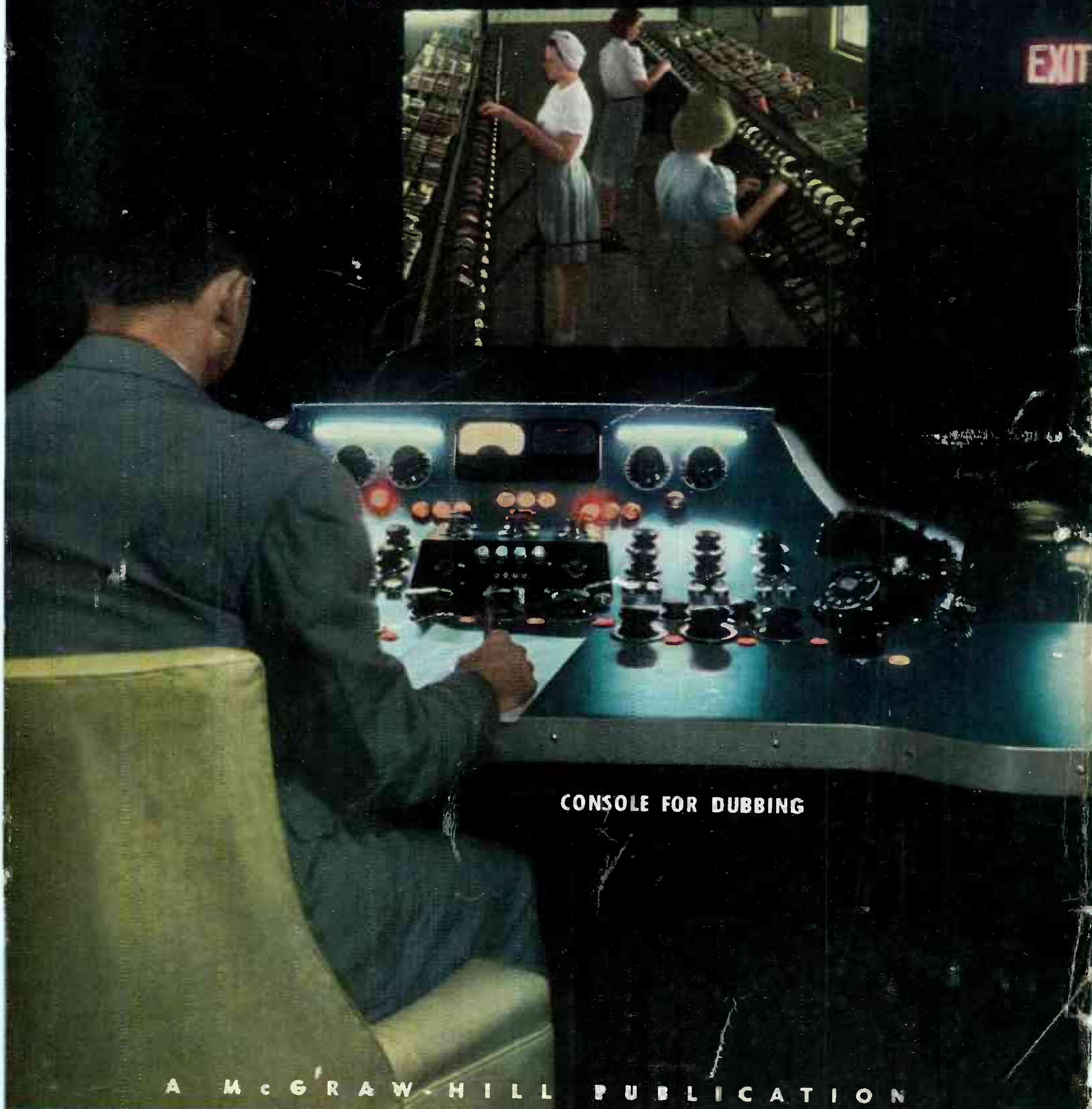
NOVEMBER · 1947

electronics



CONSOLE FOR DUBBING

A McGRAW-HILL PUBLICATION

electronics *sponsors* **CITIZENS RADIO PROJECT** see page 80

electronics

A McGRAW-HILL PUBLICATION

NOVEMBER • 1947

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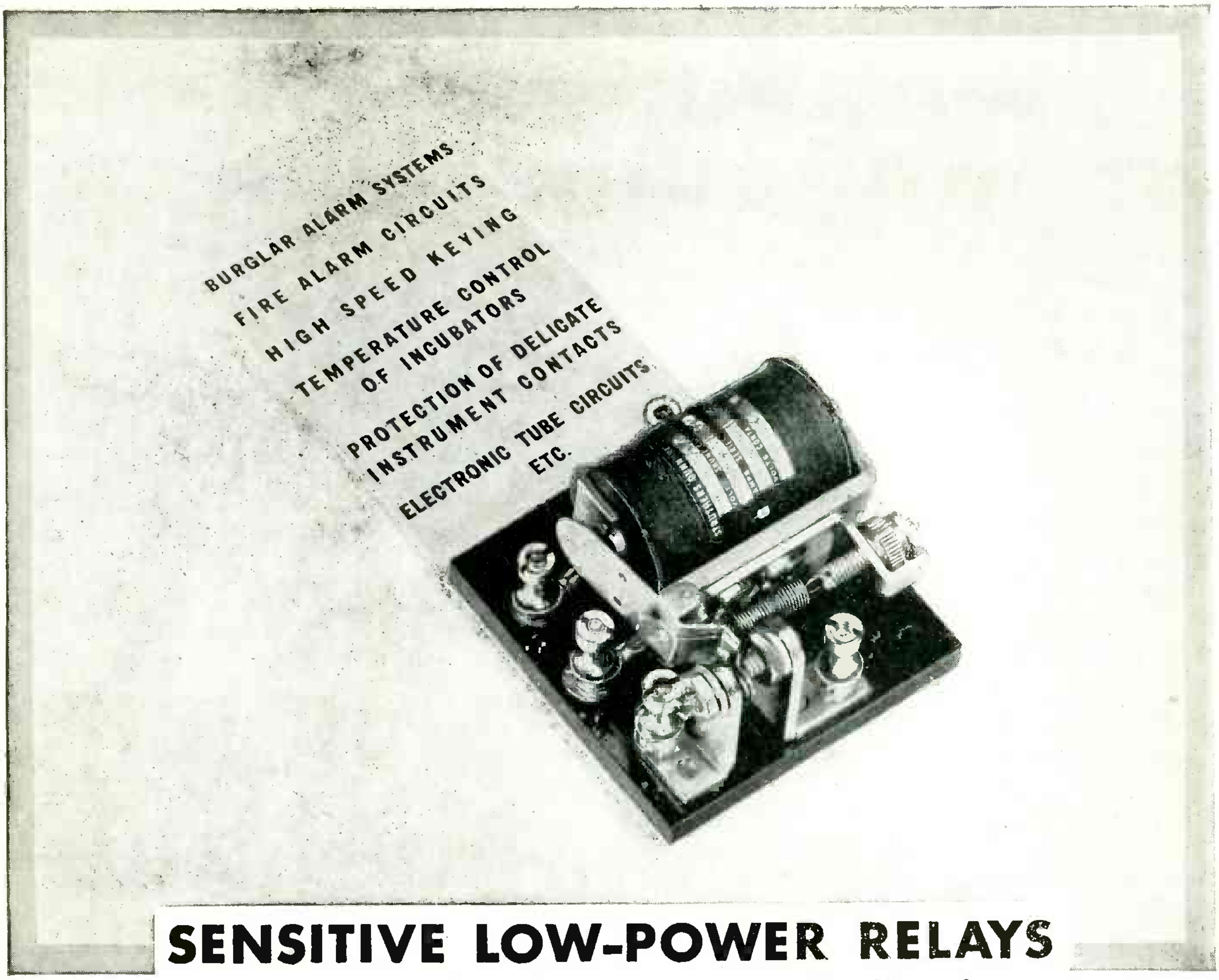

SENSITIVE LOW-POWER RELAYS
in a newly improved design

FOR USE ON AC AND DC

Engineering superiority in every mechanical and electrical detail makes Struthers-Dunn Type 112 Relays far and away "tops" for sensitivity and durability for low-power operation on the order of a few milliwatts • A "fool-proof" micrometer adjustment assures exceptionally reliable setting of the contact spring • All parts are of low-inertia, quick-acting design • Contacts are easy to adjust and stay "put" once adjusted • Coils are well insulated and vacuum impregnated • These new relays are built throughout for easier installation, higher sensitivity, longer life • Available in single-pole double-throw and double-pole double-throw contact combinations.

Write for Data Bulletin 112.

5,327 RELAY TYPES

STRUTHERS-DUNN

STRUTHERS-DUNN, Inc., 150 No. 13th St., Phila. 7, Pa.

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
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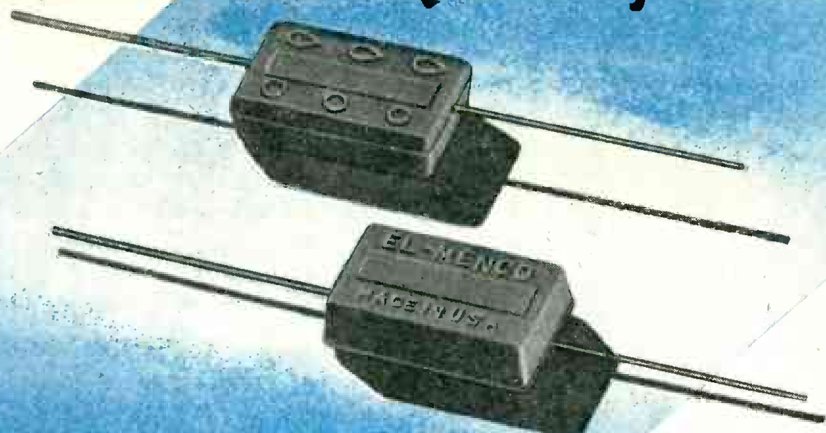
Continuous Quality . . .



is Quality that is DEPENDABLE

At any Price!

Reliability

El-Menco Capacitors contribute a great deal to the quality performance of your electronic product. In addition to being reliable in performance, El-Menco is reliable in delivery service.

Availability

You get as many El-Menco capacitors as you need . . . when you need them. Improved production techniques are your assurance of that.

Dependability

El-Menco stands ready to serve you in any emergency . . . just as El-Menco served in the recent national emergency, World War II. Our staff will assist you in solving any problem you may have.

We who design and make El-Menco Capacitors are proud of the reputation of dependability and quality that our products have earned. The use of El-Menco Capacitors throughout the electronic industry is an indisputable testimonial in behalf of their superiority.

Write on firm letterhead for catalog and samples.

MANUFACTURERS

Our silver mica department is now producing silvered mica films for all electronic applications. Send us your specifications.

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Send for samples and complete specifications. Foreign Radio and Electronic Manufacturers communicate direct with our Export Department at Willimantic, Conn., for information.

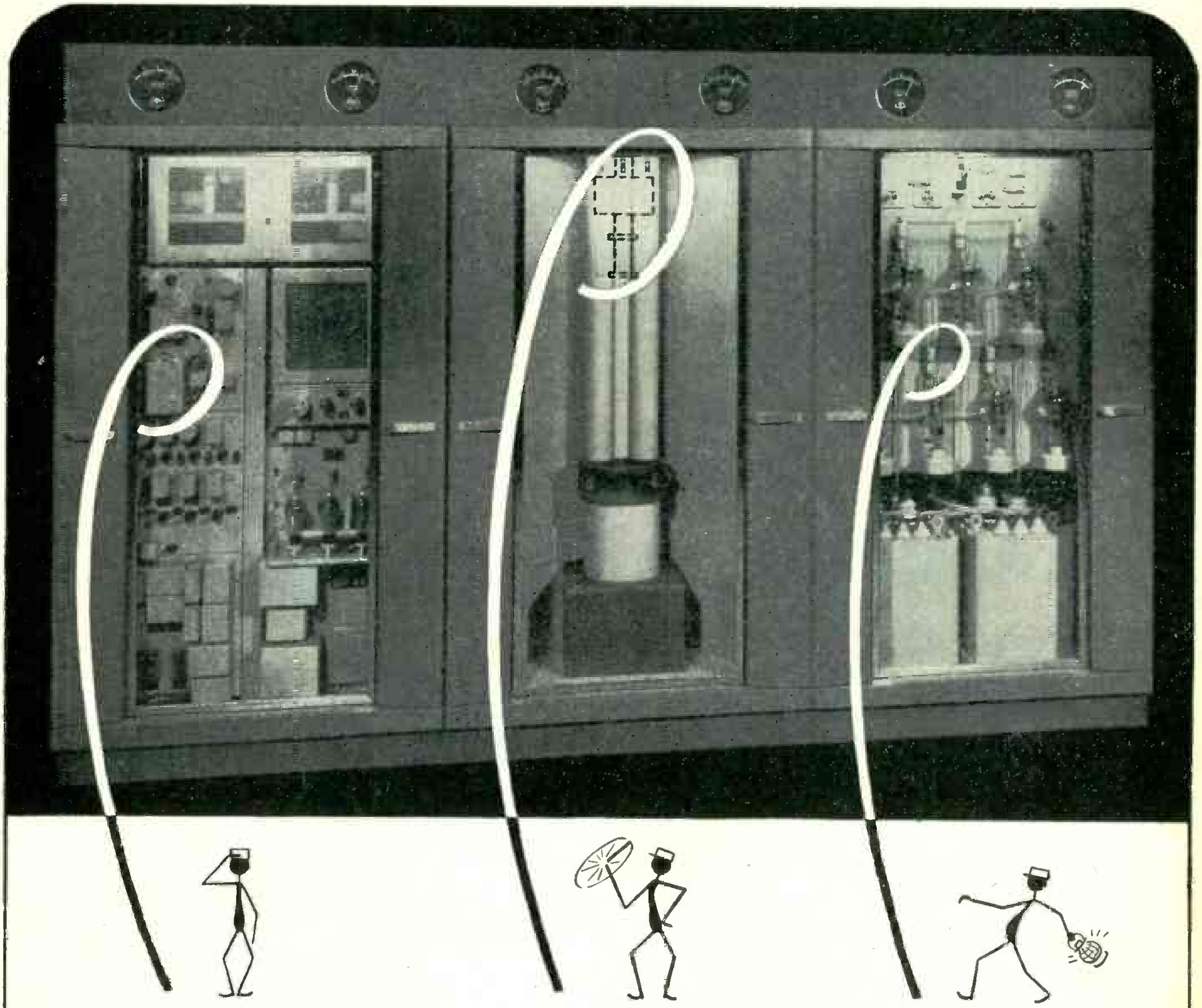
ARMY NAVY E

El-Menco

MOLDED MICA **MICA TRIMMER**

CAPACITORS

You get these 3 FM Watchmen in Western Electric transmitters only



FREQUENCY WATCHMAN

All Western Electric FM transmitters are kept constantly on their assigned frequencies by the Frequency Watchman—a simple, fool-proof, automatic device sensitive to the slightest frequency deviation. With this watchman on guard, stability of the transmitter is governed by the stability of a low temperature coefficient crystal, which varies less than *25 cycles per million* in the temperature range of from 40° to 130° F.

POWER AND IMPEDANCE WATCHMAN

The new RF Wattmeter and Impedance Monitor is available exclusively in Western Electric FM transmitters. It makes possible—for the first time—accurate, direct indication of the actual R. F. power *in kilowatts* fed into your antenna system—plus a simple method of measuring standing wave ratio under full power output. Supplied as standard equipment with all transmitters of 3 kw and up.

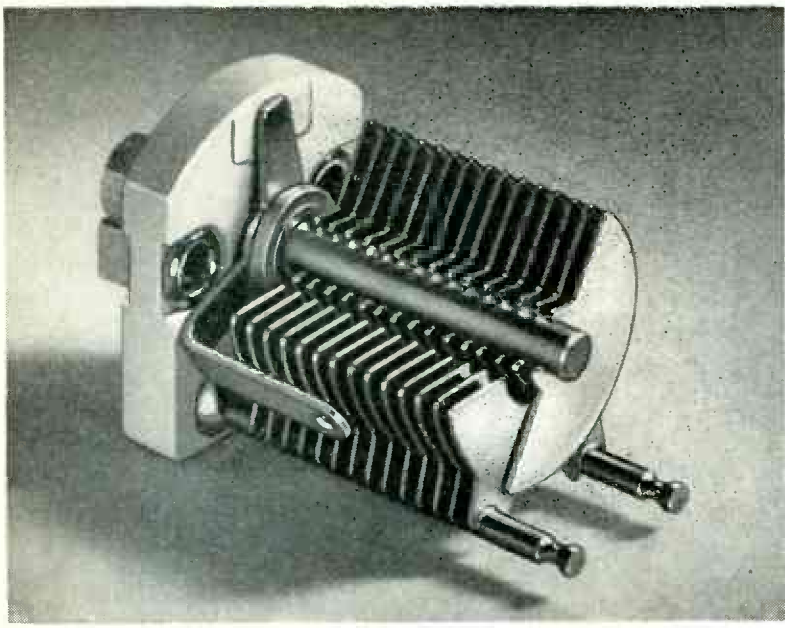
ARC-BACK WATCHMAN

Permits realization of the full life of each rectifier tube. By indicating exactly which tube has reached the end of its *reliable* service life, this watchman makes it possible to replace a worn out or faulty tube with the preheated spare and be back on the air —*with assurance*—in a few seconds.

Distributed by GraybaR
OFFICES IN 95 PRINCIPAL CITIES

FOR FURTHER DETAILS about the 3 FM Watchmen and Western Electric's new line of FM transmitters, call your local Graybar Broadcast Representative, or write Graybar Electric Company, 420 Lexington Ave., New York 17, N. Y.

Western Electric
—QUALITY COUNTS—



SMALLER! LIGHTER!

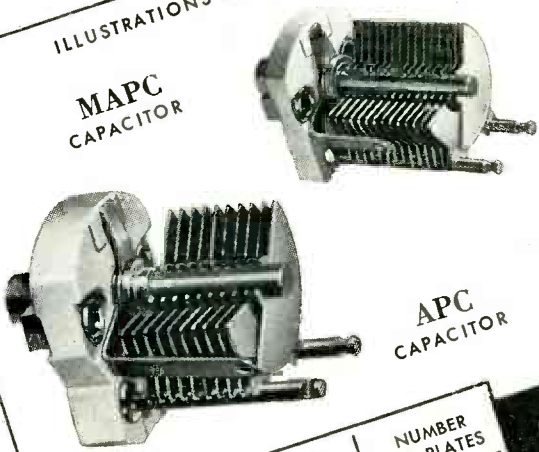
NEW 'MAPC' MIDGET APC CAPACITOR

Smaller in size than the APC and lighter in weight, the MAPC embodies all the features which made the Hammarlund APC an outstanding leader. Improvements in manufacturing technique and years of know-how have produced a variable capacitor of superior mechanical construction and electrical design.

The MAPC 75 weighs fifty percent less and is fifty percent smaller than the equivalent APC. The MAPC is so small that it can be used in place of a compression type trimmer with a resulting increase in circuit stability and efficiency. Low minimum capacities make possible a wide tuning range.

WRITE FOR TECHNICAL BOOKLET

ILLUSTRATIONS ACTUAL SIZE



CODE	NOM. MAX. CAP.-MMFD.	NOM. MIN. CAP.-MMFD.	NUMBER OF PLATES
MAPC-15	15	2.3	6
MAPC-25	25	2.6	10
MAPC-35	36	2.9	14
MAPC-50	49	3.2	19
MAPC-75	75	3.9	29
MAPC-100	99	4.5	38

THE SIGN OF QUALITY

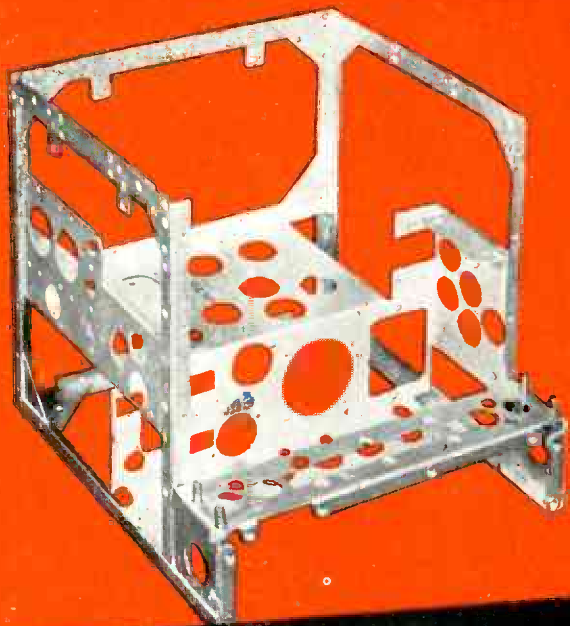
ESTABLISHED 1910

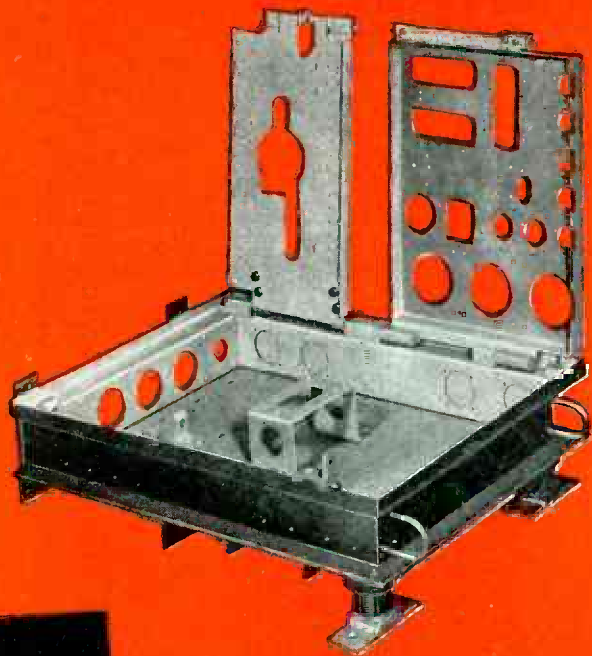
HAMMARLUND

THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.

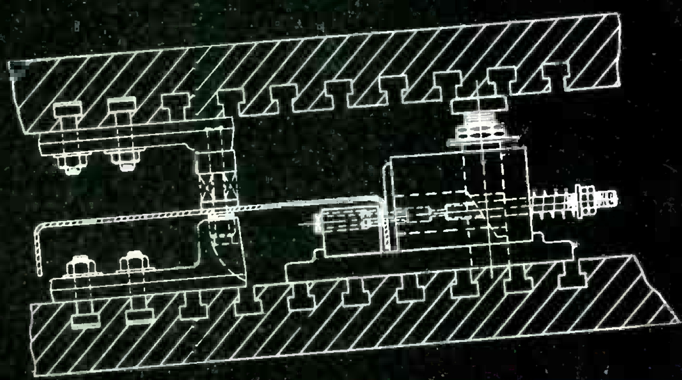
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

WHISTLER ADJUSTABLE DIES...USED BY OVER 1000 MANUFACTURERS





Simplifying Complicated Piercing Operations...



LEADING manufacturers find it fast, simple, accurate, and economical to use Whistler adjustable dies for the tough jobs. Complicated patterns can be set up quickly. It's easy to change hole arrangements too...without waiting and at no extra die cost. New HU-50 units, that pierce at 90° angle, can be used in conjunction with standard perforating equipment. Fewer press operations are necessary.

Savings, through continued re-use of the same dies in different arrangements on many jobs, are most important.

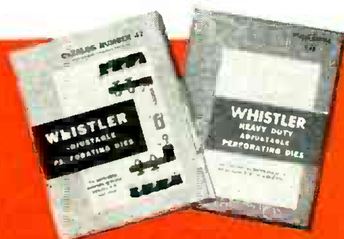
Whistler adjustable dies can be used in practically every type press. Standard sizes of punches and dies up to 3" are available in a hurry. Only a few days are necessary to get special shapes made to order.

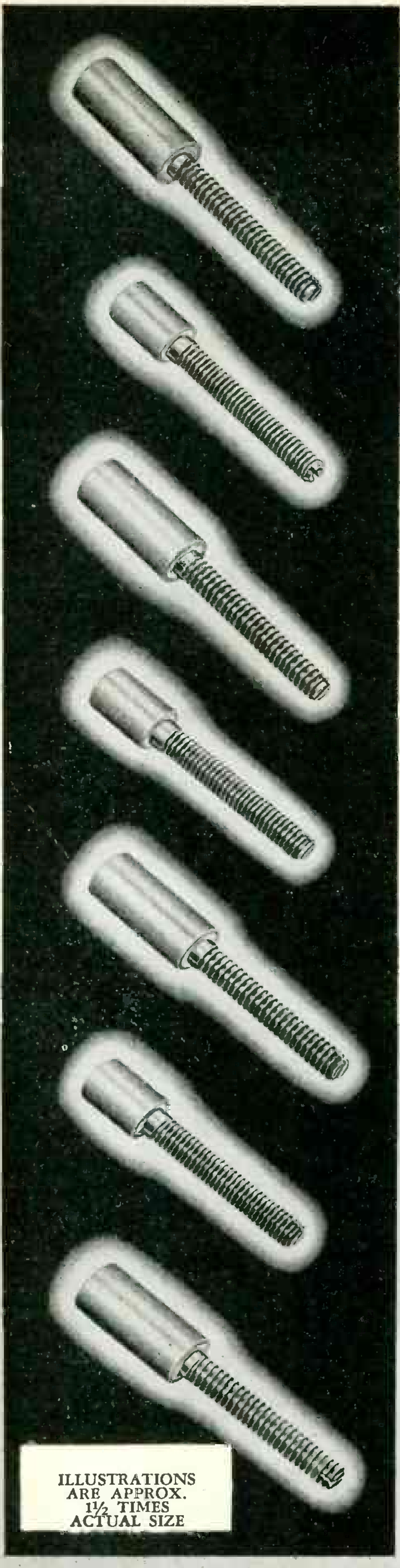
S. B. WHISTLER & SONS, INC.

746 Military Road Buffalo 17, N. Y.

HU-5C Perforating unit used in conjuction with standard Whistler adjustable dies on the same job.

For more details **on this modern way to speed production and save money, write for your copies of the Whistler catalogs.**





ILLUSTRATIONS ARE APPROX. $1\frac{1}{2}$ TIMES ACTUAL SIZE

They Lick Humidity and Vibration at High Frequencies

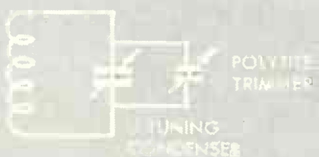
STACKPOLE

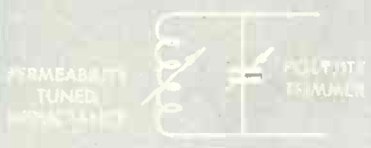
Polytite TRIMMER ELECTRODE CORES

Placed in fitted metal sleeves, Stackpole Polytite Trimmer Electrode Core Forms serve as variable capacitors that assure honest-to-goodness capacity stability in high-frequency circuits where humidity and vibration must be considered. The molded Polytite has a high dielectric constant. Cores are moisture repellent and carry a heavy dielectric coating that establishes a path of high leakage resistance between the electrodes. Since these electrode surfaces have short, symmetrical current paths, the inductance may be kept low enough for use in the 200-megacycle range. Standard types provide easy capacity adjustment with a maximum from 20 to 40 mmf., depending on the size.

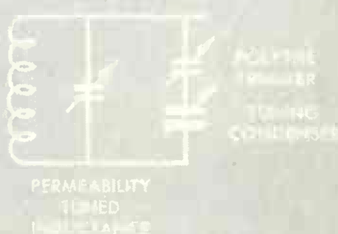
Write for Stackpole Polytite Trimmer Data Bulletin

STACKPOLE CARBON COMPANY
Electronic Components Division • St. Marys, Pa.





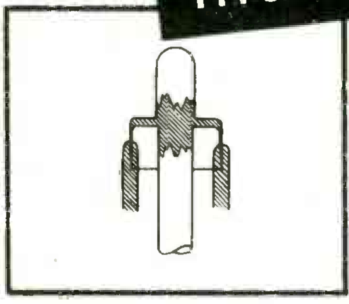
Stackpole Polytite Trimmer Electrode Capacitors are well suited for minimum capacity adjustments in tuned circuits, installed across the tuning capacitor as in Figure 1 or across the tuning inductance as in Figure 2. Trimmers may be mounted directly to the tuning capacitor.



A typical application using two Polytite Trimmer Electrode Capacitors in a circuit where band-spread tuning is desired. Various bands may be covered by the switching of coils and preadjusted trimmers.

RESISTORS • IRON CORES • SWITCHES

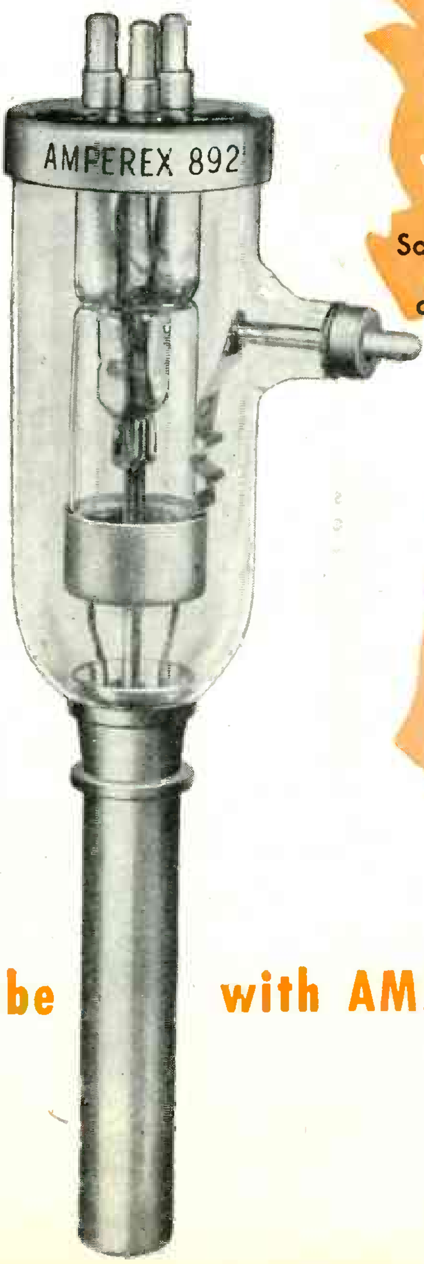
the LITTLE differences make the BIG difference



Pigs ain't pigs, we say. There are differences even within the litter. Sometimes they're visible, but often you can only tell the result of good breeding by checking the result.

It's the same with our Amperex 892. There is one of those little differences in the grid arm. It's much easier to assemble this by brazing a few parts together, but we know that a braze often offers resistance to the passage of current, sometimes enough resistance to make a big difference.

So we start this grid arm as a solid rod of oxygen-free copper and make it out of one piece, and it takes some mighty fine skill, Amperex skill, to turn that feather-edged seal from the solid. But that Amperex skill in manufacture, plus Amperex skill in design, produces a grid arm that offers the best operating conditions for both DC and RF . . . just another of the many little differences that make a big difference in the design and construction of the many, many types of tubes that comprise the extensive Amperex line.



re-tube with AMPEREX

AMPEREX ELECTRONIC CORPORATION

25 WASHINGTON STREET, BROOKLYN 1, N. Y.
In Canada and Newfoundland: Rogers Majestic Limited
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Wilco Thermometals

(THERMOSTATIC BIMETALS)

that

to Your will!

The versatile Wilco Line includes 29 WILCO THERMOMETALS which help manufacturing customers meet all conditions of bimetal application . . . all applications where response to temperature is required.

In Wilco's versatile line are Wilco Thermometals (Thermostatic Bimetals) that "bend" to your will . . . that precisely meet your requirements. Wilco Thermometals are designed for a wide variety of uses including . . . Temperature Indication . . . Temperature Control . . . Temperature Compensation . . . and Sequence Control.

CHARACTERISTICS—Wilco Thermometals cover temperature ranges of maximum resistance from 50° to 800° F. . . useful deflection from minus 100° to plus 1000° F. . . and include a wide range of electrical resistances.

PERFORMANCE—Wilco Thermometals give precision performance in hundred of applications, including Circuit Breakers, Furnace Controls, Flatirons, Safety Pilots, Electric Blankets, Carburetors, Cigarette Lighters, Fluorescent Light Starters and Automatic Toasters.

AVAILABILITY—Wilco Thermometals are supplied in all shapes, including strip, straight cantilever blades, U-shapes, spirals and helices . . . or as parts of assemblies with shafts, studs, brackets, contacts, braids or springs. Whatever your requirements for Wilco Thermometals, Wilco engineers will gladly help you.

WILCO PRODUCTS INCLUDE:

THERMOSTATIC BIMETAL—All temperature ranges, deflection rates and electrical resistivities.

CONTACTS—Silver-Platinum-Tungsten-Alloys-Sintered Powder Metal.

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

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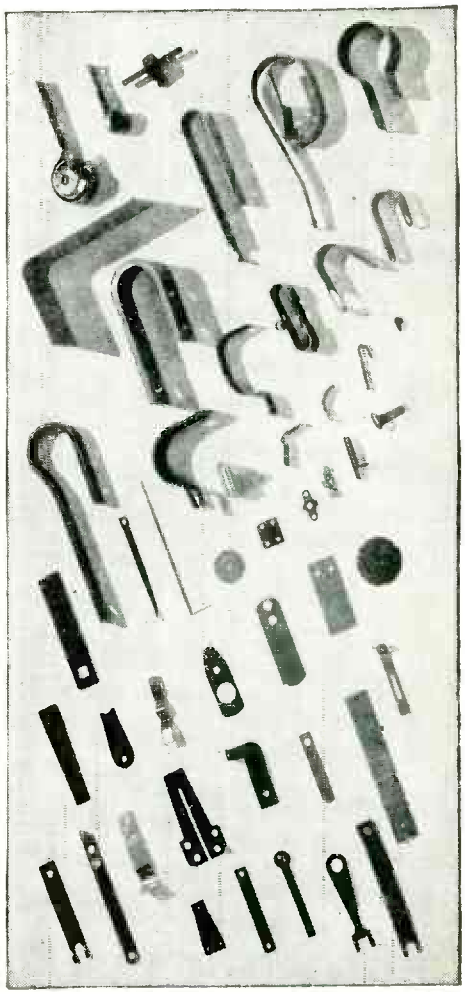
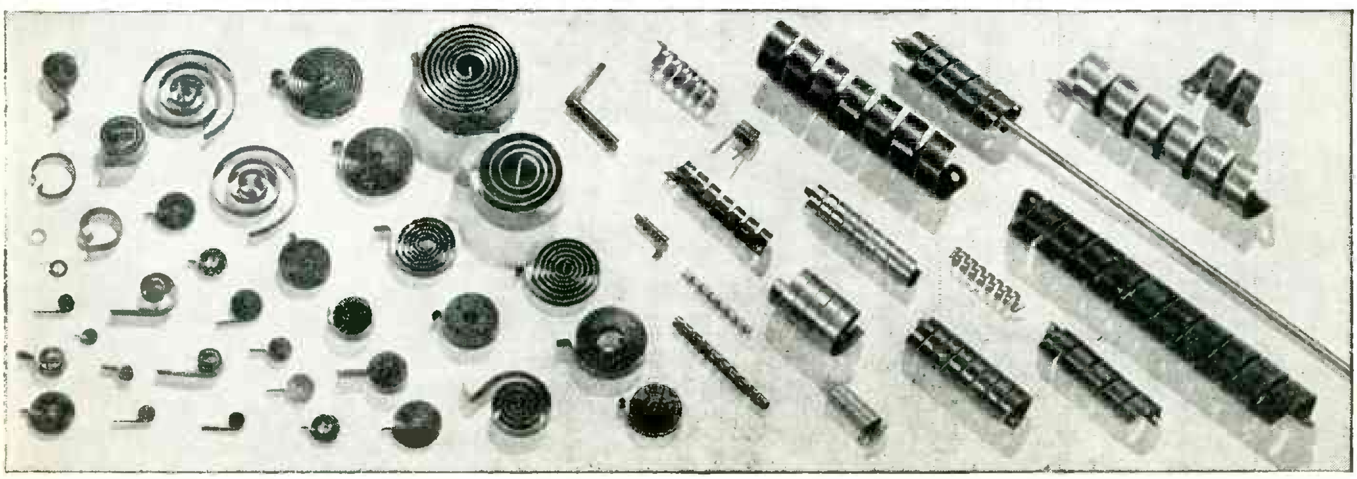


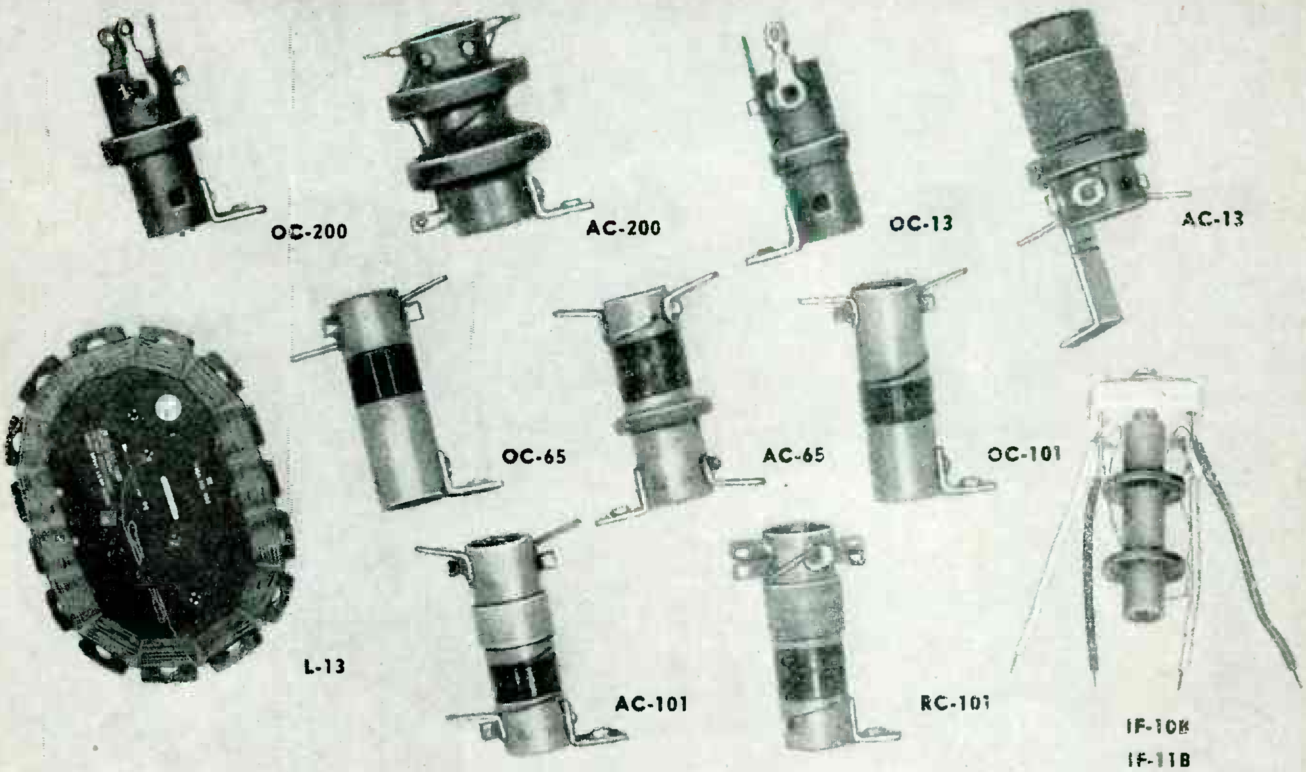
WILCO The H. A. Wilson Company

105 CHESTNUT ST. • NEWARK 5, NEW JERSEY • Branch Offices: Chicago, Detroit, Los Angeles, Providence



SPECIALISTS FOR 33 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS

Super COILS FOR USE WITH STANDARD R. M. A. 420-420 mmf VARIABLE CONDENSERS



Part No.	Type	Coilform Dimensions	Coilform Material	Basic Capacity Range	Oscillator Padder	Oscillator Trimmer	Freq. Range
OC-200	Oscillator	1/2 OD x 1-1/4 lg	Kraft	47.5-467.5 mmf	127.6 mmf	15.1 mmf	135-400 KC
AC-200	Antenna	5/8 OD x 1-1/2 lg	Kraft	47.5-467.5 mmf	—	—	—
OC-13	Oscillator	1/2 OD x 1-1/4 lg	Kraft	52.5-472.5 mmf	490.5 mmf	12.3 mmf	535-1620 KC
AC-13	Antenna	5/8 OD x 1-1/2 lg	Kraft	52.5-472.5 mmf	—	—	—
RC-13	RF Interstage	5/8 OD x 1-1/2 lg	Kraft	52.5-472.5 mmf	—	—	—
RF-13	T. R. F.	5/8 OD x 1-1/2 lg	Kraft	52.5-472.5 mmf	—	—	—
L-13	Loop Antenna	Various	Kraft	52.5-472.5 mmf	—	—	—
OC-65	Oscillator	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	1168.5 mmf	3.0 mmf	1.6-5.6 MC
AC-65	Antenna	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	—	—	—
RC-65	RF Interstage	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	—	—	—
OC-101	Oscillator	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	4666.0 mmf	1.6 mmf	5.5-19.2 MC
AC-101	Antenna	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	—	—	—
RC-101	RF Interstage	1/2 OD x 1-9/16 lg	Bakelite	37.3-457.3	—	—	—
IF-10B	Input	455 KC IF Transformer	Standard sizes and miniature				
IF-11B	Output	455 KC IF Transformer	Standard sizes and miniature				

These coils are standard components for use in the manufacture of all wave receivers.

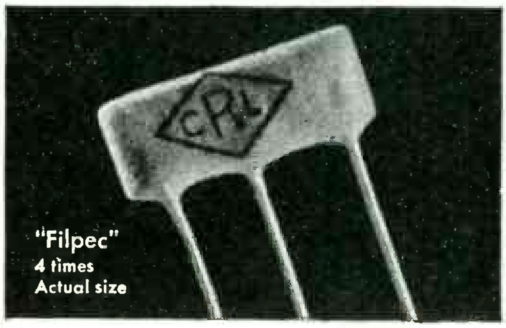
Coils for television and FM. Also built to customer's specifications.

Super ELECTRIC PRODUCTS CORP.

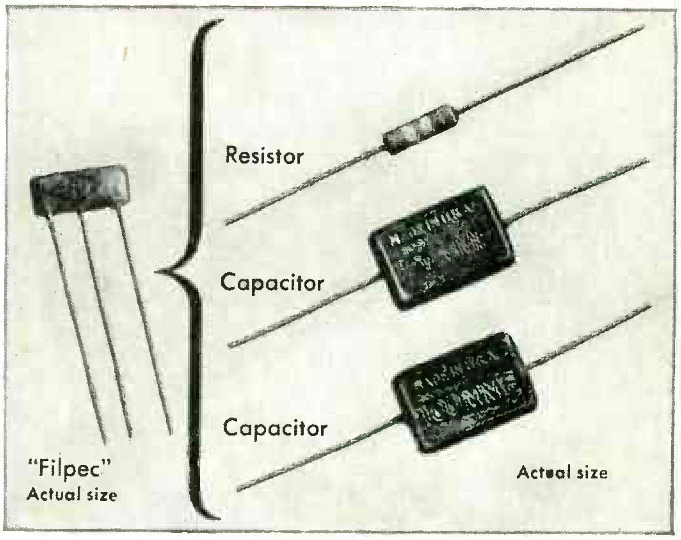
1057 SUMMIT AVENUE
JERSEY CITY 7, N. J.

Announcing "Filpec"

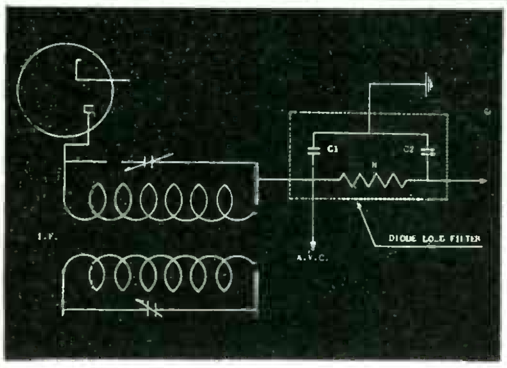
Centralab's new and revolutionary "printed electronic circuit" filter!



"Filpec" gives you integral construction! Made with high dielectric Ceramic-X, Centralab's *Filpec* assures long life, low internal inductance, resistance to humidity and vibration. Actual *Filpec* dimensions: $\frac{17}{32}$" long, $\frac{9}{32}$" wide, $\frac{7}{64}$" thick.



"Filpec" combines up to three major components into one tiny filter unit! Small, lightweight, *Filpec* reduces soldered connections 50%, saves space, cuts inventory, is highly adaptable to a variety of circuits. Capacitor values are available on *Filpec* from 50 to 200 mmf. Resistor values from 5 ohms to 5 megohms.



"Filpec" gives you flexibility! Schematic diagram above shows typical *Filpec* application as a balanced diode load filter. *Filpec* can be designed for you to meet a wide range of filter applications.

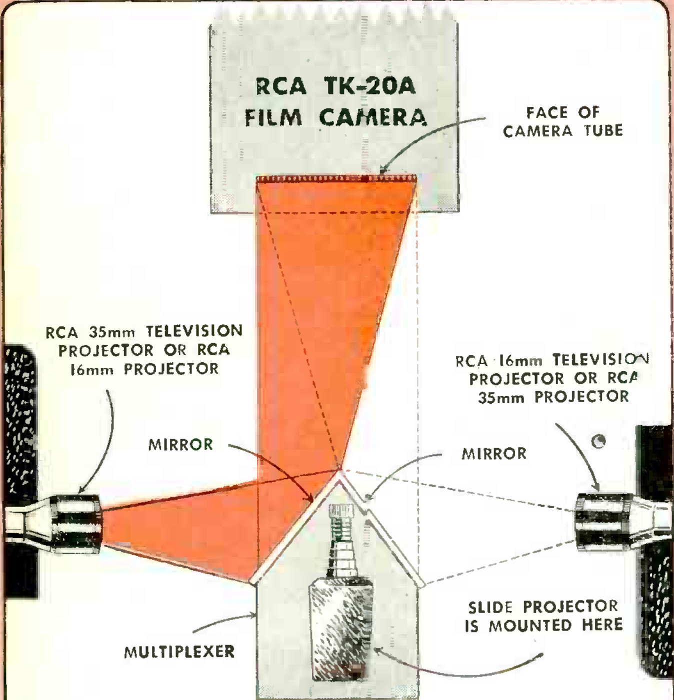
HERE IT IS — Centralab's newest application of its famous "printed electronic circuit" (PEC)! Illustrated on this page is a typical example — a brand new balanced diode load filter, lighter in weight, smaller in size than one ordinary capacitor! Think of what that offers you in higher circuit efficiency, more dependable performance as well as a reduction of line operations in set and equipment manufacturing! For complete information, send for Bulletin 976.

Ratings: Capacity values (C_1 and C_2 equal): 50 to 200 mmf. Capacity tolerance: —20% +50% over 100 mmf., ±20% below 100 mmf. Resistance values: 5 ohms to 5 megohms. Resistance rating: $\frac{1}{5}$ watt. 400 WVDC. Flash test: 800 VDC.

LOOK TO CENTRALAB IN 1947! First in component research that means lower costs for the electronic industry.

Centralab
Division of GLOBE-UNION INC., Milwaukee

RCA TK-20A FILM CAMERA . . . as outstanding for *film* programming as the RCA image-orthicon field and studio cameras have proved for "live" pick-up work. *Only one* of these cameras is required for a complete, versatile film and slide setup.

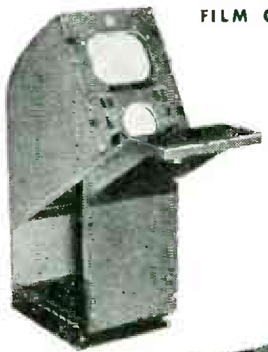


RCA FILM MULTIPLEXER

Images from the RCA television projectors are reflected from the mirrors of the multiplexer to the pick-up tube of the camera. The slide projector, mounted on the multiplexer, focuses directly on the pick-up tube. No focusing lenses are required on the film camera; distortion is negligible. Instant change from one projector image to another . . . or injection of slide pictures is performed in the projection room.

New RCA "4 way"* television film camera

* for use with one 16mm or one 35mm RCA television film projector
* for use with a 16mm and a 35mm projector
* for continuous shows with two projectors of either size
* for two film projectors and a slide projector



FILM CAMERA CONTROL—one required for each camera . . . becomes part of video console . . . permits operator to monitor and control quality of picture signal (amplifying, mixing, blanking, synchronizing, etc.).

VIDEO CONSOLE—composed of studio and film camera controls, a master monitor, and switching, lap-dissolve, and fading facilities for selecting the camera pick-up desired. "Building-block" design assures a compact, unified appearance . . . permits adding extra units at any time.

IT IS NOW POSSIBLE to use two film projectors *and* a slide projector with just *one* film camera . . . and to switch instantly from one to another *without moving the camera.*

Versatility in the RCA TK-20A is achieved through the use of a unique mirror system (see diagram at left). By this means, slide projector images may be shown in conjunction with motion picture films for special effects . . . or used separately for station identification, announcements, commercials, etc. Consecutive movie shorts or continuous multireel shows are handled with equal ease.

The camera includes a sensitive RCA pick-up tube, blanking and deflection amplifiers, and a six-stage video preamplifier. Resolution is excellent.

A separate control unit and master monitor, and two regulated power supplies (rack-mounted) complete the film-camera chain.

Only initial settings need be made at the camera; all other adjustments are made at the monitor and control units which normally become part of your video console.

Complete specifications and description of the TK-20A Film Camera are now available. Write Dept. 30-K, RCA, Camden, N. J.

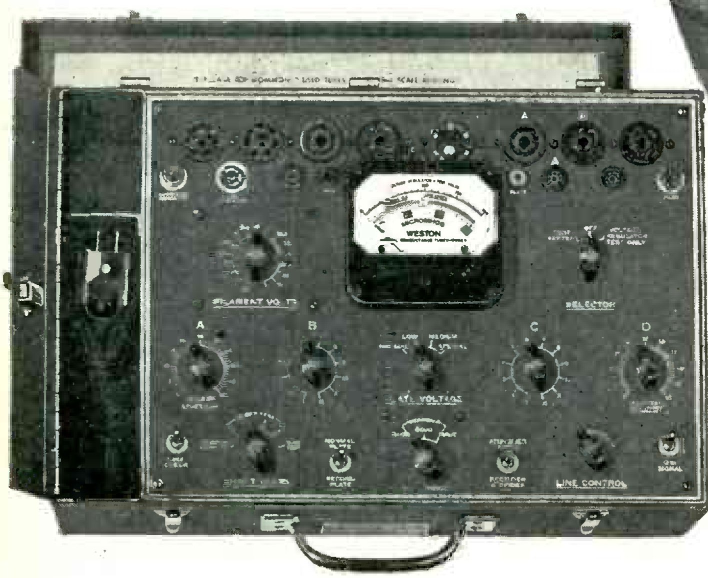
RCA

TELEVISION BROADCAST EQUIPMENT
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

INSTRUMENTS FOR ELECTRONIC MAINTENANCE

WESTON *Electronic Analyzer*—Model 769. Incorporating: 1. A conventional Volt-Ohm-Milliammeter with self-contained power source. 2. A high-impedance electronic Volt-Ohmmeter using 115 volt, 60 cycle power. 3. A stable, probe-type, Vacuum Tube Voltmeter, for use to 300 megacycles.



WESTON *Multi-Purpose TUBECHECKER*— Model 798. This universal tubechecker offers within one instrument provision for testing: 1. Receiving tubes. 2. Voltage regulator tubes. 3. Light duty thyratron tubes such as 2A4–6D4–884–885–2051. Scale is calibrated "Good-Bad" as well as in mutual conductance readings.

Direct Reading Insulation Tester —Model 799. Compact, one-hand-operated insulation tester with .1 to 10,000 megohm range, using a test potential less than 50 volts d-c. Indicates: 1. Insulation properties. 2. Leakage resistance. 3. Conductivity of insulating materials. 4. Leakage due to moisture absorption.

These portable Westons are specifically designed for expediting electronic maintenance . . . for doing the job better— faster. All are engineered and built in the strictest traditions of Weston accuracy and dependability. For further details see your local WESTON representative, or write . . . Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark 5, New Jersey.

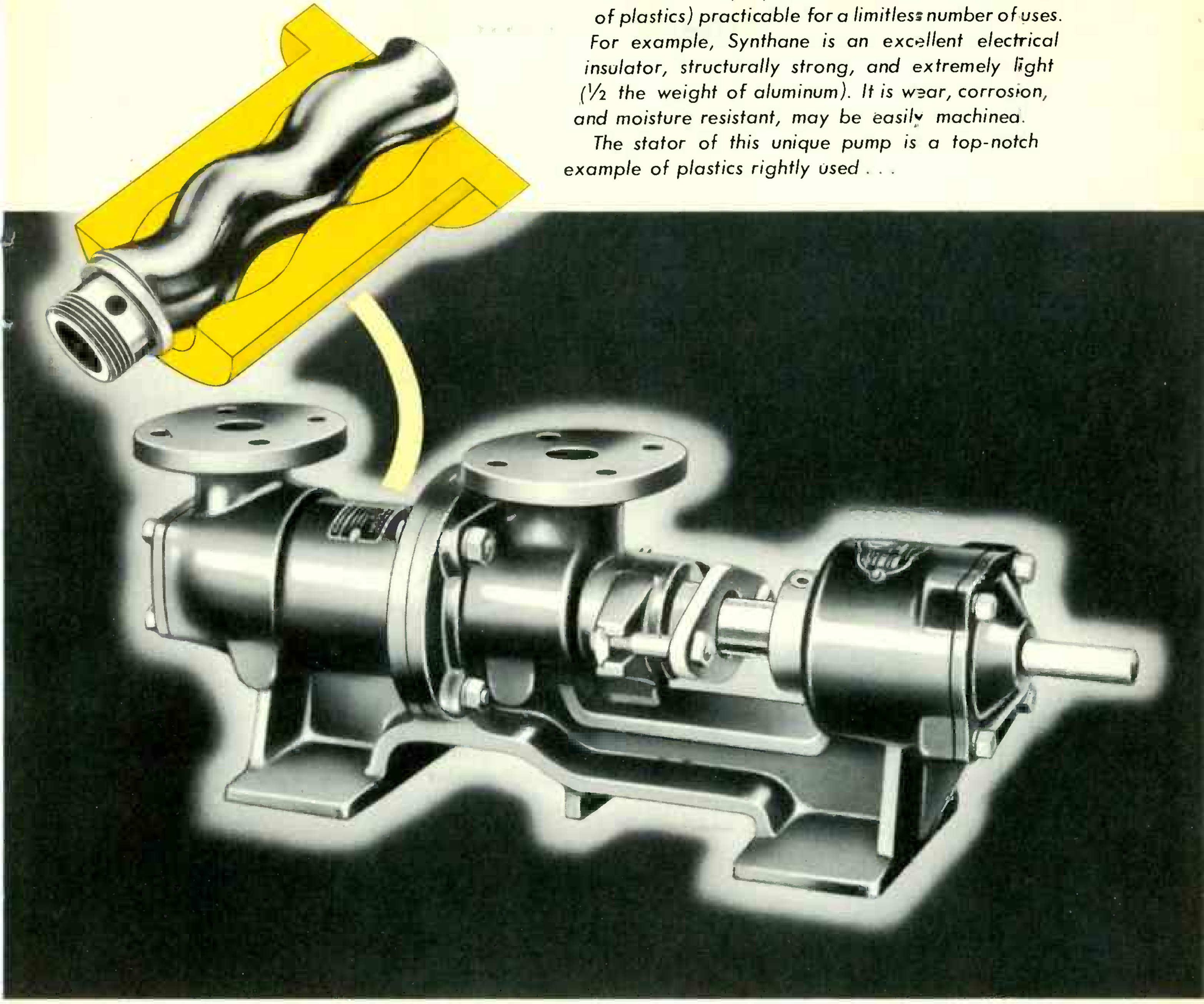
WESTON

Instruments

Plastics where plastics belong **for resistance to corrosion and wear**

An unusual combination of mechanical, electrical, and chemical properties make Synthane (our type of plastics) practicable for a limitless number of uses. For example, Synthane is an excellent electrical insulator, structurally strong, and extremely light (½ the weight of aluminum). It is wear, corrosion, and moisture resistant, may be easily machined.

The stator of this unique pump is a top-notch example of plastics rightly used . . .

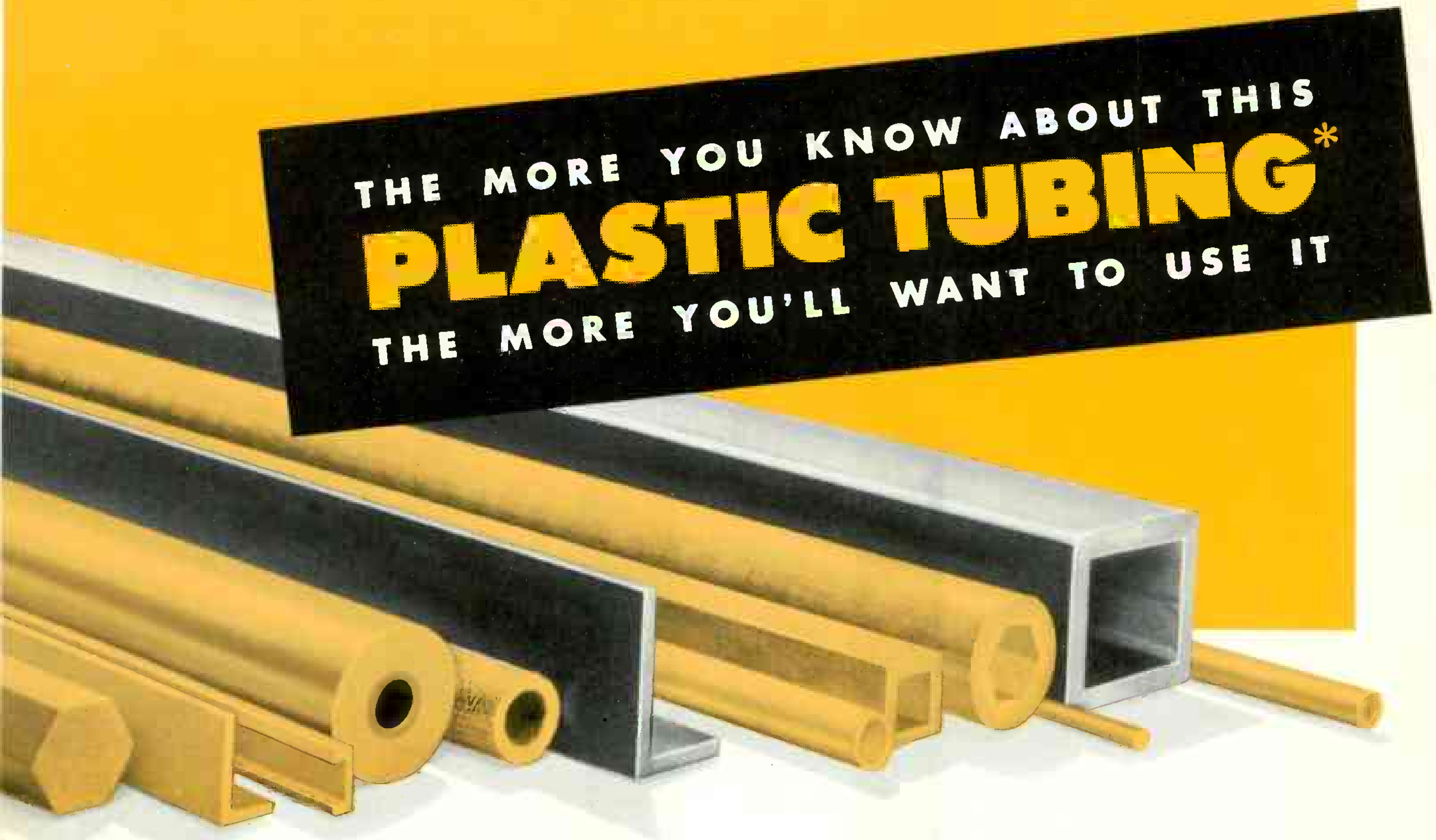


Handling a wide variety of materials, this application seriously tests corrosion and wear resistant qualities. Synthane stoutly resists the attack of many corrosive solutions and opposes the scrubbing action of pulp and small solids.

If you have an application for which Synthane seems the answer, let us know about it—before you design if possible. We are eager to help you choose the right job for plastics and the right plastics for the job. Write for our complete plastics catalog today! Synthane Corporation, 6 River Road, Oaks, Penna.

SYNTHANE **where Synthane belongs**

DESIGN · MATERIALS · FABRICATION · SHEETS · RODS · TUBES
FABRICATED PARTS · MOLDED · MACERATED · MOLDED-LAMINATED



SOME QUICK FACTS ABOUT SYNTHANE RODS AND TUBES

Diameters: Rod—1/8" to 4" O.D. (Larger diameters turned from sheet material.)
Tubing—1/8" to 22" I.D., O.D. to specifications. (Molded tubing to 4" O.D. only.)

Lengths: 18" and 36", longer on order

Colors: Natural (tan) or black

Finishes: Ground, buffed or varnished

For diameter or wall thickness tolerances, standards of quality for tensile and compressive strength, dielectric strength, density, percent of moisture absorption, power factor and dielectric constant, write for descriptive Tubing Folder.

DESIRABLE PROPERTIES OF SYNTHANE TUBES

- Non-metallic
- Light Weight (1/2 the weight of aluminum)
- Structurally strong
- Moisture Resistant
- Thermosetting
- Low Coefficient of Expansion
- Corrosion Resistant
- Excellent Electrical Insulator
- Hard, abrasion resistant
- Resilient
- Sound and Vibration Absorbing
- Easy to machine

Once it is learned how many properties are *combined* in Synthane—what sizes, and grades are available, and how easy Synthane is to machine, many new, profitable, uses for Synthane tubing and rods pop up quickly. Here, in a light weight non-metal that is an excellent electrical insulator, are all the characteristics for making thousands of products *better, faster* or *more economically.*

Synthane's plant capacity assures you a steady flow of top-quality rods and tubes or close-tolerance parts fabricated from these versatile materials.

Why not find out for yourself how Synthane rods and tubing can help you? The coupon below will quickly bring you a copy of the Synthane Tubing Folder complete with tables of characteristics. Send for it today!

SYNTHANE CORPORATION, 6 RIVER ROAD, OAKS, PENNSYLVANIA

Please send me the Synthane Tubing Folder by return mail.

Name________________

Company________________

Title________________

Address________________

City________ Zone________ State________

* *In addition to round tubes, Synthane produces a wide variety of irregular shapes by tube-making processes . . . . round with square or hexagonal centers, square, rectangular, channel, oval . . . and from a broad range of basic laminating materials—paper, fabric, asbestos, glass. The standard round tubing is always a little more economical to use, but if your needs call for an irregular shaped section, it will pay you to inquire about Synthane's diversified line of rods and tubes.*

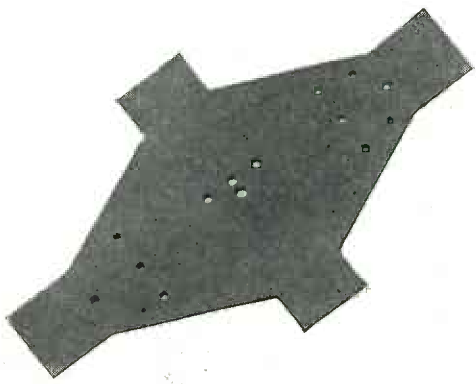
SYNTHANE

SYNTHANE CORPORATION S OAKS, PENNSYLVANIA

Representatives in ALL Principal Cities

FOR THE HIGHEST EFFICIENCY IN FIBROUS INSULATION

FOR *Simple* PARTS



FOR *Complex* PARTS

USE ROGERS FABRICATING SERVICE

HERE'S WHAT ROGERS OFFERS

- Alert, imaginative, expert design assistance.
- Complete die-making facilities.
- Rapid, accurate and economical fabricating
- Versatile line of tough, adaptable fibrous materials, backed by research and by manufacturing skills developed over a period of 115 years.

ROGERS fabricates fibrous insulation to meet your most rigid specifications. Rogers fabrications are accurate, made to simplify assembly and afford maximum protection. Design assistance, complete die-making and fabricating facilities are at your command.

Write for the Rogers Exhibit. It tells the complete story about our fabricating service.

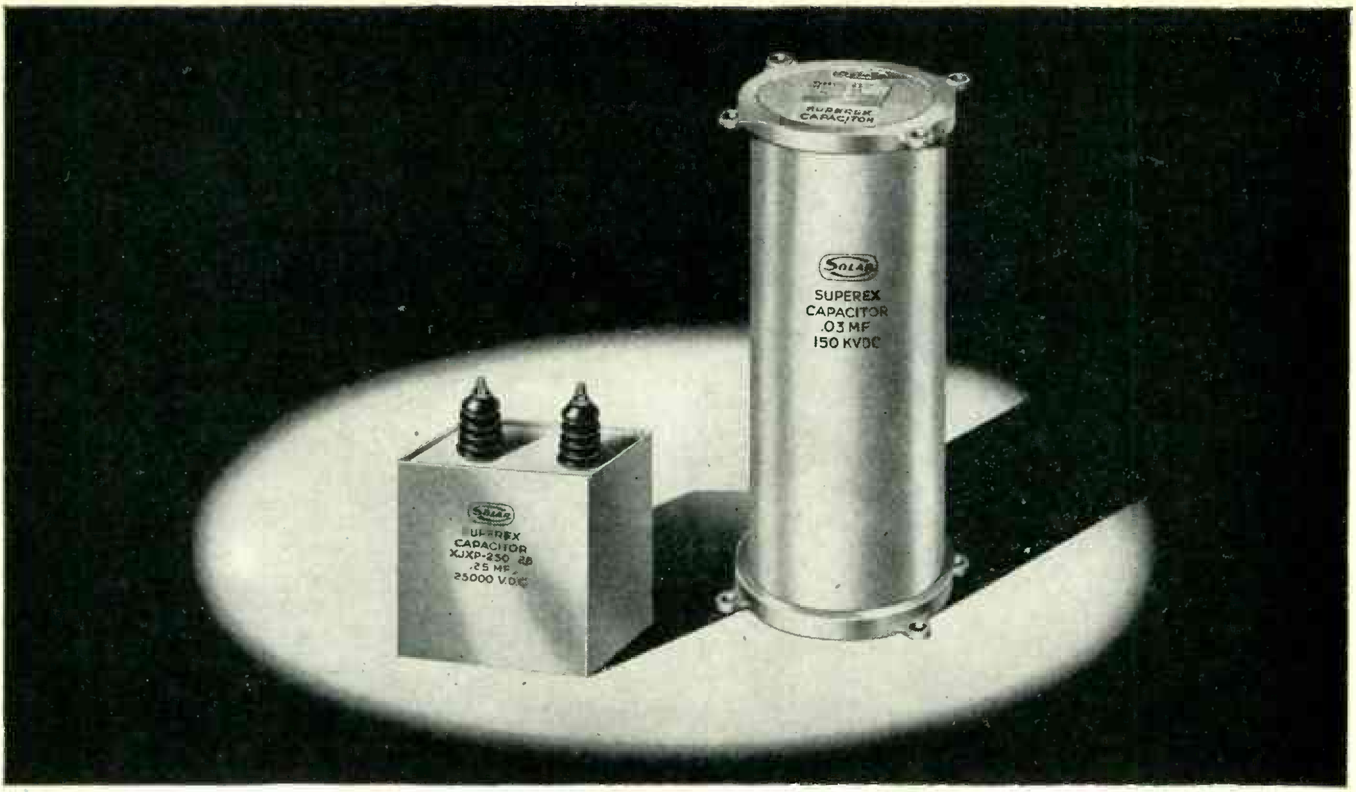
PLEASE ADDRESS 107 MILL ST.

Investigate the DUROIDS, new fibrous structural materials that are firm, yet flexible and shatterproof.

ROGERS

ROGERS CORPORATION

MANCHESTER • CONNECTICUT



HIGH RELIABILITY at HIGH VOLTAGES

Check these advantages of SUPEREX* High Voltage Capacitors

- LONG LIFE
- BUILT FOR THE APPLICATION
  - Low Voltage Stress
  - Uniform Winding Tension
  - Extra wide tabs for positive contact to sections
  - Carefully placed internal connections
  - Voltage Barriers
- NON-FLAMMABLE, NON-EXPLOSIVE SYNTHETIC IMPREGNANT
- HIGH INSULATION RESISTANCE
- STABLE CHARACTERISTICS

The dependability that is a "must" in high-voltage capacitors comes from long-time experience in design and construction. Solar SUPEREX units are outstanding in this field today.

Standard capacitors are available in ratings up to 100,000 volts in all-welded hermetically-sealed heavy steel cases with oversized porcelain bushings. Capacitors rated up to 150,000 volts are obtainable in tubular phenolic cases with leak-proof seals.

If you have any special problems in the field of high-voltage capacitors, a Solar field engineer will gladly discuss them with you. Write today.

3505

SOLAR MANUFACTURING CORPORATION
1445 HUDSON BOULEVARD, NORTH BERGEN, N. J.
Plants at: **Chicago, Ill., North Bergen and Bayonne, N. J.**

*Trade Mark

SOLAR CAPACITORS
"Quality Above All"

SOLAR

ANNOUNCEMENT NEW FOUNDATION FOR PRECISION COILS!

An exclusive Precision Development
Patents Pending

PRECISION PAPER DI-FORMED TUBES COIL FORMS

Never before so perfect!

Compare the new and the old! Note the square, even form with minimum bow of the new DI-FORMED tube—previously made only on special order, at higher prices.

Now all Precision square and rectangular paper tubes and coil bases are DI-FORMED as a standard process. And you now get these DI-FORMED tubes at no extra cost.

Use these New Precision DI-FORMED Coil Bases to
save money—speed production and increase efficiency of your equipment—because DI-FORMED coil bases have greater strength; permit automatic stacking; eliminate forming coils after winding; and cores can be engineered closer, saving wire.

Write for new Mandrel List (many new sizes now!) and ask for samples of Precison DI-FORMED Tubes — to your specifications.

PRECISION PAPER TUBE COMPANY
2041 WEST CHARLESTON STREET **CHICAGO 47, ILLINOIS**

FOR TOP U-H-F PERFORMANCE

General Electric's new GL-5648 transmitting tube—a forced-air-cooled triode of ultra-compact lighthouse design—LEADS in microwave applications such as:

FM-AND-TELEVISION STUDIO-TRANSMITTER LINKS

•

COMMERCIAL RADAR

•

PLATE OR CATHODE-PULSED CIRCUITS

2,500 mc frequency at max ratings **GL-5648**

HERE is the most modernly engineered transmitting tube of medium power to operate in the ultra-high range. Type GL-5648 will perform at frequencies up to 2,500 mc under full plate input, assuming proper adjustment of heater voltage to compensate for cathode back-heating.

The tube finds primary application in oscillator service, and as a grounded-grid power amplifier. Also, Type GL-5648 is directly suited to plate or cathode pulsing. Maximum ratings for this service now are being determined prior to definitive release.

Design follows the successful lighthouse-tube principles of parallel-plane electrodes that are closely spaced, plus a coaxial-contact structure meeting the needs of concentric-line circuits. Internal shielding is highly developed, so that the tube is especially useful in grid-separation-type circuits.

Cylindrical terminal contacts, wide in area and silver-plated, provide low-inductance current paths and reduce r-f losses. The tube is sturdy, compact in outline, and small in dimensions, requiring minimum space to mount.

Additional data on the GL-5648 gladly will be supplied on request, and G-E tube engineers are at your service to consult with you as to applications. Address *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

ELECTRICAL CHARACTERISTICS

Cathode voltage	6.3 v
current	1.1 amp
Interelectrode capacitances (with shields):	
Grid-cathode	6.50 mmfd
(with cathode hot)	8.50 mmfd
Grid-plate	1.95 mmfd
Cathode-plate	0.035 (max) mmfd
Amplification factor	100
Transconductance	17,000 micromhos
Frequency at max ratings (with proper heater-voltage adjustment)	2,500 mc
Type of cooling	forced air

Max Ratings (absolute values), Class C Telegraphy

D-c plate voltage	1,000 v
D-c grid voltage	—150 v
D-c cathode current	100 ma
D-c grid current	50 ma
Grid dissipation	1.5 w
Plate input	100 w
dissipation	100 w

Ratings for Typical Operation (as grid-separation oscillator at 500 mc), Class C Telegraphy

D-c plate voltage	1,000 v
D-c grid voltage	—48 v
D-c plate current	50 ma
D-c grid current (approx)	8 ma
Plate input	50 w
dissipation	25 w
power output	25 w

GENERAL ELECTRIC

161-F9-8850

FIRST AND GREATEST NAME IN ELECTRONICS

When you need insulators in a hurry, phone us for die pressed AlSiMag. Air shipments put us as close as if we were in your own back yard.

American Lava has the largest battery of presses in the industry and can now handle a limited number of rush orders. We make our own dies and that also saves a lot of time. Die pressing is usually the fastest and most economical way to produce steatite ceramic insulators of fine quality. Try us when you want to break that bottleneck of ceramic insulators.

46TH YEAR OF CERAMIC LEADERSHIP

ALSIMAG

TRADE MARK REGISTERED U.S. PATENT OFFICE

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE

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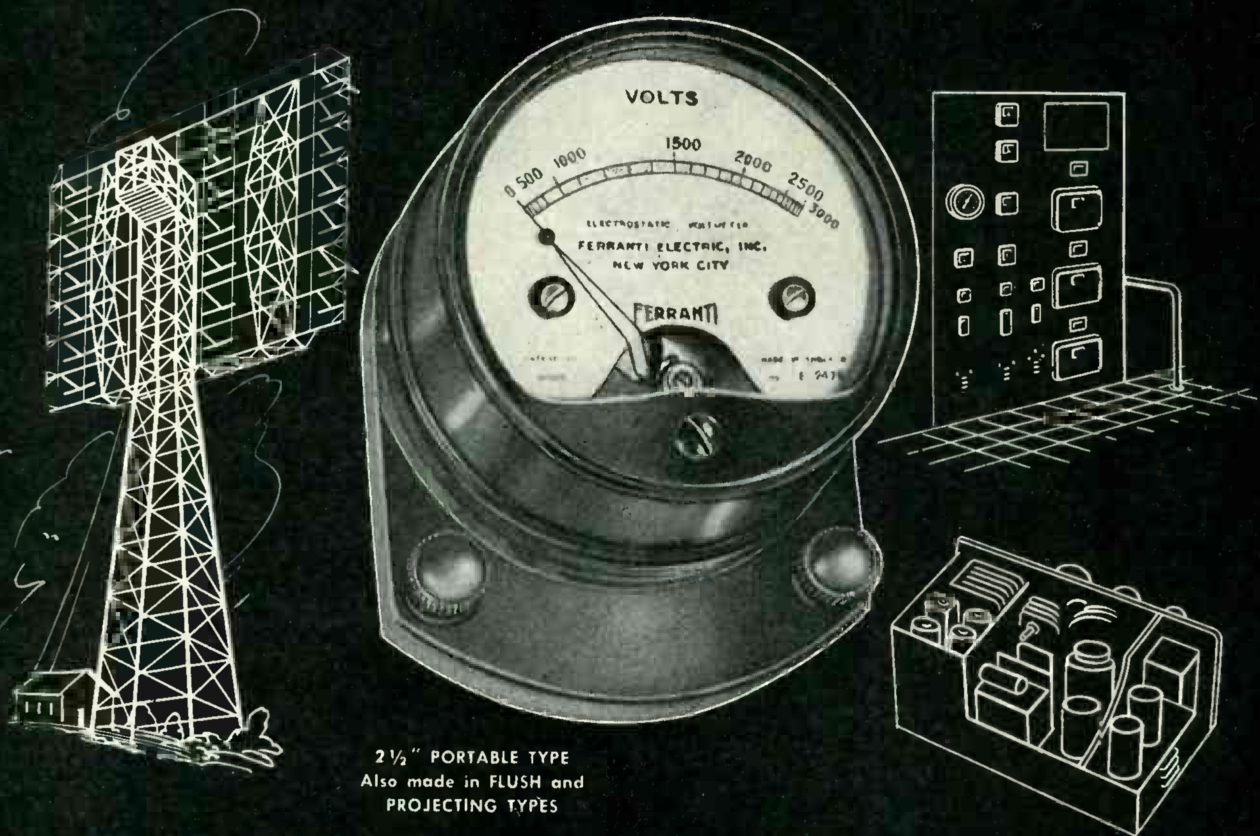
NEWARK, N. J., 671 Broad St., Tel: Mitchell 2-8159 • CHICAGO, 9 S. Clinton St., Tel: Central 1721 • SAN FRANCISCO, 163 2nd. St., Tel: Douglas 2464 • LOS ANGELES, 324 N. San Pedro St., Tel: Mutual 9076

New... FERRANTI

ELECTROSTATIC VOLTMETERS

FOR AC AND DC MEASUREMENTS



2½" PORTABLE TYPE
Also made in FLUSH and
PROJECTING TYPES

ZERO CURRENT CONSUMPTION • READING FROM 20 to 25,000 VOLTS • AC OR DC UP TO 3,500 VOLTS SELF-CONTAINED • OVER-VOLTAGE PROTECTION • 2½ in. DIALS • SINGLE, DUAL AND TRIPLE RANGES • MAGNETIC DAMPING • PRECISION BUILT, ACCURATE • THOROUGHLY RELIABLE •

A Product of over 65 years of Ferranti experience

FERRANTI ELECTRIC INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

FROM ORANGE SQUEEZERS . . .

. . TO WELDING EQUIPMENT

PWC CORDS AND CABLES DELIVER THE JUICE

PWC flexible cords and cables stand up to punishment like no old-fashioned cord you've ever used, like no other cord you can buy.

For PWC flexible cords — ST, SJT, SVT and POT — are insulated and sheathed with PWC plastic, the last word in modern insulation. Made by the world's leading exclusive manufacturer of plastic insulated wire and cable, non-aging, non-combustible PWC flexible cords shrug off moisture, abrasion, oil, grease, acids and alkalis. They won't crack, fray or rot. Just try to kink them!

Leading manufacturers of electrical tools, major and small appliances, conveyors and other electrical products have standardized on PWC cords for original equipment. They are available on reels or as cord sets with molded-on plugs, receptacles or grommets, either standard or special.

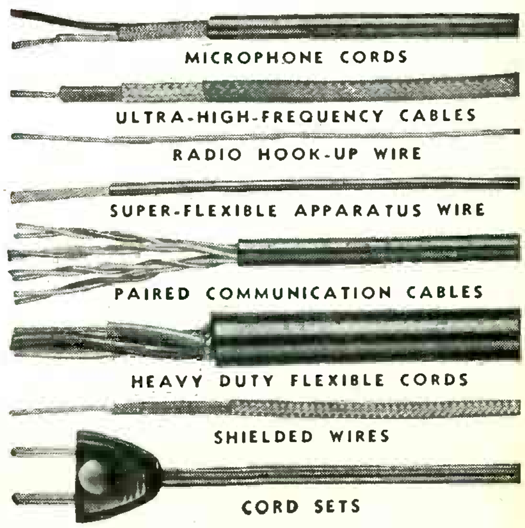
Experience shows that PWC cords and cord sets more than pay their way in freedom from maintenance costs and replacement over long, hard service.

You'll get outstanding performance in every PWC product you buy — from building wire, apparatus wire, or power cable to special purpose wires and cables.

Let us quote you prices and delivery dates today.

PLASTIC WIRE & CABLE CORP.

408 East Main St., Jewett City, Conn.



REVERE FREE-CUTTING COPPER ROD
...INCREASES ELECTRONIC PRODUCTION

SINCE its recent introduction, Revere Free-Cutting Copper has decisively proved its great value for the precision manufacture of copper parts. Uses include certain tube elements requiring both great dimensional precision, and exceptional finish. It is also being used for switch gear, high-capacity plug connectors and in similar applications requiring copper to be machined with great accuracy and smoothness. This copper may also be cold-upset to a considerable deformation, and may be hot forged.

Revere Free-Cutting Copper is oxygen-free, high conductivity, and contains a small amount of tellurium, which, plus special processing in the Revere mills, greatly increases machining speeds, makes possible closer tolerances and much smoother finish. Thus production is increased, costs are cut, rejects lessened. The material's one important limitation is that it does not make a vacuum-tight seal with glass. In all other electronic applications this special-quality material offers great advantages. Write Revere for details.

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.

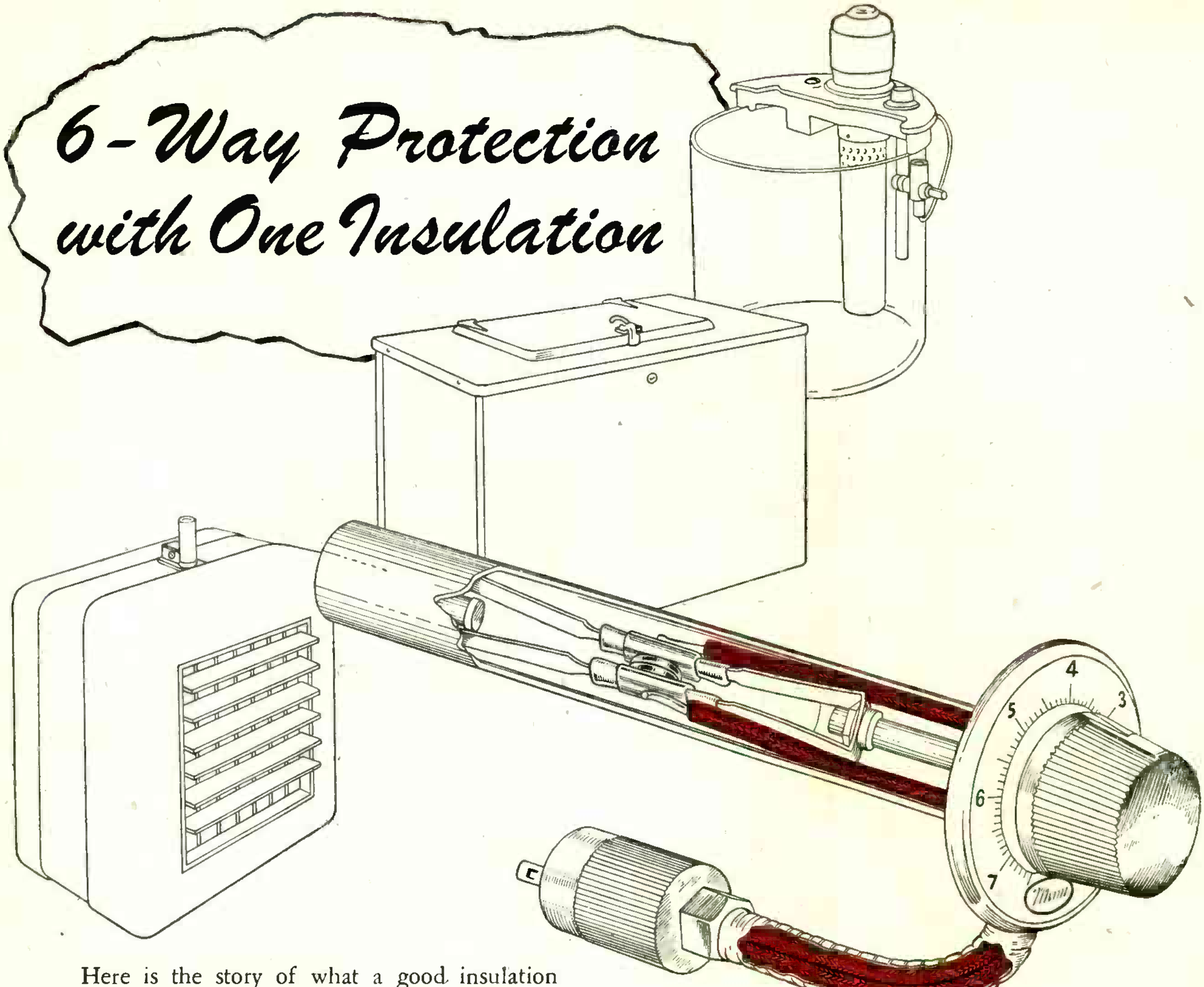
CUSTOMERS REPORT:

"This material seems to machine much better than our previous hard copper bar; it cuts off smoothly, takes a very nice thread, and does not clog the die." (Electrical parts.)

"Increased feed from 1-1/2" to 6" per minute and do five at one time instead of two." (Switch parts.)

"Spindle speed increased from 924 to 1161 RPM and feed from .0065" to .0105" per spindle revolution. This resulted in a decrease in the time required to produce the part from .0063 hours to .0036 hours. Material was capable of faster machine speeds but machine was turning over at its maximum. Chips cleared tools freely, operator did not have to remove by hand." (Disconnect studs.)

6-Way Protection with One Insulation



Here is the story of what a good insulation can do. Thermoswitch controls, made by Fenwal, Inc., are used in a wide variety of applications—unit heaters, home freezers, laboratory water baths, to mention only a few. The insulation is constantly subjected to (1) heat up to 700°F., (2) cold as low as -120°F., (3) extreme vibration, (4) friction, (5) bending, and (6) abrasion.

Over a year ago, Fenwal engineers specified Bentley, Harris Fiberglas Sleeving. Here is what they have found:

"Comparative tests made against similar insulation proved BH Fiberglas Sleeving was best suited for our use. In actual use, this Sleeving withstands abrasion, friction and bending without splitting or cracking. The non-fraying qualities and resistance to extreme temperatures are outstanding."

Daily use by America's leading manufacturers proves the value of BH Fiberglas Sleeving. Try it in your plant, in your own product.

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-16, 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 ________________

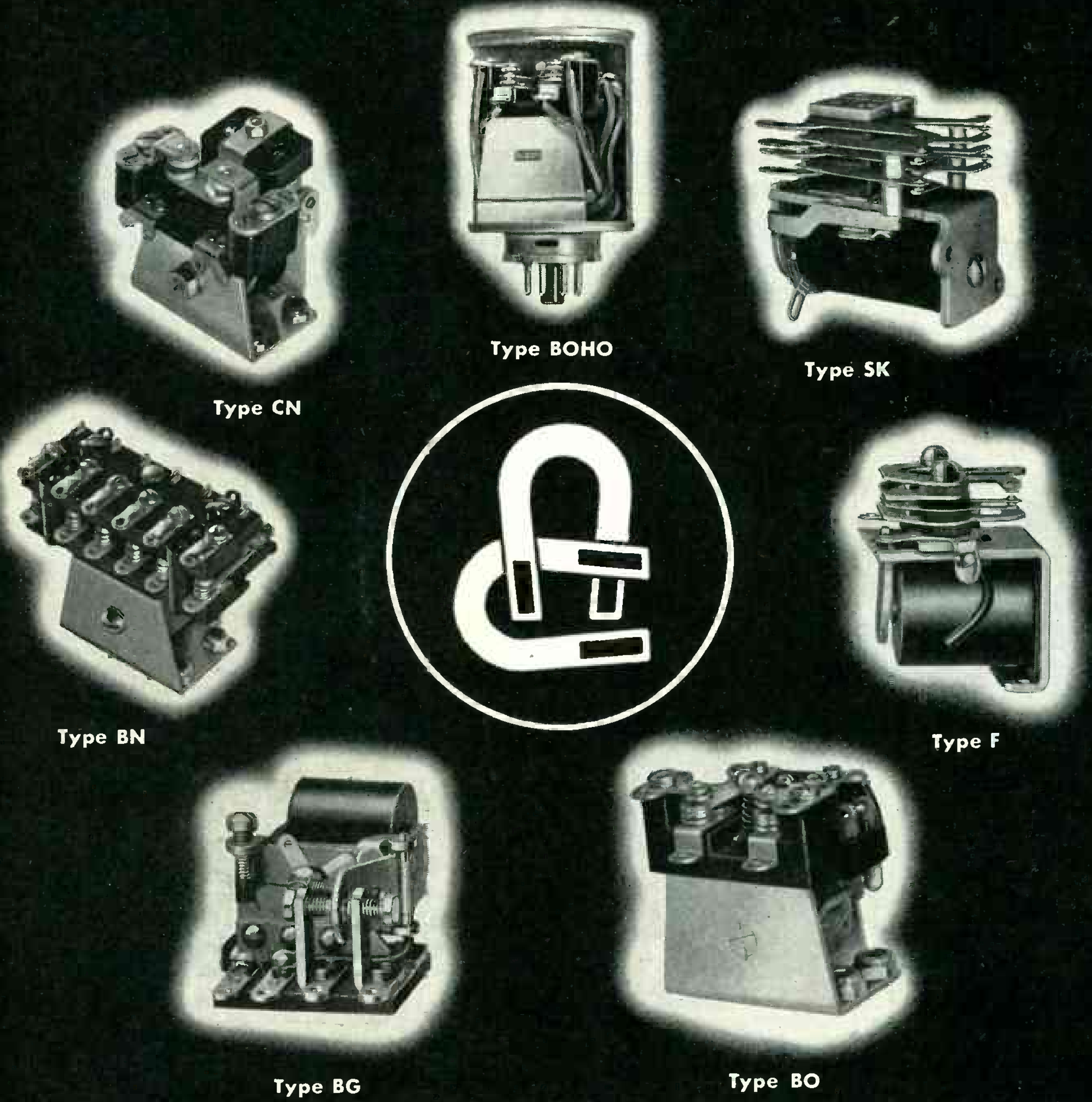
ADDRESS ________________

Send samples, pamphlet and prices on other BH Products as follows:

☐ Cotton-base Sleeving and Tubing

☐ Ben-Har Special Treated Fiberglas Tubing

RELAYS OF ADAPTABILITY



Thousands of specifications are filled by the complete line of Allied Relays—seven of which are grouped around the Allied emblem of engineering leadership.

Allied Control engineers pioneered the design of relays from signal circuits to 75 ampere contacts, coils from 12 milliwatts to 3½ watts to give the smallest mounting area and accessible wiring facilities.

**Type "BOHO"* is D.P.D.T. relay sealed with standard octal plug. Contact rating of 5 to 10 amperes and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

**Type "CN"* is S.P.S.T. double break relay with 50 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts and 220 volts; 60 cycles at 10.5 volt-amperes.

**Type "BN"* is 6 P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 3.5 watts (not available in A.C.).

**Type "BG"* is S.P.D.T. relay with 2 ampere contacts and coil capacity of 25 v. D.C. at 50 milliwatts (not available in A.C.)

**Type "BO"* is D.P.D.T. relay with 15 ampere contacts and coil capacity of 115 v. D.C. at 2.5 watts and 220 volts; 25 and 60 cycles at 4.5 volt-amperes.

**Type "F"* is S.P.D.T. with 2 ampere contacts and coil capacity of 85 v. D. C. at 1.5 watts (not available in A.C.).

**Type "SK"* from S.P.S.T. up to 4 P.D.T. with 1 ampere contacts and coil capacity of 60 v. D.C. at 750 milliwatts (for 4 P.D.T. relay) not available in A.C.

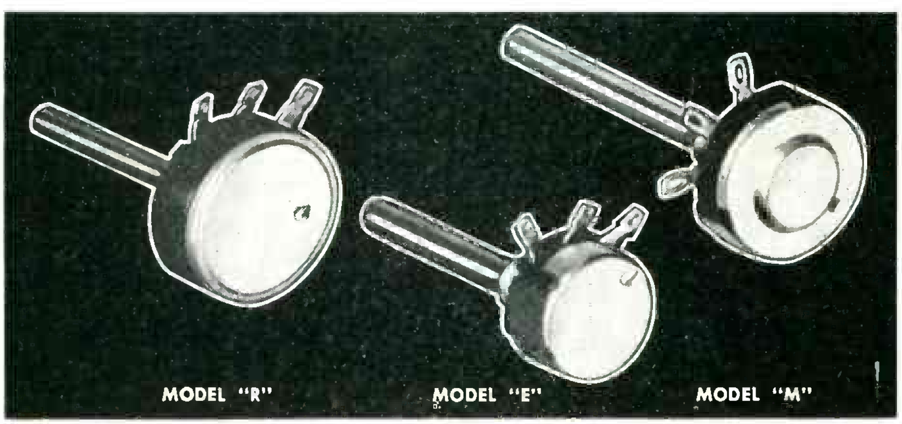
Allied Control representatives are located throughout the United States. A short note to our home office will give you the name of our nearest representative.

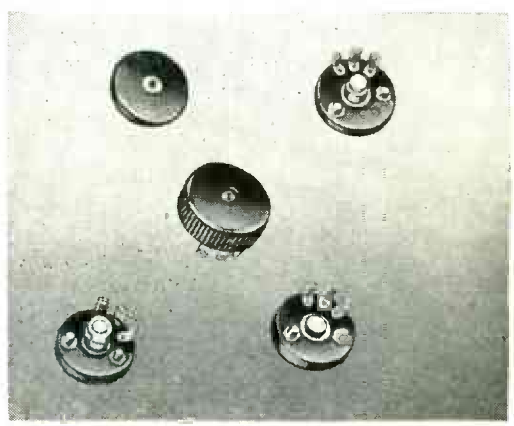
AL-119

ALLIED CONTROL CO., INC. 2 EAST END AVENUE, NEW YORK 21, N. Y.

Centralab reports to

1 100% electrical test for continuity and "shorts" completes Centralab's program of tests for each control before it is shipped. This includes testing for resistance at various degrees of rotation, taper, noise, mechanical dimensions, etc. It's the reason why Centralab controls assure you accurate ratings, precision workmanship, trouble-free installation, long field service life — above and beyond your specification requirements. But that's not all . . .

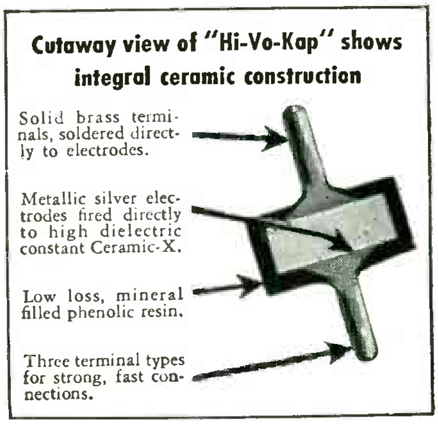




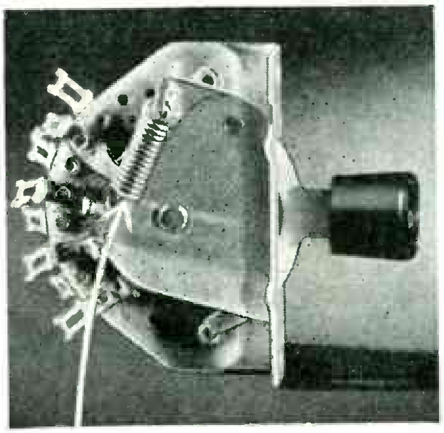
2 CRL's complete Radiohm line offers wide range of variations for special needs: *Model "R"* — wire wound, 3 watts; or composition type, 1 watt. *Model "E"* — composition type, ¼ watt. Direct contact, 6 resistance tapers. *Model "M"* — composition type, ½ watt. Write for Bulletin 697.

3 Here's Centralab's newest control for miniature receivers, amplifiers. No bigger than a dime, high quality performance is assured.

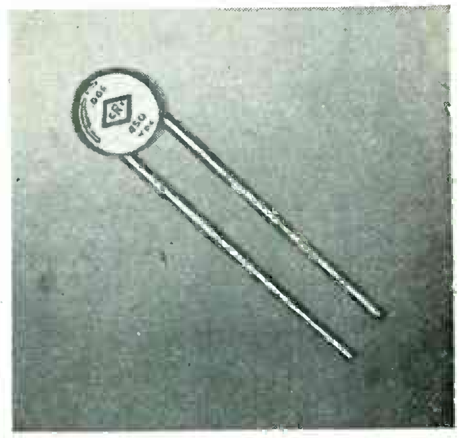
Electronic Industry



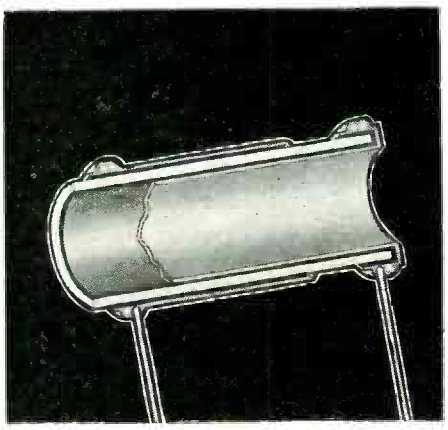
4 CRL *Hi-Vo-Kaps* combine high voltage and small size for television applications. For use as filter and by-pass capacitors in video amplifiers.



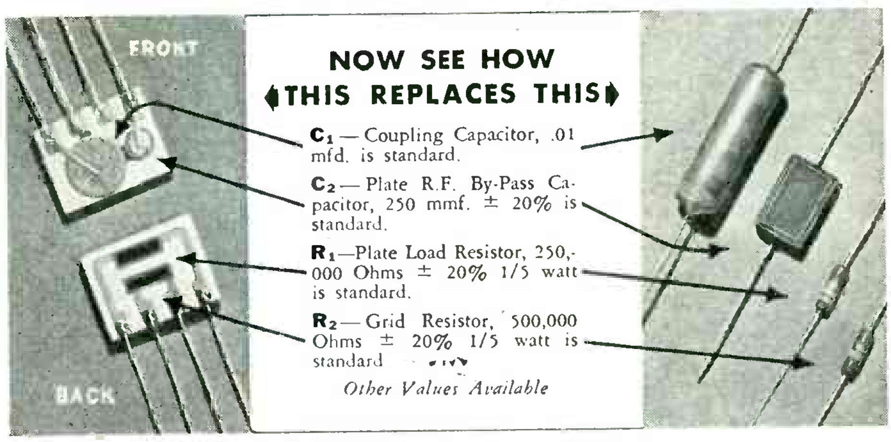
5 Revolutionary, CRL *Lever Switch* features exclusive coil spring design. Guaranteed minimum life of 50,000 cycles. Write for Bulletin 970.



6 For utmost reliability in small physical size, low mass weight, use CRL *Hi-Kaps* — miniature ceramic disc capacitors. Write for Bulletin 933.



7 The recognized dependability and high quality of Centralab's ceramic capacitor line is now available in quantities for quick delivery.



8 First commercial application of the "printed circuit", CRL's new *Couplate* offers a complete interstage coupling circuit consisting of an integral assembly of *Hi-Kap* capacitors and resistors closely bonded to a steatite ceramic plate and mutually connected by metallic silver paths "printed" on the base plate.

Look to Centralab in 1947! *First in component research that means lower costs for electronic industry. If you're planning new equipment, let Centralab's sales and engineering service work with you. Get in touch with Centralab!*

Centralab

CRL

DIVISION OF GLOBE-UNION INC., MILWAUKEE, WIS.

DU MONT *announces the new . . .*

CONTINUOUS-MOTION/SINGLE-IMAGE OSCILLOGRAPH-RECORD CAMERA Type 314

AVAILABLE NOW FOR DELIVERY FROM STOCK IN LIMITED QUANTITIES

Applicable to ALL 5-inch cathode-ray oscillographs!

SPECIFICATIONS...

- ✓ Wide range of film speeds (3600 to 1) — from 1 inch per minute to 5 feet per second.
- ✓ Instantaneous change from low- to high-speed recording.
- ✓ Calibrated electronic speed control (in./min. and in./sec.)
- ✓ Quickly detached to free oscillograph, or for use with other oscillographs.
- ✓ Fixed-focus f/2.8 or f/1.5 lens for medium- or high-speed recording.
- ✓ Capacity of 100 feet of 35 mm. film or paper; provision for 1000 feet if required. Film footage indicator.
- ✓ Operates independently of ambient light. Simultaneous viewing and recording of trace.
- ✓ Self-illustrated data card for labeling given "takes" directly on film. Provision for timing markers.

➧ To meet the need for permanent records of complex phenomena, Du Mont proudly presents a camera capable of photographing all types of traces — high or low frequency; periodic or aperiodic; continuous-motion or single-image; and for time intervals up to 200 hours.

The new Du Mont Type 314 Oscillograph-Record Camera* provides all users of cathode-ray oscillographs with a useful, simple, practical recording means. It opens the way for precise quantitative measurements. It permits direct comparisons of traces recorded at different times under varying conditions.

For maximum convenience, the mounting, operation and dismounting of this camera are reduced to simplest terms consistent with the requirements and practices of the widest range of oscillograph users.

• • •

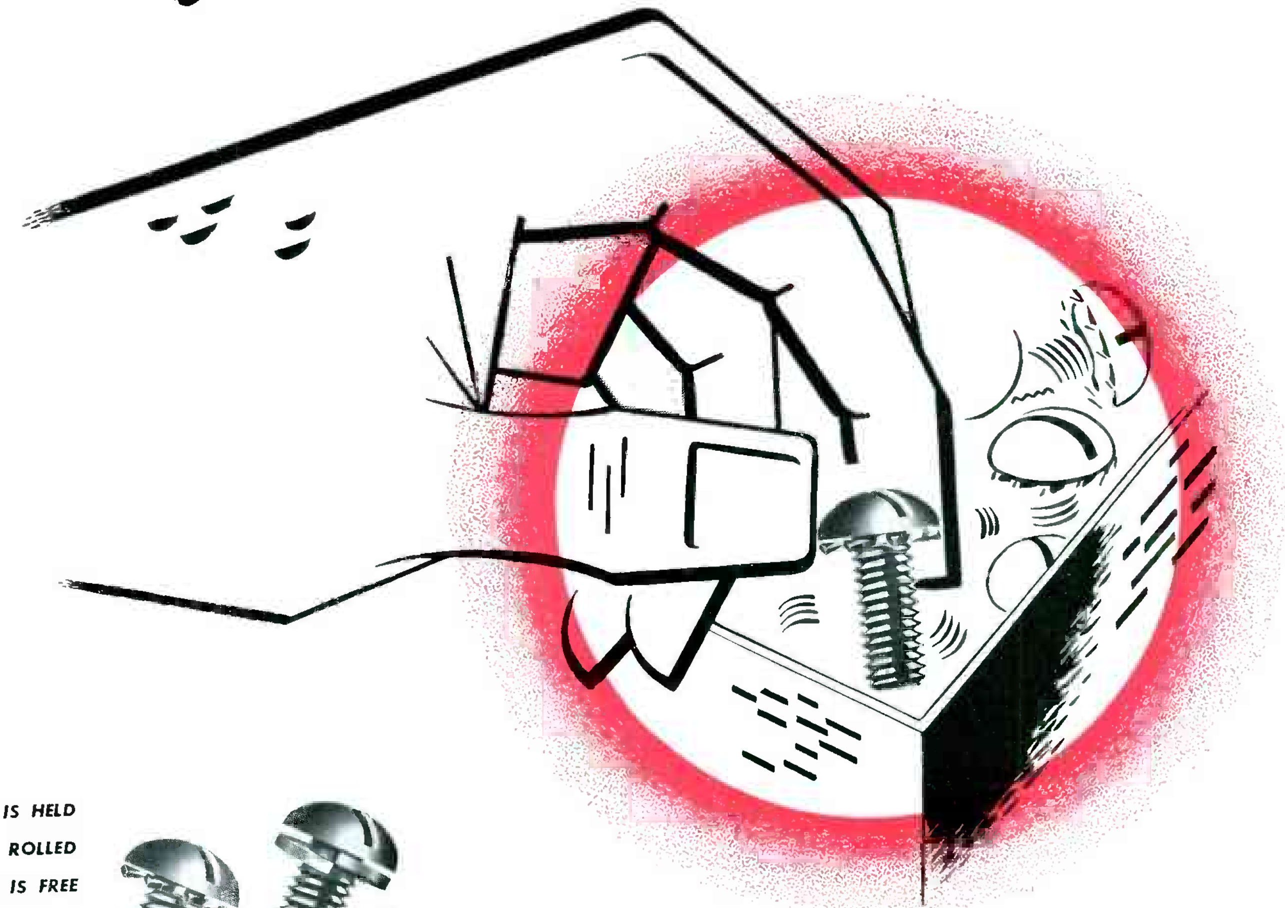
*Manufactured for Du Mont by Fairchild Camera and Instrument Co.

➧ ***Descriptive literature on request.***

DUMONT *Precision Electronics & Television*

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

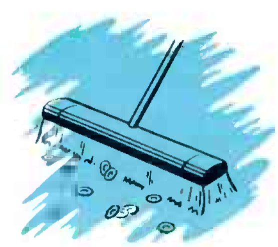
Two Parts... but *only* One unit to handle



THE WASHER IS HELD ON BY THE ROLLED THREAD AND IS FREE TO ROTATE!

save money with SEMS

DRIVING IS EASIER, FASTER. SEMS ARE PERFECT FOR HARD TO REACH PLACES



NO DROPPED OR WASTED WASHERS. ASSEMBLY MOVES SMOOTHLY.

SEMS ELIMINATE COSTLY HAND ASSEMBLY; SAVE TIME AND LABOR!

ANY OF THESE MANUFACTURERS WILL SEND YOU THE SEMS DATA BOOK, *FREE!*

Russell, Burdsall & Ward
Bolt & Nut Co.
Port Chester, N. Y.

Scovill Manufacturing Co.
Waterville Division
Waterville, Conn.

Shakeproof Inc.
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National Lock Co.
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Cleveland, Ohio

New England Screw Co.
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Pheoll Manufacturing Co.
Chicago, Illinois

ILLINOIS TOOL WORKS • CHICAGO • Originator of Sems

At Station WBRC, Birmingham, Alabama

THIS FEDERAL TUBE STAYED ON THE AIR

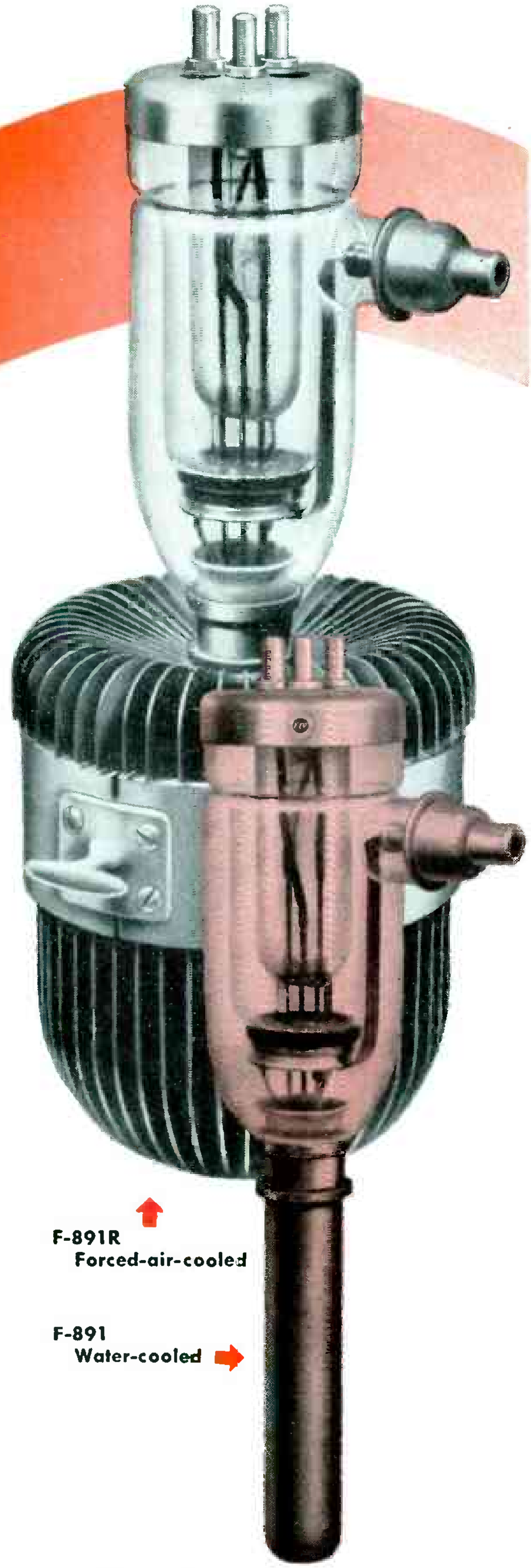
for more than

20,000 HOURS!

FEDERAL'S F-891R AM broadcast tubes have established an outstanding service record at Station WBRC—for Mr. G. P. Hamann, chief engineer, reports that "these tubes all have a life in excess of 20,000 hours"! That's well over three years of *actual operation*—and it's meant substantial savings in tube replacement costs.

In major AM stations from coast to coast, Federal broadcast tubes have won the confidence of engineers and operators—by consistently setting the standards of performance, tube life, and operating economy. The F-891R modulator tube, and the corresponding F-892R power amplifier, are two forced-air-cooled triodes which have proved extremely satisfactory for small and medium-sized AM broadcast stations. Water-cooled types of equivalent rating, the F-891 and F-892, are also available.

If you want top performance like this, specify Federal broadcast tubes. For their long life and permanence of characteristics is the cumulative result of more than 38 years of research and manufacturing experience—continual pioneering in new ways to build better tubes. For complete technical data on these AM tubes, write to Federal today—Dept. K713.



FTR
An IT&T Associate

Federal Telephone and Radio Corporation

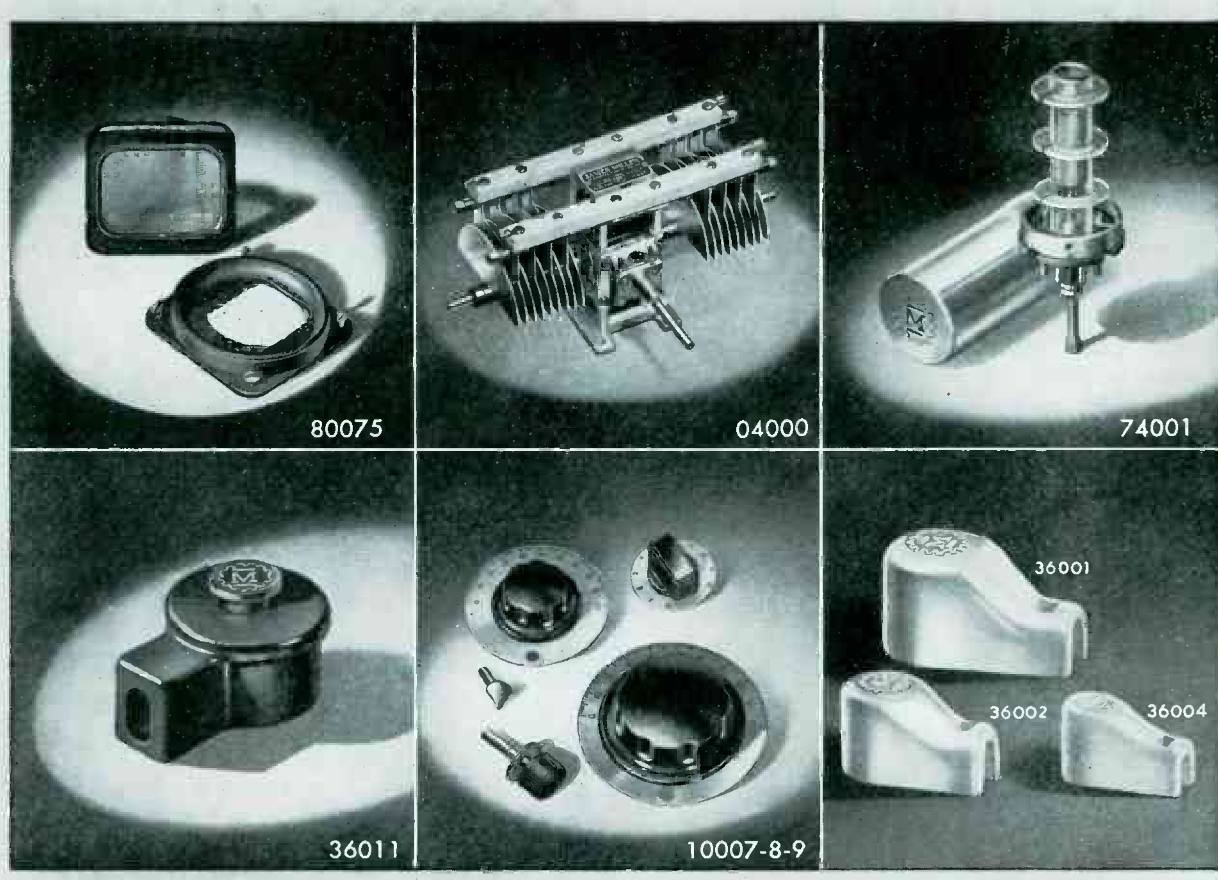
100 KINGSLAND ROAD, CLIFTON, NEW JERSEY

KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

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

Designed for Application

Millen "Designed for Application" components are different! As a designer and manufacturer for many years of complex electronic and communication equipment, we are our own best customer for component parts. Consequently, we have to perform an outstanding job of designing and manufacturing such parts in order to satisfy our own applications. Our parts are "different", also, because as symbolized by the "Gear wheel" of our registered trade mark, they are designed by mechanical engineers working in close cooperation with our electronic circuit group. Below are illustrated a typical half dozen of the thousand-odd items we manufacture.



Illustrated above, left to right; Top row: The No. 80075 cathode ray tube Bezel, the No. 04000 series of adjustable shaft angle, center drive variable transmitting condensers and the No. 74001 permeability tuned shielded plug-in coil form. Bottom row: The No. 36011 snap lock multiple finger contact plate caps, the small panel dials and finally the Ceramic insulated plate caps.

JAMES MILLEN MFG. CO., INC.

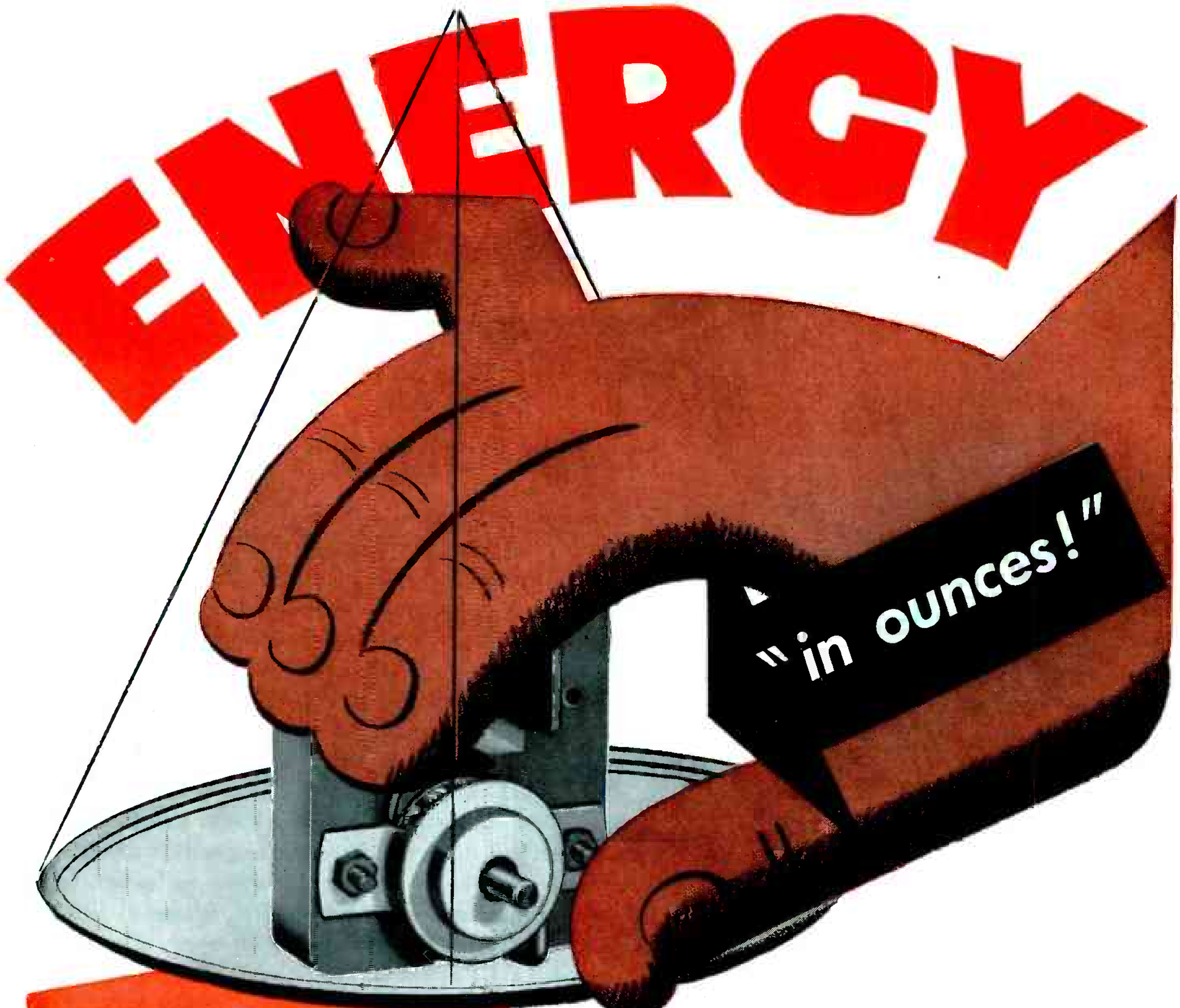
MAIN OFFICE AND FACTORY

SALES OFFICES IN ALL PRINCIPAL CITIES

MALDEN MASSACHUSETTS

CANADIAN SALES ASTRAL ELECTRIC CO. SCARBORO BLUFFS (TORONTO)

6



The Alliance Powr-Pakt Model MS Motor is for 110 volts, 60 cycle operation. Here is a truly miniature power plant so compact and light in weight that it can be used for many designs calling for more "tailored power."

The Model MS fills the growing need for small compact motors to increase the motion and utility features in thousands of new products.

Alliance Powr-Pakt motors are mass produced. They can be built with design variations to meet special load and operating conditions . . . where motors rated from less than 1/400th h.p. on up to 1/20th h.p. are required.

MINIATURE MOTORS THAT MAKE 'EM MOVE!

- **Light weight, compact, interchangeable power sources** . . . small motors that can be mass produced at low cost are in rapidly growing demand! And Alliance has a *"Head Start"* in making millions of small electric motors.
- *Alliance phonomotors* drive most of the turntables, record changers and recorders for the radio-phonograph industry. And Alliance Powr-Pakt Motors rated from less than 1-400th h. p. up to 1-20th h. p. will drive fan blades, motion displays, projectors and actuate switches and controls!
- Write today . . . find out how Alliance Motors can help to drive your products to market!

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO
EXPORT DEPARTMENT, 401 BROADWAY, NEW YORK 13, NEW YORK, U. S. A.

PUNCTURE PROOF

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

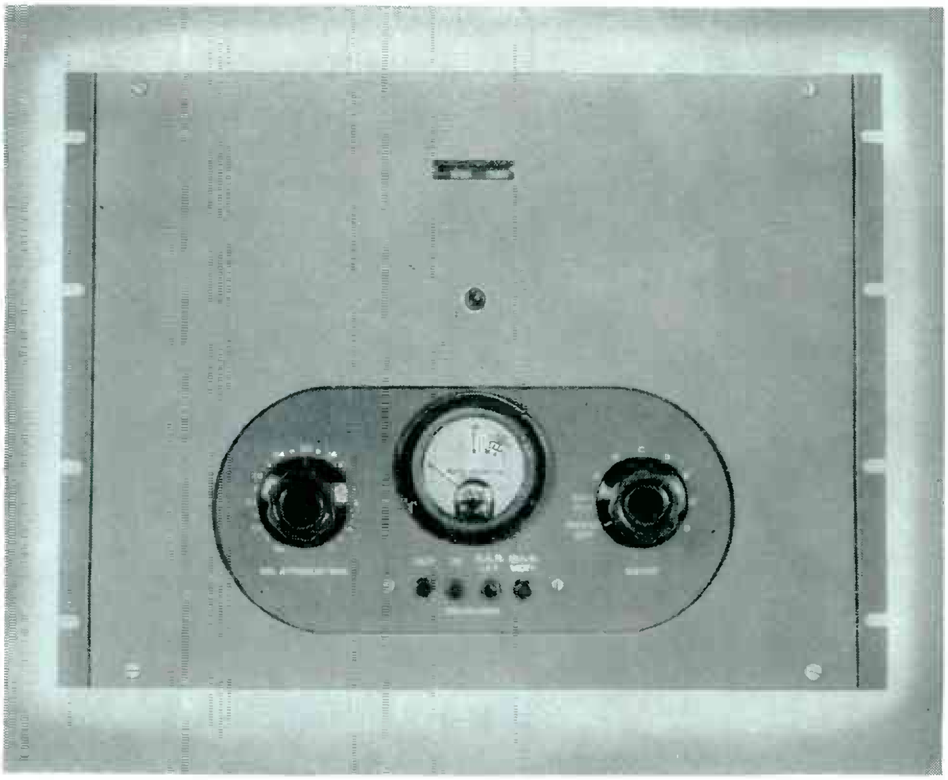
The dielectric of the Lapp condenser is an inert gas, non-deteriorating and puncture proof. After years of service, the condenser retains the same margin of security it had when installed in the circuit. Also, it offers lower loss than solid-dielectric units, with corresponding economy of power. Not 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.

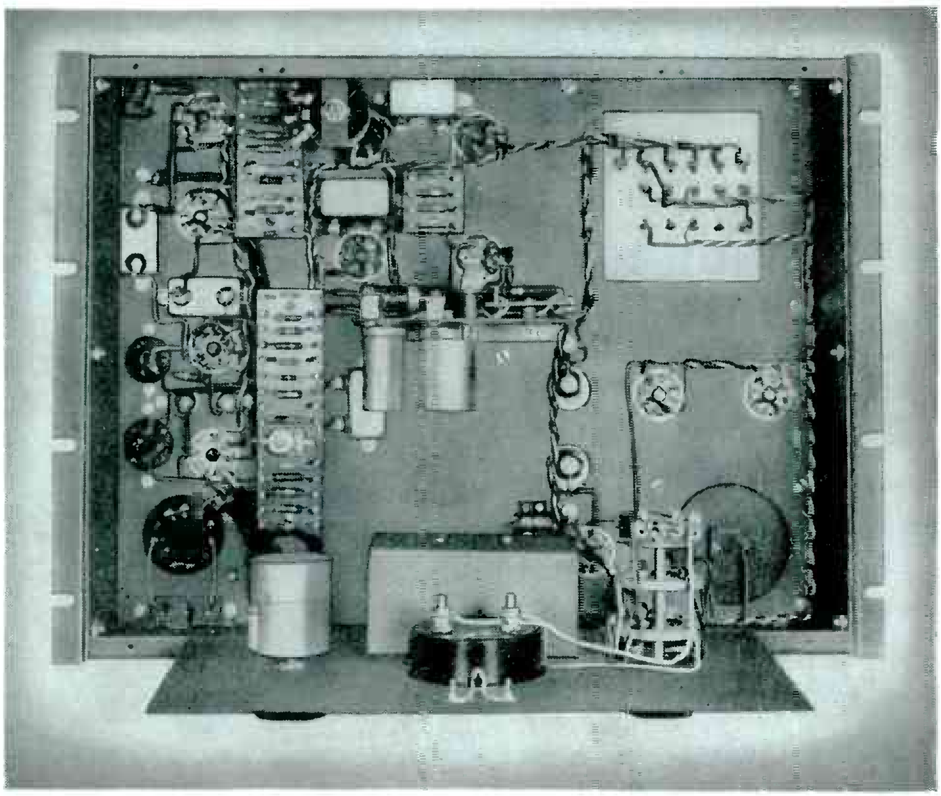
Lapp

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

Presto Presents Something New in Recording Amplifiers...

The new Presto 92-A is a 50-watt amplifier designed specifically for recording work. It answers the need for an amplifier of exceptional quality and performance, and includes a number of outstanding features thoroughly proved in operation:





1 Selector switch and meter provide both output level indicator (not for "riding gain") and plate current readings for all tubes.

2 Chassis is vertically mounted. Removal of the front panel gives access to all circuits without removing amplifier from rack.

3 The output stage has four 807's in push-pull parallel with an unusual amount of feedback. This produces ample peak power with low distortion and an extremely low internal output impedance for best performance from magnetic cutting heads.

Push buttons select any of these recording characteristics: flat, 20-17,000 cps, 78 rpm, standard NAB lateral, NAB vertical—all within an accuracy of ±1 db. Distortion is only 1½% at full output.

PRESTO

RECORDING CORPORATION

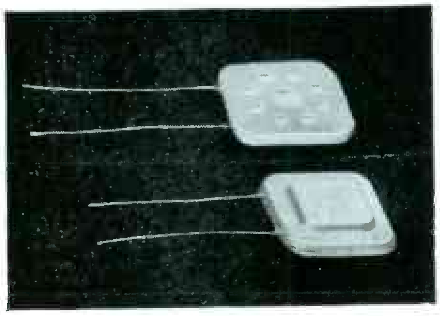
248 WEST 55TH STREET, NEW YORK 19, N. Y.

Walter P. Downs, Ltd., in Canada

FREE! Presto will send you free of charge a complete bibliography and digest of all technical and engineering articles on disc recording published since 1921. Send us a post card today.

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT & DISCS

from TIBBETTS INDUSTRIES



Model HAR-6 illustrated
1½ times actual size

★ **A SQUARE HEARING AID MICROPHONE**

★ **AN ENTIRELY NEW HEARING AID RECEIVER**

Now even smaller, better hearing aids are possible!

Here they are! — two new, infinitely better hearing aid components from Tibbetts, makers of the famous HA-30 Monobar-Diabow Hearing Aid Microphone. Thousands used in hearing aids all over the world. The results of long research, the HS-41 Microphone and HAR-6 Receiver are the **smallest for their output** on the market. Look at these outstanding performance features:

Model HS-41 SQUARE Microphone

An important improvement in hearing aid mikes.

- Only 1 1/32" square, .210" thick overall.
- Case bottom recessed to save space.
- Output at 1000 cps: minus 49-Db — volt/dyne/cm^2.
- Grilled protective cover.
- Features Tibbetts exclusive Monobar-Diabow Crystal Element.

