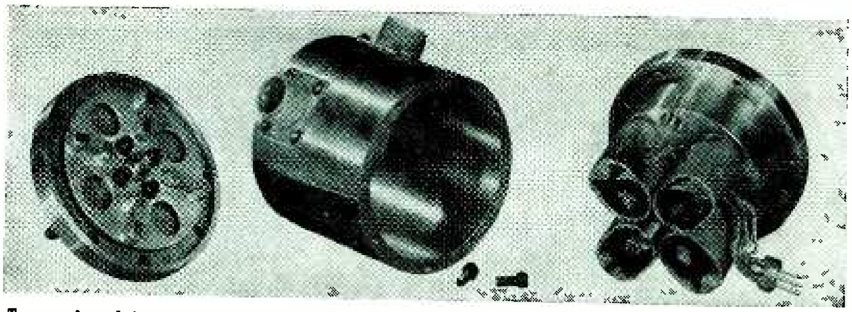
Signals used for operating the equipment under automatic contouring conditions are generated in the magnetic tracing head as shown in Fig. 2. The head contains four variable inductances. When it is properly oriented, two of these inductances (1 and 3) are in an axis parallel to the longitudinal feed, and are two legs of the corresponding bridge circuit. The other two inductances (2 and 4) are in an axis displaced 90 degrees from the first and parallel to the cross feed,



Circuits of contour controller are housed in control desk, operating controls are on slant top and are two legs of the other bridge circuit.

With no deflection of the tracing head stylus, both bridge circuits are balanced (by proper adjustment of potentiometers 1P and 3P for one bridge circuit and potentiometers 2P and 4P for the other bridge circuit) and there is no output voltage from either bridge circuit. The tracing head is so constructed mechanically that a deflection of the stylus changes the air gaps of one or both sets of inductances, depending on both direction and magnitude of the deflection. Consequently, any deflection of the stylus will result in an output voltage from one or both bridge circuits. The vector sum of these two output voltages will be directly proportional to the stylus deflection, both in magnitude and direction.

The output voltages of the two bridge circuits are fed into corresponding amplifier circuits. These two amplifier circuits, one for each bridge, amplify the relatively weak bridge output voltages to workable levels, and in turn feed them into the mixer circuit.



Tracer head (center) contains four iron-cored inductors (right). Stylus moves magnetic shunts (left) relative to inductor cores to produce control signals

Mixer Circuit

The 2,000-cycle output voltages from the amplifiers are sine waves whose individual magnitude and phase depend upon the magnitude and direction of stylus deflection. These two voltages are fed into the two primaries of a mixer transformer. The output voltage, or signal voltage, from the mixer transformer secondary will thus be a single sine wave proportional (depending on transformer turns ratio) to the sum of the two input sine waves. In effect, a single vector signal voltage is obtained from the tracing head, with its magnitude and phase dependent upon the magnitude and direction of stylus deflection.

The movable work table can be considered as operating in a rectangular co-ordinate system, with the longitudinal feed parallel to the X axis and the cross feed parallel to the Y axis. In addition, if a vector representing the reference voltage is considered as lying along the positive X axis, then the signal voltage from the mixer circuit can be plotted as another vector, with an angle with respect to the positive X axis equal to the phase angle.

From the foregoing it can be seen that there is a definite relation between the direction of stylus deflection and the phase with respect to the reference voltage of the resulting signal voltage. This relation will depend upon the mechanical orientation of the variable inductances in the tracing head and the phase of the voltages supplied to the bridge circuits.

For proper operation of the system (Fig. 1A) the relation between direction of stylus deflection and signal voltage phase is such as to give a signal voltage in phase with the direction of stylus deflection (Fig. 1B). For example, the templet deflecting the stylus in a $+ x$ direction will cause the templet to move in a $+ x$ direction, with resulting increase in deflection. Corresponding results will be obtained for all directions of stylus deflection.

Bender Circuit

As previously stated, deflecting the stylus results in a signal voltage that tells the templet to run in a direction corresponding to the direction of deflection. In other words, once the stylus is deflected by the edge of the templet, the templet starts running in the same direction as the stylus is deflected, with resulting increase in stylus deflection. Unless something is done to control it, this deflection will result in damage to the stylus, templet, or tool. The bender circuit is used to provide the necessary control.

The bender circuit of Fig. 3 operates to shift the phase of the signal voltage from the mixer circuit an amount proportional to the magnitude of the signal voltage, or, in turn, the magnitude of stylus deflection. If the phase of the signal voltage is shifted, it can be seen that, as the stylus deflection increases, the templet will tend to move in a different direction. The change in direction will depend upon the phase shift of the signal voltage. When the stylus deflection is sufficient to give a phase shift of 90 degrees, the templet will move in a direction tangential to the rim of the stylus instead of into or normal to the stylus. If the deflection increases, for any reason, the phase shift will be more than 90 degrees and the templet will tend to move away from the stylus.

Referring to Fig. 3, the signal voltage from the mixer is fed into the grid of Tube 1, and, in turn, through transformers (1T and 2T), is fed into a cathode-follower rectifier circuit (Tubes 2 and 3) and also into a saturable reactor phase shift bridge.

The amount of phase shift obtained in the phase shift bridge will depend upon the amount of d-c current flowing through the d-c winding of the saturable reactor. The amount of d-c current flowing through Tube 4, will, in turn, depend on how much the tube is turned on by the grid voltage. The grid voltage is a d-c voltage (proportional to the magnitude of the signal voltage) obtained from the cathode-follower rectifier circuit.

The voltage on the grid of Tube 4 will depend upon the magnitude of the signal voltage and also upon the settings of index point potentiometer 1P and sensitivity potentiometer 2P. The saturable reactor tube cathode resistance (potentiometer 3P) is adjusted so that when point 1 is equal in voltage to point 100, the current through Tube 4 and the d-c winding of the saturable reactor gives a 90-degree phase shift. By changing index point potentiometer 1P, the amount of deflection (index point) required to give a 90-degree phase shift can be adjusted. In addition, the index point selected will be independent of the setting of the sensitivity potentiometer 2P. Advantage can be made of the control of index point to rough out the work at a given index point around the templet; then, by increasing the index point a few thousandths of an inch, a finishing cut can be made from the same templet without other change. Increasing the sensitivity decreases the change in stylus deflection required to give a correcting phase shift.

The combination of the directional signal voltage obtained from the tracing head and the phase shifting action of the bender circuit gives the guiding characteristic needed in order to follow the contours of a templet. Once the templet is brought into contact with the stylus, it starts moving in a direction tangential to the stylus and will continue to do so until stopped by the operator.

When a corner or change of slope is reached, the direction of stylus deflection changes and the templet will tend to run in a different direction. If the stylus tends to dig into or lose contact with the edge of the templet, the bender circuit corrects this tendency by changing the amount of phase shift and thus keeps the magnitude of stylus deflection constant.

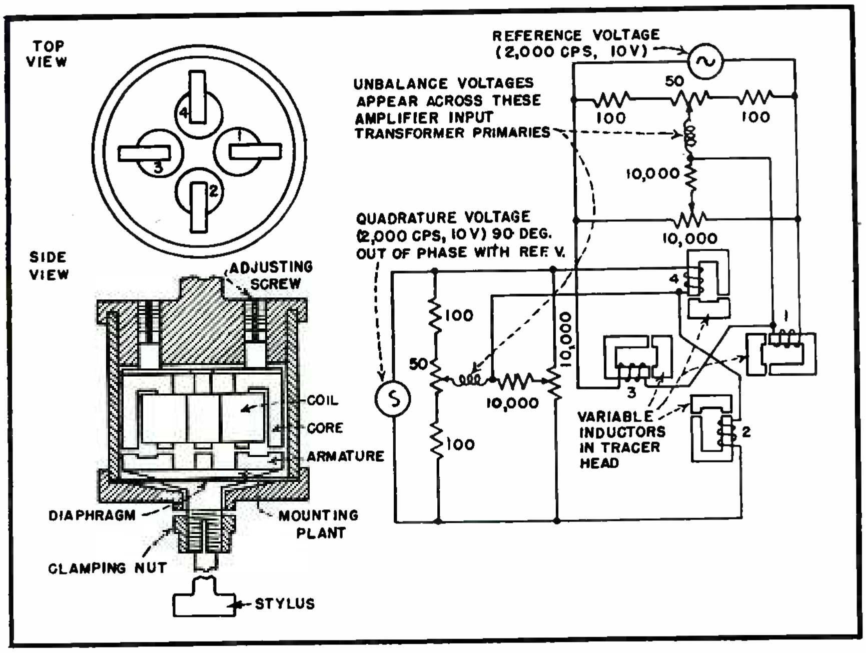


FIG. 2—Mechanical and electrical diagrams of tracer head, including its associated bridge circuit, indicate how stylus movement generates signals

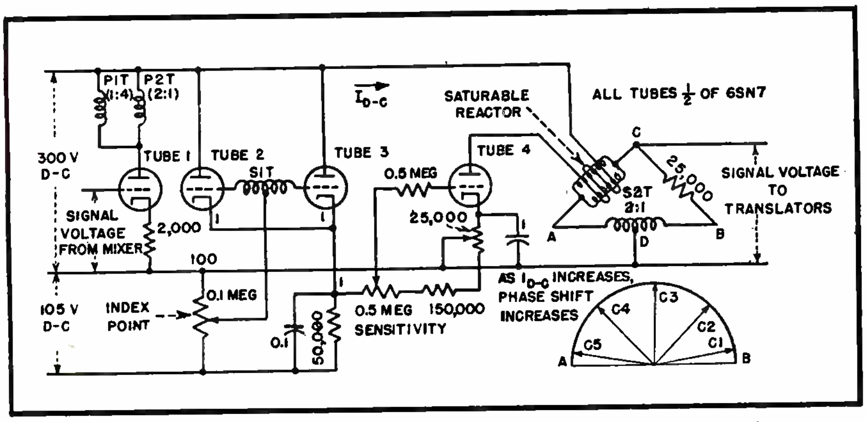


FIG. 3—Bender circuit introduces a phase shift so that drive direction is proportional to amplitude of stylus deflection

Translator Circuits

The signal voltage, after going through the bender circuit, has the necessary directional characteristics to cause correct movement of the stylus along the edge of the templet. The signal has a certain phase relation with respect to the reference voltage which depends upon the shape or slope of the templet. The one basic problem remaining is that the signal voltage is a 2,000-cycle a-c voltage, and d-c voltages are needed to operate the two motor control circuits which, in turn, operate the feed motors. The one a-c signal voltage needs to be translated into two equivalent d-c voltages, and that conversion is the function of the translator circuits.

The signal voltage from the bender circuit is fed (through Tube 1 and grid transformers 1T and 2T) to the grids of the tubes of two similar translator circuits shown in Fig. 4. The circuits are identical except that one has the 2,000-cycle reference voltage from the oscillator applied to the plates of the translator tubes, while the other uses the 2,000-cycle quadrature voltage. In other words, the signal voltage from the bender circuit is applied to the grids and the reference or quadrature voltage is applied to the plates of the translator tubes.

The function of each translator circuit is to provide a d-c voltage which can be used to govern the speed and direction of the feed motor corresponding to that translator. Each d-c voltage must have a magnitude proportional to the required speed, and a polarity to determine the direction of rotation of the feed motors.

The two translator circuits give the desired d-c voltages by utilizing the phase relation of the signal voltage from the bender circuit with respect to the reference voltage in one translator and with respect to the quadrature voltage in the other translator. The signal voltage has been amplified to such a degree that its magnitude no longer matters.

It can be seen that each translator output voltage, filtered, is a d-c voltage proportional to the cosine of the phase angle between the signal voltage (on the grids) and the reference or quadrature voltage (on the plates). For example, assume that the signal voltage is in phase with the reference voltage. In Translator No. 1 the

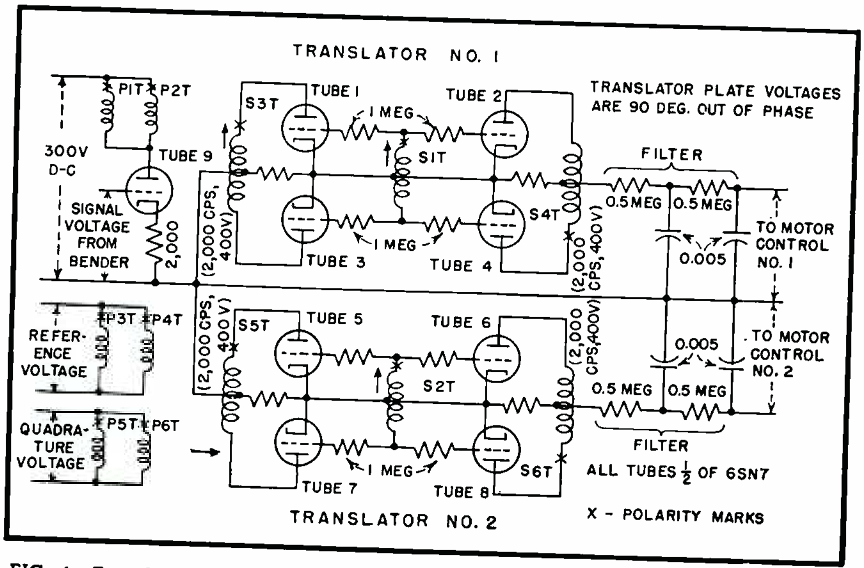


FIG. 4—Translator circuit converts phase signals from bender circuit into direct current signals for motor control

corresponding grid is positive when plates are positive on "positive" Tubes 1 and 3, but is negative when plates are positive on "negative" Tubes 2 and 4. Consequently, output voltage will be maximum positive (cos 0 = 1). If grid voltage is shifted 180 degrees, then output voltage would be maximum negative (cos 180 = −1). At the same time, the signal voltage is 90 degrees out of phase with the quadrature voltage. In translator No. 2 the corresponding grid goes positive 90 degrees after plate voltage on "positive" Tubes 5 and 7 and stays positive 90 degrees after plate voltage on "negative" Tubes 6 and 8 goes positive. The "positive" and "negative" tubes are on an equal length of time, and consequently the output voltage will be zero (cos 90 or cos 270=0).

Because the plate voltages have a 90-degree phase relationship, it follows that Translator No. 1 will have an output voltage proportional to the cosine of the phase angle between the signal voltage and the reference voltage, while Translator No. 2 has an output voltage proportional to the sine of the same phase angle. The polarity depends upon that of the function. Consequently, the two motors governing d-c voltages have a sine-cosine relationship so that the vector sum of the two feed speeds is constant, the magnitude depending on setting of the contouring speed potentiometer, and the direction depending on the slope of the templet.

Under automatic contouring conditions, the operating signal is obtained from the tracing head whenever the stylus is deflected, and this signal voltage is phase-shifted 90 degrees in the bender circuit. When there is no stylus deflection, there is no signal voltage and, consequently, no templet movement.

Controller Operation

In order to move the templet and work with no stylus deflection, a manual signal voltage is fed into the system in place of the normal signal voltage. This manual signal voltage is obtained by using a potentiometer that has a continuous 360-degree winding and four 90-degree taps. The reference voltage is connected to two opposite taps and the quadrature voltage is connected to the other two taps. The phase of the resulting signal voltage will then depend upon the position of the potentiometer slider and can be varied through 360 degrees. By feeding this manual signal voltage directly into the translator circuits (to eliminate bending due to changes in magnitude), it becomes possible to steer the work and templet in a direction depending upon the slider position. When properly connected and adjusted, the direction of travel will be indicated by an arrow on the knob.

The magnitude of the d-c output voltages from the two translators depends only on the phase angle between the signal voltage and reference voltage. In order to change the tool travel or contouring speed (maximum speed of one motor when other motor is stopped) a double potentiometer is used to take an equal percentage of both translator voltages. In other words, if the contouring speed potentiometer is set at half of its maximum value the contouring speed will be half of the contouring speed when the potentiometer is set at its maximum value.

The two d-c output voltages are then applied, through suitable electronic control circuits, to the corresponding feed motors which drive the cross and longitudinal feeds of the movable work table. The motor control is such that it holds a motor speed proportional to the magnitude of the d-c output voltages from the corresponding translator, and runs the motor in a direction depending on the polarity of that voltage. Consequently, a constant tool travel speed, or speed of movement of the stylus along the edge of the templet, is maintained, regardless of the direction of travel.

One of the most important requisites of any contouring control system is high duplicating accuracy. Exactness between successive pieces of work in connection with the development of the electronic automatic contouring control tests were made to determine what duplicating accuracy could be expected with this type of control. The results of these tests (made on a small lathe) were as follows.

With a tool travel speed along the work of one inch a minute, five small brass pieces were turned out, one after the other. These five pieces were then compared to find the maximum error, and where it occurred. The maximum error was less than 0.001 inch and occurred, as would be expected, where the direction of tool travel had to change rapidly. The error on a relatively larger radius (approximately ½ inch) was less than half of the above.

Tests made at tool travel speeds of five and ten inches a minute showed errors between finished pieces of work of approximately 0.002 inch and 0.003 inch, respectively. The use of a higher quality machine would undoubtedly improve the accuracy.

Thermistor-Regulated Low-Frequency Oscillator

Phase-shift oscillator with four cathode follower stages and a thermistor maintains output level within 10 percent over entire range of 0.9 to 10,000 cycles. Practical circuit with values of components is supplemented by design considerations and cathode follower theory

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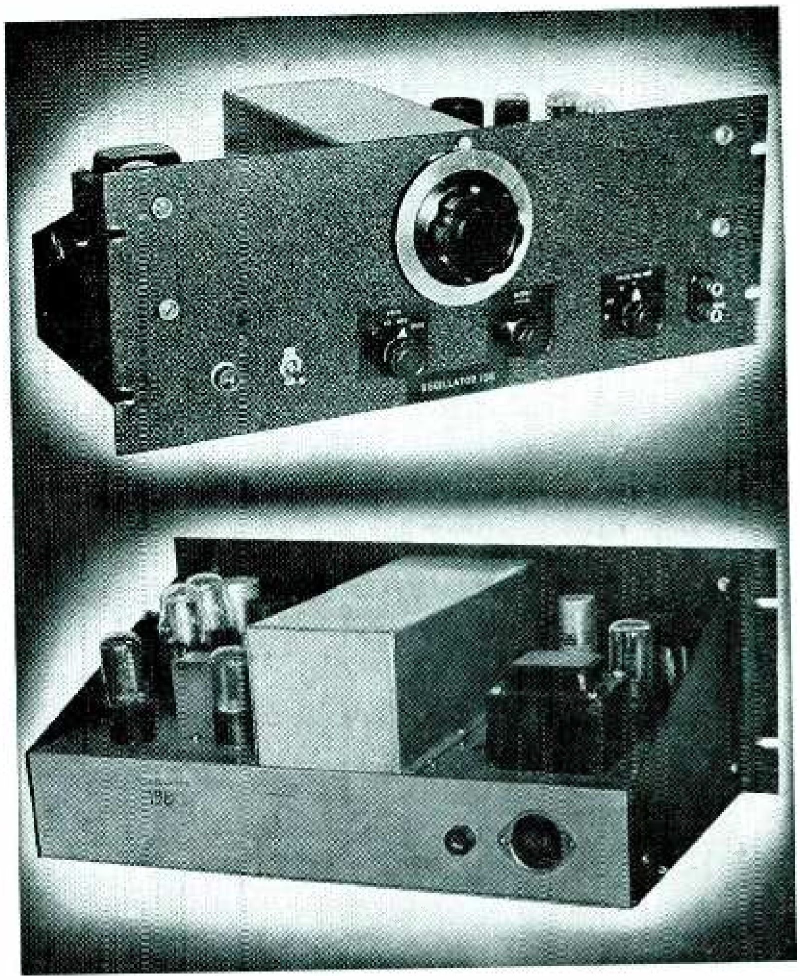
THE DEVELOPMENT of instruments for vibration measurements, magnetic testing, geophysical exploration, and many other purposes requires a good low-frequency oscillator. The compact and reliable oscillator described covers the frequency range of 0.9 cycle to 10,000 cycles in four decade ranges, with a tuning dial that varies the frequency continuously over a ratio of 0.9 to 10. The same dial engraving serves for all four ranges, and accuracy of frequency setting is within 5 percent.

Automatic amplitude control by means of a thermistor maintains the output level constant within approximately 10 percent throughout the frequency range and keeps the distortion close to 1½ percent at all frequencies where it can be measured.

The regulating action of the thermistor amplitude control is well damped, so that the output level of the oscillator has no tendency to hunt or overshoot in response to power line surges or to manipulation of the frequency dial on the range switch.



Front and rear views of stable low-frequency oscillator. Tuning dial in center of panel controls a three-gang potentiometer having special inverse square law taper to give a linear scale

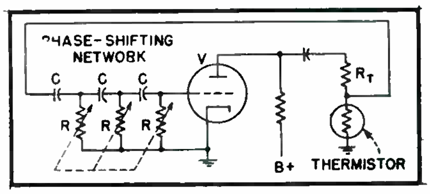


FIG. 1—Basic circuit of phase-shift oscillator

The output is also completely free from any tendency to jump about.

Phase-Shift Oscillator Circuit

The principle of the oscillator circuit is shown in Fig. 1. The *R-C* phase-shifting network is connected in the usual way between the plate and grid circuits of the triode. Roughly speaking, if the gain of the tube is greater than the loss through the network at that frequency where phase shift through the network is 180 degrees, oscillation will occur.[1,2,3] For this circuit the gain required for oscillation is 29 and the frequency is $f = 1/2\pi RC\sqrt{6}$ if the three sections of the network are alike.

For given values of R and C, the oscillating frequency is six times lower for the type of network shown than for the configuration having series resistors and shunt capacitors.

A thermistor, connected as the lower half of a voltage divider which includes resistor R_T in the feedback circuit, is employed to regulate the amplitude of oscillation. If the amplitude of oscillation increases, the current through the thermistor rises. As its temperature rises its a-c resistance goes down, reducing the percentage of signal fed back. The static characteristics of the Western Electric 1A thermistor are approximately as in Table I.

The complete circuit of a practical oscillator is given in Fig. 2. The frequency control dial rotates a three-gang potentiometer P_1 which with capacitors C_1 to C_6 forms the controlling network of the phase-shift oscillator. Sets of capacitors are selected by a three-circuit four-position range switch to provide the four frequency ranges. To compensate for the effect of stray capacitance on the highest frequency range, part of one of the capacitive legs of the network (C_6) is made adjustable.

The dial scale tends to be crowded at the high-frequency end because the frequency is inversely proportional to the resistance in the network. The scale shape was improved by using special inverse square law tapered three-gang potentiometers. A logarithmic taper would have produced a logarithmic dial scale, having the same percentage accuracy of setting at all points.

Cathode Followers

The oscillator circuit employs a single amplifier stage V_1, operating at high level, and four cathode followers. Each of the latter has a definite use.

The amplifier tube operates with no bypass, coupling, or decoupling capacitors whatever. Stray phase shifts outside the controlling network made up of ganged potentiometers P_1 and capacitors $C_1 - C_6$ affect the operations of the oscillator profoundly and must be avoided. The screen and bias voltages for the 6J7 tube are semi-fixed. The voltage divider current was selected after some experimentation to give the best compromise between high gain and stability. The gain is 80.

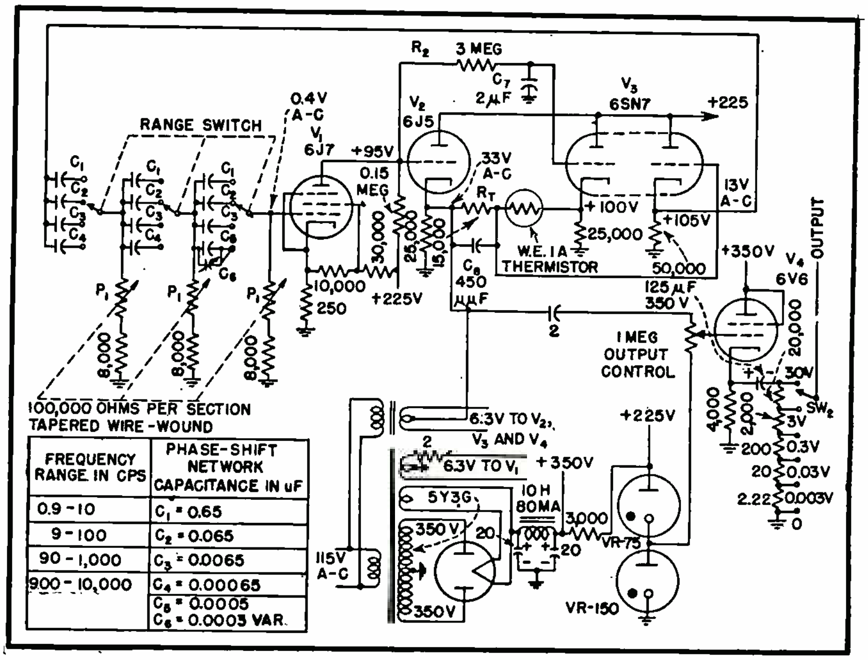
Cathode follower V_2, direct-coupled to the plate of V_1, is employed to drive the thermistor without loading down tube V_1.

The thermistor amplitude control circuit is like that of Fig. 1 except for a special method of returning the low-potential end of the thermistor to ground. The thermistor is returned to the cathode of one section of the double triode V_3. The series combination of R_T and the thermistor thus extends between the cathode of V_2 and the cathode of one section of V_3. These two cathodes are maintained at the same d-c potential by a path through 3-megohm resistor R_2, through which the grids of the two triodes are kept at the same potential. Signal voltage is kept from the grid of the ground-return section of triode V_3 by filter combination $R_2 - C_7$.

The a-c impedance to ground of the cathode of the section of V_3 being discussed is about 1,000 ohms since the tube is essentially a cathode follower. This special ground return arrangement is necessary because of practical considerations of leakage in large capacitors. The thermistor could have been returned to ground through a large capacitor, about 100 μf, but an electrolytic capacitor in this application gives trouble due to its variations in d-c leakage. The leakage causes the operating point of the thermistor, and hence the signal level, to drift about. The combination of one section of triode V_3 with R_2 and C_7 is really a scheme for making a small capacitor plus a tube act as a substitute for a very large capacitor.

The junction of R_T and the thermistor is connected to the grid of the second triode section of V_3, whose cathode acts as a low-impedance source for feeding the phase-shifting network. Thus, tube characteristics are made to have very little effect on the frequency of oscillation.

All the above tubes receive their plate voltage from a pair of voltage-regulator tubes. The reduction of coupling due to the common impedance of the power supply is very necessary to avoid degeneration at low frequencies, but decoupling capacitors produce phase shifts that cause distortion and mistracking at the lowest frequencies. The rest of



FREQUENCY RANGE IN CPS	PHASE-SHIFT NETWORK CAPACITANCE IN uF
0.9-10	C_1 = 0.65
9-100	C_2 = 0.065
90-1,000	C_3 = 0.0065
900-10,000	C_4 = 0.00065
	C_5 = 0.0005 C_6 = 0.0003 VAR.

FIG. 2—Complete circuit of practical phase-shift oscillator

the power supply is conventional.

The output stage uses a 6V6 tube, V_4, operated as a cathode follower. There is no need for amplification here, but considerable need for isolation and low output impedance. A step attenuator is provided in the output of V_4 for convenience in obtaining small output voltages.

Tubes V_2, V_3, and V_4, whose cathodes operate at high d-c potentials above ground, are heated from a separate filament winding whose center tap is connected to the cathode of V_2.

Capacitor C_8 is connected across R_T to compensate for phase shifts at high frequencies due to the plate-ground capacitance of pentode V_1. Such phase shifts make the oscillation amplitude drop and make the frequency too low at dial settings of P_1 above 3 kc on the highest frequency range. Capacitor C_8 has the opposite effect. It can be chosen to give proper amplitude and dial scale tracking up to 10 kc. If C_8 is too large, the frequency and amplitude will be too high for the dial setting.

General Design Considerations

The effect of stay phase shifts on the performance of a phase-shift oscillator is important. In resistance-capacitance coupled amplifiers the output voltage tends to lead in phase the input voltage at low frequencies and to lag at high frequencies. The phase lead is introduced by interstage coupling capacitors, plate and screen *RC* decoupling networks, cathode bypass capacitors, and the common capacitive impedance of the power supply. The phase lag at high frequencies is due to the shunt capacitances to ground across the plate and grid circuits of the tubes.

In a phase-shift oscillator employing a main network of the phase-leading type, such as the circuit of Fig. 1 and 2, additional leading phase shifts, such as those due to decoupling networks and the like, will increase the frequency of oscillation and decrease the gain required for oscillation (increase the amplitude and distortion). Stray lagging phase shifts, as those due to shunt circuit capacitance, will decrease the frequency below that which the main

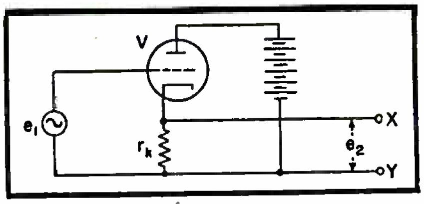


FIG. 3—Basic cathode follower circuit

network would dictate, and increase the gain required to maintain oscillation (tend to make the device go out of oscillation). In an oscillator employing a network of the phase lag type these stray phase shifts have the converse effect.

The undesirable effects of stray phase shifts become noticeable in oscillator circuits of this type perhaps two octaves nearer the midband frequency of the system than any amplitude effects of frequency response. Thus, in the oscillator described the amplifier portion is flat to well over 12,000 cycles, yet compensation is required for proper oscillation amplitude and tracking above 3,000 cycles.

For fixed-frequency or narrow-range phase-shift oscillators, the leading type of phase-shifting network is best for low frequencies, because the stray phase shifts usually present tend to aid oscillation. Conversely, for high frequencies the lagging or low-pass type of network is the easiest to get working.

Thermistor Time Constants

It is not recommended that the type 1A thermistor be employed as an amplitude control for frequencies lower than 1 cycle. This thermistor requires about 1.5 seconds to follow a change in current 90 percent of the way to equilibrium. Accordingly, the thermistor would introduce distortion at 1 cycle were it not for the degenerative properties of the oscillator at harmonics of the oscillating frequency. Slower thermistors are made, but are less sensitive and less readily available than the type 1A. The design problem is one of compromising lowest distortion at the lowest frequency with the convenience of a fast-acting amplitude control.

Measuring distortion at frequencies below 20 cycles is difficult. The waveform of the oscillator at 1 cycle looks like a pure sine wave when recorded on a Brush recorder, indicating an actual distortion of less than 5 or 10 percent at this frequency.

Cathode Follower Theory

In Fig. 3, if μ is the amplification factor of tube V, r_p is the plate resistance of the tube, and r_k is the cathode load resistor, the a-c resistance R_o looking at terminals X-Y is

$$R_o = \frac{r_p}{1 + \mu + r_p/r_k}$$

The gain VG of the stage then is

$$VG = \frac{e_2}{e_1} = \frac{\mu}{1 + \mu + r_p/r_k}$$

Values of bias, load resistor r_k, and maximum power and/or voltage output of a cathode follower are governed by exactly the same considerations as if the tube were operated as a conventional resistance-coupled amplifier. The values of μ and more particularly of r_p used should be the true values at the plate current at which the tube is operating, not the published nominal values.

The input capacitance of a cathode follower is

$$C_i = C_{gp} + C_{gs} + C_{gk}\ (1 - VG)$$

where C_i is the input capacitance, C_{gp} is the grid-plate capacitance, and C_{gs} is the grid to shell and heater capacitance.

References

(1) Gintzon and Hollingsworth, Phase-Shift Oscillators, *Proc. IRE*, 29, 43–49, Feb. 1941.

(2) Note on above paper, *Proc. IRE*, 32, p 641, Oct. 1944.

(3) Nichols, U. S. Patent 1442781, Jan. 16, 1923.

(4) Shepard and Wise, Frequency Stabilized Oscillators, *Proc. IRE*, 31, p 256–258, June 1943.

Table I—Static Characteristics of W.E. 1A Thermistor

Current in ma	Voltage in volts	A-C resistance in ohms
below 0.2	....	50,000
0.5	15	30,000
0.8	16	20,000
1.0	16	16,000
2.0	14	7,000
3.0	12	4,000
5.0	10	2,000
10.0	7	700

Radar for

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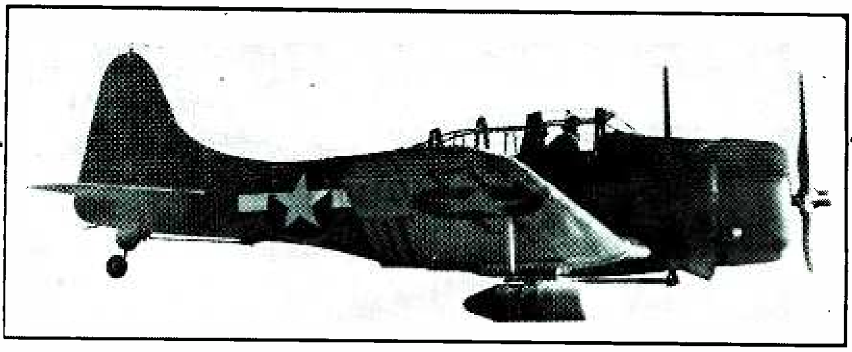
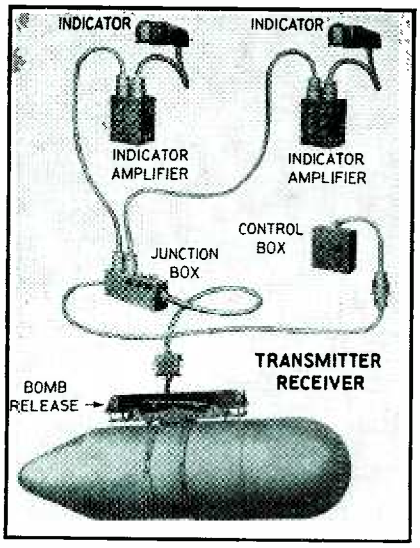


Installation on carrier-based plane, with transmitter-receiver in bomb-shaped unit under one wing. Effective ranges reported include detection of land at 90 nautical miles from a high altitude, land at 50 miles from 500 feet, aircraft carriers at 45 miles, and single planes at 11 miles

THE APS-4 light-weight X-band (9,375 mc) radar system was primarily intended for use by the U. S. Navy's carrier-based planes. During the latter part of the Pacific war it was installed in carrier-borne dive-bombers, torpedo-bombers, and fighters, as well as seaplanes based on cruisers and battleships.

The system consists of a transmitter-receiver called the bomb, a control box, two indicators, two indicator amplifiers, and a junction box. The bomb unit, which houses the majority of the circuits, is sealed



Main components of APS-4 aircraft radar. Total weight is only 175 lb, a greater part of which can be dropped in an emergency by activating the bomb release mechanism supporting the transmitter-receiver unit

and pressurized on the ground with dry air to a gage pressure of 5 pounds per square inch. This unit is usually mounted on the lower side of the wing, supported in a standard Navy bomb rack. In an emergency the pilot can dispose of the bomb unit by activating the release mechanism. In single-place planes only one indicator is used, but in larger planes the pilot has one indicator and the radio operator has another.

This equipment was developed by Bell Telephone Laboratories and manufactured by Western Electric Co. for the Navy Department Bureau of Aeronautics and Bureau of Ships.

The antenna scans 150 deg in azimuth (75 deg to the left and 75 deg to the right of dead ahead). It is also possible to tilt the antenna so as to direct the narrow beam to any angle between 10 deg above and 30 deg below the longitudinal axis of the plane.

Two types of scanning are provided: a two-line scan for the locating of ships and land targets and a four-line scan for intercepting enemy aircraft. The two-line scan consists of two horizontal sweeps per cycle, one sweep being at the tilt control setting and the next sweep at an angle 4 deg below this setting. Thus as the antenna sweeps horizontally, it also continuously nods so that the radiated energy covers an elliptical area. The radiation pattern of the antenna is 6 deg wide at the half-power points in both the vertical and horizontal planes. Therefore, the antenna searches an area 10 deg in elevation and 150 deg in azimuth during each cycle. The four-line intercept scan consists of four horizontal sweeps per cycle, each separated by 6 deg, and consequently an area 24 deg in elevation by 150 deg in azimuth is covered during each scanning cycle.

The search scanning is performed at the rate of 30 two-line cycles per minute and during intercept operation the rate is 30 four-line cycles per minute.

Beacon Operation

Besides the regular radar services of locating targets, this radar will also show the location of beacon transmitters in terms of range and azimuth with respect to the aircraft by means of a type-B scan, which employs rectangular coordinates. This beacon service is used as a navigational aid for homing. The beacon transmitters do not continuously send out signals which would also aid the enemy. Instead, pulses of energy are radiated when the beacon transmitter is triggered.

When beacon information is desired, a switch on the aircraft's radar control box is moved to the beacon position. This action causes two changes: first, the duration of the radar's output pulse is increased from 0.6 to 2.1 microseconds, since pulses of this length are required to trigger the beacon station; second, the radar receiver circuit is prepared to receive the beacon frequency of 9,310 mc by connecting in a second local oscillator which has previously been tuned to receive at the beacon frequency. During the same operation the local oscillator for radar is disconnected.

Any X-band beacon transmitter within range of the aircraft will receive on the radar's frequency of 9,375 mc. The length of the radar's pulse being correct (2.1 microseconds), the beacon station will transmit a series of pulses on its fre-

Carrier-Based Planes

Triple-purpose X-band radar weighing only 175 lb serves for search scanning of sea and land on patrol flights, beacon operation, and interception of enemy planes. Unique double-dot circuit adds third dimension to type B rectangular-coordinate scan by giving elevation

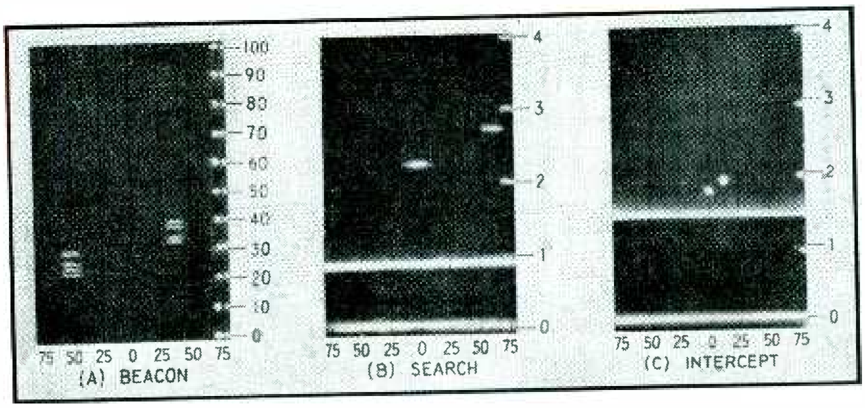


FIG. 1—Examples of indicator displays. Type-B scan is employed, with slant range to target shown along vertical axis. Bearing of target with respect to longitudinal axis of airplane is shown on horizontal scale. Circuits required are more compact than for ppi. With practice an operator can interpret the displays quite accurately

quency of 9,310 mc, with a particular time interval between pulses to identify the beacon station. These pulses are displayed on the radar's indicator, making available to the pilot the range and azimuth of the beacon station with respect to the airplane and identifying the station so that it may be located on a chart. Patterns for two characteristic groupings of beacon pulses are shown in Fig. 1A, along with typical indicator patterns for ground search (1B), and for aircraft interception (1C).

Operation of Transmitter

The transmitter consists of four circuits: (1) the triggering circuit, (2) the charging network, (3) the discharge circuit, and (4) the oscillator. The charging network is charged to a high potential, then rapidly discharged through the primary of a pulse transformer. The secondary of this transformer applies a large negative voltage of short duration to the cathode of a grounded-plate oscillator. The oscillator, a magnetron, vigorously oscillates for the duration of this pulse at a frequency of 9,375 mc, producing a powerful burst of r-f energy. The triggering circuit initiates the pulses which cause the discharge of the network.

Referring to Fig. 2, the charging network is charged from the 2,400-volt d-c supply through a charging choke, a diode, and a pulse transformer. Without the diode, the instantaneous network voltage would follow the dotted damped-sine-wave line shown in the resonance charging curve, since the network capacitance is being charged through an inductance. The diode, however, prevents a current reversal. Consequently, the network voltage is maintained at point A, the first peak of this charging characteristic. Assuming the network voltage to be zero at the start, the 2,400 volts is applied and the capacitors are charged to 4,000 volts.

The charging network is an artificial transmission line which has the same electrical characteristics as a long transmission line. When a network of this type is discharged into an impedance equal to its characteristic impedance, a single flat-top pulse is formed.

The load impedance formed by the magnetron as reflected through the pulse transformer equals the network characteristic impedance. The network is caused to discharge by breaking down the spark discharge tubes, thus forming a low impedance to ground. These type 1B22 tubes are specially constructed spark gaps sealed within a glass envelope containing a mixture of gases. The tubes are so designed that when a potential difference of approximately 3,600 volts is placed across their terminals, the enclosed gas ionizes to form a low-resistance path.

When the network is charged to 4,000 volts, there is 2,000 volts across each spark gap tube. In order to discharge the circuit, a sharp negative pulse of 5,000 volts followed by a positive pulse is ap-

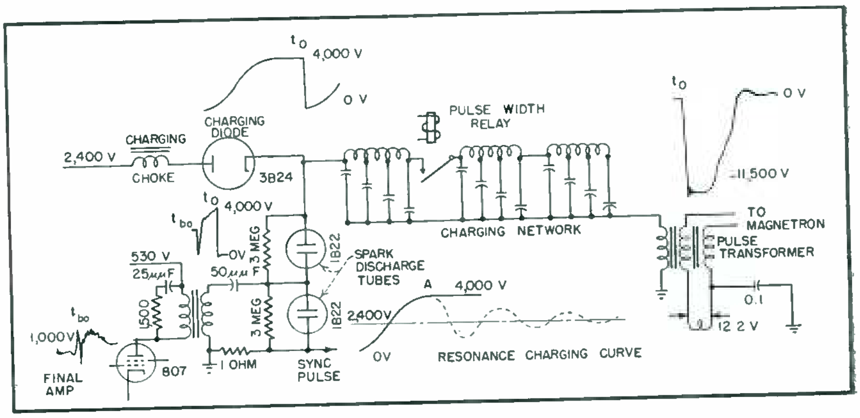


FIG. 2—Modulator circuit, showing how spark discharge tubes are used in connection with a charging network to energize the magnetron

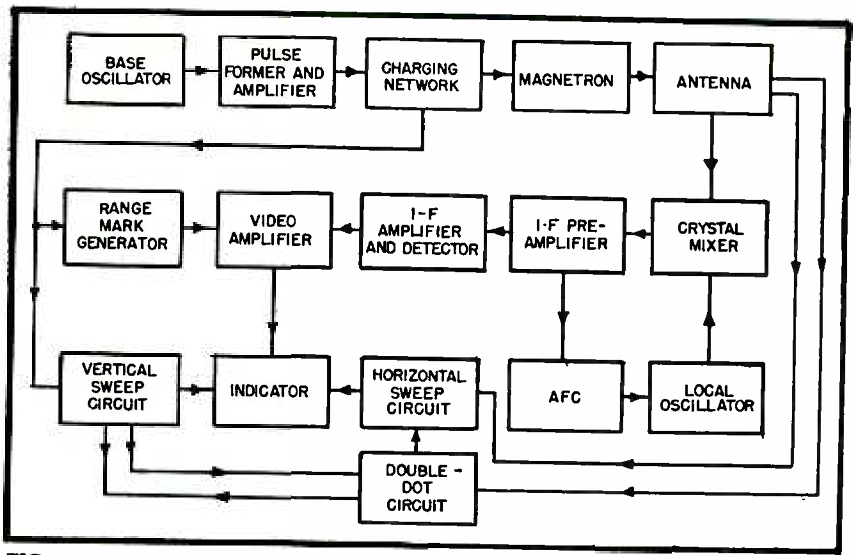


FIG. 3—Block diagram of complete APS-4 radar system. Two indicators are used on some planes

plied to the junction of the discharge tubes. The negative pulse causes the potential difference across the upper tube to rise rapidly. This tube breaks down. As the upper tube ionizes, the full 4,000 volts from the charging network is applied across the lower tube. In like manner, this tube becomes conducting and the network is discharged to zero voltage. During the discharge process, the charging choke prevents the building up of a short-circuit current in the power supply.

A flat-top pulse is developed across the primary of the output pulse transformer as the network discharges. The duration of this pulse is dependent on the electrical length of the artificial transmission line.

Pulse-Generating Circuits

Pulse repetition rate is controlled by a base oscillator, as shown by the block diagram in Fig. 3. The pulse obtained from this oscillator, after being properly formed and amplified, is supplied to the junction of the spark discharge tubes to initiate the discharge of the network circuit.

The base oscillator, a 6J6, is connected as a free-running multivibrator, the grids of which are returned through resistors to +150 volts rather than to ground. By returning the grids to B+ the steepness of the exponential grid voltage rise is increased. The voltage rise being steeper as the cutoff voltage of the tubes is approached greatly improves the stability of this type of oscillator.

During search operation on the 4, 20 and 50-mile ranges, the pulse recurs at a repetition rate of 1,000 pulses per second. For 100-mile search, the pulse rate is lowered to 600. On all ranges, during beacon operation the rate is 350 pulses per second. This changing of pulse rates is accomplished by activating relays which in turn incorporate the required circuit elements.

The pulse rate on the 100-mile search position is lowered so that an echo from 100 nautical miles can be received before another burst of r-f energy is sent out. The round-trip time for a 100-mile echo is 1,236 microseconds. However, triggering at the rate of 1,000 pulses per second leaves only 1,000 microseconds between pulses.

The beacon rate is lowered for a different reason. During beacon operation, the width of the r-f pulse is increased to 2.1 microseconds. If the pulsing rate were continued at 1,000 the average amount of time the magnetron was oscillating would be more than tripled. This would greatly impair the tube's life expectancy. Therefore, in order to maintain a nearly constant duty cycle, the beacon repetition rate is lowered by a factor of three from that of search operation.

A positive pulse is taken from the free-running multivibrator. After being differentiated, the negative spike obtained from the trailing edge is used to trigger a start-stop multivibrator. The output from this circuit is a positive rectangular pulse 20 microseconds wide and has an amplitude of approximately 40 volts. Amplification of the pulse is obtained in a 6J6, the two sections of which are operated in parallel.

The output of the 6J6 amplifier is inverted and further stepped up to an amplitude of 120 volts by means of a pulse transformer. This pulse is then applied to the control grid of the type 807 tube in the final amplifier (Fig. 2). The primary of another pulse transformer is connected in the plate circuit of the 807. Due to the transformer inductance and capacitance, transient pulses such as the one marked t_b, are produced in the final amplifier plate circuit. In the secondary, the pulse is inverted, amplified, and then applied through the 50-micromicrofarad capacitor to the junction of the spark discharge tubes to discharge the network. At the completion of the discharge process, the discharge tubes deionize and again become an open circuit, and the network recharges in preparation for the next trigger pulse. Timing pulses of 60 volts amplitude for synchronizing other circuits with the transmitted pulse are taken across a one-ohm resistor connected between the lower discharge tube and ground.

The final output pulse to the magnetron oscillator is as shown (Fig. 2). In 0.1 microsecond the voltage drops to −11,500 volts, remaining there for 0.6 (search) or 2.1 (beacon) microseconds before returning to zero. The magnetron is a Western Electric type 725A tube, described in ELECTRONICS, Jan. 1946.

R-F Circuits

A small pickup loop within the magnetron cavity couples out the r-f energy through a short coaxial line. A coaxial line to wave guide transformer radiates into a wave guide system which carries the superhigh frequencies to the antenna. There is one rotating joint in the wave guide, which allows the antenna to scan in the horizontal plane. The wave guide remains fixed in the vertical plane; tilting of the radiated beam is obtained by tilting the reflecting paraboloid only.

The same antenna is used for both transmitting and receiving. A transmit-receive box prevents the transmitted pulse from entering the receiver circuits and a receive-transmit box prevents the reflected energy (target echo) from being lost in the oscillator cavity. The boxes and all other components of the r-f system are tuned to the search frequency, 9,375 mc. During beacon operation, the received signal (9,310 mc) is attenuated 8 db in passing through the wave guide system, due to the selectivity of the r-f circuits.

When a reflected signal is received from a target, the energy passes through the transmit-receive box and into the receiver circuit. Here the signal is mixed with the local oscillator frequency in a crystal converter from which is obtained the 60-mc intermediate frequency.

There are two local oscillators, both using type 723 A/B velocity-modulated tubes (see ELECTRONICS, April 1942). One of these tubes is used during search and intercept operation and is tuned to a frequency 60 mc above the transmitter frequency, while the other is used for beacon operation and is tuned to a frequency 60 mc below the beacon frequency. When one tube is being used, the other is blocked by putting a large negative voltage on the reflector.

The i-f preamplifier consists of two stages using 6AK5 tubes in conventional single-tuned circuits. The preamplifier response is flat within 6 db over a frequency range of 4.8 mc and the gain of the two stages is 36.8 db.

The i-f amplifier consists of five single-tuned 6AK5 stages. The input to each stage is tuned by slug-tuning the coils; the distributed capacitance being sufficient, no tuning capacitors are used. The i-f gain is controlled by varying the plate and screen voltages of the first three stages. This five-stage amplifier has a gain of 92.9 db at full gain and passes a band 4.7 mc wide at points 6 db below maximum response. The detector, also a 6AK5, is connected as a cathode follower so that its video output may be sent to the video amplifier through a coaxial cable. Being operated near cutoff in the absence of signal, a positive voltage is developed across its cathode resistor when a pulse is received.

The output from the i-f preamplifier, besides being fed to the i-f amplifier, is also injected into the afc circuit which controls the frequency of the local oscillator. This afc circuit contains an i-f amplifier, a discriminator, and a d-c amplifier. A shift in the intermediate frequency from 60 mc causes a d-c voltage to be developed across the discriminator output. The polarity of this voltage depends on the direction of the deviation from 60 mc and the amount of deviation determines the amplitude of the voltage. This voltage is applied between the grid and cathode of the d-c amplifier. The plate of the amplifier is connected to the repeller electrode of the search local oscillator. A deviation below 60 mc will operate the afc system in such a way that the repeller voltage becomes more negative, thereby increasing the local oscillator frequency and in turn the intermediate frequency. During deviations above 60 mc, the action will be reversed.

The frequency of the beacon local oscillator during beacon operation is continuously swept over a narrow band. This is done so that signals can be received from all X-band beacon transmitters which are within range of the aircraft. The sweeping action is obtained by modulating the beacon local oscillator's repeller voltage with a sawtooth wave. The sawtooth voltage is of sufficient amplitude to sweep the beacon local oscillator through a frequency range of 27 mc at a rate of 84 sweeps per second.

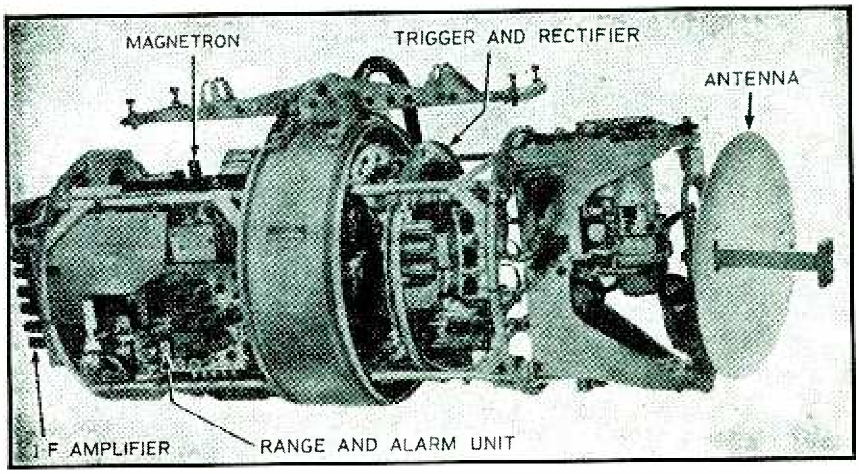
Range Sweep Circuit

The range and alarm unit contains five basic circuits: the range or vertical sweep generator, range mark generator, video amplifier, double-dot circuit, and alarm circuit.

The range sweep circuit is shown in Fig. 4. A positive synchronizing pulse is obtained from the modulator. Differentiating this pulse and removing the negative portion by means of the 6J6 clipper results in a sharp positive spike coincident with the leading edge of the sync pulse. The positive spike is then used to trigger the start-stop multivibrator.

Consider the action of this multivibrator in the absence of a trigger pulse. The grid in the second section goes positive until limited by grid current through the 2.7 megohm resistor. The resulting plate current raises the potential of the common cathode. The potential of the cathode increases to a sufficiently high level to bias off the first section even though the grid of the first section is maintained at a positive voltage.

When the positive trigger is applied, the first section becomes conducting and the resulting plate-cathode voltage drop is transferred to the grid of the second section via the coupling capacitor. In this way, the second section becomes nonconducting. The resultant decrease of its plate current allows the first section to remain in conduction even



Transmitter-receiver unit with covers removed. Power requirements are 680 watts at 115 volts, 800 to 2,400 cps a-c and 57 watts at 27 volts d-c

after the passage of the trigger pulse.

The first section will continue to conduct until sufficient charge leaks off the coupling capacitor between plate and grid to allow the second section to conduct again. At this time the start-stop multivibrator would return to its quiescent state. Thus a series of positive and negative rectangular pulses is generated, the leading edges of which are coincident with the leading edge of the transmitted pulse. The negative pulses are used to initiate the action of the sweep generator.

Prior to the negative pulse, the 6AK5 sweep tube is conducting. Applying the negative pulse to the control grid cuts off the plate current and the plate potential rises as rapidly as the sweep capacitor can charge through the chosen plate resistor. The range switch on the control box allows the operator to choose the sweep duration desired. In the control grid circuit of the sweep generator, the 220,000-ohm resistor is for d-c restoration, insuring that the sweep will start from the same point on all ranges. The sweep voltage, before being sent to the indicator amplifier units via a coaxial cable, is passed through a cathode follower circuit to obtain a low output impedance.

A portion of the cathode follower output is also fed to the sweep-stopping cathode follower. This 6J6 shares a common cathode resistor with the start-stop multivibrator. Consequently, as the plate current of the sweep-stopping tube increases, the potential at the cathode of the multivibrator rises. Eventually a tripping point is reached and the start-stop multivibrator is prematurely returned to its quiescent state. The time of the tripping action is adjusted by the sweep length control so that the sweep continues only for the required time interval and is then cut off.

Range Mark Circuit

Two sets of range marks can be generated by the range mark circuit. Pips at intervals of one mile are produced for use on the four-mile sweep. On the other three ranges the markers are spaced at ten-mile intervals. The range marks to be developed are determined by the setting of the range switch.

A negative pulse from the range sweep circuit is used to shock-excite oscillations in the range marker circuit. The sinusoidal wave obtained is used to overdrive an amplifier, resulting in a somewhat square wave which is then differentiated. The resultant positive and negative pips are applied to the control grid of a second amplifier which is biased below cutoff. The output is a series of sharp negative pulses separated in time by one- or ten-mile intervals. These range marks, if left on at all times, would draw a set of horizontal lines on the indicator screen. Since it would be feasible to lose a weak echo pulse within a range mark line, the range mark circuit is made operative only when the antenna is at its extreme right-hand position. Thus the range marks as viewed on the indicator take the form of a set of dots in a vertical column on the right side of the indicator screen (Fig. 1).

Video Amplifier

The video echo signals are mixed with the range mark pips in the plate circuit of the amplifier shown in Fig. 5. Together the range marks and the amplified video signals are applied as negative pulses to the grid of the limiter, which is operated at zero bias so that a pulse having an amplitude of approximately 7 volts will cut off the tube. When applied to the limiter control grid, pulses with larger negative amplitudes will therefore give the same output voltage as a 7-volt pulse, to show weak signals on the screen without obtaining spots of too great intensity due to the strong signals. The next two triode sections comprise the pedestal generator or unblanking pulse generator. Since the indicator tube is operated below cutoff to blank out the return or flyback trace, it is necessary to supply an unblanking pulse. The video signals are elevated on a pedestal developed by supplying a negative pulse from the range sweep start-stop multivibrator to the grids of the pedestal generator tubes. Thus these tubes are driven to cutoff, and since they share a common plate resistance with the limiter, the plate potential of the limiter is increased during the range sweep.

The output of the cathode follower is a positive signal containing the transmitted pulse T, range marks R, and echoes such as E all riding on top of the pedestal, as shown on the waveform presentation. In the indicator unit these signals are amplified by the push-pull amplifier and then applied in opposite phasing to the control grid and cathode of the indicator tube.

Double-Dot Circuit

The double-dot circuit which functions during intercept operation to give the elevation of the target with respect to the intercepting aircraft is shown in Fig. 6. The search intercept relay is energized during intercepting operation and the circuit is as shown. The function is controlled by a multivibrator having two modes of operation. In one state, the first half of the twin triode will be vigorously conducting and the second half will be biased off. During the next state, the reverse will be true. Consequently, the voltage wave forms at the plates of this multivibrator will be rec-

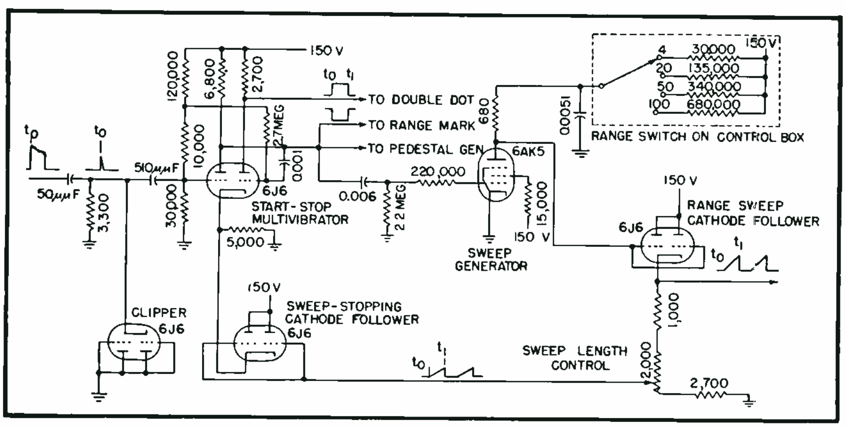


FIG. 4—Diagram of range sweep circuit

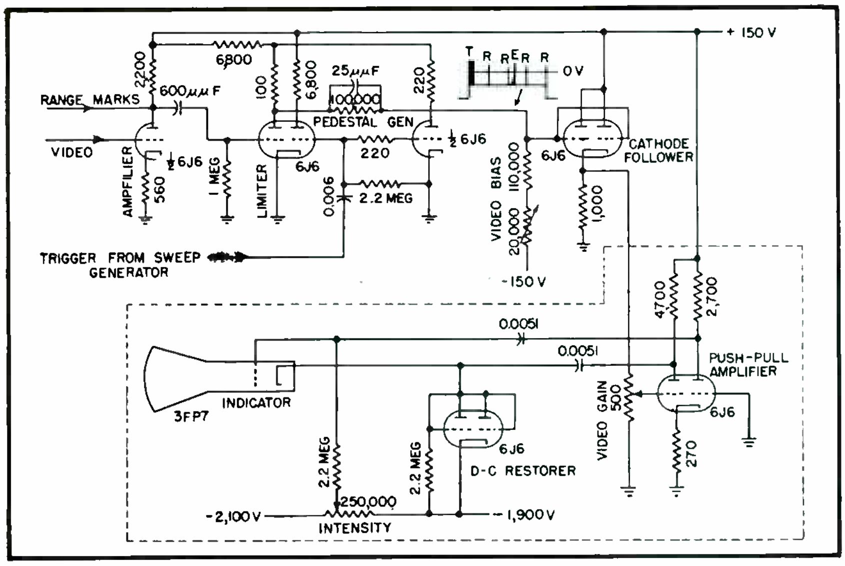


FIG. 5—Video circuits feeding the cathode-ray indicator

tangular and will be in phase opposition. It is these voltages that cause each alternate sweep trace to be displaced to the right and raised or lowered according to the antenna position.

The trigger pulse which is obtained from the range sweep start-stop multivibrator is a positive square wave. Differentiating the pulse and clipping the positive spike results in a sharp negative trigger coincident with the end of the range sweep. This trigger, occurring at time t_1, is used so that the operation of the double dot circuit can become stable before the start of the next sweep.

Just prior to the trigger pulse, assume that the first section of the multivibrator is conducting. The resultant cathode voltage biases the second section off. When the negative spike arrives at the grid of the first section, that side is cut off. The plate voltage increases and the increase is transferred to the grid of the second section, where it overcomes the incoming negative pulse. The second section goes into conduction. Its plate potential abruptly drops and this drop is transferred back to the first section's grid.

The next trigger pulse, when received from the range circuit, causes a like sequence of events to take place on the opposite section and the multivibrator is returned to the state originally assumed. The voltage wave at the multivibrator plates has a repetition frequency equal to half the radar's repetition rate.

The position of the azimuth potentiometer is controlled by the horizontal position of the antenna. The output of this potentiometer during search operation is a slowly varying voltage that increases as the antenna swings in one direction and decreases as the antenna returns. During intercept operation, the rectangular voltage wave at the plate of the multivibrator's first section is superimposed on this slowly varying voltage. The resultant output to the horizontal plates of the indicator tube is as shown. Thus each alternate range sweep is offset to the right.

To obtain the necessary change in the starting point of the range sweep, the output from both plates of the multivibrator is applied to the control grids of the cathode follower. The circuit constants of the cathode follower are so chosen that first one grid and then the other controls the cathode current. This shifting of control depends on the outputs from the multivibrator and consequently is in synchronism with the horizontal displacement of the range sweep.

The control voltage for the first section is obtained from the tilt potentiometer which is located on the antenna. As the antenna reflector nods during the four-line scanning cycle, the position of the potentiometer's rotor is changed. The grid voltage for the second section of the cathode follower is controlled by the zero-degree tilt adjustment. The cathode follower circuit is adjusted for proper operation by first stopping the antenna in such a position that the radiated beam is parallel to the transverse axis of the aircraft. The zero tilt adjustment is then set so the left and right traces on the indicator screen start from the same level. In other words, at zero tilt the cathode voltage of the cathode follower is the same when either section is in control. At all other tilt positions this voltage changes as the control shifts from one section to the other.

On the indicator screen during intercept operation (Fig. 1C), the left-hand dot gives the true range and bearing of the target just as in search and beacon operation. The right-hand dot, ⅛ inch away, indicates (in the case shown) that the target is above the flight line of the aircraft.

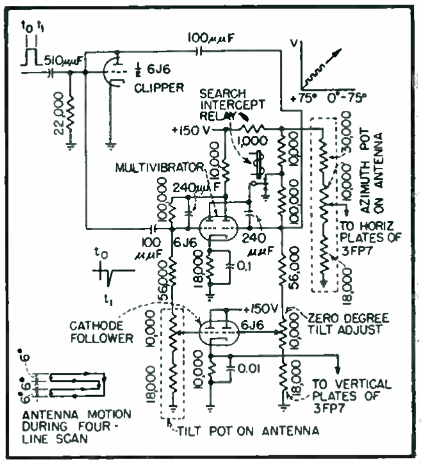


FIG. 6—Double-dot circuit, which places on the type-B presentation an extra dot, above or below the target dot according to whether the target is above or below the intercepting aircraft

Alarm Circuit

At one time an alarm was used with this radar to attract attention when echoes were received. A red light on the control box was automatically turned on whenever target echoes were received.

The solenoid coil of a relay was connected in the plate circuit of a separate video amplifier. When echoes were received, the video pulses caused an increase in amplifier plate current. This activated the relay and the closed contact turned on the warning light. In actual operation, the alarm circuit was found unnecessary and has been eliminated.

GAS-TUBE COUPLING for D-C Amplifiers

Combining a cathode follower with a gas diode gives a stable and efficient coupling network. Evolution and operation of the circuit are explained

PROBLEMS of supplying operating potentials to direct-current amplifier stages connected in cascade are bothersome. Each additional stage of amplification requires extra potential from the power supply and frequently causes trouble with insulation and voltage drift. Negative feedback is helpful in reducing drift but the difficulties of cascading direct-current amplifiers usually require the designer to minimize the total number of stages.

Figure 1 illustrates several methods of coupling. The circuit at Fig. 1A introduces no loss in transferring the signal from the plate of the first stage to the grid of the following stage, although it is very susceptible to drift introduced through supply voltages. The circuit at Fig. 1B uses a glow tube or neon lamp as a coupling element. Choice of the value of R_g in this circuit is a compromise; ordinarily R_g should be smaller than the d-c resistance (R_n) of the gas tube and larger than its a-c resistance (r_n) so that a smaller percent of the d-c voltage present on the plate of the first tube will be coupled to the grid of the second tube than the percent of a-c voltage that is so coupled. In addition, direct current flowing through the gas tube is limited by its rating and by the voltage drop caused in the plate load resistor of the first stage. As a result of these limitations on the design, R_g must sometimes be chosen in such a way that substantial coupling loss occurs. The VR type of tube with rated average current is ordinarily not considered for this application because its d-c resistance is of the same order of magnitude as the plate load resistors which may be desired.

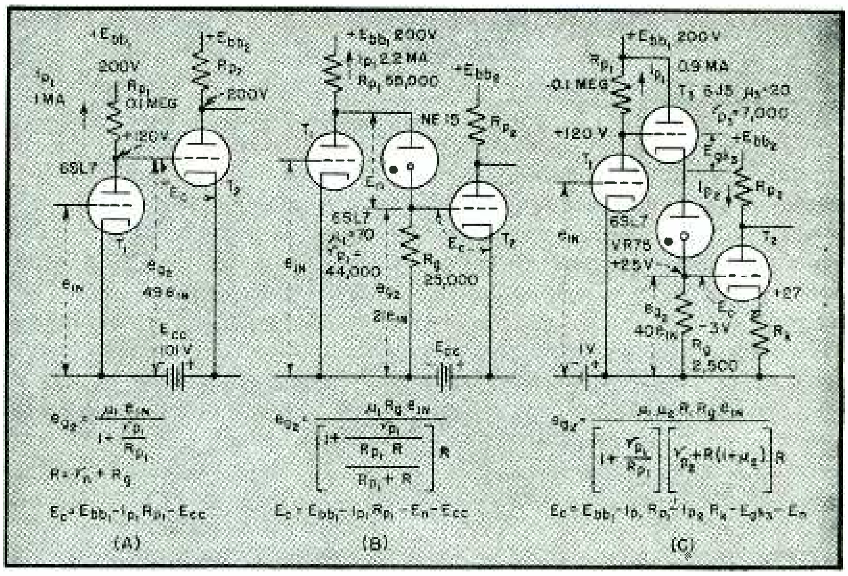


FIG. 1—Conventional d-c amplifier circuit and two methods of using gas tubes for coupling between stages. Typical values for the networks are given

Improved Coupling Circuit

The circuit illustrated in Fig. 1C suffers from none of these disadvantages. An additional tube is used as cathode follower with its cathode impedance composed of the VR tube and resistor R_g. With this arrangement there is no d-c load on the first amplifier and the input impedance of the cathode follower is so high that it does not affect the gain of the first stage. Most of the d-c voltage drop in the cathode circuit of the follower stage occurs across the VR tube while almost all of the signal drop appears across R_g. Because the current through the VR tube flows in a path separate from the d-c plate current of the first stage, the design of the first stage is independent of the d-c resistance of the VR tube. The only requirement is that R_g must be much larger than the dynamic impedance of the VR tube. Coupling loss of signal voltage from the first amplifier plate to the second amplifier grid is only slightly greater than the ordinary cathode-follower loss. Figure 1C also shows how a negative feed-back resistor (R_k) can be inserted in the cathode of the second amplifier to increase stability.

The gas tube coupling should only be applied in circuits where the signal level is high enough so that noise from the gas discharge will be negligible. A conservative figure is to keep the total signal change more than 50 mv. Maximum signal change allowable across the VR tube is a function of current and, to a slight degree, frequency. For design purposes the change of voltage across the VR tube should

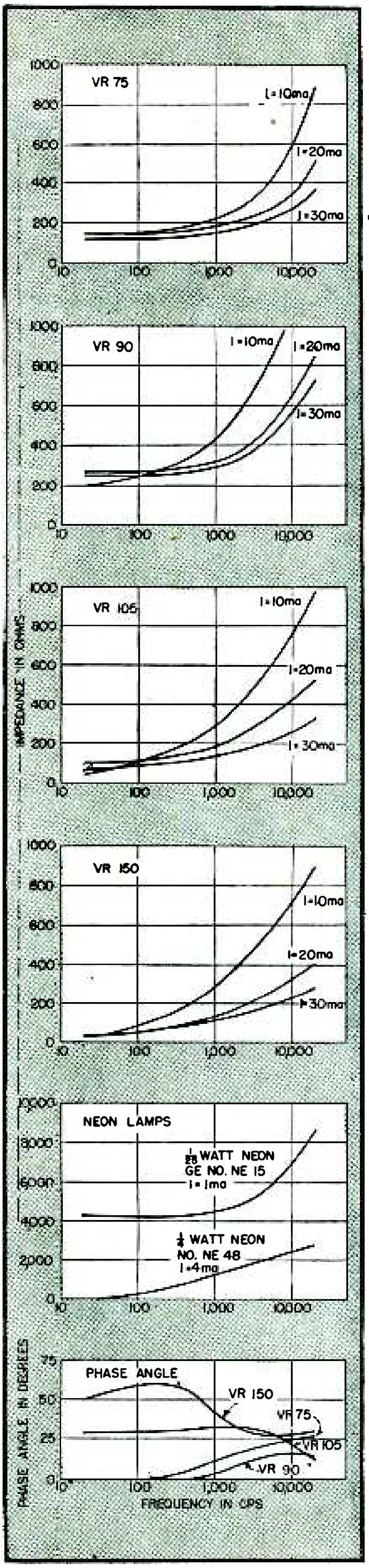


FIG. 2—Characteristics of voltage-regulator gas tubes and neon lamps

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be held to less than 0.5 volt. When neon tubes are used, the maximum allowable signal voltage drop across them is approximately one or two volts, depending on the type of tube and the d-c operating current. This limit must be observed because the signal current variations through the glow tube may be sufficient to drive it to the point of extinction on negative signal current peaks or to overload it on positive signal currents. Distortion of the waveform occurs as a result of either of these conditions.

Impedances of Gas Tubes

Magnitude and phase angle of impedance were measured for the four VR types, VR75, VR90, VR105, and VR150, and for two common neon tubes, rated at 1/25 watt and ¼ watt. The frequency range was from 20 cycles to 20 kc. The data show that impedance does not vary much at the lowest frequencies, and tests confirm the fact that the magnitude of the impedance given on the curves for a frequency of 20 cycles is very close to the value at frequencies from zero up to 20 cycles.

The results in all cases indicate (1) that there is a steady increase of the ohmic impedance with increased frequency; (2) the phase angles are always inductive, that is, the current lags the voltage by an angle between zero and 180 degrees (angles greater than 90 degrees indicate negative resistance); (3) for a given tube operated within ratings, the impedance is reduced by increasing the average current.

Figure 2 illustrates the approximate values of impedances and phase angles to be expected from typical gas tubes. All the tubes tested were made by leading manufacturers and were in good condition. However, impedances differed by as much as 20 or 30 percent when other tubes of the same type

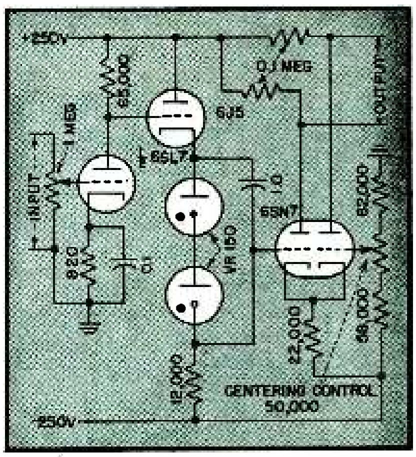


FIG. 3—Circuit of direct-coupled amplifier for an oscilloscope. The novel coupling system provides a response flat within one db to ten kilocycles

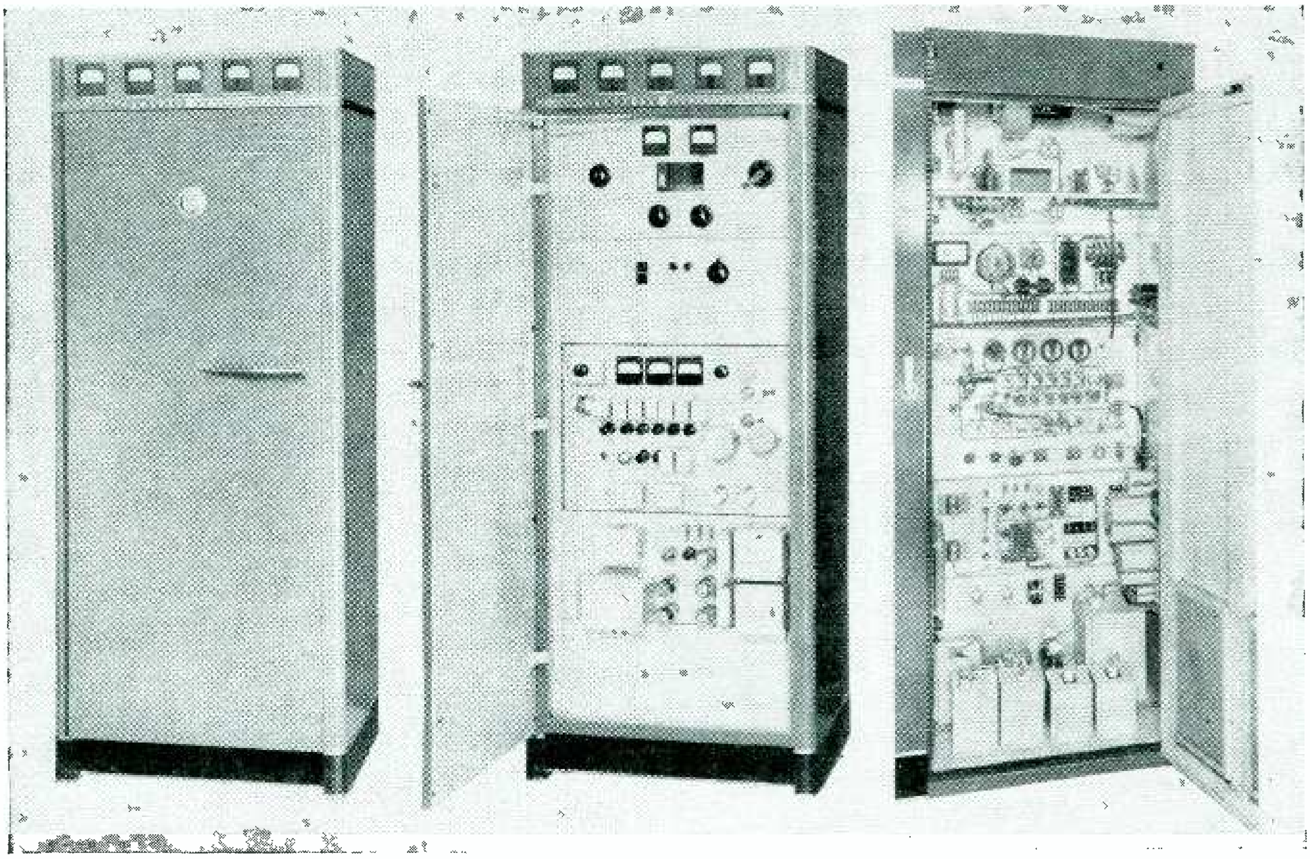
and manufacturer were substituted. Consequently, the curves should only be construed as approximate, and exact values from them cannot be relied on. This is no serious disadvantage, because the circuits in which they are applied do not require exact ohmic values, a 20 percent change in gas tube impedance producing about one percent change in grid voltage.

Bypass capacitors should be connected across the gas tubes if the rise of impedance at high frequency causes difficulty. The graph of phase angle, which is also approximate, was drawn by averaging the data on each tube for the three operating currents 10, 20, and 30 ma. There is no significant change in phase as a function of average current except for subnormal average currents, which produce negative resistances at low audio frequencies.

An application of gas tubes is illustrated in the circuit of Fig. 3, which is a direct-coupled amplifier for use in feeding a pair of deflection plates in an oscilloscope. It has a gain of about 400 and is flat within 1 db to 10 kilocycles.

PHASITRON F-M TRANSMITTER

Economies made possible by use of the new tube are illustrated in a commercial f-m broadcast transmitter design. Function of the tube is graphically described



Front and rear views of the complete 250-watt f-m broadcast trcnsmitter. Two power supplies are mounted in the lower section of the cabinet. Overload, time-delay, and high-vol:age-shorting relays protect equipment and personnel

UNTIL RECENTLY there have been two systems of generating frequency modulated carriers: the phase-modulation system, which combines the side bands of an amplitude-modulated signal with a carrier shifted 90 degrees in phase; and a reactance-tube frequency-modulated oscillator.

The first system has the advantage of crystal control but requires considerable frequency multiplication because of small phase-angle excursions. The second system provides wide frequency swing but requires an auxiliary means to hold crystal-control tolerances on the center frequency. As a result, a thorough investigation has been made of a new modulation scheme proposed by Robert Adler of the Zenith Radio Corporation.

A block diagram of the exciting unit is shown in Fig. 1. The carrier frequency is generated by a crystal oscillating in the region of 230 kilocycles and, after one stage of amplification, is used to drive a phase-splitting network to provide three-phase voltages for the input deflector grids of a "Phasitron" tube. A diagram of the tube structure is shown in Fig. 2. Anodes 1 and 2 are at positive d-c potential and draw electrons from the cathode radially in the form of a tapered thin-edged disk as dictated by the first and second focusing electrodes. This electron disk with the cathode as its axis passes between a neutral plane and a three-phase deflector-grid assembly. The deflector-grid assembly consists of 36 separate wires with every third wire connected together, forming three groups of twelve. The three-phase voltages are applied to these deflectors, which, in turn, provide a rotating electrostatic field between the deflectors and the neutral plane, and warp the electron wheel into a ruffled electron disk as shown in Fig. 3.

The sinusoidal ruffle at the edge

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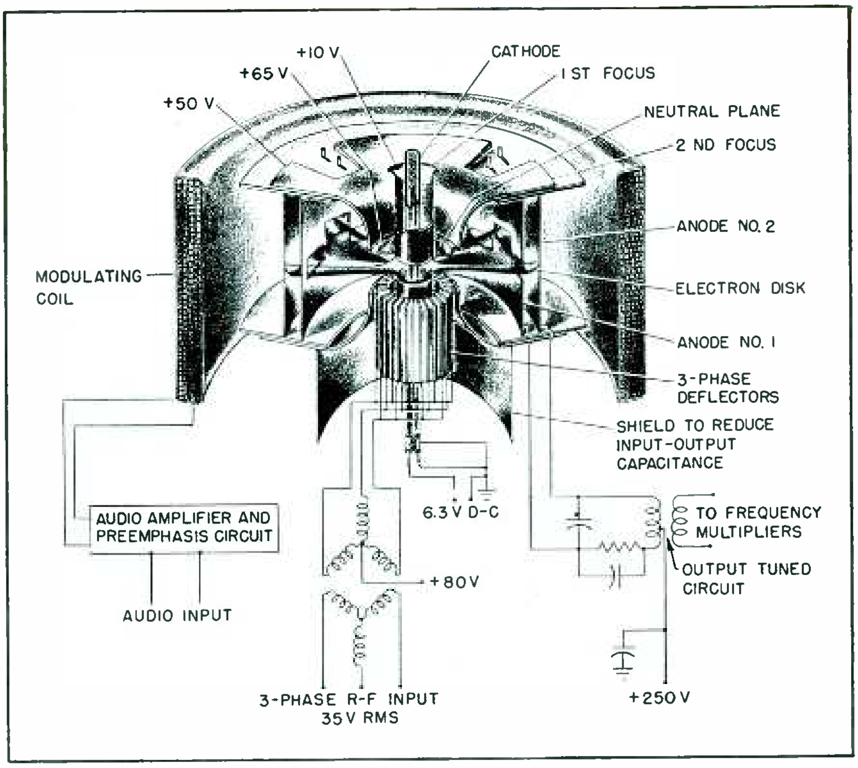


FIG. 2—Vertical section of the tube and modulator coil. Connection to a typical transmitter circuit is indicated

of the electron disks falls upon anode 1, which is perforated in a half-cycle arrangement to match the edge of the disk. As the disk rotates, the sinusoidal edge successively passes through the perforations, or is collected by the metallic barriers separating them. A push-pull tuned circuit placed between these two anodes (Fig. 2) is driven by the alternate collection of electrons by the two anodes, and supplies voltages at the crystal frequency for driving subsequent doublers and triplers to raise the frequency to that of the radiated carrier.

