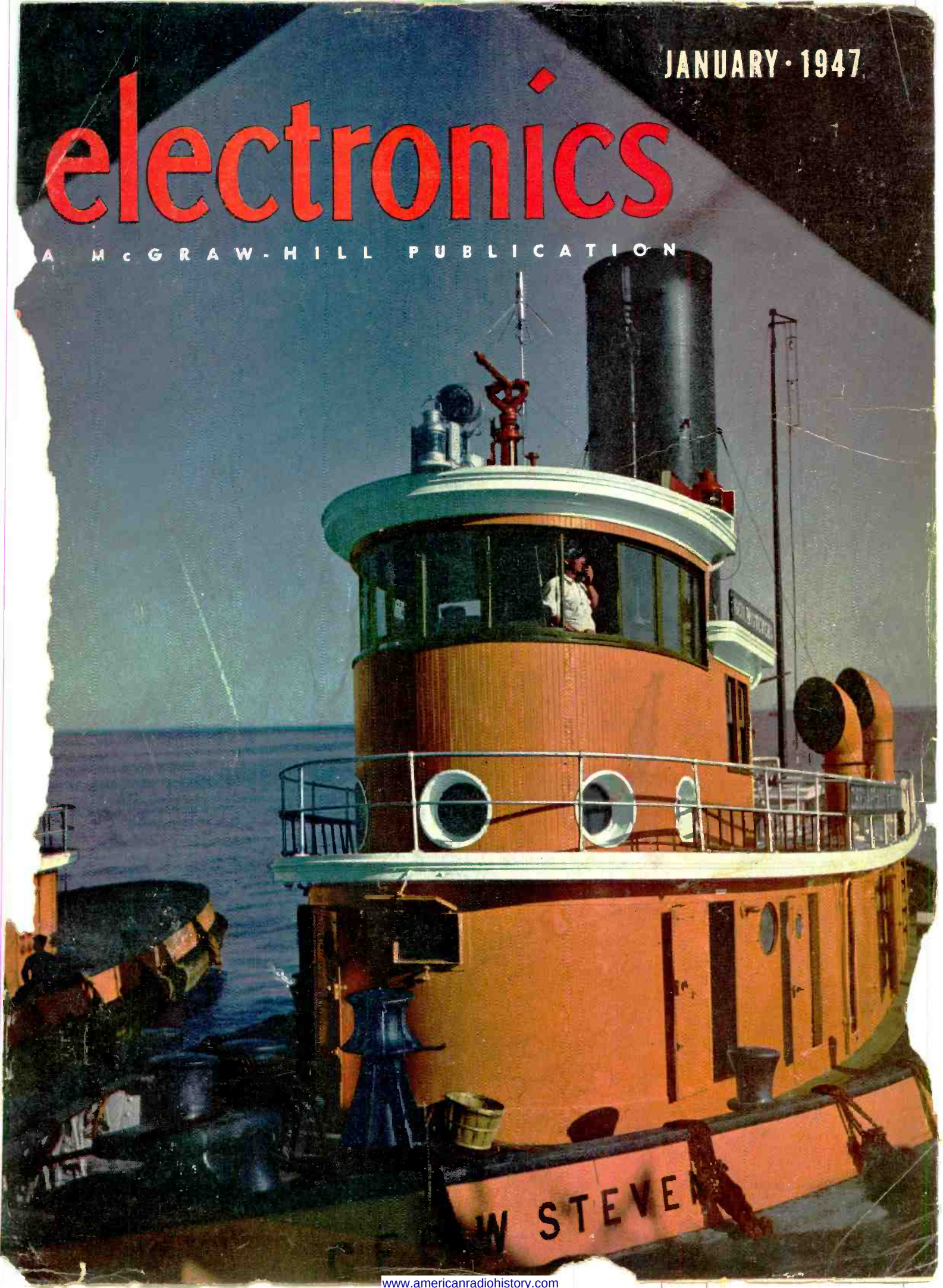
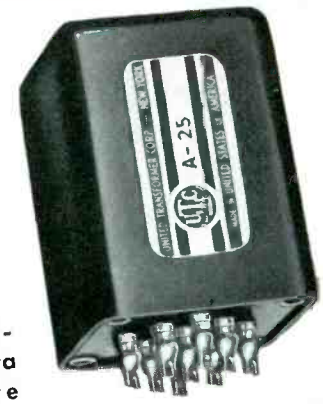


FOR THE BROADCAST STATION
THE HIGH FIDELITY AMPLIFIER
THE LABORATORY

LINEAR STANDARD

Linear Standard audio units are the closest approach to the ideal component from the standpoint of frequency response, wave form distortion, efficiency, shielding, and dependability. Guaranteed response ± 1.3 DB, 20—20,000 cycles. The standard of the broadcast industry . . . units available for every audio and power application.

ULTRA COMPACT



For compact, high fidelity equipment, UTC Ultra Compact units are unequalled. Light in weight, yet providing frequency response ± 2 DB from 30 to 20,000 cycles. All units except these carrying DC in primary employ true hum balancing coil structure which, combined with high conductivity outer case, insures good inductive shielding. Units available for all audio applications up to + 10 DB in operating level.