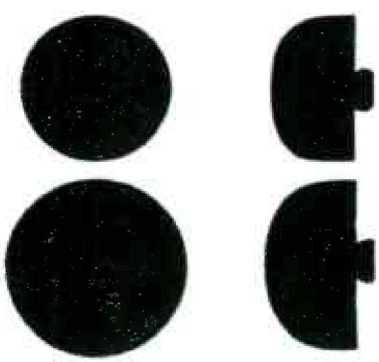
Model HAR-6 Crystal Hearing Aid Receiver

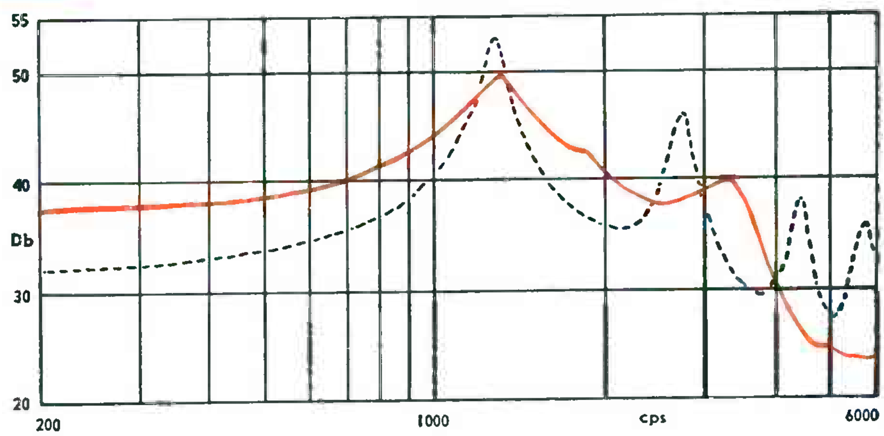
- Exceptionally sensitive (see chart)
- Smallest, lightest receiver for output available.
- Flesh-pink color case.
- Features Tibbetts exclusive Monobar-Diabow Crystal Element.

Compare for Sensitivity!
Compare for Size!

The chart* and shadowgraph show the HAR-6 compared with Receiver "X" for sensitivity and size — proof of the superiority of this new Tibbetts Product!

TIBBETTS HAR-6 ————





RECEIVER "X" - - - - - - - -

(ACTUAL SIZE)

*The curves shown are from our actual laboratory tests. The input to the receivers was held constant at 5 volts. The pressure output of the receiver was measured with a 2 cc cavity artificial ear with ear tip. 0 Db reference is 1 dyne/cm^2.

Find out more about the performance and size advantages of these new Tibbetts Products. Write today for detailed information.

TIBBETTS INDUSTRIES, INC.
CAMDEN, MAINE

MONOBAR
Tibbetts
CRYSTAL

INCREASED PRODUCTION
to meet increased demand
permits NEW LOW PRICES
for FRANKLIN AIRLOOPS*

* AIRLOOPS . . . *back panel and loop antenna in one unit*

More and more manufacturers of receiving sets are adopting **AIRLOOPS** as standard for their loop antenna and cabinet back requirements . . . this increase in demand permits manufacturing economies which are going right back to **AIRLOOP** users, in the form of NEW LOW PRICES . . . competitively **AIRLOOPS** are the lowest cost loop antenna and cabinet back and more important **AIRLOOPS** incorporate many superior features which in themselves improve set performance . . . no set builder can afford to overlook the significance of the **AIRLOOP**.

. . . FRANKLIN AIRLOOPS are flat sheets of copper die-stamped into perfect super sensitive loops . . . are air dielectric throughout . . . are lower in cost . . . are back panel and loop in one unit . . . have high uniform "Q" over entire band . . . have low distributed capacity . . . have 27% greater effective loop area . . . have electrical and mechanical stability . . . increase set sensitivity . . . eliminate individual loop adjustment . . . eliminate haywire.

FRANKLIN *Airloop* **CORPORATION**

43-20 — 34th ST., LONG ISLAND CITY 1, N. Y.

SIMPSON Model 260

World's Most Popular High Sensitivity

Volt-Ohm-Milliammeter

...with Roll Top Safety Case

At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. Unequalled for high sensitivity testing in radio and television servicing and in industrial applications.

- Model 260 permanently fastened in Roll Top Case.
- Heavily molded case with Bakelite roll front.
- Flick of finger opens or closes it.
- Leads compartment beneath instrument.
- Protects instrument from damage.

Ask your Jobber

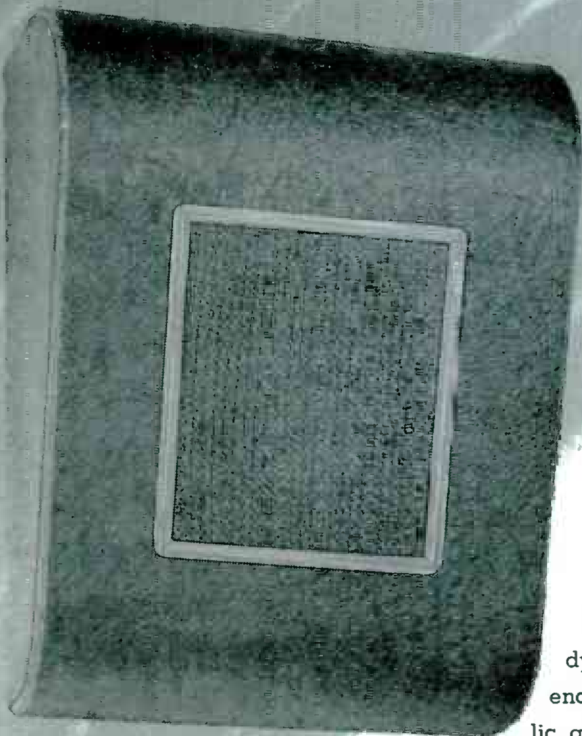
SIMPSON ELECTRIC COMPANY
5200-5218 West Kinzie Street, Chicago 44, Illinois
In Canada, Bach-Simpson Ltd., London, Ont.

Model 260—Size 5¼" x 7" x 3⅛" $38.95
Model 260, in Roll Top Safety Case—Size 5⅜" x 9" x 4¾" . $43.75
Both complete with test leads

The Ranges

Volts D.C. (At 20,000 ohms per volt)	Volts A.C. (At 1,000 ohms per volt)	Output	Milliamperes D.C.	Microamperes D.C	Amperes D.C.	D. B. Ranges	Ohms
2.5	2.5	2.5 V.	10	100	10	−10 to	0-2000
10	10	10 V.	100			+52DB	(12 ohms center)
50	50	50 V.	500				0-200,000
250	250	250 V.					(1200 ohms center)
1000	1000	1000 V.					0-20 megohms
5000	5000	5000 V.					(120,000 center)

Simpson
INSTRUMENTS THAT STAY ACCURATE



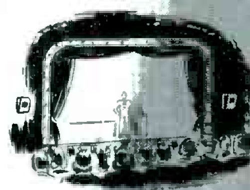
Jensen
Model J-61
WALL CABINET

Model J-61 Wall Cabinet, employing the Peri-dynamic principle, is another new JENSEN enclosure, destined for wide use in such public address installations as hotels, factories, schools, airports, railroad stations and offices. It may also be used to enclose extension speakers in homes. It can be used with any 6-inch speaker.

Model J-61 Wall Cabinet is of durable construction and beauty of design and finish and is formed of attractively textured brown composition wood over solid wood frame. The grille is of matching brown fabric with chrome trim around aperture. Brackets for wall mounting are furnished. On the back is mounted a 5-lug terminal strip. Height, 16-2/3 inches; width, 12¾ inches; depth, 6¼ inches.

Model J-61 Wall Cabinet (ST-751)....$14.50


OFFICES

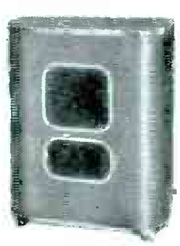

SCHOOLS

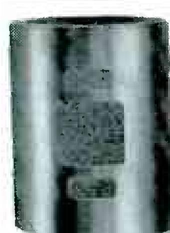

RAILROAD STATIONS


AIRPORTS

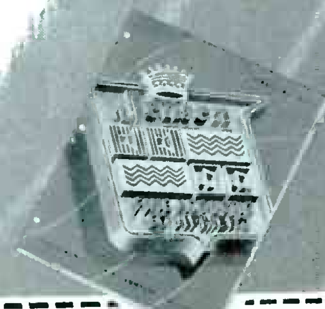
JENSEN BASS REFLEX CABINETS


TYPE D


TYPE B


TYPE H

Designers and Manufacturers of Fine Acoustic Equipment



JENSEN MANUFACTURING CO.
6607 S. LARAMIE, CHICAGO 38, ILL.

Please send me a copy of the 1947 Jensen catalog.

Name............................

Address..........................

City.............*Zone*....*State*.......

KENYON T-LINE ADDITIONS
For Amateur and Industrial Use!

KEN-O-TAP UNIVERSAL DRIVER TRANSFORMERS

500 Ohm Line to any Class B Grids — Primary to Secondary Ratio Variable from 1:13.3 to 1:.7

Type	Power Rating	Case No.	Weight	List Price
T-261	7 Watts	3A	2¾ lbs.	$ 9.70
T-262	18 Watts	4A	5¼ lbs.	13.20

Any Line or Single or Push Pull Plates to Class B Grids — Primary to ½ Secondary Ratio Variable from 7.0:1 to 1:9.0

Type	Audio Rating	Case M Size	Max. Pri. D.C.	Max. Sec. D.C.	Weight	List Price
T-264	7 Watts	3A	100 MA	100 MA	2¾ lbs.	$ 9.95
T-263	18 Watts	4A	200 MA	200 MA	5¾ lbs.	15.25

FILAMENT TRANSFORMERS

Primary 115 Volts, 50 to 60 Cycles

Type	Sec. Rating	Insul. Test	Case No.	Weight	List Price
T-393	5/5.1/5.25 V. — 26 ACT	2000 V.	5A	9½ lbs.	$17.30
T-394	5/5.1/5.25 V. — 32 ACT	2000 V.	5A	10½ lbs.	18.65
T-395	6.3 V. — 20 ACT	2000 V.	5A	9 lbs.	15.30
T-396	6.3 V. — 30 ACT	2000 V.	5½A	12 lbs.	21.00
T-397	6.3 V. — 12 ACT	2000 V.	4A	5¾ lbs.	10.90

PLATE TRANSFORMERS

Primary 115 Volt, 50 to 60 Cycles

Type	Primary Conn.	Secondary Volts D.C.	Secondary Volts A.C.	M.A. D.C.	Case No.	Weight	List Price
T-673	High	3000	3400-0-3400	400	10A	82 lbs.	$110.00
	Low	2500	2840-0-2840	500			
T-674	High	3000	3400-0-3400	800	Special	135 lbs.	155.00
	Low	2500	2840-0-2840	1000	End Castings		

These Units are designed for Continuous Duty on Low Voltage Taps at 85% of D.C. Current Rating.

REACTORS

Type	Inductance At Rated D.C.	Rated D.C. MA.	D.C. Resistance	Insul. Test	Case No.	Weight	List Price
T-180	10	500 MA.	60	7000 V.	8A	26¼ lbs.	$43.00
T-181	5	1000 MA.	18	7000 V.	9A	50 lbs.	63.00
T-530	6/20	500/50 MA.	60	7000 V.	8A	26¼ lbs.	43.00
T-531	3/10	1000/100 MA.	18	7000 V.	9A	50 lbs.	63.00

KEN-O-TAP MODULATION TRANSFORMERS

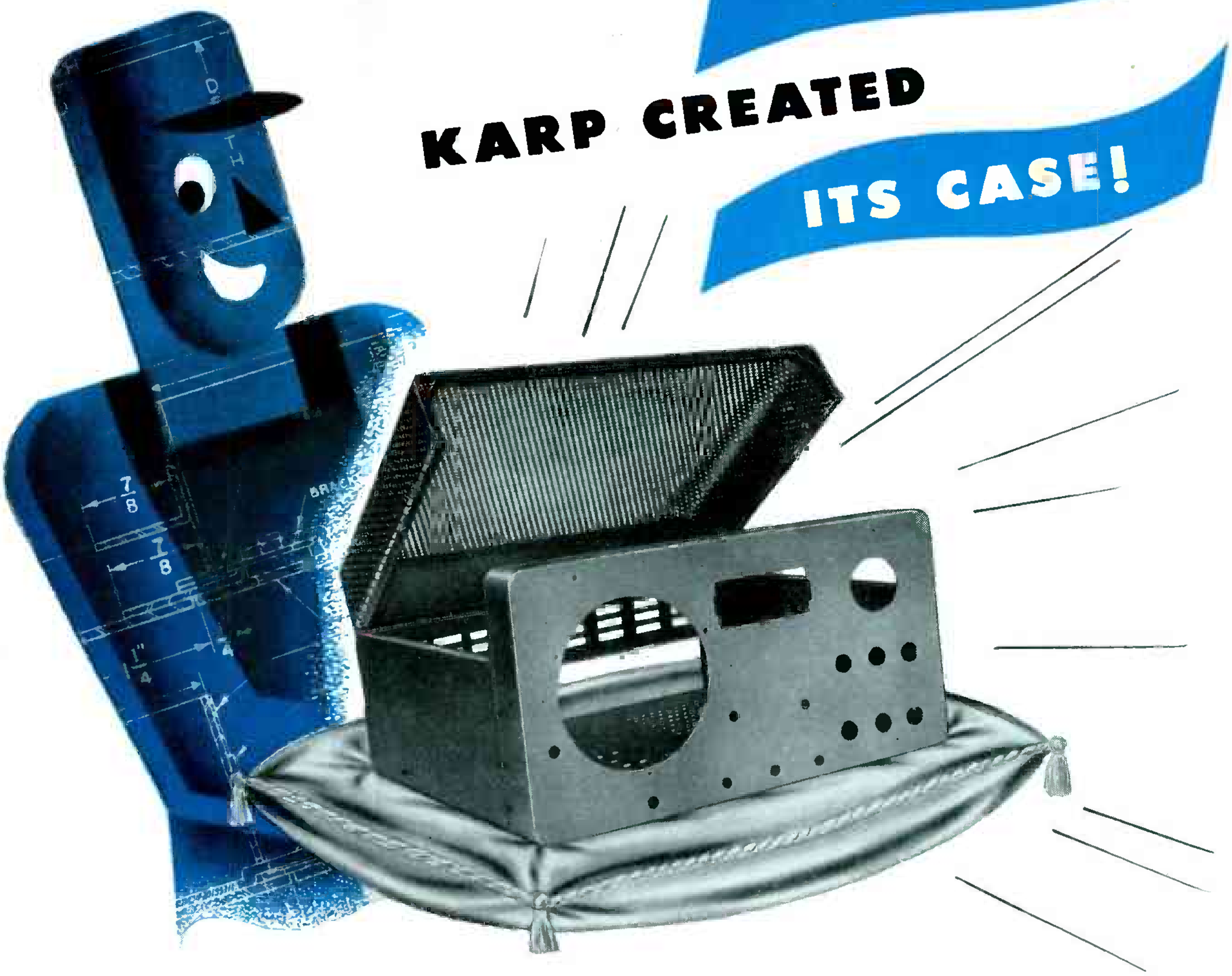
Type	Audio W. Pri.	Class C W. Sec.	Max. Pri. D.C.	Max. Sec. D.C.	Max. D.C. Voltage	Primary Range Ohms	Sec. Range Ohms	Case No.	Weight	List Price
T-441	125	250	250 MA.	250 MA.	1500	2000-20000	200-20000	6A	15½ lbs.	$25.20
T-442	600	1200	400 MA.	400 MA.	3000	500-18000	200-19000	9A	45 lbs.	67.50

YOUR INQUIRIES ARE INVITED. WRITE TODAY FOR FURTHER DETAILS.

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK 59, N.Y.

HALLICRAFTERS CREATED A JEWEL

KARP CREATED ITS CASE!



THE HALLICRAFTERS SX-43 RECEIVER is being hailed as another great advancement in communications equipment. We're glad of the part we have contributed to its success by fabricating a cabinet worthy to house this superior apparatus.

You can be sure there's a reason when manufacturers of exacting standards come 1000 miles and more for cabinets, housings and enclosures by Karp The big reason is that Karp-constructed cabinets not only enhance the appearance and market value of equipment, but afford real long-run economy as well.

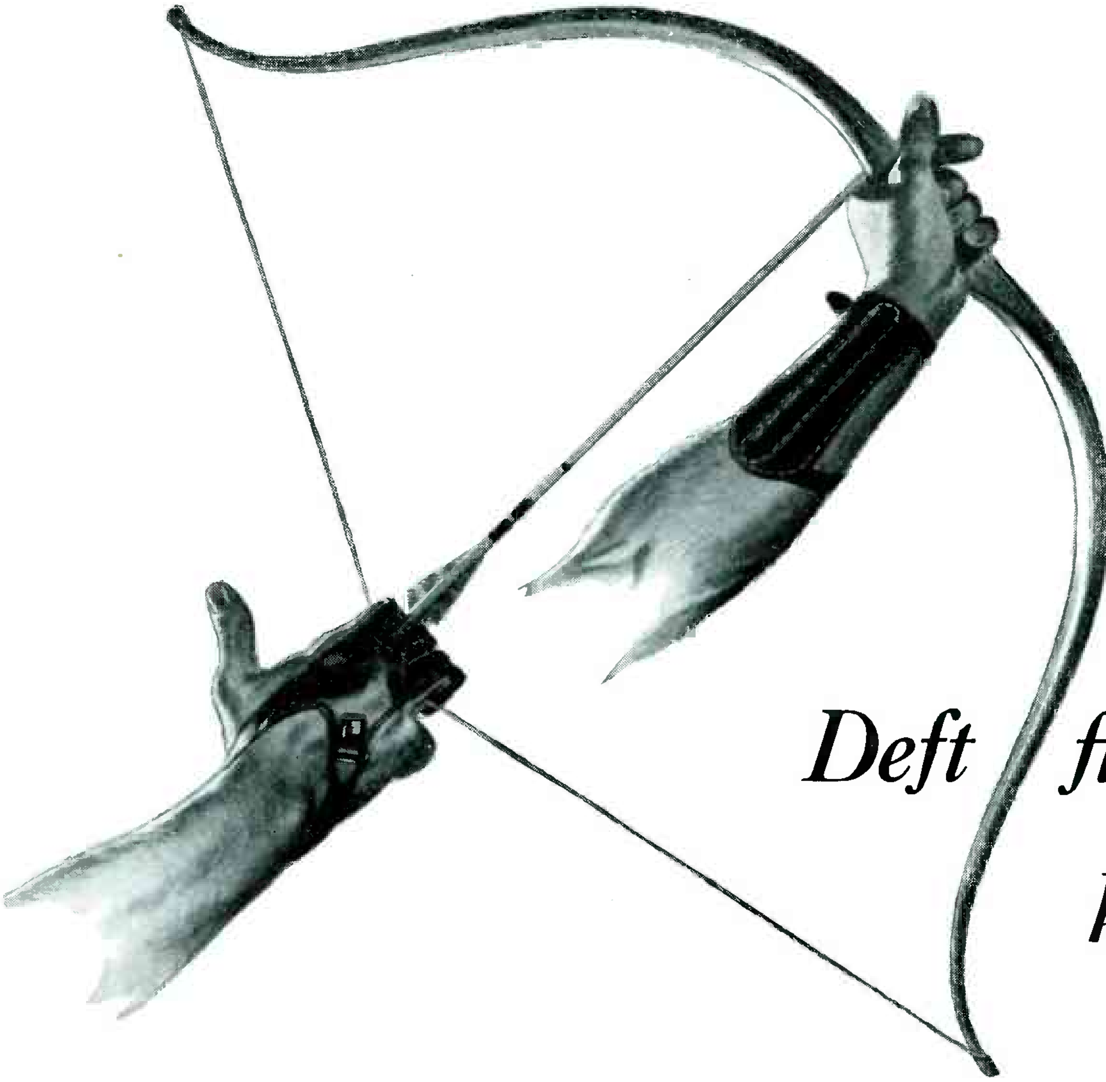
Karp cabinets are so painstakingly, so uniformly constructed that they save you time and money by their ease of assembly in your plant. Show us your blueprints. Get our quotations. Write for new brochure.

Any Metal • Any Gauge • Any Specification • Any Quantity • Any Finish

KARP METAL PRODUCTS CO., INC.

124 - 30th STREET, BROOKLYN 32, NEW YORK

Custom Craftsmen in Sheet Metal



Deft fingers know!

A skilled archer responds to the smooth, speedy cast of a fine yew bow. So does the professional draftsman respond to the smooth, easy performance of TYPHONITE ELDORADO leads. You'll learn the joy of a job well done with

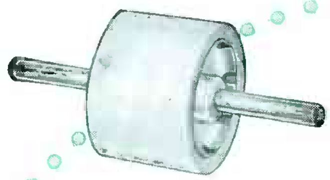
DIXON'S TYPHONITE

ELDORADO

PENCIL SALES DEPT. 59-J11, JOSEPH DIXON CRUCIBLE CO., JERSEY CITY 3, N. J.

High Voltage and HIGH KVA

CERAMICONS* *by Erie Resistor*



10,000 VOLT TELEVISION POWER SUPPLY CERAMICON

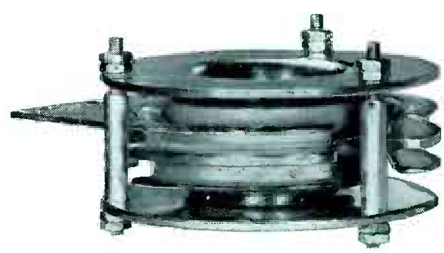
Type 401 Erie Ceramicon is a compact ceramic condenser with 10,000 Volt DC. rating. Extremely simple design employs one piece body, .860" OD x 5/8" long, 500 MMF minimum capacity, unit already has proven ideal for television power supply filter condensers. Also made in 20 and 51 MMF capacity ranges.

9,000 VOLT BY-PASS CERAMICON

This new ceramic dielectric by-pass condenser is rated at 10,000 RMS test and 7 KVA load. Maximum operating temperature is 100°C. Type 2344 Erie Ceramicon is available in capacities up to 1,000 MMF. Size approximately 4 1/8" high.

200 AMP. FEED-THRU BY-PASS CERAMICON

Erie Type 2373 Ceramicon is ideal for power line terminals to by-pass radio frequency currents on industrial heating and similar equipment. Conservatively rated at 1,000 Volts DC. operated with current carrying capacity of 200 Amps. overall length 4½". Standard capacity ranges, 250 MMF, 650 MMF, 1,000 MMF, and 10,000 MMF.



10,000 VOLT, 20 KVA CERAMICON

This plate-type ceramic condenser combines ratings of 20 KVA and 10,000 Volts DC. with compact size, only 4 3/8" dia. x 2-5/16" height. With forced air circulation rated load is above 50 KVA at 15 MC. Type 3688 Ceramicon is made in 500 MMF and 1,000 MMF capacities.

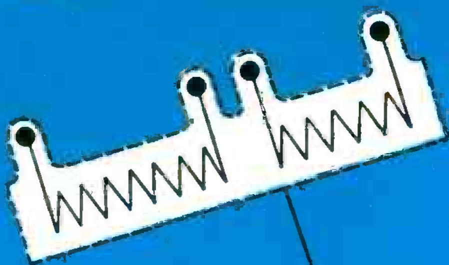
* Ceramicon is the registered trade name of silvered ceramic condensers made by Erie Resistor Corporation

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

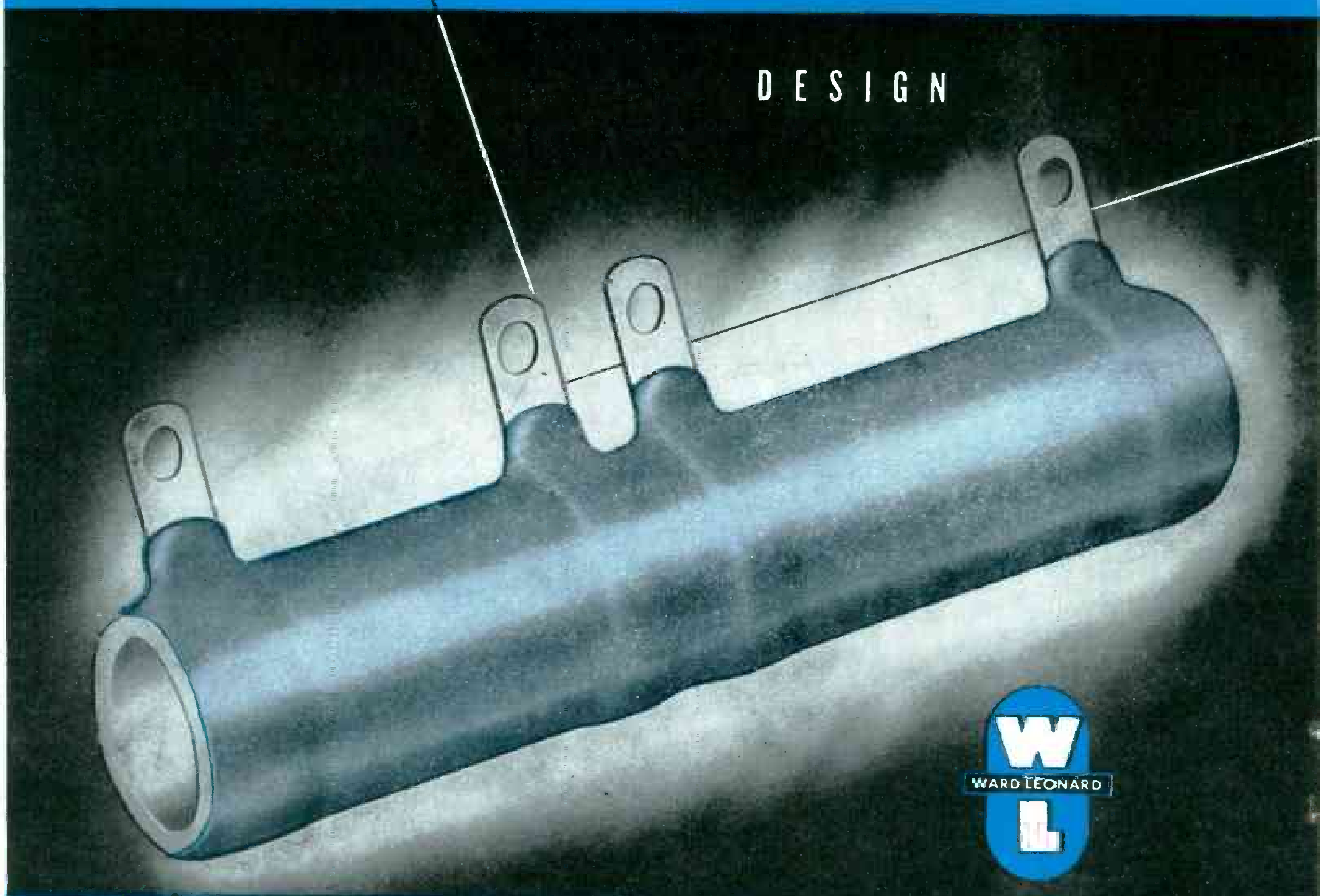
LONDON, ENGLAND • • TORONTO, CANADA

Siamese Twin Resistor



SAVES 40%

IN TELEVISION SET ASSEMBLY COST



WARD LEONARD ELECTRIC CO.

Where Basic Designs in Electric Controls

In a television receiver circuit, two power wound resistors were needed, but the space for mounting them was hard to find.

So Ward Leonard suggested: instead of two separate resistors, each requiring individual mounting and installation, let's make a single Vitrohm unit with two *electrically independent* resistance windings.

This unit is mounted just like any single resistor.

RESULT: less space needed . . . assembly cost cut 40%!

FOR YOUR PRODUCT'S FASTER ASSEMBLY... OR BETTER PERFORMANCE— PUT THE PROBLEM THROUGH

Result-Engineering

As this case shows, it often happens that by a slight modification of a basic design or by use of a certain manufacturing method, Ward Leonard can give you the *exact* result you need—without the extra cost of a *special* design.

Before you decide to "make the best" of a "standard" component, or pay a premium for a "special", submit the problem to Ward Leonard. At no obligation, see if "Result-Engineering" can't work out the solution for you.

Blue means "Result-Engineering" in resistors, rheostats, relays and other electric controls. The distinctive blue identifies Ward Leonard "Result-Engineering"

FREE BULLETINS on "Result-Engineered" Resistors. (*Please request on business letterhead, mentioning your title.*) WARD LEONARD ELECTRIC CO., Mount Vernon, New York. *Offices in principal cities of U. S. and Canada.*


MANUFACTURING

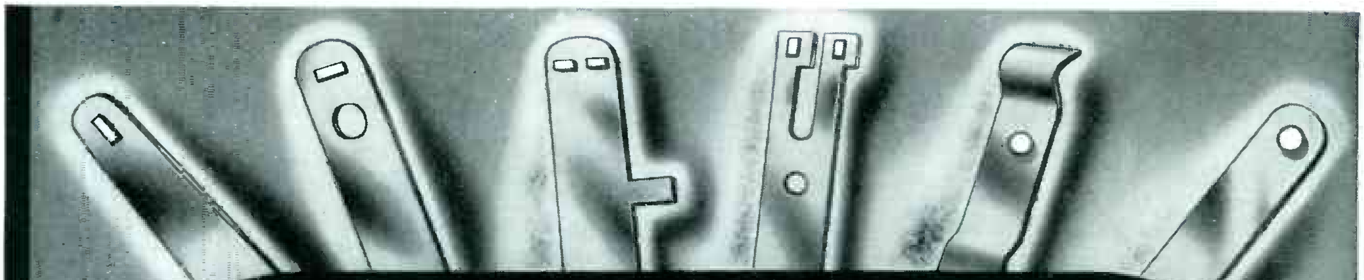
CRAZELESS ENAMEL CHASES HEAT

VITROHM Resistors are processed with a special vitreous enamel of Ward Leonard's own manufacture. VITROHM—tough, hard, moisture and acid resisting—fuses tightly to base (a) terminal connection (b) and wire (c) providing a medium (d) for quickly dissipating heat and protecting the resistance element.

Result: wire and surface temperatures maintained within close range.

RESISTORS • RHEOSTATS
RELAYS • CONTROL DEVICES

are "Result-Engineered" for You



Electrical Contact Material for Bar or Disc Contacts

Our contact material is available in bi-metallic form . . . palladium, platinum or silver, pure or alloyed, bonded to nickel or nickel silver . . . or in solid form of any precious metal or alloy.

We are prepared to –

- . . . **supply this material for your own attaching**
- . . . **attach the contact material to arms supplied by you**
- . . . **provide complete assemblies of arms with contact material attached**

Our new bar contacts result in a great saving of precious metals with assured contact area equal to the width of the bar, with larger mislocation tolerances, and with marked economy in attaching. But whether bar or disc, these contacts are permanently welded with a weld strength of 25 to 35 pounds where thickness of blade permits, and they can be positioned within .005 on length and .010 transverse.

The electrical conductivity and life of a welded contact greatly exceeds that of the mechanically applied type because it is fused . . . permanently bonded to the arm, not dependent upon mechanical pressure for electrical contact between arm and contact.

One of our sales engineers will be pleased to assist you in comparing the costs of our materials and methods of application with conventional types.

BAR CONTACT TAPE . . . under license arrangement with Western Electric Company, Inc.

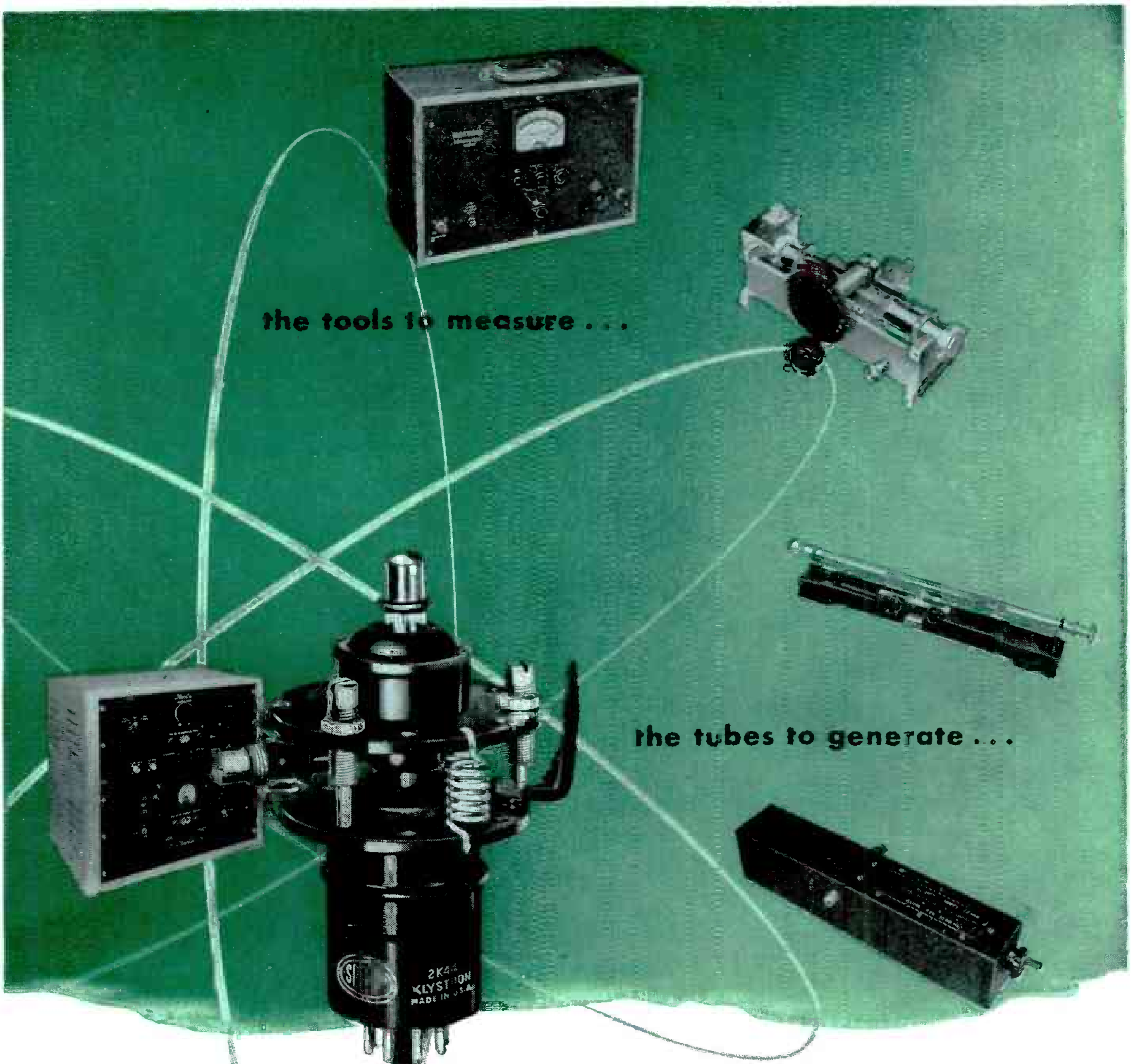
START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS • FABRICATED PARTS AND ASSEMBLIES OF SOLID AND LAMINATED PRECIOUS METALS

D. E. MAKEPEACE COMPANY

Main Office and Plant, Attleboro, Massachusetts

NEW YORK OFFICE, 30 CHURCH ST. CHICAGO OFFICE, 55 EAST WASHINGTON ST.



microwave Energy

The Sperry Klystron Tube to generate ultra-high-frequency microwaves . . .

The Sperry Klystron Signal Source to "power" them . . .

The Sperry Microline to test and measure them . . .

These Sperry products equip the research or development engineer with every essential for development or design in the microwave field.

The Sperry Klystron Tube has already opened up new vistas in navigation, aviation, medicine, radio, telephone, telegraph and other major applications. It is ready for many new local oscillator or high power uses.

The Sperry Microline includes practically every type of instrument for quick precision measurements in the microwave frequency bands.

This Sperry service — beginning with a source of microwave energy, the Klystron, and following through with every facility for measuring microwaves — opens up almost unlimited possibilities for industry.

We will be glad to supply complete information.

Sperry Gyroscope Company, Inc.

EXECUTIVE OFFICES: GREAT NECK, NEW YORK • DIVISION OF THE SPERRY CORPORATION

NEW YORK · CLEVELAND · NEW ORLEANS · LOS ANGELES · SAN FRANCISCO · SEATTLE

your product

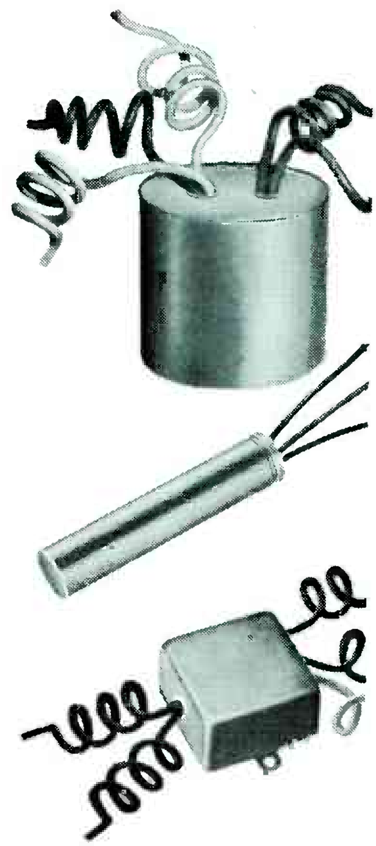
IS MORE SALEABLE WITH

Cornell-Dubilier C-D Capacitors *Quietones* Reg. U.S. Pat. Off.

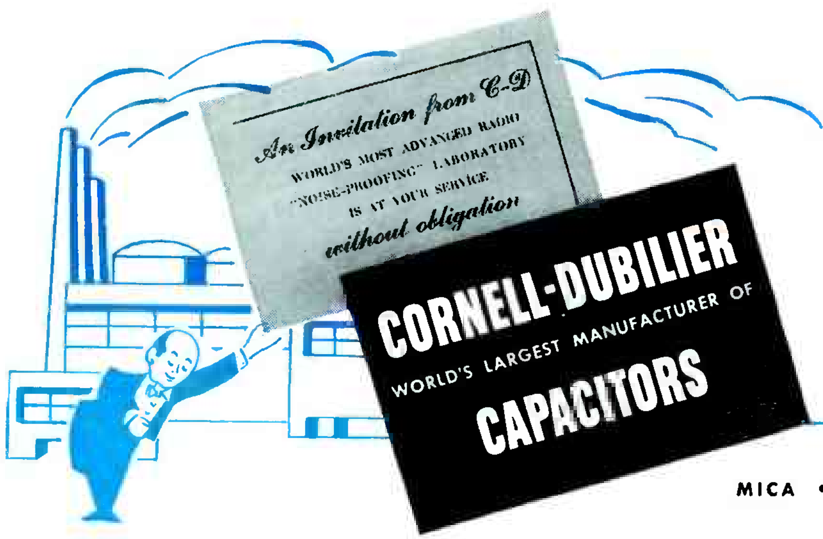
You may build the best appliance of its kind on the market — but if it sets up local radio interference—you'll have tough sledding against today's keen competition. Your customers are *demanding* radio noise-free performance in the electrical equipment they buy.

The answer, of course, is to equip *your* products with C-D Quietones. Why Quietones? First, because they're the best-engineered noise filters — second, because they guard your product's reputation by giving long trouble-free service — third, because they're designed and built to meet manufacturers' specific needs — efficiently and economically.

Speed up sales — build prestige — boost profits with C-D Quietones. Your inquiries are invited. Cornell-Dubilier Electric Corporation, Dept. K-11, South Plainfield, New Jersey. Other large plants in New Bedford, Brookline and Worcester, Mass., and Providence, Rhode Island.



Make Your Product More Saleable with C-D Quietone Radio Noise Filters and Spark Suppressors



CORNELL-DUBILIER
WORLD'S LARGEST MANUFACTURER OF
CAPACITORS

MICA • DYKANOL • PAPER • ELECTROLYTIC

★ You can **Reduce** Costs

★ You can **Improve** Performance with

ARNOLD

PERMANENT MAGNETS

Where's the manufacturer these days who doesn't need all the competitive and cost advantages he can get? Maybe you have new electrical or mechanical equipment in mind—designs or re-designs that should employ permanent magnets for best results. Maybe you have existing applications that permanent magnets will do *better*—save you time and money in production, and step up the efficiency of your product.

In either case, let Arnold's engineering service help you to find the answers to your magnet problems. Arnold offers you a fully complete line of permanent magnet materials, produced under 100% quality-control in any size or shape you require, and supplied in any stage from rough shapes to finish-ground and tested units, ready for final assembly. Write direct, or to any Allegheny Ludlum branch office.

W&D 1295

THE ARNOLD ENGINEERING CO.

Subsidiary of **ALLEGHENY LUDLUM STEEL CORPORATION**

147 East Ontario Street, Chicago 11, Illinois

Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS

SATURATED SLEEVING*

IF IT'S TURBO—IT SAFEGUARDS!

* TURBO Saturated Sleeving is available in various colors in sizes from .032" to .224" ASTM standard inside diameter in strands or continuous coils. It is recommended for all general applications that do not require unusually high dielectric strength. Dielectric breakdown is 1200 V. per A. S. T. M. test. TURBO Saturated Sleeving is a slow burning insulation.

...an all-purpose insulation with all-round advantages!

ASK THE ENGINEER! Most conditions which require an insulating material may be satisfied by the use of this general purpose insulation. TURBO Saturated Sleeving provides a flexible, high tensile strength cotton braided and impregnated insulation which is resistant to most common destructive agents—oils, acids and alkalies. These sleevings are especially recommended for industrial equipment, office machines, home appliances and similar light duty electrical devices. Investigate also the physical properties and characteristics of these other TURBO insulating products listed below

Varnished Cambrics.......... Closely woven cambric fabrics treated with multiple coats of baked-on varnish to provide protection against oils, moisture, alkalies, and voltage breakdowns under severe conditions. Supplied in sheets, rolls and tapes in standard thicknesses, weights and colors.

Plastic Insulated Wire...... Number 18 and finer stranded and solid conductor with a seamless extruded plastic insulation. Surpassing dielectric properties. Resistant to oils, organic solvents, acids, alkalies and oxidation. Minimum shrinkage and burning effects in soldering and potting.

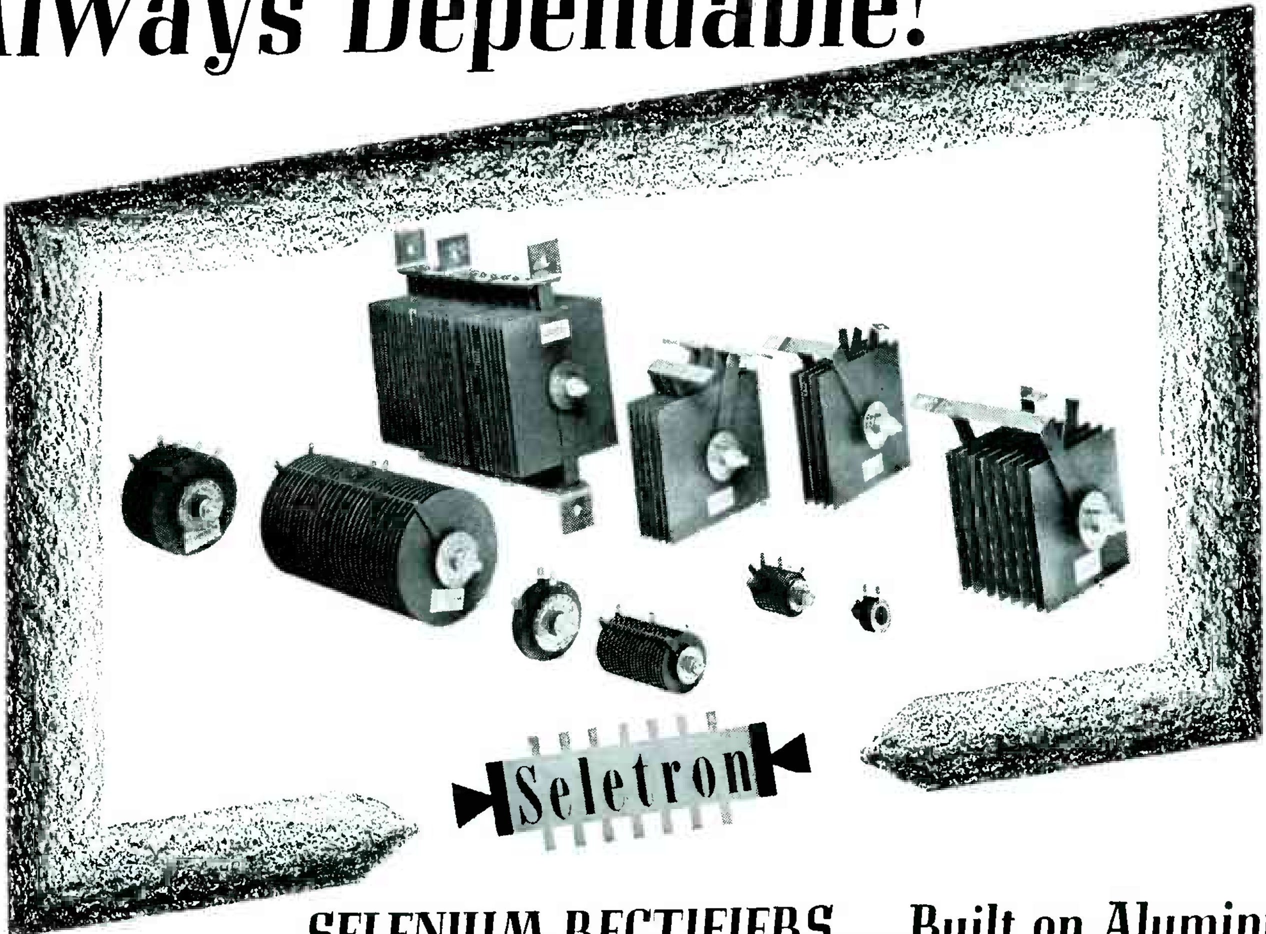
Varnished Tubing.......... A superior braided cotton insulation featuring saturation impregnation of flexible varnishes. Strong, flexible, non-peeling, non-cracking, moisture, oil, acid and flame resistant. Dielectric breakdown ASTM test—Magneto grade—7000 V., Radio grade—4000 V.

Fibrous Glass Tubing........ Fabricated of flexible fibrous glass yarn braided and impregnated with flexible varnishes and baked to form an ideal insulator, highly resistant to most reagents and to physically and electrically destructive elements. Four grades (ASTM Test) from 1200 V. to 7000 V.

TURBO

WILLIAM BRAND & COMPANY
276 FOURTH AVE., NEW YORK 10, N. Y. · 325 W. HURON ST., CHICAGO 10, ILL.

Always Dependable!



SELENIUM RECTIFIERS . . . Built on Aluminum

LARGE OR SMALL WE BUILD THEM ALL

CODE NO.	CIRCUIT	MAX. R.M.S. INPUT VOLTS	OUTPUT VOLTS	OUTPUT AMPS.
A1C1S1B	1 Phase Center Tap	24	8	.220
B2B1S1B	1 Phase Bridge	48	36	.30
C5B1S1B	1 Phase Bridge	120	90	.6
D1C1S1B	1 Phase Center Tap	24	8	1.6
E2B1S1B	1 Phase Bridge	48	35	2.4
F7B1S1B	1 Phase Bridge	168	120	4.0
G2B1S1B	1 Phase Bridge	48	35	6.0
H1B1S1B	1 Phase Bridge	24	17	10.0
FH1C3S1B	1 Phase Center Tap, Fan Cooled	24	6	60.0
FH1HA9S1B	3 Phase Half Wave, Fan Cooled	13.8	9	250.0

The above ratings for 35°C ambient continuous duty resistive inductive load.

Other combinations manufactured to meet your requirements.

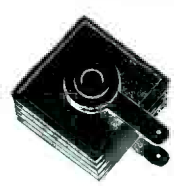
For AC-DC conversion where minimum maintenance costs and maximum efficiency are required, circuit designers write SELETRON into their specifications . . . right at the start!

These advanced type selenium rectifiers built on aluminum are engineered for long life, minimum weight, compactness and maximum heat dissipation. Ten standard sizes of discs provide outputs ranging from 50 milliamps to thousands of amperes. Arrangement of discs in infinite series and parallel combinations makes possible stacks to meet specific requirements for voltage and current.

Consultation with our engineers on any problem is invited. Their services and advice are yours without any obligation. Write TODAY for our informative bulletin on SELETRON Selenium Rectifiers and for the SELETRON application data sheet. **Address Dept. S-49**

FOR RADIO APPLICATIONS . . .

Specify SELETRON Miniature Selenium Rectifiers



- STARTS INSTANTLY
- RUNS COOL
- WILL NOT BREAK
- BOOSTS PERFORMANCE
- LASTS LIFE OF SET
- EASILY INSTALLED

5L1 75 mil 5-plate stack 7/8"x7/8"x7/8"

5P1 150 mil 5-plate stack 1 3/16"x1 3/16"x7/8"

5M1 100 mil 5-plate stack 1"x1"x7/8"

5Q1 200 mil 5-plate stack 1 1/2"x1 1/2"x7/8"

SELETRON DIVISION
RADIO RECEPTOR CO., Inc.
Since 1922 in Radio and Electronics
251 WEST 19th STREET NEW YORK 11, N. Y.

New! UNITIZED amplifier systems for recording

with plug in flexibility

Flexibility is the outstanding advantage of the *new* Fairchild Unitized Amplifier System. It includes 13 basic components which can be assembled in an endless number of combinations to meet the standard, special and changing recording requirements of schools, broadcasting and the professional recording industry. Related units are simply plugged in or cabled together. It's that easy . . . that quick!

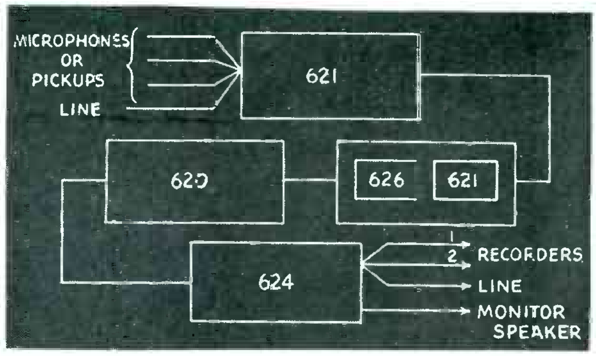
Fairchild's Unitized Amplifier System now makes it practical and economical to build highly individualized audio systems to satisfy all of the varied and changing requirements of the individual recording engineer. Further, the flexibility of the Fairchild system permits the units to be rearranged or the system to be expanded at will without obsoleting a single component.

Fairchild's 13 basic components have been especially designed by *recording* engineers to meet the specific requirements of the various types of *recording* systems.

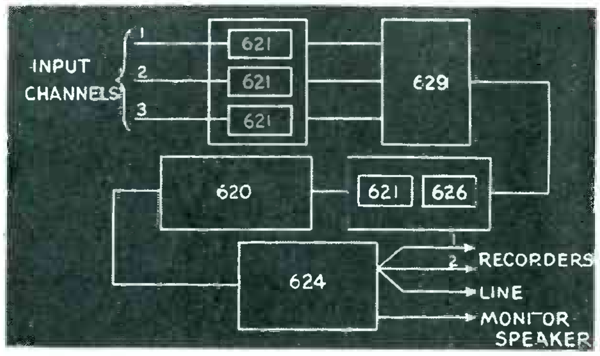
Unit 620 — Power Amplifier	Unit 626 — NAB Equalizer
Unit 621 — Microphone Preamplifier	Unit 627 — Variable Equalizer
Unit 622 — Pickup Preamplifier Equalizer	Unit 628 — Diameter Equalizer
Unit 623 — Line Amplifier	Unit 629 — Mixer
Unit 624 — Output Switch Panel	Unit 630 — VI Panel
Unit 625 — Input Switch Panel	Unit 631 — Bridging Device
	Unit 632 — Auxiliary Power Supply

Study the typical setups shown on this page. Then set down your own requirements . . . select the basic units you'll need . . . assemble them for convenient panel board operation . . . or let us do it for you. How will your specific amplifier system perform? Professionally! Like all Fairchild Sound Equipment—it keeps the original sound alive. Precisionized mechanical and electronic skill is the precise reason.

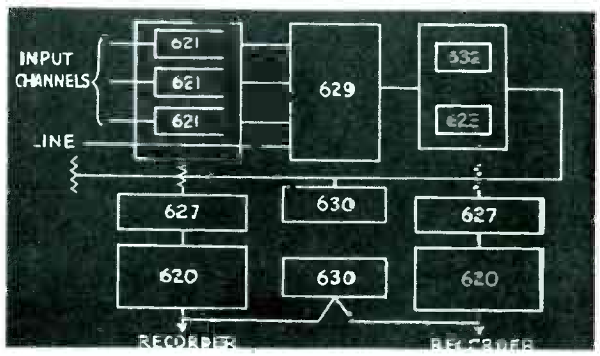
Want more details? Address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.



Single Channel Systems: for recording from a microphone or record or playing back from a pickup.



Multiple Channel Systems: for recording simultaneously through multiple input channels in conjunction with a mixer.



Dual Recording Channels: for recording simultaneously on two machines through dual channels with separate variable equalizers.

Fairchild CAMERA AND INSTRUMENT CORPORATION

SOUND EQUIPMENT

MAKERS OF: TRANSCRIPTION TURNTABLES, STUDIO RECORDERS, MAGNETIC CUTTERHEADS, PORTABLE RECORDERS AND LATERAL DYNAMIC PICKUPS

Collins

Dependability in FM

The Collins 734A
10,000 watt FM
Broadcast Transmitter

Built for Continuous Performance

Operating reliability and efficiency are your assurance of economical operation. In Collins FM transmitters each stage has been carefully designed for maximum efficiency. The requirements of every component were determined and generous safety factors allowed. You can depend on a Collins transmitter to give you continuous efficient performance.

Lasting Economy

The 10 kw 734A (shown above) consists of three basic units—a model 731A 250 watt exciter unit, a 3 kw intermediate amplifier, and a 10 kw grounded grid amplifier. The economy of thorough engineering is apparent both in the moderate initial cost and in the low operating expense. Each stage functions with high efficiency, thus a minimum number of stages is required. Only 33 tubes are utilized in the entire transmitter, *with only ten different tube types.*

Low maintenance costs are assured by the use of highest quality components operated conservatively.

Advanced Circuit Design

Frequency stability is within ± 250 cps. All circuits are metered. Exciter, intermediate amplifier and power amplifier stages utilize motor tuning. Forced air ventilation is provided for each cabinet. The vertical chassis can be tilted forward for servicing the rear side. Fuseless circuit protection is provided in both a-c and d-c power channels.

Distortion is less than 1.5% at 100% modulation over the range of 50-15,000 cps. The frequency response is flat within 1.0 db over the same range.

Twenty-five or fifty kw operation is accomplished simply by adding amplifier bays. Write us for a complete, descriptive bulletin giving detailed information.

NATIONAL RADIO WEEK, OCTOBER 26—NOVEMBER 1

FOR THE BEST IN FM, IT'S . . . COLLINS

COLLINS RADIO COMPANY, Cedar Rapids, Iowa

11 West 42nd Street, New York 18, N. Y. **458 South Spring Street, Los Angeles 13, California**

AN IMPROVED WATER JACKET FOR BETTER TUBE PERFORMANCE

Machlett's new water jacket, available for all Machlett RF Heating Tube types, embodies the first fundamental improvement in water jackets since their initial use with electron tubes. With this new jacket, it is simple to remove a tube and replace another in less than five seconds. No tools are needed; simply a twist of the wrist and the jacket is open, another twist and it is sealed — without danger to the tube, without leakage, without trial and error — a perfect seal every time.

☆ ☆ ☆

Machlett RF Heating Tubes will be supplied — where desired — with scientifically-designed terminal connectors affixed to the tubes at the factory. Flexible leads will be permanently attached in lengths to meet equipment manufacturers' requirements.

☆ ☆ ☆

To the RF Heating Equipment manufacturer these Machlett electron tubes and accessories will provide the first real freedom from "tube worries" and assure user satisfaction. They will contribute to demonstrating the effectiveness and economy of electronic heating. Priced only slightly higher than the standard communication tubes generally sold for this purpose, they will prove lowest in cost through better performance and materially longer life.

MACHLETT LABORATORIES, INC.
Springdale, Connecticut

AUTOMATIC SEAL WATER JACKET. No tools needed to open and close the new Machlett water jacket. No worry about tube breakage or water leakage. Jacket cannot be opened unless water pressure is off, nor closed unless tube is properly seated. Your hand opens and closes a perfectly safe seal with just a single twist.

ML-5619 RF HEATING TRIODE, water cooled with automatic seal jacket, or for forced-air cooling (ML-5604).
Maximum Input ....32.5 KW
Maximum Plate Dissipation (ML-5619) .... 20 KW
Maximum Plate Dissipation (ML-5604) .... 10 KW

ML-5658 RF HEATING TRIODE
Maximum Input .... 60 KW
Maximum Plate Dissipation.. 20 KW
(Will replace Type 880 without equipment modifications)
Automatic seal water jacket as shown.

ML-5667 FORCED-AIR COOLED TRIODE, available for water cooling ML-5666, with automatic seal jacket.
Maximum Input .... 20 KW
Maximum Plate Dissipation (ML-5667) .... 7.5 KW
Maximum Plate Dissipation (ML-5666) .... 12.5 KW
(Will replace Types 889A and 889RA without equipment modifications)

ML-5668 WATER-COOLED RF HEATING TRIODE, available with automatic seal jacket.
Maximum Input ....28 KW
Maximum Plate Dissipation.. 20 KW
(Will replace Types 892 and 892R [by ML-5669] without equipment modifications)

Write for complete technical data on this new line of tubes and accessories. A Machlett Application Engineer will gladly visit you at your request.

MACHLETT

50 Years of Electron Tube Experience

What's cooking *in a* "JET"

Diameter of Thermocouple compared with ordinary Pin. Temperatures only register at point of Thermocouple Junction

TO RECORD the temperatures at specific points in the anatomy of a "jet" is a tough assignment, but this small-diameter thermocouple, manufactured by Precision Tube Company of Philadelphia, does it.

Thin as a thread, it can be employed effectively in lengths up to 20 feet—laid along surfaces, snaked around obstructions, pushed down channels, fed through tiny apertures, sealed in walls and left protruding into space. Temperatures are only registered at the end where the thermocouple junction is located. Thus when inserted into pressure and exhaust chambers of jet engines, it can be maneuvered in any direction to obtain temperatures of gases with pin-point accuracy at different points.

Top performance has been achieved by use of Advance* Wire—because, in its finer forms, it has a negligible temperature coefficient of resistance, only ±.00002/°C; develops maximum and uniform thermal e.m.f. against copper; is extremely ductile; is resistant to heat and corrosion. An insulated winding of Advance is inserted into a seamless copper tube, and themocouple junction is made by cutting the assembly to length and brazing or welding the wire and the tube at one end.

Rapid response to temperature change, and small heat storage are characteristic of this thermocouple — permitting accurate readings to be obtained almost instantly. Moreover, its small proportions render it ideal for use with midget-size mechanisms.

Whether your product be small or large, if its successful operation rests upon application of special purpose alloys, send your specifications to us. We will supply the alloy with electrical and physical properties best suited to your requirements.

SPECIAL PURPOSE ALLOYS SINCE 1899

D H

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

Driver-Harris
COMPANY

HARRISON, N. J.

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

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

*Trade Mark Reg. U. S. Pat. Off.

Announcing 4

...FOR FM AND TELEVISION

They're New! They're Tops!

Designed and developed by General Electric, these new nine-pin miniatures are keyed to the requirements of advanced FM and Television receiving sets scheduled for early production by radio manufacturers.

Multi-unit design permits increased flexibility of circuit application, broadening the usefulness of the tubes. In size—seated height 1 15/16 inches—they are true miniatures, with the advantage which this brings to the electronic designer who must pack maximum receiver performance into minimum compass.

Pin-to-pin spacing is the same as with seven-pin types—made possible by a slight increase in base diameter. Both electrically and in length of service life, these fine new miniature tubes give performance which is convincing proof of their modern, efficient design and precision methods of manufacture.

Complete descriptive data is available to radio builders and circuit designers interested in applying G.E.'s new nine-pin miniatures to sets now on their boards. Also, G-E tube engineers will be glad to cooperate personally in selecting the right tubes for your commercial receiver or other electronic unit in the planning stage. Wire or write *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

6T8

High-perveance triple-diode triode with 6.3-v, 450-ma heater. For use as a radio detector and audio amplifier in FM and Television receivers.

19T8

High-perveance triple-diode triode, with 18.9-v, 150-ma heater. For FM and Television service as a radio detector and audio amplifier.

12AT7

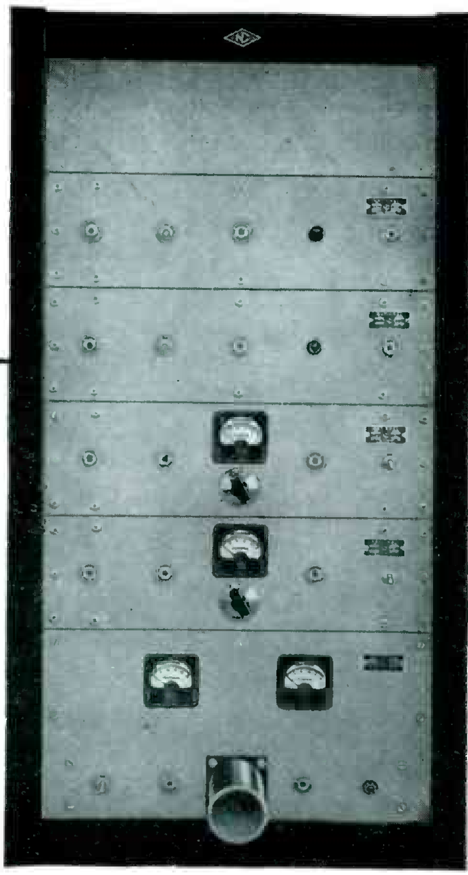
High-transconductance double triode. Used primarily as a converter in FM and Television receiver applications. Center-tapped heater permits use of the tube either in a-c/d-c receivers or in receivers with a 6.3-v heater supply.

12AU7

General-purpose double triode (its octal-series prototype is the 6SN7-GT). Center-tapped heater allows use either in a-c/d-c receivers or in sets with a 6.3-v heater supply. Chief applications are as a multi-vibrator and for special service in Television receivers and industrial-control panels.

HERE IS THE LATEST

IN MODERN TELEGRAPHIC COMMUNICATIONS



NATIONAL'S FREQUENCY SHIFT DIVERSITY RECEIVING EQUIPMENT

National
EST. 1914

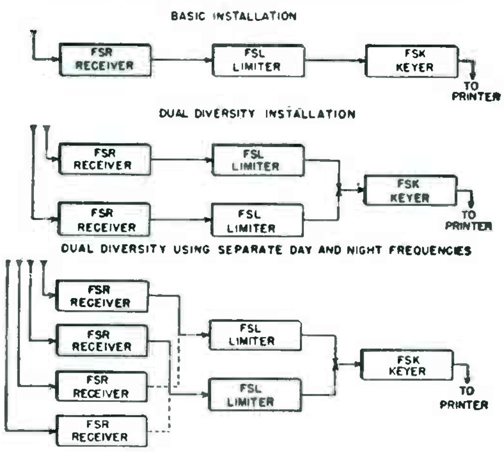
After two years of actual field operation, the National Company presents receiving equipment for a most modern and dependable system of telegraphic communications.

Airlines, shipping lines, oil companies and other industrial organizations requiring a communications network essentially free from interruptions can now secure a thoroughly dependable system that will save time, money and man-hours.

This equipment, providing reception in the 2 to 20 mc range, is especially suitable for teletypewriter operations but may also be employed with other types of terminal equipment.

Features

- Simple operation requiring only the closing of power switches.
- Oven-controlled, stable crystal oscillator assures tuning stability.
- Reception of frequency shift signals with ± 425 cycle deviation.
- Provides reception in 2-20 mc range normally. A wider range is also available on order.
- Low impedence interconnections permit varied installation arrangements.
- Tropicalized for resistance to fungus.
- Power-Source — Conventional 115v. 60 cycle AC.



The FSR Receiver, the FSL Limiter and the FSK Keyer are the three units comprising this equipment and the use of multiple FSR's and FSL's makes possible space or frequency diversity or both.

Please write our Sales Engineering Department for FSDR booklet.

National Company, Inc.
Dept. No. 10
Malden, Mass.

MAKERS OF LIFETIME RADIO EQUIPMENT

CHECK Your Wire's I.Q.*

*Insulation Quality

For Failure-Free Product Performance

If you aren't getting the sort of performance that builds product acceptance and repeat sales, it may pay you to look into the "I.Q." of the wire you are now using. Insulation that isn't designed to withstand extremes in operating and usage conditions does more than cancel good-will — it skyrockets costs through expensive repairs and replacements.

For a high "I.Q." on everything that insures dependable performance under severe conditions wire with Rockbestos wires, cables and cords. They are *permanently insulated* to prevent failure:

- They won't bake dry, crack or flow under high operating or ambient temperatures.
- They won't bloom or rot if exposed to grease, oil or destructive corrosive fumes or vapors.
- They give you greater current carrying capacity through high resistance to heat.
- They won't ignite under arcs or provide paths for flame.
- They won't bake out under conductor-heating overloads.
- They won't deteriorate under exposure to oxidation.

Rockbestos *insulation quality* gives you these reputation-protecting values in 125 permanently insulated wires, cables and cords — designed for use in appliances, cranes, electronic devices, locomotives, motors, radios, ranges, rheostats and hundreds of other products. Use them to keep customers satisfied and increase sales. Write for information, recommendations, samples or engineering assistance.

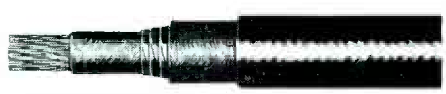
A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos.

ROCKBESTOS ALL-ASBESTOS APPLIANCE LEAO WIRE

Available in several types to fit the electrical and mechanical requirements of your product. Solid or stranded copper, nickel or monel conductors insulated with .030″ or .040″ of impregnated felted asbestos in black, white and colors.

ROCKBESTOS A.V.C. 600 VOLT SWITCHBOARO WIRE

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



ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAO CABLE

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

Rockbestos Products Corp., 453 Nicoll St., New Haven 4, Conn.

PERMANENTLY INSULATED ROCKBESTOS WIRES AND CABLES

ROCKBESTOS RESEARCH
Solves Difficult Wiring Problems

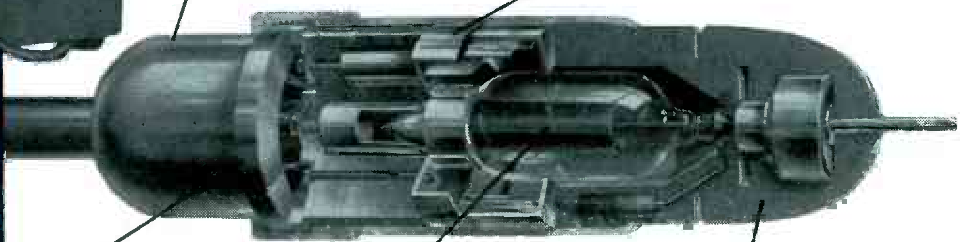
NEW YORK   BUFFALO   CLEVELAND   PITTSBURGH
DETROIT   CHICAGO   ST. LOUIS   LOS ANGELES   OAKLAND

HERE'S FLAT RESPONSE UP TO 700 MC

-hp- 410A VACUUM TUBE VOLTMETER

with its new -*hp*- low-capacity diode probe, measures all the important radio voltages without disturbing circuits under test.

CHECK THESE FACTS ABOUT THE NEW -*hp*- PROBE*:



Small size for ease in contacting hard-to-get-at components.

Ultra-short leads, direct grounding assure high frequency response.

Rugged, mechanical construction, dural shell, polystyrene insulation.

Specially-designed diode has short transit time, low input capacity, high resonant frequency of 2000 mc.

Detachable tip lowers input capacity, shortens diode lead, utilizes maximum capabilities of diode.

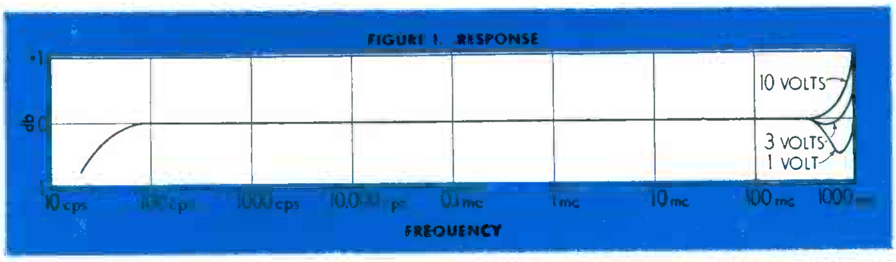
**Reproduced actual size*

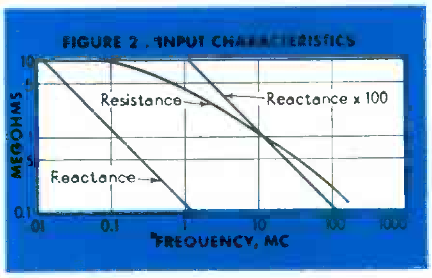
The specially-designed diode, in combination with the -*hp*- probe design, makes possible the exceedingly flat frequency response shown graphically in Figure 1.

With this flat frequency response are combined the factors of low input capacity and high input resistance. The variation of these factors with frequency is shown in Figure 2. The input resistance and reactance are high throughout the entire range of the instrument, and thus measurements are made without appreciable detuning or loading of circuit. Maximum measuring accuracy is assured.

In addition to swiftly, easily, accurately making uhf radio measurements, this -*hp*- 410A is a convenient voltage indicator up to 3000 mc. And it serves equally well as an audio or d-c voltmeter, or an ohmmeter. A-c measurements are made in 6 ranges ...full scale readings 1 to 300 v. D-c full scale readings from 1 to 1000 v in 7 ranges. Input resistance all ranges —100 megohms. As an ohmmeter, the -*hp*- 410A measures resistances from 0.2 ohms to 500 megohms in 7 ranges.

In short, this -*hp*- 410A Vacuum Tube Voltmeter is ideal for obtaining most important parameters in radio design, manufacture, or servicing. Write today for full details. Hewlett-Packard Company, 1407E Page Mill Road, Palo Alto, California.





-hp- laboratory instruments

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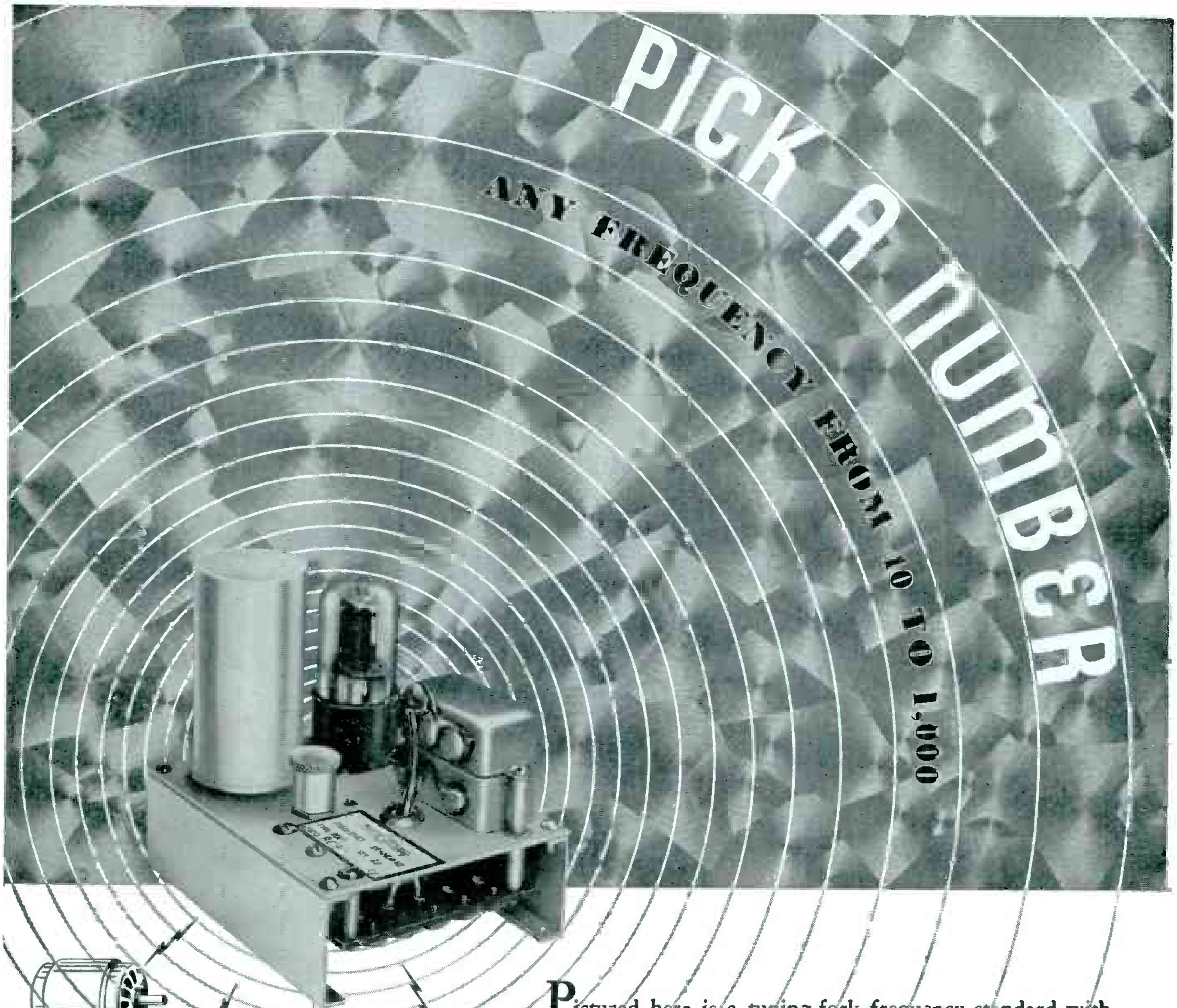
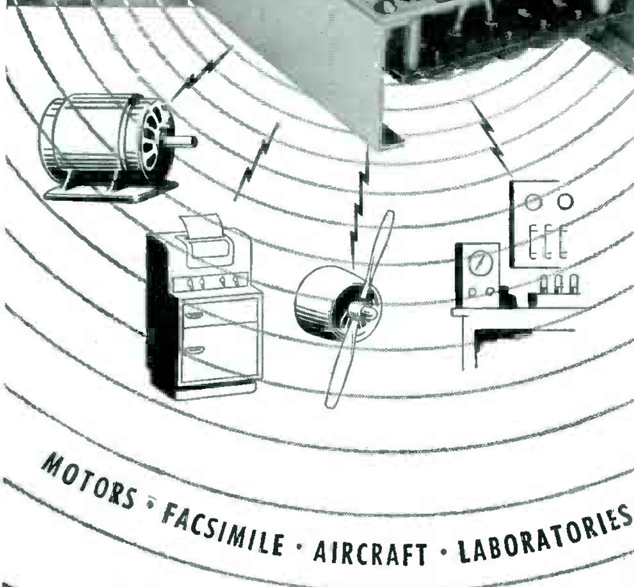
Noise and Distortion Analyzers · Wave Analyzers · Frequency Meters · Audio Frequency Oscillators · Audio Signal Generators · Vacuum Tube Voltmeters · Amplifiers · Power Supplies · UHF Signal Generators · Attenuators · Square Wave Generators · Frequency Standards · Electronic Tachometers





Pictured here is a tuning-fork frequency standard with accuracy guaranteed to one part per million per degree Centigrade. The fork is temperature-compensated and hermetically sealed against variations of barometric pressure. This standard, when combined with basic equipment, facilitates accurate speed and time control by mechanical, electrical, acoustical or optical means.

The unit is available separately or in conjunction with complete timing instruments. Our engineers are ready to cooperate on any problem.

American Time Products, Inc.

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OPERATING UNDER PATENTS OF THE WESTERN ELECTRIC COMPANY

A NEW ERA IN TUB

The *FIRST* truly practical, all-purpose *PHENOLIC*


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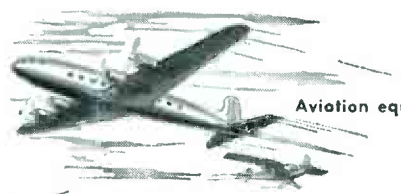
Aviation equipment

One standard type for ALL conditions of use.


Export equipment


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Pioneers of Electrical and Electronic Progress

ULAR CAPACITORS

Highly heat- and moisture-resistant

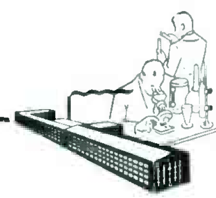
Non-inflammable

Conservatively rated for −40°C. to +85°C. operation

Small in size

Mechanically rugged

Moderately priced



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After more than four years of intensive research, plus one of the largest retooling programs in its history, Sprague announces a complete line of phenolic-molded paper tubular capacitors that offer far-reaching advantages for a long list of products ranging from home or auto radios and electrical appliances to military equipment. Their unique phenolic sealed construction assures maximum dependability even under extremes of heat, humidity and physical stress. Thus they have virtually universal application in modern equipment. In most cases the new Molded Tubulars are smaller and in no instance are they larger than ordinary Sprague paper tubular capacitors of equal rating.

Write for Sprague Capacitor Engineering Bulletin 210.

CAPACITORS **SPRAGUE** KOOLOHM* RESISTORS

Sprague Electric Company, North Adams, Mass.

*Trademark reg. U.S. Pat. Off.

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FOR THE 4 GRADES OF

VARNISHED TUBINGS

TO MEET OR EXCEED SPECIFICATIONS

SET BY VARNISHED TUBING ASSOCIATION AND AMERICAN SOCIETY FOR TESTING MATERIALS

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

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

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

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

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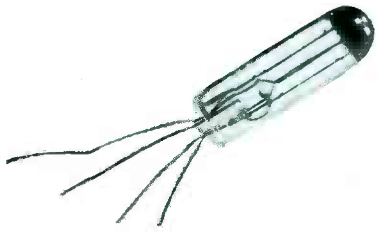

How do *Western Electric* Thermistors function?

When the temperature of thermistors (thermal resistors made of semi-conducting metallic oxides) goes *up*, their resistance goes *down*—when their temperature goes *down*, their resistance goes *up*. This one characteristic enables you to use simpler, more economical circuits with thermistors than are possible with conventional components.

Where can *Western Electric* Thermistors be used?

Thermistors can provide greater accuracy and dependability in an almost untold number of applications where temperature plays a part in the operation of your products or processes. Below are some suggested applications for the many types of thermistors now available. For further details, call your Graybar Representative, or send the coupon below.

CHEMICAL AND FOOD PROCESSING

Local and Remote Temperature Indication
Detector in Infrared Spectrometry
Automatic Temperature Control
Gas Detectors
Refrigeration Control
Pyrometry
Vacuum Gauges
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TRANSPORT

Engine Temperature Measurement and Control
Cabin Temperature Control
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Test Equipment
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Voltage Regulators
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Vacuum Gauges
Flow Meters
Differential Temperature Controllers

MINING AND METALLURGY

Fire Protection and Safety Devices
Gas Detectors
Local and Remote Temperature Measurement and Control
Pyrometry
Quality Control
Calorimetry
Time Delay Devices
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PUBLIC UTILITIES

Voltage Regulation
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420 Lexington Ave., New York 17, N. Y.

Please send me Bulletin T-2288 describing applications of Western Electric Thermistors.

Name ____________________

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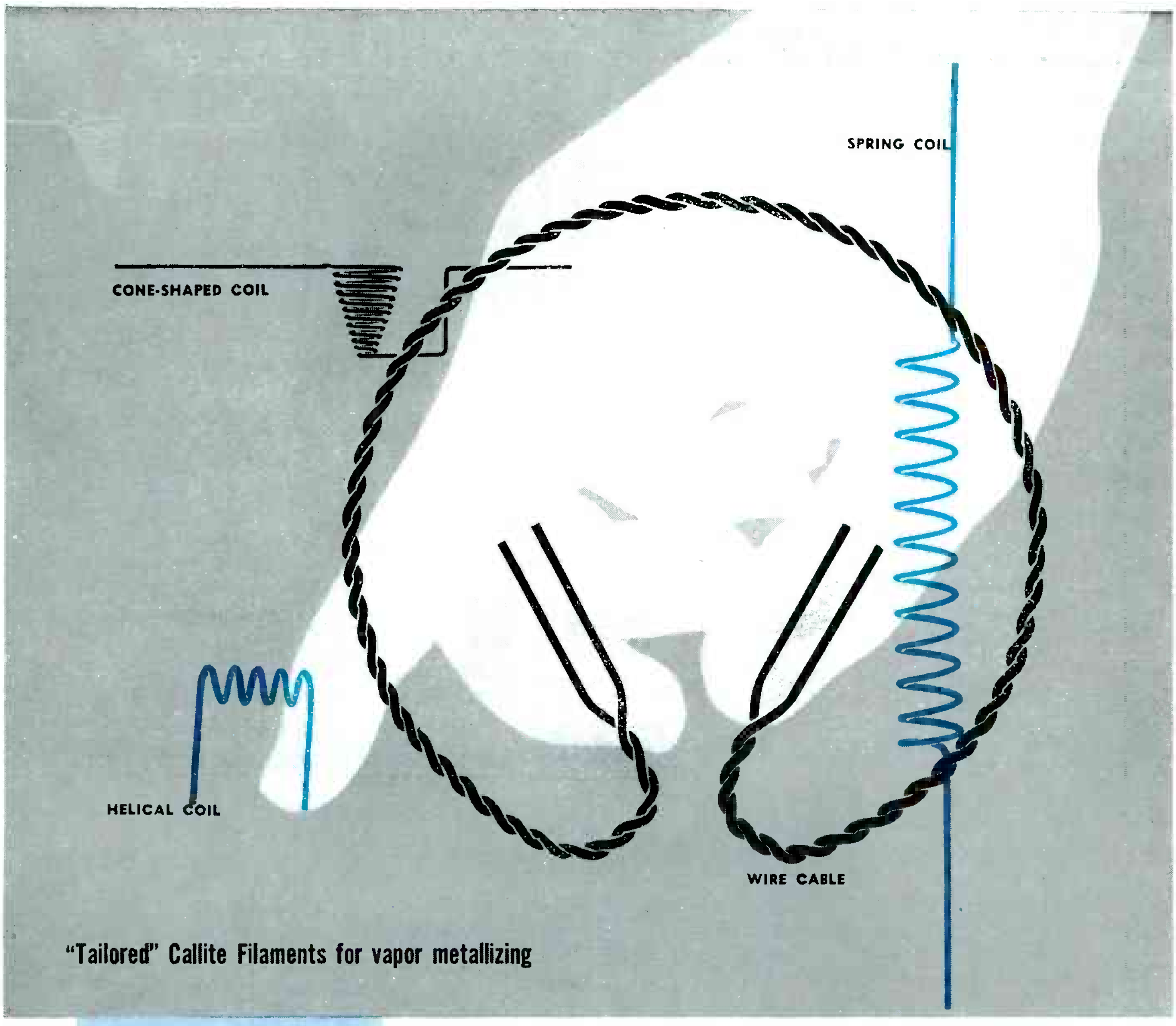

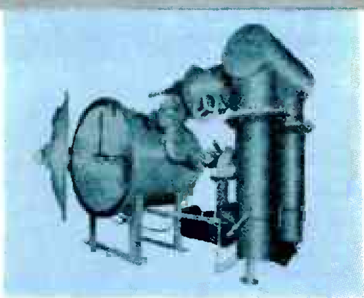

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when you use Callite heating elements to coat metals or plastics

Leading metallizers have discovered that Callite tungsten or molybdenum heating elements provide the simplest, quickest and most economical solution to their specific problem of coating materials by the vacuum evaporization process. Electrically heated, the filaments evaporate the coating metal — in pellets or wound on heater — and spread a smooth, uniform coat... often in a matter of seconds.

Let our many years of varied field experience help you, too, improve your metallizing operations. Skilled Callite engineers will gladly design special filaments — "tailor-made" to your specifications; to fit your current equipment; or to meet your production cost schedules. Prompt deliveries of all types. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago, Illinois; Cleveland, Ohio.

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WHILE WE DELAY—
Russia Drives for the Atlantic

IN THE STRUGGLE to keep western Europe west of the Iron Curtain it is later than you think. Unless the United States quickly mobilizes its own and other nations' resources, World War II will be lost as World War I was lost – by no economic follow-through.

Millions of people in western Europe, living in cold homes or no homes at all, face another winter of near starvation. Some countries are absolutely without dollars to buy abroad the food and fuel they need for survival. Others slide toward that desperate state.

In this welter of misery Russia grasps for dominion over all Europe. Everywhere, as cold and hunger deepen and as men begin to doubt America's determination to help, Russia turns on the pressure. In France the Communists drive to overthrow the Government. In Italy they do likewise. In Greece Russia kills the United Nations investigating commission. In Trieste Tito elbows us out of the way. In Germany and Austria the Soviet commanders alternately stymie and flout the Allied governments.

FACED WITH this bloodless attack, the leaders of western Europe and of the United States have not covered themselves with glory.

Look, for example, at what the sixteen European countries participating in the Paris meetings on the Marshall "plan" first proposed to the United States as a catalog of their needs. In the main it was simply an adding up — to $30 billion — of what the various countries thought they needed to keep going in the same old way at the same old stands. There was no real start on plans for the mutual aid by European states which is the essence of a successful recovery program . . . no real start on plans to knock down the barriers which divide European trade into hopelessly inadequate little pockets . . . no real plans to clean up currencies which deteriorate so fast nobody wants to work for them. *In fact no plans to make people want to work.*

Meanwhile, what have our leaders offered? Not much more than one fine commencement speech by General Marshall, outlining a good idea, and a couple of carloads of statistics, with more to come.

Not even a beginning has been made on the most crucial part of any European aid program — *that of explaining to the American people what their part must be and why.* It is true that not all the reports of all the statistical committees have been completed. They never will be. But it is also true that the broad outlines of what the United States must do to save Europe are already clear. And it is not simply to provide more dollars, although $12 to $16 billion more — the cost of 6 or 8 weeks fighting in World War II — may be required.

A far more basic requirement is leadership which will lift Europe out of the slough of despair and get recovery rolling. Without that leadership more billions for Europe will buy us nothing but more bitterness and remorse on both sides of the Atlantic.

WHAT ARE the ingredients of that leadership? Here are a few:

1. A bi-partisan program for European recovery.

It should be so thoroughly understood and so overwhelmingly supported by both parties that playing politics with it will be like selling military secrets to the enemy.

Truman and Vandenberg have failed miserably to develop and explain a complete program — one in which Europe and America can have full confidence. Nor have Taft and Dewey and other candidates for high office pledged that politics will stop at our shoreline. These men must speak out. To date Herbert Hoover alone has had the courage and vision to state a program.

2. A mobilization of American food supplies.

We must assure people at home and abroad that our crops, cut down by drought and heat, will be stretched to cover minimum European needs (with whatever help we can muster from other nations) without forcing still higher food prices here.

Some food experts are comfortably confident that the stretching can be done. But meatless and wheatless days, higher extraction of flour from wheat and similar voluntary conservation moves would make it surer. And they would demonstrate that a free country can mobilize itself to meet a very serious crisis.

3. An understanding that relief is one problem and recovery another.

Both problems must be solved. Relief emergencies must be met, some of them at once. But they must not black out the longer task of recovery. Italy illustrates the point. Italy, particularly the south, is flat broke. Help is needed right now to keep people from dying in the streets. But we must eventually do more than keep the Italian people alive. We must help them get back to useful work so that they can stand on their own feet.

4. A steady insistence on results – which means that Europe must find a way to make its people want to work.

In the U.S.S.R. they have a way to get things done. It is to liquidate those who do not work. In the U.S.A. we have a way to get things done. It is to create incentives to make people want to work. Western Europe, notably France and Britain, has fallen between two stools. It has socialized away the incentives, and it does not yet, thank heaven, enslave the laggards. We should make it crystal clear that we have no designs on the national "sovereignty" of others. But we should make it equally clear that we insist that those countries which receive our aid work hard enough to get results. To this end continued aid should be on an installment plan, each installment conditional on getting results. Otherwise more billions can easily disappear down the drain.

5. Insistence on all-out self-aid by European countries.

That is the constructive core of the Marshall idea — to help Europe to help itself. In his brilliant "Report on Germany" and how to get it "off the backs of the American taxpayer," Lewis H. Brown, Johns-Manville Chairman, shows how the export of only 10 million tons of coal a year from Britain to western Europe would speed industrial recovery of the Ruhr immeasurably. There are countless other cases where effort in one European country — or a group of countries — will break a big industrial bottleneck in another. We should insist that everything possible be done to see they are broken.

6. An agreement with Britain and France giving us authority in western Germany equal to our responsibility.

Britain is shifting to us most of the financial burden she has been carrying in the German occupation. Less directly we shall also be carrying much of the French occupation load too. We must have authority in the economic field commensurate with our responsibilities. Otherwise the management of western Germany can poison Anglo-American and Anglo-French relations in addition to wasting resources we could use to promote general European recovery.

It is truly said in the scriptures that the Lord loveth a cheerful giver. But it is not recorded anywhere that anyone, including the recipient, loves a soft-headed giver. Hence as a capstone any program of aid for Europe should have machinery assuring that only what is needed is sent; that what is sent does the job for which it is sent; and that arrangements are made for the recipients to pay back whatever they can.

THE AMERICAN PEOPLE should be told clearly by their leaders that there is no assurance that the best possible program of economic aid for Europe will do the job. The time is very late.

In France and Italy, as our help falters, the Communists right now are provoking strikes which will make the people's suffering more acute. They hope, of course, to overthrow the governments in both those countries and to seize control. If Communist dictatorships are clamped on France and Italy this fall, Russia and her satellites will have advanced to the Atlantic. The Iron Curtain will have moved 500 miles west — toward us.

Americans should be clearly told, therefore, that not to undertake an immediate program for the recovery of Europe is to bring closer the greatest possible national disaster — World War III.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

THIS IS THE 61ST OF A SERIES

LESS SPACE! LOWER COST!

That's why these "midget" thyratrons stand ace-high with equipment designers

GL-546

GL-502-A

(Tubes are shown actual size)

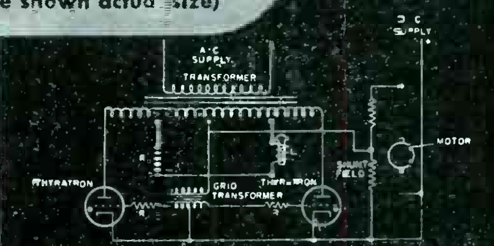
METAL Type GL-502-A and glass Type GL-546 have proved their efficiency in scores of applications such as the industrial circuits shown at the right. Designers can fit one or more of these thyratrons into an ultra-compact control panel, with knowledge that despite their small dimensions, the tubes will deliver a high rated performance . . . Because they are made in quantities by the most precise modern methods, the price is low —a prime advantage to the equipment builder seeking business in a competitive market . . . Where compactness is important but not the first need, Type GL-502-A often is preferred because of self-shielding qualities due to the metal envelope, plus a larger current capacity. This tube will replace the GL-2050, yet is only half the latter's size . . . If space available must be figured down to the fraction of an inch, Type GL-546 (with a seated height of 1¼ inches, and a diameter of ¾ inches) usually is selected . . . G-E tube engineers will be glad to work closely with you in choosing the right thyratron for any control or other circuit. For this counsel, or for further facts about the GL-502-A and GL-546, phone or write your nearby G-E electronics office or *General Electric Company, Electronics Department, Schenectady 5, New York.*

CHARACTERISTICS

	GL-502-A	GL-546
Max over-all height	2 19/32 inches	1½ inches
Max over-all diameter	1 5/16 inches	¾ inch
No. of electrodes	4	4
Cathode voltage	6.3 v	6.3 v
current, approx	0.6 amp	0.15 amp
heating time, typical	10 seconds	10 seconds
Peak voltage drop, typical	11 v	11 v
Average anode to control-grid capacitance	0.2 mmfd	0.1 mmfd
Ambient temperature limits	—55 to +90 C	—55 to +90 C

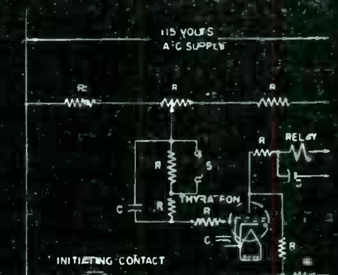
MAXIMUM RATINGS

Peak anode voltage, inverse	1,300 v	500 v
forward	650 v	500 v
Anode current, instantaneous	1 amp	100 ma
average	100 ma	20 ma
Time of averaging anode current	30 seconds	15 seconds

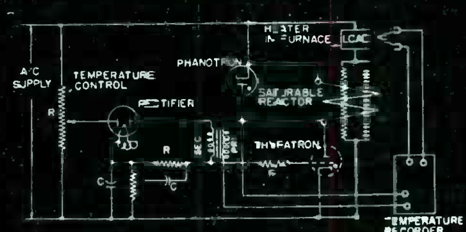


THYRATRON CIRCUIT FOR CONTROL OF SMALL D-C MOTORS

PHOTOTUBE DOUBLE-GRID THYRATRON RELAY CONTROL CIRCUIT



THYRATRON TUBE TIMER CIRCUIT



THYRATRON CIRCUIT FOR TEMPERATURE CONTROL USING A SATURABLE REACTOR

The above circuits are examples of possible tube applications and the description and illustration of them does not convey to the purchaser of tubes any license under patent rights of General Electric Company.

GENERAL ELECTRIC

162-F8-8850

FIRST AND GREATEST NAME IN ELECTRONICS

BUSINESS BRIEFS

By W. W. MacDONALD

"Electronics will dominate the next 50 years in astronomy as much as photography dominated in the past 50 years," says Otto Struve of Chicago University's Yerkes Observatory.

We Understand that IRE has already sold all exhibit space on the first floor of New York's Grand Central Palace, where the March show will be held. Space is still available on the balcony.

Superregeneration has been taken down from the commercial shelf, dusted off and once more put to work, notably in certain inexpensive f-m tuners. Not too much is known about the theory of superregenerative circuits but some studies were made during the war. ELECTRONICS is at present endeavoring to pry data loose for early publication.

Hearing Aids in use in the United States total between 500,000 and 600,000. About 125,000 were sold in 1946 and at this writing it looks like sales will reach 200,000 in 1947.

We hesitate to estimate the size of the potential market owing to wide differences of opinion in the industry regarding the number of hard-of-hearing and how many of these can be helped by hearing aids. It appears likely, however, that the popularity of single-unit models will result in a substantial increase in business during 1948.

Licenses covering some 700 patents in the radio receiver, electrical phonograph, and television receiver fields have been offered all set manufacturers by Philco.

Commercial Radar installations aboard American vessels were estimated earlier this year (p 82, April) as totalling 85. We have no later figures covering the output of the entire industry but the picture is obviously changing rapidly. RCA reports the installation of 81 equipments operating on 3.2 cm since January. Some 40 of these are aboard American ships.

Machine Tool Show exhibits featured more electronic accessories than in previous years. Motor control devices employing tubes were everywhere in evidence. Electronically controlled chucking grinders and sizing mechanisms were shown. Conversations with people attending the show also disclosed that machine manufacturers were perfecting electronically controlled hosiery knitting machines, blind gaging devices and other devices soon to be described elsewhere in ELECTRONICS.

Teaneck, N. J. Dogcatcher receives tipoffs concerning stray canines in his car from the local police radio station.

Commercial Broadcast Picture for the continental United States, as of August 1, 1947, is as follows:

Licensed A-M Stations	1,266
A-M Construction Permits	500
Licensed F-M Stations	52
F-M Construction Permits	639
F-M Conditional Grants	247
Licensed Television Stations	6
Television Construction Permits	60
TOTAL	2,770

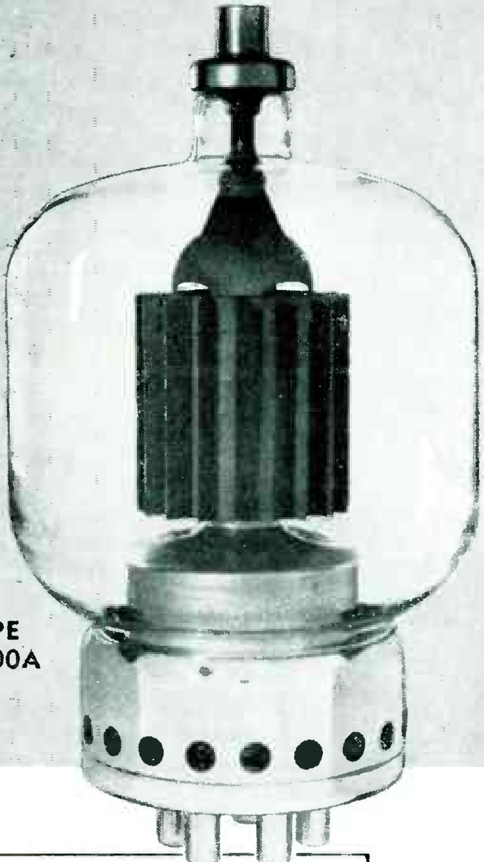
Breakdown of the 1,266 licensed a-m stations listed above:

Clear Channel	
Unlimited (50 kw)	53
Part-time (50 kw)	4
Unlimited (5 to 25 kw)	31
Part-time (5 to 25 kw)	6
Regional Channel	
Unlimited	311
Limited and day	125
Part-time	14
Local Channel	
Unlimited	665
Day and part-time	57

Minimum Cost of equipment required for a modest start in telecasting (500-watt video transmitter and 250-watt audio transmitter) is $89,000, according to DuMont's Herb Taylor.

Underscored by FCC chairman Denny in a speech before the NAB were two statements of particular significance to new applicants for a-m station licenses. Denny said (1) that applicants should be sure they

COMMUNICATIONS • BROADCAST AM & FM • INDUSTRIAL • AUDIO



TYPE
4-1000A

OUTPUT
3 Kw.
WITH 14 WATTS DRIVE

Workhorse for communications and industry, the recently announced type 4-1000A is presently the largest of Eimac radiation cooled power tetrodes. High power-gain capabilities, on the order of 230 times, fit the tube to applications requiring high power output with low driving power needs.

The tube has been ruggedly designed to withstand the abuse of the most severe application and abnormal overload. Eimac "know how" of vacuum tube design provides long life expectancy and overall economy of operation. Virtual isolation of the input and output circuits has been achieved, simplifying associated circuit design. Short, low-inductance leads, Eimac's non-emitting grids, and rugged plate impart a high degree of operational stability. High efficiency may be maintained well into the vhf, above 110-Mc. As an example, two tubes operating well within ratings, have provided 5 kw useful output power at 110-Mc.

As a functional accessory, a unique socket design to assist in adequate cooling is available. Illustrated below is the complete unit and a diagram indicating the control of air-flow past the terminals, base seals, around the envelope and to the plate seal. The pyrex glass chimney is included with each socket.

TYPE 4-1000A

ELECTRICAL CHARACTERISTICS

Filament: Thoriated tungsten	
Voltage	7.5 volts
Current	21 amperes
Grid-Screen Amplification Factor (Average)	7.2
Direct Interelectrode Capacitances (Average)	
Grid-Plate (without shielding, base grounded)	0.24 μμfd
Input	27.2 μμfd
Output	7.6 μμfd
Transconductance (i_b = 300 ma., E_b = 2500 v., E_{c2} = 500 v.)	10,000 μmhos

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy

(Key-down conditions, per tube)

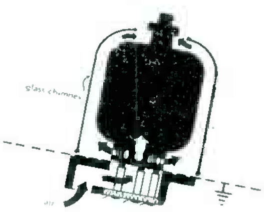
MAXIMUM RATINGS

D-C Plate Voltage	6000 Max. Volts
D-C Screen Voltage	1000 Max. Volts
D-C Grid Voltage	—500 Max. Volts
D-C Plate Current	700 Max. ma
Plate Dissipation	1000 Max. Watts
Screen Dissipation	75 Max. Watts
Grid Dissipation	25 Max. Watts

TYPICAL OPERATION

(Frequencies below 40 Mc.)

D-C Plate Voltage	6000 Volts
D-C Screen Voltage	500 Volts
D-C Grid Voltage	—200 Volts
D-C Plate Current	681 ma
D-C Screen Current	141 ma
D-C Grid Current	41 ma
Screen Dissipation	71 Watts
Grid Dissipation	6.1 Watts
Peak R-F Grid Input Voltage (approx.)	348 Volts
Driving Power (approx.)	14.3 Watts
Plate Power Input	4086 Watts
Plate Dissipation	746 Watts
Plate Power Output	3340 Watts



Follow the Leaders to

Eimac TUBES

The Power for R-F

Export Agents: Frazar & Hansen, 301 Clay Street, San Francisco, 11, California

EITEL-McCULLOUGH, Inc., 185 San Mateo Avenue, San Bruno, California are well enough financed to pay the bills until revenue from sponsored programs takes up the load and (2) that the chance of commercial success is twice as good in towns having no competitive station.

Size And Cost of average existing broadcast transmitter buildings, determined by Western Electric in a 610-station survey, is as follows:

POWER (watts)	SERVICE	TYPE*	SIZE (cu ft)	COST
250	a-m or f-m	tr	5,300	$3,700
250	a-m or f-m	tr and stu	19,100	13,200
1,000	a-m or f-m	tr	7,200	6,600
1,000	a-m or f-m	tr and stu	21,000	15,300
3,000	f-m	tr	17,600	10,700
3,000	f-m	tr and stu	30,500	36,500
5,000	a-m	tr	20,600	17,000
10,000	f-m	tr	30,800	22,700
10,000	f-m	tr and stu	51,000	46,300
50,000	a-m	tr	57,600	40,300
50,000	f-m	tr	39,100	43,200

* tr — transmitter building only. tr and stu — combination transmitter building and studios.

Today's construction costs would, of course, be considerably higher than the averages shown, since these cover construction over the period between 1930 and 1947.

Rooftop Rents asked by owners of tall buildings are a matter of concern to many prospective operators of vhf and uhf transmitters. The concern is particularly acute among people who wish to operate point-to-point communications, common-carrier, and relay services which must necessarily function at low cost.

Realtors would do well to carefully study space and facility requirements before quoting. Services such as those mentioned frequently require just a small corner for equipment, need little power and service, can often utilize existing structures for antenna support, and generally leave the lion's share of the rooftop available for f-m and television broadcast station rental.

Technical Dictation throws inexperienced stenographers for a loss. One of the boys on the editorial staff of ELECTRONICS was momentarily puzzled the other day by a letter dealing with *steam* power tubes.

We hear that a mid-western manufacturer is perfecting a protective system for large industrial plants. Watchmen carry concealed radio transmitters operating around 150 mc. When trouble is encountered the transmitters go into action, a neon lamp on the panel of a centrally located receiver flashes a warning and the watchman's code number is indicated by a tape recorder.

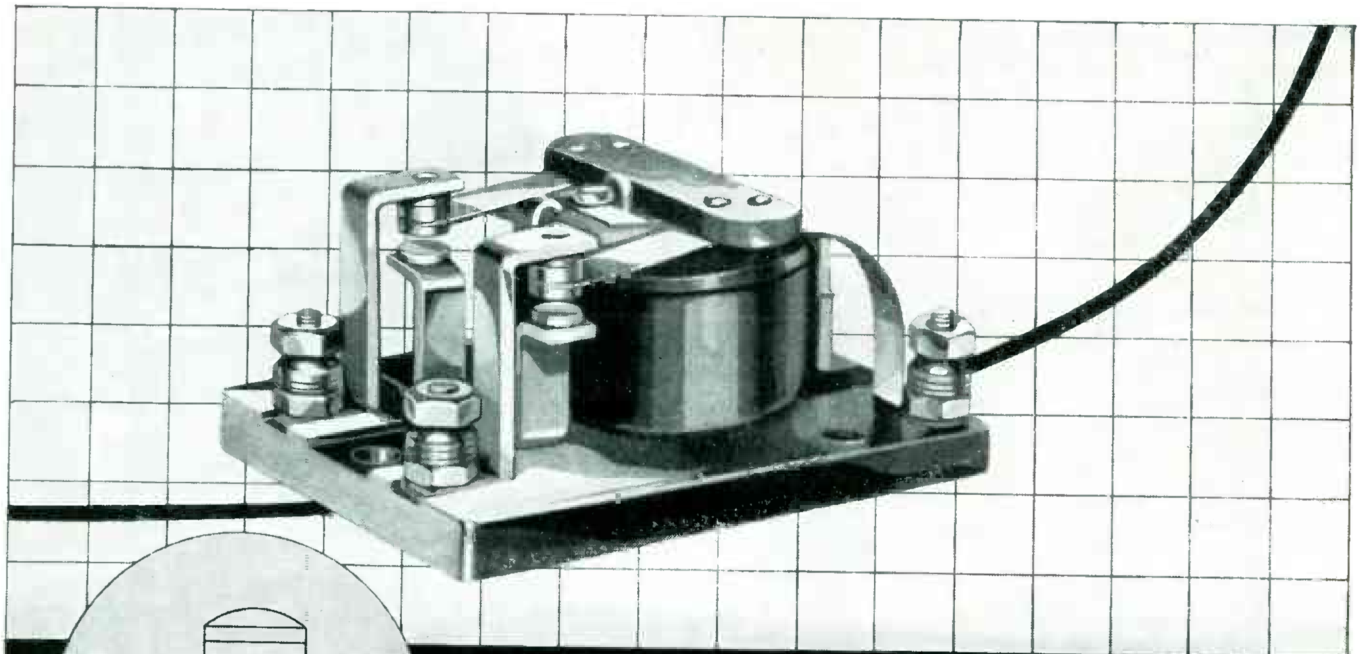
"Radio Tube Design is largely a matter of compromise," says Hytron's Vin Ulrich. "The manufacturer who hits upon the most satisfactory combination of compromises is the one who has the most widely accepted tube types for given applications."

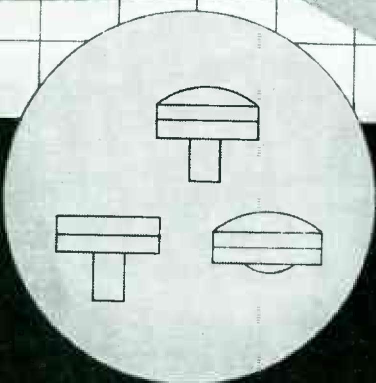
Small Boat Owners tune from one a-m broadcast station to another, hoping against hope that something resembling a complete weather forecast will be appended to news programs. Stations located near water could make a lot of friends by more regularly including wind direction and velocity.

Coast Guard stations operating near 2,600 kc transmit weather forecasts two or three times a day but hesitate to increase the frequency of this service because dissemination of such information is officially the business of the Weather Bureau. Many yachtsmen wish the matter of appropriations could be arranged to permit closer cooperation between the two government agencies. More power and personnel for Coast Guard stations would also pay dividends in safety at sea.

Step In Right Direction is General Instrument's recently inaugurated $500,000 research and engineering program designed to reduce the cost of major components used by television receiver manufacturers.

Unnoticed by most of the men who attended the recent NAB convention at Atlantic City, the aircraft beacon on top of one of the several antenna towers on display in the exhibit hall put out not only conventional flashes but also an occasional group of most unconventional code words. It seems that the boys running the exhibit got a little bored, rigged up an extra set of cams and switched them in when things began to pall.





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CROSS TALK

► **AIR** . . . Talking to one of our editors recently, Major E. H. Armstrong opined that recent advances in our knowledge of vhf waves have introduced some radical changes in some homely concepts. Time was, according to the Major, when one explained to non-technical friends that radio waves didn't really go through the air. In fact, we used to say, the waves would get there as well or better if the air weren't there. But not so with vhf waves. Refraction of these waves in the air accounts for much of their availability. If the air weren't there, the marginal service of f-m and television stations would cease to exist. Moreover, variations in the state of the air masses cause fading, once thought to be absent from very-short-wave transmission. So the old order changeth. What the Major says is only too true; the art has much to learn about the transmission of uhf and vhf waves. Much already known has not been passed out widely enough. We can offer some help on this, in the form of a bang-up manuscript by Don Kerr of the Radiation Lab, just ready to toss on the griddle. Watch for it.

► **VOICE** . . . At the recent NAB convention, a manufacturer of a limiting amplifier, advertising to the delegates, elected to speak in their language. "Our limiter," runs the ad, "gives your station a steady, loud voice!" That's the word for too many broadcast stations today: a steady, loud voice. The broadcasters code, which would limit commercial announcements to three minutes per 15 minute period, ran into heavy weather at the convention, but was finally adopted over the protests of the smaller stations. If followed, this code will do much to combat the growing public resistance to steady, loud voices on the air.

► **MORE PRIVILEGE** . . . In these columns last July we objected to a rider charge, amounting to $1.26 per month, assessed on owners of television sets in Norwich, Connecticut. Since Norwich is well outside the range of existing television stations, that threat to progress was academic. But the disease spreads. Now comes word from the Wallingford, Connecticut, municipal plant, inside the range of New York stations, that owners of television sets connected to this system must pay $2.50 for the first five kilowatt-hours they buy each month. This is roughly $2.00 extra per month, or 24 dollars a year, over and above what would be charged for the same juice if the television set were absent. This rate increase is based on the same recommendations, and subject to the same objections, as the Norwich case to which we have previously alluded with some feeing.

We are happy to note that the Radio Manufacturers Association, prompted by our outburst, has dug into the facts, intending to combat the forces of evil. The power consumptions and power factors of 15 models of television sets made by eight manufacturers have been listed. The power consumption ranges from 215 to 550 watts, with 328 watts as average. The power factor ranges from 89 to 95 percent, with 92.5 percent as average. The power factor figures are particularly interesting and show that the public utility does *not* have to install large capacity for wattless current. Moreover, the Wallingford company informs us that the peak load on their system occurs between 11 and 12 in the morning, during the spring and summer months from April to October. In the winter, from October to April, it occurs from 4 to 6 in the evening. These hours do not coincide with hours of television programs, except possibly from 4 to 5 pm in winter.

Why then, must owners of television sets pay 24 dollars a year, not for electric power, but for the privilege of being connected. This is more than half the national average electricity bill ($42.90 in 1946). It looks powerful fishy to us. Worse, it looks like charging what the traffic would bear. One ray of hope: The Wallingford authorities say they are merely experimenting with this rate, and are in contact with set owners to find out just what additional demand is placed on their system. We are sure that the facts will not support this charge, and we hope the RMA will make good use of its facts.

electronics Sponsors

Announcing a program of research, underwritten by the publishers of ELECTRONICS, to develop equipment and test the potentialities of the Citizens Radio Service. First equipment, a transmitter meeting FCC specifications, is described in this issue

THE EDITORS OF ELECTRONICS are happy to announce a series of articles, beginning in this issue, on equipment specifically developed for the Citizens Radio Service, operating in the band between 460 and 470 megacycles and ultimately intended for use by the general public for private communication. The first item of equipment, a four-tube crystal-controlled f-m transmitter, is described on pages 84 to 89. Succeeding issues will describe a high-sensitivity f-m superheterodyne receiver, a power amplifier for the transmitter, high-gain non-directional antennas, and will relate the results of comprehensive tests of this equipment in the field.

Walter Hollis, who designed Citizens Radio Service equipment for ELECTRONICS, testing transmitter at Boonton

The Citizens Radio project, the costs of which have been underwritten by McGraw-Hill as a service to the industry, is intended to reveal the potentialities of the new band for public use and to offer equipment designs suitable for production by individuals or commercial organizations. This program, which marks a new departure in technical publishing practice, was undertaken by the editors of ELECTRONICS early in 1947 after discussions with Commissioner Ewell K. Jett, sponsor of the Citizens Radio Service in the FCC.

Citizens Service Slow to Start

The 460 to 470-mc band was first proposed by the FCC before the end of the war, in May 1945, and was made an official part of the allocation table in June 1946. When the band was first announced, engineering opinion on it was generally pessimistic. While all agreed with the basic philosophy of providing a band for the general public, most observers doubted the wisdom of choosing a frequency band as high as 460 to 470-mc for the purpose. But since lower frequencies were already occupied by existing services of higher priority, the allocation stood as originally proposed. In the intervening two and one half years no equipment has been made available commercially for this band.

The reason for the inactivity was not lack of interest, since a sizable

Citizens Radio Project

Commissioner Jett Hopes ELECTRONICS Project Will Speed Citizens Radio

Shortly before the end of the war, the Federal Communications Commission announced a proposed allocation of the band 460-470 megacycles for a citizens radio service. Intended for use by the general public for private or personal communication, the new band is available to any citizen who agrees to abide by the law, with no technical license requirements. To serve such a purpose, equipment for the new band would have to be simple and virtually foolproof. In June, 1947, the Commission issued tentative specifications for the equipment and announced a plan for type approval which will assure the adequacy of the equipment before it is offered to the public.

The proposal has received widespread approval in the industry. But engineers have found it difficult to design equipment for the band which would meet the necessary specifications, particularly with respect to frequency stability. It has appeared that some time might elapse before the citizens radio service would become a practical reality.

It is, therefore, most reassuring to know that the Editors of ELECTRONICS have underwritten a comprehensive program to develop and test equipment for this important new service. It is my sincere hope that this program, in which the industry is invited to participate, will reveal the full potentialities of the new service and that the public will be able to make full use of the facilities in the near future. It is to be emphasized that type approval by the FCC will be necessary before large-scale production of any particular design of equipment begins.

(signed) **E. K. JETT**
Commissioner
Federal Communications
Commission

market for such equipment has been predicted by equipment manufacturers from the very start. The reason was rather a difficult technical problem. Stated briefly, engineers found it next to impossible to generate adequate amounts of power at the 460 to 470-mc frequency with equipment simple enough, and foolproof enough, to serve the non-technical public in portable and mobile service.

It was feared by many that interference would prove, even within a 10-megacycle band, insuperable if radiating receivers and non-stable transmitters were used in any number in heavily populated areas. Secondly, the industry has been unwilling to offer equipment for the Citizens Service until more was known about its adequacy for different uses. The 460 to 470-mc band has quasi-optical properties under normal conditions, so communication might prove impossible unless line-of-sight paths were maintained between units. While such a restriction might prove acceptable on farms in the Plains States, it would certainly prove a hindrance in built-up cities, suburbs, and in rolling or mountainous country.

Survey Conducted by Editors

A survey conducted by the editors in 1946, among manufacturers known to be interested in the Citizens Service, revealed practically no activity beyond laboratory measurements on self-excited and superregenerative units, all of which seemed inadequate. It looked as though the new service might go begging. Shortly thereafter the staff of ELECTRONICS resolved to set up a development project, to see whether technical and operational answers to the unsolved problems might be found. Encouraged by Commissioner Jett to proceed, the following plan was put in action:

An appropriation of funds was set up to underwrite the costs of parts and materials, engineers' and technicians' time, and application for an experimental license was made to the FCC. A search was then instituted to find a project engineer familiar with the problems of stable transmitters and receivers at these frequencies, who would be willing to undertake the project on his own time. This search was rewarded in the person of Walter C. Hollis, an engineer on the staff of the Sperry Gyroscope Company. Mr. Hollis, who has published an article in ELECTRONICS[1] on the design of tuned-line resonators suitable for this band, agreed to design and supervise the construction of suitable equipment.

Sperry was not involved in the project but was asked whether there was any objection to Mr. Hollis undertaking the assignment, provided all activity was confined to out-of-office hours, and graciously gave assent. The equipment is, accordingly, a personal development of Mr. Hollis. All rights in the design have been relinquished by him, as well as by the publishers of ELECTRONICS, and are hereby placed in the public domain. Any person or organization who desires to copy the designs or equipment may do so for any private or commercial purpose.*

When the project was well underway, the FCC announced tentative equipment specifications which would have to be met before type approval would be given to equipment or transmitting licenses issued. These specifications did much to remove the atmosphere of uncertainty surrounding the engineering problem. On May 20th, the FCC issued an experimental station construction permit, under the call W2XSN, to the McGraw-Hill Publishing Company to cover the development and testing of the equipment.

By mid-September the initial item of equipment, the transmitter previously mentioned, had been completed and subject to an equipment test in the field, where it performed satisfactorily, as outlined in later paragraphs. Accordingly, the editors were encouraged to announce the program and proceed with publication of technical details.

Purpose of Program

In announcing the program, the editors wish to emphasize that its purpose is developmental and experimental. Many (in fact, most) of the questions concerning the Citizens Service remain unanswered at this stage, particularly those relating to performance of the equipment in the field. Within the limits of its resources, the staff intends to test the system and to report the results objectively, good or bad, in coming issues. But the full potentialities of the service can be recognized only after an extensive test, conducted by many groups in different parts of the country and under different conditions.

To make possible the widest use of the designs, a primary objective of the program has been to use standard and conventional components throughout, and to eliminate entirely the need for specially machined cavities and other difficult-to-construct items. Cost figures will be published as the program proceeds. At the moment it appears that the investment in parts and materials, for a complete 465-mc crystal-controlled transmitter-receiver (without power amplifier) including power supply will be under one hundred dollars at current net prices.

Although the aim has been simplicity and inexpensive construction, the equipment has been required to meet the more strict of the two proposed FCC frequency tolerances and to meet standards of good engineering practice throughout.

FCC Specifications

Since the equipment under development was designed to meet FCC regulations, it is pertinent to state the proposed FCC specifications In accordance with FCC Public Notice 8387, issued June 27, 1947, it is proposed to divide the citizens band into three regions. The central region extends from 462 to 468 mc, within which any approved equipment may be used, including equipment of poor frequency stability (Class B stations, ± 0.4 per cent). The other two regions are the band edges from 460-462 mc and 468-470 mc, within which only equipment having excellent frequency stability (Class A stations, 0.02 percent) may be used. The 460 to 462-mc region is restricted to equipment operating at fixed locations; the other regions are for fixed, mobile, or portable operation.

Modulation may be of the amplitude, phase, or frequency type, and all sidebands are to be confined within a 200-kc band. Transmission may be by c-w radiotelegraphy, radiotelephone, or facsimile. The input plate power to the final stage must be limited to 50 watts in the band-edge regions and 10 watts in the central region. Spurious radiations from the transmitter must be eliminated or reduced in accordance with good engineering practice, and in any event shall not cause interference to receivers of good engineering design tuned outside the 460 to 470-mc band.

When a manufacturer intends to produce 100 or more units of a given type, he may submit a typical production equipment to the FCC for type-approval tests. If the equipment meets FCC requirements it will be awarded a type-approval certificate and thereafter transmitting licenses may be issued to applicants owning such equipments. If less than 100 units are to be manufactured, type-approval tests will not normally be conducted but full information on the unit may be forwarded to the Commission which may, at its discretion, decide to test a sample in accordance with the standard type tests.

Choice of Basic Design

In developing the ELECTRONICS Citizens Radio equipment, it was decided to construct initially an equipment which would meet the Class A specifications, that is, 0.02 percent frequency tolerance. This choice was dictated by two factors: first, such equipment can be used for any purpose, anywhere in the band; second, the specifications could be met by a straightforward engineering approach using crystal control, whereas the Class B design might require an extensive investigation into non-crystal-controlled stable oscillators. As the program proceeds, it is hoped that a suitable Class B design, consuming the minimum amount of space, weight, and power, and taking advantage of the 0.4 percent frequency tolerance, will be evolved.

Since the 0.02 percent tolerance virtually demands crystal control, it was decided to produce the simplest possible crystal-controlled transmitter, using conventional miniature tubes, tuned circuits, and simple square cavities. All metalworking would be confined to that

* Commercial organizations are reminded that licenses under various patents covering the use of vacuum tubes and circuits are required before any transmitting or receiving equipment embracing these patents may be offered for sale. Most equipment manufacturers hold licenses for this purpose. Others are advised to secure licenses before proceeding.

possible with a drill press (or, in a pinch, a portable electric drill), an ordinary vise, and usual small tools. The estimate of primary power required was 50 watts, so it was decided to build the equipment for mobile use in vehicles having a six-volt storage battery, or for fixed station operation.

The r-f power-output specification was broken down into three categories. The initial transmitter would have a power output less than one watt (the actual unit produced one-quarter watt at carrier frequency, as measured by a Bird wattmeter) and would be suitable for short-range operation. A power amplifier, employing standard components, would increase the power output to about 3 watts. A more complicated power amplifier, employing a lighthouse tube and requiring some skill in machining cavities, would permit operation at the maximum permissible level of 50 watts input to the final stage.

Frequency modulation (actually phase modulation plus frequency multiplication) was decided upon for the following reasons: A simple phase-modulation network is available which uses a germanium crystal and will provide about 15-kc deviation after multiplication from a 4.3-mc crystal frequency to the 465-mc carrier frequency. This modulation system is simpler and consumes less power and tubes than the corresponding amplitude modulator. The power efficiency of the final stage is higher when f-m is used. Finally, the signal-to-noise performance of the system as a whole, and consequently the range of coverage, is superior on f-m provided a high modulation-index is used and the receiver is built for high sensitivity. Both of the latter requirements are met in the design.

Basic Transmitter

The first equipment, the basic transmitter described in detail in the following pages, follows the plan just outlined in all respects. It employs but four tubes, produces a crystal-controlled carrier at 465 mc with 0.25-watt output power. All the tubes are standard miniature types mounted in standard sockets. Ordinary tuned circuits are used up to the final stage, at which point two resonators, (actually loaded sections of coaxial line, built in square shape) are introduced. A frequency multiplication of 108 times is achieved in three tubes, two of which are double triodes.

The transmitter is designed as one of three units of similar size, all of which will be mounted in a single container in the completed transmitter-receiver. The other two units are receiver, and power-supply control-switching unit.

Equipment Test

The basic transmitter was subjected to a test in the field at Boonton, N. J., on September 10, 1947. The assistance of Jerry Minter of the Measurements Corporation, in measuring the field strengths and providing test facilities, is much appreciated. In the test, two quarter-wave ground-plane vertical antennas were used, one mounted on the top of an automobile, the other placed on the laboratory roof at an elevation of 15 feet. The transmitter was operated from the car. The transmitter power supply, a vibrator power pack, was supplied from the car battery at 6.4 volts and produced 135 volts on the plates of the tubes. A carbon-button microphone and microphone amplifier, mounted on the power supply chassis, fed audio voltage at 5 volts level to the phase-modulation network of the transmitter proper. The transmitter was placed on the front seat of the car. During six hours of testing, including driving over rough country roads, the transmitter remained in adjustment and gave no trouble whatever.

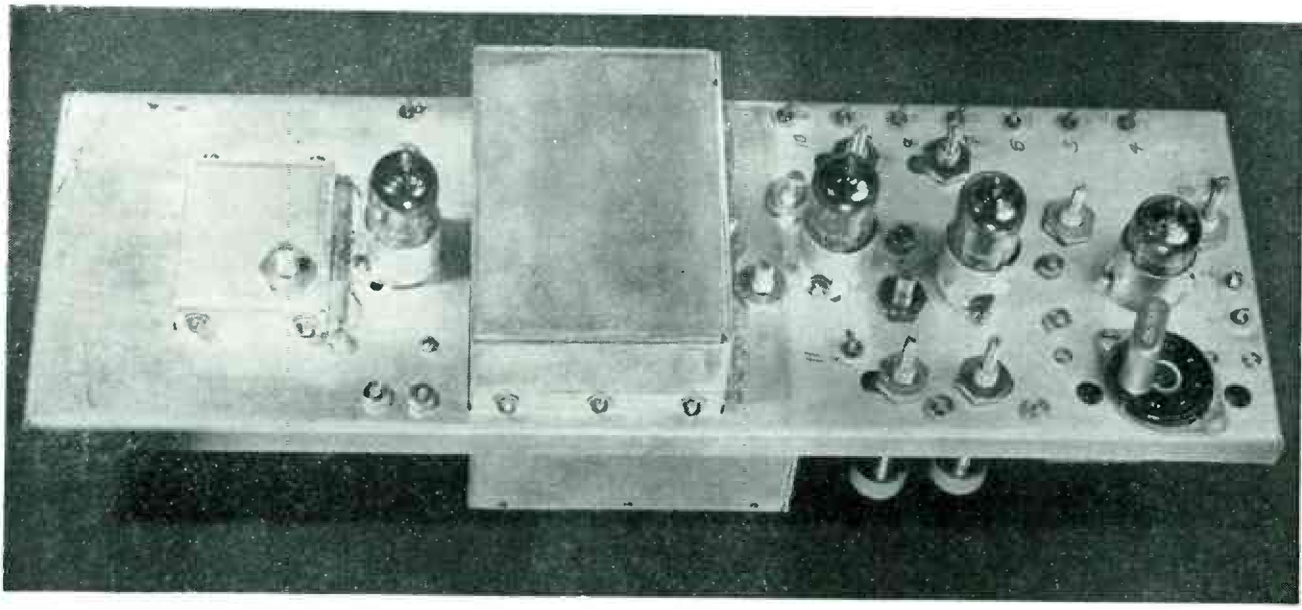
To measure field strengths, an AN/APR-4 search receiver with self-contained signal-strength meter was employed. This produced a 30-mc carrier (the intermediate frequency) which was detected by a Hallicrafters model S-27 f-m/a-m receiver and fed to a loudspeaker. The input signal to the APR-4 receiver (picked up by the ground-plane antenna on the roof) was compared by the substitution method with the output from a Measurements Corporation model 84 uhf signal generator. A matching stub was used to secure a proper match to the antenna.

The following results were obtained: An input signal of 200 microvolts was developed when the transmitter antenna was located at 25 feet. This is lower than would be expected from a radiated power of 0.25 watt, which is the output measured in the laboratory. The loss probably is accounted for by a mismatch between the transmitter and its radiator. The signal strength decreased as the inverse first power of the distance (when line of sight prevailed) out to a distance of 1600 feet (approximately one-third mile.) No longer line-of-sight path was available at this location. Complete quieting of the receiver occurred, with consequent full intelligibility of the speech modulation at a receiver input of 8 microvolts, and bare intelligibility was achieved with 4 microvolts input.

Although this test was not intended to show any propagation effects, some incidental observations were made which indicate factors to be studied at length when propagation tests are begun. It was found that foliage produced a pronounced shielding effect, so much so in fact that communication could not be maintained beyond one-half mile since heavy foliage intervened along the roads available at the Boonton location. In one quantitative test of this effect, it was found that a single row of small birch and poplar trees about 50 feet from the transmitter, then located 1500 feet from the receiver, introduced an attenuation of two-to-one in voltage.

The tests revealed that the transmitter would survive rough usage without loss of adjustment, and showed that in-the-clear transmission paths up to one-third mile could be covered adequately with the equipment putting out substantially less than its full output. However, even with a properly matched antenna, it was clear that higher power (available from the power amplifier scheduled for test in the near future) would be required for full coverage at greater distances, particularly if obstructions and foliage intervened. These matters will be investigated in tests to be conducted in future weeks. —D.G.F.