The second focus electrode, in addition to having an electrostatic influence upon the beam, is made of magnetic material and acts as a magnetic concentrator to confine the flux produced by the audio modulating coil to a narrow region at the edge of the deflector grid.

Phase-Shift Action

The action of this magnetic field is to bend the electron stream as shown in Fig. 4, advancing or retarding the phase of the sinusoidal ruffled edge with respect to the perforated anode, and introducing a corresponding phase shift in the tuned circuit.

Early modulator tubes were constructed with a double-ended electrode assembly consisting of two sets of three-phase deflecting wires placed in opposition around a central cathode. All the electrodes except the deflecting wires were of such a design as to be easily incorporated in a standard receiving tube assembly. The double-ended deflector assemblies gave difficulty because of the complicated mechanical construction and the critical positioning of the two assemblies with respect to each other.

A ceramic core with slots to hold the deflecting wires simplified mechanical assembly. The sensitivity to positioning was overcome by changing the design to that of a single deflector assembly working against a neutral plane as described above. This arrangement requires only one deflection assembly and eliminates all rotational alignment requirements. In addition, a control is provided to center the ruffled electron disk on the axis of the perforated anode.

A suppressor grid between the first and second anodes, used in early samples, has been omitted for simplicity. It is, therefore, necessary to maintain the two anodes at a potential difference of approximately 45 volts in order to prevent emission of secondary electrons from reducing the output current. Placing the electrode assembly in a single-ended bulb has required considerable shielding between the three-phase driving electrodes and the two anodes. The transfer of unbalanced three-phase voltages to the anode circuit has the effect of adding a constant r-f component of frequency to the phase-shifting component and results in a distorted audio wave. This distortion can be eliminated by neutralization, but varies from tube to tube and

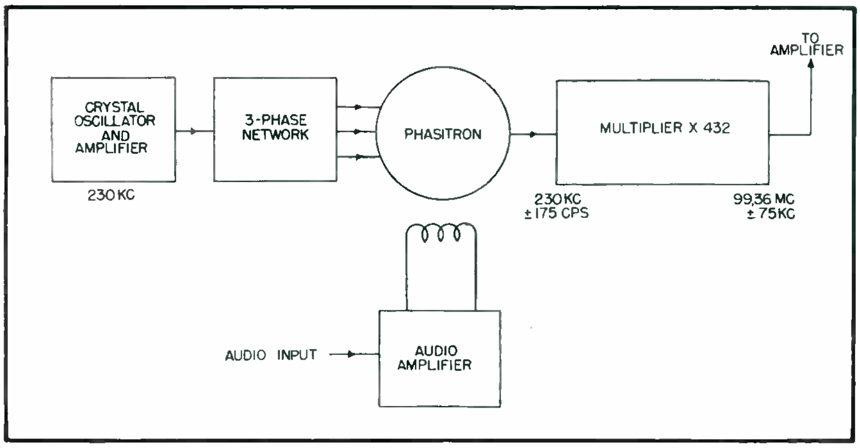


FIG. 1—Block diagram showing the use of the phasitron tube in an f-m transmitter

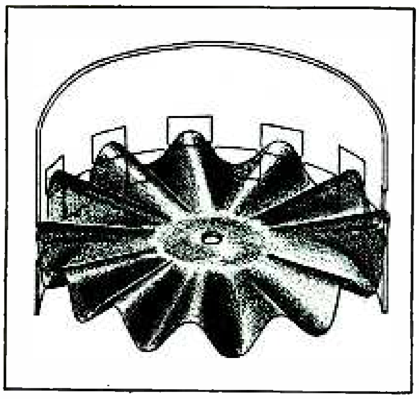


FIG. 3 — Pictorial representation of the shape of the electron disc in the Phasitron tube. In this position, minimum current is collected at perforated anode No. 1

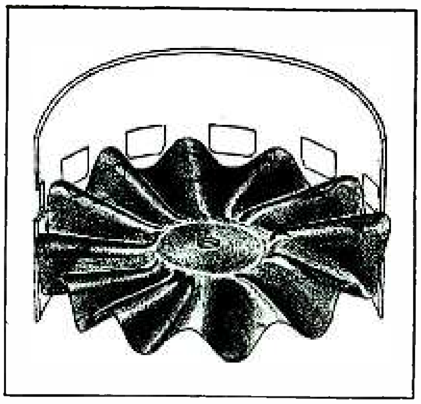


FIG. 4—Position of the electron disk for maximum current collected at anode No. 1 as a result of modulation by the magnetic coil

was not sufficiently diminished until the capacitance between the three-phase electrodes and the output circuit had been reduced to 0.08 micromicrofarads.

Magnetic Focus Electrodes

The electrode assembly is mounted with the three-phase deflector grid located at the bottom to keep the input leads as short as possible. In addition, the stem arrangement is oriented to place the first and second anode leads diametrically opposite the three-phase input leads so that intervening shielding can reduce the coupling to a minimum. The flared cone-shaped second focus electrodes are made of siliconnicaloi to provide low hysteresis loss. The concentration provided by these electrodes improves the magnetic sensitivity by a factor of three over that which could be obtained by action directly on the electron stream.

There are three radial slots cut in each plate to provide clearance for the anode ears and to reduce the eddy current loss at high frequencies. The anodes are made from nonmagnetic material to prevent a magnetic short-circuit between the two second-focus electrodes. The neutral plane is mounted in the upper half of the tube directly opposite the three-phase deflector assembly. The cathode assembly is a standard 6J5 element coated for a quarter of an inch. The active part of the electron stream is limited by the edges of the first focus electrodes.

The bulb length is made longer than the electrode assembly would normally require, to act as a handle for removing the tube from a permanently mounted modulating coil. The normal frequency at which the tube operates in an f-m broadcast transmitter is between 200 and 250 kilocycles. Operation at 60 cycles is quite satisfactory and provides a possibility of new phase control systems for power frequency equipment.

Figure 5 shows a plot of phase shift vs gauss. The sensitivity of the tube to magnetic deflection is high and is sufficient to give a phase shift of approximately one radian per each 2.7 gauss change in field. The curve indicates a high degree of linearity over a plus or minus 360-degree range, with increasing sensitivity for further excursions.

The d-c potentials associated with the first and second focus, the three-phase deflectors, and the neutral plane must be adjusted for minimum signal distortion. The only test that can be performed to insure the required limits is an actual operation test in an f-m transmitter, with subsequent measurement in a low-distortion detector. The radio-frequency driving voltages should be in excess of 35 rms volts, measured from phase to neutral.

The audio driving power is dependent to some extent upon the design of the modulating coil, with respect to the number of turns and the resistance of the wire. In general, the audio power required to modulate the tube to full swing is less than twenty milliwatts, permitting the use of a low-powered audio-driving circuit.

The performance of f-m broadcast transmitters is based primarily on the requirements of the Federal Communications Commission, which specifies overall transmitter system performance from microphone input terminals to antenna output. The performance specifications for the transmitter to be described have been set up so as to be well within the limits allowed by the Commission.

These requirements are most severe in two particular instances. The carrier frequency stability required at 108 megacycles is 0.00185 percent, which is as good as that required of a standard a-m broadcast transmitter operating at 1,080 kc. In addition, the harmonic distortion in the middle frequency range from 100 to 7,500 cycles must not exceed 2.5 percent.

Transmitter Development

A phase modulation system in which the carrier frequency is derived directly from a crystal-controlled oscillator is ideal for satisfying the carrier frequency stability requirement. Furthermore, in a phase modulator, the harmonic distortion is a function of the phase swing employed, and since, for a constant frequency swing (corresponding to modulation percentage), the phase swing is inversely proportional to the modulating frequency, a phase modulator will have inherently low harmonic distortion in the middle audio frequency range.

The chief drawback to phase modulators in the past has been the large amount of frequency-multiplication required, resulting in a large number of tubes and circuits. The multiplication required is inversely proportional to the maximum phase swing that can be

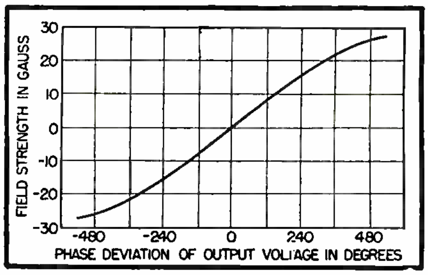


FIG. 5—Phase deviation of the output voltage with respect to field strength of the modulating coil in gauss

employed in the modulator without exceeding the permissible value of harmonic distortion. The relationship of the factors is multiplication =

$$\frac{\text{carrier swing}}{\text{audio frequency x phase swing}}$$

For plus or minus 75 kc swing of the carrier, at a modulation frequency of 50 cycles, an angular swing of 75,000/50 or 1,500 radians is required. If a total multiplication M is used between the modulator and the output of the transmitter, the modulator must be capable of operating through an angle of plus or minus $1{,}500/M$ radians within the permissible distortion limits. This immediately shows the advantage of the Phasitron tube, with which it is possible to use a phase swing of plus or minus 3.5 radians without exceeding 1.5 percent distortion. It is seen that a multiplication of as little as 428 is sufficient, compared with 7,000 required with previous types of phase modulators, for comparable performance.

A multiplication of 432 can be obtained by the use of three triplers and four doublers. Furthermore, this multiplication, when used for the carrier frequency range from 88 to 108 megacycles, results in a frequency range for the modulator from 203 to 250 kc. This condition is satisfactory both from the point of view of the design of circuits and of high-stability crystals. It will be observed that no heterodyne process is necessary, thus avoiding the use of more than one crystal.

Modulator Circuit Operation

The operation of the actual modulator circuit is shown in the simplified schematic diagram of Fig. 6. The crystal is connected in a form of a Colpitts oscillator circuit with electron-coupled output, that requires no tuned circuits other than the crystal itself. The crystal is the plated type, enclosed in a sealed cell with self-contained thermostatic control to hold it at an operating temperature of 60 C. The small mass of the crystal cell facilitates quick heating, enabling the transmitter to be within the frequency tolerance in less than two minutes, starting from room temperature.

The crystal oscillator is followed by a buffer amplifier that drives a phase-splitting circuit to develop the three-phase voltages for the deflector elements of the Phasitron modulator tube. A vector diagram showing the principle of operation of this phase splitter is shown in Fig. 7. It functions essentially as a single-phase to two-phase conversion accomplished by the capacitor C_2 and resistor R, and a Scott-connected transformer system comprising transformer T with a center-tapped secondary, and the parallel tuned circuit L, C_3, C_4.

Since the Phasitron is modulated by a magnetic field, fields other than those produced by the audio input will cause noise modulation of the carrier. These stray fields may be caused by power transformers in the transmitter unit itself or by external equipment. To avoid this source of trouble, the modulator tube and the field coil that produces the modulation are enclosed in a magnetic shield made of high permeability material. A further precaution taken to keep the carrier noise level at a low value is the use of a small selenium rectifier and filter to provide d-c filament supply.

Audio Driver

The audio system consists of two push-pull amplifier stages using twin triodes, a 6SL7 and a 6SN7, with feedback from the plates of the second stage to the cathodes of the first stage. The input is applied to the first stage through a pre-emphasis network and input transformer, and the output is connected to the Phasitron field coil through an output transformer. The field coil is designed to appear as nearly as possible like a pure inductance over the entire audio-frequency range from 50 to 15,000 cycles. By holding a constant voltage across the coil at all audio frequencies, the current through the coil and consequently the magnetic field in the Phasitron tube will be inversely proportional to the modulating frequency. This is exactly the correction required to convert from phase

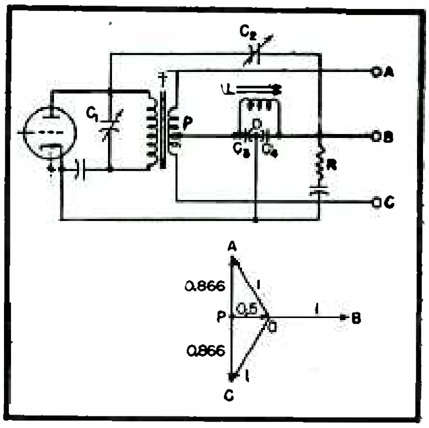


FIG. 7—The phase-splitting circuit described in the text and a vector representation of phase relations at various points in the circuit

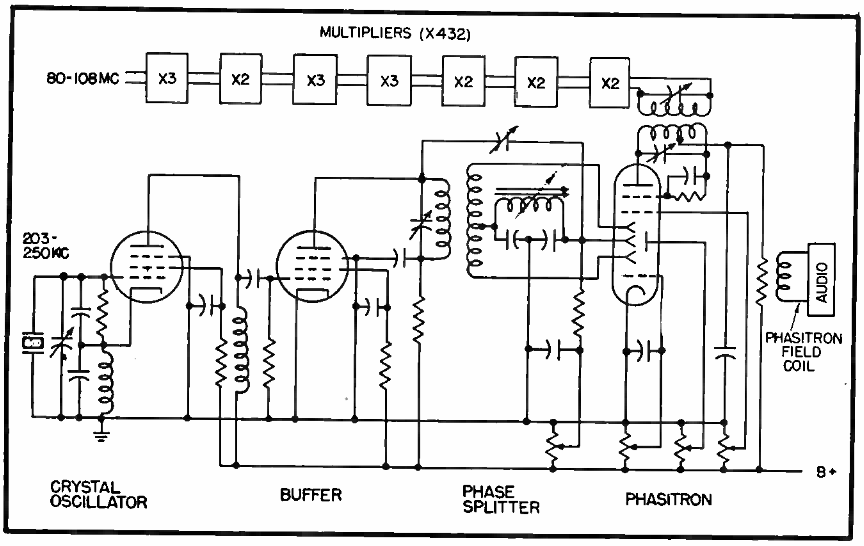


FIG. 6—Simplified block diagram of a crystal-controlled, phasitron-modulated broadcast transmitter. Audio modulation is introduced through the field coil that surrounds the new tube

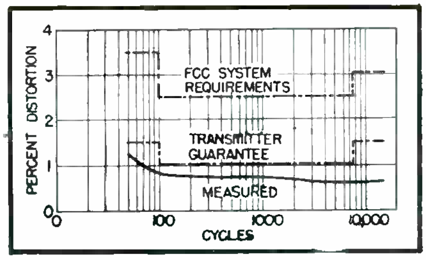
modulation to frequency modulation. The effect of the resistance of the field coil can be compensated by introducing a slight frequency characteristic in the feedback circuit to reduce the feedback at the lower frequencies and thereby increase the audio gain. This compensation is effected by choosing values of resistance and capacitance for the feedback circuit that give the same time constant as that of the field coil.

The radio-frequency circuits following the Phasitron modulator tube, in the modulator unit itself, consist of three doublers, two triplers, another doubler, and a final tripler. Type 6SJ7 tubes are used except for the last doubler, a 6V6, and the final tripler, an 815. The coupled circuits between all stages are designed to have sufficient bandwidth for desired side bands, with great attenuation beyond this range.

Commercial f-m transmitters have power ratings of 250 watts, 1 kw, 3 kw, 10 kw and 50 kw. These ratings are obtained by the use of class-C amplifiers following the modulator. The 250-watt transmitter is a basic unit. It may be used as an exciter for all the other power ratings. The first stage following the modulator unit is an 829-B tube, and the final power amplifier, illustrated, consists of two Eimac 4-250-A tetrodes operated in a push-pull circuit. These power amplifier tubes have a total plate dissipation rating of 500 watts, which is considerably in excess of the requirements of a 250-watt transmitter. They were chosen in order to provide extremely conservative operation and long life expectancy.

Inductance Tuning

The most interesting feature of the power amplifier is the use of inductance tuning of the plate tank with no circuit capacitance other than that of the tube. The variation of inductance is accomplished by moving the two metallic cylinders shown in Fig. 8 in and out of the coil by means of a double-screw thread operated from a front panel control. Such a tank circuit has a high inductance-to-capacitance ratio, thereby keeping the circulating current low and providing high circuit efficiency. The entire frequency range 88 to 108 megacycles can be covered without changing coils or taps.



Graphical presentation of audio harmonic distortion versus frequency with respect to FCC requirements, transmitter guarantee and actual performance on the preproduction model

The power amplifier grid circuit and the intermediate power amplifier plate circuit have separate tanks with adjustable inductive coupling. This provides greater stability by avoiding the use of the chassis as a part of the interstage coupling circuit. The power amplifier, although it uses tetrode tubes, requires series tuning of the screens to counteract the effect of the lead inductance at these frequencies and to hold the screens at r-f ground potential. This is done by means of a variable capacitor provided with a front-panel screwdriver adjustment.

Radio-frequency output from the power amplifier is inductively coupled by an adjustable loop to a low-impedance concentric transmission line. A vacuum-tube voltmeter mounted at the input end of the line indicates the radio-frequency voltage at that point and can be adjusted to read in percent of normal carrier output.

The electrical performance, demonstrated by a set of measurements made on a preproduction unit, compares the distortion and frequency response with performance guarantees in graphical form. These indicate that the design is capable of meeting the rigid requirements of f-m broadcast service with an adequate margin of safety.

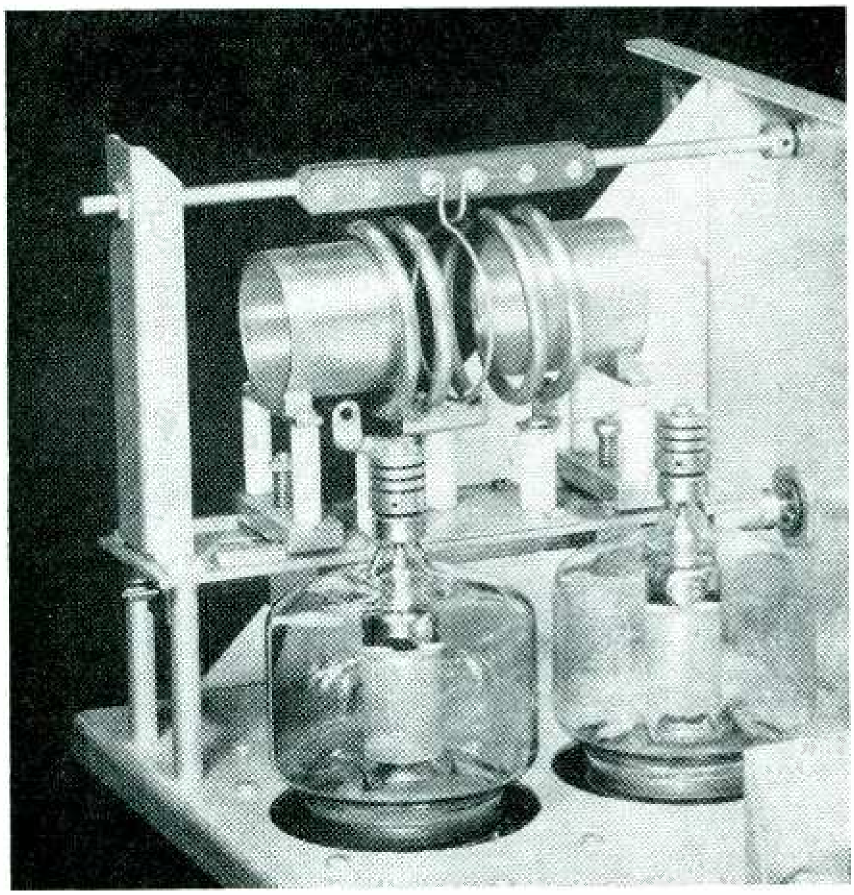


FIG. 8—Output stage of the 250-watt Phasitron f-m transmitter, showing the inductance-tuning arrangement consisting of two movable metallic cylinders in the plate circuit of the final amplifier. The output coil is shown between the two sections of the split tank coil

CRYSTAL-CONTROLLED DIATHERMY

A prototype r-f heating unit that complies with FCC requirements by means of crystal control. The basic circuit described in detail can be modified for lower power or industrial heating applications

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THE action of the FCC[1] in offering the users of medical and industrial r-f heating equipment the alternatives of either reducing radiation from such equipment to a negligible amount or operating in relatively narrow frequency bands, has posed a serious problem for the designers and users of r-f heating apparatus.

The effective shielding of an area containing r-f heating equipment, while technically possible,[2, 3] has not been found practical in many cases. This is especially true in the case of existing installations in which the problems presented by plumbing and wiring passing through the area have often proven insurmountable on a reasonably economical basis. Where portability is desirable, as it often is in the case of diathermy equipment, the necessity for a shielded room is a serious disadvantage.

An alternative to complete shielding is accurate frequency control within the bands allocated by the FCC. The frequency may be maintained within these bands by means of master-oscillator control, frequency-correcting devices,[4] or by using exceptionally stable self-controlled oscillators feeding the load directly.

Our medical department recently indicated a desire for a diathermy unit for the treatment of employees. Each of the possible methods of meeting the FCC requirement regarding diathermy equipment was considered. Complete shielding of the treatment room was out of the question from the standpoint of economy and portability. The possibility of using a very stable high-C oscillator was given serious consideration, but discarded because of previous unsatisfactory experience with similar oscillators used with fixed loads for communication purposes. Oscillators of this sort are capable of the required stability, but the overall efficiency often becomes quite poor, because of high circulating current and the resultant tank-circuit losses. Load variations present additional complications.

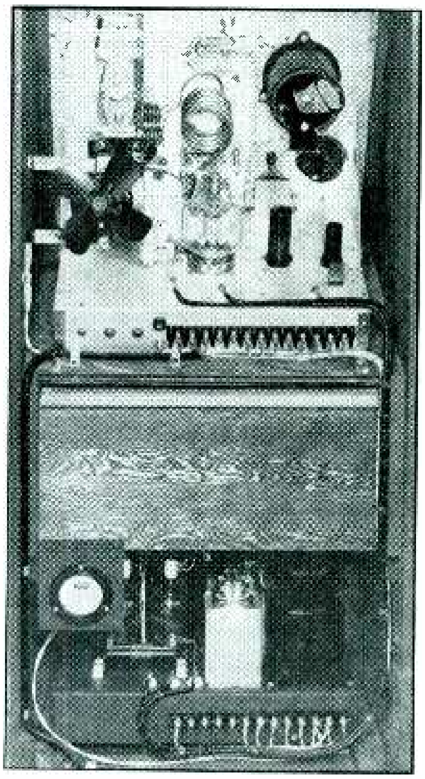


FIG. 1—Rear view of the diathermy unit with cover removed. Power supplies are at the bottom. The fan on the r-f unit draws air past the tube base and exhausts it through a hole in the rear

Of the remaining two alternatives, crystal control by direct or frequency-comparison methods, direct crystal control was selected as the simplest solution at the power level desired. This choice was in part dictated by the availability of new screen-grid transmitting tubes capable of efficient operation with a minimum of driving power, and which at the same time do not require neutralization in the high-frequency region.

Physical Layout

The complete unit is housed in a mahogany cabinet measuring roughly 48 by 22 by 16 inches. Storage space for applicator pads and other supplies is provided behind a door at the front of the cabinet.

The low- and high-voltage power supplies for the exciter and power amplifier are located on a 17 by 13 by 3 inch chassis placed near the bottom of the cabinet. The r-f section is placed on another 17 by 13 by 3 inch chassis, which is supported by a sloping shelf slightly above the center of the cabinet. The arrangement is shown in Fig. 1.

Circuit Analysis

The schematic wiring diagram of the unit is given in Fig. 2. A frequency multiplication of four is obtained in the two-tube r-f exciter section that employs a 6.83-mc crystal. The crystal oscillator tube is a 6AG7 operated in a circuit in which the grid-screen section is used as a triode Pierce oscillator. The plate circuit of the 6AG7 is tuned to the second harmonic of the crystal frequency, where sufficient output is obtained to excite the following 6L6 doubler stage.

A frequency multiplication of two is obtained in the 6L6 stage driving the final amplifier. The 6L6 operates at a plate voltage of 425 volts, and is capable of delivering more than adequate excitation to the Eimac 4-250A power amplifier stage.

The output stage operates as an amplifier at 27.32 mc, and is capable of delivering a power output in the neighborhood of 500 watts, which is more than is normally required for therapeutic purposes. Adjustment of the power output is made by means of a continuously-variable autotransformer controlling the primary voltage delivered to the high-voltage power supply. Plate voltage for the 4-250A is supplied via a shunt-feed r-f choke, to allow d-c grounding of the plate tank circuit. Screen voltage for the 4-250A is taken from the plate supply via a dropping resistor, so that plate and screen voltages vary together when the supply voltage is varied.

Coupling between the amplifier plate tank circuit and the applicator leads is by means of a balanced-T network connected to a single-turn loop placed near the tank coil. With the inductance values indicated, the matching network is capable of providing adequate loading for the amplifier for all normal applications, using applicator pads with 4-foot leads. The pick-up loop is fixed in position approximately one-half inch from the grounded end of the plate coil. The variable capacitor in the coupling network is tuned for maximum current at the generator end of the applicator leads, as indicated by a single-turn loop and panel lamp loosely coupled to the output leads. The output indicator lamp is located on the panel between the output jacks.

Two parallel 100-$\mu\mu$f-per-section split-stator capacitors are provided in the matching network. One of these is used for padding purposes, however, and is not adjustable from the panel. It has been found unnecessary in practice to retune the final amplifier capacitor if the load-matching circuit is simply tuned for maximum output in each application.

All tuned circuits preceding the power amplifier plate are located under the chassis, to prevent coupling around the 4-250A. It is worth noting in this respect that the 6L6 preceding the 4-250A must have a metal envelope. The use of a 6L6G, or ineffective grounding of the envelope of a 6L6, will allow feedback from the plate of the 4-250A to the plate of the 6L6 by direct capacitance coupling between tubes. As these two plate circuits operate on the same frequency, oscillation is al-

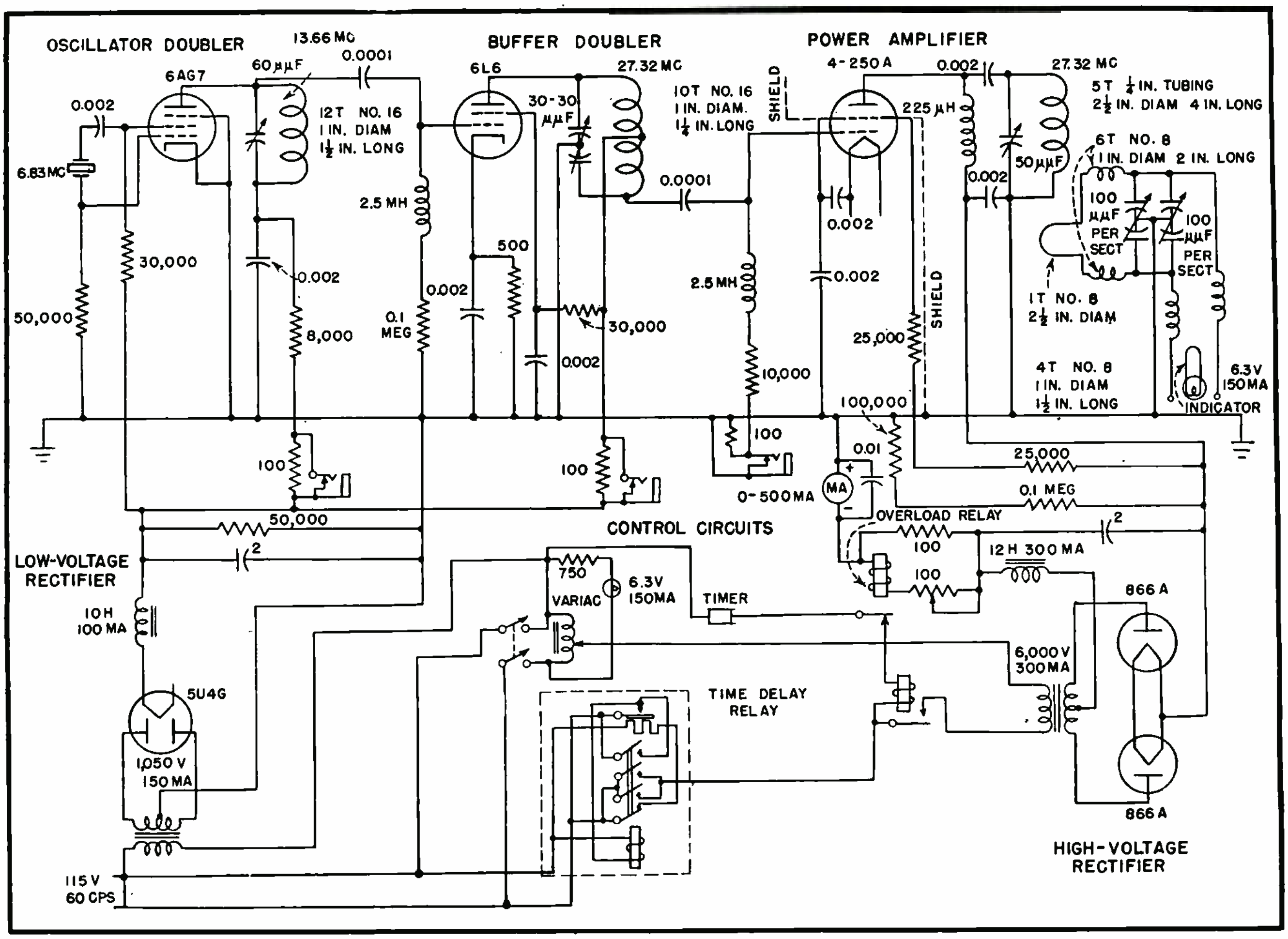


FIG. 2—Schematic circuit diagram of the three-stage r-f heater. Filament power supplies have been omitted. Power supply at the left serves the oscillator and buffer stages

most certain to result if the shielding between them is not complete.

Cooling

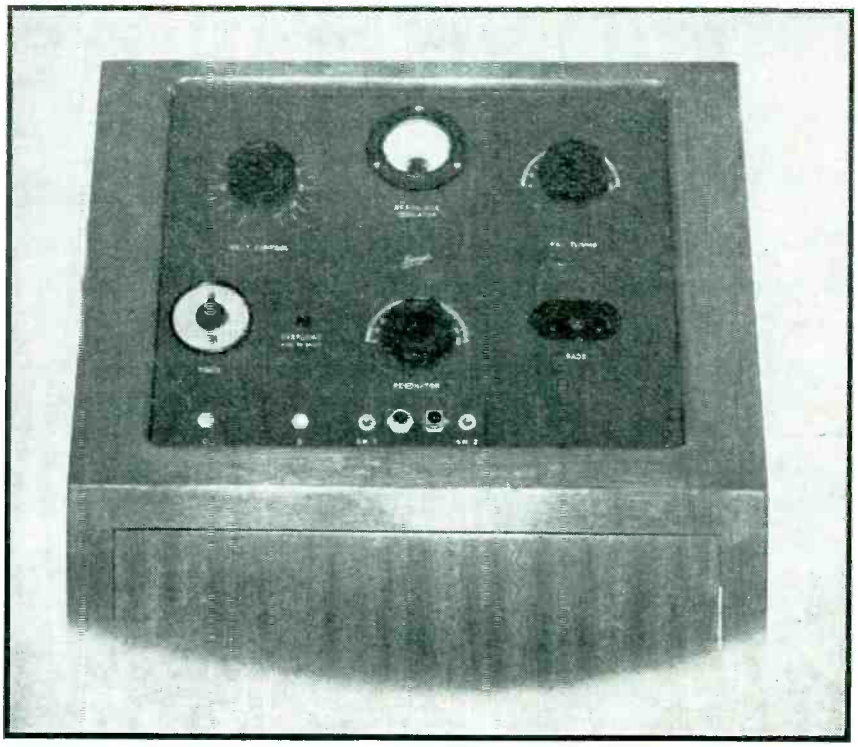
The 4-250A tube has been provided with a very compact base and stem structure, to allow its effective use at high frequencies. This type of construction causes sufficient transfer of heat to the seals and leads by conduction and radiation to make forced cooling of the base structure a necessity. The amount of cooling required is small, and is provided in the diathermy unit by a six-inch exhaust fan located near the top rear of the cabinet. This fan draws air through a dust filter at the bottom of the cabinet below the power supplies and passes it upward through the complete unit. Because the r-f chassis forms a nearly complete partition across the cabinet, a substantial portion of the air traveling upward is forced to pass through the 4-250A socket and the tube base to reach the top of the cabinet and the exhaust fan. The center portion of the shelf supporting the r-f section is cut away to allow air to enter the bottom of the chassis.

Suggested Modifications

The unit described here is probably somewhat more complex than necessary for diathermy purposes. It was thought desirable, however, to include at the outset all features that might be desirable, letting experience in actual operation determine which of them might advantageously be eliminated. The superfluity of the panel control on the plate-tuning capacitor has been indicated. Another possible modification would be the elimination of the relatively costly autotransformer plate-supply voltage control by substituting a potentiometer to vary the screen voltage on the 4-250A amplifier, for adjustment of power output.

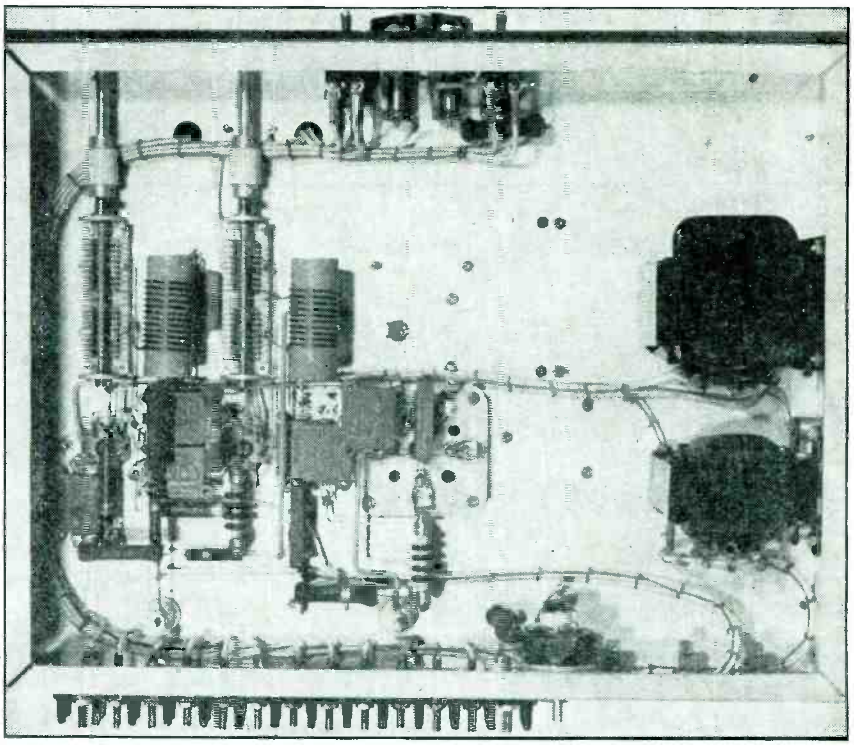
The power supply illustrated was based on an available plate transformer. A lower-voltage transformer with a small filter capacitor might very well be used, thus eliminating the filter choke.

Although the unit described is intended specifically for medical purposes, its conversion to industrial dielectric heating applications would require only minor changes. The availability of new transmitting tubes combining high power sensitivity and low interelectrode capacitances with ruggedness offers the designer of high-frequency heating apparatus a simple and inexpensive solution to the problems presented by the new regulations.



Front view of the upper portion of the diathermy cabinet, showing the control panel

Underneath the r-f chassis. The crystal-stage components are separated by the chassis from the final amplifier plate circuit to avoid feedback



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Pulse Transmission

An economic evaluation of single and double-tuned coupling circuits in pulse amplifiers is possible by setting standards for comparison of steady-state and transient response. The experimental results obtained at medium frequencies are valid much higher in the spectrum

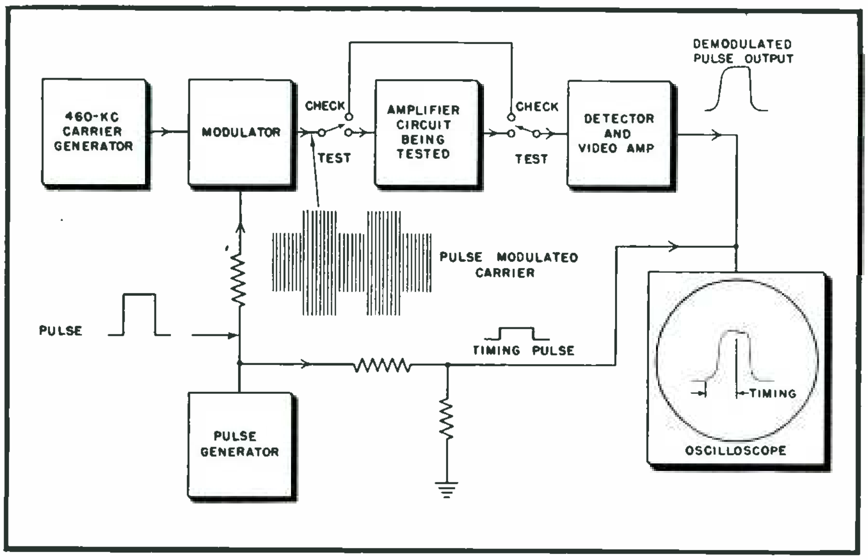

FIG. 1—Block diagram of the test equipment used in determining the response of amplifiers to pulsed signals. The pulse generator also supplies timing markers to the oscilloscope

Table I—Comparison of Transmission of Square and Half-Sine Wave Pulses

Pulse Length μsec	Pulse Width (percent) Square Pulse	Pulse Width (percent) Sine-wave Pulse	Respons Characteristic (see text)
1,300	122	108	A
600	140	121	A
680	116	96	C
260	134	117	C
220	147	132	D

Table II—Comparison of On-Tune and Off-Tune Transmission

Pulse Length (μsec)	On-Tune Rounding (percent)	On-Tune Width (percent)	Off-Tune Rounding (percent)	Off-Tune Width (percent)	Off-Tune Amplitude (percent)	Off-Tune Deviation (kc)	Off-Tune Response (percent)
Transmission Characteristic A, Fig. 3							
1,300	13	122	11	120	92	+0.81	89
1,300	13	122	7	119	60	+1.71	60
1,300	13	122	4	118	24	+2.80	33
Transmission Characteristic C, Fig. 3							
260	39	134	35	133	87	+1.91	99
260	39	134	20	134	62	+3.71	78
680	10	116	11	117	100	−1.72	101
680	10	116	5	120	55	−4.79	48

Note: Amplitude is the amplitude of output pulse compared to amplitude when on tune
Deviation is the displacement of carrier from center of pass band
Response is the steady state sine-wave response of amplifier at stated deviation

The subject of pulse transmission has been rather thoroughly treated in the literature from an analytical standpoint, but the observational and experimental aspects have not received as wide attention. This paper gives the findings of an experimental investigation made to determine bandwidth requirements for the transmission of rectangular pulses through a communication channel.

The work was motivated by a need to determine the relative advantages of single-tuned versus double-tuned coupling circuits in amplifiers used for pulse transmission.

With new uncrowded regions of the spectrum available for wideband transmissions it becomes desirable to investigate the use of amplifiers employing relatively unselective, but simple, single-tuned coupling circuits. If they can be used in place of the double-tuned type without too much loss in gain for equal pulse transmission, a considerable advantage in simplicity of manufacture, alignment and servicing of wideband amplifiers will accrue.

Experimental Procedure

Analytical demonstration can be made of the validity of frequency scaling in the study of pulse transmission. This fact was utilized, making possible the experimental use of a narrow-band, low-frequency amplifier whose band-pass characteristics were easily controlled. This test procedure permitted the use of long pulses whose shape and length could be determined accurately.

A block diagram of the test setup is shown in Fig. 1. The circuits to be tested are incorporated in an amplifier with their pass bands centering about 460 kc. A 460-kc signal, pulse modulated, is applied to the amplifier, the output of which is demodulated and observed on a wide-band oscil-

in Amplifiers

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loscope. The pulse modulating voltage is mixed with the output of the amplifier to provide accurate timing marks on the oscilloscope pattern. The patterns for each test condition have been standardized in size and photographed for subsequent analysis.

The apparatus is capable of passing a pulse less than one-half the length of the shortest used in taking the test data, without a measurable deviation from squareness in the oscilloscope pattern.

Before outlining the measuring technique, two terms used in specifying pulse shapes will be defined. Figure 2 shows a typical output pulse shape. The terms defined in the figure are percent rounding and percent width. Percent rounding is the percentage of the time duration of the input pulse required for the output pulse to reach 90 percent of its final amplitude. Percent width is the percentage of time duration of the input pulse required for the output pulse to go from 10 percent of its final amplitude, through 100 percent and back down to 10 percent.

The pulse-modulated signal is applied to the amplifier under test. Pulse length is then adjusted to give an output pulse having a specified amount of rounding. After adjusting the oscilloscope pattern size to a standard value, the figure is photographed. A series of such data has been taken for each circuit tested, with several values of pulse length to give various degrees of rounding of the output pulse.

Experimental Results

Pulse transmission was measured on four amplifiers having band-pass characteristics as shown in Fig. 3. The term response as used here is the steady state response of the circuit to an impressed sine wave of voltage. It should not be confused with the circuit's response to pulses.

Data was taken for pulse lengths varying increasingly from that length which just produced a perceptible decrease in the output pulse amplitude. That is, the pulse lengths were always sufficiently long to permit the output pulse to build up to its flat top portion.

Figure 4 summarizes pulse rounding data taken on the four amplifier circuits whose band-pass characteristics are shown in Fig. 3. Quadratic equations were fitted to the observed data to a precision of better than 5 percent. These equations are tabulated below.

Transmission characteristic A
$$L = 1{,}807 - 45.7R + 0.36R^2 \quad (1)$$

Transmission characteristic B
$$L = 1{,}521 - 41.0R + 0.32R^2 \quad (2)$$

Transmission characteristic C
$$L = 909 - 23.7R + 0.18R^2 \quad (3)$$

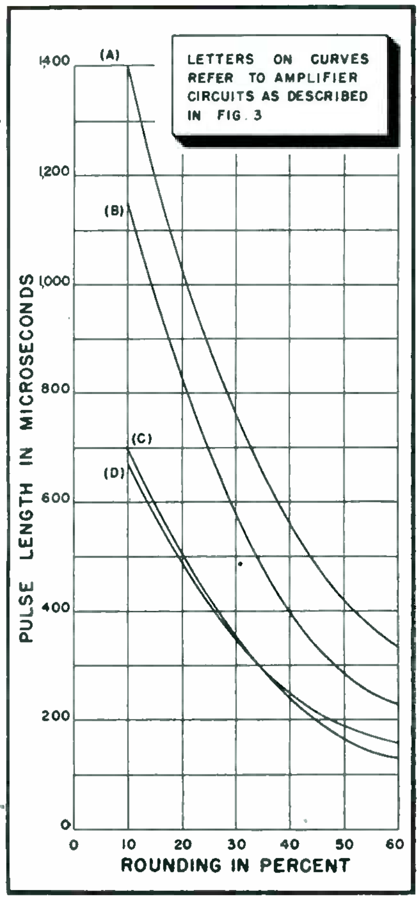


FIG. 4—As a circuit rounds the output shape of a square-wave input pulse, the length of the pulse must be increased or else the output amplitude will decrease

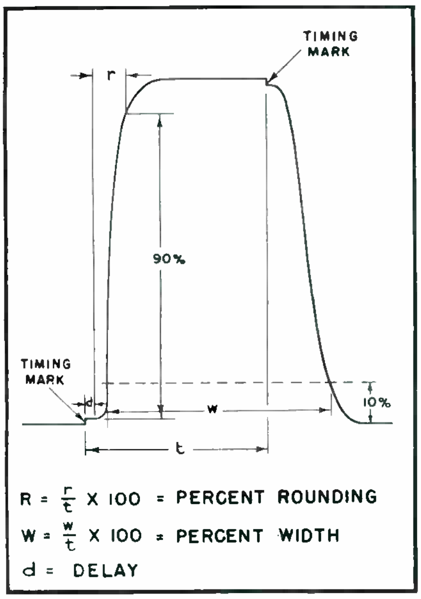


FIG. 2—Typical output pulse with the percent rounding and percent width defined. The delay between the timing mark and the initiation of the output pulse occurs in the amplifier and other circuits

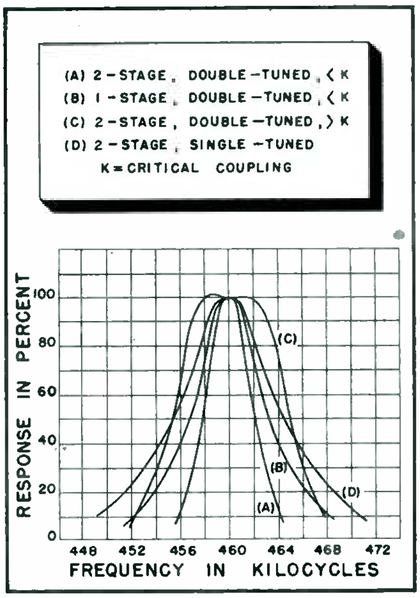


FIG. 3—Response characteristics of several amplifiers for steady-state or sine-wave amplification. The response to pulses is described in the text

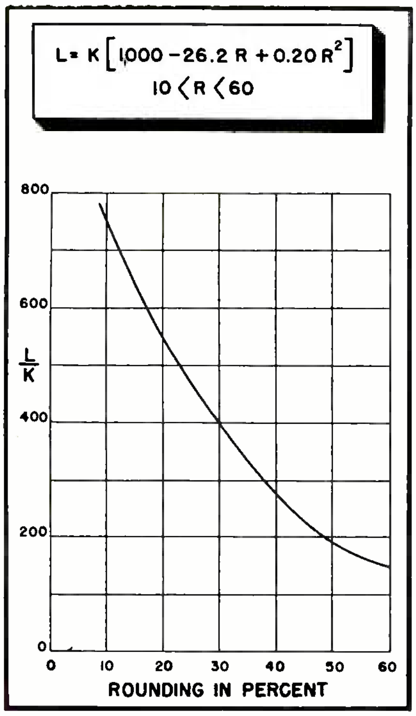


FIG. 5—Graphical representation of Eq. 5 showing percent rounding in relation to the quotient of pulse length divided by circuit response to sine waves

Transmission characteristic D

$$L = 897 - 23.6R + 0.19R^2 \quad (4)$$

The above equations are identical in form, differing only by a multiplying factor. The group can be specified by the following characteristic equation

$$L = K(1{,}000 - 26.2R + 0.20R^2) \quad (5)$$

where, L is length of pulse in microseconds; R is percent rounding; and K is a factor representing a function of the steady state response characteristic of the circuit. Equation 5 is plotted in Fig. 5. Equations 1 to 5 are valid for values of R in the range 10 to 60 percent.

Rounded Pulse Transmission

In some applications the widening of a pulse in transmission through a channel is of more interest than the time of rise; particularly is this true if clipping removes the rounded top of the pulse. It was expected that pulse width would bear a more or less simple relation to pulse rounding and the curves plotted in Fig. 6 show this to be true. Adjusting all the data to a common linear trend line, the following equation is arrived at

$$W = 109 + 0.75R \quad (6)$$

where W is percent width, and R is percent rounding. Or, the pulse width is increased by approximately the percent rounding.

Frequently in practice we have to deal with only nominally square pulses. It is therefore of interest to know how much bandwidth requirements may be relaxed if the system is not to be required to handle perfectly square pulses. A series of measurements was made with a half-wave, rectified sine wave input pulse as representing a typical rounded pulse. Table I summarizes the results of these measurements.

Off-tune operation is frequently encountered in practice due to time and temperature drift or to faulty tuning adjustment. Pulse transmission through amplifiers having characteristics A and C was investigated for several degrees of detuning and a comparison made with corresponding on-tune operation. Table II summarizes the results of these measurements.

Discussion of Experimental Findings

The derivation of Eq. 5 shows the length of pulse which can be transmitted with a specified amount of rounding through a circuit follows the same law of variation for both single- and double-tuned stages when the bandwidth is varied. This permits prediction of the effect of changes in the bandwidth of a circuit upon output pulse shape, after drawing a family of such curves for various values of K. If circuits of the same configuration and the same pass-band shape are being compared, direct scaling may be employed after K has been determined for a single bandwidth.

As an illustration of the use of Eq. 5, a computation was made to show the cost of improving the output pulse shape by progressive increases in bandwidth of a single-tuned amplifier, all the time maintaining a constant gain by increasing the number of stages. The gain, G, of a multistage, single-tuned amplifier, all stages of which are alike, is given by

$$G = \left[\frac{G_m}{\Delta\omega C}\right]^n \left[\frac{1}{P^{2/n}} - 1\right]^{n/2} \quad (7)$$

where

G_m = transconductance of amplifier tubes
P = percent response at which overall band width is measured, expressed as a decimal
C = total circuit capacitance per stage
n = number of identical stages
$\Delta\omega$ = 2π times band width at point P

For the purposes of computation the following assumptions were made:

G = 56,400
G_m = 10,000 μmhos
C = 20 μμf
P = 0.5
$\Delta\omega = 10^7$ when rounding is 60 percent

The first computation made for $\Delta\omega = 10^7$, with an output pulse rounding of 60 percent, shows 3 stages to be required in the amplifier. Reference to Fig. 5 shows L/K is equal to 145 for 60 percent rounding. To compute the bandwidth required for, say, 30 percent rounding we note that L/K equals 396, giving the new bandwidth requirement of $\Delta\omega_{30} = 396/145\ \Delta\omega_{60} = 2.73 \times 10^7$. The value of n for 30 percent rounding may now be determined from Eq. 7. Figure 7, curve I, shows the complete data for the range of 10 to 60 percent rounding for the conditions assumed.

Curve II in Fig. 7 shows how the overall gain of a 5-stage amplifier of the above characteristics varies as its bandwidth is adjusted to yield output pulses with varying degrees of rounding. The data is plotted as loss of gain compared to the gain at a bandwidth giving 60 percent pulse rounding.

The data presented in Fig. 7 show

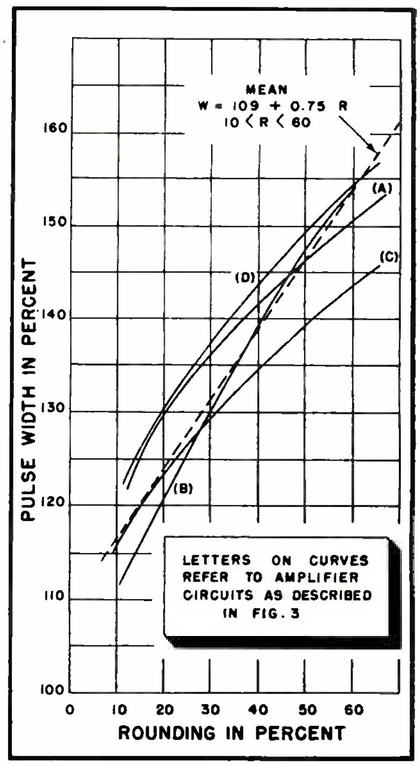


FIG. 6—Output pulse percent width as a function of percent rounding

that relatively perfect transmission of square pulses comes at a high price, and indicates that very good economic reasons must be advanced to justify pulse transmission of a better quality than that which will give 30 to 40 percent rounding.

The data given in Table I show that a square-wave pulse is increased in width more than a sine-wave pulse of the same length, when passed through the same amplifier, the average difference being 17 percent in these data. For the case of the amplifier whose gain was computed in the example above, this would mean a saving of one stage if 50 percent rounding were permissible, see Fig. 7, curve I; or, referring to Fig. 5, a pulse 47 percent shorter in duration could be transmitted if the input pulse were one-half sine wave instead of square wave in form.

An examination of Table II reveals that off-tune operation has several effects: the time of rise is decreased, pulse amplitude is decreased, and pulse width changes very little if at all.

Comparison of Single-Tuned and Double-tuned Coupling Circuits

To examine the relative merits of single-tuned and double-tuned coupling circuits from the standpoint of pulse transmission, it is first necessary to determine at what common response point the bandwidths of the respective circuits should be measured. That the comparison is markedly influenced by the choice of this point will be evident from data

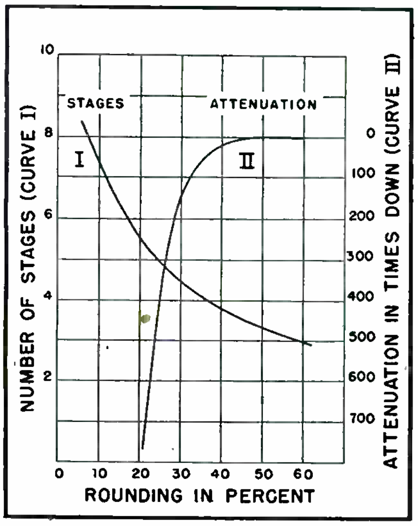


FIG. 7—Curves showing the number of stages needed and attenuation as a function of percent rounding for single-tuned amplifiers

to be given later. In setting up the circuit having response characteristic D, Fig. 3, the bandwidth was so chosen that the pulse transmission through this circuit was identical to that through the circuit having response characteristic C. Figure 4, curves D and C, will show the similarity in performance of these two circuits.

First, considering the problem qualitatively, transmission through a circuit would be expected to vary in some manner related to the area under its frequency response characteristic. It would also be expected that of two response characteristics of equal area, if one had very wide flaring skirts, and the other steep skirts, better pulse transmission would be obtained with the latter. This is because an appreciable portion of the characteristic having flaring skirts is at frequency locations remote from the center of the band. The areas under the four response characteristics in Fig. 3 were determined as listed in Table III.

The manner in which the pulse length that may be transmitted varies with the area under the response curve of the circuit is then shown in Fig. 8, with percent rounding as a parameter. These curves show the area under the response characteristic of a circuit is important in determining its pulse transmission capabilities. However, the discontinuities present in the curves indicate the shape of the transmission characteristic is also of importance. Comparing the data for transmission characteristics A and B in Fig. 8, a certain rate of improvement in going from A to B is noticed. Now, comparing the performance with characteristics B and C, a much greater rate of improvement is found. Last, comparing data on characteristics C and D, a lower rate of improvement or actual deterioration is obtained. Thus, going from a circuit having a response shape with narrow skirts to one with flaring skirts, but greater area, much less improvement in pulse transmission is effected than in making a proportional change of area from flaring skirts to narrow skirts. It is evident the transmission shape exerts an appreciable influence upon the ability of a circuit to transmit square pulses.

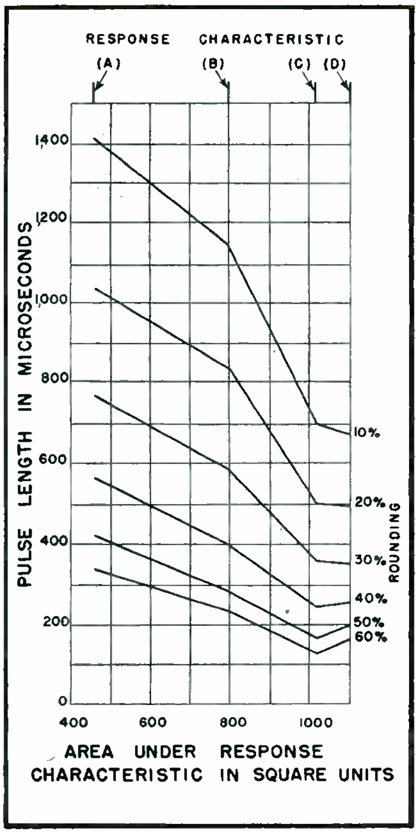


FIG. 8—Minimum pulse length expressed in terms of the area under response characteristic for several amplifiers at different percent rounding

Table III shows transmission characteristics C and D to have substantially equal areas, and curves C and D in Fig. 4 show these two circuits to have practically identical pulse transmission characteristics. Therefore, we may obtain from these two transmission characteristics a common crossover point for which a bandwidth specification may be stated. In this case, crossovers occur at 42 percent and 50 percent on either side of center in Fig. 3. That is, both amplifiers have identical response at 455.3 kc (50 percent) and at 465.5 kc (42 percent). Then, on the average, the comparison point may be said to be at approximately 46 percent response.

More of the experimental data may be used in the determination of the comparison point between single-tuned and double-tuned circuits if another method is employed. Progressing through characteristics A, B, and D, in the order listed, the pass band becomes progressively wider and the skirts flare in increasing degree, as shown in Fig. 3. These three characteristics are, broadly speaking, similar, differing mostly as to bandwidth. Bandwidth, as measured from these characteristics, is plotted against pulse length, with the percent response at which the bandwidth is measured as a parameter, in Fig. 9. The smooth curves connecting these points for a given percent response are extrapolated to the region where data from response characteristic C would fall. Now, the extrapolated curve most nearly passing through an observed point for characteristic C would indicate at what percent response the single- and double-tuned circuits should be compared. This response point turns out to be 55 percent, as compared with the 46 percent determined by the method above.

The above determination of the response point at which comparisons of single-tuned and double-tuned circuits should be made was derived on the basis of a 1- or 2-stage amplifier. In practice, an amplifier will frequently have a greater number of stages. Consequently the overall response characteristics will have steeper skirts as the number of stages is increased, and it would be expected that the basis of comparison for the two types of circuits would vary somewhat with the number of stages in the amplifier. Accordingly, transmission characteristics C and D were raised to the fourth power to give the equivalent frequency response of an 8-stage amplifier, with the results shown by the solid curves in Fig. 10. The area under the D^4 curve was then increased to be equal to that under the C^4 characteristic, see dotted curve, making the two characteristics approximately equally efficient for transmitting square pulses. For this moderate shift the previous data permits a comparison on the basis of equal areas. This assumption will not be rigorously justified, but it is believed in the present case the small amount of extrapolation necessary does not unduly reduce the accuracy of the results. After this adjustment, the average crossover point is at 40 percent response. Comparing this with the 55 percent crossover point for two stages it is seen that increasing the number of stages in an amplifier decreases the value of the response point on the frequency characteristic at which a comparison of single-tuned and double-tuned circuits should be made. The above calculations may be generalized by saying that in the average multistage amplifier the pulse transmission capabilities of an over-coupled and double-tuned amplifier and of a single-tuned amplifier will be identical if their steady state frequency response characteristics have the same bandwidth at approximately the 45 percent response point.

An analytical expression comparing single-tuned and double-tuned, over-coupled circuits would be too cumbersome for practical use. Therefore, a comparison will be made on a computed experimental basis. Computations have been made for single-tuned and double-tuned circuits typical of those likely to be encountered in wide band i-f amplifiers. The following characteristics were assumed:

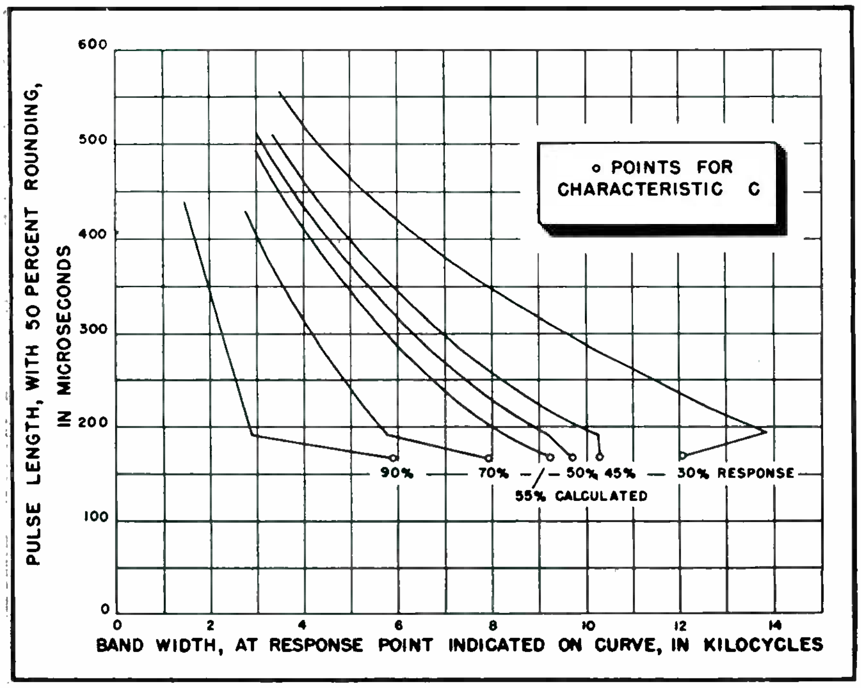


FIG. 9—Permissible pulse length as a function of bandwidth

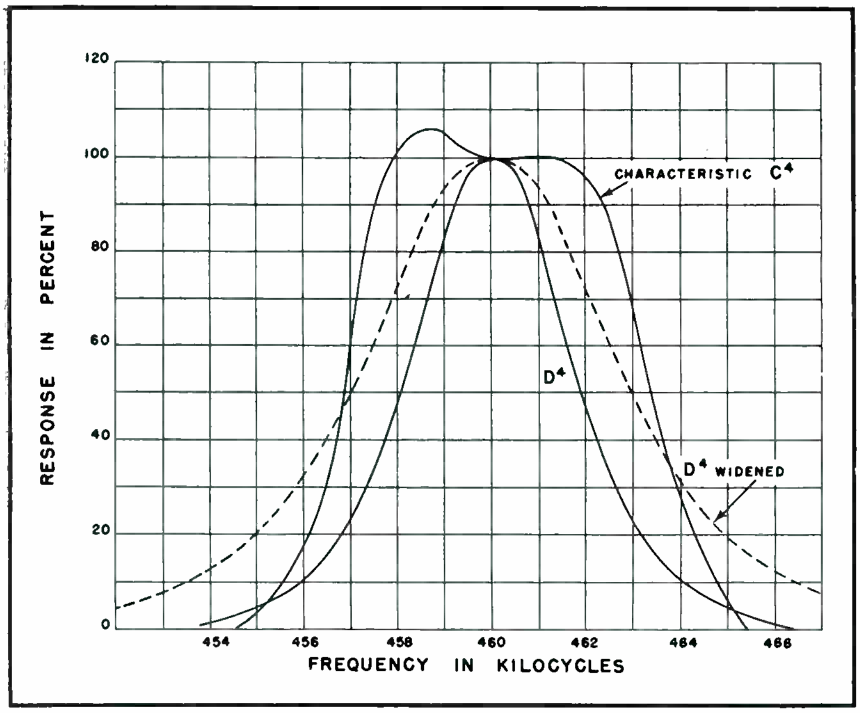


FIG. 10—Transmission characteristics of an 8-stage amplifier

Table III—Areas Under Response Characteristics

Response Characteristic (see text)	Area (square units)
A	460
B	800
C	1,020
D	1,090

Table IV—Comparative Center-Frequency Gains of Single and Doubled-Tuned Circuits

Coupling, Double-Tuned Circuits	Gain Per Stage 1-Stage		5-Stage		10-Stage	
	Single	Double	Single	Double	Single	Double
Critical..................	66	61	20	34	14	28
Overcoupled, 2 percent dip..	66	70	20	42	14	36
Overcoupled, 8 percent dip..	66	82	20	54	14	48

f_o = 30 mc

Capacitance = 22 $\mu\mu$f total for single-tuned amplifier

= 12 $\mu\mu$f per circuit for double-tuned amplifier

G_m = 9,000 μmhos

Stages = 1, 5, 10

Response at which bandwidth is measured = 45 percent

Primary and secondary circuits identical in double-tuned amplifier

Couplings = critical, over-coupled 2 percent dip at center, over-coupled 8 percent dip at center

Pulse rounding = 50 percent

Pulse length = 1 μsec

Bandwidth Requirements

Referring to Fig. 3 and 4, curves D, it is seen the bandwidth required to transmit a 1-μsec pulse is 0.0103 x 190 = 1.96 mc. That is, a single-tuned circuit, or an equivalent double-tuned circuit, 10.3 kc wide at 45 percent response will transmit a pulse 190 μsec long with 50 percent rounding. Therefore, 190 times this bandwidth is required to transmit a 1-μsec pulse. This is the overall bandwidth required regardless of the number of stages. Thus, each stage of a 10-stage amplifier would be 1.96 mc wide not at 45 percent response, but at $0.45^{0.1}$ which equals 92.3 percent response. Table IV summarizes the results of these computations.

These data show that for a single-stage amplifier there is very little choice between the single- and double-tuned type of coupling circuits. However, as the number of stages is increased the double-tuned circuit shows an increasing advantage in gain over the single-tuned circuit. Whether the increased complexity of double-tuned circuit elements is offset by the increased gain available can only be decided by a knowledge of the circumstances surrounding a given application.

As a matter of interest, Fig. 11 shows a series of curves giving bandwidth requirements for transmitting pulses varying in length between 0.1 and 7 μsec with three different degrees of rounding. Bandwidth is specified at the 45 percent response point.

Summary

Pulse transmission through several types of single- and double-tuned amplifiers is investigated experimentally. The length of pulse that can be transmitted through a circuit with a given percent rounding, R, is found to be given by: $L = K (1{,}000 - 26.2R + 0.20R^2)$, where K is a function of the transmission characteristic of the circuit. Increase in width of a pulse is found to be approximately equal to the amount of rounding. Amplifier design requirements are found to be appreciably eased if pulse input is of the form of a half sine wave. Off-tune operation is found to result in a decreased rise time and a decreased output pulse amplitude. It is shown that bandwidths of single and double-tuned circuits should be compared at approximately the 45 percent response points in determining their pulse transmission capabilities. In a multistage amplifier, double-tuned coupling circuits are shown to offer appreciable advantages from the standpoint of gain.

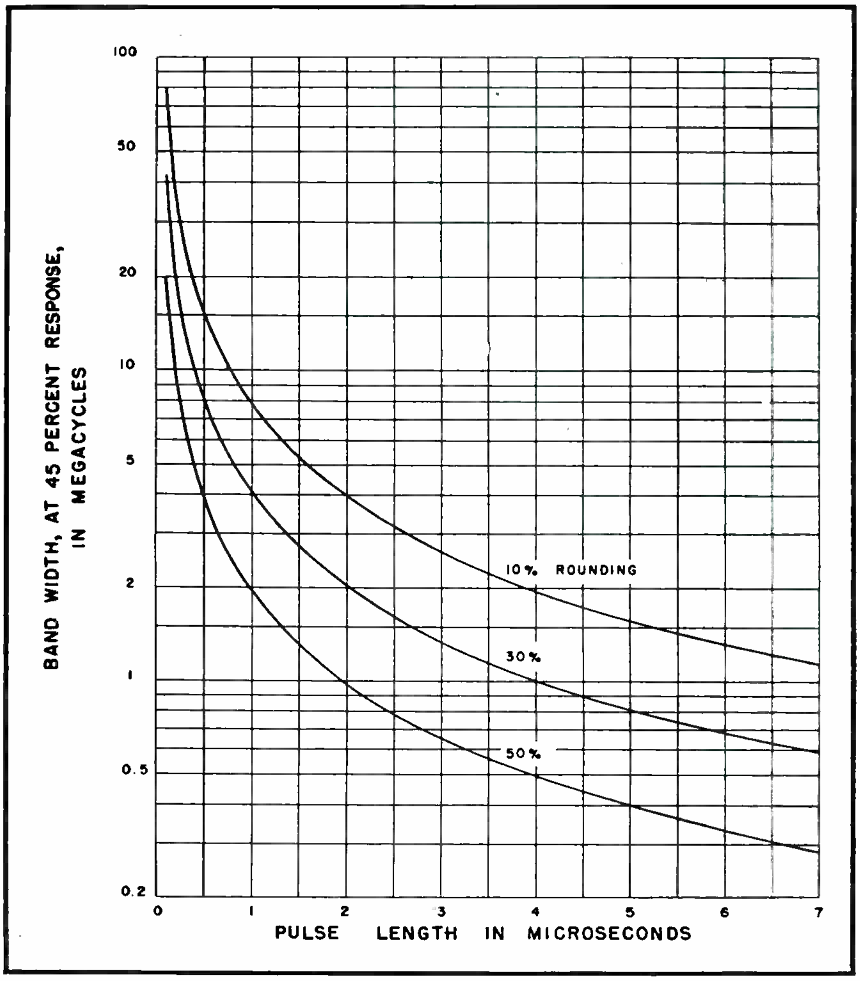
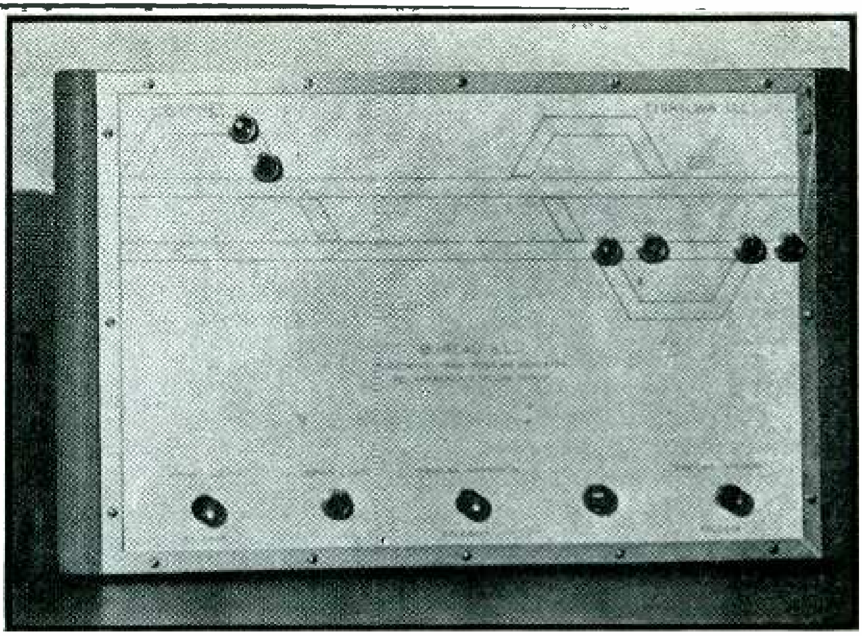


FIG. 11—Bandwidth required as a function of pulse length for three different percent rounding



Train position-indicator panel used in the dispatcher's office. The signal lamps operate when trains arrive at and leave the six points shown. Recording pens, not illustrated, keep permanent records

Train Position Indicator

By ERNEST A. DAHL

Electronic Engineer
Chicago, Rock Island & Pacific Railway Co.
Chicago, Illinois

ELECTRONICS, the key to high-speed control, positive-acting relay circuits, high sensitivity, and minimum loss in bridging circuits, has proven its usefulness in the industrial field. We decided to set up an automatic system to utilize these advantages in indicating to a dispatcher the positions of one or more trains as they progressed down the right of way.

Ideally, such a system would operate over any existing communication facilities — telephone, telegraph-carrier wires, or radio channels. It would present both temporary and permanent records to the train-control man 5 to 500 miles away. It would be impervious to static and false indications, and there would be some method by which the signal could be held until the dispatcher had acknowledged it.

Early in 1944 the design of such a system was started. An installation made in January 1945 fulfilled all the above-mentioned requirements. The following text describes this installation at Bureau, Illinois, and a block diagram is shown in Fig. 1. The installation of a more extensive system from McFarland to Belleville, Kansas, is now underway. Signals will be transmitted to a dispatcher at Kansas City, some 150 miles away.

Principle of Operation

A small audio-frequency oscillator is placed at a remote point. The oscillator is tuned to a frequency thereafter identified with that point. When a train passes, a keying unit places the oscillator in operation. This signal goes through an isolation unit and is then carried over wayside wires to the control or dispatcher's office.

At the office the signal is passed through another isolation unit and a selective filter system. It is then amplified and applied to a tube which limits the amplitude of signals and static, including miscellaneous d-c pulses and lighting. The signal is rectified and the resulting triggering voltage is then fed through a time-delay circuit to a thyratron circuit controlling a relay which operates a signal light and a pen recorder. The on-pulse of the signal indicates that the train has arrived at a certain station. When the train leaves the station, the signal stops, removing the voltage from the output of the limiter circuit at the office. This operation removes the bias voltage from an amplifier, allowing a second relay to pull in and operate another signal light to show that the train has departed from this point.

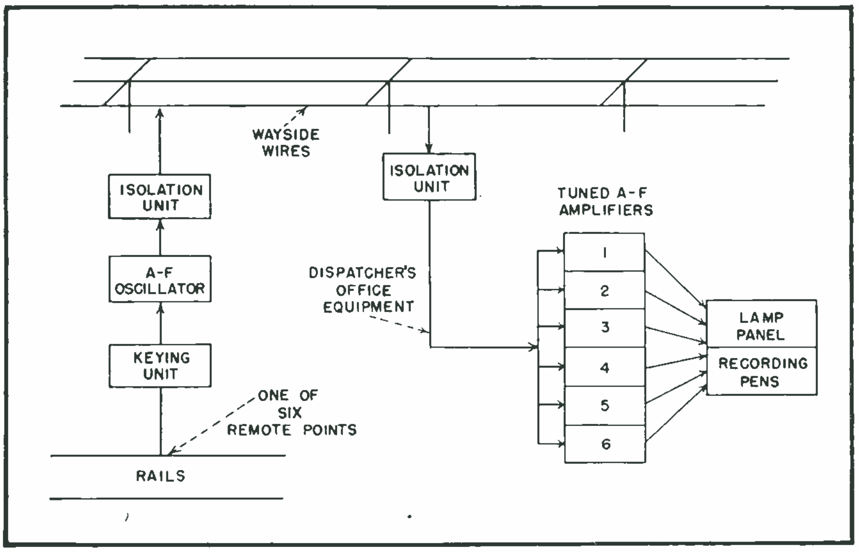
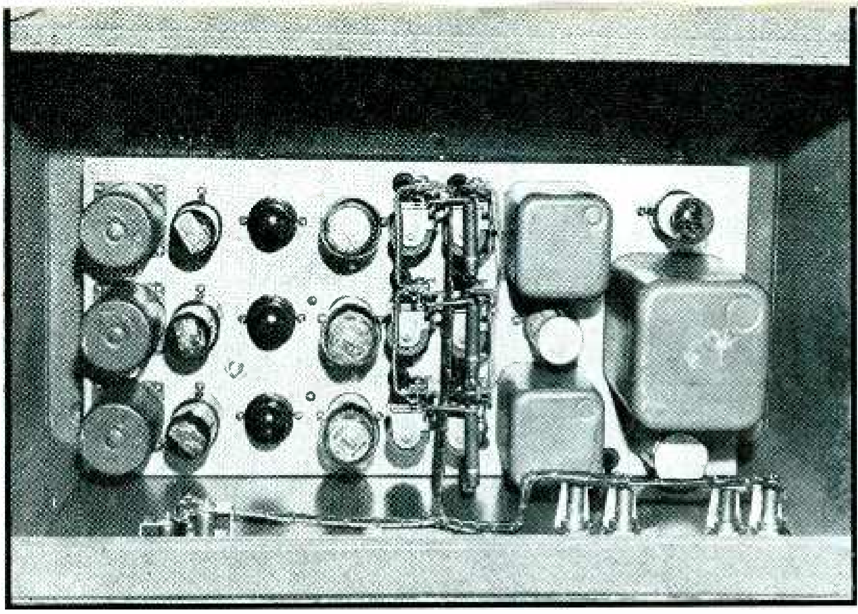


FIG. 1—Block diagram of the overall train-position indicator system installed in the vicinity of Bureau, Illinois

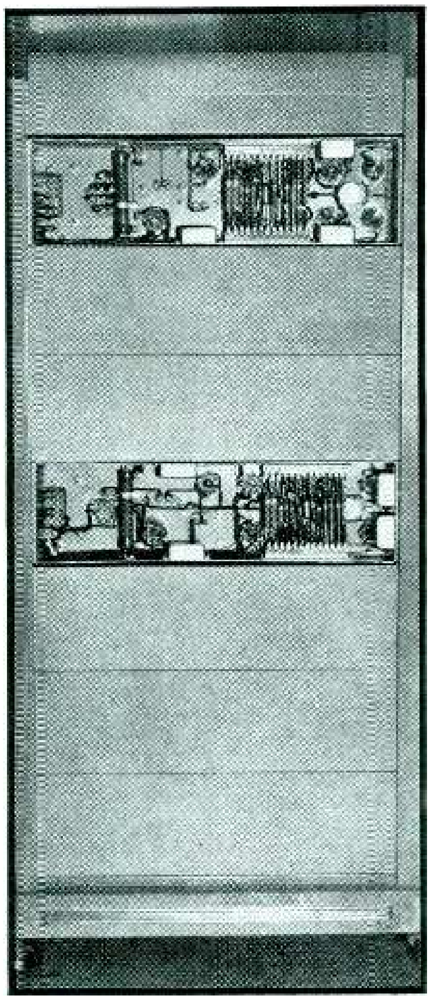
Oscillator Unit

The multivibrator-type audio oscillator used for the generation of the sine-wave signal placed on the line employs a voltage-regulating transformer as both a regulating device and an isolating transformer. The tubes used, shown in Fig. 2, are 117LM7's. Filaments are supplied directly from the 117-volt line. Plate voltage is supplied by the regulating transformer.



Interior of an early three-channel unit, one of two such units used by a dispatcher at Bureau, Illinois. The circuit for one of the channels is shown in Fig. 1

Semi-portable rack containing plug-in units, typical of those which will henceforward be installed in dispatchers' offices



Audio signals having frequencies identified with fixed points along the rail lines are transmitted over wayside wires to a distant dispatcher. They pass through selective filters, amplifiers, trigger tubes and relays to signal lamps and pens which indicate and record time of arrival and departure

Initial measurements proved this oscillator capable of power outputs of plus 15 db, with a hum component 40 db below zero level. The unit operated satisfactorily on line voltage changes from 92 to 130 volts.

Dispatcher Units

The original dispatcher unit starts out with a bridging filter tuned to the signal frequency, as shown in Fig. 3. Input voltage is amplified by one section of a 6SN7. The output of this amplifier is rectified and applied to a time-delay network and an 884 thyratron. The negative voltage from the rectifier is applied to the second section of the 6SN7 tube, operated as a d-c amplifier.

Relays are so wired that when a signal of the proper frequency comes in the thyratron fires, closing relay *A* and operating a signal lamp and pen which indicate and record arrival of a train at the remote point. Operation of relay *A* also applies plate voltage to the d-c amplifier triode. The bias set up by the incoming signal applied to the d-c amplifier grid allows no current to flow through the d-c amplifier, however, and therefore relay *B* remains open. When the signal stops, indicating that the train has left the station, the bias on the d-c amplifier disappears and relay *B* closes. Operation of the signal light and pen shows that the train has left the remote point. Since this unit might operate at times when the dispatcher is preoccupied, signals are held until acknowledged. The thyratron is brought back to normal by pressing a momentary switch and removing the plate voltage.

The schematic of an improved dispatcher unit starts off with an input filter, as shown in Fig. 4. This filter is matched to the 500-ohm telephone line through a transformer (not shown).

The output of the filter is amplified

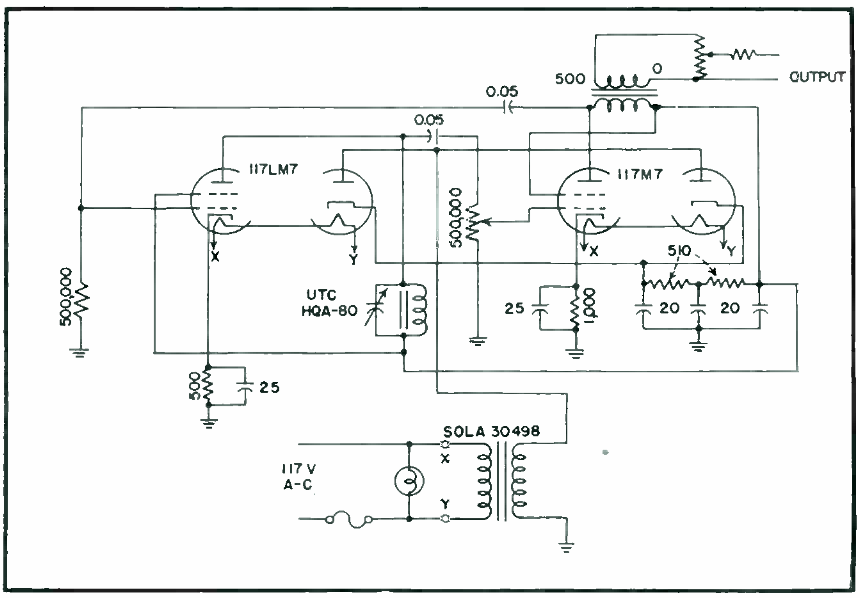


FIG. 2—Multivibrator-type audio oscillator circuit. One of these oscillators is used at each remote point

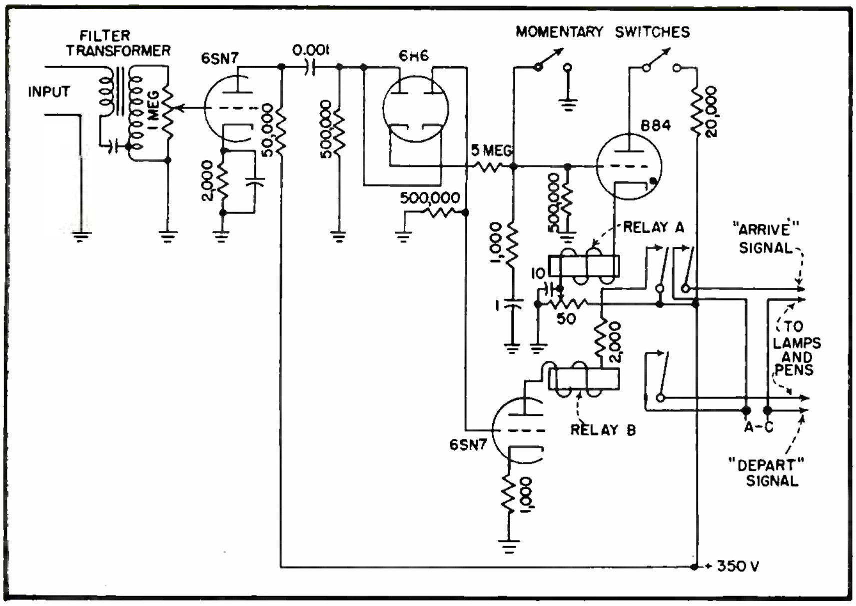


FIG. 3—The original indicating unit, showing just one of three identical channels

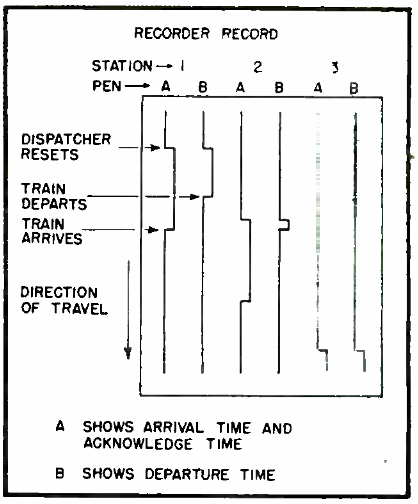


FIG. 5—Typical record of what is indicated by recording pens

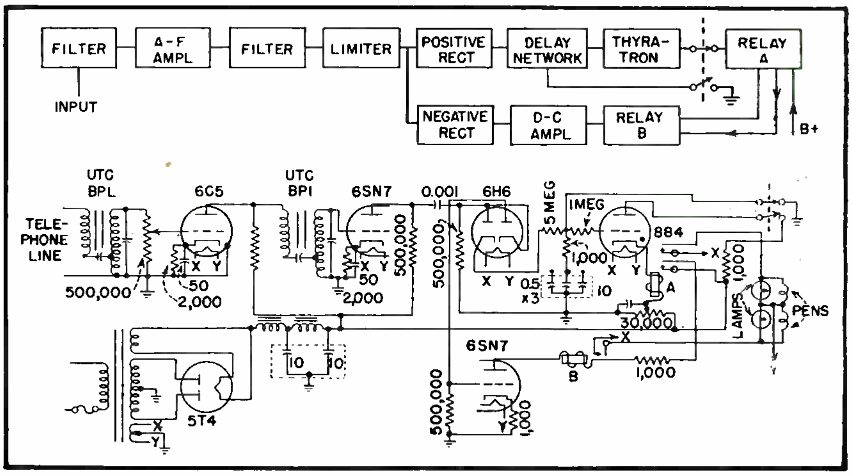


FIG. 4—The improved indicating unit, designed for increased selectivity and sensitivity

by a 6C5 class A amplifier. The output of the 6C5 is fed to a second filter, which gives increased discrimination, and to a second amplifier-limiter stage consisting of one section of a 6SN7. If the incoming signal is above a minus 20 db this stage operates on the saturation part of the curve, providing limiter action. Output voltage is then fed to a 6H6 rectifier stage and the positive half of the wave is applied to a time-delay network. The resulting voltage is applied to the grid of an 884 thyratron.

When the incoming signal fires the thyratron, plate voltage is applied to the d-c amplifier section of the 6SN7. The input signal, having been rectified by the negative rectifier, is also applied to this tube as bias. Since signals indicating train arrival and departure remain on until such time as the thyratron is brought back to normal, no relay hold-in circuits or interlock circuits are necessary. At such time as the thyratron stage is reset, both circuits are again ready for normal operation.

In the final model, the time-delay capacitor installed was a three-section block, so that additional time could be added or subtracted by changing jumper wires. This eliminates the need of major modifications in the field.

A typical record of what the dispatcher sees when the system is in operation is shown in Fig. 5.

A later, plug-in unit. Use of such units permits rapid adaptation of the system to accommodate more remote signaliling points, and facilitates servicing

Triggering

Various systems were used for triggering the oscillator to put the tone on the line as the train passed the wayside station. One satisfactory system employed a variable-Q transformer. Two r-f coils were buried in each side of the track, with a transmitter feeding one and a receiver taking the signal from the other. As a locomotive passed between these two coils, the Q of the transformer changed, the receiver signal dropped and a relay in the detector stage closed, placing the tone of the audio oscillator on the line. These units eliminated special track circuits. At other locations, conventional signal relays and warning bell relays have been utilized to close the circuit.

Grid-Controlled Rectifiers for R-F Heating

Output of vacuum-tube oscillators for industrial heating can be varied continuously by controlling the plate voltage. For output ratings from 5 kw to 100 kw, thyratron rectifiers have many advantages over power transformer primary control devices

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USERS of vacuum-tube oscillators for industrial heating will readily appreciate the added convenience and flexibility of having a smooth, continuously variable control of power output. Power control permits adjustment of the oscillator to different and varying loads in either induction or dielectric heating, provides precise synchronizing of heating rate and timing, and speeds up adjustment of new loads with unknown characteristics.

Nearly all industrial vacuum-tube oscillators are supplied with high-voltage direct current from rectifiers. Control of the rectifier voltage offers a convenient means of controlling the power output of the oscillator. One practical method of control is the variation of the primary voltage input to the rectifier transformer. Another is the use of controlled thyratron tubes in the rectifier itself. Both methods have their own best fields of application.

Control of Primary Voltage

Primary voltage variation may be achieved by using either variable-ratio autotransformers or induction regulators. These devices are most satisfactory for manual control of low-powered equipment (5 kw output or less). At higher power levels they become bulky and expensive. Thyratron rectifiers, on the other hand, are at a cost disadvantage for generators up to about 5 kw output because of the higher tube cost and the auxiliary equipment required. For power output ratings from 5 kw to 100 kw the thyratron rectifier offers a saving in space and cost over transformer primary control devices and at the same time has the added advantage of adaptability to automatic process control and rapid on-off cycling.

To study the principles of operation for a thyratron power rectifier, consider first the simple single-phase, half-wave case shown in Fig. 1. A typical high-voltage thyratron will ionize and conduct current during the positive half of the a-c cycle obtained from the plate transformer so long as the grid is biased to a value less negative than that shown on the certain-conduction critical grid voltage curve in Fig. 2. This operation is the same as for a diode-type gaseous rectifier. In fact, by removing the bias entirely and connecting the grid directly to the cathode, the tube may be used as a diode. If the bias is made more negative than the no-conduction critical value, the tube will not conduct at all.

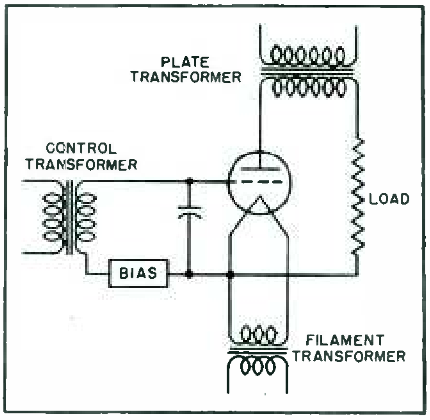


FIG. 1—Basic circuit of single-phase half-wave thyratron rectifier

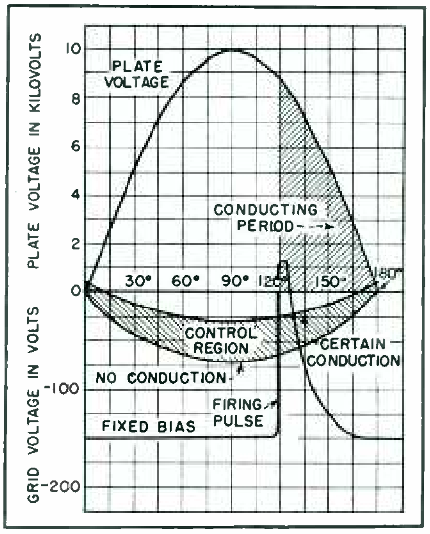
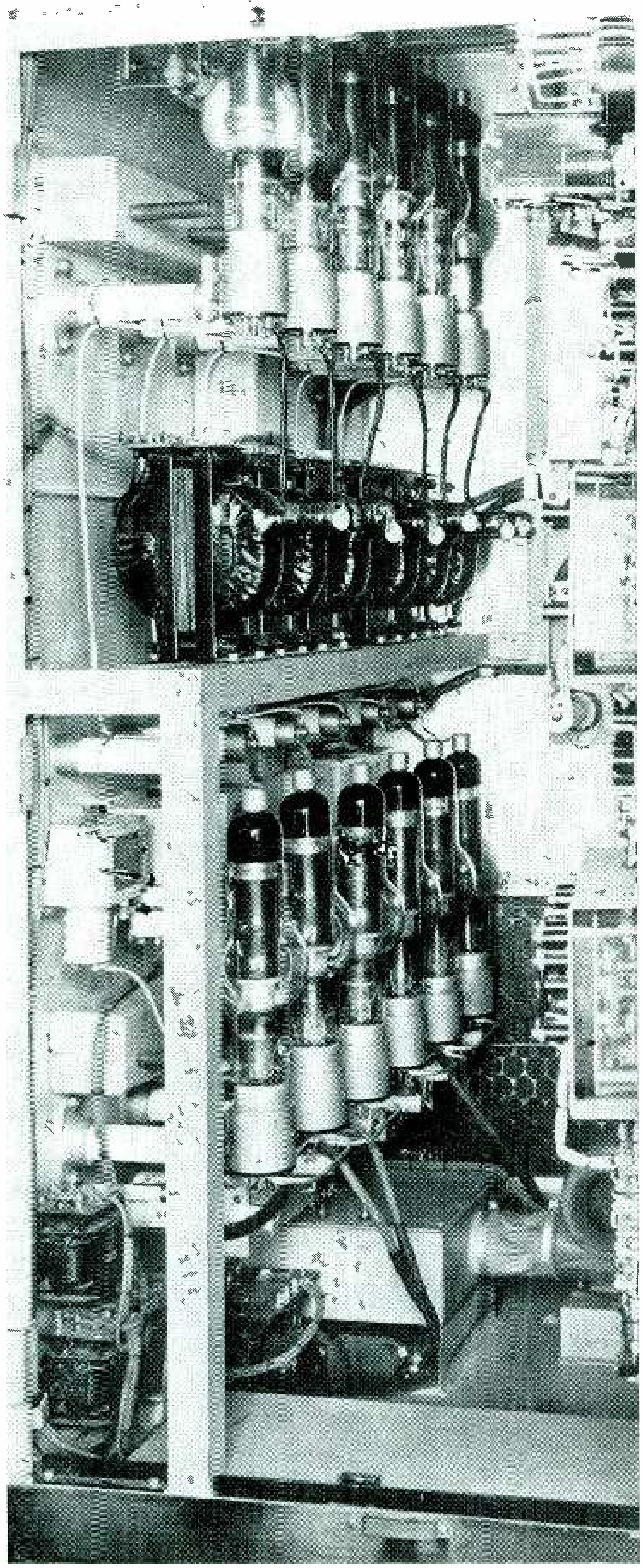


FIG. 2—Operating curves for a typical thyratron

By making the bias sufficiently negative to prevent conduction and then momentarily lowering the bias below the critical value, conduction may be started at any time during the positive half-cycle of plate voltage. Once started, of course, conduction continues until the a-c plate voltage goes to zero. Because of this, a short pulse may be superimposed on the bias to initiate conduction. The phase of this pulse with respect to the plate voltage may be shifted to start conduction at any point in the positive half-cycle, giving full control of the average rectifier output voltage.

If the plate voltage is sinusoidal and the thyratron is fired at the beginning of the positive half-cycle, the average d-c voltage will be 0.318 of the peak a-c voltage as it is with a diode rectifier. When conduction starts at a point phased back 90



Dual thyratron rectifier bank used in 100-kw industrial r-f generator

degrees, the average output voltage will be half this value or 0.159 of the peak a-c voltage. The average voltage for any amount of phase back is given by the relation

$$E_{av} = E_{max}\left(\frac{1 + \cos\theta}{2\pi}\right)$$

where θ is the phase back angle measured from the start of the positive half-cycle of plate voltage to the point where conduction starts. This approximation neglects the short interval at the start and finish of each positive half-cycle when the voltage, though positive, is too low to cause ionization.

In most practical cases, although a short pulse added to the bias will give precise control and require a minimum of energy in the grid circuit, a sine wave of grid voltage may be used instead. Greater simplification may be obtained in this way. The grid circuit resistance must be kept high enough to limit grid current.

The simple half-wave case may be easily extended to full-wave and polyphase rectifiers. Phase shift of the grid voltage may be obtained in a variety of ways. A small wound-rotor motor makes an ideal manual phase shifter. Resistance-reactance networks may also be used. Substitution of a vacuum tube for one of the resistance elements of such a network permits automatic control by phototubes, thermocouples or similar heat indicators for process control. Keying the low-power grid voltage supply allows rapid cycling of the full power output for automatic repetitive operations.

Three-Phase Application

A typical application of the grid-controlled rectifier is shown in Fig. 3, a schematic diagram of a 10-kw r-f generator. A three-phase full-wave circuit is used in this rectifier to supply 9,500 volts at 2 amperes. Three type 872-A diodes are used in the negative position and three WL-678 tubes serve as controlled thyratrons in the positive position. Since the cathodes of the three thyratrons are all at the same potential, a single bias rectifier may be used. This rectifier is assembled on a small chassis insulated from the grounded metal frame. Power to operate the bias rectifier is supplied through an insulating transformer. Insulation between the high d-c voltage and the a-c grid voltage supply is also obtained through an insulating transformer. A small wound-rotor motor is used as a manual power control and gives a continuous adjustment of plate voltage from zero to maximum. A small relay may be connected between the phase shifter and the grid transformers for rapid on-off cycling. At this point in the circuit the relay contacts have to handle only 15 milliamperes at 115 volts.

Designers of thyratron rectifiers sometimes find themselves limited by voltage or current ratings of available tubes. This difficulty may often be overcome by the choice of a suitable circuit arrangement. By way of illustration, the rectifier pictured has an output rating of 15 kv at 18 amp for use with a 100-kw r-f generator. Type WL-41 tubes having an inverse and forward peak voltage of 10 kv are used. Operation well within ratings is secured by using two completely separate 7.5-kv rectifiers connected in series. Separate plate transformer secondaries, bias rectifiers, and grid transformers permit operation with one rectifier alone or with both in series. Phase-shifted grid voltages for both rectifier banks are controlled by a single manual phase shifter, thus assuring that both rectifiers will start together.

Advantages and Drawbacks

It is seldom that the advantages of any control system are secured without some compromises. In all fairness, therefore, mention should be made of the disadvantages of thyratron rectifiers. Aside from the fact that thyratron tubes are more expensive than phanotrons of comparable rating and that a bias supply and grid control voltage must be provided, the chief disadvantage is the waveform produced with phased-back operation. The shaded area in Fig. 2 shows the shape of the output voltage wave. This waveform is difficult to filter and, if not filtered, has a peak voltage output much higher than the average voltage. When the average voltage is reduced to one half its maximum value by phasing back 90 degrees, the peak voltage is still as high as the peak voltage at full output.

When the waveform effect can be tolerated, and it usually can be, a number of real advantages are available from the use of thyratron rectifiers for r-f heating oscillators. A continuously variable manual control from zero to full power output can be had with a single small knob either on the generator or at a remote control point. Rapid keying of full power on repetitive loads is easily accomplished with small relays or electronic devices. Automatic devices to maintain constant output or variable output as required for a particular heating process may be connected into the circuit. High-speed overload protection may be secured by operating on the thyratron grid control circuits. This flexibility is not offered by other systems of power control.

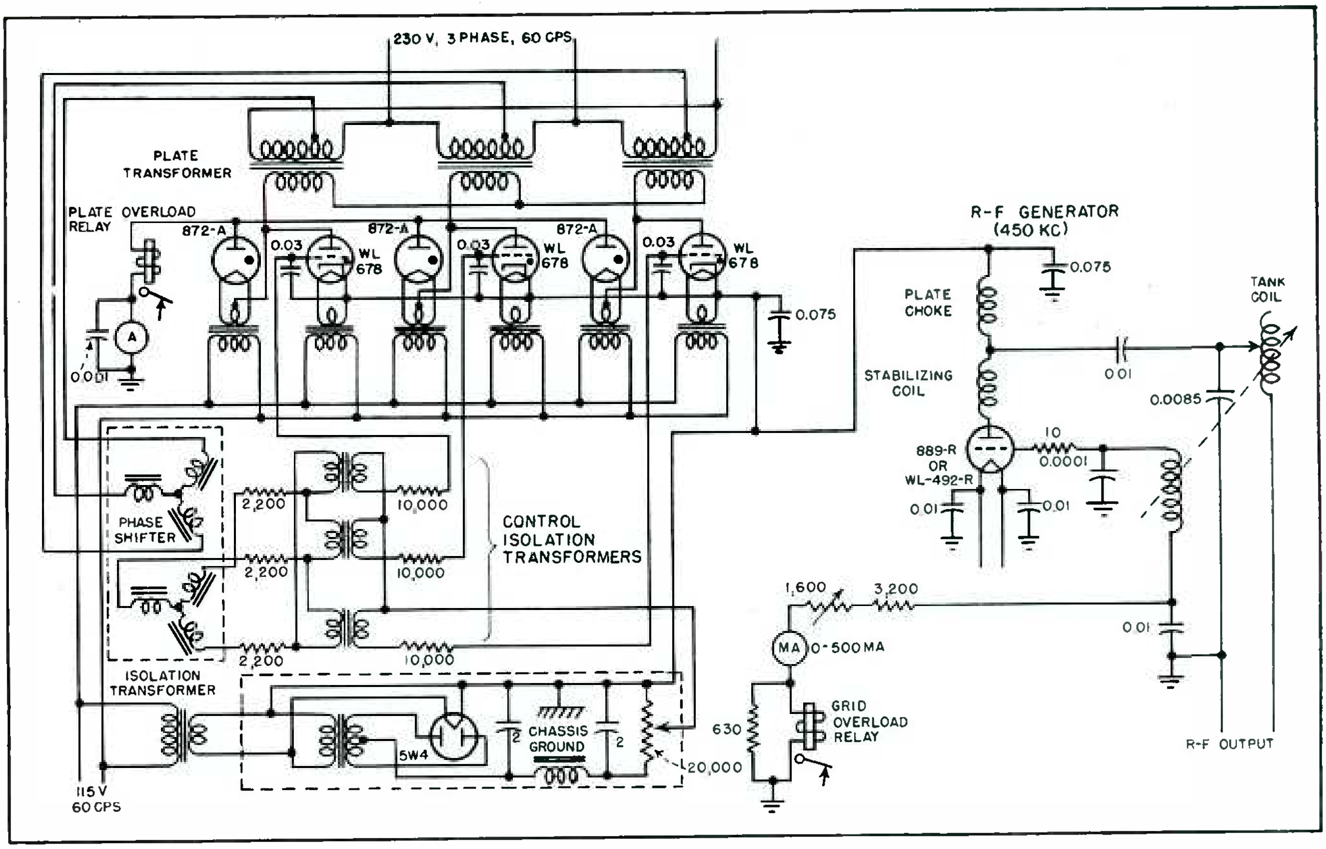


FIG. 3—Simplified schematic circuit diagram of grid-controlled rectifier as used with a 10-kw, 450-kc r-f generator

AIR-FLOW

Description of a laboratory-type instrument, suitable for calibrating of general-purpose wattmeters. A tungsten-filament dissipative element is inserted as the central conductor in a section of coaxial transmission line. Temperature of air flowing past the filament is measured by means of thermopiles

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The wattmeter to be described, designed to operate in the 30 centimeter region, was intended chiefly for calibration purposes and for applications in which accurate measurements are required, rather than for general use.

The operation involves measuring the temperature rise of a stream of air flowing past a dissipative element, the temperature rise being proportional to the dissipation.

The wattmeter is used with a coaxial feeder and is fairly simple to construct and operate. Its chief drawback is the fact that several minutes may be required for a steady state to be attained, a requirement for accurate measurements.

The arrangement is a modification of a plan conceived jointly with Dr. Hugh M. Brown. Details of the wattmeter unit are shown in Fig. 1.

The dissipative element forming part of the inner conductor of a coaxial transmission-line system consists of a tungsten filament in an evacuated envelope, the latter being blackened on the outside to convert any radiant energy from the filament into heat. A shorting stub and extensible section are employed to match the impedance of the unit to a coaxial feeder and permit the instrument to be useful over a considerable frequency range. Special care was taken in designing these matching sections to keep high-frequency losses to a minimum, and to select characteristic impedances that make the settings of these sections as noncritical as possible.

It can be shown from transmission line theory that the load can be matched to the feeder if certain minimum conditions are met, but that the adjustments will be noncritical if proper values of parameters are chosen. Let

$R + jX$ = impedance of the load,
Z_o = characteristic impedance of the extensible section,
Z_{o1} = characteristic impedance of the extensible section,
Z_{o2} = characteristic impedance of the stub.

Then the necessary requirement for matching is

$Z^2_{o1} \geqq Z_oR$ if $R \geqq Z_o$, or (1)
$Z^2_{o1} \leqq Z_oR$ if $R \leqq Z_o$, (2)

Z_{o2} having any value. However the settings of the matching sections will become less and less critical if Z_{o2} =

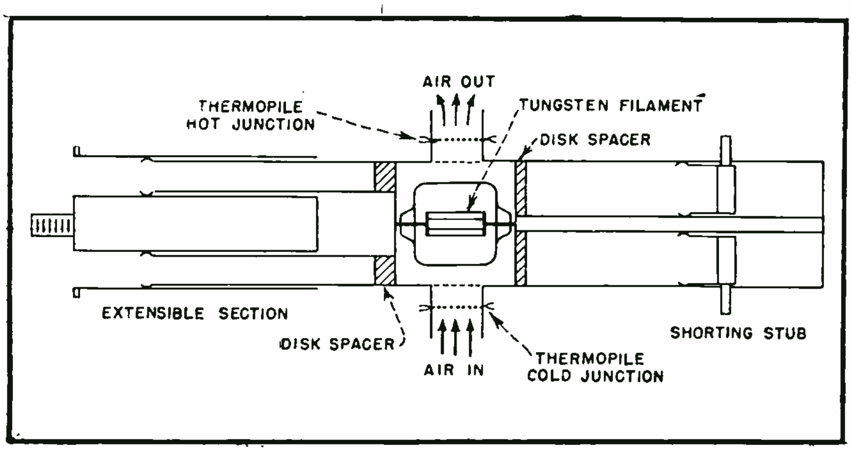


FIG. 1—Details of wattmeter unit. Disk spacers are made of insulating material having low dielectric loss at ultrahigh frequencies

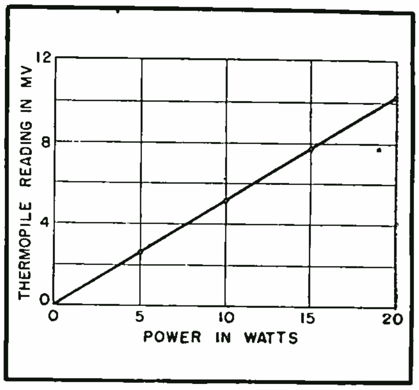
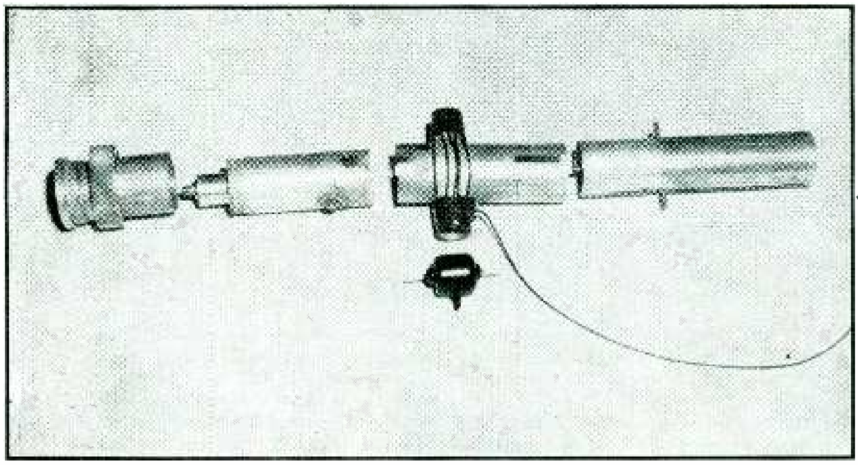


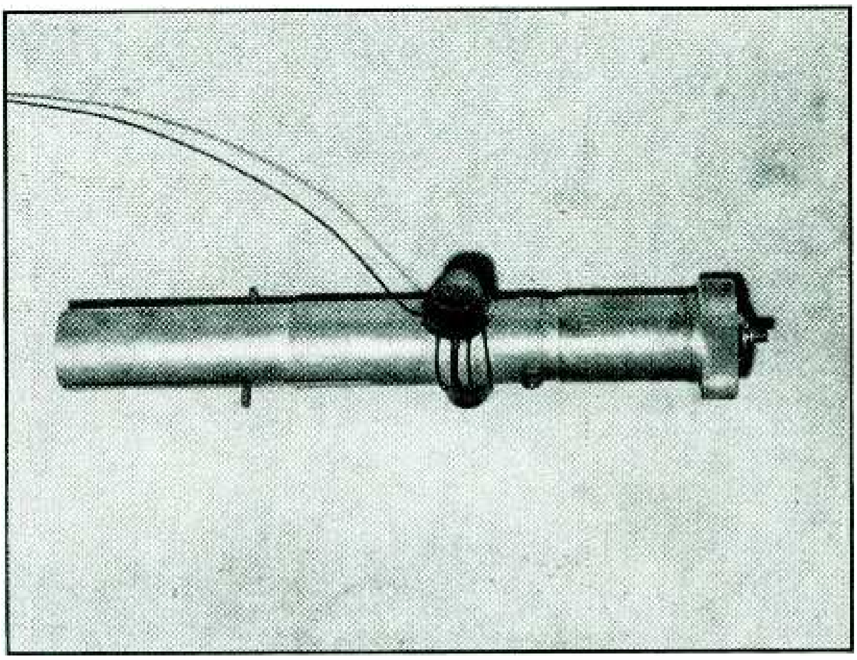
FIG. 2—Typical calibration curve for the air-flow wattmeter

UHF WATT-METER



Dismantled sections of the wattmeter, arranged to correspond with the drawing of Fig. 1 and showing mechanical details

Completely assembled, the unit readily connects to a transmission line



$|X|$, and the equalities are approached in Eq. 1 or Eq. 2 above.

The high-frequency power dissipated in the load lamp can be measured by straightforward calorimetric methods; however, it is much simpler to calibrate the device with 60-cycle alternating current. A typical calibration curve, Fig. 2, verifies the linear relationship between power dissipated and thermopile readings. Points on this curve were found to be reproducible to within 0.2 watt.

As was mentioned previously, this air-flow wattmeter can be used to calibrate or check other ultrahigh-frequency wattmeters. A given wattmeter may be substituted for the airflow wattmeter and readings correlated, or in the case of a wattmeter that operates by extracting a very small fraction of the total power from the feeder, one may place such a meter between the generator and the air-flow wattmeter. Furthermore, one may investigate the behavior of this type of low-level wattmeter when mismatches of various magnitudes and phases are introduced. An arrangement used for a study of this sort is shown in Fig. 3.

The standing-wave pattern was observed by means of the slotted line, the magnitude of the mismatch was determined by adjustments on the air-flow wattmeter unit, and the phase was varied by means of an extensible section of feeder.

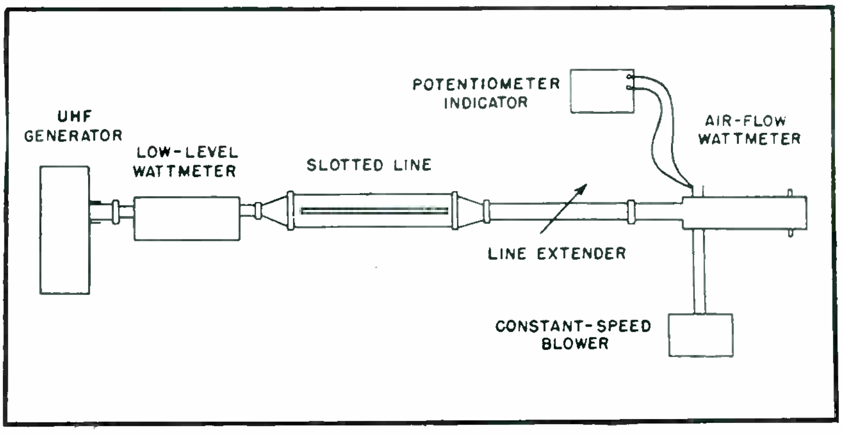


FIG. 3—Arrangement used for observing behavior of the wattmeter. It was found that it extracts very little power from a transmission line

The Effect of INCIDENTAL

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Effect of Incidental Losses

1. The theoretically infinite peaks in the attenuation loss and the reflection loss remain finite. The finite value of the attenuation (in nepers) at such a peak is given by Eq. 25 which shows the effect of the nearness of the peak to the cutoff and the dependence upon Q. Equation 50 gives the finite reflection loss (in nepers) at its peak for a filter with a single *m*-derived image impedance. For filters with more complicated image impedance, the peak reflection loss is given (in nepers) by the natural logarithm of Eq. 46 or Eq. 47 according to whether the lossless image impedance is respectively zero or infinite at this point.

2. Incidental losses cause the attenuation to be nonzero in the pass band. Here the phase is also somewhat different from its lossless value. Equations 14 and 15 may be used to compute the modified values of attenuation and phase not only within the pass band but also within the stop band where, however, the effects are less significant and of less importance (except at the peaks as already mentioned). Equations 14 and 15 apply everywhere except near attenuation peaks or near the cutoff where the special formulas given by Eq. 31 and 32 must be used.

In applying these results to a composite filter the effect upon the net attenuation loss is most expeditiously computed by considering each filter section separately and adding the losses thus found. The Q's of the various sections need not be alike. The effect upon the reflection loss depends only upon the terminal image impedance and hence involves only a single calculation regardless of the number of sections forming the composite filter.

IN the design of filters it is customary to assume that the network itself (apart from the terminating resistances) is lossless. In constructing the filter it is, therefore, essential to use coils and capacitors having losses which are as small as practicable in order that the behavior predicted by the theory be at least approximately realized. Since the size, weight, and cost of a circuit element increase as its incidental losses are reduced, it is significant to know quantitatively the effect of incidental loss upon the filter behavior in order that a satisfactory compromise may be achieved.

It is not necessary that one be able to calculate exactly the effect of incidental dissipation inasmuch as the design procedure used for the lossless structure is quite commonly rather approximate. Thus, if one designs a filter on the basis of its attenuation function alone, the so-called reflection and interaction losses are for the moment regarded as being of secondary importance. If the reflection losses are considered at all, their effect upon the net insertion loss is usually regarded as being significant only over the attenuation band where the terminal conditions depart significantly from the hoped-for

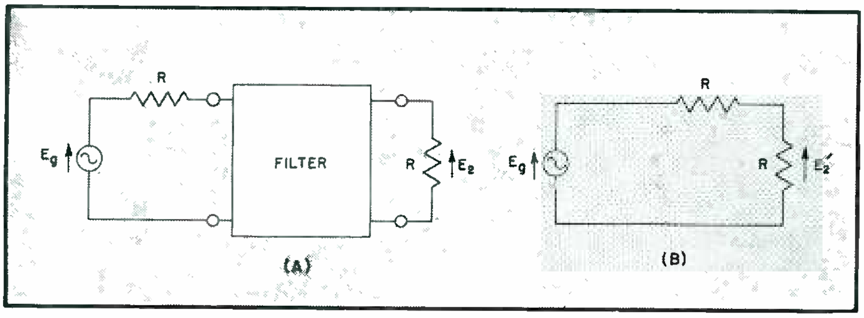

FIG. 1—Significance of insertion ratio, which is ratio of load voltages without filter to load voltage obtained with filter between source and load

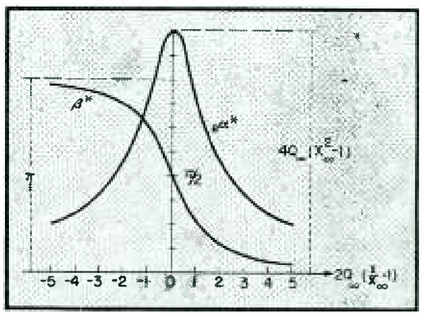

FIG. 2—Plots of attenuation factor and phase for Eq. 23 and 24

DISSIPATION in FILTERS

Where exact predictions of filter performance are necessary, account must be taken of the losses in the network components. The paper presents a method of ascertaining the effect of these losses on propagation factor, reflection factor and interaction factor

matched condition. The interaction losses are rarely regarded to be of sufficient importance to warrant their consideration in the design calculation. In cases where such procedures are inadequate it is better to abandon the conventional methods entirely and design for insertion loss directly. The conventional methods, then, are primarily suited to situations where the prediction of exact performance is unessential. In such cases the conventional methods are greatly to be preferred because of their comparative simplicity.

The present discussion relative to the effect of incidental dissipation applies specifically to the interpretation of filter behavior according to the conventional methods, whence it is consistent to adopt the point of view that these effects need be determined only to a first order of approximation. The simplicity of the resulting formulas reveals the appropriateness of this attitude.

Insertion Loss

Before proceeding with the theoretical discussion it is essential to recall the expression for insertion loss. With reference to Fig. 1, the insertion ratio is defined as E_2'/E_2; that is, as the ratio of the load voltage that would be obtained without the filter (Fig. 1B) to the load voltage that results when the filter is inserted between the source and load resistances R (Fig. 1A). It is implied here as usual that the filter is electrically symmetrical with regard to its input and output terminals.

Denoting the image impedance of the filter by Z_0, and its normalized value by $z_0 = Z_0/R$, the reflection coefficient common to both terminal-pairs becomes

$$r = \frac{1 - z_0}{1 + z_0} \qquad (1)$$

Writing for the propagation function $\gamma = \alpha + j\beta$, where α and β are respectively the attenuation and phase functions, the insertion ratio reads

$$E_2'/E_2 = e^{\gamma}(1 - r^2)^{-1}(1 - r^2e^{-2\gamma}). \qquad (2)$$

It is customary to refer to the separate factors in this expression as follows:

e^{γ} = propagation factor
$(1 - r^2)^{-1}$ = reflection factor (both ends)
$(1 - r^2e^{-2\gamma})$ = interaction factor.

With reference to the factor $(1 - r^2)^{-1}$ it may be well to recognize that

$$(1 - r^2)^{-1} = \left[\frac{1}{2}\left(\sqrt{z_0} + \frac{1}{\sqrt{z_0}}\right)\right]^2 \qquad (3)$$

the quantity in the square bracket being the more familiar expression for the reflection factor at one end of the network.

Ordinarily the propagation factor e^{γ} is of first order importance in the insertion ratio expression, while the reflection and interaction factors are regarded as being of second order. One might, therefore, consider it worth while to determine the effect of incidental dissipation only upon the factor e^{γ}. After some reflection, however, one recognizes that this conclusion is not quite correct since there are some critical

Table I—Symbols used in this Article

Z_0 = image impedance
R = source or load resistance
$z_0 = Z_0/R$ = normalized value of the image impedance, or the image impedance referred to a one-ohm level
r = reflection coefficient (common to both ends since a symmetrical network and equal source and load resistances are implied)
E'_2/E_2 = insertion ratio (voltage)
$\gamma = \alpha + j\beta$ = propagation function (or constant)
α = attenuation function (or constant)
β = phase function (or constant)
e = base of natural logarithms
e^{γ} = propagation factor
e^{α} = attenuation factor
ln = natural logarithm
$*$ = distinguishes any quantity when the effect of loss is included
$x = f/f_c = \omega/\omega_c$ = ratio of any frequency to the cutoff frequency of the filter (assumed low pass)
$\omega_{\infty} = 2\pi f_{\infty}$ = frequency of (theoretically) infinite attenuation
$x_{\infty} = f_{\infty}/f_c$
$Q = \left(\frac{R}{L\omega} + \frac{G}{C\omega}\right)^{-1}$ = uniform combined Q of coils and capacitors
$Q_c = Q$ for $\omega = \omega_c$; $Q_0 = Q$ for $\omega = \omega_0$; etc.
m = constant appearing in Zobel's theory of m-derived filters

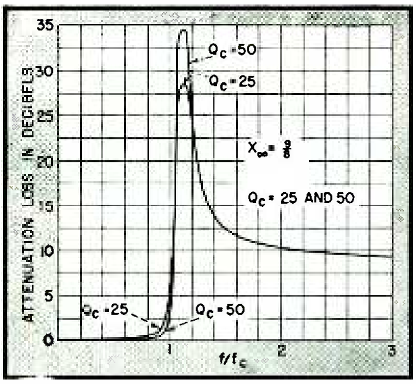

FIG. 3—Attenuation curve of network for two values of Q: m = 0.458

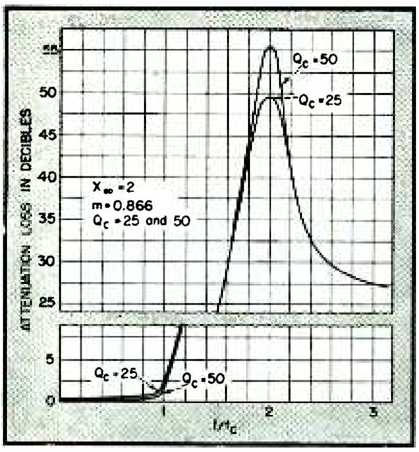

FIG. 4—Attenuation curve of network for two values of Q: m = 0.866

frequencies (such as the cutoff frequency or the zeros or poles of Z_0) at which the values of $(1 - r^2)^{-1}$ and $(1 - r^2e^{-2\gamma})$ are important. The latter factor is not important in the attenuation range where α is large or in the transmission range where $z_0 \cong 1$ and hence $r \cong 0$; but neither of these conditions obtain in the immediate vicinity of the cutoff frequency. Here the combined factor $(1 - r^2)^{-1}(1 - r^2e^{-2\gamma})$ must be considered and the question as to whether the effect of incidental dissipation upon its values may be significant, must be more carefully investigated.

The factor $(1 - r^2)^{-1}$ is not important over the transmission range where $z_0 \cong 1$ and $r \cong 0$, but in the attenuation range where z_0 is imaginary the conventional analysis shows that this factor introduces a maximum negative loss of about 6 db wherever $|z_0| = 1$, and an infinite positive loss wherever z_0 is critical (has a zero or a pole). One may conclude that it is not essential to consider the effect of incidental dissipation in this factor except at the critical frequencies of z_0. Here this effect is definitely of importance because it limits the reflection loss to a finite value which must be determined.

To summarize the discussion so far, one may say that the effect of incidental dissipation upon the insertion ratio, Eq. 2, should be investigated for

e^{γ} over the entire frequency range
$(1 - r^2)^{-1}$ at the critical frequencies of z_0 only
$(1 - r^2)^{-1}(1 - r^2e^{-2\gamma})$ at the cutoff frequency only

In the following paragraphs these items are considered in the order given.

The Propagation Function

Filters to which the present discussion is pertinent are designed without regard for the resulting phase characteristic; that is, the attenuation requirement is of primary importance. In such cases any desired result may be obtained by cascading a suitable number of simple m-derived structures with appropriately chosen m-values. It is significant to observe in this connection that the effect of incidental dissipation upon the resultant attenuation and phase shift depends only upon the form of the propagation function and not at all upon the structure of the network or upon the form of the image impedance. If, for the purpose of calculating the effect of incidental dissipation, one assumes a specific network configuration, the results are not restricted in their application to that structure but apply equally well to any other configuration having the same propagation function. Since the overall attenuation loss is additive, the consideration here may be restricted to a single m-derived filter constituent, for which the propagation function is given by the expression

$$\gamma = ln\,\frac{y_0 + 1}{y_0 - 1} \tag{4}$$

in which

$$y_0 = \frac{(x^2 - 1)^{1/2}}{mx} = \frac{(1 - x^2)^{1/2}}{jmx} \tag{5}$$

For the low-pass filter

$$x = \omega/\omega_c = f/f_c \tag{6}$$

where f_c is the cutoff frequency. The analysis pertinent to the band-pass and other filter classes may be obtained by making appropriate frequency transformations.[1]

The basis for the approximate consideration of incidental losses is given by the statement[2] that if the function $z\,(j\omega)$ is the driving point impedance of a lossless network then $z(j\omega + \delta) = z^*(j\omega)$ is approximately the impedance of the corresponding uniformly dissipative network,[3] where

$$\delta = \frac{1}{2}\left(\frac{R}{L} + \frac{G}{C}\right) \tag{7}$$

is the average uniform dissipation ratio. The asterisk is here used to designate the dissipative function, not the conjugate value. The process applies in unaltered form also to admittances and propagation functions.

The propagation function, according to Eq. 4 and 5, is a function of the frequency variable jx. If the propagation function of the corresponding uniformly dissipative network is denoted by $\gamma^*(jx)$, one has

$$\gamma^*(jx) = \gamma\,(jx + \delta/\omega_c) \tag{8}$$

and a Taylor expansion about the point $\delta = 0$ yields

$$\gamma^*(jx) = \gamma(jx) - j\left(\frac{d\gamma}{dx}\right)\frac{\delta}{\omega_c} - \frac{1}{2}\left(\frac{d^2\gamma}{dx^2}\right)\left(\frac{\delta}{\omega_c}\right)^2 + \ldots \tag{9}$$

According to Eq. 4 and 5 the derivatives appearing here are found to be

$$\frac{d\gamma}{dx} = \frac{2m}{[1 - (1 - m^2)x^2][x^2 - 1]^{1/2}} \tag{10}$$

and

$$\frac{d^2\gamma}{dx^2} = -\frac{2\,mx\,[1 + 2(1 - m^2) - 3(1 - m^2)x^2]}{[1 - (1 - m^2)x^2]^2\,(x^2 - 1)^{3/2}} \tag{11}$$

Substitution of these expressions into Eq. 9 yields the desired results.

Before carrying out this step it is useful to observe according to Eq. 7 that

$$\frac{2\delta}{\omega_c} = \frac{R}{L\omega_c} + \frac{G}{C\omega_c} = \frac{1}{Q_c} \tag{12}$$

where Q_c is a quantity which measures the quality of the coils and capacitors. The tacit assumption in the approximate analysis used here is that the Q-values are the same throughout the network. However, if the filter is realized as a cascade of component networks then it is clear that the contribution (to the total attenuation) of a given component depends only upon the Q-values of that component. If the capacitors are essentially lossless (as may usually be assumed), Q_c is the familiar expression for the Q of the coils evaluated at the cutoff frequency.

In Eq. 10 and 11 it is expedient to introduce the frequency of infinite attenuation by means of the relation (applying to m-derived filters)

$$\frac{\omega_\infty}{\omega_c} = \frac{f_\infty}{f_c} = x_\infty = \frac{1}{(1 - m^2)^{1/2}} \quad (13)$$

With the use of these relations, substitutions of Eq. 10 and 11 into Eq. 9, and subsequent separation into real and imaginary parts yields the following results for the attenuation and phase functions of the dissipative filter

$$\left.\begin{array}{ll} \alpha^* = A(x); & \beta^* = \beta - B(x); \\ \text{for } x < 1 \text{ (pass band)} & \\ \alpha^* = \alpha + B(x); & \beta^* = \beta - A(x); \\ \text{for } x > 1 \text{ (stop band)} & \end{array}\right\} \quad (14)$$

where

$$\left.\begin{array}{l} A(x) = \dfrac{m}{Q_c|1 - x^2|^{1/2}(1 - x^2/x^2_\infty)} \\ B(x) = \dfrac{mx[3(1 - x^2/x^2_\infty) - 2m^2]}{4Q^2_c|1 - x^2|^{3/2}(1 - x^2/x^2_\infty)^2} \end{array}\right\} (15)$$

x_∞ in Eq. 13. In the relations of Eq. 14, α and β are the attenuation and phase functions of the lossless structure.

These results are, of course, not applicable to points in the immediate vicinity of the cutoff ($x = 1$) or to points in the vicinity of the infinite attenuation peak. For these regions it is necessary to derive special relationships. It is observed that the effect of dissipation is to add correction terms to the attenuation in the pass band and to the phase in the stop band which are inversely proportional to the first power of Q_c, while the corrections to α in the stop band and to β in the pass band are of second order since they are inversely proportional to Q_c^2. It should also be observed that the correction terms are increased as the frequency of infinite attenuation is moved closer to the cutoff ($x_\infty \rightarrow 1$). The results apply also to the constant-k filter since the latter is obtained for $m = 1$ or $x_\infty = \infty$.

The Attenuation Peak

The effect of dissipation in the vicinity of the infinite attenuation peak is considered next. Since this is the frequency at which the quantity y_0 of (Eq. 5) passes through unity, one may write for this vicinity

$$y_0 \cong 1 + \left(\frac{dy_0}{dx}\right)_{x=x_\infty}(x - x_\infty) \quad (16)$$

Denoting the corresponding function for the dissipative network by $y_0^*(jx)$, and following the pattern of Eq. 8 and 9 pertaining to the propagation function, yields the analogous relations

$$y_0^*(jx) = y_0\left(jx + \frac{\delta}{\omega_c}\right) \quad (17)$$

$$y_0^*(jx) = y_0(jx) - j\left(\frac{dy_0}{dx}\right)\frac{\delta}{\omega_c} - \frac{1}{2}\left(\frac{d^2y_0}{dx^2}\right)\left(\frac{\delta}{\omega_c}\right)^2 + \ldots \quad (18)$$

Here only the first two terms of the Taylor expansion are needed. Use of Eq. 16 thus gives for the vicinity of the point $x = x_\infty$

$$y_0^* = 1 + \left[(x - x_\infty) - j\frac{\delta}{\omega_c}\right]\left(\frac{dy_0}{dx}\right)_{x=x_\infty} \quad (19)$$

According to Eq. 5, 6, and 13, the derivative of y_0 appearing here is found to have the value

$$\left(\frac{dy_0}{dx}\right)_{x=x_\infty} = \frac{1}{x_\infty(x^2_\infty - 1)} \quad (20)$$

so that Eq. 19 becomes

$$y_0^* = 1 + \frac{(x - x_\infty) - j\dfrac{\delta}{\omega_c}}{x_\infty(x^2_\infty - 1)} \quad (21)$$

The desired behavior of the propagation function for the vicinity of the point $x = x_\infty$ is obtained through substitution of this value of y_0^* into Eq. 4 in place of y_0 (and denoting the result by γ^*). In connection with this step it should be observed that the fractional term in Eq. 21 has a value small compared to unity throughout the frequency range of interest here and that this term, therefore, while significant in the evaluation of $y_0^* - 1$, may be ignored in considering the value of $y_0^* + 1$. Making use of the relation expressed by Eq. 12 (with ω_c replaced by ω_∞), one thus obtains the result

$$\gamma^* = ln\left\{\frac{4Q_\infty(x^2_\infty - 1)}{2Q_\infty\left(\dfrac{x}{x_\infty} - 1\right) - j}\right\} \quad (22)$$

Separation into real and imaginary parts gives

$$\alpha^* = ln\left\{\frac{4Q_\infty(x^2_\infty - 1)}{\left[1 + 4Q^2_\infty\left(\dfrac{x}{x_\infty} - 1\right)^2\right]^{1/2}}\right\} \quad (23)$$

and

$$\beta^* = \frac{\pi}{2} - \tan^{-1}\left[2Q_\infty\left(\frac{x}{x_\infty} - 1\right)\right] \quad (24)$$

Plots of the functions e^{α^*} and β^* are shown in Fig. 2 for assumed values of $Q_\infty = 50$ and $x_\infty = 5/4$, ($m = 0.6$). In contrast to the behavior of the lossless network it is observed that the attenuation (α^*) remains finite at the point $x = x_\infty$, and the phase (β^*) varies continuously from the value π to zero instead of having a discontinuity at this point. Equations 23 and 24 are, of course, applicable only to frequencies in the immediate vicinity of the attenuation peak. Of primary interest is the value of this peak, that is

$$\alpha^*_{max} = ln\,[4Q_\infty(x^2_\infty - 1)] \quad (25)$$

As might have been expected, this value increases with Q_∞ and decreases as the theoretically infinite attenuation peak is moved closer to the cutoff; that is, as the value of x_∞ approaches unity (the value of m approaches zero). The purpose of using an m-derived section with a value of x_∞ near unity is to obtain a rapid increase in attenuation beyond the cutoff. One observes that unless the value of Q_∞ is sufficiently large, however, the desired effect cannot be realized. Equation 25 presents a simple means for controlling the significant factors in a contemplated design.

Behavior at the Cutoff

At the cutoff $x = 1$ and the value of y_0, according to Eq. 5, is zero. One may expect that the effect of incidental dissipation is to yield a function y_0^* having a nonzero value at the cutoff. It is reasonable to assume, however, that this value is small compared to unity so that one may use the approximation

$$\frac{y_0^* + 1}{y_0^* - 1} \cong -(1 + 2y_0^*) \quad (26)$$

and hence, according to Eq. 4, obtain for the value of the propagation function at the cutoff

$$\gamma_c^* = ln\,(1 + 2y_0^*) + j\pi \cong 2y_0^* + j\pi \quad (27)$$

To obtain the desired value of y_0^*, it is convenient first to write Eq. 5 in the form

$$y_0 = \frac{[1 + (jx)^2]^{1/2}}{jmx} \quad (28)$$

whence y_0^* is had through replacing jx by $jx + \delta/\omega_c$. Since the denominator in Eq. 28 does not behave critically in the vicinity of the point $x = 1$, it is moreover essential only to replace jx by $jx + \delta/\omega_c$ in the numerator, and since $(jx + \delta/\omega_c)^2$

$\cong -x^2 + 2jx(\delta/\omega_c)$, one has for $x = 1$

$$y_0^* = \frac{(j\,2\delta/\omega_c)^{1/2}}{jm} = \frac{1}{m(j\,Q_c)^{1/2}} \qquad (29)$$

in which Eq. 12 is also used. Substitution of this result into Eq. 27 yields the desired value of the propagation function at the cutoff, thus

$$\gamma_c^* = \frac{2}{m(jQ_c)^{1/2}} + j\pi. \qquad (30)$$

Separation into real and imaginary parts gives the formulas

$$\alpha_c^* = \frac{1}{m}\left(\frac{2}{Q_c}\right)^{1/2} = x_\infty\left(\frac{2}{Q_c(x^2_\infty - 1)}\right)^{1/2} \text{ (nepers)} \qquad (31)$$

and

$$\beta_c^* = \pi - \frac{1}{m}\left(\frac{2}{Q_c}\right)^{1/2} \text{ (radians)} \qquad (32)$$

For $m = 0.6$ ($x_\infty = 5/4$), and $Q_c = 50$, one finds $\alpha_c^* = 1/3$ neper or 2.9 db and $\beta^* = \pi - 1/3$ radians or 161 degrees. It is significant to observe that the choice of a small m-value (attenuation peak near the cutoff) yields a larger attenuation at the cutoff and thus partially defeats the purpose for which such an m-derived section is normally used unless the factor Q_c can be made large enough.

Reflection Loss at the Critical Frequencies of z_0

Since the complete filter structure to which the present discussion is relevant may be a composite one having a fairly elaborate image impedance at its input and output terminals, it is necessary to assume for z_0 an expression of the form

$$z_0 = \frac{(1 - x^2)^{1/2}\,(1 - x^2/x^2_3)\ldots}{(1 - x^2/x^2_2)(1 - x^2/x^2_4)\ldots} \qquad (33)$$

Inasmuch as the reflection factor reads $(1 - r^2)^{-1}$ and according to Eq. 1

$$r^2 = \left(\frac{1 - z_0}{1 + z_0}\right)^2 = \left(\frac{1 - 1/z_0}{1 + 1/z_0}\right)^2 \qquad (34)$$

it is clear that the end results are the same whether Eq. 33 or its reciprocal is used for z_0; that is, it is immaterial whether z_0 is assumed to be midseries (as in Eq. 33) or midshunt.

The critical frequencies of z_0 are those corresponding to $x = x_2$, x_3, . . . etc. At these points either z_0 or $1/z_0$ becomes zero. In the vicinity of these points the value of r^2 according to Eq. 34, may be evaluated considering z_0 or $1/z_0$ to be small compared to unity, thus obtaining either

$$r^2 = 1 - 4z_0, \text{ (for } x = x_3, x_5, \ldots) \qquad (35)$$

or

$$r^2 = 1 - 4/z_0, \text{ (for } x = x_2, x_4, \ldots) \qquad (36)$$

The reflection factor may, for these vicinities, be represented by

$$(1 - r^2)^{-1} = 1/4z_0, \text{ (for } x = x_3, x_5, \ldots) \qquad (37)$$

or

$$(1 - r^2)^{-1} = z_0/4, \text{ (for } x = x_2, x_4, \ldots) \qquad (38)$$

The next step is to replace z_0 in these expressions by the corresponding dissipative function z_0^*, which is accomplished in the usual manner through use of the approximate relation

$$z_0^*(jx) = z_0\left(jx + \frac{\delta}{\omega}\right) = z_0(jx) - j\left(\frac{dz_0}{dx}\right)\frac{\delta}{\omega} + \ldots \qquad (39)$$

or

$$\frac{1}{z_0^*(jx)} = \frac{1}{z_0\left(jx + \dfrac{\delta}{\omega}\right)} = \frac{1}{z_0(jx)} - j\left(\frac{d}{dx}\frac{1}{z_0}\right)\frac{\delta}{\omega} + \ldots \qquad (40)$$

according to whether z_0 or $1/z_0$ is zero at the point in question. Use of Eq. 33 yields

$$\left(\frac{dz_0}{dx}\right)_{x=x_k} = -\frac{2}{x_k}\left[\frac{z_0}{1 - x^2/x^2_k}\right]_{x=x_k} \quad \text{for } k = 3, 5, \ldots \qquad (41)$$

and

$$\left(\frac{d}{dx}\frac{1}{z_0}\right)_{x=x_k} = -\frac{2}{x_k}\left[\frac{1/z_0}{1 - x^2/x^2_k}\right]_{x=x_k} \quad \text{for } k = 2, 4, \ldots \qquad (42)$$

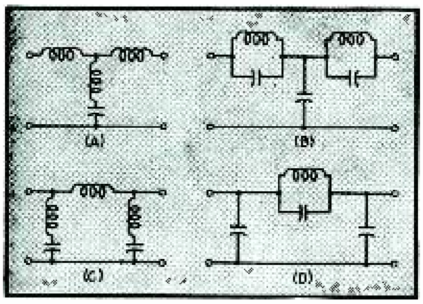

FIG. 5—Forms of single m-derived sections

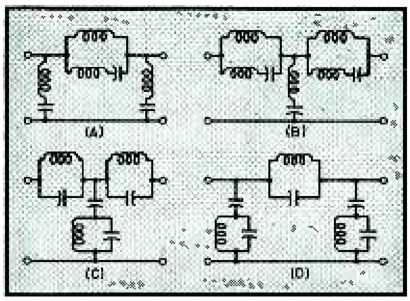

FIG. 6—Double m-derived sections obtained through performing a second m-derivation upon networks of Fig. 5B or C

Writing (by analogy to Eq. 12)

$$\frac{2\delta}{\omega_k} = \frac{1}{Q_k} \qquad (43)$$

one thus finds

$$z_0^* = \frac{j}{Q_k}\left[\frac{z_0}{1 - x^2/x^2_k}\right]_{x=x_k} \quad \text{for } k = 3, 5, \ldots \qquad (44)$$

and

$$\frac{1}{z_0^*} = \frac{j}{Q_k}\left[\frac{1/z_0}{1 - x^2/x^2_k}\right]_{x=x_k} \quad \text{for } k = 2, 4, \ldots \qquad (45)$$

Substitution of these expressions into Eq. 37 and 38 respectively yields the desired results for the reflection factor of the dissipative network at the critical frequencies of z_0, thus

$$(1 - r^2)^{-1} = \frac{Q_k}{4j}\left[\frac{1 - x^2/x^2_k}{z_0}\right]_{x=x_k} \quad \text{for } k = 3, 5, \ldots \qquad (46)$$

and

$$(1 - r^2)^{-1} = \frac{Q_k}{4j}\left[\frac{1 - x^2/x^2_k}{1/z_0}\right]_{x=x_k} \quad \text{for } k = 2, 4, \ldots \qquad (47)$$

As an illustration one may consider z_0 to be the midseries image impedance of the single shunt-derived filter; that is

$$z_0 = \frac{(1 - x^2)^{1/2}}{(1 - x^2/x^2_2)} \qquad (48)$$

Then Eq. 47 gives

$$(1 - r^2)^{-1} = \frac{Q_2}{4}(x^2_2 - 1)^{1/2} \qquad (49)$$

The reflection loss at this point is

$$\ln\left[\frac{Q_2}{4}(x^2_2 - 1)^{1/2}\right] \text{ nepers} \qquad (50)$$

In this simple filter section the critical frequency x_2 is controlled by the value of m chosen for the determination of x_∞, so that one has in this case $x_2 = x_\infty$; that is, the peak in the attenuation loss coincides with the peak in the reflection loss. The net loss at this point is given by adding the results expressed by Eq. 25 and 50, thus

$$\text{net loss} = \ln\left[4Q_\infty(x^2_\infty - 1)\right] + \ln\left[\frac{Q_\infty}{4}(x^2_\infty - 1)^{1/2}\right] = \ln\left[Q^2_\infty(x^2_\infty - 1)^{3/2}\right] \text{ nepers} \qquad (51)$$

For the numerical values: $Q_\infty = 50$, $x_\infty = 5/4$ ($m = 0.6$) one has

$$\text{net loss} = \ln 112.5 + \ln 9.37 = \ln 1{,}054 \qquad (52)$$

or in decibels

$$\text{net loss} = 41 + 19.4 = 60.4 \text{ db} \qquad (53)$$

While the contribution due to the reflection loss is moderate, it nevertheless is a significant help toward providing a satisfactory peak loss particularly when x_∞ is chosen near unity. This fact is clearly appreciated from a comparison of the resultant loss as expressed by Eq. 51 with that provided by the attenuation function alone, Eq. 25.

Combined Reflection and Interaction Factor at Cutoff

This factor reads

$$F = \frac{1 - r^2 e^{-2\gamma}}{1 - r^2} \qquad (54)$$

with r^2 given by Eq. 34, and

$$e^{-2\gamma} = \left(\frac{1 - y_0}{1 + y_0}\right)^2 \qquad (55)$$

as is evident from inspection of Eq. 4. According to Eq. 33, z_0 in the vicinity of the cutoff ($x = 1$) is very small, and hence r^2 may be approximated by Eq. 35. The function y_0, according to Eq. 5, is also very small in this vicinity and hence one may use the approximation

$$e^{-2\gamma} \doteq 1 - 4y_0 \qquad (56)$$

so that

$$r^2 e^{-2\gamma} = 1 - 4\,(y_0 + z_0) \qquad (57)$$

Thus an approximate expression for F, useful for the vicinity of the cutoff, becomes

$$F = \frac{y_0 + z_0}{z_0} = 1 + \frac{y_0}{z_0} \qquad (58)$$

Although both y_0 and z_0 become zero at the cutoff, their ratio is finite. For example, using Eq. 5 for y_0 and Eq. 48 for z_0 gives

$$F = 1 + \frac{(1 - x^2/x^2_2)}{jmx} \qquad (59)$$

If $x_\infty = x_2$, this expression becomes for $x = 1$

$$F = 1 - jm = 1 - j\,(1 - x_\infty^{-2})^{1/2} \qquad (60)$$

Since this result for the nondissipative network is finite while the attenuation at the cutoff is zero unless the effect of dissipation is considered, one may conclude that the incidental dissipation has a second order effect upon the factor F and should, therefore, be neglected inasmuch as the effect of dissipation upon γ at the cutoff has been evaluated to a first order only.

Illustrations

Figures 3 and 4 illustrate the resulting formulas given by Eq. 14, 15, 23, and 25 for several different values of Q and x_∞ or m. Each figure shows a pair of low-pass attenuation-versus-frequency curves for the same value of x_∞ or m but for Q's of 25 and 50. Specifically these figures indicate the appearance of attenuation curves for $x_\infty = 9/8$ ($m = 0.458$), and $x_\infty = 2$ ($m = 0.866$) respectively.

These attenuation curves are those obtained from physical component networks whose theoretical propagation functions are given by Eq. 4 and 5 regardless of the corresponding image impedance. For example, a component network may be any one of the familiar forms of single m-derived sections shown in Fig. 5. Alternately the component network may be the shunt derivation of the network of Fig. 5C as shown in Fig. 6A; or it may be the corresponding midseries section shown in Fig. 6B. Again one might consider the series derivation of the network of Fig. 5B as shown in Fig. 6C, or the corresponding midshunt form shown in Fig. 6D. All of these networks have fundamentally the same attenuation function, namely one having a single attenuation peak as given analytically by Eq. 4 and 5. It is important to recognize that the effect of incidental dissipation upon the resulting attenuation function depends only on the uniform dissipation ratios R/L and G/C and not at all upon the network configuration or the number of inductances or capacitors involved in the particular filter.

Figure 7 illustrates the resulting insertion loss obtained from cascading two sections like the one shown in Fig. 5A or two sections like the one shown in Fig. 5D, with $x_\infty = 9/8$ and $x_\infty = 2$ respectively. The component network for $x_\infty = 9/8$ is assumed to have a Q of 50 while that for $x_\infty = 2$ is assumed to have a Q of 25, the point being that a higher Q is needed for that component network having its attenuation peak nearer the cutoff. The insertion loss shown in Fig. 7 is calculated by adding to the sum of appropriate curves of Fig. 3 and 4 the reflection and interaction losses of the lossless constant-k filter calculated according to established methods, the effect of dissipation upon the latter being negligible (the only peak in the reflection loss in this case occurring at infinite frequency).

Band-pass Filters

In dealing with band-pass filters it is customary to make all calculations in terms of the so-called equivalent low-pass filter which is obtained by simply regarding the midband frequency of the band pass as the origin of the frequency scale for the low pass. This procedure is, of course, valid only when the band width is small compared to the midband frequency, but a large number of practical cases are thus accommodated.

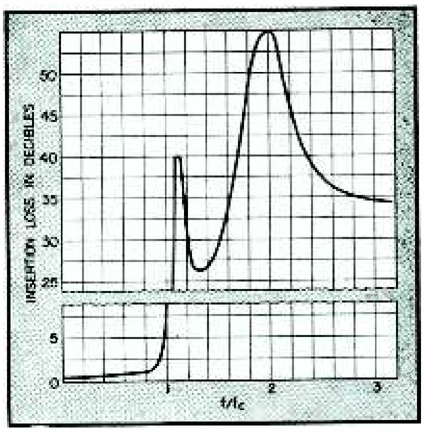

FIG. 7—Insertion loss of a composite filter consisting of two single m-derived sections in cascade having the values m = 0.458 and 0.866 and Q's of 50 and 25 respectively

It is clear that the cutoff frequency ω_c of the low pass is the equivalent of half the bandwidth of the band pass. If the bandwidth of the band pass is denoted by w and the midband frequency by ω_0, one observes that Eq. 12 for the band pass becomes

$$\frac{2\delta}{w/2} = \frac{2\delta}{\omega_0}\left(\frac{2\omega_0}{w}\right) = \frac{2\omega_0}{w}\,Q_0^{-1} \qquad (61)$$

Hence in applying the preceding formulas to a band-pass filter one must recognize that the pertinent Q is Q_0 multiplied by the factor $w/2\omega_0$, Q_0 being the value appropriate to the band-pass structure at its midband frequency. Since $w/2\omega_0$ is small, it is clear that the band-pass structure must have a much larger Q (at its mean frequency) for the net results to be comparable to those of an equivalent low-pass filter.

REFERENCES

(1) Guillemin, E. A., "Communication Networks", John Wiley and Sons, Inc., Vol II, p. 420.
(2) loc. cit. p. 445.

Multivibrator Circuits

Basic types presented for convenient reference, with characteristics of each, waveforms at different points, frequency-determining equations, and representative values of components. Three methods of injecting synchronizing signals are shown

By NORMAN W. MATHER

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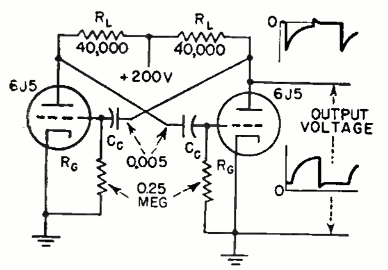
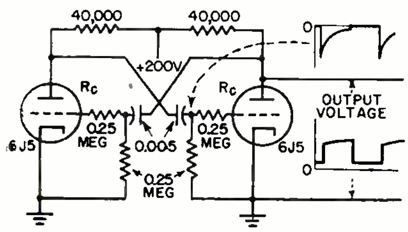
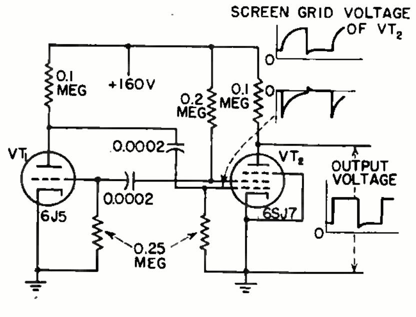


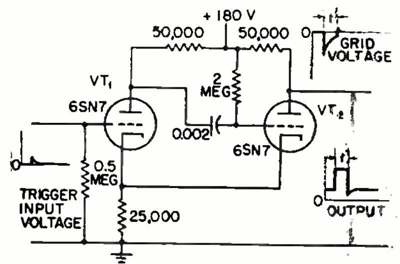
SYMMETRICAL MULTIVIBRATOR—Grid returns are made to the cathodes. This is a basic form of the multivibrator in which corresponding circuit elements used in conjunction with the two tubes are identical. The frequency depends chiefly upon the time constant and in most cases this can be simplified to R_GC_C with little error. For grid returns to the cathodes as shown, the frequency is approximately $0.3/R_GC_G$, but it also depends to a small extent on the tube characteristics and the supply voltage. Connecting the grid returns to the plate supply lead results in a higher frequency, approximately equal to $1/R_GC_C$. Frequency variation can be obtained by connecting the grid returns to an adjustable positive voltage. The amplitude of the generated waves is proportional to the supply voltage, and is only slightly affected by changes in the grid return connection. At high frequencies, distributed capacitances reduce the amplitude and make calculation of frequency difficult



SQUARE-WAVE MULTIVIBRATOR—Addition of resistors R_C to the symmetrical circuit results in a plate-voltage waveform which is approximately a square wave. The frequency of oscillation is affected only slightly by the addition of these resistors

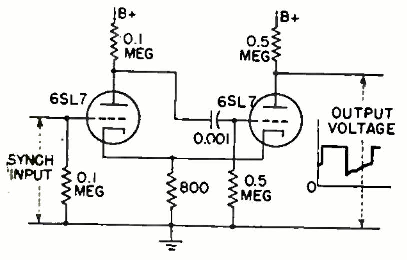
MULTIVIBRATOR WITH ELECTRON-COUPLED OUTPUT—The cathode and first two grids of the pentode operate in the same manner as the second triode in a conventional multivibrator circuit, the screen grid taking the place of the plate. The output waveform of this circuit has a large amplitude and is almost square. Due to the characteristics of pentodes, the plate voltage has little effect on the operation of the multivibrator portion of the circuit and the frequency of oscillation may be estimated in the same way as for conventional multivibrators



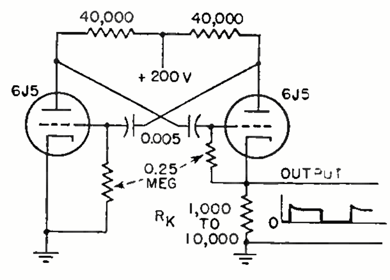


CATHODE-COUPLED ONE-SHOT MULTIVIBRATOR—Circuit values are adjusted so that VT_1 is cut off when VT_2 is conducting. The trigger signal interrupts this stable condition, but after the period t, the circuit automatically returns to the stable condition. If the grid return of VT_2 is made to cathode instead of to +180 volts, a somewhat longer period is obtained. This circuit has the advantage that the triggering circuit is isolated from the multivibrator circuit by VT_1

CATHODE-COUPLED MULTIVIBRATOR—This circuit is particularly adapted to synchronization, and the output voltage can be used without disturbing the circuit operation. As a free-running multivibrator, the frequency tends to be erratic



MULTIVIBRATOR WITH CATHODE-COUPLED OUTPUT—This circuit is useful because it has a low-impedance output and a steep wave front on the output signal. The addition of R_K affects the free-running frequency only slightly.



(Continued on page 138)

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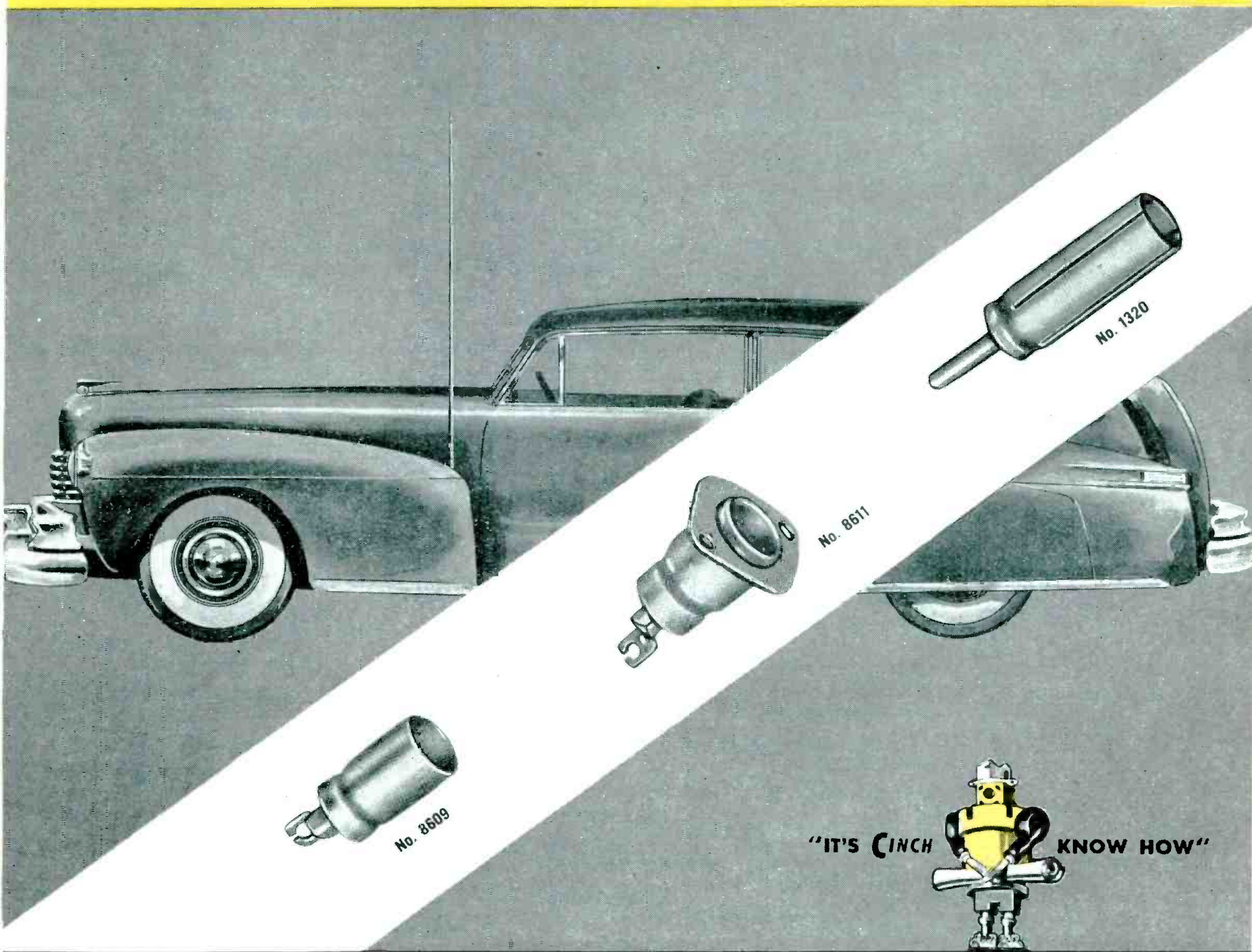
are Standard

The Cinch Antenna Connector No. 1320 provides a positive ground on the receiver side of the shielded antenna lead-in, from the exterior antenna into the receiver case. Its eight cutting edges give a positive grounded connection when inserted into an 8600 rivet socket. Socket No. 8611 is mounted on the chassis by a screw or rivet, and Socket No. 8609 may be spot welded. These antenna connectors have been recognized as *Standard* by leading automotive set makers for over a decade. Other types are available; samples and further information on request.



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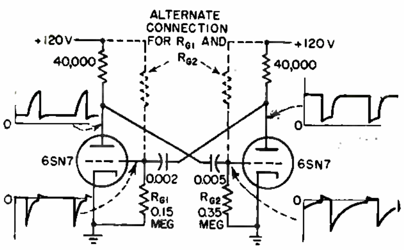
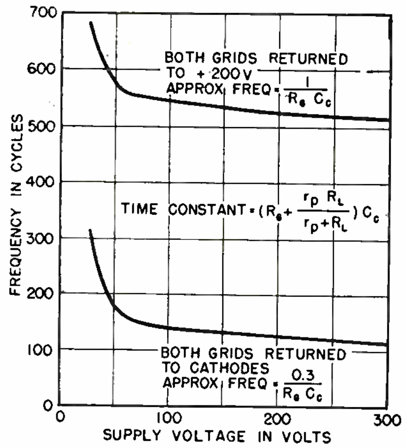
MULTIVIBRATOR CIRCUITS

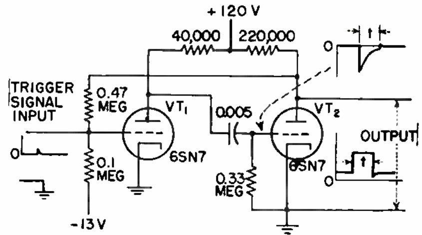
(Continued from page 136)



ASYMMETRICAL MULTIVIBRATOR—Same as symmetrical multivibrator except that corresponding circuit elements used in conjunction with the two tubes are dissimilar. One or both of the grid returns may be made to a positive voltage. The tubes used may be of different types. The frequency of oscillation can be estimated by calculating a pseudo frequency for each tube as though the circuit were symmetrical. The approximate frequency of the asymmetrical multivibrator is then $2f_1f_2/(f_1 = f_2)$ where f_1 and f_2 are the pseudo frequencies. Oscillation can be obtained with widely different circuit components, giving considerable design leeway

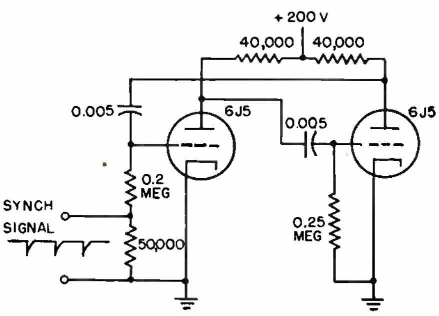


EFFECT OF SUPPLY VOLTAGE ON FREQUENCY OF TYPICAL SYMMETRICAL MULTIVIBRATOR—A multivibrator is relatively insensitive to changes in the supply voltage except when the supply voltage becomes quite low. The increase in frequency obtained by changing the grid returns from the cathodes to the plate supply lead is clearly shown. The amount of increase can be made greater by making the cathodes 2 or 3 volts positive

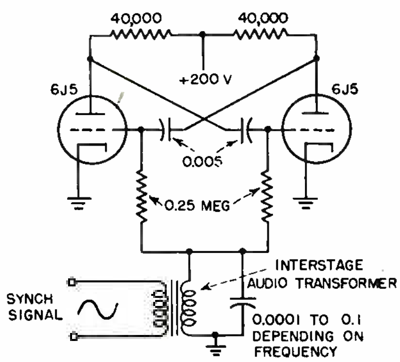


ONE-SHOT MULTIVIBRATOR—Also called one-kick trigger circuit. Feedback from VT_2 is direct coupled to VT_1. Feedback and the plate supply voltage are adjusted so that VT_1 is cut off when VT_2 is conducting. This stable condition can be interrupted by a positive trigger signal on the grid of VT_1. After a short period t the circuit automatically returns to the stable condition. Somewhat more accurate timing can be obtained by making the grid return of VT_2 to +120 volts instead of to the cathode. The period t is approximately half the period of a symmetrical multivibrator having circuit elements corresponding to those used with VT_2 in this one-shot multivibrator circuit

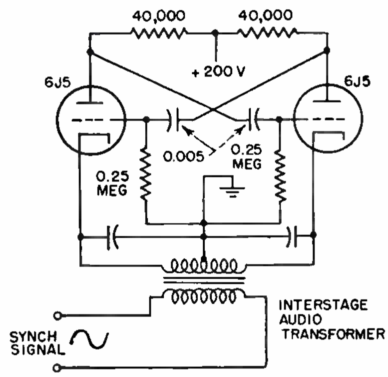
THREE METHODS OF INJECTING SYNCHRONIZING SIGNALS



SYNCH INPUT TO ONE GRID—This circuit tends to favor the odd submultiples of the synchronizing frequency when a sine-wave synchronizing signal is used. When pulses are used, synchronization occurs more readily with negative pulses



SYNCH INPUT TO BOTH GRIDS—Method of injecting synchronizing signal on both grids with the same phase. This circuit tends to favor even submultiples of the synchronizing frequency and should not be used when frequency ratio is one to one



SYNCH INPUT TO BOTH CATHODES—Method of injecting the synchronizing signal so that it is out of phase on the cathodes. This circuit tends to favor odd submultiples of the synchronizing frequency applied through the transformer

ELECTRONICS REFERENCE SHEET

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TUBES AT WORK

Edited by VIN ZELUFF

Buzzer Signal Generator for 3,000 Mc

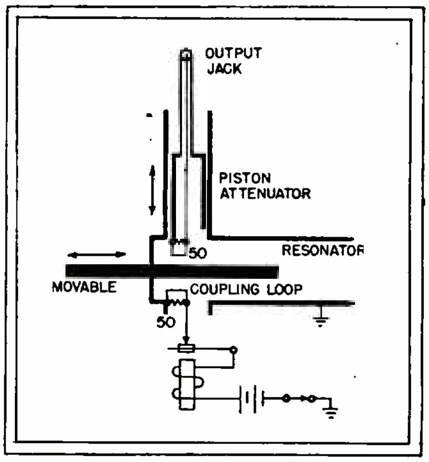
DAMPED OSCILLATIONS in a tunable concentric line resonator are produced by a battery-operated buzzer in a microwave signal generator developed under auspices of Panel 15 of OSRD.

When the buzzer is operating, the interruptions at the armature contacts produce pulses of r-f energy of complex wave form. The actual r-f energy produced is very small; it may be considered to be in the form of recurring damped oscillations with the recurrence frequency determined by the frequency of vibration of the armature of the buzzer. This frequency is adjustable between 1000 and 2,000 cps, subject to mechanical limitations of the buzzer.

The recurring pulses of r-f energy produced by the buzzer are fed to the tuning unit through a short length of concentric line connected to a coupling loop within the resonator. This coupling loop is shunted by a 50-ohm disc resistor to reduce spurious resonance in the coupling loop.

The tuning unit is a concentric line type resonator, the center conductor of which can be varied in length by means of a rack and pinion drive. This drive is controlled by the main frequency control on the front panel. Variations in the length of the portion of the center conductor that is within the fixed-length outer conductor change the resonant frequency of the resonator from 1,000 to 3,500 mc.

The pulses of r-f energy from the buzzer apparently have steep wave fronts which are capable of shock-exciting the resonator. In the complex wave form, components of many frequencies are present but the introduction of the high-Q resonant circuit causes the r-f energy at the resonant frequency to predominate. This sets up an r-f field in the resonant line of the tuning unit at the moment of each pulse. Some of this pulsed r-f energy is



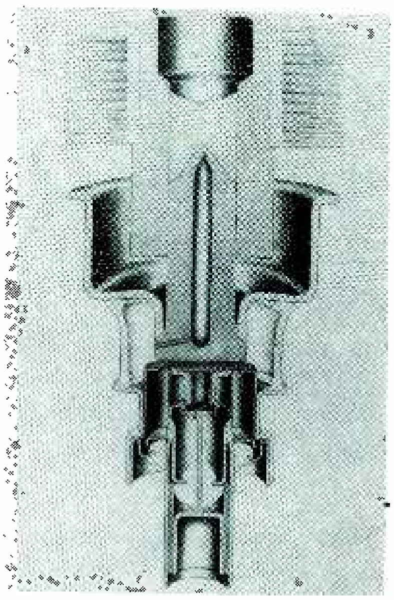
Circuit of simple microwave signal generator

fed to the output circuit through an attenuator.