(1) Walter C. Hollis, Design of Transmission Line Tank Circuits, ELECTRONICS, p 130, May 1947.



Top view of transmitter. Output of 4.3-mc crystal (lower right) is multiplied 108 times in three tubes to 465 mc. Final stage, a 6J4 triode (left), produces one-quarter watt output

TRANSMITTER for the Citizens Radio Service

Simple low-power f-m unit, using conventional tubes and components, meets FCC Class-A specifications for 460 to 470-mc band. Phase modulation and crystal control produce stable quarter-watt output in unit designed as part of portable-mobile equipment for general public

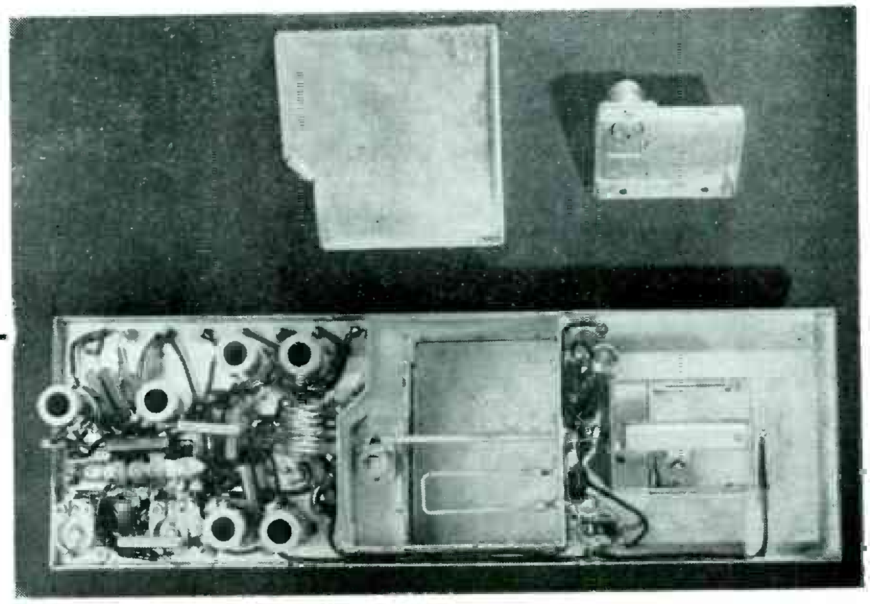
THE equipment described in this article was constructed as part of the ELECTRONICS Citizens Radio Project. The purpose of this project, as well as the philosophy underlying the design of the equipment and results of initial tests, are stated elsewhere in this issue (p 80). The present treatment is intended to provide sufficient discussion of the electrical and mechanical details of the transmitter to permit its construction and adjustment by those readers who may wish to copy it for their own use.

The transmitter is a direct crystal-controlled unit employing four tubes and a phase-modulation network. The power output of the final stage is one-quarter watt at the center frequency of the citizens band, 465 mc. This power level is small, and is admittedly not sufficient to permit full utilization of the citizens band when obstructions intervene in the transmission path. However, a surprisingly large range can be covered in direct line-of-sight with this power output. A line-of-sight path of 25 miles (transmitting and receiving antennas elevated 100 feet or higher) can be covered with a power output of only 11.5 milliwatts, using dipole antennas, with a receiver noise figure of 10 db and a carrier-to-noise ratio of 10 db. This computation is based on the well known relation which gives the attenuation between half-wave dipole antennas in free space:

$$\text{Attenuation} = 10 \log_{10} \frac{64\pi^2 r^2}{9\ \lambda^2}\ \text{db} \qquad (1)$$

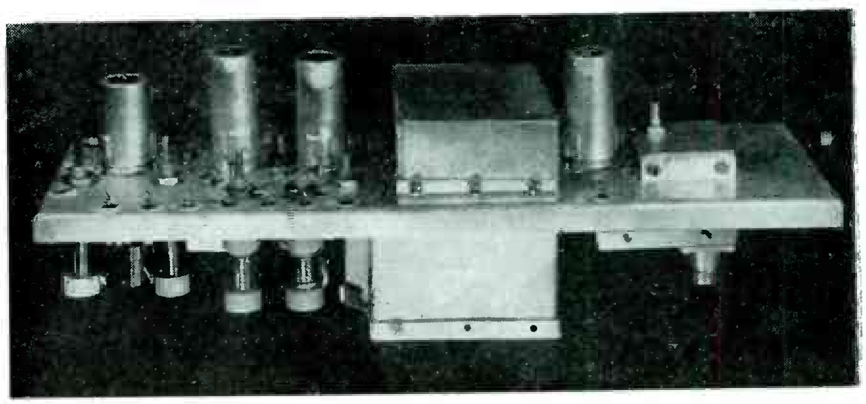
where the distance r between transmitter and receiver and the wavelength λ are in the same units, e.g. meters. It is expected (although tests have not yet been completed at maximum range) that the transmitter described will cover a 25-mile line-of-sight path with 20-db carrier-to-noise ratio.

The phase modulation network,



Bottom view, showing interior of resonators and coupling loops. Conventional coils are used up to 116 mc

By
WALTER C. HOLLIS
*Radio Engineer, Sperry Gyroscope Company**



Side view, showing enclosed quarter-wave-line resonators at input and output of final stage

Part I

of a Series

described later in this article, is designed to produce a maximum modulation of 28.6 degrees (one half radian). At the lowest modulating frequency in the voice band (300 cps) this phase deviation will produce a frequency deviation of approximately 16 kc when a frequency multiplication of 108 times is introduced between modulator and carrier output. This deviation compares favorably, in its ability to reduce noise, with the 75-kc deviation employed in f-m broadcasting provided the maximum modulating (voice) frequency is restricted to 3,000 cps. The deviation produces sidebands which are well within the 200-kc channel width specified by the FCC regulations.

Circuit Description

As shown in the block diagram of Fig. 1, the transmitter employs a 6AK5 crystal-controlled oscillator, a 1N34 germanium crystal diode in the modulation network, a 6J6 twin tripler, a 6J6 tripler-doubler, and has a 6J4 doubler in the final stage.

The oscillator employs the screen as the plate of a conventional tgtp. oscillator. The output of this crystal-controlled oscillator is electron coupled through the plate to the phase modulating network. The phase modulating network is a constant-impedance network, the phase of which is varied through audio modulation on the crystal diode.

The phase-modulated carrier of 4,305.560 kc drives one unit of the first 6J6 tube as a tripler. The tripled output then feeds the other unit of this same 6J6 as another tripler. The output of the first 6J6 is thus nine times the crystal frequency, or 38.75 mc.

One unit of the second 6J6 is driven as a tripler whose output

* The equipment described was produced by Mr. Hollis as an independent consultant to the McGraw-Hill Publishing Company. For a full account of ELECTRONICS Citizens Radio Project, see p 80.

feeds the other unit of the same 6J6 as a doubler. The output of the second 6J6 is fifty-four times the crystal frequency, or 232.5 mc. All sections of the 6J6 are conventional grid-driven harmonic generators. The output stage of the transmitter is a 6J4 employed as a grounded-grid doubler, the output feeds the antenna through a coaxial cable.

Circuit Details

The complete schematic diagram of the 465-mc transmitter is shown in Fig. 2. Values of all component parts are indicated. A 6AK5, V_1, is used as the oscillator-buffer. The screen, grid, and cathode are used as a triode in the conventional oscillator. Y_2 is a quartz crystal which, together with C_2, determines the frequency of oscillation. C_2 is used for fine frequency adjustment. R_1 in series with R_2 provide grid bias through grid rectification. In addition, R_2 is bypassed for r-f by C_3 and is used as a metering resistor for oscillator grid current. L_1 is a permeability-tuned coil which, together with C_4 and screen-to-cathode tube capacitance, forms the screen resonant circuit. R_4 drops the voltage supplied to the screen of the 6AK5 tube and, with C_5, forms a decoupling filter.

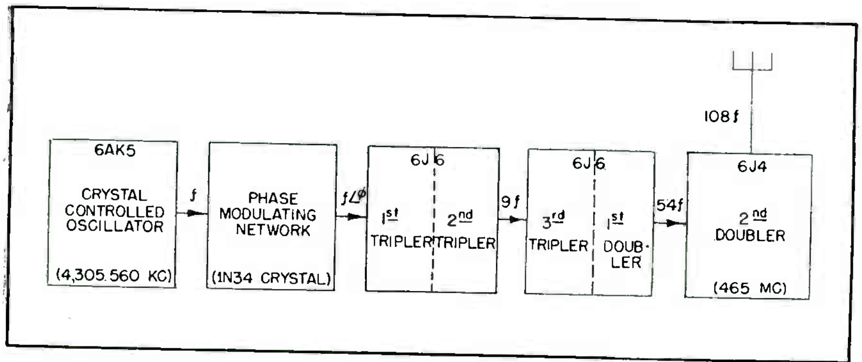
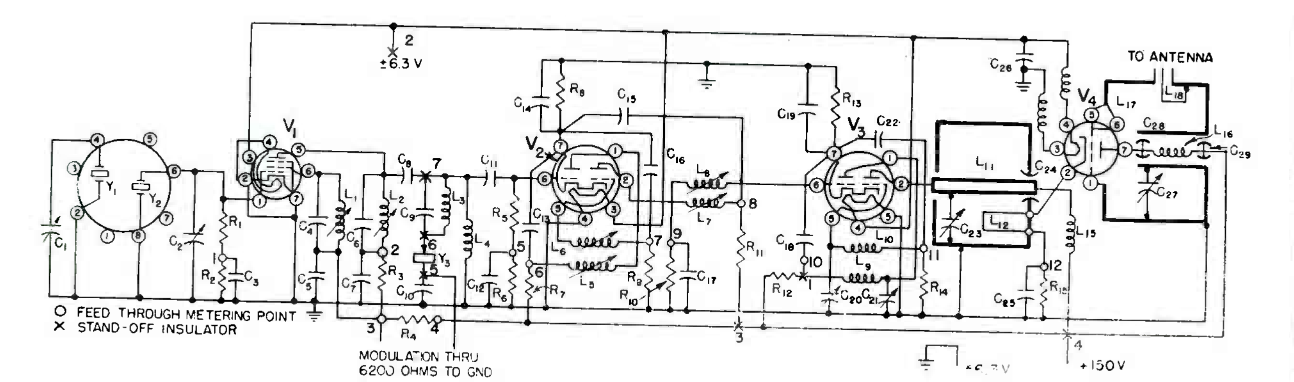


FIG. 1—Block diagram of transmitter. Tubes are conserved by operating three 6J6 triode sections as triplers. Phase modulation network produces 25-kc deviation

The output is coupled through the plate. Output voltage for driving the first tripler is developed across the modulating network to be described later. L_2 is a permeability-tuned coil which, with C_6, the output capacitance of the oscillator and the input capacitance of the first tripler, constitutes the plate resonant circuit. R_3 is a dropping resistor which places the plate voltage below the screen by a sufficient amount to reduce output voltage to the level required by the modulating network. R_3 and C_7 form the plate decoupling filter. C_8 and C_{11} are blocking capacitors. R_5 and R_6 develop the necessary grid bias for the first tripler through grid rectification. R_6 bypassed by C_{12} serves as a grid metering resistor for the first tripler.

Components Y_1 and C_1 are the frequency control and frequency



C_1, C_2—Erie Ceramicon TS2A trimmer, 7 to 45 $\mu\mu f$
C_3, C_8, C_{10}, C_{11}, C_{15}, C_{17}—350 $\mu\mu f$ silvered mica
C_4, C_6—56 $\mu\mu f$ silvered mica
C_5, C_7, C_{12}, C_{13}, C_{14}, C_{16}—700 $\mu\mu f$ silvered mica
C_9—Erie insulated Ceramicon, 12 $\mu\mu f$
C_{18}, C_{22}—70 $\mu\mu f$ silvered mica
C_{19}, C_{25}, C_{26}—Erie 370FA button mica, 235 $\mu\mu f$
C_{20}, C_{21}, C_{23}, C_{27}—see text
C_{24}—Erie 470BH button mica, 1,000 $\mu\mu f$
C_{28}, C_{29}—Erie 370BB button mica, 1,000 $\mu\mu f$

L_1, L_2—see text
L_3—r-f choke, 1 mh
L_4 to L_{18}—see text

R_1—Allen-Bradley, 250,000, ½ w
R_2, R_6—Allen-Bradley, 10,000, ½ w
R_3, R_4—Allen-Bradley, 15,000, ½ w
R_5, R_9, R_{10}—Allen-Bradley, 10,000, ½ w
R_7, R_{11}, R_{12}—Allen-Bradley, 1,000, ½ w
R_8, R_{13}—Allen-Bradley, 100, ½ w
R_{14}—Allen-Bradley, 6,800, ½ w
R_{15}—Allen-Bradley, 390, 1 w

V_1—6AK5
V_2, V_3—6J6
V_4—6J4

Y_1—Auxiliary crystal
Y_2—Hunt Corp. CR7, 4,305.560-kc crystal
Y_3—IN34 crystal diode

FIG. 2—Complete schematic of transmitter. Socket orientation and feed-through numbers correspond to mechanical layout of chassis, shown in the drawing at the right

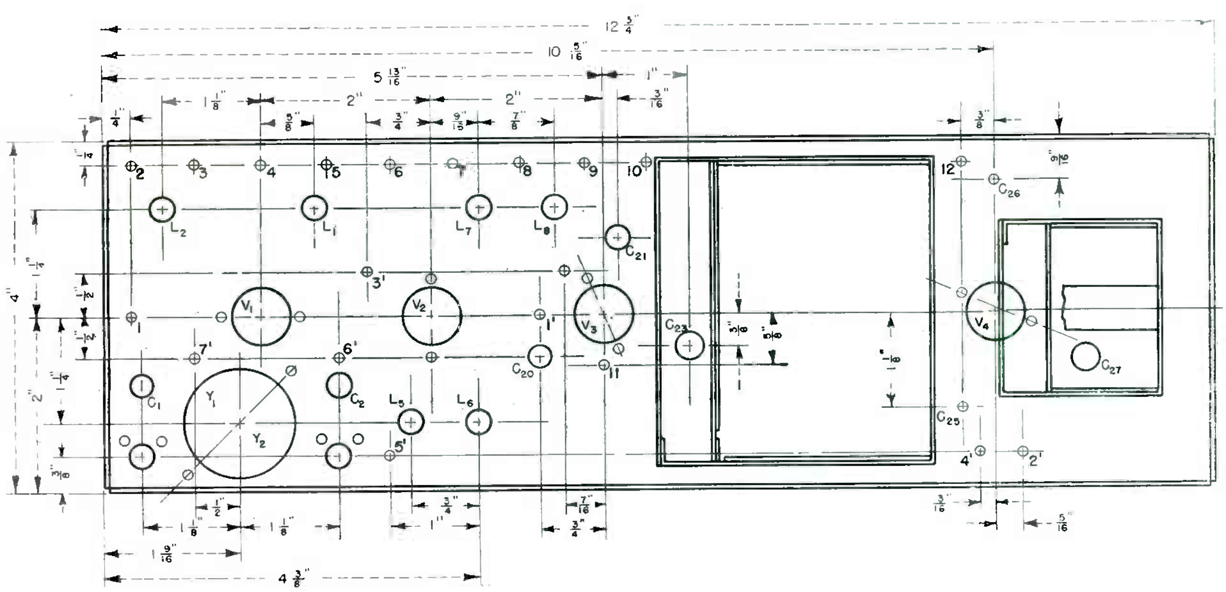
adjusting elements for supplying the local oscillator frequency for the receiver, to be described in a later issue.

The oscillator plate circuit load is the modulating network consisting of C_9, Y_3, L_4, L_3, C_{10}, and a 6,200-ohm resistor in series with a low-impedance modulating source. This network is the same as that used in the Raytheon cascade-phase-shift system[1], with a IN34 crystal (Y_3) replacing the cathode follower. For the network to present a constant impedance, the reactance of L_4 must be twice the reactance of C_9. L_3 presents a high impedance to the oscillator frequency, but provides a low-resistance d-c return for the rectified current of modulating crystal, Y_3. Y_3, in combination with C_{10} and the 6,200-ohm resistor in series with the modulating voltage, presents a variable resistor which is a function of the modulating voltage, in series with C_9. This variation in resistance causes the phase angle of the impedance to vary in accordance with the modulating voltage. As the electron-coupled oscillator output is essentially a constant-current generator, the voltage developed across the modulating network is phase modulated with negligible residual amplitude modulation. This property of negligible residual amplitude modulation is used to tune L_2. The procedure used is discussed under tuning adjustments.

All succeeding multiplier stages, except the final stage, are conventional grid-driven triode harmonic generators, employing the dual triode 6J6. Each stage except the first doubler employs conventional double-tuned circuits. These offer ease of excitation adjustment, freedom from parasitic oscillations, and good harmonic rejection. Grid bias resistors have been chosen for optimum output. Both 6J6 tubes, V_2 and V_3, are protected from overload due to loss of excitation by cathode bias resistors R_8 and R_{13} respectively.

The output tank circuit for the first doubler is unconventional. The tank circuit is a reentrant resonator of the capacitive-loaded transmission-line type[2]. The capacitive loading is a variable capacitor, C_{23}, and the inductive portion L_{11} consists of a length of short-circuited transmission line in a sheet metal shield. The plate supply is bypassed to ground by capacitor C_{24}, and is series fed through filter choke L_{15}, self-resonant at about 230 mc.

The output tube, V_4, is a 6J4 employed as a grounded-grid doubler. The output of the first doubler, at 232.5 mc, is inductively coupled to the cathode of V_4 by means of pickup loop L_{12}. As the driving impedance of a grounded-grid doubler is very low (a few hundred ohms), the circuit is untuned and noncritical. The output tank circuit is another transmission line resonator consisting of a variable capacitor, C_{27}, and a length of short-circuited transmission line, L_{17}. The plate supply is shunt fed through the filter arrangement consisting of C_{28}, L_{16}, and C_{29}. The output to the antenna is coupled through a pickup loop, L_{18}. Grid bias is supplied by the voltage drop through cathode resistor R_{15}, bypassed for r-f by C_{25}. L_{13}, and L_{14}, are self resonant chokes



HOLE SPECS:
Feed-throughs 1 to 12-G drill (2 to 10, Spaced 3/4")
Stand-offs 1' to 7', #30 drill
Coils L1, L2, L5, L6, L7, L8–1/4" drill
Capacitors C1, C2–3/16" drill spaced 7/8", #30 drill spaced 7/16"
Capacitors C19, C25, C26–#36 drill
Capacitors C20, C21, C23, C27–1/4" drill
Tube sockets for V1, V2, V3, V4–21/32" hole, #30 drill spaced 7/8"
Lock-in socket for Y1, Y2–1 5/16" hole, #30 drill spaced 1 11/16"

FIG. 3—Mechanical layout of chassis. Slight differences from layout shown in photos have been introduced to simplify construction. Relative location of tube sockets and resonators is critical

which place the filament at the same r-f potential as the cathode. C_{26} bypasses all filaments to ground.

Parts List

In addition to the parts listed with the circuit diagram, the following are required:

1 lock-in socket
4 miniature tube sockets
6 National XR50 coil forms
4 E. F. Johnson capacitors, type 160-107 (3-15 $\mu\mu f$)
Note: Modify Johnson capacitors C_{20}, C_{21}, C_{23}, and C_{27} to have three stator plates and four rotor plates.
14 glass-sealed feed-throughs (such as Electrical Industries, Inc. type AB-60W-PP)
7 stand-off terminals (such as Winchester Co., stand-off No. 754)
3 1-watt Allen Bradley resistors, 100,000 ohms or larger
1 ½-watt Allen Bradley resistor, 100,000 ohms or larger
1 CIU-UG-58/U panel mounting connector
Miscellaneous hardware, wire, solder, 1/32-inch half-hard sheet brass

At current net prices, total cost of parts is approximately $40.00.

Coil Specifications

L^1, L^2, L^6—41 turns No. 27 heavy formvar wire, close wound on National XR-50 form
L_4—250-microhenry universal-wound r-f choke (commercial tolerances can be compensated by adjustment of C_6)
L^5—50 turns No. 29 heavy formvar wire, close wound on National XR-50 form
L^7—15 turns No. 20 heavy formvar wire, close wound and centered on National XR-50 form
L^8—12 turns No. 20 heavy formvar wire, close wound and centered on National XR-50 form
L^9—4 turns No. 14 tinned copper wire, ½ inch diameter, space wound for 7/16 inch length, self-supported between C_{21} and stand-off No. 1.
L_{10}—3 turns No. 14 tinned copper wire, ½ inch diameter, space wound for ¼ inch length, self supported between C_{20} and feed-through No. 11
L_{13}, L_{14}, L_{15}—15½ turns No. 22 plain enameled, close wound on 1-watt Allen-Bradley resistor, 100,000 ohms or larger, dipped in glyptal
L^{16}—12 turns No. 22 plain enameled, close wound on ½-watt Allen-Bradley resistor, 100,000 ohms or larger, dipped in glyptal

Chassis Construction

The chassis is of conventional sheet metal construction shown in the photographs. The chassis is made entirely of 1/32 inch half hard sheet brass. The completed chassis consists of a drilled base 12¾ by 4 by 13/32 inches upon which are mounted two resonators for the final multiplier stages. With the resonators and all parts and tubes in place, the overall height is 4¼ inches. The details given below are slightly different from the photographs. These changes have been made to simplify the construction and do not impair the performance.

The bottom view of the chassis layout is shown in Fig. 3. All holes have been identified with the component indicated on the circuit diagram of Fig. 2. A mounting lip projects ⅜ inch below the bottom of the chassis on all four sides, as is seen in the sectional elevation view of Fig. 4. Two mounting holes for the resonators are provided in the chassis base. The cutout for the resonator for the first doubler is 2 9/16 x 3 9/16 inches; for the second it is 2 1/16 x 1 5/16 inches. Lips projecting ⅜ inch above the top of the chassis base are provided for mounting each resonator.

The layouts for the first doubler resonator shield and the second doubler shield are shown in Fig. 5 and 6. After cutting, the shields should be bent as shown in Fig. 3 and 4, and soft soldered along the quarter-inch lips provided in the layouts. The shield for the second doubler resonator should have its center conductor, consisting of ½-inch diameter by 1/16-inch wall brass tubing, soldered into place as indicated in Fig. 3 and 4. In addition, covers with ⅜-inch lips should be made to fit each shield. These may be anchored in place by 4-40 screws tapped into the shields. The cover for the output resonator should be drilled for mounting a UG-58/U r-f fitting for the output connection, as shown in the photographs. All chassis parts should be cadmium plated to resist corrosion.

After plating, the parts are assembled as follows: C_{24}, a 1,000-$\mu\mu$f type 470-BA button mica capacitor, is centered and soft soldered over the ½-inch hole in the shorted end of the first doubler shield. In addition, two glass-sealed feed-throughs are soft soldered into the G drill holes provided. These are used to mount output pickup loop L_{12}, which is made of No. 14 tinned copper wire, approximately 1 x ½ inch. The center conductor should next be installed. It is made of ⅛-inch brass rod of length indicated in Fig. 4 and threaded on the end for 2-56 nuts. The center conductor should be bolted through C_{24} with a lug provided for mounting L_{15}. The assembly constituting L_{11} and L_{12} is then mounted on the chassis base by means of the mounting lip and 4-40 screws tapped into the shield. The inside junction between the shield and the chassis base should be soldered to provide a solid electrical connection. C_{23} should then be mounted on the chassis and the two stator uprights soldered to the center conductor. This assembly constitutes the complete resonator for the first doubler. The mounting holes for the socket for V_3 are so aligned that terminal No. 2 may be soldered directly to the center conductor of the resonator.

The output resonator is next assembled. C_{28}, L_{16}, and C_{29} are assembled to the center conductor by soldering as indicated in Fig. 4. C_{27} is mounted and the two uprights soldered to the center conductor. The resonator then is mounted on the chassis base by means of the mounting lips and 4-40 screws tapped into the resonator shield. The socket for V_2 is next mounted and terminals 1, 5, and 6 soldered directly to the output resonator.

All feed-through connectors should next be soldered into holes provided in the chassis base. All other components may then be mounted on the chassis base, taking care to align all terminals for shortest connections. C_{20} and C_{21} are mounted such that terminals 5 and 1, respectively, on the tube socket for V_3 may be soldered directly to the terminal lugs provided on the capacitors. L_9 and L_{10} are mounted axially and the spacing adjusted during tune-up for maximum drive to the first doubler. Where possible, series resonance is employed in the mica bypass capacitors.[3]

Tune-up Procedure

After the transmitter wiring has been checked, the tubes and crystal may be installed in their respective sockets and voltages applied. Filament supply at 6.3 volts is applied between stand-off terminal No. 2 and ground, and 150-volt d-c plate supply between terminal No. 4 and ground.

Test equipment used included a 20,000 ohms-per-volt test analyzer such as the Simpson Model 260, an audio oscillator, and a cathode-ray oscilloscope. A set of absorption wavemeters is useful to assure that the proper harmonic is tuned in each stage.

First connect the voltmeter between metering point 1 and ground. Starting with the poly-iron slug of L_1 all the way in, screw out the slug, watching grid current as registered on the voltmeter. Note

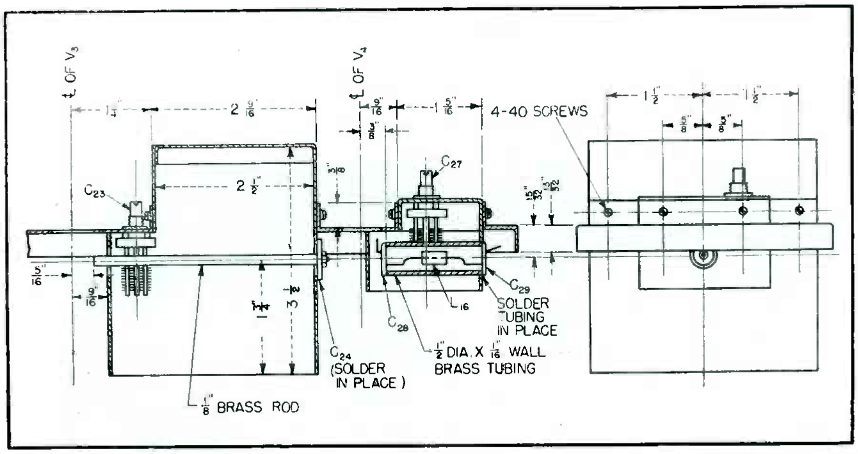


FIG. 4—Side view of chassis, showing constructional details of resonators operating at 232.5 and 465 mc

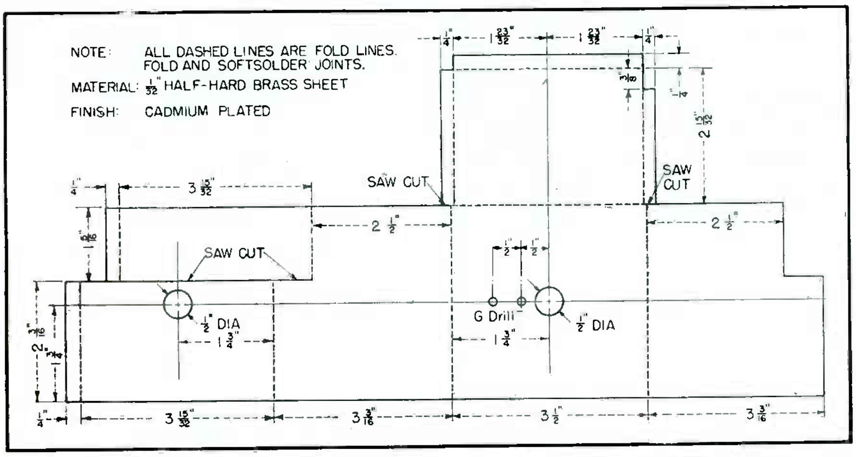


FIG. 5—Shield can for 232.5-mc resonator. Made from brass sheet, this structure can be bent into shape without machining

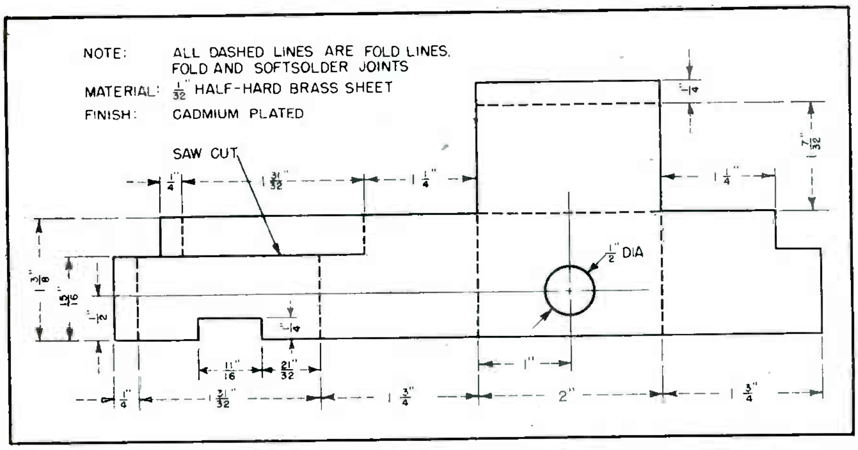


FIG. 6—Shield can for 465-mc resonator. If dimensions are followed accurately, both resonators may be tuned over band without mechanical adjustment, by adjusting loading capacitors

maximum reading and back off to about half of the maximum reading.

Next connect the audio oscillator through a 6,200-ohm resistor between stand-off 5 and ground, and set the output to about 5 volts. Connect the vertical amplifier of the cathode-ray oscilloscope between metering point 5 and ground. Through grid rectification in the first tripler, any amplitude modulation occurring in the modulation network appears across R_8 and may be seen on the oscilloscope. Adjust L_2 for a null (or minimum) as seen on the oscilloscope. L_2 is now properly adjusted and should *never* be retuned except by this method. The audio oscillator and oscilloscope may now be disconnected and the 6,200-ohm resistor returned to ground.

The voltmeter should now be connected between metering point 7 and ground and L_5 and L_6 adjusted for maximum grid drive as indicated on the voltmeter. The absorption wavemeter should be used to make sure that the proper harmonic is tuned. All other stages are tuned in a similar manner using successively metering points 9, 11, and 12. The output resonator is tuned for maximum output into a load or antenna. Output loop L_{18} should be adjusted for maximum output.

The following table gives representative readings obtained with a 20,000 ohms-per-volt analyzer connected to various stages.

Analyzer Lead Connections +	Analyzer Lead Connections −	Meter Reading (Volts)
Ground	1	0.6
Ground	5	3.2
Ground	7	38
Ground	9	33
Ground	11	15
12	Ground	8
4	3	65
3	2	30
4	2	103
4	6	5.2
4	8	8.2
4	10	7.4
4	L_{16}	23.5 ma
4	L_{18}	18 ma

The last two readings should be taken by opening up the plate supply leads and inserting the meter in series.

An output of approximately ¼ watt was measured using a Bird Wattmeter, Model 63-A. The output loop was made of No. 14 tinned copper wire with dimensions ¾ x ½ inch. Using improved coupling means, it is expected to increase the output to ½ watt.

Acknowledgements

The author gratefully acknowledges the cooperation of the Hunt Corporation, Carlisle, Pennsylvania, who supplied the quartz crystals. In addition, he is indebted to the fine craftsmanship of Herbert Hardy, who constructed the final model and the test resonators used in the development.

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(2) W. C. Hollis, Design of Transmission Line Tank Circuits, ELECTRONICS, p 130, May 1947.
(3) A. P. Green and C. T. McComb, Resonance in Mica Condensers, ELECTRONICS, p 19, March 1944.

Explosion-pressure recorder setup for use with remotely located capacitance-type pressure pickup. Operator adjusts bridge control unit with left hand and single-sweep generator with right hand while viewing pattern on oscilloscope screen through peephole alongside camera on hood. Unit at right is sweep tripper control unit

Measuring Pressures of

INVESTIGATIONS and tests to eliminate or reduce damage from explosions have been devoted to methods of preventing explosion damage in rooms or buildings, both from dust and from flammable liquid vapors. The method usually involved determining, in a specially constructed building, the ratio of free venting area to building volume required to prevent obvious excessive pressure or stress in the structure. The work has also included explosions in vessels and pipe lines with vapor-air mixtures and also mixtures of air with hydrogen and acetylene.

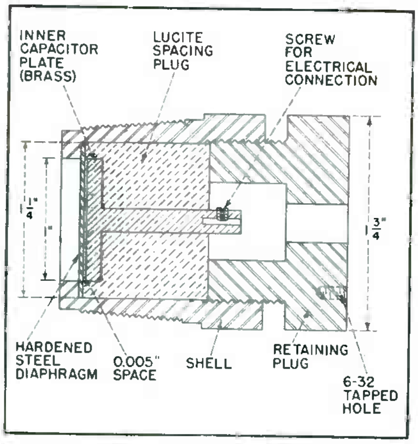


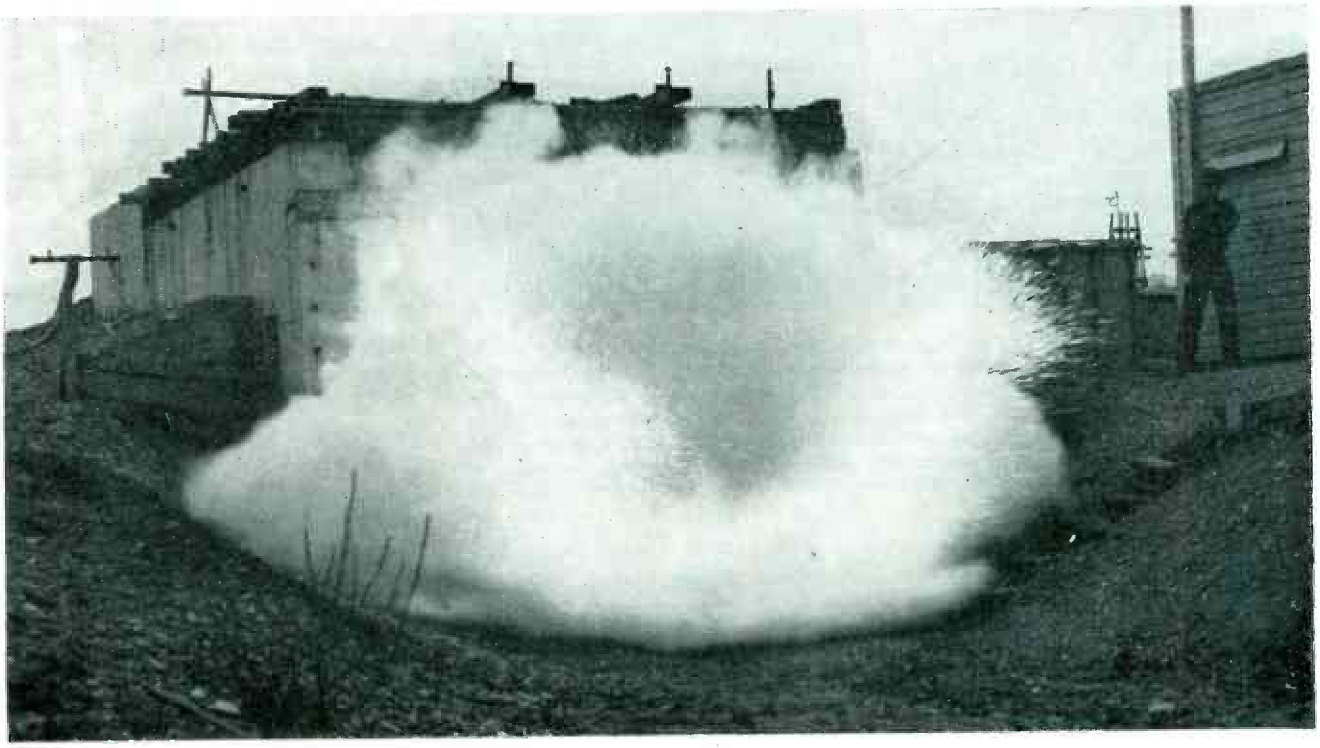
FIG. 1—Cross-section of capacitance-type pressure pickup. Sound waves act on steel diaphragm at left, causing capacitance between grounded diaphragm and insulated brass plate behind it to vary. Shell and retaining plug are turned from 1¾-inch hexagonal steel stock

Until recently, no wholly satisfactory instrument was available for obtaining pressure-time diagrams under such a wide variety of test conditions. Without an accurate pressure record there was no assurance that presumably identical explosion tests were being duplicated with respect to pressure, and the results of tests could not be applied with any degree of confidence to other conditions.

The pressure recorder described here meets all requirements for explosion research. It is adaptable to a wide range of maximum pressure, and it can be used for static conditions as well as for varying rates of pressure change, including those encountered in industrial explosions and water hammer. Because of the characteristics of the design, it is relatively independent of humidity, temperature, and extraneous pressure. A most important feature is that the design facilitates calibration in a very short time either before or after an explosion or other pressure test.

General Test Requirements

Occasionally tests are run which represent considerable time and expense for the setup, and it may be desired to obtain an accurate pressure record on an explosion which may not again be reproduced quickly, so that checking of results by many tests is not practical. Consequently, every individual test record should be completely reliable. Sometimes it is desired to measure pressures from an explosion the exact time of which is not predictable. For such cases the recording



Explosion of magnesium powder in a heavy concrete test tunnel at the Factory Mutual Laboratories is typical of accidental explosions but is set off under controlled conditions so that pressures can be measured and recorded to determine safety of various industrial conditions. Other tests include explosions of cleaning fluids in enclosed spaces and explosions of black powder in pipes

Industrial Explosions

Capacitance-type pickup feeds cro through 10,000-cps bridge to give pressure-time diagrams covering from 2 psi for dust explosions to 3,000 psi for gas-air mixtures in pipes, with calibration on static pressures. Automatic tripper circuit responds to explosions

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apparatus must be actuated automatically by the explosion pressure wave.

Some explosions, such as dust explosions in building structures, may give rise to maximum pressures of only two or three psi and the time required to reach peak pressure may be one-half second or even more. With other explosions, such as gas-air mixtures in pipe lines or closed vessels, maximum pressures may be of the order of 100 psi, or in some cases 2,000 to 3,000 psi, with pressure rise rates at very high values. Pressures due to water hammer in supply lines to sprinklers or in other hydraulic systems also develop very rapidly and may reach high peak values.

In explosion tests involving dusts or vapors in large areas, the decay of pressure may occur at such a slow rate that the pressure condition is almost static. Since the device must be used on static or near-static conditions, it is desirable to be able to calibrate the device statically in a very short period of time, either before or after any test.

In some tests it may be desired to locate the gage inside a building or

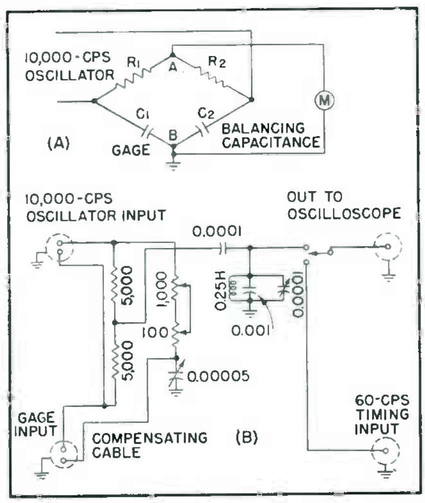

FIG. 2—Basic bridge circuit (A) used with gage, and final version (B) using tuned filter and compensating cable for limiting response to narrow band of frequencies around 10,000 cps

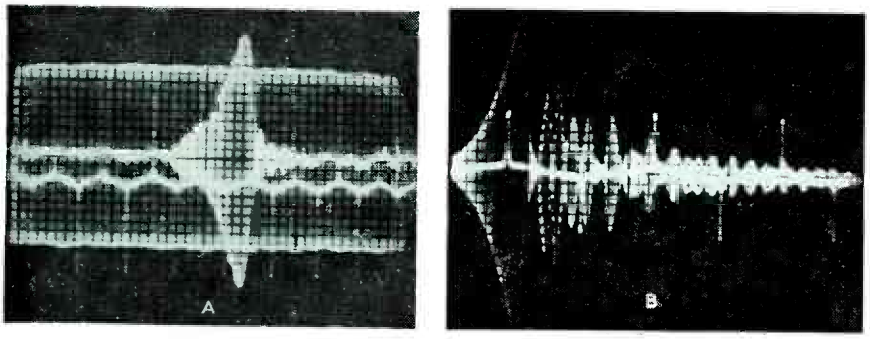

FIG. 3—Pressure-time diagram for typical industrial explosion producing 6.7 psi in 25 milliseconds (A), with peaked 60-cps timing wave and static calibration (horizontal traces) at 5 psi, as photographed with Super XX film at f/4.5 on 5LPI green tube using maximum beam intensity. Improved contrast (B) is obtained by using a 5LP11 blue tube at reduced beam intensity with Eastman Linograph 5244 film and an f/3.5 camera; this diagram is for a similar explosion producing maximum pressure of 7.6 psi, taken by means of automatic sweep tripper that started record at 0.57 psi

vessel as a space gage, whereas in other tests the gage must be external to piping or vessels.

In order to carry on varied experimental work, both inside and outdoors, it is essential that a pressure gage have certain characteristics. It should be accurate at least within 5 percent, and preferably within 2 percent or less. It should be able to operate satisfactorily at ambient temperatures from well above 100 F down to minus 50 F. Neither humidity nor transient temperature conditions should produce any serious error in results. The pressure pickup should be designed in such a manner that a wide variety of pressure ranges can be quickly and easily obtained by replacement of a simple element.

In the gage developed, a resistance-capacitance bridge circuit is used in which the pressure pickup acts as a variable capacitance in one leg of the bridge. Apparatus used includes an RCA 154 beat-frequency oscillator, a Du Mont 208B oscilloscope, and a Du Mont 215 single-sweep generator.

It is desirable in many cases to have a definite record of negative pressures, because there are times when these may not be so small nor of such duration as to be entirely disregarded. Experimental work on the new gage was conducted without such differentiation (that is, in a condition of complete balance at zero pressure) because this revealed the most about the gage characteristics. However, negative pressures can be shown easily by adjusting the bridge circuit to an unbalanced condition at zero pressure.

The pressure pickup was built according to the design shown in Fig. 1. The diaphragm thickness may be selected to accommodate a wide range of maximum pressures. For use as a space gage the hole in the retaining plug would be threaded to accommodate half-inch pipe or conduit to support the gage and shield the connecting cable from temperature and pressure changes. The conduit, plug, and shell would be grounded.

Circuit Characteristics

In order to utilize the special pickup, its capacitance and the capacitance of the connecting cable are balanced out so that only a change in capacitance will be indicated. A conventional RC bridge circuit is shown in Fig. 2A in which C_1 is the gage, C_2 the balancing capacitance, R_1 and R_2 the resistance elements of the bridge, and M a current or voltage detector.

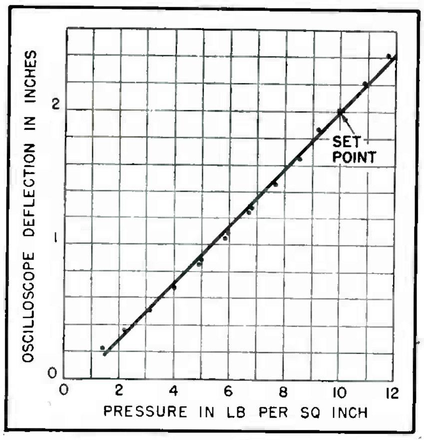

FIG. 4—Static calibration curve of pickup when using 0.02-inch thick steel diaphragm

It was found desirable to energize the bridge circuit at a frequency of approximately 10,000 cycles. In order to avoid serious frequency drift, it was necessary to use a voltage regulator between the 60-cycle power supply and the beat-frequency oscillator.

For maximum facility in operation, it would be desirable to ground the shell of the gage, the voltage detector, and also one side or a center tap in the power supply, but there is of course no common point for all three. Accordingly, for high-speed work, where it is necessary to use a cathode-ray oscilloscope as a detector, it is essential that the oscilloscope be grounded in its connection at point B, which requires that the power supply be isolated from ground.

It was found necessary to shield thoroughly all parts of the bridge circuit and its controls in order to eliminate 60-cycle pickup, some of which came through from the oscillator and could not be entirely balanced out. Grounding the center tap of the oscillator output transformer would eliminate most of the 60-cycle current transmitted from the oscillator, but this would bypass the bridge circuit with a signal direct to the grounded oscilloscope.

Attempts to eliminate 60-cycle current by inserting a small capacitance in each lead from the oscillator resulted in no advantage because even though the 60-cycle current was eliminated, harmonics of the oscillator frequency appeared, undoubtedly due to the inductance of the beat-frequency oscillator output transformer. Similar difficulties, either by generation of or sensitivity to high-frequency voltages, resulted from an attempt to use a simple inductance choke between the bridge output and ground.

The final solution, which gave satisfactory results, involved the use of a tuned filter connected across the oscilloscope input to reject all but a relatively narrow band of frequencies around 10,000 cycles. This was accomplished by the use of a 250-millihenry choke in parallel with a 0.001-μf capacitor with a variable vernier, as shown in Fig. 2B. With this circuit it was possible to balance the bridge to a point where the residual unbalance was about 0.001 volt, equal to 0.1 inch deflection on the oscilloscope with its amplifier adjusted to maximum sensitivity. Since the bridge has a ratio of unity, and the applied 10,000-cycle current to the bridge is approximately 30 volts peak, this represents a balance to within 1 part in 15,000.

In actual use, it was noted that there was occasionally considerable zero drift. This was caused by a change in temperature, and was almost wholly due to changes in temperature of the single-conductor microphone cable (20 feet long) used to connect the gage to the bridge circuit. Both resistance and capacitance of the cable were affected. To correct for these factors a two-conductor cable was substituted, with one inner conductor and the grounded outer shield connecting the gage and bridge, and the other inner conductor connected in parallel with the balancing capacitance of the bridge. In spite of this balancing arrangement, the cable was found to be somewhat pressure-sensitive. If the pickup is used as a space gage, it would be desirable to enclose the cable within the space by pipe or conduit.

Application to Explosion Tests

In a series of preliminary tests, the gage was used to measure the pressure required to break glass panes (14 x 19 inch) in one side of a 3 cu ft enclosure and subjected to explosions of flammable liquid vapors with air. A typical result is shown on Fig. 3A with accompanying 60-cycle timing wave.

Other tests included breaking a 0.003-inch thick paper diaphragm by explosions of black powder in a short length of 6-inch diameter pipe. A typical result is shown on Fig. 3B. These pictures were made with the 0.020 inch thick diaphragm in the gage; the static calibration for this diaphragm is given in Fig. 4. With a maximum useful range of approximately ten pounds per square inch, there is a range of about 10 psi where the departure from linearity is less than 0.2 psi.

When using this gage near maximum oscilloscope deflection, the speed of travel of the beam at 10,000 cycles is too fast with the usual green cathode-ray tube to give photographs having maximum sharpness. One solution for this would be the use of a rectifier between the bridge and the oscilloscope input. However, this would require an amplifier capable of a wide range of frequency amplification down to and including direct current for static calibration. The difficulty was overcome by substituting a cathode-ray tube of much higher actinic intensity, the blue Du Mont 5LP11.

For explosions the exact time of which can not be predicted in advance, an automatic tripper circuit was developed, utilizing a 6C5 amplifier and a 2051 relay tube as in Fig. 5. The input is taken from the oscilloscope deflection plate, and the output is connected to the single-sweep generator. This equipment operates on a signal (with some adjustment) equal to about 3 percent of the maximum useful deflection of 2 inches but under such adjustment it is especially sensitive to exterior electrical disturbances such as turning on and off an incandescent lamp. In actual practice the adjustment was made so as to trip at 0.1 inch deflection, or about 5 percent of the maximum. For explosion work the loss of the first fraction of the record is of no importance. Possibly for other applications it might be worth while to develop a satisfactory delay, so as to be able to photograph the entire pressure-time diagram.

Stability and Pressure Range

The shape of the calibration curve is affected only slightly by the initial spacing between the gage plates; within practical limits the calibration of the pressure pickup is essentially independent of the spacing. The pickup was disassembled many times with only a minimum of care to recover the same initial spacing (about 0.001 inch with normal takeup). In each case when a known pressure was applied to the pickup and the gain control on the oscilloscope adjusted to give the same deflection as the original calibration, other pressure points also fell on the original calibration curve. This is important since it eliminates any necessity for careful temperature compensation.

The stiffness and consequently the linear limit of indication of similar diaphragms of different thicknesses will vary with the cube of the thickness. Practically, in order to obtain an essentially linear calibration, the deflection of the diaphragm at its center should not exceed 50 percent of the initial spacing. This relation of thickness to useful limit was shown by test to be true in calibration of diaphragms of 0.010, 0.020, and 0.030-inch thickness. Accordingly, the maximum useful pressures of hardened steel diaphragms of various thicknesses would be 1.5 psi at 0.010 inch, 12 psi at 0.020 inch, 40 psi at 0.030 inch, 100 psi at 0.040 inch, and 200 psi at 0.050 inch. The natural vibration frequencies of these diaphragms are respectively 3,960, 7,920, 11,900, 15,800 and 19,800 cycles per second.

Since the modulus of elasticity in compression of Lucite is of the order of 500,000 psi, this material cannot be used safely in the design shown at pressures beyond about 3,000 psi. Bakelite or other insulators having higher compression modulus would have to be substituted, but these have a higher dielectric constant which should be avoided. It would be best for operation in the range up to 10,000 psi to use a design in which the diaphraghm and shell are combined integrally by machining from a single piece of steel, thus avoiding strain on the insulating space plug.

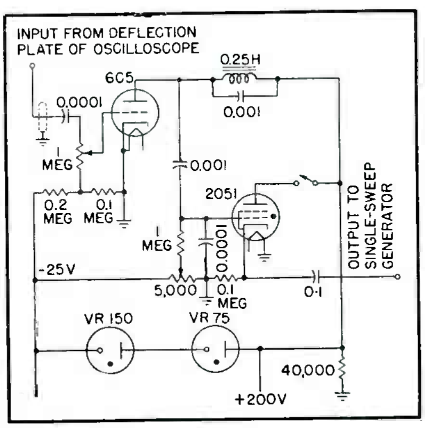

FIG. 5—Automatic tripper circuit for starting single-sweep generator when voltage on deflection plate of cathode-ray oscilloscope reaches about 5 percent of maximum

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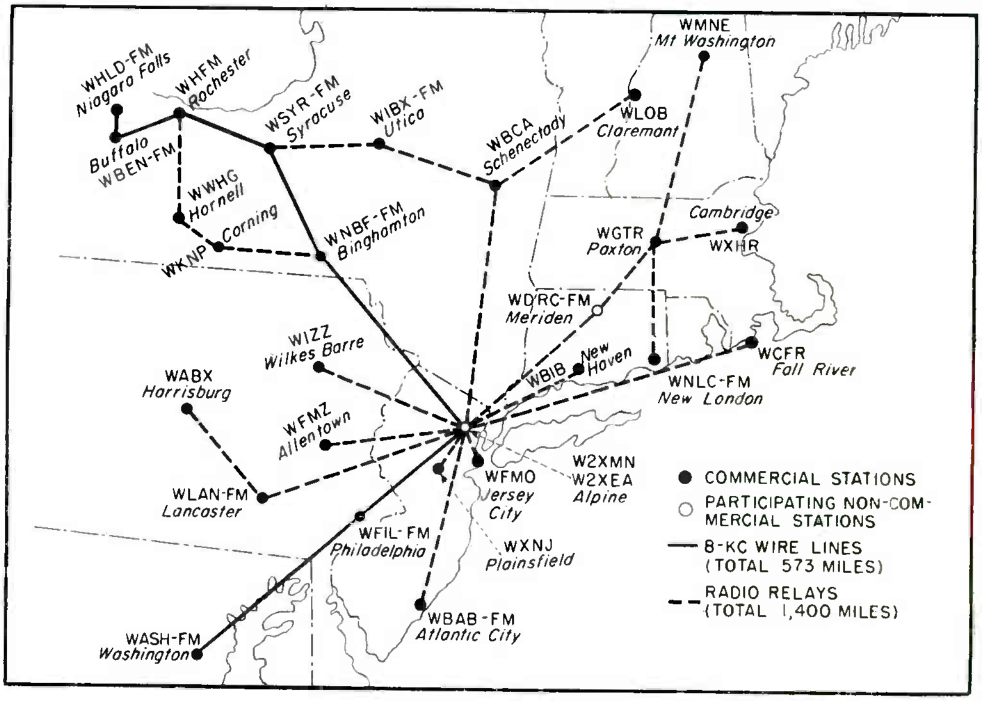
Map of the Continental Network as of Sept. 15; WSBA-FM, York, Pa. has since been added. Wire and f-m relay paths are shown by solid and dashed lines respectively



F-M Chain Broadcasting

Economic salvation for the small f-m broadcaster may lie in the methods of relaying high-fidelity programs from one station to another now used by the Continental Network and others. Techniques employed successfully since 1939 include one that does not require conversion to audio

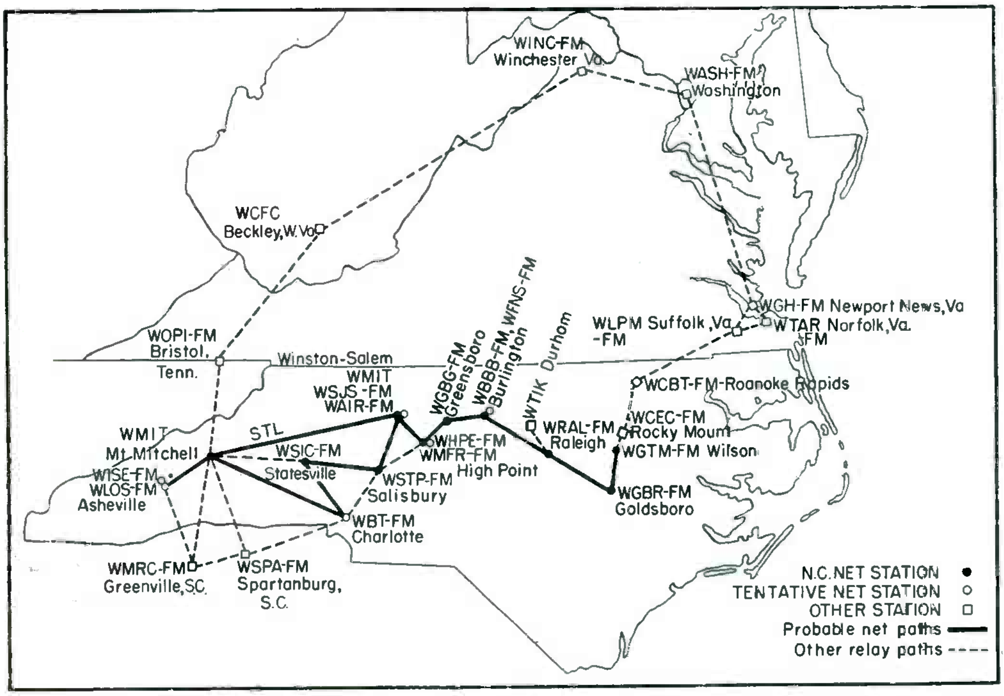
THERE are many aspects to the problem of f-m broadcast economics, all leading to the important consideration, can f-m pay its way? One important factor is how to utilize a good, and probably expensive, live-talent program on two or more stations, each of which is located in a mutually noncompetitive market area. This is a problem that can not be solved by the vice-president in charge of advertising sales alone, nor by the technical director alone. But both these men know, or should know, that they are treading on neither strange nor dangerous ground when considering the feasibility of chain f-m broadcasting.

A certain elementary book on calculus bears an inscription to the effect that what one fool can learn another can also. Although the f-m pioneers are certainly no more foolish than their new and enthusiastic colleagues, the methods by which they achieved success in a relatively uncharted area were less often dry victories of the slide rule than the adoption of Major Armstrong's philosophy,—"Make it work; then find out what makes it work". Newcomers in the f-m field may be heartened by a review of a successful past as well as by an active present. The facts are here.

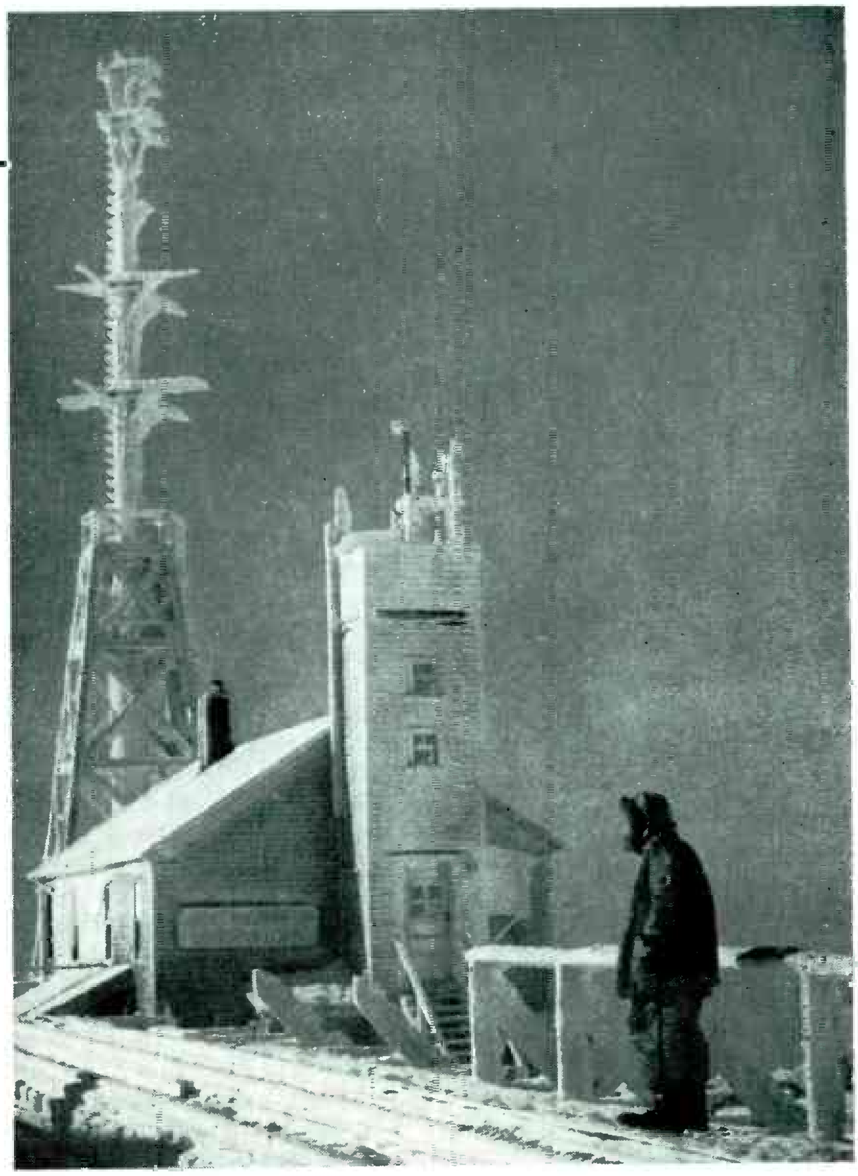
Original Relay System

The technique of relaying f-m programs from a high-frequency low-power station to a lower-frequency high-power station more suitable for broadcast coverage originated in the early experiments of E. H. Armstrong and C. R. Runyon, Jr., particularly between Yonkers, N. Y. and Alpine, N. J. Aware of the success of these relays, P. A. deMars, technical director of the Yankee Network, felt secure in planning a three-station network without wires. He had been further encouraged by frequent periods of good reception on Mount Washington, N. H. (37,600 feet below the optical horizon) of Alpine signals on 44.1 megacycles since 1938.

This original commercial relay system comprises a low-power transmitter operating on 156 megacycles (first assigned 133 mc) located on the roof of the Boston studios used to program the a-m and f-m stations of the Yankee Network. The signals from WEOD, Boston, are beamed towards the main 50-kilowatt transmitter WGTR in Paxton, Mass., serving Boston and southern New England, and are picked up there, about 45



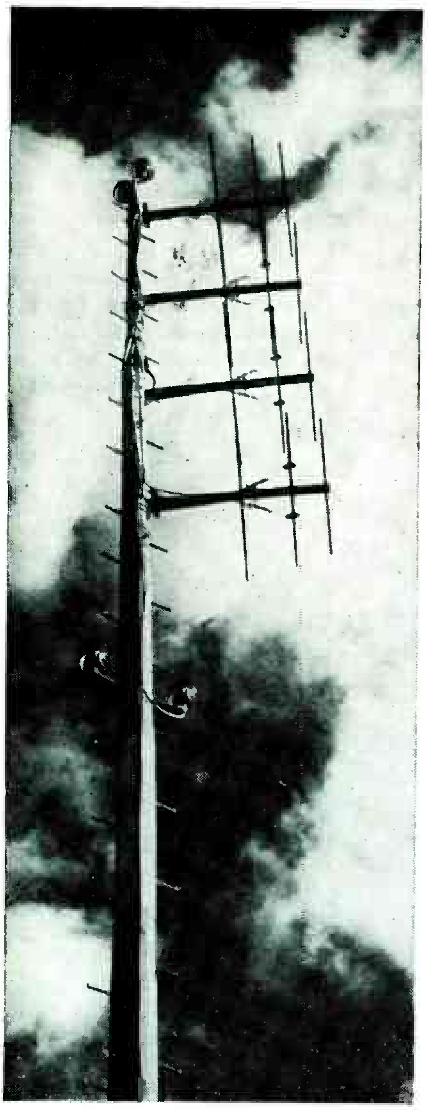
North Carolina demonstration relay net planned for National Radio Week. Oct. 27-Nov. 1. Other possible relay paths are also indicated



Present northeastern terminus of the Yankee and Continental f-m Networks, on Mt. Washington, N. H. The upper bays of the turnstile antenna are used for high-band transmissions

miles away, on a directional receiving array. The program is then broadcast on 44.3 and 99.1 mc and picked up on Mt. Washington, N. H., about 140 miles away, where it is rebroadcast from WMNE, serving northern New England on 45.1 and 100.5 mc. Broadcasts from Paxton started in May, 1939 and from Mount Washington during the winter of 1939–40. Although there have been failures at various points in the circuits the total time off the air has been such an extremely small fraction of the total that it has never been considered necessary even to install local turntables and transcriptions so as to provide local sustaining programs during repairs.

In general, two modulator equipments are provided at each station. The class-C amplifiers following are not overworked and give relatively



Beam antenna for 156 mc atop Yankee Network studios in Boston is used to program Paxton transmitter about 45 miles to west

little trouble. In a few instances, the 50-kw pushpull amplifier at Paxton was operated from several hours up to two days with only one tube filament lighted. Slight retuning of the final was necessary, but the majority of listeners were never aware of the impairment to the signal strength.

Cost Considerations

Time has indeed shown the feasibility of the Yankee Network system, but the original daring conception of the network was predicated on two points. Although it might have been possible to program the Paxton transmitter by a wire line, such facilities were not then available. The best offer that the telephone company could make was a line reasonably flat from 30 to 15,000 cycles at an initial cost, to be borne by the broadcaster, of more than $75,000. The usual toll charges for use of the facility would follow. There could be no guarantee that the line would be noise-free. On that account, the radio program circuit was adopted as a major tenet of the plan, and Radio Engineering Laboratories furnished a unique 133-mc transmitter built to Major Armstrong's specifications at a fraction of the wire line cost.

Inaccessible Location

Mount Washington is remote from good wire lines. The broadcasting facilities designed to use to best advantage the summit of the peak were approachable, at best, through 7 miles of woods, to the foot of the mountain, and then three miles upward along a cog railroad. Although winter telephone communication has been maintained off and on since 1932 along this route, the cost of installing high-fidelity lines from the nearest suitable toll center and maintaining them in the high winds and other generally inclement weather would be extremely costly. Practically, the only way to program a Mount Washington transmitter is by radio link.

The techniques and equipment required for the relay system are simple, but the actual installations made were designed for less than optimum conditions. At the Boston studios (WEOD), a 3-element array of dipoles, reflectors and directors mounted one above the other on a steel mast on the roof of the building was used. At Paxton a pair of multiwave vee antennas, one above the other and each backed by a closely spaced parasitic reflector, furnished more than adequate gain for the program receiver used. In actual practice, the final amplifier in Boston was discarded at the time of a change in frequency assignment from 133 to 156 mc. Besides tolerating a power reduction at the relay transmitter, it was found that under conditions of abnormal icing at Paxton a simple dipole with reflector and director, mounted behind a glass-block wall near the 50-kw transmitter, furnished adequate signal for the program circuit.

On Mount Washington where small structures must be protected from accumulations of ice or the force of superhurricane winds, a wooden tower was included in the special building design to house receiving or emergency transmitting antennas.

The receivers used in the relay technique were originally simply good f-m receivers built for Major Armstrong for general demonstration purposes. When Mount Washington went on the air, the General Electric type JFM-90 home receiver had become available and so this equipment was modified slightly for somewhat greater r-f gain and selectivity as well as for a more convenient output impedance. In general all these receivers were also provided with two audio outputs, one with a standard RMA restorer (de-emphasis circuit) for audio monitoring and the other maintaining the pre-emphasis introduced in the original transmitter. In this way, it is not necessary to restore and pre-emphasize the signal again at each succeeding station in the chain. At a later date, simple heterodyne converters were added to the JFM-90 receivers and they serve for reception on 156 megacycles as well.

Intercompany Relays

On Dec. 4, 1939, a program originating at W2XCR in Yonkers was picked up and relayed through W2XMN Alpine, then rebroadcast from W1XPW, operated by Franklin M. Doolittle at Meriden, Conn., since May 13, 1939. The success of this venture created considerable furore and K. B. Warner of the American Radio Relay League stated: "In 10 years there won't be any orthodox brand of broadcasting remaining except for the lowest grade of local service". Early in the morning of Dec. 29 a similar test program was tried again, this time including the Paxton transmitter. No difficulty was experienced when the Meriden program was picked up at a farmhouse somewhat lower in elevation than the station and sent through about a thousand yards of wire line to the transmitter modulator. The remote receiver and antenna were soon replaced by a local antenna and a receiver in the transmitter building. On Jan. 4 and again on Jan. 5, 1940, an hour's program starting at 6 pm was originated in Yonkers and sent over the net for the benefit of regular listeners. Mount Washington received the program and relayed it by a-m to the communications center in Boston, where it was put on a telephone line and returned to Yonkers.

On Feb. 21, the Paxton program was successfully rebroadcast during a 15-minute test by the a-m stations WNAC Boston and WEAN Providence. With this success, a new chain was composed for a half-hour broadcast on the evening of Feb. 29, using W2XAG Yonkers (key station), W2XMN Alpine, W1XPW Meriden, W1XOJ Paxton and W1XER Mount Washington,—all f-m stations. In addition, the Alpine broadcast was picked up by a-m station WICC Bridgeport. Stations WEAN Providence, and WAAB Boston picked up the Paxton broadcast. Listeners in Boston to the Mount Washington f-m broadcast felt that it was fully as good as that from Paxton.

Further relay experiments conducted during 1940 were complicated by the continual violent evolution of the stations. At Paxton alone from May 1939 until May 1941 transmitter power was raised from 2 to 50 kilowatts and three different types of turnstile antennas were tried. One imposing 400-foot tower toppled over in an ice- and wind-storm early on the morning of Jan. 15, 1940. Every change in transmitting power or antenna required at least a slight change in the receiving setup.

Yet despite these difficulties it was possible to relay a live half-hour dinner music program from Meriden through the Yankee f-m network six days a week from January until December, 1941, as well as a number of other irregularly scheduled chain programs. On July 17, 1941, a special program was broadcast from Paxton for the dedication of W47A Albany, and thereafter for some time the bulk of the Albany station's program material consisted of rebroadcasts from the Yankee Network. On Nov. 30 the same year, the W71NY dedicatory program was heard over the network from New York after which live programs from Boston and Hartford were relayed in the reverse direction through the Meriden station.

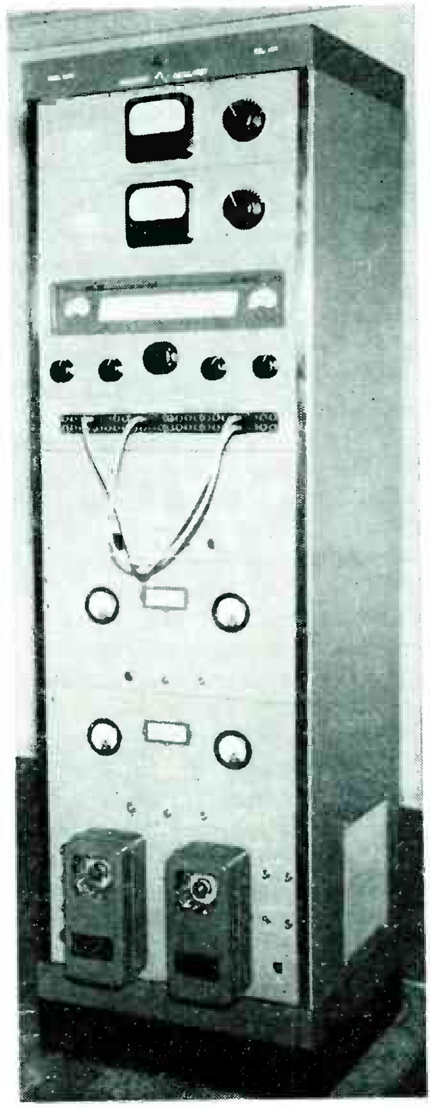
For three months, the Paxton programs were picked up at Trumbull, Conn., relayed on about 150 and later 200 megacycles, picked up at Alpine with a corner-reflector antenna on the middle arm of the famous tower, and fed via a coaxial line to the receiver that programmed the Alpine transmitter, providing a two-way circuit between Alpine and Paxton.

Some different relay techniques were also employed experimentally. Instead of receiving a signal, converting it to audio and using it to modulate another transmitter, the incoming carrier signal was caused to beat with a local oscillator so the difference frequency that was further amplified occurred at the assigned carrier frequency of the relay station. This system was used for some time with great success at Meriden in relaying to the north.

Beginning March 3, 1942, f-m chain broadcasting came of age when General Electric paid out cash money to sponsor the Frazier Hunt news program Tuesday, Thursday and Saturday evenings until May 29, 1943. The American Network chain included W53PH (now WFIL-FM) Philadelphia which picked up Alpine direct, W71NY (now WBAM) New York, W2XMN Alpine, W65H (now WDRC-FM) Meriden, W43B (Now WGTR) Paxton, W47A (now WBCA Schenectady) Albany and W39B (now WMNE) Mount Washington. The broadcasts went off with little technical difficulty, but unfortunately the program was transcribed—a fact only too apparent with the high-fidelity equipment used!

Postwar F-M

For a number of real and sufficient reasons, f-m broadcasting was unable to capitalize fully upon its rapid early gains and plateau of accomplishment after the cessation of hostilities in 1945. Because of the fear on the part of FCC that occasional long-range anomalous propagation would interfere with service areas far removed, new frequency assignments were made transferring the f-m broadcast band from 40–50 megacycles to 88–108 megacycles. Transmitters with any appreciable power were not immediately available for the new band.



Radio-relay receiving panel used at FMA convention demonstration. Two vu meters for monitoring, high and low-band tunable receiver, jackfield, amplifier, and two fixed-tune receivers can be switched at will or automatically by time clocks below

With understandable if not commendable hesitancy, many manufacturers of receivers put off the evil day when a choice would have to be made whether to manufacture high-band or high-and-low-band f-m receivers, or no f-m receivers at all. F-m program material generally deteriorated or broadcasting time was cut because of an edict from the head of the American Federation of Musicians banning duplication of a-m programs on f-m stations unless suitable quid pro quo was forthcoming from the broadcasters.

Once again, under the aegis of the pioneers the Gordian knot has been badly frayed. The Continental Network with WASH-FM Washington as key station. has been picking up since March 26, 1947 public-service concerts of Army and Army Air Force bands. relaying them by wire line and the rebroadcasting technique to an ever increasing network of f-m stations. Wire lines, necessary until the participating stations increase power or decrease distance between relays, constitute a bottleneck so far as fidelity is concerned. It has not yet been possible to obtain intercity telephone facilities that pass higher than 8,000 cycles a second so that with the exception of the key station, and despite the extensive radio links, (see map) the listeners lose a certain amount of the program's realism. The noise-free aspect is, however, a boon contributing a greater share to enjoyment than can be understood without listening.

It is probably not without significance that most of the relay circuits emanate from the older stations that are licensed to broadcast on both the low and the high bands. It is likely that consistent reception over distances possible with the low band may require greater power or more intermediates when the high-band frequencies are used.

At the moment of this writing Continental has grown to 28 stations, using 573 miles of wire line and over 1,400 miles of radio relays, and is still expanding rapidly. Starting Sept. 12, 1947, commercial operation of the network was begun with a half-hour program from WHFM Rochester sponsored by Stromberg-Carlson following a half-hour sustaining show. The schedule was varied on the first evening to include a pickup from the Frequency Modulation Association convention in New York where previously the delegates had heard Alpine broadcasts sent from Boston via three relays and one from Allentown, Pa. in two hops.

More than 90 applications have come in to Everett L. Dillard of WASH-FM, president of the Continental Network, requesting affiliation, one from the owner of a potential chain to cover California. There are inquiries from Florida and the Gulf states. The most immediate interest is in a plan that calls for a telephone line to Chicago with satellite relay stations branching from the wire line to the north and south.

Practical technical limitations to the length of a relay chain without wires is unknown, so that future plans for expansion will depend on further experience. The heterodyne frequency-changing method used successfully at the Meriden station is thought to be the most satisfactory solution, and the technique is being further developed experimentally.

The North Carolina State Hookup

The mountainous region in the Carolinas has proved, like New England, a fertile ground for f-m broadcasting. A-m signals are so rapidly attenuated that it is not economically feasible to give large segments of territory with small populations adequate or enjoyable service. F-m, on the other hand, is much less adversely affected by the terrain, particularly since high land is available for the siting of stations.

Plans are being formulated by the North Carolina FM Association for a statewide, one-time hookup of f-m stations that are on the air in time to participate in a broadcast to take place during National Radio Week, Oct. 26 through Nov. 2. A map included here shows the ten stations most likely to take part as heavy dots and the six remaining licensees as open circles. Relay paths expected to be used are indicated by solid lines. These circuits will probably be used in both directions as each station takes over as key station of the net, puts on its best program and then retires to a relay function as the next station originates rather than relays a program. The stations shown as squares are added to this map for convenience, but will not take part in the Radio Week hookup. The dotted lines show circuits that have been already tried experimentally or seem feasible for obvious reasons, indicating possible future potentialities for relaying.

Missouri-Kansas Net

Aside from the many inevitable studio-transmitter links connecting remote transmitters with their program source, there are other station networks now in operation or in the formulative stage. Ambitious plans for a Missouri-Kansas network have been set into motion by the establishment of a receiving station atop the Kansan Hotel in Topeka, Kansas for reception of KOZY, Kansas City, Mo. One half-hour show each Sunday is by this means picked up and rebroadcast by WIBW-FM. As soon as station facilities at KOZY, now undergoing alteration, shall have reached a stable state more extensive hookups, possibly on a commercial basis, will be tried.

Owners of Radio Diablo, operating a 50-kw high-band transmitter, are considering establishment of a relay network that will tie together Los Angeles and Mt. Diablo, Calif. The latter station will then program transmitters in outlying communities roughly representing a hub to the spokes formed by the relay circuits.

Although f-m relays can do much to aid the growth of a new broadcasting service and the inexpensive dissemination of good programs, the time may eventually come when the f-m broadcaster will find it necessary to re-evaluate his position. A few moments, or even an hour of lost time from a sustaining program at this stage of the game can be tolerated, although it is undesirable. When more and more commercial programs are handled, the broadcaster may find that the additional expense of wire lines is still less than the maintenance of standby equipment at each station in a long chain. While it is still too early to predict the exact shape of the combined wire and relay facilities to be used by f-m broadcasters, it seems safe to assume that nearly as many miles of wire, coaxial, or microwave circuits will be used in the future as for the present major a-m networks.

Acknowledgments

Thanks are due a large number of people for information made available. The author feels particularly indebted to E. H. Armstrong, E. L. Dillard, F. M. Doolittle, F. A. Gunther, P. Hedrick, B. Ludy, and I. B. Robinson as well as to other members of their organizations for friendly assistance. —A. A. McK.

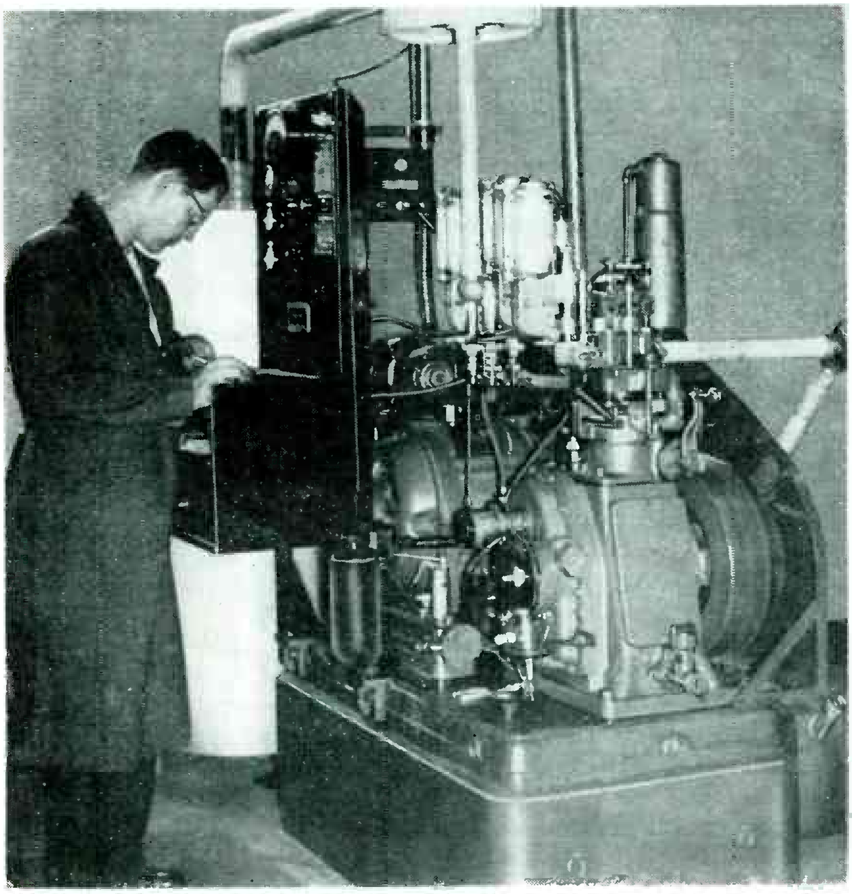
Temperature Control for Octane Tests

Transformless vacuum-tube relay circuit controls temperature of gas-air mixture fed into knock-testing engine by switching electric heater from low heat to high heat as often as 250 times per minute. In industrial service, the 117N7GT tubes used are highly reliable

By PIERRE J. MALRAISON
Mount Vernon, N. Y.

CONTROL of the temperature of the gasoline-air mixture fed into a knock-testing engine presented a series of interesting technical problems. According to ASTM specifications, the mixture temperature must be maintained at 300F ±2F as indicated by mercury thermometer. The equipment described here has been approved as optional by the ASTM.

The fuel intake system of the engine is diagrammed in Fig. 1. Air is supplied to the carburetor where it is mixed with atomized gasoline. The gasoline and air mixture passes through a heater housing containing a two-blade 1-kw immersion-type heater. It then passes around the bulb of the indicating thermometer and into the engine.



Knock-testing engine in Ethyl Corporation plant, using Malraison Mixture Thermostat for maintaining temperature of gas-air input mixture within 2 degrees of 300 F as indicated by mercury thermometer. Vacuum-tube relay housing is mounted behind control panel at eye level

The operating temperature of the mixture is well above its flash point and only slightly below the fire point, so that the most minute spark in this portion of the system will cause a partial or total combustion of the mixture before intake, destroying the validity of the test. The lag of the heating system is very large compared to that of a system specifically designed for automatic control, but could not be changed without exhaustive test work to prove that the changes would not affect the existing data.

Bimetallic Thermostat

Tests showed that the most satisfactory sensing element for control was a bimetallic strip mounted in the intake stream of the engine as near the indicating thermometer as practicable, with contacts arranged to close with rising temperature. Since the volume of the heater housing is considerably less than the volume of the cylinder, the mixture travels through the housing at a high velocity during the intake stroke of each cycle.

An oscillation of the bimetal due to mechanical action of the mixture stream on the bimetal and to cooling of the strip as the tail of the

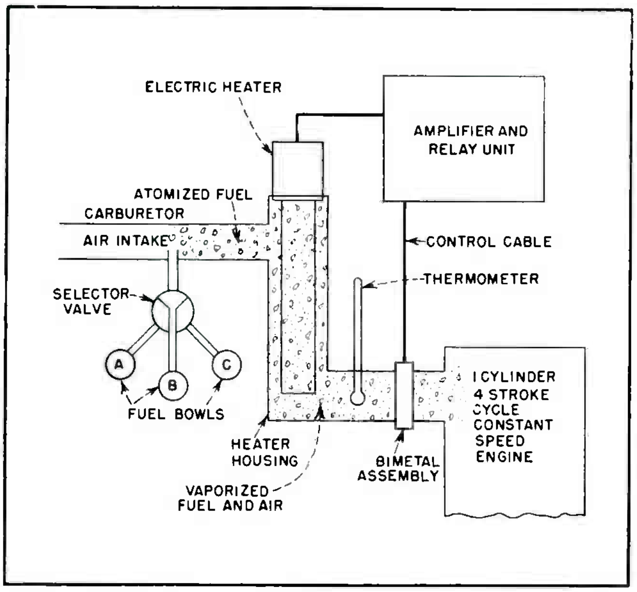


FIG. 1—Block diagram of knock-testing engine used for determination of octane ratings of various gasolines in refineries and petroleum-testing laboratories, showing location of bimetal assembly used with vacuum tube for temperature control

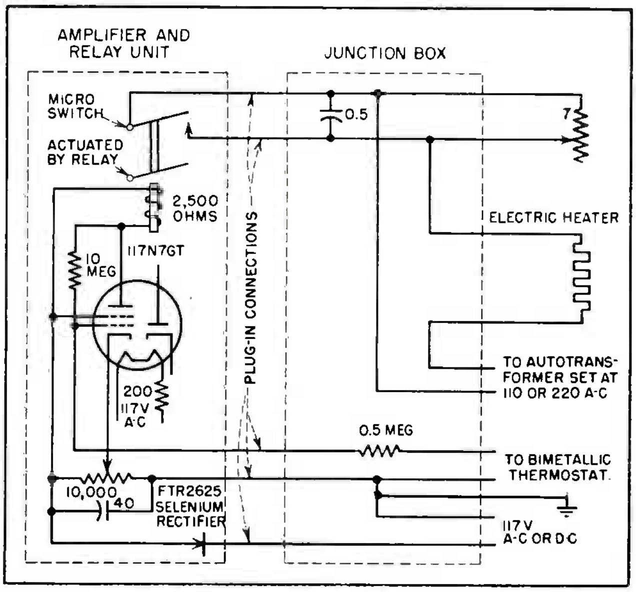


FIG. 2—Circuit of vacuum-tube relay having unique advantages for industrial control applications. Plug-in feature permits carrying standby unit in plant for quick replacement of entire amplifier unit in case of tube failure or other trouble

charge passed through was noted. Although no measurements of these rapid changes in temperature have been achieved, it is obvious from the characteristics of the system that they are present. The bimetal contacts are connected into the grid circuit as shown in Fig. 2.

Contact Problems

In initial tests a conventional vacuum-tube relay was used, with raw a-c fed to the plate and with a capacitor across the relay coil to eliminate chatter.

A spark (believed due to the discharge of the grid-cathode interelectrode capacitance) was observed at the contacts of the bimetallic strip. The current at this point is of the order of microamperes and gives no spark with the tube disconnected. A 0.5-megohm resistor in series with the grid of the tube successfully eliminated the spark.

The lag of the heating system was so great that it was impossible to achieve control to better than ±15 degrees F with complete on-off operation. A variable autotransformer was inserted to limit the high-heat current, and a series resistor shunted by the Micro Switch in the vacuum-tube relay was installed to limit the low-heat current. In order to provide temperature control to ±1 degree F it was found necessary to adjust the differential between high heat and low heat to such a small value that manual control was required to compensate for any but the smallest changes in temperature-influencing factors. The capacitance across the relay coil was then reduced so that the relay would respond to 10 contacts per second and a passable degree of automatic control was achieved. Under these conditions the switch life varied from 4 hours to 1,000 hours, depending on the installation.

Since a relay which gave a thousand hours service in one laboratory gave 4 hours service in another (where an isolation transformer was required between the line and the relay), it was guessed that some sort of synchronization occurred between the power line frequencies and the operation of the relay. This guess was confirmed by inspection of the switch contact points, which in every case had the characteristic appearance of having carried direct current. In other words, the contacts were always breaking on the same portion of the a-c cycle.

A rectifier and filter capacitor were inserted to provide d-c plate current for the tube, and the capacitor across the relay was removed from the circuit. Inspection of the switch contacts after 500 hours of operation showed a satin finish characteristic of a-c service. From the data obtained, an improved Micro Switch was developed for this relay and was used with a 0.5-μf capacitor shunting it to minimize oxidation of the contacts.

When the capacitor across the relay coil was eliminated, the time constant of the relay circuit was markedly reduced, permitting response to more than 60 contacts per second in the grid circuit. For a given differential between high heat and low heat, larger and more rapid variations in temperature influencing factors could now be compensated for automatically.

Relay Circuit

A universal a-c/d-c transformerless circuit is used in the relay because of the greatly varying power line voltages and frequencies encountered in industrial plants.

Tubes of the 117-volt series are used because they have low operating current requirements and thus dissipate less heat than other types. The power output type of tube is used because it has been found to give long, satisfactory operation when lightly loaded, as it is in this application.

The 10-megohm resistor connected between grid and plate assures that the grid will not block when the grid circuit is open. The 200-ohm resistor was inserted in the tube heater lead to overcome the effects of high line voltage encount-

Vacuum-tube relay unit. Phantom view of cover was obtained by taking two exposures on same negative, one with and one without cover

ered in many industrial plants. The rectifier and electrolytic capacitor provide sufficient filtering to eliminate synchronization with power line frequencies.

The circuit is arranged so that plate current flows with the grid circuit open. Adjustment of the various clearances, spring tensions, and the cathode circuit potentiometer are made so that when the Micro Switch is used as an interrupter in buzzer fashion and connected into the grid circuit, the relay will operate at a minimum rate of 20 times a second at 95 volts a-c input and 30 times a second at normal line voltage of 117 volts a-c. Acceptance tests require that it shall continue to function at 140 volts input. These speeds are adequate for the control of temperature on engines in the ASTM motor, research, and aviation knock-testing methods.

In order to provide continuous service from an installation it is customary to change Micro Switches after approximately 2,000 hours of service. On breakdown tests, switches have operated in excess of 7,000 hours. While these times of operation do not appear impressive, it is to be noted that the contacts can operate as often as once per intake stroke or 450 times per minute for the 900-rpm ASTM motor method. By actual count, contact closure occurred an average of 250 times per minute, which means that 2,000 hours is equivalent to 30,000,000 contact closures.

Since the installation of the switch and adjustment of the relay to these operating conditions are fairly critical, the relay has been assembled on a plug-in mount so that the changeover can be facilitated and factory service of the units easily provided. Parts requiring adjustment for individual installations, such as the 0.5-megohm resistor and a 7-ohm adjustable series resistor, are installed in a junction box having a receptacle for the plug-in amplifier unit. The series resistor is adjusted to give a 2-ampere reduction in electric heater current on a 110-volt line. The line voltage is adjusted so that the average of the high and low heater currents is approximately equal to 7.5 amperes on 110-volt lines. This is accomplished by means of the standard manual temperature-control rheostat supplied with each engine for the electric heater.

Operation of Relay

When the engine is started, the Micro Switch is open and current flows through the series resistor to the electric heater. As soon as the 117N7 tube has warmed up to the point where plate current is drawn, the relay pulls in to close the Micro Switch, permitting high-heat current to flow directly to the heating element. As the temperature of the intake mixture rises, the mean position of the bimetallic strip moves nearer the adjustable contact. As the temperature approaches the desired point, the bimetallic strip makes instantaneous contact at the crest of its upward movement, grounding the grid of the tube and cutting plate current nearly to zero. The relay drops out and the Micro Switch opens, thereby removing the short from across the series resistor and reducing the current to low-heat value.

As soon as the momentary contact is broken, the plate current goes up and initial high-heat conditions are restored. As temperature continues to rise, the time of contact closure on the bimetal increases until an equilibrium is reached at which the correct average heat input is supplied.

Variations in line voltage, ambient temperature, and latent heat of fuel are compensated for automatically by changes in the time of contact closure. It is notable that the approach to equilibrium is asymptotic and that the equilibrium is mobile. Under these conditions the system provides a degree of anticipation of heat requirement which permits stability within the desired limits even with rapidly varying conditions. For instance, when changing from fuel to fuel by means of the carburetor selector valve, with benzene having a latent heat of about 75 calories per gram in one bowl and ethyl alcohol having a latent heat of about 200 calories per gram in another, sensible equilibrium was reached within one minute.

Except in one instance when the fuel could not be vaporized in the heater housing and both the bimetal and thermometer bulb became wet with fuel and therefore could not be depended upon, it has always been possible to maintain thermometer readings constant within ±2 degrees F. Under average conditions, control to ±0.5 degrees F is readily achieved and certain operators have reported even closer control.

The author wishes to acknowledge the cooperation given him by J. C. Pope and E. N. Garnsey of the Ethyl Corporation in designing and testing the initial equipment.

OTHER INDUSTRIAL APPLICATIONS

Similar relay units have been used to control the temperature of water baths to within 0.0001 degree C and air baths to within 0.001 degree C

With suitable hair hygrometers or humidity-sensitive resistors, the unit is readily adapted for control of humidity

Use of photoelectric input provides a rugged counter, alarm circuit, or safety circuit for industrial use

Interconnecting Facilities for Television Broadcasting

Video facilities now available, or to be completed by 1950, include a 12,000-mile nation-wide system using coaxial cable, local networks employing shielded-pair telephone cables, and microwave radio circuits. Provisions are made for direct connection of broadcasters' equipment to shielded-pair systems

INTERCONNECTING facilities for television broadcasting stations fall into two general classifications: short haul circuits, which include those connecting studio to transmitter, remote pick-up point to studio, and studio to point of interconnection with intercity networks; and long haul circuits which interconnect cities to form networks.

In both short haul and long haul circuits, the principal technical characteristics affecting the transmission of television signals are (1) frequency bandwidth, (2) echoes, and transmission and phase deviations, and (3) noise, modulation and crosstalk.

The bandwidth of a given television transmission circuit influences the definition obtainable with a particular rate and method of scanning. Reflections from objects in a radio path and from impedance irregularities in wire plant, which cause deviations in the transmission-frequency and phase-frequency characteristics of the circuit, produce ghosts in television pictures. Transmission and phase deviations resulting from causes other than reflections, such as imperfect equalization, give the same sort of picture ghosts. Reflections may be greater in one part of the band than in another. Thus, a high-frequency echo might produce a complete ghost of a thin vertical line, such as a flagpole, while the ghost of a wider object would show only at its edge. Very short delay echoes produce picture ghosts so slightly displaced that they merely blur the edges of sharp discontinuities in the picture. Long delay echoes, on the other hand, cause discrete images displaced from the principal image. These effects are minimized by introducing transmission and delay equalizers at amplifier points.

Systematic noise resulting from harmonics of the power frequency produces objectionable patterns on the picture; resistance noise produces a general fuzziness and boiling effect. While raising the level of the signal can reduce the effects of the noise, modulation in the amplifiers tends to increase. This modulation usually produces spurious patterns appearing as sharp demarcations in brightness over the televised scene. Crosstalk from another television system produces a type of interference which shimmers, or crosstalk can result in the superposition of a weak copy of the picture from the interfering system.

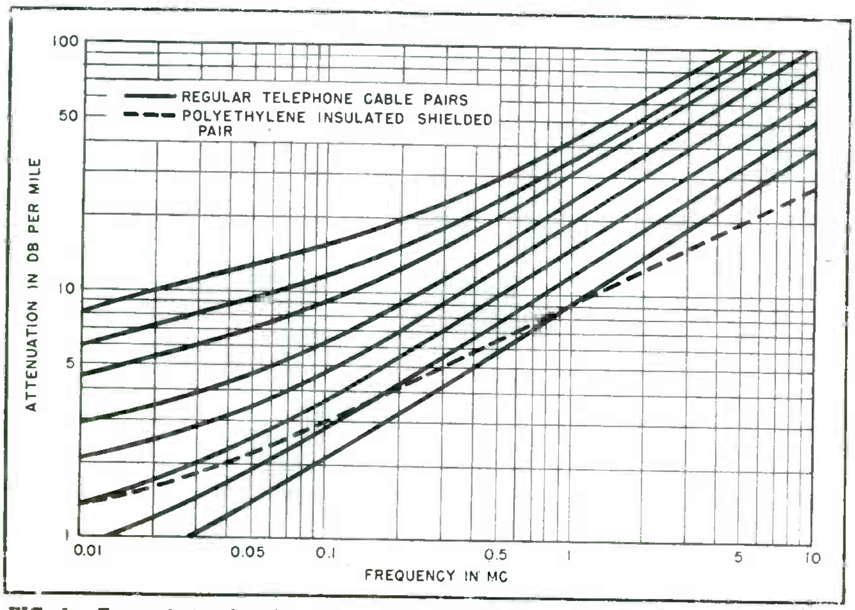
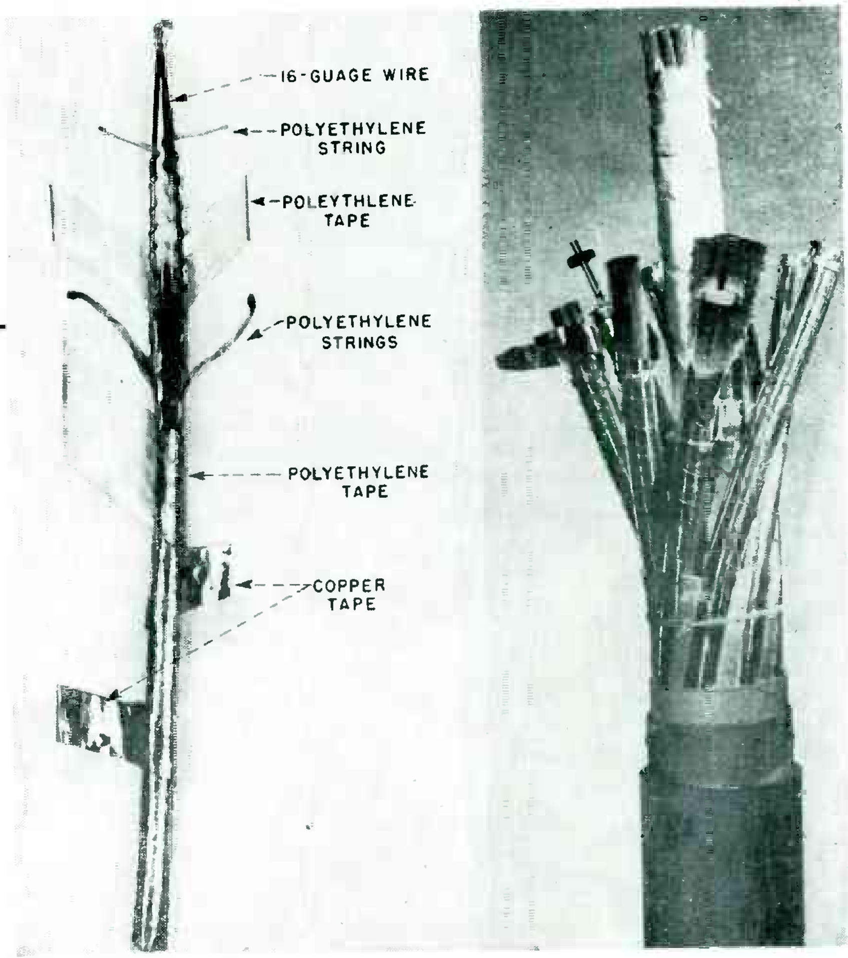


FIG. 1.—Transmission loss-frequency characteristics of regular telephone cable pairs as compared with the characteristic of a polyethylene-insulated shielded pair

Shielded-pair video cable is used for local television facilities; coaxial cable for intercity facilities. Use of polyethylene insulation in construction of both types minimizes transmission losses



By W. E. BLOECKER
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Special attention in the design, operation and layout of facilities is required to provide adequate bandwidth for good picture definition, to eliminate ghosts and to minimize noise and crosstalk.

Short Haul Circuits

Short haul television facilities are usually equalized to accommodate a bandwidth of about 4 mc. Because of the relatively short lengths of local television circuits, carrier methods are not economical when wire circuits are used because of the cost of the terminal equipment. Transmission, therefore, is at video frequency, that is, in a band extending from the very low frequencies up to about 4 mc. The associated sound channels are furnished separately over regular program transmission circuits.

In large city areas, regular telephone cable pairs literally appear everywhere and consequently are attractive as a vehicle for television transmission. The transmission losses of such facilities at 4 mc, however, are high, ranging from about 94 db per mile, for the smallest gauge cable conductors in general use, to 36 db per mile for larger gauge conductors frequently found along main trunk routes. These attenuation figures compare with values of 7 db to 2½ db per mile at 8 kc for corresponding types of

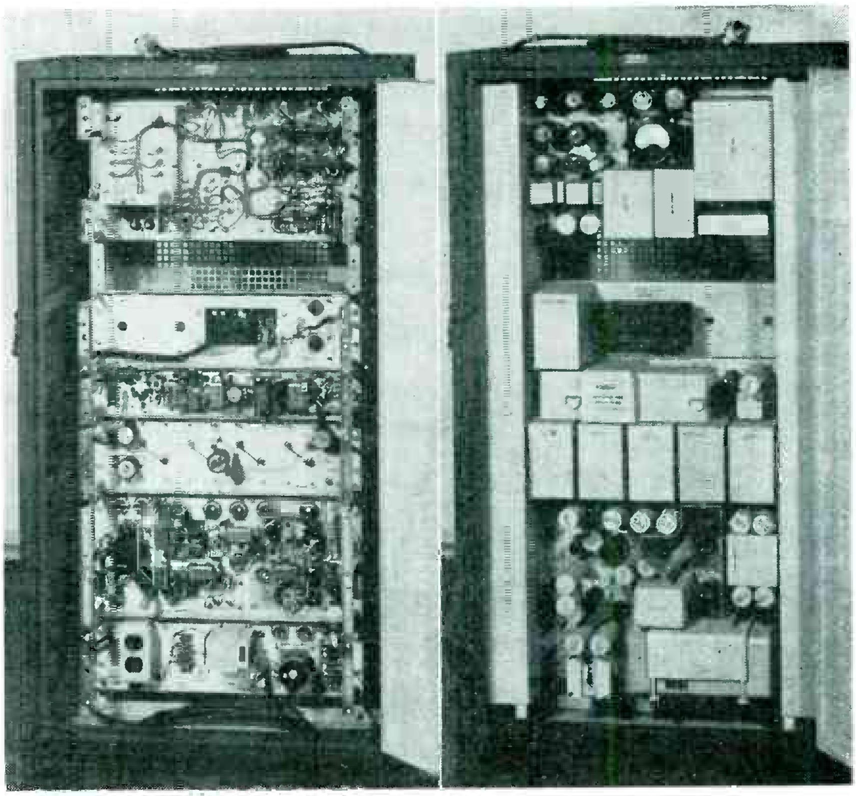

FIG. 2—Front and rear views of video amplifiers used in short haul circuits

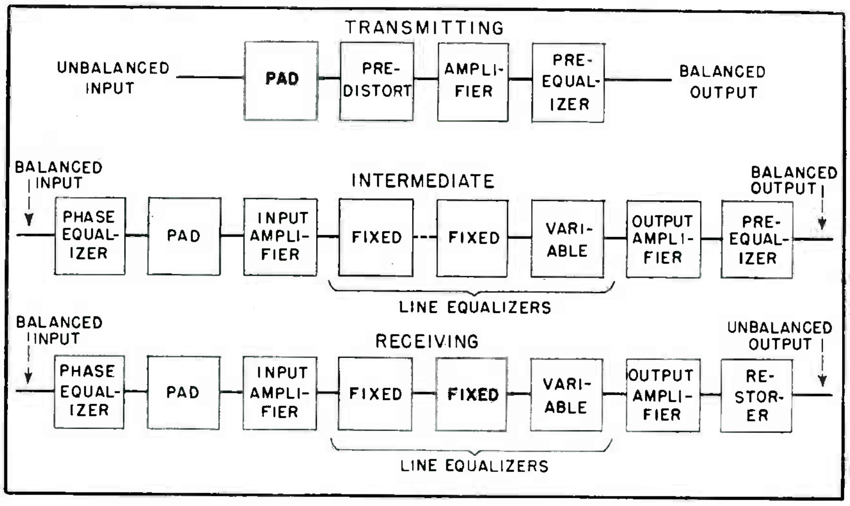

FIG. 3—Unbalanced-input transmitting amplifiers and unbalanced-output receiving amplifiers readily permit interconnection of broadcasters' equipment

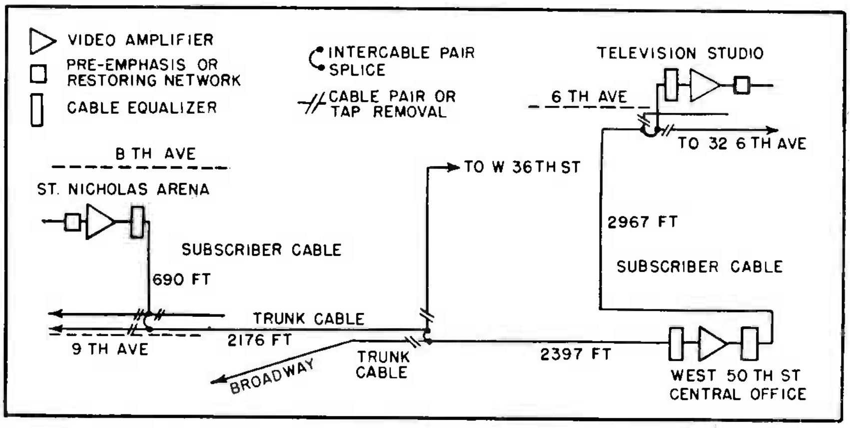

FIG. 4—A typical short haul circuit connects studio, telephone central office, and remote pick-up points

plant used for sound program transmission. Figure 1 shows representative attenuation characteristics of the usual types of exchange telephone cables.

The use of exchange cable pairs for television transmission requires special preparation such as the removal of all bridged taps and all cable stubs over 4 feet in length, the removal of any loading present, and in some cases special measures to reduce noise. Because of the high losses at the upper video frequencies, it is frequently desirable, in order to minimize the number of intermediate amplifiers required, to make special splices between cables to utilize available larger gauge cable conductors and obtain the most favorable routing.

The crosstalk coupling between cable pairs at the higher video frequencies is high, limiting the number of television channels which can be carried in a single cable sheath, even when they are operated at comparable levels in the same direction. Special coordination measures, usually involving separate cable sheaths, are required for oppositely directed television circuits along a route. This high crosstalk coupling also introduces another interesting problem in the control of amplifier gain, in that high level signals from the output of the amplifier, by cross induction into other pairs of the cable, are reintroduced into the pair connected to the input of the amplifier.

Shielded-Pair Video Cables

In order to overcome the limitations of regular telephone pairs and to provide greater flexibility in the use of the plant, shielded low-loss facilities, designed specially for video transmission, are now being introduced. Such special conductors can be provided most economically when they are included in full size cables along with other pairs provided to meet normal telephone requirements. To do this requires long range planning as telephone cables are generally designed to meet prospective requirements for a number of years.

The new shielded video facility now being installed consists of a balanced 16-gauge pair with polyethylene insulation. The transmission loss of this facility, also shown in Fig. 1, is about 18 db per mile at 4 mc. While initially circuits of this type will be equalized to 4 mc, the facility itself will not be a limitation in the transmission of much wider bands if the demand for such circuits should later materialize.

The impedance of the polyethylene insulated pair is such that it can be spliced directly to regular telephone cable pairs. It is thus possible to envision the ultimate development of a backbone television network of this type of facility reaching the most important television points in an area, to which regular telephone cable pairs can be connected to reach occasional service points. Fundamental studies looking to the orderly development of such networks are now under way in many cities.

One might ask why the use of coaxial structures is not contemplated in local areas. This type of structure is unbalanced and since local television transmission extends down to very low frequencies where the shielding is not effective, coaxial cable is susceptible to low-frequency noise induction and cross induction between adjacent coaxials within the same cable. In the intercity system, carrier methods put the line transmission at frequencies where the shielding can eliminate these effects. There are a few cases at present where coaxial cables are being employed for studio-transmitter circuits and are giving satisfactory service, but these circuits are short and well within the lengths at which it is possible to correct these effects.

Amplifiers and Equalizers

The amplifiers and equalizers now being used can accommodate line sections averaging as high as 60 db loss at 4 mc. Thus, depending on the gauge of conductors available, amplifier spacings on regular telephone cable pairs will range from about 0.6 mile to about 1.5 miles for the types of cables usually encountered. In the case of the polyethylene-insulated video pair, amplifier spacings of about 3.5 miles are practicable. Because central office spacings sometimes exceed these lengths, it is necessary in some cases to use rented quarters as amplifier locations. This involves a number of special considerations such as finding suitable space near the desired location, ready access at all hours, power supply, and the like. The future design of video line amplifiers contemplates supplying power over separate cable pairs, which should simplify installations in rented quarters and make possible the installation of amplifiers in manholes.

The equalization of the line facility, including amplifiers and terminating equipment, involves the adjustment of the attenuation and phase characteristics over the desired transmission band. In wide-band transmission systems of the type being discussed, it is practicable to design attenuation equalizers which also automatically correct for the phase deviations except in the regions near the edges of the band. Since the edges of the band are determined principally by the characteristics of the amplifiers and associated attenuation equalizers, the phase deviation is substantially independent of the length of line section between amplifiers. For this reason, a relatively simple fixed network in each amplifier (except the transmitting amplifier) provides the required phase correction and the field equalization job becomes one of adjusting only the attenuation over the desired band.

The line attenuation equalization is in the form of fixed units to provide basic equalization for various lengths of circuit. These are supplemented by two variable equalizers, one which corrects for slope by adjusting the loss at 4 mc with reference to the loss at 10 kc, and the other a bulge adjustment for varying the loss at 1 mc without substantial effect on the loss at 10 kc or 4 mc. A portion of the basic line equalization is provided at the output of the amplifier feeding the line section, the remainder being included in the amplifier terminating the line section. This pre-equalization improves the signal-to-noise ratio at higher video frequencies.

In order further to minimize the effects of noise, particularly on regular telephone cable pairs, predistortion is employed at the transmitting point which causes the 4-mc level to be 20 db higher than the 10-kc level. A complementary restoring network is used at the receiving end of the circuit.

Connection to Studio Equipment

Broadcasters' pick-up and studio equipments generally operate on an unbalanced basis. The amplifiers used to connect such equipment with the balanced telephone lines are shown in Fig. 2. Block diagrams of these amplifiers are shown in Fig. 3. Intermediate line amplifiers have both input and output balanced. Present plans contemplate that any switching or patching done in Telephone Company offices will be on a balanced circuit basis. A typical wire line video circuit, using regular telephone cable pairs and the amplifiers described, is shown in Fig. 4. Two frequency characteristics of such video circuits are shown in Fig. 5.

Microwave Radio

Radio facilities for short haul television circuits appear to have advantages for the occasional pick-up of a special news or sports event, and for unusual geographical situations, such as that between several studios in Hollywood and their proposed associated transmitters on Mount Wilson. In this latter case, wire video circuits would require a long and circuitous route with many amplifiers, whereas a single-link direct radio path can be obtained. Radio circuits at microwave frequencies need line-of-sight transmission paths, and in addition fading effects must be taken into account by allowing margins over the requirements for normal free space transmission conditions. Through the use of highly directive antennas, difficulties with interference and ghosts due to reflections can be minimized and low power can be used. The requirement for line-of-sight paths has in some cases resulted in a combination wire and radio circuit, the wire video facilities being employed to reach favorable radio transmitting or receiving sites.

Long Haul Coaxial Cable Systems

The search for increased efficiency in the use of conductors for multiplex telephony has resulted in the development of the coaxial cable system which is suitable for television transmission as well. The present standard coaxial unit, which has been used for installations since 1946, is 0.375 inches in diameter as compared to 0.27 inches for the earlier installations. The insulating discs supporting the central conductor are now of polyethylene rather than hard rubber previously used. The construction of coaxials and their arrangement in a typical cable are shown in the photograph. The coaxial itself does not limit the frequency range which

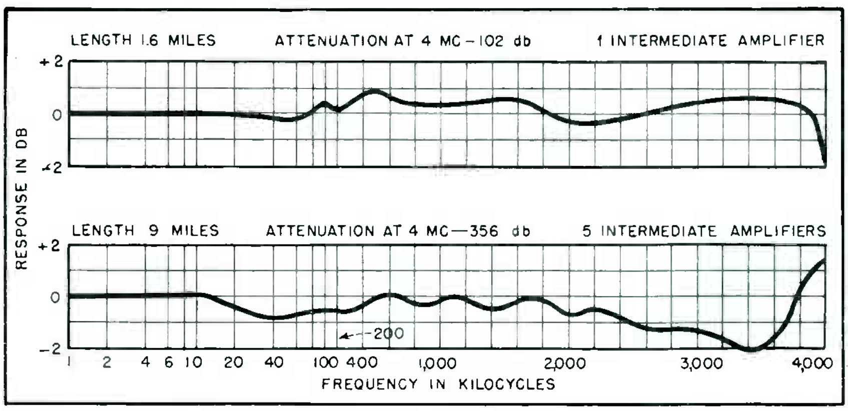

FIG. 5—Frequency characteristics for two video circuits of the type shown in Fig. 3

can be transmitted. This depends upon the bandwidth handled by the amplifiers and equalizers and the intervals at which they are placed.

The general layout of coaxial cable system is shown in Fig. 6. The present repeaters provide about 50 db gain at 3 mc and have a gain-frequency characteristic which very closely matches the cable loss characteristic. On the new 0.375-inch coaxials, these repeaters are spaced at intervals of about 8 miles whereas a spacing of about 5½ miles is used on the 0.27-inch coaxials.

Repeater stations are of two varieties, auxiliary and main. The majority of the stations are of the auxiliary type, the main stations being located at intervals of 40 to 165 miles. Most of these auxiliary repeaters are housed in small closed huts, requiring no heat or power connections. The auxiliary repeaters operate from 60-cycle a-c power furnished over the central conductors of the coaxial from the main repeater stations.

For telephone use, terminals are provided for stacking 480 circuits in the 68-kc to 2,044-kc frequency space. It is proposed later on to operate additional short haul telephone circuits in the 2 to 3-mc band. For television transmission, the video signal, by a process of double modulation, is transmitted as an upper side band and a vestigial lower side band on a carrier of about 311 kc. The frequency space below about 200 kc is not used for television purposes because of the difficulties of equalizing this range and the less effective shielding provided by the coaxial structure at these frequencies. The associated sound channel is transmitted on a single-sideband basis between 76 and 88 kc. Transmission and phase characteristics of the 240-mile New York-Washington television circuit are shown in Fig. 7.

It is recognized that this television system provides a video band of about 2.8 mc instead of 4 mc provided for in the television channel assignment. Experience with this system has demonstrated that very acceptable pictures are being transmitted. Development work is continuing, however, on repeater equipment which will permit utilizing the coaxial structure to higher frequencies. One system considered employs closer repeater spacings than the present and would provide a usable frequency band of about 7 mc. This would permit the simultaneous transmission of about 500 telephone conversations and two oppositely directed 4-mc television programs on a pair of coaxials.

Service Protection Features

Many features have been included in the system to insure stability and continuity of service. Variations in transmission resulting from temperature and other changes are compensated automatically by regulators under control of four pilot frequencies—64 kc, 556 kc, 2064 kc and 3096 kc sent continuously from the main repeater stations over the coaxial line. The cables are generally buried deep in the earth or put in conduit, are protected against corrosion, lightning or mechanical damage, and are maintained under gas pressure with arrangements to detect any leak in the outer sheath so that repairs can be made before failures occur. Each stage of amplification in the repeaters has parallel tubes, and one tube in any stage can fail to function without interrupting service. Pilot alarms at each auxiliary repeater warn the nearest attended main station of excessive pilot deviations. The power supply is arranged so that if commercial power fails, a-c will automatically be supplied, through rectifier inverters or motor generators, from large storage batteries. Gas engines are available if the commercial power should be off for some time. Finally, a spare line is provided in each direction through each switching section, which may be up to 200 miles in length. Whenever a given coaxial line fails or its pilot gets out of limits, the spare line is automatically switched into the circuit so quickly that no interruption of any telephone conversation or television program occurs, and an alarm is given so that the trouble may be cleared.

Microwave Radio Relay

Wire communication is characterized by certain desirable features which have heretofore been lacking to a large extent in radio. For example, an unlimited number of channels can be established, the energy can be precisely directed, circuits can be made very stable, and noise and interference can be controlled. With the development of techniques permitting the use of frequencies of thousands of megacycles, radio is beginning to approach wire lines in these respects, permitting its extension over long distances by the use of repeaters, a method which has long been used for wire lines.

Experiments are now under way to determine the practicability of radio relay systems from the standpoints of cost, performance, and reliability. As a part of the Bell System experiments, a full-scale radio relay system is being established between New York and Boston. Preliminary indications are that satisfactory television operation could be provided by this means.

Seven intermediate radio repeater points will be employed, spaced at intervals of 10 to 35 miles, with an average spacing of 27 miles for a total circuit length of about 220 miles. These repeaters are located on high points of ground so that a direct line-of-sight path is available between adjacent repeaters.

In New York, the terminal is in

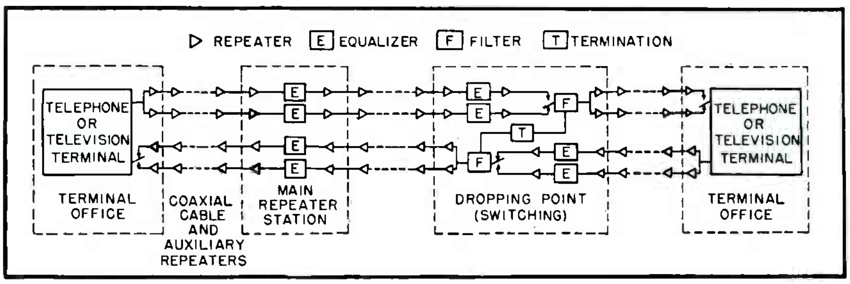

FIG. 6—An auxiliary parallel circuit in each direction is provided for emergency use in this layout of a typical coaxial system

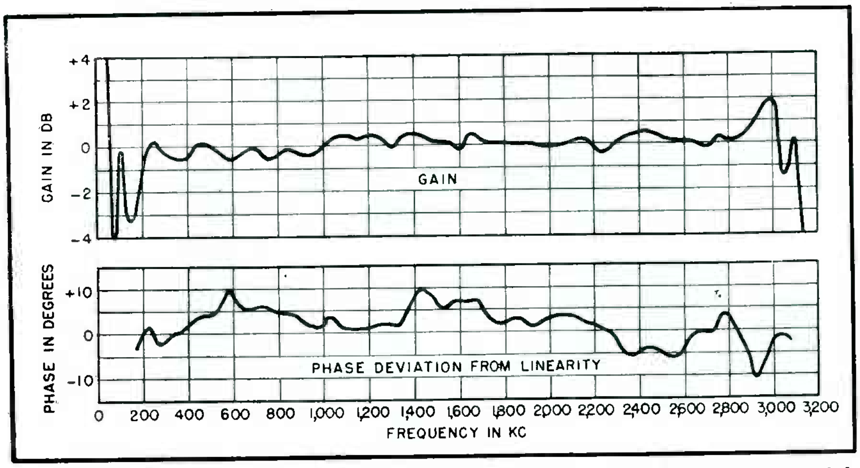

FIG. 7—Transmission and phase characteristics of the New York-Washington coaxial television circuit. Video bandwidth is limited to about 2.8 mc by the characteristics of the repeaters used

the long-distance building. In Boston, the radio terminal is about 1 mile from the main long-distance building with which it will be connected by short haul video facilities of the type discussed earlier.

The system will employ frequencies in the vicinity of 4,000 mc. A total of four channels will be established, two in each direction of transmission. Tests will be made on the transmission of large blocks of telephone circuits and of television. It is probable that a usable frequency band of at least 4 mc can be obtained for television transmission.

The antennas will be horns with 10-foot square apertures equipped with a metal lens to focus the radio waves. It is expected that a satisfactory signal-to-noise ratio can be obtained for the number of sections involved in this experiment using transmitting power in the order of 1 watt.

Recent Use of Television Circuits

A very considerable use has already been made of the television transmission facilities now available, particularly since the television broadcasting stations have been operating on a regularly scheduled basis. During the past year, some thirty short haul television circuits were established for one of more occasions of use, employing wire, experimental microwave radio or both in combination. The longest wire circuit—Yankee Stadium to Radio City—was about 9 miles in length and required the use of seven amplifiers. The longest radio circuit was one of two links between Michie Stadium at West Point and Radio City in New York, a distance of about 47 miles. In addition to those in New York, services were also established in Philadelphia, Baltimore, Washington, Pittsburgh, St. Louis and Los Angeles. Some of these channels have been continuously in service for several years.

A television circuit in coaxial cable arranged to transmit from Washington to New York was first used in connection with the Lincoln's Birthday ceremony on February 12, 1946. CBS, DuMont and NBC cooperated in arranging for the program which started with an introduction from the NBC studios in New York, after which a switch was made to Washington where pick-ups were successively made from the DuMont studio in the Harrington Hotel, the steps of the Capitol, and ceremonies at the Lincoln Memorial. By April 15, 1946, the New York-Washington coaxial cable was equipped for television transmission in both directions and was used by DuMont in connection with the opening of new studios in New York. Shortly afterwards, the two circuits between New York and Washington went into active use on practically a daily basis for the several broadcasters.

Further plans include the provision of shielded polyethylene-insulated video pairs in connection with cable construction programs in city areas to meet requirements for short haul television circuits quickly and economically. These plans are being carried out to the extent practicable with the scarce materials which can be allotted to this type of plant.

Great progress has been made in the construction of a nationwide coaxial cable network since the close of the war. As of January 1, 1947, about 4,000 route miles of coaxial cable had been placed in the ground and construction is continuing. Cables now in place or under construction and the extensions planned for the next three or four years total about 12,000 miles. It is expected that by early 1948 a southern coaxial cable route will be ready for telephone service to points as far west as Los Angeles, and that by the end of 1948 a central coaxial route will extend from New York to Chicago and St. Louis. Television service, if required, can probably be made available on most coaxial routes some time after the opening of telephone service, the date depending to some extent upon the demand.

In addition to the New York-Boston radio relay system, there is under construction a radio relay system between New York and Philadelphia, utilizing four links in tandem of a simplified type of equipment. Plans have also been projected for establishing a New York-Chicago radio relay system for multichannel telephone and television transmission. This is expected to be available by about 1950.

Future Prospects

The trend to wider and wider frequency bands, no doubt, will continue. These wider bands will be needed to handle the ever increasing demand for telephone communications and, perhaps, for greater definition or color television. Wider band circuits such as the 7-mc coaxial system discussed earlier are already under development by the Bell System. Still further in the future is the possibility of using long wave guides which are merely hollow tubes without central conductors and which provide transmission paths for enormously wider bands sealed away from interference of all sorts. It is quite clear that the future holds promise for advances far beyond the present status.

Electronic Computer

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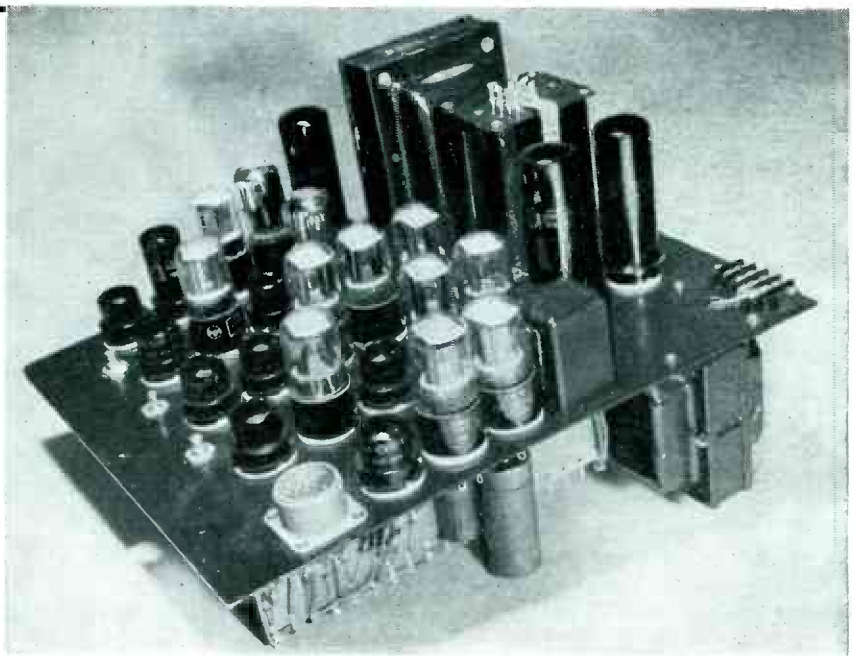


Each 24-tube control amplifier that feeds a Diehl motor contains eight 6H6 tubes used to sharpen and clean the pulse caused by a registration mark to a width of less than 20 microseconds. This is necessary to distinguish the pulse caused by a registration mark from that caused by irregular reflections from the web of metal foil

THE OUTSTANDING industrial feature of electronic controls is their ability to "think" much as a trained operator thinks, that is, to anticipate changes in the process under control from experience and introduce corrections in time to prevent the state of the process from leaving the control point by a large amount.

Computing equipment with rate and acceleration elements has this anticipatory feature. It sees a rate of accumulation of error, or even its derivative, and begins corrective action long before the process has left the control point by an appreciable amount.

Large mathematical computers are not suitable either from a cost or equipment standpoint, for the great and ever increasing number of industrial control problems. Smaller equipment which, to a limited extent, can perform their functions are, on the other hand, in demand, particularly at present when increased productivity with higher quality from existing plants is a primary engineering problem.

Ideal Industrial Control

The following is a good set of general specifications for industrial control equipment: It must be infinitely superior in function to manual control on a cost or quality of product basis. It must give long periods of service with little attention and should not require special, on-the-job, maintenance personnel. It must be rugged, so as to stand general factory use and in a large number of instances it must be explosion or oil proof. It must be fairly high power (for control) equipment, say ½ horsepower to 50 horsepower. It must not set up unexpected stresses in the machines to which attached, therefore accelerations must be accurately controlled, and it must function under the vibration conditions of the equipment it is controlling. Preferably, it should be built to fit the job, of standard components, so as to make service and replacement easy.

It is the writer's opinion after six years experience in several fields

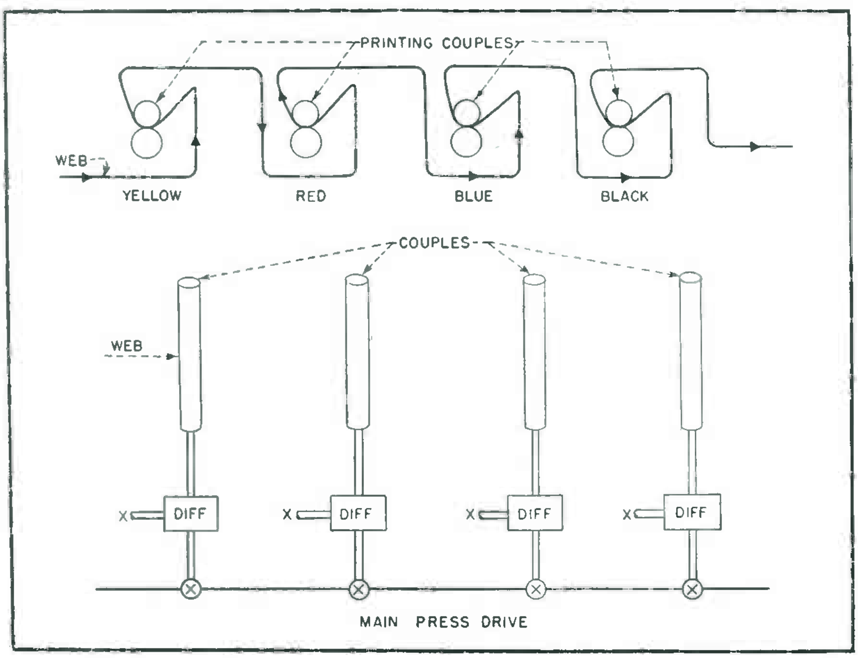
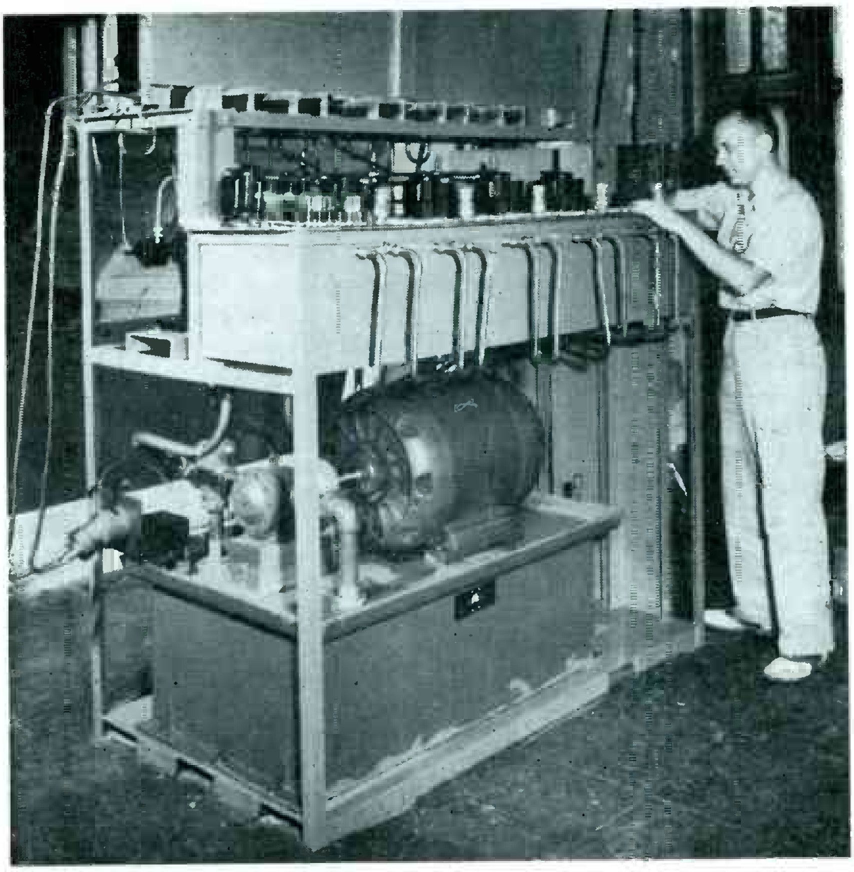


FIG 1.—Schematic views of mechanical arrangement of printing couples used in multicolor web. For register control, correction is applied to the differential systems at points marked *X*

for Printing Control

Speed of a multicolor web printing press is tripled by application of an electronic-hydraulic system that holds running register accurate from zero to 0.001 inch. Register marks actuate a phototube whose output is compared with a sample of a sine wave taken at the same instant



Complete setup of electronic and hydraulic units that connect to the printing press. Five 24-tube chassis are being immersed in oil inside the long steel box in which they normally operate

with industrial equipment that nearly all these specifications can, in general, best be met with a combination electronic-hydraulic system. For example, a hydraulic motor, which is a device which converts oil pressure and flow into continuous rotary motion, can be obtained which can deliver 10 horsepower and is 4 inches in diameter and 8 inches long with a moment of inertia of the rotating parts of only 13 lb-in.[2] Hydraulic preamplifier valves can be obtained which require negligible torque and only 0.080-inch movement to control the hydraulic motor from zero to maximum horsepower in either direction.

Components such as these furnish their own lubrication, are explosion proof, give long periods of service, and are not adversely affected by the vibration usually encountered. Their use enables the use of low-power electronic apparatus of about 25 watts which can be made very reliable.

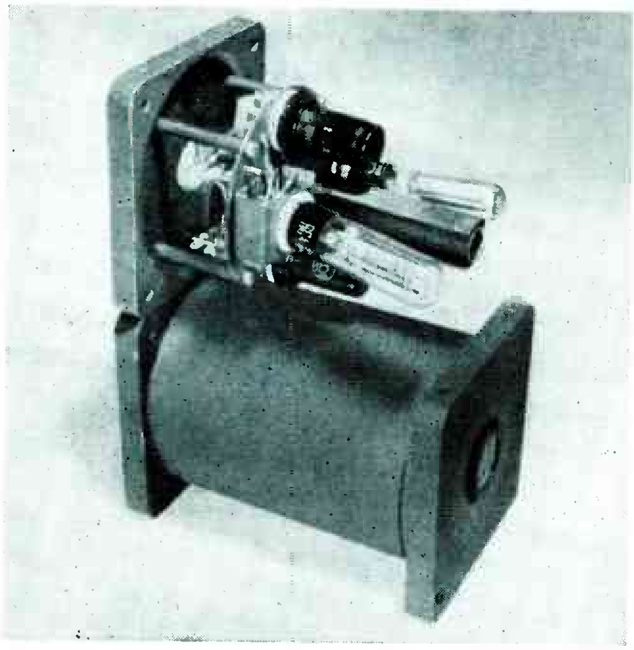
By combining electronic and hydraulic means it is possible to use low-power electronic equipment (usually without gas tubes in the control circuits) whose components are well standardized, long lived, reliable, easily obtained and relatively inexpensive. Hydraulic final actuating elements offer the advantages of high power with low inertia and small size, rapid response, and intrinsic explosion and oil proofing.

Delays which occur in the hydraulic system can be largely compensated in the electronic equipment. The electronic stages are flexible in that their performance can be varied without the necessity for major mechanical changes.

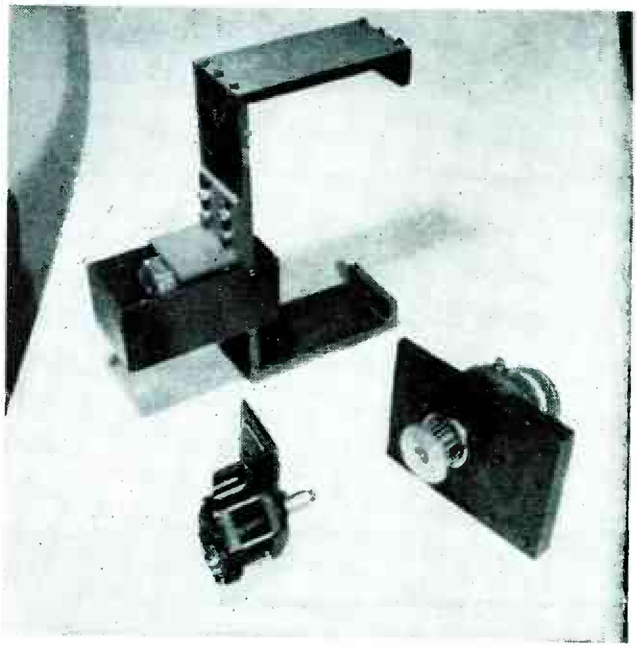
Typical Application

The problem to be discussed here was the design of running register controlling equipment that would enable a multicolor, roll fed, printing press to be stepped up in speed from 300 feet per minute to 1,000 feet per minute and still keep the register accurate from 0.000 to $\pm$0.001 inch. The control decided upon drives into the press through a planetary gear system with a reduction of approximately 800-1 and had to be capable of continuous rotation in either direction.

Among the major problems in high speed color-printing are running or longitudinal register, lateral register, ink flow, and ink drying. Satisfactory solutions to the last two have been developed for today's press speeds and of the first two running register is the big problem, because sideways move-



The pickup head and explosion-proof housing are mounted on the press. It contains two phototubes and two amplifier tubes so that if one set fails, the other set is switched into the circuit



Sinewave p-m generator at lower left, ten-horsepower hydraulic motor at right, and induction generator for tachometer feedback at top

ments of the web are very small. The problem of running register can be explained by Fig. 1.

As the web travels through the press, it is important that each succeeding color be printed to the same baseline as the yellow, or the completed picture will be out of register, that is, one or more of the colors will be shifted with respect to the yellow. The register is maintained by scanning the web and controlling the X member of the differential which is inserted in the drive system of the press between each printing couple and the main drive. At present, running register cannot be accurately enough controlled for precision printing jobs at the high press speeds at which the other problems have been conquered, therefore the development of register-controlling equipment has been one of the industry's greatest needs.

Inasmuch as it would operate in an explosive atmosphere an additional requirement was that the control equipment meet the Underwriters Laboratories requirements for equipment in hazardous locations, Class I, Group D. These requirements in general specify that explosive atmosphere be prevented from reaching the equipment by immersing it in oil or that the equipment be encased strongly and tightly enough so that should an explosion occur within the case no effects of the explosion can reach the surrounding atmosphere.

Other requirements were that the control have a minimum of oscillation as that would cause excessive wear on the printing cylinder, and that the corrective action not take place so rapidly that excessive stresses were set up in the paper, metal foil, or cloth web being printed. (The web is the actual material being printed, not a conveyor for the material.)

The limits of automatic control were to be from 100 ft per min to 1,000 ft per min web speed. It is interesting to note that the problem of control became easier as the speed increased. If it had been possible to ignore such factors as web-strength, press design, ink-drying speed, and ink-flow characteristics, the maximum web speed could have been increased several times without decreasing the effectiveness of the control. The printing cylinder was 7 inches in diameter, thus the press varied from 54.5 to 545 rpm.

Measurements and calculations determined the inertia and friction torque characteristics of the press. The torque of the actuating element necessary to introduce the maximum correction in the time decided —approximately 0.15 second—figured out to be approximately 25 lb in. This relatively high torque requirement, coupled with the high speed of response needed, lead early in the design to the choice of piston-type hydraulic motors for the actuating element.

The problem of controlling electronically the power required for an electric motor developing the above stalled torque would present certain difficulties because of the need for high speed of response, the desirability of eliminating gas tubes in the control circuit, and the explosion-proof requirement.

The hydraulic motor, a Vickers MF-12-2, is controlled by an Askania standard regulator which is stroked by a Diehl two-phase motor type FPE-49-10 with a positive coupling whose rotor is allowed to turn only ± 1 degree. The electronic amplifier controls one phase of this motor and the power requirement is 25 volt amperes. This power is easily handled by components of the radio and telephone class and that is what was used.

Hydraulic power is furnished by a standard Vickers unit comprising a vane pump, explosion-proof drive motor, reservoir, and relief valve. The system pressure is approximately 200-250 psi.

Electronics in Oil

To meet the Underwriters specifications it was decided to immerse all electronic control elements in oil. To this end, a test program was undertaken and the effect of immersion in transformer oil studied on sine wave generators, induction generators, two-phase motors, potentiometers, wire, vacuum tubes, capacitors, sockets, and terminal strips. These tests were conducted over a four-month period and as a result it was possible to obtain all necessary components as standard items which would satisfy the oil immersion requirement.

With the exception of the phototube scanning head, all apparatus is immersed in oil, the electronic components in transformer oil and the hydraulic components in their own oil supply. All connections to the press and between units are made through oil or pitch-filled tubing. Necessary controls are brought out above the oil level in all units or are accessible from above the oil with screw drivers or wrenches. The scanning head is made to meet the requirements for air-break explosion-proof gear.

The electronic amplifiers are all immersed to a depth of one inch over the tops of the tubes in a common oil bath and the leads brought out in copper tubing which starts well below the oil level. The electrical units, an induction generator and a permanent magnet generator are mounted on the press, and each is immersed in an oil tank and the leads brought out through oil-filled copper tubing.

The control amplifier is a d-c amplifier whose output is used to modulate the 60-cycle supply voltage for the control phase of the torque motor through a phase-sensitive modulator. The input to the amplifier is the error voltage obtained by sampling the voltage generated by the permanent magnet generator coupled to the printing cylinder at every register mark interval.

The voltage on the sine wave at each sampling instant is clamped,[1] then filtered into a smooth wave which serves as the input to the control amplifier. This error signal is differentiated to reduce dynamic errors and integrated to reduce accumulative errors.

Tachometer feed back, proportional to the rpm of the correction motor, is used to check that the correction motor is faithfully following the designed function of input signal. An induction generator geared to the hydraulic motor furnishes this feedback.

The time to introduce a correction should the web be subjected to a step function between register marks, rather than the usual error change, would, of course, be greater; but it would still be far shorter than can be accomplished by manual control (which, to date, has been the most universally satisfactory method) since the control will see the error at the next printing station and will start correction immediately rather than waiting until the affected section of web has left the press.

Constant Performance

The gain of the control amplifier and its frequency characteristics are fixed, to assure constant performance of the control even though the operating conditions change. Detailed measurements and calculations of the inertia and friction forces in the press and of the torque characteristics of the actuating means were made and the stability of the system was investigated. In the present case an ample margin of stability does exist provided the delays in the hydraulic system are compensated. Provision for such compensation is included in the electronic amplifier.

A schematic of the entire system is shown in Fig. 2. Provision is made for returning each roll individually to manual control if the error signal from that roll exceeds a preset value for more than a given time, thus indicating that that control is not functioning properly.

Labor Upgrading Effect

A control such as the one described has an upgrading effect on highly skilled labor. A pressman's production is tripled. He is removed from the negative, routine task of register control and applied to more technical ones such as ink color and flow, drying, printing pressure. In this way his position becomes more important at the same time that he becomes more productive.

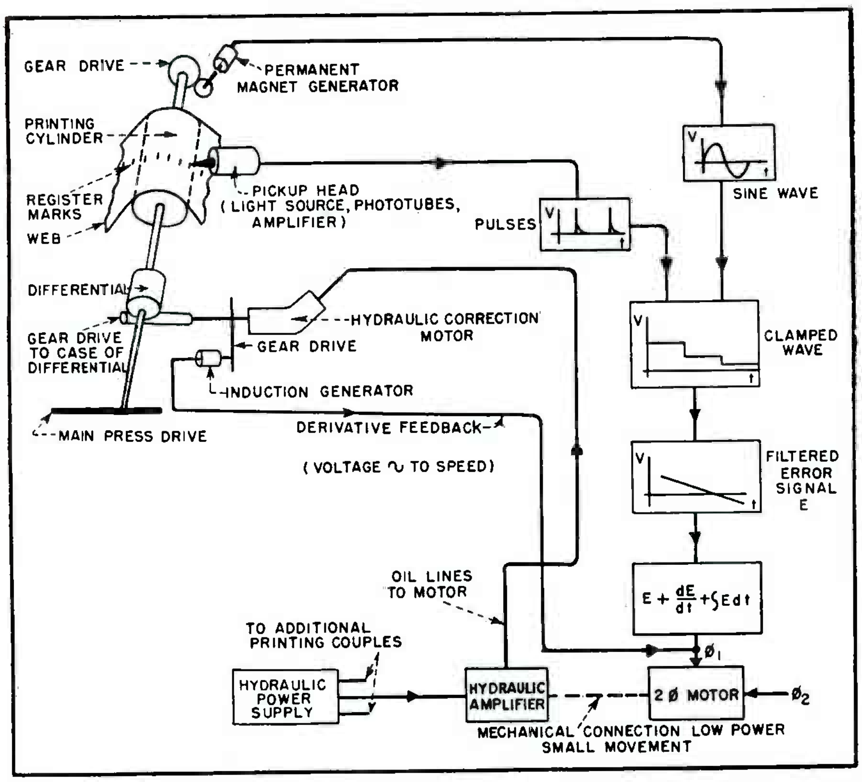


FIG. 2.—Schematic of the register control system. Functions of the electronic stages are illustrated in blocks at right

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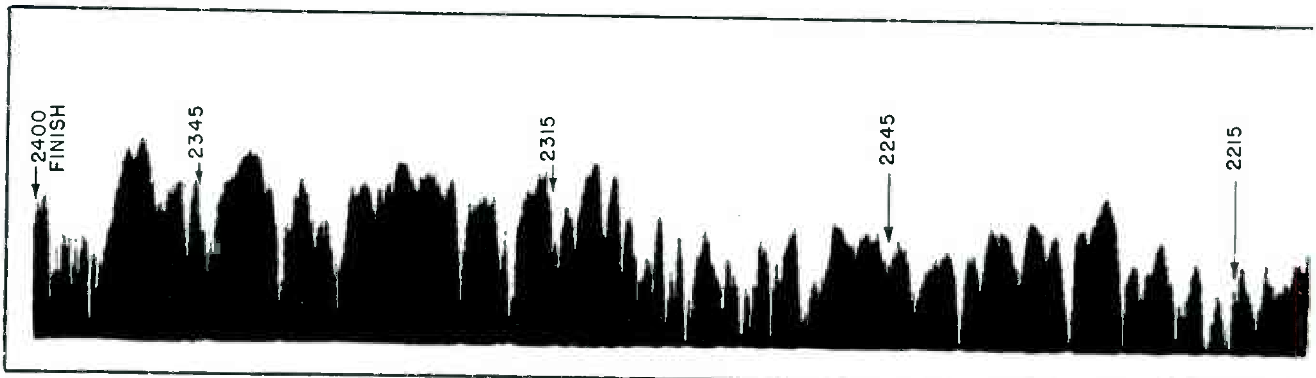
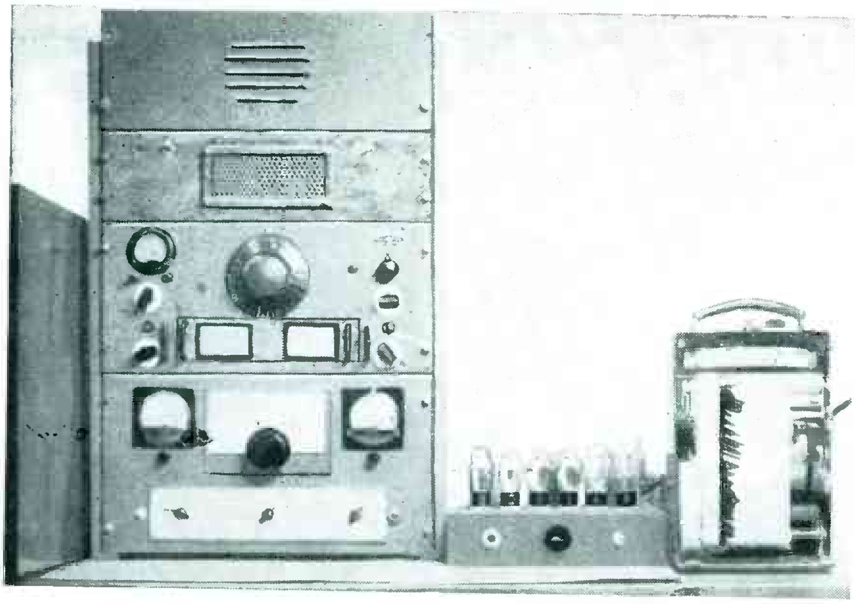


Example of strip chart obtained with sky-wave signal recording equipment at Strathburn, Ontario. Curve shows variation in input signal strength to receiver over period of several hours at night for signals of station WGY, Schenectady, N. Y.

Recording Sky-Wave Signals



Receiving rack, cycler chassis, and graphical recorder used at Ottawa frequency monitoring station for recording sky-wave signals from broadcast stations

By WILBERT B. SMITH
Assistant Radio Engineer, Radio Division Department of Transport, Ottawa, Ontario, Canada

A GOOD DEAL of the energy radiated from standard-band broadcasting stations is reflected from the ionosphere and returns to earth at a distance from the station. This phenomenon is an advantage in the case of clear-channel stations since it augments the coverage, but where channels are shared by two or more stations in the same region it may produce interference which seriously limits the coverage otherwise obtainable.

In the broadcast allocation structure, due cognizance must be taken of the effects of sky-wave signals. Ground-wave propagation is calculated from verified theoretical curves, but because of the many indeterminable factors involved in sky-wave propagation, no corresponding curves exist, and calculations must be made from entirely empirical curves. These curves are plotted from measured data on the sky-wave signal intensities of distant stations over an extended period, and are based on the signal exceeded for certain percentages of time.

Early curves took no separate account of variations due to latitude, or between north-south and east-west propagation, or of ionospheric focusing, but assumed an average propagation characteristic for all sky-wave signals. The early curves are the ones which have been in use up to the present time, under the North American Regional Broadcasting Agreement, Havana, 1937.

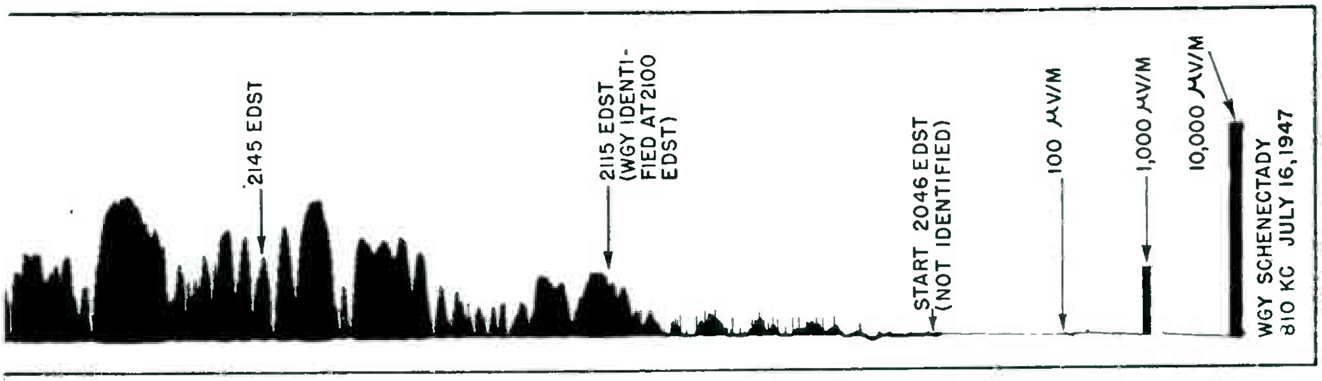
The Modus Vivendi, Washington, 1946, which extends the above-mentioned agreement, recognized the need for more up-to-date information on which to base new technical standards to be drafted in 1948, and charged the signatory countries with making the necessary studies towards this end. A program of sky-wave recording was therefore drafted by the Canadian authorities to determine the propagation characteristics of sky-wave signals in Canadian latitudes.

Sky-Wave Recording Technique

Equipment for the recording of sky-wave signals must be accurate and stable, yet simple enough to be used in outlying stations. It must produce records which are readily analysed in terms of the absolute field intensity of the radio wave, in microvolts per meter.

The essential components of field-intensity recording equipment are the radio receiver and antenna, comparison standard signal generator or other calibration means, and the graphical recorder.

In the system as finally developed by the author for the Canadian recording program, the incoming signal is received on a National HRO



Analysis of above chart with photoelectric scanner showed that signal exceeded 6,100 µv 5% of the time, 5,300 µv 10%, 3,000 µv 30%, 1,700 µv 50%, 1,400 µv 60%, 820 µv 90%, and exceeded 700 µv 95% of the time

from Broadcast Stations

Description of monitoring station set up by Canadian government to investigate sky-wave interference occurring when two or more broadcast stations share the same channel. Signal strength of a station is recorded on strip chart for several hours, and photoelectric scanner then determines percent of time signal exceeds any selected value

receiver which has been peaked for maximum i-f response, and from which the avc voltage is fed to a vacuum-tube amplifier which drives a 5-ma graphical recorder. In series with the graphical recorder is a device which periodically returns the recorder pen to zero so as to blank in the area between the curve and zero to facilitate analysis of the graphs. The incoming signal as delivered by the antenna is compared with the output of a standard signal generator for calibration of receiver output. The antenna itself is calibrated by comparison with a field-strength meter of known accuracy.

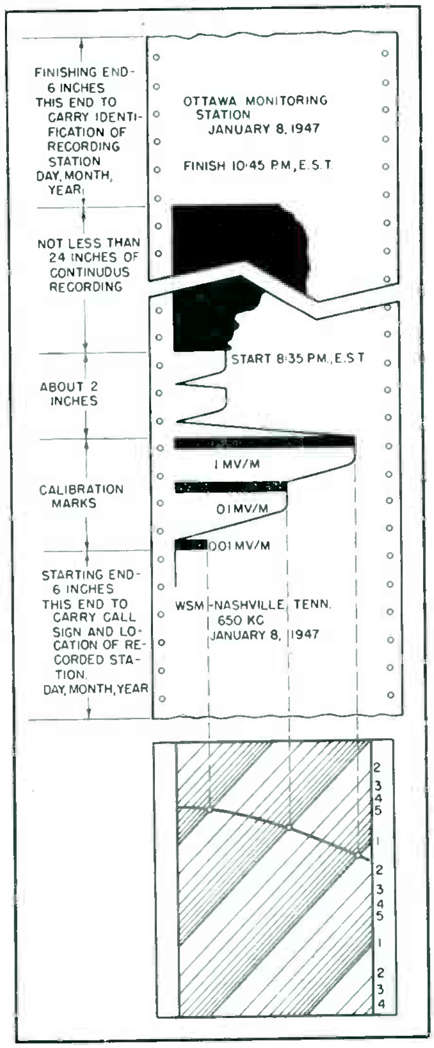
Analysis of the charts is accomplished by means of an electronic scanner, in which a spot of light rapidly traverses the chart along the time scale. The reflected light operates, through a phototube and amplifier, an electronic gate which permits current to flow through a meter calibrated directly in percentage only during the periods when the spot is on the blanked-in portion of the chart. In this manner the scanner integrates the time during which a particular value of signal was exceeded. Suitable scales used in conjunction with calibration marks placed on the charts permit direct determination of the field intensity exceeded for any specified percentage of time.

Signal Generator

The circuit diagram of the standard signal generator is shown in Fig. 1. It is a straightforward design, the only unique features being the shielding, the use of a coupling tube between the r-f sources and the receiver, and the vacuum-tube voltmeter circuit.

Effective shielding is achieved by locating the oscillator and the circuits associated with it in individual cast aluminum boxes which are insulated from ground, connected together in sequence at one point only, and grounded to the main chassis at one point only. Circuits entering the boxes are individually filtered by means of chokes and capacitors, and control shafts entering the boxes are broken with insulated couplings. Circuits within the box are grounded at one point only, near where the r-f voltages are finally delivered.

Under the provisions of present



Format followed in recording signal strength of broadcast station on strip chart, and (below chart) method of obtaining calibration curve used in connection with electronic scanner

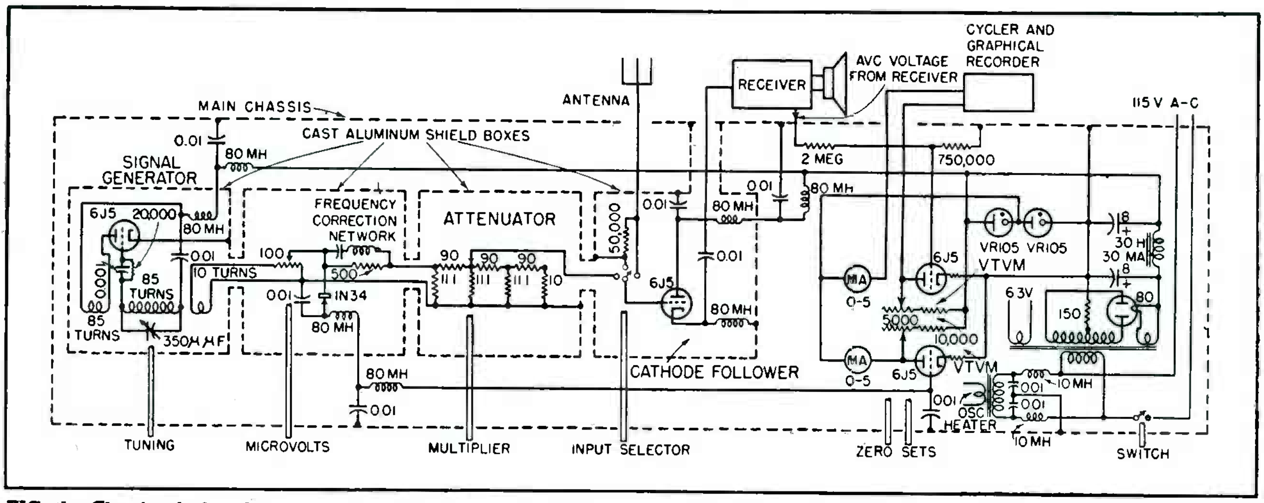


FIG. 1—Circuit of signal generator used for calibration in connection with recording of sky-wave signals, showing elaborate shielding technique employed and relationship to other units of recording system

international agreements the lowest sky-wave field which has any significance is 25 microvolts per meter, so there is little advantage in making studies on field intensities much less than this. Therefore the signal generator was designed to deliver calibrated r-f voltages only down to 10 microvolts, which with the usual broadcast type of antenna permits accurate recording of fields as low as 5 microvolts per meter.

In order to simplify operation and minimize effects of antenna variations, a cathode-follower coupling tube is included in the circuit between the r-f sources and the receiver input, with a switch to change the input from antenna to signal generator for calibrations. Since this tube is in the circuit for both calibration and recorded signals, it is in effect part of the receiver and is calibrated with it. It does not introduce spurious effects unless subjected to r-f signal intensities of the order of 2 volts, which may drive the tube beyond its range of linearity. Localities where high signal strength exists are avoided in selecting a site for the recording equipment.

Two similar vacuum-tube voltmeters are provided, one for measuring the r-f voltage applied to the attenuator, and the other for operating the graphic recorder from the received avc voltage. They consist of triodes with the indicating meters bridged between their plates and the midpoint of two voltage regulators in series. The tubes are operated under conditions of no input voltage with about 0.8 volt

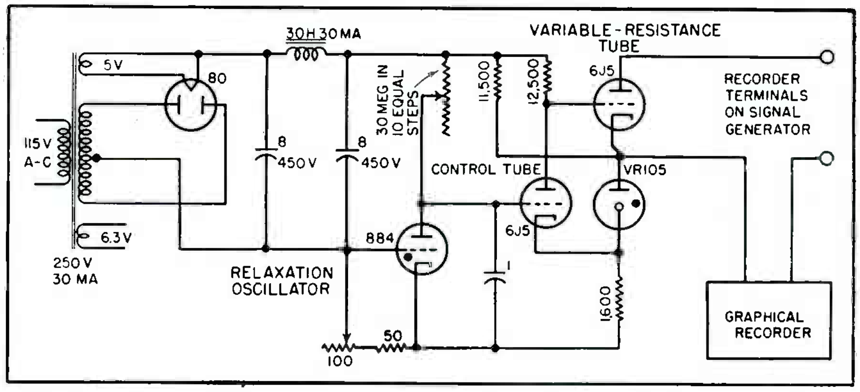


FIG. 2—Cycler circuit for sweeping pen of recorder periodically back to zero, to black in entire area between signal strength curve and zero. Rate of sweep may be varied from once per second to once every 5 seconds by adjusting 30-megohm resistor

bias, obtained from a cathode resistor. The plate resistances are varied for zero reading on the respective meters, as zero-sets. For any negative voltage applied to the triode grid, the plate current will decrease a proportionate amount over the corresponding portion of the tube characteristic, which in the case of the 6J5 triodes is quite linear. The change in plate current will result in the difference current flowing through the meter, giving after calibration the measure of the applied voltage.

Provides Protection

This circuit was selected to utilize the negative avc voltage from the receiver, and to provide protection against accidental overload of the meters or recorder from excessive input voltage. Excessive input voltage can only drive the triode to cutoff, when the meter will be called upon to carry not more than the normal plate current of the triode, which is approximately 8 ma and not dangerous for a 5-ma meter.

The vacuum-tube voltmeter which reads the r-f voltage applied to the attenuator obtains its grid voltage from a germanium crystal rectifier. No return resistance path is provided for this rectified voltage as the germanium rectifier itself has a sufficiently low resistance in the reverse direction to permit the grid charge to leak off. Since the voltage applied to the tube grid is very nearly equal to the peak value of the r-f voltage applied to the attenuator, the original calibration of the signal generator can be against a standard cell, although comparison against a laboratory standard signal generator may be more convenient.

The second vacuum-tube voltmeter obtains its grid voltage from potential-dividing resistances across the avc circuit of the receiver. The values of these resistances are such as to bring the range

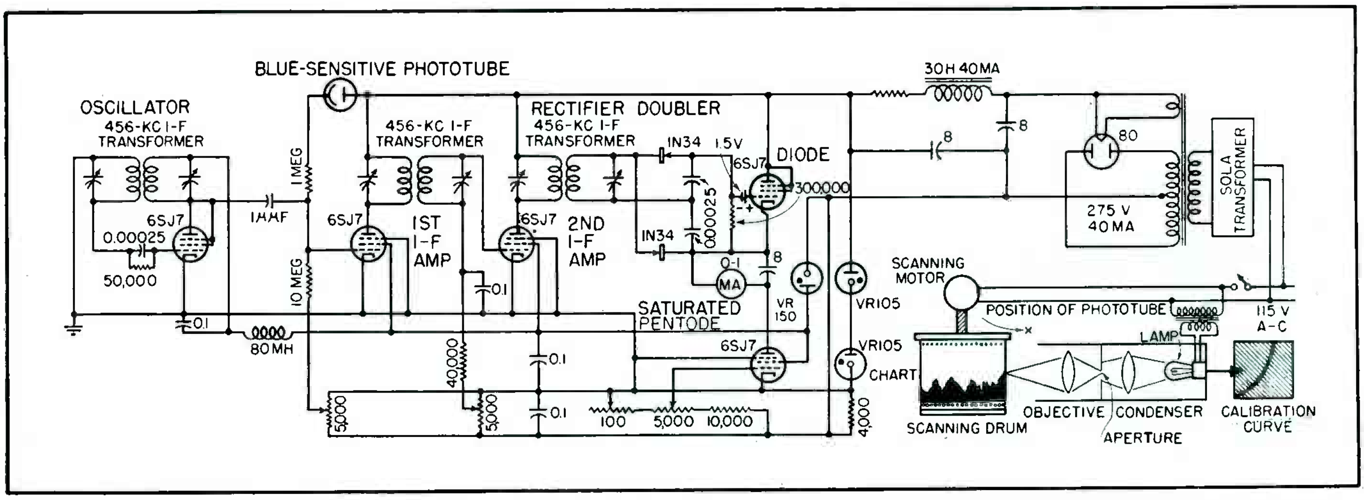


FIG. 3—Circuit of electronic scanner used for analysis of charts. Arrangement of optical system is shown at lower right; phototube is mounted on carriage along with lenses and lamp, and picks up light reflected from spot on chart

of the meter onto the portion of the receiver gain characteristic which is most nearly logarithmic. It is therefore possible to get better than two complete ranges, or a ratio of 100:1 within the scale of 0-5 ma, using a National HRO receiver.

Chart-Blanking Circuit

The circuit for blanking in the area on the chart between the curve and the zero for analysis by means of an electronic scanner is shown in Fig. 2. Electrically it consists of a small resistance in series with the graphical recorder, which resistance remains constant for about four-fifths of the cycle, and then increases to infinity over the remaining fifth, after which it suddenly returns to its previous value and the cycle starts over again.

The resistance which performs in this unusual manner is the plate resistance of a 6J5 triode, the grid of which is held about 4 volts positive for the first four-fifths of the cycle. Under these conditions the tube shows a linear plate resistance characteristic of about 300 ohms for currents as high as 8 ma.

The grid of the output or variable-resistance tube is connected to the plate of another 6J5 triode which acts as a control tube to translate the voltage developed by the relaxation oscillator into an increasing bias. Since the control tube is biased well beyond cutoff for four-fifths of the cycle developed by the relaxation oscillator, it does not come into action until the last fifth of the cycle. It then diverts the current previously flowing through the grid circuit of the output tube, permitting the bias of that element to increase to cutoff.

The relaxation oscillator is conventional, being a capacitor charged through a high resistance and discharged through a type 884 thyratron. By using a tapped 30-megohm resistance and a 1-μf oil-filled paper capacitor, good stability was obtained with periods from 1 to 5 seconds long.

For chart speeds of 1 foot per hour the 5-second period is required, but for faster speeds a correspondingly faster rate applies.

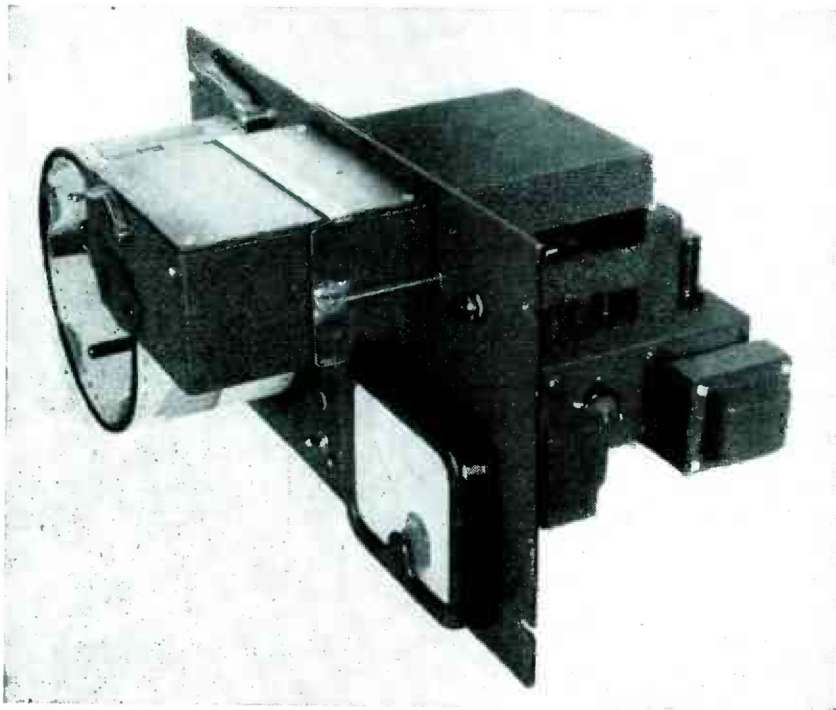
An Evershed-Vignoles graphical recorder with 5-ma range and clockwork drive is used. This instrument is fitted with an oil dashpot so that control can be had over damping, which is important for the cyclic operation to which the instrument must respond. Wrinkling of paper was overcome by using No-Rinkle ink and Albanene paper produced by Keuffel & Esser. The combination of a red ink and a blue-sensitive phototube in the electronic scanner was found to give best results.

Electronic Scanner

A substantial part of the information to be gleaned from the chart is statistical and involves the determination of the signal exceeded for certain percentages of time, during certain periods relative to sunset. Heretofore, the method of analysis has been to step off with dividers and scales the time increments corresponding to certain signal intensities, replot the values so obtained and from the resultant curve read off the required information of the signal exceeded for certain percentages of time. Needless to say, this manual method is tedious and inefficient, and opens wide the door to personal error which it is almost impossible to check. Fortunately, however, when a great deal of data is so analyzed most of the errors balance out in the subsequent statistical mathematical treatment, but there still remains the tedious labor of the manual analysis.

The electronic scanner was developed for the dual purpose of speeding up analysis and eliminating largely the personal error. Due to the shortness of time during which the Canadian program could operate before the data would be required for the production of propagation curves, speed and accuracy of analysis were essential.

The circuit of the scanner is shown in Fig. 3. The chart to be scanned is wound around the scanning drum, which will accommodate 24 inches of chart for each operation. The lamp-house contains a carriage which slides along ways under the control of a crank on the front of the lamp-house. Mounted on this carriage is a light source consisting of a 32-candlepower automobile lamp, condenser lens, diaphragm with a 1-mil aperture, and an objective lens which focuses the image of the aperture as a small spot of light on the chart undergoing analysis. Also mounted on the carriage is a phototube so arranged as to pick up diffused reflected light



Electronic scanner unit used at Radio Standards Office in Ottawa for analysing sky-wave charts obtained with recording equipment. Logarithmic calibration chart is placed under pointer on table just above drum. Pointer is mechanically coupled to optical system

the amplifier bias controls, so that no special precautions are necessary in regard to room lighting. A Sola constant-voltage transformer supplies the electronic circuits. This transformer combined with the voltage regulators used to obtain the various internal voltages gives maximum stability and the instrument can be easily read to an accuracy within 1 percent.

The image of the aperture in the diaphragm on the chart being scanned is about 0.03 inch in diameter, which is about the width of the line traced by the pen on the graphical recorder. Consequently, the scanner can resolve and analyse any record normally taken by the recorder. The accuracy with which the percentage-of-time meter and the calibration on the graph can be read is about 2 percent.

In using the scanner, the chart to be analysed is first placed on the drum with the zero side to the front and with the calibration marks showing on the outside. The pointer is then wound successively to the top of each calibration mark and a short pencil line drawn along the straight-edge intersecting an appropriate unit line on the graph. These points are then joined up by a smooth curve which provides the scale from which signal intensities pertaining to that particular chart are read. The curve so plotted is in reality the received signal versus avc voltage curve, and consequently provides the means for reading directly in microvolts per meter the field intensity from the recorded values of the resultant avc voltage. A new curve is drawn for each chart analysed.

After the calibration curve is established, the chart is moved around the drum until the portion of which the analysis is desired is on the outside and visible to the scanning spot. The drum is then started rotating and the percentage-of-time meter checked for zero and full scale. The scanning spot with its attendant pointer is then wound across the chart until the meter reads the desired percentage of time, when the corresponding field intensity can be read off directly from the intersection of the straight edge of the pointer with the calibration curve.

from the spot on the chart. The top of the lamp-house carries a special logarithmic graph under roughened plastic to take pencil lines. Crossing the chart is a pointer which is connected to the carriage and arranged to track with the position of the spot of light. The near side of the pointer acts as a straight edge to place the calibration lines on the graph, and to read off the values of signal exceeded.

The electronic section consists of an amplifier responsive to the standard i-f value of 456 kc but normally biased slightly beyond cutoff. This amplifier is supplied with 456-kc excitation from an oscillator through a small capacitor, but does not come into action until the bias on its first stage is reduced by illumination of the phototube. The output of the amplifier is rectified by two germanium rectifiers in a doubler circuit, and applied to the grid of a triode-connected 6SJ7, which is in series with a 6SJ7 saturation pentode and the percentage-of-time meter.

When the phototube is not illuminated there is no appreciable output from the amplifier and the grid of the triode is maintained at zero potential by a flashlight battery, permitting the full saturation current of 1 ma to flow through the saturation pentode and give a full-scale reading on the percentage-of-time meter. This condition corresponds to the scanning of a completely inked-in portion of a chart undergoing analysis.

When the phototube is illuminated the amplifier comes into action and produces at the output of the germanium rectifier 50 volts or more, which produces immediate cutoff of the triode. For the period when this condition prevails no current flows through the percentage-of-time meter. This corresponds to the scanning of a blank portion of the chart.

Since the percentage-of-time meter is of the uniform scale type, it will read the average current flowing through it, provided the cycle is fast enough to prevent the meter movement from following the individual fluctuations. Hence it follows that in the scanning operation the meter will read directly the percentage of time during which the phototube has not been illuminated, which is the percentage of time a certain signal strength has been exceeded.

The instrument can be made unresponsive to residual room illumination by judicious adjustment of

Electromechanical D-C Amplifier

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and

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Small chassis at left contains the d-c amplifier and power supply used with the recorder and thermocouple (bottom) to measure transients in a thermal process

APPLICATIONS

Production matching of resistors. Gives quick response with high sensitivity to replace galvanometer
Experimental production of thermocouples. Used with recorder to measure time response characteristic of thermocouple element
Development of temperature regulators to drive transient response recorder
Serves as power or impedance changer to make possible long distance transmission or telemetering of low level d-c signals
Amplify outputs of barrier layer photocells, Pirani or ionization-type vacuum gages
Amplifier for control equipment, and servomechanisms
Bridge detector
Preamplifier in radiometry recording

A moving-coil system actuates a metal flag in an oscillator tank to provide high gain and stable d-c amplification. Operating principle, mechanical details, and circuits of a degenerative system for low-impedance, low-current inputs are given

WHOLLY ELECTRONIC d-c amplifiers are subject to drift resulting from supply voltage variation, tube characteristic instability, and variations of temperature and humidity. Also, this type of amplifier does not lend itself to low-impedance inputs.

When voltage regulation and balanced circuits are used to reduce drift, the amplifier becomes complicated and unwieldy. For laboratory use this last point is perhaps no handicap, but for industrial and aircraft usage, complexity and size, not to mention cost, become vitally important.

The chopper type d-c amplifier, while it can be used with a low-impedance input, structurally is difficult and expensive to make. For many industrial purposes, as well as aircraft applications where space and weight are at a premium, it is inconvenient, and its extremely high gain is unnecessary.

Combination System

The principle of electromechanical d-c amplification is illustrated in Fig. 1.

In Fig. 1A, a low-level voltage input to a galvanometer is converted into motion, and this motion is then employed to tune an oscillator by having a metal flag move be-

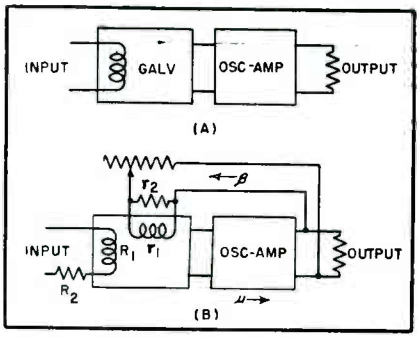
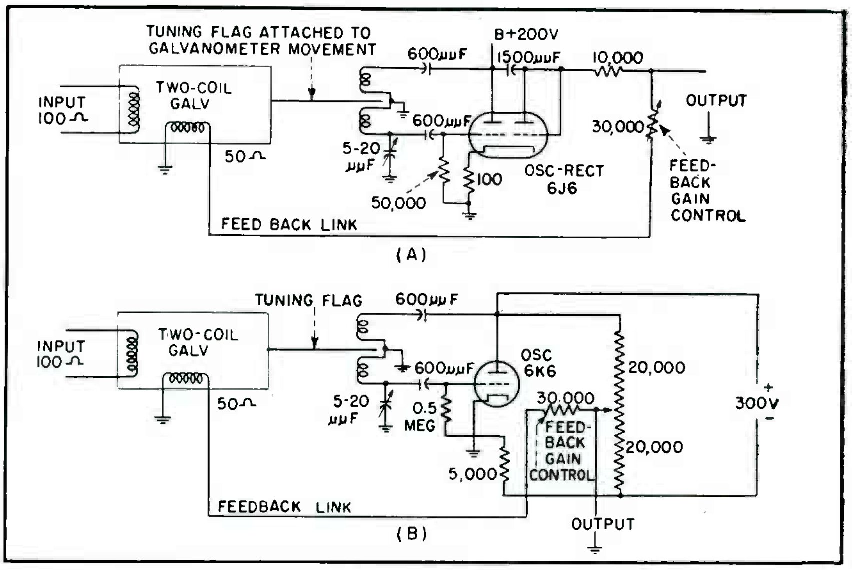


FIG 1—Basic principle of the electromechanical system is illustrated at (A). The method of adding feedback is shown at (B)

FIG. 2—Two practical circuits for using the current-sensitive tuning flag and an electronic oscillator to obtain amplification. Both provide a voltage gain of 1,000



tween coils of a tuned-grid, tuned-plate oscillator. The motion of the metal flag loads and unloads the tank circuits with consequent variation in input voltage of the oscillator. With a reasonably sensitive galvanometer movement, such a conventional setup can easily provide voltage gains higher than 10^6.

In Fig. 1B, an extra coil has been added to the galvanometer, and the output voltage is fed back to the galvanometer input. Basically, this is the complete d-c feedback amplifier. Feedback could be applied to the input coil, but the advantage of an isolated input would then be lost.

Since a galvanometer input is used, a low-impedance input offers no difficulties. So, too, this extremely high-gain mechanical input stage does away with input tube selection and fastidious care of operating conditions.

Considering the overall circuit, the gain of a feedback amplifier may be written as[1]

$$\frac{E_{out}}{E_{in}} = A = \frac{\mu}{1 - \mu\beta}$$

where A = gain of feedback amplifier, μ = forward gain without feedback and β = feedback fraction.

This can be rewritten as

$$A = \frac{-1}{\beta}\frac{1}{1 - 1/\mu\beta} \qquad (1)$$

Thus as long as the quantity $\mu\beta$ is large, A is practically equal to $-1/\beta$, and the gain is almost independent of changes in μ.

The actual reduction in gain variation as a result of change in μ may be computed as follows:

$$E_0 = \frac{\mu}{1 - \mu\beta} E_i$$

differentiating with respect to μ

$$\frac{\partial E_0}{\partial \mu} = E_i \frac{1 - \mu\beta + \mu\beta}{(1 - \mu\beta)^2}$$

$$= \frac{1 - \mu\beta}{\mu} E_0 \frac{1 - \mu\beta + \mu\beta}{(1 - \mu\beta)^2}$$

$$= \frac{E_0}{\mu\,(1 - \mu\beta)}$$

$$\text{or } \frac{\partial E_0}{E_0} = \frac{1}{1 - \mu\beta}\frac{\partial \mu}{\mu} \qquad (2)$$

Thus, the variations in gain as a result of changes in circuit are reduced by a ratio of $1/(1-\mu\beta)$.

The extremely high initial gain of this electromechanical d-c amplifier permits of large feedback factor $\mu\beta$ to reduce drift, while resultant gain which has been shown to be virtually equal to $1/\beta$ is still, for many purposes, quite satisfactory.

Faster Action

The feedback to the galvanometer is also advantageous from another point of view. The time response of the galvanometer is greatly improved; that is, the natural undamped period of such a mechanical system is reduced to a fraction of its original value.[2]

It can be shown that feedback in the galvanometer is given by,

$$C' = (1 + \mu\beta)C$$

where C = stiffness of suspension and C' = stiffness with feedback. Since the unclamped period of the galvanometer is given by,

$$\tau = 2\pi\sqrt{\frac{K}{C}}$$

where τ = period and K = moment of inertia then the period with feedback becomes,

$$\tau = 2\pi\sqrt{\frac{K}{C'}} = 2\pi\sqrt{\frac{K}{\mu\beta C}}$$

Thus, feedback has reduced the period by a factor of $1\sqrt{\mu\beta}$.

Temperature Compensation

When the amplifier is used with a current input, change in resistance of the input coil with temperature is of no consequence. However, for a voltage input there is one other major advantage to be considered; that is the input circuit can be completely compensated for copper temperature error. This eliminates necessity for insulating the input circuit or for adding large zero temperature coefficient resistors in the input circuit.

The method of temperature compensation can be explained with reference to Fig. 1B. Both coils on the galvanometer movement are copper and, therefore, for any temperature change undergo the same percentage change of resistance.

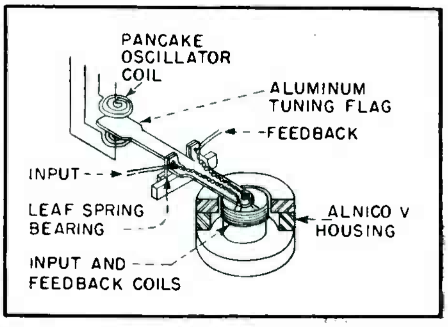


FIG. 3—Construction details of the galvanometer-type movement. The input and feedback coils are wound one above the other

Now when $\mu\beta$ is much greater than unity and the gain, A, is equal to $1/\beta$, the feedback current is directly proportional to output voltage. A zero temperature coefficient resistor, r_2, is placed across the feedback coil, r_1, to divide the feedback current; and this division of current varies as the resistance of the copper feedback coil changes.

On the input side, R_2 is placed in series with R_1, the copper input coil, and changes in the resistance of R_1 result in changes of input current. It can be shown that with change in resistance of the two copper coils, the percentage change of current through the input coil is exactly equal to the percentage change of current in the feedback coil if $R_1/R_2 = r_1/r_2$. Thus loss of input sensitivity is balanced by a decrease in β, the feedback fraction, and the gain remains constant as the temperature changes. Since the ratio r_1/r_2 can be made as small as the feedback power available will allow, the ratio, R_1/R_2, which also represents loss of gain as a result of compensation, can be kept correspondingly small.

In general, two convenient possibilities for the circuit of the amplifier have been tested. They are shown schematically in Fig. 2. In Fig. 2A, the r-f oscillator output is rectified to provide d-c output and feedback current. In Fig. 2B, the change in the d-c impedance of the oscillator tube with strength of oscillation is employed to unbalance a bridge. It is worthy of note that frequency variation is not considered in either of these methods and that one need not be concerned with exact frequency stabilization. Only the magnitude of the r-f signal is significant.

FIG. 4—Four inches long, this bench model of the d-c amplifier contains a miniature tube inside the chassis for applications where space is limited

The argument might be raised that this amplifier would only be useful in the laboratory, since a galvanometer is too fragile an instrument and is subject to accelerations and vibration. However, this application lends itself to a revamping of galvanometer design to give a very rugged structure.

Figure 3 shows a sketch of such a galvanometer. Since only a few thousandths motion is required of the flag moving between the oscillator coils, this design becomes feasible. Some advantages are immediately obvious. With the moving coil suspended in this manner, all coil turns are at right angles to the radial field and, therefore, useful.

In conventional galvanometer design, the portions of every turn that lie parallel to the magnetic field are wasted. So, too, a cylindrical coil is easier to wind than a conventional galvanometer coil, and the structure lends itself to the addition of the extra feedback coil without difficulty.

As a result of the small motion required, short frictionless leaf spring bearings may be used, making a more easily assembled movement. Having the coil at the end of the beam provides a torque-input current ratio that is higher than that usually attainable, but which would be detrimental were it not for the feedback used. The long natural period of the beam is reduced by feedback as has been shown.

Thus, combining the advantages of a high torque to current input ratio, rugged shockworthy construction, simplicity of assembly, and a fast time response as a result of feedback, the galvanometer is suitable for use as the input stage of a high-gain, stable field model d-c amplifier.

Practical Instrument

To answer a demand for an amplifier for aircraft purposes, the Micrcsen d-c amplifier pictured in Fig. 4 was developed. The unit shown is a bench model, flight models being shock-mounted and weather-sealed.

This instrument is exemplary of the general principles discussed, and its specific characteristics will

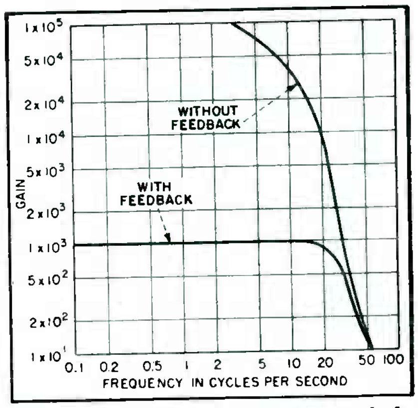


FIG. 5—Frequency characteristics of the electromechanical system with and without feedback

be considered in more detail. The design throughout was influenced by the stringent specifications of aircraft apparatus. It occupies less than 40 cubic inches, weighs approximately 2 pounds, requires less than 5 watts power and is mechanically constructed to insure its ability to withstand heavy vibrational and acceleration loading.

The circuit of Fig. 2A was used in this instance, and the feedback fraction chosen was 0.001, giving a gain of 1,000. Its specific use is to provide a voltage output of 5 volts for a thermocouple input of 5 millivolts. It is powered by an unregulated d-c supply of nominal 200-volt value. With line voltage variation from 100 to 200 volts, output drifts only 0.5 percent.

Feedback has greatly improved the time response as is witnessed by the frequency characteristics with and without feedback shown in Fig. 5. The gain remains constant as long as $\mu\beta$ is much greater than unity. At higher frequencies $\mu\beta$ becomes smaller as μ is reduced.

If it were desirable to extend the frequency characteristic and still retain the same gain, a stage of d-c amplification might be added, thus increasing $\mu\beta$ without increasing β, the reciprocal of the latter still determining the gain value. Of course, the gain is not limited to 1,000. Stable gains as high as 50,000 can be provided if the application demands.

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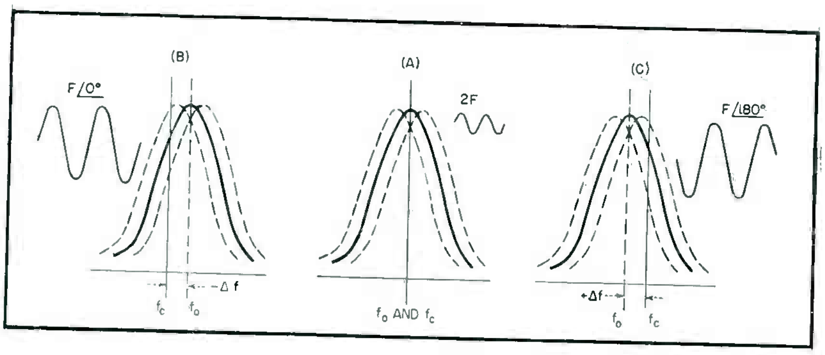

FIG. 1—Phase method of obtaining frequency drift sense

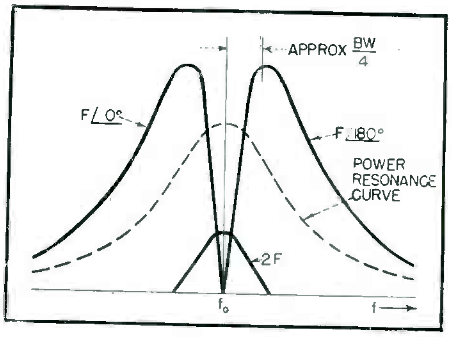

FIG. 2—Resonator-detector output

Simplified Microwave AFC

Part I

WITH the rapidly spreading interest in microwave relay systems, there appears a need for a relatively simple means of keeping a microwave oscillator within the required frequency tolerances. Accurately controlled temperature and voltages at the tube can be used with good success, but this requires complicated and bulky equipment.

Techniques using automatic frequency control (afc) of the microwave oscillator have also been developed, and many of these operate exceptionally well. Some of them have sufficient bandwidth and stability characteristics to provide a frequency correction to the oscillator of better than several parts per million over reasonable periods of time.

The afc system to be described is not as precise as the best that can be built, neither is it as complicated as a precision unit. Instead it is relatively simple, compact, easy to adjust, and can operate with either tunable klystrons or tunable magnetrons.

Most of the relay systems on microwave channels are rather wide band, in the order of 2 mc or more. Consequently, if the transmitter carrier is held to within about ± 200 kc of the assigned frequency, it will remain well within the channel limits. A simplified motor-operated afc system will serve.

In all automatic frequency control systems, the frequency of the controlled oscillator is compared with a known reference frequency, and any discrepancy between the two, as indicated by the detection circuit, is used to apply a correction to the afc oscillator. One method uses a cavity resonator as the reference frequency standard. The resonator is used in such a way as to obtain a sensing or directioning of the oscillator drifts for applying the proper corrections. This correction may be accomplished by coupling the resonator to a waveguide bridge circuit.[1]

The type of sensing used in the system to be described is somewhat novel because it applies a sensing modulation to the reference resonator itself. This sensing modulation provides a means of detecting the magnitude and direction of frequency shift of the oscillator. The signal carrying this information is used to shift the oscillator back to the correct frequency setting. Either mechanical or electronic means can be used to tune the tube, or both can be used in combination.

Several useful afc systems are discussed: motor afc system alone; motor and reflector afc system combination; pushbutton scanning means for such systems; automatic scanning means. Their discussion is preceded by an analysis of certain basic operating principles.

Method of Sensing

If the resonant frequency of an excited resonator is moved back and forth at a given rate, the resulting signal from a crystal detector coupled to the cavity is in phase with the signal producing the resonant frequency shift when the carrier is effectively detuned to one side of resonance, and 180 degrees out of phase when it is detuned to the other side of resonance. As far as the crystal detector is concerned, variation of the cavity resonant frequency is equivalent to frequency modulation of the carrier generator. When the carrier is exactly in tune with the resonator, the detector output is entirely the second harmonic of the sweep rate, with no fundamental component present.

Figures 1 and 2 illustrate these basic sensing functions graphically. Figure 2 shows that increasing the

* The equipment described was developed while the author was with Sperry Gyroscope Co.

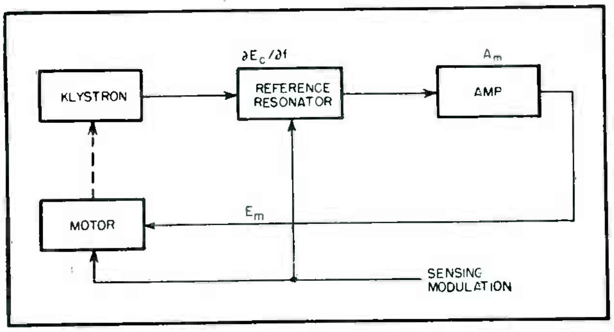

FIG. 3—A basic motor-operated automatic frequency control

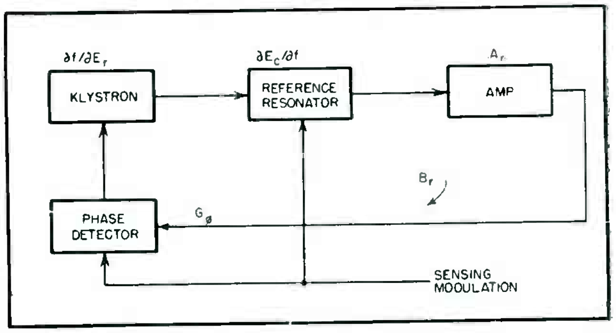

FIG. 4—A basic electronic automatic frequency control

Combinations of motor and electronic afc action for microwave oscillators are discussed. Methods of automatic and manual correction scanning complete the design considerations for a 3,000-mc radio-relay system that remains within 200 kc of assigned frequency

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carrier detuning will enhance the voltage of the fundamental frequency-modulating frequency obtained from the crystal detector until the detuning has gone about one-quarter of the resonator bandwidth, at which point the voltage of the fundamental begins to drop off, although remaining in the same phase. The output signal from the detector crystal is a reversing-phase variable-magnitude voltage of the same frequency as that used to modulate the resonator.

Figure 2 is correct for small frequency deviations of the resonator frequency, a condition which is employed in the present afc system. Wider deviations move the fundamental peaks out to about the half-power points on the resonance curve. The slope of the fundamental curve at or near resonance is called the conversion factor or sensitivity of the resonator-detector unit, dE_c/df, and is stated in volts per cycle for a given radio-frequency power into the resonator and a given frequency deviation.

To prevent modulation of the cavity from reacting on the oscillator, careful adjustment of the coupling between the two is necessary. It is desirable to use only a small amount of power in the resonator, as this aids in meeting the decoupling requirement by allowing loose coupling and avoids absorbing too much energy from the oscillator.

Basic Motor AFC

To illustrate each functional section of the complete afc system, the two methods of control will be discussed separately. Figure 3 shows a block diagram of the essential elements of the motor afc without antihunt. Since the resonator-detector output is a reversing-phase variable-magnitude voltage of the fundamental sweep frequency, it is suitable for operating a two-phase motor. If one winding is excited with a constant voltage of fixed phase, and the other, called the control winding, is excited by a variable-magnitude voltage of either 0 or 180-deg phase relationship with respect to the first winding, the direction of rotation of the motor will depend upon whether 0-deg or 180-deg phase voltage is in the control winding. The speed at which the motor runs is dependent upon the amplitude of the voltage in the control winding, with zero voltage producing no rotation, even though full voltage is maintained on the first or reference phase winding. The motor, in essence, becomes a phase detector in this type of afc system.

From the diagram of Fig. 3, it is seen that the resonator-detector signal is amplified and applied directly to the control winding of the motor. The fixed phase winding derives its excitation from the same source that is used to produce the resonator frequency deviations for the sensing operations.

Since the two-phase motor is a mechanical device, it is subject to certain evils, namely bearing friction, inertia, and unbalance. In a good motor the rotor will be balanced rather carefully, and static inertia troubles will not begin to appear until the static friction in the bearings has been virtually eliminated. Owing to this friction, a finite signal voltage E_m at the motor winding is needed to overcome these forces and produce rotation. Usually the rotational friction is lower than the static friction, and consequently it is not the important factor in the problem.

Assuming then that the system is exactly in tune, no fundamental voltage will appear at the motor winding. As the oscillator begins to drift, the error signal on the motor winding has to reach a value of E_m volts before motor-operated afc action takes place. Therefore, the unavoidable frequency error owing to friction is the frequency drift required to produce E_m volts at the motor.

Referring again to Fig. 3, the terms used to describe the action around the feedback loop may be summarized and defined. E_m is the motor voltage required to overcome static friction; dE_e/df is the resonator-detector voltage frequency sensitivity, near resonance; A_m is the gain of the motor amplifier section; Δf is the frequency deviation error without afc.

To cause afc action to take place the error signal must equal E_m, and that quantity may be evaluated by

$$E_m = A_m\,(dE_e/df)\,\Delta f \qquad (1)$$

Solving for the frequency error produced by the motor afc because of frictional forces gives

$$\Delta f_m = (E_m/A_m)\,(df/dE_e) \qquad (2)$$

The error shown in Eq. 2 is the long-time error encountered in the motor-operated type of afc system (assuming negligible resonator and modulator drift), since the motor will drive until the error voltage on its winding has reached some value less than E_m. Driving toward the correct frequency, the inertia of the mechanical system will carry the tuning well into the region where the error signal is less than E_m. The fact that rotational frictional at slow speeds is less than static friction emphasizes this condition.

It may happen that the mechanical inertia of the gear train actually carries the tuning through the correct value and to a reverse voltage greater than E_m. This new error signal drives the system in the other direction and the overrun may then be encountered a second time. This can result in hunting, where the motor oscillates the tuning back and forth around the correct frequency setting.

The problem of eliminating hunting will be taken up in a later section. The correction response time of the motor afc is usually slow due to the mass and drag of the mechanical linkages.

Basic Electronic AFC

Using electronic afc, for example by varying the reflector voltage of a reflex klystron, a residual error signal is required to produce a correction voltage with which the afc must operate. This is unlike the motor-operated afc in which the error signal would go to zero if no static frictional forces existed. Figure 4 shows a block diagram of an electronic afc section. The essential difference between this and the previous case is the replacement of the motor by a phase-detector whose output is coupled directly into the reflector circuit of a klystron. Since the reflector is frequency-voltage sensitive, the control loop is complete to provide afc action.

As such an electronic afc system does not have any mechanical circuits, it can be treated in the usual feedback manner. The terms used around the feedback loop in Fig. 4 are defined as follows:

G_ϕ = conversion gain of phase detector
df/dE_r = klystron reflector frequency—voltage sensitivity
dE_e/df = resonator-detector voltage-frequency sensitivity near resonance (as before)
A_r = gain of reflector amplifier section
Δf = frequency deviation error without afc
B_r = feedback gain around loop, excluding amplifier A_r

The residual error in the electronic afc is the frequency error drift divided by the total loop gain

$$\Delta f_r = \frac{\Delta f}{\textit{loop gain}} = \frac{\Delta f}{A_r B_r} \qquad (3)$$

$$A_r B_r = A_r\left(G_\phi \frac{df}{dE_r}\,\frac{dE_e}{df}\right) \qquad (4)$$

Substituting Eq. 4 in Eq. 3

$$\Delta f_r = \frac{\Delta f}{A_r\, G_\phi \dfrac{df}{dE_r}\,\dfrac{dE_e}{df}} \qquad (5)$$

The residual error signal can be made smaller by increasing the gain around the feedback loop ($A_r B_r$).

Combination Motor and Electronic AFC

The motor and electronic afc systems have one interesting thing in common; neither afc system can produce complete error correction. The motor system is afflicted with frictional troubles, and the electronic system requires some error signal to produce afc action. Operating in combination, however, the electronic afc has to handle all transient errors greater than the maximum frequency error allowed by the motor friction given by Eq. 2. Its long-time error signal will be less than this amount. Consequently, the resulting long-time error of the combined systems is given by substituting Eq. 2 into Eq. 5

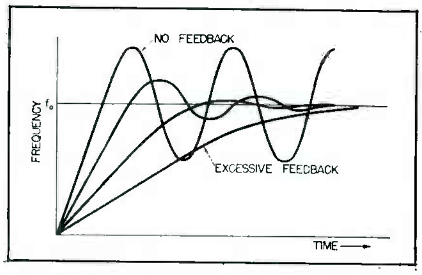


FIG. 5—Motor tuning time plotted against corrective feedback

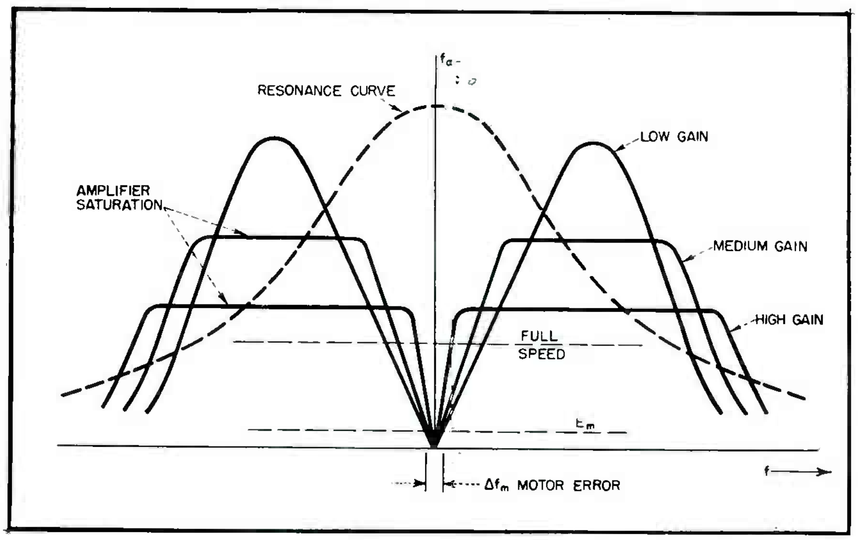
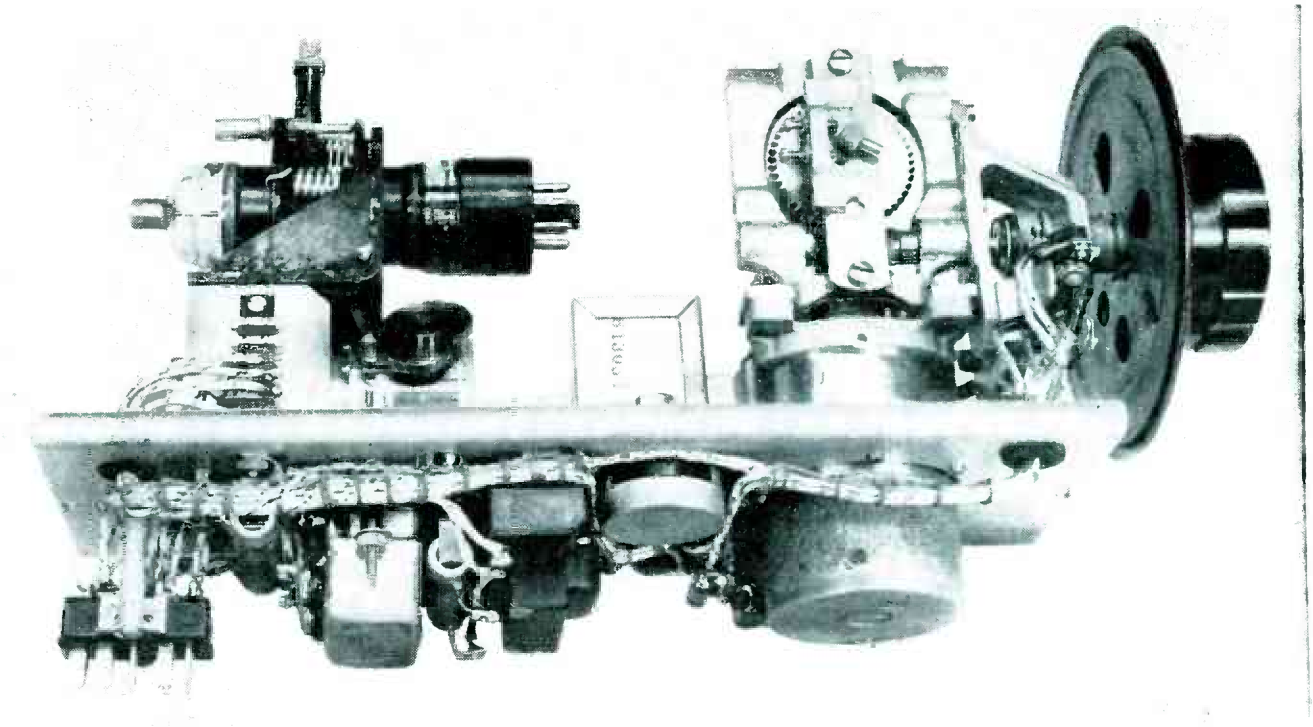


FIG. 6—The hold-in characteristic versus motor-amplifier gain indicates how well motor error can be compensated



Microwave section of signal generator. **Resonator and speaker-unit modulator are shown beneath the gear mechanism at right. Tuning motor with cam is above chassis at left**

$$\Delta f_{mr} = \frac{\Delta f_m}{A_r B_r} = \frac{(df/dE_c)\ (E_m/A_m)}{(df/dE_r)\ (dE_c/df)} \quad (6)$$

$$\Delta f_{mr} = \left(\frac{df}{dE_c}\right)^2 \left(\frac{dE_r}{df}\right) \left(\frac{E_m}{A_m\ A_r\ G_\phi}\right) \quad (7)$$

Several things are gained when the electronic afc system is combined with the motor-operated afc. First, the response of the electronic system is faster than its mechanical counterpart. This feature relieves the motor of trying to respond to transients which it can not handle. Second, the quicker action of the electronic system acts as an antihunt circuit for the motor afc. If the motor inertia carries the corrective tuning past the center frequency, the electronic afc corrects this situation by electronic tuning, thus wiping out or materially reducing (by an amount equal to $-\Delta f/A_r B_r$) the reverse error signal which the motor winding would have otherwise seen. Action such as this removes any tendency to hunt or oscillate about the center frequency, and gives a smoothly damped motor operation. Third, when the combined system is in tune, the output from the phase detector is zero.

This last condition is most important in transmitters whose modulation characteristics are critical as to distortion, and the oscillator must be operated at the center of a mode as dictated by the reflector characteristics. Consider a step-function frequency disturbance. The action of the electronic afc causes it to make its best possible correction as given by Eq. 5. During this time the motor has also begun to operate, to wipe out the error voltage on its winding. As the system approaches the correct mechanical tuning of the klystron, the error voltage is reduced. When the correction is complete, the output of the phase detector goes essentially to zero, thereby putting no additional voltage from electronic afc action onto the already existing reflector potential. In this way, the best modulation characteristics are maintained, even under rather severe afc hold-in conditions.

Motor Circuit Antihunt Control

When the motor-operated afc is considered alone, some means of reducing the tendency to oscillate about the center-frequency must be introduced. One of the most satisfactory methods is to couple an eddy current generator to the motor shaft, and excite one of its fields at the motor frequency. The amplitude of the resulting voltage in its output winding will be proportional to the speed of the motor, and its phase will be either 0 or 180 deg with respect to the exciting voltage, depending upon the direction of rotation. No slip rings are needed so no additional friction forces are incurred.

The eddy-current generator signal is introduced into the motor control circuit in such a way that its phase is in opposition to that of the error signal. When a frequency disturbance occurs, the motor operates to reduce the error as usual, but some signal of opposite phase proportional to the motor speed is supplied by the generator to reduce the apparent error signal. Such a reduction in error voltage slows down the motor, which procedure in turn reduces the injected antihunt voltage.

Should the inertia of the mechanical system carry the correction too far, and cross the center frequency, the error signal will change phase. This condition puts both error and antihunt signals in phase, and the sum of the two act to brake and reverse the direction of rotation. Once this reversal is accomplished they are again out of phase, because the phase of the generator voltage depends upon the direction of shaft rotation only, and the antihunt signal is again tending to slow down the motor. One important

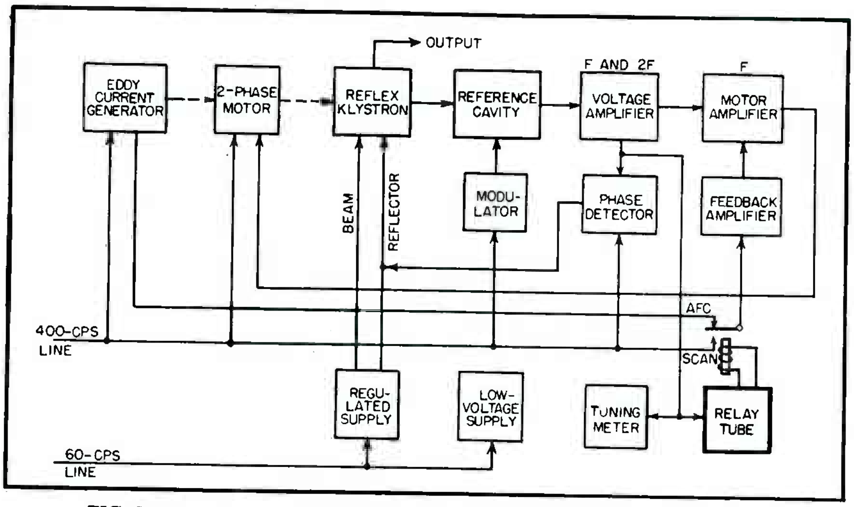


FIG. 7—Block diagram of a motor afc system connected for antihunting

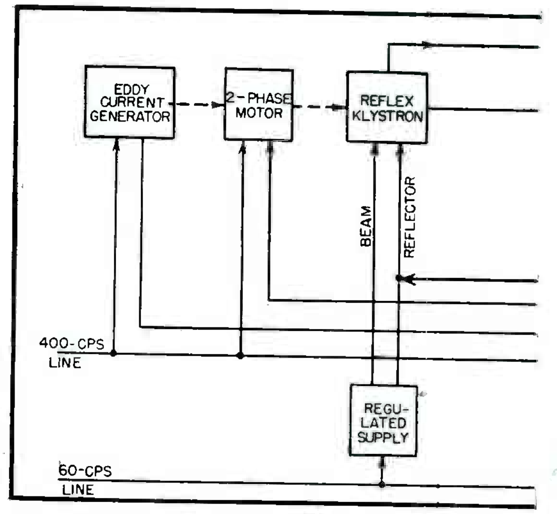


FIG. 8—Block diagram of

point should be noted; the antihunt signal becomes less and less as the motor slows down when approaching the correct tuning, and it is zero when the motor arrives at a dead stop. In this latter condition the system has its greatest sensitivity.

The amplitude of the antihunt signal plays a large part in determining the characteristics of the motor afc system. In Fig. 5 is shown a series of curves for different amounts of speed feedback voltage. It is possible to go from the case of oscillation with no antihunt voltage through a gradual approach to the condition with no overshoot, and beyond to a point using excessive antihunt signal. The proper adjustment is somewhere between the two extremes, depending upon the operating requirements of the individual equipment.

Hold-in Tightness

From Eq. 2 it is apparent that the motor error caused by static friction varies inversely as the gain of the motor amplifier, A_m. Figure 6 illustrates a family of curves which show increasing tightness of afc control (that is, less frequency error) with increasing amplifier gain. The section near the center, before overloading occurs, is most interesting. As the gain increases, the motor-error width decreases accordingly.

The ability of the system to respond to transient disturbances is dependent upon the electronic afc. Assuming that a 400-cps motor is used, and the same sensing frequency is used for both motor and electronic afc, it is apparent that the error information is arriving into the system at only a 400-cps rate. This relatively slow rate of gathering information puts a definite limit upon the transient response of the electronic afc. If at least 20 complete information cycles are needed for reproducing error data of a transient pulse, then the transient response that can be handled by such a system is in the order of 0.1 second, or longer.

The difficulty in filtering out 400 cps from the output of the phase detector to prevent 400-cps frequency modulation of the klystron necessitated a brute-force filter, which would preclude attempting to raise the transient response when using such a low sensing frequency. It is entirely possible to use two sensing frequencies to overcome this trouble, such as 400 cps for motor control and 50 kc to 100 kc for electronic control, with good transient response.

Motor AFC with Antihunt Generator

The simplest form of afc system that has been discussed is one using just motor control, with antihunt signals supplied by an eddy-current generator. A block diagram of this arrangement is shown in Fig. 7. The performance to be expected from this circuit is given by Eq. 2, and the response to transients is relatively poor. However, such an afc is characterized by extreme simplicity, low power drain, compact size, and a wide tuning range.

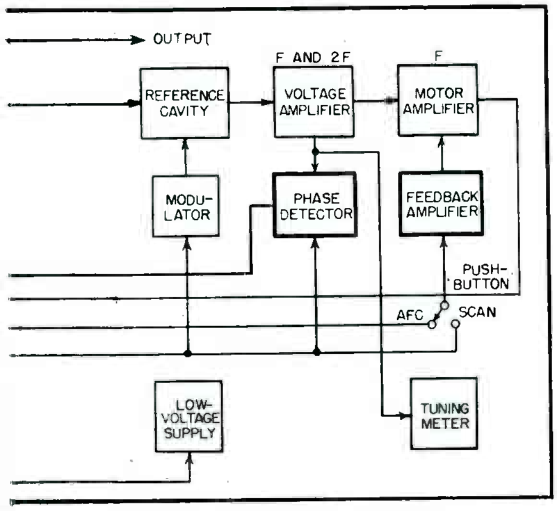
The mechanical details are most important, such as good linkages between the motor shaft and the tuning member, stable frequency-temperature characteristics of the reference resonator, and stable resonator-modulator characteristics. Some means of reducing the second harmonic voltage of the sensing frequency is necessary to prevent overheating the motor winding with a signal that contributes no rotational torque.

A slightly different type of motor-operated afc is possible by coupling the motor to a potentiometer which in turn varies the reflector voltage of the reflex klystron. No mechanical work is done on the klystron, consequently less torque is needed from the motor. The frequency control range of this system is limited, however, to the electrical tuning of the reflector circuit. Unlike the electronic afc, no sensing voltage has to be filtered from the reflector circuit.

Motor-Electronic System

The combination of motor and electronic afc systems gives more flexibility of operation. Figure 8 shows a block diagram of this combination system. Note that the antihunt signals for the motor are now amplified in a separate stage and fed into the signal amplifier at a point beyond where the phase detector signals are picked off. The change in antihunt injection is necessary to prevent the generator voltage from getting into the phase detector circuit.

Several points of caution are necessary to observe if this com-



motor and electronic afc system

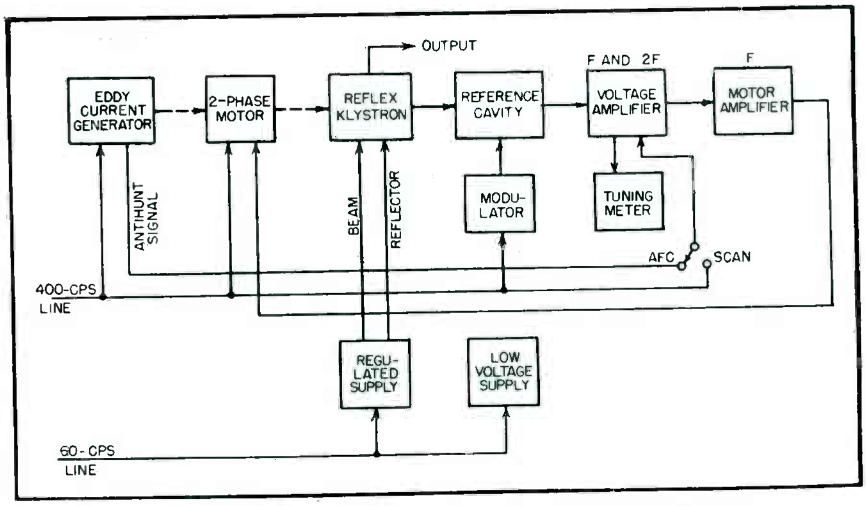


FIG. 9—Block diagram of an afc system with automatic scan

bination afc is to function properly. Referring again to Fig. 8, the phase of the signal at the motor winding should be either 0 or 180 deg with respect to the voltage on its fixed phase winding. The phase of the amplified antihunt signal should be 180 deg with respect to the signal voltage at the point of injection into the motor amplifier chain. Last, the phase of the signal voltage at the secondary winding of the pushpull transformer of the phase detector should be either 0 or 180 deg with respect to the reference voltage in the center leg of the phase detector. Also, the frequency response around the electronic afc loop should drop to unity before the phase shift has reached 180 deg, otherwise the reflector afc will oscillate at the frequency where the 180-deg shift occurs.

Pushbutton Scanning

The two systems described above will pull into frequency if the drifting oscillator signal is within the skirts of the reference resonator response. However, the oscillator may not be within this frequency range, especially with a tunable reference resonator as used in signal generator applications. To make the motor tune the oscillator without error signal from the resonator, a switch or pushbutton arrangement can be used to inject scanning voltage into the motor amplifier and to disconnect the motor antihunt signals during the scanning operation.

The simplest method is to allow the motor to drive always in the same direction during scanning. If the resonator is tunable or channelled, a better method is to connect a set of contacts to the frequency-shifting mechanism which selects the proper phase of the scanning voltage for driving in the correct direction. Such a scheme will be described in more detail in a later section.

Automatic Scanning

Certain applications require that the afc system automatically search and lock onto the signal if it should not be within the pass-band limits of the reference resonator. This type of operation is relatively easy to accomplish with the afc equipment under discussion.

Figure 2 shows the output voltages from the resonator-detector within the resonant characteristics of the cavity. Notice that the second harmonic of the sensing modulation frequency peaks at resonance, while the fundamental goes to zero. It is obvious then that if both the fundamental and second harmonic frequencies are amplified and rectified, a control bias can be developed whenever the carrier lies within the resonator limits. Should the carrier drop out of the pass band of the resonator, no bias will be produced and scanning can be made to commence. An automatic scanning system is shown in block diagram form in Fig. 9.

First, it is important that the d-c bias developed by this rectified sensing signal be sufficiently great at resonance to cut off the control or relay tube with a reasonable margin of safety. Second, if this bias is used to cut off a scanning tube (instead of operate a relay tube) it must be great enough to eliminate completely all trace of scanning voltage in its output circuit; otherwise the afc system will remain slightly off to one side or the other of resonance. During scanning, some means to reduce or eliminate the speed feedback voltage is required. If this reduction is not effected the scanning will be slow and jerky.

A more desirable method than cutting off a vacuum tube is to use the bias voltage to operate a relay tube. The relay, when relaxed, allows the generator feedback voltage to be applied in the normal manner, and when energized it injects scanning voltage into the system instead of antihunt voltage from the generator.

As mentioned earlier, the phase of the scanning voltage can be selected automatically so that the motor will drive in the shortest direction to pick up the signal. A pair of contacts operated by the resonator tuning or channeling mechanism though a clutch will work satisfactorily for this phasing operation.

The special components used in a representative system and their necessary physical properties will be described in the second and concluding part of this article, to appear in a forthcoming issue.

REFERENCE

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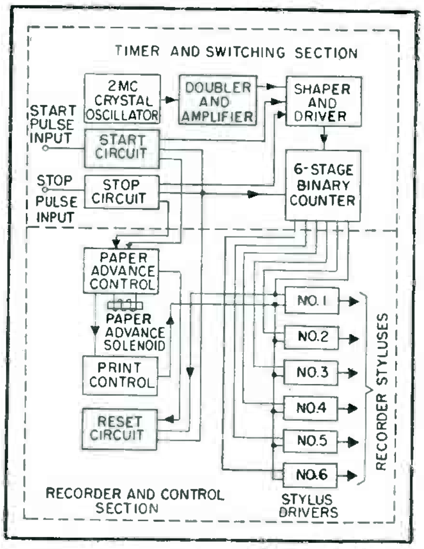
FIG. 1—Start and stop input pulses limit the duration of the high-frequency train of cycles delivered by the shaper and driver to the binary counter. Count attained when the stop pulse occurs is marked on paper by the recorder styluses



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RECORDER and TIMER for Short Intervals

Designed to meet the needs of nucleonic research, this interval timer measures and records intervals up to 16 microseconds with an accuracy of 0.25 microsecond. Intervals to be measured may occur at random and be widely separated

NUMEROUS RESEARCH projects, and the field of nucleonics in particular, require a practical method of measuring very short time intervals that occur at random. Lengths of periodic or recurring intervals can be observed by conventional oscilloscope patterns, but when it is desired to measure the interval between a pair of closely spaced pulses that may appear only a few times in an hour, the technique is difficult. A common method of measurement has been to use a long-persistence cathode-ray trace with rotary sweep and triggered control. For measurements of the order of a few microseconds, the sweep speed must be so great that the trace is dim and hard to photograph or observe.

Gated Counter Technique

A better method has been found by the application of electronic counter techniques. Currently available commercial counters do not have as good resolution as desired for such measurements, and do not record the result and repeat the operation automatically. Consequently, a special development was undertaken that resulted in the design and construction of the Short Interval Timer and Recorder (sometimes called SITAR).

System Operation

The basic element of the interval timer is a binary scaler or counter chain connected through a gating circuit to a 4-mc driving source. Pulses marking off the interval to be measured are applied to a gate or switching circuit which passes a representative block of the high-frequency cycles to the binary chain, where they are counted and registered. The result is then automatically recorded as a dot pattern across a strip of special paper and the machine resets itself in readiness for the next measurement.

The block diagram of Fig. 1 illustrates the various elements of the device with the necessary interconnections. The components are arranged physically in two groups and are mounted accordingly on two chassis units. The upper section contains the 4-mc source, the switching circuit, and the counter chain. The lower section contains the recorder, its control circuits, and the reset circuit which restores the upper section to its standby condition after each measurement.

The 4-mc timing frequency is obtained by doubling the output of a 2-mc crystal oscillator. A shaper and driver stage, under control of start and stop elements, transmit a gated block of 4-mc pulses to the counter. The initiating and terminating pulses of the time interval to be measured are applied to trigger the start and stop circuits, respectively.

The counter or scaling circuit consists of six binary stages of the usual locking-trigger type and has a capacity of 64 counts (2^6). Because the head or highest-speed

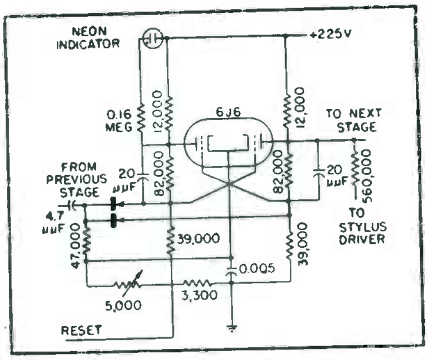


FIG. 2—Binary counter stages use this typical flip-flop circuit

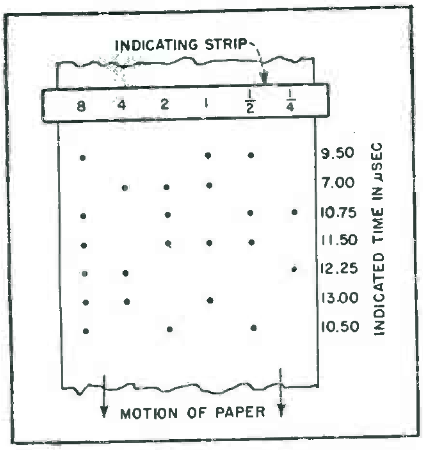
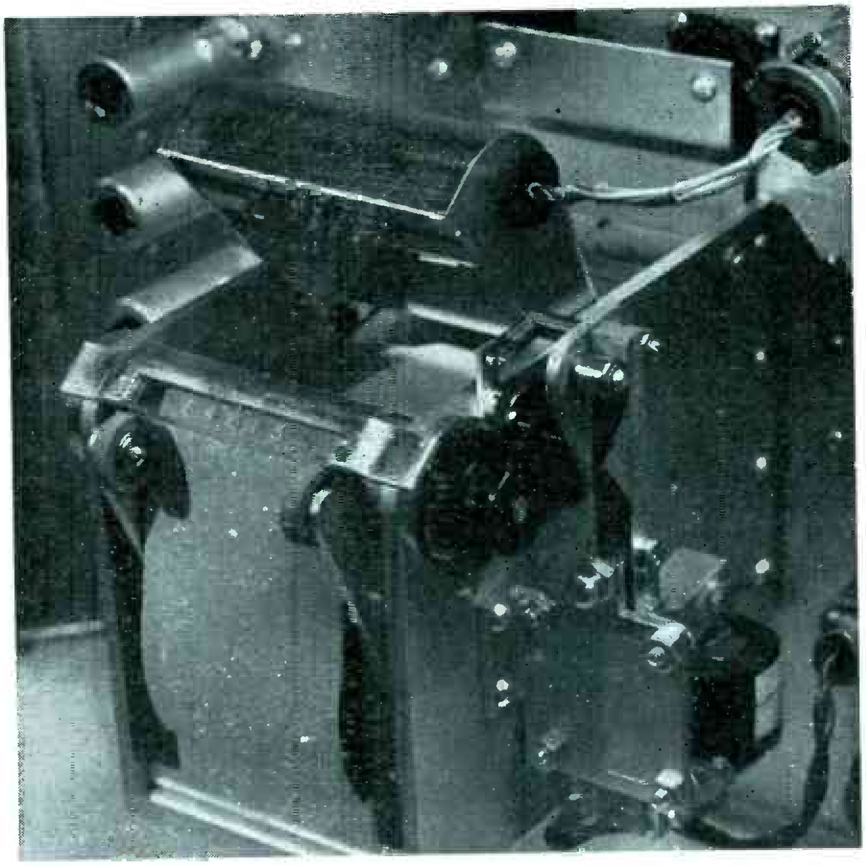


FIG. 3—Interval measurements are shown as rows of dots. Sum of dot values in each row equals interval duration



Six styluses projecting from the raised recorder head electrically mark the count on a 2.25-inch strip of Teledeltos paper. Strip is advanced in one-eighth inch steps by the ratchet wheel and magnet-actuated pawl on right of housing

stage operates at a 4-mc rate, the time capacity of the chain is 16 microseconds and the definition is ±0.25 microsecond. Obviously the capacity could be increased by adding more stages. At the end of any given count, the result is shown by the positions in which the various stages are left after receiving the last input pulse. This information is indicated directly by means of neon lamps and is transmitted to the recorder. A typical binary stage as used in the SITAR is shown in Fig. 2.

Interval Recording

In the recorder and control section the paper advance control is triggered at the end of the count or measurement and the recording paper is moved ahead one space. While the paper is in motion the print control circuit produces a trigger pulse to trip the stylus drivers. The gas-tube stylus drivers respond according to received information from the counter and apply current through the appropriate styluses to print the result as a row of dots on the recording paper.

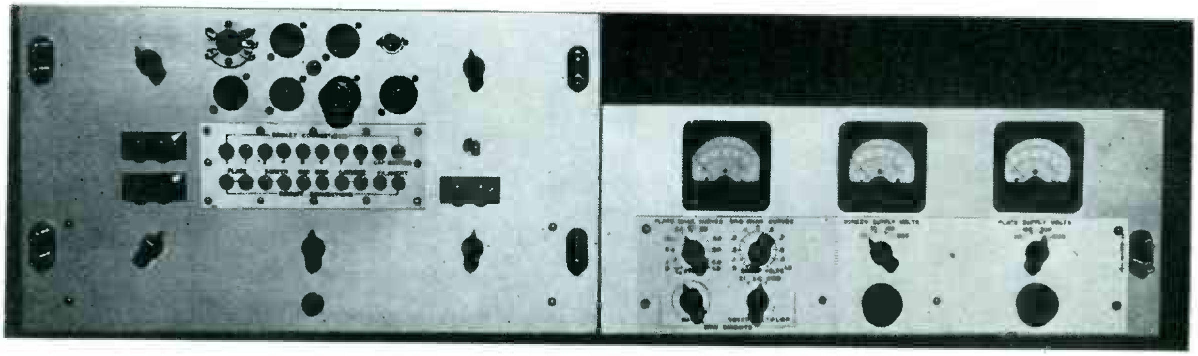
After each recorder operation, the reset circuit is tripped. This circuit supplies suitable reset pulses to the start and stop tubes and the counter chain to restore them to the zero or standby condition. If an applied start pulse is not followed within 16 microseconds by a stop pulse, the equipment automatically resets itself. An interlock connection allows the stop circuit to be tripped only after the start circuit has operated. Thus the interval timer is protected against false operation due to any stray or unwanted pulses that may be applied to it.

Figure 3 illustrates the nature of the record and how it is read.

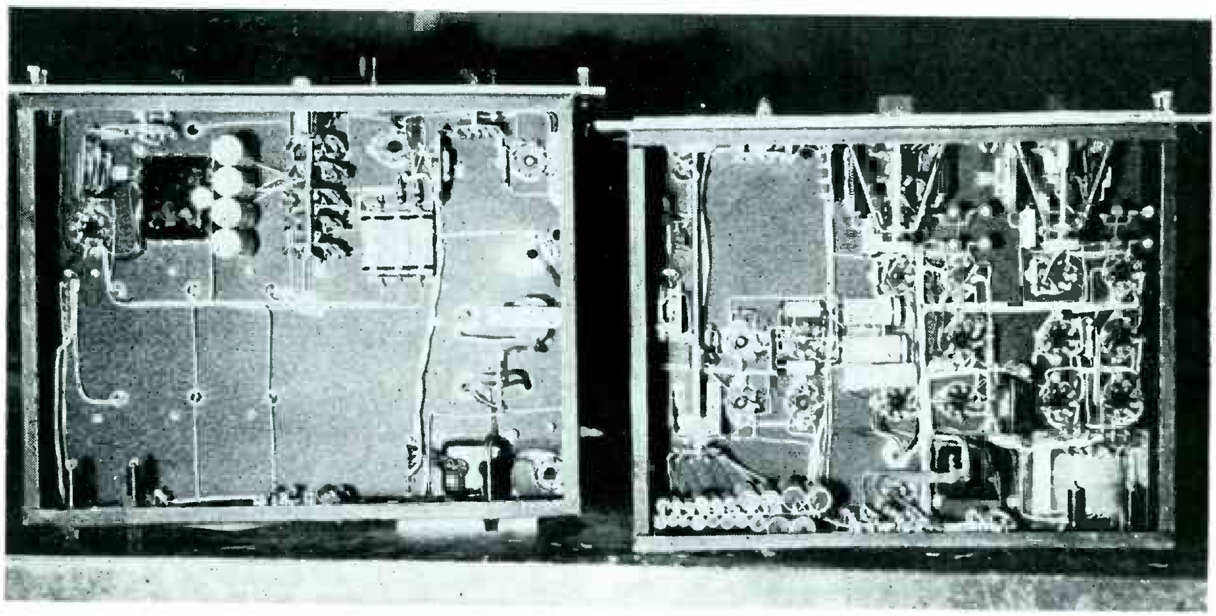
Timing Precision

The interval timer and recorder has possible application in many fields. The device offers a practical means of making time interval measurements in which the interval is very short and does not repeat. Each pair of applied start-stop pulses causes an independent measurement to be made and recorded. Due to the mechanical action of moving the record paper, each measurement requires approximately 0.5 second to complete. The time between measurements may be as long as desired because the circuit will remain in the standby condition indefinitely.

The timer was designed and built to meet a request from the Physics Department of Princeton University. The machine is being successfully used there in current nuclear research. It was originally equipped to have a definition of ±0.5 microsecond but this was improved later to ±0.25 microsecond. Use of techniques and circuits more recently developed would make it entirely possible to construct a machine having a timing frequency as high as 10 mc, giving a definition of ±0.1 microsecond.



Front panels of equipment contain sockets for all types of tubes



Wiring is kept close to chassis to minimize stray fields

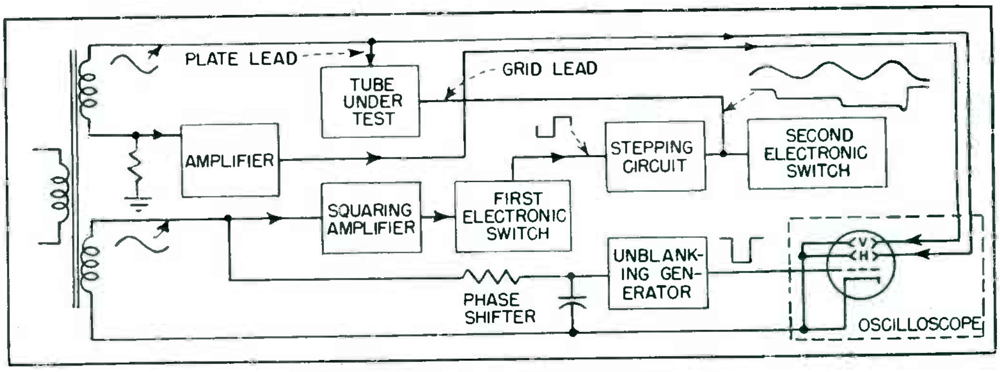
Producing Tube Curves

AN EASY and common method of predicting performance of vacuum tubes is by using plate-current versus plate-voltage characteristic curves, commonly called plate characteristic curves, and plate-current versus grid-voltage or transfer characteristic curves. From these curves it is possible to determine, among other things, plate resistance of the tube, amplification factor, transconductance, power output, and percentage of harmonic distortion introduced.

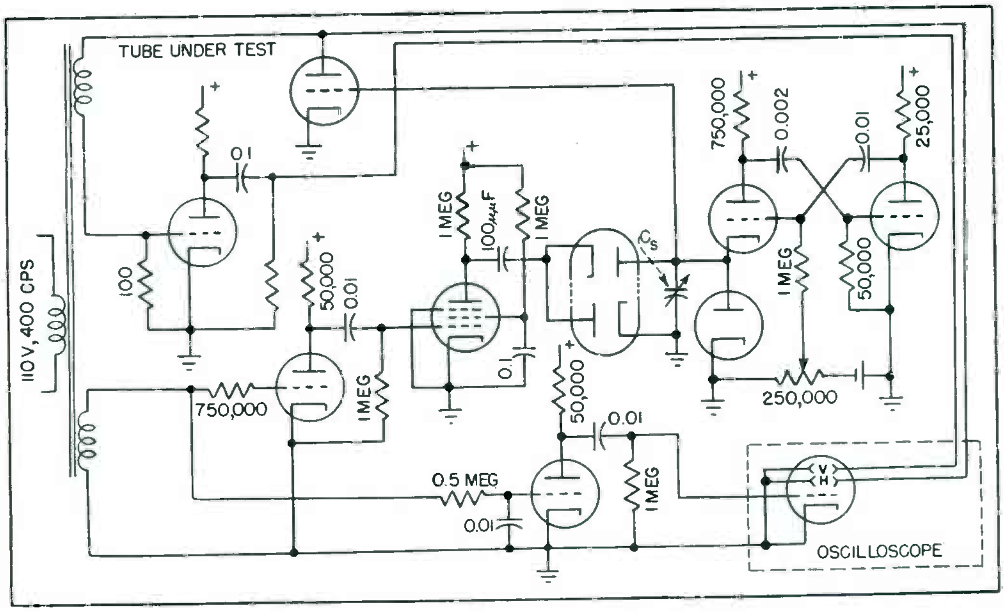
Desirability of More Curves

Useful as they may be, ordinarily available curves are subject to limitations. For instance, plate characteristic curves such as are given in tube manuals and electronic books are usually static curves and, for pentodes, are given only for one particular set of screen and suppressor grid voltages. From the designer's standpoint, a set of characteristic curves for each possible combination of these voltages would be very advantageous. With such a set of curves, it would be easy to select the optimum set of conditions under which to operate the particular tube. In the design of audio amplifiers, for example, it would be a relatively simple problem to select the set of operating conditions under which a given output could be obtained with minimum distortion. In electronic control systems, where the irregular portions of the characteristic curves are utilized, a complete set of these curves would enable the designer to pick the operating conditions under which these irregularities could be used to greatest advantage.

Desirable as it would be, to include in tube manuals such a set of curves is impractical, because of the vast number that would be required. The designer then has two choices. He may be satisfied with one set of static curves from which to make his calculations or he may actually plot, point by point, a set of curves for each given set of conditions. Such a process is long and laborious and unless an excessive number of readings are taken, small irregularities, such as appear on 6L6



Block diagram relates elements of system



Circuit shows principal components of each stage

on an Oscilloscope

Stepping circuit switches grid voltage after each characteristic curve is traced on cathode-ray oscilloscope. In this way a complete family of curves is automatically produced. Equipment makes possible rapid and detailed studies of all factors affecting tube operation

characteristic curves, are not likely to show.

Automatic Curve Plotter

Instead of manually plotting such curves, the circuit given here offers a method of showing these characteristic curves on the screen of a cathode-ray tube.[1] By the use of a few calibrated controls, it is possible to produce practically any combination of operating conditions and to observe the shape of the curves under these conditions, as

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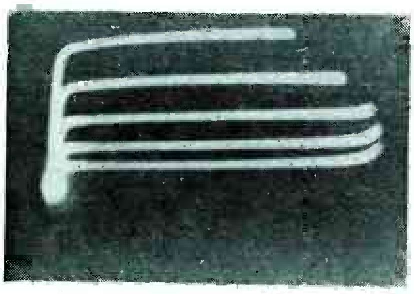
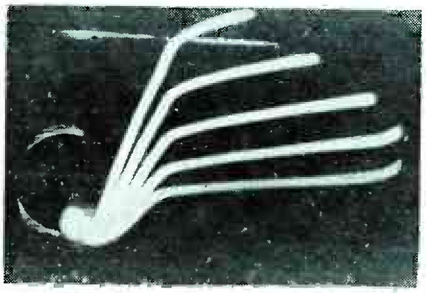
demonstrated by the accompanying traces obtained with this equipment. These curves offer a visual indication of the changes in such things as amplification and linearity with changes in operating conditions. Additional flexibility is provided by controls on the front panel which vary the magnitude of the grid bias steps as well as the number of steps. Consequently, any number of curves with any desired spacing may be shown on the screen of the cathode-ray tube.

In addition to the plate characteristic curves, this circuit (by changing connections to the tube under test) is capable of producing a dynamic transfer characteristic curve (grid-voltage versus plate-current curve) on the screen of the cathode-ray tube. As with the plate



Family of plate curves for 6SK7



Type 6SK7 connected as tetrode

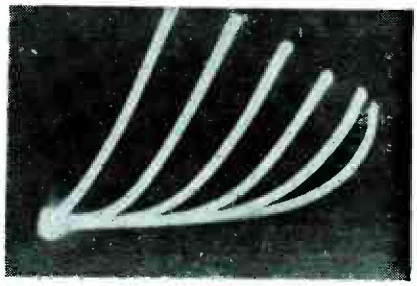


Plate characteristics of 6J5

characteristic curves, the operating conditions under which this transfer characteristic curve is produced may be varied, giving a visual indication of the corresponding changes in the shape of the curve. Because this is a dynamic curve, nonlinearity of the curve itself indicates the amount of distortion that will be produced by the tube when operated under the given conditions. This fact is utilized a great deal in the design of audio amplifiers even though the usual manner of obtaining such a curve is to plot it with values obtained from the tube's plate characteristic curves. The technique has also been used to measure tube characteristics under extreme conditions.[3]

The equipment is so constructed that any type of tube can be tested. Meters are built in to indicate the various element voltages. A switch located in the middle of the larger panel has five positions and enables the operator to show curves of (1) plate current versus plate voltage, (2) screen current versus plate voltage, (3) plate current versus control grid voltage, (4) screen current versus control grid voltage, and (5) output waveform of the tube with an external signal applied to the grid.

Circuit Operation

The block diagram shows the complete circuit. A 110-volt 400-cps sinewave (readily available from surplus aircraft dynamotors) is fed into the primary of the transformer, producing sinewave voltages across both secondary windings. The high frequency is used to avoid flicker on the cathode-ray tube, which would be noticeable at 60 cps. The 300-volt rms voltage across the upper winding is applied to the tube under test and also provides the horizontal sweep for the cathode-ray tube. Because the plate current of the tube under test flows through the small grounded resistor connected to the upper winding, the voltage across this resistor, when amplified and applied to the vertical plates of the cathode-ray oscilloscope, produces a vertical deflection proportional to the plate current in the tube under test and in synchronism with the corresponding plate voltage independently of waveshape. Thus the curve traced on the screen of the oscilloscope will be a graph of plate current versus plate voltage or a plate characteristic curve.

The output voltage of the lower transformer secondary winding is first fed into a squaring (overdriven) amplifier. (Coming from the common source, this voltage is in synchronism with that applied to the tube under test.) This amplifier changes the sinewave input into a squarewave and changes the phase by 180 degrees. The resultant squarewave is fed into the first electronic switch, which in turn applies voltage on alternate half-cycles to the stepping circuit, the switch being closed during positive half-cycles of its squarewave input and open during negative half-cycles.

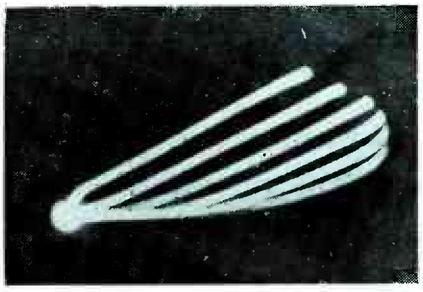
The stepping circuit is so arranged that each time voltage is applied, its output voltage will increase by a predetermined amount. Because the first electronic switch applies voltage to the stepping circuit only on alternate half-cycles, the output voltage will correspondingly increase only on alternate half-cycles. Consequently the voltage on the grid of the tube under test, which is controlled by the stepping circuit, changes only during the time that its plate voltage is negative and consequently when it is not conducting. The grid voltage remains constant during the positive half-cycle of the applied sinewave (the time during which the plate characteristic curve is traced on the screen), but has a larger negative value for each successive positive half-cycle of plate voltage. Thus each successive characteristic curve traced on the screen of the cathode-ray oscilloscope will be for a larger value of grid bias, and a complete family of curves is traced.

This process continues until the maximum desired value of grid bias is reached. At this time, the second electronic switch operates long enough to reduce the stepping circuit output voltage to zero. The stepping process is then repeated.

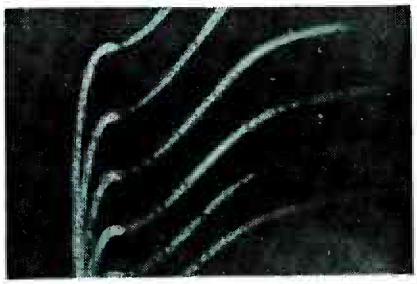
The output of the lower secondary is also fed into a 90-degree phase-shifter ($10X_c \leq R$) and its output in turn is applied to the unblanking pulse generator (squaring amplifier). Its squarewave output, applied to the control grid of the cathode-ray tube, is used to increase the beam intensity during the time that the plate voltage of the tube under test is increasing and thus during the first quarter-cycle of the applied sinewave, or for the time that each plate characteristic curve is being traced on the screen of the oscilloscope.

Stepping Circuit

The second electronic switch, which discharges the grid voltage stepping circuit, is designed so that it remains open until the voltage



Type 6J7 with cathode degeneration



Nonlinear portion of 6L6 curves

across it builds up to a predetermined value, at which time it closes and remains closed until the voltage across it decreases nearly to zero. As shown in the circuit diagram, in which all elements are in their same relative positions as in the block diagram, this second electronic switch can be a one-shot multivibrator with the lefthand tube normally beyond cutoff. The first electronic switch is a gated pentode, while the stepping circuit proper is a variable capacitor having one value of 0.01 microfarad.

During the positive half-cycle of the applied sinewave, the first electronic switch is open (pentode cut off) and the capacitor in its output is charged through one half of the duodiode to approximately the d-c power supply voltage. The R-C time constant of this circuit should be a small fraction (1/20) of the period of the base frequency to permit full charging in the half-cycle. During the negative half-cycle of the input sinewave (squared before being applied to the switch) this switch is closed and its output capacitor discharges through the other half of the duodiode, thereby charging the grid voltage stepping capacitor and making the grid of the tube under test become more negative with respect to ground. The voltage step produced across the stepping circuit depends on the ratio of its capacitor to that in the output of the first switch and the plate d-c supply voltage ($N \approx CE_{BB}/C_S$, where N is the voltage of each step). The second electronic switch is open during this operation.

The charging of the stepping circuit capacitor continues every alternate half-cycle, maintaining the phase relation to the input sinewave shown in the block diagram. When the voltage across the stepping circuit reaches a sufficiently high value, determined by the potentiometer in the multivibrator circuit, the lefthand triode of the multivibrator conducts and the stepping circuit discharges through the diode in its cathode circuit. Thus this diode is the second electronic switch and the multivibrator is the switch control. After the stepping circuit is substantially discharged, the multivibrator returns to normal.

Versatility of Application

The circuit can be built into a compact unit and arranged so that any ordinary type of tube can be tested. A calibrated switch can be provided for changing the magnitude of grid voltage steps and a potentiometer for varying the number of steps. A small resistor with a shorting switch, placed in the cathode circuit of the tube under test, enables the operator to show the effect of cathode degeneration on the tube characteristic. Similarly, a switch in series with the screen by-pass capacitor will permit showing the effect of screen degeneration. Another potentiometer may be provided to vary the screen grid voltage of tetrode and pentode tubes.

Some interesting observations may be made if a potentiometer is connected between the screen grid and ground with the suppressor grid connected to the movable arm. As the potential on the suppressor grid is varied from a positive value to zero, the characteristic curves change from those of a tetrode to those of a pentode. This effect is shown in the accompanying pictures. There are many possibilities for additional potentiometers and switches which will make the circuit even more flexible.

One of the main applications of this circuit, its use in the design of electronic circuits, has already been pointed out. This application offers the designer a method of easily trying all possible circuit combinations in order to ascertain the best combination for a particular case. It also affords him a method for noting the effects on the characteristic curves of such things as feedback and degeneration.

In addition, an opportunity is provided for making a more detailed study of any portion of the curves by merely increasing the gain of the amplifier in the cathode-ray oscilloscope. Such an enlarged picture would be useful, for instance, in the design of low-level audio amplifiers. These amplifiers are usually operated with such low plate voltages that the portion of the characteristic curves actually required for design purposes is either not given or is too small to be of any practical value.

This circuit can also be used to obtain a full set of characteristic curves and thus check the comparative performance of new tubes during manufacture. These curves can be photographed and used for further study. If small irregularities appear on the curves, that portion of the curves on which they appear can be enlarged on the screen of the cathode-ray tube, making it easier to determine their exact nature.

Another application of this circuit is its use as a lecture-room or laboratory demonstration apparatus. It provides a positive means of demonstrating what happens to a tube's characteristic curves, and consequently to its operating characteristics, when element voltages are varied, when degeneration is used, and when various circuit parameters are changed.

REFERENCES

(1) Jacob Millman and Sidney Moskowitz, Tracing Tube Characteristics on a Cathode-Ray Oscilloscope, ELECTRONICS, p 36, March 1941.

(2) E. C. Easton and E. L. Chaffee, Pulse-Type Tester for High-Power Tubes, ELECTRONICS, p 97, Feb. 1947.

VOLTMETER

Simple nomograph gives true voltage in high-impedance circuit when measurements are made with two different voltage ranges of an ordinary low-sensitivity voltmeter. Underlying equations for voltmeter error are given, with examples of use

MEASURING voltages across high-impedance circuits with voltmeters of sensitivities in the order of 1,000 ohms per volt will give readings that are appreciably less than the true voltages.

The higher the input resistance of a voltmeter, the lower will be the required deflection current and hence the smaller the error. With voltmeters of 20,000 ohms per volt sensitivity or greater, the error is usually negligible.

There are many voltmeters in use of the 1,000 and 5,000 ohms per volt class, and frequently these are the only instruments available when it is desired to know the actual voltage across a circuit.

The purpose of this paper is to provide an equation (suitable for slide rule calculations) and a nomograph (which only requires a straightedge) that will quickly yield the true voltage in a circuit after two measurements are taken with a voltmeter of low sensitivity. The only requirement of the voltmeter employed is that the internal resistance of the meter be directly proportional to the voltage range selected. All of the common type of current-operated voltmeters come under this classification.

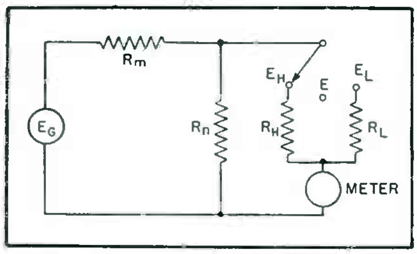


FIG. 1—Circuit of two-range voltmeter used as example

The circuit shown in Fig. 1 represents a voltmeter with two ranges connected to a simple network. In practice, circuits are usually more complex than this, but they can be reduced to an equivalent circuit similar to that in Fig. 1.

Let E = true voltage across R_n with voltmeter disconnected
E_H = voltage measured across R_n on highest meter range that will give an accurate reading
E_L = voltage measured across R_n on next lower range
E_G = source of constant voltage
R_H = internal resistance of voltmeter when measuring E_H
R_L = internal resistance of voltmeter when measuring E_L
S = ratio of two scales used; $S = R_H/R_L$
R_n = resistance across which output voltage is developed
R_m = series dropping resistance that accounts for difference in E_L, E_H, and E.

Derivation of Equation

Simple circuit theory allows us to write

$$E = E_G \frac{R_n}{R_n + R_m}$$

$$E_H = E_G \frac{R_H R_n}{R_H R_m + R_H R_n + R_m R_n}$$

$$E_H = E \frac{R_m + R_n}{R_m + R_n + (R_m R_n / R_H)} \quad (1)$$

$$E_L = E \frac{R_m + R_n}{R_m + R_n + (R_m R_n / R_L)} \quad (2)$$

Substituting SR_L for R_H in Eq. 1 and solving for E in both equations, we have

$$E = E_H \frac{R_m + R_n + (R_m R_n / S R_L)}{R_m + R_n} \quad (3)$$

$$E = E_L \frac{R_m + R_n + (R_m R_n / R_L)}{R_m + R_n} \quad (4)$$

Rearranging Eq. 3 and 4

$$(R_m + R_n)(E - E_H) = E_H \frac{R_m R_n}{S R_L} \quad (5)$$

$$(R_m + R_n)(E - E_L) = E_L \frac{R_m R_n}{R_L} \quad (6)$$

Dividing Eq. 5 by Eq. 6

$$SE_L (E - E_H) = E_H (E - E_L)$$

$$E = \frac{(S-1) E_H}{S - (E_H/E_L)}$$

This equation is particularly suited to slide rule calculations.

Example 1: A voltmeter, when placed across two terminals, reads 105 volts on its 200-volt range. The meter is switched to the 100-volt range and reads 70 volts. Divide 105 by 70 and subtract the quotient from the scale ratio of 2.0. This gives us 0.5 for the denominator. It should be noted at this time that when the scale ratio is 2.0, the term $(S - 1)$ in the numerator equals 1.0. Now divide 105 volts by 0.5 and the result is the true voltage of 210 volts.

Example 2: A voltmeter reads 50 volts on its 150-volt range. On the 60-volt scale it reads 40 volts. $E_H/E_L = 50/40 = 1.25$. Subtract this from the scale ratio of 2.5 and the denominator equals 1.25. Divide this into E_H (50 volts) and multiply the quotient by $(2.5 - 1)$ or 1.5. The true voltage is 60 volts.

Use of Nomograph

Although this equation is not difficult to use when one has become familiar with it, still it is less trouble and quicker to lay a straightedge on a nomograph and read the unknown value directly.

The nomograph presented in this paper is divided diagonally into two parts. Each half is used in the same way. The graph was divided to facilitate reading the four scales for S = 5, 2, 4, and 2.5. These values of S were chosen after 26 volt-ohm-milliammeters of 10 manufacturers were examined for their most

LOADING

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popular switching ratios of both d-c and a-c ranges. The favorites are 5 and 2, with 4 and 2.5 used least. The ratio of 10 was used so seldom that it was not included in this nomograph.

As in the case of the equation, the best way to explain the use of the nomograph is with example problems. To compare the results of the equation with that of the nomograph, use the same problems as before.

Example 1: $E_H = 105$ volts and $E_L = 70$ volts. Place a straightedge between these values on the E_H and E_L scales for $S = 2.0$ and let it extend to the E scale. The straightedge will pass through 210 volts on the E scale, which is the true voltage. Note: This lower right half of the nomograph is also used when $S = 5$. Since values here are beyond range of nomograph, values on all three scales were multiplied by 10.

Example 2: $E_H = 50$ volts and $E_L = 40$ volts. This solution requires the use of the upper left half of the nomograph since $S = 2.5$. Using the scales for $S = 2.5$, with all scale values multiplied by 10, the true voltage is found to be 60 volts on the E scale.

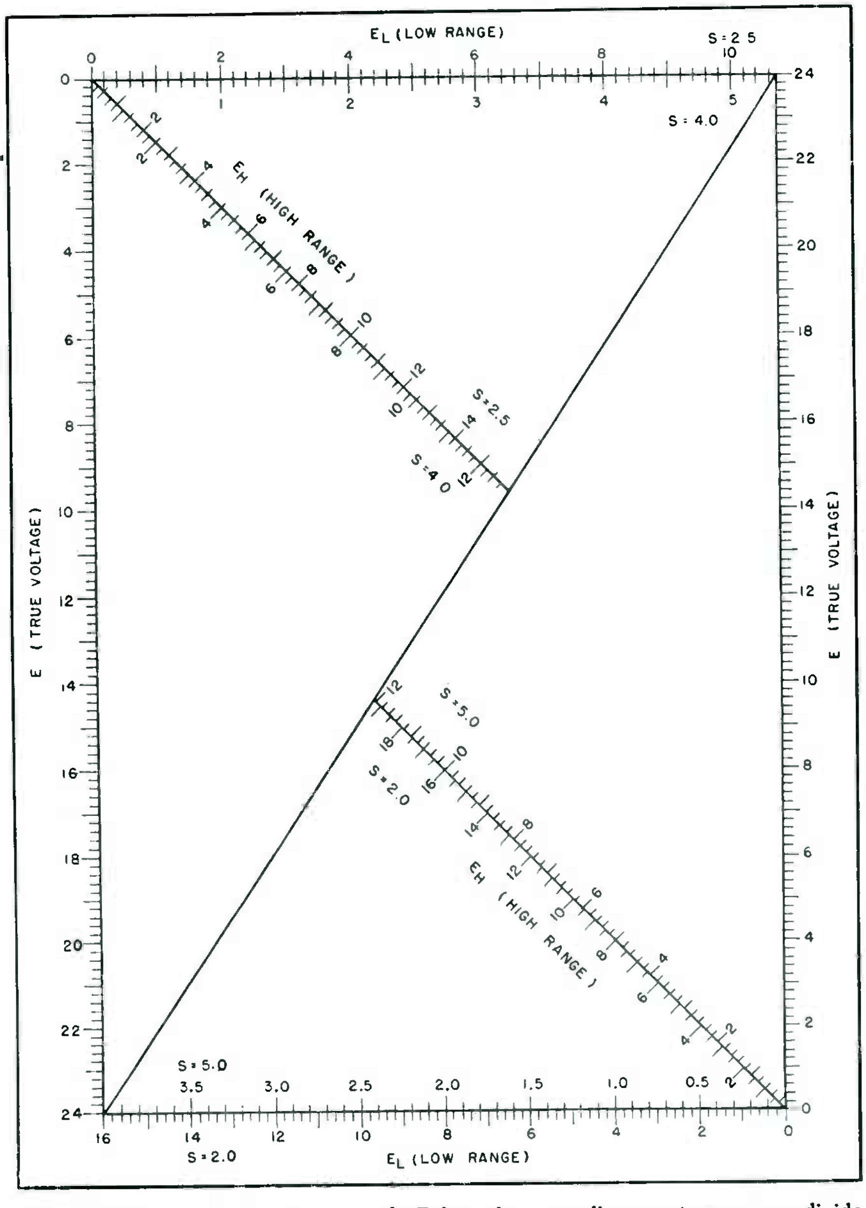
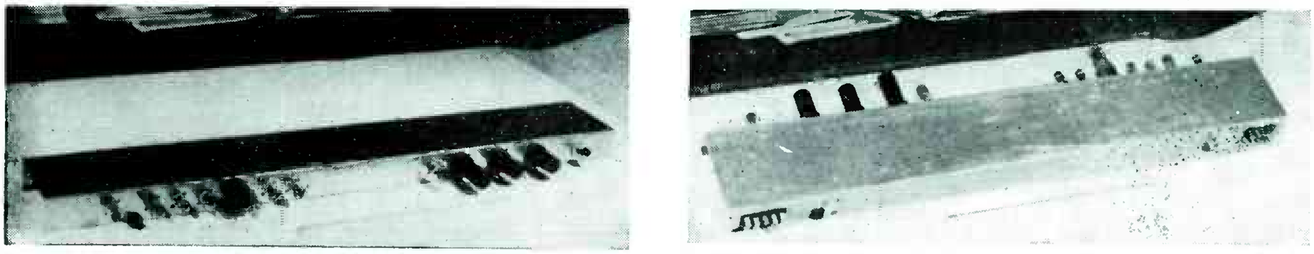


FIG. 2—Voltmeter loading nomograph. Take voltage readings on two ranges, divide higher range scale by lower to get S (either 2, 2.5, 4, or 5 on standard volt-ohm-milliammeters), then place straightedge on measured values (E_L and E_H) for S scale in question and read true voltage on adjoining E scale. If range of any scale is inadequate, multiply all scale values by 10, 100, or any other convenient factor

The equation and nomograph will yield the true voltage only when the measurements are taken across linear circuits. Should lowering the voltage, due to voltmeter loading, change the network resistance, the nomograph can not be used.

The question arises as to how well the nomograph will apply to vacuum-tube circuits. Placing a current-operated voltmeter between a tube element and ground will lower the voltage on that element. Experiment shows that when the tube is operated with fixed bias the element resistance changes considerably with changes in element potential and the nomograph should not be used.

When cathode bias is employed, the reduction in voltage is accompanied by a proportional reduction in current. Thus the resistance of the tube remains substantially constant within the normal limits of operating voltage for the tube. In this instance the nomograph may be used, but with reserve. The resulting error is usually less than 5 percent but higher errors have been encountered. However, the error before using the nomograph was in some cases as high as 60 percent.