Some of the magnetic flux developed in the resonator extends into the end of the attenuator cylinder. This flux within the cylinder decreases exponentially with increasing distance from the resonator. Therefore, as the coupling loop is moved up and down the tube, a varying amount of magnetic flux is linked by the loop; this results in a variable pickup of energy. Maximum pickup occurs when the coupling loop projects out of the tube just into the resonant cavity. An output of several hundred microvolts into a 50-ohm load is provided.

A piston-type attenuator is used, consisting of a cylinder and a piston which carries the output coupling loop. A coaxial cable connects the loop to the output connector. This assembly is attached to a port on the resonator cavity. The position of the piston coupling loop in the cylinder is adjusted by means of a rack and pinion connected to the attenuator control on the panel.

The Front Cover



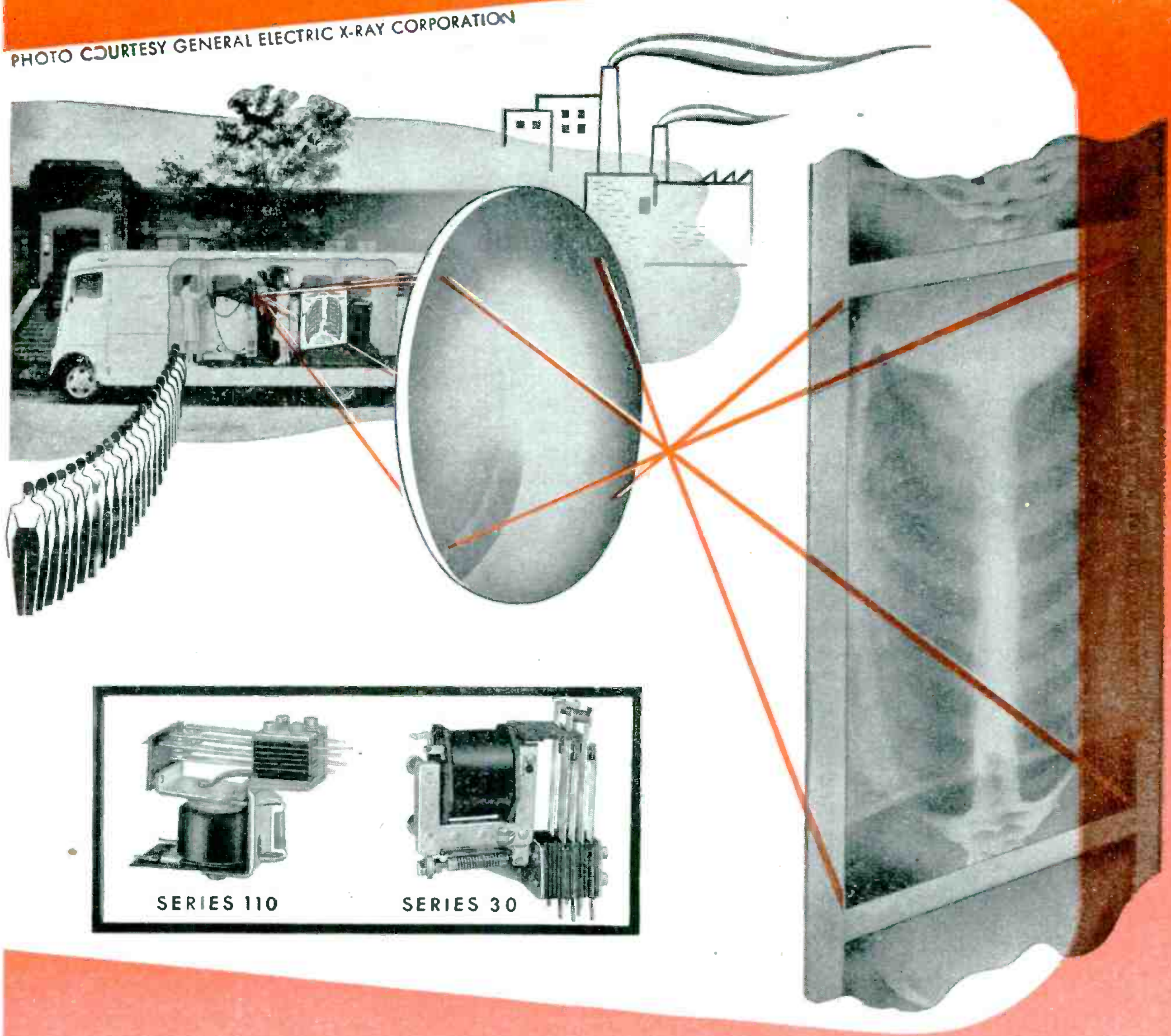
Cut-away view of the Eitel-McCullough, Inc., type 2C38 triode used to generate the 12-cm waves shown on the front cover of this issue. The tube is 2¾ inches long, and has a maximum diameter of 1¼ inches. At 2500-mc the 2C38 in the oscillator pictured delivers a minimum power output of 12 watts at 15 per cent efficiency.

The extremely close electrode spacings required in the 2C38 are maintained in mass production by the mating of preformed stepped cylinders and rings mounting the grid and cathode. Such spacings, plus functional electrode terminations, permit the tube to operate as an oscillator and amplifier throughout the uhf region.

Tubeless Converter for New F-M Band

By H. A. AUDET
Engineer, Canadian Broadcasting Corporation Montreal, P. Q.

A SIMPLE AND EFFICIENT method of converting f-m receivers for use in the new 88 to 108-mc band is to use the original local oscillator to supply r-f to the mixers to be added ahead of the receiver. Germanium



GUARDIAN RELAYS
AID MASS X-RAY SURVEYS

The mobile X-ray unit shown above (product of General Electric X-Ray Corporation) is accomplishing early diagnosis of tuberculosis through mass surveys. Hastens isolation and timely treatment, prevents spreading the infection through municipalities and worker ranks.

Guardian Relays perform important duties in this unit. The exposure button energizes a Guardian Series 110 Relay. This closes the circuit to the holding coil of the X-ray magnetic contactor which controls the timing circuit of the high voltage transformer. As X-rays cause the screen to fluoresce, the image passes thru the lens to a photographic film, a photo-electric cell picks up the light energy, timing the exposure by transferring the light energy in the form of an electric charge into the condenser up to the saturation point. Then a trigger tube (OA 4-G) flashes, energizing a Guardian Series 30 Relay to open the holding coil contactor circuit and terminate the exposure. From start to finish—Guardian Relays perform with utmost dependability. They will perform dependably for you. Write.

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1625-L W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

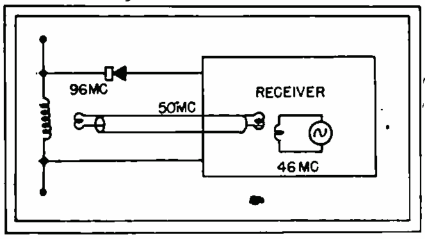


Fig. 1—Simple converter for prewar f-m receivers. The line couples the original oscillator to the new mixer

crystals suggest a simple arrangement for the mixers.

Figure 1 shows a receiver designed to operate at 50 mc. A simple converter formed of a coupling coil and a crystal mixer has been added between the antenna and the receiver. The local oscillator frequency is fed back through a coaxial line to the coupling coil. This arrangement permits receiving a 96-mc signal on the 50-mc receiver. This system has given excellent results and the efficiency of conversion is good.

A particular case is that of the JFM-90 General Electric translator, in which the antenna coil and the local oscillator coil are wound on the same form. It was found that enough of the local oscillations were fed into the antenna coil to operate the converter successfully without the coupling link between the local oscillator and the coupling coil. As the local oscillator frequency is approximately 19 to 23 mc, it was found desirable to raise that frequency to 21 to 26 mc to cover the new band. A better band coverage can be obtained by the addition of capacitors in the tuning and oscillator circuits of the translator. The best results were obtained with a two-stage converter as shown in Fig. 2, although a one-stage converter gave satisfactory results.

Performance

On program material, no difference could be noticed between reception on the old band with the JFM-90 translator alone and reception on the new band with the JFM-90 equipped with the new converter. Tests with a signal generator showed a maximum sensitivity of ten microvolts, while the maximum sensitivity of the JFM-90 alone was in the vicinity of five

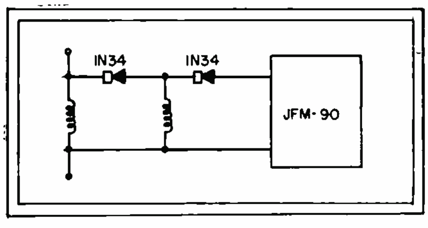


Fig. 2—Double converter for the JFM-90. The coils are ten turns of No. 16 wire on a ½-inch diameter form

microvolts. These voltages were taken at the point where the limiter tube began drawing grid current. No serious frequency drifts were experienced during the tests. The construction of the equipment needs no special care and the crystal cartridges can be mounted in any position.

Sonar Uses Doppler Effect

A WELL-KNOWN scientific principle, the Doppler effect, provides the means for determining the motion and speed of a moving underwater target with echo ranging equipment. If the distance between the sonar-equipped search vessel and the target is increasing, the frequency of the echo will be lower than that of the outgoing pulse. Conversely, if the distance is decreasing, the echo frequency will be higher.

By comparing the frequencies of the echo and transmitted pulse, the sonar operator can determine the relative motion of the target with respect to the ship. This is less important, however, than determination of the absolute motion of the target. Water discontinuities, such as surface waves, provide fixed reflecting points (reverberations) that provide a more useful reference than the outgoing pulse does. By comparing the frequency of the target echo with the frequency of the reverberations, the operator can determine if the target is moving and whether it is moving toward or away from the projector. The change in frequency is 17 cycles per second per knot of absolute speed of the target when echo ranging at a frequency of 24 kc. Sonar operators are trained to distinguish frequency changes as small as 10 cycles, hence target speed can be determined to an accuracy of better than 1 knot.

Radioactive Infrared Detector

THE METASCOPE is another infrared device that, secret until now, was used during the war. It is small enough to be held in one hand, and was used to detect the presence of infrared light. By looking through the eyepiece, paratroopers in planes could detect infrared radiation which signaled them where to land. For such use, the comparatively heavy power pack needed for the sniperscope and the snooperscope (ELECTRONICS, June 1946, p. 95) prohibited its use where weight was a critical factor. Like those units, the metascope was made by Electronic Laboratories of Indianapolis.

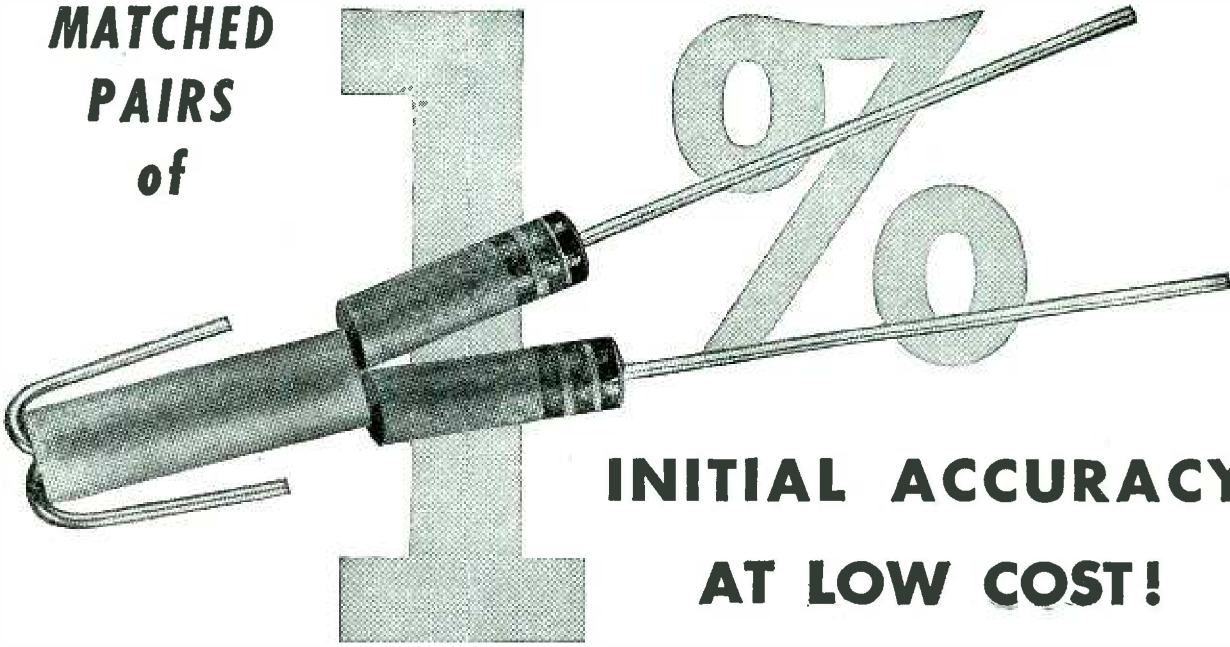
A type of nuclear reaction is the operating principle of the unit. A

The metascope, an infrared detector used by the U. S. Army

small lead-sheathed compartment in the base of the metascope, containing a radio-active material, is the power source. Energy from the radioactive material is used to charge a viewing screen which is thus made sensitive to infrared radiation. Mounted in the cover of the device is a periscope-like mirror with an infrared filter. This is raised to pick up the infrared rays and in use faces the direction the operator is looking.

Because of its small size and light weight, the metascope was carried by field units and used to determine whether the enemy in a

MATCHED PAIRS of



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IRC introduced Matched Pairs, has matched millions of BT Metallized and BW Wire Wound Resistors. Both types are stable, excellent for close tolerance requirements. Matched Pairs are widely used as meter multipliers and recommended for any application requiring low cost close initial tolerances.

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Type	*Minimum Resistance*	*Maximum Resistance*	*Minimum Resistance*	*Maximum Resistance*
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BW-1	2.5 Ohms	2550 Ohms	10 Ohms	10,200 Ohms
BW-2	3.75 Ohms	4100 Ohms	15 Ohms	16,400 Ohms
BTS	235 Ohms	10.0 Megohms	940 Ohms	40.0 Megohms
BTA	165 Ohms	10.0 Megohms	660 Ohms	40.0 Megohms
BT-2	235 Ohms	10.0 Megohms	940 Ohms	40.0 Megohms

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HERMETIC SEALING—A wondrous process which was a government "Must" when ordering Transformers and Reactors for war use. At that time we could take no chances on faulty equipment that might seriously hinder military operations and inadvertently cause unnecessary loss of life among our fighting men.

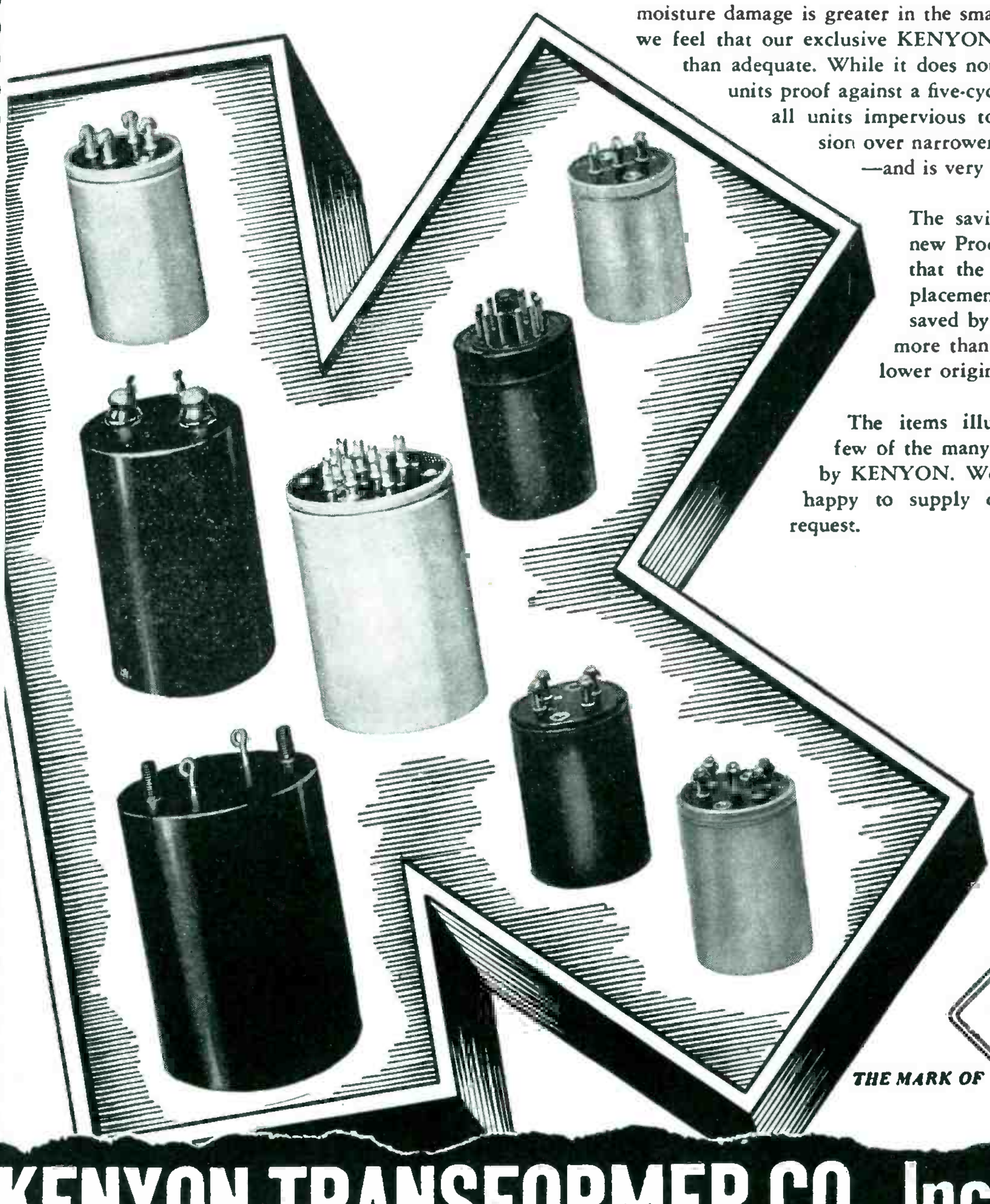
EXPENSIVE—yes, but added costs meant little when the only thing really important was winning the war.

IN PEACE—we at KENYON are of the opinion that such expense is not warranted. Past performance of ordinary transformers shows conclusively that sealing in a metal case with humidity proof compound along with proper mechanical design is sufficient. This conclusion is self-evident if you will weigh all cost factors involved.

SMALL AUDIO-COMPONENTS — KENYON has developed a range of case sizes (illustrated) which are adaptable to Hermetic Sealing and also to a new exclusive KENYON PROCESS. Despite the fact that the danger of moisture damage is greater in the small audio-component, we feel that our exclusive KENYON PROCESS is more than adequate. While it does not make 100% of the units proof against a five-cycle test, it does make all units impervious to salt water immersion over narrower temperature ranges —and is very much less expensive.

The saving involved by this new Process is so substantial that the cost of the few replacements that might be saved by Hermetic Sealing is more than offset by this much lower original cost.

The items illustrated are only a few of the many possibilities offered by KENYON. We will be more than happy to supply complete details on request.



THE MARK OF EXCELLENCE

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

particular area was employing infrared light. It indicates the presence of infrared light in a greenish-white glow. However, it does not permit identification of objects seen at night, as does the sniperscope and snooperscope. The device was also used for reading an infrared blinker signal utilized by the Navy.

Facsimile Over 4,000-Mc Relay System

OPERATING EXPERIMENTALLY for nearly a year, a two-way radio relay system on 4,000 megacycles has been serving Raytheon with data on field tests of its equipment between the plant at Waltham, Massachusetts, and its New York City office.

Recently, Hogan Faximile, with equipment manufactured in Radio Inventions laboratories, utilized a 4.8-kilocycle band within the 15-kilocycle wide Raytheon channel for the transmission of facsimile text, maps, and photographs from New York to the Waltham terminal. The facsimile signal was transmitted at the rate of 3 linear inches, or 24 square inches a minute of copy. A wire line carried the signal from Radio Inventions laboratories in New York to the Lincoln Building, where it modulated a microwave radio transmitter.

Later, a radio program from

Facsimile receiver at Waltham recording a map of repeater station locations over Raytheon 4,000-mc relay circuit from transmitter in New York

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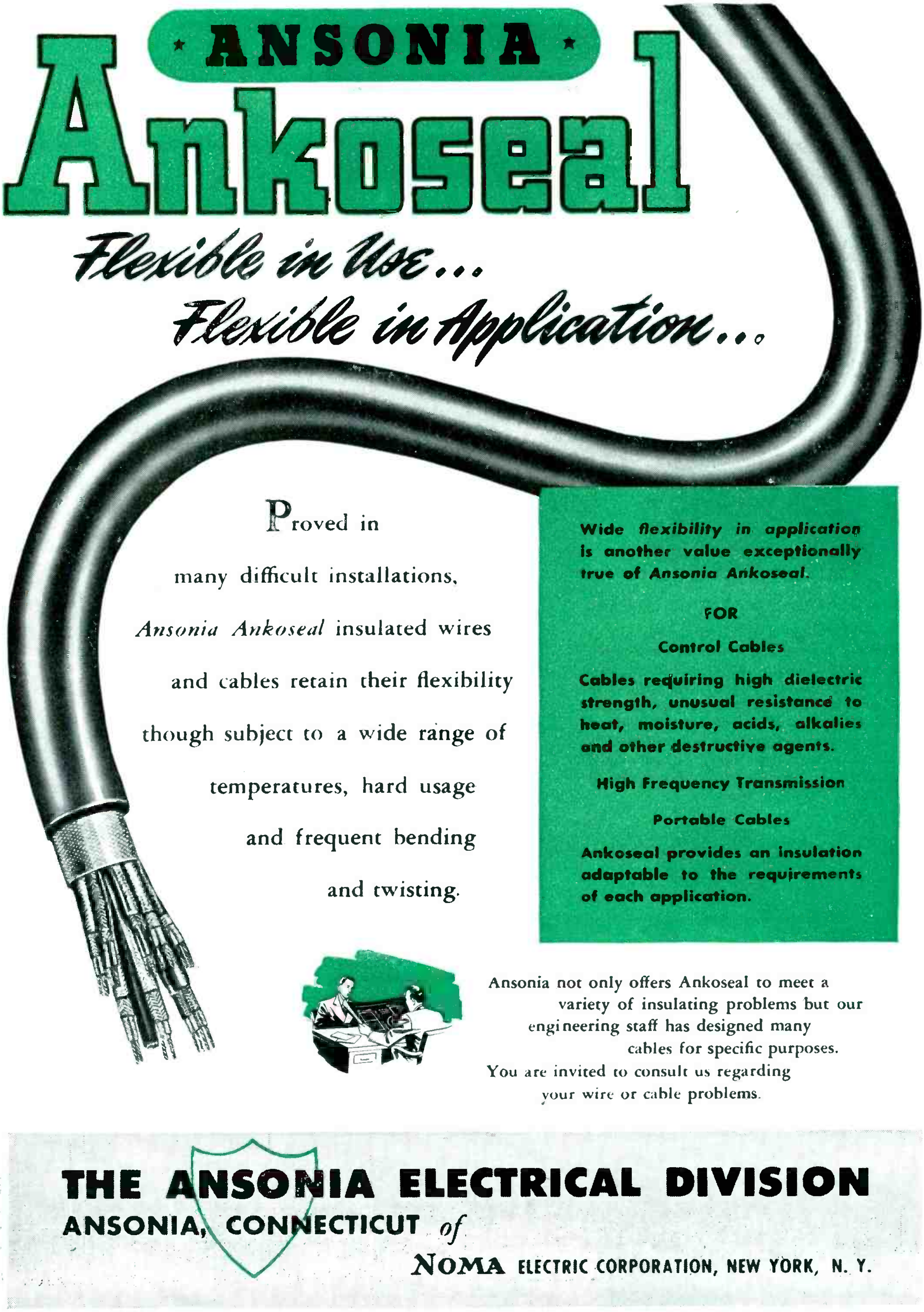
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THE ANSONIA ELECTRICAL DIVISION
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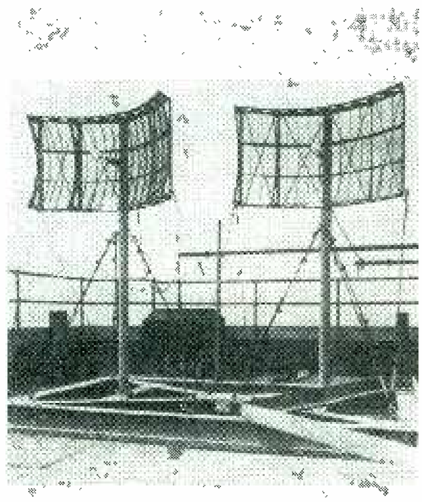
WOR in New York was transmitted over the circuit simultaneously with text from a teleprinter in the New York terminal.

Automatic repeater stations in



Transmitting and receiving antennas of the Raytheon microwave relay system atop the Lincoln Building, New York City

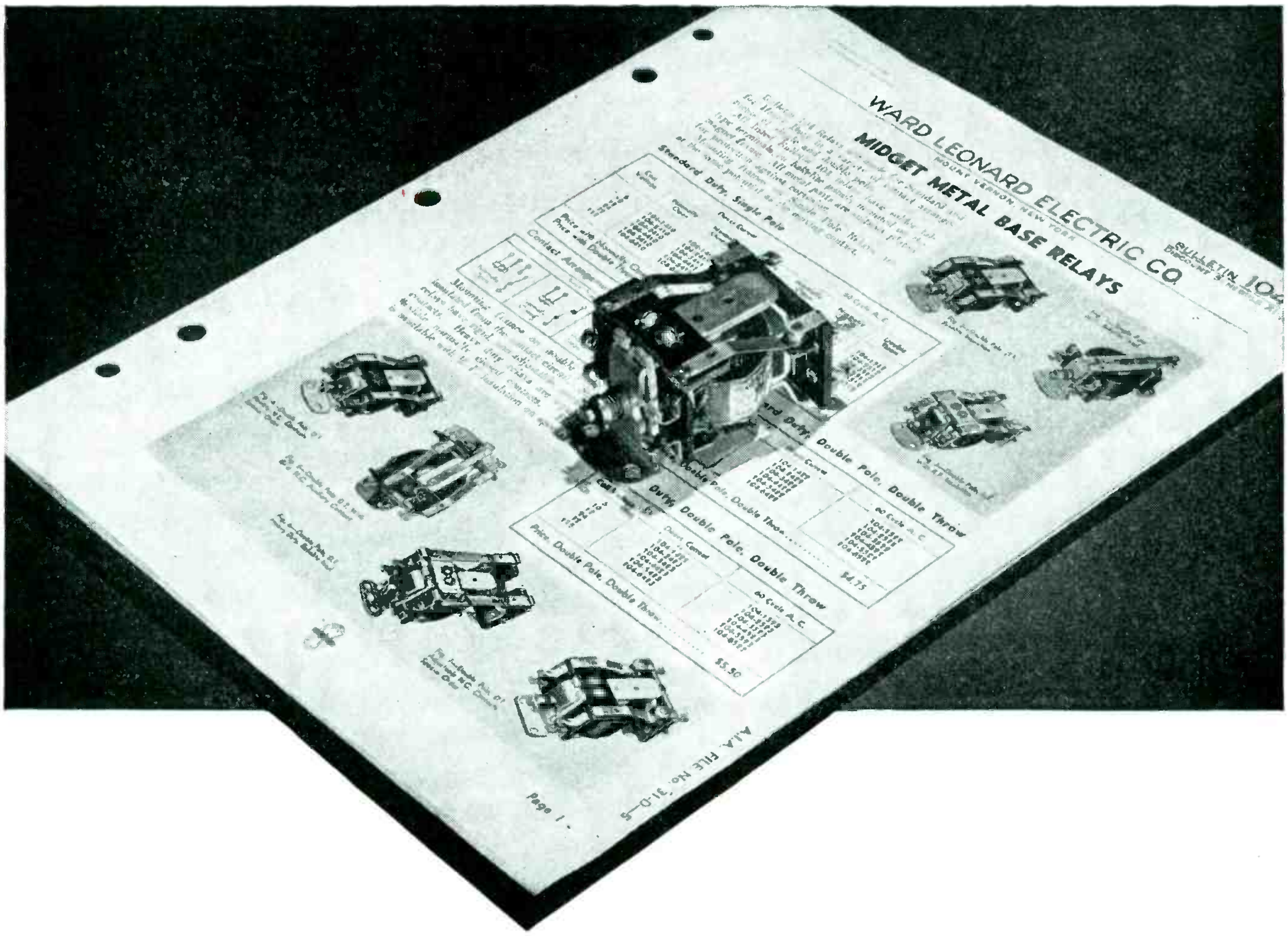
the system are located at Waban and Webster, Massachusetts; Tolland, Bristol, and Oxford, Conn.; and Lewisboro, New York. A two-way circuit operates 24 hours per day over the system, carrying various types of intelligence on an experimental basis.

London Letter

By JOHN H. JUPE
London Correspondent

336 Channels for VHF. The ASAC (Automatic Selection of All Channels) system was originated by the General Electric Co. of Great Britain to provide communication on any one of a large number of equally spaced crystal-controlled radio channels. The equipment shown at the Physical Society's Exhibition in London early in the year provided 336 channels, controlled during transmission and reception by only 3 crystals, selection being made remotely by means of numbered or lettered dials. During tuning, the master oscillator tuner is driven by a motor, controlled by the counting on a telephone-type uniselector of coincidences with harmonics of a multivibrator.

Any channel can be reached



you want to know more about

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This group, Bulletin 104 Relays, includes standard and heavy-duty types, in a wide variety of contact arrangements, of single and double pole for front or rear mounting. They are positive in action, they are compact, they are sturdy. When designing any equipment that requires a relay function, see what Ward Leonard has to offer you. Ward Leonard Relays include types and sizes for every application. They all have crisp action, are dependable and durable yet consume but little current.

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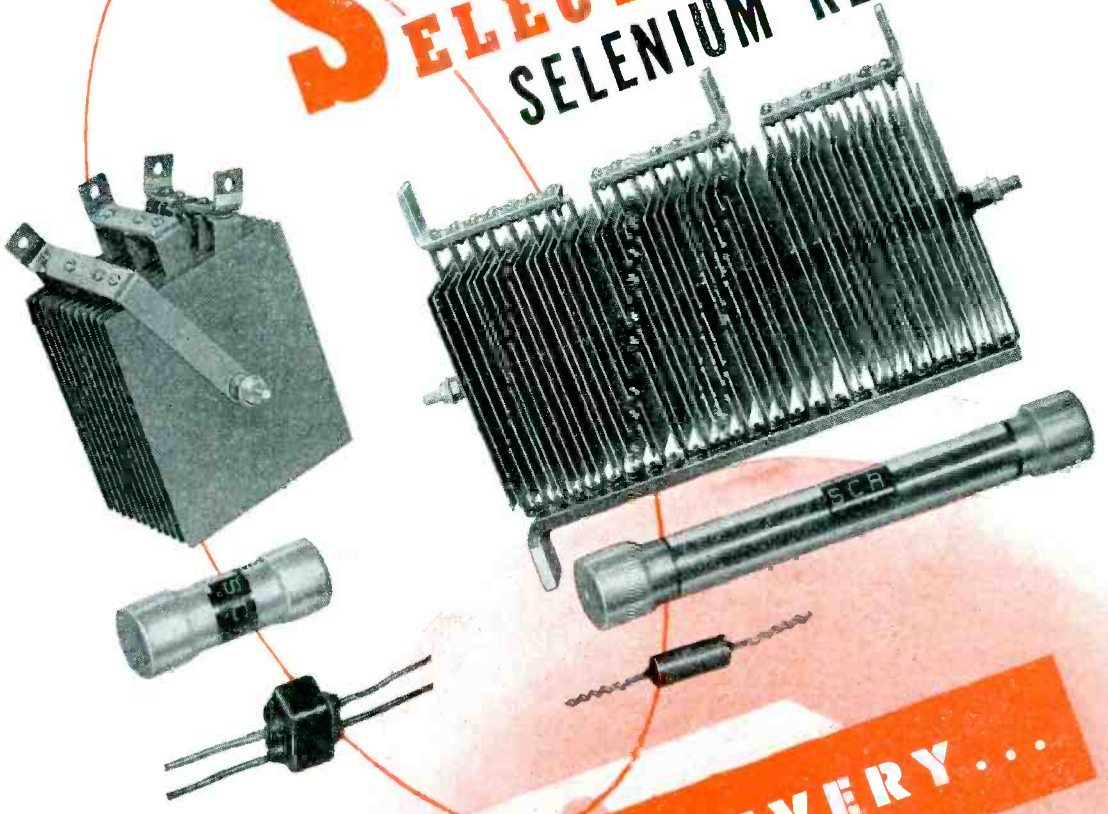

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SCA

46-B

within five seconds and the frequency is held constant within ten kilocycles by an automatic frequency control system. The set exhibited covered the region of three meters but the principle can be applied to other bands.

Low-Brightness Measuring Equipment. Portable equipment, made by the same company, is suitable for measuring brightness of the order of 0.3 candle per sq.ft. It is intended for:

(a) Brightness measurement in lighting schemes (including studio sets), (b) Brightness distribution measurement on sources and fittings, (c) cinema screen brightness areas and for checking narrow beam projectors.

The principle of operation consists in forming an image, by means of a lens, of the object and scanning this with a scanning disc. The light passing through the disc is focussed on an electron-multiplier type of phototube and the signal generated is amplified and applied to the Y plates of an oscilloscope. The linear time-base sweep is applied to the X plates and is locked synchronously to the scanning disc.

Thus the luminous spot on the tube moves in accordance with the brightness distribution of the subject under observation. A view finder is mounted beside the oscilloscope screen so that the instrument can be trained on the object desired.

Recording Magnetometer. An instrument shown by the British and Allied Industries Research Association is designed to measure and record a given component of a magnetic field of the order of 10^{-3} gauss and is intended for investigations on the earth's magnetic field in an east-west direction. At maximum sensitivity, a field of 0.5×10^{-3} gauss will give full scale deflection on the recorder but the sensitivity can be reduced to cover fields up to 50×10^{-3} gauss. Errors due to power supply and temperature variations have been reduced to small dimensions and the error on maximum sensitivity of the whole instrument does not exceed one per cent.

The sensitive element of the magnetometer consists of two lengths

Here's one place radiography more than pays its way . . .

IN MACHINING: it's big money lost when parts with internal defects aren't discovered until after machining starts. Using x-ray, you can screen out all but an irreducible minimum of such faulty castings *before* machining . . . never miss what you pay out for x-rays because of what you get back in time and labor savings.

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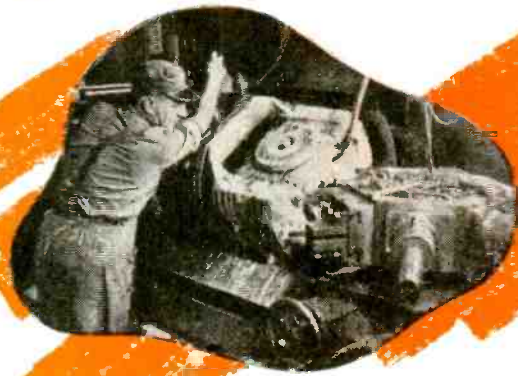

IN FOUNDRY OPERATIONS: no need to spend a lot of time and money testing the practicality of new casting designs . . . the soundness and safety of proposed weight reduction . . . the correctness of foundry technics. With radiography, you can quickly correct unsound practices . . . save enough thereby to more than pay for the radiographs used.

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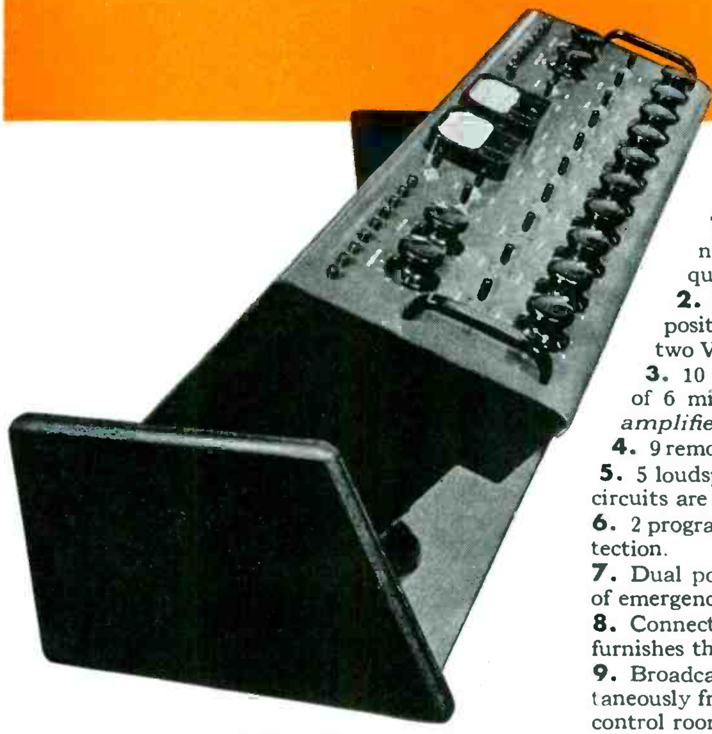
of Mumetal wire, the a-c resistances of which change with the magnetic field in which they lie. They are placed in the direction of the field to be measured and connected in adjacent arms of a bridge circuit. A field of 0.4 gauss is applied to each in opposite directions and reversed at intervals. The unbalance of the bridge is amplified, rectified, and applied to a vacuum-tube switching device which also controls the reversion of the 0.4-gauss field. This switching device enables the two out-of-balance voltages across the bridge to be stored in separate capacitors, which are connected to a vtvm so that its indication is a measure of the difference of the two voltages.

If there is no external field in the direction of the wires, the reversing of the 0.4-gauss field will not result in an out-of-balance voltage and the vtvm will indicate zero. With an external super-imposed field, an out-of-balance voltage will appear and the voltmeter will indicate it. Such an instrument has many uses apart from the one mentioned.

Piezoelectric Vibration Pickup. A hand-held instrument was exhibited by the De Havilland Aircraft Co. Its chief uses are to indicate resonance peaks, phase angles, and vibration frequencies, and also for exploring nodal patterns in large and irregular structures. It consists of a seismic body element conveniently shaped and inside which is a cantilever spring vane. At the free end of this is pressed the pickup stylus, which slides in Oilite bushings. This stylus transmits vibration movements to the vane and the resulting bending strains at the root of the vane are transferred to a piezoelectric element of the bender type which is cemented flat to its surface. The crystal develops a potential between its surfaces directly proportional to the bending and therefore directly proportional to the vibration amplitude, without the use of integrating circuits.

The vibration of the vane is damped, to prevent chatter, by pads of rubber clamped about it, between the stylus and the crystal. The pickup body is fitted with two rubber feet so that it may be stood on

Everything you need in a console



Here are 9 good reasons why the Collins 212A-1 speech input console is superior for AM and FM applications:

1. High fidelity—30-15,000 cps within 2 db. The clear noise-free output of this new console maintains the high quality of your program.

2. Operator convenience—sloping front panel, lever type positive action switches, push button remote line selection, two VU meters, and maximum accessibility.

3. 10 independent input channels—simultaneous operation of 6 microphones and two turntables, *with individual pre-amplifiers for each,* and two remote channels.

4. 9 remote lines with push button selection and monitor facilities.

5. 5 loudspeakers fed by the monitor amplifier—selective talkback circuits are interlocked to prevent program interruption.

6. 2 program amplifiers—provide dual operation or emergency protection.

7. Dual power supplies available—automatic switch-over in case of emergency.

8. Connections for external on-the-air light relays. The 212A-1 furnishes the power.

9. Broadcasting, rehearsing and cueing can be performed simultaneously from any combination of two studios, an announce booth, control room microphone, two turntables, and nine remote lines.

The 212A-1 will give added efficiency to your operations. Its attractive, dignified, metallic gray and black finish will enhance the appearance of your studio. Let us send you complete details of this and other Collins broadcast accessories.

Exclusive with Collins! The up-to-the-minute design allows the entire console to be tilted for under-chassis access, *without requiring any additional space.* The 212A-1 can be placed against a window or wall without sacrificing accessibility.

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a vibrating body as a vibration indicator while the exciting frequencies are adjusted.

Remote Cloud Indicator. This instrument was developed by the B.T.H. Co. and government departments to give information as to when a barrage balloon was flying in clouds. The balloon unit consists of a detector and a simple amplifier-radio transmitter.

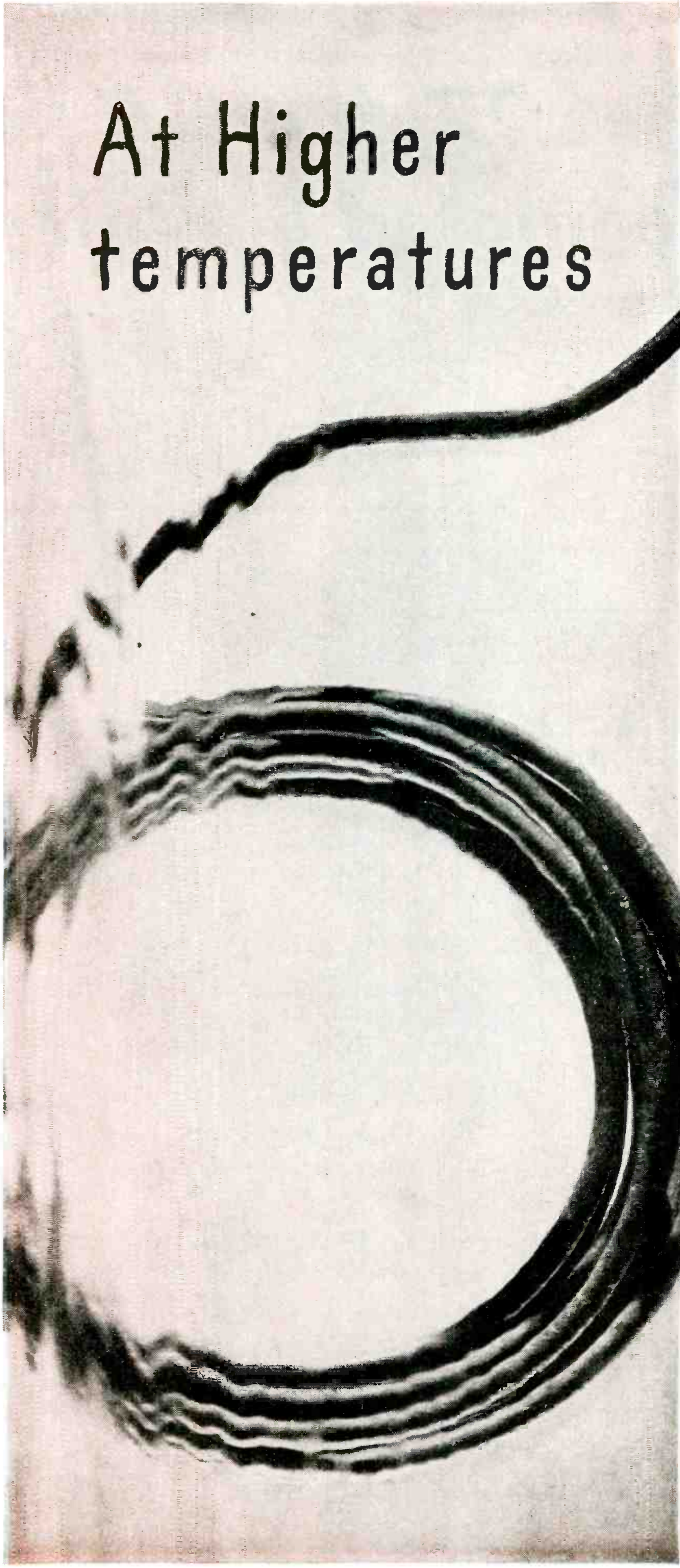
The detector element consists of electrical conductors separated by a gap which can be bridged by cloud particles, the surface being maintained at such a temperature that dew cannot be deposited. One conductor, the potential of which is varied by the cloud drops, is of platinum foil and is insulated from two similar conductors by 0.0004-inch thick mica sheets. The sandwich is placed between mica sheets and then gripped between two stainless steel plates. The surface of this unit is then ground to expose the conductor edges and a low-power heater is bolted alongside to maintain the temperature at about 60 C.

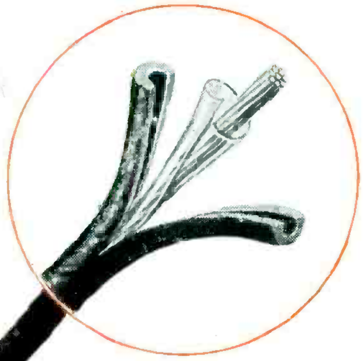
When cloud particles bridge the gaps, which are connected in a thyratron circuit, the tube fires and the anode current operates a relay and small buzzer which transmits the radio signal, the latter being received on an ordinary receiver. The bead of moisture across the gap is blown away by a spark discharge initiated by the operating circuit.

Fuzes for Electronic Mines

ANOTHER WARTIME development to emerge from secrecy with Navy approval is a complex yet highly compact electronic and magnetic fuze for electronic mines. This fuze was used in the 12,053 mines dropped in the shipping lanes and ports of Japan from March 1945 to the end of the war in Operation Starvation. The mines were dropped from Superforts in 1,528 sorties, chiefly with parachutes to break their fall. Toward the end of the war, mines using the same fuzes were developed that could survive a free fall into the water from as high as 30,000 feet, permitting aiming with

At Higher temperatures





You Can Still Give Electrical Equipment The Moisture And Corrosion Protection Of Lumarith Cellulose Acetate Film Insulation.

In combination with asbestos, glass braid, mica or silicones, Lumarith film insulation can be counted on for efficient, long-life operation at temperatures considerably above its rated softening point. That is because Lumarith is a thermoplastic, with chemical breakdown point far higher than this softening point. Lumarith cellulose acetate film insulation will not promote corrosion—even when in contact with current-carrying copper wire and moisture. It provides complete corrosion protection for even the most delicate equipment.

Investigate the electrical possibilities of all Lumarith plastic materials: molding materials, sheets, rods, tubes, films. Send for booklet entitled, "Celanese Synthetics for the Electrical Industry". Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y., producers of LUMARITH, FORTICEL†, CELCON†, CELLULOID*, VIMLITE*.

• • •

ELECTRIC RANGE WIRE (Size 16) . . . Primary insulation, Lumarith *Cellulose Acetate*, secondary insulation, Asbestos. This Lumarith insulated wire is depended upon for efficient operation at temperatures considerably higher than those encountered in average electrical installations

LUMARITH*

A Celanese Plastic*

*Reg. U. S. Pat. Off. †Trade Mark

now . . . N1400

AN IMPORTANT NEW SERIES

of *Erie Ceramicons*

REG. U. S. PAT. OFF.

WITH HIGHER CAPACITIES

CAPACITY RANGES		
STYLES	MIN.	MAX.
A or K	5	100 MMF
T	101	221 MMF
B or L	101	175 MMF
S	222	460 MMF
C or M	175	550 MMF
D	551	895 MMF
E	896	1390 MMF
F	1391	1770 MMF

CHARACTERISTICS

- Temperature Characteristic: −1400 parts/million/°C ±210 parts/million/°C
- K: 135 approx.
- Flash Test: 1300 volts D. C.
- Working Voltage: 500 volts D. C.
- Leakage Resistance: Over 10,000 megohms at 1000 volts D. C.
- Q Factor: 1000 or higher above 30 MMF. Q Factor limit below 30 MMF decreases in a straight line to 500 at 5 MMF.

ERIE is now in production on all standard styles of its new series, N1400 Ceramicons, with a temperature coefficient of −1400 parts/million/°C.

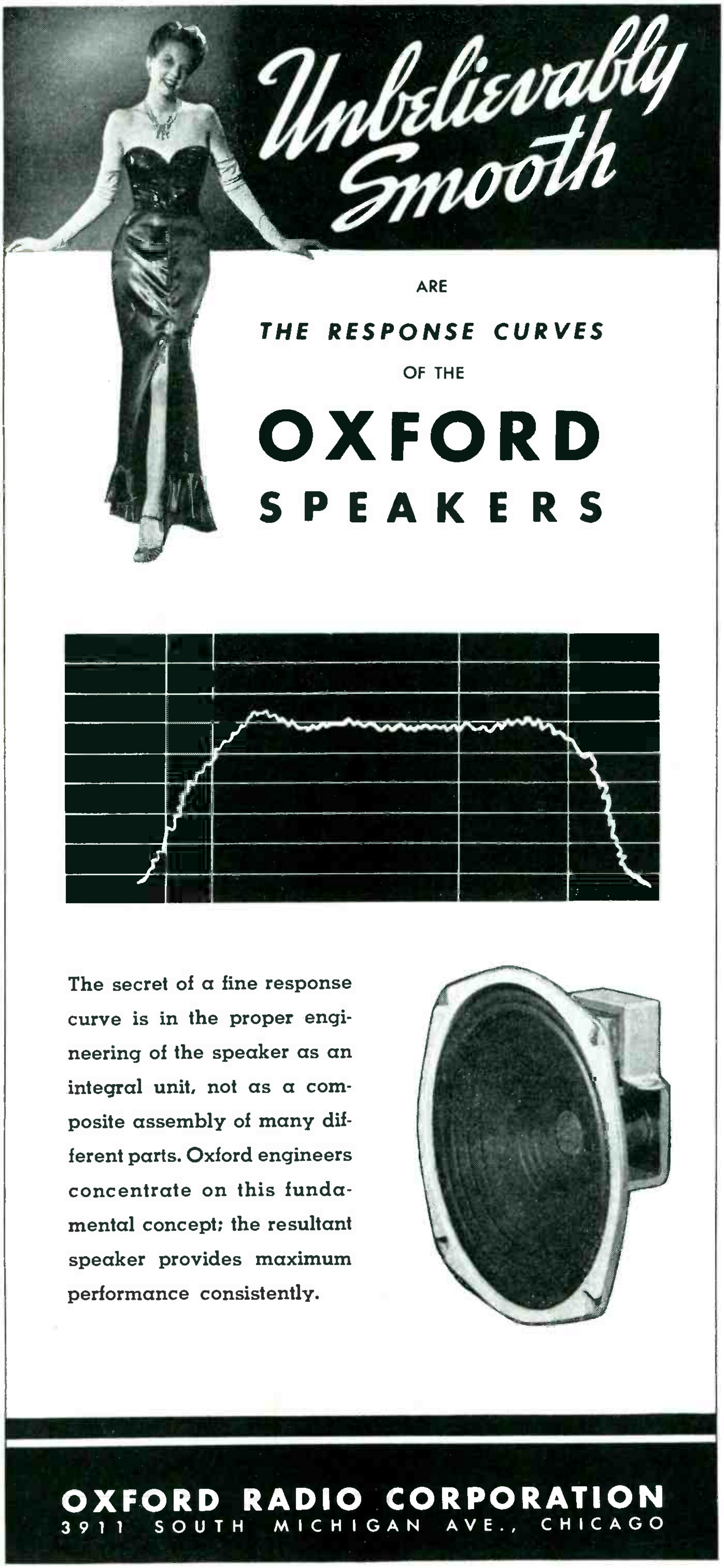
The higher negative temperature coefficient permits use of smaller capacity condensers as compensators, which is often necessary to obtain required tuning range in radio receivers. In addition, for general purpose applications where temperature compensation is not a factor, Erie N1400 Ceramicons offer higher capacity ranges without increased physical size.

The Erie N1400 Ceramicon series has the same characteristics as other Erie temperature compensating Ceramicons; definite and entirely reproducible temperature coefficient of capacity, high Q factor, and inherent stability. Electrical characteristics and capacity ranges are given at the left.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • TORONTO, CANADA



the greater accuracy of the aircraft's bombsight.

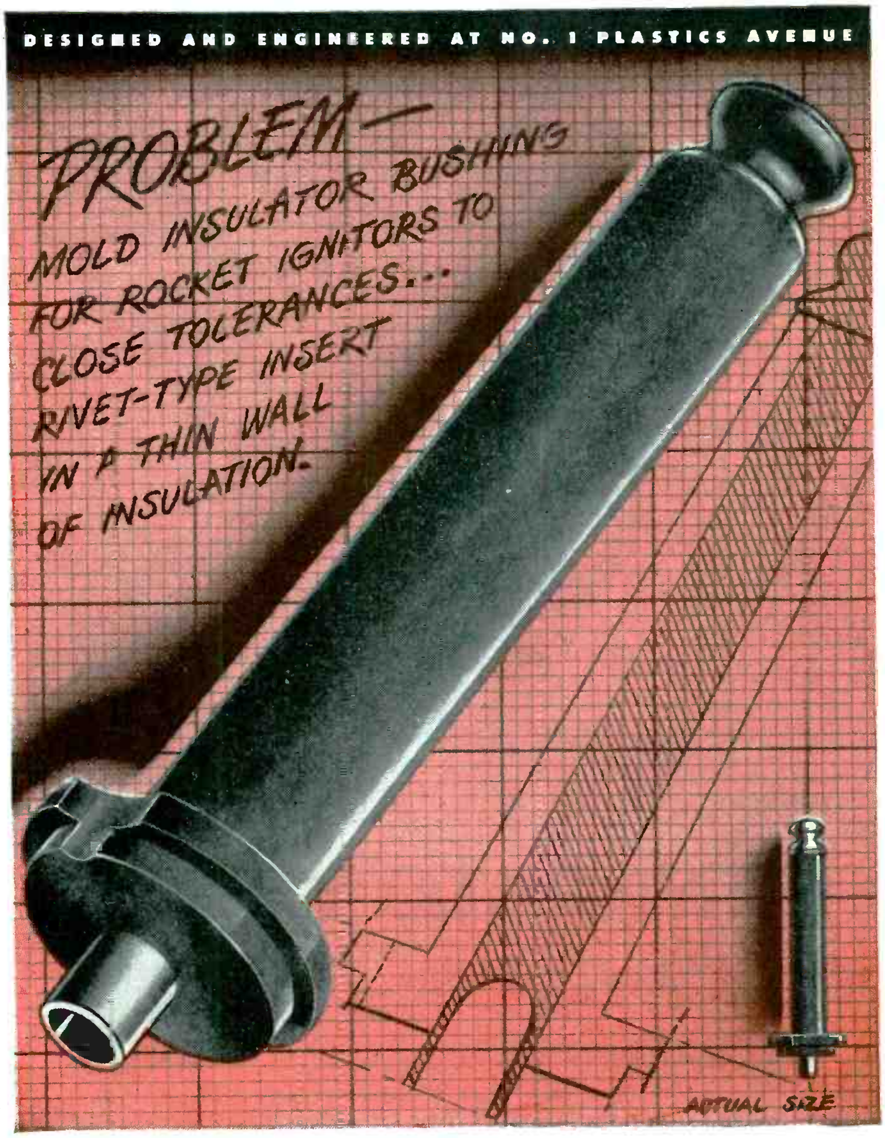
The new fuzes are dependent for their action on permalloy, an alloy so responsive to magnetic influence that it is readily saturated by the earth's magnetic field. A bar of permalloy held in a north-south direction becomes a magnet strong enough to pick up tacks and small nails. The magnetic action of the fuzes was such that they always blew up at the closest point of the designated victim's approach. A large metal-containing object such as a ship disturbs the magnetic influence of the earth around it slightly. The fuze recognizes a ship by the characteristic gradual sequence of increasing and decreasing disturbance, and sets off the mine at the precise moment when the disturbance stops increasing and begins to decrease.

Cold Cathodes

Signals from the detector unit in the fuze are magnified approximately a million times by a magnetic amplifier that also uses permalloy-type magnetic material. Electronic portions of the fuze include electron tubes of a special cold-filament design that operate on minute quantities of power. Other features of the fuze include a timing device that delays arming until a specified time has elapsed, and renders the mine impotent after a predetermined period. A counter in the fuze could be set to let the first ship or any preset number of ships pass by without action, thereby prolonging the effect of a given mine-laying operation. Passage of a ship was no assurance of safety.

Resting on the bottom, the mine could not be swept in the normal way. It could not be detonated by magnetic charges, and its timing device would not permit response to the more rapidly changing magnetic disturbances of mine-sweeping enemy airplanes. The detector likewise would not respond to the magnetic influence of a ship passing too far away to be damaged.

H. O. Siegmund was project engineer at Bell Telephone Laboratories for magnetic fuze development. The fuzes were mass-produced for the Navy by Western Electric Co.



G-E mycalex — precision-molded for rocket ignitors

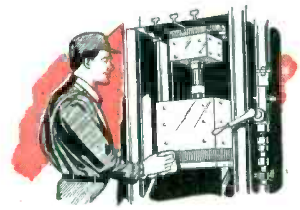
● Here is an experimental redesign of the Rocket Ignitor Bushing, precision-molded in G-E mycalex with a very thin wall section to save assembly operations in the manufacture of the original component. The few parts molded before the end of the war proved successful. And the molded Rocket Ignitor Bushing is an example of how an intricate part can be molded to close tolerances in G-E mycalex.

General Electric engineers who solved tough wartime insulation problems with G-E mycalex will be glad to give you the benefit of their experience. They may show you how precision-molded G-E mycalex parts can save on your over-all insulation costs by eliminating off-size rejects.

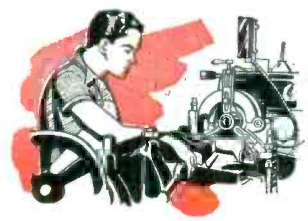
Find out more about G-E mycalex — a stone-hard, gray-colored material, produced by fusing special glass and powdered mica. It is now available in standard sheets and rods . . . fabricated parts . . . parts molded to your own design. Send for our new bulletin, "G-E Mycalex"—it tells the whole story of this unique insulating material. Write to Plastics Divisions, S-14, Chemical Department, General Electric Co., 1 Plastics Avenue, Pittsfield, Massachusetts.

HOW THE G-E MYCALEX SERVICES CAN BENEFIT YOU NOW

You may order fabrication of sample G-E mycalex parts at surprisingly low cost. Test them yourself in your own equipment. Then, if you decide to specify G-E mycalex, your design can be converted to a molding process which permits speedy and economical production runs.



MOLDING SERVICE



FABRICATING SERVICE

Get This Unique Combination of Properties with G-E Mycalex

1. High dielectric strength
2. Low power factor
3. Prolonged resistance to electrical arcs
4. Chemical stability—no deterioration with age
5. Dimensional stability—freedom from warpage and shrinkage
6. Impervious to water, oil, and gas
7. Resistance to sudden temperature changes
8. Low coefficient of thermal expansion
9. High heat resistance

Samples Supplied on Request

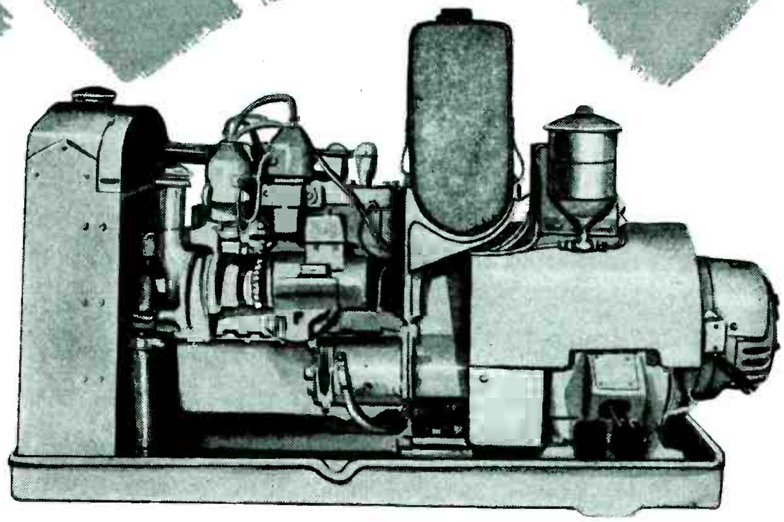
MYCALEX

GENERAL ELECTRIC

CD46-M11

PACKAGED POWER

PORTABLE DIESEL and GASOLINE ENGINE DRIVEN



GENERATOR SETS

Many Generator Sets, produced by well known manufacturers are now available from government-owned surplus. The majority of them are new, unused sets. Used sets in good condition are also available at reduced prices. The following types provide a rugged, dependable, economical source of electric power for:

Stand-by Units	Summer Camps
Small Machine Shops	Trailer Camps
Saw Mills	Carnivals and Fairs
Radio Stations	Mobile Power Units

Rural and Farm Installations

ALTERNATING CURRENT: 50 and 60 cycles; single and three phase; 120-480 volts; 1½ kva. and up; priced from $250 up.

DIRECT CURRENT: 24, 110 and 220 volts; ¼ to 40 KW; priced from $80 up.

The units are compact—versatile—built to endure. They are immediately available to your nearest War Assets Administration Regional Office. Write, wire or phone today.

All Portable Generator Sets are subject to priority regulations. VETERANS OF WORLD WAR II are invited to be certified at the War Assets Administration Certifying Office serving their area and then to purchase the equipment offered herein.

EXPORTERS:

The War Assets Administration solicits your inquiries. Communicate with your foreign clients promptly.

All items are subject to prior sale.

HOW TO PURCHASE:

1. If you can claim a priority, obtain your priority certificates at the nearest W.A.A. Certifying Office. Contact the W.A.A. office below for Certifying Office address and make application to purchase.

2. If you do not have priority status simply call any W.A.A. Office below; state the approximate KW rating you desire and the type of machine. You will be told where the machines you wish may be seen and how to complete purchase.

3. If the equipment you wish is not available in your local W.A.A. Regional Office—ask to have national inventories checked by the W.A.A. Inter-Regional Division of your local office and wait for notification of availability.

WAR ASSETS ADMINISTRATION

GOVERNMENT OWNED SURPLUS

Offices located at: Atlanta • Birmingham Boston • Charlotte • Chicago • Cincinnati Cleveland • Dallas • Denver • Detroit • Fort Worth • Helena • Houston • Jacksonville Kansas City, Mo. • Little Rock • Los Angeles Louisville • Minneapolis • Nashville • New Orleans • New York • Oklahoma City Omaha • Philadelphia • Portland, Ore. Richmond • St. Louis • Salt Lake City • San Antonio • San Francisco • Seattle • Spokane

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PERFECTED MICA CERAMIC INSULATION
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SOCKETS and INSULATORS
NOW AVAILABLE FOR THE FIRST TIME FOR CIVILIAN USE
ETS-4 Standard 4 Prong Socket
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EAT-75 5-7 Prong Acorn Socket
ETS-5 Standard 5 Prong Socket
ETS-6 Standard 6 Prong Socket
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BEST FOR HIGH FREQUENCY AND HIGH VOLTAGE APPLICATIONS
EBI-250H 2 1/2" Feed Through Insulator
EMS-4-125A Five Prong H. F. Socket with Air Holes
ENB-750 Through Panel Bushing with Plug Terminal
Sheet and Rod Stock Available in many sizes
EBI-175H 1 3/4" Feed Through Insulator
EBI-187H 1 7/8" Compact Feed Through Insulator
ESO-150 Stand-off Insulator 1 1/2"
High-Voltage Twin Bushing for Transformers
ORDER FROM YOUR DEALER OR WRITE TO
MADE EXCLUSIVELY BY
ELECTRONIC MECHANICS INC.
70 CLIFTON BLVD., CLIFTON, N. J.
CHICAGO 47; 1917 N. Springfield Ave., Tel. Albany 4310
EXPORT OFFICE: 89 Broad Street, New York 4, New York

INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Electronic Smithy Makes Horseshoes

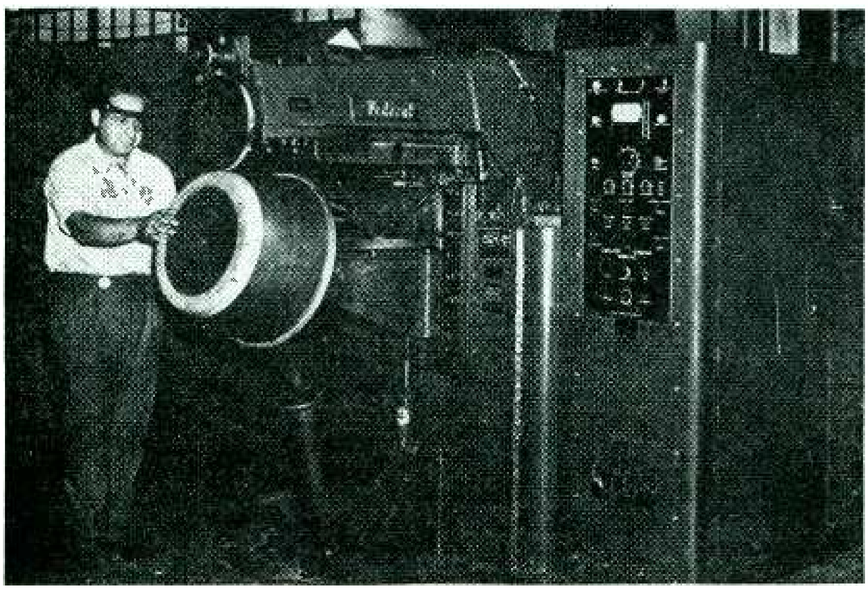
ELECTRONICALLY CONTROLLED resistance welding presses join the toe calks to formed horseshoes in a mass-production operation at Phoenix Manufacturing Company, Joliet, Illinois. (Surprisingly, some twenty million horseshoes are made annually.) The six-station, 300-kva welding unit not only welds but preheats the shoes and ejects the finished work while under full automatic electronic time and sequence control.

Preheating is performed by an induction-heating coil that is powered by a 20-kw high-frequency generator adjacent to the welder. It takes 7 or 8 seconds to heat up a shoe to approximately 1,200 F, and it is the heating rather than the welding operation that sets the pace. Allowing about 2½ seconds for indexing the feed table, a welded shoe is produced every ten seconds.

Welding is accomplished by the pulsation method. A synchronous electronic timer determines the duration of current flow for each pulsation. The cool time between each pulsation as well as the total number of pulsations are controlled by a sequence timer.

Of six stations on the horseshoe welding unit, three take care of loading the calks and the shoes. The others are working stations for preheating, welding, and automatic ejection. An electronic sequence panel controls the entire operation. When starting up, for example, the horseshoe in the heating station will be heated but the welding head will not come down on the shoe in the welding station because this shoe will be cold. Similarly, when the operation is stopped, the welding station will operate on the shoe that is there but the heating station will not heat the incoming shoe until operation is resumed.

CAPACITOR-DISCHARGE WELDER



Roll spot welder, reported to be the world's largest, uses electronic rectifiers to charge 84 120-μf capacitors that discharge into welding transformers. Westinghouse electronic controls permit 300 welds per minute on sheets of 0.032-inch aluminum

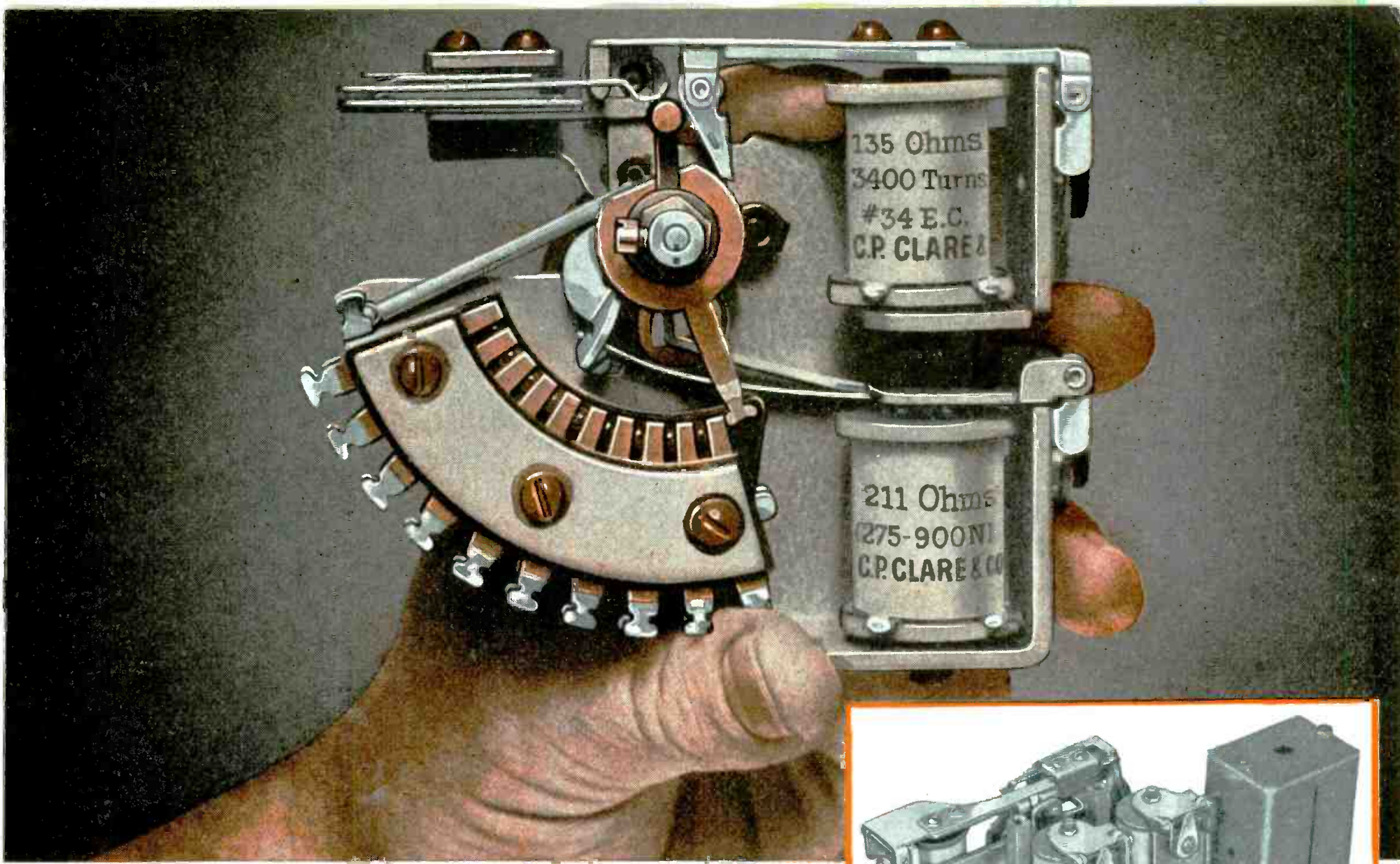
Radio-Beam Speedometer for Aircraft

INSTALLATION of radio detection beams at the Army Air Forces' speed courses at Dayton, Ohio and Muroc Army Air Base, California makes it possible to measure accurately the speed of aircraft flying at any altitude in any weather. The installations employ three parallel beams at right angles to the charted course of the plane. As the plane crosses each beam a signal is flashed to a central recording station, and the time elapsed between signals is measured against the known distance between beams to show the speed at which the plane is traveling. The radio beam system operates accurately in any weather and any altitude and is the first system capable of measuring speed at or above the speed of sound.

The Dayton course, with beams at Patterson Field, Sulphur Springs and Vandalia, will be used for checking supersonic-speed aircraft, while the California course will be used to check the speed of rockets and pilotless aircraft.

Electronic Timer for Inductive Load

RECENT WORK in the physical chemistry laboratory of the National Bureau of Standards in Washington involved the use of a solenoid-operated pump. The circuit employed for this purpose is shown in Fig. 1. It uses a type 2050 gas-filled tetrode with a 170-ohm resistor in series to limit the current. The value shown limits the charging surge of the electrolytic capacitor to less than the rated maximum of one ampere of the 2050 tube. The circuit is described by J. K. Taylor and J. G. Reid, Jr. of the Bureau in



Clare Stepping Switch Dials Radio Telephone Call in 3½ Seconds

● All or any one of 84 mobile units can be signalled in 3½ seconds from the master station of "Fleet Control," the new radio dial telephone system of the Hammarlund Manufacturing Company of New York.

This attachment, or addition, to a standard two-way radio system, employs a Clare Direct Drive Stepping Switch to provide the selective calling of trucks, taxicabs, busses, maintenance trucks, or any mobile units with which communication is desirable.

Calls are initiated by energizing the rotary stepping magnet of the Clare Stepping Switch which causes it to notch up the number of points called for by the digit dialed. It remains at this point to receive the impulses caused by dialing the second code number digit. Dialing of the four-digit code number, which must add up to 10, thus causes a succession of stepping operations which bring the rotary arm to Point 10.

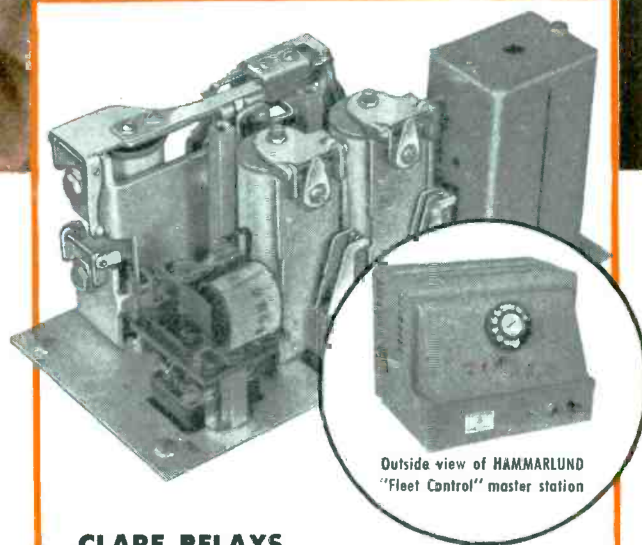
The only unit that will step up to Point 10 on the Clare Stepping Switch will be the one with the code identical to the four digit order of the number dialed. Unwanted units are not bothered with calls for other stations.

Two Type "C" Clare Relays with pivot damping springs are also included in the Hammarlund "Fleet Control." These Relays and the Clare Direct Drive Stepping Switch were selected for this service because of their maximum reliability under the severe shock and vibration encountered in mobile operation.

Experienced Clare engineers are located in principal cities to assist in your relay or stepping switch problems. Look them up in your classified telephone directory or write: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY. *In Canada: Canadian Line Material Ltd., Toronto 13.*

CLARE RELAYS

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



Outside view of HAMMARLUND "Fleet Control" master station

CLARE RELAYS AND STEPPING SWITCH MOUNTED IN "FLEET CONTROL." This view of the sub assembly of the Hammarlund "Fleet Control" shows the locotion of the two Clare Relays and the Clare Direct Drive Stepping Switch.

Use of these Clare products makes possible the signalling of 84 mobile units with a four digit calling number . . . 126 mobile units with a five digit number.

Other features of this Clare equipped unit give:

1. Calls made and message started in 3 to 3½ seconds.
2. System returned from "in use" condition to normal standby in less than 0.6 seconds.
3. Unwanted units not affected by calls for other stations.
4. Other units unable to break in during transmission.
5. Any unit can call central station during standby.
6. Any number of units can be coded identically for simultaneous calls.
7. All units can be called simultaneously or selected groups may be called.

Specifications of Clare Ten-Point Direct Drive Stepping Switch

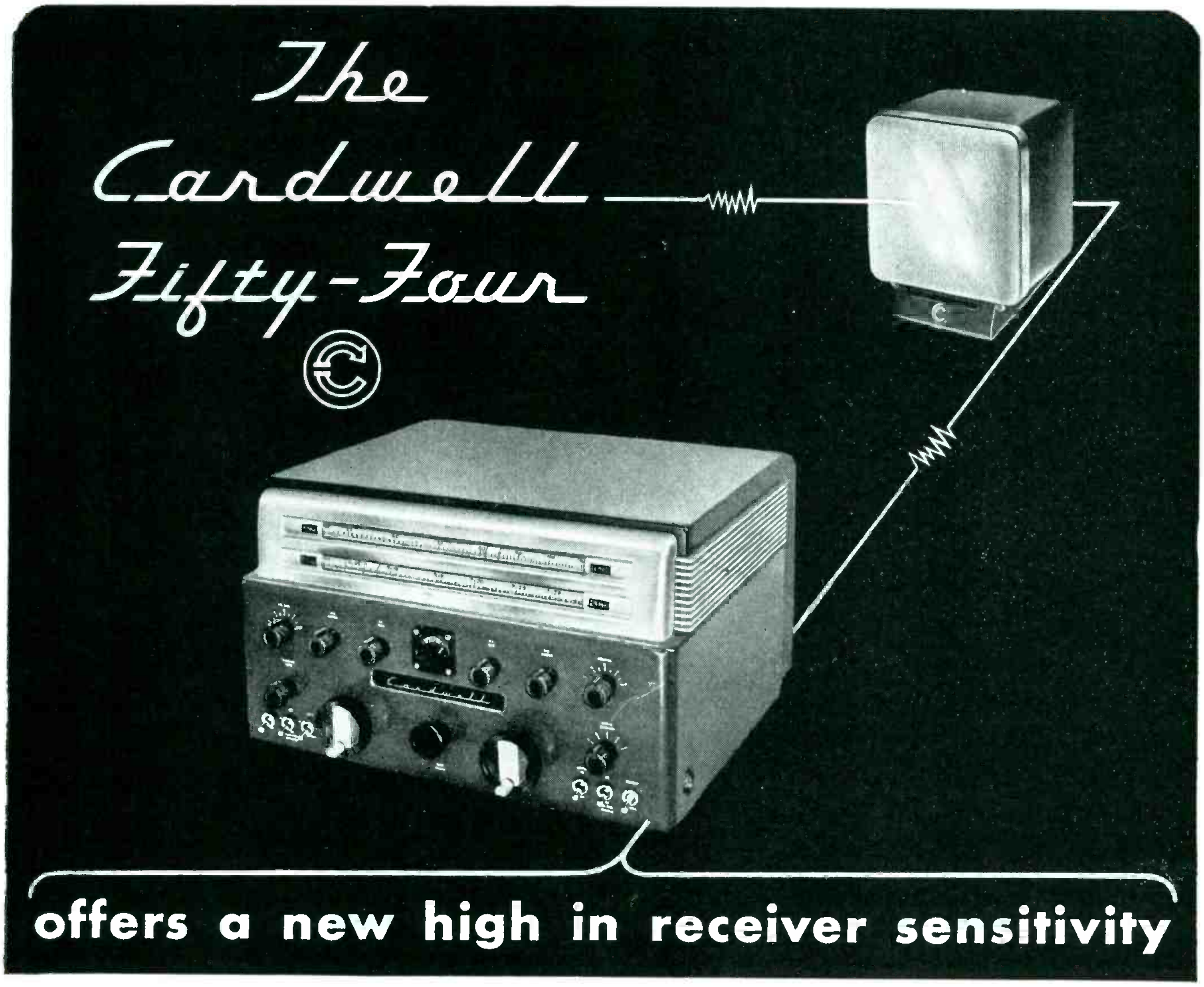
Bank Levels . . . One, two or three.

Operating Voltage . . . Nominal: 6, 12, 24, 48—Maximum: 8, 16, 32, 58.

Standard Test Voltage . . . 1000 volts.

Maximum Operating Speed . . . 35 steps per second on 48 volt switch under ideal conditions. Lower maximum on lower voltages.

Release Time . . . 0.030 second.



Probably the most important performance characteristic in a communications receiver is sensitivity expressed as signal to noise ratio. In the Cardwell Fifty-Four, you will find this characteristic developed to within 6db of theoretical perfection. Features like this make the Cardwell Fifty-Four the outstanding communications receiver of the present day.

The following features combine to make this the first really new communications receiver in years:

1. Full Turret Type R.F. Section.
(Sturdy cast aluminum construction.)

2. Wide Frequency Coverage.
(Range .54 to 54.0 mcs. Basic turret covers .54 through 40 mcs. in six bands. Extra coil strip supplied with set extends range to 54 mcs.)

3. Secondary Frequency Standard.
(Unique type crystal calibrator provides check points of either 100 or 1000 kcs.)

4. Variable Selectivity Crystal Filter.
(Choice of 5 degrees of selectivity—three with crystal, two without.)

5. Exceptional Signal to Noise Ratio.
(Receiver noise less than 6 db above thermal!)

6. New Type Noise Limiter.
(A really effective aid in reducing local ignition interference and similar noises.)

7. Electrical Band Spread.
(Band spread scales calibrated directly. Arbitrary scale 0-100 also visible on each setting.)

8. Direct Reading Precision Dials.
(Excellent visibility—pointer travel better than 10½ inches—velvet smooth dial action.)