Amplifier and gate for memory is compactly constructed on channel that plugs into computer for quick servicing

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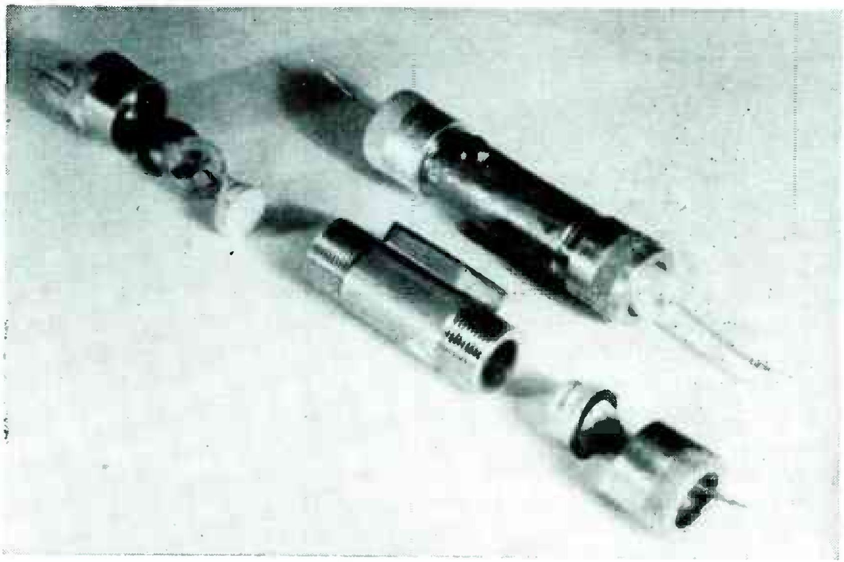


This 2-inch long mercury line introduces about 40 microseconds delay

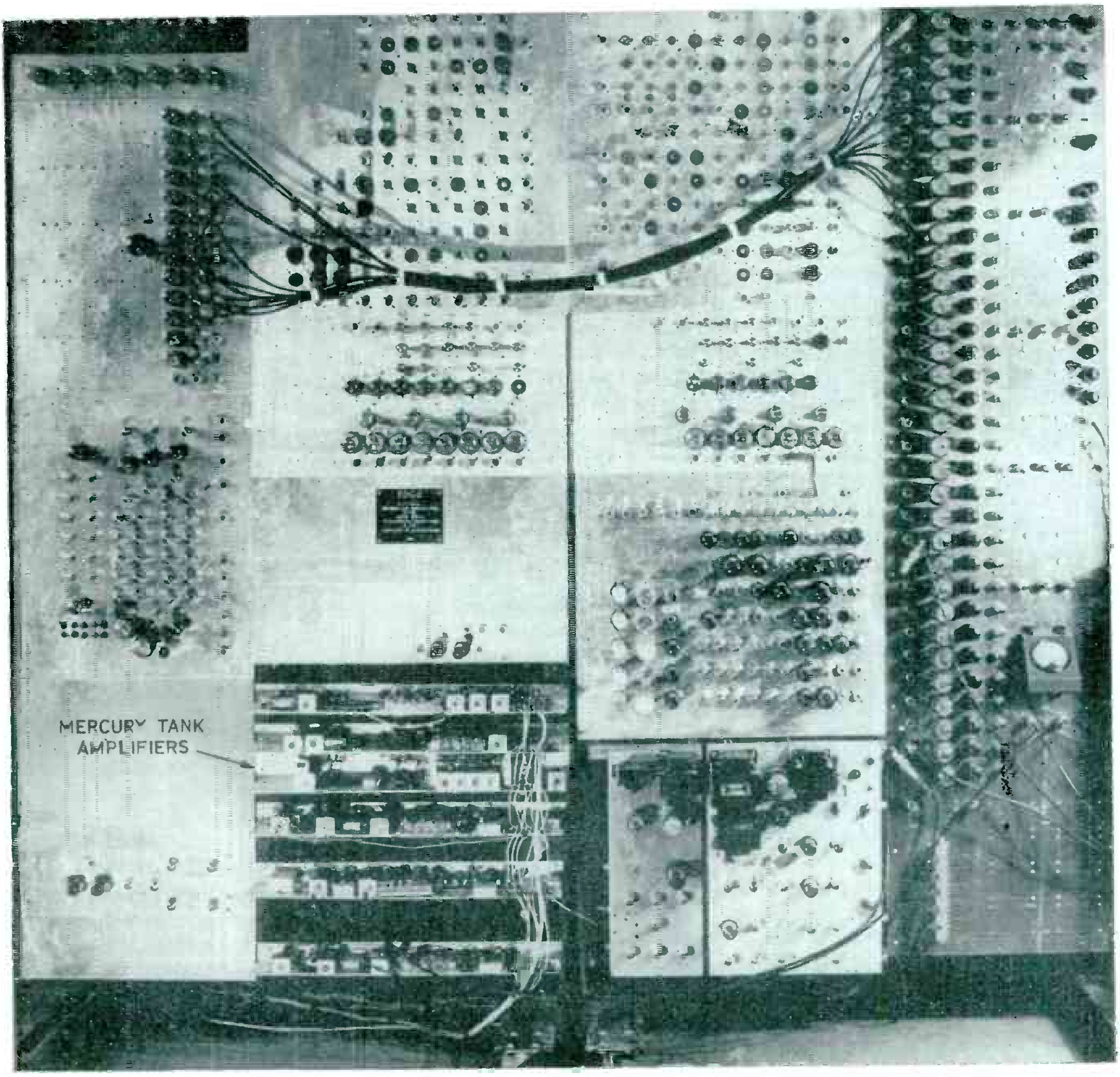
Design of MERCURY DELAY LINES

Mercury is used to obtain millisecond delays for radar, computers, and memory devices because it transmits compression waves relatively slowly, introduces negligible loss, and has an impedance comparable to that of crystal transducers. Recirculation and temperature compensation techniques are presented

STORING information and timing events are two applications of electronics that have recently become important. Electronic timers for providing oscilloscope and radar indicator sweeps, and image storage tubes that retain patterns for protracted periods are familiar devices that perform these functions. The mercury delay line is a basic component that also performs these and many related useful functions.

The line consists of a column of mercury in a container. At one end of the column is a quartz crystal that is connected to the electrical circuit of which the line is a part. Electrical pulses from the circuit vibrate the crystal sending ultrasonic wave trains down the mercury column. The wave trains are reflected at the far end of the line and return to the crystal where they are converted into electrical pulses and re-enter the circuit. A second crystal can be used at the far end of the line instead of the reflector, or multiple reflections can be used. The mercury delay line can be used in any circuit requiring delays of hundreds of microseconds with rise times in the order of 0.05 to 0.1 microseconds.

Before analysing the time delay action of the mercury line, it is well to review a few special examples of its applications. Timing of sweeps is one of the first uses to which the mercury line was put. When a repeating time base, such as that used for range measurement in ra-



Mercury delay lines are installed in heavy thermal-conducting holders behind this pilot model of the 3,000-tube EDVAC automatic computer. The final model will use mercury lines in glass tubing about 2-ft long, providing 384 microseconds delay

dar, is required, it can be generated by triggering a sweep oscillator and simultaneously applying the triggering pulse to a mercury line. The pulse traverses the line in a certain fixed time and reappears to retrigger the sweep generator, and is again applied to the mercury line. Because the mercury line always delays the triggering pulse for the same interval, the sweep repeats itself with extreme regularity. The delay is proportional to the length of the mercury line[1].

Mercury lines are also used for storage. A pulse fed into the line or storage tank remains in it for a predetermined period, dependent on the length of the mercury column.

Inasmuch as this storage function is similar to the mental process of remembering, it is referred to, especially in connection with automatic computers, as memory. In these computers the result of one manipulation, forming a portion of an extensive computation, is required in a subsequent manipulation. In such cases, the signal that is to be re-used, usually a binary pulse sequence, is fed to the mercury memory tank. The line is made of a length that will store or delay the required amount of signal until the time when it will be re-used in the computation[2].

Data Storage in Digital Computers

Experience with large scale computing machines indicates that the most important problem to be solved in their design is that of providing high speed information storage. Moreover, if a suitable low cost memory can be developed, all information, both numerical data and routine intruction may be stored in the same medium and, indeed, in the same organ. If such a memory were provided, the question of how much problem and routine storage must be provided reduces to the question of how much total storage is required. In addition, a single organ for all storage opens the possibility for the machine to perform logical and arithmetical operations on its own instruction, thus greatly increasing its generality. The mercury line provides such storage at a cost of approximately ten cents per binary digit.

Storing Pulse Chains

The system of storage used with delay lines depends upon timed distribution of the electrical impulses that represent the information, called time division in communication circles. The coding of the pulses in this application is of no consequence except that it is assumed that the presence or absence of the pulse are the only indications possible in each time position. Figure 1A shows a typical "word" of five pulses; T represents the pulse spacing in time, and p the pulse width.

With information in the form of pulse chains, a possible method for storing or remembering the data is to insert the timed series of pulses into a suitable delay medium that requires a duration W for one pulse to traverse its length. Thus there is trapped in the delay at any time W/T pulses. If the output of the delay line is fed back to the input, through suitable amplifiers and pulse shaping circuits, as shown in Fig. 1B, the data is trapped and circulating, ready to be called out when needed.

The primary design limitation of the delay storage line is its high-frequency response or rise time of the circuits. For, clearly, the higher the repetition rate of the pulses, in other words the smaller is T, the more information can be stored in a given delay W. The next factor in importance is the amount of loss in the delay medium itself, for loss limits the length W that can be employed. Along with this factor, consideration must be given to overall physical size. Thirdly, the delay must be fairly constant with such factors as temperature, pressure, and humidity. Fourthly, it must be possible to properly terminate the delay line to prevent reflections from bouncing back and forth. Finally, it should be possible to build the device relatively easily and cheaply and yet have a rugged, reliable piece of equipment. The mecury line satisfactorily meets all of these requirements.

Ultrasonic Delay Lines

Mercury is used as the transmission medium for several reasons. Being a liquid it has a relatively low acoustic velocity and also will transmit only one mode of vibration, namely compressional waves. Moreover, the acoustic impedance of mercury is high, of the same order of magnitude as that of quartz and other crystals suitable for use as electromechanical transducers at high frequencies, so that adequate coupling can be obtained. Mercury also has low attentuation per unit length up to frequencies in the order of ten megacycles.

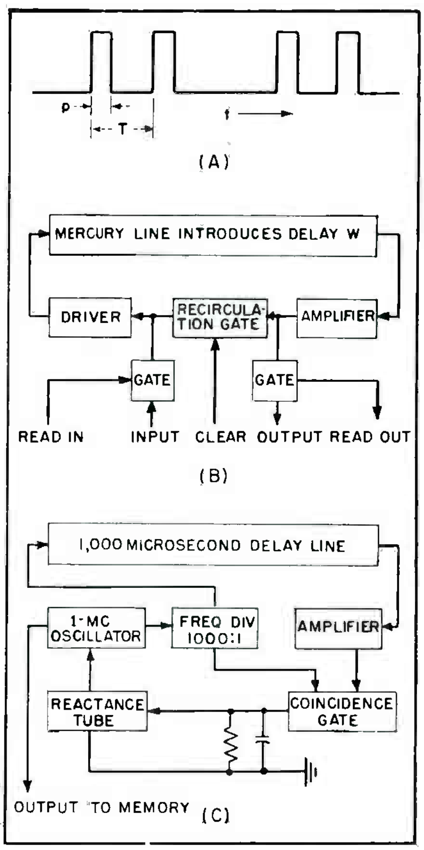


FIG. 1—For use with delay lines, information is in the form of pulse chains (A). These chains can be recirculated (B) through gates and the line so as to be stored as long as necessary. To compensate for temperature effects on the mercury lines, a timing oscillator (C) can be frequency controlled by an auxiliary line, the output being used to time pulses to the bank of mercury memories

Compressional acoustic velocity in any medium is $V=(E/\rho)^{\frac{1}{2}}$ where E is Young's modulus and ρ is density. For mercury at 20 C, the velocity of the wave is 57,100 in. per sec, corresponding to a time delay of 17.52 microsec per in. Acoustic impedance of any medium is $Z=\rho V$, giving, for mercury at 20 C, 19,700 acoustic ohms per square cm. The attenuation of a rectangular pulse of 0.25 to 0.5 microsec duration applied at the driving crystal is 1.9 db per ft. measured at 20 C. The attenuation for sinewaves, including wall effects of 0.5 in. inside diameter tubing, is $0.012f^2$ db per ft. where f is measured in megacycles. The temperature coefficient of time delay is 0.0003 microsec per microsec per deg C.

A delay line designed from these parameters and suitable for storing 40 pulses spaced one microsecond apart was built in a 2-in. piece of stainless steel tubing 0.5-in. inside diameter. Knurled caps at each end hold the end cell assemblies in place. These end cells consist of 7.5-mc X-cut circular quartz crystals each soldered to ceramic end pieces to which the leads are soldered. The rise time on the line is limited by the time thickness of the crystal driver and is about 1/30 microsec.

There are two principal sources of loss: a voltage loss of 400 resulting from the limitations of the piezoelectric effect, and a transmission loss in the mercury, which is negligible for this short line. Because a gain of slightly over 400 is fairly easily achieved even at these frequencies by means of electron tube amplifiers, the losses are not very important.

Although the delay through mercury depends on temperature, variations from that factor are very

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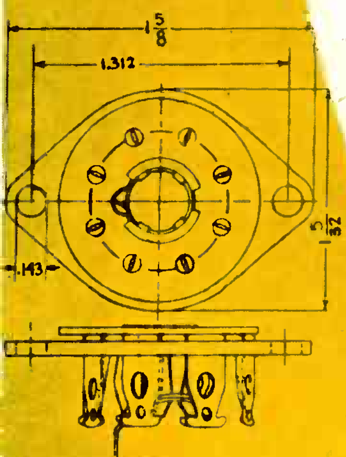

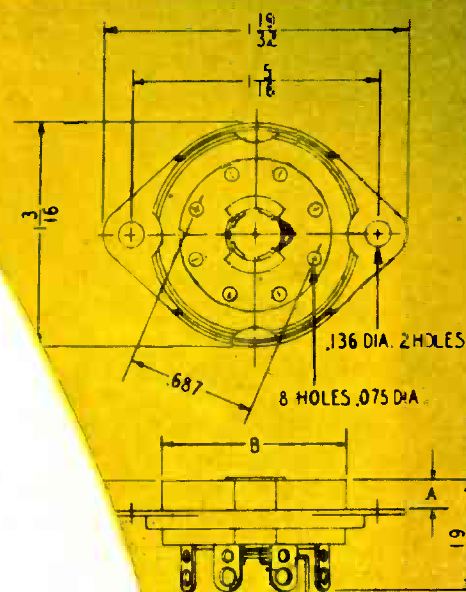

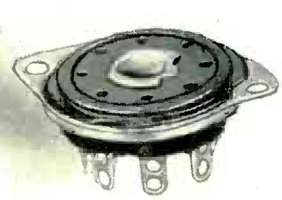

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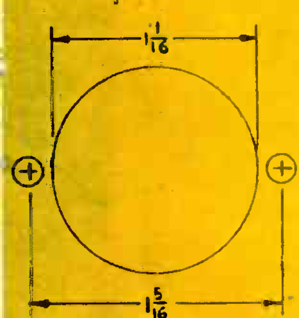

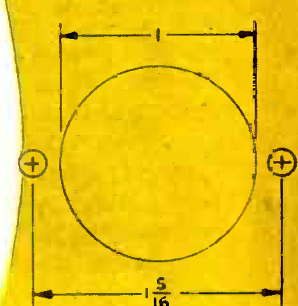

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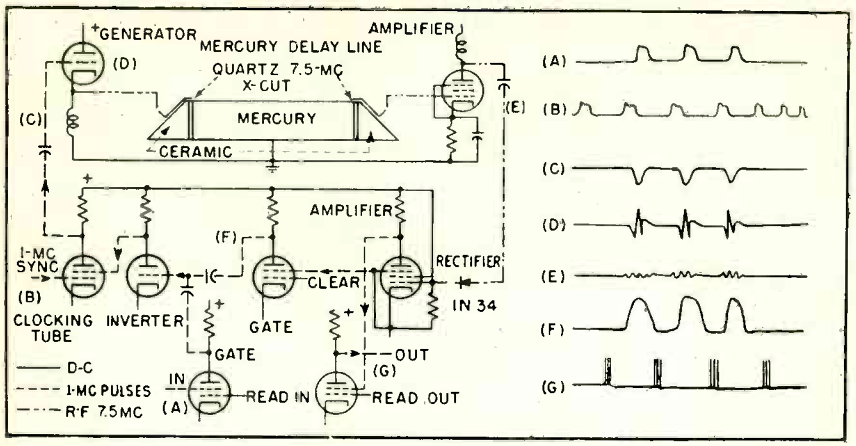

FIG. 2—Waveshapes at critical points throughout the recirculation mercury memory are shown at the right

small, one part in 3,000 per deg C. The quartz crystal matches the impedance of the mercury very closely, giving a reflection coefficient of only 12 percent. The quartz-ceramic match is practically perfect, and in addition, the ceramic end pieces are cut at an angle to break up the back wave eliminating its reflection. The construction of the line is simple and straightforward, as this brief description indicates.

Auxiliary Circuits

Figure 2 shows a complete unit as set up in the laboratory. This circuit held groups of pulses for as long as three days, after which the pulses were cleared out for convenience. The pulses applied to the transmitter crystal (D) are packets of 7.5-mc waves about 0.3 microsec long. These packets travel down the line, are picked up by the receiving crystal, and amplified. The packets are then rectified by a germanium crystal and the pulse envelope again amplified to a level sufficient to operate the recirculation gate tube and the output gate tube. The pulses then proceed through an inverter tube to the clocking or synchronizing gate tube. Here coincidence with a standard synchronizing pulse each microsecond produces a standard pulse at a fixed time that drives the 7.5-mc oscillator or packet generator, starting a new cycle. The clocking is very important because it keeps the pulses in step as well as preventing degeneration of the pulses over a number of circulations.

The waveshapes at various points throughout the experimental circuit are also shown in Fig. 2. A group of three pulses is sent into the tank (A). The standard clock pulses (B) coincide with the three stored pulses to produce pulses (C) that drive the packet generator. The output of the generator (D) traverses the mercury line and is amplified giving pulses (E) that are rectified and re-enter the gating circuit. The pulses are then ready to be relocked (F) or they can be drawn out of the tank (G) as remembered data. (The time base of the output pulses (G) is to a different scale than the others so as to show several groups of three pulses spaced 40 microsec apart, illustrating the storage of several pulse groups.)

Temperature Compensation

Because direct transmission losses in the mercury column are small, it would seem feasible to extend the length of the line to hold many more than 40 pulses. The major practical limitation to this extension is that of delay variations with temperature. With a ± 0.1 microsec tolerance, a tank 1,000 microsec long would have to be kept within ± 0.3 C. To keep a group of tanks at a temperature fixed within these limits is a difficult, though not impossible, job.

If a tank is used to establish the frequency of the pulses, in other words—their spacing, it becomes necessary only to keep all tanks at the same temperature ± 0.3 C. A block diagram of an automatic frequency control unit for this purpose is shown in Fig. 1C. A 1.0-mc oscillator is tuned by a reactance tube whose control voltage is obtained from the coincidence of a pulse from a dividing counter. A single pulse is delivered to the tank when the counter starts counting the pulses that are coming from the oscillator.

For storing N pulses in a tank, one uses a tank of NT length at a given temperature and an N-stage counter. In this case N is 1,000 and T is 1 microsec at 20 C. At the end of 1,000 microsec the pulse emerges from the tank and the 1,000th pulse leaves the counter. These two pulses are fed to a coincidence tube whose output voltage is used to control the frequency of the oscillator and hence the pulse spacing is adjusted to keep 1,000 pulse spaces available in a similar tank at similar temperature.

The temperature compensating system has been set up in the laboratory and has proved capable of control over a temperature range of 45 C. All the tanks are kept within ± 0.3 C by mounting them all on a thermally conductive base that prevents sizable thermal potential differences between them. Also, care in placing the memory cabinet will remove thermal sources and sinks.

The mercury delay memory tank appears to be such a promising device that plans at the Moore School include a future large scale digital computer using this memory means. It is hoped that within a year such a machine will be an actuality; a machine that will have a high speed memory equivalent of 1,000 ten-digit numbers, computing speeds somewhat faster than the ENIAC, and employing only 3,000 tubes. The mercury delay tank described in this paper is the result of many peoples' efforts. Among those whose contributions are known to the author are J. P. Eckert, Jr., J. W. Mauchly, C. B. Sheppard, Joseph Chedaker, and Herman Lukoff.

References

(1) L. N. Ridenour, "Radar System Engineering", McGraw-Hill Book Co., p 667, New York, 1947.
(2) Mercury Memory Tanks in New EDVAC Computer, ELECTRONICS, p 168, May, 1947.

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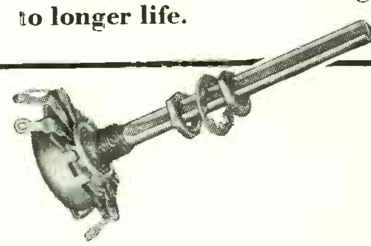

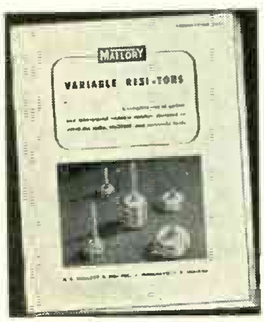

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TUBES AT WORK

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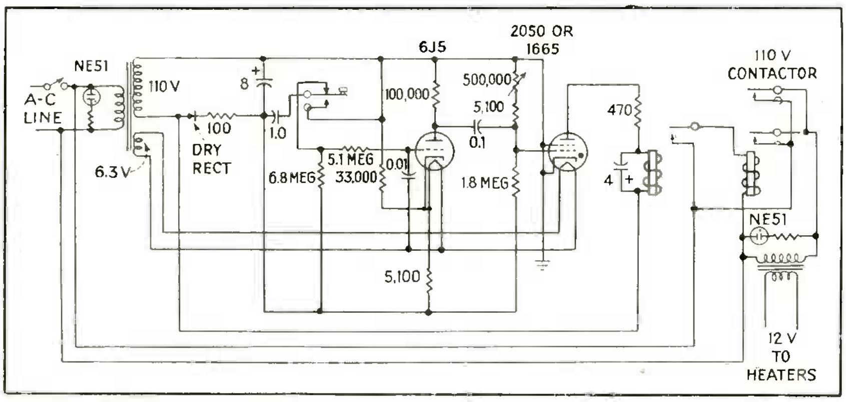
Edited by VIN ZELUFF

Electronically Controlled Permanent Wave Machine

By Eugene W. Nelson
Detroit, Michigan

AN ELECTRONIC permanent wave machine, known to the beauty culture trade as the Flash Wave, is said to effect important economies in the operation of beauty salons and promises better service to the customers of these shops. The machine and the permanent wave solution used with it for waving hair are the products of seven years of research and testing.



Timer circuit for automatic control of heat from the permanent wave machine


Electrically controlled Flash Wave in use. The box on top of cabinet contains the electronic controls of the machine made by Vernan Mfg. Company, Johnstown, Pa.

Sixty-cycle current from the line is stepped down to 12 volts at about 35 amperes and is applied to the lightweight insulated plastic "heaters" in which are placed the prepared curls of hair. Control of the heating current is done by an electronic circuit which offers a completely automatic means of utilizing the advantages of high heat without the danger of over-processing the hair as would be the case without such controls. Its circuit is shown in the diagram.

Steam-Heated Curl

The heaters used with the Flash Wave machine are closed at each end. Thus the steam which is instantaneously generated by the intense shot of heat acting on the permanent wave solution with which each curl of hair is treated is retained (under negligible pressure) around the curl.

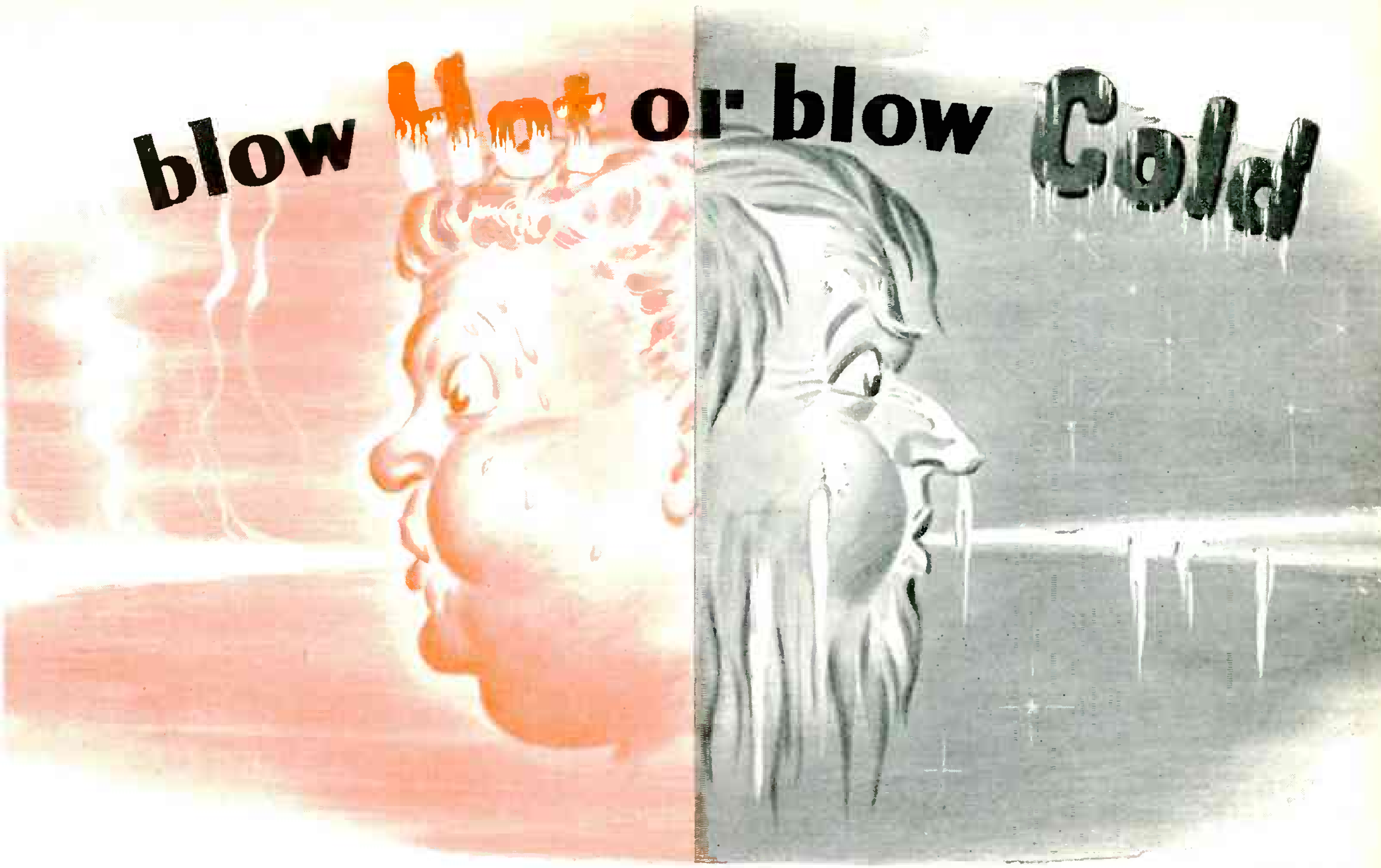
Conventional permanent wave machines apply heat much more slowly than does the Flash Wave. Thus, the steam inside the individual heater is generated more slowly than in the electronically-controlled machine and the moisture created by vaporization of the wave lotion is dissipated almost as rapidly as it is formed. Consequently, the hair may dry out and become brittle. In addition, most of the heaters used on conventional machines are open at each end, instead of being closed as in the Flash Wave. The open ends help the drying process.

Application of Flash Wave heat to the hair lasts from as little as 5 seconds to as much as 20 seconds. Actual duration of the heat depends upon condition of the hair. Normal hair requires a shot of heat lasting from 7 to 10 seconds.

After the proper application time has been determined by a test curl, the electronic controls are set and connection is made to each heater. The machine is also equipped with safety devices which prevent any current from flowing unless all parts of the apparatus are functioning perfectly.

Reports from the field indicate that six permanent waves can be given in a single hour with this

blow Hot or blow Cold



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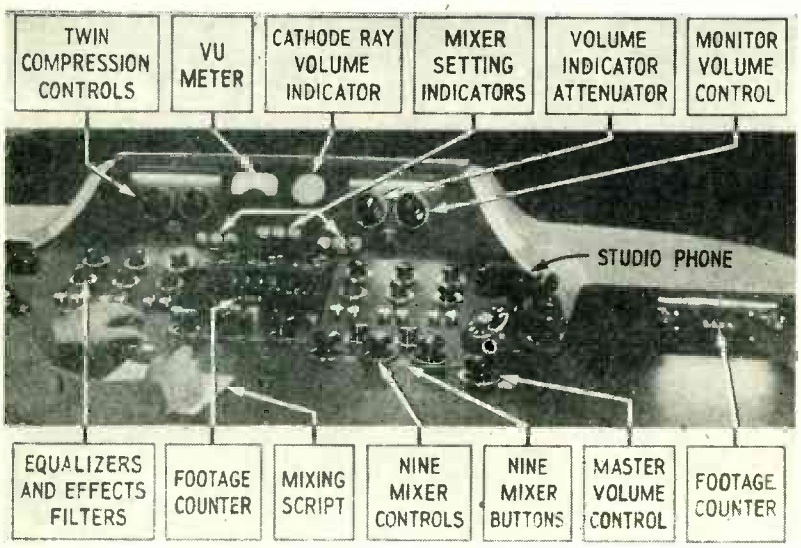
The Front Cover—Console for Dubbing



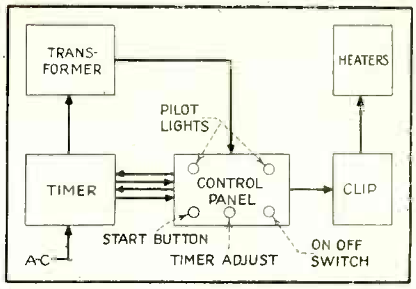
A SOLUTION to the problem of mixing the outputs of up to nine different sound channels while watching a slidefilm or motion picture in a darkened projection room is pictured on this month's cover. Taken at Reeves Sound Laboratories, New York City, it shows their new recording console that can accommodate up to four persons without crowding, as required for introducing, combining, and fading out narration, background music, and sound effects smoothly at precisely correct instants during production of the final sound track or master record.

For each channel there is a mixer control, linked to a numbered tape indicator on the volume indicator panel so that the operator can see at a glance the level settings of all channels and can set each channel to the precise level called for on the cue sheet. Each channel has twin equalizer controls to permit accentuation or attenuation of low and high audio frequencies separately. Switch-controlled twin filters provide varying low and high-frequency cutoff over a wide range as required for such unusual effects as simulating telephone conversations or the tone of an old orthophonic phonograph. Selective volume compression controls operate on a split-channel basis to permit nondiscriminative compression adjustments. Twin master mixer potentiometers are provided for split-channel operation. Remote indicators for all mixer controls are illuminated from the rear in such a way as to show red when the mixer is keyed off; operation of the mixer key changes the illumination from red to white, and the white illumination increases in intensity as the mixer control is advanced.

One of the two volume indicators is a conventional illuminated-scale high-speed type reading in vu, while the other is a unique cathode-ray instrument that shows on its screen a duplicate of the actual sound track as it is being recorded. Distortion and track modulation are thus indicated to the operators at all times.

All static sound channel units are remotely located. Elimination of preamplifiers in this way insures prevention of objectionable microphonic noise during recording.

An illuminated footage counter on the panel furnishes an exact check on film position and length, allowing the mixer operator to record vital timing cues on his mixing script. Side panels for the film editor and director have similar footage counters. Fluorescent strip lamps on the console provide ample illumination of controls when the room is darkened for projection.



Block diagram of the electronically controlled permanent wave machine

electronically-controlled machine. In addition, there is almost no heat dissipated to either customer or operator; heaters can be removed immediately after application of heat with no time wasted in cooling before removal; and operation requires no special training on the part of an operator who is already experienced in standard techniques of giving permanent waves.

Tracking the Permeability-Tuned Circuits

By A. W. Simon
*Assistant Professor of Applied Mechanics
Washington University
St. Louis 5, Mo.*

IN A previous article[1,2] the author has given simple formulas for the calculation of the padder and trimmer coils required to reduce to a minimum the mistracking between the oscillator and r-f sections of permeability-tuned superheterodyne receivers. By the application of these formulas, the maximum deviation due to mistracking between sections can be reduced usually to less than 1 db.

There is another cause of mistracking, namely, the reactance coupled into the r-f section by the antenna circuit. While the effect of this reactance is not serious in the case of a rod or wire antenna, it becomes quite marked for the now widely used loop antenna, due to the higher degree of coupling used. However, the reasoning which underlies the deduction of the above mentioned formulas also suggests how the effect of the antenna circuit can be neutralized.

The basic principle of the permeability-tuned circuit is that the inductance of the respective ganged

(continued on p 156)

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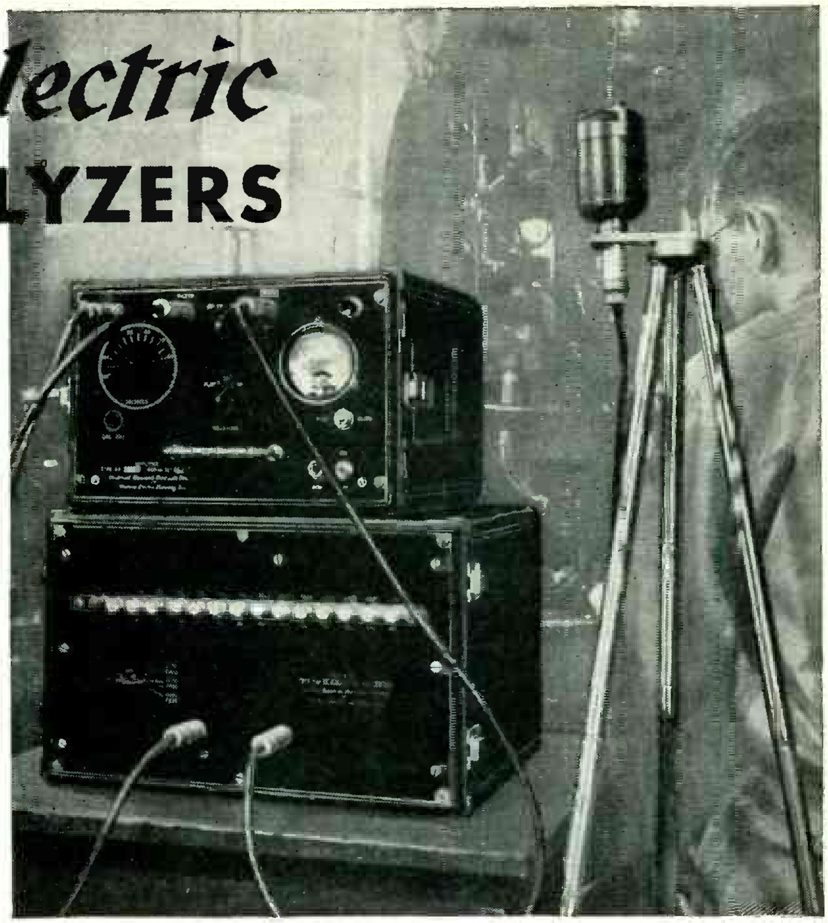

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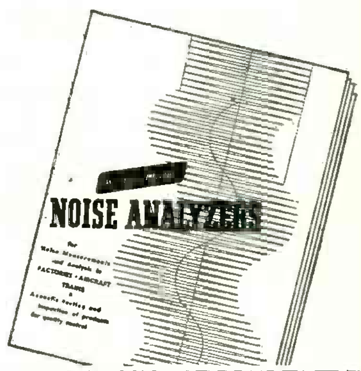

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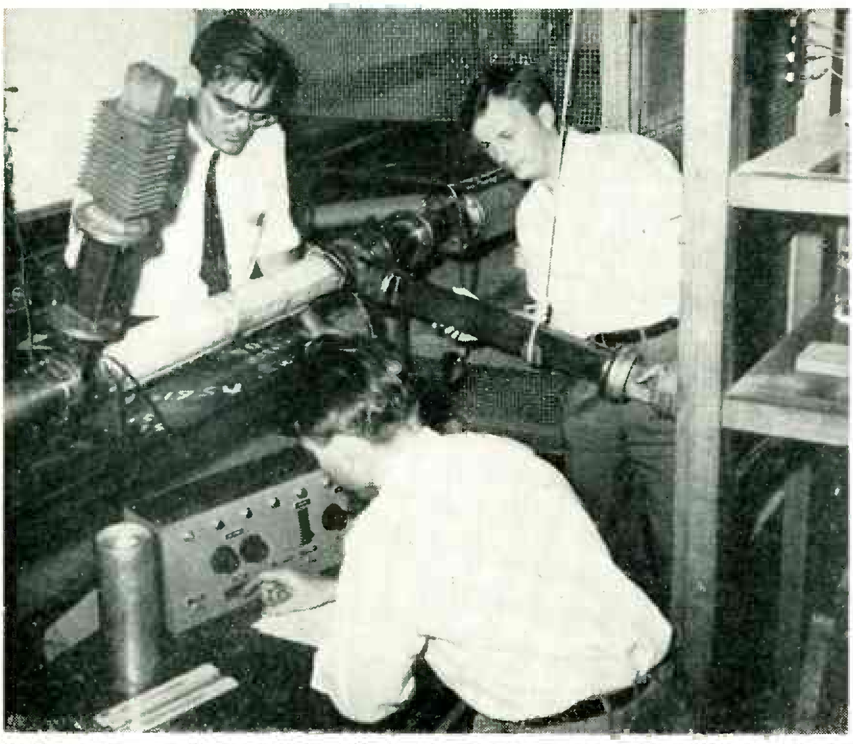
THE ELECTRON ART

Edited by FRANK ROCKETT

Electron Linear Accelerator Demonstrated



A 3-ft long waveguide lined with gold-plated disks, which retards 4-cm microwaves to a velocity equal to that of the injected electrons, accelerates electrons to within 99 percent of the free-space speed of electromagnetic waves, giving the electrons an apparent mass 2,000 times their rest mass and an energy of 1.5 mev. The electrons, traveling with the wave, are accelerated by its potential gradient. The accelerator, described by Dr. William W. Hansen (left) at the IRE west coast convention, is to be extended to 20 ft in the basement of the Microwave Laboratory at Stanford University. This size presents no problem in shielding against radioactivity, and will provide experience for building the final 100 to 200-ft model that will develop 1,000 mev electrons. The accelerator will make available artificial cosmic rays corresponding to fairly energetic natural rays, and thus simplify investigations now conducted in flying laboratories. The accelerator is excited for a millionth of a second every sixtieth of a second from a one-megawatt magnetron. It is hoped that the final model can use 1,000 megawatts. This accelerator is simpler and cheaper than a synchrotron, and, using light-weight electrons instead of heavy protons as in cyclotrons, can produce higher-velocity particles, with which much information about the constitution of the electron can be gained. Dr. E. L. Ginzton, of the physics department faculty, and postgraduate students in physics, William Kennedy (center) and Richard Post (operating controls), are assisting in the development that is being sponsored by the Office of Naval Research

Culturing Crystals

Pilot production paved the way for quantity culturing of synthetic piezoelectric crystals

PIEZOELECTRIC CRYSTALS, artificially cultured by Western Electric Co. using techniques developed by Bell Telephone Labs. will replace about 90 percent of the natural quartz in the telephone system in a few years. The artificial crystals, ethylene diamine tartrate, although differing chemically from natural quartz, are piezoelectric and so are cut into plates and gold coated to form crystal filters. (Synthetic piezoelectric crystals for sonar, developed during the war to meet the tremendous need for transducers, were ammonium dihydrogen phosphate.) In commercial production, the artificial crystals weigh about a pound, are six inches long, and two by three inches in cross section. Seeds of crystals, about a third of an inch across, are first grown by evaporation of a saturated solution of the chemical. The seeds are then constantly slowly washed by a supersaturated solution, the temperature being kept within a tenth of a degree. With this production technique a crop of crystals can be harvested every three months.

Improvements in Small Tubes

COMPACT, mechanically dependable electronic equipment requires small tubes of exceptional characteristics. Recent developments have produced smaller and less microphonic tubes. For example, the Victoreen Instrument Co. has changed the construc-

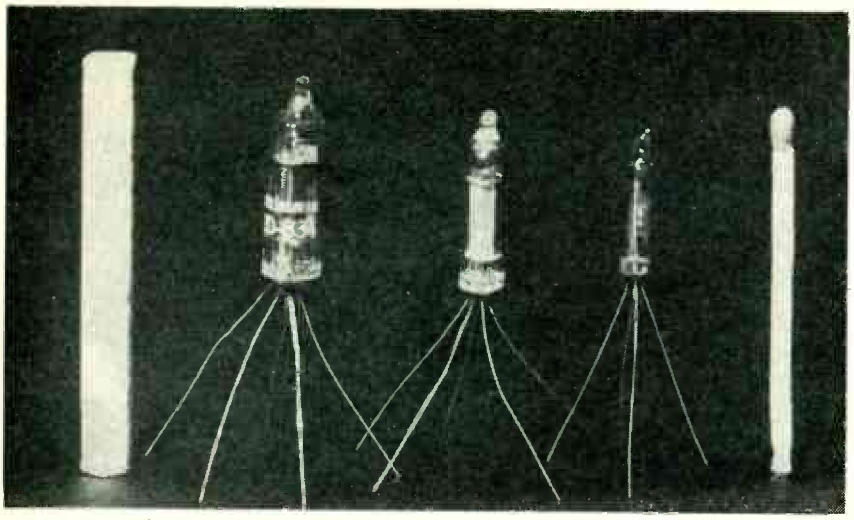


FIG. 1—Triode in T-3 bulb compares in size to cigarette; diode in T-1 bulb is approximately the same diameter as a wooden match; triode at center in T-2 bulb

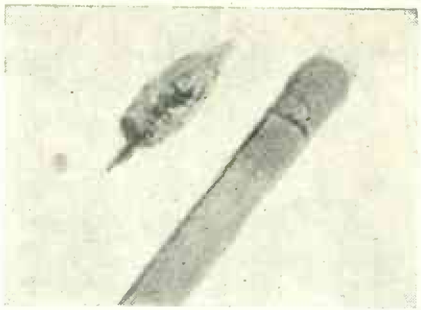


FIG. 2—Diode microtube illustrates extreme reduction in size possible for tubes

tion of their VX-41 subminiature electrometer tube (ELECTRONICS, p 106 March 1947) so that it is less microphonic and thus more widely applicable than heretofore. This tube, requiring 12.5 milliwatts of heating power, has a grid current of less than 10^{-15} ampere and a grid input resistance greater than 10^{15} ohms and yet is sufficiently stable to be used in d-c amplifiers and portable equipment.

Where power drain is not limited but space is, indirectly heated subminiature tubes (ELECTRONICS, p 154 May 1946) can be used. These tubes, using the button stem, are being made by Sylvania Electric Products in a variety of types in the T-3 bulb, some types in a T-2 bulb, and a diode in a T-1 bulb (SN-946) having the characteristics of half a 6AL5 is under development (available under allocation). Figure 1 shows the relative sizes of these tubes.

Although these tubes represent the smallest size available in any quantity, the Tube Laboratory of the National Bureau of Standards has developed an even smaller experimental microtube shown in Fig. 2. This tube, scaled down from a conventional subminiature type by successive simplifications, is a development of the basic and applied research program on vacuum tubes undertaken by the Laboratory in collaboration with industry. In such electronic devices as automatic computers where thousands of tubes are used, such tubes will represent a great saving in space.

One of the limitations to uniformity, life, and cheapness of tubes is the unpredicability of electron emission from cathodes and other elements within the tube envelope. Although the exact mechanism of cathode emission of electrons is not understood, it is recognized that such impurities in the base nickel as iron, carbon, silicon, and manganese affect the emission. The matter is so important that the American Society for Testing Materials has created a special committee with industry wide representation to study the problem.

To obtain quantitative data on the effect of any one impurity, tube manufacturers are applying stastical techniques to large samplings of their outputs. The NBS Tube Laboratory, on the other hand, is attacking the problem in the laboratory by controlled syntheses. Impurities, singly or in combinations, are deposited directly on the base nickel in measured quantities, thus isolating the variables for investigation.

Preliminary studies are encouraging, but not conclusive thus far. Other research at the Tube Lab. is directed toward preventing gas cleanup in high-current industrial relay and rectifier tubes. Apparently the major part of the cleanup in low pressure (3 to 10 microns) gas tubes is caused by ions reaching the anode at sufficiently high velocities to penetrate into the material. The gas can be driven from the anode by heating it.

Microphonic disturbances are another limitation to the operation of electron tubes, as previously mentioned. Mechanical studies made at the Tube Laboratory by vibrating tubes at various frequencies with a dynamic driver and optically observing the motion under stroboscopic light as shown in Fig. 3, are indicating how microphonics can be minimized. Two chief sources of microphonics are insecure crimping and welding of internal parts and vibration of the individual turns of the grid helix.

FIG. 3—Sources of microphonics are detected by vibrating tube and observing motion of internal parts

Whereas in amplifier tubes microphonic effects arise chiefly from a variation of the tube amplification factor as the relative grid-filament and plate-filament spacing changes, the microphonic effects in electrometer tubes, which are used in circuits in which the resistance from grid to filament is virtually infinite, arise also from the change in grid voltage accompanying variations of interelectrode capacitance produced by vibration. The effect of this

(continued on p 182)

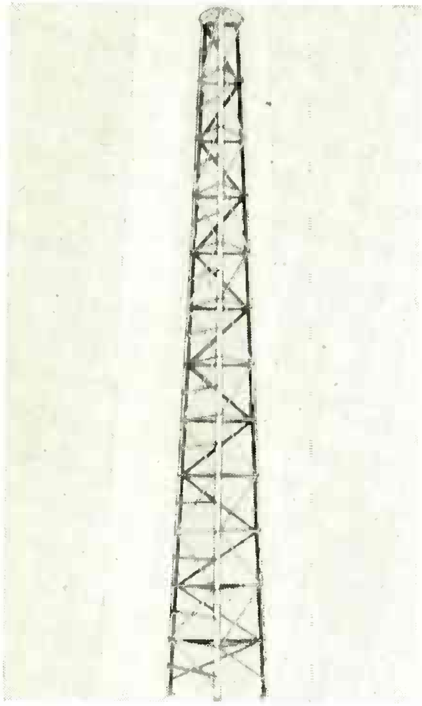
NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed.

Packaged Tower (1)

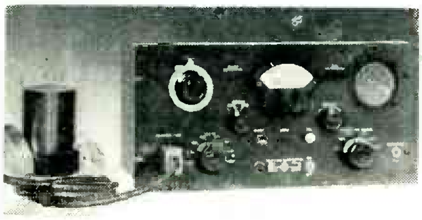
ROSTAN CORP., 202 East 44th St., New York 17, N. Y. The Trig tower is a selfsupporting triangular tapered structure fabricated from



61ST aluminum alloy. Delivered knockeddown, it can be erected by one man. It is designed for low cost developments in the f-m, a-m, and television broadcast fields.

Counting-Rate Meter (2)

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 1500-A counting rate meter indicates directly in counts per minute the rate at which nuclear transformations occur in radioactive materials. Counting rate is shown on a panel meter, the range of operation being from 5 to 20,000 counts a minute. An adjustable and regulated high-voltage supply from



400 to 2,000 volts and a quenching circuit permit either selfquenching or nonquenching Geiger tubes to be used. Accuracy is plus or minus 3 percent of full scale on all five ranges.

Mercury Contact Relays (3)

GRAYBAR ELECTRIC CO., 420 Lexington Ave., New York 17, N. Y. West-

USING THE NUMBERS

Readers desiring further details concerning any item listed in the New Products department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

ern Electric type 275 and 276 relays use a mercury-wetted contact in a hermetically sealed envelope. The units have standard octal bases and provide almost instantaneous break of contacts with high current-handling capacity. Useful in computers, sorting machines, servomechanisms, or high-speed keying systems, the relays are described in bulletin T2398.

Electronic Servo (4)

ASKANIA REGULATOR CO., 240 East Ontario St., Chicago 11, Ill. A remote control and positioning unit for valves, dampers, and other mechanical mechanisms consists of a transmitter, vacuum-tube ampli-

fier, and a receiver. Signal lamps or other audible or visual monitoring indicators can be provided. A ten-page booklet, no. 138, is available.

F-M Amplifier (5)

ALTEC SERVICE CORP., 250 West 57th St., New York 19, N. Y. Type A-323B amplifier designed for operation with f-m tuners and a good loudspeaker has built-in equaliza-

VERSATILITY *in the*

Design - Development - Production of LF, HF and UHF Equipment

For Example...

THE ELECTROMYOGRAPH

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RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

***Specialists** in the Development and Manufacture of LF and HF Equipment* tion to allow direct operation from the variable reluctance or Pickering pickups. A treble tone control for use with shellac pressings is provided. There are two inputs, one for phonograph pickup and the other for radio. The amplifier is rated at 15 watts and has a frequency response within 1 db from 35 to 12,000 cycles. Response is essentially flat from 20 to 20,000 cycles.

Pulse Generator (6)

RADAR ENGINEERS, Arcade Building, Seattle 1, Wash. The type PG-5 pulse generator covers a range of pulse widths from 0.1 to 2.0 microseconds with rise and fall times of 0.05 microsecond. A positive input

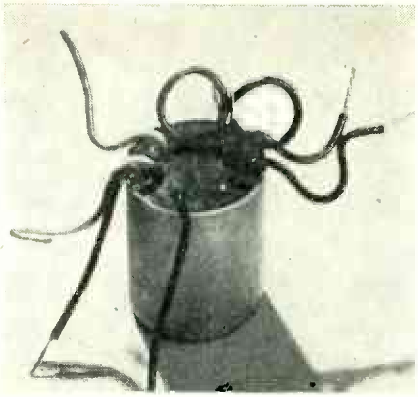
trigger of from 10 to 20 volts is required for each output pulse, the latter being variable in amplitude from minus 20 to plus 20 volts. The unit consumes 40 watts at 115 volts, 60 cycles.

Crystal Units (7)

CLARK CRYSTAL CO., 2 Farm Road, Marlboro, Mass. A new line of resonator and oscillator crystal units is announced for the frequency range 50 kc to 54 mc.

Input Transformer (8)

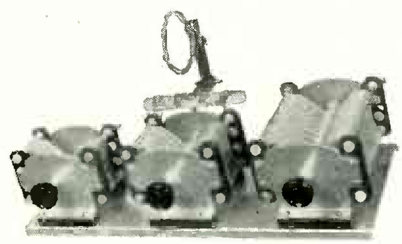
J. W. NEWTON CO., INC., 234 Seventh Ave., New York 11, N. Y. The transformer illustrated consists of two coils so wound on a specially shaped core that the unit forms its own shield in almost any position. The four windings can be



connected to give primary impedances of 500, 150, or 50 ohms. The coils can also be used in a pushpull circuit. The unit is flat within plus or minus 1 db up to 25,000 cycles. Further characteristics can be obtained from the manufacturer.

Butterfly Capacitors (9)

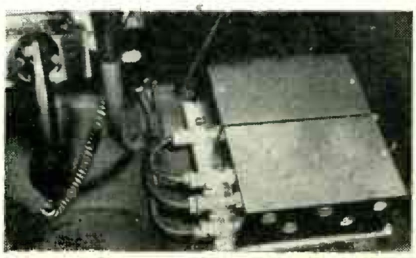
BARKER AND WILLIAMSON, INC., 237 Fairfield Ave., Upper Darby, Pa. Type JCX variable capacitors employ opposed stator sections and butterfly rotors that can be grounded at the center of the r-f



voltage point with respect to stators. The capacitors will handle plate potentials up to 1,500 volts.

Taxi Radio (10)

MOBILE COMMUNICATIONS CO., 202 East Fourth St., Long Beach 2, Calif. Complete main and mobile f-m vhf stations are available for taxicab two-way communications. The Taxi-Talkie system employs a lockout mechanism designed to



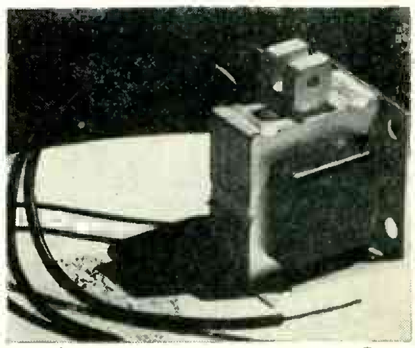
speed dispatching and yet insure a minimum of confusion among a large number of mobile units. Literature is available.

Silicone-Asbestos Paper (11)

CONNECTICUT HARD RUBBER CO., 407 East St., New Haven 9, Conn. Cohrlastic is a Silicone rubber coated asbestos paper with high heat resistance that is available in rolls 12 inches wide. It withstands temperatures in the range of 500 F to minus 70 F. It has a dielectric strength of 400 volts per mil (9,600 volts for the present standard sheet that is 0.024 inch). The material is corona resistant, will not carbon track and has good surface resistivity. Being more resilient than untreated asbestos paper, it is suitable for gasket or washer stock in applications in which compression aids sealing or holding.

All-Welded Solenoid (12)

GENERAL ELECTRIC CO., Schenectady 5, N. Y., announces a small all-welded solenoid designed for use where powerful pull is needed in a small space. It develops a maximum pull of 0.26 lb in a half-inch stroke and operates on 110 volts, 60 cycles.



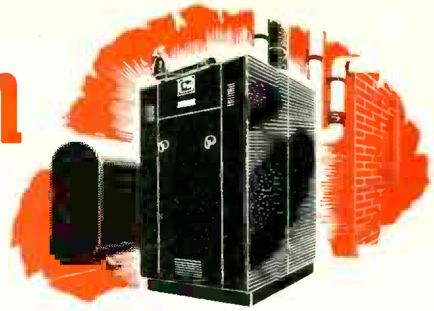
Frame and bracket as well as frame laminations are all welded together. Eddy current losses are thus reduced.

Photoelectric Relay (13)

GENERAL ELECTRIC CO., Schenectady 5, N. Y. The new photoelectric relay and light source can operate at

(continued on p 210)

Putting The Heat On



Oil Burner Coil Production

Transformer coils are wound, 14 at once on the same machine, at speeds up to 2500 rpm . . . on the No. 104 Universal Coil Winding Machines used by a company famous in the field of electronics.

No attention is required from the operator other than to load and unload. Paper of various types and thicknesses, one or two-ply, is inserted automatically . . . length of insert increased automatically . . . spindle stopped at completion of coil automatically.

OTHER FEATURES

- *Adjustable traverse mechanism — wire layer length adjustable without removing cams.*
- *Slow start — avoids wire breakage.*
- *Rapid transfer — using secondary arbor.*
- *Electric stop motion available to detect wire breaks and stop machine.*

Write for Bulletin 104. Universal Winding Company, P. O. Box 1605, Providence 1, R. I.

LEESONA REG. U.S. PAT. OFF.

FOR WINDING COILS IN QUANTITY ACCURATELY . . . AUTOMATICALLY USE UNIVERSAL WINDING MACHINES

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Program of Rochester Fall Meeting; network f-m and television broadcasting; pilotless ocean flight; x-ray conference; personnel items

MEETINGS

Nov. 3-5: National Electronics Conference, Edgewater Beach Hotel, Chicago. See p 240, Oct. issue for program.

Nov. 3-7: AIEE Midwest General Meeting, Chicago, Ill.

Nov. 7-8: Conference on X-ray and Electron Diffraction, Mellon Institute of Industrial Research, Pittsburgh, Pa. Program on p 254.

Nov. 17-19: Rochester Fall Meeting, Sheraton Hotel, Rochester, N. Y.; technical papers and exhibits. Program on p 154.

MARCH 22-25; IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.

Radio for Play Directors

TO TEST the usefulness of radio for communication between a television control room and stage directors in the studio, National Broadcasting Co. was granted FCC authorization for an experimental class 2 station. Since the proposed radio system will be entirely within a shielded television studio, it is not expected to cause outside interference. The frequency used will be in the Industrial, Scientific, Medical band which is available for assignment to low-power convenience radio communication.

Stage directors will be equipped with lightweight battery-operated receivers for receiving the instructions from the control booth. Heretofore this communication has been available only through use of headsets and long connecting cords plugged into various outlets about the stage.

Microwave Television Relay

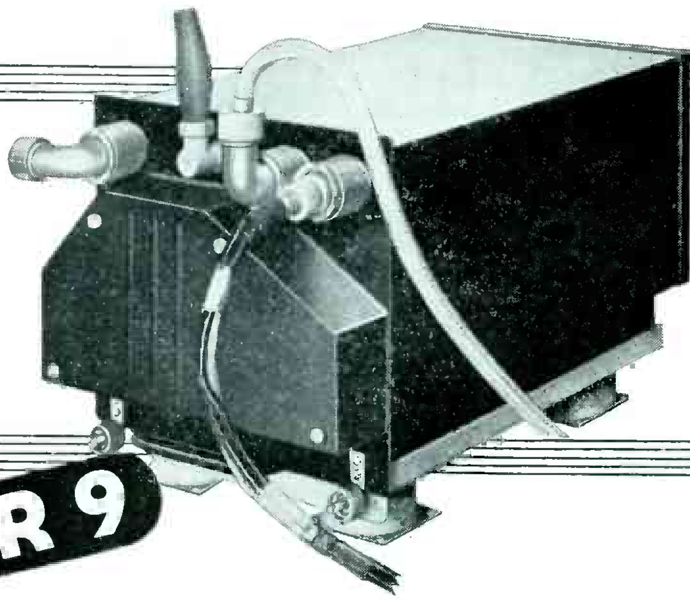
ESTABLISHMENT of a permanent microwave relay system between New York and Schenectady for a more complete programming of television station WRGB paves the way for larger audiences and more economical use of video facilities.

In a preview of the system, which was scheduled for regular operation beginning Sept. 29, engineers and the press were shown Schenectady broadcasts of programs picked up in New York from WNBT and WABD that were indis-

RMA Board of Directors for 1947-1948

lightweight • compact • built-in power-unit

Standard aircraft RADIO



STR 9

V.H.F. TRANSMITTER —RECEIVER

Employing

MINIATURE COMPONENTS

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4 spot frequencies over a wide band

STR 9. A miniaturised low power-high performance transmitter/receiver designed to reduce operating to 'switch-and-talk.'

WEIGHT : 22 lb.

TOTAL INPUT : 180 watts at 26 volts.

FREQUENCIES : 4 spot frequencies, remotely selected, in the band 115–145 Mc/s.

SERVICE : Telephony.

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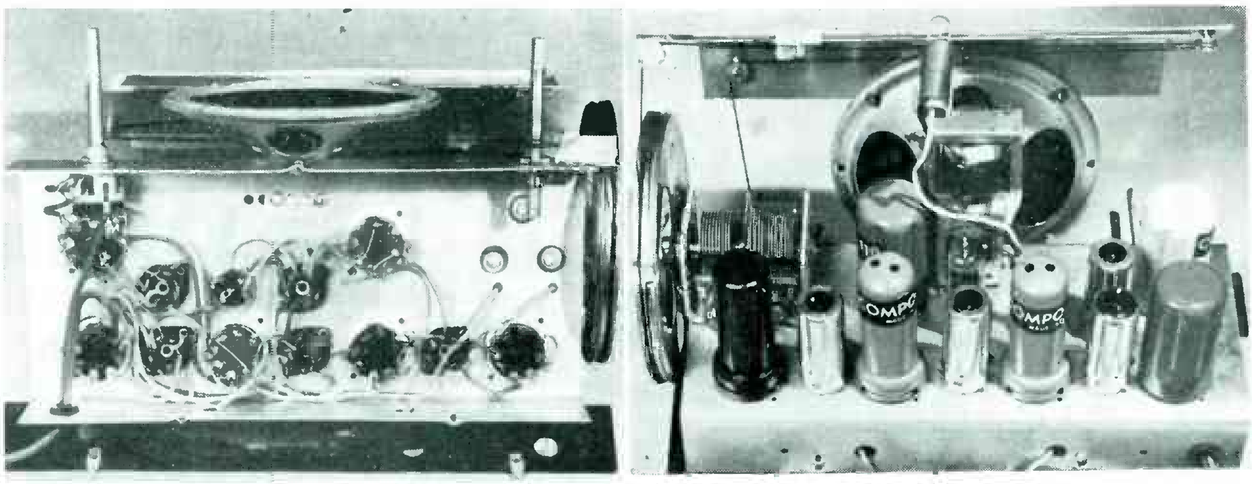
LONDON

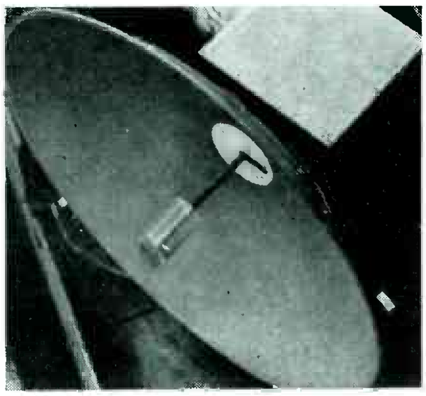
Plug-in Construction Eliminates Under-Chassis Parts in New Superhet Receiver



PHOTOGRAPHS here show how Cosmo Electronic Corp., New York City, achieves complete plug-in construction (except for the gang tuning capacitor) in their five-tube universal a-c/d-c superheterodyne radio receiver. Promotion will feature ease of servicing; any plug-in unit, including loudspeaker unit which screws to chassis but has plug-in connections, is to be available from dealers at price of $1.85. Each plug-in can is a different color, and purchaser of receiver gets instruction book telling how to figure out which can needs replacement when set goes bad. Filtering unit, most likely to fail, is red, and audio can is brown. Same plug-in technique is contemplated for use with Franklin Airloop Corporation's stamped wiring, described in June 1947 ELECTRONICS, p 82. One can has nine small parts inside.

tinguishable in clarity from a locally produced show.

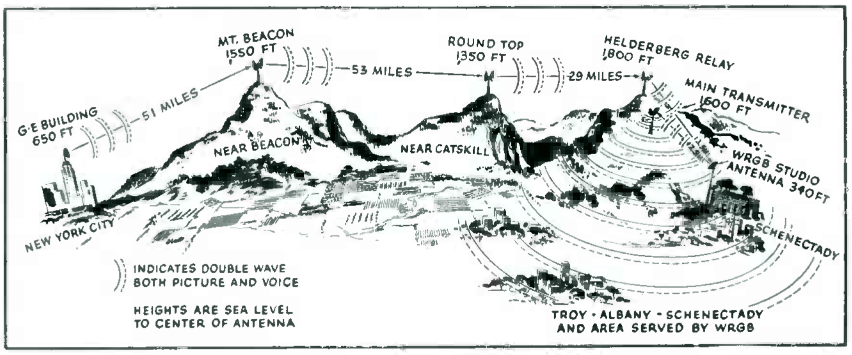
Three unattended relay stations are required to establish line-of-sight paths shown on the map. Each receiver is in operation at all times. When the New York relay transmitter is turned on, its received signal operates the Mt. Beacon transmitter, which then energizes the rest of the chain in like manner. Although the Helderberg relay is only about 1.5 miles from the WRGB transmitter, the video and audio signals are sent to the studio control room to facilitate switching between local and remote programs. The main transmitter is fed by a microwave studio-transmitter link.



New York microwave relay transmitter (in the box) and beam antenna. Each relay receiver and transmitter is similar in appearance

Frequencies employed are in the band between 1,800 and 2,000 mc so that directional antenna gains of 1,400 are possible using 6-foot dish reflectors with a beam width of only 6 degrees. Relay transmitter power is about 10 watts.

Although the present 125-foot towers are provided with large rooms at the top for further experimentation, General Electric engineers point out that the essential relay receiving and transmitting equipment occupies a small fraction of the space. If suitable tower sites can be reasonably procured this system should compete favorably with other means of establishing television networks.



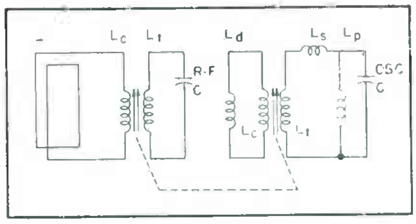
New York-Schenectady television relay using frequencies between 1,800 and 2,000 mc. The New York receiving point can pick up Washington, Philadelphia, or New York station programs, which are then relayed and rebroadcast from Schenectady

Rochester Fall Meeting

THE PROGRAM of the Rochester Fall Meeting of members of the RMA Engineering Department and the Institute of Radio Engineers at the Sheraton Hotel, Rochester, N. Y.,

(Continued on p 246)

TUBES AT WORK
(continued from p 142)



Method of neutralizing effect of loop antenna reactance on tracking of permeability-tuned receiver

coils be identical in every position, that is, at every frequency. The effect of the coupled reactance is to upset this condition. Hence a simple solution suggests itself, namely, to couple into the oscillator section a dummy coil of the same inductance as that of the loop antenna. The reactance coupled into both sections is then the same at every frequency and mistracking does not result. A typical circuit is shown. Here L_1, L_1 represent identical coils and cores, L_c L_c identical primaries wound over them, and L_d the dummy coil simulating the effect of the loop L.

(1) ELECTRONICS, 19, p 138. Sept. 1946.
(2) *Radio*, 30, p 20, Nov. 1946.

Automatic Audio Phase Reverser

By ALVIN H. SMITH
Technical Supervisor
Radio Station KSJC
Sioux City, Iowa

IT IS a well known fact that the waveform of most speech and some music is not symmetrical. When such a nonsymmetrical signal modulates an a-m transmitter, it is possible for the modulation envelope to undergo excursions below the unmodulated level that are greater than the envelope excursions above this level. Such a condition is referred to as negative modulation. Most broadcast transmitters can accommodate positive modulation peaks in excess of 100 percent, but in no case can the negative modulation peaks exceed 100 percent, or serious distortion and interference to other radio services will result. Moreover, most detector distortion in modern broadcast receivers occurs on the negative portion of the detection curve. Thus, if a nonsymmetrical modulating signal can be made to produce more positive than

negative modulation peaks, the coverage of a radio station may be increased, and, at the same time, overall distortion can be reduced.

The purpose of this a-f phase reverser is to adjust automatically the polarity of the audio input signal to the transmitter to produce the desired modulation polarity. This device is particularly useful when the modulating signal is of local studio origin; after an audio signal has passed through a number of repeater amplifiers, as in the case of a network program, phase and amplitude distortion cause the lack of waveform symmetry to be less pronounced.

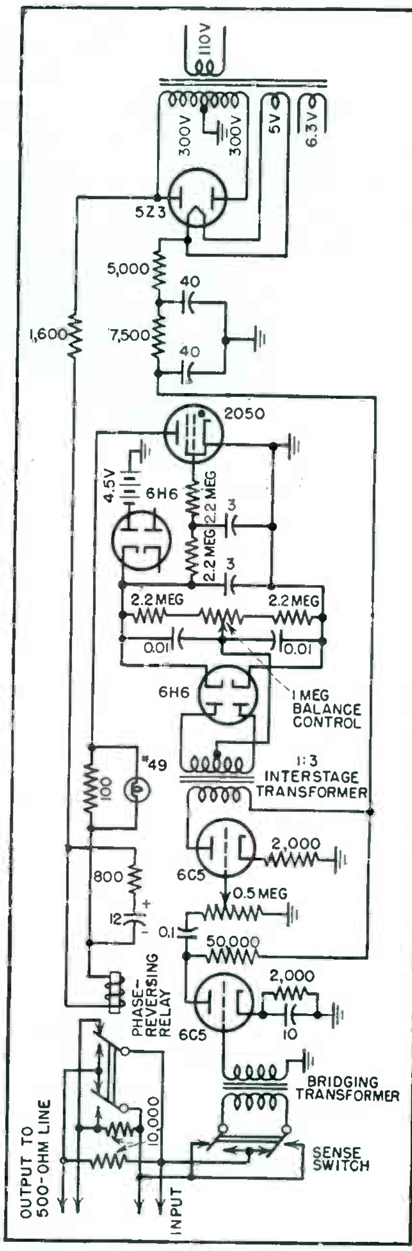
Circuit Operation

The circuit of the automatic phase reverser is shown schematically in the accompanying illustration. Basically, the device consists of a two-stage bridging audio amplifier using 6C5 tubes, a balanced rectifier, consisting of a 6H6 with one cathode grounded, and an R-C delay network, the output of which is connected to the control grid of a 2050 thyratron. The firing of this thyratron actuates a polarity-switching relay.

A dpdt sense switch is connected in the input of the phase reverser unit. This switch is used to preset the phase reverser so that on modulation peaks, the transmitter will be modulated more positively than negatively. Once the proper switch position is selected, no further adjustment is required and the operation of the device is entirely automatic.

Conventional audio amplifiers are used and are designed to produce minimum distortion, since the waveform of the incoming audio signal must be preserved as nearly as possible. The 6H6 balanced rectifier operates in such a manner that for low audio input voltages, the potentials across the two halves of the output load are approximately equal. Under this condition, the net voltage across the R-C delay network is nearly zero.

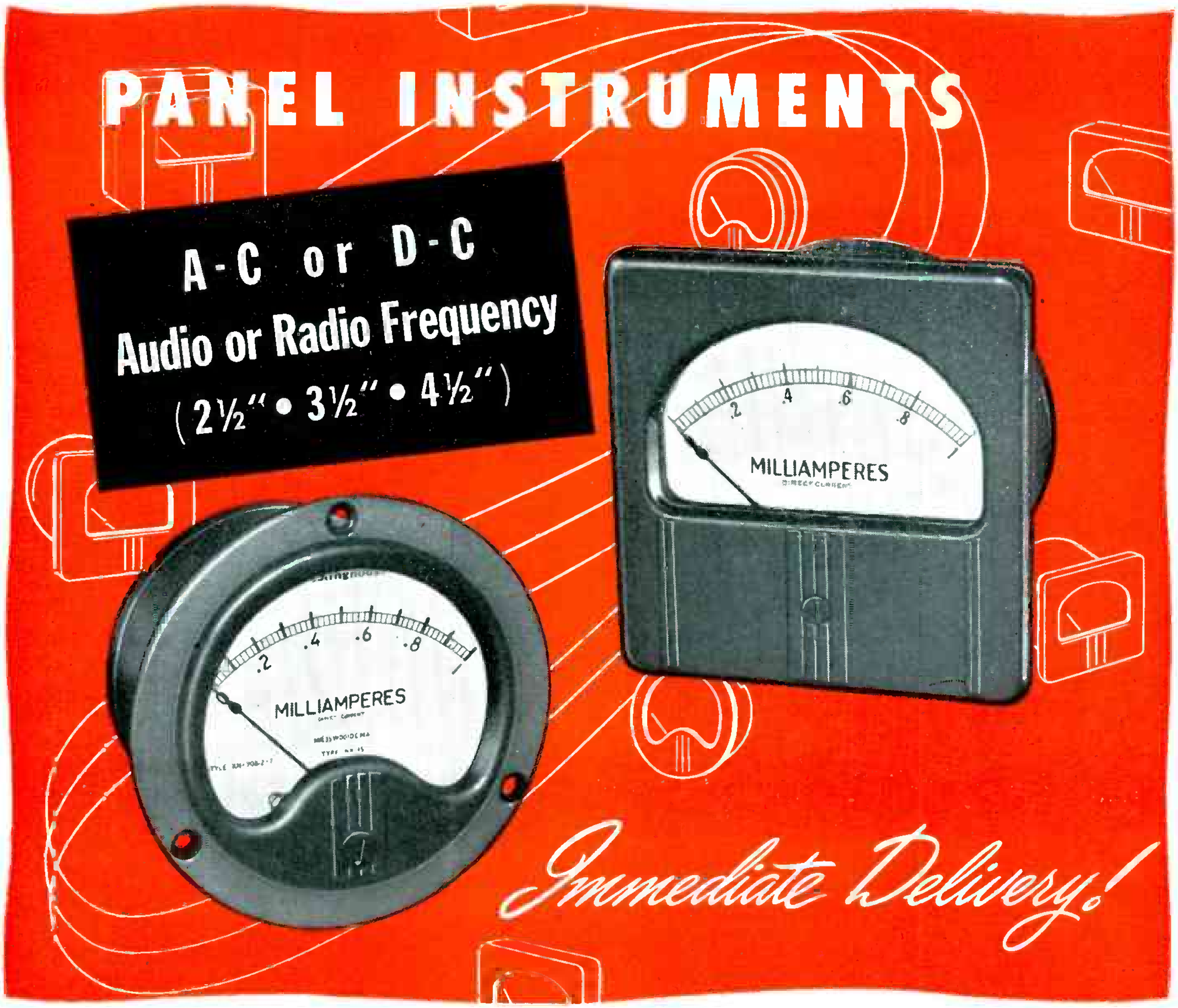
On input voltage peaks, the rectification efficiency increases, and the diode having the higher input voltage peak develops the larger voltage across its load. As a result, a voltage is impressed across the input



Automatic phase reversal of an audio signal is done by this circuit

of the delay network having a polarity that is determined by the predominance of negative or positive peaks at the rectifier input.

Plate voltage for the 2050 thyratron is supplied by one-half of the high-voltage winding of the power-supply transformer through the winding of the polarity-switching relay. The thyratron normally conducts on every positive half-cycle of its plate voltage. Whenever the net voltage from the balanced rectifier is such that the grid voltage of the thyratron is approximately 3 volts negative, the thyratron ceases to fire and the relay switches to its unenergized position, reversing the polarity of the



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Westinghouse panel instruments meet the highest standards of performance in every field of application. They have been proved in every industry and military requirement—on land, sea and in the air. You don't need to experiment.

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audio signal delivered to the transmitter.

A two-section R-C delay network is connected to the grid of the thyratron. This delay network aids in preventing chattering of the relay and delays switching until several peaks of the same polarity have occurred. Two 10,000-ohm resistors across the relay contacts act to reduce key clicks in switching; relay contacts should be set as close as possible for the same reason. The combination of the 12-μf capacitor in series with the 800-ohm resistor also acts to prevent relay chattering.

Control of Switching Time

A 6H6 clipper tube prevents the delay-network capacitors from charging negatively to such a degree that the switching action of the thyratron can not follow rapidly the peak polarity changes of the audio signal. The grid circuit of the thyratron performs this function for positive capacitor charges. Adjustment of the audio input to the balanced rectifier also affects the time required for switching.

The value of the resistor in series with the plate of the 2050 depends upon the characteristics of the particular relay used. This resistor should have as high a value as will give good switching action. A desired switching delay can be obtained by changing the values of the circuit constants in the R-C delay network. The only limitation is that the resistance in series with the 2050 grid must be at least 300,000 ohms.

The automatic phase reverser neither adds to the distortion nor increases the noise level of the audio circuit with which it is connected. This condition results from the fact that the audio circuit has only a dpdt relay added to it. This device has proved to be very useful in several months of service at KSJC.

Dust Precipitators for Air Conditioning

NO LONGER must spectators at Madison Square Garden see sporting events and spectacles through a discomforting haze of tobacco smoke and dust. In conjunction with the air conditioning system recently in-

Studying the output of pulsed oscillators?

ANALYZE THEIR SPECTRA VISUALLY WITH THIS COMPACT INSTRUMENT!

THE SYLVANIA SPECTRUM ANALYZER

provides a convenient means of studying the energy spectrum of microwave generators operating as pulsed oscillators or modulated CW oscillators. The output of magnetron, klystron, rocket and similar UHF and SHF tubes can be readily investigated.

Essentially, the Sylvania Spectrum Analyzer consists of a sharply tuned superheterodyne receiver with a cathode ray oscilloscope indicator. The instrument incorporates a sawtooth generator, which performs the two functions of frequency-modulating the local oscillator and of providing the horizontal sweep for the oscilloscope. Thus automatic synchronization is assured at all times.

An input probe is provided for insertion into cavities or wave-guides.

The energy emitted by the oscillator at various frequencies is displayed on the cathode ray tube as a pattern of vertical lines. The envelope of the pattern represents the spectral distribution.

The Spectrum Analyzer illustrated—the TSX-4SE—is designed for the 9,300 Mc region. A second model—the TSS-4SE—is available for the 3,000 Mc region, and a third model—the TSK-2SE—is available for the 24,000 Mc region.

TYPICAL APPLICATIONS OF THE SPECTRUM ANALYZER

Some of the possible uses include:

Viewing the output of a radar system, to make sure that the output energy is not being wasted by being distributed over a wider frequency band than the radar receiver can accommodate.

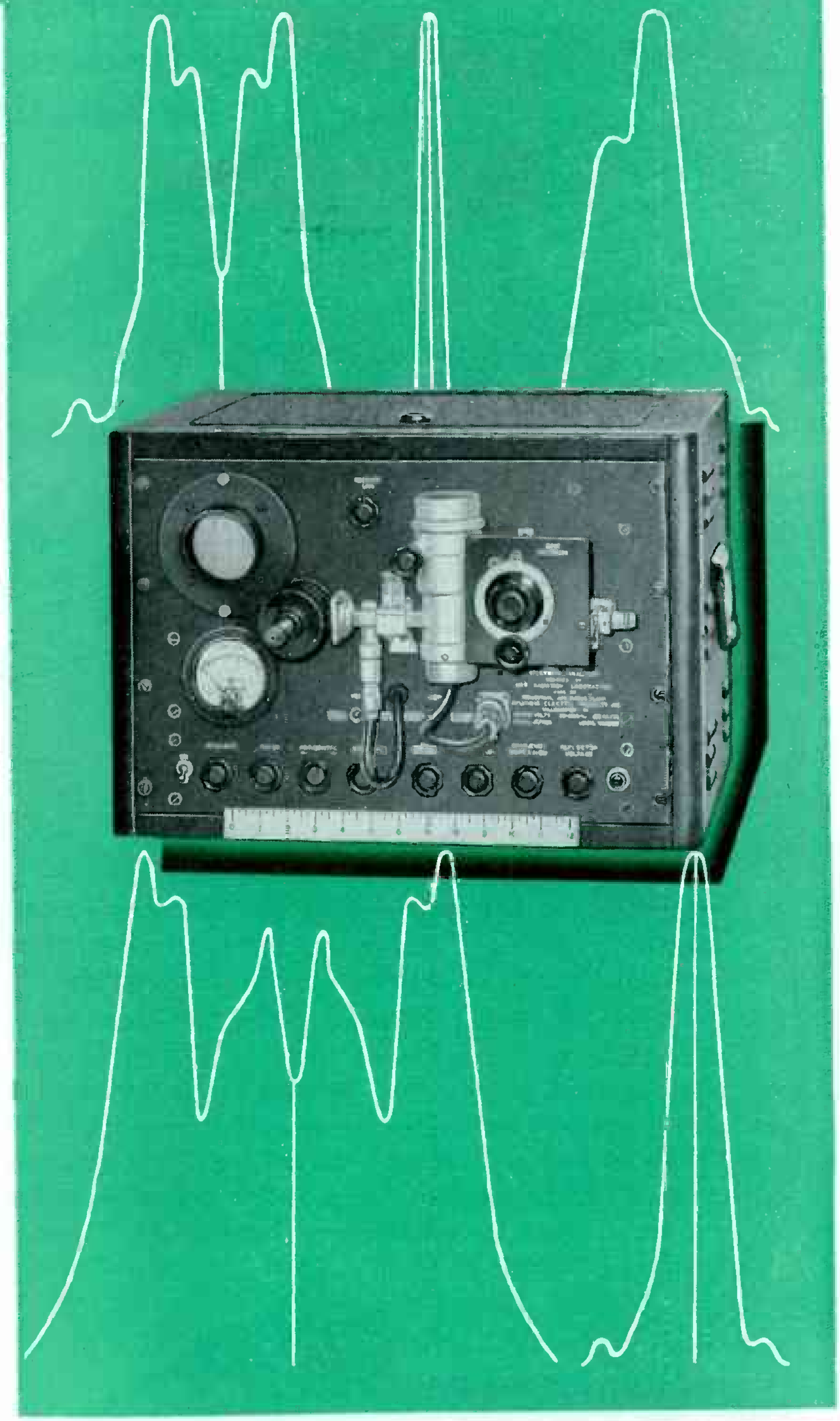
Determining the frequency of a pulsed oscillator.

Adjusting the local oscillator frequency of a radar receiver to space it properly with respect to transmitter frequency.

Checking of pulling or shifting in frequency of the pulsed oscillator of a radar transmitter, by observing the spectrum while the antenna is in motion.

Measurement of standing wave ratios by using the Spectrum Analyzer in conjunction with a slotted section.

WRITE FOR DETAILED SPECIFICATIONS



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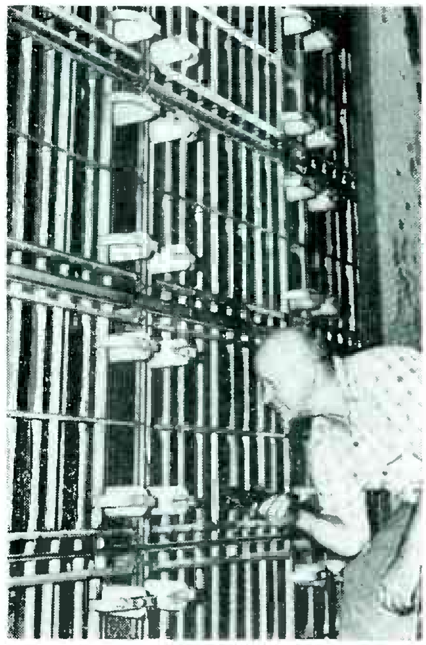

FIG. 1—Airborne particles receive a positive charge as they pass through this ionizer unit

stalled in the Garden, one of the largest indoor installations in the world of electrostatic precipitators has been made.

The air conditioning system in the Garden comprises eight individual systems, each handling 67,500 cu ft per min, or a total of 540,000 cu ft per min. The precipitator installation also comprises eight units, each having thirty cells and ionizers. The cross-section area of each bank of precipitators is 13 by 15 feet. These are installed in the duct work between the dehumidifiers and the fan in such a man-

FIG. 2—Positively charged particles are deposited on these negative collector plates

The Finest Cored Solder in the World

ENCORE!

Ersin Multicore Solder was the first solder in the world to be made with THREE cores—and it is the *only* solder in the world made with extra-active non-corrosive ERSIN FLUX. No other solder offers you the same advantages of speed, efficiency, and economy per joint.

THE ADVANTAGES OF ERSIN FLUX
Ersin Flux, contained in the three cores of Multicore Solder, is a high grade rosin, subjected to a complex chemical process which increases its fluxing action without impairing the well-known non-corrosive properties of the original rosin.

THE ADVANTAGES OF THREE CORES
The three core construction of Multicore gives High Speed precision production. Thinner solder walls provide extra rapid melting. Flux continuity eliminates waste of solder lengths without flux.

THE ADVANTAGES OF QUALITY
Only the purest tin and lead are used in the manufacture of Ersin Multicore Solder. Multicore is made as standard in gauges between 10 and 22 S.W.G. (.128 to .028 in., 3.251 to .711 mm.) and in five standard antimony-free alloys. Other alloys and gauges can be supplied to special order.

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THREE CORE

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SNI-DOR RADIOLECTRIC LTD., 455 Craig Street West, Montreal

Enquiries regarding other territories to
MULTICORE SOLDERS LTD., Mellier House, Albemarle Street, London, W.1. England.
Tel.: REGent 1411. Cables: Dustickon, Piccy, London

FIG. 3—High-voltage power supply for the precipitator units

ner that all of the air supplied to the Garden passes through the electronic filters.

In the electrostatic precipitators installed by Raytheon Manufacturing Co., all airborne particles are taken through an electrostatic field. These particles become positively charged and are precipitated onto negative collector plates. In this manner, 85 percent of all particles as small as 4×10^{-6} inch, a size that includes smoke particles, are effectively removed.

Figure 1 shows the ionizer section of one precipitator unit. A collector unit is shown in Fig. 2, and the high-voltage power supply in Fig. 3.

Five smaller electrostatic precipitator installations are now being placed in operation in the air conditioning system of the New York Stock Exchange. Two of them have been in operation since last November. These installations handle 54,000, 27,000, 22,500, 18,000 and 15,000 cu ft per min; all are equipped with precipitators primarily to remove coal dust and other types of dust usually prevalent in the downtown area of New York.

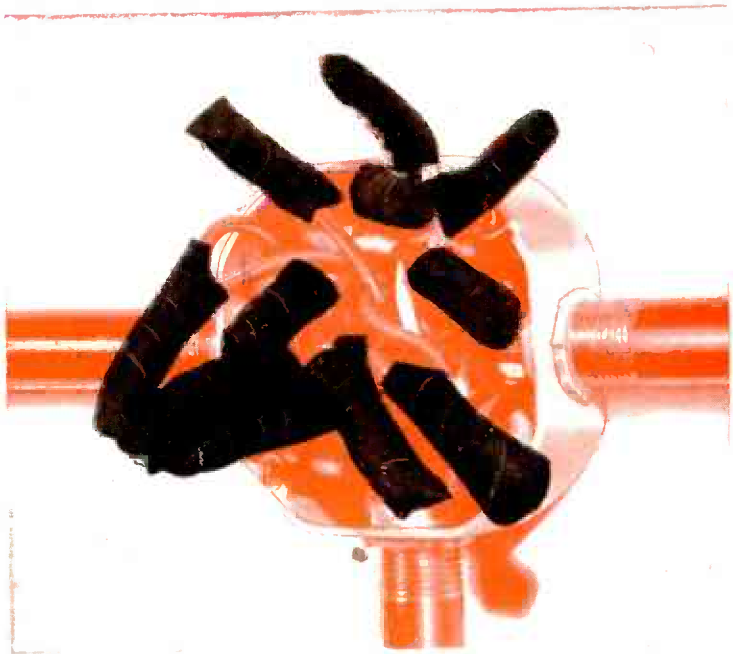
Spectrophotometer for FBI

BY USING a recording spectrophotometer, the Federal Bureau of Investigation Laboratory in Washington, D. C. can trace cars used by hit-and-run drivers.

According to D. J. Parsons of the Laboratory, in a General Electric Science Forum talk, the clue most helpful to the investigators is information as to the kind of car involved.

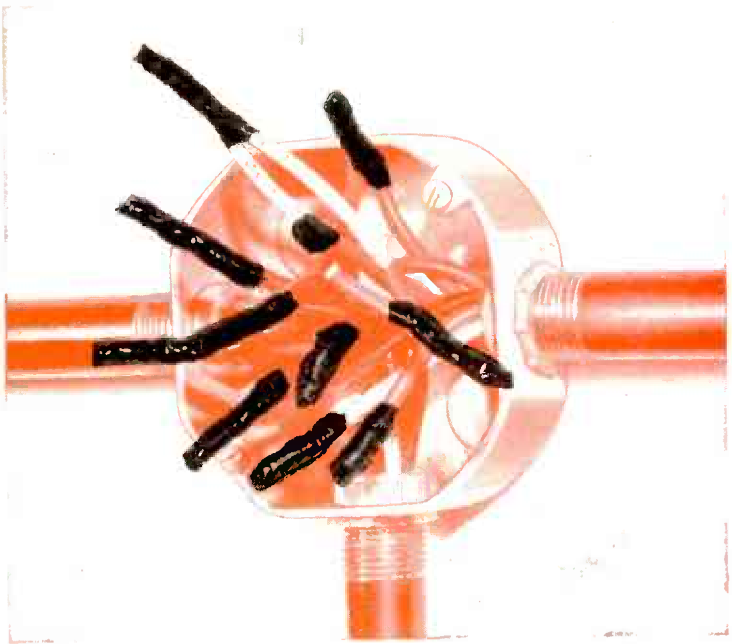
Frequently the clothing of the victim struck down on the highway will be examined, and minute specks or smears of paint from the auto-

Do your junction boxes look like *THIS..*



Junction box overstuffed with wire splices wrapped with rubber tape and an outside wrap of friction tape. When these bulky splices are jammed in you really have an overstuffed junction box.

or like *THIS?*



This junction box has the same number of splices, but they are wrapped with No. 33 "SCOTCH" Electrical Tape with Vinyl Plastic Backing. The thinness of the tape makes the difference in the bulk of the wrapped splices.

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mobile are found and removed. The ability of the questioned material to absorb or reflect the various colors and hues of the visible spectrum is determined. The instrument most useful in this procedure is the recording spectrophotometer.

The results of the analysis are searched in the National Automotive Paint File which contains the standard samples of paints and finishes used by the various automobile manufacturers and the make of the car is determined.

Instruments Speed Oil Refining

THE MOST advanced techniques of electronics, pneumatics, and pyrometry are being incorporated in modern oil refineries to obtain practical operation of the huge refining units being built for continuous, mass processing of tens to hundreds of thousands of barrels of crude oil daily. Instrumentation is also achieving the lower costs that go with mass production in refineries.

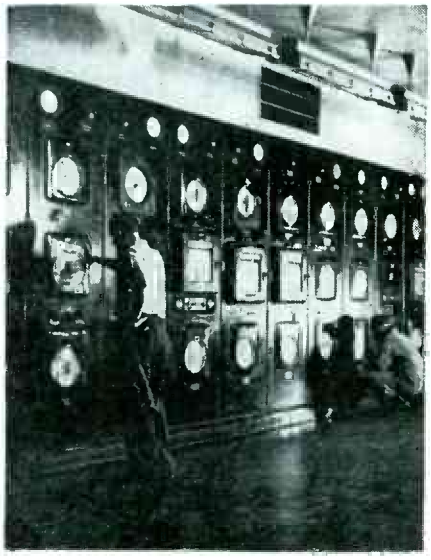
An instrument nerve system measures and automatically regulates the pulses of speed, volume, pressure and heat in every refinery pipe and tower and enables the handling of massive forces and volumes, which man could not otherwise control with the necessary precision.

Large control rooms now built into each major unit are connected to as many as 500 instruments and control points throughout the unit as in the case of the Gulf Oil Corp. new fluid catalytic cracking installation at Philadelphia.

Varying reactions of the process are conveyed from the outside instruments into the control house where recording and adjustment of the variations is effected under the eye of the chief operator, either automatically by the instruments, by manual instrument control, or by communication with workers manning the installation. Pneumatic lines both bring in the instrument responses and activate process adjustments and form an elaborate air pressure transmission system developed to eliminate hazard of fire or explosion from electric wiring.

Low-voltage electronic amplifiers

are used to record temperatures where high speed recording is essential. Absolute safety is provided by automatic pre-alarms, alarms, and shut-offs that signal the operators when any part of the complicated processing system is failing to operate according to set conditions. If corrections are not made, the warning device automatically shuts off the affected installations before a danger point is reached.



Scores of electronic, pyrometric, and pneumatic instruments are mounted on the four walls of this air-pressurized control room to direct 500 control points in the giant new catalytic refining unit built by Gulf at Philadelphia

In the early days of the oil refining industry, instruments had to be read and the process adjusted at points located about the stills. This made impossible the coordinated picture needed for large operations and the stills sometimes could not be kept operating up to 100 hours. Today, giant, precision-directed units can run from six months to as long as a year in some cases without interruption, turning out a greater volume of gasolines and lubricants than ever before.

Devices which have effected the change from small batch operation to mass production include level controllers to chart and manipulate the level of fluid in towers and stills; flow, temperature, and pressure indicators, recorders and controllers; interconnected controls where valves are operated by different instruments in response to varying conditions; and special scanning graphic pyrometers, which

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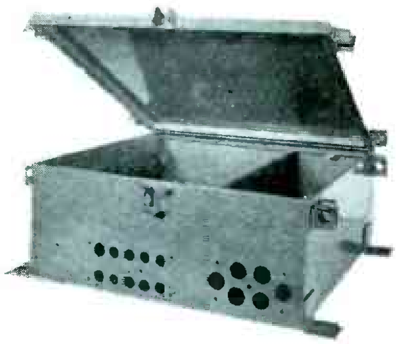

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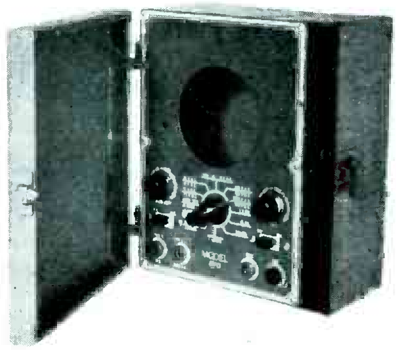

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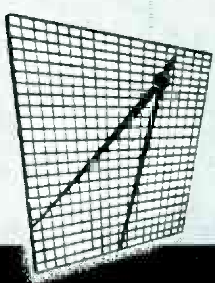

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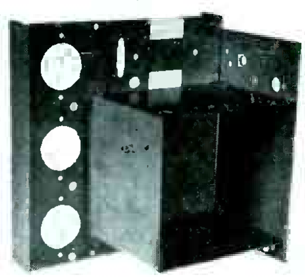

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show a pattern of temperature at a glance.

Technical Data on Electronic Micrometer

CIRCUIT diagram and construction details of the electronic micrometer first described in this department (ELECTRONICS, July, 1947) have now been made available by the National Bureau of Standards. This device utilizes the variation in mutual inductance between two coils in a pickup assembly when the latter is displaced from a fixed metallic surface, to obtain a linear thickness-measuring characteristic.

Such a micrometer, designed to measure insulation thickness, is shown in Fig. 1. The instrument has two full-scale ranges: 0 to 0.005 inch, and 0 to 0.05 inch. Accuracy is better than 0.00005 inch on the low range and 0.0005 inch on the high scale. With suitable meter multiplier resistances, displacements in the order of 10^{-5} inch have been measured, although this is by no means the limit of sensitivity of this method of measurement.

Probe Coil Assembly

Experimental investigation was made of the effect of probe coil geometry on the linearity of the displacement characteristic. For a fixed primary and movable secondary coil having the same diameter, it was found that the mutual inductance increased linearly as displacement values changed from zero to

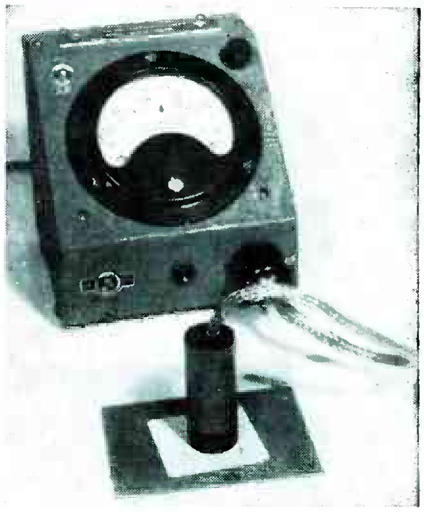

FIG. 1—Electronic micrometer measures change in coupling between probe coils caused by displacement of probe from metallic reference surface

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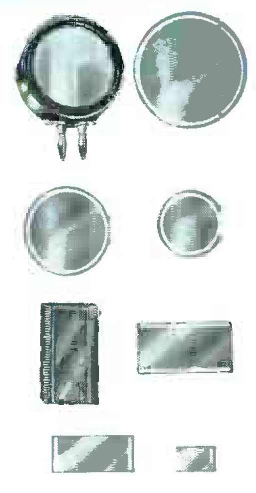

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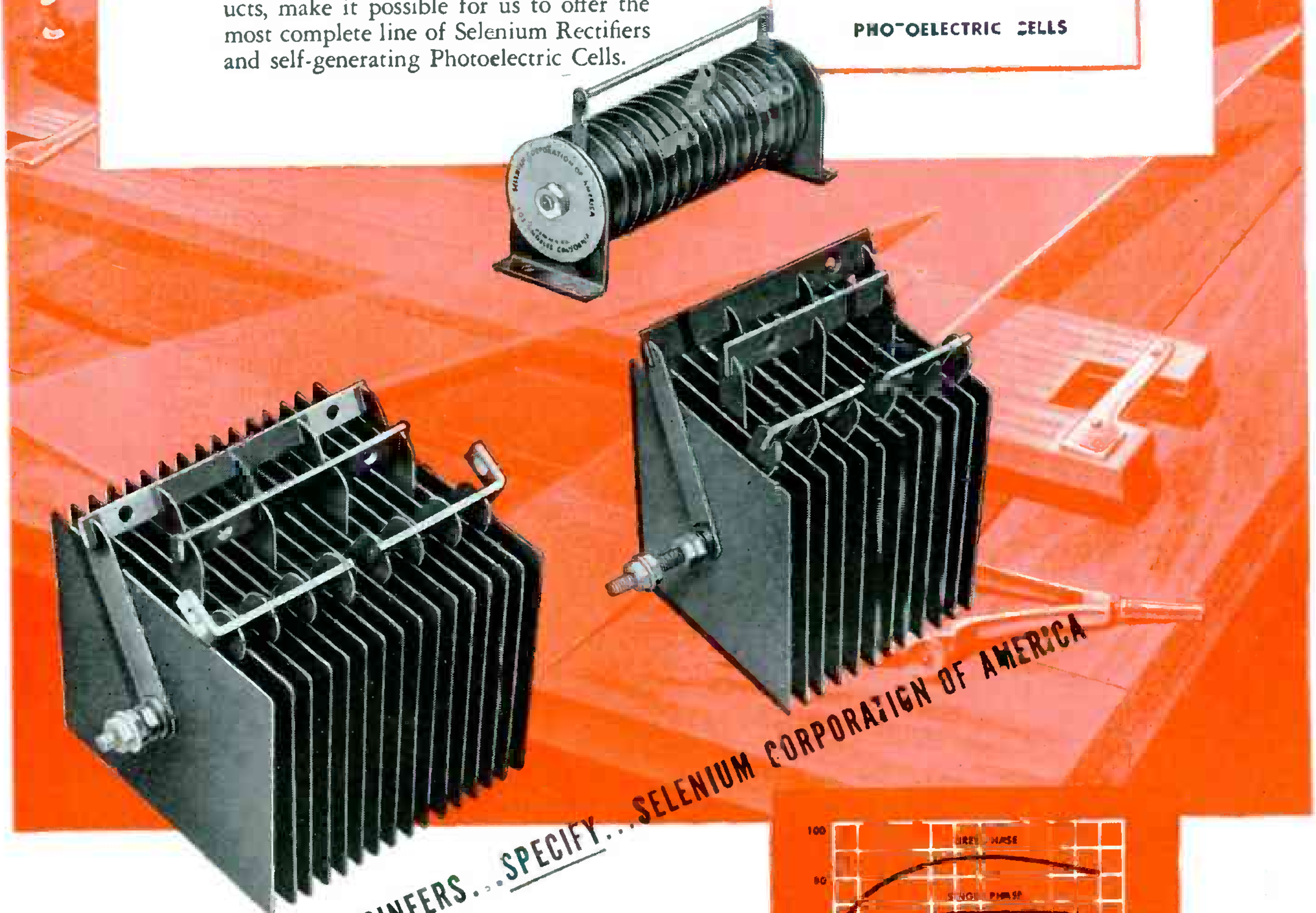

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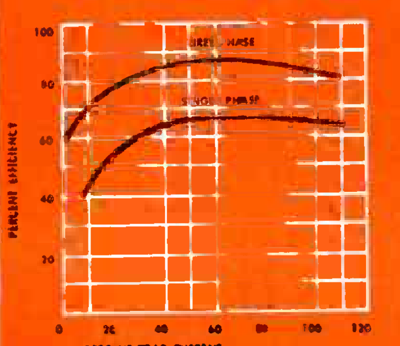

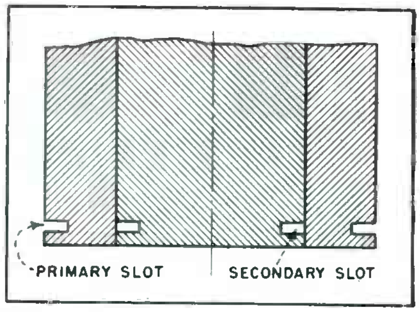

FIG. 2—Cross section of probe coil form

about 5 percent of the coil diameter.

The most advantageous mechanical design for the probe coil assembly necessitated the use of fixed windings on a single form. With this restriction on mechanical design, it was found that the optimum displacement-measuring characteristic was obtained by making the windings concentric and coplanar, with the diameter of one winding 70 percent of that of the other. The primary exciting coil consists of 8 turns of No. 26 enamelled copper wire; the secondary coil has 55 turns of No. 38 enamelled wire. The high-current exciting coil is wound with the larger diameter because of its greater heat-dissipating area. A cross section of the coil assembly is shown in Fig. 2.

The transfer characteristics of the probe coil system can be represented by a single mutual inductance if resonance effects are avoided. Non-resonant operation is desirable for precision applications because of its independence of operating frequency and lower coil losses. Operation at frequencies below resonance may not be satisfactory because harmonics of the exciting frequency may be accentuated, possibly causing distortion of the linear relation of output voltage with displacement. To keep the resonant frequency as high as possible, the rectifier is mounted directly on the probe coil form. A simple low-pass filter, consisting of a series resistor and the shunt capacitance of the diode rectifier, has been found to reduce the resonance rise to negligible proportions.

Oscillator and Control Circuits

The primary winding of the probe assembly is driven by a 3-mc oscillator shown schematically in Fig. 3. A feedback network controls the oscillator screen voltage so

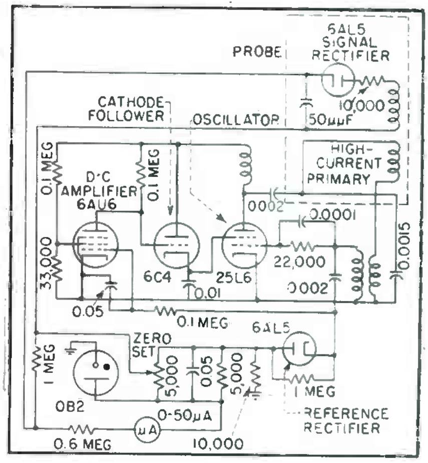

FIG. 3—Changes in probe coil coupling produce variations in rectified output of secondary winding. These are measured by microammeter to give readings of thickness. Reference rectifier, d-c amplifier, and cathode follower form feedback network controlling oscillator screen voltage to give practically constant output

that the oscillator serves as a constant-current source. Since the instrument monitors current in the secondary winding of the probe rather than the voltage across this winding, changes in lead length and in copper resistance have no effect upon the scale factor of the output of the probe.

To supply as much power as possible to the exciting coil, and to reduce the number of tuned elements, the exciting winding forms part of the oscillator plate tank inductance. The remaining inductance is obtained from the plate winding of the oscillator feedback transformer. This transformer is wound on a ½-inch form and consists of a 5-turn grid winding of No. 24 enamelled copper wire over a 50-turn plate winding of No. 30 enamelled ssc wire.

The combination of exciting coil, primary winding of the current transformer, and tank capacitor, form a parallel-resonant circuit. This design requires the oscillator tube itself to furnish only a small fraction of the current in the probe exciting coil.

Voltage from the secondary of the current transformer is rectified, compared to the d-c potential across a voltage regulator and fed to the d-c amplifier. Through a cathode follower, this amplifier controls the screen voltage of the oscillator tube. This regulator feedback circuit has a loop gain of the order of 100, so

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that the oscillator output is held quite constant regardless of tube, line-voltage or other variations.

The output circuit for the secondary probe coil consists of a diode peak rectifier and a d-c voltmeter. Cancellation of initial coupling is accomplished by adjusting the zero set control which inserts a bucking voltage in series with the rectified probe input.

Any pentode or beam power tube is suitable as an oscillator. A 25L6 using a 115-volt plate supply is adequate for driving one micrometer at 50-volt-amperes. A single 807 is capable of supplying 1,000 volt-amperes, more than enough for four micrometers.

Micrometer Performance

The metal used as a reference surface has some influence upon the performance of the micrometer. While there is still a significant change in mutual inductance when magnetic materials are used, a relatively large initial coupling and a loss in scale factor are manifested. Ferromagnetic materials have appreciable permeability effects at radio frequencies so that there is an opposing effect added to the reduction in coupling caused by eddy currents. As the frequency is increased, the performance with ferromagnetic materials tends to improve, but nonmagnetic metals are still preferable.

Very little difference in performance can be observed between surfaces of various nonmagnetic conducting materials. Brass works equally well as silver, for example. At a frequency of 3 mc, it has been found that the metal need be only about 0.0001 inch thick; what lies beneath this layer does not matter. Thus, a convenient way to make measurements with magnetic materials is to plate them with a layer of copper or silver, for instance, to a thickness of 0.001 inch.

If the diameter of the metal plate is greater than $1\frac{1}{2}$ times that of the larger probe coil, there appears to be little further effect due to the size of the plate. For most applications, it is suggested that the plate be no smaller than the coil. A hole in the center of the plate is not particularly detrimental to performance in those cases where lightness

of the metal plate or vane is important.

If the surface of the metal is curved, the indicated reading is relative to some average displacement. The initial mutual inductance is larger, so that more buckout voltage is required, but incremental readings are very nearly the same as for a flat plate. There is no necessity to shape the end of the probe form to match the surface, as would be the case with capacitive micrometers. The useful linear range is reduced, however, because the effective surface of the metal is at a greater distance from the end of the coil form.

Some measurements have been made with the micrometer to examine the effect of placing materials of various dielectric constants between the probe and the metal. This is the usual way of measuring insulation thickness. It was found that any error resulting from the dielectric constant is so small as to be within the accuracy of the instrument.

The electronic micrometer was developed in connection with projects for the Navy Department, Bureau of Ships, by M. L. Greenough and W. E. Williams of the Electronic Instrumentation Laboratory of the Bureau of Standards. A patent application has been taken out in the name of the United States Government and will be made available to industry without charge.

SPEED COP AGAIN

Close-up view of the electronic portion of the speed cop for clocking motorists (ELECTRONICS, July 1947, p. 148). The transmitter is at right with its antenna; the receiver is at left. An insulating panel protects the antennas from damage

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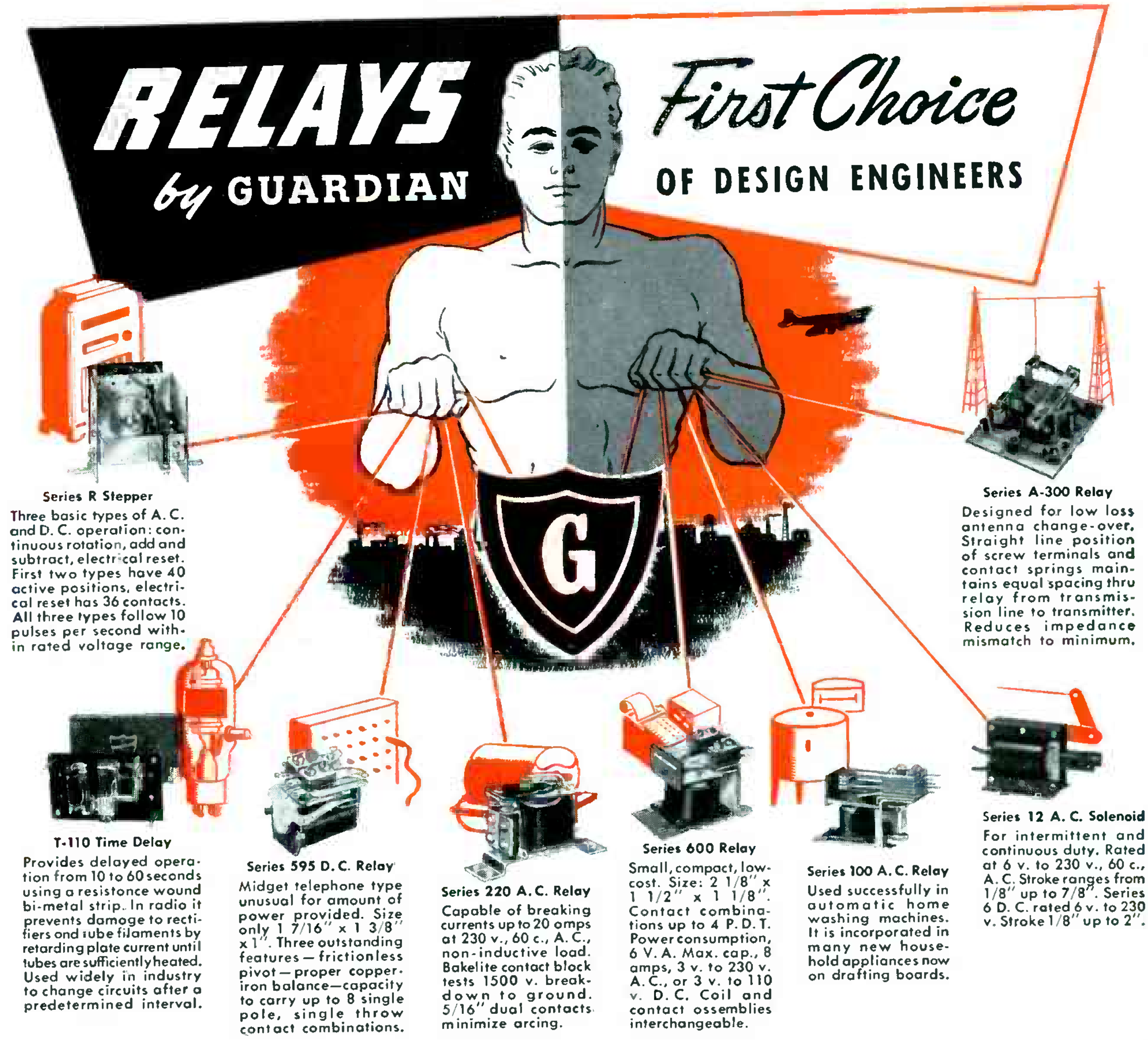

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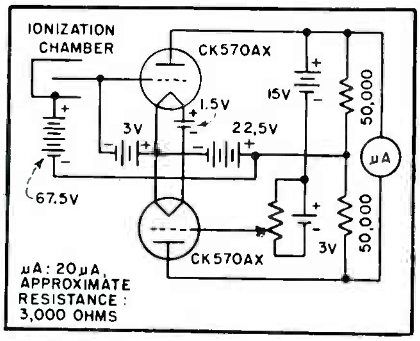

FIG. 4—Radioactivity meter uses nonmicrophonic subminiature electrometer tube

capacitance variation can be minimized by connecting the tube directly across a large fixed capacitance, if rapid changes are not to be measured.

In portable equipment, the subminiature, battery operated (hearing aid) tubes have been used. Because such equipment is subject to severe vibration, microphonics in these tubes are particularly troublesome. However the nonmicrophonic subminiature CK570AX electrometer triode (developed by the Special Tube Section of Raytheon Mfg. Co. for the U. S. Atomic Energy Commission in cooperation with their Argonne National Lab. and now commercially available) measures currents as low as 10^{-14} ampere (0.01 micromicroampere) without developing objectionable microphonics in its output when vibrated. Filament heating power is 12.5 milliwatts. This tube was designed for use in the recently declassified Zeus circuit shown in Fig. 4. The ionization chamber has a one-litre capacity, a 0.25 volt input across the grid resistor giving full meter deflection. The circuit constitutes a simple, portable, inexpensive meter for health surveys to protect personnel working with radioactive materials or x-rays.

Magnetron as D-C Amplifier

CONTROL of one current by another can be effected with a classical magnetron. (As originally used, "magnetron" meant a magnetically controlled diode, not an oscillator depending on the reaction of an alternating potential field on electrons moving in a static magnetic field. This abstract concerns the magneti-

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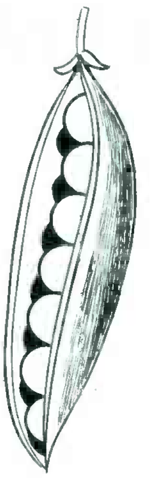

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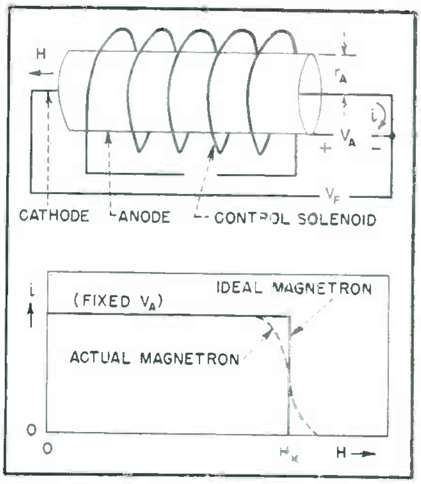

At the top is the basic magnetron connection; current in the solenoid produces a magnetic flux H. Below is the magnetron characteristic for a fixed anode-cathode potential, decreasing that potential moves the cutoff to the left, decreasing the heater current lowers the saturation current available at low magnetic flux

cally controlled diode.) The advantage of the magnetron over a grid controlled tube is that the controlling circuit can be at a radically different potential with respect to ground than the controlled circuit. Thus, in a particular x-ray application, the solenoid that was wound about the diode for control was at ground potential while the anode-cathode circuit of the diode was about 100 kv above ground in the target circuit of the x-ray tube. Furthermore, variations in solenoid-ground potential, except as they might affect the solenoid current, do not affect the output circuit, thus the magnetron is ideally suited to direct-current amplification.

Magnetic Sensitivity

The analogous paramaters amplification factor and internal resistance of a triode are magnetic sensitivity $\mu_M = (\partial v_A/\partial H)_i$ and internal resistance $R_i = 1/(\partial i/\partial V_A)_H$. In an ideal magnetron, current flows for a fixed value of anode-cathode voltage V_A until a critical magnetic field H_K is reached at which point the current abruptly drops from its saturation value to zero. However, in an actual magnetron, because of asymmetry in its radial and axial geometry and other variations especially edge effects of the electrodes, the discontinuity of current is less abrupt, being as shown in the accompanying drawing. For not too small values of V_A and H_K the mag-

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(1) At left in illustration
(2) Center of illustration
(3) At right of illustration
† All data for 60-cycle operation

The 230-volt‡ models (V-5H)‡ are similar in external appearance and size to the corresponding 115-volt (V-5) units shown in the illustration

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netic sensitivity can be taken as the slope of the magnetic characteristic curve, or as $\mu = 2(r_A/6.74)^2 H_K = (r_A/3.37) V_A^{1/2}$ in which r_A is the effective anode radius (its geometric radius if the cathode is of negligible radius and the tube is axially symmetrical).

If a grid is placed close to the anode and at cathode potential, the sensitivity of the magnetron will be increased because the magnetic field will then have an opportunity to deflect the electrons in a weak electric field over most of their path. If the amplification factor of the grid is G, the sensitivity of the grid magnetron is $\mu = 2G(r_A/6.74)^2 H$. The anode potential will have to be higher for the tube to conduct a reasonable current, but this is usually no drawback considering the enhanced sensitivity (A Magnetron for D. C. Voltage Amplification, H. B. G. Casimer, *Philips Technical Review*, p 361, Dec. 1946).

Measuring Distance Precisely

RELATIVE PHASE RELATIONSHIP between continuous-wave radio signals is used (as in an interferometer) to measure distance to accuracies within several inches per mile with the Raydist (radio distance) developed by Charles E. Hastings. Using a heterodyne system, circuit errors are canceled thus producing high precision. The equipment can be used in surveying, indicating positions of airplanes and their true ground speeds, plotting the trajectory of missiles, or maritime navigation. The equipment is light enough to be readily transportable.

Hyperbolic Coordinates

As used in most applications, the equipment is arranged as in Fig. 1. The mobile transmitter is carried by the vehicle whose position is to be measured. The system as shown provides one set of hyperbolic interference lines in space. Motion along the pattern is detected by the differences in phase at two a-m receivers. Operation is at 12,862.5 kc so that each half wavelength is 38.225 feet. The beat frequency developed at an a-m re-

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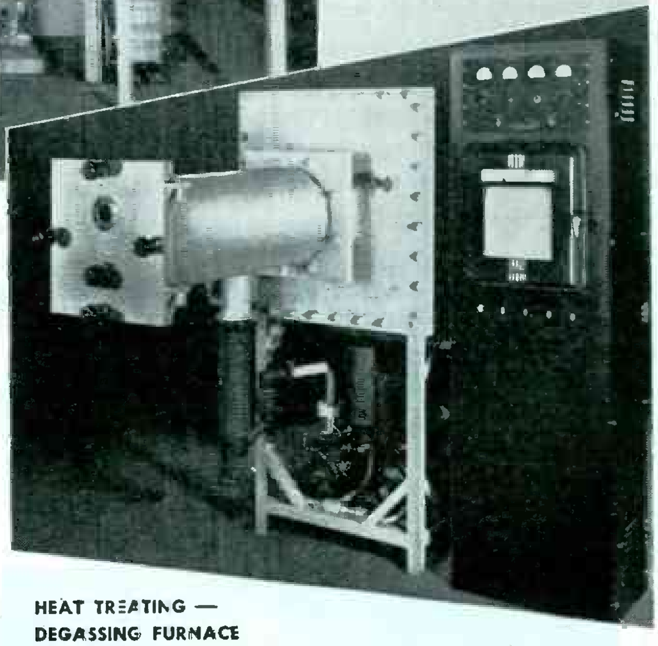

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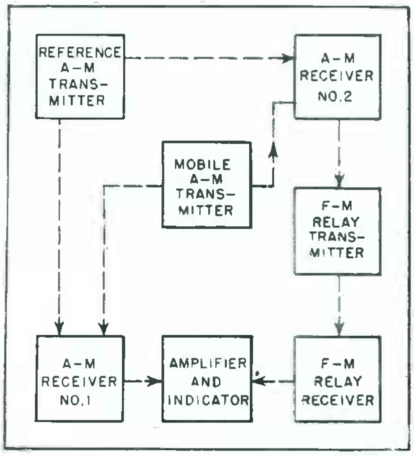


FIG. 1—Airline distance is measured with this setup

ceiver is relayed by f-m radio or land line to the amplifier-indicator.

Such an arrangement of equipment as described above indicates range from a reference point. If position is to be indicated, an additional a-m receiver is added and the beat frequency developed by it used with the beat frequency from either of the other two receivers to obtain an additional coordinate thus giving a fix.

Phase Integration

The beat frequency developed at each a-m receiver as a consequence of its receiving signals from two transmitters, the fixed reference one and the mobile one, is fed as a phase shift through the amplifier shown in Fig. 2 to a counting synchro. As the received phases change, the synchro rotor revolves driving the distance counter. Because the frequency of the beat is proportional to the speed of the mobile transmitter, true ground speed of an aircraft can be indicated by feeding the beat frequency to a direct-reading frequency meter calibrated in units of speed.

That only the frequency of the

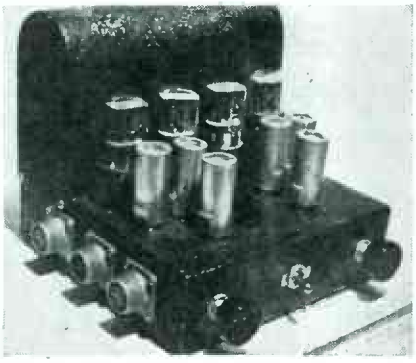
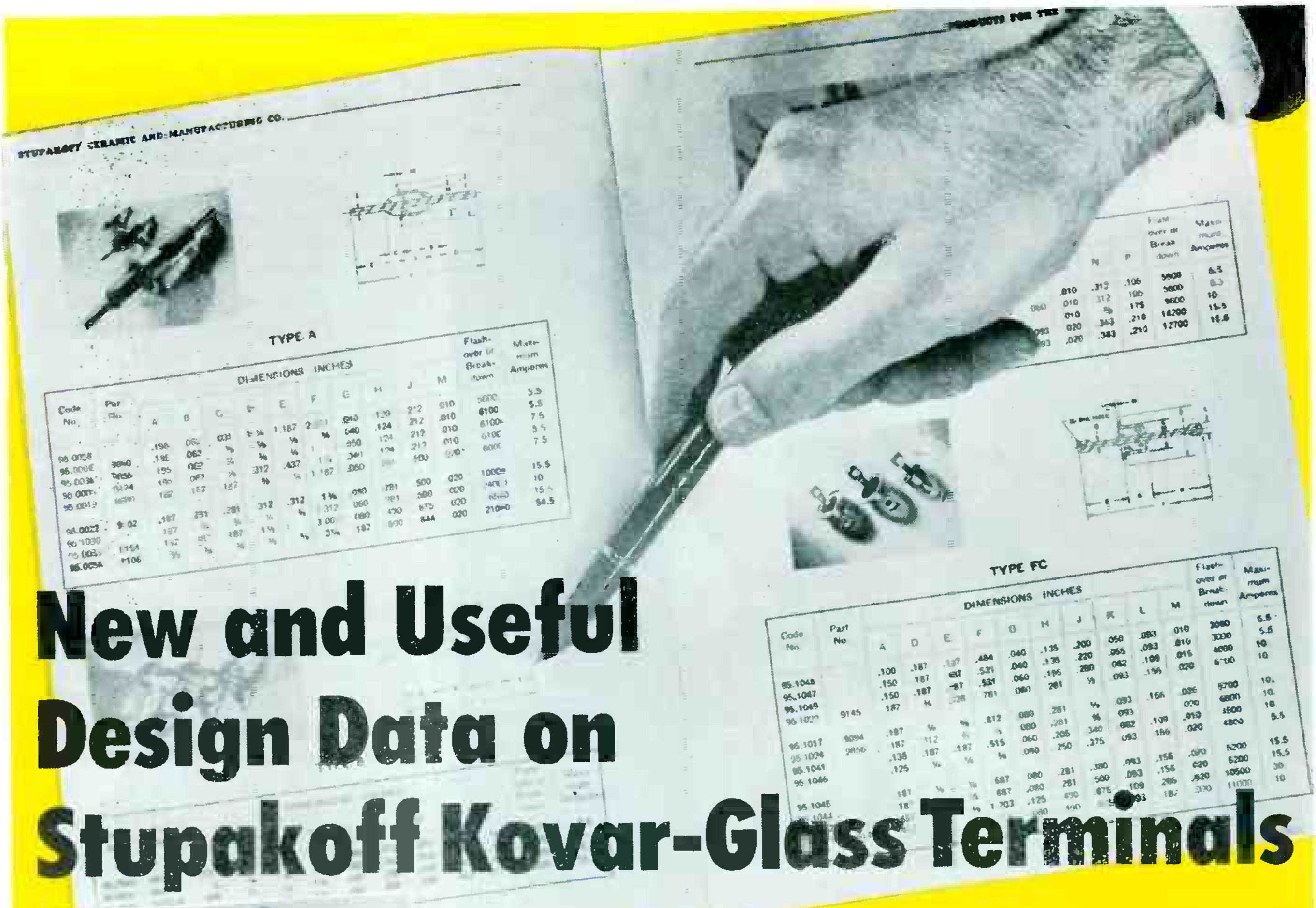


FIG. 2—Two-channel amplifier drives distance indicator



New and Useful Design Data on Stupakoff Kovar-Glass Terminals

Complete dimensions, capacities and ratings for more than one hundred and sixty different standard Stupakoff Kovar-Glass Terminals are included in Bulletin 447, pages of which are reproduced above. In addition to these, Stupakoff is prepared to make special designs when required. The illustrations at the left show a few of the varieties of terminals listed in this bulletin. If you use—or expect to use—metal-glass terminals, you should have a copy of this informative data book. Send today—it's free!

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Ceramic and Manufacturing Co.
Latrobe, Pa.
Cable Address "STUPAKOFF, LATROBE, PA."

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mobile transmitter determines the accuracy of the system can be seen from the following considerations. The mobile transmitter frequency f is heterodyned by a reference transmitter operating on a slightly higher frequency $(f + \Delta f)$. The first receiver, which the mobile transmitter is approaching, receives the signal from the mobile transmitter at a slightly higher frequency as a result of Doppler effect, but receives the signal from the fixed transmitter without modification. This receiver beats these two frequencies giving a frequency

$$\begin{aligned} f_{R1} &= (f + \Delta f) - (f + fV/C) \\ &= f + \Delta f - f - fV/C \\ &= \Delta f - fV/C \end{aligned}$$

where C is the velocity of propagation of the radio signals, and V is the velocity of the mobile transmitter toward the first receiver. Similarly, the frequency developed by the receiver from which the mobile transmitter is receding is

$$f_{R2} = \Delta f + fV/C$$

These two heterodyne signals are mixed giving a beat frequency

$$f_B = f_{R1} - f_{R2} = 2fV/C$$

Thus all but the mobile transmitter frequency, the velocity of propagation, and the desired speed (integrated into distance) cancel out.

Because the system compares beats produced at two different points from the same two frequencies, it is free from drifts in the receiving equipment. Use of a transmitter in an airplane or other vehicle whose position is to be indicated increases the efficiency of the system over that of radar methods depending on reflections from passive targets, and is more accurate than methods relying on transponders. In applications, the indicator can be at any position, such as with the mobile transmitter on the airplane, the two receivers being at airports between which the plane flies and the reference transmitter between them. The system is especially useful in measuring velocity of propagation of radio waves.

Vertical Position Indicator

GAS-FILLED Y-type position convectron tube develops an unbalance voltage proportional to the sine of the angle of rotation from the vertical. Thus the tube is a useful

SOLVING TOUGH RESISTOR PROBLEMS

"Globar" Type "A" Ceramic Resistors by "CARBORUNDUM" are fired at temperatures up to 2500°F. in electrically heated furnaces under carefully controlled conditions.

They are conservatively rated and possess a high degree of Permanence of Characteristics. They will not exhibit a permanent change of characteristics after moderate temporary overloads.

They have a small negative temperature coefficient of resistance ranging from 0.08 per cent per degree C. for low resistance values up to 0.12 per cent per degree Centigrade, for resistance values up to 0.1 megohm.

Type "A" resistors in R.M.A. values are calibrated by the comparison method on the voltages specified in Joint Army and Navy specification JAN-R-11. Type "A" resistors can be manufactured in any size and resistance range listed in the accompanying tables. The Carborundum Company, Globar Division, Niagara Falls, N. Y.

TABLE I

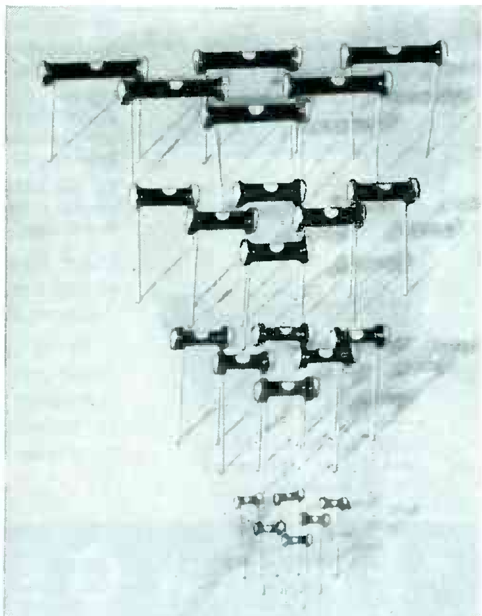
Part Number	Rating in Watts	Resistance Range*	Overall Length Inches	Overall Diameter Inches	Tinned Wire Length	Copper Leads Diameter
997-A	1/5	10 Ohms — 4.7 Megohms	21/64	7/64	1 1/8"	0.016"
763-A	1/4	10 Ohms — 15 Megohms	5/8	7/32	1 1/2"	0.032"
759-A	1/2	10 Ohms — 15 Megohms	3/4	1/4	1 1/2"	0.032"
766-A	1	10 Ohms — 15 Megohms	1 1/8	1/4	1 1/2"	0.032"
792-A	3	10 Ohms — 150000 Ohms	1 7/8	15/32	1 1/2"	0.040"
774-A	5	10 Ohms — 220000 Ohms	2 5/8	15/32	1 1/2"	0.040"

*R.M.A. Values ± 10% and ± 20% only.

TABLE II

Diameter in Inches	Resistance in Ohms Per Inch of Length		Length in Inches		RATING
	Minimum	Maximum	Minimum	Maximum	
1/2	10	250000	2	8	Continuous Duty Rating is based on one watt per sq. in. of external radiating surface.
5/8	7	250000	2	10	
3/4	3	100000	3	18	
1	2	50000	4	18	

Resistors listed in Table II can be supplied with metallized ends of brass, copper, nickel, tinned brass or tinned copper, also with tinned copper wire (No. 14 B.S.G.) leads approximately six inches long. Resistance tolerances on Type "A" Resistors limited to ± 10% and ± 20% only.



GLOBAR

Ceramic Resistors

BY CARBORUNDUM

TRADE MARK

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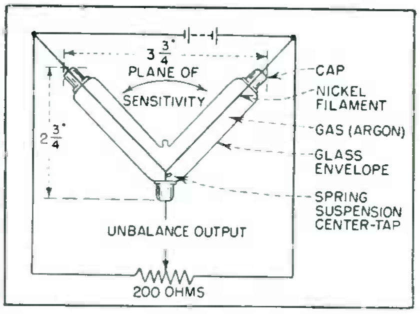


Convectron vertical position sensing tube made by Eclipse-Pioneer Div. of Bendix changes resistance of its two arms when displaced in the plane through its legs

sensing element in positioning servomechanisms. It is simpler to mount than mechanical indicators, has no moving parts, and directly gives an electrical output.