9. Temperature Compensated Oscillator.
(Stability is better than 25 parts per million per degree centigrade. V. R. tube maintains maximum frequency stability against line voltage fluctuations.)

10. Mechanical Coupling Provisions.
(Control shafts are brought out at rear for linkage to other units such as a transmitter exciter.)

11. All Aluminum Unit Construction.
(Receiver and power supply combined in one sturdy, lightweight unit 18¼" wide x 16" deep x 11" high. Weight approximately 70 lbs.)

12. Heavy Duty Speaker.
(Compact tilting unit 9¼" wide x 8¼" deep x 11" high for wall or table mounting.)

13. Eight Watts Audio Output.
(Push-pull class AB—with four output impedances. Connections provided for phonopickup or microphone input.)

14. 18 Tubes—All Miniature.

15. Threshold Squelch.

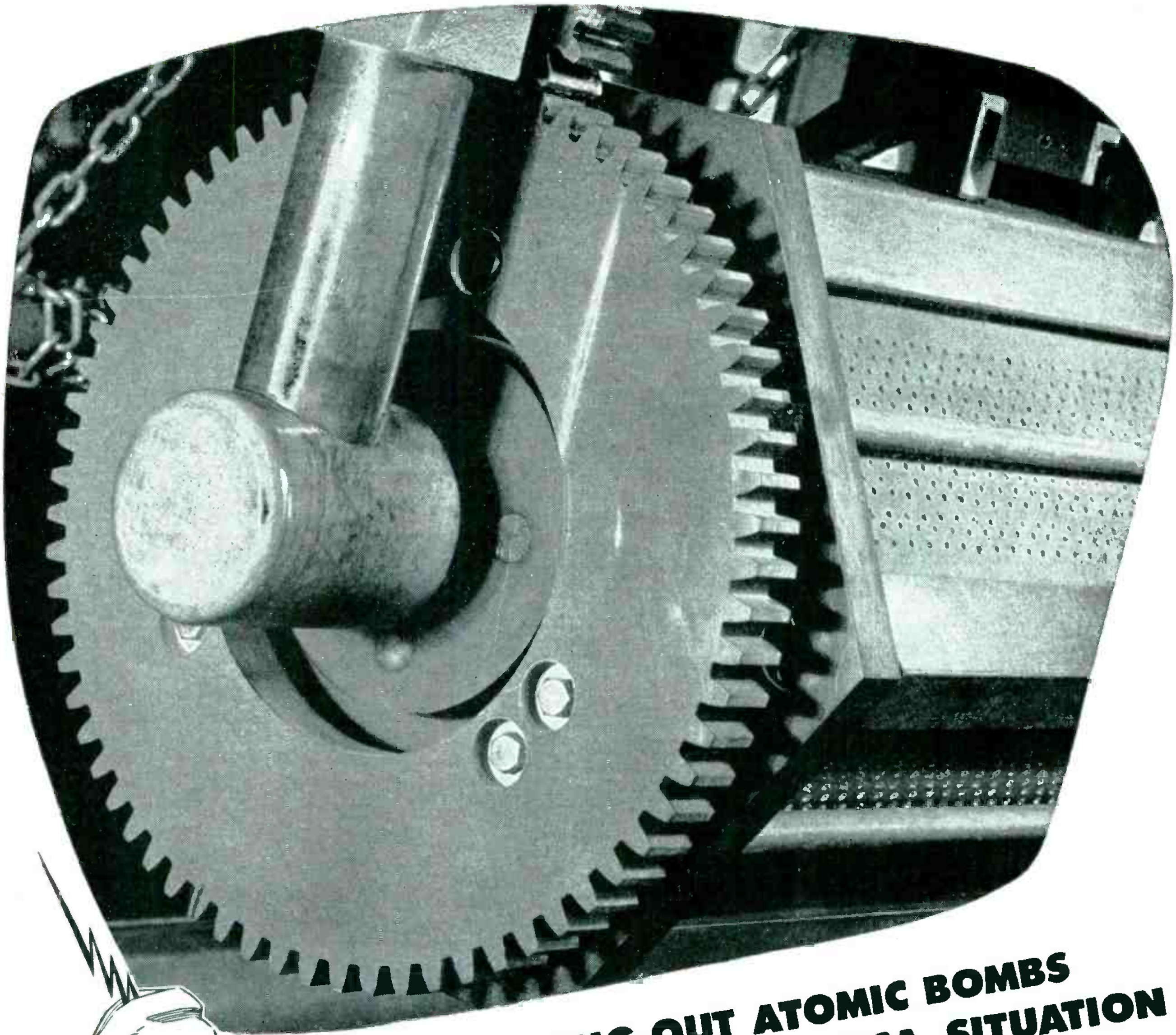
16. Panoramic Adaptor Jack.

17. Rack Mounting Model.
(Will also be available.)

WRITE FOR COMPLETE TECHNICAL BULLETIN

THE ALLEN D. CARDWELL MANUFACTURING CORP.

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



IT ISN'T GRINDING OUT ATOMIC BOMBS BUT IT'S A TYPICAL FORMICA SITUATION

THE apparatus illustrated is a bit of plating equipment dealing with the all powerful if slower acting forces of chemistry and electricity, forces which when on the move have to be handled with better gloves than were ever made of leather. In situations like this one, Formica laminated plastic of high chemical and electrical resistance handles these forces better than any other material available can handle them.

There are many grades of Formica with special properties, from which you can make indestructible gloves to handle dynamic materials in scores of industries where chemicals and electricity are pretty hot to handle. Why not state your problems, or state the properties of the material you require and start a get-together for the purpose of ascertaining if Formica will best fit your needs.

FORMICA

THE FORMICA INSULATION COMPANY, 4645 SPRING GROVE AVENUE, CINCINNATI 32, OHIO

Industrial and Engineering Chemistry for January 1946.

The modified circuit has provided over 200 hours of operation, including continuous periods of as long as 60 hours, with no evidence of tube failure. This is in contrast to a life of 12 hours obtained from an 884 originally used. Its pulse rate is adjusted by potentiometer R_1 and the adjustability of the range of rates depending upon the values of R_1, R_2, and C_1, make it applicable to a wide variety of timing operations.

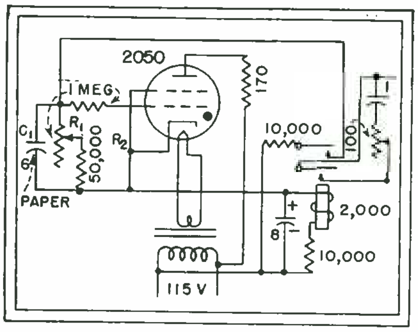


FIG. 1—Circuit of electronic timer that has a number of industrial applications

Sensitive Photoelectric Control

By K. M. Laing

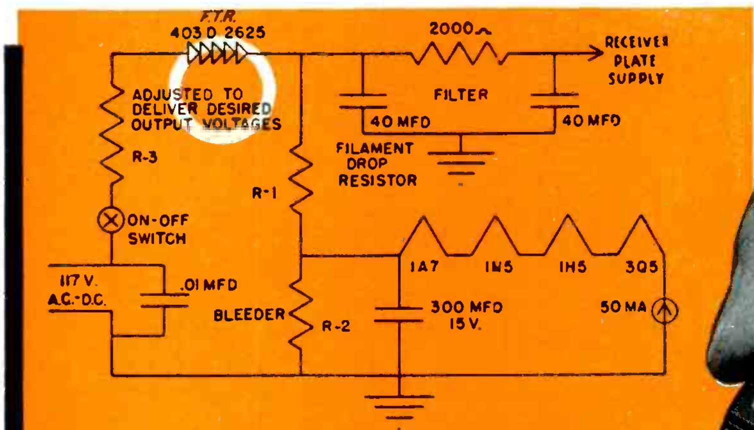
North American Philips Company, Inc. Dobbs Ferry, N. Y.

On many occasions, the engineer needs a control apparatus with greater sensitivity than is provided by most devices which are readily obtainable on the market. Such circumstances made it necessary for the writer to develop the arrangement to be described. Those who encounter the same problem may find the design useful.

Most meter mechanisms are designed to use very little energy, and it would impair their accuracy and dependability if they were called on to do more than move the pointer. But the meter movement is loaded imperceptibly, if at all, when the pointer intercepts a beam of light. The beam is made to pass at right angles to the plane of the pointer travel. A convenient way to do this is to mount a miniature lamp bulb in the meter case under the scale, and to drill a small hole in the scale through which the light passes. The bulb may be of the type used in a

SHORT CIRCUIT THE RECTIFIER TUBE SHORTAGE

...with Federal's PROFIT-BOOSTING Miniature Rectifier Stack



Recommended simplified circuit. R-1 and R-2 resistors existing in receiver. R-3 will be 25 to 150 ohms as required for proper voltage in set.

29 DIFFERENT RECTIFIER TUBE TYPES NOW REPLACEABLE IN CONSOLE RADIOS, AC-DC PORTABLES, VIBRATOR POWER SUPPLIES!

YOU don't have to turn away repair jobs because there are no rectifier tubes on your shelf. Here's a replacement that is actually an *improvement* . . . and permits you to *earn more money!*

Install this remarkable, new rectifier stack which *costs less than a tube*, and the repaired set starts instantly without warmup, and runs cooler. Only 1¼ x 1¼ x ¹¹⁄₁₆ inches, it fits anywhere in the chassis. What's more, you can tell your customer it's in for good! For this Federal stack is built to last the life of the set. It withstands overloads, even when charging deformed electrolytic condensers. All metal construction prevents breakage.

Every one of Federal's famous "Center Contact" Selenium rectifiers is designed to give the full measure of dependable performance that has made them the standard of the industry. This miniature, 5-unit stack will help you to more business. A Federal engineer will send full information to assist you in their application. Write department F654.

REPLACEMENT FOR THESE TUBES

5T4	5Y3	6Y5	25Z6	50Y6
5U4	5Y4	6Z5	35W4	50Z7
5V4	5Z4	12Z5	35Z3	117Z3
5Z3	6X5	7Y4	35Z4	117Z6
5W4	0Z4	12Z3	35Z5	OY4
5X4	80	25Z5	35Z6	

ELECTRICAL CHARACTERISTICS

Maximum RMS voltage	130 volts
Maximum inverse voltage	380 volts
Maximum peak current	1200 ma.
Maximum RMS current	325 ma.
Maximum DC output	100 ma.
Approximate rectifier drop	5 volts

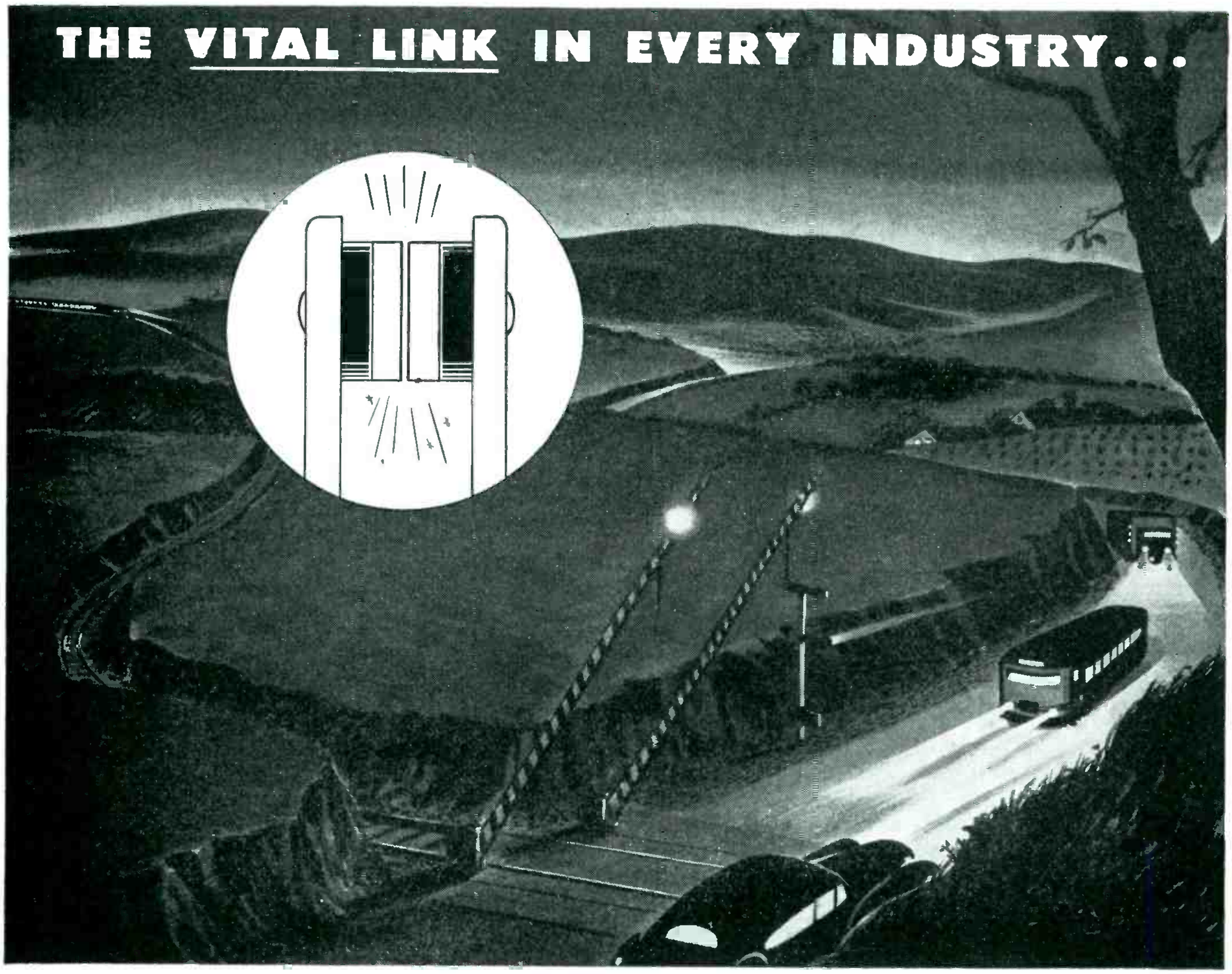
Two Federal Miniature Rectifiers in a voltage doubler circuit give 250 volts and 80 milliampere output from 117 volt AC source.

Federal Telephone and Radio Corporation

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

An IT&T Associate — FTR Federal Telephone & Radio

Newark 1, New Jersey



WILCO CONTACTS

DEPENDABLE, PRECISION, DURABLE, WILCO CONTACTS ARE VITAL TO THE FLOW OF POWER

Because contacts are so vital, modern industry increasingly uses *dependable* WILCO contacts. For heavy or light duty, WILCO CONTACTS offer maximum ductility, hardness, density, together with freedom from sticking, low metal transfer, high conductivity, arc-resistance.

You can depend on Wilco Contacts to keep the power flowing in your products because WILCO contacts are produced through exclusive, patented Wilco processes which give them qualities unduplicated by competitive materials. In many cases, where new alloys are needed, WILCO engineers can develop them for you. These skilled technicians are at your service at all times . . . to help you select the particular contacts suited to your needs.

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J. • *Branch Offices:* Chicago, Detroit, Los Angeles

WILCO PRODUCTS INCLUDE:

CONTACTS
Silver - Platinum - Tungsten - Alloys
Sintered Powder Metal

THERMOSTATIC BIMETAL
All temperature ranges, deflection rates and electrical resistivities.

SILVER CLAD STEEL
JACKETED WIRE
Silver on Steel, Copper, Invar or other combinations requested.

ROLLED GOLD PLATE AND WIRE

NI-SPAN C*
New Constant Modulus Alloy

SPECIAL MATERIALS

* Reg. Trade Mark, The International Nickel Co., Inc.

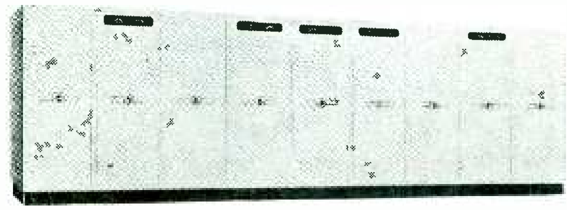
WILCO

SPECIALISTS FOR 30 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS

AMERTRAN TRANSFORMERS

ARE *designed into* THE SPECIFICATIONS OF PROGRESSIVE ELECTRONIC MANUFACTURERS

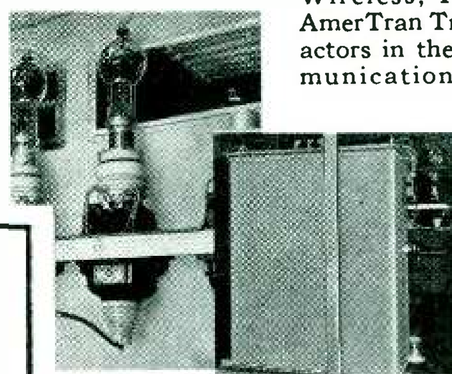
Federal BROADCAST TRANSMITTERS



● AmerTran Transformers and Reactors have been specified for Federal Transmitters over a period of many years. WABC's 50,000 watt station, OWI's 200,000 watt Tokyo Broadcast Pacific stations, CBS short wave and many other important Federal installations are AmerTran-equipped. Latest development is the new series of Federal AM broadcast transmitters, 5 KW to 50 KW, AmerTran-equipped, now in process of manufacture.

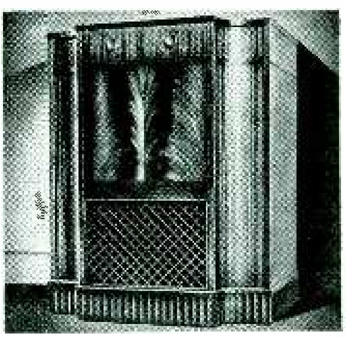
PRESS WIRELESS

COMMERCIAL AND GOVERNMENT TRANSMITTERS



● Internationally known Press Wireless, Inc. depend upon AmerTran Transformers and Reactors in their world wide communications network. Press Wireless Manufacturing Corporation Engineers design AmerTrans into their streamlined transmitters for commercial and government use.

DUMONT "20-20 teleVISION" for home entertainment



Allen B. Du Mont Laboratories, Inc., authorities in modern television, use AmerTran Transformers in their de luxe receivers designed for the quality home-television field.

AMERTRAN engineers have "grown up" with the electronics industry. The entire AmerTran organization is streamlined for efficient design and manufacture of transformers and allied products exclusively. AmerTran has *progressed* with the industry, through many important contributions to electronic development. Why not let AmerTran work for *you*, too?

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

TRANSFORMER SUPPLIERS TO THE ELECTRONICS INDUSTRY

AMERTRAN
REG. U. S. PAT. OFF.
MANUFACTURING SINCE 1901 AT NEWARK, N. J.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission small flashlight, having a lens cast in the glass envelope.

A suitable panel lamp socket assembly is mounted on the meter case. For small meters, the only available space is in the center region. The hole must be located in the scale card so that it will be completely covered by the pointer at one place in the arc. A phototube, preferably one designed for relay service, is mounted over the glass meter cover so that the light beam from the uneclipsed hole will fall on the sensitive cathode.

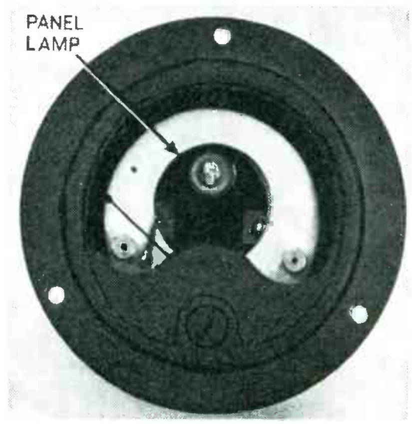
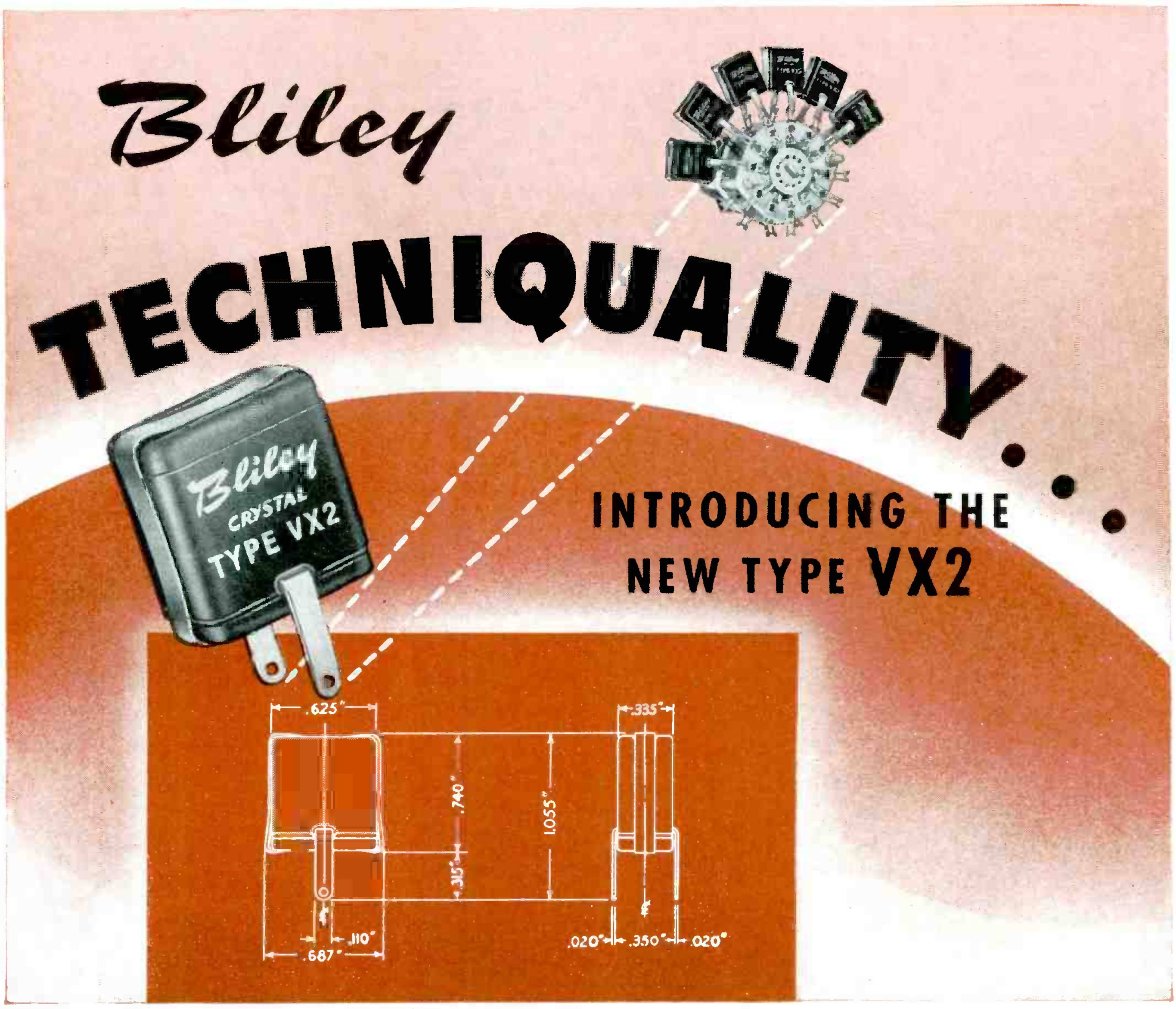


FIG. 1—Close-up of panel instrument with scale removed to show panel lamp mounted inside the case

Light Shield

It is advisable to have the phototube operate at very low light level, and to protect it from unwanted changes in extraneous light. One way to enclose a small meter and a phototube in a light-tight box is to use a can with a press-on lid, about 1½ inches larger in diameter than the meter, and deep enough to accommodate the phototube and its socket. A hole is made in the lid of the can as large as the meter hole in the regular panel. The hole in the can lid should be off center as much as possible. The lid is held between the panel and the meter flange. The body of the can may be pressed on or removed at will.

As shown in Fig. 2, the space at the side of the meter is used to mount a bracket that supports the phototube socket. A socket hole is also cut through the can lid and panel in this region, as well as a smaller opening for leads. The socket is for the tube which amplifies the



Designed for use where space is at a premium

Take a look at the space saving dimensions of this new Type VX2 crystal unit. Into this compact holder, Bliley engineers have packed a quartz crystal assembly that will perform, under rugged service conditions, with more dependable accuracy than was formerly possible in a crystal many times the size of Type VX2.

This new Type VX2 unit is available for frequencies from 3000 kc to 11000 kc. Solder lugs, replacing the conventional pin type connections, permit easy mounting under chassis. For multifrequency applications a group of units may be mounted on a conventional rotary selector switch. Gasket seals assure reliable operation under adverse service conditions.

Whenever there is an important frequency control problem to be solved—make it a habit to consult Bliley engineers first. You'll find their 15 years experience, in frequency control engineering exclusively, a short cut from the experimental models to your production line.

Bliley CRYSTALS

Communications Engineers

Here are two important Bliley Bulletins that should be in your file—

Ask for Bulletins { **P 27** / **P 31** }

BLILEY ELECTRIC COMPANY • UNION STATION BUILDING, ERIE, PENNSYLVANIA

All the *Precision Parts* You Want *with* NO Production Troubles

● If you want a reliable source for electronic parts—without increasing your own manufacturing facilities—investigate Paul and Beekman service. Paul and Beekman has the equipment and the skilled personnel to produce the items you need in large quantities.

Cans, chassis, coil shields, condenser shells, housings, complete and sub-assemblies . . . all these and many other items are produced every day at our plant. They are made to exacting specifications and finished to close tolerances.

Find out about the many advantages of using Paul and Beekman as your parts division. Our engineers are always available for consultation, with no obligation. Write us concerning your requirements.

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PORTABLE PRODUCTS CORPORATION

MANUFACTURERS OF: LAWN MOWERS • ELECTRICAL APPLIANCES • PRECISION STAMPINGS
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. . . Impromptu Discussions about Miniature Tubes

Sure audio voltage amplifiers are available in miniatures . . . TUNG-SOL Miniatures 1S5, 6AQ6, 6AT6 and 12AT6.

Those AT6's are used for about everything . . . automobile or household receivers, television, aircraft, marine equipment, public address systems and industrial instruments. They give top-notch performance, they are rugged and they are small . . . everything you are looking for in a tube.

With voltage gains ranging between 37 at 100 volts supply to 47 at 300 volts, they are ideally suited to the economical "grid current biased" circuit resulting in remarkable uniformity from tube to tube. The AT6's are designed to provide distortionless output voltage adequate to drive the power stages to full output with but a few tenths of a volt input signal. And don't forget the two diodes which permit high efficiency detection in the same tube. Low capacity coupling to the triode grid and low electronic coupling between the two diodes both add to this tube's versatility.

You can use AT6's with either the diodes or the triode not connected in the circuit. With sufficiently high plate supply voltage, they are adaptable to d.c. amplification of the diode output providing a useful circuit for field strength meters and a lot of other industrial applications.

Why don't you talk to the TUNG-SOL service engineers about their miniatures. You can, without tipping your hand. You know they don't build sets.

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors photo-current from the phototube. Since on-off operation is required as well as high gain, a gaseous grid-controlled rectifier is employed.

Phototube in Meter

Another mechanical arrangement uses a phototube that is itself about the size of a panel lamp. If this is mounted behind the hole in the meter scale card, one can use a large external light source. Then the meter may be used for ordinary visual indications as well.

The sensitive point can be shifted in absolute value by several means. Some control is afforded by the zero adjust mechanism of the meter. More control is possible, aside from choosing a meter of the desired rating, by shunting the meter with a variable resistor. Movement of the pointer above or below the sensitive point is eliminated by changing one or the other of the stops that restrict the pointer at the ends of its travel. The stop is so modified that the pointer cannot pass the sensitive spot.

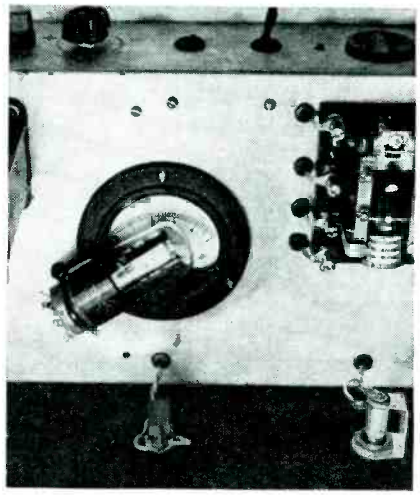
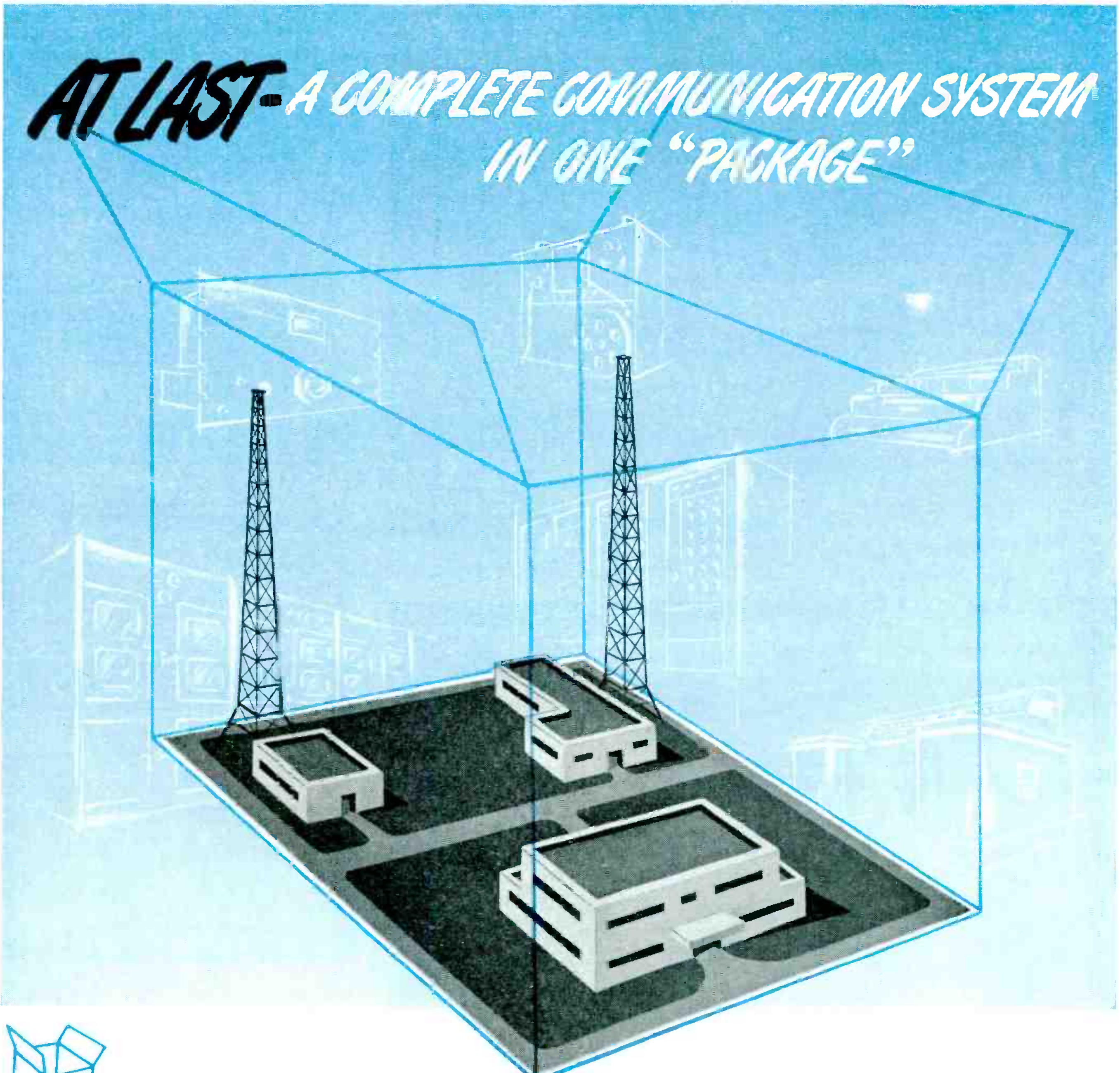


FIG. 2—Arrangement of photoelectric relay with phototube in place, but with the light-tight cover removed

Soap Dispenser for Dish-washing

AN ELECTRONICALLY controlled soap dispenser for automatic dish-washing machines which makes possible constant and completely automatic regulation of the concentration of detergents in the wash solution has been designed by Barnes & Reinecke, Chicago, for Economics



PRESS WIRELESS has conceived and developed a "packaged" line of communications systems — transmitting and receiving — from antenna tower to operating console. Each system is complete and individually packaged. Each "packaged" system includes modern radiotelegraph, radio-telephone, frequency shift and radio-photo-transmitters; dual diversity and general coverage radio receivers, radiophoto-receivers, high speed tape recorders, optical tape scanners—plus associated terminal equipment. Together, these units provide a highly flexible group of complete communication systems from which you may select the basic "packaged" units to meet the requirements of your proposed installation—or you may modernize your existing facilities by the addition of this equipment.

For nearly two decades PW engineers have designed new radio transmitters and complete telecommunications systems to meet the requirements of our own and other world-wide radio press circuits. PW pioneered in simultaneous voice and telegraph or photo transmission from the same transmitter, made important contributions to the technique of radio photo transmission and reception. PW was among the first to apply the principle of "frequency shift" to communication circuits—a method which permits operation of circuits at higher speeds with far greater efficiency. Today PW is prepared to advise and assist you with your next communication requirement.

Address inquiries to Press Wireless Mfg. Corp., Executive Offices, 1475 Broadway, New York 18.

PRESS WIRELESS

First in "Packaged" Communications Equipment

Laboratory, St. Paul. Operation of the device depends upon the change of conductivity of the solution with change of concentration.

Basically the unit consists of an a-c resistance bridge and amplifier. The amplifier was necessitated because of the low output of the bridge circuit, which is operated at six volts for considerations of safety. Use is made of a duel triode, the 6SL7. One section of the tube is used as a rectifier, with grid and plate connected, to supply the amplifier section. The latter is coupled to the grid circuit of a 6AC7, which is operated with an a-c potential on the plate. Change in plate current of the 6AC7 is a function not only of amplitude, but also of the phase of the grid potential, and the operation of the relay is thus unidirectional.

Operation

Initially, the bridge is balanced by adjustment of a variable resistor in the grid circuit of the amplifier section of the 6SL7. One arm of the bridge is furnished by the resistance between two electrodes suspended in the cleansing solution. This arm is balanced by a temperature-compensating cell, a cylinder containing a solution whose resistance approximates that existing between the electrodes in the tank and whose temperature coefficient is almost identical with that of the wash solution. Thus variations in temperature affect the two sides of the bridge equally.

All the electrodes are contained in a speecial housing and are connected to the electronic unit by flexible cable. The potentiometer as well as the mechanical construction of the cells, which permits variation in the area of one electrode, allows a wide range of settings for balance at whatever concentration is desired.

Decrease in the concentration of detergent produces an increase in resistance in one arm of the bridge. This unbalances the bridge and applies an a-c signal to the amplifier grid of the 6SL7. Operation of the relay in the plate circuit of the 6AC7 controls a magnetic valve which is closed when the bridge is in balance. The valve is connected to the water input to the dish-

ANOTHER NEW VARIAC

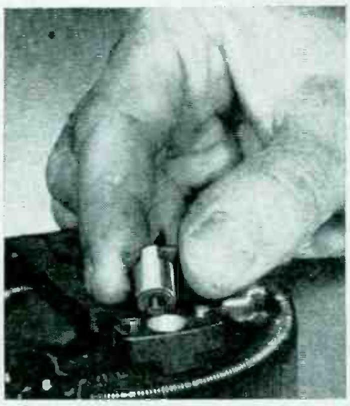
FOR some time there has been a steady demand for an intermediate size VARIAC . . . something between the new Type V-5 (old Type 200-C) with a 5 ampere rated output, and the Type 100 rated at 18 amperes. The new Type V-10 has been designed to supply this need. Its rated output is 10 amperes, with a maximum of 15. This maximum rating coincides with the capacity of outlets, plugs, cords and No. 14 circuits ordinarily found in the laboratory and in the home.

The electrical and mechanical features . . . most of them exclusively found in the VARIAC . . . are similar to those in the Type V-5, and include:

1. New Unit Brush—Brush, holder, pressure spring and current lead in one unit; removable in a second without any tools; when brush wears away, holder cannot short-circuit winding
2. Improved terminal plate with molded barriers between terminals to prevent short-circuits from strands of wire; both screw and solder-type terminals: wiring diagram on terminal plate shows normal voltage between terminals
3. New strip-wound, silicon-steel core contributes to increased efficiency and to weight reduction of 25% below normal
4. Entirely new mechanical design of structural parts, mostly in aluminum
5. Double-pole line switch breaks both sides of the line
6. New, large output-voltage dial with additional calibration points and larger figures
7. A single screw, readily accessible under dial, loosens shaft for reversing dial and knob to change from table to panel mounting without affecting brush or stop settings

The Type V-10 VARIAC is now in production Deliveries are scheduled to start early in November. Prices of the six models of the Type V-10 range between $27.50 and $35.50.

Write for a copy of the new VARIAC BULLETIN . . . it describes the new Type V-10 and all other VARIACS



GENERAL RADIO COMPANY Cambridge 39, Massachusetts

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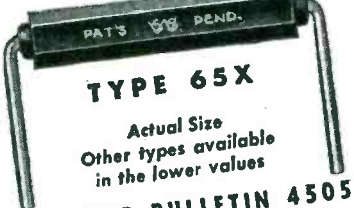
The "All-Weather" Resistors



TYPE 65X

Actual Size
Other types available in the lower values

RESISTOR BULLETIN 4505 GIVES FULL DETAILS . . .

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it—today.

- Noiseless in operation
- Strong and durable
- Good performance in all climates

STANDARD RANGE
1000 ohms to 10 megohms

• NOISE TESTED •

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

HIGH VALUES
15 to 1,000,000 megohms

S.S.WHITE INDUSTRIAL DIVISION
THE S. S. WHITE DENTAL MFG. CO.
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FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

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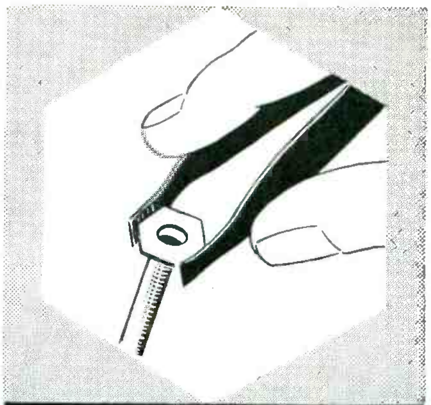

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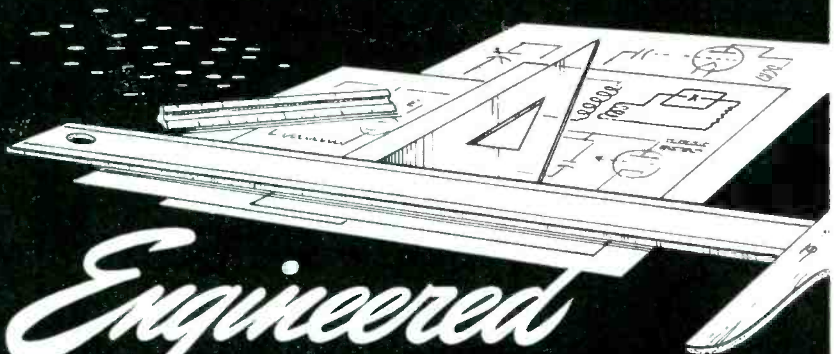

Engineered TRANSFORMERS

To make a transformer that will successfully meet your most exacting requirements, call for engineering of the highest order.

Engineering transformers for every kind of application, ordinary or unique, is the day to day business of Electronic Engineering Company. The finest engineering talent and most complete electronic laboratories are ready *today* to consult with and help you.

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YOU GET MANY *Extras!*

Rowe No. 7 Permanent Magnetic Driver Unit

Extra *power*, extra *long life*, extra *freedom from breakdowns*, extra *ease of replacement* . . . these are but a few of the many *extras* you get in the ROWE No. 7 PERMANENT MAGNET........first choice of sound engineers who investigate thoroughly and analyze carefully.

The 3 lb., 4 oz. ALNICO Magnet gives power and permanency; combined voice coil and diaphragm assembly heads off trouble, provides for quick replacement if necessary. Write for circular 83, giving complete details.

ELECTRONICS DIVISION
ROWE *Industries*
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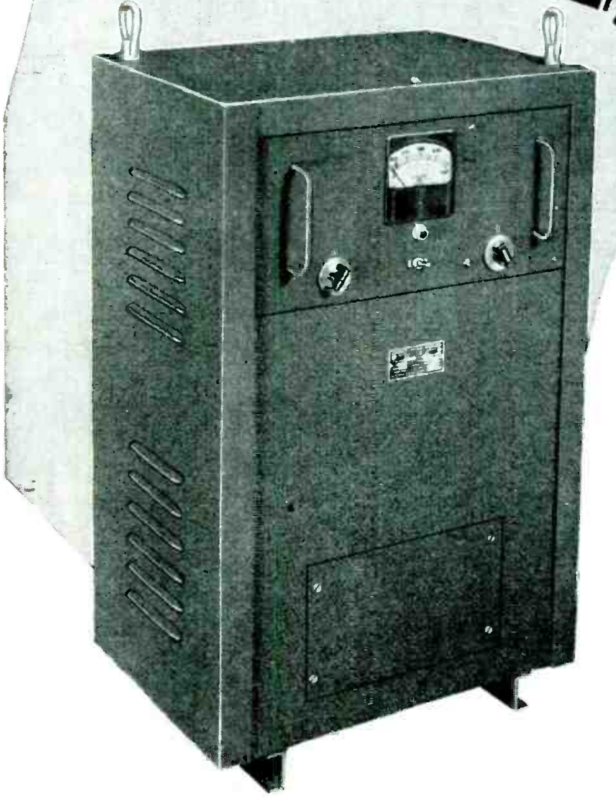
SECO AUTOMATIC VOLTAGE REGULATORS

RATINGS

TYPE	INPUT VOLTS	OUTPUT VOLTS	PHASE	OUTPUT KVA	DIMENSIONS (Inches) LENGTH	WIDTH	DEPTH
SVR6210-Y	195-255	230	3	10	38	23¼	15¼
SVR6215-Y	195-255	230	3	15	38	23¼	15¼
SVR6220-Y	195-255	230	3	20	38	23¼	15¼
SVR6245-Y	195-255	230	3	45	41	31	25
SVR6258-Y	195-255	230	3	58	41	31	25
SVR6412-Y	380-500	440	3	12	38	23¼	15¼
SVR6417-Y	380-500	440	3	17	38	23¼	15¼
SVR6425-Y	380-500	440	3	25	38	23¼	15¼
SVR6450-Y	380-500	440	3	50	41	31	25
SVR6475-Y	380-500	440	3	75	41	31	25

PACKAGED POWER



CONDENSED . . . concentrated . . . compressed . . . compact . . . are all words that might be substituted for "packaged". The descriptive wording is unimportant. Of importance is the large power controlling capabilities packed into SECO Automatic Voltage Regulators.

The rating chart gives an idea but only three phase units are listed. To learn about single phase models and the superior characteristics of all SECO regulators contact the factory. You will learn . . . SECO Automatic Voltage Regulators maintain a constant output voltage regardless of variations in input voltage or output load current . . . there is no wave form distortion — no mechanical adjustments — low cost per KVA. *Write us today.*

Send for Bulletin 150 LE

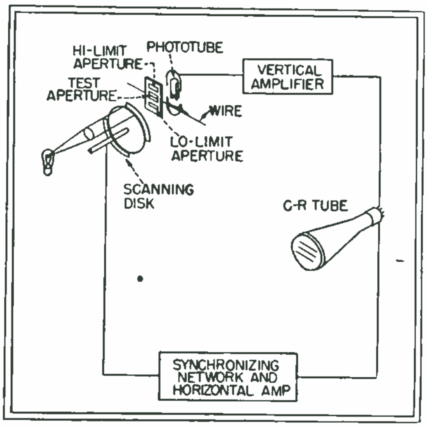
THE SUPERIOR ELECTRIC COMPANY

710 LAUREL STREET • BRISTOL, CONNECTICUT, U. S. A.

washing machine so that opening permits intake into a small auxiliary tank containing a supersaturated solution of detergent which enters the main tank through an overflow. When detergent sufficient to rebalance the bridge is added to the wash tank the initial conditions are established and the valve is closed. Two insulated bushing electrodes are mounted in a small tank in series with a thermostatic bimetal switch and a six-volt supply so that considerable increase in resistance of this solution due to dilution operates a flashing light to indicate need of additional detergent.

Electronic Micrometer for Thin Materials

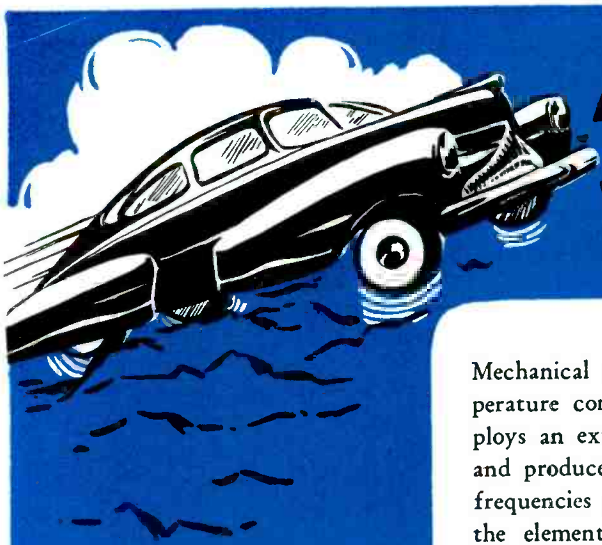
CONTINUOUS PRODUCTION measurement of wire diameter and strip thickness without interference with high-speed manufacturing methods is accomplished in an electronic micrometer that uses a phototube to measure the shadow of the material under observation as it varies from a standard width. Significant economies are claimed when the instrument is used in the manufac-



Essential units of the electronic micrometer for continuous examination of wire and strip thickness

ture of plastic-covered wire, razor blades, rod, bar and tube stock, coated or bare filament wire.

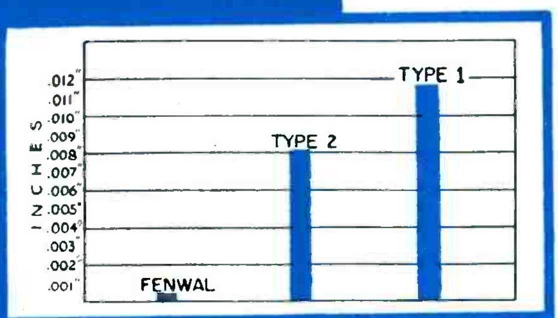
A measuring head contains the aperture across which is fed the material to be measured. This is illuminated by a projection lamp that casts a shadow of the object on the cathode of a phototube located behind the measuring aperture. The area on the surface of the cath-



MINIMAL VIBRATION EFFECTS *

Mechanical vibration should not effect the control point of a reliable temperature control device. The FENWAL THERMOSWITCH Control employs an extremely light and stiff bridge structure which resists vibration and produces an extremely high natural frequency — far above vibration frequencies encountered in industrial applications. The spring gradient of the element assembly is non-linear, therefore the entire system has no natural resonance.

Chart shows the amount of motion in the switch element assembly of a FENWAL THERMOSWITCH Control compared to Type 1 and Type 2 Thermostats — when experimentally subjected to an oscillatory motion of 1/10″ at 2000 cycles per minute.



VIBRATION EFFECTS

The ability of the THERMOSWITCH Control to hold to set-point under severe vibration has led to its use in large quantities in aircraft and railroad applications as well as many other applications of all types. This and other unique features of the FENWAL THERMOSWITCH Control make it the ideal temperature regulating unit. Apply its advantages to your temperature control applications. Complete information in the Thermotechnics Booklet which includes the "Fourteen Facts in FENWAL's Favor" — sent upon request.


AIRCRAFT THERMOSWITCH CONTROL

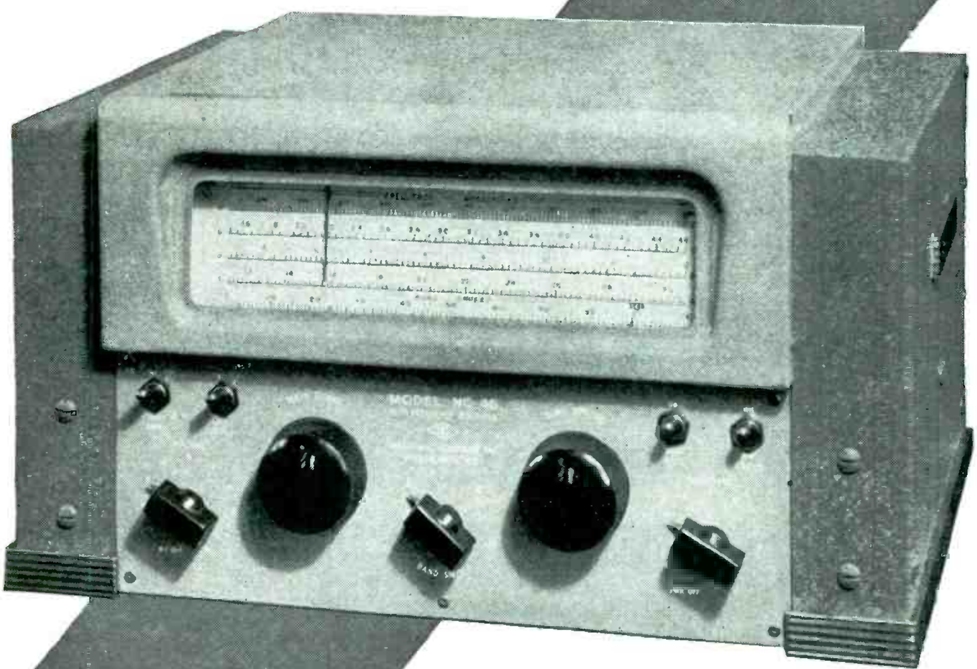
FOURTEEN FACTS IN FENWAL'S FAVOR

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

* #7 of the "Fourteen Facts in FENWAL's Favor"

Fenwal

FENWAL INCORPORATED
43 PLEASANT STREET
ASHLAND MASSACHUSETTS
Thermotechnics for Complete Temperature Regulation



NC-46

Clean modern styling combines with advanced electrical design to make the NC-46 an outstanding choice for the amateur. Workmanship is of traditional National quality in spite of moderate price. Features of the NC-46 include a series valve noise limiter with automatic threshold control, CW oscillator, separate RF and AF gain controls, and amplified and delayed AVC. Four coil ranges cover from 550 Kc. to 30 Mc. A straight-line-frequency condenser is used in combination with a separate bandspread condenser. Look over an NC-46 at your dealer's, study it inside and out. It's a lot of receiver for your money.

ARMY E NAVY

ARMY E NAVY

NATIONAL COMPANY, INC. NC **MALDEN, MASSACHUSETTS**

ode that is not in a shadow produces a voltage signal in the load resistor of the phototube.

Two other openings, one on each side of the measuring aperture, are separately adjustable to represent the positive and negative tolerance limits to which the material must conform.

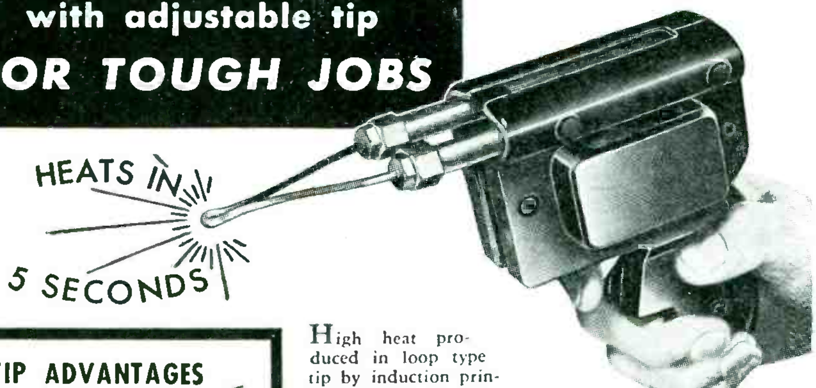
A scanning disc rotates between the phototube and the apertures, exposing each of the three in sequence. As a result of this rotation, three voltage pedestals are fed to the amplifier circuit, each following the other in a time sequence that is synchronized with the disc rotation. At the points in the cycle where the scanning disc changes from one aperture to another, particular care in design is taken so that the total area uncovered at any one time is constant.

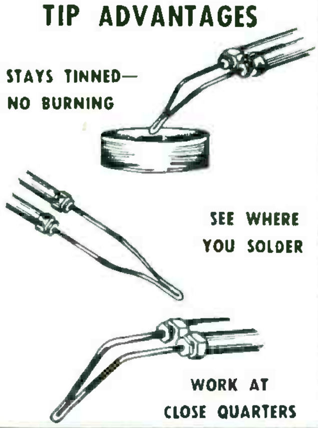
The phototube emits a voltage signal that is a-c in character and allows the use of a-c amplification. Signal level changes only in proportion to the tolerance of the material under measurement and does not change with respect to the absolute dimension of the material. The sensitivity of the instrument developed by Wilmotte Manufacturing Co. is not dependent on the size of material being measured. For instance, it is possible to measure a dimension of either 0.6 or 0.005 inch within the accuracy of ± 0.0002 inch.

Display of Information

Each of the three voltage pedestals produced by the phototube is amplified in a common amplifier circuit and is then applied to the vertical deflection plates of an oscilloscope. The sweep voltage is applied to the horizontal plates of the oscilloscope so that termination of each viewing cycle occurs at the same time that the scanning disc alternates from one aperture to another. Each of the three voltage pedestals now appears as a horizontal line on the face of the oscilloscope screen, and, owing to the persistence of the screen, combined with a rapid scanning rate, the three lines appear as simultaneous and continuous traces.

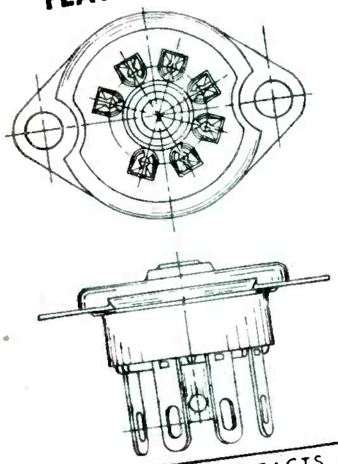
When the size of the material under measurement changes, the voltage signal represented by the


HEATS IN
5 SECONDS


STAYS TINNED—
NO BURNING
SEE WHERE
YOU SOLDER
WORK AT
CLOSE QUARTERS

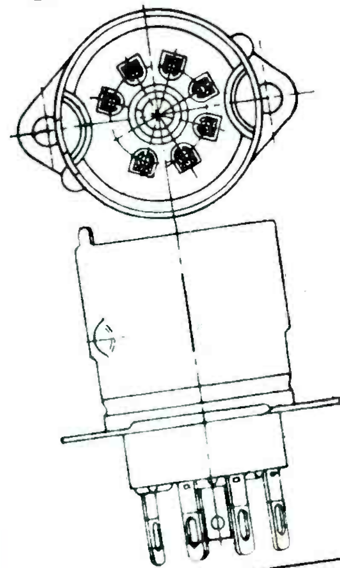
NEW EBY MINIATURE SOCKETS

FLAT SADDLE



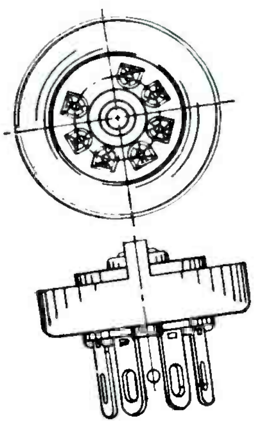
INSULATOR	CONTACTS	
	Phos. Bronze	Beryl. Copper
General Purpose	8323	8100
Ceramic	8326	8083
Mica-filled Phenolic	8327	8082

SHOCK SHIELD

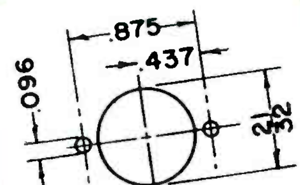


INSULATOR	CONTACTS	
	Phos. Bronze	Beryl. Copper
General Purpose	8322	
Ceramic	8328	7676
Mica-filled Phenolic	8329	7670

NON-MICROPHONIC



PART NO. 8341



MOUNTING LAYOUT

Flat Saddle
Shock Shield
Non-Microphonic

HUGH H.
EBY
INCORPORATED

WRITE TODAY for complete details —

HUGH H. EBY, INC.

18 W. Chelten Ave. Phila. 44, Pa.

test trace varies proportionately, and causes this test trace to change its position relative to the two limit traces. The two limit traces maintain their relative positions exactly as they have been adjusted for a given production run.

Design Features

Voltage variations that normally cause fluctuation of an oscilloscope pattern cause no error, as all three traces move together. In the same manner, gain variations in the scope or amplifier circuits cancel out, as all three signals are amplified in the same channel. The use of a single phototube eliminates error owing to fatigue, temperature change, and other variations that are commonly attributed to the phototube as limiting factors in its use as a quantitative measuring means.

Vibration of the material under test does not cause an error in measurement since the apertures are so constructed that vibration in the horizontal plane merely changes the position of the shadow on the phototube and does not change its magnitude. The effect of vibration in the vertical plane is minimized by the use of parallel light, which avoids a change in the size of the shadow on the phototube with change in position of the material

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For making large and complex glass-to-metal seals, engineers at Westinghouse Lamp Division have developed a method in which the metal Kovar is heated in a temperature-controlled oven, then cooled and sprayed as shown above with powdered glass suspended in liquid. A second heating fuses the glass into a film to which the glass tube envelope can be sealed in the ordinary manner

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for very high pulse repetition frequencies

ELECTRICAL RATINGS AND OPERATING CONDITIONS (TENTATIVE)

CHARACTERISTIC	4C35	5C22
Heater voltage	6.3 v $^{+5\%}_{-10\%}$	6.3 v ± 7.5%
Heater current at 6.3 volts	5.5 to 6.7 amps	9.6 to 11.6 amps
Cathode heating time	180 sec. min.	300 sec. min.
Peak anode voltage	8.0 KV max.	16.0 KV max.
Peak anode current	90 amps max.	325 amps max.
Peak inverse anode voltage (Note 1)	6.0 KV max.	16.0 KV max. 5% of e_{py} min.
Average anode current	100 ma d-c max.	200 ma max.
Pulse duration (measured at ½ amplitude)	6.0 μsec. max.	6.0 μsec. max.
Pulse repetition frequency	4000 p.p.s. max.	Note 2
Duty cycle (Note 3)	0.0008 max.	0.001 max.
Grid drive (Note 4)		
a) peak grid voltage	150 v min.	150 v min.
b) time of rise	1.0 μsec. max.	1.0 μsec. max.
c) grid pulse duration at 50 v min. amplitude	4.0 μsec. min.	4.0 μsec. min.
d) impedance of grid drive circuit	1500 ohms max.	500 ohms max.
Peak inverse grid voltage	200 v max.	200 v max.
Ambient temperature	−50° to + 90° C	−50° to +90° C

NOTE 1: In pulsed operation, peak inverse anode voltage during the first 25 microseconds after the pulse should not exceed 2.5 KV for the 4C35; 5 KV for the 5C22.

NOTE 2: Maximum pulse repetition frequency for the 5C22 (prf in pulse per second) depends on peak forward anode voltage (e_{py} in volts) and peak anode current (i_b in amps) according to formula

$$e_{py} \times i_b \times prf = 2.8 \times 10^9$$

NOTE 3: Duty cycle is defined as the product of pulse duration in seconds and pulse repetition frequency in pulses per second.

NOTE 4: Measurements at tube socket with thyratron grid disconnected.

FEATURES

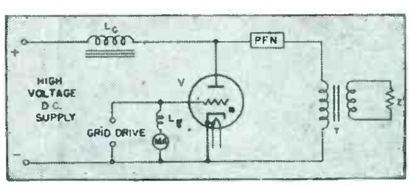
The 4C35 and 5C22 Hydrogen Thyratrons developed by Sylvania Electric are specifically designed for pulsing service at high repetition frequencies, high peak current, and high voltages.

Because of the high mobility of hydrogen, the gaseous ions are converted to neutral molecules within a very short time after tube is shut off. This feature of the 4C35 and 5C22 permits operation at exceptionally high repetition frequencies.

Tubes may be operated over a wide range of ambient temperatures without significant change in their electrical characteristics.

CIRCUIT FOR PRODUCING RECTANGULAR PULSES

The 4C35 and 5C22 were specifically developed for use in the circuit below, designed to produce periodic rectangular pulses. Pulses are formed at levels of about twice the power supply voltage, thus giving savings in size and cost of supply.



L_g Grid Choke
L_c Charging Choke
PFN Pulse-Forming-Network
T Matching or Pulse Transformer
Z Load
V 4C35 or 5C22

OTHER APPLICATIONS

Other suggested applications of the 4C35 and 5C22 include:

1. Switching in welding circuits, particularly of the capacitor discharge type.
2. Shock excitation of tuned circuit.
3. Excitation of piezoelectric crystals.
4. Use in induction heating circuits to replace spark-gap heaters, resulting in trouble-free and quieter performance.
5. Pulser for pulse time modulation circuits in which signals are produced by modulating the pulse repetition rate.
6. Servomechanisms and control circuits where relatively high a-c supply frequencies are used.

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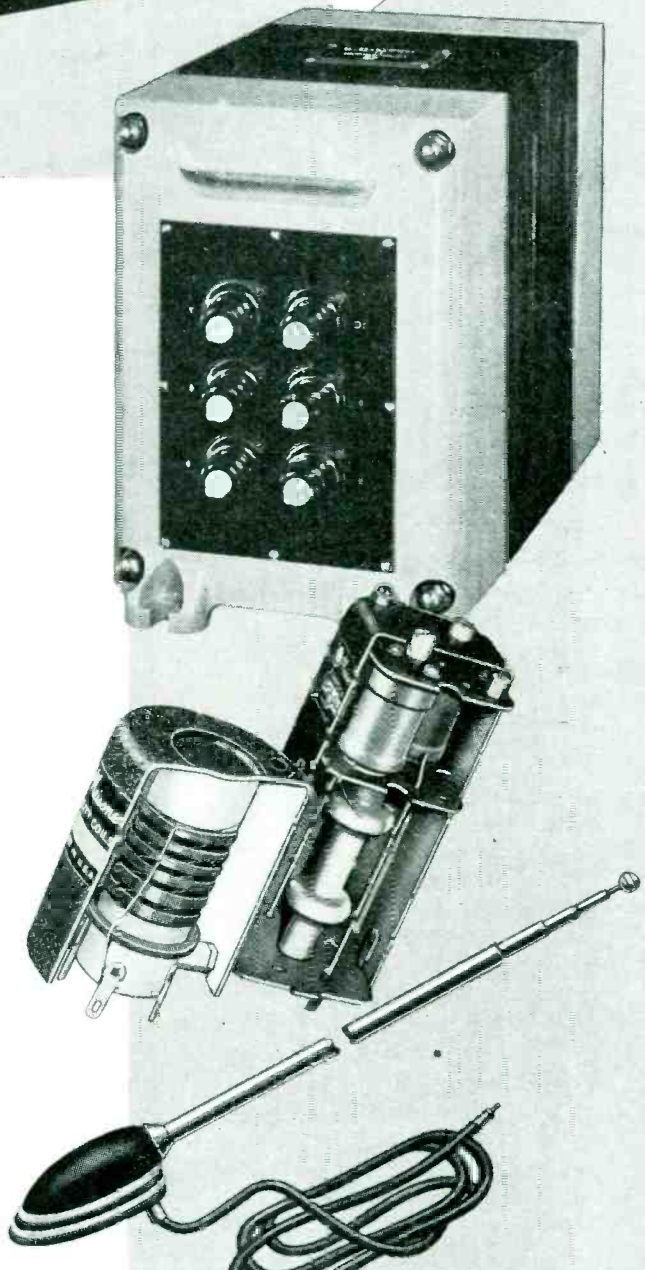

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Edited by FRANK ROCKETT

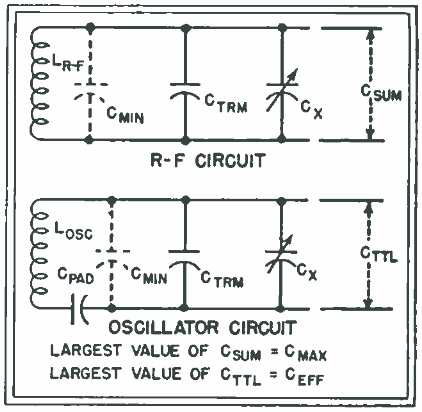


Fig. 1—Resonant circuits of oscillator and r-f input

Superhet Tracking Formulas

By JOSEPH MARSHALL
Ozone, Tennessee

PADDING AND TRIMMING capacitors used to adjust the tracking of oscillators and r-f circuits of superheterodyne receivers employing ganged, equal-section, variable capacitors can be calculated with sufficient accuracy for practical purposes from the two formulas presented below. Design procedure using these equations is described and illustrated.

Simplified Tracking Formulas

Using the following tracking formulas, derived in the appendix, simplifies calculation of superhetrodyne tuning constants

$$C_{pad} = \frac{1}{(1/C_{eff}) - (1/C_{max})} \qquad (1)$$

$$C_{trm} = \frac{1}{(1/C_{min}) - (1/C_{pad})} - C_{min} \qquad (2)$$

where

C_{min}—minimum capacitance in circuits

C_{max}—Maximum capacitance required to tune lowest r-f with given inductance

C_{eff}—capacitance required to tune oscillator to a frequency equal to the lowest r-f plus the i-f

C_{pad}—padding capacitance required to provide low-frequency tracking

C_{trm}—oscillator trimming capacitance to secure high-frequency tracking

f_1—highest radio frequency

f_2—lowest radio frequency

f—intermediate frequency

Design Procedure

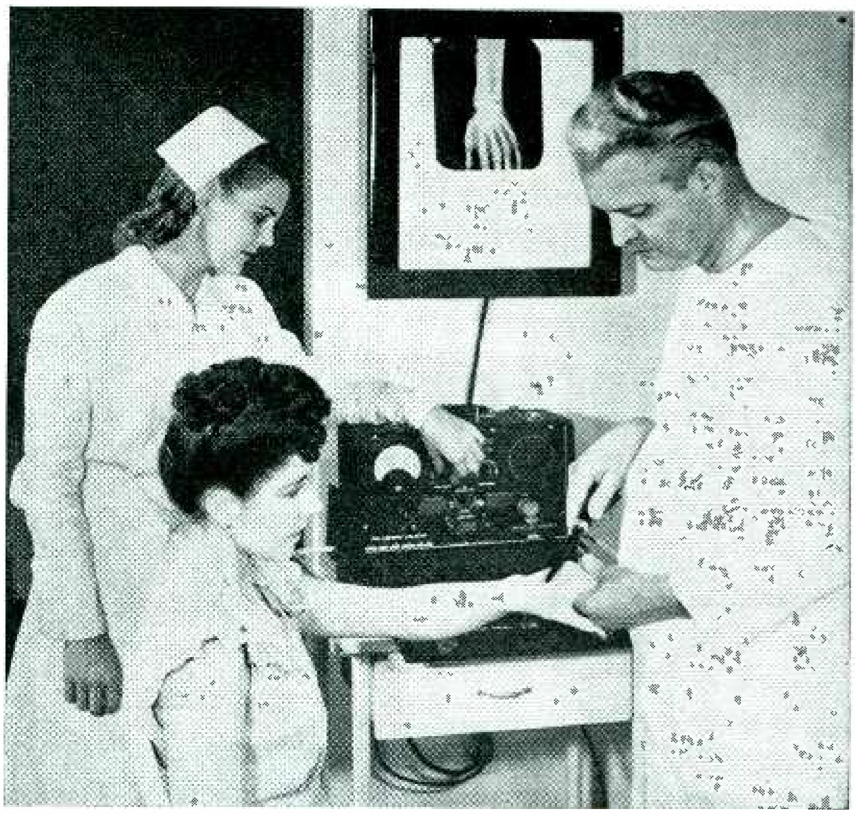
Design of the circuit shown in Fig. 1 is carried out in seven steps.

(1) Determine C_{min}, which can be estimated to be between two and three times the tuning capacitor minimum. This capacitance is composed of wiring, minimum tuning, and half the trimmer capacitances. The more accurately it is determined, the more accurately will tracking be calculated. However, because all tracking formulas require pragmatic adjustment, any error if not too great can be compensated in the working circuit by the trimmer. Using half the expected trimmer capacitance affords adjustment in either direction. In usual circuits at usual frequencies, C_{min} will be about 30 to 35 $\mu\mu$f.

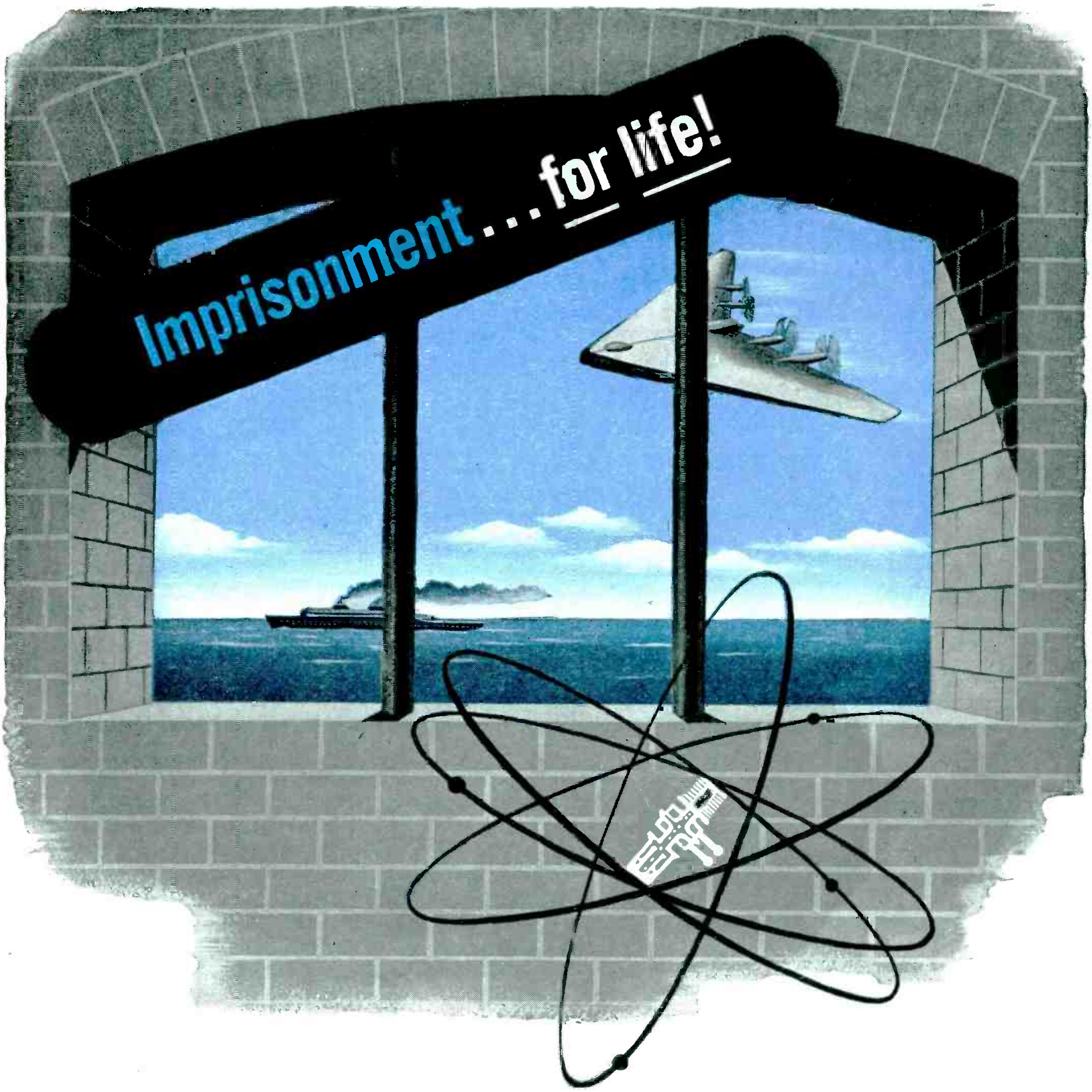
(2) By resonance formulas determine the necessary inductance to tune the r-f circuit to the highest radio frequency with the estimated minimum capacitance.

(3) By the same means determine the inductance necessary to tune the local oscillator to the highest radio frequency plus the intermediate fre-

MEDICAL DIAGNOSIS



Used to supplement x-ray examination or where x-rays are not available, this metal locator quickly spots foreign particles imbedded in patients. For examination prior to operation, the probe is initially used on its side to detect the imbedded metal, then tipped foremost to locate the particle's exact position. Increasing pitch of the tone generated by the metal locator indicates approach to the particle



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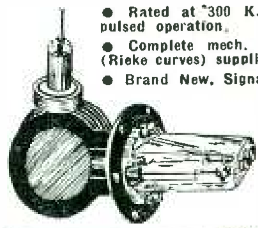

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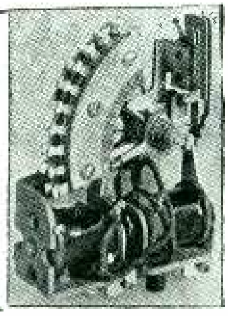

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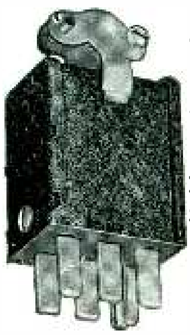

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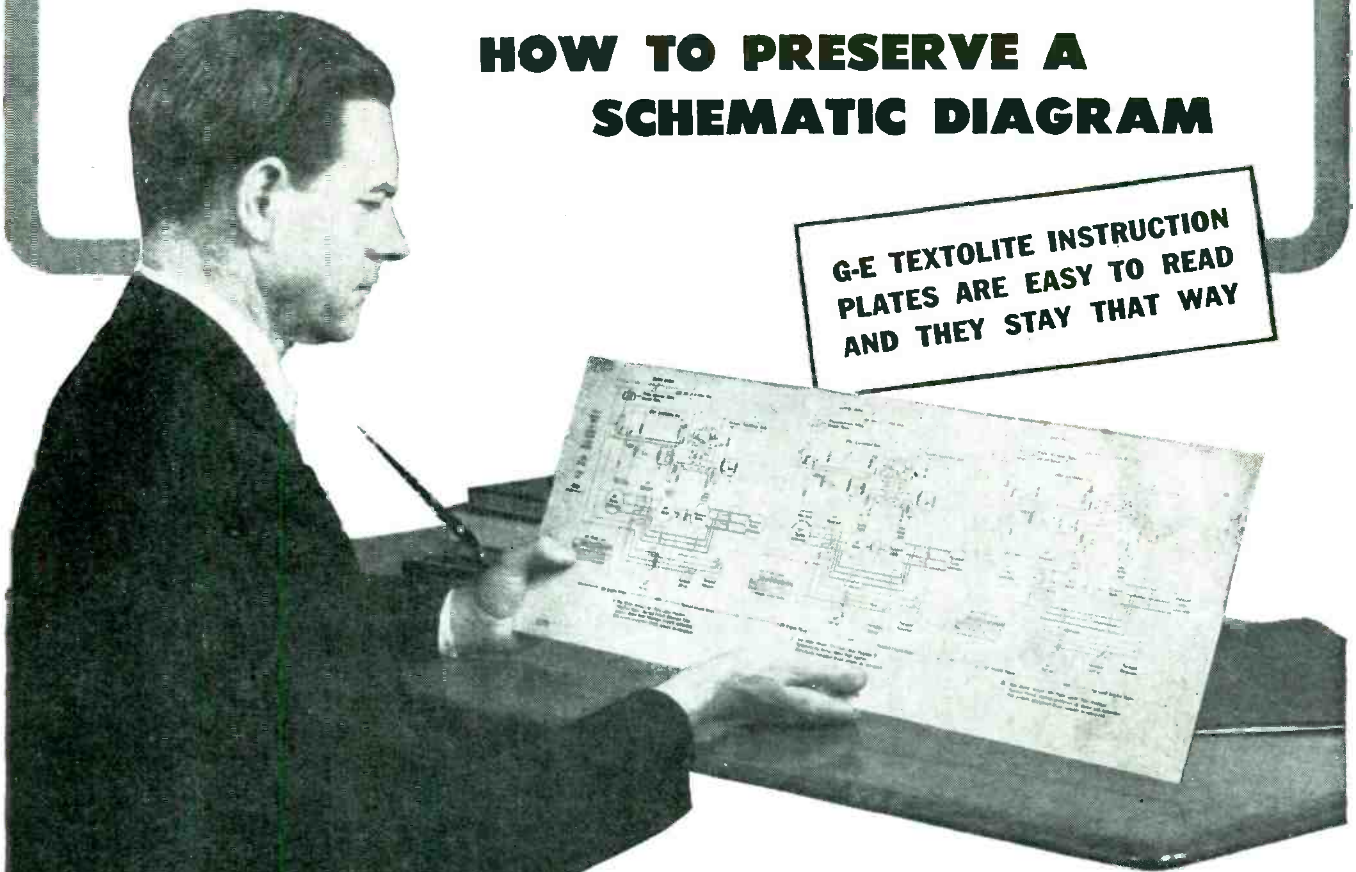

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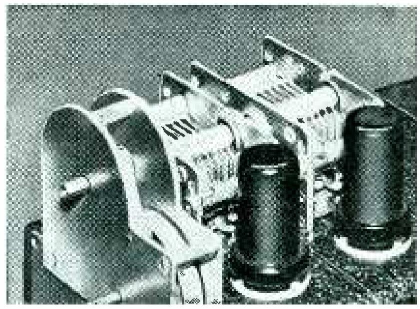
quency $(f_1 + f)$ with C_{min}.

(4) Using the inductance determined in step 2, determine C_{max} to tune the r-f circuit to the required lowest radio frequency.

(5) In the same manner but using the inductance determined in step 3, determine the effective capacitance necessary to tune the oscillator to the lowest radio frequency plus the intermediate frequency $(f_2 + f)$.

(6) The required maximum capacitance of the main tuning capaci-



Converter using twin ganged tuning capacitors

tor will equal C_{max} — (C_{min} minus minimum capacitance of main tuning capacitance).

(7) Determine the values of C_{pad} and C_{trm} using the constants determined in previous steps and Eq. 1 and 2.

A check for tracking can be made by determining from resonance formulas the frequencies tuned by the r-f and oscillator circuits at various capacitance settings and comparing their differences to the intermediate frequency. The total oscillator circuit capacitance at any given point is given by

$$C_{ttl} = \frac{1}{\dfrac{1}{C_x + C_{trm}} + \dfrac{1}{C_{pad}}} \qquad (3)$$

where

C_{ttl}—total capacitance in oscillator circuit when tuning capacitance is set at C_x

C_x—any particular setting of capacitance of the oscillator tuning capacitor, includes minimum tuning and wiring capacitance

Example

For a circuit required to tune from 7 to 15 mc with a capacitor having a minimum capacitance of 10 $\mu\mu$f, C_{min} is estimated to be 20 $\mu\mu$f, as suggested in step 1. By step 2, an inductance of 5.6 μh is necessary to tune the r-f circuit to 15 mc with

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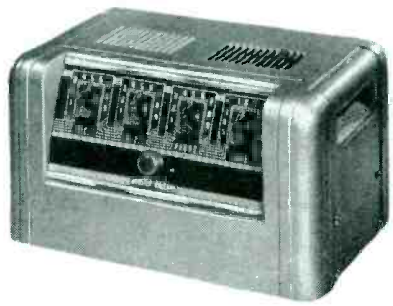

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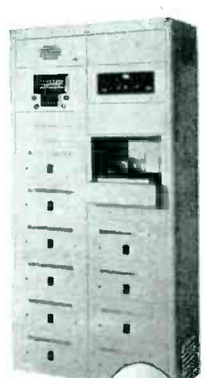

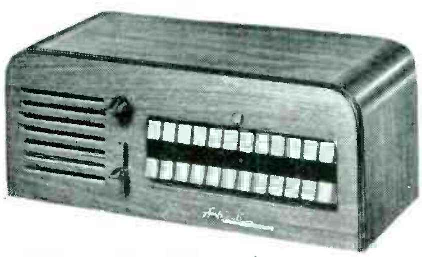

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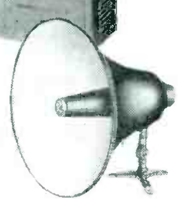

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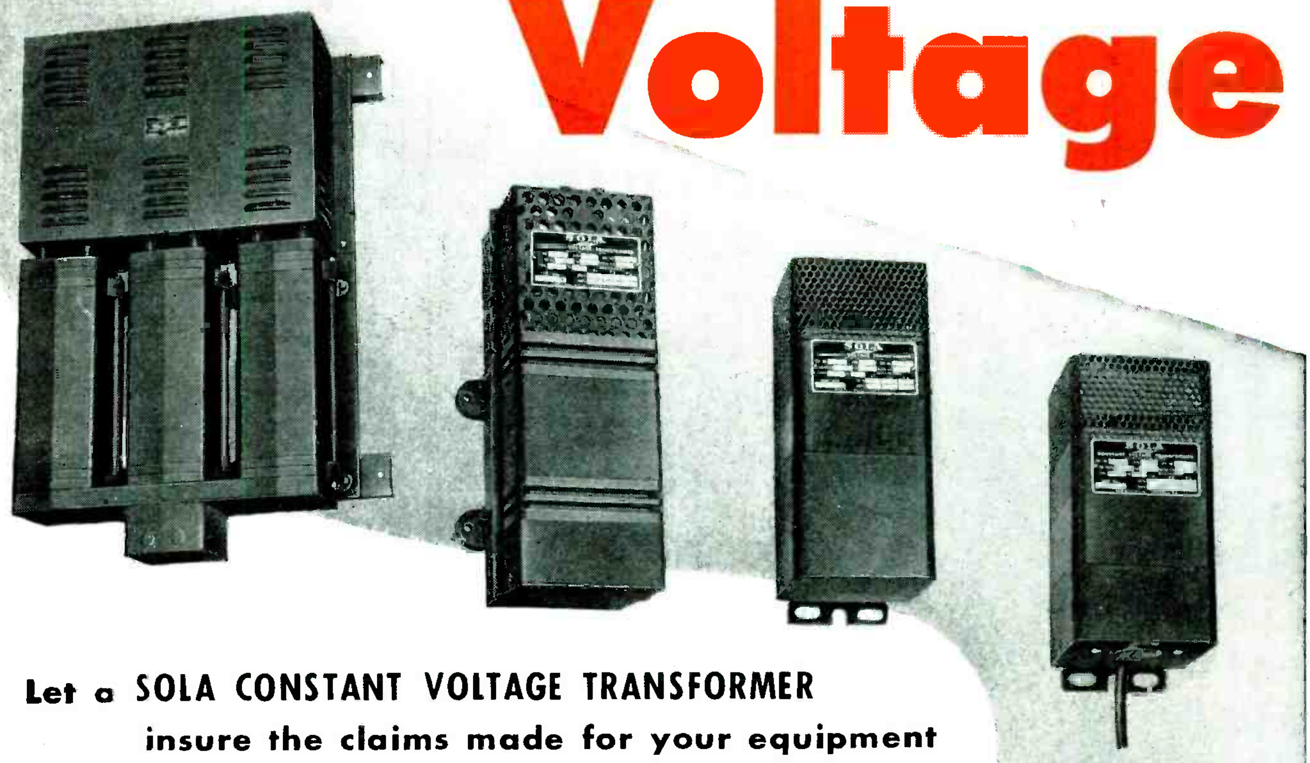

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20 $\mu\mu f$. For step 3 the intermediate frequency is to be 500 kc, therefore the oscillator frequency at the highest frequency must be 15.5 mc. The necessary inductance with 20 $\mu\mu f$ is 5.2 μh. By step 4, the maximum capacitance C_{max} required to tune to 7 mc with an inductance of 5.6 μh is 92.5 $\mu\mu f$. By step 5, the effective capacitance C_{eff} necessary to tune an inductance of 5.2 μf to a frequency of 7.5 mc is 86.6 $\mu\mu f$. From step 6, the maximum capacitance of the required gang capacitor is 82.5 $\mu\mu f$ per section. Using Eq. 1 and 2 for step 7, the padder and trimmer capacitances are found to be

$$C_{pad} = \frac{1}{(1/86.6) - (1/92.5)} = 1370\ \mu\mu f$$

$$C_{trm} = \frac{1}{(1/20) - (1/1370)} - 20 = 0.3\ \mu\mu f$$

The tracking obtained by these design values is shown in Table I. The large tracking error at minimum capacitance is due to the fact that inductance values given are slightly lower than actually required, 5.62 and 5.28 μh respectively. The design values were given to only one decimal place because in practice it is difficult to wind coils more accurately. The tracking error can be restored in the working circuit. Measurements on a circuit built with these parameters are given in Fig. 2. Final alignment was made at the customary points about ten percent in from the extreme ends. The inductance can be adjusted to obtain tracking in the middle of the band if desired.

I—Calculated Tracking Error

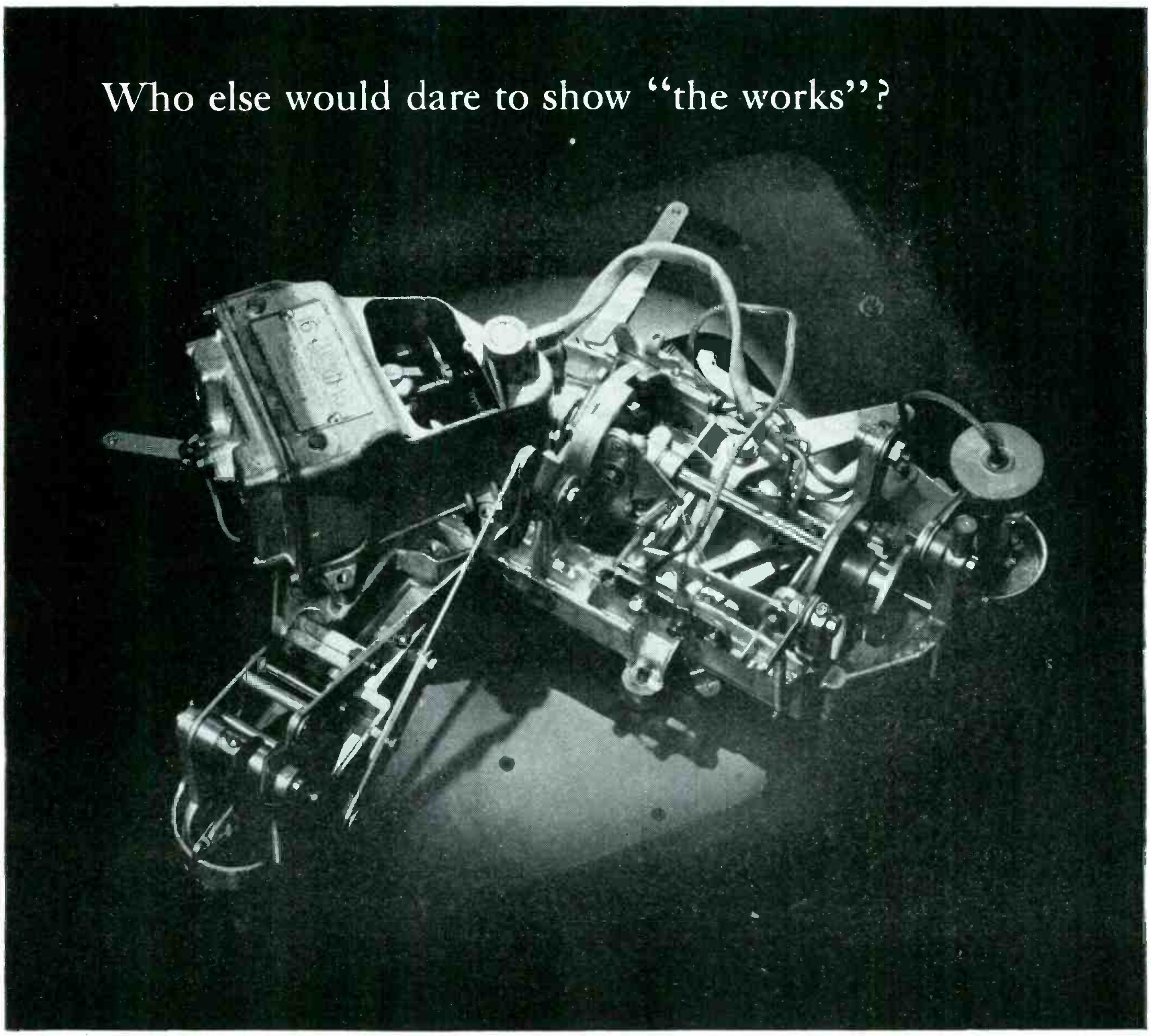
(capacitances in micromicrofarads)

Mn r-f cap.	50% r-f cap.	Max r-f cap.
20.0	50.0	92.5
Min osc cap.	**50% osc cap.**	**Max osc cap.**
20.0	48.5	86.6
Corresponding radio frequency in mc		
15.036	9.509	6.992
Corresponding oscillator freq in mc		
15.588	10.042	7.502
Resultant intermediate freq in kc		
552	533	510

Design i-f is 500 kilocycles

Appendix

Equations 1 and 2 are derived from the superheterodyne circuit of Fig. 1 in which C_{min} includes the minimum capacitance of the tuning



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capacitor, trimmer and wiring capacitance. The total capacitance in the oscillator circuit at any setting of C_x is as given by Eq. 3, from circuit theory. The sum of the capacitances in the r-f circuit is

$$C_{sum} = C_{trm} + C_x \qquad (4)$$

Using the least value of C_{sum}, the necessary inductance to tune the r-f circuit to the highest required frequency is uniquely determined. This inductance and the lowest required

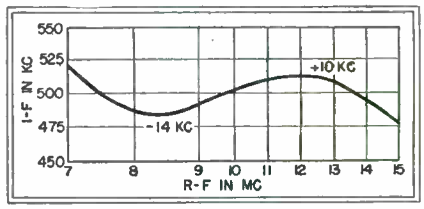


Fig. 2—Measured tracking error after alignment

frequency uniquely determine the largest required value of C_{sum}, that is C_{max}, which in turn determines the maximum value of the variable capacitance C_x.

Likewise, in the oscillator circuit the least value of C_{ttl} and the highest required oscillator frequency determine the oscillator inductance. Because C_{pad} is normally very high compared to C_{min}, its effect in Eq. 3 on C_{ttl} can be neglected when C_x is zero. Similarly C_{trm} is small and can be considered a part of C_{min}. Therefore at the higher frequencies the total capacitance of the oscillator circuit is very nearly equal the minimum circuit capacitance, and this value can be used to determine the value of the oscillator inductance.

Because the capacitors in both r-f and oscillator circuits are equal, as their capacitances are increased the difference in circuit inductances will cease being sufficiently effective to maintain the intermediate frequency, the oscillator resonating too low. The required C_{eff} to tune to $f_2 + f$ is given by

$$C_{eff} = \frac{25{,}330}{(f_2 + f)^2 L_{osc}} \qquad (5)$$

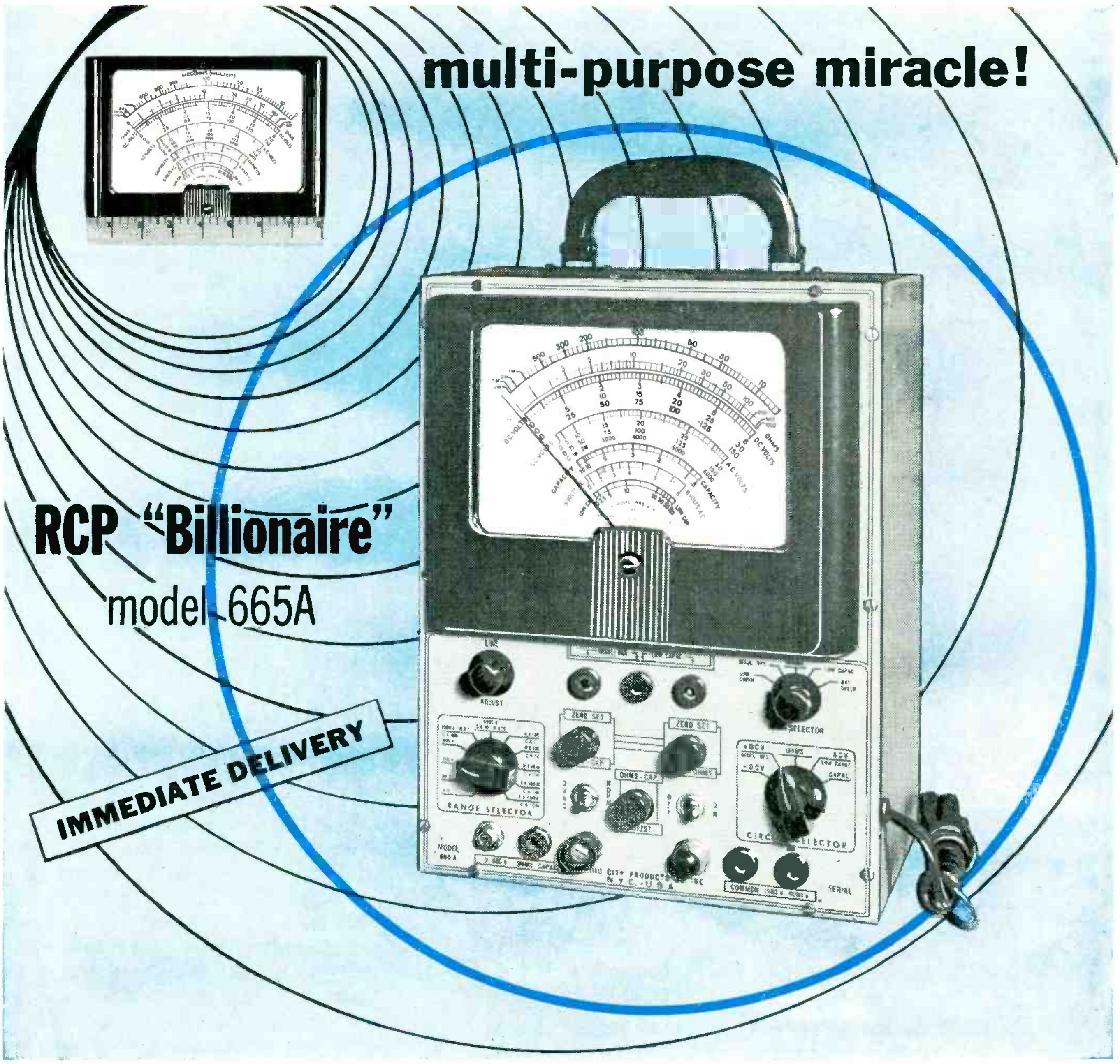
where

L_{osc}—oscillator inductance

To correct the oscillator circuit capacitance to this value, the padder is introduced. Its value can be found is set to a large value, thus

$$C_{pad} = \frac{1}{(1/C_{eff}) - (1/C_{x2})} \qquad (6)$$

where



A five-in-one instrument answering any and all of the varied, involved test problems for manufacturers of electronic equipment; a multi-purpose test mechanism spanning twenty-nine separate ranges involving any laboratory, inspection, or service test job. Here is an insulation tester reaching a range of *ten* billion ohms . . . an AC-DC vacuum tube voltmeter . . . an ohmmeter . . . and a capacity meter. Complete your testing equipment with this multi-purpose miracle. Ask your jobber about it today, or write us direct for RCP Catalog #129.

OUTSTANDING RCP FEATURES

★ Readings as low as 0.1 ohms, 0.000002 mfd., 0.5 volt AC and 0.05 volt DC

★ One of the few instruments of its kind that has an accurate direct-reading capacity meter with a range of 2 mmf. to 2000 mfd. — a 40,000,000 to 1 measurement ratio

★ The "Megger" provides accurate insulation resistance tests at 500 volts from 0 to 10 billion ohms

★ Giant 8" rectangular wide-scale, high torque Alnico meter, accurate to within 2%

★ The Vacuum Tube Voltmeter measures signal and output voltages from 10 to 250,000 c.p.s.

★ The meter cannot be damaged by using the low range for high voltage readings

★ Constant accuracy of low resistance ohmmeter ranges is guaranteed by test of ohmmeter battery under load to determine its condition.

RCP Instruments—Best For Every Test!

RANGES

Insulation Tester: 1 megohm to 10,000 megohms at 500 volts.
AC Vacuum Tube Voltmeter: (Direct Reading) **Input Capacity:** 0.00005 mfd. at terminals of instrument. **Input Resistance:** 160 megohms on 1500 and 6000 volt ranges, and 16 megohms on low ranges. Seven Ranges: 0/3/6/30/150/600/1500/6000 volts.
DC Vacuum Tube Voltemeter: (Direct Reading) **Sensitivity:** 160 megohms on 1500 and 6000 volt ranges, and 16 megohms on low ranges.
Six Ranges: 0/6/30/150/600/1500/6000 volts.
Vacuum Tube Ohmeter: (Direct Reading) Seven Ranges: 0/1,000/10,000/100,000 ohms, 1/10/100/1000 megohms.
Vacuum Tube Capacity Meter: 8 separate ranges from 0.000002 — 2,000 mfd.
Model 665A—in sturdy, grey, crackle-finish steel case, complete with four test leads, self-contained batteries and carrying handles.

RADIO CITY PRODUCTS COMPANY, INC.

127 WEST 26th STREET — NEW YORK CITY 1, N.Y.

MANUFACTURERS OF PRECISION ELECTRONIC LIMIT BRIDGES, VACUUM TUBE VOLTMETERS, VOLT-OHM-MILLIAMMETERS, SIGNAL GENERATORS, ANALYZER UNITS, TUBE TESTERS, MULTI - TESTERS.

C_{x2}—largest value of oscillator tuning capacitor (because the r-f and oscillator tuning capacitances are equal, C_{x2} can be closely approximated by C_{max} which substituted in Eq. 6 gives Eq. 1.)

Addition of the padder will reduce the capacitance at the high frequency end necessitating inclusion of the trimmer giving

$$C_{ttl} = \frac{}{\dfrac{1}{C_{min} + C_{trm}} + \dfrac{1}{C_{pad}}} \quad (7)$$

Because we started by producing resonance with only C_{min}, we need a trimmer capacitance that will make C_{ttl} equal C_{min}, thus

$$C_{trm} = \frac{1}{(1/C_{min}) - (1/C_{pad})} - C_{min} \quad (2)$$

The trimmer capacitance will be so small that it will not affect tracking at the low frequency end of the tuning range. Therefore we can stop this sequence of approximations here.

Evolution of Radiolocation

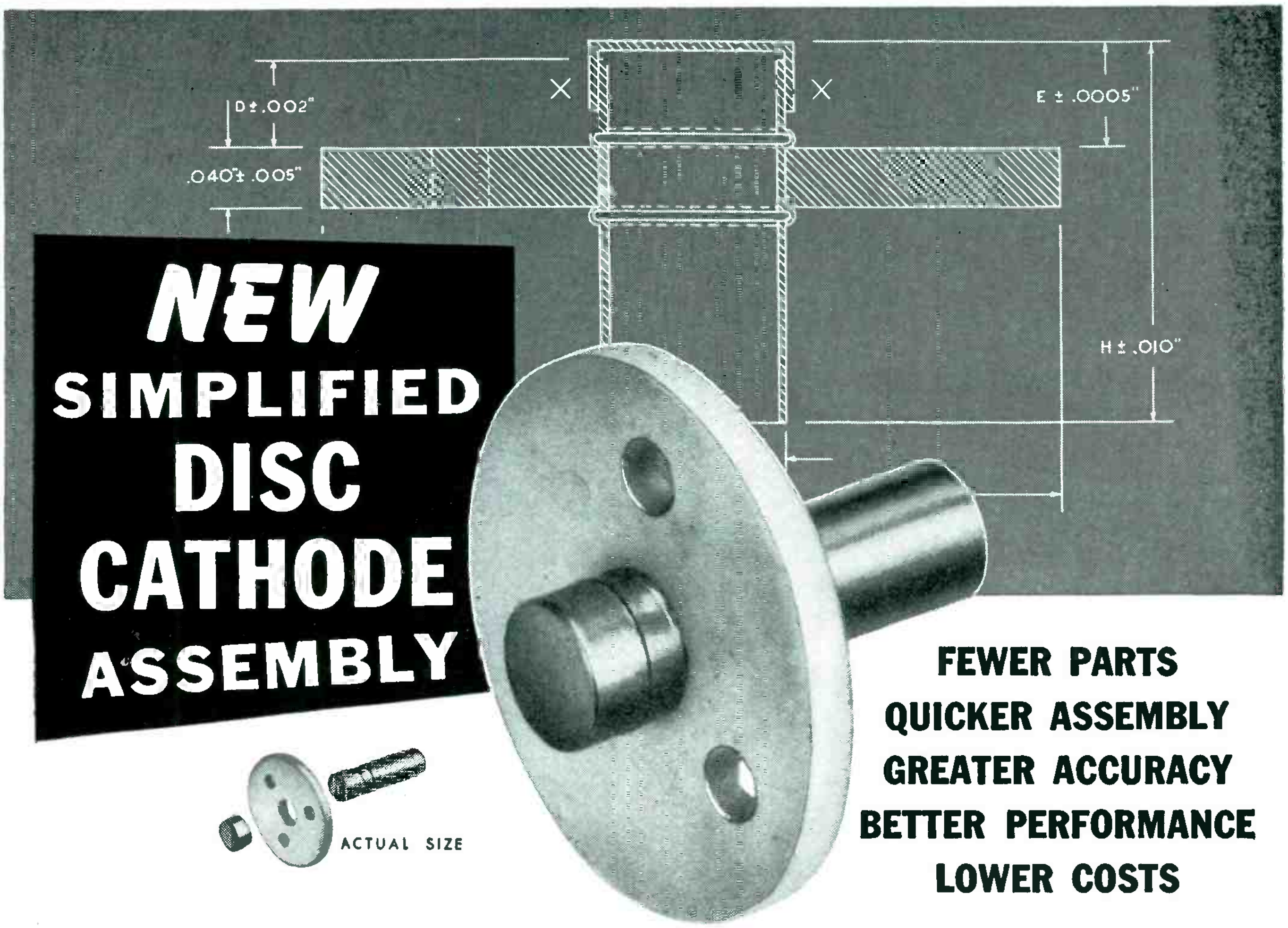
RADIOLOCATION SYSTEMS measure at least two of the three coordinates which are required to define the position of one object relative to another. Sir Robert Watson-Watt, in reviewing the development of military radiolocation in Britain at the March Radiolocation Convention in England, differentiated between simple direction finding and radiolocation on the basis that only in radiolocation can distance be unambiguously inferred from measurement of the time of travel of the radio wave.

Types of Systems

Radar is one form of radiolocation. There are a variety of radar systems. In *primary radar* no cooperation of the target is required. Such a system is useful in locating icebergs and enemies, but is an extravagance when used against friends. *Secondary radar* requires a small measure of cooperation on the part of the target in that the target carries an automatic responder, which replies to interrogation in a coded manner that gives the identity and possibility such additional information as flying height if it is on an aircraft. This system avoids the ground clutter of primary radar.

Radiolocation for navigation does

ANOTHER SUPERIOR DEVELOPMENT IN METAL TUBING FOR THE ELECTRONICS INDUSTRY!



NEW SIMPLIFIED DISC CATHODE ASSEMBLY

FEWER PARTS
QUICKER ASSEMBLY
GREATER ACCURACY
BETTER PERFORMANCE
LOWER COSTS

The Electronics Division of Superior Tube Company offers the Radio Industry a new and improved disc cathode for Cathode Ray Tubes. This simplified design reduces the number of parts and for the first time permits efficient low cost production. Our usual close control of materials and dimensions insures low loss and greater uniformity in Cathode Ray Tube production and performance.

Through use of integral embosses on the tubing it is possible to hold the insulator firmly yet with less heat loss than previous designs.

Greater flexibility has been achieved as an important feature of this new product. It is possible to meet Customers' requirements as to dimensions and type of ceramic used. The emitting caps may be made from any of the familiar alloys.

Dimensional accuracy is greater, thus permitting closer control of cathode to grid spacing, and resulting in improved electrical tube characteristics and performance in television receivers.

The facilities of the Engineering Staff of Superior's Electronics Division are at your service — we welcome the opportunity to help you with your cathode, anode, and other electronic metal tubing problems.

THE BIGGER NAME IN SMALL TUBING Superior

SUPERIOR TUBE COMPANY
ELECTRONICS DIVISION
Post Office Drawer 191 • Norristown, Pa.
Telephones Norristown 2070, Collegeville 3711

not necessarily depend on the return of an echo either directly or amplified, as in *oboe*. In *G-H*, *babs* (blind approach beacon system), and *Rebecca-Eureka* a coded response is sent back by a ground responder-beacon in reply to pulses from an airborne or shipborne interrogator. In *gee* and *loran*, the location is obtained from measurements of the time-difference of arrival of primary pulses from synchronized ground stations at accurately surveyed positions.

A major step in the progress of radiolocation was made in 1935 with the development of techniques for measuring range, bearing, and angle of elevation of a large number of aircraft without confusion between targets by a monostatic radiolocation station, that is, a single combined transmitting and receiving station. Conditions for the birth of centimetric radiolocation were established by calling upon the facilities of the physics schools in 1939. The industry which took the half-sheets of notepaper and the telephone conversations and perhaps an occasional breadboard and converted them into dependable equipment, often made major developmental contributions of their own.

Skiatron

A DARK-TRACE radar display tube provides means for projecting an enlarged ppi display on a screen. The tube consists of a conventional magnetically focused cathode-ray tube but with a white translucent layer of microcrystalline potassium chloride for the screen. Electron bombardment at 10 kv and 300 μa produces a magenta coloration of this screen. Light, normally reflected to the viewing position by the screen, is absorbed by the coloration. Thus where the screen has been bombarded, no light is reflected and a dark area appears at the viewing position. Maximum color contrast is obtained with the magenta color if the greenish light from mercury lamps, which are fortunately efficient sources of illumination, is used.

Formation of Color Centers

All alkali halides are colored by electron bombardment, each having

FRANKLIN AIRLOOPS now covered by basic patent #2,401,472

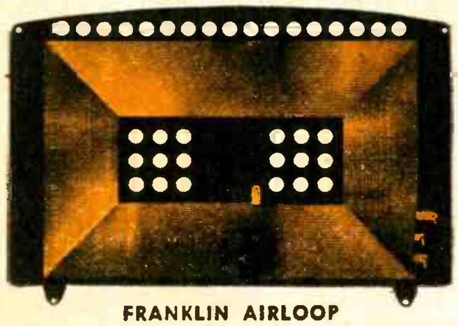
FRANKLIN AIRLOOPS NOW COVERED BY BASIC PATENT

Patent No. 2,401,472 covering the new loop antenna, known as the AIRLOOP, has just been issued by the U. S. Patent Office. The claims issued are basic in scope as is evidenced in claim No. 1 which is typical and follows:

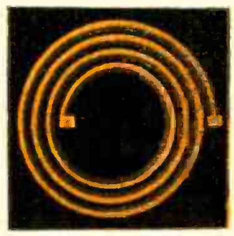
1—An air dielectric inductance comprising a panel of insulating material and a continuous metal strip formed from a metal sheet and attached to one face of said panel in the form of a spiral, the planar width of said strip being equal to the pitch of said spiral and said strip being in channel form to provide a free air space between adjacent turns of said spiral.

In addition to the above, other patents are pending, domestic and foreign, covering the methods of manufacture and items such as stamped electrostatic shields, stamped disc type commutators, stamped inductance coils, stamped wiring circuits and for the molding of loops and creative metal designs in cabinets which are of plastic or inert materials.

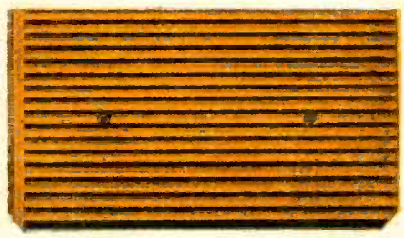
The Franklin Airloop Corp., which has the rights to the use of this patent, offers its experimental laboratories to assist in the development of any item which can be manufactured by the stamping method covered in these patents.



FRANKLIN AIRLOOP



SHORT WAVE INDUCTANCE COIL



ELECTROSTATIC SHIELD

Illustrated are but a few of the items that can be manufactured by the method covered in this patent . . . many others are now in development . . . you, too, may conceive a use for this patented method and in such case the Franklin experimental laboratories will be glad to assist in its development.

DISC TYPE COMMUTATOR
MULTIPLE SWITCH
VARIABLE RESISTANCE

FRANKLIN *Airloop* CORPORATION

43-20 34th ST. LONG ISLAND CITY 1, N. Y.

its peculiar color and sensitivity; potassium chloride is the most sensitive. There are crystal inperfections in these compounds due to the absence of equal numbers of halogen and metal ions. When the electron beam bombards a halogen ion, an electron is trapped, causing a color center having an absorption band corresponding to transitions between its various energy levels. This color center can be cleared by migration of the electron that caused it.

If the electron bombardment is continued, the combined effects of primary and secondary bombardment produce metal ions which immobilize a corresponding number of color centers. Coloration under these conditions can therefore clear only at the slow rate set by ionic mobility.

Production and Application

Adequate sensitivity can only be obtained from screens formed by evaporation and viewed by reflection. Exposure to air harms the screen. Therefore the screen is formed by evaporation from a nickel cup mounted on one side of the tube's bulb during pumping. The cup is left in the tube. Best results are obtained when the molecular beam from the cup strikes the glass at angles between about 30 to 60 degrees. The cup is placed in the bulb so that the active portion of the screen will receive deposition from this angle.

The decay rate is affected by light, temperature, and electron bombardment. Increasing the illumination falling on the screen up to 5,000 foot-candles increases the rate of decay, but above this limit, the decay becomes no faster. The color is cleared more quickly if the screen is scanned by a low-intensity electron beam, which is accomplished by the noise in the radar signal. The screen clears faster at higher temperatures, but has less contrast. Color centers produced by a single electron bombardment, resulting in solely electronic coloration, clear in about a minute; color centers produced by repeated electron bombardment as in repetitive scanning of a fixed target, resulting in ionically immobilized color centers, may take an hour to

...a metal for inserts that won't work loose from ceramic insulation as temperatures fluctuate.
Mycalex Corp.

...a metal to hold other parts in place under the searing heat of a high-voltage discharge.
General Electric Co.

...a metal that won't develop high surface resistance because of corrosion.
Vendo Corp.

...a metal whose electrical resistance varies measurably with temperature changes.
The Simmons Co.

...a metal for an armature that vibrates continuously 94,000,000 times a year.
Union Switch and Signal Co.

...a metal that can stand spark erosion without pitting or burning.
Scintilla Magneto Co.

...a metal that will remain non-magnetic during spot-welding.
General Thermostat Corp.

THESE ARE TYPICAL METAL SELECTION PROBLEMS THAT WERE SOLVED BY USE OF

MONEL NICKEL INCONEL

	MONEL	"R" MONEL	"K" MONEL	"KR" MONEL	"S" MONEL	NICKEL	"Z" NICKEL	INCONEL
CORROSION RESISTANCE	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
STRENGTH	GOOD	GOOD	HIGH	HIGH	GOOD	GOOD	HIGH	GOOD
TOUGHNESS	GOOD	GOOD	HIGH	GOOD	GOOD	HIGH	HIGH	HIGH
HARDNESS	GOOD	GOOD	GOOD	GOOD	HIGH	FAIR	HIGH	GOOD
MACHINABILITY	GOOD	HIGH	GOOD	HIGH	GOOD	GOOD	GOOD	GOOD
NON-GALLING	NO	NO	NO	NO	HIGH	NO	NO	NO
SPRING PROPERTIES	GOOD	NO	HIGH	NO	NO	GOOD	HIGH	HIGH
ELEC. CONDUCTIVITY	POOR	POOR	POOR	POOR	POOR	GOOD	GOOD	POOR
HEAT RESISTANCE	GOOD	GOOD	GOOD	GOOD	HIGH	GOOD	GOOD	HIGH
HEAT TREATABLE	NO	NO	YES	YES	YES	NO	YES	NO
NON MAGNETIC	NO	NO	YES	YES	YES	NO	NO	YES

Think of the INCO Nickel Alloys first when you need a metal with a hard-to-find combination of properties.

These high-Nickel alloys are Strong... Tough... Hard... Rustless.

They resist High Temperatures... Corrosion... Wear... Fatigue. Their use is insurance for long, trouble-free service.

MORE INFORMATION! Tell us the alloy that interests you, and we'll mail more information. Or, send for "List B-100" which lists over 100 bulletins explaining the properties and applications of the INCO Nickel Alloys.

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NICKEL INCO ALLOYS

MONEL* • "K" MONEL* • "R" MONEL* • "KR" MONEL* "S" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*
*Reg. U. S. Pat. Off.

clear. Impurities increase the rate of clearing, but their effect is lost in a short time.

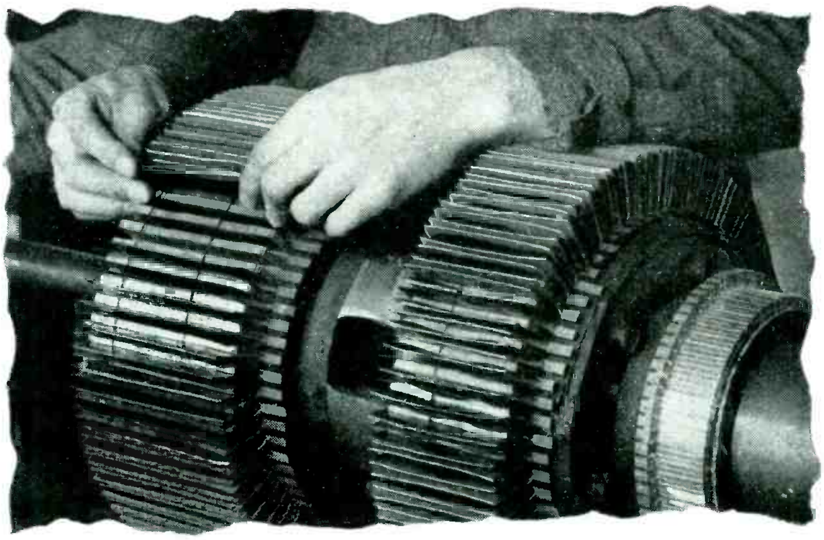
Using two 500-watt mercury vapor lamps illuminating a tube screen of about 3 in. diameter, an episcopic type of projection through an $f/1.5$ lens gave a 2 ft. diameter image. (The Skiatron, or Dark-Trace Tube, by P. G. R. King; A Survey of Cathode-Ray Tube Problems in Service Applications, with Special Reference to Radar, by J. G. Bartlett, D. S. Watson, and G. Bradfield; both papers presented at the Inst. of Elec. Engr. Radio Convention, March 1946. A very similar tube was manufactured in Germany during the war. A transparent tungsten film between the potassium-chloride screen and fused quartz support was heated to erase the image; PB-23089, Dept. of Comm. The tube was to have been used to record rapidly transmitted messages; PB-23090, 21 p. Dept. of Comm.).

Relativity

ABSTRACT SPECULATION indicates that electromagnetic waves lose negligible energy in establishing gravitational fields. Just as a projectile moving faster than sound (in the medium of the motion) establishes sound waves, so electrons moving faster than the phase velocity of propagation of electromagnetic waves in the medium of transit establish electromagnetic fields. Furthermore, in a curved (non-Euclidian) universe, the gravitational and electromagnetic waves propagate, in the general case, with different velocities. Therefore it is reasonable to expect that electromagnetic waves will create gravitational fields. An analysis indicates that for spherical waves, such is the case. However, the magnitude of the energy transformed into gravitational field from the electromagnetic field is so small as not even to account for the red displacement that has been observed in the spectra of distant nebulae. (Radiation of Gravitational Waves by Electromagnetic Waves, by L. M. Brekhovskich, *Comptes Rendus*

IRV-O-SLOT for all needs from IRVINGTON —

headquarters for bonded varnished SLOT insulations!



Irv-O-Slot provides the electrical protection necessary for top-quality slot insulation. Moreover, it possesses the mechanical strength required to withstand punishment received during motor assembly and operation. A complete range of varnished fabrics duplexed to selected rag and fish papers allows wide selection. All the base fabrics secure their high dielectric strength from uniform coatings of Irvington-formulated insulating varnishes.

TYPES: Bias and straight-cut varnished cambrics, black or yellow, are standard . . . varnished nylon, rayon, cambric, style S.I.C., silk, and Fiberglas are also bonded to the tough backing papers on special order.

BONDING AGENT: When forming the slot cell, the Irvington binder permits sufficient slippage to prevent rupture of the insulating varnish film, yet the bonded material does not delaminate or bleed.

THICKNESSES: Standard Irv-O-Slot insulations are supplied from .011″ to .028″. Some of the special combinations are as thin as .009″. For slot insulation on smaller fractional horsepower motors, all varnished fabrics are available without paper backing.

Additional information and test samples gladly supplied.

IRVINGTON *Varnish and Insulator Company* IRVINGTON 11, NEW JERSEY, U.S.A.

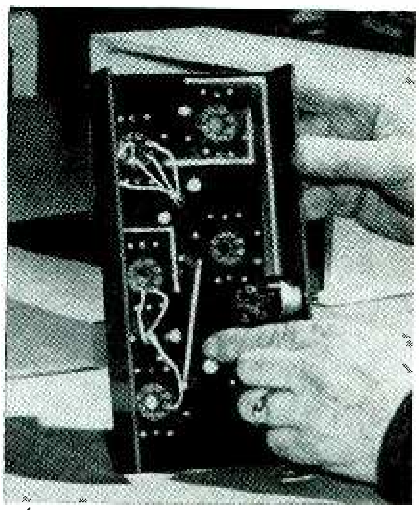
Authorized distributors in: BALTIMORE · BLUEFIELD, W. VA. · BOSTON · CHARLOTTE · CHICAGO · CLEVELAND · DALLAS · DENVER · LOS ANGELES · MINNEAPOLIS · NEW HARTFORD, N. Y. · NEW YORK · NEW ORLEANS · PHILADELPHIA · PITTSBURGH · ST. LOUIS · SAN FRANCISCO · SEATTLE · HAMILTON, ONT., CANADA

(*Doklady*) *de l'Academie des Sciences de l' URSS*, 1945, XLIX, No. 7, p 482-485).

Feasibility of Dielectric Waveguides

SOLID DIELECTRIC waveguides, because they are more easily fabricated than hollow metal guides, might be used at the upper limits of the superhigh frequency range. However, some of the transmitted energy is carried outside of dielectric waveguides, unless the guide is made large enough or of material having so high a dielectric contant that very many modes are carried. Because energy is carried outside dielectric waveguides, bends and external supports, even objects in the vicinity of the guides, constitute discontinuities. Installation of such guides is extremely difficult. If a guide that will accommodate a multiude of modes were used there would be the as yet unsolved problem of coupling in such a manner as to match to these many higher modes. (Waveguides Without Metal Walls by R. M. Whitmer, Report 726, Radiation Lab., MIT, Cambridge, Mass.)

SPRAYED WIRING

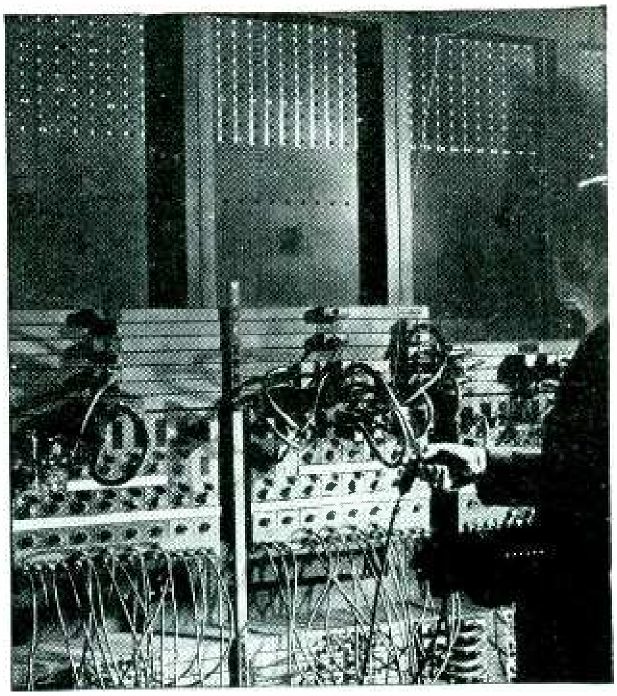


By using a cutout mask as a stencil, sand blasting the plastic chassis to cut the wiring channels, and spraying molten metal into the channels, radio receivers are being turned out at the Buffalo plant of Promenette Radio and Television

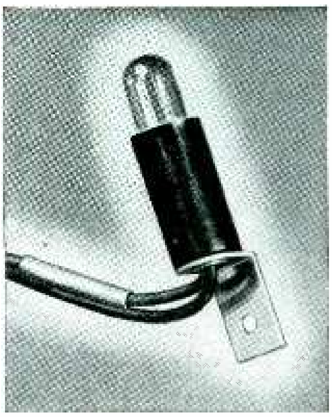
Answer to a schoolboy's dream-

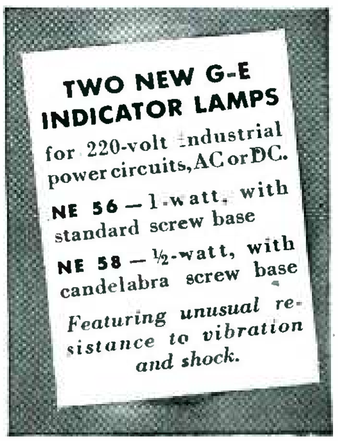
YES, Johnnie could go fishin' with Gramps and leave his homework to ENIAC, the amazing new robot calculator that solves electrically, in a matter of hours, complex mathematical problems which would require months to solve by ordinary means. Developed by the University of Pennsylvania, under contract with the U. S. Army Ordnance Dept., the Electronic Numerical Integrator and Calculator will speed progress in such vital research as nuclear physics and aerodynamics.

The signal lamps shown on the ENIAC's accumulator panels are part of the 3600 G-E Neon Glow Lamps which are used to assure dependable, low-cost visual indication in this intricate, accurate tool of science.



-can it solve your problem, too?





TYPICAL new products improved with G-E Glow Lamps are pictured here. They merely hint at hundreds of other unbelievably low cost applications on home appliances, wiring devices, and many types of industrial equipment. Why not consider the following sales features of G-E Glow Lamps on *your* new products:

1. Distinctive orange red glow, needs no cover glass.
2. Dependable long life—rated at 3,000 hours.
3. Very low current consumption.
4. Variety of sizes and wattages.
5. High resistance to vibration and shock.
6. Usable on AC or DC circuits.
7. Work on regular 105-125 volt circuits without the use of step-down transformers.
8. Practically no heat.

FREE NEW FOLDER *describes typical uses for G-E Neon Glow Lamps and gives lamp data. Write address below.*

G·E LAMPS

GENERAL ELECTRIC

Nela Specialty Div. Lamp Dept., 1 Newark St., Hoboken, N. J.

NEW PRODUCTS

Edited by A. A. McKENZIE

Latest developments in new apparatus, components, materials. New literature

Tube Tester

RADIO CITY PRODUCTS CO., 127 West 26th St., New York 1, N. Y. The model 322 tube tester requires the manipulation of only four controls. Furnished in two styles, one is

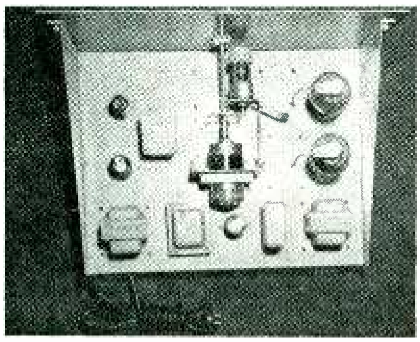
open-faced and has a sloping front panel. It measures 12 x 6 x 8 inches and weighs 8½ pounds. The model 322-P instrument is enclosed in a metal carrying case, measures 13 x 7 x 9 inches, and weighs 9½ pounds.

Chemical Wire Stripper

ELLANAR CHEMICAL CO., 308 W. Randolph St., Chicago 6, Ill. Cold Wire Stripper #416 has been developed for removing enamel, Formvar, Formex, impregnating varnish, and many other coatings. Wires are immersed the desired depth from 15 seconds to 2 minutes. When withdrawn, the coating can be removed with a cloth. The chemical is described as noninflammable.

Servo Follow-up

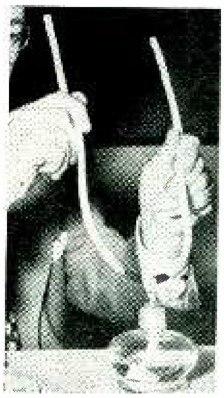
ELECTRONIC ASSOCIATES, INC., Long Branch, N. J. The transmission of mechanical rotation over several miles of wire line is possible using



the equipment illustrated. Less than 100 millivolts rms input voltage results in an output torque of 96 inch-ounces. Maximum following speed for the unit in question is approximately 50 rpm, with an accuracy of better than plus or minus 0.0027 percent.

Aircraft Wire

UNITED STATES RUBBER CO., Rockefeller Center, New York, announces a new aircraft wire known as Neolay, said to be enough lighter than that presently used to save 300 pounds in a plane the size of a B-29 Superfortress. The insula-



tion consists of a layer of glass fiber covered with synthetic rubber. It resists oil, mildew, fungus and most chemicals.

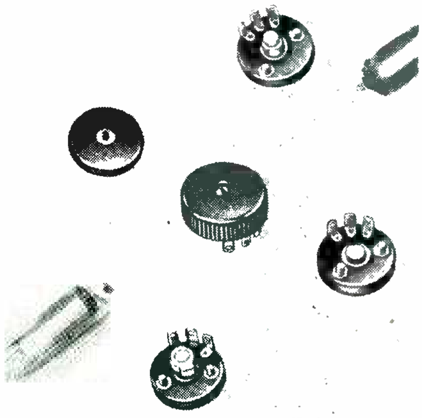
Low-voltage Rectifiers

ELECTRO-TECH EQUIPMENT CO., 119 Lafayette St., New York 13, N. Y. A series of rectifier units giving d-c output continuously variable from zero to 12 or 8 volts in current capacities up to 150 amperes em-

ploy full-wave bridge selenium rectifiers. A voltmeter, ammeter, and fuse are provided on the front panel.

Miniature Attenuator

CENTRALAB, 900 E. Keefe Ave., Milwaukee 1, Wis. Smaller than a dime, the new Model 1 Radiohm attenuator is available in values from



500 ohms to 5 megohms. Six tapers are furnished in this line designed for pocket receivers and miniature amplifiers.

Communication Receiver

PIERSON ELECTRONIC CORP., 533 East Fifth St., Los Angeles 13, Calif. The KP-81 receiver tunes from 550 kilocycles to 40 megacycles in five bands with good image suppression and a separate band-spread control. Power supply and

Now You Can SEE The Performance Of Your Circuits

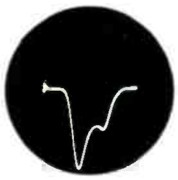
With the

HAR-CAM

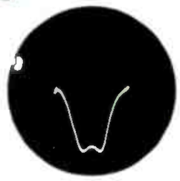
Visual Alignment

SIGNAL GENERATOR

The HAR-CAM Visual Alignment SIGNAL GENERATOR provides the swiftest and surest method for the adjustment and alignment of tuned circuits. With it the complete radio frequency response curve of any circuit under observation can be presented on an oscilloscope screen. Variations in circuit alignment can be accurately evaluated and necessary changes made in a matter of seconds — a far simpler, more precise method than the old technique of tuning for maximum audio or voltage output which often leads to improper alignment of I-F, discriminator or other circuits.



The HAR-CAM Visual Alignment Signal Generator instantly shows up the misalignment in the I-F circuit shown above.



With the assistance of the HAR-CAM Signal Generator, the performance of the circuit is easily and correctly adjusted.

SPECIFICATIONS

1. Linear frequency sweep deviation adjustable from zero to 900 kc peak to peak.

2. Vernier frequency control of 100 kc allows zero beat calibration of main tuning dial or for vernier frequency deviations, about main dial frequency setting.

3. Stable r-f gain control independent of frequency.

4. Five-step attenuator of r-f output giving over-all voltage range of 1 microvolt to .1 volt when used in conjunction with the gain control.

5. Output impedance, 1 ohm to 2500 ohms.

6. Phone jack for aural monitoring of zero beat calibration of main tuning dial.

7. Panel jack to feed linear sweep voltage to x-axis amplifier of oscilloscope, thus synchronizing the frequency linear sweep of the generator with the spot trace on the scope screen.

8. Voltage regulated supply for internal oscillators. Careful oscillator design to minimize drift.

9. Size, 7" wide, 9½" high, 10½" deep. Weight 18 pounds.

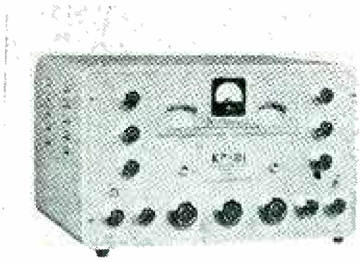
Write for Bulletin

HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

HAR-CAM
HARVEY OF CAMBRIDGE

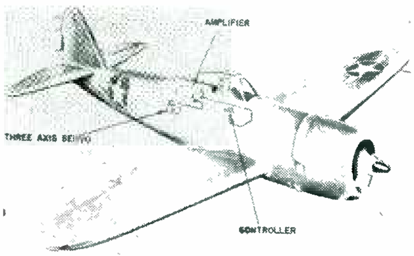
Typical HARVEY products: Above *left:* The HARVEY Marine Radio Telephone Model M-25; *center:* The HARVEY Regulated Power Supply 106 PA; *right:* The HAR-CAM Model MFT-25 FM Transmitter.
Write for Bulletins.



speaker are housed together in a cabinet matching that in which the receiver is contained. A crystal filter and beat oscillator are provided for c-w reception. A brochure is available describing the receiver in detail.

Automatic Flight Control

LEAR, INC., Grand Rapids, Mich. The C-2 fatigue relief pilot is a 27-pound electronic device suitable for operating fighter or other aircraft.



Operating from a 24- to 28-volt system, it consists essentially of a control unit. amplifier, and servo unit.

Phone Cushion

AVIOMETER CORP., 370 West 35th St., New York, N. Y., is now manufacturing a molded synthetic heat-conducting rubber cushion for head telephones. shown here.

Field Indicator

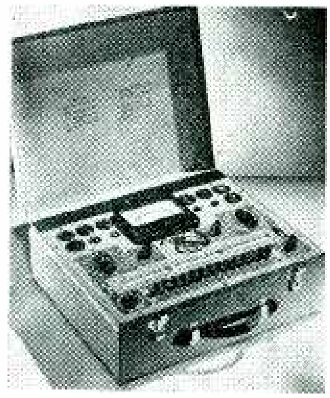
RADIO FREQUENCY LABORATORIES, INC., Boonton, N. J. A new r-f probe for testing high-frequency power circuits can be used for detection of standing waves and r-f circuit tracing in a-m, f-m, television, and electronic heating equipment operating at frequencies up to 1,500 megacycles. The probe element measures ¾ inch in diameter and the overall length of probe and meter is 11 inches.

Monitor Amplifier

PAN AMERICAN ELECTRIC CO., INC., 132 Front St., New York 5, N. Y. The PAB-1500 monitor amplifier is the first item in a line of broadcast and recording studio equipment now being manufactured. Designed to operate from a 600-ohm source, the unit will work into loads of 4 to 500 ohms. A special connection allows its use as a bridging amplifier. The frequency characteristic from 40 to 10,000 cycles is plus 0 to minus 1 db. A feature of the equipment is the oversize power supply that can supply other associated units. Shelf or relay-rack mounting can be furnished. Overall size is 8 x 7 x 10½ inches and weight is 25 pounds.

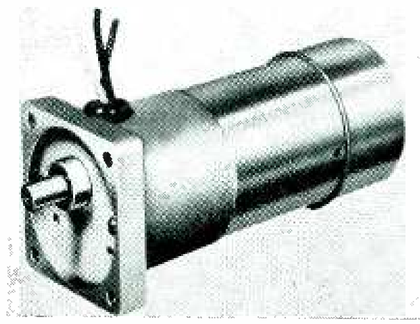
Electron Tube Tester

SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. Two types of tube testers, one for service bench (type 139) and the other portable (type 140) are available, both operating from 105 to 125-volt lines, 50 to 60 cycles. Extra sockets and switch contacts are provided for future tube types.



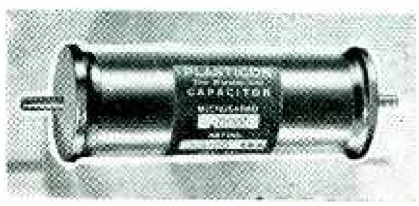
Rotary Actuator

LEAR, INC., Grand Rapids, Mich. The model 181 actuator weighs 0.6 pound and has been designed for loads ranging from 0.1 to 15 pound-inches and speeds from 2.5 to 375 rpm. Available for operation at any voltage, a-c or d-c, the units can be employed to control remote fuel valves, camera shutters, radio tuners, and allied equipment.

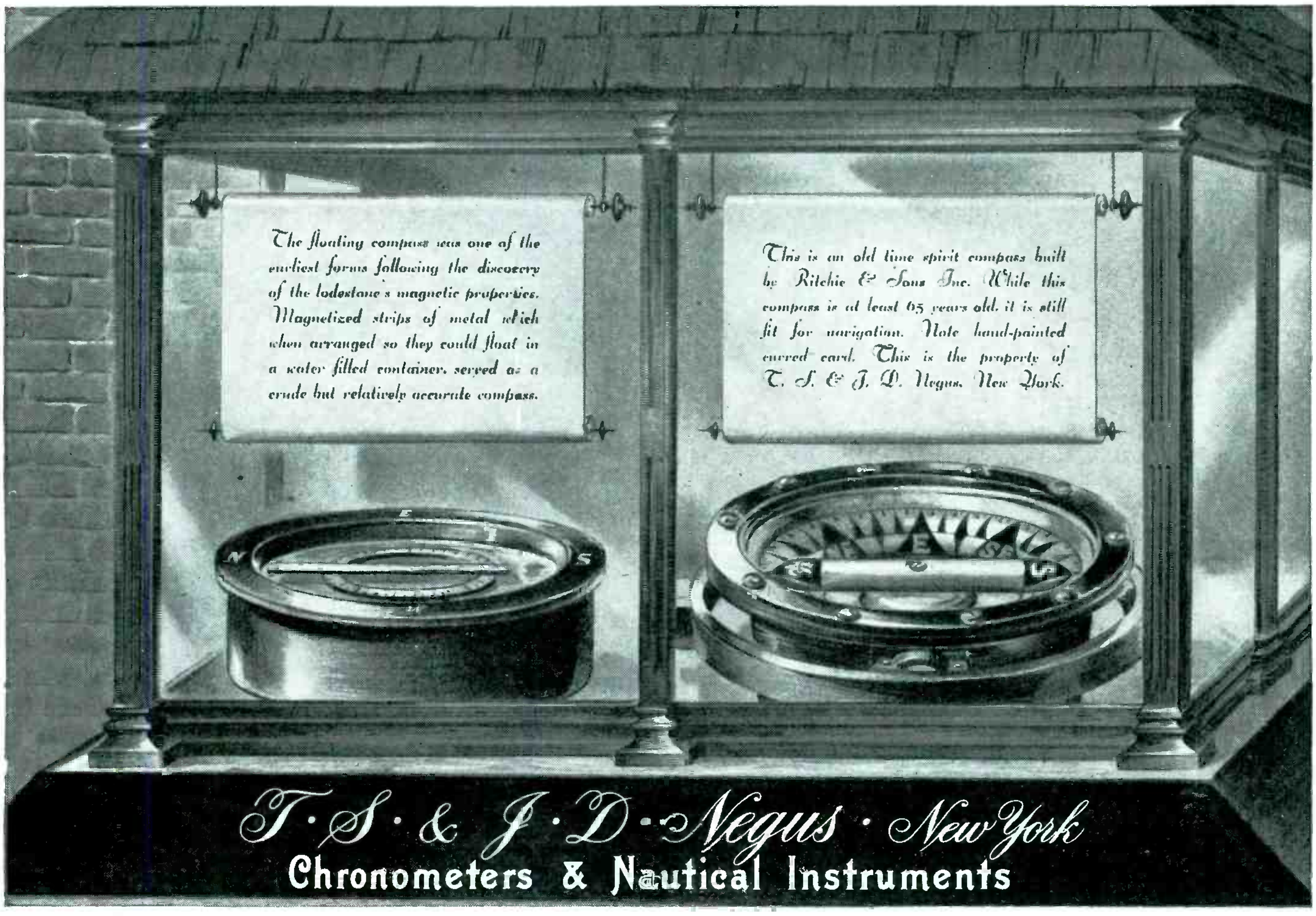


Silicone-filled Capacitors

CONDENSER PRODUCTS CO., 1375 North Branch St., Chicago, Ill. Type ASG and type AOG Glassmikes operate successfully over the



PERMANENT MAGNETS MAY DO IT BETTER!



How Permanent IS A Permanent Magnet?

Since its discovery, the permanent magnet has been one of man's most faithful servants (as an aid in transportation and navigation). In most instances the life of the permanent magnet exceeds the life of the instrument it serves. After 65 years of faithful performance the Ritchie spirit compass, illustrated above, is still fit for navigation—the directing power of the permanent magnet is still accurate.

The permanent magnet used in the speedometer normally outlives the life of the automobile, despite the demagnetizing influences, physical strain, and vibration of high speed service. Although modern magnetic materials of greater retentive power have been developed, many of the antiquated permanent magnets are still serving adequately.

With the use of modern magnetic-alloy materials, infinitely more energy can now be packaged into permanent magnets. They are greater in strength . . . smaller in size . . . more functional in design . . . with greater stability in an electrical and steel age of vastly greater demagnetizing forces.

The Indiana Steel Products Company is a pioneer producer of "packaged energy", having made more than 24,000 applications in the 36 years of specialized permanent magnet production. Permanent magnets may have some application in your industry . . . may do some job or process better for you. Our engineers will gladly help you develop your plans for magnet application. For complete information and valuable technical data on magnet application and materials, please write for our "Permanent Magnet Manual."

★ **THE INDIANA STEEL PRODUCTS COMPANY** ★

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILL.

ISP

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910
PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN. (CINAUDAGRAPH DIV.)

ranges minus 60 to plus 125 C and minus 40 to plus 105 C, respectively. Insulation ranges up to 20,000 megohms per microfarad have been obtained with the silicone impregnation and plastic film dielectric. Working voltages from 600 to over 30,000 volts are possible among the various types.

Wiener Warmer

ELECTRONIC CHEMICAL ENGINEERING CO., Los Angeles, Calif. The early production model of a new electronic frankfurter heater is il-

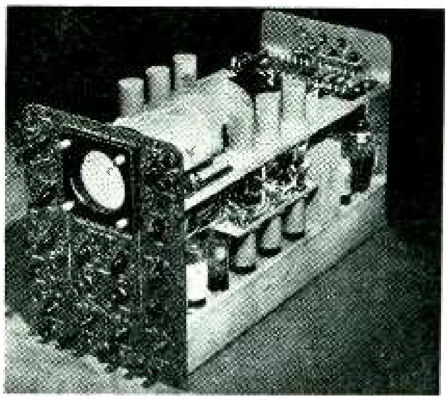
lustrated. The apparatus uses 2½ kilowatts from the power line, converted to high-frequency current to heat the hot dog in less than 10 seconds. The equipment is elaborately protected against overloads.

Slot-machine Timer

LANSING ENGINEERING CO., 934-36 Clark St., Lansing 6, Mich. A new electronic timer particularly adapted for coin machines has been developed. Timing range is from five minutes to two hours. It operates on either alternating or direct current.

Oscilloscope

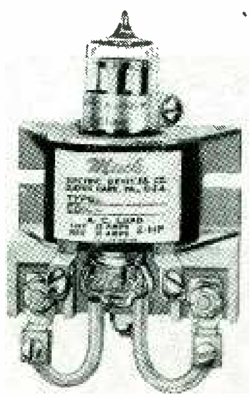
FURZEHILL LABORATORIES, LTD., Boreham Wood, Herts, England, distributed through American British Technology Inc., 381 Fourth Ave., New York 16, N. Y. The type 1684B cathode-ray oscillo-



scope has been found useful for strain-gage, diesel engine, and servo development work as well as for the more conventional radio and electronic testing. A 3½-inch fine-focus cathode-ray tube is used. The Y-axis sensitivity with amplification is about 24 millivolts rms per centimeter (about 61 millivolts per inch) and the X sensitivity approximately half that. Input impedance is 1.2 megohms shunted by 30 micromicrofarads. Frequency range of the sweep is 2 to 200,000 cycles, but can be reduced to 0.2 cycles. The unit measures 22 x 10 x 15 inches and weighs 75 pounds.

Mercury Contactor

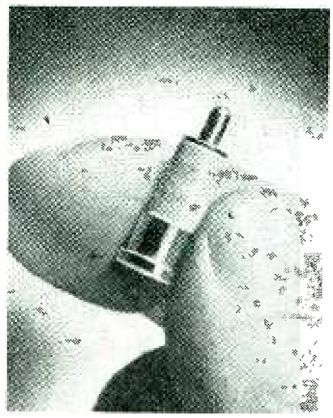
MACK ELECTRIC DEVICES CO., Elkins Park, Pa. A contactor capable of handling motor loads up to 2 hp consists essentially of a plunger floating on a pool of mercury. When a surrounding sole-



noid is energized, the plunger is pulled down into the mercury, displacing some and thereby closing a contact. The whole contact mechanism is hermetically sealed.

Crystal Converter

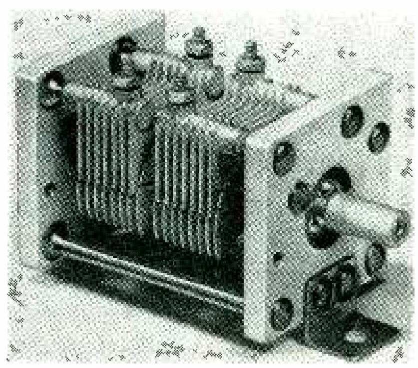
SYLVANIA ELECTRIC PRODUCTS, INC., 500 5th Ave., New York 18, N. Y. The type IN21B silicon crystals can be used as first detectors in high-frequency superheterodyne receivers in the region of 3,000



megacycles. Types IN25 and IN23B are suitable for use up to 1,000 and 10,000 megacycles, respectively. The units take up little room, require no filament supply, and have a lower thermal noise than tubes used in the same circuit applications.

Vhf-uhf Capacitor

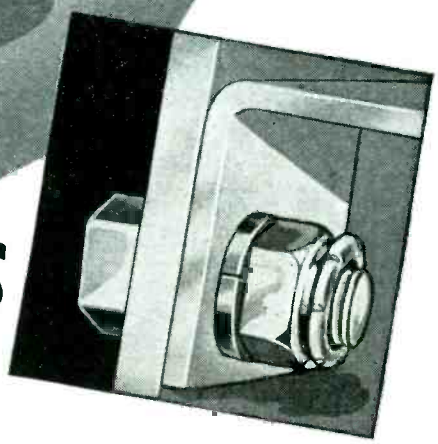
HAMMARLUND MFG. CO., INC., 460 W. 34th St., New York 1, N. Y. Standard stock sizes of a new vari-



able capacitor for conventional tuned circuits in the region of 500 megacycles are furnished in types VU-20, -30 and -45 with minimum capacitance in the order of 3.5 micromicrofarads and maximum capacitance ranging between 25.9

USE SPRING LOCK WASHERS

WITH LOCK NUTS



The lock nut may prevent the nut from slipping, but it can't compensate for the wear or corrosion of the assembly parts or the stretching of the bolt. That's why you need a spring lock washer. Lock nuts with spring lock washers make an ideal combination—safeguard against loss of nut and provide protection against looseness with positive tension.

Diamond G Spring Lock Washers—scientifically designed with CONTROLLED TENSION—assure unfailing spring tension . . . plus a thrust washer bearing. They permit full tightening of bolts and screws and safeguard against excessive vibration, shock and wear.

Specify Diamond G's today! Samples on request. Write for your free copy of the latest data on the new ASA and SAE specifications on spring lock washers.

GEORGE K. GARRETT CO., INC.
1421 CHESTNUT STREET, PHILADELPHIA 2, PA.
MANUFACTURERS OF

DIAMOND G PRODUCTS

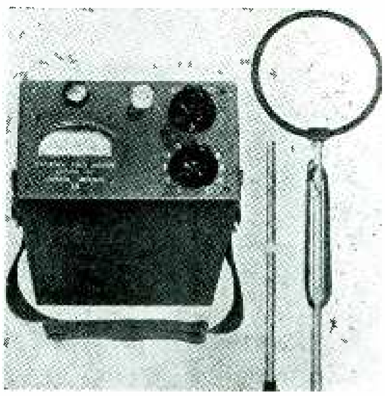
LOCK WASHERS • • FLAT WASHERS • • STAMPINGS • • SPRINGS • • HOSE CLAMPS • • SNAP AND RETAINER RINGS and 49 micromicrofarads. The capacitors resemble split-stator types, but are equipped with rotors insulated from the end plates by Pyrex ball bearings.

I-f Transformers

NATIONAL CO., INC., Malden, Mass. Two types of iron-core i-f transformers tuned to 10.7 megacycles are now available, the IFN with a bandwidth of 100 kilocycles and the IFM with 150 kilocycles bandwidth. Insulation is polystyrene and the mechanical construction is compact. Each transformer is $\frac{3}{8}$ inch square and stands $3\frac{3}{8}$ inches above the chassis.

Fault Locator

RAYTRON, INC., 407 N. Jackson St., Jackson, Mich. The Electronic Fault Locator is a tuned electromagnetic detector that follows the path of a 300-cycle signal introduced onto a faulty power line. A

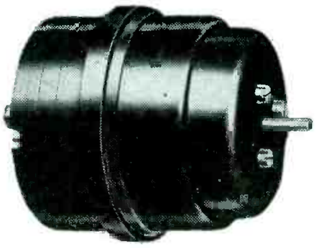


60-cycle signal can be used if desired. Battery-operated and self-contained, the locator used with a separate loop weighs only $9\frac{1}{4}$ pounds and measures $4\frac{1}{2}$ x 7 x $10\frac{1}{2}$ pounds. The loop mounted at the end of a pole weighs 5 pounds.

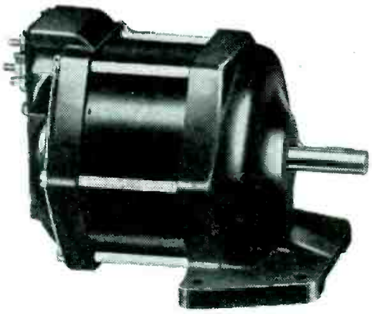
Portable Sound System

BELL SOUND SYSTEMS, INC., 1183 Essex Ave., Columbus 3, Ohio. The Model PA-3710-P sound system consists of a 10-watt amplifier, two 10-inch speakers, turntable and

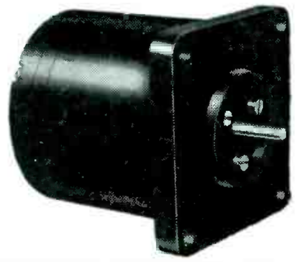
For precise, positive linkage between instrumentation and control



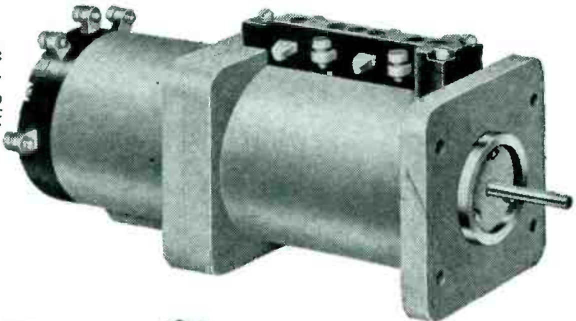
INDUCTION GENERATOR: when fed from AC source produces voltage proportional to speed of rotation. Used in circuits as velocity control component.



PERMANENT MAGNET GENERATOR: designed as AC potential source. Produces sinusoidal wave form with harmonic content under 2%.

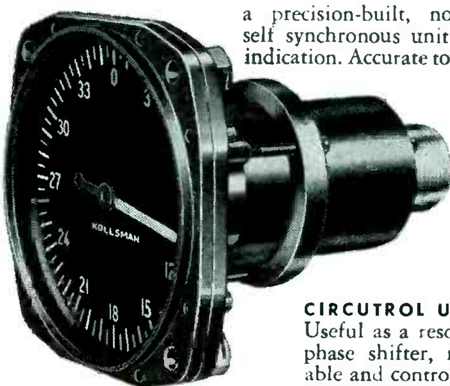


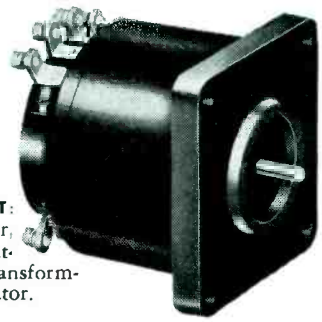
INDUCTION GENERATOR: type designed particularly for use where low residual voltage is required.



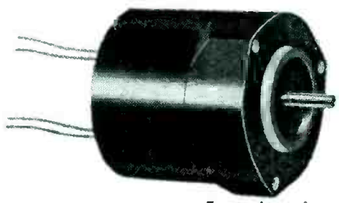
MOTOR DRIVEN INDUCTION GENERATOR: powered by 2-phase, low-inertia induction motor. Used as fast reversing servo motor where maximum stall torques of less than 7 oz. in. are required.

TELETORQUE UNIT — below left: a precision-built, non-motoring, self synchronous unit for remote indication. Accurate to ± 1 degree.





CIRCUTROL UNIT: Useful as a resolver, phase shifter, rotatable and control transformer or phase indicator.



INDUCTION MOTOR: Low inertia, two-phase squirrel cage unit for use as precision servo motor.

KOLLSMAN OFFERS A LINE OF SPECIAL PURPOSE AC UNITS

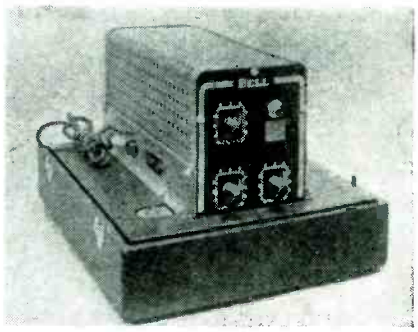
To meet the varying needs of the electronics engineer in linking instrumentation up to control, Kollsman offers a group of units with sufficiently varied functions to solve a wide range of control problems. In nearly every case, units are available for operation at various voltages and frequencies to fit widely diversified electronic control and remote indication applications. These Kollsman units are the outgrowth of long development in aircraft instrumentation and control and — more recently — Kollsman's considerable work in this field for naval and military applications. They are light in weight, compact, and highly precise, so that engineers working with exact quantities will find them reliable to a high degree. Complete data on any or all of these units may be had upon request. Kollsman Instrument Division, Square D Company, 80-08 45th Avenue, Elmhurst, N. Y.

KOLLSMAN AIRCRAFT INSTRUMENTS

PRODUCT OF

SQUARE D COMPANY

ELMHURST, NEW YORK · GLENDALE, CALIFORNIA pickup assembly, microphone, and associated equipment. The phono



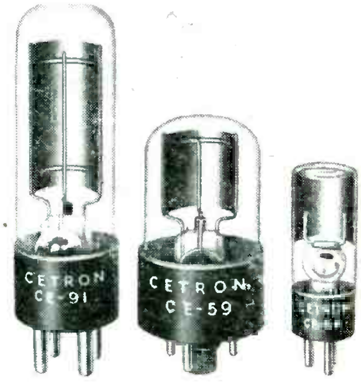
equipment is mounted beneath the amplifier illustrated, which is turned over in operation.

Pulse Generator

RAYMOND M. WILMOTTE, INC., 236 West 55th St., New York 19, N. Y. The Model P54 pulse generator has been designed as the heart of control equipment in which wide flexibility of pulse width, amplitude, and polarity is required. At high amplitude the width is continuously variable from 1.5 to 70 microseconds; at low amplitude, from 0.75 to 22 microseconds. The repetition frequency is 60 cycles to 100 kilocycles.

Phototubes for Sound

CONTINENTAL ELECTRIC CO., 188 W. Randolph St., Chicago, Ill. A new complete line of gas-filled blue-sensitive phototubes (RMA spectral response S4) is available for use with conventional projection equipment using dye-recorded or silver sound tracks. The new types CE-64, CE-91 and CE-59 are dimensionally identical to the most pop-



ular sizes CE-25, -1, and -30. When used with dye sound tracks, the new tubes give much greater output than the standard S1 red-sensitive types.

Small Craft Fathometer

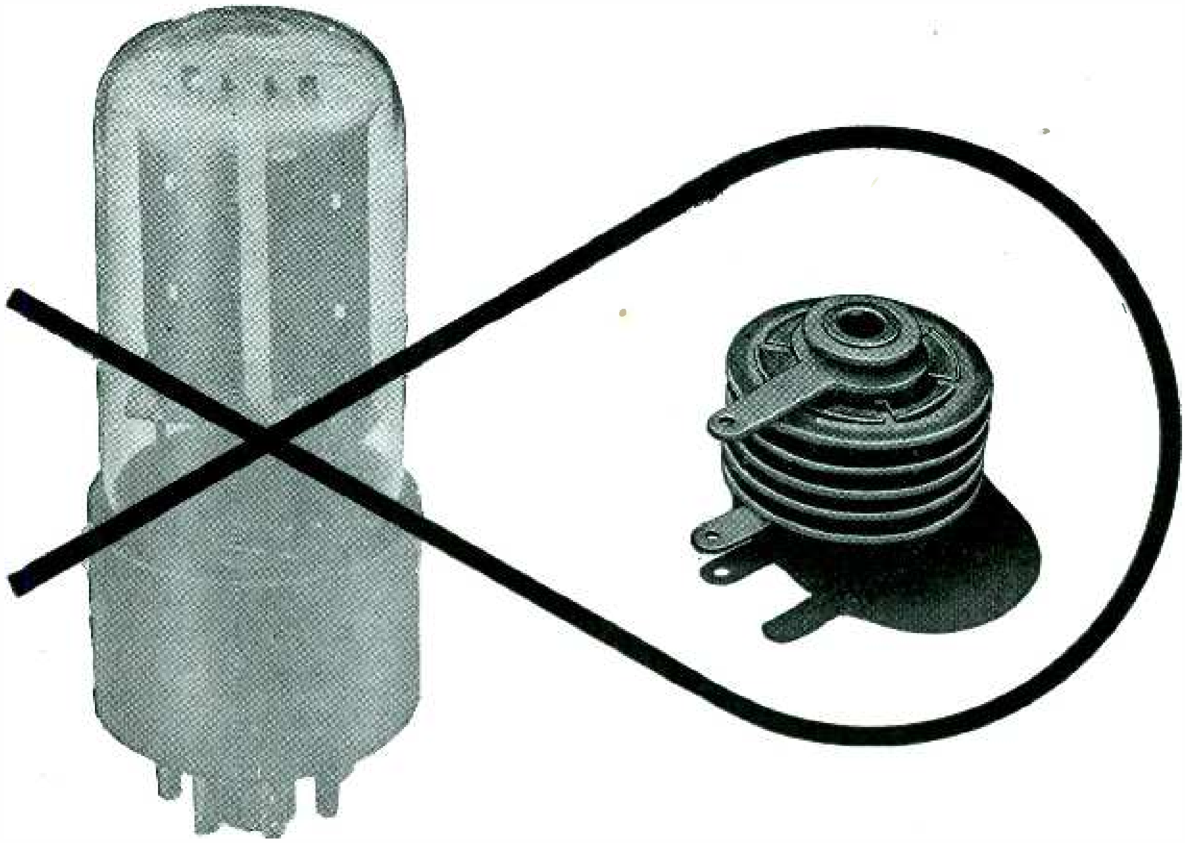
SUBMARINE SIGNAL CO., Boston, Mass. A new compact fathometer for small fishing and pleasure craft, complete with vibrator power supply, but with the exception of the projector, is contained in the single

unit illustrated. It gives accurate measurements within a range of 400 feet at the rate of 360 soundings a minute. Used with a chart, it serves to identify reefs and shoals or depths where fish abound.

Recording Dilatometer

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Avenue, New York, N. Y. Designed to provide continuous graphic recording of the twelve-

hour expansion and contraction cycles of samples, a new dilatometer accommodates temperatures up to 1,000 C held to within 1 C. Its oper-



SIMPLER — SMALLER — STRONGER
NEW G-E SELENIUM RECTIFIER
REPLACES TUBE IN PORTABLE RADIOS

This new selenium rectifier, *less than one inch long* and only one inch in diameter, offers builders of portable and car radios a new way to cut manufacturing costs and to build a better product.

You gain *six* ways when you incorporate it in your designs:

Saves Space — **Can be mounted in places where a rectifier tube and socket won't fit. Radio cabinets can be made smaller when this new selenium rectifier is used.**

Cuts Installation Cost — **No socket or filament circuit is necessary. Only two soldering operations and a minimum of mounting hardware are required.**

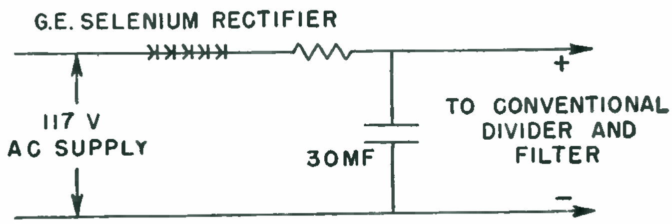
Ample Current Capacity — **Designed to withstand safely the inverse peak voltages obtained when rectifying (half-wave) 110-125 volts, rms, and feeding into a capacitor as required in various radio circuits. Half-wave rectification of the a-c line is employed.**

Withstands Rough Usage — **Withstands rougher handling than the fragile tubes which it replaces. It won't break when dropped.**

Gives Instant Starting — **Eliminates usual warm-up period before radio starts. It runs cool, too, because of the absence of the heat-producing filament in the tube which it supplants.**

Longer Life — **Continuous tests have proved that this new selenium rectifier will outlast several 117-volt rectifier tubes —last the life of the product for which it is designed.**

For information that will help you make efficient use of G-E selenium rectifiers in your designs, write for booklet *Two Steps Ahead.* Section A23-10119, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.



GENERAL ELECTRIC

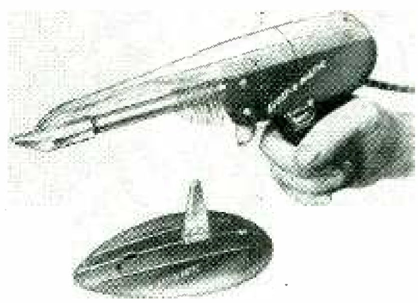
ation is nearly fully automatic, freeing the time of the operator after the equipment has been started. The unit illustrated weighs 450 pounds and measures 56 x 50 x 26 inches. It operates from 110- to 120-volt, 50- to 60-cycle lines and consumes about 1,000 watts.

F-M Antenna

HI-PAR PRODUCTS CO., Fitchburg, Mass. A new antenna for f-m receivers consists of a single-element turnstile fabricated from aluminum alloy rods, porcelain insulator, and varnished hardwood support. Any standard transmission line can be used with the matching section furnished.

Soldering Tool

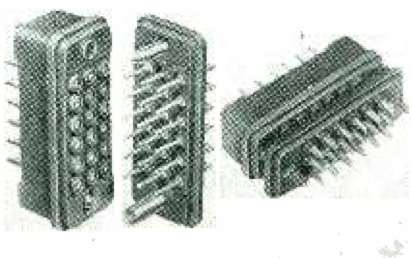
MULTI-PRODUCTS TOOL CO., 1123 Sussex Ave., Newark, N. J. The Eject-O-Matic electric soldering tool ejects a measured amount of solder from a reel concealed in the



handle when a trigger is pulled. The amount of solder fed to the tip can be quickly adjusted. A special stand is furnished with the tool. Fully loaded, the tool weighs 1¼ pounds.

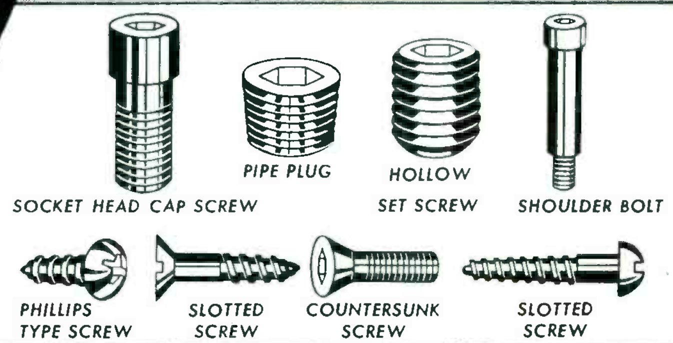
Monoblock Connector

THE WINCHESTER CO., 6 East 46 St., New York 17, N. Y. Two sizes



BITS

FOR DRIVING ALL THESE SCREWS



Contained in this Handle

Handle is molded of sturdy Celanese* plastic; tools are of high grade alloy steel

HALLOWELL

"SOCKET SCREW" KIT

with interchangeable bits

For men who like to have a complete supply of tools, yet dislike bulk and confusion, the Hallowell "Socket Screw" Kit is the answer. It is one of the neatest tricks of the year. The hollow Celanese* plastic handle holds interchangeable bits for most all purposes . . . Phillips, Hex and Flat. There is a swivel bit-chuck, which locks securely in position, and makes it possible to twirl a screw using the vertical position, and then snapping the chuck to an angle or ell position, to get the final tightening pull.