Operating Characteristics

The tube and bridge circuit in which it can be used are shown in the diagram. The filament is heated by either alternating or direct current. It looses heat chiefly by gas convection. Because the gas convection currents rise vertically passing the filament at an angle dependent on the tube's orientation, the cooling of the two legs of the filament is different for different angular positions in the plane through the tube. The filament is made of nickel so that its resistance changes appreciably with temperature, thus, in a bridge circuit, these resistance changes upset the balance when the tube is displaced from its normal position.

Convection currents in the tube are caused by differences in mass between heated and cooled portions of the gas. As a vertical position indicator, these differences of mass react with the force of gravity to produce convection flow. However, if the tube is accelerating (linearly or rotationally), there is an acceleration force against which the differences of mass react to produce convection currents. Under this condition the tube will indicate displacement from the vector sum of the gravitational and accelerational forces. The Convectron can, consequently, be used as an accelerometer (but is insensitive during free fall).

In operation the filament is heated to an average of about 400 C. If a d-c source is used for the bridge, the unbalance output re-

verses polarity as the tube moves through its null position; if an a-c source is used, the output reverses phase. The tube thus senses direction as well as degree of displacement. Time constant of the tube is about 0.1 sec, and the displacement signal is about 50 millivolts per degree at null. Resistance is a function of operating voltage

Supply Emf in volts	Current in ma	Resistance in ohms
0	0	50
5	56	89
10	74	133
15	80	188

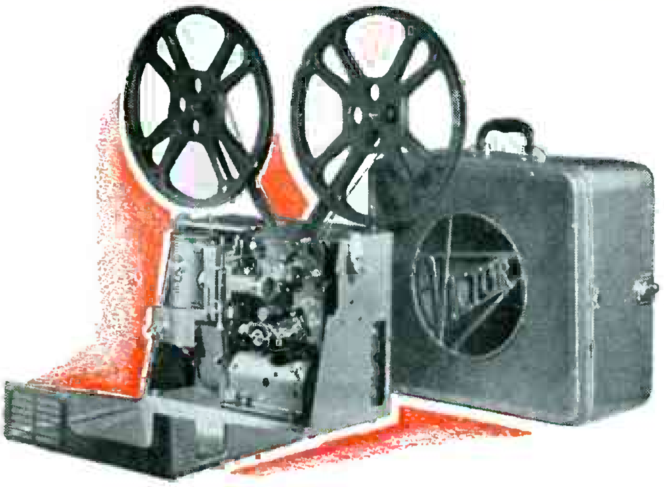
the tube being most sensitive with a supply of about 10 volts, at which voltage it draws less than a watt. With an a-c supply the noise level is between 1 and 5 millivolts, and is less for d-c supply. Using a d-c supply, displacements as small as one second of rotation can be detected. For such extreme sensitivity the null is affected by ambient temperature and supply voltage; random air currents striking the tube affect ambient temperature.

Statistical Methods Simplify Evaluation of Data

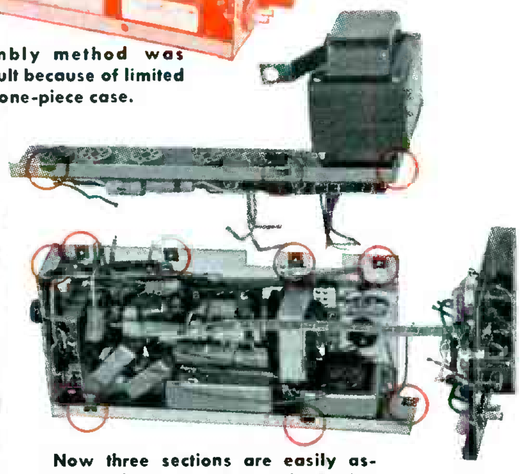
INTERPRETATION of many forms of data can best be done statistically. Although the usual approach to a series of measurements is to determine a simple mathematical equation that describes them (and can be considered an expression of the natural law governing the phenomena under study), it is frequently more realistic to approach the measurements from a statistical basis, recognizing the fact that there is a spread in the measurements for any one condition. (Quantum mechanics on which modern physics is based is predicated on this statistical approach.) How such a statistical analysis can be made is illustrated by the recently developed method of predicting sunspot activity in connection with forecasting radio propagation by the National Bureau of Standards, and by the technique of determining the specifications for and the evaluation of the terrain clearance indicator for

"WE DO FIND THAT WE HAVE REDUCED OUR ASSEMBLY COST APPROXIMATELY 36% ON THIS UNIT SINCE BEGINNING TO USE THE TINNERMAN SPEED NUT"

This is a direct quotation from a letter from A. S. Webeck, Works Manager of the Victor Animatograph Corporation, Davenport, Iowa, makers of 16 MM sound motion picture equipment.



Former assembly method was extremely difficult because of limited confines of this one-piece case.



Now three sections are easily assembled separately, and quickly fastened together with SPEED NUTS into completed unit.

SPEED NUTS always effect substantial savings in assembly cost, but here is a case of unusually high savings.

Victor Animatograph Corporation accepted our suggestions on the assembly of their amplifier unit. They discarded their time-consuming practice of assembling a myriad of small parts in a crowded case. Now the amplifier is assembled in three easy-to-get-at sections that are quickly fastened together with SPEED NUTS to complete the unit.

Assembler training time is cut from two months to a few hours. Assembly time is slashed, employee morale improved, and with three assembly lines instead of one, the risk of complete production stoppage due to shortage of one or two parts is avoided.

Let us demonstrate what SPEED NUTS can accomplish in improving the assembly of your product.

TINNERMAN PRODUCTS, INC.
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anticollosion aircraft flying developed by Hughes Aircraft Co.

Predicting Sunspot Activity

Solar activity, which greatly affects radio communication, is evidenced by sunspots. The number and activity of the sunspots varies greatly over an 11-year period, indicating local variations in sun's temperature, and hence the relative intensity of radiation from the sun that in turn determines the condition of the earth's ionsphere. Basic information on sunspot numbers is obtained from the Zurich Observatory in Switzerland, which has made continuous records of solar activity since 1849, and from other observers. Sunspot number is obtained by counting the number of sunspot groups, multiplying by ten, and adding to the result the number of individual sunspots in each group. This statistical convention is the worldwide standard method of recording such data.

Whereas previous methods of prediction depended on harmonic analysis, assumption that cycles repeat after a number of years, and various empirical relationships between heights of maxima and rates of rise, the statistical method advanced by A. G. McNish and Virginia Lincoln of the National Bureau of Standards assumes that, in a time series exhibiting cyclical tendencies, a first approximation to a future value is the mean of all past values at the same stage of the cycle, and that this first approximation can be improved by adding to the mean a correction proportional to the departure of earlier values of the same cycle from their respective means. The second assumption is justified by the observed tendency in sunspot numbers from annual deviations from the mean to have the same sign and similar magnitudes in con-

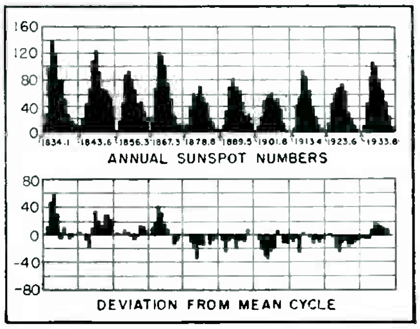

FIG. 1—Sunspots from 1834 to 1944

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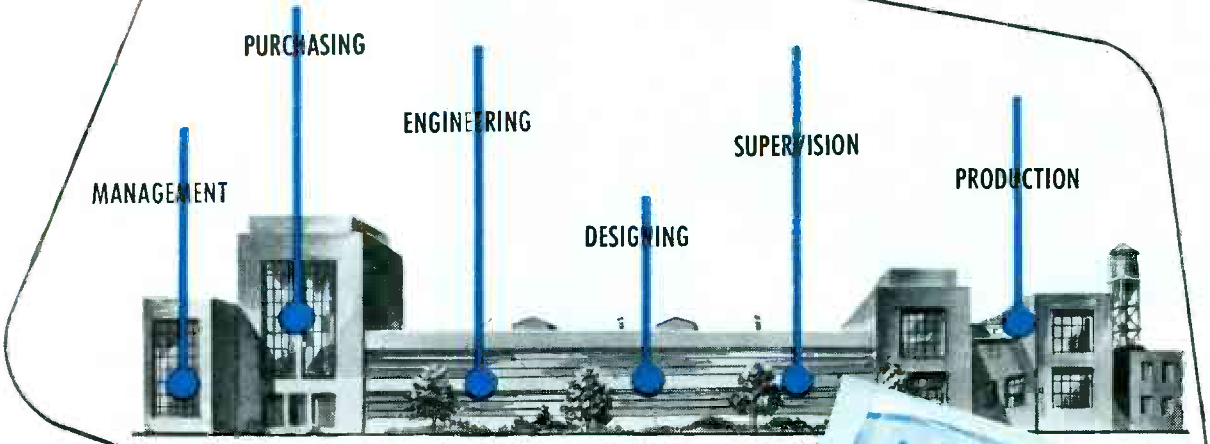

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These men have learned to rely on, and use the Buyers' Guide for information on product sources *and* technical data on those products. A handy desk package for the time-pressed designers—the only directory of its kind—containing accurate information on all products concerned with their work. When they look up a needed component or product and find one with correct characteristics—a sale has been made.

As a matter of fact, that is your Point of Sale. Once a product has been designed into the pilot model the time for selling, 9 times out of 10, is passed. It is either too late or too difficult to change or fit in a substitute. Don't overlook this year round salesman—be sure to include it in your 1948 advertising budget.

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electronics BUYERS' GUIDE

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secutive years. Figure 1 shows, at the top, the sunspot numbers recorded in the past, and, at the bottom, the deviation from the cyclic mean. The prediction formula for the future is of the form

$$R_n' = R_n + k_{n-1} \Delta R_{n-1} + k_{n-2} \Delta R_{n-2} + \ldots$$

where R_n' is the predicted value in a particular cycle, R_n is the mean of all corresponding values in preceding cycles, $\Delta R_{n-1}'$ is the deviation of the particular R_{n-1} for this cycle from the mean of all R_{n-1} values from previous cycles, and the k values are proportionality constants.

Probability of Aircraft Collision

Airplane collisions with mountains have always constituted one of the spectacular hazards of airline operation. Statistical studies of terrain contours in the vicinity of principal airways over mountainous territory, and of CAA and CBA terrain collision reports from 1933 to 1946, have revealed two significant facts. Most accidents took place within 500 feet of the summit of the obstacle. Secondly, the profiles are such that if planes approaching peaks are given warning of terrain clearance of 2,000 feet (by a radio altimeter for example), the pilot could rise clear of the mountain by a routine evasive action of continuing in a straight course but climbing 900 feet in the first mile after clearance warning and continuing to climb at 500 feet a mile until the plane had climbed 2,000 feet or enough higher so that the warning signal disappears. This maneuver is readily executed at sustained power by most transports. Figure 2 shows a typical profile and how the evasive maneuver would avoid a collision. From these profiles it was found that pilots would be warned of flying too low on a weighted average of 7.5 miles from the peak, and in extreme cases only within 3 miles or as far away as 30 miles. The collision records (and normal expectations) indicate that pilots are more often flying close to the peak altitude than well below it. However, planes might attack at any altitude. Therefore, a weighting (that is conservative, judged by actual records) was assigned each 500-foot altitude interval; assuming that, of all the planes that might

Television buyers expect a lot...

They expect

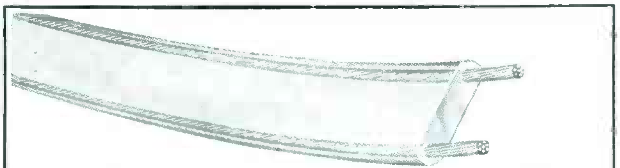
...ATV helps deliver

"It is interesting to note," writes Dan Halpin, RCA Victor Television Sales Manager, that this new kind of transmission line (ATV*), now widely used in television transmission between the antenna on a customer's roof and a receiver installed in the home, is identical with the line developed for wartime radar use, and which had to stand severe temperature changes and unusual climatic conditions.

"It is many times more efficient than any prewar line and is playing a large part in the success we are enjoying with RCA Victor television. By the end of this year television should serve approximately 35% of our nation's wired homes."

The well balanced design of conductors and dielectric in Anaconda Type ATV lead-in lines fulfills the exacting requirements of wide-band reception. For FM and television reception, these lead-in lines minimize the effects of attenuation and impedance mismatch—providing maximum freedom from distortion.

No wonder manufacturers are enthusiastic about ATV! Television buyers expect a lot and ATV helps to deliver. 47465



Anaconda offers to the industry a wide selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and 150 ohms shielded—each designed for a particular application. Anaconda also manufactures a complete line of coaxial cables. For characteristics of these products, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York.

ANACONDA from mine to consumer

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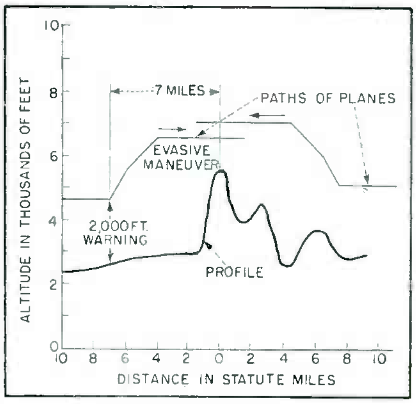


FIG. 2—Typical terrain profile

crash into a mountain side, five would be in the 500-foot level just below the peak, four in the next lower level, and so on with one plane each in all the very low levels. On this basis a 1,000-foot terrain clearance warning would avert 82 percent of all hypothetical crashes, and a 2,000-foot warning would avert 96 percent of them. In the east, where mountainous terrain is less rugged, a 500-foot warning would be sufficient to avert most accidents. On this basis a simple terrain clearance radar with a 2,000-foot and a 500-foot range that has been recently publicised was adopted for commercial use.

In the case of sunspot prediction, the analysis assures that, although the forecast will not be exactly correct, it will indicate the most likely condition. In providing anticollision radar, it would be difficult to determine the required range and predict the probable reliability of any specified radar without resorting to statistical analysis. Many engineering problems involving gross phenomena (sunspots and the like) or many variables and probabilities (terrain clearance) can be best solved by such statistical approaches as these.

Myographs

BY W. E. GILSON
Department of Medical Electronics

J. A. E. EYSTER
Department of Physiology
The University of Wisconsin Medical School
Madison, Wis.

IN STUDYING the sequence of heart action of the dog and the turtle, particular interest was centered on the fractionate contraction occur-

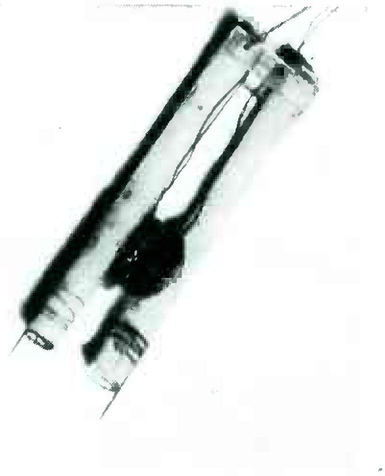


FIG. 1—Variable-inductance myograph has supporting columns made of 5-cm lengths of soda straw. Points are usually so spaced on specimens that coils are 2 to 3 mm apart

ring at the onset of a complete contraction cycle. To observe this effect, it was necessary to construct a myograph, an instrument to measure displacement or velocity of muscular contraction.

It was assumed that the onset of contraction was signalled by the coming together of two closely spaced points on the surface of the heart. Consequently, the basic myograph element was a light frame, rather like a drafting divider, whose points rested on the surface of the heart and were drawn together as fractionate contraction occurred.

Overcoming Inadequacies

To record precisely the onset of contraction with the least possible time lag, the myograph had to have small inertia. In addition, the instrument had to rest lightly on the heart and be capable of being actuated by a very small force. Several myographs were constructed which proved less satisfactory than the variable-inductance unit finally developed.

The first unit constructed was based on a capacitance principle. Two insulated plates, forming a variable capacitance, were mounted on the arms of the myograph so that the capacitance increased when the points came together. This capacitor was connected across the tank circuit of a variable-frequency oscillator, working at approximately 456 kc. The output of the oscillator was detected after passing

through a 456 kc i-f transformer. The frequency of the oscillator was set so that it came in the middle of the sloping side of the response characteristic of the transformer. Thus the d-c output of the detector was a direct function of the capacitance of the myograph. An alternative method used the same myograph in a bridge circuit.

Curves were obtained with this myograph measuring fractionate contraction of the turtle venticle. These curves, however, indicated that the entire heart contracted simultaneously, which did not agree with other data obtained from the same animal. The myograph was then tested by tying its points together and placing it on the heart. The same type of curve was obtained as before, showing that the effect of the varying capacitance to the body with movement of the heart practically obliterated the curve of local contraction.

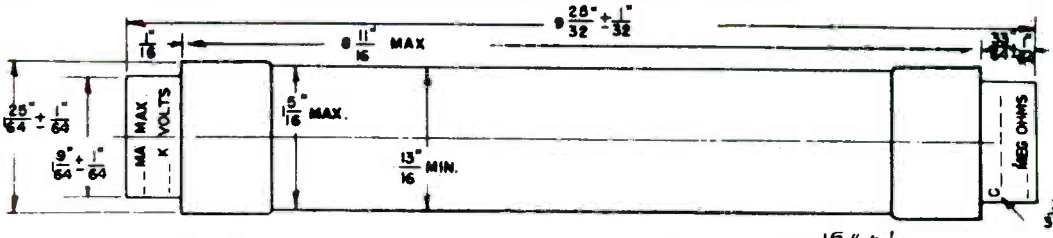
A second instrument was then built, in which the plates were completely shielded from external changes of capacitance, and a shielded lead was used to connect to the plates. This model worked considerably better, but was still not satisfactory, because when the points were tied together and the myograph placed on the turtle heart, a small curve was still obtained. This curve was found to be caused by a change in the capacitance of the shielded lead even with slight bending.

Satisfactory Types

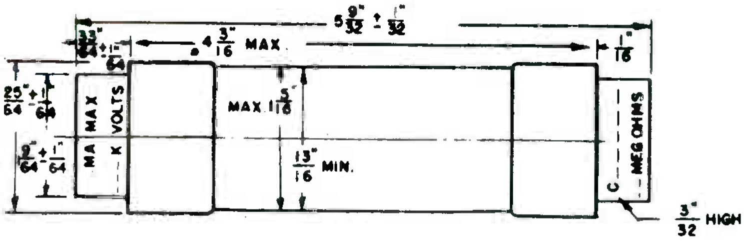
The third type of myograph' was considerably more satisfactory. It consisted of two pieces of filter paper wet with salt solution, mounted in a V on the arms of the myograph, so arranged that when the points were brought together, the V would shorten, decreasing its resistance. This variable resistance was placed in a bridge circuit energized by a 50,000-cycle oscillator to eliminate polarization. The output of the bridge was rectified and connected to the recording mechanism.

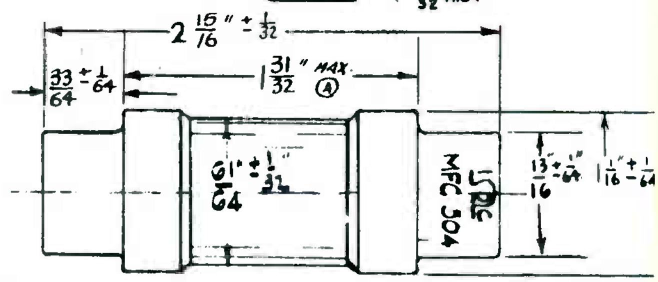
Many excellent records were obtained with this device, but it was still not altogether satisfactory as there was drift of the reference

VOLTMETER MULTIPLIERS



TYPE MFA





TYPE MFB

Type	Resistance Megohms	K. Volts	Navy Type No.
MFB 105	1.0	1.0	63754
MFB 155	1.5	1.5	63755
MFB 205	2.0	2.0	63747
MFB 255	2.5	2.5	63774
MFB 305	3.0	3.0	63825
MFB 355	3.5	3.5	—

TYPE MFA

Type	Resistance Megohms	K. Volts	Navy Type No.
MFA 355	3.5	3.5	63775
MFA 405	4.0	4.0	63815
MFA	4.5	4.5	—
MFA 505	5.0	5.0	—
MFA 605	6.0	6.0	—

TYPE MFC

Type	Resistance Megohms	Maximum Current M.A.	K. Volts
MFC 504	0.5	1.0	0.5
MFC 804	0.8	1.0	0.8
MFC 105	1.0	1.0	1.0

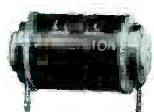
IRC PRECISION WIRE WOUND RESISTOR SPECIFICATIONS

WW-1
WW-2

WW-3

Type	Wattage	Length	Diameter	Range: Minimum	Range: Maximum	Terminal	Winding
WW-1	Below .36 meg. 1 watt—above 600 volts max.	2 1/8"	9/16"	.1 ohm	600,000 ohms	Binding Post and nut	Non-inductive
WW-2	Below 1 meg. 1 watt—above 1,000 volts max.	2 15/16"	7/8"	.5 meg.	2.5 meg.	Binding Post and nut	Non-inductive
WW-3	Below 40M ohms 1 watt—above 200 volts max.	9/16"	9/16"	1.0 ohm	150,000 ohms	lugs leads	Non-inductive
WW-4	Below .16 meg. 1 watt—above 400 volts max.	1"	9/16"	.1 ohm	600,000 ohms	lugs leads	Non-inductive
WW-5	Below .2 meg. 1 watt—above 400 volts max.	1 1/4"	3/4"	.25 ohm	1.0 meg.	lugs leads	Non-inductive

WW-4



WW-5

CONSTRUCTION

CERAMIC — The winding form of these units is made of a non-hygroscopic ceramic having high insulation qualities, high mechanical strength and low coefficient of expansion.

WIRE — Only ample size, special alloy wire, specially enamelled to meet a rigid insulation test, is used in making these units. Not less than .0014" in diameter.

IMPREGNATION – The winding is impregnated with a special varnish, which improves the insulation and eliminates breakdowns and shorted turns. The characteristics of this impregnating compound are such that it hardens with high temperatures instead of softening as is the case with the wax impregnation found in the average wire wound resistor. Almost complete protection from the effects of high humidity results from this impregnation.

TECHNIQUE — Special attention has been paid to insure transfer of special enamelled wire to winding form without strain or break in insulation. Special tests such as voltage flash, etc., are utilized to indicate possible shorted turns thus insuring finest quality.

TERMINALS — To insure positive connection at the terminals, the exclusive IRC molded contact is employed on these units. This eliminates the weakness encountered in a mechanically clamped, soldered or welded contact and forestalls contact resistance, loose connections and noise.

TOLERANCE — Standard 1.0% tolerance. ½, ¼ and 1/10% are available. ¼ and 1/10% tolerance are measured with a temperature correction to 68°F.

TEMPERATURE COEFFICIENT — Up to approximately 25% of maximum value shown—.002%/°C. Beyond 25%—.017%/°C.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

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PRECISION

VOLTMETER MULTIPLIERS

JOINT ARMY-NAVY SPECIFICATION — JAN R-29

Types MFA, MFB and MFC Resistors offer a proven solution to the problem of finding suitable and dependable multipliers for use under the most severe humidity conditions, such as are encountered in marine service. They may be used with the commonly available one milliampere DC instruments, as well as with other instruments. Sensitivities of 1000 ohms per volt or more may thus be obtained, which results in very little drain on the power supply. They are compact, rugged, stable, fully moisture-proof and easy to install.

RATING

(a) *Current rating:* 1.0 milliamperes maximum.

(b) *Voltage rating:* The voltage rating in kilovolts is numerically equal to the resistance expressed in megohms, e.g., a 3 megohm resistor would be rated at 3 kilovolts.

TEMPERATURE COEFFICIENT

Not greater than 0.02% per degree centigrade over temperature range—40° to 100° C.

SURFACE TEMPERATURE RISE

Not over 25° C. at standard voltage rating.

INTERNAL TEMPERATURE RISE

Not over 55° C. at standard voltage rating.

FREQUENCY CHARACTERISTICS

Resistance non-inductively wound. Resistance varies less than ±1% at any frequency up to and including 1,000 c.p.s.

DIELECTRIC STRENGTH

Multiplier will withstand a voltage of more than 20,000 volts peak between center band around resistor and shorted terminals.

WIRE

Nichrome and advance enameled. .0015" diameter minimum.

TERMINALS

Monel metal ferrules suitable for mounting in 60 ampere form #1 fuse clips.

INSULATION RESISTANCE

Greater than 10,000 megohms.

FERRULE SECURING

Ferrules will resist a torque greater than 5 inch pounds without shifting or loosening.

TRANSVERSE LOADING

Resistor will withstand transverse load of more than 25 lbs.

RESISTANCE TO HUMIDITY

The resistor will withstand more than 9 cycles of the following test without changing more than 1%:

(a) Keep resistor at temperature of 80° C. for 5½ hours and then measure resistance.

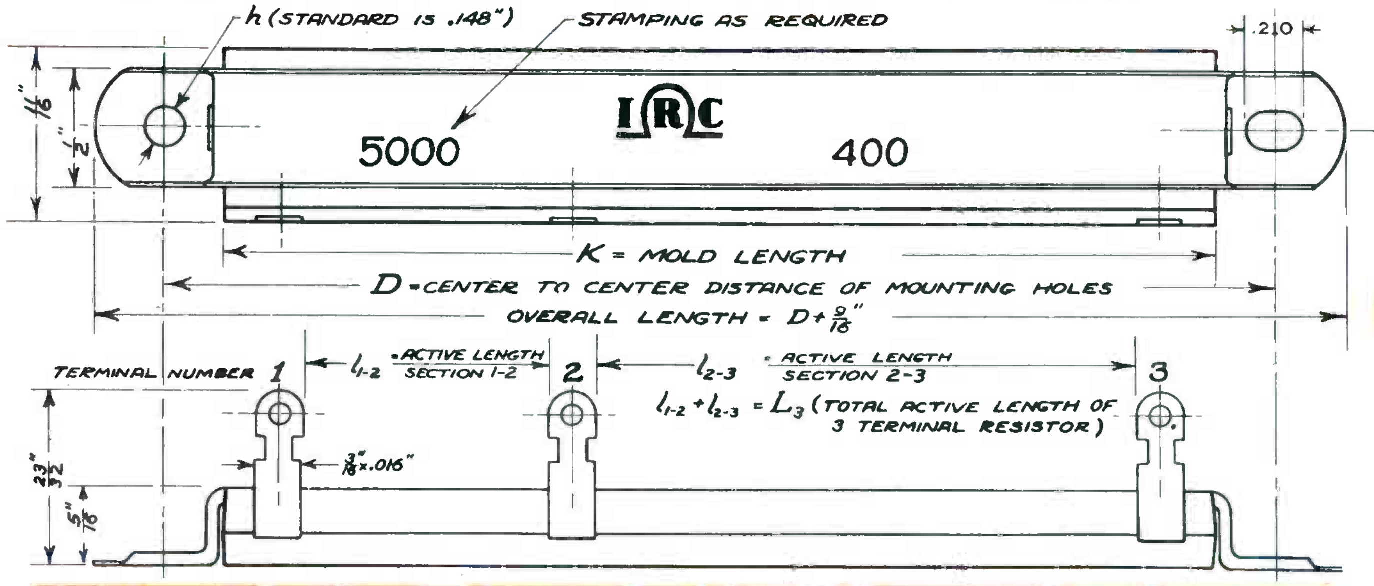
(b) Immerse resistor in 65° C. saturated salt solution for 2 hours.

(c) Transfer to bath of 0° C. saturated salt solution for 2 hours. Wash in clear water.

(d) Maintain resistor at 80° C. for ½ hour.

(e) Apply rated voltage for 1½ hours.

SPECIFICATIONS
TYPE MW
INSULATED WIRE WOUNDS



Unit Type IRC Designation	K = Mold Length	Dmin. = Minimum Mounting Center Distance (= IRC Std.)	Two Terminal Resistor Only*				Minimum length per section 1/3" between terminals Minimum value—3 ohms per inch of winding length Maximum value—7400 ohms per inch of winding length Minimum ohms given are based on No. 90 alloy wire						
			Rated Watts 100° C. Rise		Range in Resistance Value		Active winding length for Multi-Section Units						
			Free Air	On Plate	Min. Ohms	Max. Ohms	1 Sec.	2 Sec.	3 Sec.	4 Sec.	5 Sec.	6 Sec.	7 Sec.
MW-2	2"	2 1/2"	3.9	7.4	4.13	10,000	1.375	1.187	1.000	—	—	—	—
MW-3	3"	3 1/2"	5.8	10.9	7.13	17,500	2.375	2.187	2.000	1.812	1.625	—	—
MW-4	4"	4 1/2"	7.6	14.4	10.1	25,000	3.375	3.187	3.000	2.812	2.625	2.437	—
MW-5	5"	5 1/2"	9.5	17.9	13.1	32,500	4.375	4.187	4.000	3.812	3.625	3.437	3.250

NOTE—Specify resistance value and actual wattage load per section when ordering.

TOLERANCE

Standard Tolerance 10%—Closer tolerance available at extra cost.

MARKING

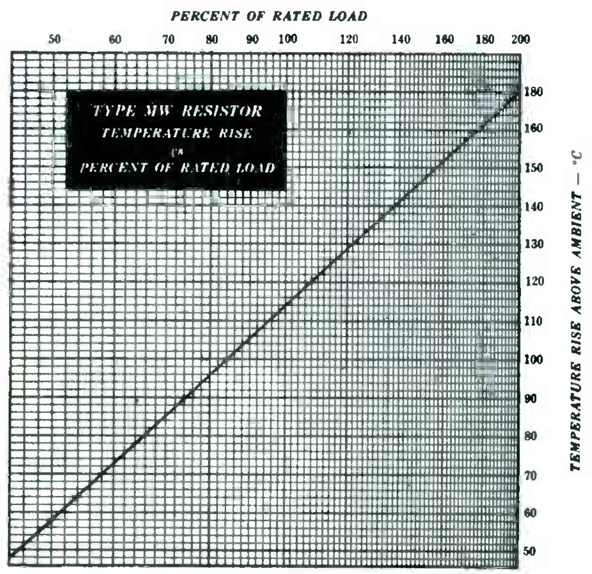
Any required marking can be printed on the top of the mounting bracket.

OVERLOAD

Conservative ratings and high heat dissipating efficiency allow overloads of 150% indefinitely with negligible adverse effects.

HUMIDITY

Continuous operation at 40° C. in an atmosphere of 90% relative humidity at any load—either AC or DC produces no effect on the resistor element—operation in a saturated salt spray bath for 1000 hours at 30° C. has no effect other than terminal corrosion. The resistor is virtually impervious to atmospheric conditions of any type.



(Fig. 3)

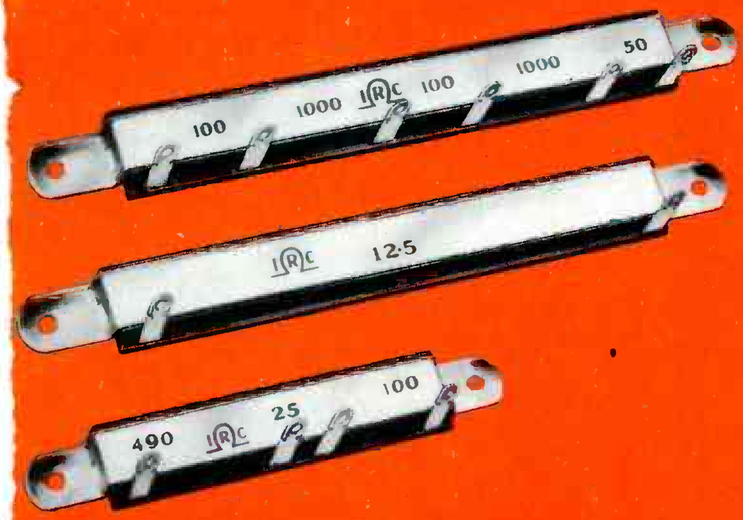
CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

TYPE MW



WIRE WOUND RESISTORS

Because of its radical departure from conventional design, the type MW Insulated Wire Wound Resistor is unsurpassed for adaptability to an extremely wide variety of design requirements. Completely insulated and protected, these flat type resistors are encased in durable molded phenolic compound and mounted with a metal bracket of unique design. The mounting bracket actually transfers heat from inside the chassis to the outside, thus providing unusually rapid heat dissipation.

The type MW is virtually impervious to the elements, including moisture and salt spray—the common causes of trouble in ordinary wire wounds.

Many excellent opportunities for cost reduction are offered by use of the MW with its low initial cost, lower mounting cost, flexibility in providing taps at low cost, and saving in space.

Equally important, is the common-sense wattage rating established for the MW, in that it is rated at 100°C. to conform with modern engineering practice. Unlike most wire wounds, the MW may be operated at its full "on plate" rating, whether enclosed or not, without exceeding its rated temperature rise of 100°C. This permits, for example, the use of an MW 5 at 20 watts where a 60 watt tubular resistor would normally be required.

CONSTRUCTION

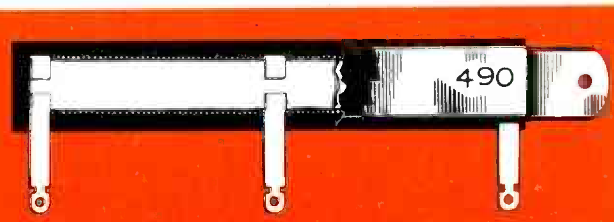
The Type MW is a flat wire wound resistor strip, permanently enclosed by high pressure molding in a special asbestos-filled phenolic compound. A permanently attached metal bracket with mounting feet permits mounting of the resistor on any flat metal surface, thus allowing rapid dissipation of heat.

TERMINALS. Standard Terminals are of rolled edge, heavily tinned strip punched with hole to take No. 14 B & S gauge wire and side notches for wrapping connections. Contact to the resistance element is made by clamping the specially formed terminal under high pressure.

Design of the terminal is such that no sheared edge can ever come in contact with the resistance wire, thus precluding the possibility of nicked wires.

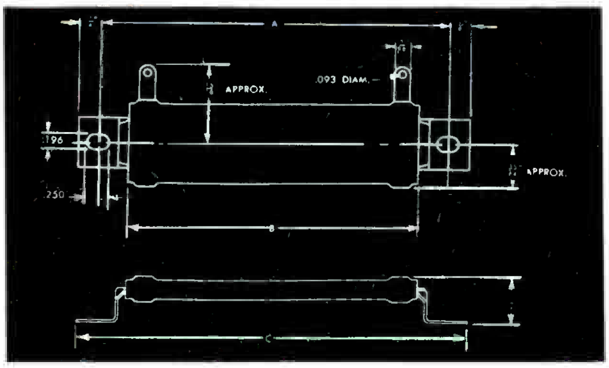
MOUNTING BRACKETS. Standard mounting brackets of tinned steel (brass provided on special request). Designed with mounting feet to be bolted or riveted to any flat surface. By extending mounting feet of brackets, almost any requirement for distance between mounting centers can be met. "D" dimension plus 2" is maximum.

INSULATION. All resistors are rated and tested at 1000 volts R.M.S. 60 cycle (1400 Volt Peak) applied along entire length between element and metal plate between all terminals and ground.



CROSS SECTIONAL VIEW

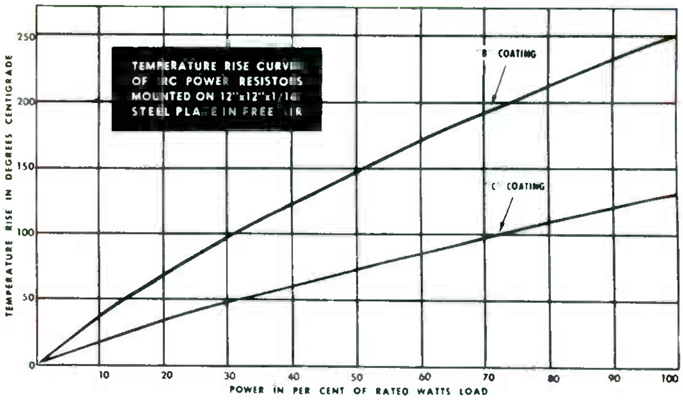
SPECIFICATIONS TYPE FRW POWER WIRE WOUND RESISTORS

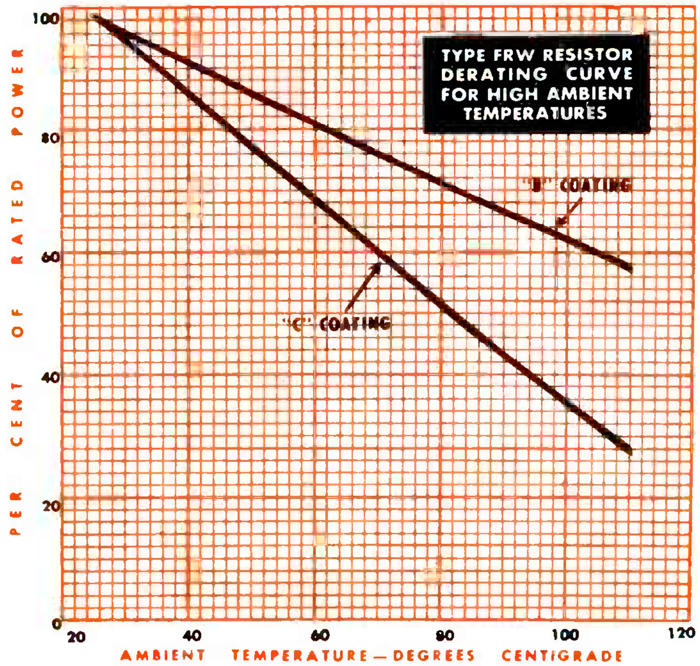


STANDARD IRC TYPE NUMBERS, DIMENSIONS and RESISTANCE RANGES									
IRC Type	IRC Power Rating (See Note)		Corre-sponding JAN Type	Dimensions			Minimum Ohms Available	Max. Ohms Available Wound With 0.0025" diam. wire	Max. Ohms Available Wound With 0.0014" diam. wire
	"B" Coat	"C" Coat		A Mounting Centers	B Ceramic Length	C Overall Length			
FRW-20	20 w.	8 w.	RW-20	2"	1¼"	2½"	0.5	2,000	9,500
FRW-21	30 w.	12 w.	RW-21	2¾"	2"	3¼"	0.5	5,000	23,000
FRW-22	50 w.	20 w.	RW-22	4¼"	3½"	4¾"	0.75	11,000	50,000
FRW-23	65 w.	26 w.	RW-23	5½"	4¾"	6"	1.0	15,000	80,000
FRW-24	75 w.	30 w.	RW-24	6¾"	6"	7¼"	1.5	21,000	100,000

NOTE: IRC RATINGS are based upon temperature rise of 250° C. for "B" Coat and 130° C. temperature rise for "C" Coat, for single resistors, mounted on a steel plate 12" x 12" x 1/16", in free air. For resistors mounted on a non-metallic surface, it is recommended that the standard power rating be reduced by 15%.

IRC POWER WIRE WOUND CHARACTERISTICS





DERATING. If necessary to operate Type FRW Resistors in an ambient higher than 25° C., it is recommended that they be derated according to the Derating Curve for High Ambient Temperatures. For example, if the resistor is normally a 50-watt type and is to operate at 60° C. ambient, it should not be loaded to more than 82% of 50 watts, or 41 watts.

COATINGS. Coatings "B" and "C" are especially developed cement coats, having as common characteristics neutral chemical reactions, processing temperatures not over 200° C. and extreme denseness. Through the use of low temperatures in processing the ceramic, wire and terminals maintain maximum life and strength, thus insuring long life at normal loads.

TYPE "B" COATING. Type "B" Coating is designed for high-temperature requirements where wire size is large enough to insure dependability. In Table A, the power ratings for Type "B" coat are based on a temperature rise of 250° C., from a 25° C. ambient. This coating is well suited to the requirements for normal humidity conditions.

TYPE "C" COATING. Type "C" Coating is a specially developed organic cement coat, designed to withstand the most extreme conditions . . . such as on shipboard, in tropical countries, and extremely humid climates. Power ratings shown in Table A for this Coat are based on a temperature rise of 130° C. above an ambient of 25° C. in free air. At no time should the total temperature (ambient plus rise) exceed 160° C.

TOLERANCE. On single and multi-section resistors, ±10% is standard tolerance. On single section resistors only, ±5% is available for resistance values above 50 ohms.

MULTI-SECTION RESISTORS. Tapped Resistors may be supplied, within the limitations of the resistor size used as listed below. The use of taps results in a reduction in total resistance available, due to loss of winding space. When specifying Tapped Resistors, provide wattage per section.

FRW-20	Single section only.
FRW-21	Two sections maximum.
FRW-22	Three sections maximum.
FRW-23	Four sections maximum.
FRW-24	Five sections maximum.

TERMINALS. Securely clamped around the ceramic winding form by spot welding; heavily hot-tin dipped for easy soldering.

BRACKETS. Non-magnetic metal brackets, so designed that resistors are readily mounted by rivets or screws. Bracket holes will clear #10 Machine screw.

MARKINGS. Permanently marked with type number and resistance.

WINDING FORMS. Highest grade, non-hygroscopic ceramic winding form, chosen for mechanical strength, resistance to thermal shock and freedom from moisture absorption.

WIRE. Copper-nickel and nickel-chrome alloys, largest sizes compatible with adequate spacing, wound with uniform spacing and tension.

INSULATION. 3000 volts A. C., R. M. S., between terminals and bracket.

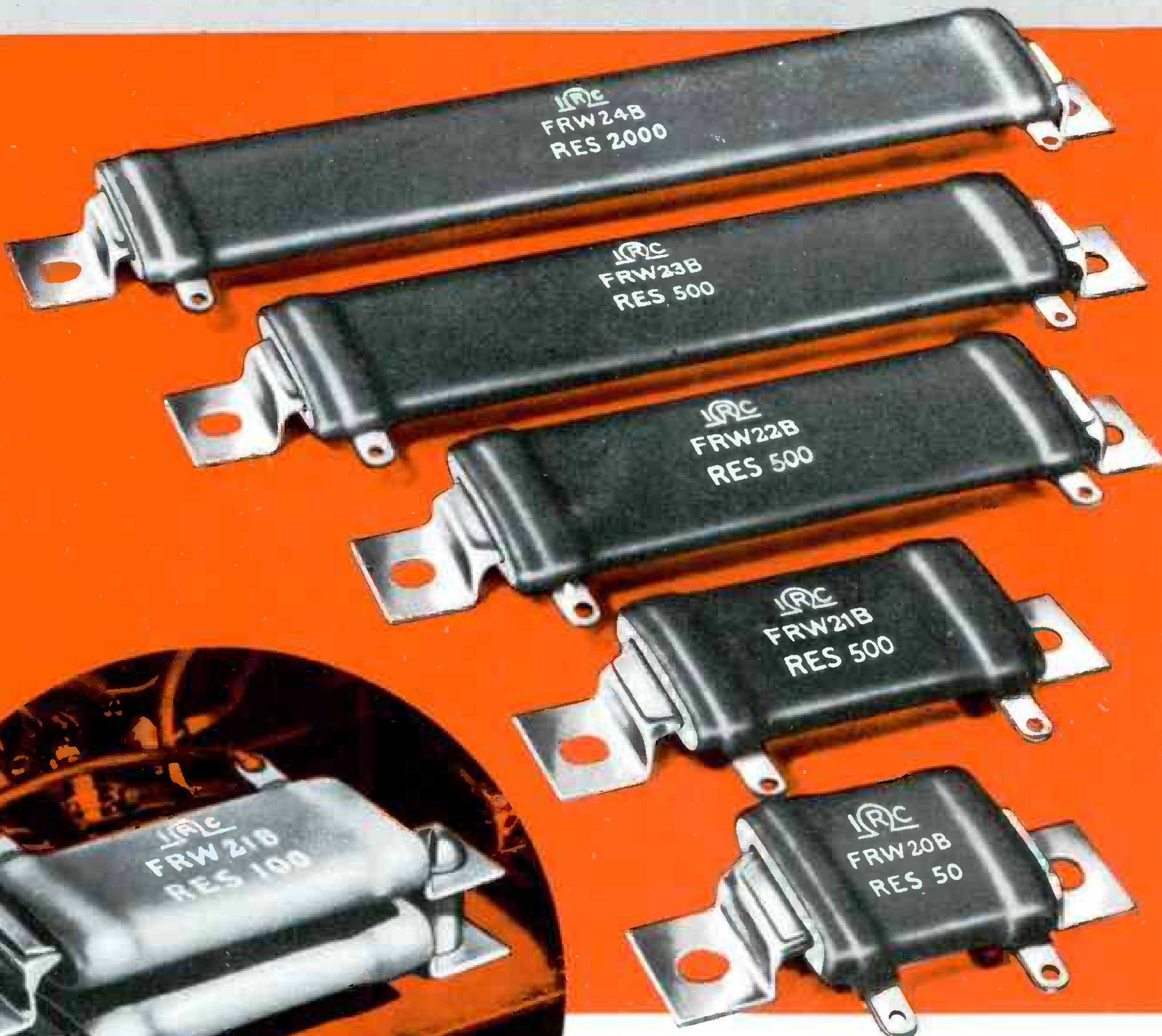
MECHANICAL STRENGTH. Will withstand a transverse load in excess of 25 pounds without mechanical or electrical damage.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee



TYPE FRW
FLAT
WIRE WOUND RESISTORS

Designed to fulfill requirements of high wattage dissipation in limited-space applications, the IRC Type FRW Flat Wire Wound Resistor has a higher space-power ratio than standard tubular wire wounds. For different operating conditions, IRC makes these compact resistors available in two coatings, the IRC "B Coat" or "C Coat."

The Type FRW is designed for vertical or horizontal mounting, either singly or in stacks. Non-magnetic mounting brackets extending through the resistor allow easy and economical mounting, aid in heat distribution along its entire length and serve as conductors to transfer internal heat to the chassis.

Other features of the Type FRW are light-weight construction, combined with exceptional mechanical strength; and the ability to withstand severe vibration. In every detail, Type FRW Flat Wire Wound Resistors reflect IRC's traditional standards of high quality.

ADJUSTABLE POWER RESISTORS

The IRC Adjustable Power Wire Wound Resistor consists of a standard tubular resistor with a track of exposed wire. Contact is kept with the wire by means of a metal band which, when power is turned off, can be adjusted to any position along the resistor.

The adjustable band, designated as IRC Type "X," features a stainless steel spring with a silver contact button. Constant pressure is provided regardless of temperature because the steel spring is tempered for temperatures above resistor operating temperatures. The silver button, being oxidation free, cannot corrode to cause open circuits or high resistance at point of contact.

Type "X" Adjustable Bands are furnished for "D," "E" and "H" size ceramics; size "A" ceramics, because of their small size, are furnished with an adjustable band specially suited for smaller size units.

By the use of more than one band, various taps can be brought out and the unit used as a voltage divider. Additional adjustable bands can be furnished separately.

Since, on adjustable units, the resistance wire cannot be completely covered for protection against humidity, care should be taken not to use high resistance values requiring the use of extremely small wire sizes. The following table shows the adjustable types available, with their minimum and maximum resistance values. Additional information pertaining to IRC Adjustable Power Wire Wounds is given in the specification table on page 2.

	IRC TYPE	Former Designation	MINIMUM OHMS Recom.	MINIMUM OHMS Available	MAXIMUM OHMS Recom. .0025 Wire	MAXIMUM OHMS Available .0014 Wire	IRC TYPE	Former Designation	MINIMUM OHMS Recom.	MINIMUM OHMS Available	MAXIMUM OHMS Recom. .0025 Wire	MAXIMUM OHMS Available .0014 Wire
STANDARD SIZES												
These standard sizes available from IRC Distributors' stocks	1¾" AA	ABA	.50	.10	1,700	7,500	6½" HA	HAA	7.	2.	50,000	160,000
	2" DA	DGA	1.	.20	3,750	15,250	8½" HA	HEA	8.	2.	70,000	200,000
	3½" EA	ENA	3.	.50	15,000	49,000	10½" HA	HOA	10.	3.	90,000	275,000
	4½" EA	EPA	3.	.60	21,000	68,000						
	6½" EA	ESA	4.	1.	32,500	100,000						
NON-STANDARD SIZES												
These non-standard sizes are manufactured to order	2½" DA	DHA	2.	.20	6,250	22,000	5" EA	ERA	4.	.70	24,000	78,000
	3" DA	DJA	2.	.30	8,750	30,000	4" HA	HDA	4.	1.	26,000	89,000
	4" DA	DDA	3.	.40	14,000	44,500	6" HA	HRA	7.	2.	45,000	145,000
	5" DA	DKA	3.	.60	18,000	58,000	8" HA	HSA	9.	3.	72,500	200,000
	3" EA	ETA	2.	.40	11,500	39,000	12" HA	HTA	14.	4.	100,000	300,000
	4" EA	EDA	3.	.50	17,500	58,000						

NON-INDUCTIVE POWER RESISTORS

IRC Non-Inductive Power Wire Wound Resistors utilize the Ayrton-Perry type winding which consists of two windings in parallel, wound in a single layer, in opposite directions. The turns of these windings touch at fixed points which are at the same potential and so eliminate capacitance effects. The power ratings are the same as those of standard inductive units.

The degree to which the inductance of these resistors is reduced is illustrated in the following table which shows the inductance of various size standard resistors as compared with that of the same size resistors wound with the Ayrton-Perry type winding.

TYPE RESISTOR	RESISTANCE OHMS	STANDARD WINDING INDUCTANCE MICRO-HENRIES	AYRTON-PERRY WINDING INDUCTANCE MICRO-HENRIES
1¾" A			
2" D	100	14	0.25
4½" E	80	76	0.3
6½" H	4,000	3,360	0.3

MAXIMUM RESISTANCE VALUES
FOR SOME NON-INDUCTIVE TYPES

TYPE	MAXIMUM RESISTANCE
1¾" NA	500 OHMS
2" ND	1,150 OHMS
4½" NE	5,000 OHMS
6½" NH	12,500 OHMS
10½" NH	22,000 OHMS

Since the Ayrton-Perry type winding consists of two windings and allowance must be made for suitable insulation between turns, it is impossible to wind the maximum resistance values given for standard resistors. The above table gives the maximum resistance values obtainable for some of the non-inductive types.

Non-inductive resistors are available in any of the standard Power Wire Wound sizes shown on page 2. The addition of the prefix letter N in front of the designation of a standard resistor is the designation of the non-inductive feature (4½" NE is a non-inductive 50 watt resistor).

INTERNATIONAL RESISTANCE CO.

401 NORTH BROAD STREET
PHILADELPHIA 8, PA. U. S. A.
TELEPHONE: WA 2-2166

IN CANADA: INTERNATIONAL RESISTANCE CO., LTD.
11 KING STREET WEST, TORONTO, LICENSEE

BRANCH OFFICE: 165 BROADWAY, NEW YORK, N. Y., Courtland 7-5020

SALES REPRESENTATIVES:

Hollingsworth & Still
407 Norris Bldg.
ATLANTA, Ga.
Main 5878

Ray Perron & Co.
131 Clarendon St.
BOSTON, Mass.
Kenmore 1370

Segor & Taylor Co.
4508 E. Genesse St.
DE WITT, N. Y.

S. B. Dormstader
308 W. Washington St.
CHICAGO, Ill.
Franklin 4818

Albert M. Baehr
11621 Detroit Ave.
CLEVELAND, Ohio
Lakewood 8468

George E. Anderson Co.
1903 Griffin St.
DALLAS, Tex.
Riverside 1272

Ronald G. Bowen
1886 S. Humboldt St.
DENVER, Colo.
Spruce 9368

Koehler-Pasmore Co.
8316 Woodward Ave.
DETROIT, Mich.
Madison 8086

Vernon C. Macnabb
P. O. Box 5971
INDIANAPOLIS, Ind.
Broadway 6770

Marshank Sales Co.
672 S. Lafayette Park Place
LOS ANGELES, Calif.
Drexel 8235

George C. Tanner
600 Grant St.
PITTSBURGH, Pa.
Court 0131

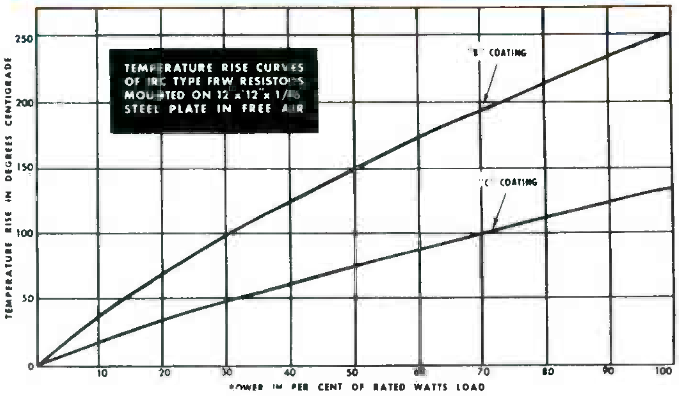
Norman W. Kathrinus
1218 Olive St.
ST. LOUIS, Mo.
Central 6300

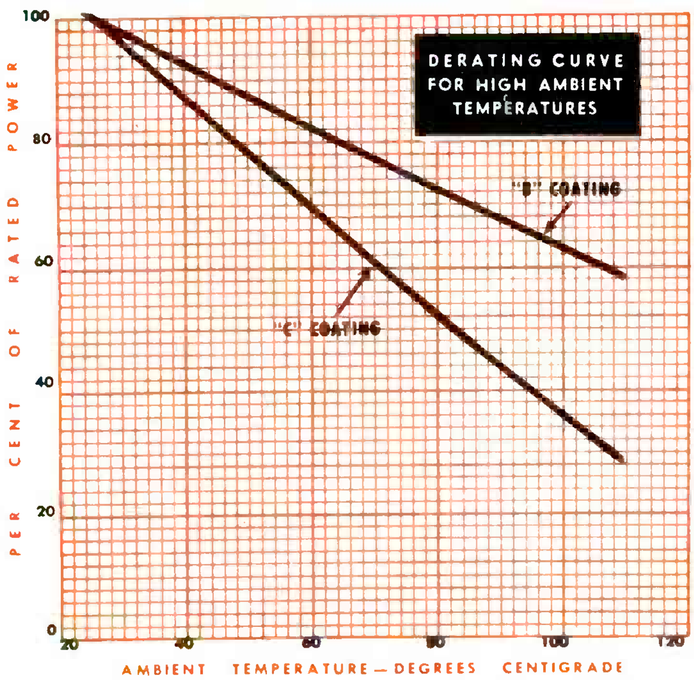
J. U. McCarthy
1725 Hillcrest Ave.
ST. PAUL, Minn.
Emerson 8619

James P. Hermans Co.
1234 Folsom St.
SAN FRANCISCO, Calif.
Market 4166

David M. Lee
2626 Second Ave.
SEATTLE, Wash.
Main 5512

CHARACTERISTICS TYPE FRW POWER WIRE WOUND RESISTORS





POWER RATINGS. Based on standards of the AIEE and NEMA — 250° C. temperature rise at hottest external spot when suspended in free air for the "B" Coat; this is reduced for the "C" Coat to 40% of rating and 130° C. temperature rise. Maximum protection against moisture is provided with organic materials. Actual wattage load versus size of resistor used should take into consideration maximum ambient expected, ventilation, proximity of other parts susceptible to excessive temperatures, as well as temperature limitation of coating used.

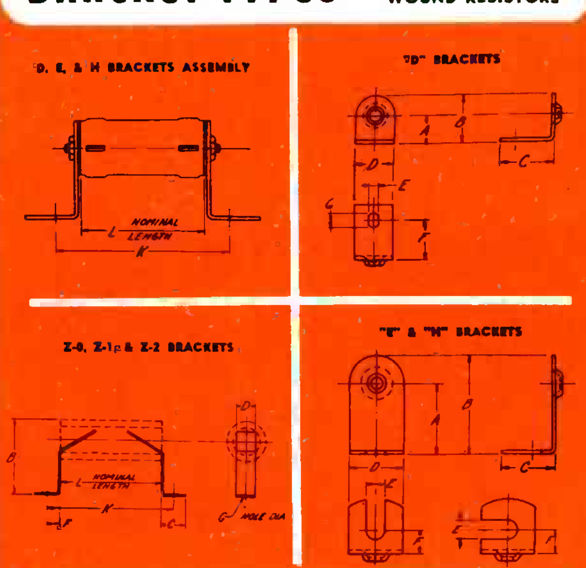
DERATING. If necessary to operate IRC Power Resistors in an ambient higher than 25° C., it is recommended that they be derated according to the Derating Curve for High Ambient Temperatures.

TAPS. Tapped resistors may be supplied within the limitation of the resistor size used. The use of a tap results in a small reduction of the power rating and ohmage available, since winding space is lost.

TOLERANCES. Standard tolerance 5% over 50 ohms. 10% below 50 ohms. Tolerances as low as 1.0% can be supplied at increased cost. The following table shows the minimum resistance value in which the various tolerances can be furnished for standard units. Minimum resistance value for non-standard units will be given upon request

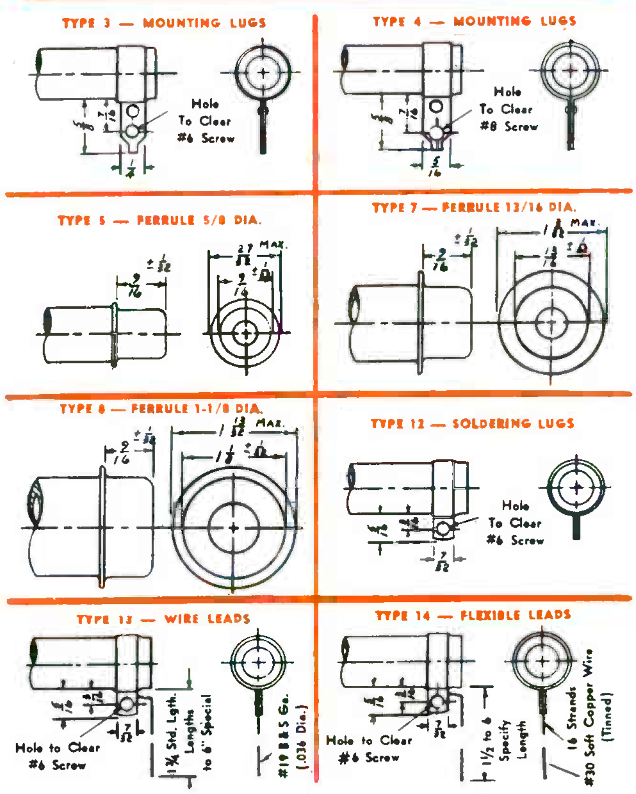
TYPE	1%	2%	3%	5%
1" A	——	3500 Ohms	1050 Ohms	50 Ohms
1¾" A	250 Ohms	35	11	2
2" D	300	35	9	3
3½" E	100	12	2	.30
4½" E	40	8	.75	.40
6½" E	45	6	.60	.20
6½" H	30	10	2	.50
8½" H	18	10	2	.50
10½" H	12	1	.50	.20

BRACKET TYPES POWER WIRE WOUND RESISTORS



Bracket Type	Used With Resistor Type	Dia.	A	B	C	D	E	F	G	Mounting Hole Centers
D	D	9/16	7/16	¾	⅞	⅝	.144	⅝	.218	K = L + 1-5/16
E	E	¾	1⅛	1-9/16	⅞	⅞	9/32	⅝		K = L + 13/16
H	H	1⅛	1½	2-1/16	1	1⅛	⅜	½		K = L + 1-1/16
Z-0	A	5/16		⅝	½	5/16		¼	.173	K = L + ⅜ to ½
Z-1	D	9/16		1⅜	½	5/16		¼	.173	K = L + ½
Z-2	E	¾		1½	½	⅝		¼	.173	K = L + ½

TERMINAL TYPES POWER WIRE WOUND RESISTORS



TERMINAL NUMBER	CERAMIC TYPE A 5/16" O.D.	C 7/16" O.D.	D 9/16" O.D.	E ¾" O.D.	H 1⅛" O.D.	FERRULE TYPES ONLY		TERMINAL MATERIALS
3	X	X	X	X	X			Brass
4	X	X	X	X	X			Brass
5							RW-15 RW-16	Monel
7			X			RW-13 RW-14		Monel
8					RW-16, 11, 12			Monel
12	X		X					Phosphor-Bronze
13	X		X					Phosphor-Bronze Lug • Copper Pigtail
14	X		X					Phosphor-Bronze Lug • Stranded Copper Lead

ON ADJUSTABLE RESISTORS #12 TERMINAL IS STANDARD FOR TYPES "A" AND "D" CERAMICS

SPECIFICATIONS

POWER WIRE WOUND RESISTORS

STANDARD STOCK SIZES

These standard sizes are available from IRC distributors' stocks

IRC TYPE	Former Designation	Corresponding JAN Type	Wattage "B" Coat 250°C. Rise	Wattage "C" Coat 130°C. Rise	Ceramic Length	O. D.	I. D.	Minimum Possible Ohms	Minimum Recom'd. Ohms	Max. Ohms Using .0025 Wire	Max. Ohms Using .0014 Wire
1" A	—		5	2	1"	5/16"	3/16"	.05	.50	450	4,000
1¾" A*	AB		10	4	1¾"	5/16"	3/16"	.10	.30	1,250	12,000
2" D*	DG		20	8	2"	9/16"	⅜"	.10	.40	2,750	24,200
3½" E*	EN		40	16	3½"	¾"	½"	.10	.80	9,500	77,500
4½" E*	EP		50	20	4½"	¾"	½"	.10	1.0	13,000	108,000
6½" E*	ES		75	30	6½"	¾"	½"	.50	1.5	21,000	169,000
6½" H*	HA		100	40	6½"	1⅛"	¾"	.10	2.0	30,000	254,000
8½" H*	HE		150	60	8½"	1⅛"	¾"	.15	2.5	41,000	342,000
10½" H*	HO		200	80	10½"	1⅛"	¾"	.20	3.0	53,000	436,000

NON-STANDARD SIZES

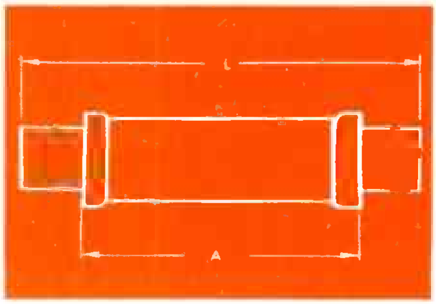
These non-standard sizes are manufactured to order

IRC TYPE	Former Designation	Corresponding JAN Type	Wattage "B" Coat 250°C. Rise	Wattage "C" Coat 130°C. Rise	Ceramic Length	O. D.	I. D.	Minimum Possible Ohms	Minimum Recom'd. Ohms	Max. Ohms Using .0025 Wire	Max. Ohms Using .0014 Wire
1" C	CA	RW-30	7	2.8	1"	7/16"	¼"	.10	.50	400	3,320
1½" C	CB	RW-31	10	4	1½"	7/16"	¼"	.10	.20	1,200	9,950
2" C	CG	RW-32	15	4	2"	7/16"	¼"	.10	.30	2,250	18,800
3" C	CJ	RW-33	18	5	3"	7/16"	¼"	.10	.50	4,250	36,600
2½" D*	DH		25	10	2½"	9/16"	⅜"	.10	.50	4,250	35,600
3" D*	DJ		30	12	3"	9/16"	⅜"	.10	.50	5,500	47,000
4" D*	DD		35	15	4"	9/16"	⅜"	.10	.50	8,500	70,000
5" D*	DK		45	18	5"	9/16"	⅜"	.10	.50	11,250	93,000
3" E*	ET	RW-34 RW-40	35	14	3"	¾"	½"	.10	.50	7,500	62,500
4" E*	ED	RW-35 RW-41	45	18	4"	¾"	½"	.10	.75	11,000	93,000
5" E*	ER		60	24	5"	¾"	½"	.10	.70	15,000	123,000
4" H*	HD	RW-36 RW-42	60	16	4"	1⅛"	¾"	.10	1.5	17,000	140,000
6" H*	HR	RW-37 RW-43	90	22	6"	1⅛"	¾"	.10	1.8	28,000	231,000
8" H*	HS	RW-38 RW-44	110	30	8"	1⅛"	¾"	.15	.50	39,000	323,000
12" H*	HT	RW-39 RW-45	225	90	12"	1⅛"	¾"	.25	3.0	61,000	505,000

* These sizes available with Adjustable Feature — see page 6 for additional information on adjustable power resistors and contact band. Add suffix "A" to type designation when specifying adjustable power wire wound resistors.
It is recommended that standard stock sizes be used wherever practicable.
See page 5 for Terminal Types available.

STANDARD FERRULE TYPE POWER RESISTORS (JAN AND RMA)

STYLE	WATTS "B" Coat	WATTS "C" Coat	Maximum Overall Length "L" Dimension	"A" Dimension ± 1/16"	Maximum Shoulder Diameter*	Maximum Ohms .0025" Wire	Fits Form #1 Standard Fuse Clip		Ferrule Terminal Number **
RW-10	140	37	11⅝"	10-7/16"	1-13/32"	63,000	60 A.	600 V.	8
RW-11	116	33	9-13/16"	8⅝"	1-13/32"	63,000	60 A.	600 V.	8
RW-12	86	23	7⅝"	6-7/16"	1-13/32"	50,000	60 A.	600 V.	8
RW-13	50	13	5-5/16"	4⅛"	1-3/32"	25,000	30 A. 60 A.	600 V. 250 V.	7
RW-14	40	12	4⅝"	3-7/16"	1-3/32"	16,000	30 A. 60 A.	600 V. 250 V.	7
RW-15	20	6	3⅛"	1-15/16"	27/32"	6,300	30 A.	250 V.	5
RW-16	14	4	2-9/16"	1⅜"	27/32"	4,000	30 A.	250 V.	5



* Body diameter always less than shoulder diameter.
** See page25 for Ferrule details.

WINDING FORMS. Highest grade, non-hygroscopic ceramic winding form, chosen for mechanical strength, resistance to thermal shock and freedom from moisture absorption.

WIRE. Copper-nickel and nickel-chrome-iron alloys, largest sizes compatible with adequate spacing, wound with uniform spacing and tension.

INSULATION. 3000 volts A.C., R.M.S., between terminals and bracket.

TERMINALS. Securely clamped around the ceramic winding form by spot welding; heavily tin dipped for easy soldering. Terminal types and specifications are given on page 25

BRACKETS. Sturdy metal brackets, so designed that resistors are readily mounted by rivets or screws. Bracket holes will clear No. 10 machine screw. Specifications are given on page 25

MARKINGS Permanently marked with type number and resistance.

MECHANICAL STRENGTH. Will withstand a transverse load in excess of 25 pounds without mechanical or electrical damage.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

IRC POWER WIRE WOUND RESISTORS

IRC Fixed and Adjustable Power Wire Wound Resistors are designed to give *balanced* performance in *every* characteristic.

To guard the windings against the harmful inroads of atmospheric moisture and corrosion, all IRC power resistors are coated with a special cement. The development of this particular coating was pioneered by IRC, and years of rigorous laboratory and field tests have proven its superiority in the rapid dissipation of heat, ability to withstand reasonable overloads without breakdowns or "opens," moisture protection, immunity to salt water immersion and extreme mechanical strength. The IRC cement coating contains no chemically active ingredients, no salts to attack the wire. The cement is crack-proof and cured and hardened at low temperature; thereby, not endangering the resistance windings.

Unexcelled in essential electrical and mechanical characteristics, IRC Power Wire Wound Resistors are uniformly wound with the highest grade alloy wire on tough, non-hygroscopic tubes, with rugged terminals securely attached. They are available in a full range of sizes, types and terminals.

For exacting, heavy-duty applications, high voltage bleeders, bias supply, grid, and filament dropping resistors, leading industrial, aircraft, broadcast, maritime and other commercial users have specified IRC Power Wire Wound Resistors for over 14 years.

COATING SPECIFICATIONS. Because of the varied types of service power resistors must provide, IRC makes available two types of cement coatings. Each coating is designed to furnish maximum dependability at minimum cost for its class of service.

TYPE "B" COATING. The Type "B" Coating is designed for relatively low range high temperature requirements where wire size is large enough to insure dependability. The power ratings shown for Type "B" Coating are based on a temperature rise of 250° C. from a 25° C. ambient in free air. This coating is well suited for all wire sizes and normal humidity conditions.

TYPE "C" COATING. The Type "C" Coating is a specially developed organic cement coat designed to withstand the most extreme atmospheric conditions . . . such as on ships, in tropical countries, and in extremely humid climates. Power ratings shown for Type "C" Coating are based on a temperature rise of 130° C. above an ambient of 25° C. in free air. At no time should the total temperature (ambient plus rise) exceed 155° C.

TEST CYCLE FOR TYPE "C" COATING. The Type "C" Coating will withstand nine cycles of the following severe test when protecting wire of a diameter of .0025" or larger, on any size ceramic:

1. Operation at maximum rated temperature for six hours . . .
2. Immediate immersion in saturated solution of sodium chloride for two hours at 100° C. . . .
3. Immediate transference to zero degree saturated solution of sodium chloride and immersion for two hours . . .
4. Washed in clear water, wiped clean and operated on D.C. potential at maximum rated temperature for two hours.

SPECIFICATIONS
TYPE PRT (AN3155) POWER RHEOSTAT

IRC PART NUMBERS AND STANDARD AN3155 RESISTANCE RANGES

Order by IRC Part No.	Army-Navy Part No.	Nominal Watts Rating	Total Resistance Ohms	Amperes at Min. Resist.	Amperes at Max. Resist.	Type of Winding
PRT-25-10	AN3155-25-10	25	10	1.95	0.30	Tapered
-25-15	-25-15	25	15	1.30	1.30	Linear
-25-25	-25-25	25	25	1.00	1.00	Linear
-25-50	-25-50	25	50	0.71	0.71	Linear
-25-75	-25-75	25	75	0.58	0.58	Linear
-25-100	-25-100	25	100	0.85	0.16	Tapered
-25-200	-25-200	25	200	0.35	0.35	Linear
PRT-50-5	AN3155-50-5	50	5	5.50	1.82	Tapered
-50-8*	-50-8*	50	8	2.50	2.50	Linear*
-50-10	-50-10	50	10	2.50	1.60	Tapered
-50-25	-50-25	50	25	2.70	0.70	Tapered
-50-30*	-50-30*	50	30	1.70	0.90	Tapered*
-50-50	-50-50	50	50	1.00	1.00	Linear
-50-75	-50-75	50	75	0.82	0.82	Linear
-50-100	-50-100	50	100	1.35	0.25	Tapered
-50-150	-50-150	50	150	0.69	0.17	Tapered
-50-200	-50-200	50	200	1.35	0.15	Tapered

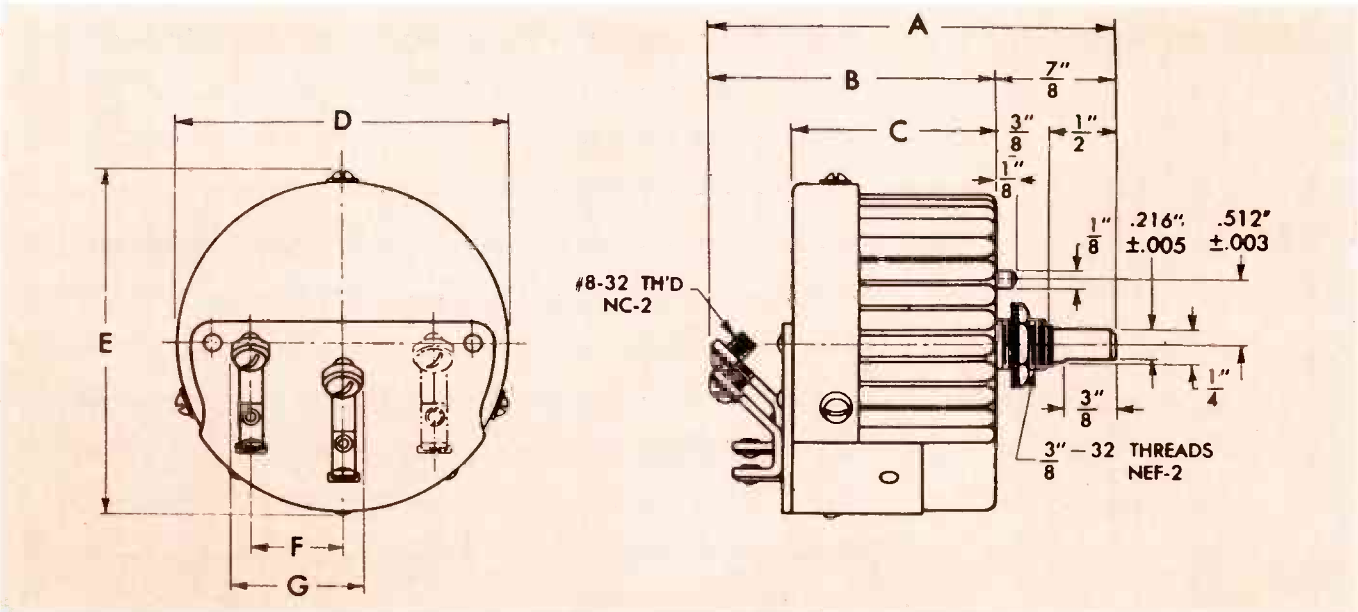
*On AN3155-50-8 and AN3155-50-30, rotation clockwise increases resistance, and minimum resistance is obtained when the rheostat is turned on from the "Off" position. On all other numbers maximum resistance is obtained when rheostat is turned on from "Off" position and rotation clockwise decreases resistance.

VARIATIONS AVAILABLE

The Type PRT Rheostat has been standardized both mechanically and electrically, as required for U. S. Government aircraft applications. Full details are contained in Army-Navy Specifications AN-R-14a and Drawing AN3155.
IRC Type PRT Rheostats are approved by the Air Technical Service Command and the Bureau of Aeronautics. PRT 25 and PRT 50 Rheostats are approved by the U. S. Signal Corps for types RP-11 and RP-16 respectively under JAN-R-22. When ordering against JAN-R-22 please give complete type designation. Variations in resistance values—to 5,000 ohms in the 25-watt Rheostat and to 10,000 ohms in the 50-watt type—are available on special order. For potentiometer applications, three terminals (left, right and center) can be supplied.

TOLERANCE

−5% +15% is standard.



DIMENSIONS

Type	A	B	C	D	E	F	G
PRT-25 (25-watt)	2-5/8"	1-3/4"	1-1/8"	1-23/32"	1-7/8"	13/32"	23/32"
PRT-50 (50-watt)	3-1/16"	2-3/16"	1-9/32"	2-7/16"	2-19/32"	11/16"	1"

CHARACTERISTICS PR-25 AND PR-50 RHEOSTATS

TYPE PR-25
25 - WATT RHEOSTAT

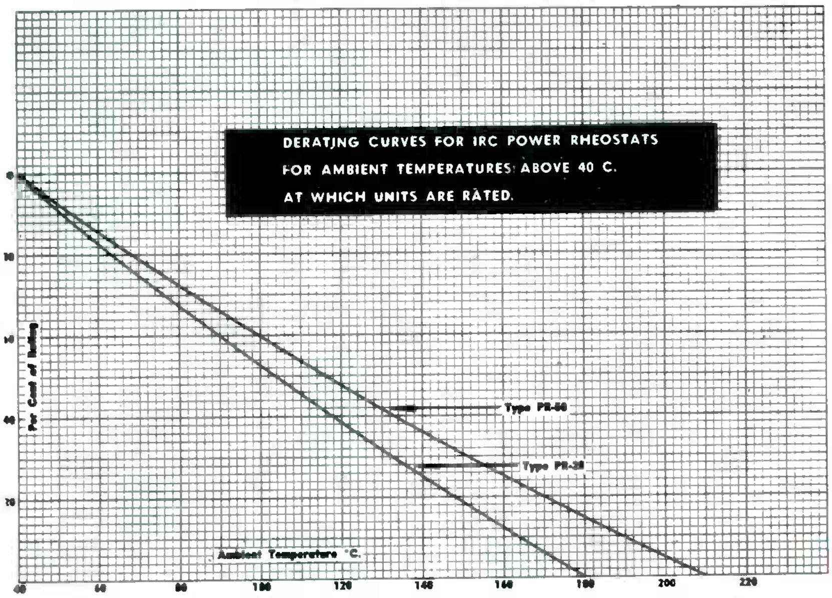
Total Ohms Resistance	* Max. Current Milliamps	Approx. Total Steps	Total Ohms Resistance	* Max. Current Milliamps	Approx. Total Steps
1	5,000	28	125	445	132
2	3,530	31	175	375	146
3	2,880	34	250	315	150
6	2,040	48	350	267	180
8	1,770	48	500	222	158
10	1,580	57	750	182	185
15	1,265	48	1,000	155	255
25	1,000	100	1,500	129	250
35	845	72	2,500	100	330
50	707	80	3,500	84	370
75	575	100	5,000	70	540
100	500	100			

* Max. current at full winding.
These are standard values available from IRC Distributors stocks. Intermediate values available on special order.

TYPE PR-50
50 - WATT RHEOSTAT

Total Ohms Resistance	* Max. Current Milliamps	Approx. Total Steps	Total Ohms Resistance	* Max. Current Milliamps	Approx. Total Steps
0.5	10,000	27	150	575	160
1	7,070	27	225	470	170
2	5,000	35	300	405	210
4	3,530	45	500	315	220
6	2,880	45	800	250	280
8	2,500	45	1,000	220	280
12	2,040	66	1,600	176	360
16	1,760	70	2,500	140	360
22	1,500	66	3,500	119	390
35	1,190	115	5,000	100	435
50	1,000	125	8,000	79	540
80	790	107	10,000	70	680
125	630	135			

* Max. current at full winding.
These are standard values available from IRC Distributors stocks. Intermediate values available on special order.



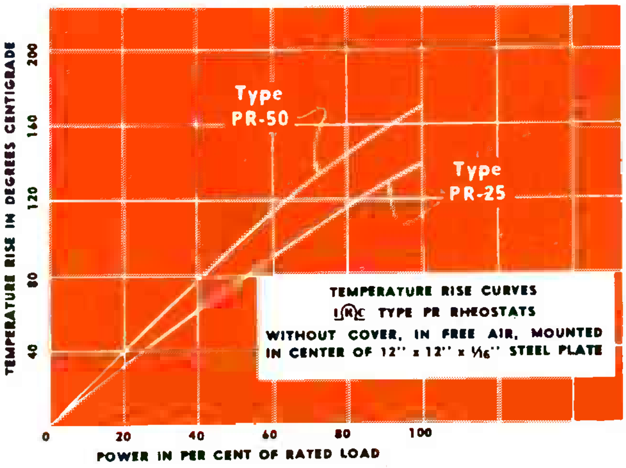
RESISTANCE VALUES. 1 ohm to 5,000 ohms for the PR 25 Rheostat, and 0.5 ohm to 10,000 ohms for the PR 50 Rheostat are standard.

TOLERANCE. ±10% is standard. ±5% available at extra cost on ranges above 10 ohms with linear taper.

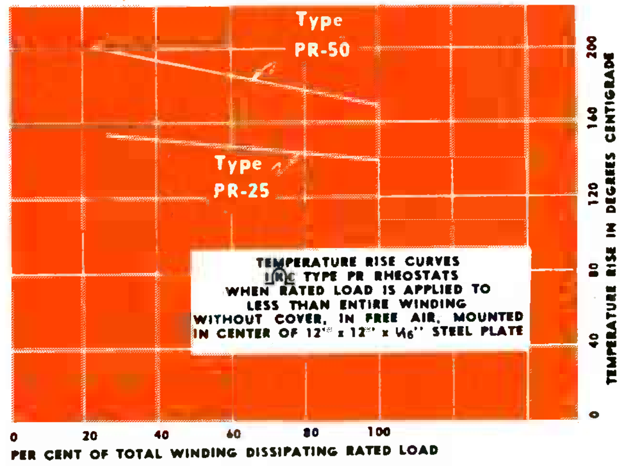
RATING. PR Rheostats are rated at 25 and 50 watts, based upon a 140°C temperature rise above a 40°C. ambient for PR 25, and 170°C. temperature rise above a 40°C. ambient for PR 50.

DERATING. If units are to be operated at an ambient higher than 40°C., they should be derated according to the Derating Curve on the last page. For example: A PR 50 Rheostat is to be operated at an ambient temperature of 80°C. From the Derating Curve it can be seen that only 73% of the 50 watt rating can be used, or 36.5 watts.

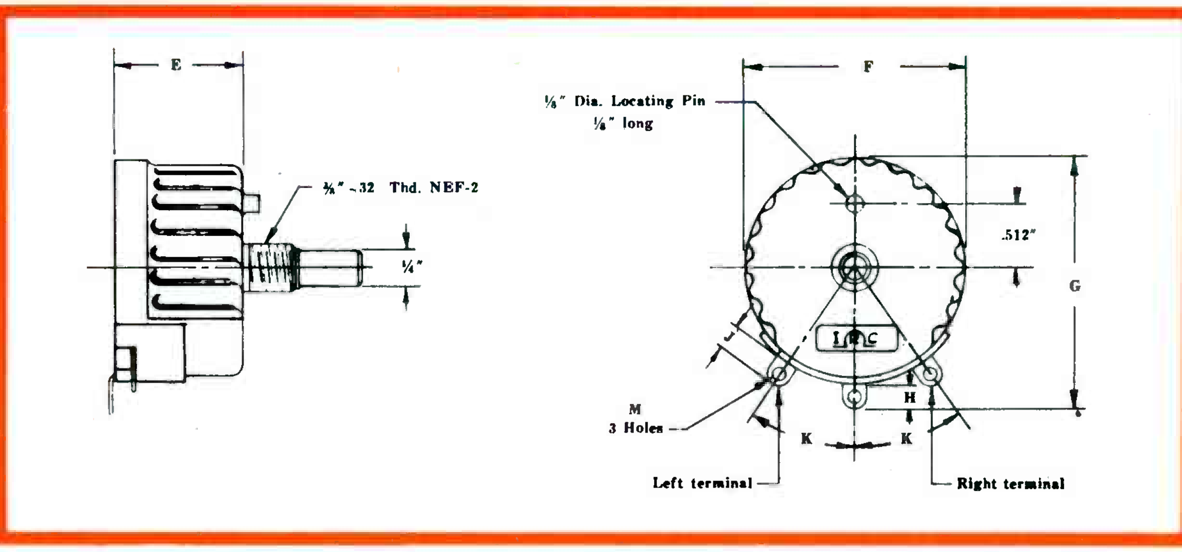
LOW TEMPERATURE RISE



LOW TEMPERATURE OPERATION WITH FULL LOAD ON PART OF WINDING



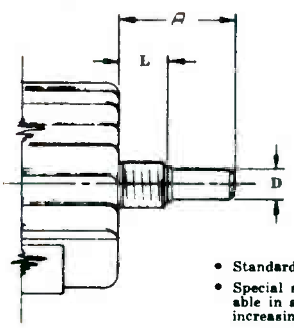
SPECIFICATIONS PR-25 AND PR-50 RHEOSTATS

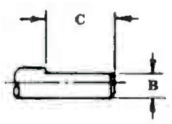


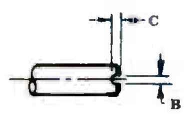
DIMENSIONS

TYPE	E	F	G	H	J	K	M
PR-25	1"	1 21/31"	1 15/16"	7/32"	3/16"	35°	5/32" dia.
PR-50	1 13/32"	2⅜"	2 15/16"	½"	7/16"	40°	Clear #8 screw

STANDARD SHAFT TREATMENT







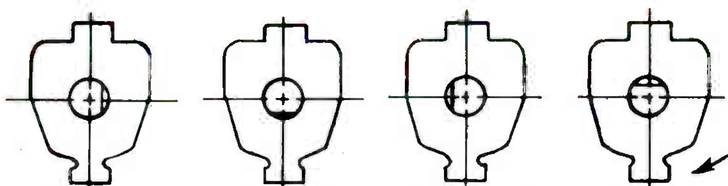
- Standard shaft length (A dim.) 1".
- Special shaft lengths (A dim.) available in all practical lengths from ⅝" increasing by 1/16" increments.
- Standard bushing length (L dim.) ⅜"
- Special bushing lengths: ¼", ½" and ⅝".

ROUND	
TYPE	DIM. D
1	.250 +.000 —.002

FLAT		
TYPE	DIM. B	DIM. C
2	.216 ±.002	7/16"
3	.216 ±.002	⅜"
4	.216 ±.002	11/32"
5	.216 ±.002	5/16"
6	.216 ±.002	¼"

SLOT		
TYPE	DIM. B	DIM. C
7	.075"	1/16"
8	1/16"	1/16"
9	3/64"	1/16"

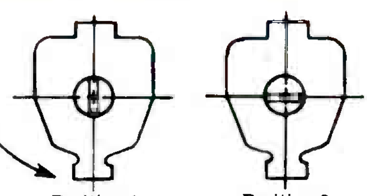
STANDARD FLAT POSITION



Position 1 Position 2 Position 3 Position 4

CONTACT FINGERS

STANDARD SLOT POSITION



Position 1 Position 2

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

POWER RHEOSTATS

TYPE PR-25 — FRONT VIEW
25 WATTS

TYPE PR-50 — REAR VIEW
50 WATTS

ALL-METAL CONSTRUCTION

The basis of the vast superiority of IRC PR 25 and PR 50 Power Rheostats over conventional types is a unique design featuring all-metal construction. The excellent heat dissipating properties of aluminum are utilized to full advantage in the housing and in the winding core of the resistance element of these IRC Rheostats.

PR 25 and PR 50 Rheostats operate at full rating at approximately half the temperature rise of equivalent units, and can be operated at full power in as low as 25% of rotation without any appreciable difference in temperature rise.

Through efficient use of the best grade mica and special asbestos, the insulation properties of these rheostats satisfactorily meet all service requirements. The heat dissipating and insulation features of IRC PR 25 will allow safe operation at 25 watts down to 25% of full rotation with a temperature rise of about 160°C., and for the PR 50, at 50 watts down to 25% of full rotation with a temperature rise of approximately 200°C.

HOUSING. Ribbed die cast aluminum alloy case designed to conduct heat away from resistance element. Since the external sides of the case are ribbed, it offers exceptionally efficient heat radiation. Intimate contact between rheostat and mounting panel allows rapid conduction to the panel of a portion of the heat dissipated.

RESISTANCE ELEMENT. Low temperature coefficient wire is uniformly wound on a strip aluminum core insulated by top grade asbestos. This insures uniform heat distribution throughout the entire resistance element regardless of how much of the element is actually in service.

Through the use of layers of best grade mica, the resistance element is insulated from the die cast housing. This construction allows more than sufficient insulation and at the same time, aids in conducting heat from the element to the housing.

CONTACT. Contact is made to the large radius edge of the resistance element by means of a special alloy which will neither pit nor stick. Close calibration and smooth variations in resistance are made possible over entire element. Pressure is provided by means of a separate steel spring, not in the current carrying path, thus separating the two functions of carrying current and applying pressure.

SPIRAL SPRING CONNECTOR. A flat clockspring, the famous IRC Spiral Spring Connector, is used to connect the sliding contactor to the center terminal. This eliminates the conventional series pressure contact, and insures long life and dependability.

MOUNTING. Single ⅜" hole mounting, bushing ½" long x ⅜" x 32 thread—brass. Other lengths available on special order.

SHAFT. Standard shaft nickel plated steel ¼" diameter. Length of shaft beyond bushing ½". Other lengths available as indicated on Page 2. Shaft is insulated, permitting mounting of rheostat on metal panel.

SHAFT ROTATION. PR 25 Rheostat — 290°
PR 50 Rheostat — 280°

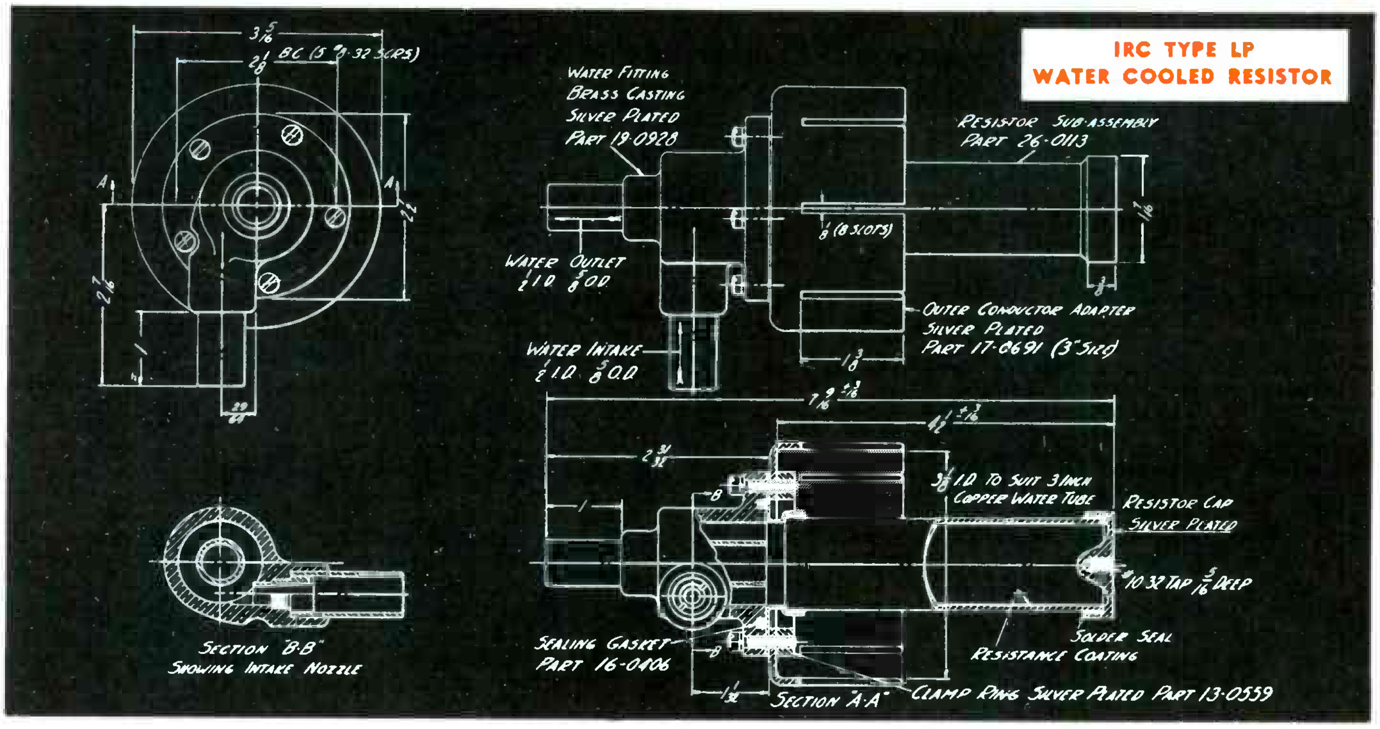
LOCATING PIN. ⅛" diameter pin cast in base on 0.512" radius, as shown in diagram on Page 2.

KNOB. Conventional type knob of molded bakelite is available on order.

COVER. Cover for protection against mechanical injury is available on order. Use of cover necessitates reduction of rating by ⅓ of standard.

OFF POSITION. Positive-action "off" position is standard.

INSTALLATION OF IRC TYPE LP WATER COOLED RESISTORS



WATER COOLING: The resistor film on the interior of the Pyrex tube is less than 0.001" thick and has negligible heat storage capacity. High water velocity and intimate thermal contact between the water and carbon over its entire surface are necessary for proper heat dissipation. Oil or even perspiration on the inside surface may prevent wetting, so it is recommended that the resistor film inside be inspected before final installation. Warm soapy water will clean the resistor without harm to the carbon coating. This resistor is not recommended for DC applications.

Abrasive grit, metal filings, or particles of solder in the water supply will score the resistor film due to the velocity and centrifugal force of the liquid. Supply lines should be carefully flushed out before installation of the resistor, and a filter installed, if ordinary tap water is used for cooling. Before power is applied to the resistor, water should be allowed to circulate through the unit for at least three minutes in order to thoroughly wet resistance element and clear out air bubbles.

The position of mounting the resistor does not affect its operation. It will work satisfactorily with either end up or on its side.

The ⅝" tubing at the side of the water fitting, with the nozzle installed, is the water intake. The outlet tubing is on the axis of the resistor.

An intake nozzle with the proper hole size must be installed to ensure velocity and volume flow for a given power dissipation. Our No. 4 nozzle, normally supplied, has a 0.203" hole diameter and passes approximately 4 gals. per minute with a water pressure differential between inlet and outlet of 22 lbs. per square inch. This flow will handle 5 kilowatts A.C. at normal water temperatures. For a power dissipation of 2 kilowatts, our No. 2 nozzle has a 0.156" hole and will pass approximately 2 gals. per minute at 16 lbs. pressure. For powers of 1,000 watts or less, our No. 1 nozzle with a 0.109" hole, will pass approximately 1 gal. per minute at 20 lbs. pressure. Care should be used when installing these nozzles to prevent burring the inside which would disturb the flow. If a circulatory water system is used, output water should be cooled to counteract temperature rise.

Suitable couplings for connection to the external water supply are manufactured by the Imperial Brass Company. Their part No. 62F-⅝" union is a straight coupling for connection to ⅝" O.D. copper tubing. Their part No. 68F-⅝" is a similar coupling for connection to ½" standard pipe thread.

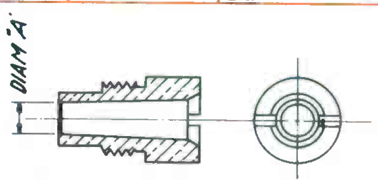
FITTING TO A COAXIAL LINE: Outer conductor adapter, our drawing No. B-17.0691, can be assembled in place under the clamp ring which holds the resistor flange. The resistor flange must always be assembled next to the water fitting with gasket, the outer conductor adapter next, and the clamp ring on top. This adapter is designed to clamp around the outside of a "three inch" coaxial line.

The inner conductor of the coaxial line is cut off 4½" shorter than the outer conductor (the approximate length of the resistor unit sub-assembly) and assembled by an appropriate adapter to the cap on the end of the resistor.

Care must be taken in fitting the assembly to a line to insure that the inner and outer parts are lined up concentric, otherwise excessive strain may be placed on the glass tubing.

LP RESISTOR

NOZZLE	DIAM "A"	WATER FLOW GAL. PER MIN.	PRESSURE DIFF. INLET TO OUTLET	MAXIMUM POWER
1	0.109"	1	20# PER SQ.IN.	1.0 K.W.
2	0.156"	2	16 "	2.0 "
4	0.203"	4	22 "	5.0 "



INTERNATIONAL RESISTANCE CO.

401 NORTH BROAD STREET
PHILADELPHIA 8, PA., U. S. A.

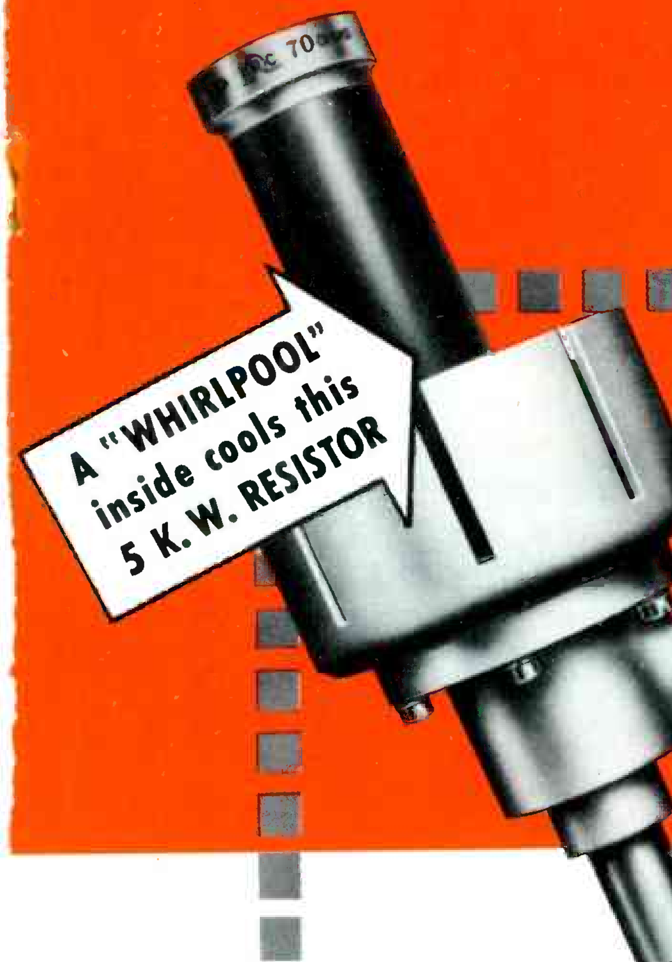
In Canada: INTERNATIONAL RESISTANCE CO., LTD.
11 KING STREET WEST, TORONTO 1, LICENSEE

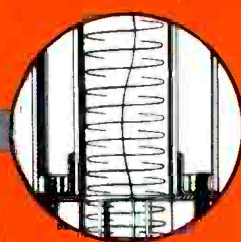
CATALOG DATA BULLETIN

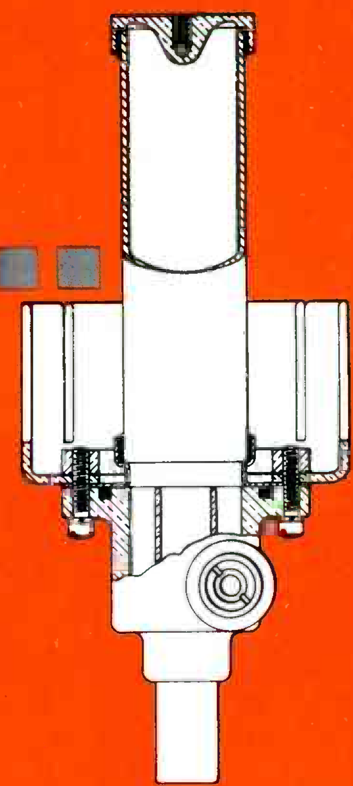
Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad Street, Philadelphia 8, Pa., U.S.A.

IN CANADA. INTERNATIONAL RESISTANCE CO., LTD., TORONTO, LICENSEE







Unique IRC High Frequency-High Power Resistor for Television, FM, and Dielectric Heating Applications

Inside IRC's new Type LP resistor a high velocity stream of water flows in a spiral path against the *metallized* resistance film and, through centrifugal force, maintains intimate thermal contact with the entire surface. Interchangeable intake nozzles permit adjusting the rate of water flow and therefore the cooling action to suit local water pressure and power dissipation up to 5 K.W.

A resistance film less than 0.001" thick, with an active length considerably less than ¼ wave length at FM and television frequencies, gives good inherent frequency characteristics.

The mechanical design permits direct mounting on the end of a coaxial line with both water intake and outlet connections at R.F. ground potential. Resistor elements are interchangeable. Different values or service replacements can be readily installed in the field.

The IRC Type LP Liquid Cooled High Frequency High Power Unit is the latest in IRC's continuing development of resistors. It is available in resistance values of 35 ohms to 1500 ohms. Resistance tolerance: ±15% standard. Tolerances of ±10% and ±5% can be supplied at increased cost.

SHORT DELIVERY CYCLE

Fittings are now carried in stock. Resistance elements are made to order for range and tolerance.

TYPE MPM RESISTORS

OUTLINE ASSEMBLY OF MPM RESISTOR

IRC Type MPM Resistors are miniature units suitable for high frequency receiver and similar applications. They are constructed of solid steatite ceramic rods to which a thin resistance film is permanently bonded. Wire lead terminals have "cupped" ends into which the resistor body is firmly cemented to form axial pigtails. The entire assembly is then coated with phenolic varnish. The electrical characteristics of these units are similar, except for frequency, to those of the larger type IRC MP Resistors. The approximate frequency characteristics for various ranges are shown below. Terminals are axial wire pigtails, 1½ inches long. Resistor body is 9/16" by 0.100" (over cups), and the active resistance section is 3/8" long.

AVAILABLE RESISTANCE VALUES:

30 ohms to 1.0 megohms.

RESISTANCE TOLERANCE:

Standard: ±20%; Special: ±10%. 5% not available.

POWER RATING:

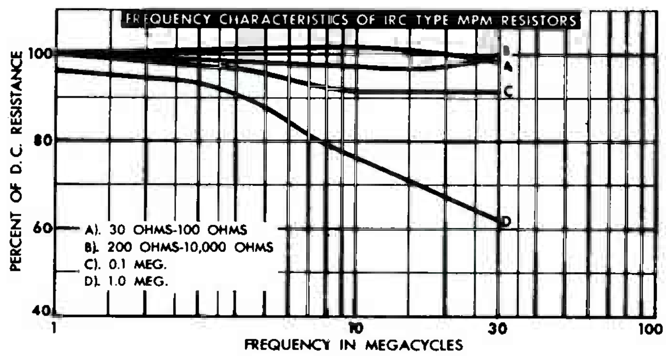
¼ watt, at 40°C. ambient temperature.

MAXIMUM VOLTAGE RATING:

200 volts peak.

CAPACITY BETWEEN TERMINALS:

0.015 Micro-microfarads.



TEMPERATURE COEFFICIENT OF RESISTANCE:

Approximately minus 0.04% per degree over temperature range of –55°C. to +80°C.

INTERNATIONAL RESISTANCE CO.

IRC

401 NORTH BROAD STREET
PHILADELPHIA 8, PA. U. S. A.
TELEPHONE: WA 2-2166

IN CANADA: INTERNATIONAL RESISTANCE CO., LTD.
11 KING STREET WEST, TORONTO, LICENSEE

BRANCH OFFICE: 165 BROADWAY, NEW YORK, N. Y., Courtland 7-5020

SALES REPRESENTATIVES:

Hollingsworth & Still
407 Norris Bldg.
ATLANTA, Ga.
Main 5878

Ray Perron & Co.
131 Clarendon St.
BOSTON, Mass.
Kenmore 1370

Segar & Taylor Co.
4508 E. Genesse St.
DE WITT, N. Y.

S. B. Darmstader
308 W. Washington St.
CHICAGO, Ill.
Franklin 4818

Albert M. Baehr
11621 Detroit Ave.
CLEVELAND, Ohio
Lakewood 8468

George E. Anderson Co.
1903 Griffin St.
DALLAS, Tex.
Riverside 1272

Ronald G. Bowen
1886 S. Humboldt St.
DENVER, Colo.
Spruce 9368

Koehler-Pasmore Co.
8316 Woodward Ave.
DETROIT, Mich.
Madison 8086

Vernon C. Macnabb
P. O. Box 5971
INDIANAPOLIS, Ind.
Broadway 6770

Marshank Sales Co.
672 S. Lafayette Park Place
LOS ANGELES, Calif.
Drexel 8235

George C. Tanner
600 Grant St.
PITTSBURGH, Pa.
Court 0131

Norman W. Kathrinus
1218 Olive St.
ST. LOUIS, Mo.
Central 6300

J. U. McCarthy
1725 Hillcrest Ave.
ST. PAUL, Minn.
Emerson 8619

James P. Hermans Co.
1234 Folsom St.
SAN FRANCISCO, Calif.
Market 4166

David M. Lee
2626 Second Ave.
SEATTLE, Wash.
Main 5512

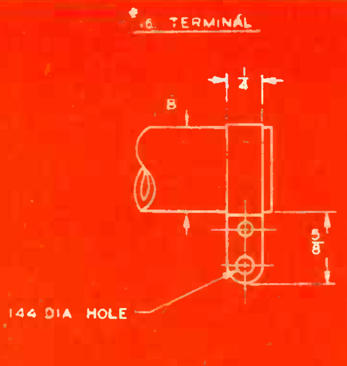


FIGURE 2

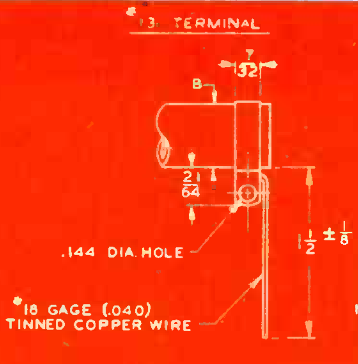


FIGURE 3

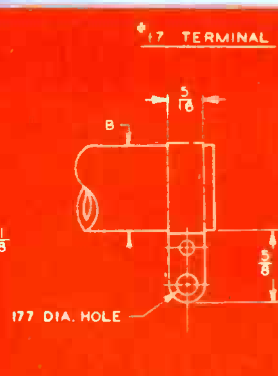


FIGURE 4

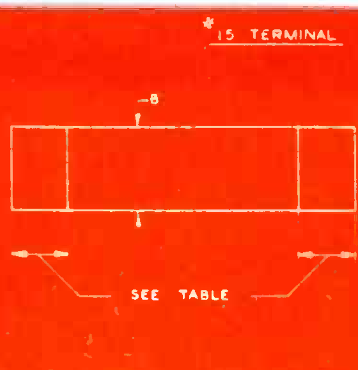


FIGURE 5

TYPE	POWER RATING	PEAK VOLTAGE RATING	MINIMUM AVAILABLE RESISTANCE AT ± 15% OR ± 10% TOLERANCE	MINIMUM AVAILABLE RESISTANCE AT ± 5% TOLERANCE	MAXIMUM AVAILABLE RESISTANCE AT ± 5%, ± 10% OR ± 15% TOLERANCE	OUTLINE DRAWING	DIMENSIONS: OVERALL LENGTH "A"	DIMENSIONS: NOMINAL DIAMETER "B"	DIMENSIONS: FERRULE SPACING "C"	DIMENSIONS: FERRULE DIAMETER "D"	DIMENSIONS: FERRULE LENGTH "E"
MPS-5	4.0 watts	500	10 ohms	75 ohms	1.0 megohm	Fig. 6	2-7/16" ± 1/8"	11/16" ± 1/32"	1-3/8" ± 1/16"	9/16" ± 1/32"	1/2" + 1/16-0"
MPT-5	5.0 watts	750	15 ohms	100 ohms	1.5 megohms	" "	3" ± 1/8"	11/16" ± 1/32"	1-15/16" ± 1/16"	9/16" ± 1/32"	1/2" + 1/16-0"
MPB-7	7.5 watts	1200	20 ohms	125 ohms	2.5 megohms	" "	4-1/2" ± 1/8"	1" ± 1/32"	3-7/16" ± 1/16"	13/16" ± 1/32"	1/2" + 1/16-0"
MPD-7	10.0 watts	1500	25 ohms	150 ohms	3.0 megohms	" "	5-3/16" ± 1/8"	1" ± 1/32"	4-1/8" ± 1/16"	13/16" ± 1/32"	1/2" + 1/16-0"
MPZ-8	20.0 watts	2750	35 ohms	250 ohms	4.0 megohms	" "	7-1/2" ± 1/8"	1-1/8" ± 1/32"	6-7/16" ± 1/16"	1-1/8" ± 1/32"	1/2" + 1/16-0"
MPE-8	25.0 watts	3800	40 ohms	300 ohms	4.5 megohms	" "	9-11/16" ± 1/8"	1-1/8" ± 1/32"	8-5/8" ± 1/16"	1-1/8" ± 1/32"	1/2" + 1/16-0"
MPO-7	30.0 watts	4750	50 ohms	400 ohms	5.0 megohms	" "	11-3/4" ± 1/8"	1-1/8" ± 1/32"	10-13/16" ± 1/16"	13/16" ± 1/32"	1/2" + 1/16-0"
MPR-8	90.0 watts	8500	60 ohms	500 ohms	6.0 megohms	" "	19-3/4" ± 3/16"	2" ± 3/64"	18-1/2" ± 5/32"	1-1/8" ± 1/32"	9/16" + 1/32-0"

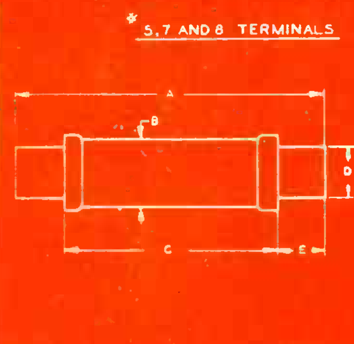


FIGURE 6

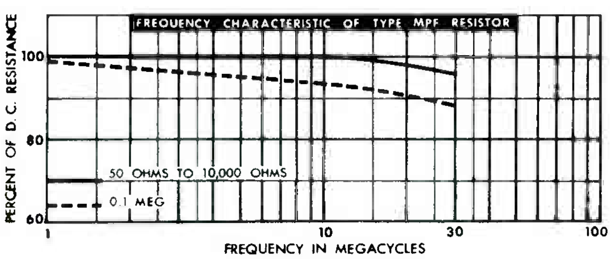
HUMIDITY. Several protective coatings of special varnish, baked individually at high temperature, provide protection against the effects of abnormal humidity. Maximum resistance change of ±5% can be expected due to humidity. Resistance will return to original value when humidity conditions become normal.

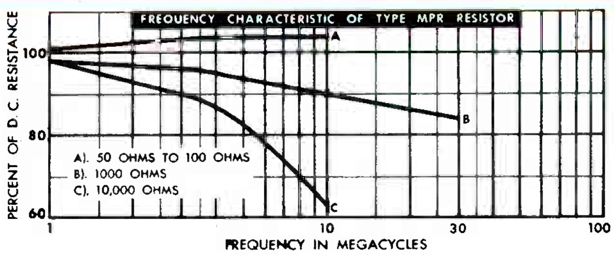
VOLTAGE COEFFICIENT OF RESISTANCE. Type MP Resistors have a voltage coefficient of resistance which varies from approximately −.002% to −.03% per volt per inch of length of resistance path. The active length of resistance path is given in the following table to facilitate the calculation of voltage coefficients.

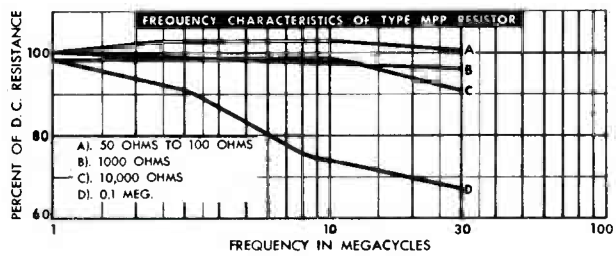
MP TYPE	LENGTH OF RESISTANCE PATH IN INCHES	MP TYPE	LENGTH OF RESISTANCE PATH IN INCHES
MPF	1.0	MPP	3.5
MPG	1.0	MPZ	5.25
MPS	1.0	MPA	5.5
MPT	1.5	MPE	7.5
MPJ	2.0	MPO	9.5
MPB	2.25	MPR	17.0
MPD	3.0		

AGING. Pre-curing and stabilizing of resistance coating at high temperature eliminates appreciable aging. Laboratory tests and field experience indicate that aging rarely exceeds ±3% of the original value.

FREQUENCY. Approximate frequency characteristics of typical MP units are illustrated by the following charts:







INSTALLATION

HANDLING. Type MP Resistors will stand ordinary handling; however, it is recommended that the units be installed after other mechanical work has been completed, and that the protective wrapping on the body of the resistor be left in place until the unit has been installed in the equipment.

MOUNTING. When Type MP Resistors are required to operate at elevated temperatures, they should be positioned so that free circulation of cool air can reach every part of the surface.

Where resistors are to be used near maximum allowable operating temperature they should be kept from close proximity to other parts radiating appreciable heat.

SPECIFICATIONS IRC MP RESISTORS

TYPE	TERMINAL TYPE AND DRAWING NO.	POWER RATING	PEAK VOLTAGE RATING	MINIMUM AVAILABLE RESISTANCE		MAXIMUM AVAILABLE RESISTANCE AT ± 5%, ± 10% OR ± 15% TOLERANCE	DIMENSIONS			
				AT ± 15% OR ± 10% TOLERANCE	AT ± 5% TOLERANCE		CERAMIC LENGTH	RESISTOR BODY DIAMETER	CERAMIC I. D.	WIDTH OF COLLOIDAL SILVER BANDS #15 TERMINALS, FIG. 5
MPF-12	#12, Fig. 1	2 watts	500	20 ohms	100 ohms	1.5 megohms	1-3/4" ± 1/32"	5/16" ± 1/32"	3/16"	9/16" ± 1/16"
MPF-13	#13, Fig. 3									
MPG-13	#13, Fig. 3	4 watts	500	20 ohms	100 ohms	1.5 megohms	2" ± 1/32"	9/16" ± 1/32"	3/8"	9/16" ± 1/16"
MPG-15	#15, Fig. 5									
MPG-16	#16, Fig. 2									
MPG-17	#17, Fig. 4									
MPJ-15	#15, Fig. 5	5 watts	1000	35 ohms	200 ohms	3.0 megohms	3" ± 1/32"	9/16" ± 1/32"	3/8"	9/16" ± 1/16"
MPJ-16	#16, Fig. 2									
MPJ-17	#17, Fig. 4									
MPP-15	#15, Fig. 5	10 watts	1750	25 ohms	150 ohms	2.5 megohms	4-1/2" ± 1/16"	3/4" ± 1/32"	1/2"	9/16" ± 1/16"
MPP-16	#16, Fig. 2									
MPP-17	#17, Fig. 4									
MPA-15	#15, Fig. 5	20 watts	2750	35 ohms	250 ohms	4.0 megohms	6-1/2" ± 1/16"	1-1/8" ± 1/32"	3/4"	9/16" ± 1/16"
MPA-16	#16, Fig. 2									
MPA-17	#17, Fig. 4									
MPO-15	#15, Fig. 5	30 watts	4750	50 ohms	400 ohms	5.0 megohms	10-1/2" ± 1/16"	1-1/8" ± 1/32"	3/4"	9/16" ± 1/16"
MPO-16	#16, Fig. 2									
MPO-17	#17, Fig. 4									
MPR-15	#15, Fig. 5	90 watts	8500	60 ohms	500 ohms	6.0 megohms	18-1/2" ± 1/8"	2" ± 3/64"	1-9/16"	7/8" ± 1/16"
MPR-17	#17, Fig. 4									

#12 TERMINAL

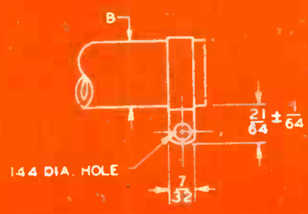


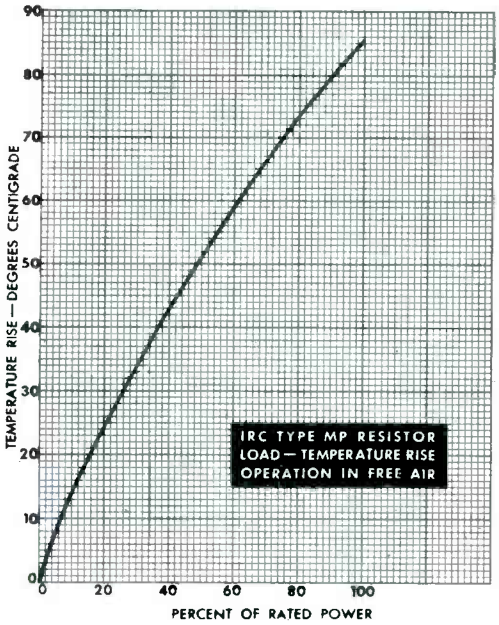
FIGURE 1

◀ WITH LUG TERMINALS OR COLLOIDAL SILVER TERMINALS

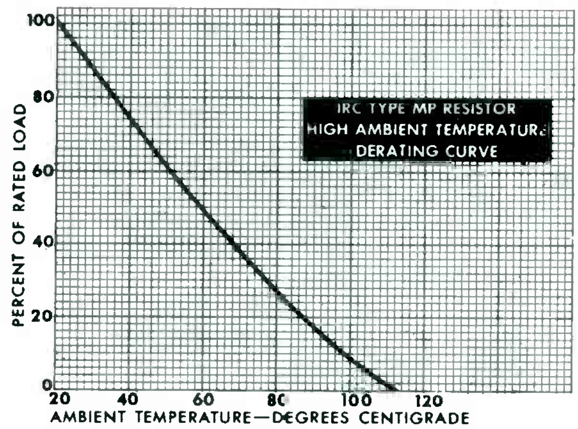
WITH FERRULE TERMINALS, #5, #7, AND #8 ▶

CHARACTERISTICS IRC MP HIGH FREQUENCY RESISTORS

POWER RATINGS. The ratings shown in the above specification charts are based on free air operation at 20°C. ambient and should not be exceeded.



DERATING. Type MP Resistor power ratings are based on an ambient temperature of 20°C. When operated at any higher ambient, it is recommended that they be derated according to the following curve. For example, suppose an MPO Resistor is to be operated in an ambient temperature of 40°C. From the curve it is seen that the permissible load is 74% of the rated load. Since the MPO is normally rated at 30 watts, then at 40°C., it should not be loaded to more than 74% of 30 watts, or 22.2 watts.



TEMPERATURE COEFFICIENT. —.005% °C. for low resistance to —.07% °C. for high resistance value.

COOLING TO INCREASE POWER RATING. Various methods may be used for artificially removing heat from Type MP Resistors to increase their power capacity. In any cooling method, however, the maximum voltage rating and "hot spot" temperature (110°C. for short-time intermittent operation or 90°C. for continuous operation) must not be exceeded.

Safe power dissipation may be materially increased by cooling the units in a forced air draft. By efficient water cooling, safe operation at a power exceeding 100 times that for operation in air may be secured. (See IRC Catalog Bulletin F-2 pertaining to Type LP Water-Cooled Resistors up to 5 K.W.) Type MP units also can be furnished for operation in oil as a means of increasing power and voltage ratings.

When planning the use of any special cooling method for Type MP installations, it is advisable to furnish complete details of the specific application so that IRC engineers may recommend the proper units and installation methods.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad Street, Philadelphia 8, Pa., U.S.A.

IN CANADA: INTERNATIONAL RESISTANCE CO., LTD., TORONTO, LICENSEE

TYPE MP HIGH FREQUENCY RESISTORS

TYPE MP HIGH FREQUENCY RESISTORS

IRC Type MP Resistors are intended for frequencies above those of conventional resistors. They are suitable for such applications as broad band RF amplifiers, RF probes, rhombic antenna terminating resistors, dummy loads for transmitters and dielectric heating equipment, television side-band filters, surge generator and other circuits involving steep wave fronts, high frequency measuring circuits and radar pulse equipment. They are available in sizes from ¼ watt to 90 watts.

The IRC Type MP design utilizes the basic IRC technique of bonding a thin film of resistance material on a steatite ceramic form to provide a stable resistor with low inherent inductance and capacity.

The resistance film used on Type MP Resistors was developed especially for these units in order to obtain the best combination of mechanical stability and uniform electrical characteristics. Changes due to humidity and aging are held to a minimum. Voltage and temperature coefficients of resistance are low. The small cross-sectional area of the film (it is less than 0.001" thick) provides low inherent capacity and freedom from "skin effect". Inductance is materially reduced by the large ratio of diameter to length.

The steatite ceramic tubes used in Type MP Resistors are chosen for their mechanical uniformity and strength, and stability under temperature and humidity variations. They are non-hygroscopic and have excellent electrical characteristics.

Terminal bands of colloidal silver are applied at each end of the unit to provide permanent low resistance contact to the resistance coating. Lug or ferrule type terminals, if required, are secured over the silver end bands and a heavy protective coating is baked on the entire resistor.

SPECIFICATIONS TYPE MV HIGH VOLTAGE RESISTORS

TYPE MV RESISTORS

WITH LUG TERMINALS OR COLLOIDAL SILVER TERMINALS

TYPE	TERMINAL TYPE AND DRAWING NO.	POWER RATING	PEAK VOLTAGE RATING	MINIMUM AVAILABLE RESISTANCE AT ±15% or ±10% TOLERANCE	MINIMUM AVAILABLE RESISTANCE AT ±5% TOLERANCE	MAXIMUM AVAILABLE RESISTANCE (See Note 1, Below, for Tolerance Limitations)	DIMENSIONS: CERAMIC LENGTH	DIMENSIONS: RESISTOR BODY DIAMETER	DIMENSIONS: CERAMIC I.D.	DIMENSIONS: WIDTH OF COLLOIDAL SILVER BANDS #15 TERMINALS, Fig. 5
MVF-12	#12, Fig. 1	2 watts	5,000	2,500 ohms	25,000 ohms	250 megohms	1¾" ±1/32"	5/16" ±1/32"	3/16"	3/8" ±1/16"
MVF-13	#13, Fig. 3									
MVG-13	#13, Fig. 3	4 watts	5,000	10,000 ohms	0.1 megohm	700 megohms	2" ±1/32"	9/16" ±1/32"	3/8"	5/16" ±1/16"
MVG-15	#15, Fig. 5									
MVG-16	#16, Fig. 2									
MVG-17	#17, Fig. 4									
MVJ-15	#15, Fig. 5	5 watts	10,000	20,000 ohms	0.2 megohm	1,500 megohms	3" ±1/32"	9/16" ±1/32"	3/8"	5/16" ±1/16"
MVJ-16	#16, Fig. 2									
MVJ-17	#17, Fig. 4									
MVP-15	#15, Fig. 5	10 watts	15,000	50,000 ohms	0.4 megohm	2,000 megohms	4½" ±1/16"	¾" ±1/32"	½"	5/16" ±1/16"
MVP-16	#16, Fig. 2									
MVP-17	#17, Fig. 4									
MVA-15	#15, Fig. 5	20 watts	25,000	0.2 megohm	1.0 megohm	4,000 megohms	6½" ±1/16"	1⅛" ±1/32"	¾"	5/16" ±1/16"
MVA-16	#16, Fig. 2									
MVA-17	#17, Fig. 4									
MVO-15	#15, Fig. 5	30 watts	50,000	0.4 megohm	2.0 megohms	8,000 megohms	10½" ±1/16"	1⅛" ±1/32"	¾"	5/16" ±1/16"
MVO-16	#16, Fig. 2									
MVO-17	#17, Fig. 4									
MVR-15	#15, Fig. 5	90 watts	100,000	1.0 megohm	7.0 megohms	20,000 megohms	18½" ±⅛"	2" ±3/64"	1 5/16"	⅞" ±1/16"
MVR-17	#17, Fig. 4									

Note 1:—At ±5% tolerance, 1000 megohms is the maximum available. (Except where maximum available tabulated is less than 1,000 megohms.)
At ±10% tolerance, 10,000 megohms is the maximum available. (Except where maximum available tabulated is less than 10,000 megohms.)
Above 10,000 megohms, ±20% is the only available tolerance.

WITH LUG TERMINALS OR COLLOIDAL SILVER TERMINALS ↑ ↓ **WITH FERRULE TERMINALS #5, #7, and #8**

TYPE MV RESISTORS

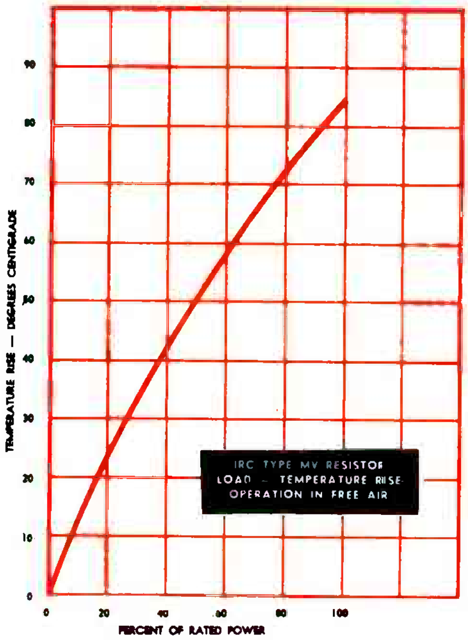
WITH FERRULE TERMINALS, #5, #7 AND #8

TYPE	POWER RATING	PEAK VOLTAGE RATING	MINIMUM AVAILABLE RESISTANCE AT ±15% or ±10% TOLERANCE	MINIMUM AVAILABLE RESISTANCE AT ±5% TOLERANCE	MAXIMUM AVAILABLE RESISTANCE (See Note 1, Below, for Tolerance Limitations)	DIMENSIONS: OUTLINE DRAWING	DIMENSIONS: OVERALL LENGTH "A"	DIMENSIONS: NOMINAL DIAMETER "B"	DIMENSIONS: FERRULE SPACING "C"	DIMENSIONS: FERRULE DIAMETER "D"	DIMENSIONS: FERRULE LENGTH "E"
MVS-5	4.0 watts	5,000	10,000 ohms	0.1 megohm	500 meg.	Fig. 6	2 7/16" ±⅛"	1 1/16" ±1/32"	1⅝" ±1/16"	9/16" ±1/32"	½" +1/16"-0"
MVT-5	5.0 watts	7,500	15,000 ohms	0.15 megohm	800 meg.	"	3" ±⅛"	1 1/16" ±1/32"	1 15/16" ±1/16"	9/16" ±1/32"	½" +1/16"-0"
MVB-7	7.5 watts	*12,000	50,000 ohms	0.4 megohm	1,500 meg.	"	4½" ±⅛"	1" ±1/32"	3 7/16" ±1/16"	13/16" ±1/32"	½" +1/16"-0"
MVD-7	10.0 watts	15,000	0.1 megohm	0.7 megohm	2,000 meg.	"	5 9/16" ±⅛"	1" ±1/32"	4⅛" ±1/16"	13/16" ±1/32"	½" +1/16"-0"
MVZ-8	20.0 watts	25,000	0.2 megohm	1.0 megohm	4,000 meg.	"	7½" ±⅛"	1⅛" ±1/32"	6 1/16" ±1/16"	1⅛" ±1/32"	½" +1/16"-0"
MVE-8	25.0 watts	40,000	0.3 megohm	1.5 megohms	6,000 meg.	"	9 11/16" ±⅛"	1⅛" ±1/32"	8⅝" ±1/16"	1⅛" ±1/32"	½" +1/16"-0"
MVO-7	30.0 watts	50,000	0.4 megohm	2.0 megohms	8,000 meg.	"	12" ±⅛"	1⅛" ±1/32"	10 13/16" ±1/16"	13/16" ±1/32"	½" +1/16"-0"
MVR-8	90.0 watts	100,000	1.0 megohm	7.0 megohms	20,000 meg.	"	19¾" ±3/16"	2" ±3/64"	18½" ±5/32"	1⅛" ±1/32"	9/16" +1/32"-0"

Note 1:—For ±5% tolerance, 1,000 megohms is maximum available. (Except where maximum available, tabulated above, is less than 1,000 megohms.)
For ±10% tolerance, 10,000 megohms is maximum available. (Except where maximum available, tabulated above, is less than 10,000 megohms.)
Above 10,000 megohms, ±20% is the only available tolerance.