Not illustrated: "Socket Wrench" Kit; the "Auto" Kit; the "Home" Kit. Write for our 8-page booklet that fully describes these handy Tool Kits. Obtainable at Suppliers throughout the country.

If your Supplier does not carry these Kits, send his name to us, along with yours, and you will be taken care of promptly.

Kits: Patents Pending

OVER 43 YEARS IN BUSINESS

*Reg. U. S. Pat. Off.

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 596 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO of multiple connectors with telescoping barriers for higher voltage breakdown are available in 12- and 18-contact sizes, designated RE12S and RE18S respectively. Contacts are designed for use with a maximum wire size of No. 16. The rectangular blocks illustrated can be provided with a self-locking arrangement if desired.

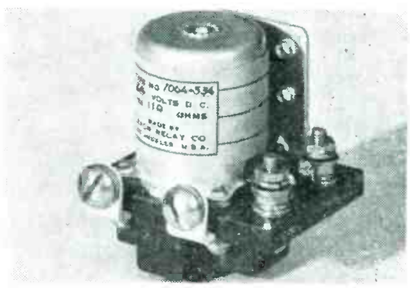
Volt-ohmmeter

GENERAL ELECTRIC Co., Syracuse, N. Y. The type PM-17 meter illustrated measures audio and r-f

voltages from 60 cycles to over 100 megacycles. The equipment features extremely high input impedance. It is powered from a 105 to 120-volt line, 60 cycles, and weighs 15 pounds.

Aircraft Relay

LEACH RELAY Co., Los Angeles, Calif. A new direct-current relay,



type 7064-53 4, has been designed for small airplane service. It operates successfully at 50,000 feet and at temperatures between minus 54 and plus 71 C. Contacts are rated at 100 amperes for 12-volt

When mill-ordered ARMCO Electrical Steels are unloaded in your plant you can be sure of this:

The steel is "job-tailored" to your needs — *before* and *during* rolling operations. Metallurgists and mill representatives see that you get the *one right steel* for your products.

For almost 20 years Armco men have called this "Q. C."— Quality Control. Metallurgists who study your requirements specify the analysis of steel, the temper rolling, annealing, and all other operations that affect the qualities of finished sheets and strip. Then mill operators follow through closely with these instructions on your individual routing card.

In recent years, Armco control charts and statistical analyses have further helped assure consistent production of prime electrical steels. They are an added safeguard for the steels that go into your products.

"Quality Controls" like these are one reason why leading manufacturers look first to Armco for special-purpose sheet steels.

Back of it all are the research and experience that contribute to a higher "Q. C." at our end and better quality at yours. The American Rolling Mill Company, 4231 Curtis St., Middletown, Ohio.

Export: Armco International Corporation

more scrap means more steel

We urge you to collect every pound of iron and steel scrap, including unused and obsolete equipment. Speed it to the steel industry through your regular channels. Present high production cannot be maintained unless more scrap is shipped to the mills promptly. The situation is critical; so act today.

The American Rolling Mill Company

Special-Purpose Sheet Steels · Stainless Steel Sheets, Bars and Wire

ARMCO

d-c operation. The unit is completely sealed against humidity, dust, and salt spray and weighs about 8½ ounces.

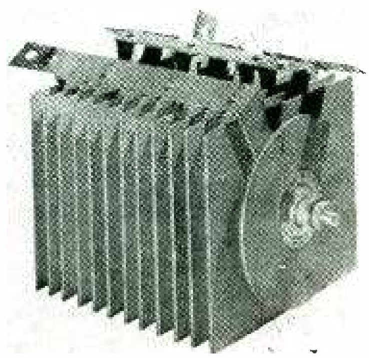
Time Delay Relay

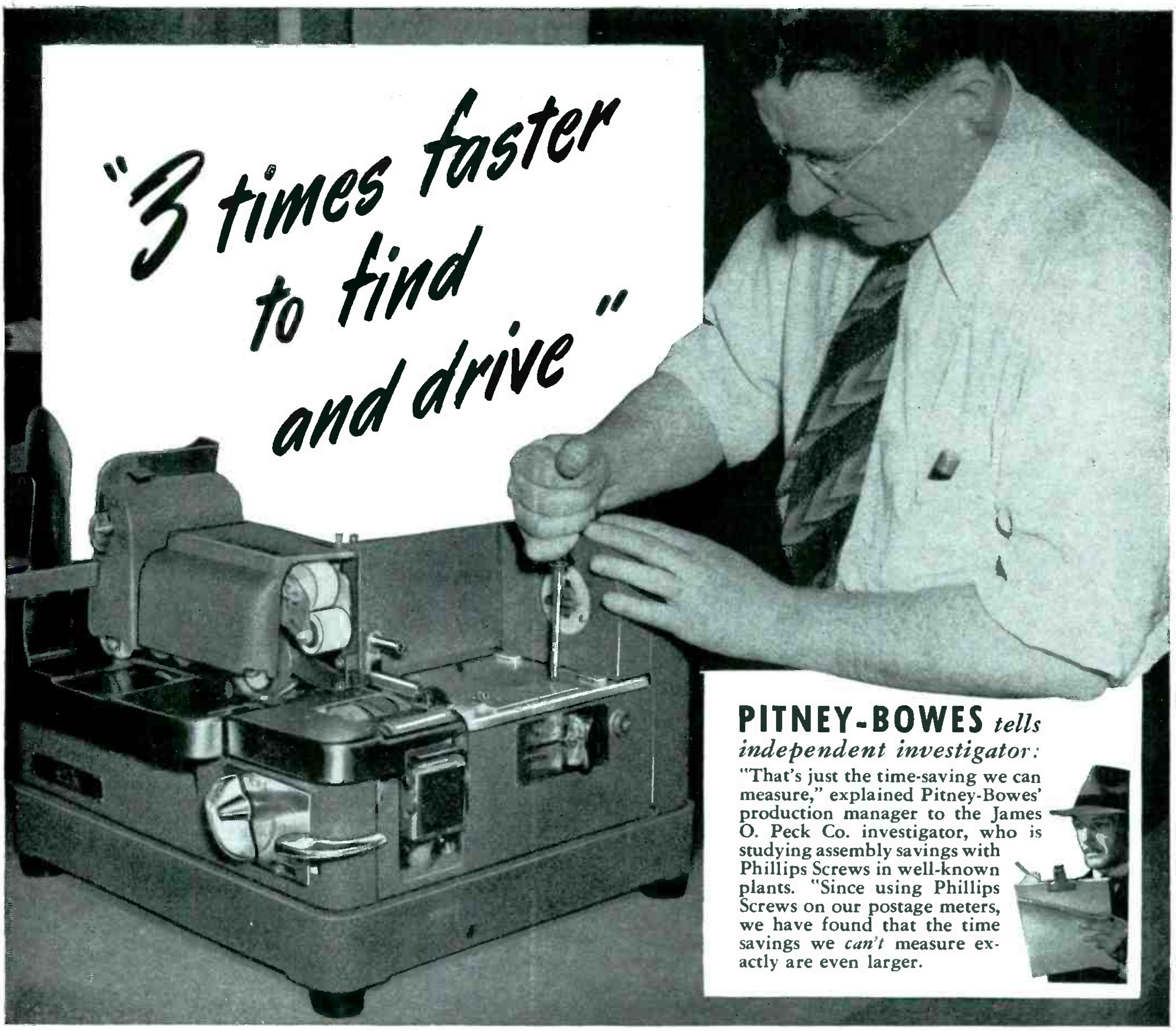
THE R. W. CRAMER CO., INC., Centerbrook, Conn. The type TECTER time-delay relays provide an adjustable or fixed time delay be-

tween the operation of a control circuit and the subsequent closing or opening of a load circuit. The devices are easy to set and indicate at all times the unexpired portion of the time cycle as well as the elapsed operating time. A brochure is available describing types of operation and time ranges of the instruments in production.

Rectifier Stacks

RADIO RECEPTOR CO., INC., 251 West 19th St., New York 11, N. Y. Selenium rectifier stacks suitable for high current use as in electroplat-





PITNEY-BOWES *tells independent investigator:*

"That's just the time-saving we can measure," explained Pitney-Bowes' production manager to the James O. Peck Co. investigator, who is studying assembly savings with Phillips Screws in well-known plants. "Since using Phillips Screws on our postage meters, we have found that the time savings we *can't* measure exactly are even larger.

"NO TIME WASTED STARTING THE SCREW . . . the Phillips Screw doesn't wobble and slip off the driver. The operator uses his left hand only to start the screw. He can drive it up tight without wasting time. With a slotted screw, he'd have to ease it home more slowly to avoid burring the head. And, we can't risk mail-tearing burrs on screws that secure the polished mail feed plate and mail stacking assembly.

"TAKES LESS TIME TO BREAK IN NEW OPERATORS. Anyone can learn faster to drive Phillips Screws than slotted screws. The Phillips driver automatically aligns itself with the screw and holds its position as the hand shifts, while the conventional driver is apt to slip out of a slotted head screw.

"DRIVER SLIPS USED TO COST US ONE MAN-HOUR PER SLIP . . . before we changed to Phillips Screws. When a driver marred one of the satin-finished, nickel-plated pieces which guide the mail in these machines, the part had to be removed, pickled, refinished, and replated. That took about one man-hour . . . not to mention time lost through interruption of production line momentum."

GET PITNEY-BOWES REPORT AND OTHERS. Available to you now are nine independently made studies of assembly practice in famous plants, making metal, wood, and plastic products. A mine of ideas for cutting costs and ending trouble. FREE, of course. Use the coupon TODAY.

PHILLIPS *Recessed Head* SCREWS

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

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International Screw Co.
Lamson & Sessions Co.
Manufacturers Screw Products
Milford Rivet and Machine Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Wolverine Bolt Company

Phillips Screw Mfrs., c/o Horton-Noyes 9
2300 Industrial Trust Bldg., Providence, R. I.

Send me reports on Assembly Savings with Phillips Screws.

Name..

Company..

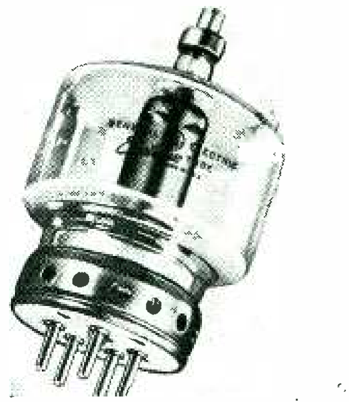
Address..

....

ing and battery charging are now available employing new 5 x 5¾-inch plates.

Power Tetrode

GENERAL ELECTRIC CO., Syracuse, New York. The type GL-5D24 tetrode transmitting tube can be used at full plate voltage of 3,500 volts up to 85 megacycles. In continuous service the tube has a maximum plate dissipation of 200 watts. It has been designed as a basic power tube for f-m transmitters, but will doubtless find use in amateur transmitters.



Electronic Timer

PHOTOSWITCH, INC., 77 Broadway, Cambridge 42, Mass. The type 30HL1 universal timer is capable of controlling intervals between 1/20th second and 4 minutes with

Identification

HITTING THE NAIL ON THE HEAD!

THE AMERICAN FORK AND HOE COMPANY DURABLY IDENTIFY

TRUE TEMPER PRODUCTS

AT PRODUCTION LINE SPEEDS WITH ....

MEYERCORD DECALS

Here's brilliant, lasting product identification that meets the demand for quantity output on high speed production lines. Whatever your needs . . . trademarks, instructions, or patent data . . . whatever your surface . . . wood, metal, glass, plastic—even crinkled finish . . . there's a Meyercord Decal to do the job. They're easy to apply and "stay put". Any size, colors or designs can be reproduced. No screws, bolts or rivets required. Investigate Meyercord Decal nameplates. Technical consultation and designing service on request. Mail inquiries to Dept. 9-10.

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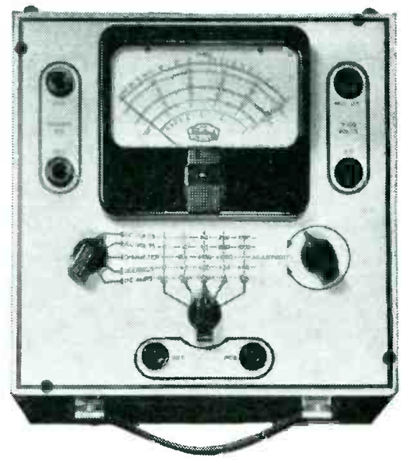
5323 WEST LAKE STREET • • • CHICAGO 44, ILLINOIS a variation of less than 2 percent. Its output circuit operates a pair of single-pole, double-throw switches and can break up to 10 amperes, 115 volts, a-c. The equipment operates on 115 or 230 volts and weighs 8 pounds.

Graphic Tester

STERLING MANUFACTURING CO., 9205 Detroit Ave., Cleveland, Ohio. Desired function and voltage or



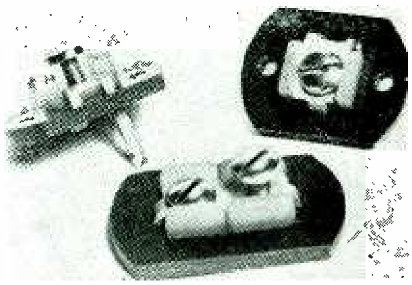
current range of the instrument is chosen by the setting of appropriate knobs. A separate knob is provided for three ohmmeter ranges

Self-locking Terminals

SELF-LOCKING TERMINAL CO., Box 57, Bergenfield, N. J. The terminals illustrated are model 5S screw and solder type and model 2D, two-screw front-of-board connector. The terminal is assembled with a plastic locking plate of Nylon or an equally elastic plastic. The center hole of this plate is made less than the diameter of the screw. When the screw enters, it presses into the material but does not cut. Unlike fiber this material retains its locking grip through limitless ins and outs of the screw. The terminal eliminates the danger of loose connections from vibration or

movement of the connecting wires. Since the screw remains under constant torque throughout its entire travel, it can be run out to a wiring position and still remain rigid when a connection is being made. The torque also prevents the chance of the screw falling into the equipment.

The side walls and plate are



molded as a unit. The walls serve two purposes—hold the wire firmly under the screw and act as a insulating barrier between terminals. Since the walls are slightly elastic, they will not chip or break under impact. The terminal is furnished in standard strips as well as panels.

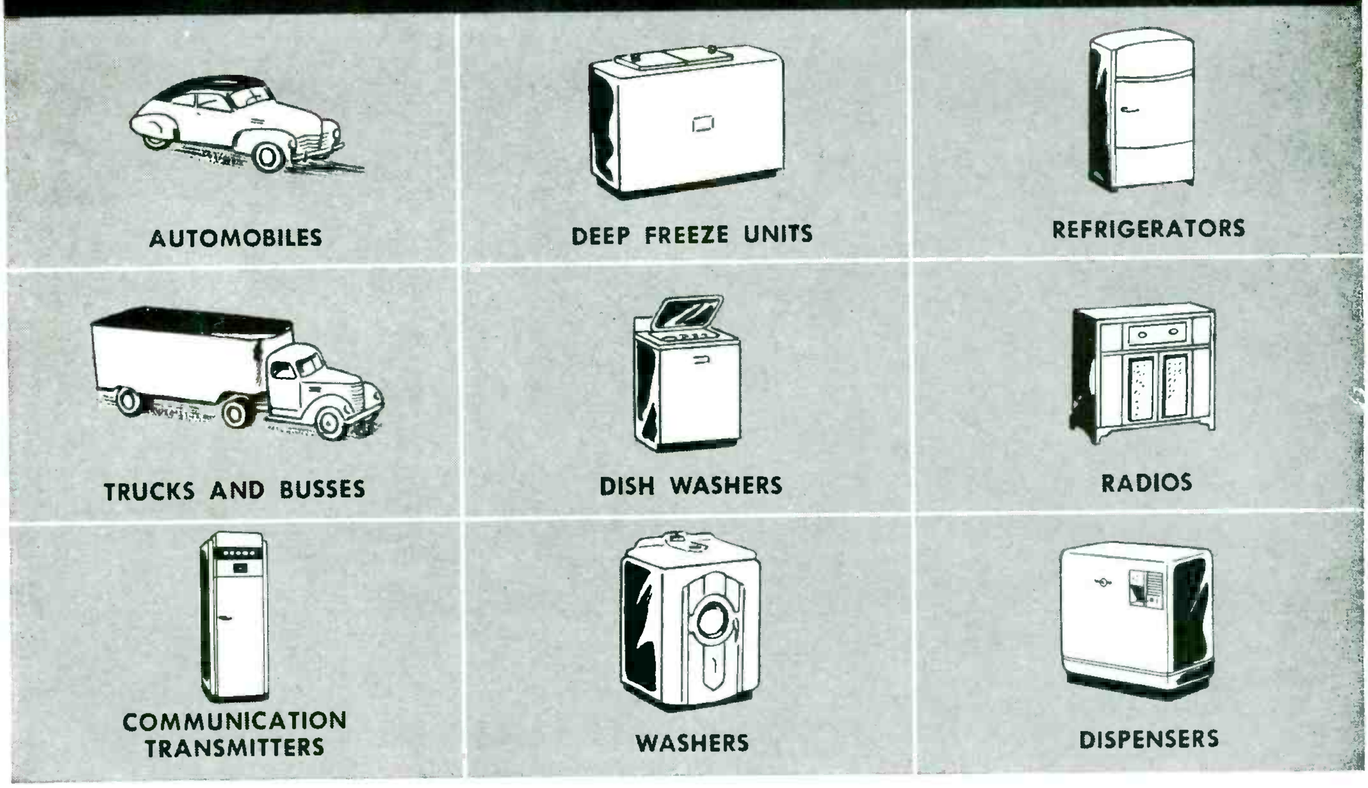
C-r Tube Sealing Machine

EISLER ENGINEERING CO., 740-770 South 13th St., Newark, N. J. The No. 57-SAI-16 single-head sealing machine can seal bulbs up to 24 inches in diameter of any height. It is equipped with a variable-speed motor and can be quickly adapted to many diverse sealing operations such as butt sealing and cracking off.

Universal Rectifier

BRADLEY LABORATORIES, INC., 82 Meadow St., New Haven 10, Conn. The Coprox Model CX2E4U replacement rectifier is provided with leads that can be connected in various combinations to provide four different rectifier circuits. As a full-wave bridge, the unit delivers 5 milliamperes d-c for 6 volts a-c input. In a half-wave hookup

If you Manufacture...



YOU CAN SAVE *3 Ways* WITH ESSEX "PACKAGED" WIRING HARNESS

1 Engineering
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Scores of users have found that they save time, trouble and money by turning their electrical wiring harness problems over to Essex specialists.

Essex *One-Source* service handles the intricate job of producing lighting, ignition and control harness assemblies *custom-built* to your exact specifications and *complete* with all manual and electrical control devices for quick, efficient installation.

Through intensive specialization in wiring harness assemblies, Essex has developed line production methods of manufacturing, assembly and inspection, for the economical production of high grade, individually tested, specially engineered assemblies.

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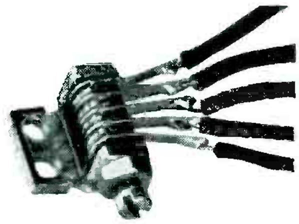
Plants: Fort Wayne, Indiana; Detroit, Michigan; Anaheim, California
Warehouses* and Sales Offices: *Atlanta, Georgia; *Boston, Mass.; *Chicago, Ill.; Cleveland, Ohio; Dayton, Ohio; *Detroit, Mich.; Kansas City, Mo.; *Los Angeles, Calif.; Milwaukee, Wisc.; *Minneapolis, Minn.; *Newark, N. J.; Philadelphia, Pa.; San Francisco, Calif.; *St. Louis, Mo.

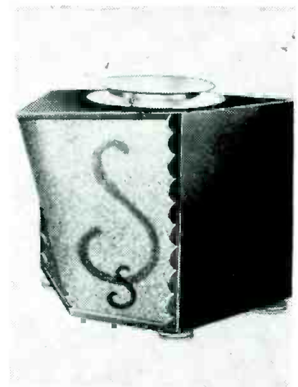
it carries a rating of 6 or 12 volts a-c at 3 milliamperes d-c or 12



volts a-c at 5 milliamperes d-c.

Robot Salesman

SOUND MEDIA, 17 East 48th St., New York, N. Y. A wire recorder known as Sound Salesman is now



available in a black plastic cabinet 12 x 12 x 14 inches. The unit can be used in connection with billboards, in museums, or at amusement centers to repeat desired information.

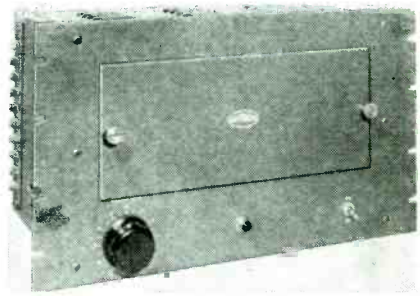
Contact Springs

GIBSON ELECTRIC CO., 8350 Frankstown Ave., Pittsburgh, Pa. Beryllium copper contact springs are available in quantity when the lesser conductivity of phosphor bronze assemblies, also available, does not allow their use. Contacts of silver, alloy, or powder metal composition can be furnished attached to the springs.

Monitoring Amplifier

RAYTHEON MANUFACTURING CO., 60 East 42 Street, New York 17, N. Y. A high-fidelity monitoring amplifier for a-m or f-m use, designated

the RM-10, is flat from 30 to 15,000 cycles. At 5 watts output the har-



monic distortion is less than 0.6 percent. Gain from a 500-ohm source to a 15-ohm load is 102 db. The unit is equipped with a gain control and a remote control for volume.

Electrostatic Voltmeter

RAWSON ELECTRICAL INSTRUMENT, Co., 110 Potter St., Cambridge 42, Mass. The cut on page 220 of the September issue illustrating the type 518 electrostatic voltmeter appeared in error and does not represent the instrument described.

Literature

Manual Guide—Ken Cook Co., 710 N. Plankinton Ave., Milwaukee 1, Wis. Sales and service manuals, parts catalogs, and government technical manuals require careful and exacting preparation. Available free of charge is the booklet "How to Plan an Owner Manual" that gives a few hints on how to tackle the problem.

Electrical Porcelain — Electrical Manufacturers Public Information Center, 155 East 44 St., New York 17, N. Y. A new booklet published by thirteen cooperating manufacturers of electrical porcelain products describes the physical properties, uses, mechanical properties, and other pertinent data on the material.

Microphones and Pickups—The Astatic Corp., Conneaut, Ohio. The complete history of the company's development is carried up through recording heads on page 24. In between are descriptions of typi-

No electrical equipment can be any better than its insulation

Because of its excellent weather resistance, this insulating varnish was used for all kinds of war communications equipment . . .

G-E INSULATING VARNISH 9564

A clear synthetic resin varnish . . . may be air-dried or quick-baked . . . for heavy-duty communications equipment

. . . and the same varnish is now being used for protection in peacetime communications systems far and wide.

GENERAL ELECTRIC'S unrivaled facilities for synthetic resin insulating varnish research, development and manufacture are now available to all who make or repair electrical equipment. Be sure of product uniformity, by virtue of G-E Quality Control—specify G-E Insulating Varnishes. For full details consult your local General Electric Merchandise Distributor. Or write direct to Section RIMA-10614, Resin and Insulation Materials Division, Chemical Department, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

CD46-16

G. E. OFFERS A COMPLETE LINE OF INSULATING MATERIALS

cal uses, specifications, ordering information, and prices of phonograph pickups, recording heads, and accessories. The publication is designated Catalog No. 46.

Industrial Tubes—General Electric Co., Syracuse, N. Y. Characteristics, ratings, prices, and an interchangeability chart of transmitting and industrial tubes are contained in booklet ETX-10.

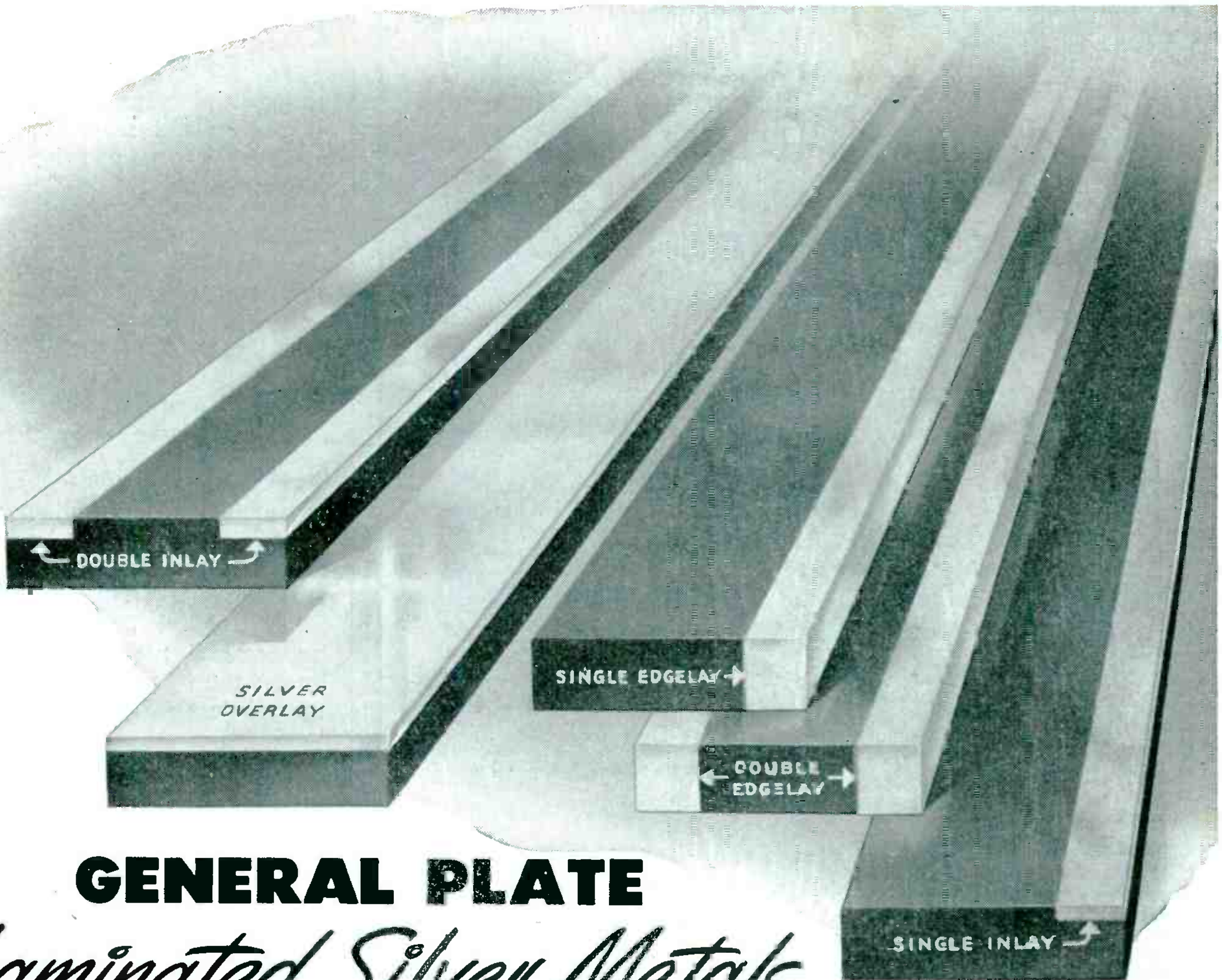
Selenium Rectifiers—Radio Receptor Co., Inc., 251 West 19th St., New York 11, N. Y. An 8-page bulletin describes in detail the various types of standard selenium rectifier equipments for direct-current requirements. Complete specifications and ratings are included.

Sheet Metal Cabinets—S. Walter Co., 144-146 Centre St., Brooklyn 31, N. Y. Instrument panels, chassis units, and waterproof cabinets, including Navy-specification parts boxes, are available or can be fabricated on order. The service is described in a 4-page brochure.

Capacitor Catalog—Aerovox Corp., New Bedford, Mass. Most engineers have probably received the new 1946 Aerovox General Catalog in a loose-leaf binder that will enable them to replace old pages with latest information as it becomes available. The catalog is an exhaustive and complete compendium of information on the line of capacitors manufactured by the company.

Impedance Measurements—Technology Instrument Corp., 1058 Main St., Waltham 54, Mass. The type 310-A Z-Angle Meter measures impedance in ohms and phase angle in degrees. The instrument is direct reading over the entire a-f spectrum. It uses a circuit basically different from that of conventional a-c bridges. A pamphlet has been prepared to describe the instrument.

Radioactivity Measurements—Tracerlab, Inc., 55 Oliver St., Boston, Mass. The Autoscaler supplies operating voltage for a Geiger tube and counts the impulses, measuring the time re-



GENERAL PLATE

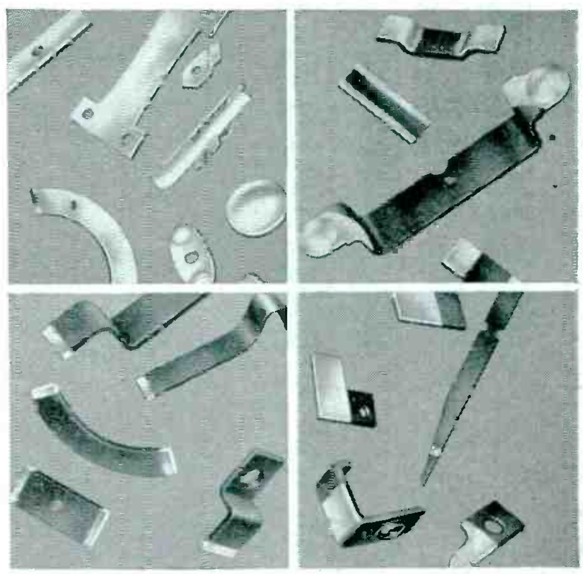
Laminated Silver Metals

Assure Lower Costs, Provide Efficient Performance and Give Longer Life to Electrical Contacts

Why pay the new high costs of silver when General Plate Laminated Metals give you solid precious metal performance at exceptionally low costs. How . . . because General Plate Laminated Metals give you a silver contact face *at the actual point of contact* where the precious metal performance is desired. The result, you get the high electrical conductivity desired at a fraction of the cost of costly solid silver contacts.

General Plate Laminated Silver Metals make fabrication of contact assemblies easy. In addition, they provide longer wearing life. The base metal adds strength, better spring properties, and makes spot welding or soldering more practical.

Investigate General Plate Laminated Silver Metals for your contact problems. Write:



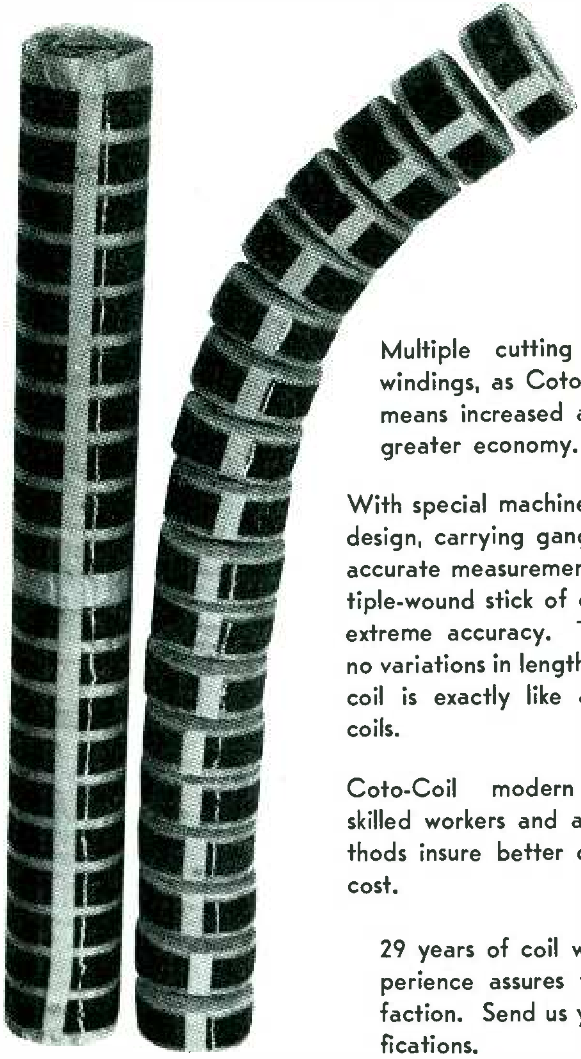
Typical contacts fabricated from General Plate Laminated Silver Metals.

GENERAL PLATE DIVISION

of Metals and Controls Corporation

50 Church Street, New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, Calif.; Grant Bldg., Pittsburgh, Pa.

ATTLEBORO, MASSACHUSETTS



quired for reception of a given number. Further details of the apparatus and associated equipment are given in an 8-page brochure just printed.

Relays—Automatic Electric Mfg. Co., Mankato, Minn. A 4-page bulletin recently issued shows a few of the representative types of overload, midget power, and latching relays available for circuit controls in communications and industrial electronic applications.

Service Encyclopedia—P. R. Mallory and Co., Inc., Indianapolis 6, Ind. The fifth edition of the Radio Service Encyclopedia lists recommended component replacements for all prewar receivers, besides giving the complete tube lineup and i-f value. List price of the publication is $1.25.

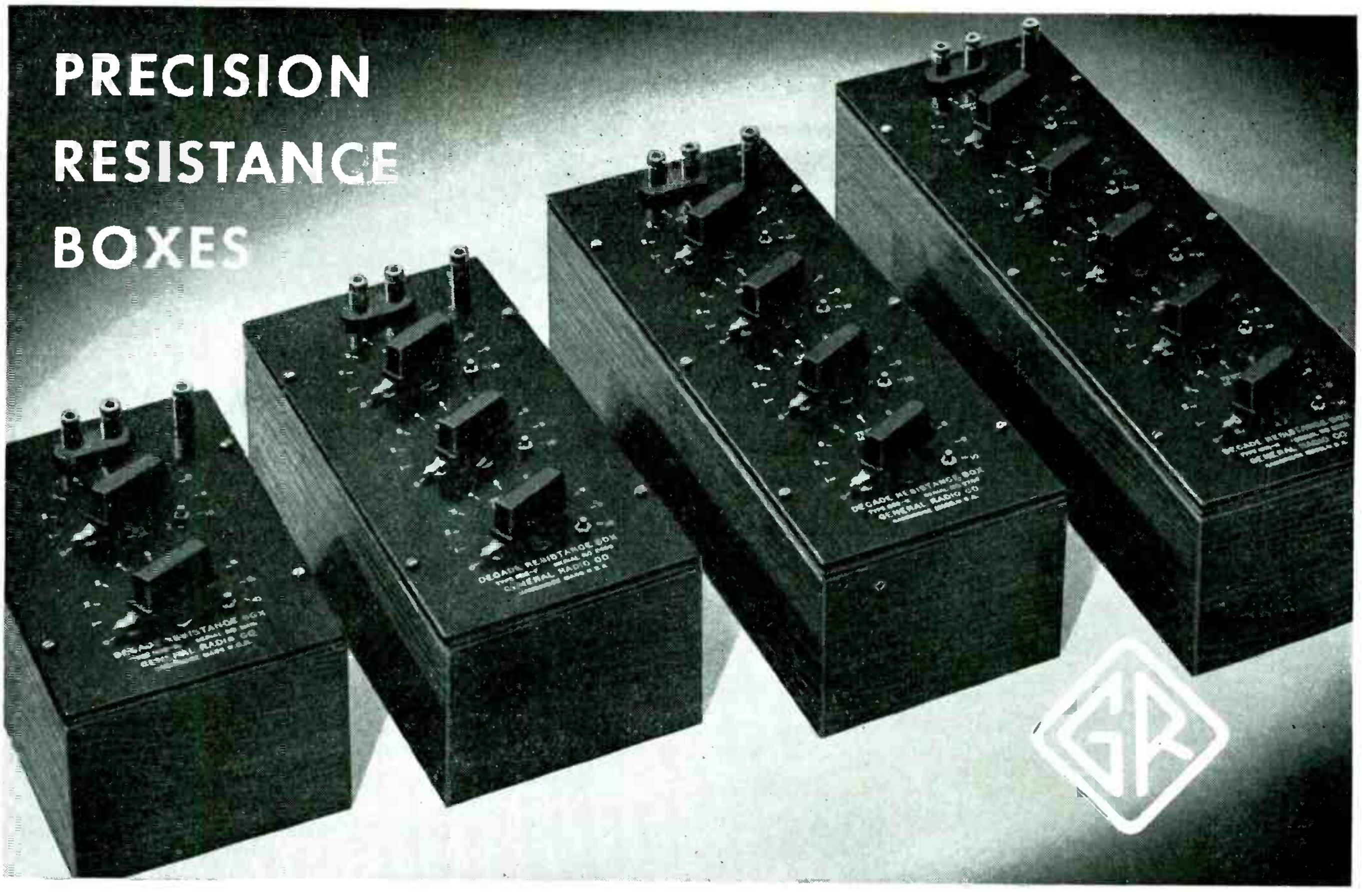
Capacitors and Filters—Cornell-Dubilier Electric Corp., South Plainfield, N. J. The latest 24-page catalog describing C-D electrolytic, paper, and mica capacitors, capacitor test instruments, and interference filters is now available from jobbers or on direct request to the company.

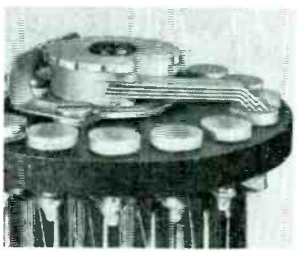
Mycalex Catalog—Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J. The latest catalog describing typical applications, types of molding and fabricating, and salient characteristics of glass-bonded mica insulating material is now available.

Sheet Metal Enclosures—Karp Metal Products Co., Inc., 139 30th St., Brooklyn, N. Y. Custom-built panels, relay racks, meter panels, and cases are pictured in an 8-page bulletin just issued.

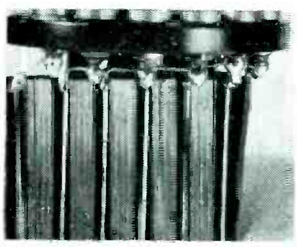
Graphic Recorders—Sound Apparatus Co., 233 Broadway, New York 7, N. Y., will send its catalog describing in 19 pages a line of frequency-response and power-level recorders and allied equipment.

Terminals and Lugs—Aircraft Marine Products Inc., 1521-53 N. 4th St., Harrisburg, Pa. An interesting indexed catalog complete to the point of including samples in transparent envelopes has just been turned out by these makers

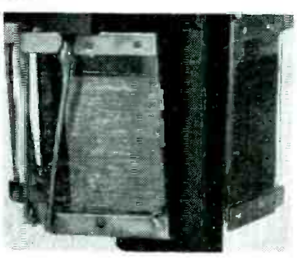




Quadruple-leaf, phosphor-bronze switches with wiping contact. Contact surfaces ground flat. Contact resistance only 0.002 ohm. Cam-type positive detent mechanism. Entire unit shielded behind panel.



Ayrton-Perry windings of the 1-, 10-, and 100-ohm decades on bakelite cards.



Unifilar windings of the 1,000- and 10,000-ohm decades on mica cards.

● The General Radio Type 602 Decade-Resistance Boxes are universally accepted as the adjustable standards of resistance in laboratories where a wide range of resistance values is required.

FEATURES

- PERMANENT CALIBRATION
- THOROUGH AGING
- ACCURATELY ADJUSTED RESISTANCE VALUES
- LOW TEMPERATURE COEFFICIENT
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- PROTECTED WINDINGS AND SWITCHES
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- CURRENT-CARRYING CAPACITY ENGRAVED ON EACH DECADE
- NINE SIZES BETWEEN 0.1 TO 111 OHMS AND 1 TO 111, 110 OHMS
- MODERATELY PRICED BETWEEN $30 and $80

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Write for Detailed Information and Complete Specifications

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of lugs, parallel and butt connectors, and knife-disconnect splices. These various products are useful either for permanent installations or in experimental setups in which haywire connections cannot be tolerated and the more conventional connectors are unnecessary.

Micro-Switch Catalog—Micro-Switch, Freeport, Ill. Copies of catalog No. 61 comprising the complete line of snap-action switches for industrial and electronic use can be had by writing the company.

Rectifiers — Electronic Rectifier Co., Inc., Rochester 2, N. Y. A 16-page catalog containing a complete line of selenium-plate and vacuum-tube rectifiers has been published, containing illustrations, specifications, and prices.

Transmitting Tube Manual—General Electric Co., Syracuse, N. Y. A new 600-page technical manual on electronic transmitting tubes, containing information and application data on 94 tube types, sells for $2. As new data is prepared it will be supplied to purchasers at an annual charge of $1.

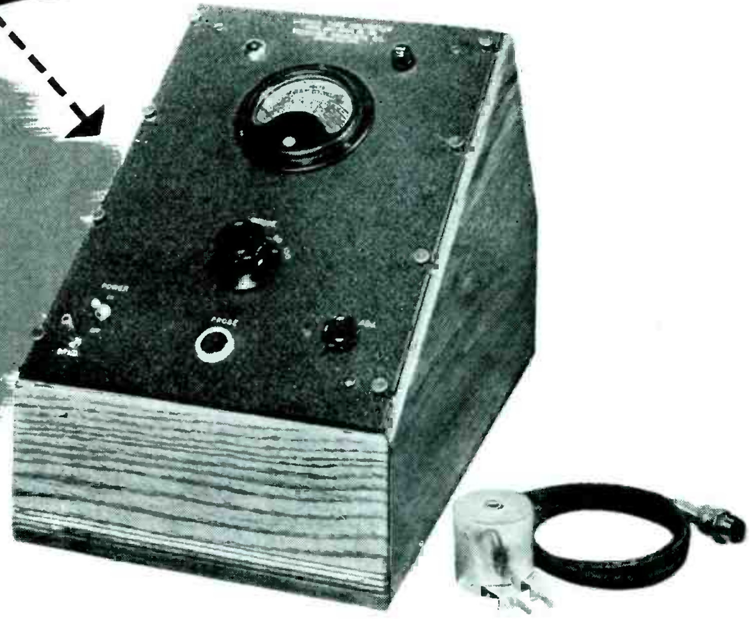
Pulsing Drive—Yardeny Laboratories, Inc., 105-107 Chambers St., New York 7, N. Y. A brochure describes the new pulsing drive that, by the turn of a knob, applies pulses of voltage to the motor under control. As the knob is turned farther in the desired direction the pulses become longer, effectively increasing the speed.

Components Catalog—P. R. Mallory and Co., Inc., Indianapolis 6, Ind. Catalog No. 467 lists capacitors, controls, switches, resistors, power supplies, and other components together with their prices.

F-m Transmission Lines—Andrew Co., 363 East 75th St., Chicago 19, Ill. Bulletin 42 contains complete technical information on transmission lines with solderless connections developed particularly for f-m and television installations.

Mercury Switches — Minneapolis-Honeywell Regulator Co., 2753 Fourth Avenue South, Minneapnew! improved!

VACUUM TUBE VOLTMETER SERIES 200A



• high impedance triode input
• high sensitivity on AF and RF
• stabilized zero setting

Facts . . . Figures that Make Televiso's *New* Series 200A a *BETTER* Vacuum Tube Voltmeter . . .

High impedance input, high sensitivity and zero adjustment stabilization are the prime requirements in a vacuum tube voltmeter for use in modern electronic and industrial manufacturing. Televiso's new Series 200A combines these three qualities to an unusual degree. It is a direct reading instrument with a full scale sensitivity of .5 volt for use at audio *and* radio frequencies. Readings as low as 100,000 microvolts are accurate. Only one zero adjustment is needed for all ranges. The instrument covers the radio frequency range to 500 megacycles, is linearly responsive to the low audio frequency range of four cps. and useful to two cps.

The new Series 200A is the result of years of testing and research. Stray capacitances and detuning effects are reduced to a minimum by bringing the input connections of the voltmeter close to the circuit to be measured. Connections can be made directly to the measured circuit by wires or by a contact clamping fixture for production work. It has an external probe to which connections can be soldered, or binding posts that can receive wires or banana plugs.

The input tube is a triode plate circuit rectifier type in which the input voltage is rectified under full wave, square law operating conditions and indicates RMS values.

The rear storage compartment of the instrument contains a source of calibration voltage equal to five RMS volts ± 2%, making possible continuous checks on calibration accuracy.

Range: .05-150 volts AC in 5 ranges. Full-scale ranges are .5 volt, 2 volts, 15 volts, 50 volts and 150 volts. The 150-volt range may be extended to 1500 volts by means of a type 10:1 capacitive divider available on special order.

Accuracy: Accuracy is ±2% of full scale on all ranges on sinusoidal voltages. Middle scale accuracy is within 5% on all ranges.

Dimensions: Length, 17.5"; width, 11.5"; height, 12.5"; panel, 30° slope.

Guarantee: The instrument is fully guaranteed for a period of two years against defective material and workmanship.

Like all Televiso measuring instruments, the new Series 200A vacuum tube voltmeter is a model of modern design and construction—assuring dependability and extreme accuracy over extended periods of time. Cabinets are copper lined to prevent extraneous radio frequency fields from affecting readings. The panel is of caustic dipped aluminum, flat black painted with a fine baked enamel finish.

Write for Bulletin 32 for complete details

Price $170.00 F.O.B. Chicago. Deliveries from stock

Televiso
PRODUCTS CO.
7466 IRVING PARK ROAD
CHICAGO 34, ILLINOIS

olis 8, Minn. A total of 66 basic switch models are manufactured by this company for direct control of electrical loads up to 50 amperes. A new 15-page booklet lists complete details on the line.

Hearing Aid—Paraphone Hearing Aid, Inc., 2056 East Fourth St., Cleveland 15, Ohio. A hearing aid featuring a replaceable chassis to avoid repair delays is pictured in an 8-page brochure recently published.

Microphones—Electro-Voice, Inc., 1239 South Bend Ave., South Bend 24, Ind. A complete new catalog and selection guide describes cardioid, dynamic, crystal, velocity, differential, and carbon microphones and suggests the best microphone for any particular use.

Components Catalog—Croname, Inc., 3701 Ravenswood Ave., Chicago 13, Ill. Knobs, dial plates, tuning units, drives, and accessory items are among the products listed in Bulletin No. 244, Issue 2.

Waterproof Connectors—Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif. The new series of waterproof connectors designed for underwater use and presently employing AN-type inserts is pictured in Bulletin No. W-146.

A-m Transmitters—Federal Telephone and Radio Corp., Newark 1, N. J. Technical data on 5-kw and 50-kw a-m broadcast transmitters is presented in recent literature issued by the company. Simplified circuits, layout drawings, and dimensional outlines are included.

Small Motors—The Alliance Manufacturing Co., Alliance, Ohio. Several separate sheets have recently been printed, each describing small motors useful as adjuncts to electronic equipment. Some are suitable for blowers, others for driving record changers. One reversible motor with gear train has been designed for radio tuning.

X-ray Spectrometer—North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y. An 8-page booklet (R1041) titled "The Geiger-Mueller X-ray Spectrom-

From 600 to over 30,000 Volts

Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.

Applications

- **For low and medium power coupling and bypass circuits where mica capacitors have previously been required**
- **Television and Oscilloscope Circuits**
- **Vibrator Buffer and Arc Elimination**
- **Geiger Counter and Instrument Capacitors**

Write for illustrated literature featuring our complete line of Glassmike Capacitors.

PLASTICONS: *Plastic-Film Dielectric Capacitors

Order from your jobber: If he cannot supply you, order direct

Condenser Products Company

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eter", reprinted from a recent article, is available at no cost. Construction details, practical applications, and illustrations are treated at some length.

Process Controllers—Bailey Meter Com, 1050 Ivanhoe Road, Cleveland 10, Ohio. Process controllers, measuring and telemetering components, and gas analyzers are described in an 8-page bulletin No. 17 recently issued.

High-gain Radiator—Federal Telephone and Radio Corp., Newark 1, N. J. Engineering details of the square-loop f-m broadcast antenna have just been published in a booklet containing illustrations and graphs of characteristics and performance.

Grommet Bushings—Creative Plastics Corp., 963. Kent Ave., Brooklyn 5, N. Y. Copies of a chart of grommet bushings covering all dimensions, including collars, and ranges from ⅛ to ½ inch inside diameter may be obtained for the asking.

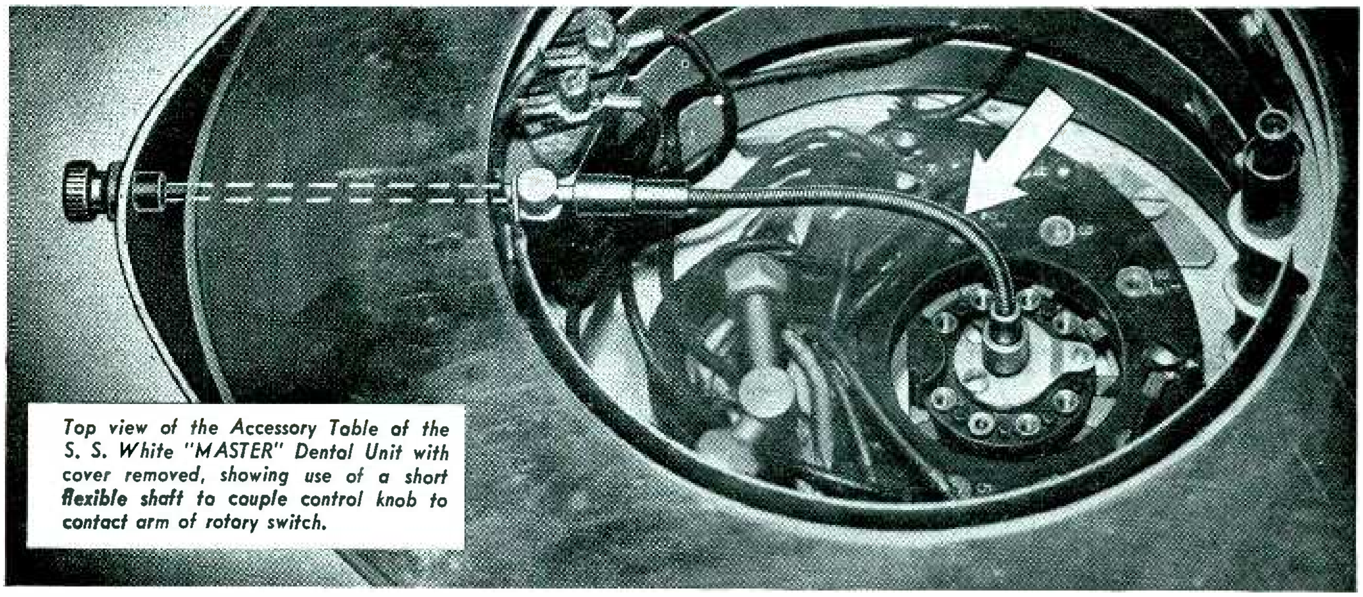
Color Code—Allied Radio Corp., 833 West Jackson Blvd., Chicago 7, Ill. A new RMA-JAN color code guide that quickly translates resistor colors to their numerical values is available from the company at a cost of 10 cents each.

Heating and Sealing—Radio Receptor Co., Inc., 251 West 19th St., New York 11, N. Y. An 8-page booklet "Electronic Heating and Sealing With the Thermatron" describes the use of industrial heat generators for preheating and sealing of plastics, rubber, plywood, and other dielectric materials.

Loudspeakers — University Loudspeakers, Inc., 225 Varick St., New York 14, N. Y. has compiled a new twenty-two page catalog of heavy-duty loudspeakers for outdoor use.

Interval Timer—Electronic Controls, Inc., 44 Summer Ave., Newark 4, N. J. A 1-page data sheet is available describing an electronic interval timer.

S. S. White Flexible Shafts



Top view of the Accessory Table of the S. S. White "MASTER" Dental Unit with cover removed, showing use of a short ***flexible shaft*** *to couple control knob to contact arm of rotary switch.*

THE SIMPLE WAY TO OPERATE VARIABLE ELEMENTS IN INACCESSIBLE PLACES

Just consider the picture above for a minute. Imagine the flexible shaft wasn't there, and figure how else you would operate that rotary switch. We believe you'll quickly agree that for jobs of this kind you can't beat a flexible shaft.

Also, as you look at the picture you can appreciate that the switch could have been located anywhere and in any position in the unit . . . and the one flexible shaft would still have served the purpose.

S. S. White remote control flexible shafts are expressly designed to do just such jobs . . . transmitting remote control to parts in inaccessible places regardless of turns, obstacles, distance. Properly applied, they give you a quality of control that rivals a direct connection in sensitivity and smoothness.

WRITE FOR BULLETIN 4501

It gives essential facts and engineering data about flexible shafts and their application.

S.S.WHITE INDUSTRIAL DIVISION

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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Dates and programs of forthcoming electronic conferences; reports on surplus disposal and f-m station construction; industry news

Technical Program for Rochester Fall Meeting

THE TENTATIVE TECHNICAL program of the Rochester Fall Meeting, to be held Nov. 11, 12, and 13, 1946 at the Sheraton Hotel, Rochester, N. Y., is as follows:

Monday, Nov. 11

9:30 a. m.—Technical session; Electronic Transducers, by H. F. Olson of RCA Laboratories; Some Canadian Television Aspects, by G. W. Olive of Canadian Broadcasting Corp.; Television at Bikini, by D. G. Fink of ELECTRONICS and Captain C. L. Engleman, Electronics Coordinating Officer of Operation Crossroads.

2:00 p. m.—Technical session; Television Broadcasting as a Public Service, by R. F. Guy of National Broadcasting Co.; Color Television, by P. H. Reedy of Columbia Broadcasting System.

8:15 p. m.—General session; Death Rays—Are There Such Things–, by A. F. Murray, consulting engineer.

Tuesday, Nov. 12

9:30 a. m.—Technical session; Television Sound Channel, by R. B. Dome of General Electric Co.; Report of RMA Data Bureau, by L. C. F. Horle of RMA Data Bureau; Some New Tube Developments, by M. A. Acheson of Sylvania Electric Products Inc.

2:00 p. m.—Technical session; A Comparison of A-M with F-M in Broadcasting, by M. G. Nicholson of Colonial Radio Corp.; A New Frequency-Modulated Signal Generator, by D. M. Hill of Boonton Radio Corp.

Wednesday, Nov. 13

9:30 a. m.—Technical session; Report on Television Standards, by D. B. Smith of Philco Corp.; Recent Improvements in Television Equipment, with demonstration, by G. L. Beers of RCA Victor Division.

2:00 p. m.—Technical session; Production Design of Magnetic Wire Recorders, by R. S. Anderson and G. W. Carlson of Stromberg-Carlson Co.; Measurement Methods for Ferromagnetic Materials, by H. W. Lamson of General Radio Co.

New RMA Standards for F-M and Television Sets

ONE OF THE NEW standards adopted by the RMA Engineering Department fixes the intermediate frequency for vhf broadcast receivers at 10.7 megacycles. This will apply to all f-m receivers, simplifying the production of i-f transformers for these sets and minimizing the variety of testing equipment required in production and servicing of f-m receivers.

The antenna-to-set transmission line for television receivers shall have a characteristic impedance of 300 ohms and consist of parallel unshielded pair, according to another recent RMA standard. Without this standardization, television set makers would generally have to supply their own lines and antennas with sets to assure proper operation.

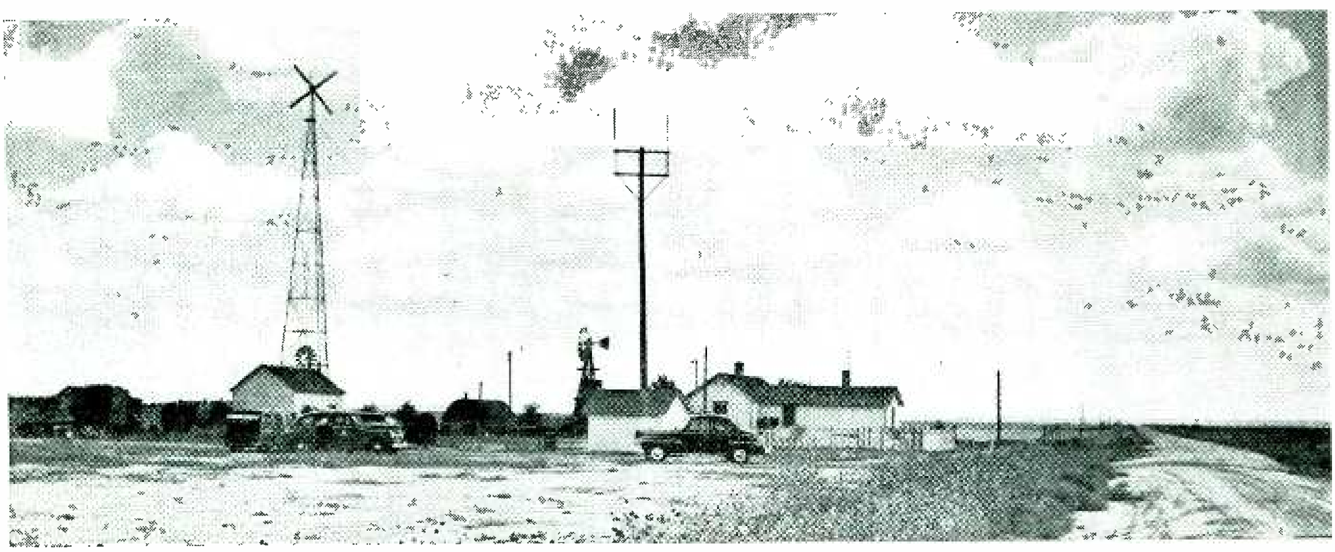
The i-f value for the sound channel of television receivers has been standardized at between 21.25 and 21.9 megacycles, with the oscillator at a frequency higher than that of the incoming signal.

Interim Research

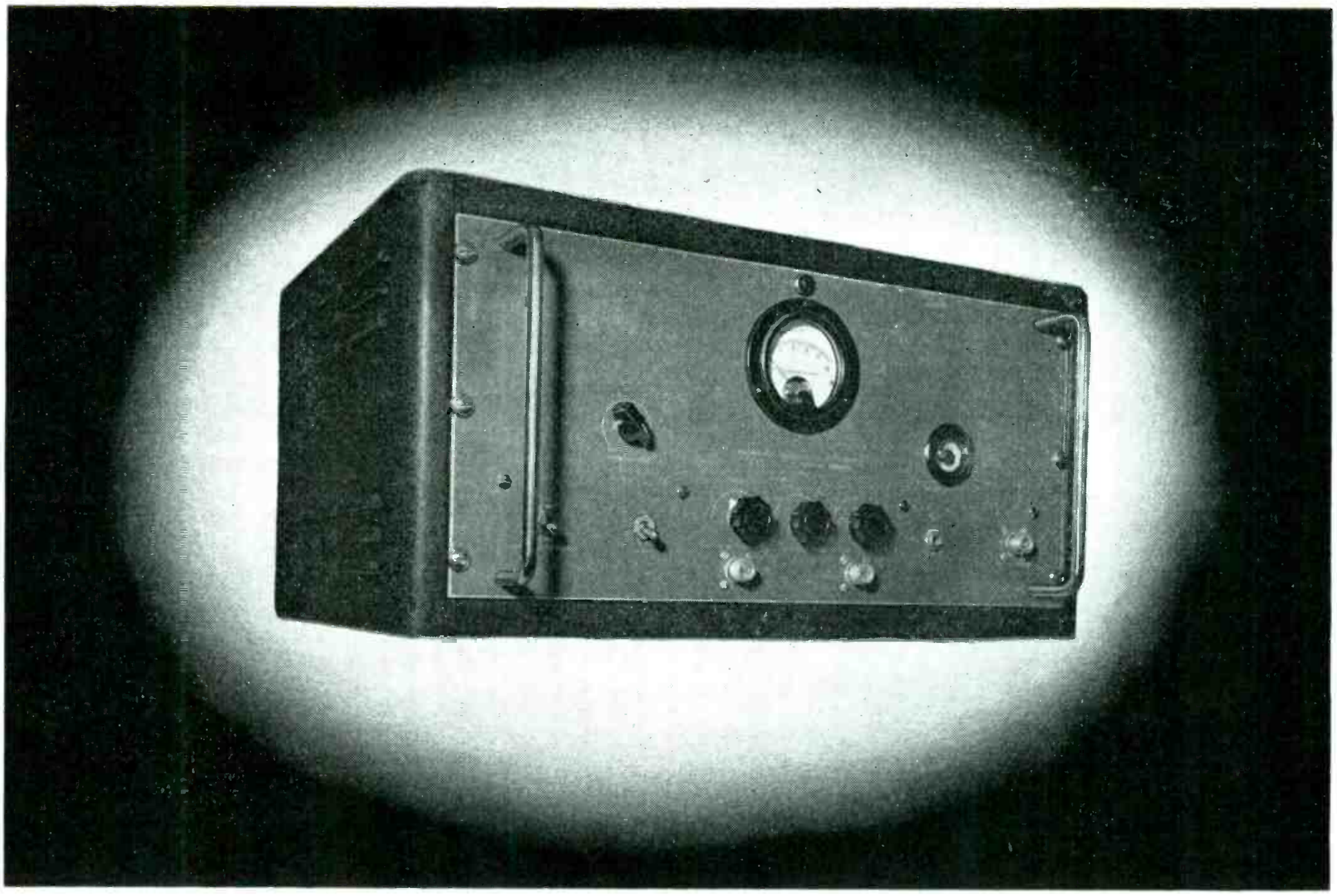
WITH OSRD IN process of demobilization and its permanent replacement, the National Science Foundation, not yet legislated into existence, the War and Navy departments are utilizing the research and engineering staffs of educational institutions, industries, and foundations for continuation of scientific research during the interim period.

To assure coordination between War and Navy department research the respective Secretaries have set up a five-member Joint Research and Development Board. Doctor Vannevar Bush, former OSRD head, is chairman; Navy members are Assistant Secretary

RADIOTELEPHONE FOR COLORADO RANCHERS



Two-pronged pole supports separate sending and receiving antennas of rural radiotelephone equipment installed at ranch of Cecil F. Blackwelder, about 20 miles from Cheyenne Wells, Colorado. Wind generator unit at left supplies electric power for ranch and radio. Seven other ranches in this area have been linked via radio with the nation's telephone system by Mountain States Telephone and Telegraph Co. (See p. 270 of July 1946 ELECTRONICS for further details)



LAVOIE C-200

Harmonic Frequency Generator

Now you can obtain precision calibration up to and beyond 2000 megacycles of receivers and wavemeters at a fraction of the time previously required. Also, by means of a Beat Detector built into the instrument, you can calibrate oscillators and signal generators with equal ease.

The C-200 Harmonic Frequency Generator is a secondary frequency standard, designed especially for calibration work above 100 MC, with an accuracy of .02%. If greater accuracy is desired, the crystal may be supplied with temperature control.

The output voltage is supplied at a UG 58/U, 50 ohm connector with output coupling controls to obtain peak performance for a given harmonic. A milliammeter is incorporated in the instrument to facilitate easy adjustment of the output controls. The output voltage may be either unmodulated, or modulated with 400 C.P.S. internal oscillator. The calibrator provides output voltages every 10 MC, or every 40 MC. This selection is made by a switch on the front panel. The harmonic voltage is in the order of thousands of microvolts for each harmonic with a value of approximately 50,000 microvolts at 100 MC's and 1500 microvolts at 1000 MC's.

Provision is made for the calibration of signal generators and oscillators by the incorporation of a beat frequency detector in the calibrator. The output of this beat frequency detector may be monitored, either aurally or visually with a tuning eye indicator.

To facilitate harmonic identification, frequency identifiers can be supplied for any harmonic frequency (multiple of 10 MC) between 100 and 1000 MC. The identifier is adjusted at our factory.

The C-200 Harmonic Frequency Generator can be used to calibrate signal generators, receivers, transmitters, wavemeters and oscillators. It provides a fast, accurate and easy method of calibrating in 10 or 40 MC steps.

This instrument is supplied with accessories needed for its operation, including tubes, 5 MC crystal, output coupling cable and instruction book.

U H F

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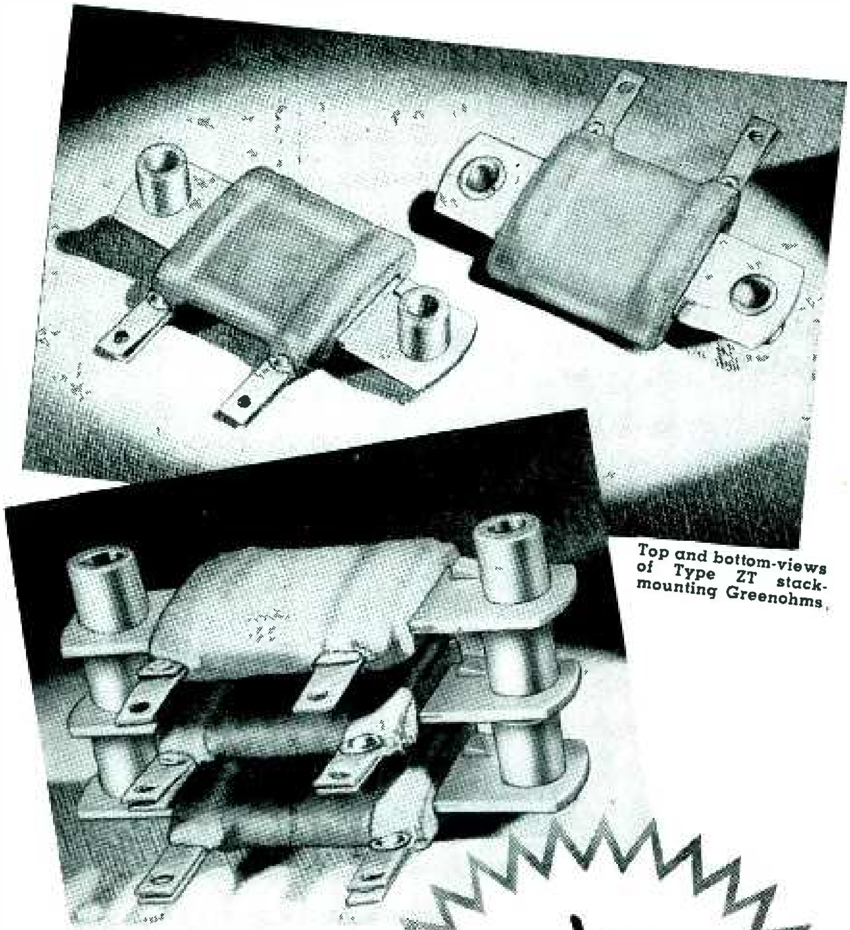


Kenney and Admiral Ramsey; Army members are General Spaatz for the Air Forces and General Devers for the Ground Forces. Executive Secretary, with offices in the new War Department building on 21st St. in Washington, is Dr. L. V. Berkner.

The second policy in General Eisenhower's memorandum establishing the War Department directorate for research and development is, "Scientists and industrialists must be given the greatest freedom to carry out their research." Insofar as this applies to the attitude of Army personnel, the Research and Development division headed by Major General H. S. Aurand will promote this program. Within the limits of present laws affecting government contracts, all possible freedom will be given the universities, industries, and foundations receiving research contracts, and bills permitting full freedom have already been introduced in Congress.

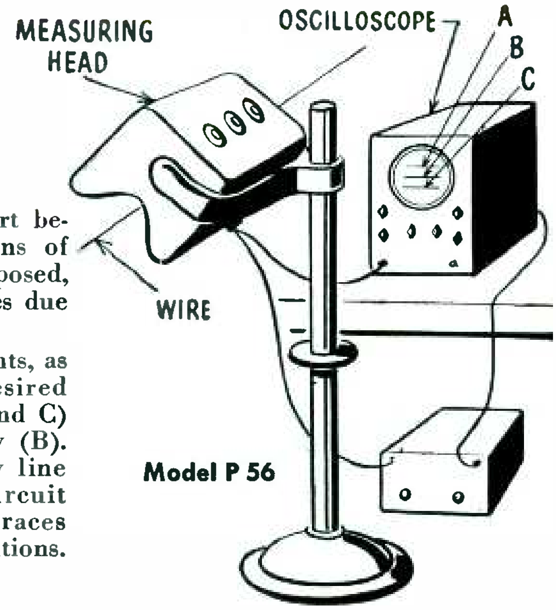
Any group of scientists that is uncertain as to which operating agency would be able to profit most from their efforts in military research and development work is urged to contact General Aurand, Director, Research and Development Division, War Department General Staff, Washington, D. C.

Admiral Bowen Heads New Office of Naval Research

PERMANENT STATUS for the government's biggest program in support of fundamental research was achieved with the passing by Congress Aug. 1, 1946 of Public Law 588 and signing by President Truman on Aug. 3, creating the Office of Naval Research to succeed the Office of Research and Inventions. The new ONR will carry on, in effect, where ORI pioneered, with essentially the same objectives, staff, and general organization. Vice Admiral Harold G. Bowen, USN is chief of the new Office, and Rear Admiral Luis de Florez is assistant chief.

There are now 177 Naval Research contracts in force with 81 university, private, and industrial research laboratories throughout

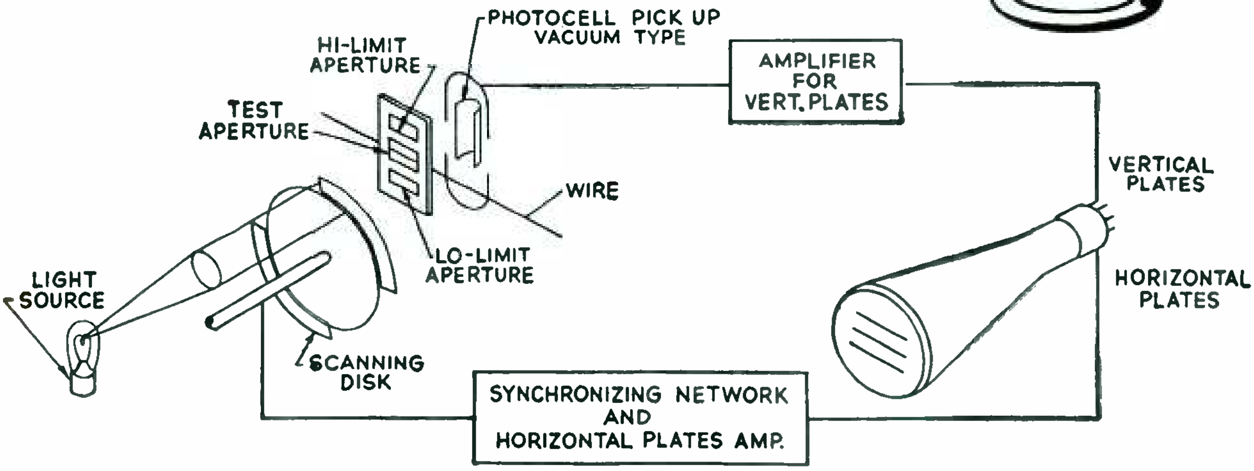
Wilmotte "Visi-Limit" Electronic Micrometer



An important advance in the field of measurement. Manufactured for direct installation on the production line for continuous indication of outside diameter of wire, tubing or rod, edge-to-edge dimensions on machined or extruded parts, strip stock, thickness of sheets.

Size range of standard unit is .005″ to .600″ in diameter. Items of other sizes can be accepted through special design. Tolerance limits are + or − .0002″ without physical contact with the part being measured. No limitations of speed of operation are imposed, nor are there any inaccuracies due to deformation of the part.

The "scope" screen presents, as three parallel lines, the desired tolerance requirements (A and C) with the measured quantity (B). No error is introduced by line voltage fluctuations or circuit changes since all three traces maintain their relative positions.



Wilmotte "Visi-Limit" Curve Tracer

For rapid alignment of I.F. coils of frequencies from 85 kc to 11 mc. Operator adjusts test trace (B) to fall between traces of limit coils (A and C), set up to production specifications. Defective coils immediately detected. All error is eliminated as circuit changes or line voltage variations affect all three traces equally.

Standard equipment includes one plug-in oscillator assembly at frequency specified by purchaser, and jigs for limit and test coils having "pig tail" leads. Jigs for special applications furnished to purchaser's specifications.

These industrial electronic devices, as well as the

WILMOTTE PULSE GENERATOR, MODEL P54

will be demonstrated at the

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We anticipate with pleasure the opportunity of meeting you at this conference.

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the United States. The bulk of the work is conducted by civilian scientists, and customary publication takes place in scientific journals.

The head of ONR will serve as the principal representative of the Navy department in research dealings of Navy-wide interest with other government agencies, corporations, and research organizations. Planning and coordination of Naval research will be aided by a civilian committee known as the Naval Research Advisory Council, consisting of not more than 15 persons to be appointed by the Secretary from those persons in civilian life who are preeminent in the fields of science, research, and development work.

A total of $45,000,000 was appropriated to the Navy Department for fundamental research initiated by ORI during the fiscal year 1947 in nuclear physics, medicine, physics, chemistry, mathematics, meteorology, and applied research, as well as coordination with the rest of the Navy on projects dealing with power, guided missiles, air, subsurface, and surface warfare.

Books for China

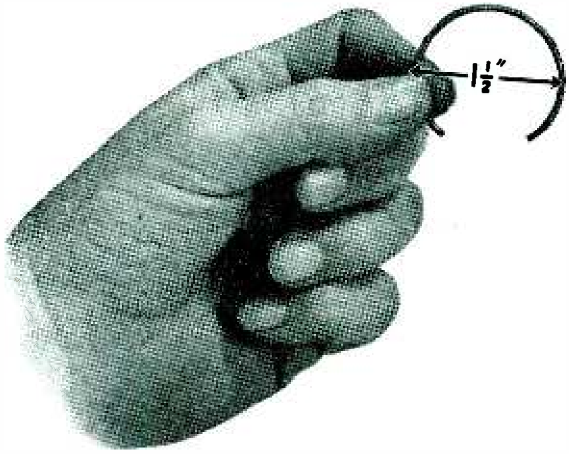
CONTRIBUTIONS OF SCIENTIFIC and technical books and journals for Chinese universities and schools may be shipped by freight collect to Dr. C. D. Shia, National Resources Commission of China, 111 Broadway, New York 6, N. Y. For over nine years practically no technical books have been received in China, so that anything having reference value in the various fields of science and technology is badly needed.

NAB Session on F-M

PANEL MEMBERS FOR the special session on frequency-modulation broadcasting scheduled for the afternoon of Oct. 21 at the National Association of Broadcasters' annual convention in Chicago include Charles R. Denny, acting chairman of the Federal Communications Commission, who will discuss the Commission's policy concerning f-m allocations; Lester H. Nafzger, general manager of f-m station WELD in Columbus, Ohio, who

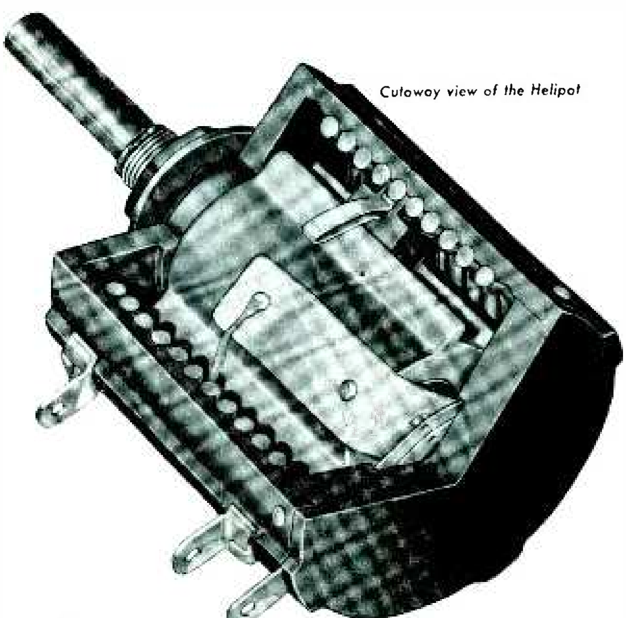
Compare!

Here's the **Helipot** Principle that is Revolutionizing Potentiometer Control in Today's Electronic Circuits



CONVENTIONAL POTENTIOMETERS have a coil diameter of approximately 1½" and provide only 4" (about 300°) of potentiometer slide wire control.

THE BECKMAN HELIPOT has the same coil diameter, yet gives up to 46" (3600°)* of potentiometer slide wire control—nearly TWELVE times as much!



Cutaway view of the Helipot

***HELIPOTS ARE AVAILABLE IN 3 STANDARD SIZES:**

TYPE A—5 watts, incorporating 10 helical turns and a slide wire length of 46 inches, case diameter 1¾", is available with resistance values from 25 ohms to 30,000 ohms.

TYPE B—10 watts, with 15 helical turns and 140" slide wire, case diameter 3¼", is available with resistance values from 100 ohms to 100,000 ohms.

TYPE C—2 watts, with 3 helical turns and 13½" slide wire, case diameter 1¾", available in resistances from 5 ohms to 10,000 ohms.

The Type B is also available in special sizes of 25 and 40 helical turns, with resistances ranging from 500 ohms to 300,000 ohms, and containing more than 100,000 change-of-resistance steps.

*Data above is for the standard Type A unit.

Some of the multiple **Helipot** advantages

EXTENSIVELY used on precision electronic equipment during the war, the Helipot is now being widely adopted by manufacturers of quality electronic equipment to increase the accuracy, convenience and utility of their instruments. The Helipot permits much finer adjustment of circuits and greater accuracy in resistance control. It permits simplifying controls and eliminating extra knobs. Its low-torque characteristics (only one inch-ounce starting torque*, running torque even less) make the Helipot ideal for power-driven operations, Servo mechanisms, etc.

And one of the most important Helipot advantages is its unusually accurate linearity. The Helipot tolerance for deviations from true linearity is normally held to within ± 0.5%, while precision units are available with tolerances held to 0.1%, .05%, and even less—an accuracy heretofore obtainable only in costly and delicate laboratory apparatus.

The Helipot is available in a wide range of types and resistances to meet the requirements of many applications, and its versatile design permits ready adaptation of a variety of special features, as may be called for in meeting new problems of resistance control. Let us study your potentiometer-rheostat problem and make recommendations on the application of Helipot advantages to *your* equipment. No obligation of course. Write today.

Send for the New Helipot Booklet!

THE Helipot CORPORATION, 1011 MISSION STREET, SOUTH PASADENA 2, CALIFORNIA

will discuss station promotion and program sources; W. R. G. Baker, vice-president of General Electric Co., who will discuss the transmitter and receiver situation; T. A. M. Craven, vice-president in charge of engineering for the Cowles stations, who will cover the subject of technical operations for f-m stations; Walter J. Damm, chairman of the NAB f-m executive committee and president of FM Broadcasters, Inc., who will preside and answer questions concerning managerial and operational aspects of f-m broadcasting.

Electronics Conference

THE FINAL PROGRAM of the National Electronics Conference, to be held Oct. 3, 4, and 5 at the Edgewater Beach Hotel, Chicago, lists the following papers in addition to those given in the tentative program on page 270 of the August 1946 issue of ELECTRONICS:

J. O. McNalley and W. G. Shepherd of Bell Telephone Laboratories—Reflex Oscillators for Radar Systems.
C. J. Marshall of Wright Field and Leonhard Katz of Raytheon Mfg. Co.—Television Equipment for Guided Missiles.
Wm. R. Rambo of Airborne Instruments Laboratories—Frequency Modulation of High-Frequency Power Oscillators.
K. W. Jarvis, Consulting Engineer—Signal Systems for Improving Railroad Safety.
A. L. Samuel of University of Illinois—An Oscillographic Method of Presenting Impedances on the Reflection Coefficient Plane.
R. G. E. Hutter of Sylvania Products—Electron Optics of Deflection Fields.

With a total of 63 papers scheduled for the three days, adequate time for each paper is being achieved by having five sessions running concurrently for Thursday and Friday technical sessions and four concurrently on Saturday morning. The time schedule for the 19 groups of papers and the other events of the conference is given below.