All above resistor types can be supplied in resistance ranges above standard to a maximum of 1,000,000 megohms. Tolerance ± 20%. Prices special depending on resistance range.

POWER RATINGS. The ratings shown in the specification chart C. ambient and are based on free air operation at 20° should not be exceeded.

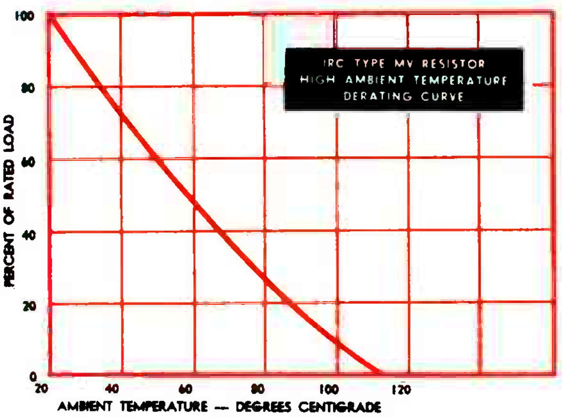


TEMPERATURE COEFFICIENT. —.005%° C. for low resistance to —.07%° C. for high resistance values.

AGING. Pre-curing and stabilizing of resistance coating at high temperature eliminates appreciable aging. Laboratory tests and field experience indicate that aging rarely exceeds ±3% of the original value.

DERATING

When MV Resistors are operating at any ambient higher than 20° C., it is recommended that they be derated according to the following curve.



VOLTAGE COEFFICIENT OF RESISTANCE. Type MV Resistors have a voltage coefficient of resistance which varies from approximately —.002% to —.03% per volt per inch of length of resistance path.

TERMINALS. Terminal types all the same as those shown for MP resistors on page 15.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

TYPE MV HIGH VOLTAGE RESISTORS

IRC Type MV Resistors are designed for high voltage applications where high resistance and power are required. Unique application of IRC's famous filament resistance coating in helical turns on a ceramic tube provides a conducting path of long effective length.

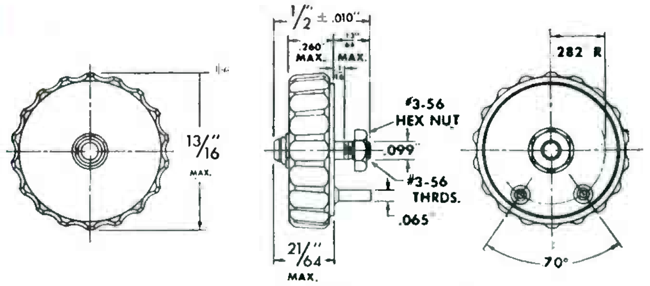
The long resistance path makes it possible to produce a unit of high resistance value with resistance materials having relatively low specific resistance. For this reason, Type MV Resistors have exceptional stability even in very high resistance values. The long resistance path permits the use of high voltage on the resistor while keeping the voltage per unit length of path comparatively low.

HANDLING. Type MV Resistors will stand ordinary handling; however, it is recommended that the units be installed after other mechanical work has been completed, and that the protective wrapping on the body of the resistor be left in place until the unit has been installed in the equipment.

HUMIDITY. General protective coatings of special varnish, baked individually at high temperature, provide protection against the effects of abnormal humidity. Maximum resistance change of ±5% can be expected due to humidity. Resistance will return to original value when humidity conditions become normal.

INSULATION. Base is ceramic with excellent high voltage characteristics. The spacing of the turns of the helical conducting path is designed to provide adequate protection against breakdowns between turns.

TYPE H FINGERTIP CONTROL



DIMENSIONS, TYPE H CONTROL

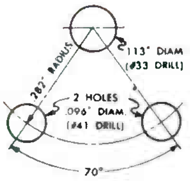
RESISTANCE ELEMENT: IRC Metallized coating, bonded to a phenolic strip, cured and stabilized at high temperature, in the same manner as IRC Type CS and D Controls. *Integral molding of this element with the phenolic base* results in improved strength, more efficient heat dissipation, and increased resistance to humidity.

CONTACTOR: A two-finger, ball-point, radial contact, of silver-plated spring alloy.

TERMINALS: Center Contact is a silver-plated brass stud with the external portion provided with No. 3-56 thread. The shoulder of the internal portion of the stud forms the bearing surface on which the moving contactor rotates when driven by the cover. The end terminals are silver-plated brass.

ROTATION: 290° rotation is standard.

POWER RATING: 0.25 Watts for linear taper.



Recommended mounting template for Type H Control

MOUNTING: Designed for mounting on an insulating bracket or panel having a 1/16" min. thickness or a max. thickness of 7/64". The center terminal, provided with a No. 3-56 Hex nut, is the principal mounting means. A three-hole mounting is recommended with the two end terminals acting as locating devices. If a suitable grommet or insulating bushing is used, the control can be mounted on a metal panel.

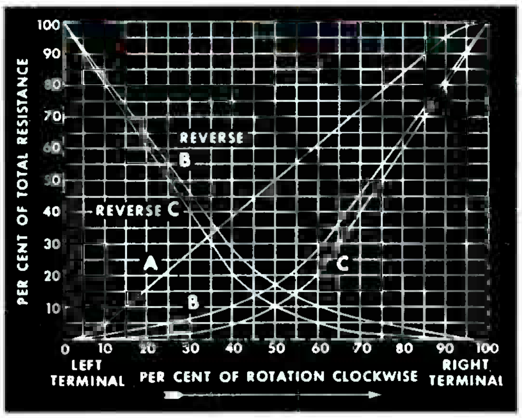


CHART "A"

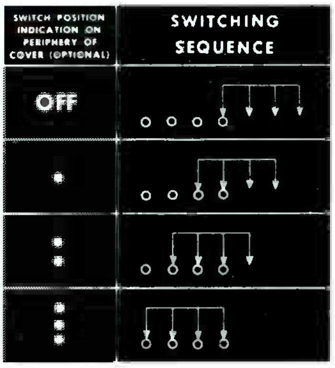
RESISTANCE VALUE and TAPERS: Available resistance values depend upon tapers, as listed below. Type H Controls can be provided with linear taper or any of the standard audio tapers, such as Curve B, Curve C, Reverse B or Reverse C, as shown in Chart "A." NOTE: Reversed B and Reversed C Curves show resistance change as measured between Clockwise and Center Terminals.

Curve	Min. Res.	Max. Res.
A	500 ohms	5.0 meg.
B or Reverse B	750 ohms	3.0 meg.
C or Reverse C	1000 ohms	2.0 meg.

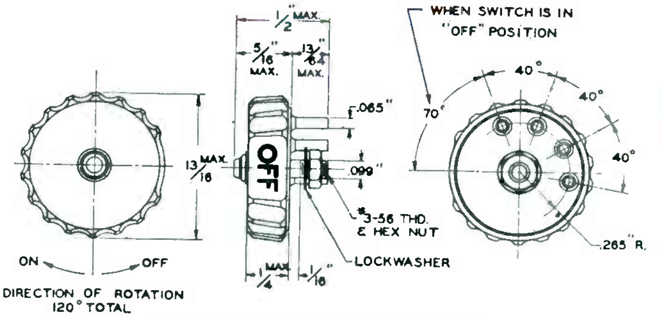
STANDARD TOLERANCE: ± 20%

TYPE SH FINGERTIP SWITCH

TYPE OF SWITCH: Type SH is a three-position switch. In addition to the "OFF" position, there are three operating positions, as shown in the Switch Contact Diagram. In Position 1, the first 2 terminals are connected together; in Position 2, the first, second and third terminals are shorted together, and in Position 3, all four of the terminals are connected together.

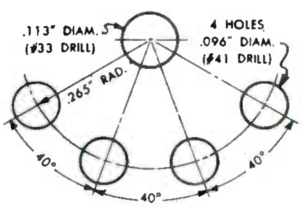


SWITCH CONTACT DIAGRAM



DIMENSIONS, TYPE SH SWITCH

MOUNTING: The central mounting stud, molded into the base, has a No. 3-56 thread and is provided with a lockwasher and a No. 3-56 Hex nut for mounting purposes. The Type SH Switch is designed to be mounted on an insulating bracket or panel having a 1/16" min. thickness, or a max. thickness of 7/64". As with the Type H Control, the terminals of the switch may function as locating devices in mounting.



Recommended mounting template for Type SH Switch

CONTACTOR: Silver-plated spring alloy, web-shaped contact.

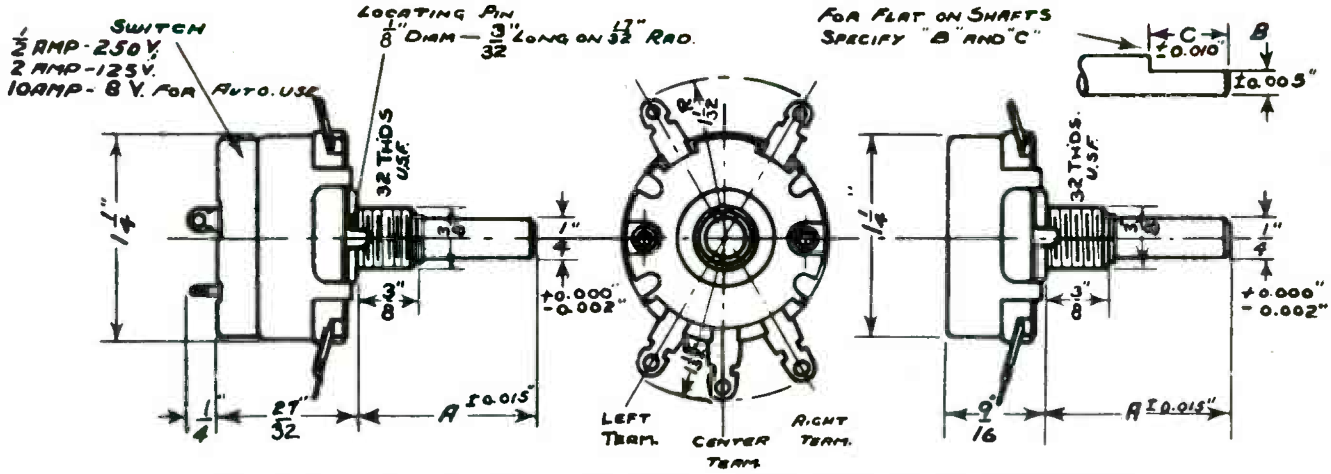
TERMINALS: The four silver-plated brass terminals are molded into a phenolic base. The central mounting stud in the switch is "live," as it is in direct contact with the contactor, but is not intended to be used as an external wiring connection.

ROTATION: Total rotation is 120°; 40° rotation per position.

DETENT: Positive in all positions, including "OFF" position.

CONTACT RATING: Suitable for filament circuit switch in pocket radios; for tone control circuits, or for combination filament switch and tone control applications.

SPECIFICATIONS WIRE WOUND CONTROLS



Depth from Mounting Face. Dual 1¼" Triple 1 23/32" For Switch Add 9/32"

SIZE. 1¼" diameter; depth behind panel, 9/16".

RESISTANCE ELEMENT. Copper-nickel or nickel-chrome alloy wire wound uniformly under tension on specially treated bakelite. Element securely seated in grooved bakelite base. Resistance wire welded to terminals for perfect contact.

CONTACTOR. Long-wearing contactor of unique design provides uniform pressure at any point, providing smooth progression of resistance. Contactor is riveted to spring connector which in turn is riveted to center terminal. This insures long life and absolute dependability.

ROTATION. Total rotation 295°; effective rotation 265° without switch, 218° with switch.

SHAFT. Brass shaft is standard; aluminum, steel, or stainless steel available on special order. ¼" diameter — length as required. Screw driver slot available. Flat available — specify dimensions "B" and "C" as shown on above drawing. Shaft is fully insulated from terminals.

BUSHING. Brass bushing. Diameter 3/8", thread 32 per inch. Standard length is 3/8"; ¼", ½" or 5/8" lengths available on special order.

SWITCH. S.P.S.T. is standard; S.P.D.T. and D.P.S.T. available on request. All switches carry Underwriters' approval.

LOCATING PIN. One pin is standard; either two or none may be had when specified.

COVER. Cover is grounded to bushing.

OFF POSITION. Off position is available when specified.

GANGED CONTROLS. The Type W is available as a dual or triple control and may be "ganged" with the Type C carbon control.

TERMINALS. Terminals are hot tin dipped. Three are standard; one may be omitted when specified.

IRC Control	Resistance	Max. Current (Amps.)
W-2	2	1.000
W-3	3	.815
W-5	5	.630
W-6	6	.560
W-8	8	.500
W-10	10	.450
W-15	15	.370
W-20	20	.320
W-25	25	.285
W-30	30	.260
W-40	40	.225
W-50	50	.200
W-60	60	.183
W-75	75	.164
W-100	100	.142
W-200	200	.100
W-300	300	.083
W-400	400	.071
W-500	500	.063
W-750	750	.052
W-1000	1000	.045
W-2000	2000	.032
W-3000	3000	.026
W-4000	4000	.022
W-5000	5000	.020
W-7500	7500	.016
W-10000	10000	.014

These standard values are available from IRC distributors' stocks. Intermediate values are manufactured to special order.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

IRC WIRE WOUND CONTROLS

2 WATT RHEOSTAT-POTENTIOMETER

The IRC Type W Control is designed for long, dependable service and balanced performance in every characteristic. A 2 watt variable wire wound unit, this control provides maximum adaptability to most rheostat and potentiometer applications within its power rating. It's small 1¼" by 9/16" design features the exclusive IRC spiral spring connector, a long-wearing alloy contactor, and welded connections between resistance element wire and terminals.

The Type W Control is widely used in many electronic applications, and with center tap is particularly suited for television receivers as vertical and horizontal centering control.

The highest grade alloy wire is wound with uniform spacing and tension on specially treated bakelite to form a precision resistance element. Element is securely seated in grooved bakelite base. Contactor slides on edge of element which prevents loosening of wire. Compact construction insures efficient electrical and mechanical operation even when subjected to severe vibration.

Combination metal and bakelite housing provides maximum heat dissipation as well as protection against dust and mechanical damage. Effects of humidity, temperature and aging are negligible.

CHARACTERISTICS

RESISTANCE VALUES. 2 ohms to 10,000 ohms.

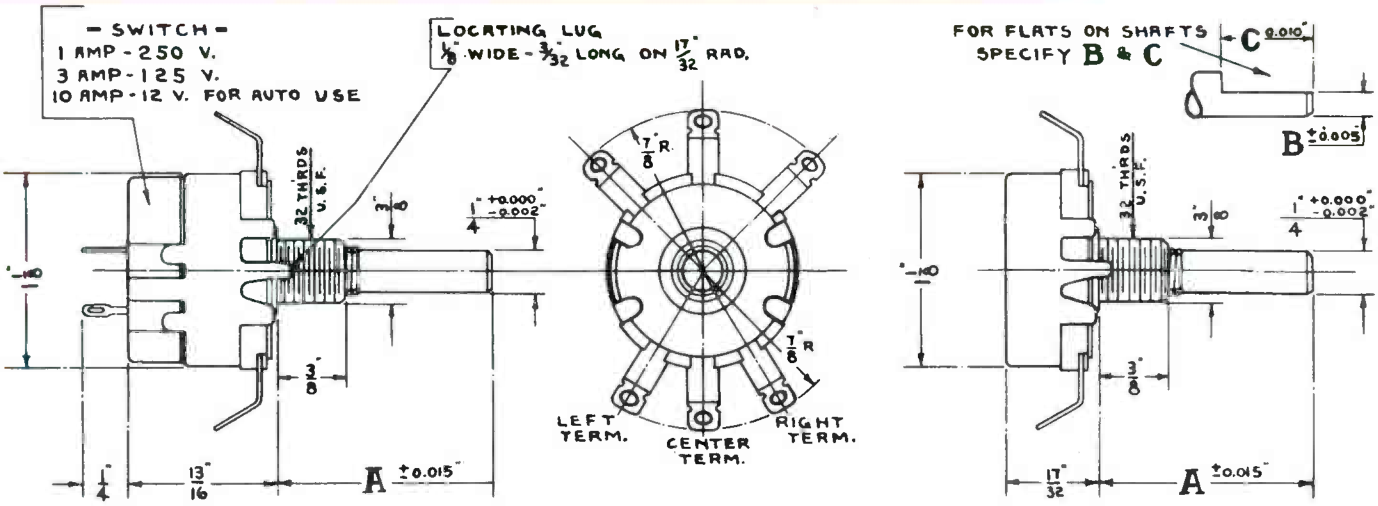
TOLERANCES. ± 10% standard; ± 5% available at extra cost.

POWER RATING. 2 watts. This rating allows 70°C. temperature rise at hottest spot on winding from a 25°C. ambient temperature.

TAPS. One tap is available at either of the following positions: 40%, 50%, or 60% of electrical rotation.

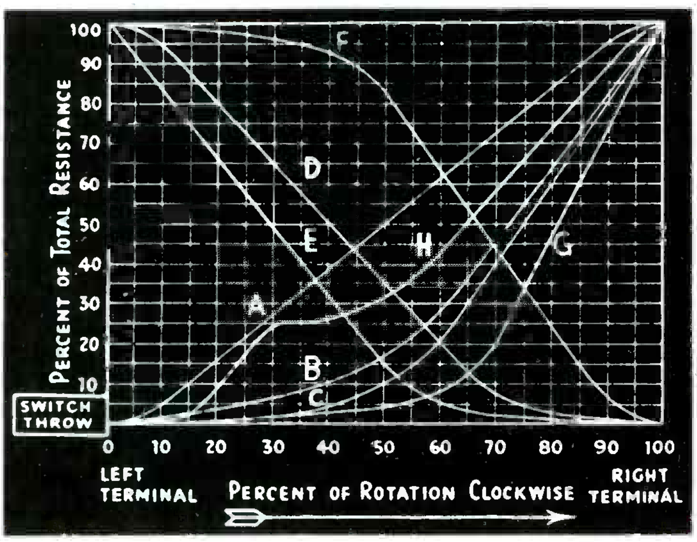
TAPERS. Linear taper is standard. Tolerance linearity is within ±3%. Special tapers available at extra cost.

SPECIFICATIONS TYPE DS VOLUME CONTROLS



	Without Switch	With Switch
Dual Control: Depth from Mounting face	1 1/16	1 11/32
Triple Control: Depth from Mounting face	1 19/32	1 7/8

STANDARD TAPERS



Special Tapers Available—
Only Linear Taper below 500 ohms.

SWITCH

Standard S.P.S.T.
Special D.P.S.T.

LOCATING PINS

One pin standard—two or none as specified.

GANGED CONTROLS

Type D S may be ganged in any combination required.

CONCENTRIC DUAL CONTROLS

Available with outer shaft controlling panel.

RESISTANCE VALUE

200 ohms to 10 megohms.

TOLERANCES

± 20% standard; ± 3% Rotational Tolerance.

POWER DISSIPATION

1/3 watt over entire element.

ROTATION

300° Standard.

SHAFT

1/4" diameter—length—Dim. A as required—Screw Driver Slot — Flats, etc., available—Standard material Brass.

BUSHING

Brass — diameter 3/8" thread, 32 per inch—Standard length 3/8"; special 1/4", 1/2" and 5/8".

TAPS

One or two available as required—Standard tap location: 35%, 50%, 65%.

COVER

Cover Grounded to Bushing.

INTERNATIONAL RESISTANCE CO.

IRC

401 NORTH BROAD STREET
PHILADELPHIA 8, PA. U. S. A.
TELEPHONE: WA 2-2166

IN CANADA: INTERNATIONAL RESISTANCE CO., LTD.
KING STREET WEST, TORONTO, LICENSEE

BRANCH OFFICE: 165 BROADWAY, NEW YORK, N. Y., Courtland 7-5020

SALES REPRESENTATIVES:

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ST. LOUIS, Mo.
Central 6300

J. U. McCarthy
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ST. PAUL, Minn.
Emerson 8619

James P. Hermans Co.
1234 Folsom St.
SAN FRANCISCO, Calif.
Market 4166

David M. Lee
2626 Second Ave.
SEATTLE, Wash.
Main 5512

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

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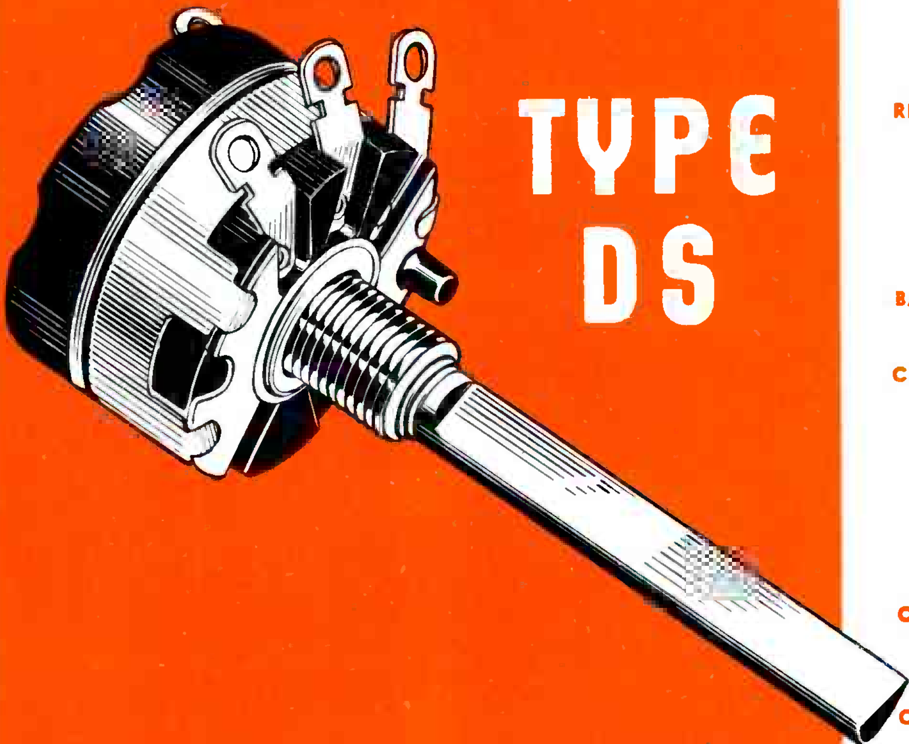


TYPE DS

VOLUME CONTROL POTENTIOMETER

The IRC type DS is a high quality 1⅛" diameter control conservatively rated at 1/3 watt over the entire element. Nothing has been sacrificed in the design or manufacture of this control. The finest materials are employed, and its compact design embodies many exclusive IRC engineering features.

The resistance coating is an adaptation of the IRC filament principle, famous for its stability. A smooth, moisture-proof element is provided by bonding the resistance material to a bakelite base. The conventional type collector ring is supplanted by a silent spiral spring in the DS control. This positive type of electrical connection eliminates sliding metal-to-metal contact, the primary source of control noise. Contact with element is made by a unique multi-finger contactor utilizing the "knee-action" engineering principle.

IRC is the world's largest exclusive manufacturer of resistance products. Over twenty years' experience, engineering "know-how" and manufacturing technique are incorporated in the production of each DS control. An unsurpassed record of dependability over long operational life, low noise level and stability have made the IRC type DS the industry's "number one" control-potentiometer for applications requiring quality components.

CONSTRUCTION

RESISTANCE ELEMENT

Resistance material permanently bonded to bakelite base by carefully controlled heat treatment process, resulting in a smooth, moisture-proof resistance element of excellent stability.

BASE

Highest grade molded bakelite.

CONTACTOR

Exclusive IRC five-finger contactor consisting of five tinned phosphor bronze spring wires. Each finger operates independently on "knee-action" principle, assuring positive uniform contact. Contactor surfaces are rounded and smooth, minimizing noise and wear.

CONTACTS

All parts making fixed pressure contact silver plated to prevent corrosion.

CONNECTOR

Permanent connection is established between contactor and terminal with silent spiral spring connector—an exclusive IRC feature. This advanced form of design eliminates sliding metal-to-metal contacts, thus removing the most troublesome source of control noise.

THRUST WASHER

Coil spring thrust washer eliminates shaft wobble and "end play."

CHARACTERISTICS

AGEING

Control element is aged during processing, thus minimizing change during service to 1 or 2%.

WEAR

Average variation is 5% after 25,000 rotations—slight increase in percentage as rotations increase.

HUMIDITY

Exposure to most humid climatic conditions for long periods causes positive change in range of approximately 10%. Control returns to initial value upon drying.

NOISE

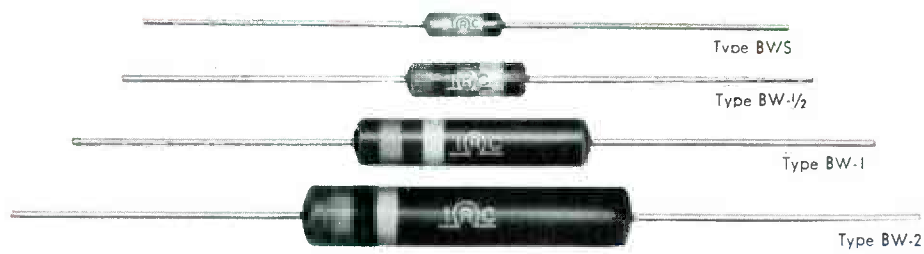
Silent Spiral Spring Connector and Five-Finger Contactor reduce contact noise to a negligible minimum.

TEMPERATURE COEFFICIENT

.02%/°C. to .05%/ °C.

TYPE BW INSULATED WIRE WOUND RESISTORS

(Illustrations Actual Size)



GENERAL SPECIFICATIONS AND CHARACTERISTICS

TOLERANCES. ± 10% is standard. Values above 10 ohms available in ± 5% tolerance. For closer tolerance requirements, see paragraph "Matched Pairs."

COLOR CODING; IDENTIFICATION. Type BW Resistors are dark brown in color, with a waxed, non-gloss surface. Resistance values indicated by standard RMA Color Code bands. It is not practical to provide special stamping because of their small size.

STANDARD RESISTANCE VALUES. RMA Preferred Ranges, subject to minimum and maximum values as listed for each BW type.

NOISE. Negligible.

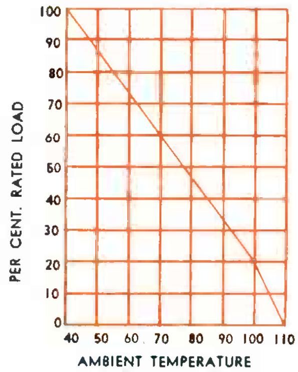
HUMIDITY. Designed to withstand abnormal atmospheric conditions.

OVERLOAD. 50% to 100% overloads may be applied with negligible changes and return to initial value.

AGING. Negligible.

DERATING

Ratings of Type BW Resistors are based on an ambient temperature of 40°C. When BW's are used at ambient temperatures exceeding 40°C., load should not exceed that indicated by the JAN-R Derating Curve reproduced here.



TYPE BW
(DEGREES CENTIGRADE)

FREQUENCY CHARACTERISTICS. The inductance of BW Resistors is relatively low, making them suitable for use at carrier frequencies. The following table gives the approximate inductance for maximum and minimum resistance values.

TYPE	Minimum Resistance	Approx. Inductance in Microhenries	Maximum Resistance	Approx. Inductance in Microhenries
BWS	1.0 Ohm	0.08 mh.	300 Ohms	1.3 mh.
BW-½	0.24 Ohm	0.02 mh.	820 Ohms	4.02 mh.
BW-1	0.47 Ohm	0.20 mh.	5100 Ohms	60.0 mh.
BW-2	1.0 Ohm	0.50 mh.	8200 Ohms	115.0 mh.

Type BWS

NOTE: *Type BWS will not be available for general use during the war. Samples supplied for postwar designs upon request.*

POWER RATING: ¼ watt (at 40°C. ambient).

DIMENSIONS: Length 13/32". Diameter ⅛". Lead length 1½". ± ⅛". Lead diameter 0.032".

TEMPERATURE RISE AT RATED LOAD: 30°C.

STANDARD RESISTANCE VALUES: Minimum, 1.0 ohm, Maximum, 300 ohms.

Type BW-½

JAN-R-184 TYPE: RU3. **POWER RATING:** ½ watt (at 40°C. ambient).

DIMENSIONS: Length ⅝". Diameter 3/16". Lead length 1½", ± ⅛". Lead diameter 0.032".

TEMPERATURE RISE AT RATED LOAD: 50°C.

INSULATION: 700 volts breakdown to ground.

STANDARD RESISTANCE VALUES: Minimum, 0.24 ohm. Maximum, 820 ohms. **JAN-R-184:** Maximum, 420 ohms.

Type BW-1

JAN-R-184 TYPE: RU4. **POWER RATING:** 1 watt (at 40°C. ambient).

DIMENSIONS: Length 1¼". Diameter ¼". Lead length 1½", ±⅛". Lead diameter 0.036".

TEMPERATURE RISE AT RATED LOAD: 65°C.

INSULATION: 1000 volts breakdown to ground.

STANDARD RESISTANCE VALUES: Minimum, 0.47 ohm. Maximum, 5100 ohms. **JAN-R-184:** Maximum, 2200 ohms.

Type BW-2

JAN-R-184 TYPE: RU6. **POWER RATING:** 2-watts.

DIMENSIONS: Length 1¾". Diameter 21/64". Lead length 1½". ± ⅛". Lead diameter 0.036".

TEMPERATURE RISE AT RATED LOAD: 90°C.

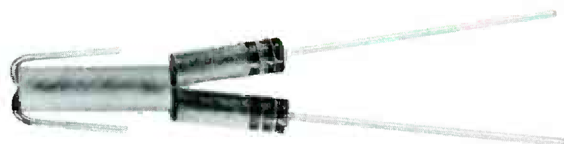
INSULATION: 1000 volts breakdown to ground.

STANDARD RESISTANCE VALUES: Minimum, 1.0 ohm. Maximum, 8200 ohms. **JAN-R-184:** Maximum, 3300 ohms.

TEMPERATURE COEFFICIENT. To cover a wide range of resistance values, it is necessary to use several different wire alloys, which have different temperature coefficients, as indicated by the following table.

TYPE	0.12%/°C	0.038%/°C	0.002%/°C	0.017%/°C
BWS		1.0 Ohm to 3.0 Ohms	3.3 Ohms to 10.0 Ohms	11 Ohms to 300 Ohms
BW-½		0.24 Ohm to 0.75 Ohm	0.82 Ohm to 5.1 Ohms	5.6 Ohms to 820 Ohms
BW-1	0.51 Ohm to 1.10 Ohms	1.2 Ohms to 3.6 Ohms	3.9 Ohms to 36.0 Ohms	39.0 Ohms to 5100 Ohms
BW-2	1.0 Ohm to 2.0 Ohms	2.2 Ohms to 6.8 Ohms	7.5 Ohms to 51.0 Ohms	56 Ohms to 8200 Ohms

MATCHED PAIR RESISTORS



IRC Matched Pairs—two resistors matched in series or parallel to as close as 1% initial accuracy provide a dependable low cost solution to close tolerance requirements.

Both IRC BT Insulated Filament-type resistors and type BW Insulated Wire Wounds are available in Matched Pairs. Tolerances from ± 5% to ± 1% can be furnished. They are supplied random color coded or unmarked, and held together for shipping by a paper band upon which is noted the resistance value and tolerance, or any two digit part number.

IRC Matched Pairs are widely used as meter multipliers, and in many other close tolerance applications where low cost is an important factor. When ordering, the higher ohmic values should be specified to be matched in series and the lower values in parallel.

Due to temperature coefficients and possible variations in resistance value as a result of testing conditions, type BT Matched Pairs are not returnable for out-of-tolerance measurement unless variations exceed ± 3½% from nominal value.

NOTE: Matched Pairs should not be soldered closer than ¼" from body of the resistors, mounted against any heat dissipating component, or used at full rating of the resistors—as any one of these conditions may force the resistors out of tolerance.

MATCHED PAIR RESISTANCE LIMITS

Parallel Matched Pairs

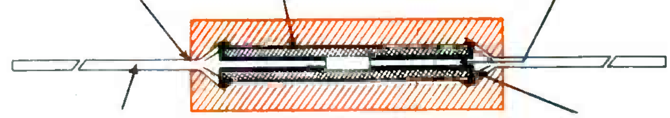
Type	Minimum Resistance	Maximum Resistance
BW-½	5 Ohms	410 Ohms
BW-1	2.5 Ohms	2550 Ohms
BW-2	3.75 Ohms	4100 Ohms
BTS	235 Ohms	10.0 Megohms
BTA	165 Ohms	10.0 Megohms
BT-2	235 Ohms	10.0 Megohms

Series Matched Pairs

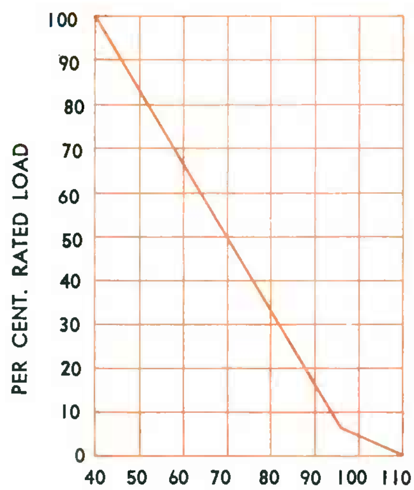
Type	Minimum Resistance	Maximum Resistance
BW-½	20 Ohms	1640 Ohms
BW-1	10 Ohms	10,200 Ohms
BW-2	15 Ohms	16,400 Ohms
BTS	940 Ohms	40.0 Megohms
BTA	660 Ohms	40.0 Megohms
BT-2	940 Ohms	40.0 Megohms

IRC TYPE BT RESISTORS

CONSTRUCTION



DERATING CURVE FOR HIGH AMBIENT TEMPERATURES



Ratings of Type BT are based on an ambient temperature of 40°C. Ambient conditions as well as voltage ratings and actual power requirements should be considered when determining the proper size of resistor for any application. When BT's are used at ambient temperatures exceeding 40°C., load should not exceed that indicated by the JAN-R Derating Curve reproduced here.

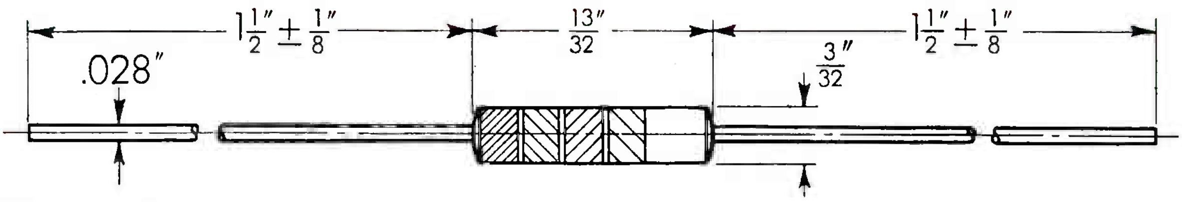
STANDARD VALUES TYPES BT AND BW

(In accordance with JAN-R-11 and RMA Preferred Resistance Values)

Because of general adoption of these values, it has become necessary to standardize all Type BT and BW production and stocks on JAN-R-11 values. Available ranges for each type of BT and BW Resistor are limited by the minimum and maximum values listed for each type.

	OHMS						MEGOHMS		
RMA No.	0 to 1.0	1 to 9.1	10 to 91	100 to 910	1,000 to 9,100	10,000 to 91,000	0.1 to 0.91	1.0 to 9.1	10 to 91
10	—	1.0	10	100	1,000	10,000	0.1	1.0	10.0
11	—	1.1	11	110	1.100	11,000	0.11	1.1	11.0
12	—	1.2	12	120	1.200	12,000	0.12	1.2	12.0
13	—	1.3	13	130	1.300	13,000	0.13	1.3	13.0
15	—	1.5	15	150	1.500	15,000	0.15	1.5	15.0
16	—	1.6	16	160	1.600	16,000	0.16	1.6	16.0
18	—	1.8	18	180	1,800	18.000	0.18	1.8	18.0
20	—	2.0	20	200	2,000	20.000	0.20	2.0	20.0
22	—	2.2	22	220	2,200	22,000	0.22	2.2	22.0
24	0.24	2.4	24	240	2,400	24,000	0.24	2.4	24.0
27	0.27	2.7	27	270	2,700	27,000	0.27	2.7	27.0
30	0.30	3.0	30	300	3,000	30,000	0.30	3.0	30.0
33	0.33	3.3	33	330	3,300	33,000	0.33	3.3	33.0
36	0.36	3.6	36	360	3.600	36.000	0.36	3.6	36.0
39	0.39	3.9	39	390	3,900	39,000	0.39	3.9	39.0
43	0.43	4.3	43	430	4,300	43,000	0.43	4.3	43.0
47	0.47	4.7	47	470	4,700	47,000	0.47	4.7	47.0
51	0.51	5.1	51	510	5,100	51,000	0.51	5.1	51.0
56	0.56	5.6	56	560	5,600	56.000	0.56	5.6	56.0
62	0.62	6.2	62	620	6,200	62.000	0.62	6.2	62.0
68	0.68	6.8	68	680	6.800	68.000	0.68	6.8	68.0
75	0.75	7.5	75	750	7,500	75,000	0.75	7.5	75.0
82	0.82	8.2	82	820	8,200	82.000	0.82	8.2	82.0
91	0.91	9.1	91	910	9,100	91.000	0.91	9.1	91.0

TYPE BTR (⅓ WATT) *METALLIZED* INSULATED RESISTOR



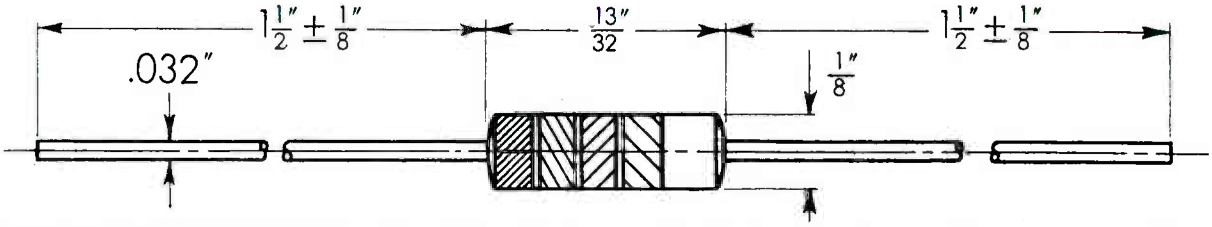
POWER AND VOLTAGE RATING: ⅓ watt (at 40°C. ambient) . . . 250 volts maximum continuous voltage. See Derating Curves, page 4 for higher ambients.

INSULATION BREAKDOWN VOLTAGE: 500 volts to ground.

STANDARD RESISTANCE VALUES: Minimum, 470 ohms; maximum, 22 megohms. Higher values on special order.

TEMPERATURE RISE: At ⅓-watt rating, 40°C. (At ¼-watt rating, 30°C.)

TYPE BTS (½ WATT) *METALLIZED* INSULATED RESISTOR



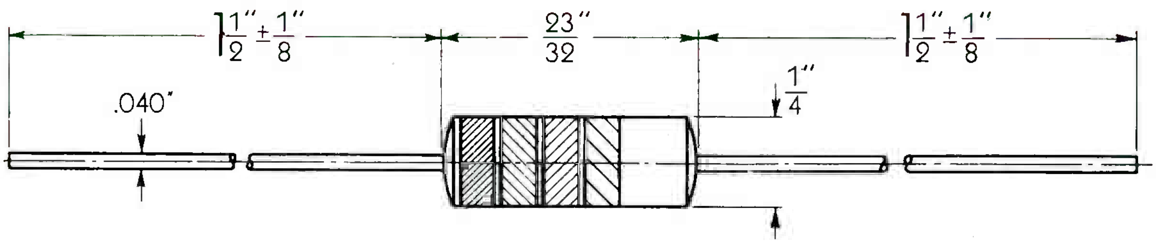
POWER AND VOLTAGE RATING: ½ watt (at 40°C. ambient) . . . 350 volts maximum continuous voltage. See Derating Curves, page 4 for higher ambients.

TEMPERATURE RISE AT RATED LOAD: 45°C.

STANDARD VALUES: Minimum, 470 ohms; maximum, 22 megohms. Higher values on special order.

INSULATION BREAKDOWN VOLTAGE: 750 volts to ground.

TYPE BTA (1 WATT) *METALLIZED* INSULATED RESISTOR



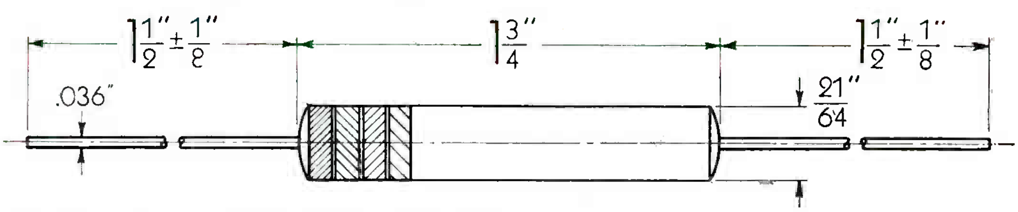
POWER AND VOLTAGE RATING: 1 watt (at 40°C. ambient) . . . 500 volts maximum continuous voltage. See Derating Curves, page 4. for higher ambients.

TEMPERATURE RISE AT RATED LOAD: 52°C.

STANDARD RESISTANCE VALUES: Minimum, 330 ohms; Maximum, 22 megohms. Higher values on special order.

INSULATION BREAKDOWN VOLTAGE: 1000 volts to ground.

TYPE BT-2 (2 WATT) *METALLIZED* INSULATED RESISTOR



POWER AND VOLTAGE RATING: 2 watts (at 40°C. ambient) . . . 500 volts maximum continuous voltage. See Derating Curves, page 4, for higher ambients.

TEMPERATURE RISE AT RATED LOAD: 62°C.

STANDARD RESISTANCE VALUES: Minimum, 470 ohms; Maximum, 22 megohms. Higher values on special order.

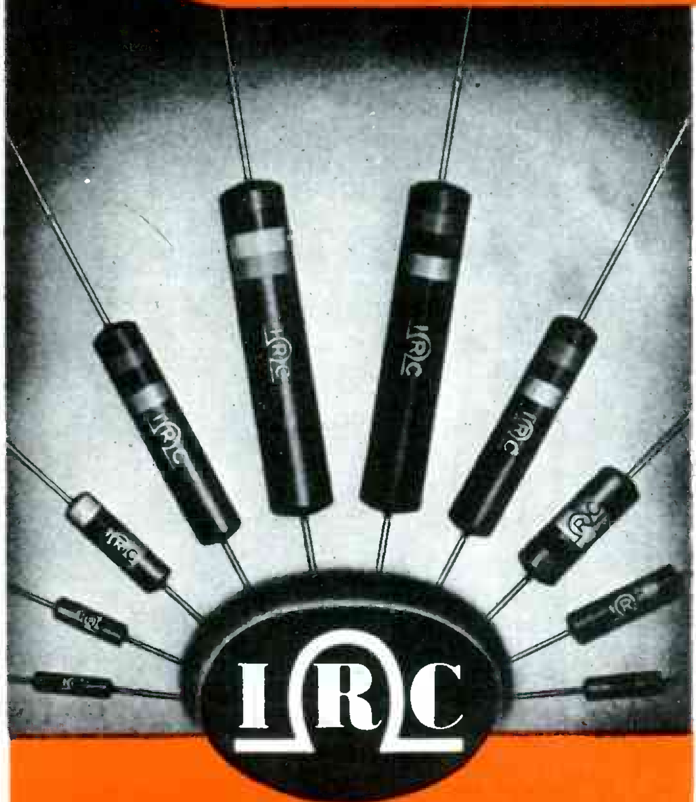
INSULATION BREAKDOWN VOLTAGE: 1000 volts to ground.

CATALOG DATA BULLETIN

Important information for Engineering and Purchasing Depts. Please file with your IRC Catalog.

INTERNATIONAL RESISTANCE CO., 401 N. Broad St., Philadelphia 8, Pa., U. S. A.

In Canada: International Resistance Co., Ltd., Toronto, Licensee



TYPE

BT

METALLIZED

INSULATED RESISTORS

and

TYPE

BW

INSULATED WIRE WOUND RESISTORS

TYPE BT METALLIZED INSULATED RESISTORS

IRC's Metallized filament principle and the unique construction of Type BT Resistors insures low operating temperatures with good wattage dissipation in small, sturdy, light weight, fully insulated units. The BT design also provides exceptionally low noise level and maximum protection against humidity.

GENERAL SPECIFICATIONS

STANDARD RESISTANCE VALUES. In keeping with the trend toward standardization of electronic components, Type BT Resistors are supplied only in RMA (Radio Manufacturers' Association) Preferred Resistance Ranges, subject to minimum and maximum values listed for each type. RMA Ranges are identical to Joint Army-Navy War Standard Ranges.

COLOR CODING; IDENTIFICATION. BT Resistors are natural-bakelite color, non-gloss surface, waxed. Resistance values are indicated by standard RMA Color Code Bands. Because of their small size, it is not practical to provide special stamping.

TOLERANCES. ± 10% standard. Available in ± 5%, ± 10 % and ± 20% tolerance.

TEMPERATURE COEFFICIENT. The temperature coefficient of Type BT Resistors varies from 0.02%/°C for low ranges to 0.14%/°C for high ranges. The low temperature coefficients qualify Type BT Resistors under JAN-R-11 Resistance-Temperature Characteristic "F", which is the better of the two grades of specified resistance-temperature characteristics. Type BT Resistors also successfully undergo the Temperature Cycling test of JAN-R-11.

VOLTAGE COEFFICIENT. Varies from 0.0% to 0.027% per volt, depending upon range and size of resistor. Each BT type fulfills the voltage coefficient requirement of its applicable JAN-R-11 specification.

NOISE LEVEL. Because of the inherent features of the Metallized filament and the low resistance contact of Type BT Resistors, noise level is uniform and consistently low.

OVERLOAD. 50% to 100% overload may be applied with nominal changes and return to initial value. Five-second overloads of 2.5 times rated load (double maximum continuous working voltage in the higher ranges) also result in negligible resistance change.

AGING. The pre-curing and stabilizing of the BT filament eliminates to a very large degree the aging problem.

INSULATION BREAKDOWN VOLTAGE. All BT Resistors are conservatively rated, and, in all cases, ratings fulfill JAN-R-11 requirements.

HIGH ALTITUDE FLASHOVER. Type BT Resistors do not flash over when subjected to the JAN-R-11 High Altitude Flashover test.

VIBRATION. BT Resistors show a resistance change of less than the JAN-R-11 permissible maximum of 1% under the 5-hour vibration test.

IRC Presents

a condensation of technical literature covering the industry's most complete line of resistors

CLASSIFICATION	PRODUCT	PAGE
fixed insulated resistors	Insulated Composition Resistors ⅓, ½, 1 & 2 Watt BT Type	2, 3, 4
	Insulated Wire Wound Resistors ¼, ½, 1 & 2 Watt BW Type	5
	Insulated Wire Wound Molded Resistors MW TYPE	29, 30
	Close Tolerance Resistors Matched Pairs BT or BW Type	4
fixed power resistors	Power Wire Wounds Tubular PWW Type	23, 24 25, 26
	Power Wire Wounds Flat FRW Type	27, 28
	High Power Resistors Composition MP TYPE	13, 14 15, 16
	High Voltage Resistors Composition MV Type	11, 12
	Water-Cooled Resistors LP Type	17, 18
precision resistors	Precision Wire Wound Resistors WW Type	32
	Voltmeter Multipliers MF Type	31, 32
variable resistors	Control-Potentiometer DS Type	6, 7
	Wire Wound Control 2 Watt W Type	8, 9
	Power Rheostat PR Type	19, 20 21
	Power Rheostat AN3155 PRT Type	22
	Finger-Tip Control H Type	10

More detailed information on the characteristics and specifications of IRC products is available in separate catalog bulletins. When requesting these bulletins please specify the products in which you are interested.

INTERNATIONAL RESISTANCE COMPANY

UNBRAKO SELF-LOCKERS

Reg. U. S. Pat. Off.

They dig-in and "stay put"

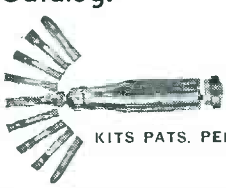
PAT'D AND PATS. PEND.

Self-Lockers—because their knurled cup points dig in and *stay tight*—even when subjected to the most chattering vibration. Yet, they can be backed out with a wrench and used *again* and *again*. That's why so many millions of these tough, dependable "Unbrako" Socket Set Screws with the Knurled Cup Points are used in industry. For complete information about these and other "Unbrako" Socket Screw Products . . . write for the "Unbrako" Catalog.

These "Unbrako" Screw Products are available in sizes ranging from No. 4 to 1½" in diameter and in a full range of lengths.

"Unbrako" and "Hallowell" Products are sold entirely through Industrial Distributors.

Knurling of Socket Screws originated with "Unbrako" in 1934.



KITS PATS. PEND.

You can't tighten or loosen socket screws without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

"Unbrako" Socket Head Cap Screws with the knurled head save assembly time because the knurling provides a slip- and fumble-proof grip—though the fingers and head be ever so oily, therefore, they can be screwed in faster and farther before it becomes necessary to use a wrench. They can also be locked in place if heads are countersunk.

PAT'D AND PATS. PEND.

The "Unbrako" Socket Set Screw with Knurled Threads is a most excellent Self-Locker, too, because the knurling as shown, swages the threads when locking results. To be used with points such as: flat, dog, cone and oval which do not lend themselves to knurling.

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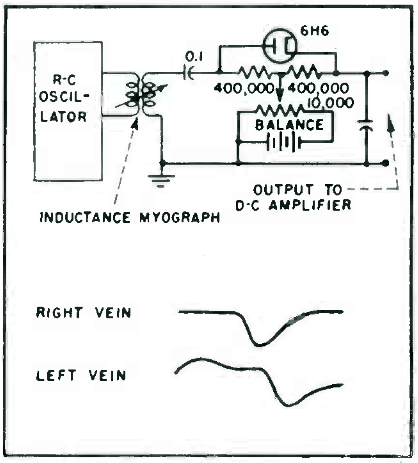
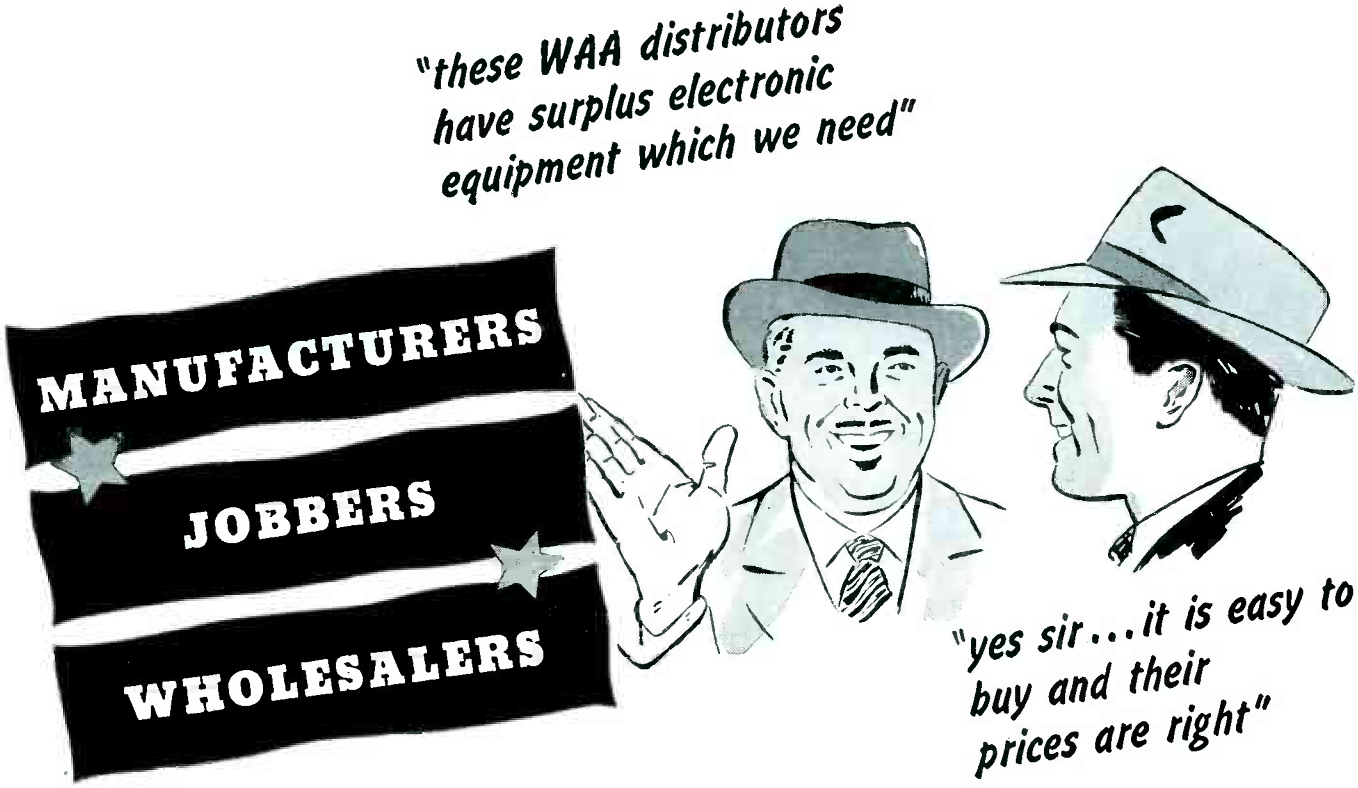


FIG. 2—Two variable-inductance myographs, of the type shown in the schematic diagram, were used to make this record of fractionate contraction of the veins going to a turtle heart

line with evaporation of the salt solution. In addition there was a theoretical possibility of a variable lag due to surface tension of the solution.

Another myograph was then constructed which utilized the photoelectric principle. A very small photocell and a bronchoscope light were mounted on one arm of the myograph so that the light projected directly onto the photocell. A shutter extended from the other arm, cutting off the light as the points were brought together by contraction. This was satisfactory, except that it was too heavy for practical use in many circumstances[2].

The instrument in use at present is of the inductance type. One coil is mounted on each of the arms which are so arranged that they are almost in contact when the points are separated by about 3 mm. The coils of No. 41 wire are wound on extremely light plastic forms about 1 mm thick and 11 mm in diameter. One is energized by 50,000-cycle current from an R-C oscillator. The other coil acts as the secondary of a transformer, and produces a voltage of varying magnitude, depending on the separation of the coils. The output of the secondary coil is rectified and fed to the recording apparatus as varying d-c. The myograph is shown in Fig. 1. This instrument is sufficiently sensitive so that it can be used for recording the fractionate contraction of the veins going to



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the turtle heart. A schematic circuit diagram of the myograph together with a record obtained using two instruments of this type are shown in Fig. 2.

This research was supported in part by the Wisconsin Alumni Research Foundation and the Brittingham Research Fund.

(1) H. Goldberg and J. A. E. Eyster, *Am. J. Physiol., p* 390, *Vol.* 128, 1940.

(2) W. E. Gilson, Applications of Electronics to Physiology, ELECTRONICS, Jan. 1943.

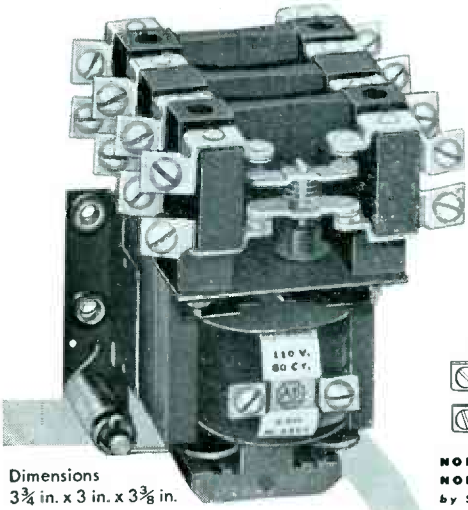
SURVEY OF NEW TECHNIQUES

GLASS-METAL TUBE SEALS of the copper or Kovar type having an oxide surface between metal and glass—as in usual seals—have high resistance at very high and ultrahigh frequencies. The oxide surface carries most of the current. Gold coating at the glass-metal seal improves the conductivity by about 30 times.

INSTRUMENT PANELS and scales can be made luminescent by using phosphorescent Lucite, which retains its afterglow for about 12 hours after exposure to light.

USING WAVEGUIDES for trunk lines in communications systems such as the telephone and telegraph services is considered possible by Dr. H. M. Barlow of the University of London. Although fraught with difficulties, waveguides can introduce less attenuation than coaxial cables, provide such good screening that a 60 db power drop can be tolerated between repeaters (against 20—40 db for l-f carrier systems), and the waveguide, like the coaxial cable, can be arranged to carry power for the repeaters. The size of the waveguide compares favorably with that of current multiconductor cables, and it could readily accommodate the same number of channels.

CALCULATING MACHINE has been developed by the Soviet Power Institute that solves up to six linear differential equations or six algebraic equations with complex coefficients. It uses electronic circuits and operates by electrical analogy of physical phenomena, and has been used to solve problems involving turbogenerators, airplane stability, and fluctuations of control systems (no further details were available).

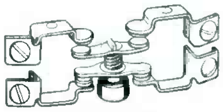


Dimensions
3¾ in. x 3 in. x 3⅜ in.

RELAYS

for Electronic Circuits

BULLETIN 700 UNIVERSAL RELAYS are a new and important addition to the standard line of Allen-Bradley solenoid relays with a 10-ampere rating. These universal relays have two banks of contacts which permit quick and easy changes from NORMALLY OPEN TO NORMALLY CLOSED contacts ...or vice versa... merely by shifting terminal connections. (See diagrams at left.) They are ideal for electronic applications in which circuit connections must be interchangeable to meet varied operating conditions. Available in 2, 4, 6, and 8 poles, with double break, silver alloy contacts which need no maintenance. There are no pins, pivots, bearings, or hinges to bind or stick. Hence, these relays are good for millions of trouble-free operations in electronic service. Send for bulletin, today.



Change from NORMALLY-OPEN Contacts to NORMALLY-CLOSED Contacts by Simply Shifting Connections

Typical Contact Connections

Relay with 4 NORMALLY-OPEN 0 NORMALLY-CLOSED CONTACTS

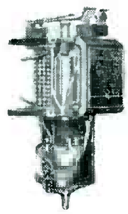
Relay with 3 NORMALLY-OPEN 1 NORMALLY-CLOSED CONTACTS

Relay with 2 NORMALLY-OPEN 2 NORMALLY-CLOSED CONTACTS

Relay with 1 NORMALLY-OPEN 3 NORMALLY-CLOSED CONTACTS

Relay with 0 NORMALLY-OPEN 4 NORMALLY-CLOSED CONTACTS

OTHER ALLEN-BRADLEY RELAYS & CONTACTORS



BULLETIN 848 TIMING RELAYS are ideal for any service requiring an adjustable delayed action relay. Have normally open or normally closed contacts.

Magnetic solenoid core is restrained from rising by the piston in oil dash-pot. Adjustable valve in piston regulates time required to pull piston through oil-seal and trip the contacts, which open or close with quick, snap action. Ideal for transmitter plate voltage control.

BULLETIN 702 SOLENOID CONTACTORS for heavy duty ratings up to 300 amperes. Arranged for 2- or 3-wire remote control with push buttons or automatic pilot devices.

Enclosing cabinets for all service conditions. Double break, silver alloy contacts require no maintenance. Solenoid mechanism is simple and trouble-free.

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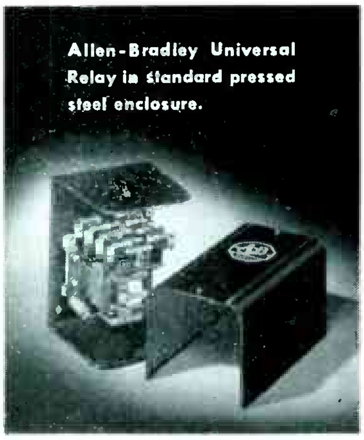
ALLEN-BRADLEY

RESISTORS QUALITY **RELAYS**



Allen-Bradley Universal Relay in standard pressed steel enclosure.

NEW PRODUCTS
(continued from p 150)

distances up to 1,000 ft. Its applications include traffic control, counting and limiting, and the like. The light source contains a lamp, transformer, and motor-driven slotted disk which modulates the light beam at about 900 cps. The relay, because of its tuned circuit, is responsive only at this frequency.

Insulation Testing Ohmmeter (14)

HERMAN H. STICHT CO., INC., 27 Park Place, New York 7, N. Y. Model B-7 Megohmer has ranges of 0-200 megohms at 500 volts d-c, 0-20 megohms at 250 volts d-c, 0-200 and 0-20,000 ohms. On the 0-200

ohm scale testing to 0.1 ohm is possible. Bulletin No. 440, with complete description and pertinent information, is available on request.

Crystal-Controlled Signal Generator (15)

PREMIER CRYSTAL LABORATORIES, INC., 57-67 Park Row, New York 7, N. Y. With the model 117 crystal-controlled signal generator any frequency from 100 kc to 10.8 mc can be obtained using 110 volt power supply, a-c or d-c. The instrument

draws 17 watts, and comes equipped with a 6-foot cord and 53-inch leads with insulated clips.

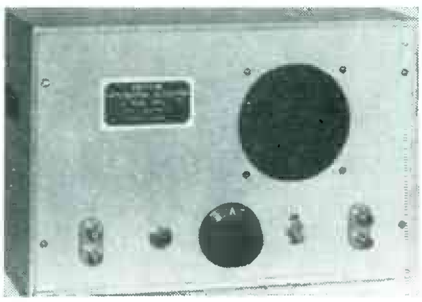
Calibration Units (16)

JAMES MILLEN MFG. CO., INC., 150 Exchange St., Malden 48, Mass., announces two new frequency calibration units for use in checking trans-

mitter carrier frequencies and other h-f signals against WWV. Model 90515 combines the functions of the secondary frequency standard model 90505 and the h-f multiple and mixer unit, model 90511. Model 90511 is also available separately.

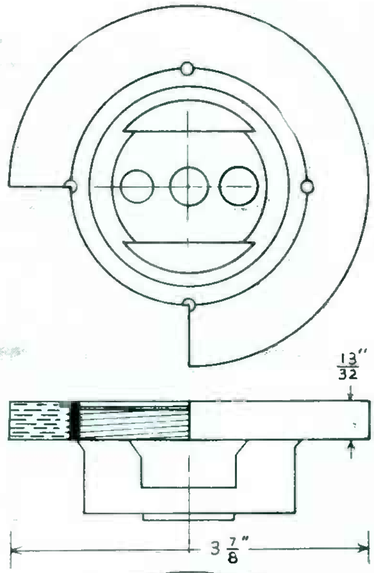
Heterodyne Detector (17)

KALBFELL LABORATORIES, INC., 1076 Morena Blvd., San Diego 10, Calif. The Kay-Lab heterodyne detector will measure signals of 100 microvolts and is usable from 500 cycles to 50 mc. It is used to compare an

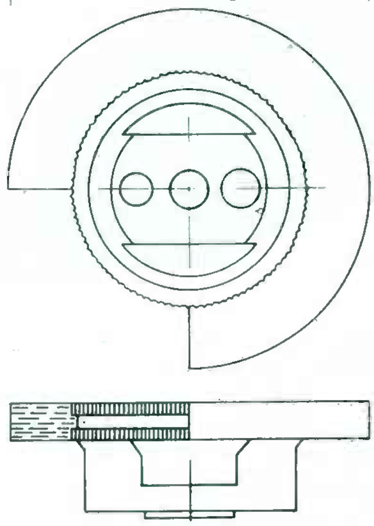


Problems solved by Richardson...in Plastics

#2 - DESIGN OF A PLASTIC AIRCRAFT GEAR



PROBLEM: MAGNETO GEAR AS ORIGINALLY DESIGNED WAS A DISK OF INSUROK LAMINATED MATERIAL. BORED & THREADED ON THE INSIDE DIAMETER, & SCREWED ONTO A METAL SPIDER. AFTER WHICH, HOLES WERE DRILLED THROUGH THREADED SECTIONS, INTO WHICH METAL PINS WERE DRIVEN & RIVETED. THIS METHOD OF ASSEMBLY PROVED INEFFICIENT DUE TO THE STRENUOUS STRESSES REQUIRED FOR AIRCRAFT, & DISKS HAD TENDENCY TO LOOSEN. THUS THE PROBLEM WAS TO SECURE A PERMANENT MOUNTING WHICH COULDN'T BE LOOSENED FROM THE SPIDER.



SOLUTION: RICHARDSON PLASTICIANS RECOMMENDED ADOPTION OF MOLDED PROCEDURE. INSTEAD OF THREADING THE SPIDER, THIS SECTION WAS DEEPLY KNURLED & A CENTRAL GROOVED RECESS WAS CUT AFTER KNURLING. THE SPIDER WAS MOUNTED IN A SUITABLE MOLD & DISKS OF SATURATED MATERIALS WERE MOLDED INTO PLACE. MATERIAL FILLED RECESS & KNURLED PORTIONS TO GIVE PERFECT BONDING.

WHEN ELECTRICAL FLASH-OVERS OCCURRED AT LATER DATE, MOLD WAS CHANGED TO PERMIT INCLUSION OF SATURATED DISKS TO COVER METAL WHERE FLASH-OVERS OCCURRED. THIS DESIGN CHANGE ELIMINATED ALL PREVIOUS DIFFICULTIES.

INSUROK Precision Plastics

INSUROK is the family name of a great variety of laminated and molded plastic products produced by Richardson. Laminated **INSUROK** is available in sheets, rods, tubes, punched and machined parts, made with paper, fabric, glass, etc. Molded **INSUROK** products are made from Beetle, Bakelite, Plaskon, Tenite, Styron, Durez, Lucite, etc., by compression, injection and transfer molding.

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RICHARDSON MEANS *Versatility* IN PLASTICS

unknown frequency with that of a signal generator. In addition it will demodulate an a-m signal without use of a second oscillator. The circuit consists of a pentagrid converter and a high-gain audio amplifier with loudspeaker.

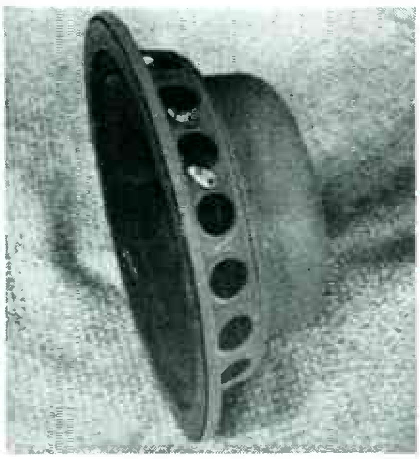
Welding Timer (18)

RIPLEY CO., INC., Middletown, Conn. The 52D Timatron can time any welding machine up to 10 kva and is adjustable from 0.1 second to 5 seconds by a hand control covering

any timing range desired. Once set for a particular thickness of metal, timing becomes automatic for the entire production run.

Loudspeaker (19)

GRAYBAR ELECTRIC CO., 420 Lexington Ave., New York 17, N. Y. Western Electric type 755A loudspeaker is an 8-inch unit with a frequency



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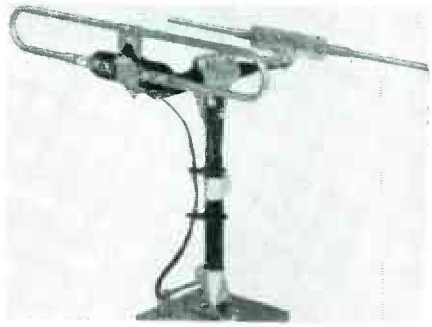
response from 60 to 13,000 cycles. With 8 watts output, the speaker is only $3\frac{1}{8}$ inches deep and requires a baffling enclosure of only two cubic feet.

F-M and Television Antennas (20)

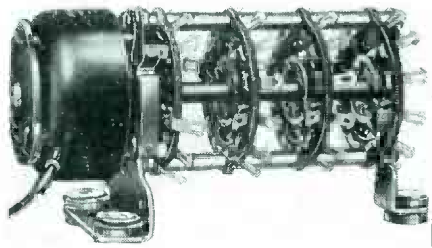
WARD PRODUCTS CORP., 1523 E. 45th St., Cleveland 3, Ohio, is now producing a line of Magic Wand dipole



f-m and television antennas. Included are a choice of straight or folded dipoles for both the 88- to 108-mc f-m band and the 44- to 88-mc television band.

Solenoid-Operated Switch (21)

G. H. LELAND, INC., 116 Webster St., Dayton 2, Ohio, announces a new circuit selector switch, the rotor of which is driven by a solenoid. The solenoid operates on d-c



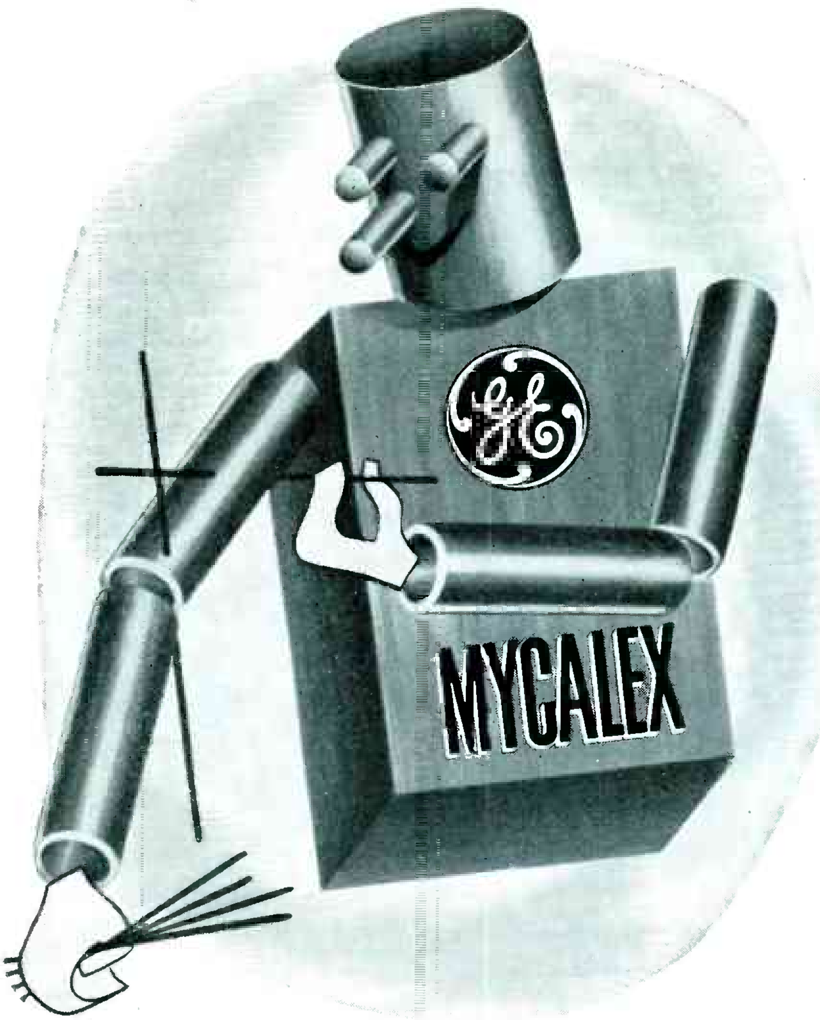
and the unit can be incorporated in many appliances employing selection of electrical control circuits. Typical application is for an automobile radio.

Ceramic Form (22)

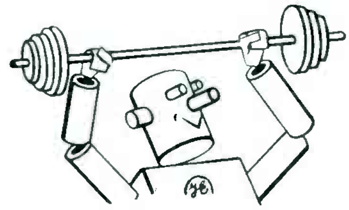
HENRY L. CROWLEY & CO., INC., 1 Central Ave., West Orange, N. J. A new universal ceramic coil form eliminates the need for special holes to take leads or mount terminals. The fluted coil form has dovetail grooves that allow taking a tap lead which can be passed down under the

USE G-E MYCALEX INSULATION

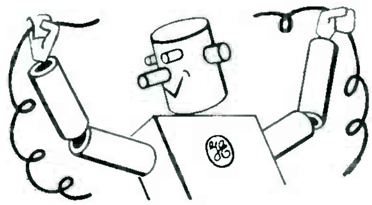
For a FIRM BOND TO METAL INSERTS...



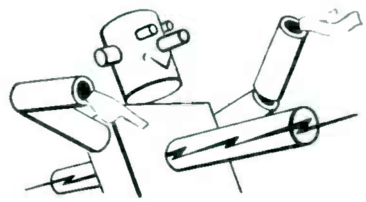
Plus these 5
Insulation Advantages...



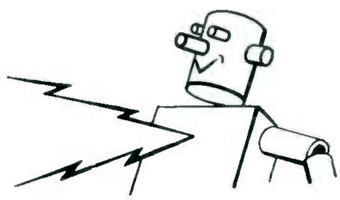
- **HIGH MECHANICAL STRENGTH**



- **HIGH DIELECTRIC STRENGTH**



- **LOW LOSS FACTOR**



- **HIGH ARC RESISTANCE**

- **HIGH HEAT RESISTANCE**

●General Electric mycalex is an exceptional insulation material because of its unique combination of properties. Use G-E mycalex when insulator designs call for inserts to be firmly molded in the insulation—*plus* excellent resistance to heat and arcing, high dielectric and mechanical strength, and a low loss factor. G-E mycalex is a gray, stone-hard compound of glass and mica that can be ordered in standard rods and sheets, or molded or fabricated to your specifications. Samples supplied on request.

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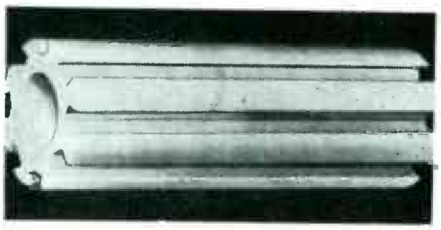
GENERAL ELECTRIC

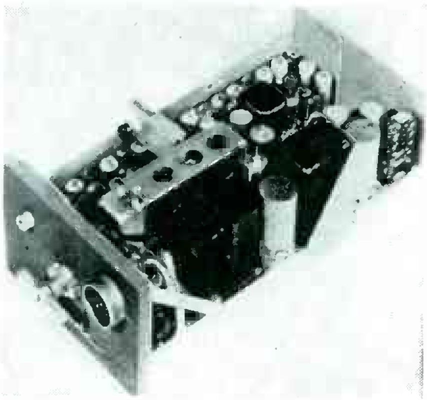
CD-47-M22



turns to either end, or fastening a spring clip in the groove. The form is easy to mount or equip for iron-core tuning.

157-Mc Communicator (23)

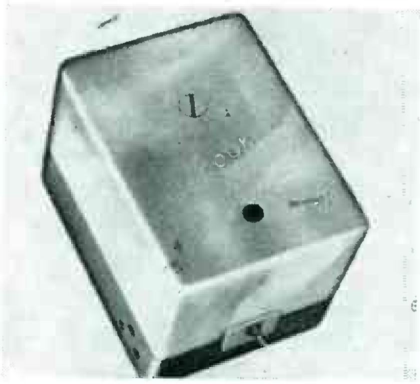
MOTOROLA, INC., 4545 W. Augusta, Chicago 51, Ill. The Dispatcher is a compact f-m radiotelephone transmitter and receiver for mobile service in the 152 to 162 megacycle band. It will sell for $397.50. Power



output is from 7 to 10 watts for a total transmitter drain of 20 amperes and a transmitter-receiver standby of 9.2 amperes. Full details of this equipment are available from the manufacturer.

Record Cutter (24)

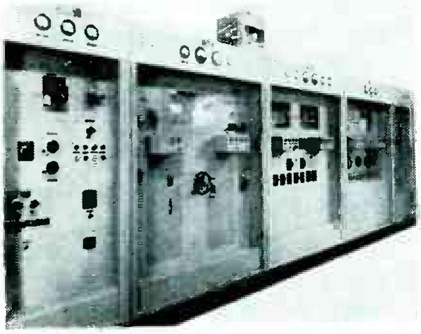
COOK LABORATORIES, 139 Gordon Blvd., Floral Park, N. Y. The model 5-A lateral recording system combines the cutter illustrated and a



50-watt amplifier that provides a stable high-frequency response and low intermodulation distortion. More than 30 db feedback is used. A switch located on the amplifier allows a selection of any of the three usual recording frequency characteristics.

Shortwave Transmitter (25)

J. H. BUNNELL & Co., 81 Prospect St., Brooklyn 1, N. Y. Intended for international broadcast and communications service, the 20-kw



transmitter illustrated features front-panel continuous tuning over its entire frequency range from 2.85 to 22.5 mc.

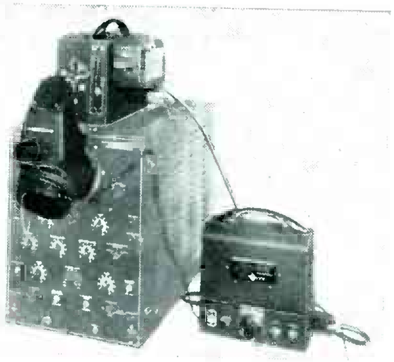
Linear Acceleration Transmitter (26)

G. M. GIANNINI & Co., INC., 285 West Colorado St., Pasadena 1, Calif. The linear acceleration transmitter illustrated has an output proportional to longitudinal

acceleration, but is highly insensitive to quadrature accelerations. Ranges up to plus or minus 25 g are stocked with resistances in the range from 100 to 20,000 ohms.

Oscilloscope Camera (27)

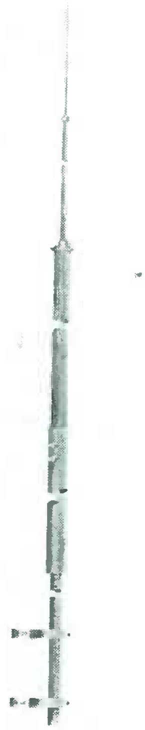
FAIRCHILD CAMERA AND INSTRUMENT CORP., 88–06 Van Wyck Blvd., Jamaica 1, N. Y. Equipped for mounting atop standard laboratory oscilloscopes, a 35-mm camera makes still or continuously moving



film records of the tube displays. Speed of the film is variable so as to allow recording of successive traces at the instant of their presentation. The film can be driven in conjunction with the sweep or the film itself can be used as the sweep, giving a continuous record.

H-F Antenna (28)

RADIO SPECIALTY MFG. CO., Portland 14, Oregon. This coax-antenna, constructed of aluminum and steel



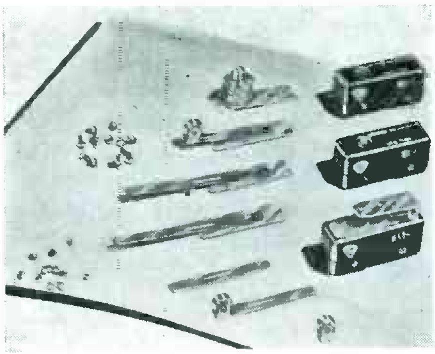
tubing, will handle inputs up to 250 watts on frequencies between 30 and 200 mc. Maximum weight is 12 pounds.

Extruded Nylon Strip (29)

THE POLYMER CORP., Reading, Pa. Now available for blanking in production of washers, spacers, gaskets, tension devices are two types of Nylon strip designated FM1 and FM3. Melting point of the former is about 505 F. Type FM3 has a lower melting point but is somewhat less hygroscopic.

Precision Switch Kit (30)

UNIMAX SWITCH CORP., 460 W. 34th St., New York 1, N. Y. Using standard components, this design kit comprises a number of precision snap-action switches, and an assortment of Adaptaplates, by means



of which the switches may apply actuating force in various ways. The Adaptaplates include spring-plunger over-travel device for single-hole panel mount, plain leaf, leaf-and-roller, and hinge-arm actuator styles.

Tension Unit and Insulator (31)

DAYTON AIRCRAFT PRODUCTS, INC., 342 Xenia Ave., Dayton 10, Ohio. These antenna tension and insulator units, developed in wartime, are now being made available for com-

mercial and private aviation. They shield the antenna from corona discharge which dangerously interferes with radio communication when aircraft accumulate a static charge in bad weather flying.

Electronic Microammeter (32)

BETA ELECTRONICS CO., 1762 Third Ave., New York 29, N. Y. Model 301

electronic microammeter has five sensitivity ranges from 0.01 microamperes full scale to 100 microamperes full scale with 40 millivolts full-scale input on all ranges. The instrument can also be used as a null-detecting galvanometer with a sensitivity of about 10 millivolts full scale. Write for descriptive literature.

Belt-Type Dielectric Heater (33)

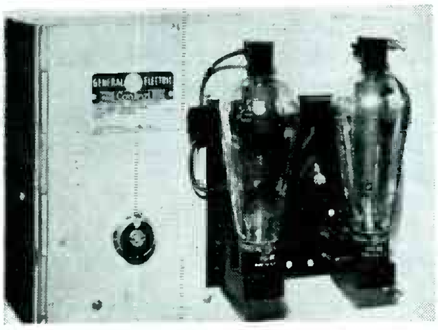
SHERMAN INDUSTRIAL ELECTRONICS CO., INC., 503 Washington Ave., Belleville 9, N. J. The 2-kw belt-type dielectric heater for processing in laboratory or production setups operates from 220-v, 60-cycle single-phase power. It can operate in either the 13- or 27-mc range, and at full load, power consumption is 3.6 kva. Total weight is 350 pounds.

Light-Weight Distortion Meter (34)

BARKER & WILLIAMSON, INC., 237 Fairfield Ave., Upper Darby, Pa. Model 400, weighing 11½ lb, measures low-level audio voltages and determines their noise and harmonic content. It also measures frequency and gain characteristics of audio amplifiers. The frequency range as a distortion meter is from 50 to 15,000 cycles; as a voltmeter, from 30 to 30,000 cycles.

Resistance Welding Control (35)

GENERAL ELECTRIC CO., Schenectady, N. Y., announces a new phase-shift heat control accessory for resistance welding machines. It is designed



for use with ignitron contactors or nonsynchronous control combinations not having the heat control feature, when the power supply is 230 or 460 volts.

High-Voltage Midget Capacitors (36)

AEROVOX CORP., New Bedford, Mass. Type PRS midget-can electrolytic capacitors formerly available in voltage ratings up to 450 volts d-c working can now be procured for

working voltages as high as 700 volts. Capacitance values are 8, 10, 12, and 16 microfarads.

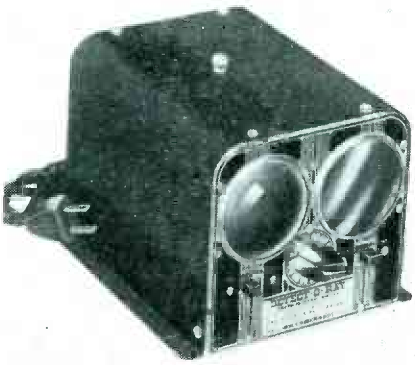
Vacuum Monitor (37)

SKANEATELES MFG. CO., INC., 122 Dickerson St., Syracuse 2, N. Y. The type DM Skanascope is an electronic device designed for accurate indication of vacuum pressures in the 1 to 200 micron range. Signals

are registered by luminous tube units, connected in series with a pair of gage tubes which, in turn, operate a rated 3-ampere inductive load relay for the actuation of external apparatus.

Photo Switch (38)

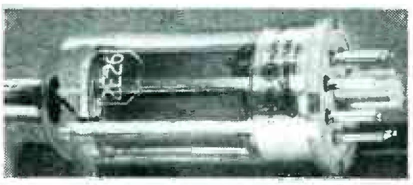
DETECT-O-RAY CO., 2622 N. Halsted St., Chicago 14, Ill. Light source, photoelectric cell, power switch, volume control, visible or invisible beam selector all housed in a single



unit are supplied complete. The reflecting mirror with adjustable bracket is mounted at a distance. The assemblage of equipment can be used for burglar alarm, safety switch, door opener, or similar service.

F-M Amplifier (39)

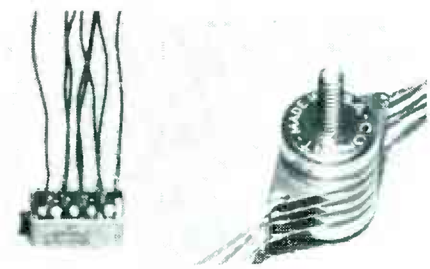
GENERAL ELECTRIC CO., Schenectady, N. Y. Designed for use in fm



transmitters either as a driver or low-power output, the type GL-2E26 is a five-electrode beam power amplifier with 12.5 watts plate dissipation. Maximum ratings apply up to 125 megacycles.

Experimenters' Rectifier (40)

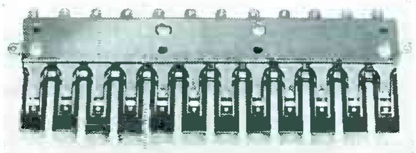
CONANT ELECTRICAL LABORATORIES, 6500 "O" St., Lincoln 5, Neb. A new four-disc instrument rectifier is provided with insulation between each disc and each has its own pair of leads so that all possible combinations or connection can be made.



Type X has 0.5-inch 30-mil discs and type BX-C has 0.165-inch diameter, 5-mil discs.

Gang Switch (41)

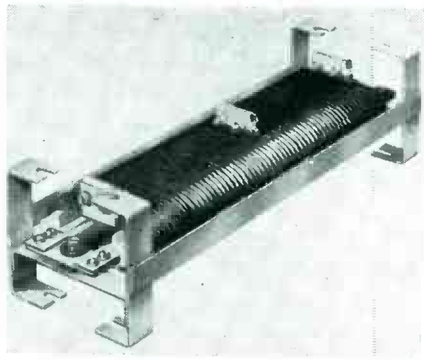
ACRO ELECTRIC CO., 1316 Superior Ave., Cleveland 14, Ohio. A new 12-gang open blade switch illustrated is available with normally open or normally closed combinations for 10-ampere, 125-volt a-c operation.



Information on operating force, engineering details, and suggested uses will be furnished by the manufacturer.

High-Current Resistor (42)

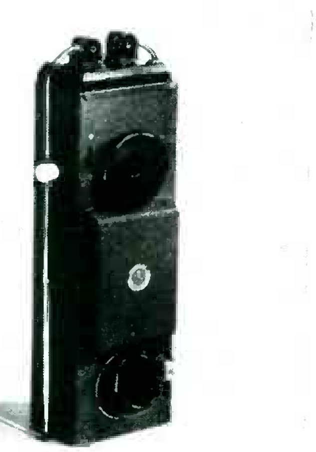
WARD LEONARD ELECTRIC CO., 31 South St., Mount Vernon, N. Y. The Edgeohm high-current resistor consists of a continuous piece of noncorrosive alloy ribbon wound on edge in the form of oval coils. The shape facilitates locating and fastening movable taps. Standard units are rated at 2,200 watts and are available with resistances from 0.32 to 4.35 ohms. Originally designed



for starting, dynamic braking, and load banks, the new units have similar applications in the electronic field.

Two-Way Radio (43)

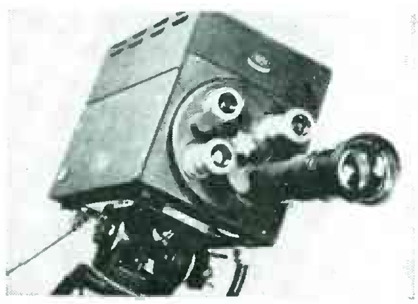
SPERTI INC., Norwood Station, Cincinnati 12, Ohio. The new hand-held radio weighs only 3½ pounds



complete with batteries. It operates in the 144 to 148-mc band up to three miles or farther. Featured in the design is adjustable tuning on both transmitter and receiver.

Image-Orthicon Camera (44)

ALLEN B. DUMONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. Employing the new supersensitive image-orthicon pickup tube, this



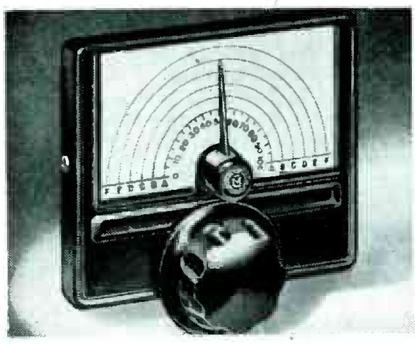
camera features a lens turret that takes up to four lenses of various focal lengths. Turret, diaphragm setting, and focusing are controlled from the rear of the camera. Hinged and removable panels make components and circuits immediately accessible. The electronic viewfinder avoids parallax difficulties.

Marine Radio (45)

APPLIED ELECTRONICS CO., San Francisco. Calif. Available in three models with input of 22 watts (four channels) up to 260 watts (ten channels) the marine radio-telephone equipment illustrated is completely pretuned and prealigned. A feature of the gear is its shallow construction that makes it suitable for bulkhead mounting.

Midget Vernier Dial (46)

JAMES MILLEN MFG. CO., 150 Exchange St., Malden, Mass. Type 10039 multiscale midget dial has a vernier ratio of 8 to 1 and measures 3¼ by 4 inches. It is made of black art metal.



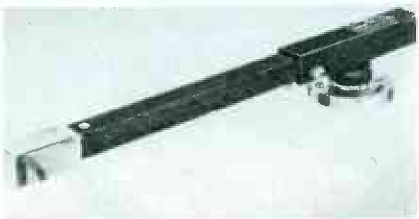
Crystal Holder Socket (47)

JAMES MILLEN MFG. CO., INC., 150 Exchange St., Malden 48, Mass. The

No. 33302 socket, designed for the midget hermetically-sealed CR7 crystal, is made of steatite and its contacts are silver-plated phosphor bronze. Pin spacing, center to center, is 0.5, and pin diameter, 0.05 in.

Pickup Arm (48)

BARBER AND HOWARD, East Ave., Westerly, R. I. Model G. 1 pickup arm is designed for use with the GE variable reluctance cartridge.



The arm is fabricated from aluminum and has a stylus pressure of approximately 24 grams with cartridge installed. The head is removable.

Oscilloscope Recorder (49)

ELECTRODYNE CO., 899 Boylston St., Boston 15, Mass. Custom-built recorders for ionosphere or telemetering research can be fabricated

on short order following basic specifications available from the manufacturer. Machines can be furnished for use with continuously moving tape or film.

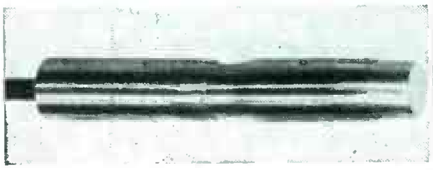
Dual C-R Tube (50)

ELECTRONIC TUBE CORP., 1200 E. Mermaid Ave., Philadelphia 18, Pa. Type 5Z2P-S1 dual-gun electrostatic focus and deflection c-r tube has an additional pair of deflecting plates provided for each electron gun. The additional pair of plates is particularly useful in deflecting a beam along the one axis by application of two isolated inputs instead of one composite input. Sug-

gested uses, which may not be immediately apparent, and further technical information are available.

Microphone Multipliers (51)

Massa Laboratories, Inc., 3868 Carnegie Ave., Cleveland 15, Ohio. Multipliers for extending the dynamic range of sound-pressure measurement equipment are inserted between the M-101 microphone and the M-109 socket, as illustrated. Two units are available



both extending range from 20,000 dynes per square centimeter up to 200,000 dynes per square centimeter, but for different frequency ranges.

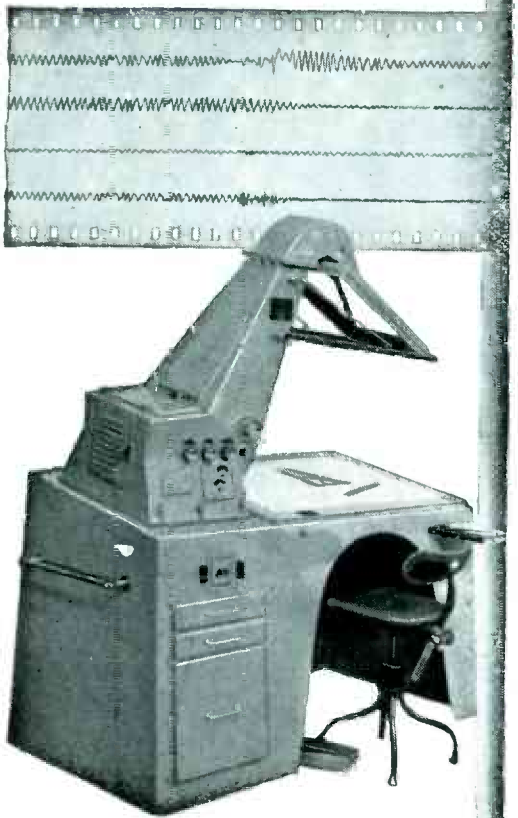
Thermistor Bridge (52)

Sylvania Electric Products Inc., 500 Fifth Ave., New York 18, N. Y. Two new thermistor bridges, types TBN-7SE and TBN-6SE provide r-f

power measurements up to two milliwatts at frequencies in the shorter microwave region. Good accuracy is provided up to this power level. Further information is available.

Quick-Heating Thyratron (53)

National Electronics, Inc., Batavia Ave., Geneva, Ill. The NL-714



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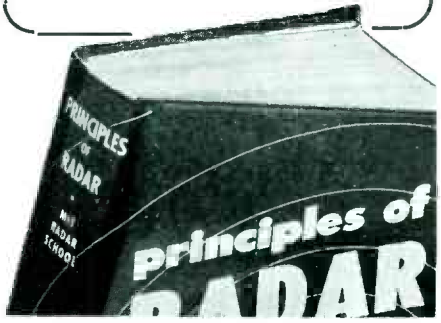

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is a quick-heating industrial thyratron designed especially for timing control and regulated rectifier applications. It is gas and mercury filled for quick starting and constancy of characteristics within wide temperature limits. A looseleaf sheet gives complete technical information.

Television Coil Kit (54)

RAY-LECTRON CO., Belmar, N. J. A television coil kit and instruction book make it possible for the amateur or experimenter to build his own television receiver for about \$125. Kit and manual are \$23.50.

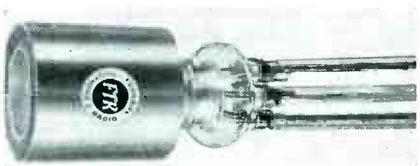
Miniature Receiving Tubes (55)

GENERAL ELECTRIC CO., Syracuse, N. Y. Three new 9-pin miniature tubes recently developed are the types 6T8, 19T8, and 12AT7. The latter is a twin-triode for use as a grounded-grid r-f amplifier or converter at frequencies below 300 mc.

Both the triple-diode triodes contain three high-perveance diodes and a high-mu triode in the same envelope. They are designed as combined a-m and f-m detectors and audio-frequency amplifiers.

Industrial Heating Tube (56)

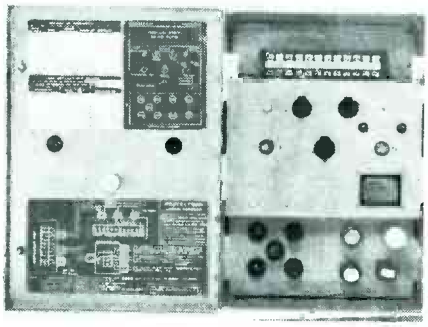
FEDERAL TELEPHONE AND RADIO CORP., Clifton, N. J. Type 7C25, a 2,500-watt oscillating tube, is designed for use in dielectric heating. Two tubes in a coupled circuit will give a power output of 4½ to 5 kw at frequencies up to 50 mc. Com-



plete technical data, with dimensional diagram and graphs, are given in a 4-page folder.

Machine Protector (57)

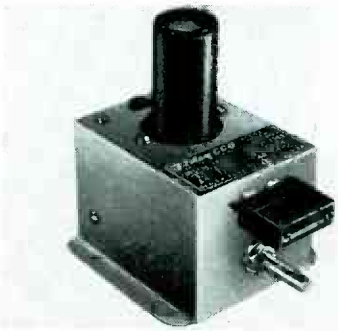
THE BRINNELL CO., Granby, Conn., manufactures the Protectron, an electronic device for use in conjunction with an electric motor-



driven machine to trip at any preset mechanical load increase above normal. It is available for 220 and 440 volt 60-cycle motors in two models; for operating current of 1 to 5 amperes and 5 to 10 amperes.

VHF Xtal (58)

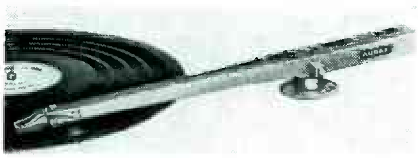
BLILEY ELECTRIC CO., Erie, Pa. A crystal controlled oscillator unit CCO model 2A is a packaged unit for crystal control of 2, 6, 10, and

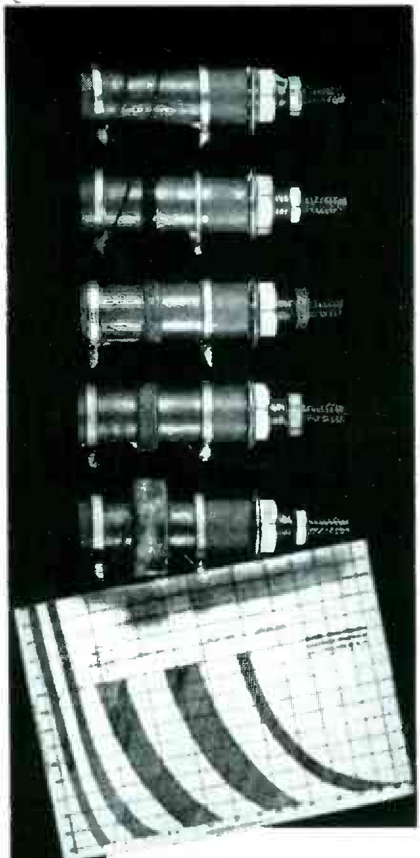


11 meter transmitters. A type 6AG7 tube and AX2 or AX3 crystals are used. Send for Bulletin 34.

Studio Pickup (59)

AUDAK CO., 500 Fifth Ave., New York, N. Y. Model Studio-81 has sufficient gain for most conventional





This graph shows frequency ranges covered by each unit. Write us for your full-size copy.

Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc

For strip amplifier work, the compact (1⅛" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

Five Standard Windings— 1, 5, 10, 30 and 60 megacycle coils cover inductance ranges between 750 and 0.065 microhenries.

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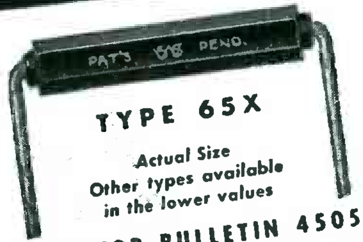

TYPE 65X

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

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THE S. S. WHITE DENTAL MFG. CO. DEPT. R. 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
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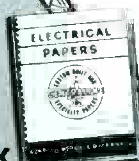

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contains data on Electrical Paper Properties and a wide variety of samples. Write for your copy today.

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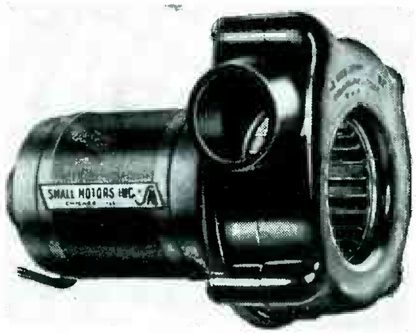
CUSTOM BUILT AND SPECIALTY PAPERS — CENTRALINE — REG. U. S. PAT. OFF.

amplifiers, small dynamic mass and linear response to better than 10 kc. Point pressure is 14 grams.

Ventilating Device (60)

Small Motors, Inc., 2076 Elston Ave., Chicago, Ill., has developed the B-2 blower for ventilating and



cooling electronic tubes, projectors and other units. It operates on 110 volts, a-c and d-c.

Dual Channel Oscilloscope (61)

Electronic Tube Corp., 1200 E. Mermaid Ave., Philadelphia 18, Pa. Model E-2G15 dual channel oscilloscope comprises two separate channels operating into a single dual-gun

cathode ray tube. Provisions are made for various connections to increase the versatility of the instrument. Further details, including price, are available in mimeographed form from the manufacturer.

Twin Diode (62)

Hytron Radio & Electronics Corp., Salem, Mass. Type 12AL5 twin diode is intended for use as a detector in circuits utilizing wide-band amplifiers. It can be used as

It's a GREENOHM!

★ Here's a GREENOHM on 500% overload. It's hot enough to light a cigarette. Yet its special cold-setting inorganic cement coating doesn't soften, bubble or change. When cooled, it doesn't crack, peel, flake. Yes, GREENOHMS can take it. They're tough.

Other GREENOHM advantages are: Excellent heat-shock qualities. Minimum through-coating leakage. Wire winding unimpaired in manufacture. No wire corrosion because cement does not contain usual water glass. Fixed and adjustable types; 5 to 200 watts; standard resistance values.

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Copy of "Why Cement-Coated Power Resistors?" sent on request. Also Engineering Bulletin No. 113. Send us your resistance requirements.

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CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

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STANDING WAVE RATIO AND RF POWER MONITOR

MODEL MM 200

MORE POWER WITH SAME TRANSMITTER AND ANTENNA

FOR FM TELEVISION INDUSTRIAL HEATING OR ANY TRANSMITTER WITHIN 20-122 Mc

With transmitter operating, Micromatch continuously and simultaneously measures standing wave ratio and actual r.f. power output.

Permits antenna or load adjustment for perfect match to transmission line—minimizing power loss and improving loading.

Permits control of heating processes for uniformity in industrial heating applications.

Price complete $150

MM 200 Specifications
Frequency Range 20 to 122 MC
Power up to 4.0 KW
Impedance 51.5 Ohms
Connectors 1 5/8 inch coaxial line
Wattmeter scale 0 to 0.4, 1.2 and 4.0 KW

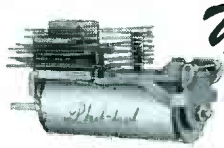
Write for complete information on the MM200 and models for other applications.

M. C. JONES ELECTRONICS COMPANY

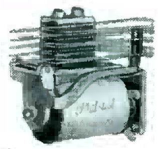
BRISTOL, CONNECTICUT

Distributed outside continental U.S.A. by RCA International Division Radio Corporation of America.

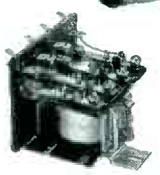
Want New Standards of Performance and Service in *Your* Relays?



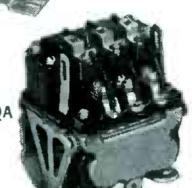
TYPE 2QA



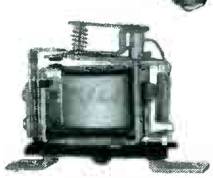
TYPE 3QA



TYPE 22QA



TYPE 27QA



TYPE 23QA

Phil-trol RELAYS

The variable "built-in" features of all Phil-trol Relays makes it possible for us to supply you with engineered units designed to expressly meet your relay requirements. Adaptability of coil and contact arrangements means you receive the equivalent of "custom-built" relays—but at mass production prices.

Various special features can be furnished to specifications, including Allegheny metal parts, special bearings, anti-vibration equipment, special insulation and impregnation.

Phil-trol relays are engineered to the highest standards insuring top quality for life-long service and performance. Continuous research by Phillips' engineers parallels our efforts to supply the widely expanding electrical and electronic market with the most efficient and dependable designs possible.

It will pay you to investigate the Phil-trol line before your next relay order. We shall be glad to discuss your relay problems, no matter how small or large, with no obligation to you.

A NEW CATALOG completely describing and illustrating the Phil-trol line of relays is available without obligation. Send for your copy today.

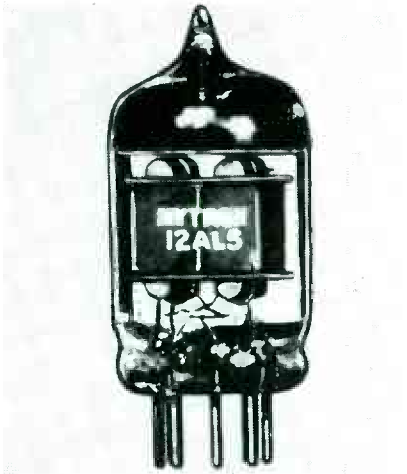
Phil-trol Actuators

Actual pull tests show that Phil-trol Actuators develop greater power than ordinary solenoids of the solid frame type. Available in five standard sizes or we'll design to specifications. SEND FOR NEW BULLETIN

Phil-trol PRODUCTS — RELAYS, ACTUATORS, SOLENOIDS, CONTACTORS, STARTING SWITCHES, FOCUS COILS, ION TRAPS AND SPECIAL PROCESS CONTROL ASSEMBLIES

PHILLIPS CONTROL CORP. • 612 N. Michigan Ave., Chicago 11, Ill.

PLANT: Joliet, Ill. SALES OFFICES: New York, Boston, Philadelphia, Charlotte, St. Louis Kansas City, Los Angeles



a discriminator, ratio or diode detector, avc. diode, clipper, or low-power rectifier. Each set of elements can be used independently of the other and each has a resonant frequency of about 700 megacycles.

Equalizer

A. F. SMUCKLER & Co., 338 East 23rd St., New York 10, N. Y. The Afsco equalizer type 200X-1B was described in item 2, New Products department, of the October issue of ELECTRONICS. Both the trade and company names were misspelled.

Literature

(63)

Monochromators. Farrand Optical Co., Inc., Bronx Blvd. & E. 238th St., New York 66, N. Y. Bulletin 801 covers the design, operation, and performance of a monochromator for research in the ultraviolet spectral region.

(64)

Special Oscilloscope. Allen B. DuMont Laboratories, Inc., 1000 Main Ave., Clifton, N. J. Type 256-D cathode-ray oscilloscope is an outgrowth of the MIT Radiation Laboratory type 256-B A/R range scope. The new commercial equipment has delay dial and markers calibrated in terms of microseconds. Characteristics available in printed form.

(65)

Antenna Rotator. Gordon Specialties Co., 542 So. Dearborn St., Chicago 5, Ill., has an attractive two-color folder showing a line of equipment suitable for construction or erection of rotary antenna

BRADLEY

PHOTO ELECTRIC CELLS

Reduce Production Costs

Bradley Luxtron* photocells improve control over manufacturing operations, reducing your costs. They meet the most exacting requirements. Advanced manufacturing techniques make light-actuated Bradley cells the choice all over the world.

Luxtron photocells convert light directly into electrical energy. No external source of voltage is required. Besides the housed model shown with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings. In addition, Luxtron unmounted cells are available in many different sizes and shapes.

*T. M. REG. U. S. PAT OFF.

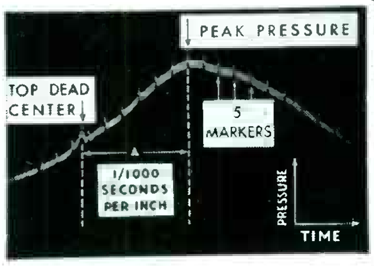
Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

Have you ever seen the INSIDE of an EXPLOSION?

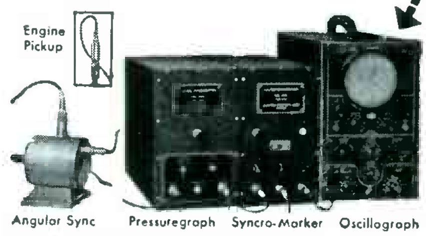
or the rate of engine flame propagation



Seeing now made possible by remarkable new electronic features, embodied in

PRESSUREGRAPH with Syncro-Marker

Reproduces on oscillograph screen, accurate picture of pressures during and after explosion, relates pressure variations to time, top dead center, angular velocity, etc. Also accurate tracing of rate of flame propagation with relation to top dead center and peak pressure. See pressure-time characteristics of automotive, jet and Diesel engines, also compressors, pumps, etc. Operates over range from static up to 10,000 cycles at pressures from 0 to 10,000 lbs.



Send for description and full engineering data.

ELECTRO PRODUCTS LABORATORIES

549 W. Randolph St., Chicago 6, Ill. **Phone STate 7444**

IT'S HERE! for the users of cartridges... THE RMC CARTRIDGE ARM

(Patents Applied for)

The new RMC CARTRIDGE ARM with Plug-in Head Shell enables you to plug in any pick-up cartridge. Your cartridges can be mounted in RMC Head Shells thereby providing instantaneous plug-in change.

RMC CARTRIDGE ARM advantages:

A superior tone arm at a moderate price . . . precision die-cast . . . variable head pressure . . . friction-free (less friction than can be had with ball bearings) . . . tangential tracking (less than ½ degree tracking error) . . . suitable for 12" or 16" tables.

List prices: RMC Cartridge Arm, including one Head Shell $25.00. Spare Head Shell $5.00 each.

Available through your local Jobber. Write for Cartridge Arm Bulletin CA6.

For commercial operation where finest quality is desired, use *PARA-FLUX REPRODUCERS.*

Export: Rocke International Corporation, 13 East 40th St., New York 16, N. Y.

RADIO-MUSIC CORPORATION

PORT CHESTER • NEW YORK

beams for transmitting or receiving on the higher frequencies.

(66)

Picture Tube. Sylvania Electric Products Inc., Emporium, Pa. Specifications sheets on the 7-inch picture tubes 7GP1 and 7GP4 have recently been issued.

(67)

Film Recorders. The Electrodyne Co., 899 Boylston St., Boston 15, Mass. A three-page mimeographed publication lists types of moving film or paper recorders for oscilloscopes.

(68)

Extrusion Devices. Industrial Ovens, Inc., 13825 Triskett Road, Cleveland, Ohio. Those interested in the fabrication of thermoplastic insulated wire, cable, and tubings will find a recent 12-page illustrated brochure of use. It describes continuous takeup devices.

(69)

Amplifiers. R. W. Neill Co., 1811 Carroll Ave., Chicago 12, Ill. Model 710-A way-station amplifier designed for amplification of low level signals or voice from telephone transmission lines to loudspeaker volume.

(70)

Marine Radar. Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pa., announces publication of a new booklet (B-3845-A) dealing with marine radar. Installation views of radar equipment and actual radar scope photographs taken at strategic points are contained therein.

(71)

Mixer Information. The Daven Co., 191 Central Ave., Newark, N. J. A new folder contains a table showing impedance versus decibel loss with values calculated for impedance mismatch, minimum T loss, and bridging-pad loss. Data on mixer circuits are also shown.

(72)

Small Tubing. Superior Tube Co., 2112 Germantown Ave., Norristown, Pa. Bulletin 31 lists information on seamless as well as welded and drawn small tubing in various

metals. Nickel cathodes and similar types useful to the electronic engineer are described.

(73)
Variable Speed. Louis Allis Co., Milwaukee 7, Wis. Bulletin 611C describes the Adjusto-Spede that is designated an alternating current adjustable speed drive using electronic principles.

(74)
Ceramics. General Ceramics and Steatite Corp., Keasbey, N. J. Engineers will be glad to have a copy of the 32-page booklet on the subject of dielectric and other ceramics, including a bibliography on the subject.

(75)
H-V Resistors. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. A four-page technical data bulletin gives complete specifications and characteristics of type MV high-voltage resistors in the power range from 2 to 90 watts. Ask for bulletin G-1.

(76)
Plastic Insulation. Bakelite Corp., 30 E. 42nd St., New York 17, N. Y. Booklet No. 16 consists of eight pages of technical data on Vinylite plastic wire and cable insulating compounds. Included are tables giving their physical and electrical properties.

(77)
Recorder-Controller. Wheelco Instruments Co., 847 W. Harrison St. Chicago 7, Ill., is releasing an 8-page two-color bulletin C2 that describes the Capacilog electronic recorder and controller for industrial processes.

(78)
Coil Winder. Allied Control Co., 2 East End Ave., New York, N. Y. Information is available on a new coil winder that can be operated at 6,500 rpm using fine wire.

(79)
Radio Wire. Cornish Wire Co., Inc., 15 Park Row, New York, N. Y., is distributing a four-page catalog of electrical, radio and industrial wires, cables, and spe-

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DEPENDABILITY
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G-E Variable Reluctance Pickup

CHECK these characteristics of the G-E Variable Reluctance Pickup against your present reproducer head. Make your own exacting tests. Prove to yourself that this pickup will improve the reproduction quality given by your own phonographs.

The G-E Variable Reluctance Pickup has:

- No resonant peaks.
- Wide frequency response—essentially flat from 30 to 8000 cycles.
- High compliance of the stylus—hence more faithful reproduction and exceptionally low record wear.
- Self protecting genuine sapphire stylus.
- Virtual freedom from "needle talk".
- Practical insensitivity to vertical vibration—the source of surface noise.
- Stability under humidity, heat and cold.

We are equipped to make prompt delivery to meet your production schedules. For complete information on this finer pick-up write *General Electric Company, Electronics Park, Syracuse, N. Y.*

GENERAL ELECTRIC

168-F4

JONES 400 SERIES PLUGS and SOCKETS

P-406-CCT

A medium size Plug and Socket that fulfills practically every requirement in the public address, radio and kindred fields. Socket contacts are of phosphor bronze, cadmium plated.

S-406-AB

Plug contacts are of hard brass, silver plated. Insulation is of molded Bakelite. All Plugs and Sockets are Polarized. Made in 2, 4, 6, 8, 10 and 12 contacts. Caps are of steel with baked black crackle enamel. A quality item at popular prices.

Send today for catalog No. 14 listing complete line of Jones Electrical Connecting Devices—Plugs, Sockets and Terminal Strips.

HOWARD B. JONES DIVISION
CINCH MFG. CORP.
2460 W. GEORGE ST. CHICAGO 18

NEW . . . *the* MULTI-PURPOSE *ELECTRAN* STEP-DOWN TRANSFORMER

ONE TRANSFORMER OR *THREE*—
OPERATES FROM 230 and/or 460 V. LINES

1. Permits use of combination power and light circuits—one entrance service—one meter—one central conduit to run.
2. Allows maximum power distribution on minimum sizes of wiring—smaller conduit runs result in installation cost savings.
3. Old installations can be made to handle greater loads by increasing voltages at the distribution panel and installing step-down transformers at machines or other power take-off points.
4. Permits 115/230 volt single phase lighting circuits to be operated direct from 3 phase 460 volt mains.
5. Results in savings when power is bought at higher voltages—less copper line loss is experienced.

WRITE FOR BULLETIN

ELECTRAN MFG. CO.

4589 ELSTON AVE. CHICAGO 30, ILL.

cialties such as antenna accessories.

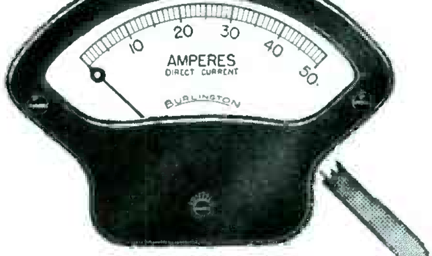
(80)
Sky-Broadcasting. University Loudspeakers, Inc., 225 Varick St., New York, N. Y. Currently off the press is a four-page bulletin compiled by the technical staff on the use of loudspeakers for airplane sound-broadcasting service. Power requirements (100 watts or more), methods of installation, and approximate weights are presented as an aid to those contemplating aircraft use. There is no charge for the bulletin.

(81)
Handie-Talkie. Motorola, Inc., 4545 W. Augusta Blvd., Chicago 51, Ill. The crystal-controlled f-m handie-talkie weighs only 8½ pounds. Its receiver has a power output of 2.5 milliwatts, and the transmitter, 0.6 watts. The unit is fully described in an illustrated folder. Also available is a small 24-page booklet on two-way communications equipment.

(82)
Photoelectric Cells. Selenium Corp. of America, 2160 E. Imperial Highway, El Segundo, Calif., has a 12-page brochure on selfgenerating photoelectric cells. Characteristics, applications and design factors are included, along with appropriate diagrams.

(83)
Relays. Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill. Catalog No. 7 describes and illustrates a variety of a-c and d-c relays designed for electronic and industrial control, signal and traffic control, radio and communication. Coil characteristics, contact assemblies, operating and release times and dimensional drawings of each are given.

(84)
Ultrasonic Gage. Sperry Products, Inc., 15th St. and Willow Ave., Hoboken, N. J. The Reflectogage is an ultrasonic device for thickness measurement and the inspection of bonds. Technical data sheet 3700 explains the principle of operation and methods of use.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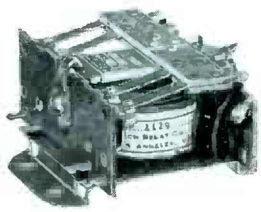
AMPERES
DIRECT CURRENT
BURLINGTON



NEWS OF THE INDUSTRY
(continued from p. 154)

November 17, 18 and 19, 1947, has been announced as follows by Virgil M. Graham, chairman:

9:30 A.M. Monday Nov. 17—Chairman—A. E. Newlon:

V-H-F Direction Finder for Airport Use, by A. G. Richardson of Federal Telecommunication Laboratories
R-F Inductance Meter with Direct Reading Linear Scale, by Harold A. Wheeler of Wheeler Laboratories Inc.
Design and Layout of Radio Receivers and the Maintenance Man, by A. C. W. Saunders of Saunders Radio & Electronics School
12:30 P.M.—Group Luncheon
2:00 P.M.—Chairman—B. S. Ellefson:

Use of Miniature Tubes in AC/DC Receivers for AM and FM, by R. F. Dunn of RCA
Two Signal Performance of Some F-M Receiver Systems, by B. D. Loughlin and D. E. Foster of Hazeltine Electronics Corp.
6:30 P.M.—Group Dinner
8:15 P.M.—Chairman—George R. Town:

Engineering Responsibilities in Today's Economy, by E. F. Carter of Sylvania
9:15 P.M.—Stag Party, Courtesy of American Lava Corp.

9:30 A.M. Tuesday Nov. 18—Chairman—L. C. F. Horle:

Avenues of Improvement in Present Day Television, by Donald G. Fink of ELECTRONICS
Standardization of Transient Response of Television Transmitters and Receivers, by R. D. Kell and G. L. Fredendall of RCA Laboratories
Psychoacoustic Factors in Radio Receiver Loudspeaker Selection, by Hugh S. Knowles of Jensen Manufacturing Co.
12:30 P.M.—Group Luncheon
2:00 P.M.—Chairman—Clinton B. DeSoto:

Spectral Energy Distribution of Cathode Ray Phosphors, by R. M. Bowie and A. E. Martin of Sylvania
Quality Control in Receiving Tube Manufacture, by J. A. Davies of G-E
6:15 P.M.—Cocktail Party Courtesy of Stackpole Carbon Co.
7:00 P.M.—Fall Meeting Dinner (Stag); Toastmaster Ralph A. Hackbusch:

The British Radio Industry Today, by Fred S. Barton

9:30 A.M. Wednesday Nov. 19—Chairman—B. E. Shackelford:

Metallized Film Coaxial Attenuators, by John W. E. Griemsmann of Polytechnic Institute of Brooklyn
I-F Selectivity Considerations in F-M Receivers, by R. B. Dome of G-E
A New Television Projection System, by William E. Bradley of Philco
12:30 P.M.—Group Luncheon
2:00 P.M.—Chairman—R. M. Wise:

The Organization of the Work of the I.R.E. Technical Committees, by L. G. Cumming of I.R.E.
V-H-F Bridge for Impedance Measurements Between 20 and 140 Megacycles, by Robert A. Soderman of General Radio Co.
6:30 P.M.—Group Dinner
8:15 P.M.—Photographic Session; Chairman—A. L. Schoen:

The Problem of Amateur Color Photography, by Ralph M. Evans of Eastman Kodak Co.

Network Projection Television

DEVELOPMENTAL equipment that produced television pictures 6 by 8 feet in size on a beaded screen was demonstrated at the Atlantic City NAB convention by engineers of the Radio Corporation of America. The projector, suitable for accommodation of overflow crowds at conventions and for theater television,

Experimental large-screen projection system depends on 7-inch cathode-ray tube

comprises a reflective optical system and experimental cathode-ray tube. The optical system, comparable to a conventional f/2 projection lens but transmitting about six times the light, consists of a 21-inch spherical mirror and a 14-inch aspherical correcting lens mounted vertically in a tubular housing. The 50,000-volt cathode-ray tube has a 7-inch screen coated with new types of phosphors that produce white light; metal backing is used. The electron gun and internal tube construction are modified to withstand the high voltage. An r-f power supply is used. Program material, originating at WNBT, New York, was relayed via Philco facilities at Mt. Rose, N. J., and Wyndmoor, Pa. to RCA relays at Philadelphia, Blue Anchor, and Batsto, N. J., reaching Atlantic City at the end of the 200-mile microwave link.

Automatic Flight Controller

As an extension of pushbutton flying, the All Weather Flying Division of the Air Forces recently demonstrated publicly a completely automatic flight sequence controller by flying across the North Atlantic. The controller is set to make the plane take off, fly a specified route (series great circle rhumb lines) and land at its destination.

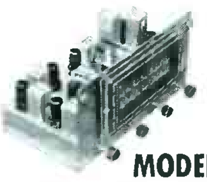
Although the controller itself is an electromechanical unit, it operates in conjunction with such electronic equipment as the familiar instrument landing system for takeoff and approach, an electronic autopilot, and a magnetically sta-

BROWNING LABORATORIES

Precision Instruments for Electronics and Radio Research and Testing

Versatile, Precision OSCILLOSCOPE MODEL OL-15

This is a highly flexible instrument particularly adaptable for production testing or research work in television, radar, facsimile work, and radio-frequency equipment.



MODEL RJ-12 FM-AM TUNER

An easy-to-install highly-sensitive tuner that provides distortion-free reception on FM and quality reception on AM. Tuning eye shows correct tuning. One antenna serves both FM and AM. Many other features. Armstrong circuit.

WWV FREQUENCY CALIBRATOR

Full, accurate use of station WWV, the world's finest primary frequency and time standard, is obtained from the Browning Model RH-10 Standard Frequency Calibrator.

WRITE FOR LITERATURE

OTHER EQUIPMENT manufactured by Browning Laboratories includes an accurate frequency meter and ECO Model MJ-9, for operating in the Ham bands, and a frequency meter (Model S-4) especially designed for checking mobile transmitters.

BROWNING LABORATORIES, INC. WINCHESTER, MASS.

DESIGN ENGINEERS – *send for this booklet!*

If you are concerned with material specifications you'll want this 28-page booklet . . . because LINDE synthetic sapphire is a material for key parts on which successful operation of a whole machine can depend.

This booklet describes the successful uses of this material, the properties, and the forms and grades available. It's full of pertinent illustrations, including a picture-caption story of fabricating techniques.

Send for this booklet on your letterhead. Ask for Booklet 4-B—today!

The word "Linde" is a trade-mark of The Linde Air Products Company

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

NEW...IMPROVED PRECISION ATTENUATORS by TECH LABS

TYPE 850-A 850-B

The units illustrated represent a complete redesign of our older precision attenuators for laboratory standards. Flat for all frequencies in the audio range. Reasonably flat to 200 k.c. up to 70 db.

Bulletin sent on request.

TECH LABORATORIES, INC.

Manufacturers of Precision Electrical Resistance Instruments

337 CENTRAL AVE. • JERSEY CITY 7, N. J.

Instrument panel of the electromechanical predetermined flight controller is shown aboard the C-54 Skymaster, which made a trans-Atlantic round trip flight in September and October between Newfoundland and England

bilized gyro-compass. The controller regulates engine power for takeoff and cruising, adjusts trim, and performs all the integrated operations usually done by pilot, flight engineer, and navigator.

Using similar equipment the All Weather Flying Division has made two flights daily irrespective of weather conditions between Ohio and Maryland. Such equipment as this will relieve pilots of much flying routine, enabling them to monitor the flight of their planes more fully and observe flight conditions in greater detail and thereby assuring greater safety.

Televising Surgical Operations

TELEVISION broadcasts of operations performed in the operating room of the New York Hospital were presented to surgeons at the Waldorf-Astoria as an indication of the possible application of television to surgical education. These telecasts, with running commentary by the operating surgeon and his assistant, were made available to 5,000 surgeons attending the Clinical Congress of the American College of Surgeons on September 12. By this means, each surgeon had a view comparable to that which he might have had from the side of the operating table. This was the first time that televised

pictures of surgical operations were transmitted from an operating room in one location to television receivers in another part of the city.

For these telecasts, two local receivers were installed at the hospital. One of these was located in the operating room to enable the surgeon to see the operative area covered by the camera and to permit positioning the camera so as to prevent obstruction of the view. The other receiver was located in an adjoining office for the benefit of some members of the hospital staff.

The operating-room microphone was connected with a foot switch so that the operating surgeon could make comments at will. Because some surgeons prefer not to talk while operating, an auxiliary microphone is provided in the adjoining office so that the commentary can be delivered by another person.

Seven RCA Victor television receivers were installed in the hotel where seating facilities were provided for about 300 surgeons at a time. Pictures were transmitted via a 2-mile, 7,000-mc radio link between the roof of a nine-story extension of the hospital building and the 18th-floor terrace of the hotel.

Paraboloid-reflector antennas were used for both transmitting and receiving. Transmission was thus confined to a narrow beam, in-

The three-lens television camera, requiring no special lighting, is installed on a track above the operating table. The microphone mounted just behind the camera picks up the running commentary of the operating surgeon. RCA equipment was used

suring privacy for these telecasts, which were of a nature not suitable for public view. With this system, line-of-sight transmission is possible over a distance as great as 30 miles.

The microwave relay transmitter passed a video bandwidth of 8 mc as compared with the usual transmitter video bandwidth of only 4 mc. Standard receivers having a 5-mc bandwidth were used. With this combination of equipment, it was possible for the surgeons to see pictures having better definition than those seen by the viewer of ordinary telecasts.

Clinics, operative and nonoperative, in hospitals are the principal means of video education in surgery. Since the accommodations for observers in operating rooms are limited, television provides a teaching medium that can serve large numbers of surgeons in class rooms and at conventions.

X-Ray Conference

FOUR PAPERS dealing with Geiger-counter x-ray spectrometer studies are on the program of the Fifth Annual Pittsburgh Conference on X-Ray and Electron Diffraction, scheduled for Nov. 7 and 8 at the Mellon Institute and the University of Pittsburgh. Registration begins at 9:00 a.m. Nov. 7 in the foyer of Mellon Institute. Papers that morning start at 9:40 and deal with interstitial compounds, while papers for Saturday morning start at 9:00 a.m. and deal with lattice imperfections and general subjects. Other papers, more likely to interest electronic engineers, are as follows:

2:00-5:00 p.m. Nov. 7—X-Ray and Electron Diffraction Studies at High Temperatures

(1) Some Results of High Temperature Studies, by H. F. McMurdie of NBS

(2) A Comparison of Crystal Structures of Ten Wrought Heat-Resisting Alloys at Elevated Temperatures with their Crystal Structures at Room Temperature, by J. H. Kittel of NACA

(3) Design Problems in High Temperature X-Ray and Electron Diffraction Cameras, by J. W. Hickman, E. A. Gulbransen, and R. J. Bertl of Westinghouse

(4) High Temperature X-Ray Camera Design Using Induction Heating, by J. W. Edwards, R. Speiser, and H. L. Johnston of the Cryogenic Laboratory, Ohio State University

(5) An Electron Diffraction Study of Oxides Formed on Copper-Nickel Alloys at Elevated Temperatures, by J. W. Hickman of Westinghouse

(6) The Interpretation and Use of Electron Diffraction Studies on Metals at High Temperatures, by E. A. Gulbransen of Westinghouse

2:00-5:00 p.m. Nov. 8—Symposium on

Geiger-Counter X-Ray Spectrometer Studies

(1) Application of X-Ray Analyses to Ceramic Clays, by G. L. McCreery of The Ohio Brass Co.