Thursday, Oct. 3

9:00 a. m.—Registration.
10:15 a. m.—General meeting, with J. E. Hobson, chairman of board of directors of the National Electronics Conference, as chairman; address of welcome by H. T. Heald, president of Illinois Institute of Technology; speaker is E. U. Condon, director of National Bureau of Standards.
12:15 p. m.—Luncheon meeting, with O. W. Eshbach, dean of Technological Institute of Northwestern University, as chairman; speaker is F. L. Hovde, president of Purdue University.
2:00 p. m.—Technical session; 1—TELEVISION (part A), with J. E. Brown of Zenith Radio Corp. as chairman; 2—ANTENNAS AND WAVE PROPAGATION (part A), with R. K. Honaman of Bell Telephone Laboratories as chairman; 3—INFRARED AND MICROWAVE SYSTEMS; 4—SPECTROSCOPY AND MEDICAL APPLICATIONS, with H. J. Holmquist of General Electric X-Ray Co. and Northwestern University as chairman; 5—

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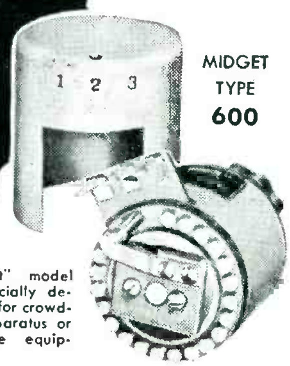

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"Midget" model is especially designed for crowded apparatus or portable equipment.

STANDARD TYPE **700**

- Solid silver contacts and stainless silver alloy wiper arms.
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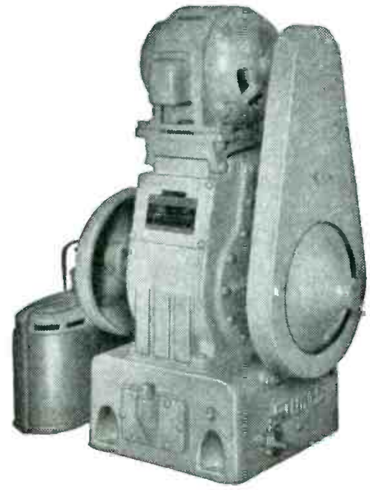

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PUMPS • GAUGES • EQUIPMENT

Northwestern University as chairman; 5—INDUSTRIAL APPLICATIONS, with W. Richter of Allis-Chalmers Co. as chairman.

7:00 p. m.—Banquet, floor show, and dancing in Marine Dining Room of Edgewater Beach Hotel; informal, with ladies invited.

Friday, Oct. 4

9:00 a. m.—Technical session; 6—TELEVISION (part B), with D. E. Foster, consulting engineer, as chairman; 7—AIR-NAVIGATION SYSTEMS, with C. A. Petry of United Air Lines as chairman; 8—THEORETICAL DEVELOPMENTS; 9—ELECTRONIC INSTRUMENTATION (part A), with J. Ryder of Iowa State College as chairman; 10—INDUCTION AND DIELECTRIC HEATING, with J. Callanan of Illinois Tool Works as chairman.

12:15 p. m.—Luncheon meeting, with W. O. Swinyard, president of the National Electronics Conference, as chairman; speaker is C. G. Suits, vice-president of General Electric Co.

2:00 p. m.—Technical session; 11—ANTENNAS AND WAVE PROPAGATION (part B), with W. L. Everitt of University of Illinois as chairman; 12—RADIO RELAY SYSTEMS, with C. W. Hansell of RCA as chairman; 13—FREQUENCY MODULATION, with D. E. Noble of Galvin Mfg. Co. as chairman; 14—ELECTRONIC INSTRUMENTATION (part B), with J. A. M. Lyon of Northwestern University as chairman; 15—RECORDING AND FACSIMILE, with R. Glover, consulting engineer, as chairman.

8:00 p. m.—Demonstration lecture (joint meeting with Chicago sections of AIEE and IRE), with A. W. Graf, chairman of IRE Chicago section, as chairman; speaker is J. O. Perrine, assistant vice-president of Bell Telephone Laboratories.

Saturday, Oct. 5

9:00 a. m.—Technical session; 16—MICROWAVE GENERATORS, with R. Samuelson of Hallicrafters Co. as chairman; 17—MOBILE RADIO COMMUNICATION, with Ross Herrick of Lorain Telephone Co. as chairman; 18—ELECTRONIC INSTRUMENTATION (part C); 19—NUCLEAR PHYSICS.

Papers presented at the Conference will be made available in conveniently bound printed form as a transcription of current achievements in various fields of electronic developments. Copies may be ordered from E. H. Schultz, Secretary, National Electronics Conference, Technology Center, Chicago 16, Illinois at $3.50 each.

Recent electronic developments will be on display in exhibits by various manufacturers in the lounge and conservatory of the hotel.

Set Production Figures

EIGHT MILLION RADIO sets were produced in the twelve-month period following VJ day, according to an RMA announcement. This constituted 60 percent of production in the last prewar year, 1941, when nearly 14,000,000 radio receivers were manufactured.

July production of 1,061,853 sets by RMA-member companies slightly exceeded the record-breaking figures for June, despite the long July Fourth holiday and the

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40 YEARS DEPENDABILITY

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ANTENNAS

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Make pleased customers and bigger profits . . . ask your distributor for BRACH Puratone ANTENNAS.

Special - purpose transmitting antennas designed for volume production to your own specifications. Collapsible — sectional — direction finding — radar and coaxial type. All sizes, lengths and materials. Consult us on your needs.

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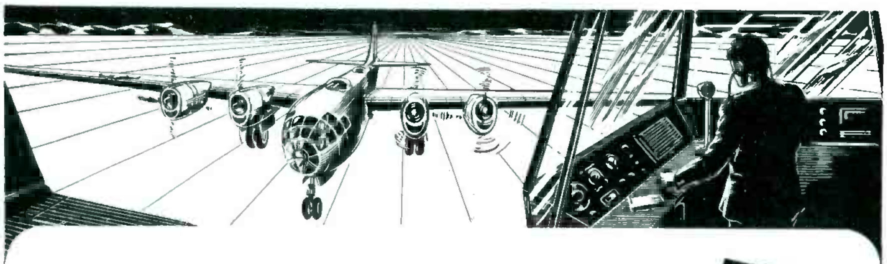

An Invitation to All Electrical Designers to
TRY SILVER GRAPHALLOY

for RELAYS MOTORS CONTROLS ELECTRONICS

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High current density, low contact drop, low electrical noise, and self-lubrication are characteristics of this silver-impregnated molded graphite that may be the answer to your electrical brush problems

FOR CONTACTS
Low contact resistance and non-welding when breaking surge currents are inherent properties of this unique combination of conductive silver and self-lubricating graphite

SAMPLES of Silver Graphalloy will be gladly furnished for test on your applications. Silver Graphalloy is usually silver plated to permit easy soldering to leaf springs or holders. Why not WRITE NOW for your test samples?

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Trade Mark Reg. U.S. Pat. Off.

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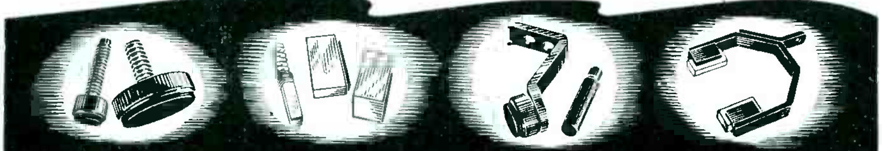

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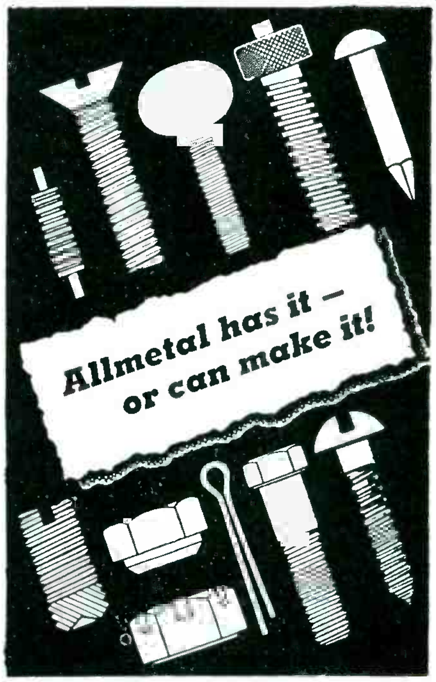
What type of STAINLESS FASTENER do you need?



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Screws . . . nuts . . . washers . . . pins . . . Allmetal carries the largest stock in the country of stainless steel fasteners and screw machine parts. We also have facilities for heading, tapping, drilling, reaming, slotting, turning, stamping, broaching and centerless grinding . . . and we work not only with stainless and monel, but also with duralumin, aluminum, brass, bronze, or any other non-corrosive metal. All parts produced to close tolerances. Write for our catalog today. Allmetal Screw Products Co., 33 Greene St., New York.

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This new, 83-page catalog helps you select the correct size and type of non-corrosive fastening device for any particular job. Includes stock sizes, specials that can be made, engineering data, etc. Make request on company letterhead.

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SPECIALISTS in STAINLESS FASTENERS

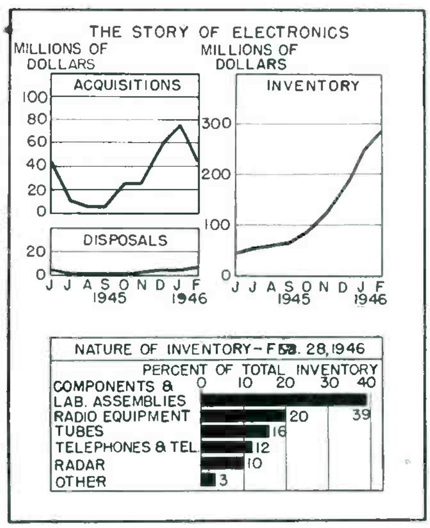
abrupt ending of OPA controls. Production of f-m sets in July rose slightly, to 19,642 sets, while 110,375 auto radios, 41 television sets, 770,633 table models, 71,500 consoles and combinations, and 152,165 table and portable battery sets were reported.

The Civilian Production Administration estimate for July is 1,330,000 sets, or 3 percent less than their June figure. Production continues to be retarded by shortages of parts, particularly tubes, gang capacitors, and wood cabinets.

A new peak in radio receiving tube production was reached in June with shipment of 17,979,636 tubes. Of these, 10,442,841 were intended for new radio sets and 828,740 for export.

Report on Surplus

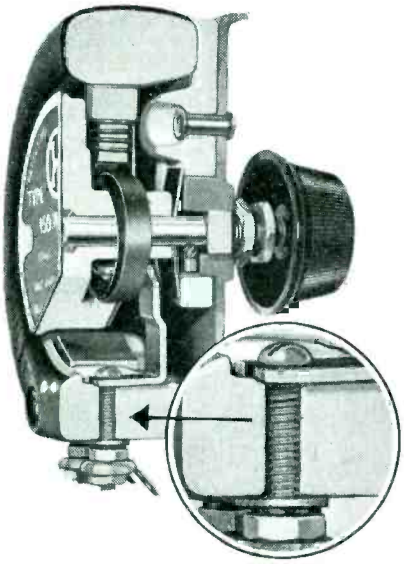
NEXT TO MACHINE TOOLS, the largest inventory of war surplus capital goods consists of communication and electronic equipment, with $300 million of this property acquired for disposal by the end of February 1946 and somewhere between $1 and $2 billion more at reported original cost awaiting disposal. It



Acquisitions of electronic equipment have been coming in rapidly, but governmental red tape and unreasonably high asking prices combine to make very slow, so inventory grows steadily

is expected that a large portion of this surplus will be scrapped as being commercially unsalable. The accompanying War Assets Administration graphs, portraying the

RUGGED Screw Terminals for a RUGGED Rheostat



The sturdy screw terminals are integral with the massive ceramic winding core—a *great* core that gives 25% more capacity. These solid screw studs cannot be deformed nor ripped loose.

And this is only one of several exclusive features of this line of rheostats, ranging from 50 to 500 watt capacity.

Our 10 watt and 25 watt rheostats also, and many different types of Hardwick-Hindle resistors, offer other exclusive advantages.

Write us today. Our engineers are at your service.

HARDWICK, HINDLE, INC.
RHEOSTATS and RESISTORS
Subsidiary of THE NATIONAL LOCK WASHER COMPANY
NEWARK 5, N. J. ESTABLISHED 1886 U. S. A.

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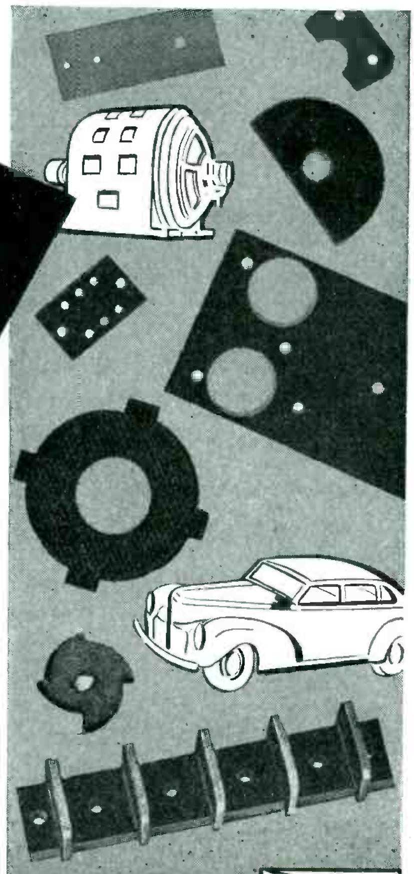
WRITE FOR BULLETIN 120

Baer
PHENOL AND VULCANIZED FIBRE FABRICATIONS FOR INDUSTRY



Design short-cuts- cutting engineering and assembling time

Time saved in preliminary planning is directly proportionate to efficiencies effected in the blueprint stage. By designing-in BAER fibre fabrications—whether your product is instrument, machine, appliance or equipment—the utmost in production stream-lining is assured. Further, the inherent advantages of the material—accurately machined, stamped, punched, drilled, milled or sawed by BAER craftsmen—adds a full measure of dependability under varying service conditions.

N. S. BAER COMPANY, 9-11 MONTGOMERY ST., HILLSIDE, N. J.

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ADVANCE ULTRA SENSITIVE* D. C. RELAYS

★ **2½ TO 5 MILLIWATT OPERATION 25% TO 15% DIFFERENTIAL**

COVER: Moulded Plastic, Cellulose Acetate, Clear, Tough Single Screw Attachment • No dust or dirt on contacts • No accidental operation • No short circuits • Instant visual inspection • Low maintenance of contact adjustment

BASE: Moulded black BAKELITE • Good mechanical strength • High dielectric strength and insulation • Negligible water absorption • Compactness and fine appearance

OPERATING POWER: 5 Milliwatts for positive operation • 2½ Milliwatts with careful adjustment and light contact loads

MAGNETIC CIRCUIT: Armature and pole of Nickel-Iron alloy, Hydrogen annealed for high permeability and low retentivity • High overall sensitivity • Small make-break coil current differential—(25% to 15% less current to break than to make)

ARMATURE: Counterbalanced • Prevents action of relay due to moderate vibration • Allows operation in any position

SENSITIVITY ADJUSTMENT: Vernier screw for coil spring tension on armature • Accuracy • Permanent setting, easily changed

CONTACTS: Pure Silver (palladium, platinum or other specified materials at extra cost) • Single pole, double throw • 1 ampere on 110 volt A.C., non-inductive load • Screwdriver adjustment

COIL: Standard resistance from 1 ohm to 10,000 ohms, up to 30,000 ohms at small extra cost • Cellulose acetate insulation • Varnish vacuum impregnation

TERMINALS: Solder lugs and screws, recessed on bottom of base, accessible through panel or through knockouts on side of base

MOUNTING: Surface mounting, any position, fastens with two No. 6 screws

SIZE: 2″ x 2-9/16″ x 1½″ high

WEIGHT: 6¼ ounces

PRICE: Moderate
Write for quotations and catalogs on the Advance Type 1200 Ultra Sensitive D. C. Relay and other Advance Relays

Advance Relays

ADVANCE ELECTRIC & RELAY CO.
1260 West 2nd Street
Los Angeles 26, Calif., U. S. A.
Phone Michigan 9331

situation as of about six months ago, show trends fairly representative of the situation today; inventory is high, but prices on items displayed by WAA agents are high also and disposal is correspondingly slow.

F-M Station Construction

To COUNTERACT DILATORY planning and construction of f-m stations and assure operation with interim equipment when complete equipment is not immediately available, the FCC has shortened from 90 days to 30 days the period within which additional engineering information must be supplied by grantees seek- to convert conditional grants to construction permits. Also, progress information is being requested of those already holding permits. When request for extension of completion date is requested by a permit holder, the Commission will consider the promptness of a permittee's efforts to secure equipment and other materials and his efforts to provide an f-m broadcast service promptly with interim equipment in determining whether such extension should be granted or whether the original application shall be designated for hearing and the grant cancelled.

MEETINGS

OCT. 3-5; NATIONAL ELECTRONICS CONFERENCE; Edgewater Hotel, Chicago, Ill.; technical programs under three main heads—communications, industrial electronics, and scientific and medical developments.

OCT. 3-5; OPTICAL SOCIETY OF AMERICA; annual meeting; Hotel Pennsylvania, New York City.

OCT. 10-11; TELEVISION BROADCASTERS ASSOCIATION CONFERENCE; Waldorf-Astoria Hotel, New York City; latest television equipment will be exhibited.

OCT. 18-20; ELECTRONICS TRADE SHOW; sponsored by West Coast Electronics Manufacturers Association; Elks Temple building, Los Angeles, California.

OCT. 21; F-M SYMPOSIUM; annual

(Patent Pending)

"DIALCO" PLN-849 *Pilot Lights*

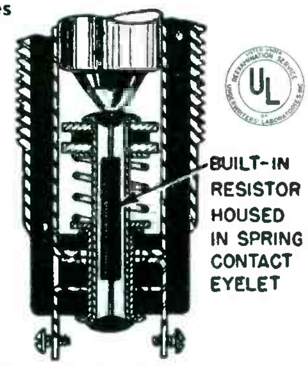
Designed for the New Neon-51 Lamp

Feature BUILT-IN RESISTORS

For 110 Volts (and higher)

A RUGGED UNIT. Consumes a small amount of current (under one milliampere) and has dependable long life. Note these important features of the PLN-849 Pilot Light:

(1) RESISTOR INTEGRAL with socket assembly. Value to suit supply voltage.
(2) Moulded Bakelite Socket.
(3) Full-view Jewel Plastic Cap for visibility at all angles.
(4) Rugged terminals, binding screw or permanent soldering type.
(5) High resistance to vibration or shock.
(6) Supplied complete with General Electric Neon NE-51 Bulbs. May also be adapted to accommodate General Electric Radio Panel Bulbs such as 47, 44, etc., for low voltage circuits. Bulbs removable from front of panel.



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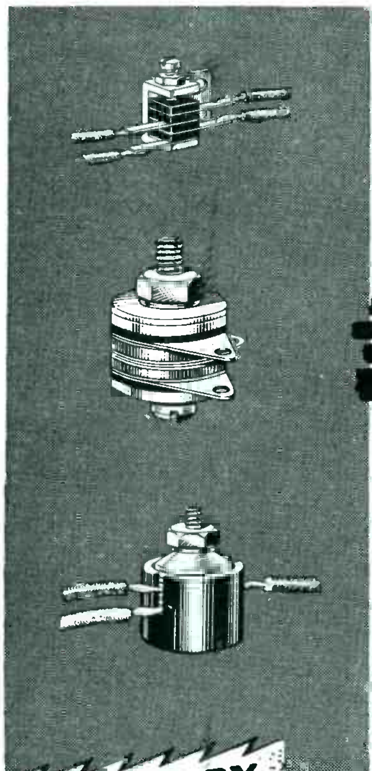

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RECTIFIERS

Quality units, made by one of the oldest manufacturers of dry disc rectifiers. You can rely absolutely on Electrox Rectifiers for all types of electronic applications — such as instruments, test sets, precision measuring equipment and similar uses.

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Whether you are recording for broadcast, rebroadcast, audition, or movie playback, it is a satisfaction to know that the disc you use will not fail.

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are your guarantee of highest professional quality.

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convention of National Association of Broadcasters; luncheon and afternoon session commencing at 12:30; Palmer House, Chicago.

OCT. 21-23; SCHOOL BROADCAST CONFERENCE; Continental Hotel, Chicago, Ill.; papers on programming and choice of equipment for educational uses of radio, and exhibits of equipment; George Jennings, director, School Broadcast Conference, 228 N. LaSalle St., Chicago 1, Ill.

OCT. 21-25; SOCIETY OF MOTION PICTURE ENGINEERS; semiannual convention; Hollywood - Roosevelt Hotel, Hollywood, California.

NOV. 11-13; ROCHESTER FALL MEETING; Sheraton Hotel, Rochester, N. Y.; technical papers and exhibits.

NOV. 11-14; INTERNATIONAL MUNICIPAL SIGNAL ASSOCIATION; Annual Meeting; Miami, Florida; technical program and exhibits cover fire and police radio, signaling, etc.

NOV. 18-22; THE NATIONAL METAL EXPOSITION; Municipal Auditorium, Atlantic City, N. J.; held in conjunction with annual meetings of The American Industrial Radium and X-ray Society, The American Welding Society, The American Society for Metals, and two sections of the American Institute of Mining and Metallurgical Engineers.

DEC. 2-7; NATIONAL POWER SHOW; Grand Central Palace, New York City.

JAN. 23-26; SOCIETY OF THE PLASTICS INDUSTRY; technical papers and exhibit; Edgewater Beach Hotel, Chicago.

JAN. 27-31; ELECTRICAL ENGINEERING EXPOSITION; held concurrently with AIEE winter convention; 71st Regiment Armory, New York City.

BUSINESS NEWS

AUTOMOBILE MANUFACTURERS ASSOCIATION, Detroit, has submitted to automotive manufacturers the results of a joint SAE-RMA research project establishing tentative standards that will place within tolerable limits automotive ignition interference with radio reception. Recommendations call for all manufacturers to meet the standards by Jan. 1, 1948. In some cases this will involve redesign of ignition systems but in others it merely involves addition of suppressor resistors.

AVIOMETER CORP., New York City, announces an inter-communication maintenance service for the aircraft industry, with facilities for supplying standard replacement parts for microphones, headsets, handsets, and other parts.

TELEVISION BROADCASTERS ASSOCIATION, INC., New York City, announces that all exhibitors' space has been engaged for their Second Television Conference and Exhibition, to be held at the Waldorf-Astoria hotel Oct. 10-11.

LEAR, INC., has leased all facilities of the Grand Rapids Woodcraft Corp., thereby acquiring 35,000 square feet of floor space containing modern woodworking and finishing machinery to be used in assembling and finishing Lear radio cabinets and consoles.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP. added 16,701 telephones to its facilities in Argentina, Brazil, Chile, Cuba, Mexico, Peru, Puerto Rico, and Shanghai, giving a total of 968,221 telephones in service on June 30 and a backlog of 199,514 applications for telephone service. The unfilled orders are due principally to shortages of automatic central office equipment.

TACO WEST CORP., Chicago, has been formed by T. A. Cohen as a consulting, designing, and manufacturing organization specializing in electronic and electromechanical automatic control equipment for industrial process control. The founder was formerly vice-president and chief engineer of Wheelco Instruments Co.

NATIONAL BUREAU OF STANDARDS, Washington, D. C., has been granted a Civilian Production Administration permit to construct a $230,000 building to house a new radiation laboratory that will contain a 50,000,000-volt betatron.

BENDIX RADIO DIVISION, Baltimore, Md., has equipped a Lodestar trans-

port plane owned by Hercules Powder Co. with a Bendix aircraft transmitter-receiver modified to permit contact with ship-to-shore stations maintained by telephone companies. Commercial telephone communications from planes in flight have been found entirely practicable.

JEFFERSON-TRAVIS CORP., New York City, has supplied standard ship-to-shore radio communication equipment to Alaska Radio, Inc. for installation at 18 Alaskan outposts not connected now by telephone lines to larger centers. Up until now Alaska has been served by the U. S. Army's Alaska Communications System, but this is available to the public only when military commitments permit.

SAM TOUR & CO., INC., New York City, offer a nondestructive testing service for high-pressure pipe lines, ship hulls, tanks, and other structures accessible from only one side, using such electronic equipment as the Penetron and the Probolog.

KELLOGG SWITCHBOARD AND SUPPLY CO., Chicago, has begun construction of a large new addition adjacent to present buildings. It will provide nearly 55,000 square feet of manufacturing space for telephones and switchboards.

ALNI CORPORATION, New York City, has been formed to manufacture miniature d-c motors operating on as little as 30 milliwatts power, along with electromechanical devices.

NATIONAL UNION RADIO CORP., Newark, N. J., has added radio receivers to their line of electronic equipment and parts.

WILMOTTE MFG. CO., has moved to newer and larger quarters at 1713 Kalorama Road NW, Washington, D. C.

EMERSON RADIO AND PHONOGRAPH CORP., New York City, has acquired all capital stock of Plastimold Corp., Attleboro, Mass., which for many years has been a manufacturer of radio plastic cabinets and molded plastic products.

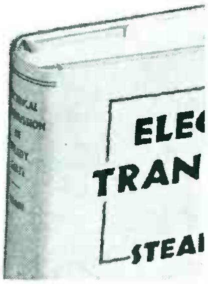
ASSOCIATION OF ELECTRONIC PARTS AND EQUIPMENT MANUFACTURERS elected the following officers for

Bringing you . . .

full, handy, useful data on methods of

NETWORKS THEORY

Here is a comprehensive coverage of the methods of network theory for the practicing engineer and advanced student in the communications field. It presents a full treatment of impedance transformation and transfer of power through lines and networks, particularly in the ultra-high frequency range. Stress is placed upon graphical methods of study and computation and upon the application of mapping methods to communications.



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ELECTRICAL TRANSMISSION IN STEADY STATE

McGraw-Hill RADIO COMMUNICATION SERIES

By Paul J. Selgin
Research Engineer, Farnsworth Television and Radio Corporation; formerly instructor, Polytechnic Institute of Brooklyn.

427 pages, 5¼x8¼, 100 figures, $5.00.

This important new volume in the McGraw-Hill Radio Communication Series brings together much factual and helpful information for the first time. Progressing systematically from the simpler type of problem to the more advanced, the book presents practical material on such subjects as:—

—how to use the "reflection factor" in computing input impedance, insertion loss

—maps of characteristics of transmission lines at telephonic frequencies

—insertion, transmission and reflection losses

—evaluation of selectivity, including that of systems with distributed constants

—tuners

—analysis of the multi-section line, used to provide an impedance match over a wide range of frequencies

—quantities of electro-magnetic theory showing their mutual relationship

—the principle of "invariance of plane fields"

—the exponential stub, showing its advantages over uniform stubs in many applications

—theory of magnetic coupling and flux linkages analysis of power transmission through amplifiers at high frequency, showing the condition for stability and giving graphically the power gain in terms of the load impedance

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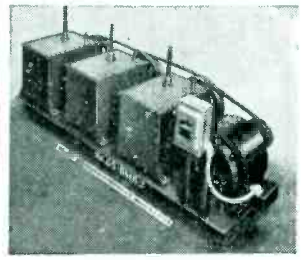
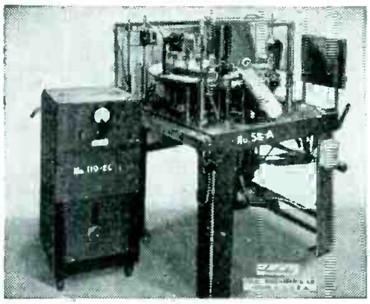
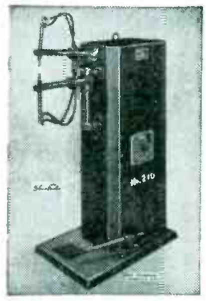
Transformers supplied from ¼ to 300 KVA.



EISLER Compound Vacuum Pump.



24 Head Radio Tube Exhausting Machine.



EISLER Spotwelders from ¼ to 250 KVA.

*EISLER machines are in use and in production by 99% of all American radio tube and incandescent lamp manufacturers and throughout the world.

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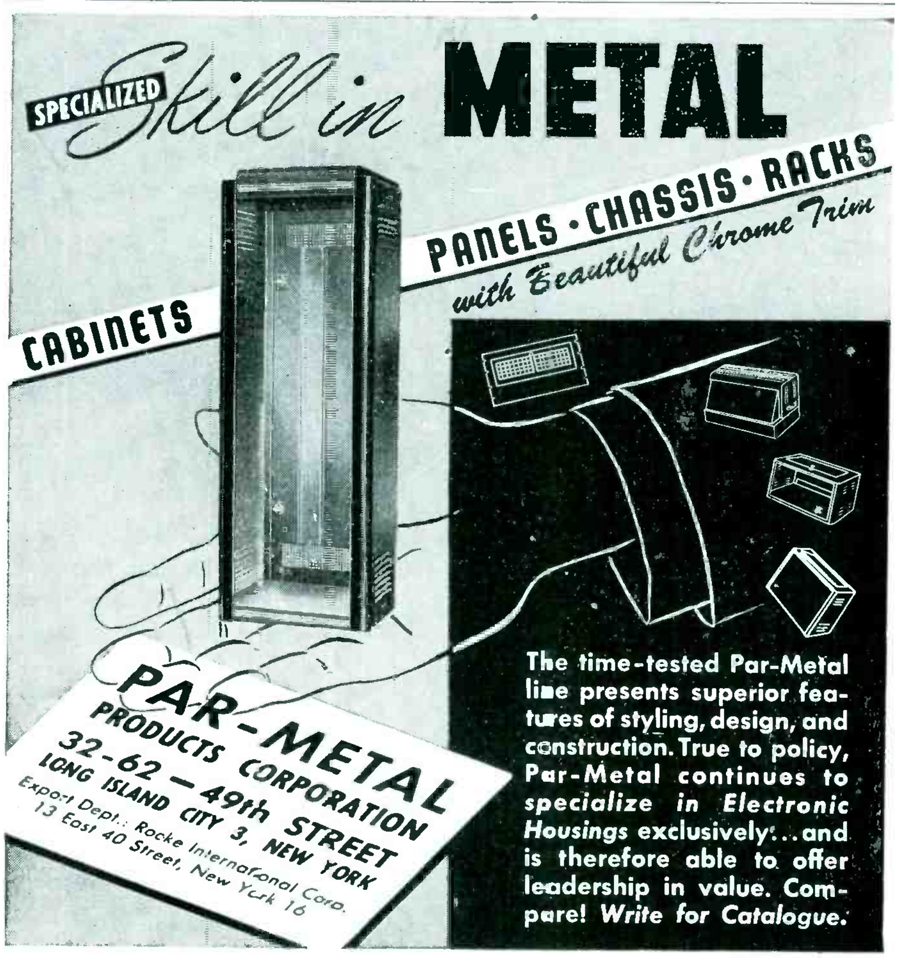


the ensuing year: chairman—Roy S. Laird of Ohmite Mfg. Co.; vice-chairman—Les A. Thayer of Belden Mfg. Co.; treasurer—H. A. Staniland; executive secretary—Kenneth C. Prince.

CLAROSTAT MFG. CO., INC., Brooklyn, N. Y. has acquired all outstanding stock of Kurman Electronics.

RICH-MARC MFG. CO., INC., New York City has been organized by L. M. Braun, formerly vice-president of Electronic Corporation of America, to manufacture metal and plastic radio components and electronic equipment.

TELEVISION INSTALLATIONS, set up before the war by U. S. Television Mfg. Corp., New York City as an independent television receiver installation company, plans to make available in television-served cities a number of installation groups consisting of teams of two men, one to read the pattern at the receiver and the other to make the necessary antenna adjustments on the roof. Intercommunication will be by two-way telephone.

PERSONNEL

CHARLES E. B. BERNARD, former staff member of MIT Radiation Laboratory, has opened offices in the Newbury Building in Boston and will specialize in preparation of technical illustrations for physics and electronics laboratories.

WILLIS E. CLEAVES, until recently in command of the aircraft carrier Pallau and having the rank of Captain, has retired from the Navy after 22 years of commissioned service, mostly in aviation radio communication, and will become manager of the Aviation Sales Department of Collins Radio Co., Cedar Rapids, Iowa.

LEON PODOLSKY is manager of a new Field Engineering Department set up by Sprague Electric Co., North Adams, Mass.

HARRY B. OSBORN, JR., authority on induction heating and formerly research and development engineer in the Tocco Induction Heating Division of The Ohio Crankshaft Co., Cleveland, has been promoted

to the position of sales manager of the Tocco Division.

LOUIS McCOMAS YOUNG has returned to radio station KMOX, St. Louis, Mo. as chief engineer, having retired from active duty in the Army Air Forces at Wright Field with the rank of Colonel.

THEODORE K. BURGENBAUCH joins Ellinwood Industries, Los Angeles, as Electronics Division production manager, after 15 years with General Electric Co. in Schenectady.

T. K. BURGENBAUCH

R. O. CURRY

R. O. CURRY has been appointed appointed audio and acoustical engineer for Farnsworth Television and Radio Corp., Fort Wayne, Indiana. He was previously engaged in audio research for the Capehart Division of the company.

LLEWELLYN B. KEIM is now field electronics engineer for The Daven Co., Newark, N. J. For more than a year he was chief engineer of Muzak's early f-m station W47NY, and operates amateur station W2IKV.

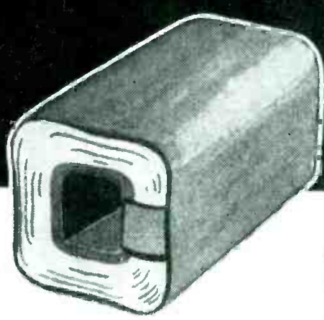
RAY M. WAINWRIGHT has been named an assistant professor of electrical engineering at the University of Illinois. During the war he directed writing of books on fundamentals of radar issued jointly by the Army and Navy for reference and training, and later was technical consultant with the Signal Corps on analysis of enemy equipment.

HAROLD C. WEINGARTNER is now chief engineer of the Vacuum Engineering Division of National Research Corporation, Boston, Mass.

WILFRED L. LARSON now heads the new firm of Switchcraft Inc., Chicago, which will make contact switches, phone jacks and plugs,

Electrical Papers

COIL WINDING



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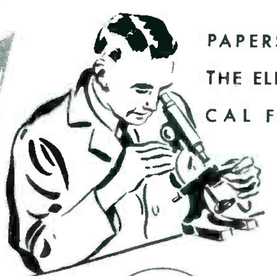

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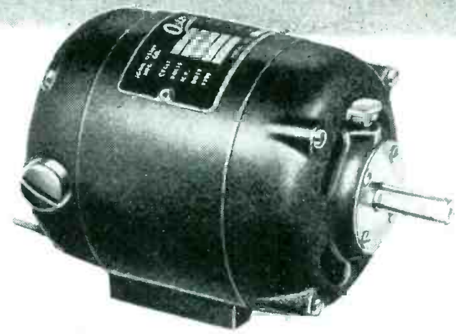
This Universal Ostermotor may solve your Motor Problem!

Specifications

1/15 HP; 4500 RPM
Series Wound; Continuous Duty
115 Volts AC and DC
3-21/64" diameter; 4½" overall
Weight — 3 lbs. 13 oz
Type EU-450; Model 3



This high-speed Ostermotor gives smooth, vibrationless performance for long, trouble-free life . . .

The Type EU-450 high-speed Ostermotor (4000 to 8000 RPM at full load) has high starting torque and varying speed characteristics. Light weight and small, it operates on both AC and DC and has a wide variety of applications, such as small tools and blowers.

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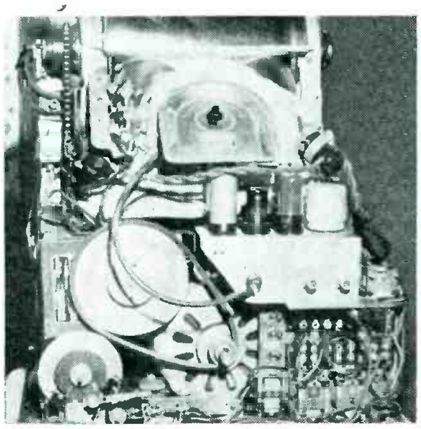
plug-in resistance devices, and small machine tools. He was formerly manager of the Carter Division of Utah Radio Products Co.

M. D. BURNS becomes general manufacturing manager of Sylvania Electric Products Inc., and will direct the company's radio tube manufacturing operations.

TOBE DEUTSCHMANN, manufacturer of electronic components, presented homesites in Honor Village, Canton, Mass. to 19 married local veterans at $1 per lot as part of his program for demonstrating the practicability of local, privately financed, self-supporting housing for veterans.

ELECTRONIC COFFEE ROASTER

Automatic roasting of coffee completely and uniformly is done in less than two minutes with radiant energy by the machine shown with its inventor, August S. Torres of Medellin, Columbia. Electronic elements of the unit are shown after covers are removed



NEW BOOKS

Nucleonics

BASED ON OFFICIAL MATERIAL PREPARED UNDER THE AUSPICES OF THE U. S. NAVY DEPARTMENT. *Progress Press, Washington, D. C.*, 1946, 38 *pages*, $1.00.

IN NONTECHNICAL, descriptive terms the fundamentals of nuclear physics are presented ot the interested layman. The material is complete, within security limitations, and accurate. To those who remember their high school physics or chemistry the book will be light reading. The choice of anrrow columns and small type is unfortunate for a popular book. For those who wish more than was contained in the two inserts in ELECTRONICS (Sept. 1945 and Aug. 1946) the pahphlet is commendable.—F. R.

EDITOR'S NOTE: Two books on piezoelectricity have recently been published; one is an addition to the distinguished series from the Bell Telephone Laboratories, the other is a scholarly contribution to the International Series in Pure and Applied Physics published by McGraw-Hill Book Company. Both books were reviewed by the same reader, whose evaluation and comparison follows the formal reviews.

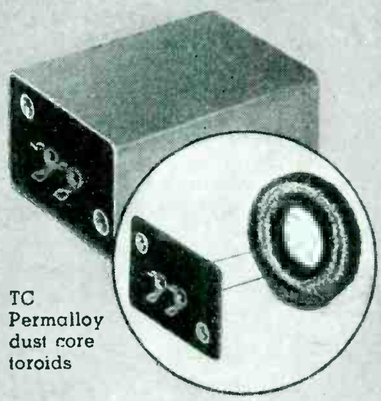
Quartz Crystals for Electrical Circuits

By RAYMOND A. HEISING. *D. Van Nostrand Co., Inc., New York, N. Y.*, 563 *pages*, $6.50.

PRODUCTION and research leaders of Bell Laboratories and Western Electric describe their experiences and practices in producing quartz crystals for use in electrical circuits. Chapters, written by specialists in the particular subject, cover specifications of quartz crystal orientation as devised by the Institute of Radio Engineers, evaluation of raw quartz for use as piezoelectric resonators, and the processing of quartz into plates, including sawing, grinding, lapping, adjusting to frequency, and mounting. All these subjects will be of value to those manufacturing quartz crystals.

The chapter on crystals in oscillators is of general interest to all circuit design engineers. Of par-

Toroidal Coils for high "Q"



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"Q"—55 at 1000 cy.; 150 at 3000 cy.
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TOROIDAL COILS IN FILTERS

Communications:

KF-40 — Keying frequency filters providing over 60 DB attenuations at crossover points between channels. Also discriminators.

Aircraft Radio (Personal)

BF-10—Range filters to permit separation of the 1020 cy. beam signal from voice transmission. Employs unique method of impedance matching permitting use of minimum number of components. Weighs only 10 ounces and measures 1⅛"x1⅝"x3".

Broadcasting:

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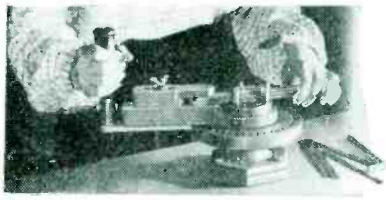

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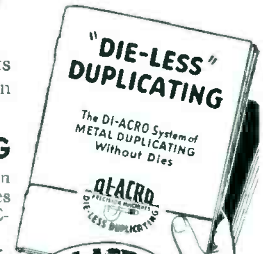

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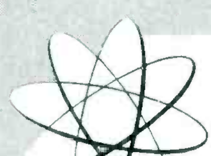

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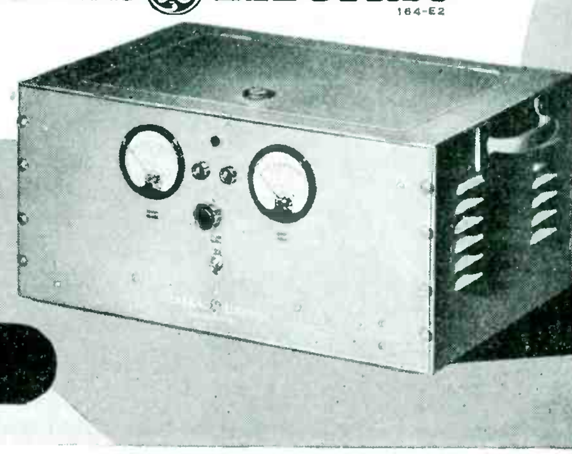

PS-1

ticular interest is the introduction of two new terms by which the goodness of crystals can be specified. A figure of merit, which can be readily obtained from measurable crystal characteristics, is indicative of crystal activity. A performance index indicates the utility of a specified crystal in a given circuit. A later chapter describes a test set for measuring performance index.—F. R.

Piezoelectricity

By WALTER GUYTON CADY, *McGraw-Hill Book Co., Inc., New York, N. Y.*, 1946, 806 *pages*, $9.00.

PHYSICAL PROPERTIES of piezoelectric crystals (displaying coupling between mechanical pressure and electrical potential — pronounced pie-ease'-o-electric), especially quartz crystals, are described at length. The material is introduced with essential terminology and theory of crystallography so that those without other background than basic mechanics, electricity, and mathematics through calculus can follow the entire text. For those with less mathematics, much of the material will nevertheless be intelligible. The author lists in his preface those sections and chapters in which a general treatment of physics and applications, elementary and survey material, and results of research at Wesleyan University will be found.

While the text itself maintains the abstract generality of basic physics, it is augmented by sufficient references to less abstract works so that it forms an excellent guide to published literature on practices. The completeness of this presentation makes it a valuable reference text. The nontechnical chapter on miscellaneous applications of piezoelectricity is of wide general interest.—F. R.

Evaluation and Comparison

Both of the books just reviewed cover substantially the same subject, but in widely different ways. The one is technological, the other is scientific. The technological work is the contribution of sixteen leading engineers in the field; the scientific work, although its author admittedly draws widely from other workers, represents the effort of

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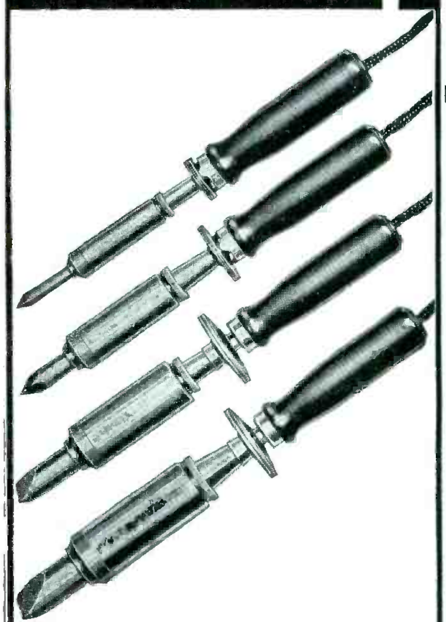

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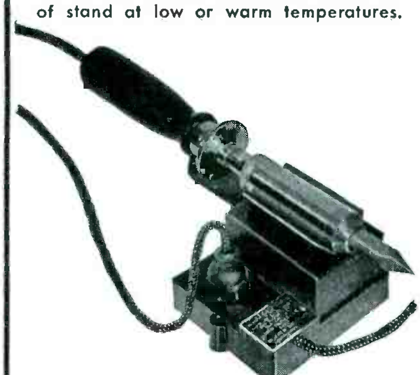

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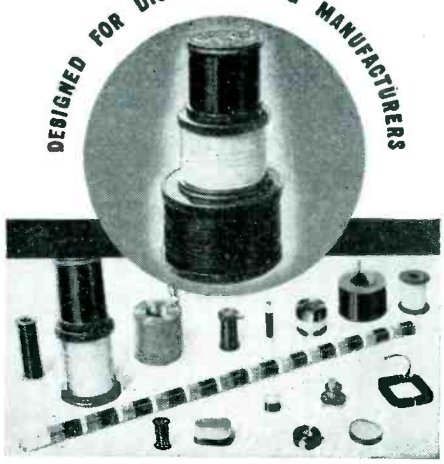

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the outstanding investigator in the field of piezoelectricity. The technological work suffers seriously from lack of references; the scientific book, being a highly scholarly presentation, is well documented and lists numerous references—in fact, the author seems reticent on those points he considers to have been already adequately presented elsewhere, and just gives the reference. The immediately usable techniques described and illustrated in the technological book made it obviously useful to workers with and users of quartz crystals. The fundamental information of the scientific book will be sought by design and developmental engineers and scientists, although others will want to refer to portions of it. Considered together, the two volumes supplement each other; Professor Cady presents the phenomena, and the Bell Laboratory staff describes methods.—F. R.

Reference Data for Radio Engineers

Published by Federal Telephone and Radio Corporation, 67 Broad St., New York City, second edition, 1946, 336 *pages,* $2.00.

THE SUCCESS of the first edition of this radio handbook, of which over 50,000 copies were sold, prompted this revised and enlarged new edition having 136 more pages and more than twice as many illustrations. The format is new and modern and a complete subject index has been added. New chapters have been added covering transformers and room acoustics. Data on radio propagation and radio noise has been rewritten with special emphasis on practical aspects, cathode-ray tube data has been expanded, many equations and illustrations have been added to the section on wave guides, and mathematical formulas have been expanded. Design data covers rectangular electromagnetic horn radiators and gain of a paraboloid reflector, and the newest method of determining optimum short-wave frequencies for propagation over specific distances is given. Just as in the first edition, chapter 1 with general information and chapter 2 with engineering and material data are high

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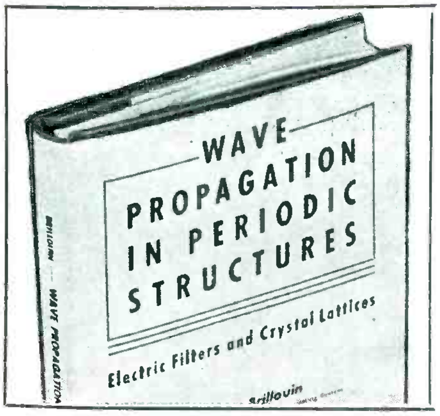

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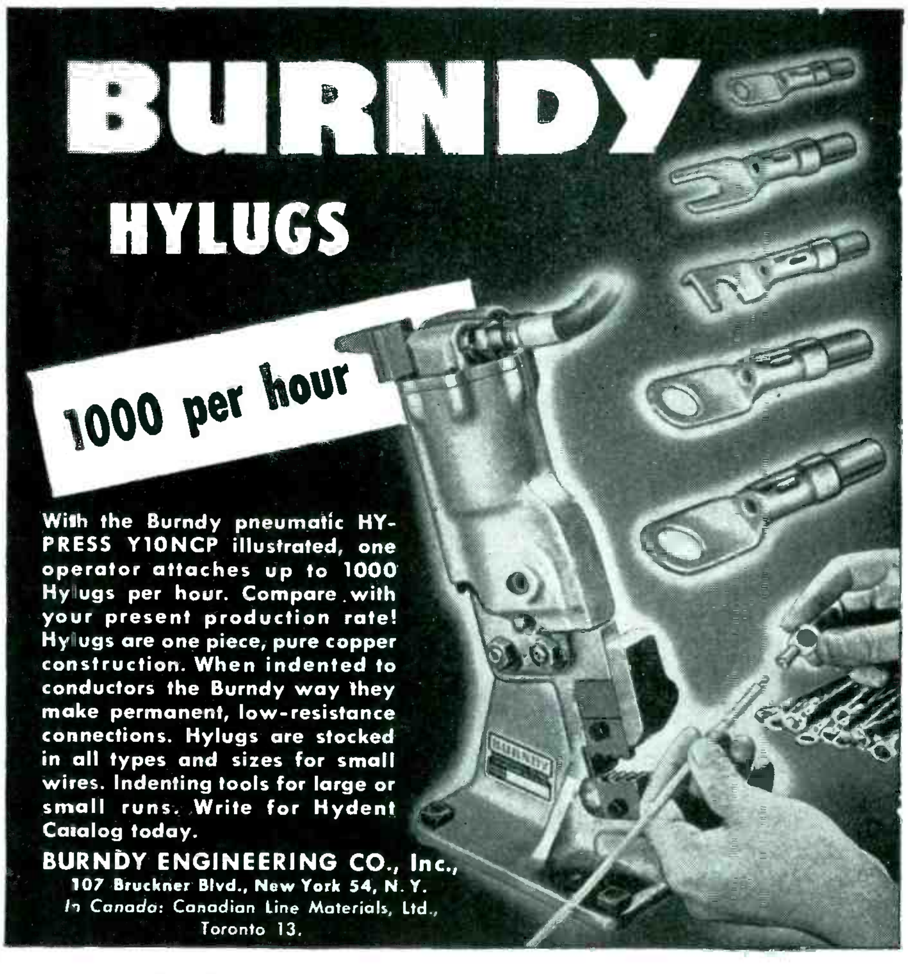

in reference value because the data they contain cannot generally be quickly found in the average engineer's library yet is often badly needed. All in all, the book does credit to its publisher and to the many FTR engineers and editors who worked on it.—J. M.

An Index of Mathematical Tables

By A. Fletcher, J. C. P. Miller, and L. Rosenhead, *University of Liverpool. McGraw-Hill Book Co., Inc., New York, and Scientific Computing Service Ltd., London,* 1946, 450 *pages,* $16.00.

The accumulation over the years of mathematical tables and the increased reliability of calculating machines have made numerical mathematics scientifically and engineering important. An up-to-date index to the more useful tables has been needed for some years, and is, as D. R. Hartree writes in his forward to this work, "of great value—both to users and to makers of mathematical tables." The index is intended as a working tool, not as a definitive or historical catalogue; in it are listed the ranges and means of interpolation of numerical tables of mathematical functions. The index admirably fills its purpose; it will be a welcome reference guide in university and industrial libraries and on the desks of those specializing in numerical computation. The work was conceived prior to the recent war, executed with thoroughness, brought to fruition despite wartime disruption of university scholarship, and published by L. J. Comrie of Scientific Computing Service.—F. R.

Calculus

By Frederic H. Miller, *Professor of Mathematics, The Cooper Union School of Engineering. John Wiley & Sons, Inc., New York,* 1946, *second edition,* 416 *pages,* $3.50.

The second edition of this calculus text designed for mathematics and engineering students exhibits no marked change from the original. Some problems have been revised. Articles on graphical integration and approximate integration have been added for their utility. A sum-

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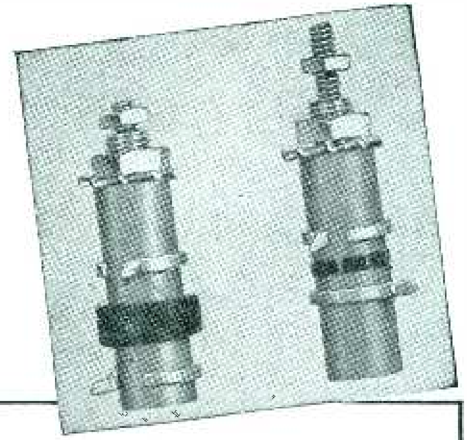

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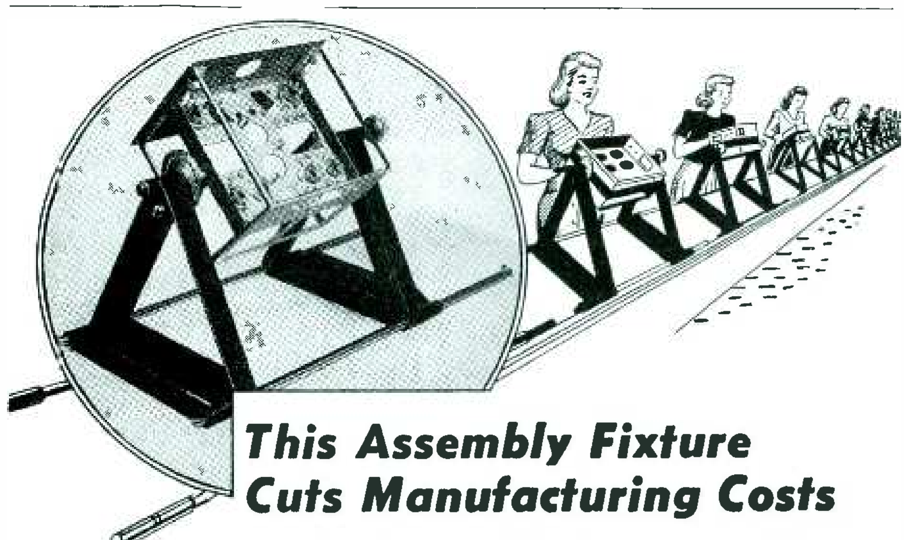

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mary of integrating processes a list of miscellaneous integrals a theorem on moments of inertia, and several formulas of algebra, geometry, and trigonometry serve to increase the practical value of the text. Symbols have been standardized in conformity with current scientific writing. The physical appearance of the pages is clean, with graphical representations heavy and distinct.—A. A. MCK.

Electric Motor Repair

By ROBERT ROSENBERG. *Murray Hill Books, Inc., New York* 16, *N. Y.*, 1946, 570 *pages*, $5.00.

INSTRUCTIONS for repairing practically all types of a-c and d-c motors are given, with rewinding instructions. The book is useful to factory technicians or engineers who have to repair a motor, despite the fact that it was prepared primarily for vocational school students, appliance servicemen, and beginners desirous of entering the motor repair field. The binding is unique to say the least, with all illustrations in one spirally bound section and all text in another spiral binding. The two bindings in turn are joined by heavy paper that serves as the outer jacket when the book is closed; when open, four pages are visible at once, with all pages lying flat for convenient reference on the workbench. How well this tricky binding will stand up under shop usage remains to be seen.—J. M.

Understanding Microwaves

By VICTOR J. YOUNG. *John F. Rider Publisher, Inc., New York* 16, *N. Y.*, 1946, 385 *pages*, $6.00.

THE TITLE of this book tells most succinctly the author's aim—to make clear the new field of microwaves which the war has brought upon us. Such an aim, imposed by the author on himself is no light task since the phenomena and the concepts which one will meet on wavelengths shorter than 10 centimeters require totally new thinking from the days when two conductors were necessary to "complete the circuit." In spite of the difficulties of really explaining Maxwell's equations, Poynting's vector, Gauss'

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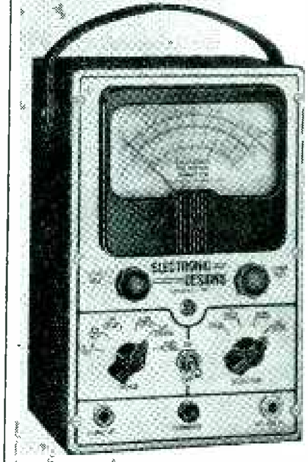

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theorem, the curl, divergence, and gradients of vector analysis, the author has packed much meat into his book, meat that has been predigested about as much as seems possible. Newcomers to the field of microwaves, with minds untrammeled by old-fashioned ideas of the way electric energy should behave, will have less trouble with the concepts described than will those who are already familiar with radio, but oldtimers will find much in this book that is good for them and comparatively easy to take.

In addition to basic concepts, the reader will learn a great deal about resonant cavities, waveguides, microwave oscillators and all the minutiae of a new art.—K. H.

Capacitors—Their Use in Electric Circuits

By M. BROTHERTON, *Bell Telephone Laboratories. D. Van Nostrand Co., Inc., New York, N. Y.,* 1946, 107 *pages,* $3.00.

A BRINGING-TOGETHER for quick reading, as on railroad trains, of a host of basic practical factors that should be understood when choosing from the multiplicity of capacitor styles now on the market. After a brief introductory history culminating in the conclusion that the making of capacitors has grown to be a major branch of the electrical art, there is a highly interesting discussion of the problems of the harassed capacitor specialist whose unavoidable packages of microfarads are allotted space on a chassis only with greatest reluctance. Counteracting the typical radio repair manual's first advice to "check the capacitors", the author brings forth the theme of his entire book—that capacitors rarely fail when the operating conditions have been intelligently analyzed and specified. In most cases the responsibility lies rather with ignorance, carelessness, or an uneducated sense of economy.

In general, this little volume gives instructions for tempering the generous optimism that sometimes crops up in trade catalogs. Two chapters tell in detail how capacitors behave under direct voltage and under alternating voltage (with a bit of math thrown in here

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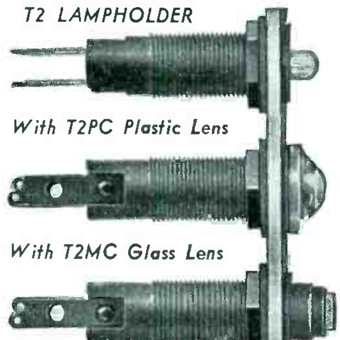

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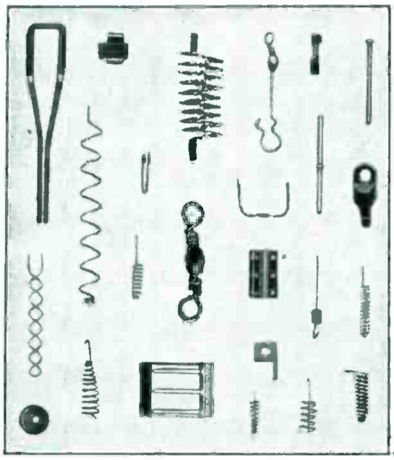

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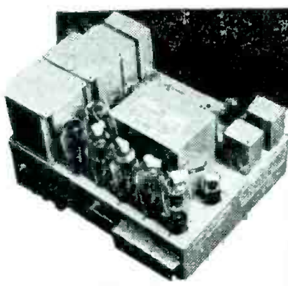

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COOK LABORATORIES • 139 Gordon Blvd. • Floral Park • New York for those that like it). Chapter three announces that capacitors wear out in the normal course of events and explains how come. The next five chapters help find answers to the question, "Which capacitor shall we use—electrolytic, impregnated paper, mica, ceramic, air, or synthetic-dielectric?". Finally there are some twenty questions a user must answer in order for the capacitor art to supply a satisfactory capacitor, and thirteen examples of how capacitors are selected to meet specific electrical and mechanical operating conditions.—J. M.

Radar - - - What It Is

By JOHN F. RIDER, LT. COL., SIGNAL CORPS (RET.) AND G. C. BAXTER ROWE. *John F. Rider Publisher, Inc., New York*, 1946, 80 *pages*, $1.00.

THIS IS EXACTLY the sort of book that the engineer needs to pass along to nontechnical friends and relatives who demand a complete five-minute explanation of radar and its uses. Even this abbreviated account runs to more nearly an hour's reading, although the neat sound-wave analogy in Chapter 1 should completely explain the underlying principles of radar to the laymen. From here on, the going is only slightly rougher because the authors have contented themselves with descriptions and explanations of the external aspects of the equipment, foregoing accounts of circuit niceties. Mechanical analogies and graphical demonstrations are freely used in describing the functions of antennas and indicators and the various means of using the radar principle for gun-firing, navigation, as an absolute altimeter, or for blind landing. Of interest to both engineer and layman are the frequent chatty allusions to specific cases in which radar helped win the war. The concluding pages fairly summarize the future of radar and allied techniques.—A. A. MCK.

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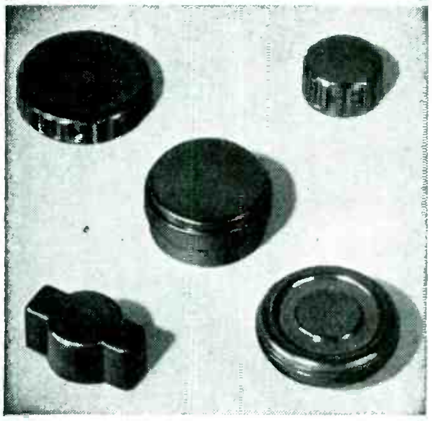

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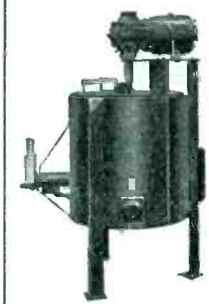

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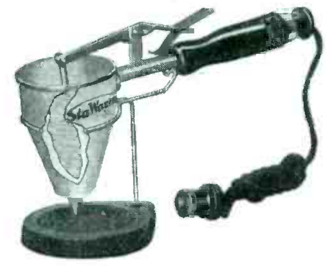

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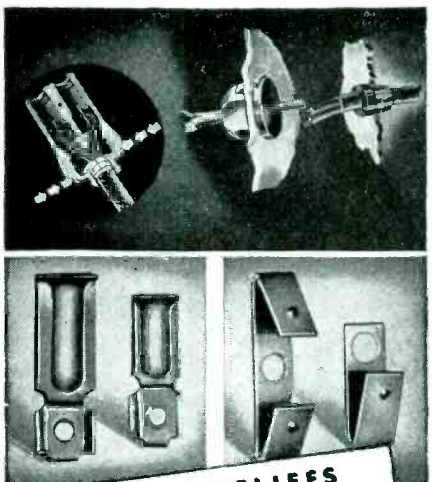

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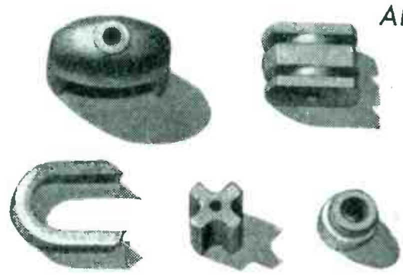

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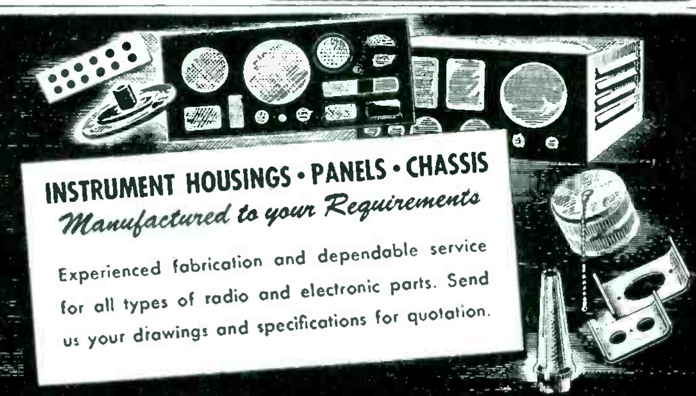

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Backtalk

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.

Railroad Communications

Dear Sir:

THIS RELATES to the editorial entitled "Wreck," in Crosstalk, ELECTRONICS, July, 1946.

It occurred to me how unfortunate it is that each of us in our own fields seems unable to keep others in other fields advised of progress we are constantly making. In this instance, we should have told our story so well that you would not be under the impression that railroads are operating on 90 miles-per-hour schedules with 40 miles-per-hour communications.

Perhaps the principal reason for the ignorance each of us has of the other fellow's activities is the latter's difficulty in putting his story across. Although the Pennsylvania Railroad has issued various pamphlets, articles and advertisements on the general subject of communication and signaling, it is apparent that it is not generally known how completely signaling communication and automatic safeguards have kept in advance of increases in speed and traffic density. With respect to the wreck of the Congressional it has been definitely determined that no means of communication could have been used to warn the engineman of the train of the presence of the hot box on his train; the time element of seconds between discovery and accident was too short.

The Pennsylvania Railroad, typical of the railroad industry, is constantly looking for better ways of doing things. It is engaged in research and development in every phase of its operations. In communication, it employs radio, inductive train communication, facsimile, telephone and teletype; in sig-

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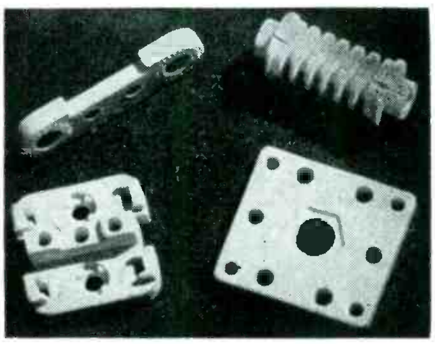

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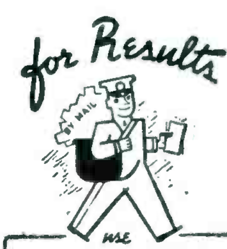

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Auditory Perception

Dear Editor:

WE HAVE BEEN greatly surprised and pleased with the widespread response in connection with our article titled "Auditory Perception" in the July issue of ELECTRONICS. There have been a large number of requests for reprints and a good many letters asking for additional information. It is of some interest that none of this correspondence has been in connection with the circuit for automatic tone control described in the article, but rather with respect to the characteristics of hearing and associated material. Specifically, there has been a good deal of discussion pertaining to the paragraph titled "Low Frequency Cutoff."

We are enclosing a copy of a portion of one of these letters together with a copy of our reply.

JOHN D. GOODELL,

The Minnesota Electronics Co.
St. Paul, Minnesota

Dear Mr. Goodell: —

I TAKE this opportunity to compliment you on the article in ELECTRONICS for July entitled "Auditory Perception." It is one of the most common sense and realistic papers on sound reproduction I have ever seen. However, there is one point on which our findings and yours do not agree.

The paragraph on page 148 entitled "Low Frequency Cut-off" clearly states that the audience usually failed to perceive the difference between a 70-cycle cut-off and, say, a

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30-cycle cut-off. Based on our experience, I would deduce from that that either the system did not reproduce energy at frequencies lower than 70 cycles, or else the program material transmitted did not contain appreciable energy at frequencies lower than 70 cycles.

We have found that one instrument of the orchestra disappears completely with a 70 cycle cut-off, namely, the large bass drum. Pizzicato tones on the "E" string of the stringed bass either disappear completely (when played piano) or lose their "bassy" character. Organ music also suffers severely with the loss of the lowest octave.

We have a speaker system which is reasonably flat to 30 cycles and the audience reaction to sound transmitted through this system is usually very impressive.

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Dear Mr. Pickering:

WE APPRECIATE your letter of July 23 very much and are most pleased to know that you liked our article on "Auditory Perception." We have received a surprising amount of correspondence as a result of this article and, of course, are very glad that it has had such good reception.

You have quite accurately put your finger on the one point in this material that I am prepared to admit is controversial. The system used in the experimental work referenced in the paper was capable of responding to brain wave frequencies which, as you doubtless know, are in the neighborhood of 12 cps. It is true that the ear has a tendency to supply the subjective experience of a low frequency's fundamental tone if all of its harmonics are present in their proper relationship. Most systems that cut off at 70 cycles have appreciable loss considerably above 70 cycles. If the effect referred to in the article is to be obtained, it is necessary that the system be effectively flat or have a slight rising characteristic down to the 70-cycle cutoff. We did not mean to imply that it was desirable to cut off at 70 cycles but rather that the effect was sufficiently interesting to point out the possibility of a compromise in equipment with

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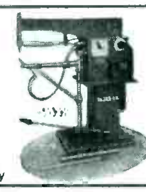

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design limitations based on economic considerations.

It may be true that the large bass drum, as well as the pizzicato tones on the E string of the stringed bass, do lose their character with the 70-cycle cutoff. It is entirely possible that the program material we used was not adequate to permit completely valid or final conclusions. I shall be interested in investigating this at some future time.

JOHN D. GOODELL
The Minnesota Electronics Co.

Old Friends

Dear Editor:

I THOUGHT it would be of some interest to you if I told you of some of the letters I have been getting since VE day and VJ day from various parts of the world.

Mostly all of them come from good friends of mine whom I knew from the times when I was connected with the European Laboratories of the International Telephone and Telegraph Company, and with whom I lost all contact since the war broke out in Europe. I received such letters from Persia, or Iran, from Australia and the last one I got was from the Phillipine Islands.

All these letters have one thing in common, namely that my old acquaintances read a paper of mine in ELECTRONICS and used your magazine as an indirect medium to get in touch with me again. The last one I received from Manila was very interesting and the man who writes it, Mr. Picker, had been, since the surrender of Bataan, in St. Thomas prison in Manila under the Jap occupation and as he tells me among the first things he wanted to do was to get hold of some technical magazines which, incidentally, was the February issue of ELECTRONICS, 1945.

You see that ELECTRONICS has—I think deservedly—a faithful following all over the world and I am more than pleased to tell you about this, the more so because some very fine people whom I thought dead or missing are still alive.

EUGENE MITTELMANN
Director of Electronic Research
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(Continued on page 310)

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Research and Development Guided Missiles

Experience required for each position

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2. ELECTRONIC DESIGN and ADMINSTRATION 10 YEARS
3. ELECTRO-MECHANICAL DESIGN and SUPERVISION 12 YEARS

APPLY BY LETTER

giving full information concerning education and experience.

All replies held confidential

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College Graduate — good theoretical background in aerodynamics, capable of handling research & development in aircraft control problems. Experience desirable.

Research & Development Engineer

Preferably with recent doctor's degree in physics, electronics, or mathematics. Good theoretical background in these fields. Capable of directing a development group doing development work in electronics, servo-mechanisms, control systems. Experience essential.

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Vacuum Tube Research

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Director of Research

NATIONAL UNION RADIO CORPORATION
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POSITIONS WANTED
(Continued from page 308)

CAPABLE ENGINEERING executive interested in making a new connection. Age 34. Resourceful, practical, aggressive. Excellent theoretical and practical background in electronics and communications. Proven ability on military and civilian design and development projects. PW-237, Electronics, 330 W. 42nd St., New York 18, N. Y.

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W. E. 3½" concentric style, 0-200 ua $4.00

G.E., DO-41, 3½" microamp mvt scale 20 K.V., comp with paper V.O.-M.A. sc $4.95

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Weston 643, 4½ 150 volt $9.00

Gruen, 2½" 150 volt $3.50

Weston, 506, 2½" 200 volt D.C. $3.95

G.E., DO-41, 3½" 500 volt, 1000 r/v, bk sc $5.95

W.E., 3½" 500 volt, 1000 r/v, concentric style $5.00

G.E., DO-41, 3½" 1.5 K.V. comp with 1000 r/v ext prec resist $6.95

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G.E., DO-41, 3½", 50 M.A. $4.50

G.E., DO-53, 3½", square case 50 M.A....$4.50

G.E., DO-41, 3½", 80 M.A. $4.50

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Simpson #26, 3½", 200 M.A..............$4.95

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G.E., DO-41, 3½" 200 M.A. $4.95

Weston, 506, 2½" 200 M.A. $3.95

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W.E. 3½" 20-0-20 Amp, concentric sc....$3.00

Weston, 506, 2½" 200 Amp, with ext shunt $9.50

G.E., DO-41, 3½" 200 Amp with ext shunt $12.50

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Weston, 425, 3½" 1 Amp Surf Mtd $6.50

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Weston, 507, 2½" 3 Amp bk sc $3.50

G.E., DW-44, 2½" Black scale 0-6 A.R.F. $2.95

G.E., DO-44, 3½" 0-20 A.R.F. $4.95

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Simpson, 3½" square case 60 Amp S.C...$4.50

G.E., AO-22, 3½" 80 Amp S.C. $3.50

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G.E., AO-22, 3½" 150 volt bk sc..........$4.50

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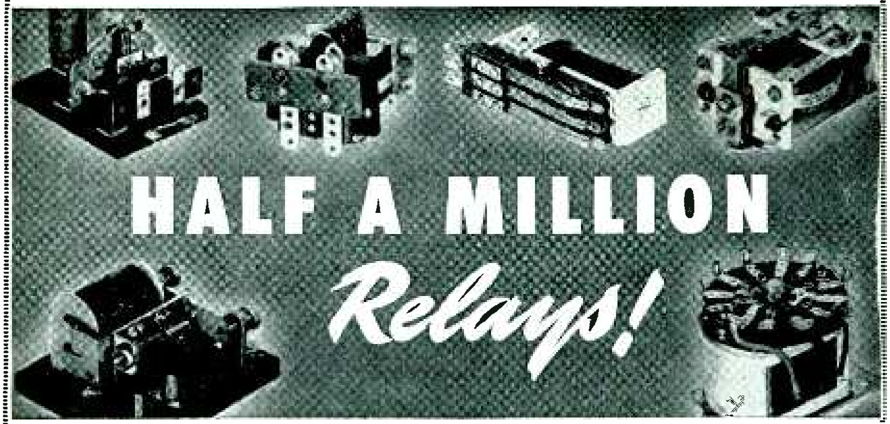

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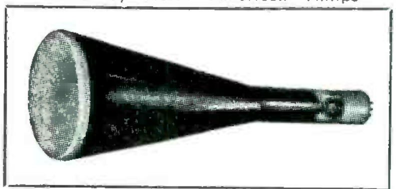

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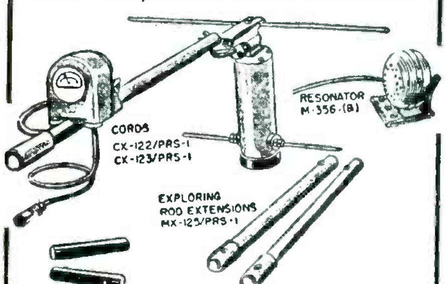

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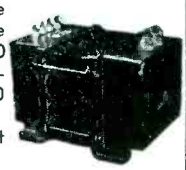

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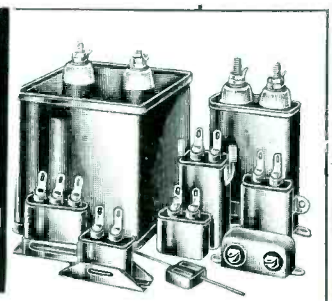

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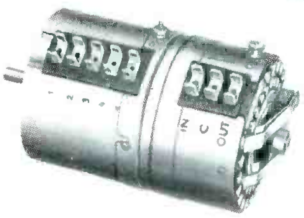
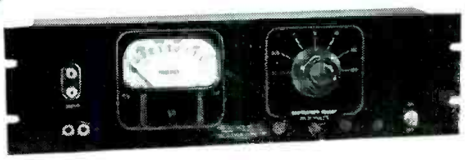


TONE COMPENSATING ATTENUATOR TYPE LAC-720

. . . frequency characteristics follow the hearing response curves of the human ear. Base frequencies have smaller loss than the middle or upper registers.
(Pat. Pend.)

Here are 4 of the more recent DAVEN "firsts". DAVEN long has been known for leadership . . . particularly in engineering and design. Many of our developments have been incorporated in the equipment of broadcasting stations, sound recording studios, and electrical laboratories throughout the world, and are specified as standard.

The DAVEN products, including these new developments, will be on display at the NAB Convention, Oct. 21 to 24 . . . at the Palmer House in Chicago.



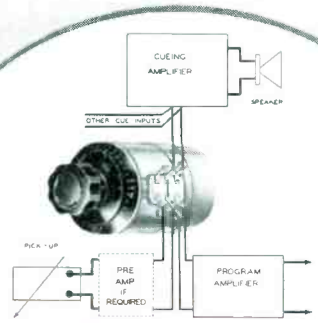
FREQUENCY METER TYPE 838

. . . frequencies read directly to 100,000 cycles with an accuracy of ± 2% of full scale in use . . . 7 ranges available . . . low input voltage requirements . . . large, easy-to-read illuminated meter . . . mounted on a 5¼" relay rack panel.

THE **DAVEN** CO.
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

TRANSMISSION TEST SET TYPE 8A

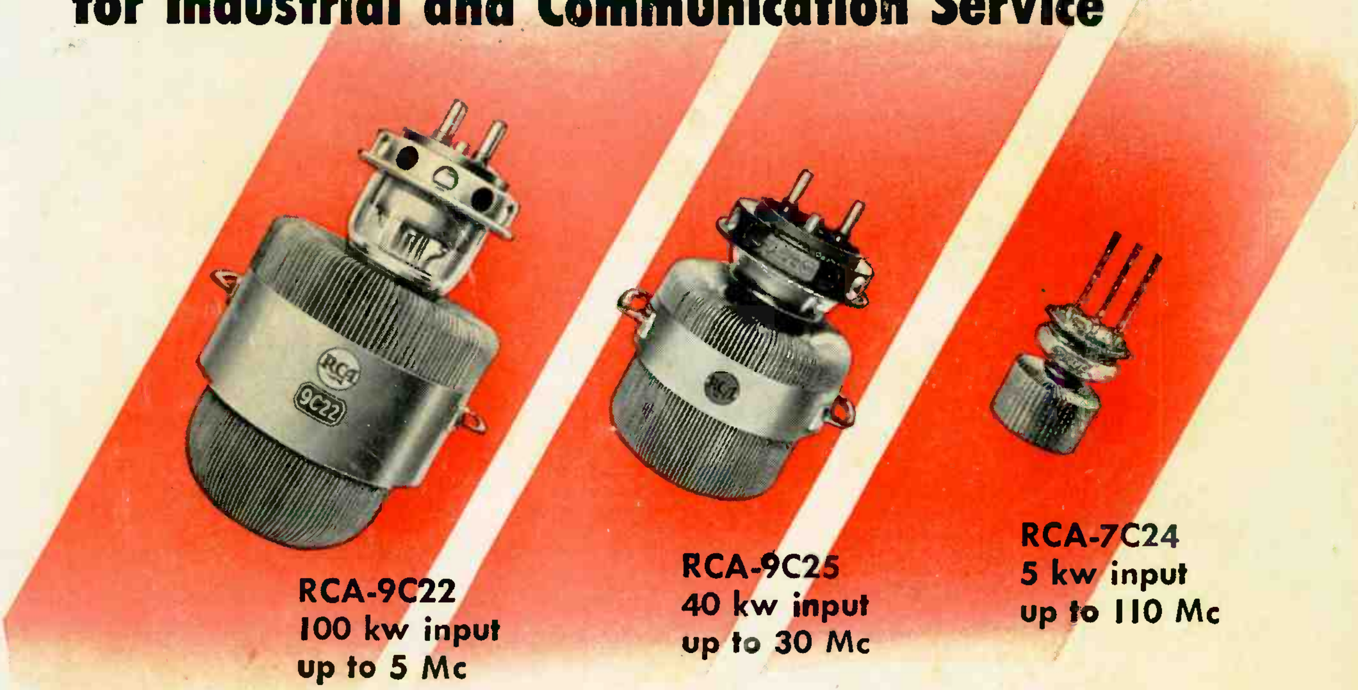
. . a portable, 12-pound battery operated set . . . receiving amplifier measures levels down to −50 DBM . . . contains an internal 1000 cycle oscillator . . . can also serve as a bridging V.U. indicator with range of −40 to +23 V.U.



ATTENUATORS WITH BUILT-IN CUEING CONTROLS

. . . eliminate the need for auxiliary switching mechanisms . . . also available with built-in switchette for a pilot light . . . may be obtained on Ladder, "T", Potentiometer, and Ladder Fader controls.
(Pat. Pend.)

RCA "Metal-Header" Power Tubes
for Industrial and Communication Service



Improved construction offers greater over-all performance in grounded-grid or grounded-cathode circuits.

Tube Type	Max. Power Input*	100% Input to	Reduced Input for Higher Freq.	Cooling Methods	Ampl. Factor
7C24	5 KW	110 Mc	....	Forced Air	25
9C25	40 KW	30 Mc	61% at 100 Mc	Forced Air	32
9C27	40 KW	30 Mc	61% at 100 Mc	Water	32
9C22	100 KW	5 Mc	70% at 25 Mc	Forced Air	38
9C21	150 KW	15 Mc	70% at 25 Mc	Water	38

*Grounded-cathode, class C telegraphy.

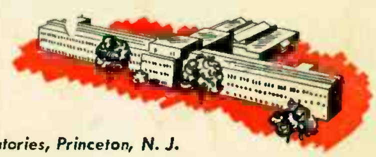
RCA's family of "metal-header" power triodes incorporates constructional features that provide increased ruggedness and stability, superior shielding of electrodes, and a greater degree of operating economy.

The flanged-header grid terminal and the external plate provide greater heat dissipation and unusually low lead inductance. When used in a grounded-grid circuit, with a large circular connector, the flanged-header grid terminal effectively isolates the filament from the plate. As a result, neutralization is seldom necessary in grounded-grid service.

The types listed may also be used to advantage in conventional grounded-cathode circuits.

All types have unusually good high-frequency characteristics. In addition, RCA 7C24, 9C25, and 9C27 have high-efficiency thoriated-tungsten filaments that offer substantial savings in filament power.

Technical bulletins on these RCA "metal-header" tubes are available on request. RCA tube application engineers will be pleased to co-operate with you in adapting these or other RCA tube types to your equipment designs. Just write RCA, Commercial Engineering, Section D-6J, Harrison, N. J.



RCA Laboratories, Princeton, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.