(2) Application of Geiger-Counter Spectrometer to the Measurement of Particle Size, by L. E. Alexander and E. Kummer of Mellon Institute

(3) Quantitative Organic Analysis with the Geiger-Counter X-Ray Spectrometer, by C. L. Christ, R. B. Barnes, and E. F. Williams of American Cyanamid

(4) Geometric Factors Affecting the Contours of Geiger Spectrometer Maxima, by L. E. Alexander of Mellon Institute

(5) The Photomultiplier Radiation Detector, by Fitz-Hugh Marshall and J. W. Coltman of Westinghouse

Second Annual Instrument Conference

MORE THAN 7,000 engineers and technicians, nearly double last year's attendance, registered at the Instrument Society of America Conference and Exhibit in September. Held at the Stevens Hotel in Chicago, the exhibition attracted 139 manufacturers of equipment who showed six million dollars worth of equipment.

Newly elected officers for 1947-48 are: president, Paul G. Exline, section engineer, Gulf Research Corp., Pittsburgh; vice-president, H. C. Frost, assistant director of engineering, Chemical Division, Corn Products Refining Co., Argo, Illinois; vice-president, F. H. Trapnell, instruments engineer, E. I. duPont de Nemours Co., Wilmington, Del.

Carry-over officers who are serving the second year of a two-year term are: first vice-president, Prof. Carl P. Kayan, Department of Me-

Paul G. Exline of Gulf Research Corporation, new president of ISA

chanical Engineering, Columbia University, New York; vice-president, Herbert H. Barnum, H. H. Barnum Co., Detroit; treasurer, Hugh E. Ferguson, Peoples Gas Light and Coke Co., Chicago; and executive secretary, Richard Rimbach, Instruments Publishing Co., Pittsburgh.

A considerable number of the instruments exhibited utilize electronic tubes and a number of the technical papers delivered at the technical session contained references to electronic equipment. These included an electronic potentiometer used in turbine testing, an electronic dewpoint indicator for moisture measurement, a metals comparator, an oscillator circuit for Q-metric analysis, radio telemetering equipment for aircraft, and the automatic recording spectrophotometer as adapted for chemical concentration measurements.

F-M Rebroadcasting

NETWORK f-m broadcasting without use of long-distance telephone wire circuits was demonstrated to International Telecommunications Conference delegates at Atlantic City, N. J. recently. Programs originating in Dr. E. H. Armstrong's f-m station W2XMN-W2XEA at Alpine, N. J. were picked up by a special receiver at station WBAB-FM in Atlantic City, a distance of 116 miles, and rebroadcast to the delegates a few miles away. The demonstration showed that high-quality static-free f-m broadcasting in the 100-mc range is not limited to a 30-mile line-of-sight radius, but can be extended over much greater distances for rebroadcast purposes. The engineering involved in setting up the special high-fidelity receiving equipment and connecting it to the wire lines was carried out under the direction of S. L. Bailey of Jansky and Bailey, consulting engineers.

Changes in NBC's Television Personnel

TO SPEED development of NBC's nation-wide television network as

well as its sight-and-sound programming, O. B. Hanson, vice-president and chief engineer, has been named to assist the executive vice-president in planning the technical phases of television. He will supervise the building and installation of new stations, interconnections, relays and other engineering facilities. Norman E. Kersta, director of television operations, will be in charge of broadcast operations of the television department.

George McElrath has been appointed director of engineering operations. He will manage the technical aspects of sound broadcasting.

Filling the new post of director of television engineering operations and reporting to N. E. Kersta is Robert E. Shelby, whose former position as director of technical development is now held by George M. Nixon.

BUSINESS NEWS

BART-MESSING CORP., manufacturers of the Sel-Rex selenium rectifiers, have a new plant over 6,000

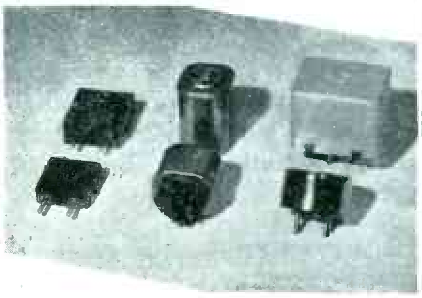
New Bart-Messing Corp. plant

square feet in area at 45 Morgan Ave., Brooklyn, N. Y.

HERMON HOSMER SCOTT, INC., Cambridge, Mass., has been formed to provide increased manufacturing and engineering facilities for equipment employing the Dynamic Noise Suppressor, and is taking over the unfilled orders and inventory of such items from Technology Instrument Corp., Waltham, Mass.

PHILCO CORPORATION, Philadelphia, is offering formal licenses to all set manufacturers to use, subject to royalties, its approximately 700 patents and inventions in the radio

The New "LF" Series
QUARTZ CRYSTAL UNITS



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- higher Q
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- quicker starting
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Technical characteristics:

Frequency range:—50 kc to 500 kc
Frequency calibration—.01% to .002%
Temperature coefficient—1cy/mc/°C
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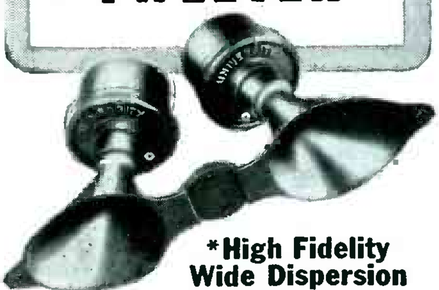

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Wide Dispersion
Low Cost

It's the new UNIVERSITY Tweeter! Extends the range of any cone speaker to 15,000 cycles. Install it in your present equipment by merely attaching two wires to the voice coil terminals of the existing speaker, without creating any electrical unbalance. Simply connect, listen and enjoy. Twin units provide 100° horizontal and 50° vertical dispersion. Three models to choose from—walnut cabinet type, and single or dual unmounted types. Priced from $20.00. Write today for complete details to UNIVERSITY LOUDSPEAKERS, INC., 80 South Kensico Avenue, White Plains, N.Y.

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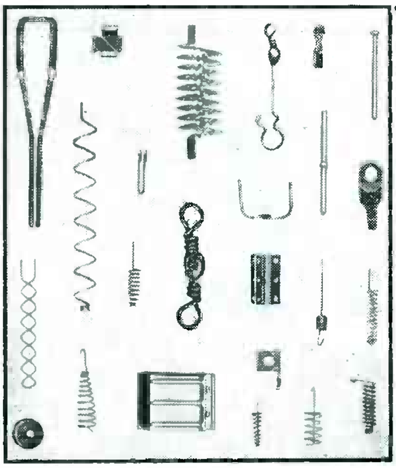

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receiver, electrical phonograph, and television receiver fields. RCA, G-E, and Westinghouse have already been licensed by Philco.

ANDREW ALFORD, CONSULTING ENGINEERS, have moved their laboratory to 299 Atlantic Ave., Boston 10, Mass.

ASSOCIATION OF ELECTRONIC PARTS AND EQUIPMENT MANUFACTURERS has elected the following officers: Les A. Thayer of Belden Mfg. Co., Chicago, chairman; Charles Hansen of Jensen Mfg. Co., Chicago, vice-chairman; Helen Staniland of Quam-Nichols Co., Chicago, treasurer; Ken C. Prince, Chicago attorney, executive secretary.

PERSONNEL

JAMES R. RINKE is now chief engineer at Potter & Brumfield Manufacturing Co., Princeton, Indiana, manufacturers of electrical relays. He was formerly in charge of development of vibrator-type power supplies and converters at Electronic Laboratories, Inc. of Indianapolis.

JAMES T. WATSON, former president of Meissner Mfg. Co. and until recently manager of the Meissner Division of Maguire Industries, is now a member of the board of directors of Potter & Brumfield Manufacturing Co., Princeton, Indiana, electrical relay manufacturers.

HENRY BUTZ was appointed chief engineer of the Nelson Electric Corp., Santa Monica, Cal.

R. C. MASON, on leave of absence from the atomic energy project in Oak Ridge for the past year, was named manager of the electro-physics department of Westinghouse Research Laboratories in Pittsburgh, Pa.

PAUL WEATHERS, after 16 years with RCA, is now vice-president and chief engineer of Airdesign, Inc. of Upper Darby, Pa.

HUGH L. DRYDEN has left the National Bureau of Standards to become director of research for the National Advisory Committee for Aeronautics. He played an important part in the development of the

BAT, the only successful guided missile used during the war.

H. C. CARROLL has been promoted to engineer in charge of General Electric's Marine and Aeronautics Engineering Division.


H. C. Carroll


A. A. Ward

A. A. WARD has been promoted from vice-president of Altec Lansing to vice-president in charge of manufacturing of the Altec Service Corp., New York City.

W. L. BARROW, at one time on the MIT electrical engineering staff, is the newly appointed chief engineer of Sperry Gyroscope Co., Inc., Great Neck, N. Y.


M. W. Scheldorf


W. L. Barrow

M. W. SCHELDORF, co-inventor of the circular-loop f-m antenna, after 19 years with General Electric, has joined Andrew Co., Chicago, as head of engineering research. He will be in charge of the development of new antennas, transmission lines, and other related items.

STANLEY GLASER was appointed manager of the radio section of the Crosley Division, Avco Manufacturing Corp., Cincinnati, Ohio.

WALTER REMBERG, who developed the vacuum-tube acceleration pickup which depends on the internal vibration of a vacuum tube to measure changes in acceleration of vibrating parts of an aircraft in flight, was appointed chief of the Mechanics Division of the National Bureau of Standards.

NEW BOOKS

Radar System Engineering

Volume I of the MIT Radiation Laboratory Series, edited by Louis N. Ridenour *and written by 32 authors. McGraw-Hill Book Co., New York, 1947, 750 pages, $7.50.*

Just as even in war it takes a long time to design and build radar sets, so even in peace it takes a long time to write and publish a technical book. The first volume of the history-making library known as the Radiation Laboratory Series is an example. So difficult is it to get things done today that a full year must elapse between the time a good-sized manuscript is received and the time printed copies are ready for readers. The editor's preface for this volume was written in June 1946; the book appeared in the middle of 1947.

The whole project for widely distributing the important facts and data developed during the life of the Radiation Laboratory has an interesting history, one which will never be published. The essential facts are that plans for the Series were made in the fall of 1944; a large staff of RL men was chosen to prepare the manuscripts and drawings, and actual work began about a year later. What started out to be a few books on microwave theory and techniques began to grow until material for 28 volumes was prepared. The concept of publishing this data, developed in deep secrecy, was bold and its execution was not without difficulty, what with security problems, ideas about government property and government expense and whatnot—not to leave out the vast investment to be made by the publishers.

But the essential fact remains that out of all the work carried out by thousands of scientists and engineers during the war, both in and out of the OSRD, only about 100 volumes will be published and of these less than 50 will be distributed so that their contents will be available. Except for the RL Series, a great bulk of the wartime developments in all branches of technology is locked up in the files, practically unobtainable; even the books—again excepting this radar library—will be difficult to see.

The Radiation Laboratory Series

therefore is a remarkable undertaking, in fact, a monument. Volume I deals, quite properly, with the broad radar picture, describing the components, the subassemblies, and the numerous radar systems. Although the subject matter is technical the editor of the volume is correct when he says in his preface "no special mathematical, physical, or engineering background is needed to read and understand this book," although it is barely possible that he has perpetrated one of the greatest understatements of the technical world when he says that "radar is a very simple subject."

The complexity of radar, the fascination of the things radar can do, the sidelights on its history and usage one finds in this volume, the truth that unbelievably complicated electronic circuits were developed complete and ready to go during the short life of the Radiation Laboratory—the fact that this book is interesting to read as well as worthwhile from the technical standpoint — all indicate that Volume I should rank high on engineers' purchase orders.

Only the chapter headings can be enumerated here—the radar equation, properties of radar targets, limitations of pulse radar, c-w radar systems, gathering and presentation of data, employment of radar data, radar beacons, antennas, scanners and stabilization, the magnetron and pulser, r-f components, radar receivers, indicators, power supplies, system design, moving target indication, radar relay.

The last two chapters present material hitherto unpublished. Here and there in this large book one gets glimpses of other items, paragraphs and chapters of radar history, and techniques and applications that are new to most and which will be useful as a technical storehouse for a long time.—K.H.

Alternating Currents

By CHESTER L. DAWES. *McGraw-Hill Book Co., Inc., New York, N. Y., 1947, Fourth Edition, 708 pages, $5.00.*

THIS fourth edition contains much new material, especially on electronic topics such as dynamic measurements, frequency modulation, selenium rectifiers, ignitrons, and electronic motor control.—J.M.

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.

Triode Versus Pentode

Dear Editor:

ARTICLES published by ELECTRONICS in recent months indicate that at least a small group of engineers are aware that radio can, and should, bring the listener reasonably faithful reproduction of the speech or music transmitted. It seems timely to suggest that we "go ahead by going back"—back to triodes.

It has long been the contention of the writer that the tube manufacturers could, if they were gently prodded, produce a small triode capable of, say, two watts undistorted output, with little, if any, higher grid excitation necessary than is common to pentodes. To forestall possible comment, it should be noted that two watts of triode power, using a loud speaker load, actually means two watts of useful power, in contrast to the fraction of rated power that can be obtained from a pentode or beam tetrode without excessive distortion, at even moderately high frequencies.

Congratulations to ELECTRONICS for its efforts to further the cause of better sound reproduction.

WORCESTER BOWEN
Barstow, California

Pulse Technique Nomenclature

DEAR SIRS:

THERE appears to be some confusion in the minds of many people (even some engineers) concerning the use of the word "radar". There is a tendency to lump all microwave and navigational systems, particularly those employing pulse techniques, under the umbrella-title of radar.

I should like to suggest a system . . . there would be three broad headings, relating to systems operating in the fashion indicated:

1. *Radar* includes systems em-

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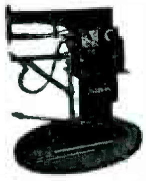

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This CONTACTS Section

supplements other advertising in this issue with these additional announcements of products essential to efficient and economical operation and maintenance. Make a habit of checking this page, each issue.

Classified Advertising Division

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ploying a radio frequency energy source transmitting in a preferred direction toward a *passive* object (target), which scatters the radiation incident upon it. A fraction of the scattered energy is then detected by a receiver, usually at the same location as the transmitter.

2. *Racon* (radar beacon) systems employ an interrogating transmitter, the signal from which is detected by a receiver at a second location. This signal, after suitable processing, then actuates a transmitter that replies with a signal bearing appropriate information (the answering signal need not employ the same wavelength as the interrogating signal). The answering signal is then detected by a receiver at location of interrogator. Examples are Oboe and Shoran.

3. *One-way navigational systems* employ a system of transmitters that establish a grid system in space for use by anyone having the necessary receiving equipment. Examples are Loran, Gee, and Decca.

Under this classification distinction is made between systems employing an echo from a passive target (radar) and those depending upon a triggered reply from a secondary system (racon); and finally the navigational systems involving transmission of energy in only one direction are considered to be separate. Obviously one type of system can perform part of the function of another; for instance, a radar system commonly provides a major fraction of the components at the interrogating end of a racon system. Also, radar systems function as navigational systems. This large degree of overlap does not alter the fact that there are two functions to be performed, and that there are some major differences in the manner of operation.

DONALD E. KERR
Massachusetts Institute of Technology
Cambridge, Massachusetts

THE EDITORS are informed that the word "Fathometer" is a copyrighted trademark of the Submarine Signal Company and was, accordingly, improperly used in the October 1947 issue of ELECTRONICS in the article "Telemetering Fathometer" since the equipment described was not manufactured by the Submarine Signal Company.

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Engineer, preferably with radio-phonograph mechanical design background, capable of producing practical, low cost, mass production designs starting from performance specifications.

The work involves specifications for purchase of components, establishing of inspection and quality standards, coordination of appearance styling, and follow-up of initial production.

Reply giving a brief resume of personal data, educational background, and details of type of product worked on, and extent of responsibility therefor, over the past ten years.

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Must be graduate E. E. Must have heavy experience in audio work, particularly with sub-miniature parts. Some mechanical knowledge and production experience. Will be completely responsible for research, design and assembly small electronic device. Give complete education, experience—particularly as applied to above, age and salary required. Unusual opportunity and permanent security for right person. Box

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WANTED: MECHANICAL Engineer or Electrical Engineer with background in product design, tooling, assembly, etc., of communications equipment. Must be able to carry the ball on a new development. This position is permanent. Salary open. Apply to: Audio Development Co., 2833 13th Ave. So., Minneapolis 7, Minn.

DESIGNER: 3 to 6 years experience in aircraft engine accessories, such as manifold pressure controls or carburetors. Prefer age under 30. Give full details on education, experience, and previous positions. Personnel Dept., The Bristol Co., Waterbury 91, Conn.

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EXECUTIVES $3,000-$25,000. This reliable service, established 1927, is geared to needs of high grade men who seek a change of connection under conditions assuring, if employed, full protection to present position. Send name and address only for details. Personal consultation invited. Jira Thayer, Jennings, Dept. E, 109 Church Street, New Haven, Conn.

(Continued on opposite page)

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An advertising inch is measured ⅞" vertically on one column, 3 columns—30 inches—to a page.

NEW ADVERTISEMENTS received by October 31st will appear in the November issue, subject to limitations of space available.

ENGINEERS NEEDED

Large Eastern manufacturer of communication and broadcast radio equipment has positions available for the following personnel:

Broadcast Receiver Project Engineers and Assistant Project Engineers

Television Receiver Project Engineers and Assistant Project Engineers

Mechanical Engineers — Senior Draftsmen Detail Draftsmen

Personnel experienced in design methods on broadcast, television and automobile radio receivers preferred. Pleasant working conditions. Unlimited advancement opportunities. Reply in detail, giving complete resume of business experience.

P-1568, Electronics
520 North Michigan Ave., Chicago 11, Ill.

RADAR AND ELECTRONIC ENGINEERS
MISSILE GUIDANCE PROJECT

New Navy electronic guidance and control project requires engineers for analysis, development and test of radar equipment, electro-mechanical servomechanisms, electronic timing and control circuits, and other guided missile equipment. Bachelor's degree in Electrical Engineering or Physics required; Master's degree or equivalent study of Mathematics, electronics and applied physics very desirable for responsible positions. Salary to $7500 depending upon qualifications.

Write or phone Mr. C. D. Perrine, Jr., Chief Electronics Engineer

PILOTLESS PLANE DIVISION
Fairchild Engine and Airplane Corporation
FARMINGDALE ***Farmingdale 1410*** **LONG ISLAND**

WANTED

PHYSICISTS & ELECTRONIC ENGINEERS

A major oil company located in the Southwest requires the services of a few competent physicists and electronic engineers as permanent research staff members. Positions are available for project engineers and group leaders. Preference will be given to men with the Ph.D. degree or equivalent in training and experience.

Work involves research in the field of physics, physical chemistry, and geophysical exploration, and development of analytical instruments and equipment. Applicant should have training and experience along theoretical as well as experimental lines. These positions are permanent and offer unusual opportunities for the right men.

Give complete details as to personal history, education, experience, and salary required. All applications will be treated confidentially.

P-2159, Electronics, 520 North Michigan Ave., Chicago 11, Ill.

ADDITIONAL POSITION VACANT AD ON OPPOSITE PAGE

BELGIUM

American Firms desirous to extend their activity to Belgium, are invited to contact with

SOCIETE INDUSTRIELLE ALFA

80, rue de la Senne

BRUSSELS

Oldest importer of American radio, electrical and electronic material.

TELEVISION ENGINEERS

Several project engineers required with experience in:

1) television receiver production or circuit development

2) design, operation, and maintenance of television test equipment. Familiarity with the operation of synchronizing-signal generators and sweep generators is desirable.

This is an unusual opportunity to join a progressive, congenial group and participate in an interesting program of development.

Write details to

TELE-TONE RADIO CORPORATION
Employment Section
540 West 58th Street
New York City

(Continued from opposite page)

POSITIONS WANTED

GRADUATE ELECTRICAL Engineer, age 28, four years experience in motor control sales promotion and development coordination wants sales promotion or development work in electronics, particularly communications. Active in amateur radio operating, building, experimenting since 1934. PW-2202, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

JUNIOR ELECTRICAL Engineer. Age 23. Two years laboratory experience, electrical and electronic development. Desire position in N. Y. area. Leonard Goldberg, 625 West End Ave., 24, N. Y.

SALES-ELECTRICAL Engineer. Ex-officer. 15 years experience in every branch of radio. Competent administrative executive. Aggressive sales producer. Sales-contact and trouble-shooting. Wide intimate contacts throughout entire radio field in metropolitan area and leaders nationally. Commercial phone and amateur licenses. Financially responsible. PW-2435, Electronics, 330 W. 42nd St., New York 18, N. Y.

ENGINEER, BSEE, electronics. Extensive experience design, development, research circuits, radar, microwaves, etc. Allied executive and sales experience. PW-2574, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRICAL ENGINEER, 6 years experience in development, design, and manufacture of communications, electronic, and control apparatus. Good, usable fundamental knowledge of above fields. B.S. in E.E. Desire position as research and development engineer. PW-2589, Electronics, 520 N. Michigan Ave., Chicago 11, Ill.

EXECUTIVE

Formally trained in engineering and law. Experienced as Chief Engineer and as head of Legal Department for corporations specializing in radio, radar and electronic instrumentation. Complete patent background. Available on reasonable notice.

PW-2134, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Experience proves . .

to maintain the reputation of your product, you must have an effective, well trained Service Department.

The maintenance of such an organization requires the services of an energetic young man with far reaching ideas.

Five active years of radio and electronic service management and department organizing plus a college education in electrical engineering, have equipped this man for just such a position.

WRITE FOR FURTHER INFORMATION
PW-2442, Electronics
330 West 42nd St., New York 18, N. Y.

FOR SALE

SOUTHWESTERN RADIO REPAIR SCHOOL

VA approved. Fully equipped. 100 student capacity. Only Radio School in area. A profitable business. Reasonable.

BO-2575, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Northern Ohio

SALES REPRESENTATIVE

Solicits connection with manufacturers of high quality electronic components and equipment.

Fully experienced

J. R. DANNEMILLER ASSOCIATES
4334 Groveland
Cleveland 18, Ohio

FOR SALE

Eastern transformer plant. Well equipped—fully staffed—good business. All types of power transformers up to 5 KVA, chokes and audio. Special apparatus transformers our specialty. Plant capacity $75,000 monthly. This is not a sacrifice sale—asking no good will, net worth only. If you want to manufacture transformers or if you are a large user this is worth investigating.

BO-1257, Electronics
330 West 42nd Street, New York 18, N. Y.

LEADING SWISS FIRM

Manufacturer of small and medium sizes electric apparatus would be willing to manufacture under license or carry out any kind of contracts in the electric machinery line, appliances, variable speed devices, special machinery or similar apparatuses. Please send your inquiry to

CW-2081, Electronics
330 West 42nd Street, New York 18, N. Y.

Mr. Production Manager:

NEED OUTSIDE HELP?

We assemble and wire small Radio, Electrical, and Electronic devices in small lots. Satisfaction guaranteed.

TROY ELECTRONICS LABORATORIES
TROY, N. Y.

Nomograms, Charts, Tables, Graphs
Made to order

You may save valuable computing time. Free Brochure.

H. D. RUDERMAN
Time-Saving Computing Devices
1533 Townsend Ave., New York 52, N. Y.

WANTED

WANTED

Synchros—(selsyns-autosyns)
Types 5F, 5G, 5 CT, 5DG, 6G, AY101D, AY120D, AY130D, etc.

Navy Test Oscillator Model T.S. 47APR

Navy type 211916, 1-125th H.P. motors

Type DY12, DY 17 Russell Dynamotors for ART 13

W-2186, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

USED 10 KW BROADCAST TRANSMITTER

Write to

KWSC, PULLMAN, WASH.

SPECIAL METERS

Marion "S" meter, Made for National Co., 1 MA mvt, sc cal 1-9 units S and 0-40 DB above S 9, 2" ring mtd fl metal case............$3.50

Simpson, 25, Signal Strength ("S") Meter, 3½", rd fl bake case. Use this on the plate circuit of your receiver to show the relative strength of incoming signals. Sc calibrated—6 to 100 DB above 1 microvolt. 5 MA Zero right mvt with translucent sc, for internal sc illumination from rear of meter. Comp with socket, lamp and leads. For further details refer to pages 164-165 & Fig. 730 B of Radio Amateur's Handbook......$4.50

Weston, 301, Type 21 Standard Decibel Meter, 3½", rd fl bake case, minus 10 to plus 6, 6 M.W., 600 ohms; General purpose type 0.5—0.7 Second to final reading, 45-62% overthrow. 5000 ohms internal resistance at ODB.........$8.50

J.B.T., 30-F, Dual range Frequency Meter Covers Frequency ranges from 48-52 cycles and 58-62 cycles; Dual element, Vibrating Reed type, 115 volt, 3½", rd flush metal case............$5.95

Voltage Polarity Phase Rotation Tester, Triplett 337 AVP, Checks 115, 220 and 440 line voltage; locates open circuits, blown fuses, damaged wiring, etc., Indicates whether A.C. or D.C. and polarity of D.C.; Checks phase rotation to determine direction of rotation of motors, operation of controls, etc.; Consists of a 3" square meter and a small polarized vane movement in a small handy sized case. Complete with 36" leads with test prods...........................$8.50

G.E., DO-46, 3.0 V A.C., 400 microampere mvt, Rectifier type, special sc, 3½" round flush bakelite case $5.50

G.E., DO-53, 550 microampere movement, with internal resistor for 50 volt D.C. 10 division scale calibrated 0-10, Scale marked "Channel", 3" square fl bake case with paper Volt Ohm M.A. scale $4.50

Time Totalizer Indicates up to 9,999.9 hours for 50 or 60 cycle operation on 105 to 130 volts. Black scale 3" rd fl bakelite case, Clamp mounted. Made by Industrial Timer Corp..$4.00

W.H., DB Meter, RC-35, minus 10 to plus 6, ODB equals 1.897 V, 6 MW, 600 ohms, 3" square $4.50

D. C. MILLIAMMETERS

G.E., DO-41, 1 MA, black scale, supp with paper V.O.M.A. sc. $4.50

G.E., DO-41, 30 MA, 3½", rd fl bake case .$3.50

G.E., DO-41, 50 MA, black scale, 3½", rd fl bake case $3.25

G.E., DO-41, 200 MA, 3½", rd fl bake case..$3.25

W.H., NX-35, 200 MA, 3½", rd fl bake case.$3.95

Simpson 25, 1 MA, 3½", rd fl bake case.....$4.50

Simpson 25, 200 MA, 3½", rd fl bake case...$4.50

Weston 506, 1 MA, 2½", rd fl bake case....$3.95

Weston 506, 50 MA, 2½", rd fl bake case...$3.95

Weston 506, 200 MA, black scale, 2½", rd fl bake case $3.50

G.E., DW-51, 1 MA, 100 MV mvt, sc cal 0-50 MA, 2½", rd fl bake case................$3.50

G.E., DO-53, 1 MA, 3" sq fl bake case......$4.95

G.E., DO-53, 20 MA, 3", sq fl bake case....$3.25

G.E., DO-41, 80 MA, 3½", rd fl bake case...$3.25

Weston 506, 1.5 MA, 2½", rd fl bake case....$2.95

Weston 506, 3 MA, 2½", rd fl metal case....$2.50

Sun 3AP259, 1 MA, 3½", rd fl bake case.....$3.00

Triplett 0321, 1 MA, 3½", rd fl bake case....$3.95

DeJur Amsco 310, 1 MA, sc cal 0-4 KV sc, 3½", rd fl bake case, supp with V.O.M.A. sc and circuit diagram $3.95

DeJur Amsco 310, 1000 MA (1 Amp) 3½", rd fl bake case $3.00

Gruen 508, 150 MA, 2½", rd fl bake case....$3.00

Gruen 511, 200 MA, 2½", rd fl bake case....$3.00

Hickok, 1.4 MA, 70 ohms resistance; Meter used in Mutual Conductance Tube-Checker sc cal 0-3000, 6000, 15000 Micromhos, "Replace? Good" Line Test"........................$3.50

D. C. MICROAMMETERS

W.E., 100-0-100 microampere, approximately 950 ohms resistance, 3½", rd fl bake case, concentric style $6.50

G.E., DO-41, 200 microampere mvt, Knife edge pointer, sc mkd "Set Carrier" supp with paper V.O.M.A. sc. 3½", rd fl bake case........$4.95

G.E., DO-41, 500 microampere mvt, sc cal 0-20 KV, supp with paper V.O.M.A. sc, 3½", rd fl bake case $4.50

G.E., DO-53, 500 ua mvt, sc cal 0-15 KV, supp with paper V.O.M.A. sc, 3½", sq fl bake case $4.50

Triplett, 100 ua mvt, 950 ohms resist, made for 666-Sc Analyzer; sc cal in Volts, MA & Ohms, 3½", sq fl bake case....................$6.95

Marion, 200 ua undamped mvt, spec sc, 2½", rd fl bake case............................$3.50

Triumph, 400 ua mvt, approx 500 ohms resist, sc cal 0-3, 0-15 & 60 V MA, 4" Rect fl bake case, Knife edge pointer.......................$5.50

McClintock #2001, 150 microampere, approx 740 ohms resistance, black scale, 2½", rd fl bake case $3.50

D. C. AMMETERS

G.E., DW-51, 30-0-30 A, 2½", rd fl metal case $3.50

W.H., F-1 (NX-33), 150 A, black scale, comp with ext 50 MV (Aircraft style) shunt, 2½", rd fl bake case $2.50

Weston 506, 200 A, comp with ext 50 MV shunt, 2½", rd fl bake case....................$7.50

Triplett 0321-T, 15 A, 3½", rd fl bake case..$4.00

Beede, 30-0-30, A, 2½", rd fl metal case.....$3.00

Hoyt, 50 A, 2½", rd fl metal case...........$2.95

W.H., Aircraft type, 240 A, Complete with ext 50 MV shunt, 2½", Aircraft style case........$3.95

D. C. VOLTMETERS

Weston 301, 500 V, D.C., 1000 ohms per volt, 3½", rd fl bake case..........................$9.00

Weston 301, 500 V, D.C., 1000 ohms per volt, 3" sq fl bake case..........................$9.50

Weston 301, 3½", 4 K.V., with external prec resistor $8.50

Weston 301, 5 KV, Complete with 1000 ohms per volt ext prec wire wound resistor & mtg clips, 3½", rd fl bake case....................$9.95

G.E., DW-41, 15 volt, black sc, no Caption, sc cal 0-15, 2½", rd fl bake case...........$2.50

G.E., DO-41, 200 V, black scale, 3½", rd fl bake case 1000 r/v..........................$3.95

G.E., DO-41, 500 V, black scale, 1000 ohms per volt $7.00

G.E., DO-41, 2.5 KV, black sc, with 1000 r/v ext wire wound resist...........................$6.95

W.E., 40 V, 400 microampere mvt, concentric style, 4½", rd fl bake case................$3.95

W.E., 75 V, 1000 ohms per volt, 3½", rd fl bake case, concentric style $3.00

W.E., 500 V, 1000 ohms per volt, 3½", rd fl bake case, concentric style $5.00

W.H., SX-33, 3-0-3, V, 200 ohms per volt, 2½", rd surf mtd, bake case....................$1.25

W.H., NX-35, 50 V, 200 ohms per volt, 3½", rd fl bake case..............................$3.95

W.H., NX-35, 200 V, 200 ohms per volt, 3½", rd fl bake case $3.95

W.H., NX-35, 200 V, 200 ohms per volt, mounted on 45° metal angle panel with binding posts.$4.95

W.H., NX-35, 750 V, 1000 ohms per volt, 3½", rd fl bake case..........................$11.50

W.H., NX-35, 1.5 KV with 1000 ohms per volt, ext prec wire wound resistor & mtg clips, 3½", rd fl bake case..........................$7.25

W.H., RX-35, 4 KV with 1000 ohms per volt ext wire wound resist.........................$8.50

W.H., NX-35, 20 KV with ext prec wire wound 1000 ohms per volt resistor and mtg clips.$21.00

Gruen, GW 505, 15 V, 2½", rd fl bake case..$3.50

Sun, 2 AP458, 10 V D.C. 100 ohms per volt, 2¼", rd fl bake case..........................$2.50

McClintock D-100-R-1, 15 V D.C. 1000 r/v bl sc, 2½", rd fl bake case......................$3.00

Triplett 521, 0-50 V 1000 r/v, 5½", rd fl bake case $5.50

W.H., NX-33, 5 V D.C. 200 ohms per volt, 2½", bake case $3.50

A. C. VOLTMETERS

G.E., AO-22, 15 V, 3½", black scale, rd fl bake case $3.00

G.E., AO-22, 150 V, 3½", rd fl bake case....$5.50

G.E., AO-22, 150 V, 400 cycle, 3½", rd fl bake case $4.00

G.E., AO-22, 150 V with external resistor for 300 volt to make dual range 150 and 300 volt. (multiply scale readings by two)..........$6.50

Weston 517, 75 V, ring mtd 2" rd fl metal case $2.95

Weston 517, 300 V, 2½", rd fl bake case...$6.00

Weston 476, 8 V, 3½", rd fl bake case......$3.50

Weston 476, 130 V, 3½", rd fl bake case.....$4.95

W.H., NA-35, 15 V, (100 MA) 3½", rd fl bake case $3.95

W.H., NA-35, 130 V, blank sc, Red line at 115 V, 3½", rd fl bake case..................$3.00

W.H., NA-35, 150 V (10 MA) 3½", rd fl bake case $5.50

Triplett 331-J.P., 150 V with external resist for series connection to increase range to 300 V, (multiply reading by 2) to make a dual range 150/300 Voltmeter, 3½", rd fl bake case...$5.50

Burlington 32 XA, 150 V, 3" square flush bakelite case $4.00

G.E., AW-41, 15 V Black scale, no scale calibration SC 1S-122 blank scale reference mark at 10 volts $2.50

Burlington 32 C, 300/600 with external resistor for 600 volt; sc calibrated 300 and 600 volts $8.00

A. C. AMMETERS

Roller Smith, Type TAS, 8 A. A.C., 3½", rd fl bake case $4.50

Triplett, 331-J.P., 30 A, 3½", rd fl bake case.$4.00

Triplett, 331-J.P.C., 75 A, 3½", rd fl bake case $3.50

W.H., NA-35, 75 A, 3½", rd fl bake case...$4.00

G.E., AO-22, 50 A, 3½", rd fl bake case....$4.50

Burlington 32XC 60 and 120 Amp with external current transformer $7.50

RADIO FREQUENCY AMMETERS

Weston 507, 750 MA, sc cal 0-10 Antennae Current Indicator comp with ext thermocouple, 2½", rd fl bake case, black scale.........$2.95

Weston 507, 1 A, 2½", rd fl metal case.....$3.50

Weston 507, 1.5 A, black scale, 2½", rd fl metal case $2.50

Weston 507, 2.5 A, 2½", rd fl bake case....$3.95

Weston 507, 3 A, black scale, 2½", rd fl bake case $3.50

Weston 507, 9 A, black scale, 2½", rd fl bake case $2.50

W.H., NT-33, 250 MA, black sc, sc cal 0-5, mkd "Antennae Current" 2½", rd fl bake case..$3.50

W.H., NT-35, 3 A, 3½", rd fl bake case....$5.50

W.H., NT-33, 9 A, bl sc, 2½", rd fl bake case $2.50

G.E., DW-52, 250 MA, black sc, sc cal 0-5 mkd "Antennae Current" 2½", rd fl bake case.$3.50

G.E., DW-44, 1 A, 2½", rd fl bake case.....$3.50

G.E., DW-44, 1 A, black scale, 2½", rd fl bake case $2.95

G.E., DW-52, 1.5 A, black scale, 2½", rd fl metal case $2.95

G.E., DW-52, 3 A, black scale, 2½", rd. fl bake case $2.95

G.E., DW-44, 4 A, black scale, 2½", rd fl bake case $2.95

G.E., DW-44, 6 A, black scale, 2½", rd fl bake case $2.50

G.E., DW-44, 8 A, black scale, 2½", rd fl bake case $2.95

G.E., DO-44, 20 A, 3½", rd fl bake case...$4.95

Simpson 135, 2 A, 2½", rd fl bake case......$3.50

Simpson 135, 8 A, 2½", rd fl bake case......$3.50

Simpson 36, 1 A, 3½", rd fl bake case.......$4.95

G.E., DW-52, 1 A R.F. 2½", metal case.....$3.00

Weston 425, 1 A R.F., 3½", rd fl bake case.$7.50

All items are Guaranteed and are Surplus New unless specified otherwise. All prices FOB, N. Y.— 25% deposit required on C.O.D.'s. Orders accepted from rated concerns on open account. Net 30 days

MARITIME SWITCHBOARD

338 Canal Street . . . . . . Worth 4-8217 . . . . New York 13, New York

PORTABLE CURRENT TRANSFORMER

Weston Model 461 Type 4 (see illustration). This unit can be used with any precision 5 Amperes A.C. Meter to extend the ranges of the meter to 50, 100, 200, 250, 500 or 1000 Amperes A.C. Accuracy within ¼ of 1%; Normal Secondary Capacity = 15 Va; Binding Posts for 50 Ampere tap; Inserted primary for 100, 200, 250, 500 and 1000 Amperes; Insulated for use up to 2500 volts. List Price $98.00.........NET fob, NY $35.00

PORTABLE A. C. VOLTMETER

Weston Model 433. 0-600 volt A.C.; accuracy within ¾ of 1% from 25 to 125 cycles. Hand Calibrated Mirror Scale 4.04" long with 150 Scale divisions; Knife edge pointer. Moving Iron Vane type magnetically shielded. Dimensions 5"x6"x3½". List Price $59.50............NET fob, NY $27.50

PORTABLE A. C. AMMETERS

Surplus New WESTON MODEL 528

DUAL RANGE 0-3 Amp. and 0-15 Amp. full scale for use on any frequency from 25 to 500 cycles. The ideal instrument for all commercial, industrial, experimental, home, radio, motor and general repair shop testing. Comes complete with a genuine leather, plushlined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at less than 50% of manufacturers list. Your cost..............ONLY $12.50

PORTABLE A. C. VOLTMETERS

(See illustration of Ammeters)

SURPLUS NEW WESTON MODEL 528

DUAL RANGE 0-15 and 0-150 Volts for use on any frequency from 25 to 125 cycles. Complete with plushlined leather carrying case and a pair of test leads. This Voltmeter, with the matching model Ammeter as illustrated above, makes an ideal pair of test meters for any mechanic to carry around in his tool box.........ONLY $9.50
Combination Offer: 528 Voltmeter—528 Ammeter BOTH For $21.00

PORTABLE D. C. AMMETER & SHUNTS

Westinghouse Type PX-4, Multirange 0-1000, 0-2000 and 0-4000 Amps. D.C. (50 MV movement) Accuracy within ¾ of 1%, long Mirror 3 range scale with 80 scale divisions; Knife edge pointer; Moving coil D'Arsonval movement; Dimensions 4½"x4½"x2". Complete with leads and external 50 MV shunts.............NET fob. N.Y. $80.00
Meter & Leads Only.....................$17.00
1000 Amp shunt Only....................$12.00
2000 Amp shunt Only....................$20.00
4000 Amp shunt Only....................$40.00

POWER LEVEL INDICATOR

Weston Model 695 Type 3 A; A rectifier type voltmeter with 5 ranges of 1.5, 6, 15, 60 and 150 volts and
A multirange DB meter for a zero signal level of 6 milliwatt on a 500 ohm line. Arranged to indicate -8, -4, "O", +4, +8, +12, +16, +20, +24, +28, +32 DB at "O" on the DB scale or a total spread of 56 DB.
A plate fastened on back of instrument gives instructions and conversion data for use on other than 500 ohm circuits.
Dimensions 5½"x3¾"x3⅛".

$19.50

VOLT OHM MILLIAMMETER SUPERIOR MODEL 1553

A.C. Voltage 7.5, 15, 150, & 750
D.C. Voltage 7.5, 15, 150, & 750
D.C. Current 7.5, & 75, M.A.
Resistance 0-5000, C-500,000
In hardwood case 6½"x4½"x2¾".
Complete with genuine leather carrying case, test leads & instructions........ **$17.95**

INSULATION TESTER

0-20 and 0-200 Megohms, full scale
0- .5 and 0-5 Megohm, center scale

The original unit, The Weston Model 796 Insulation Tester operated at a 500 volt test potential supplied by eight 67½ volt batteries. This has been modified by us to utilize two 1½ volt standard No. 6 dry cells and a vibrator power supply for the 500 volt test potential thereby eliminating the high replacement cost of batteries. Enclosed in a hardwood carrying case 8⅜"x9⅛"x8". The Weston Model 801. 4⅛" Rectangular 0—50 microampere meter guarantees extreme accuracy on all ranges. Surplus—New—Guaranteed.
NET fob, NY $39.50

"VIBROTEST" RESISTANCE & VOLTAGE TESTER

Associated Research, Inc. Model #201.
Resistance Range 0—200 megohms (at 500 volts potential) 0—2000 ohms.
Voltage Range 150-300-600 Volts D.C. 150-300-600 Volts A.C.
Push button action for resistance readings—no hand cranking!
Operates from internal Vibrator power supply off two number 6 dry cells.
Complete with batteries, test leads and instructions in metal carrying case.
NET fob, N Y..........................$60.00

WESTON 687 OUTPUT METER

3 full scale ranges 0-2, 0-10, 0-50 Volts Audio Frequency. Complete with 3' lead with pin plugs and plug (PL 55)
NET fob, NY.............................7.50

TEST UNIT 1-35-E

One of the component units required to test the "Walkie Talkie" Transmitter and Receiver BC-611. Consists of a 4" rectangular multi-range meter, Switching facilities, Microphone, receiver, earphone, R.F. oscillator, audio oscillator, crystal test socket, pin jacks, test terminal cable & plug. Comes in cabinet with removable cover 9" wide, 14" long, x 5" high with Technical Manual and circuit diagram. Full scale ranges of 3 & 150 V D.C.; 1.5, 15, 60 & 600 MA D.C.; and 60 V A.C. Suitable for modication into a versatile radio test unit.
NET fob, NY............................$13.50

FILAMENT TRANSFORMER

FILAMENT TRANSFORMER G.E. 110 volt 60 cycle input. 2.5 volt 40 Amp. Output 100 KVA 3 K.V. insulation. @ $2.75 each Ten for $17.50
STEP DOWN TRANSFORMER Jefferson Electric 115 volt 60 cycle primary. 20 volts 10 Amp. secondary, mounted in watertight box. @ $3.95 each Ten for $30.00
STRIP HEATER G.E., Cat #2A305, 250 ohms 50 watt 115 V., 1½" x ½" x 6" @ 60¢ each Minimum order Ten pieces
MICROSWITCH Single Pole Normally closed, 10 A; 125 V. @ 30¢ each. Minimum order Ten pieces.

BC-1161-A RADIO RECEIVER

150 to 210 Megacycles. Can be used with the BC-1072-A, listed below for a "ham rig." Operates off 115 volt 60 cycle Power supply. Inductance tuning for R.F., Antennae, detector and oscillator. With a few modications this unit makes an ideal F.M. Receiver. Each set complete with circuit diagram and the 14 following tubes; 1—6SN7 Cathode Follower; 1—6H6 second Detector; 2—6SH7 1st and 2nd R.F. Amp.; 1—6SH7 Video Amp.; 3—6AC7/1852 1st, 2nd, 3rd IF Amp.; 2—6AB7/1853 4th, 5th, IF Amp.; 1—9006 Mod.; 1—6J5 Osc.; 1—5U4G Rect.; 1—6E5 Tuning Indicator.
Complete in a metal cabinet 10" high 16½- wide and 15" deep.

NET fob, N. Y. $34.50

BC-1072-A RADAR TRANSMITTER

150 to 210 Megacycles: Operates off 115 volt, 60 cycle power line. This unit can be adapted to a 2 meter band transmitter but its chief value is for the parts it contains.
BLOWER. 115 volt 60 cycle 28 watts .38 1525 R.P.M. A.G. Redmond.
VARIAC. Gen. Radio type 200 B 115 volt input. 135 volt 1.5 amps. Max. output.
TUBES. 2—5U4G's: 1—807; 1—2x2; 1—6SN7; 1—6J5; 1—9002; 2—9006; 2—826.
METER. Simpson, 3½", round, 0-5 Kilovolt and 0-10 M.A., D.C.
TRANSFORMERS. 1—with primary variable from 0-135 volt, secondary from 0-3500 volt; 1—with primary 117 volt secondary 6.3 V at 1.2 Amp. 275 volt center tap to each side, 5.0 volt at 3 Amp.; 1—with 117 volt primary, secondary 4 volt at 16 amp. and 2.5 volt at 1.75 amp.
Consists also of many other parts, relays, transformers, circuit breakers, interlocks, resistors, chokes, too numerous to itemize.
Complete in metal cabinet 18"x20"x17½"; net wt. 150 lbs.

NET fob, N. Y. $22.50

VARIABLE RHEOSTAT WARD LEONARD

20 Ohms 4.05 Amperes 8" Class, complete with handle and all accessories for rear of board mounting. Can also be used for front of board mounting.

800 Units in Stock

Special Prices on Large Quantities

Minimum Order 10 Pieces ....$2.95 Each fob N. Y.

RADIO NOISE FILTER

General Electric Co., Cat # 1C202G2. 100 Amps. 50 Volts D.C.
Can be used on vehicles and boats, or with aircraft equipment to filter generator "noises". For use on low voltage generator outputs up to 50 volts; Dimensions 4¼" L x 3¾" W x 2½" D. 75¢ each. Minimum order 10 pieces.

VIBRATOR TRANSFORMER ASSEMBLY

PRIMARY WINDING—center tapped 6 volt D.C. at 1.6 Ampere on each half of winding. Center tap is brought out directly from primary winding and also through a 3.5 Millihenry series choke.
SECONDARY WINDING—center tapped 360 volts A.C. at 30 M.A. total. Center tap is brought out directly and also through a 5 Henry series choke.
DIMENSIONS—2¼" dia. x 3⅜" overall height.
United Transformer Co. type #82834.

Minimum Order 50 Pieces at 60c Each fob N. Y.

HYDROMETER

Storage Battery Testing Kit made for Navy Type A. lead acid batteries. Consists of:
A Hydrometer with a spare 10" glass barrel
B Two 13" mercurial thermometers from 20 to 150° F with specific correction calibration markings.
C Two pipettes for electrolyte measuring
D Two hydrometer floats from 1060 to 1240 Baume
E Two hydrometer floats from 1120 to 1300 Baume
Each set comes complete in a compartmented wood box with slide cover 5½" x 3½" x 22¾". Surplus—New.

NET FOB, NY **$2.75 each**
Minimum Order 10 Pieces.

All items are Guaranteed and are Surplus New unless specified otherwise. All prices FOB, N. Y.—25% deposit required on C.O.D.'s. Orders accepted from rated concerns on open account. Net 30 days

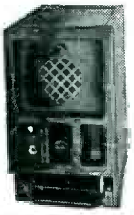
MARITIME SWITCHBOARD

338 Canal Street . . . . Worth 4-8217 . . . . . . New York 13, New York

 - Digby -
9-1132

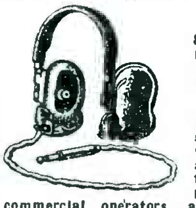
NOW AVAILABLE FOR IMMEDIATE SHIPMENT!

TWO PARTY INTERCOM SPECIAL
$29.50



Ideal for factory or office use. Momentary Press - to - Talk switch provides fast positive action. Built for rugged use, has terrific pick-up. 115 v. 50-60 cy. panel controls includes volume control 110 v. switch 11x11½x6½—weight 28 lbs. Complete with tubes and additional speaker in metal case.

HS-16 HEADSET



8000 ohms Hi-impedance
Noise proof
Most sensitive phone built
May be used as a sound powered intercom
Light, durable, efficient. Molded neoprene earcups shaped to completely envelope entire ear. Adjustable steel headband extends or retracts. Especially suited to hams, commercial operators, aircraft pilots, recording engineers and many others. Can be used with simple Xtal to make complete radio receiver. Special **$1.89**
Original cost $25.00
6 foot extension cord .... **.49**

AMERTRAN VOLTAGE REGULATOR
(TRANSTAT)

17.4 amps. maximum output 2 KVA single phase 115 v. 50 to 60 cy. 90 to 130 v. shipping weight 20 lbs.—a marvelous buy—First come first served **$24.95**

PIONEER GENEMOTOR HIGH POWER ON WHEELS

Delivers output 500 V. @ 160 mils, Input 6 or 12 V.—completely filtered—has relays and magnetic circuit breakers in specially constructed casing. The job that will deliver the watts to that mobile rig. Slightly used, perfect condition. Specially priced **$5.95**

G. E. INTERLOCK SWITCH

Hi-voltage is lethal—protect yourself and family—this switch automatically shuts off Hi-volt. circuits while adjustments are being made—low pressure—hi current capacity, positive action. Silver plated contacts. Pr...... **$2.49**

CONDENSERS

CF- 1—2MFD 400 V. DC.	$ .39
CF- 5—2MFD 600 V. DC.	.60
CF- 6—4MFD 600 V. DC.	.75
CF- 8—Tobe Dual 8MFD 600 V. DC. fits 4 prong socket	1.25
CF-10—1MFD 1000 V. DC.	.90
CF-13—4MFD 1000 V. DC.	1.10
CF-14—4MFD 1500 V. DC.	1.89
CF-19-1MFD 600 V. DC.	.39
CF-22—2MFD 4000 V. DC.	5.50
CF-27—1MFD 2500 V. DC.	1.19
CF-28—7MFD 800 V. DC.	1.50
CF-29—2MFD 2000 V. DC.	2.19
CF-30—1MFD 5000 V. DC.	6.75
CF-31—8MFD 600 V. DC.	1.20
CF-32—4MFD 100 V. DC.	.69
CF-33—10MFD 600 V. DC.	1.40
CF-37—8MFD 2000 V. DC.	4.95
CF-40—2.87MFD 3500 V. DC.	16.95
CF-41—'15MFD 12,000 V. DC.	14.95
CF-42—7MFD 600 V. DC.	1.35
CF-43—6MFD 600 V. DC.	1.09
CF-44—1000MFD 25 V. DC.	1.20
CF-45—.1MFD 3500 V. DC.	1.98
CF-46—1MFD 3500 V. DC.	3.49
CF-47—6MFD 1500 V. DC.	2.39
CF-48—.05MFD 2500 V. DC. Perfect for Television	1.09
CB-12—.2MFD 2000 V. DC.	2.75
CB-14—.5-.5 9000 V. DC	19.95
CB-18—.25MFD 4000 V. DC.	2.95
CB-35—.5MFD 2000 V. DC.	2.10
CF-34—2MFD 440 V. AC.	.98
CB-16—.1MFD 440 V. AC.	.79
CB-21—.25MFD 20,000 V. DC.	19.95
BATH TUB	
CB-13—.1-.1MFD 600 V. DC.	.45
CB-17—.5MFD 400 V. DC.	.39
CB-19—100MFD 25 V. DC	.59
CB-20—2MFD 400 V. DC.	.59
CB-36—.25MFD 600 V. DC	.39

Mallory Vibrapack 12 v. input, 150 v. @ 85 mils output—Extra Soecial at **$3.75**

75,000 ohm bleeder, 200 watts Ohmite—special **$1.65**
50,000 ohm bleeder, 100 watts, I.R.C. .... **.89**

XTALS

We can supply power xtals of any frequency ground to .02 tolerance in any type of holder for any surplus or standard transmitters or test equipment as well as any receiver IF frequency. Prices on request—write to our engineering department.

Write For Latest Flyer 2SL

NEW, STANDARD BRAND TUBES

TYPE	PRICE
1A3	98c
1A7GT	1.10
1H4G	98c
1L4	1.10
1R4	1.29
1T4	1.10
1H5	99c
1N5GT	1.10
1N21B	35c
1LN5	1.92
1R5	1.10
1S5	1.10
3Q4	1.10
3Q5GT	1.10
1S4	1.10
6AB7/1853	99c
6AC7	99c
6AG5	99c
6AG7	99c
6AK5	99c
6AL5	99c
6AT5	98c
6B4	1.29
6B6G	89c
6B8	99c
6C4	64c
6C5	51c
6C21	12.95
6C6	75c
6D6	75c
6F5	51c
6F6	95c
6F6G	80c
6F7	1.25
6F8	1.10
6G6	1.10
6H6	59c
6H6GT	89c
6J4	1.50
6J5	59c
6J6	89c
6J7	80c
6K6	69c
6K7	79c
6K8	1.25
6L6	1.25
6L6G	1.20
6L7	98c
6N7	1.25
6R7	98c
6SA7	90c
6SC7	85c
6SF5	79c
6SG7	89c
6SH7	65c
6SJ7GT	69c
6SK7	79c
6SL7	89c
6SN7GT	69c
6SQ7	89c
6SR7	89c
6SS7	75c
6Q5	98c
6Q5G	98c
6U5	98c
6V6GT	99c
6Y6G	89c
7AE7	75c
7C4	1.50
7F7	1.25
7L7GT	1.39
12AT6	1.10

TYPE	PRICE
12SA7GT	99c
12SG7	89c
12SH7	89c
12SJ7	79c
12SK7	89c
12SN7GT	79c
12SQ7GT	99c
12KS	1.25
14B6	99c
28D7	75c
30	78c
34	98c
35Z3	99c
35L6	99c
32L7	1.50
35W4	89c
37	69c
38	89c
39/44	59c
41	69c
45	64c
46	65c
47	90c
50B5	1.59
50L6	99c
70L7	1.59
71A	69c
75	69c
713A	1.65
717A	1.25
954	75c
955	75c
956	75c
957	75c
958A	75c
959	75c
1614	1.75
9001	1.15
9002	98c
9003	98c
9004	98c
9005	98c
9006	69c
10Y	1.50
15E	1.50
HF100	6.95
HY69	1.75
HY75	1.25
HY615	1.25
T20	1.95
TZ40	2.95
V70D	6.90
100TS/	3.00
2C26A	75c
2C34	1.15
2C40	2.60
2C44	1.75
2E25	3.95
2E30	2.25
2J32	20.00
2J33	20.00
211	1.25
2J56	20.00
3C24/	1.35
3E29/	2.95
75T	2.95
304TH	9.85
304TL	4.95
307A	6.25
446A	2.60
6C4	64c
703A	7.50
705A	4.95
715B	4.95
723A/B	9.95
800	2.25
801A	1.25
802	1.49
803	8.95

TYPE	PRICE
805	3.75
807	95c
808	2.95
809	1.50
811	1.95
812	3.25
812H	6.90
813	5.95
814	4.49
815	2.25
826	1.75
829B	3.95
830B	5.25
832	2.25
832A	2.25
837	2.50
838	3.75
860	3.00
5514	3.95
7193	49c
8005	3.25
8011	4.95
8012	4.95
8016	1.49
0Z4	1.25
2D21	75c
2X2	84c
3B24	1.95
4C/35	7.95
5R4GY	1.15
5T4	98c
5U4	98c
5W4	98c
5Y3	60c
5Y4G	59c
5Z3	89c
5Z4	89c
6X5	89c
25Z6	98c
35Y4	99c
35Z5	99c
80	75c
82	98c
83	94c
83V	98c
84	90c
217C	7.50
250R	3.95
836	1.15
866A	75c
872A	2.25
884	75c
991	50c
2050	90c
2051	90c
8020	5.95
RK60	1.25
RK72	3.50
VR78	75c
VR90	75c
VR105	75c
VR150	75c
Z225	1.95
874	1.95
1613	95c
1616	7.95
1619	98c
1624	98c
1625	98c
2AP1	2.25
3AP1	3.45
3BP1	2.95
5BP1	3.95
5RP4	5.45
5CP1	3.95
7BP7	7.95
913	3.00
7DP4	14.95
7EP4	18.95

ND MAIL ORDER FOR LESS THAN $5.00

AMPHENOL COAX CONNECTORS

83-1SPN	$0.45
83-1R	.45
UG-12/U	.59
83-1T	1.49
83-1AP	.79
UG-28-U	1.49
83-1F	.99

SELSYN MOTORS
Synchronous Type

Pair in Series for 110 v. AC.
Type I—5¼" long, 3" dia.—50 v. AC. 50 cy.—4 lbs. .... $ 9.95 pr.
Type II—6¼" long, 4¼" dia.—115 v. AC. 50 cy. 11 oz. .... 12.95 pr.
Type III2½" long, 2½" dia.—50 v. AC. 50 cy.—11 oz. .... 6.95 pr.

SYNCHRO—DIFFERENTIAL

Model #1943—C78249-CAL-11280 Bendix Aviation 115 v.—60 cy. 6" length to end of shaft x 4¼" diameter .... $ 9.95

NEW BANTAM BLOWER

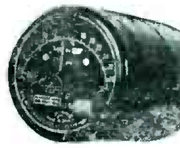
Blower 6 v. AC or DC hi speed blower made by John Oster. Rated at 5000 RPM—1.8 AMP—made for continuous duty—1½" overall diameter—1" blower output—1¼" blower intake **$5.95**

CONTINUITY CHECKER

Neon type—in black metal box 3-⅝" x 5" x 3½" complete with leads & AC Cords...... **$2.50**

300 OHM TWINEX—unaffected by moisture—will handle 3 kilowatts of R.F.—losses at 40 MC per 100 ft., are 3/10 DB. Best buy in the houses, per foot .... **.08**

CRAMER TIMER



Type #7766346P2 adjustable from 1-30 sec. S.P.D.T. with starting relay for remote control motor and contacts separate. **$9.95**

Type #P7766346P4 adjustable from 4-120 sec. S.P.S.T. normally closed motor and contacts separate. **$6.95**

FULL WAVE SELENIUM RECTIFIER

Perfect for bias application — Use your DC relays from an AC source. Only requires 3" x ½" mounting space Rectifier for input up to 300V @ 40 ma output.
$.89 or 5 for $4.00

R. F. INDICATOR PROBE

Z601—has a fixed xtal (VHF) type and a pick up coil. Coax lead, coax connector at end. Probe has 4" bakelite handle. Used with a 0-1 Ma. meter across it. For checking R.F. in lines, neutralizing finals, etc........ **$1.98**

HEINEMANN CIRCUIT BREAKERS

10 Amp, 117.5 V. A.C., Curve 1........ **$1.25**

0.010 amp coil, 2340 V., Rect. D.C. Curve 4.2899, Res. 5000 ohms Max........ **$2.95**

TRANSFORMER SCOOP

TC-5—Western Elec—KS9547—332-0-332 v @ 246 MA, 10 v. C.T. 10 A., 2.5 v. C.T. @ 10 A., 2.000 v. ins., 5.1 v. @ 3 A., 6.4 v. C.T. @ 5 A.—Will supply every voltage for rig except plate of modulators and final........ **$4.25**

TS 5—Western Electric—D303184—Hi. Volt 4200 v. @ 9 MA Lo. Volt. 640 v. @ 200 MA—Fil. 6.4 v. @ 5 A., 5.4 v. @ 3 A., 5.1 v. @ 3 A., 2.5 v. @ 1.75 A., Complete Television Hi. & Lo. Volt. Trans. In one compact oil filled unit—Will handle any television tube... **$12.95**

TS 6—Scope Transformer—2500 v. @ .4 A., 2.5 v. @ 1.75 A., 6.3 v. Z .6 A........ **$9.95**

TCH 2—Scope Transformer 1750 v. @ 4 MA and matching fil., trans 6.3 v. @ .8 A., 2.5 v. @ 1.75 A., 2.5 v. @ 1.25 A........ **$7.95**

HF 16—Filter Choke 10 Hy. @ 150 MA **$1.95**

LC 2—25 MH R.F. Choke........ **$ .59**

METERS

MM 4-0-100MA Model 301 Weston 3½"	$3.95
MM 10-0-1 amp DC-Model 301 Weston 3½"	3.95
MM 14-0-150MA NX 35 Westinghouse 3½"	3.95
MM 19-0-800MA Weston Model 301MA	3.35
MM 33-0-1MA-MD-300 I K-McClintock 3½"	3.95
MR 13-0-8 R.F. amp—425AM-Weston 3½"	4.95
MZ-1-0.130 V. AC-25 to 125 cy.—375M Weston 3½"	3.95
MV 8-0-4 K.V. DC—Roller-Smith 3½"	2.95

RELAYS

KR 5—Leach Type 1357—115 v. AC—DPDT $2.00
KR 6—Struther Dunn—115 v. AC—DPDT $1.65
KR 10—Allied #KS5910—115 v. AC 10 amp contacts TPDT $1.98
KR 11—Allied #KS5910—115 v. AC 4 PDT 10 A. contact $2.59
KR 12—Struther Dunn—115 v. AC—2 relays on one mount. SPDT & SPST 10 A. cont. $3.95
KR 13—Kurman Elect. #X1400 D.C. overload relay with AC reset coil 115 v. AC SPDT $4.95
KR 15—Sperry—Thermo Time Delay ADJ 15-45 Sec. 115 v. AC 60 cy SPDT $3.50
KR 17—Leach—1177BF—115 v. AC Ceramic Insul. TPDT $1.75
KR 21—Wheelock Sig.—115 v. AC—5 Amp. Contacts DPDT—B3 x 4 .... $2.25
KR 22—G.E. # CR2790E105—115 v. AC or 230 AC Heavy Duty DPDT $4.95
KR 24—Adlake Mercury Time Delay Relay—#1040-80 normally opened .3 to 5 sec 115 AC $8.95
KR 25—Struther Dunn—115 v. AC 30 amp. contacts DPST $4.95
KR 26—G.E. Instantaneous over current relay—Type PBC 3 amps @ 115 v. $24.95

Birnbach No. 4175 feed thru insulator...... **.29**

ROTARY SWITCH — 3 deck 9 position non-shortening ceramic wafers. Each..... **$1.25**

R.F. Choke R154 1MH @ H600 MA with mounting bracket **$1.25**

R.F. Choke 3½ MH @ 100 MA on ceramic with threaded mounting hole .... **.18**

All Prices f.o.b. N. Y. C.

NIAGARA RADIO SUPPLY CORP.
160 GREENWICH STREET, NEW YORK 6, N. Y.

CREDIT EXTENDED TO RATED ACCT'S

NOW AVAILABLE FOR IMMEDIATE SHIPMENT!

TELEVISION *Values!*

TELEVISION FOUNDATION KIT

The television foundation kit consists of the most essential (and expensive) parts needed in the construction of a television receiver starting with the high voltage power supply, for the picture tube, right through to the antenna. The kit contains the high voltage picture tube transformer (for five or seven inch tube), 2X2 filament transformer, low voltage transformer for the receiver, cathode ray filament transformer, filter choke, 6.3 filament transformer for the 16 six volt tubes along with the five volt transformer for the 5U4. The two high voltage filter condensers, blocking oscillator, transformer all R.F.'s sound and video I.F.'s, peaking coils, discriminator transformer. Rectifier tubes 2X2 and 5U4, the picture tube 5BP4, an all aluminum Elincor dipole antenna are also included. Of course there is the easy-to-follow 26-page instruction book, with a large 12 by 18 schematic diagram. The instructions include television theory, circuit functions, explain scanning, give preliminary voltage measurements, parts layout and final adjustment of the television receiver which facilitates easy alignment without the use of elaborate test equipment. The only knowledge necessary to build this set is the ability to read a simple schematic diagram. Most radio men will have many or all of the minor parts not included in the foundation kit **$34.75**

Remaining set of necessary tubes.......... $16.95

TRANSVISION TELEVISION KITS

12" Kit—Complete with all tubes—a real honey.......... **$289.50**

7" Kit—Thousands of satisfied users.......... **$159.50**

RAY-LECTRON COIL KIT

INCLUDES:

1 Oscillator Tank Coil, 1 Antenna Coil, 6 RF Tuning Coils, all mounted on Switch Assembly Plate; 5 Video IF Coils, Shielded, Permeability Tuned; 1 Shielded Discriminator Coil; 3 Video Peaking Coils, and Instruction Manual containing Circuit Diagram for 20 Tube Seven Inch Picture Tube Set, together with detailed Assembly Instructions, and Parts list.

The design of these Coils makes it possible to obtain satisfactory operation within the ENTIRE service range of ANY Television Station. Complete.. **$23.50**

NEW TELEVISION COIL KIT 510

Build a 10" or 15" television receiver. • Complete kit of permeability tuned video IF, RF, and Sound Coils for high quality television receiver designs. Contains all necessary coils for 3 stages 4mc. wide video, 2 stages sound, discriminator, peaking, oscillator, and RF. Complete instructions included.

Priced at Only.......... **$9.95**

NIAGARA COMPONENTS

CONDENSERS

CF 45—. mfd—3500 volt DC..........	$ 1.98
CF 48—.05 mfd—2500 volt DC..........	1.09
CB 18—.25 mfd—4000 volt DC..........	2.95
ER25AD—dual 25 mmf per sect. variable condenser	2.04

SOCKETS

11 prong isolant scope socket..........	$ 0.39
Octal socket	.12
Special hi. voltage socket for 2x2..........	.59

TRANSFORMERS

TS.6—Scope transformer—2500 v. @ .4 a., 2.5 v. @ 1.75 a., 6.3 v. @ .6 a..........	$ 9.95
TS.5—Western Electric—D303184—hi. volt 4200 v. @ 9 ma lo. volt. 640 v. @ 200 ma—fil. 6.4 v. @ 5 a., 5.4 v. @ 3 a., 5.1 v. @ 3 a., 2.5 v. @ 1.75 a.—complete television hi. & lo. volt. trans. in one compact oil filled unit—will handle any television tube	12.95
TCH 2—Scope transformer 1750 v. @ 1 ma and matching fil. trans. 6.3 v. @ .8 a., 2.5 v. @ 1.75 a., 2.5 v. @ 1.25 a..........	7.95
HF 16—Filter choke 10 hy @ 150 ma..........	1.95
LC 2—25 ma R.F. choke..........	.59

MISCELLANEOUS

Pots—all sizes less switch..........	$0.69
Pots—all sizes with switch..........	1.09
Trimmers—single 3—30 uuf..........	.20
dual 5—50 uuf..........	.35
13" x 17" x 3" steel chassis cadmium plated	1.95
High voltage wire—50 ft. roll..........	1.00
Peaking coil	.45

Complete Line of Television Components in Stock

Write for Free Listing

5TP4 PROJECTION TUBE

Perfectly operating condition but with very slight imperfection. Ideal for engineers, experimenters, inventors, or school instructors. Regular price of these tubes is $65.00—Special Bargain.....$20.00

REGULATED POWER SUPPLY

Designed by RCA electronically regulated 300 v. output—maximum current 400 mills—½ v. variation between no load and full load output—uses 10 tubes; 5—6Y6G; 2—5U4G; 2—VR150/30; 1—1852—Perfect for Television sweep circuits for field or station use or wherever 300 v. must be maintained under varying load conditions—specially priced $135.00—less tubes.

SOCKETS

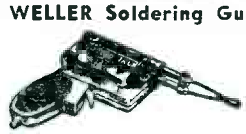
KS- 3—Amphenol—octal type, ceramic, chassis type elastic stop nuts..........	$0.12
KS- 5—Isolantite—5 prong, ceramic, large chassis type	.12
KS- 6—Isolantite—6 prong, ceramic, large chassis type	.12
KS- 7—Johnson—4 prong ux base, bayonet, ceramic 25 watt..........	.75
KS- 8—Hammarlund—S7 — Isolantite, with hardware	.19
KS-14—Chassis type octal, mica filled bakelite, low loss, 1⅛" mounting with retaining ring..........	.09
KS-16—Uhf acorn steatite for 6F4, 955 etc. (metal shield with spring—10 cents extra)	.29
KS-17—Johnson—5 prong socket for RK-28, 803 ceramic, bayonet..........	1.49
KS-20—Johnson—ceramic for 304TH, 304TL.	1.00
KS-21—7 prong for RCA 813, mykroy, 2⅝" square	.69
KS-22—Magnal—14 prong scope socket, mica filled low-loss bakelite..........	1.00
KS-24—Ucinite 829, 832 socket, recessed aluminum case for sub chassis mounting. Socket has built in by-pass condensers for 6 volt tubes	1.75
KS-25—Johnson—7 prong for 829, 832 tubes, ceramic	.29
KS-27—Mykroy socket for VT127/100TS....	1.25
KS-28—7 prong miniature with shield......	.39

OTHER TYPES IN STOCK—PRICES ON REQUEST

BAT HANDLE SWITCH

Mfgd. by Cutler-Hammer—10 amp. SPDT with neutral position—Perfect for rotary beam control—a positive steal at.......... **29c**

WELLER Soldering Gun



A must in the kit of every man who makes soldered electrical connections. Heats in five seconds; see where you work; gets into tight corners. Operating on the same principle as the resistance welder. 100 watts, 115 volts, 60 cycles AC.

—Your COST **$12.95**

Tip Fastening Stud..........	.10
Copper Tip	.05

ANTENNA LEAD IN BOWLS

Made of genuine Pyrex—3" in diameter; brass rod 5½" long—complet with hardware and waterproof rubber gaskets

Special—$1.49

WESTINGHOUSE MN OVERCURRENT RELAY

Adjustable to .4 amp. Has automatic 110 v. AC reset—glass encased—perfect for any overload application where tube damage must be avoided

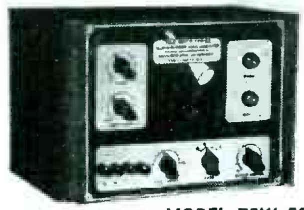
A Steal—$12.95

VACUUM CONDENSER VC50

Capacity 55 mmfd—test voltage 20,000 v. peak.

WHILE THEY LAST $4.95

TELEVISION SWEEP GENERATOR



MODEL TSW 50

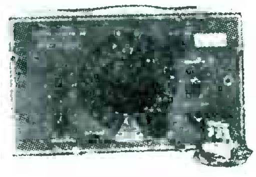
The TELE-SWEEP is designed specifically for use in visual alignment of FM and television receivers and broad band amplifiers. It generates a broad frequency modulated test signal which, when used in conjunction with any standard oscilloscope provides this means for visually aligning the complex circuits encountered in FM television work.

SPECIFICATIONS

* Tubes: 6C4 — Osc #1, 6C4 — Osc #2, 6AG5 — MIXER 6AG5—Cathode Follower, 5Y3—Rectifier
* Mean Frequency Range: 5 — 100 mc. 170 — 216 mc. (covers television and FM IF and Broadcast Frequencies)
* Sweep Width: Variable from 500 KC — 10 mc
* Maximum Output: 1 volt
* Output Impedance: 100, 10 ohms
* RF Probe for Point to Point check
* Electro-mechanical sweep mechanism
* Terminated coaxial output cable

Furnished complete with tubes, probe and output cable and instruction booklet

McMURDO SILVER AM-FM 906 SIGNAL GENERATOR

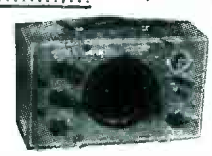


Available Now

What an instrument: 90 kc through 170 mc. on foundamentals . . . 8 airtrimmed bands . . . variable % 400—amplitude modulation . . . built-in variable electronic FM sweep . . . laboratory triply adjustable attenuator . . . metered microvolts . . . output ½ microvolt to over 1 volt . . . multiply shielded . . . strays lower than $500.00 laboratory generators! Yet all this costs you only **$99.50**

Model 904 Capacitance Resistance Bridge

Net Price $49.90



¼ mmfd./ohm thru 1,000 mfd/megohm: 0-50% power factor: 0-500 volt adjustable internal polarizing voltage: 0-10 and 0-100 ma. electron-ray leakage current meter: measures resistance, capacitance under actual operating voltages!

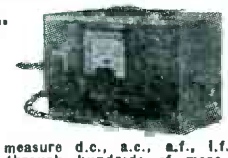
Model 905 COBINATION "SPARX" DYNAMIC SIGNAL TRACER

Net Price $39.90

Frequency range from 20 cycles to over 200 megacycles. Contains isolating capacitor, resistor and one of the new radar U.H.F. crystal diodes. Loads a circuit being tested with only 3 mmfd. and higher than .5 megohm.

Model "Vomax" Vacuum Tube Voltmeter

Net $59.85



51 ranges directly measure d.c., a.c., a.f., i.f. and r.f. volts up through hundreds of megacycles, six resistance ranges six direct current ranges measuring from 50 microamperes through 12 ampheres. Voltage ranges measure from .1 through 3000 volts d.c., .1 through 1200 volts a.c.

All Prices f.o.b. N. Y. C.

NIAGARA RADIO SUPPLY CORP.

160 GREENWICH STREET, NEW YORK 6, N. Y.

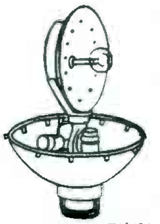
CREDIT EXTENDED TO RATED ACCT'S

THE FINEST QUALITY "Communications" AT LOWEST PRICES

MICROWAVE TUBES

3J31 (1cm) $17.50
Magnet for 3J31 .... 8.00
2J32 (10cm) 25.00
Magnet for 2J32 .... 10.00
2J38 (10cm with Magnet) 37.50
WE700A (L band) 45.00
WE720BY (S band 1000 KW) 25.00
2K25-723AB Klystron 7.75
QK 59, QK 60, QK 62 Tunable packaged Magnetrons (10 cm) .... ea. 45.00
Small Quantities of Other Types Write For Information

MICROWAVE ANTENNAS



Relay System Parabolic reflectors apprx. range: 2000 to 6000Mc. Dimensions 4.-5'x3 New $85.00
Dipole for above $5.00
TDY "Jam" Radar rotating antenna, 10cm, 30 deg. beam, 115V AC drive. New $100.00
SO Surface Search Radar rotating antenna, 10cm. 24" dish, complete with drive and selsyn motors.
New $90.00
Used $45.00
3 CM. ANTENNA WITH DISH 14½". Cutler Feed horizontal and vertical scan with 28 V DC drive motor and drive mechanism. Complete. New $65.00

MICROWAVE PLUMBING

10 CENTIMETER

Sand Load (Dummy Antenna) wave guide section with cooling fins, app 23" high ... $28.00
Rigid Coax Directional Coupler CU-90/UP 20 DB drop, has short right angle, about 8" 5.50
Coax Rotary Joint with mounting plate 8.00
Dipole Antenna in Lucite Ball for use w/Parabola 5.00
Flexible Coaxial Connector, rigid coax to rigid coax ⅞" diam 2.50
10 CM Dipole and Reflector with Type "N" Fitting 2.75
Waveguide to flexible coax coupler (RG 18 U), with flange. Gold plated. App 10" high 17.50
Rigid coax slotted section CU-60/Ap 5.00
Stub-supported rigid coax, gold plated. 5' lengths. Per 5' length 5.00

3 CENTIMETER

Wave Guide Sections 2.5' long, silver plated with choke flange 5.75
Wave Guide 90 deg. bend E Plane 18" long. 4.00
Wave Guide 90 deg. bend E plane with 20DB directional coupler 4.75
Wave Guide 18" long "S" curve 2.00
Rotary wave guide in/out choke to choke joint 6.00
Rotary Coupler choke input: round guide output 5.25
S-Curve Wave Guide 8" long cover to choke. 2.50
Wave Guide 2.5' long, silver plate, 180 deg. bend choke to cover 5.95
Duplexer Section using 1B24 .... 10.00
Wave Guide 5' length per foot 1.50
Pick-up loop with adjustable tuning section, used in duplexer 1.50
3 CM Wavemeter Maquire 1539TFX 15.00
3 cm. stabilizer cavity, tunable transmission type. Model 1551 (TFX 11 GA) 20.00

1.25 CENTIMETER

Wave Guide Section 1" cover to cover 2.00
T Section choke to cover 4.50
Mitred Elbow cover to cover 3.00
Mitred Elbow and "S" sections choke to cover 3.50
Flexible Section 1" long choke to choke 3.00
Tunable Cavity with Coax input and output 6.00

CONNECTORS

UG 21/U, Type "N", Male .... .85
UG 86/U, Gold Plated .... .95

RADAR SETS

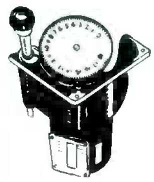
S09-10CM. SURFACE SEARCH 4, 20 and 80 mile ranges Raytheon, 250 KW peak power input to 2J27 magnetron. Complete set including: spare parts, tubes, wave guides and fittings.

SO13-IDENTICAL TO S09. Complete set, used. Consists of: transmitter and receiver, PPI scope modulator, motor alternator, rectifier, power unit and new rotating antenna.

SN RADAR-GE, low power, 5 and 25 mile ranges. Uses GL464 as pulsed oscillator, 5" "A" scope. "S" band. Extremely compact, ideal for demonstration and laboratory work. 115V 60C operation.

SEND FOR INFORMATION

MICROWAVE TEST EQUIPMENT



Wave guide experimental kit. Consists of: One direct-reading wavemeter, app 2600-3400 mc. (cavity type); One dummy load w/crystal probe. One line stretcher, full wave; two wave guide to RG 18/U coax couplers; two 1' sections w/flanges. Complete $250.00

10 CM ECHO BOX, complete with micrometer adjust cavity & resonance indicator. Type TS 238/GP. With calibration chart $105.00

10 CM WAVEMETER. Model "SL". Micrometer adjust cavity with micro-ammeter resonance indicator. Includes 115 VAC operation converter section. In grey metal carrying case, complete with cables & spares. Made by Western Electric $135.00

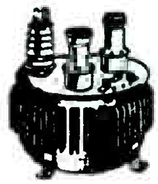
W.E. I138 A. Signal generator, 2700-2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram $50.00

MOTOR-GEN. PU 43/A

Input: 24-28 VDC @ 62 A. Output: 115 VAC, 7 A., 800 C.P.S. $15.00

PULSE TRANSFORMERS

All Standard name Items



Type G.E. K2450A Will receive 13KV. 4 microsecond pulse on pri., secondary delivers 14 KV Peak power out 100KW **$15.00.**

Hi Volt. Magnetron Input transformer W.E. #D-166173 with cooling fins **$12.00**

UX 4298E Raytheon Pri. 4 KV, 1 microsecond Sec. 16 KV 16 Amps. Fil. pri. 115V 400 Cycle .. $15.00

Hi Volt input pulse Transformer W.E. #D169271 $9.95

Radar pulse Tformer G.E. K2731 Diameter App. 11" vertical cooling fins $19.50

Pulse Input, line to magnetron G.E. K2748A . $12.00

Utah Pulse or Blocking Oscillator Transformer Freq limits 790-810 cy-3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1⅛ x 19/32 ... .75

10 Cm. RF Package. Consists of: SO Xmtr.—receiver using 2J27 magnetron oscillator, 250 KW peak input. 707-B receiver-mixer $150.00

Modulator-motor-alternator unit for above .. $75.00
Receiver rectifier power unit for above $25.00

Rotating antenna using dipole feed and parabolic reflector. New, Less Hood $75.00

Used $45.00

RT39APG15 Transmitter-receiver. Lighthouse tube oscillator, .5 KW. App. 2700 Mc. operation. With lighthouse and TR tubes $100.00

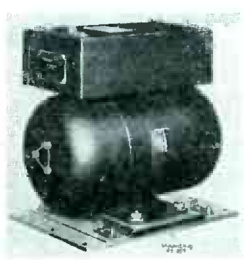
COAX CABLE

RG9U 51 ohm Silver Coated .... ft. $ .07½
RG8U 52 ohm .... ft. .04½
COAX Connectors Amphenol Loss type 831R, 831AP, ... ea. .27
831F .... ea. .45

THERMISTORS

D67332 bead .... $ .95
D170396 bead .... .95
D163392 Button .... .95

DYNA-MOTORS



PE 73 CM. Power supply for BC 375. Input: 28 VDC. Output: 1000 VDC @ 350 Ma. Starting relay, filter, etc. $4.95
Mfrs: Write for quantity, prices & discounts on above item.
BD 77KM. Power supply for BC 191. Input: 14 VDC. Output 1000 VDC @ 350 Ma. New. with spare fuse links, etc. $5.95
PE 101C, Input: 13/26 VDC @ 12.6/6.3 A. Output: 400 VDC @ 135 Ma., 800 VDC @ 20 Ma. (9VAC @ 1.12 A.) $3.49
PE 86 N. Input: 28 VDC, Output: 250 VDC @ 60 Ma. Westinghouse w/Filter $1.95
Without Filter $1.60
PC 77, Input: 12 VDC, Output 275 VDC @ 110 Ma. 500 VDC @ 50 Ma. $3.25
DAG 33 A; Input: 18 VDC @ 3.2 A, Output: 450 VDC @ 60 Ma. $2.45
DM 33 A. Input: 28 VDC @ 7 A. Output: 540 VDC @ 250 MA. Power supply for modulator for SCR 274 N. $3.95
Dyn. Model 23350. Input 27 VDC @ 1.75 A. Output: 285 VDC @ 75 Ma. $1.75
DM-21: In 14DVC 3.3A Out 235VDC 90 ma with filter $2.59
DM-25: In 12VDC 2.3A Out 250VDC 50 ma. $2.49
DM-34: In 14VDC 2.8A Out 220VDC 80 ma... $2.49
DM-42 In 14VDC. Out 515/1030 VDC 215/260 ma & 2/8VDC $3.95
BD-77 input 14VDC, output 1000V 350ma DC $5.95
Motor-Gen PU43/A Input: 24-28 VDC, @ 62 A. Output: 115 VAC @ 7 A., 800 Cycles/sec. $15.00

POWER EQUIPMENT

TRANSFORMERS

Filament Trans Pri 220v50/60cy Sec. 5v 10 A 34000 volt insulation $26.50
Filament Trans 29000v test Pri 115 60cy Sec two 5v@5A Raytheon $24.50
2 KVA Trans and Choke 115v 50/60 cy 1 ph Output 17000 v @ 144 ma $74.50
2.5 KVA Amertran rectifier-Input 208 v 3 ph 50/60 cy Out 0-25000 v @ .1 A 10% Reg 2.5% Ripple

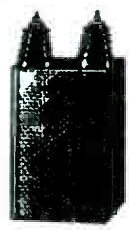
REACTORS

GE 0.116 **HY** @ 15A Res 5.5 ohms $7.50
Raytheon 0.1 **Hy** @ 1.4 A Test 1780v 1.50
6 Hy 0.15 A **Herm** sealed 2.00
6 Hy @ 300 Ma 4.50
1 Hy @ 800 Ma—7.5 ohms resistance 8.95

REGULATORS

LINE VOLTAGE REG 2 KW Saturable reactor type Pri 95-130 v 60 cy Sec 115 v 60 cy. 17.4 A 2 Kw 100% PF $160.00
LINE VOLTAGE/REG Pri 92-138v 57/63 cy 1ph 15A Sec 115v 7.15A .32 Kv 96% PF $135.00
Self-Contained Unit in Grey Cabinet.

OIL CONDENSERS



.25 mf @ 20000 VDC Aerovox $17.50
1.5 mf @ 6000 VDC Aerovox $12.50
10 mf @ 25KV $75.00
.01 mf @ 25 KV $20.00

MICA

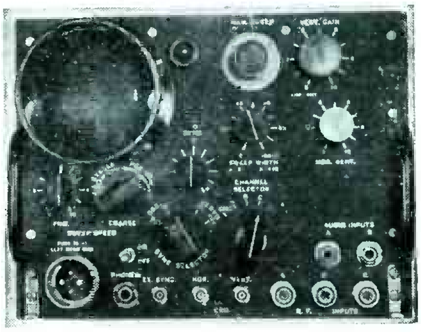
.08 mf @ 1500 VDC, Sprague MX60 .... $11.50
.03 mf @ 2000 VDC, CD 551A-50 .... $12.75
.045 mf @ 2000 VDC, Sangamo, G1 .... $12.75
.00015 mf @ 20 KV, Aerovox 1970-404 .... $25.00
.0001 mf @ 20KV, Sangamo G3 .... $25.00
.0051 mf @ 15KV, Sangamo G4 .... $25.00
.006 mf @ 10 KV, Sangamo G3 .... $17.50
.002 mf @ 15 KV, Sangamo $20.00
Isolating Capacitor, Cornell-Dubelier PL 1417. 106-110 mmf @ 10KV AC (peak) Each.... $3.50
MFRS: Send your requirements for bathtubs, Micas, Hardware, resistors, & connectors.

Mail orders promptly filled. All prices: F. O. B. New York City
Send Money Order or Check. Rated firms send P. O. Shipping charges only sent C. O. D.
Send for our latest microwave flyer, also our complete parts catalog.

COMMUNICATIONS EQUIPMENT CO.
131 E. LIBERTY STREET NEW YORK CITY 7, N. Y.
Telephone DIGBY-9-4124

PAN-OSCILLO-RECEIVER

Ideal for laboratory, television and general service work



Model AN/APA 10

Performs work of four units

1. **PANORAMIC ADAPTOR:** For use with any receiver with I.F. frequency of 405-505 kcs., 4.75 to 5.75 mcs., and 29-31 mcs.
2. **OSCILLOSCOPE:** Visually checks received signals, monitors transmitter output — percentage modulation, carrier wave-shape, etc.
3. **SYNCHROSCOPE:** External inputs provide synchroscope action.
4. **RECEIVER:** Three inputs provide facilities for use with convertors to cover wide range of frequencies to 10,000 mcs.

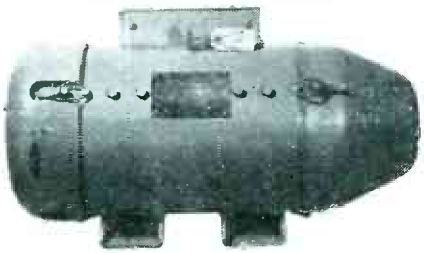
FEATURES:
* 3" scope tube
* 21 tubes
* Aircraft type construction
* Variable sweep 35-40,000 cy
* Weight 40 lbs.
* Transformer built in for 110 V. 60 cycle operation.
* 2 I.F. stages—double conversion.
* 2 Video stages in push pull to vertical plates.
* Pentode output audio monitor.
* Multi-Vibrator horizontal sweep (radar type).
* Horizontal sweep amplifiers P. P. to horizontal plates.

Surplus equipment tested and guaranteed in perfect operating condition. We have sold hundred of these units during the past year to leading schools, laboratories, amateur operators all over the world.

Price $97.50

(Mail $1.00 for 80 page Technical manual and instruction book)

MOTOR GENERATORS



Brand new. Built by Allis Chalmers to rigid specifications of the U. S. Navy.

K.V.A. output 1.250	R.P.M. 3600
K.W. output 1.	Cont. Duty Ph. Single
P.F. .80	Cycles 60
Volts input 115 D.C.	Volts output 120 A.C.
Amps input 14	Amps output 10.4

Length 26"; width 12-7/8"; height 13". Compound accumulative A.C. and D.C. fields. Centrifugal starter. Splashproof covered. Frequency adjustable to load, plus or minus five cycles.

Price $87.50

Identical Machine, but 230 volts D. C. input, $125.00

Set of Replacement Spare Parts for Either Machine $29.50

SYNCHROS: (Selsyns—Autosyns, Etc.)

G.E. Selsyn Control Transformers model 2J5FBI. 115-55V. 60 cy. Bendix Cal-18300, 115 V. 60 cy.

Bendix repeaters, type X, CAL-5328A-1, 115 V. 60 cy.

Bendix repeaters, type II-2, C-69406-1, 115 V. 60 cy.

Bendix transmitters, type I-1, C-69405-2

G.E. differential generators, type 2J5S1, 115 V. 60 cy.

Electrolux synchro repeaters, type XXI, C78863, 115 V. 60 cy.

Bendix, Mod. 4, type 5SF synchro motors, 115 V. 400 cy.

Bendix synchro repeaters type X Cal-5328A-1, 115 V. 60 cy.

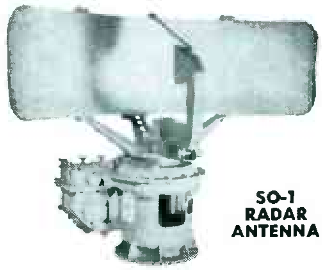
Diehl synchro transmitters, type 1V C-78414, 115 V. 60 cy.

Esco synchro repeaters C-56776-1, 110 V. 60 cy.

Ford Inst. Type 5 SDG, 400 cy. differential.

Many other types and sizes of synchros in stock.

RADAR EQUIPMENT



SO-1 RADAR ANTENNA

SO-1 Antenna Assembly Comprises:
* A drive mechanism including a drive motor and gear train.
* A synchro 400 cycle generator with gear train and mechanical differential.
* A rotating radiator system including a right angle radiator nozzle, a reflector in the form of a paraboloidal section, R.F. fittings for coupling the rotating system to a stationary waveguide.
* A supporting pedestal and base plate.

Brand new packed in export cases.

Price $90.00

These antenna assemblies have many uses as replacements on vessels now using SO-1 equipment, experimental radar and microwave work, amateur beam rotators, etc.

SO-8 Antenna assemblies also available, brand new and export packed.

Price $120.00

S.G. Radar complete sets of yard spares.
S.O. 3 Radar complete sets of tender spares.

S.Q. complete portable units manufactured by General Electric Co. Brand new and ready to operate on 90-130 volts, 60 cycles, 320 watts. Choice of A, B, or P.P.I. presentation. 300 yards minimum range; max. 3, 15, 45 miles. 10 cm. Ideal for schools, laboratories, small boats, etc.

RADAR CRYSTALS—98.35 kc

TRANSMITTING EQUIPMENT

BC-325 types B & C. Freq. range 1.5 to 18 mcs. Output 400 watts C. W. or 50 watts phone. 110 V. 60 cy., used but in excellent operating condition.

Components for T-4/FRC and T-5/FRC transmitters as follows:

MD1/FRC Modulator Units
SA-2/FRC Switch Panels
O-2/FRC Oscillator Units
AM-2/FRC Amplifiers

All prices quoted are F.O.B. Tuckahoe, N. Y. (About 20 miles north of New York City). All merchandise guaranteed. Immediate delivery subject to prior sale.

LABORATORY EQUIPMENT

Model TS-487/U

Peak to Peak V. T. Voltmeter

Designed by Radiation Lab M.I.T. and built by McGuire Industries for the Navy. Range 3-10-50-volts, complete in grey metal cabinet with coax input cable, A.C. cable, spare fuses and pilot lights.

Measurements Corp. Model 84 standard signal generators, 300-1000 mcs.

Ferris Crystal Calibrator, Model 34A.

Hewlett Packard Interpolation Oscillator, Model 6225B.

Weston #1 Precision 0-150, 0-1500 milliammeters in leather cases.

G. E. Model LU Radar test set.

General Radio 700A wide range B.F.O.

General Radio 561 V.T. Bridge with adapters.

General Radio 539A Variable Condenser.

Hewlett Packard 505B Tachometer.

Hewlett Packard 506 Tachometer optical head assembly.

Ferris 20A Microvolter.

Ferris 20A-1 Microvolter.

Shallcross 621H Limit Bridges.

Daven OP-961 Power output meters.

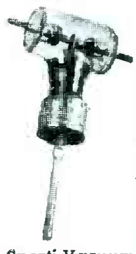
(All Lab. equipment priced from 25 to 50% off manufacturers prices.)

RELAYS & SWITCHES

W. E. D-168479

Western Electric D-168479 mercury-contact, enclosed in sealed metal tube base.

A high speed switching relay for use where large amounts of current are used, and in servo mechanical systems. Will operate at 100 times per second and is also employed in vibrator power supplies for square wave generators.



Sperti Vacuum Switch

This switch has many applications such as switching or interrupting high voltages, antenna circuit switching at high altitudes, power supply switching for high-voltage vacuum tubes and high-speed keying operations at any voltage up to 10,000, or current up to 5 amperes, frequency up to 30Mc., or any power factor.

LEACH, types 1355, 1154-A, 455C.

STRUTHERS DUNN, types IBXX129, IBXX-107, 1XBX105

WESTERN ELECTRIC, type D124001

ELECTRONICRAFT, INC.

5 WAVERLY PLACE — ***Telephone: Tuckahoe 3-0044*** — **TUCKAHOE 7, NEW YORK**

R·H·S SPECIALS OF THE MONTH

BLEEDER RESISTOR

50,000 ohm 100 watt........... **89c**

VERNIER TUNING GEAR BOX

18:1 and 36:1 Ratio. Ideal for osc. tuning section of SCR-522.................. **$2.49**

SELENIUM RECTIFIERS
Full Wave Bridge Type

INPUT	OUTPUT	
up to 18v A.C.	up to 12v D.C 1 Amp.	$1.95
up to 18v A.C.	up to 12v D.C 5 Amp.	4.45
up to 18v A.C.	up to 12v D.C 10 Amp.	7.45
up to 18v A.C.	up to 12v D.C 15 Amp.	9.95
up to 18v A.C.	up to 12v D.C 30 Amp.	14.95
up to 36v A.C.	up to 28v D.C 1 Amp.	3.45
up to 36v A.C.	up to 28v D.C 5 Amp.	7.45
up to 36v A.C.	up to 28v D.C 10 Amp.	12.45
up to 36v A.C.	up to 28v D.C 15 Amp.	18.95
up to 115v A.C.	up to 100v D.C .25 Amp.	2.95
up to 115v A.C.	up to 100v D.C .6 Amp.	6.05
up to 115v A.C.	up to 100v D.C 5 Amp.	19.95

HALF WAVE TYPE

up to 196v A.C.	up to 150v D.C .075 Amp.	1.95
up to 395v A.C.	up to 350v D.C .075 Amp.	2.95
up to 396v A.C.	up to 330v D.C .110 Amp.	3.95

OIL CONDENSERS:
G.E., AEROVOX, CD., ETC.

ALL RATINGS, D.C.

1mfd.	600v..	$0.35	2mfd.	2000v..	$1.75
2mfd.	600v..	.35	3mfd.	2000v..	2.75
4mfd.	600v..	.60	4mfd.	2000v..	3.75
8mfd.	600v..	1.10	15mfd.	2000v..	4.95
10mfd.	600v..	1.15	.1mfd.	2500v..	1.25
1mfd.	1000v..	.60	.25mfd.	2500v..	1.45
2mfd.	1000v..	.70	.5mfd.	2500v..	1.75
4mfd.	1000v..	.95	.05mfd.	3000v..	1.95
8mfd.	1000v..	1.95	.1mfd.	3000v..	2.25
10mfd.	1000v..	2.10	.25mfd.	3000v..	2.65
15mfd.	1000v..	2.25	.5mfd.	3000v..	2.85
20mfd.	1000v..	2.95	1mfd.	3000v..	3.50
24mfd.	1500v..	6.95	12mfd.	3000v..	6.95
.25mfd.	2000v..	1.05	2mfd.	4000v..	5.95
.5mfd.	2000v..	1.15	1mfd.	5000v..	4.95
1mfd.	2000v..	.95	.1mfd.	7000v..	2.95

SPECIAL 2 mfd. 3000v $4.45

HIGH CAPACITY CONDENSERS

4000 mfd.—18WVDC........................	$1.95
4000 mfd.—30WVDC........................	2.95
1000 mfd.—15WVDC........................	.99
2000 mfd.—50WVDC........................	1.95

ART/13 MODULATION KIT

Consists of driver, speech amplifier, sidetone amplifier assembly and modulation transformer. With complete diagram for the famous ART/13 transmitter.
SUPER BUY at........................$8.95

PORTABLE FM TRANSMITTER
(Sonobuoy)

Operates on standard 67½v Minimax and 1½v Flashlight cells. Frequency 72 mc (easily doubled to 144 mc). Complete with 5 tubes and diagram. (Less batteries)
EXCEPTIONAL BUY at............... **$12.95**

GIBSON GIRL TRANSMITTER
(SCR-578B)

Emergency life transmitter. 100% complete. Includes balloon, hydrogen generator, kite, signal lamp, antenna and instruction manual. Self-powered merely by turning crank. Automatically transmits S.O.S. on 500 cycles.
FULLY GUARANTEED **$29.95**

DYNAMOTORS

Ideal for Mobile
Input: 6 or 12 volts
Output: 500VDC at 160 ma Volt. Regulated & Filtered. PE-103 (slightly used)...$5.95
Input: 24-28 volts
Output: 150 VDC at 10 ma: 14.5 VDC at 5 amps. Voltage Regulated and Filtered. DA-3A (slightly used) $4.95

RCA-158 OSCILLOSCOPE

Brand New—110v 60 cyc. 5 inch tube. Complete ready to operate. Regular price much higher.
Limited Quantity $99.50

TUBES (*Brand New*)
Army-Navy Inspected

1B24	$ 4.95	311	$ 1.98
2AP1	2.25	371B	5.95
2C40	1.19	450TH	39.95
2D21	.89	703A	7.95
2V3G	1.25	705A	3.95
2X2	.84	715B	29.50
3AP1	3.00	721A	4.35
3BP1	2.95	726/AC	7.50
3E29	2.95	801	1.49
5BP1	3.95	802	1.98
5BP4	4.95	803	8.95
5CP1	3.95	804	9.95
5JP1	11.95	805	4.95
5LP1	8.95	806	14.95
5R4GY	.98	807	.95
5Y3	.41	808	2.95
6AB7	.99	809	1.50
6AC7	.99	810	5.95
6AG5	.99	811	1.95
6AG7	.99	812	3.15
6AJ5	.99	812H	6.90
6AK5	.90	813	8.95
6AL5	.99	814	4.45
6AR6	1.29	815	3.95
6B4G	1.29	826	2.25
6C4	.69	829-A-B	3.00
6C5	.49	832	2.25
6F6	.89	833A	39.50
6F6G	.59	834	2.95
6J4	1.50	835	2.95
6J5	.55	836	1.75
6J6	.89	837	2.50
6L6	1.23	838	3.95
6L7	.98	841	1.20
6N7	1.02	861	69.50
6SH7	.59	866	.75
6SL7	.89	872A	2.50
6SN7	.69	884	.98
6SR7	.89	885	.98
7A4	.81	902	2.25
7F7	1.25	913	3.00
7L7	1.59	954	.75
9JP1	3.95	955	.75
10Y	.98	956	.75
12X3	1.50	957	.75
15E	1.50	958	.75
HK24Ct.	1.75	959	.75
28D7	.98	1005	.69
30	.75	1616	2.95
35T/TG	3.50	1619	.75
VR90	.75	1624	.90
VR105	.75	1625	.75
VR150	.75	1626	.75
100TH	7.95	8001	6.49
100TS	3.00	8003	9.95
211	1.25	8005	4.95
75T	2.95	8011	1.95
250TH	14.95	8016	1.65
257B	6.49	8025A	4.95
304TH	9.95	1654	1.98

SCR-522 100-156 MC.
RECEIVER AND TRANSMITTER
Licensed for Railway and Taxicab Use

The ideal all-purpose transmitter-receiver for work in the 100-156 mc. spectrum. Four channel pushbutton operation, crystal-controlled, AM, phone, mobile or fixed station service. Ideal for amateur, aircraft, marine, railroad, taxicabs, police and experimental. Amplitude modulated—High transmitter output. Receiver has 10 tubes and transmitter has 7 tubes including two 832's. 60 cycle operation. Complete conversion instructions and schematic furnished with each unit. Tube complement 2—832; 3—12A6; 1—6G6; 2—6557; 1—12J5GT; 1—12C8; 1—9002; 3—9003; 1—12AH7GT and 3—12SG7.
Complete with tubes **$14.95**

BC-375-E TRANSMITTER

Operates from 200KC—12.5 mc. Complete with all tubes, dynamotor, 6 tuning and one antenna tuning unit.
LIKE NEW $39.50

TRANSFORMERS—115 v. 60 cyc.
HI-VOLTAGE INSULATION

1600v at 4ma; 700v at 150ma; 6.3v at 8A.	$8.50
3710v at 4ma; 2 X 2.5v at 3A.	9.95
2500v at 10ma..............................	6.50
2150v at 15ma..............................	6.50
1750v at 4ma; 6.3v at 3A..................	7.95
1540v at 4ma; 340-0340 at 240ma......	7.50
550-0-550v at 150ma; 5v at 3A; 2 X 6.3 5A	7.95
500-0-500v at 100ma; 5v ct at 3A......	4.95
442-0-442v at 1000ma	9.95
425-0-425v at 150 ma; 6.3v at 7.5A; 6.3v at 3A; 5v at 3A	5.95
400-0-400v at 200 ma; 5v at 3A........	4.95
350-0-350v at 150ma; 6.3v at 6A; 5v at 3A; 78v at 1A	4.95
350-0-350v at 35ma-XLNT for VOLT-DOUBLER	1.49
300-0-300v at 65ma; 2X 5v at 2A; 6.3v at 2½A; 6.3v at 1A....................	3.49
325-0-325v at 120ma; 10v at 5A; 6.3v at 7A	3.49
350-0-350v at 85ma; 2X 5v at 2A; 6.3v at .6A; 6.3v at 3.75A..................	7.50
250-0-250v at 100ma; 2X 6.3 at 4A; 6.3 at 5A; 6.3v at 1A	4.95
2.5v at 2A; 5v at 3A......................	2.95
2.5v at 10A	3.25
5v at 115A	9.95
5v at 190A	17.50
6.3v at 6.6A	3.25
6.3v at 3.1A................................	1.95
6.3v at 21.5A; 6.3v at 2A; 2.5v at 2A....	6.95
1600 V @ 2 Ma; 2.5 V @ 1.75A; 6.3 @ .6A	9.95

FILTER CHOKES
HI-VOLTAGE INSULATION

4 Hy at 250ma..	$1.98	12 Hy at 300ma..	$3.95
10 Hy at 250ma..	2.49	15 Hy at 100ma..	2.95
10 Hy at 400ma..	4.95	15 Hy at 125ma..	3.25
12 Hy at 100ma..	2.95	30 Hy at 70ma..	1.95
4 Hy at 600ma..	5.95	.1 Hy at 5 Amps	6.95
10 Hy at 200ma..	1.98	15 Hy at 75ma..	1.49
200 Hy at 12ma..	1.39	10/20 Hy at 85ma.	1.95

BLOWER

Hi-air blast, designed for transmitting tube service. Motor operates on 100-125v 60 cycle at 7000 RPM. Noise free with self contained chokes and filters. Enclosed in satin finish, aluminum cabinet. Measures 4" high x 2¾x3¼". Many uses.
Super buy at **$5.95**

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RADIO HAM SHACK Inc.
63 DEY STREET • NEW YORK 7, N. Y.

SPECIALIZED ELECTRONIC MATERIAL

IMMEDIATE SHIPMENT— HIGH QUALITY—LOW PRICE

TUBES

Type	Price
50	$ .95
VR90	.55
VR105	.55
6Y6	.55
807	.95
836	.75
866A	.95
3D6/1299	.75
28D7	.75
3A4	.35
3Q4	.45
1L4	.40
6SL7	.55
12SL7	.65
12SN7	.45
3B2H	.95
ELC5B	.95
RK72	1.65
RK73	1.95
724A/B	1.95
724B	1.25
1R4/1294	.65
7F7	.65
7F8	.65
7N7	.65
12SF5	.45
12A6	.35
1626	.45
1629	.45
1631	.45
1632	.35
1633	.45
1644	.85
3FP	1.95
5FP7	2.95
7193	.45

CONDENSERS

Oil filled in rectangular metal case

15 mfd. 100 volts sprague suitable for 300 W. V.	Price	.45
4 mfd.	600 W. V.	.60
2 mfd.	600 W. V.	.35
1 mfd.	600 W. V.	.25
1 mfd.	400 W. V.	.20
1 mfd.	200 W. V.	.15
1 mfd.	1000 W. V.	.35
210-260 mfd.	125 VAC (13/4" dia. 4")	.95
400-450 mfd.	110 VAC 2" dia. x 4½"	1.65
90 mfd.	45 VAC 2" dia. x 3½"	.35

CAPACITORS

Paper tubular dual	015 at 1500 V	Price 8.50/C
Paper tubular dual	02 at 1600	.10 ea
Paper tubular dual	0002 at 600	25.00/M
Paper tubular dual	004 at 400	27.50/M
Paper tubular dual	007 at 400	29.50/M
Paper tubular dual	008 at 400	29.50/M

WIRE WOUND RESISTORS

5% Ward Leonard IRC, Etc.

Ohmage	Wattage	Price
1	4	.06
60	4	.06
200	4	.06

WIRE WOUND RESISTORS

(Cont.)

Ohmage	Wattage		Price
1500	4		.06
8000	4		.06
12	5		.06
15	5		.06
40	5		.06
1000 Tapped at 100	5		.10
3500	5		.06
4000	5		.06
6000	5		.06
23000	5		.06
75000	5		.06
2.2 meg.	5		.06
10	7		.08
180	7		.08
100	7		.08
500	7		.08
20	8		.08
25	8		.08
31	8		.08
40	8		.08
56	8		.08
400	8		.08
1000	8		.08
1200	8		.08
2000	8		.08
3000	8		.08
1	10		.10
3	10		.10
3.25	10		.10
10	10		.10
12	10		.10
18	10		.10
50	10		.10
55	10		.10
70	10		.10
88	10		.10
250	10		.10
300	10		.10
310	10		.10
440	10		.10
750	10		.10
800	10		.10
1000	10		.10
1600	10		.10
2000	10		.10
11000	20		.15
11500	20		.15
12000	20		.15
15000	20		.15
20000	20		.15
25000	20		.15
40000	20		.15
50000	20		.15
10 meg.	20		.15
5	25		.15
7.5	25		.15
18	25		.15
30	25		.15
75	25		.15
3000	25		.15
5000	25		.15
11000	25		.15
20000	25		.15
50000	25		.15
20	30		.18
22	30		.18
31	30		.18
86 tapped at 1.5, 50	30		.20
145 C. T.	30		.20
11	100		.35
15	100		.35
1000	100		.35
2000	100		.35
5000	100		.35
8700 tapped at 2500, 5000	100		.35
10000	100		.35
32.5 tapped at 3, 6, 9	200		.50
105 tapped at 35	200		.50
320	200		.45
3150	200		.45
4000	200		.45
.1	25	Adjustable	.25
5	10	"	.20
10	25	"	.25
80	10	"	.20
100	10	"	.20
350	10	"	.20
700	100	"	.75
2500	10	"	.25
5000	10	"	.25
6000	20	"	.35
7500	100	"	.75
10000	20	"	.35

RELAYS

DESCRIPTION	PRICE
Allied 30 ohm. Operate on 9 volts DC	$ .45
Allied TYPE BNXI. Six pole double throw. Heavy contacts 24 volts DC 175 ohms.	.75
4 Pole single throw. 3 normally open 1 normally closed. 400 ohm resistance	.65
Kurman type 509. DP. 115 Volts 60 cycles	.95
G. E., CR279 two circuit coil 10 volts contacts 50/20 Amps 115 Volt AC	.75
Allied BOH XII. Hermetically sealed DP DT Heavy contacts 110 volts DC 500 ohms	.75
Price Bros. TYPE 36A DP DT 110 Volts AC 60 cycles. Dust Proof cased	1.45
S. P. S. T. with red-black indicator plug 7.5-12.5 volts DC 60 ohms	.45
G. E. D107F 36 D. P. D. T. RF Antenna Change over type Isolantete insulation 6 Volts DC 28 ohms	.95
Allied AN133 Single circuit normally open very heavy contacts 24 volt DC 200 ohms	.65
G. E. two circuit 9-15 Volts DC 50 ohms	.45
Price Bros. type TB-302 miniature Isolantete spacers 24 volts DC 300 ohms	.65
G. E. type B100J42 Three pole DT 7½-16½ Volts DC 75 ohms	.75
Allied type DC 43 Three pole two throw Heavy Duty Contacts 24 Volts DC 250 ohms	.75
Allied type BO13D35 two circuit heavy duty contacts 24 Volt DC 250 ohms	.75
Ward Leonard Heavy Duty keying type 70 Volts DC 2000 ohms	1.25
Allied type BOYX-20 Two Circuit Heavy contacts 12-24 Volts DC 130-260 ohms	.75
Clare #814680—Miniature 4 Pole DT 24 UDC 300 ohms	.75
Vacuum Relay contacts rating 10 amps. Will break 3000 volts. Suitable for RF antenna Relay Solenoid resistance 200 volts. 24 volts D.C.	.95
Leach type 1054 DP. S.T. plus holding contact. Heavy contacts 20-28 D.C. 265 ohms	.75
Allied type 15D35 DP. D.T. heavy contacts 240 ohms 20-28 volts D.C.	.75
Clare, miniature type, 3 pole, D.T., double contacts 24 volts D.C. 440 ohms	.65
Clare 818062—Momentary two pole single throw 115 Volts A.C.	1.25
Telephone type 3 pole single throw normally open 1000 ohms	.65
Time Delay Relay—Thermal vacuum type S.P.S.T. 100 ohm coil—24 volt A.C. and D.C. Time 90 seconds	.95

Plugs, PI 291 .... Price 25.00/M

Varnished tubing and Vinelyte all sizes Price 10.00/M

Thermoswitch Sperry Type Consists of microswitch. flat wound, 30 ohm heating element, heat expansion element, operating control..... Price .95

EDLIE ELECTRONIC INC.

135 LIBERTY ST. **BArclay 7-4763** **NEW YORK 6, N. Y.**

SURPLUS BARGAINS!

TRANSTATS—3 K. V. A.

Type RH. Input: 115 V 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-36 Volts at 30 Amps.

A Real Buy at....$18.00

(same type, but .25 KVA, Input: 103-126 V.; Output: 115 V.-2.17 A.

Price $6.50

STEPDOWN TRANSFORMER

Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3-½" x 3-½" x 4".

Your Cost $3.75

Quantity prices available

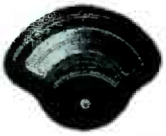
VOLT-OHM MILLIAMMETER

Simpson Model #235

A Simpson Microtester. Ranges: 1-10-50-250-500-1000 Volts. 0-10-100-500 Milliamperes. 0-250 Microamps. 0-2000 Ohms; 0-29,000 ohms; 0-2 Megohms.

Your Cost $12.00

WESTON MODEL 269 FAN SHAPED METER



One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy — within 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, MA., etc. Full scale deflection—5 M.A.—40 M.V.

List $29.83
Your Cost $8.95
10 for $75.00

D. C. VOLT

0-15 V. 2" whse BX33 (black scale)	$2.75
0-15 2" Simpson #125	2.95
0-20 V. 2" Weston 506 (1000 ohms/V)	2.95
0-15 V. 3" Whse NX-35	3.95
0-150 V. 3" G.E. DO-41	4.75
0-50 V. 4" Whse NX-37	6.00
0-150 V. 4" Weston 643 (black scale-flush-metal)	6.75

SELENIUM RECTIFIERS

Full Wave Bridge

Federal Type #	Approximate Rating Input Max.	Output Max.	Amps.	PRICE
10B1CV1	18 V.	14 V.	.5	.98
10B2CV1	36 V.	28 V.	.5	1.50
4B3CV2	48 V.	36 V.	.5	2.75
5B2AV1	36 V.	28 V.	1.6	4.25
5B2AV5	36 V.	28 V.	8	11.75
11BA6AM1	120 V.	100 V.	1.6	11.95
9DO612R	150 V.	115 V.	1.6	14.50

OHMMETER

Weston — 689 1-F
Convenient pocket size with sturdy leather case, for low resistance readings. Double Scale.
0-10 Ohms Full scale.
0-1000 Ohms Full scale.
Size: 5"x2-⅞"x1-⅞".

Your Cost $14.75
(with case & batteries)

SPECIAL METERS

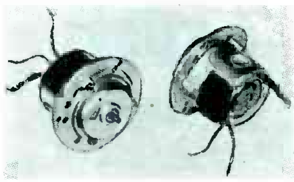
Frequency Meter—350/450 CPS Aircraft type 4" Weston Model 637	$4.95
Resistance Thermometer—30°F to 230°F. Complete with res. bulb. aircraft type—2" Weston #727	$4.75
Weston Thermometer #221-D—4" rd. 50°F—300°F—2½" stem	$4.95

D. C. AMPS & MILLS

0-1 Ma 2" G.E. DW41 (special scale)	$1.95
0-1 Ma 2" Weston 506	3.75
0-2 Ma 2" Sun 2AP525-5	2.25
0-5 Ma 2" Dejur S-210	1.95
0-15 Ma 2" Weston 506	3.95
0-25 Ma 2" G.E. DW41	2.95
0-30 Ma 2" G.E. DW41	2.95
0-100 Ma 2" sq. Simpson 127	2.95
0-500 Ma 2" G.E. DW41	3.25
0-1 Ma 3" sq. Whse RX35 (scale: 1.5 KV)	4.25
1-0-1 Ma 3" W.E. concentric. scale: 100-0-100. NEW. cracked glasses. 10 for	9.50
0-1 Ma 3" sq. Weston 301 (scale 1.5 KV)	5.25
0-1 Ma 3" sq. Weston 301	6.00
0-1 Ma 3" G.E. DO-53	4.75
0-15 Ma 3" Whse NX35 (scale: 15/150/300)	2.95
0-30 Ma 3" Weston 301 Metal Case	3.75
0-30/120/600 Ma. Weston Model 280 portable—slightly used.	4.75
0-1 A. 3" sq. Weston 301	5.50
0-10 A. 3" sq. Triplett in wooden case	2.50
0-10 A. 3" Simpson #25	4.50
30-0-30 A. 3" Simpson #25	4.50
0-300 A. 3" Roller-Smith (Fl. Bake. Type TD—50 MV with ext. shunt)	4.95
0-300 A. Same as above without shunt	2.25
0-300 A. 4" Weston 643 (fl. metal bl. scale ext. shunt)	8.50
0-300 A. 4" same as above (without shunt)	5.50

All meters are white scale flush bakelite case unless otherwise specified.

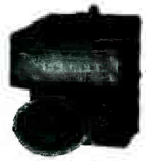
"MIDGET" SELSYNS



A real midget selsyn, ideal for position indicators. Precision built by Bendix. Exceptionally light weight. Aluminum case. Operates on 24 volts, 60 cycles.

Your Cost $3.95
A Pair

WHEELCO CAPACITROL #221



The original Wheelco electronically controlled temperature regulating pyrometer, cold junction compensated, high resistance movement. Scale length:

Ranges available:—0-400°F. 0-1200°F. 0-800°F. 0-2000°F.

Your cost: $98.75

OHMMETER

Simpson #282

One of the famous Microtester lines. Has wide range .2 to 10 megohms. Ranges: 1000 ohms, 10 ohms center: 10.000 ohms, 100 ohms center; 100,000 ohms, 1000 ohms center; 1 Megohm, 10,000 ohms center; 10 Megohms, 100,000 ohms center. Complete with batteries.

Your Cost $11.75

D. C. MICROAMPS

0-150 Microamps—2" rd. G.E.—DW51 or Whse NX33. Res: 500 Ohms. Your Cost	$3.75

A. C. VOLTS

0-10 V. 2" G.E. AW-42	$2.95
0-10 V. 3" sq. G.E. AO-41	3.75
0-15 V. 3" G.E. AO-41 (black scale)	2.95
0-150 V. 2" Simpson #155 (metal case)	2.95
0-150 V. 3" G.E. AO-41	5.50
0-150 V. 3" Simpson #55	5.95
0-75 V. 4" Weston 642 (surface metal)	6.75
0-300 V. 4" sq. Triplett #431A (300/600 V. scale)	3.25

A. C. AMPS

0-1.5 A. 2" Weston 507 (RF)	$3.50
0-2 A. 3" Whse RT35 (RF)	3.95
0-3 A. 3" Whse NA35 (scale 120 A.)	3.95
0-30 A. 3" Triplett (metal)	2.95
0-5 A. 4" Weston 642 (surface metal)	7.95
0-5 A. 4" sq. Triplett 431A (scale 150/300)	2.95

All meters are white scale flush bakelite case unless otherwise specified.

POWERTRON Electrical Equipment Co.

SURPLUS DIVISION: ELECTRO-TECH EQUIPMENT CO.

119 LAFAYETTE STREET ***Phone:*** **WOrth 4-8610** **NEW YORK 13, N. Y.**

"TAB"

• NEW GUARANTEED That's A Buy **ELECTRONIC PARTS •**

X Band WAVEMETER 3CM Maguire........$16.95
OSC mtg 723AB on 3CM WAVEGUIDE & Attntr output T section & Thermistor & Crystal DIODE mtg & bead Thermistor mtg & 2nd Attntr. po/TS13.................... 18.95
SAME MTG & X BAND WAVEMETER..... 29.95
723AB OSC MTG & Transition to Two type N coaxial fittings (RG9U etc.)......... 4.95
723AB Osc Mtg & adj Cavity & Coax term.... 3.95
XTAL DIODE mtg in wveguide mtg.......... 2.50
VARISTOR WE D168391/85c@...........2 for 1.50
Resonant adj line osc 150-200msc/PP826 200Watts tuneable from front panel......... 5.95
Autosyn AY1 & 5/24-28V/60 & 400cy....... 3.95
Autosyn Type 5/115V-60cy NEW pair........ 18.00
Autosyn Differential 115V-60cy new......... 6.95
Autosyns Type 5/50V/2 for 115V/60cy......... 8.00
Repeater AC synchronous 115V/60c/II-2 pr... 18.00
Repeater AC synchronous XXI/pair........... 8.95
Switch GE DOOR INTERLOCK G4.......... .69
Switch SPDT 4 for $1, DPDT 15A/115V...... .69
Switch 3PDT/10A/115-575V/69c@.......5 for 2.00
Switch AH&H 60A/600V, 250amp/125V...... 1.00
GE VOLTAGE CONTROL RELAY PJV/115V/60c self rest, 70/85/110/160V ($36)......... 5.95
GE TEMP CONTROL 70-170°F/25Amp to 250V & Capillary adj new ($18)................. 3.95
BLOWERS 100CFM/28VACDC new.......... 4.95
BLOWERS & Transformer 115VAC......... 5.95
BLOWER 125CFM CASED TURBO............ 7.95
MICROSWITCHES 2 for 39c.........TEN for 1.49
Mu Switch leaf SPDT 15A/125V/2 for...... 1.10
Plunger type 2 for $1.10; Roller type....2 for 1.10

"TAB" FOR TUBES

1E7G	$0.89	6T5M	$.55		
1L4	.98	6J6	.88		
2A5	.54	6K7	.66		
2X2	.83	6K8	.81		
2V3G	.75	6L6	1.15		
3A4	.75	6SA7	.81		
3S4	1.00	6SC7	.84		
5W4	.97	6SG7	.54		
5R4	.97	6SJ7	.68		
5U4	.63	6SL7	.87		
5Y3	.41	6SN7	.68		
5Z3	.55	6V6	.97		
5Z4	.89	6X5	.75	954	$.50
6AB7	.89	30	.74	955 & S	.90
6AC7	.80	80	.41	956 & S	.90
6AG5	.97	VR105	.74	957 & S	.90
6AG7	.90	VR150	.74	958A & S	.90
6AK5	.90	12A6	1.00	9002	.80
6AL5	.81	12SA7	.81	9004	.90
6B4	1.25	12SQ7	.90	9006	.80
6B8G	.95	35L6	.90	2050	.89
6C4	.65	35Z5	.90	1613	.89
6C5	.48	50L6	.90	1625	.65
6C8G	1.00	807	.95	446A	2.50
6E5	.69	808	2.50	631P1/SN4	3.73
6F6	.85	815	2.20	3BP1 & S	2.99
6F7	1.20	450TL	29.00	5AP1	3.55
6F8	1.26	24G	1.50	5BP1	3.55
2C26	.75	304TL	3.95	100TS	2.95
2C40	2.50	1291	.49	6H6	.58
3B24	1.90	1299	.49	991	.39
703A	3.95	5CP1	3.55	717A	1.20
RK60	.89	826	2.23	723	2.95
VT127A	2.95	954 Five for	2.00	703A	3.95
5BP4	3.95	6G6	1.08	832	2.00
1813-7BP7	7.90	6C6	.73	8014A	20.00
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289B/3E29	2.95	866A & S	1.00	12SG7	.80
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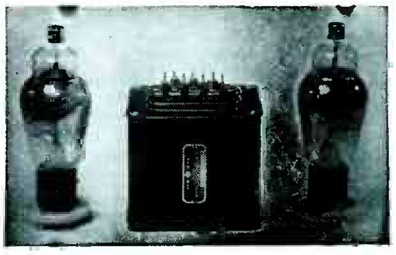

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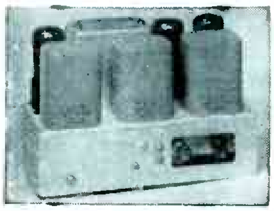

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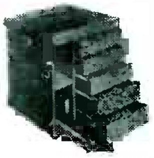

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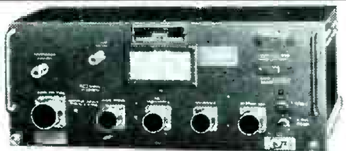

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Of Electronics, published monthly at Albany, N. Y., for October 1, 1947.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. A. Gerardi, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company Inc., publishers of ELECTRONICS, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the name and address of the publisher, editor, and business manager is: McGraw-Hill Publishing Company, Inc.; Editor, D. G. Fink; Managing Editor, W. W. MacDonald; Manager, W. B. Blood, all of 330 West 42nd Street, New York 18, N. Y.

2. That the owner is: McGraw-Hill Publishing Company, Inc., 330 West 42nd Street, New York City. Stockholders holding 1% or more of stock: James H. McGraw; James H. McGraw, Jr.; James H. McGraw, Jr., Curtis W. McGraw and Willard T. Chevalier, Trustees for: Harold W. McGraw, James H. McGraw, Jr., Donald C. McGraw and Curtis W. McGraw, all of 330 West 42nd Street, New York City; Edwin S. Wilsey and Curtis W. McGraw, Trustees for James H. McGraw, 3rd, Madison, New Jersey; Curtis W. McGraw, Donald C. McGraw, both of 330 West 42nd Street, New York City; Mildred W. McGraw, Madison, New Jersey; Grace W. Mehren, 536 Arenas St., La Jolla, Calif.

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J. A. GERARDI, Secretary.
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Sworn to and subscribed before me this 25th day of September, 1947.

[SEAL] ELVA G. MASLIN.
(My commission expires March 30, 1948.)

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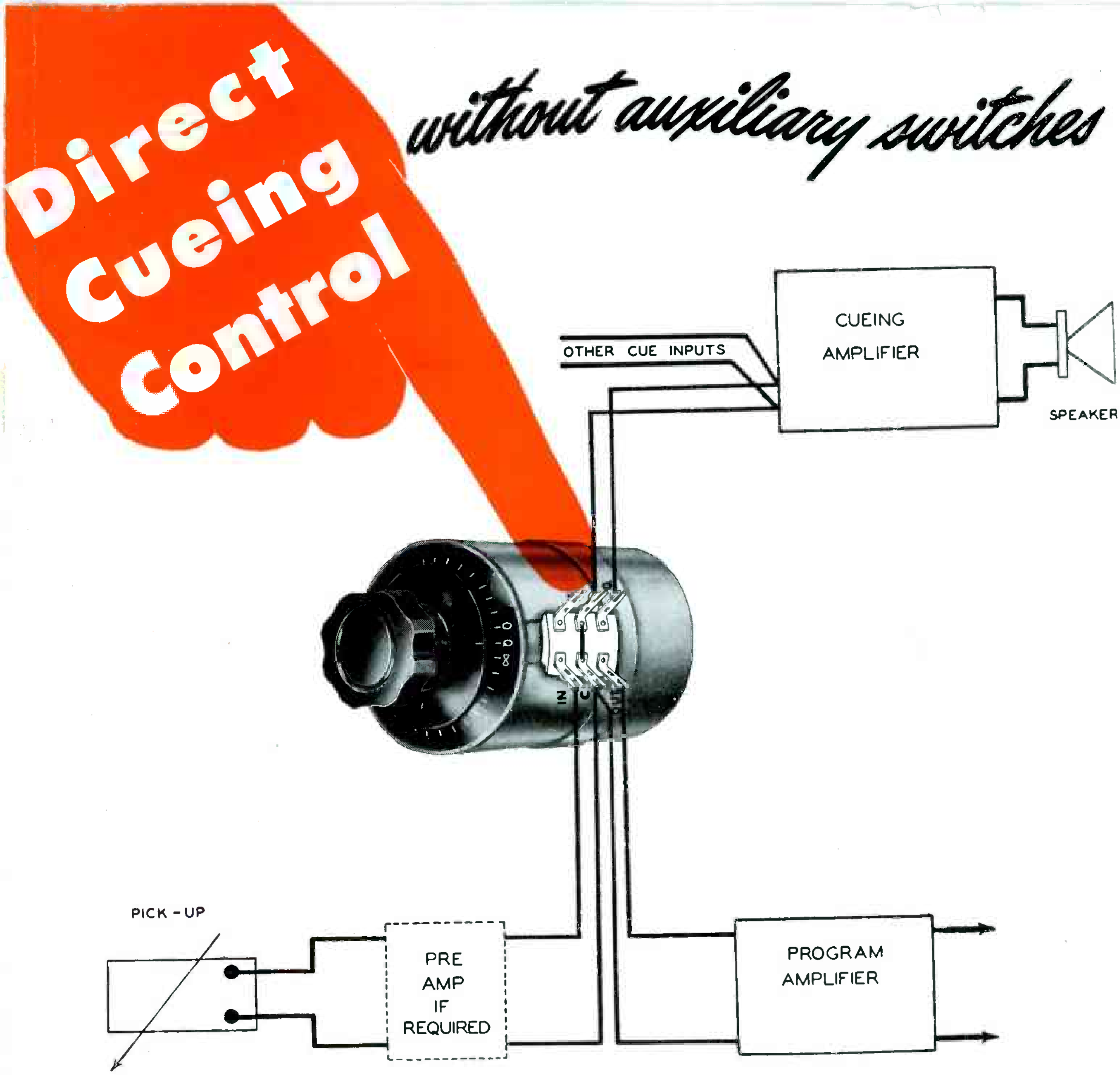

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134 - mercury delay lines