INTERSTAGE FILTERS

UTC Interstage Filters (10,000 ohms impedance) are available in low pass (LPI), high pass (HPI), and band pass (BPI) types for all frequencies from 200 to 10,000 cycles. Designed to effect 6 DB loss at cutoff frequency . . . 35 DB at .75 and 1.5 times cutoff frequency . . . 40 DB at .5 and twice cutoff frequency. Dual alloy magnetic shielding reduces pickup to 150 Mv. per gauss.

VARITRAN

Varitran units provide an ideal means of voltage control for AC equipment. Performance features include high efficiency . . . excellent regulation . . . universal mounting features . . . self-contained fuse protection. Available in 115 volt and 230 volt mocels with from 1 to 11 Amp. output rating. These units afford stepless adjustment of voltage from 0 to 113% of line voltage.

United Transformer Corp.

150 VARICK STREET • NEW YORK 13, N. Y.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"

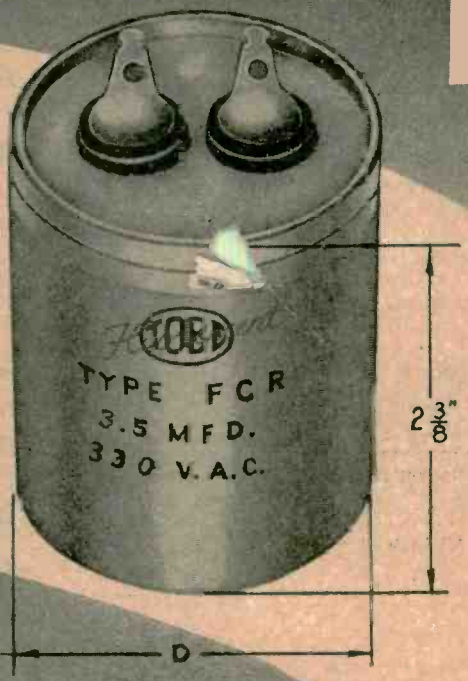
electronics

A McGRAW-HILL PUBLICATION

JANUARY • 1947

ELECTRONICS, January, 1947, Vol. 20; No. 1. Published monthly, with an additional issue in June, price 75c a copy. Directory Issue $1.00. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation. Subscription rates—United States and possessions, $6.00 a year, $9.00 for two years, $12.00 for three years. Canada (Canadian funds accepted) $7.00 a year, $11.00 for two years, $14.00 for three years. Pan American countries $10.00 for one year, $16.00 for two years, $20.00 for three years. All other countries $15.00 for one year, $30.00 for three years. Please indicate position and company connection on all subscription orders. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 68 Post Street, San Francisco 4; Aldwych House, Aldwych, London, W.C. 2; Washington, D. C. 4; Philadelphia 2; Cleveland 15; Detroit 26; St. Louis 8; Boston 16; Atlanta 3, Ga.; 621 So. Hope St., Los Angeles 14; 738-9 Oliver Building, Pittsburgh 22.

Use these data WHEN YOU Choose FLUORESCENT LAMP Capacitors



Tobe Fluorescent Lamp Capacitors embody design features to meet exacting conditions of high ambient temperatures, low power factor, stable performance, accurate capacitance ratings, and limited space requirements.

For consistent long life in power factor correction service, these specifications cannot be compromised.

Mechanical

Impregnation: mineral oil.
Case: hermetically sealed with corrosion-resistant finish.
Terminals: solder-lug terminals riveted to phenolic bushings.
Terminal Seal: leakproof terminal assembly.
Markings: type number, voltage rating, and capacitance rating ink-stamped on case.

Electrical

Winding: non-inductive.
Capacitance Tolerance: ± 10% or to specification.
Power Factor: less than ¾ of 1% (at 60 cycles).
Operating Temperature: minus 40C to plus 85C.
Life Test Performance: minimum of 1000 hours at 140% of rated voltage at 85C.

ROUND TYPE

VOLTS A-C	TYPE NO.	MFD.	DIA.	VOLTS A-C	TYPE NO.	MFD.	DIA.
330	FCR-332-5	2.5	2-1/32	330	FCR 334	4.0	2-7/32
330	FCR-333	3.0	2-1/32	440	FCR 442-5	1.5	2-1/32
330	FCR-333-5	3.5	2-1/32	440	FCR-442	2.0	2-1/32

OVAL TYPE

VOLTS A-C	TYPE NO.	MFD.	HEIGHT	VOLTS A-C	TYPE NO.	MFD.	HEIGHT
220	FCO-223-5	3.5	3-7/8	330	FCO-333	3.0	3-5/8
220	FCO-223-75	3.75	4-1/8	330	FCO-333-5	3.5	3-7/8
220	FCO-224	4.0	4-3/8	330	FCO-333-75	3.75	4-1/8
220	FCO-224-5	4.5	4-7/8	330	FCO-334	4.0	4-3/8
220	FCO-224-75	4.75	4-7/8	330	FCO-334-25	4.25	4-5/8

TOBE

TOBE DEUTSCHMANN *Corporation* CANTON, MASSACHUSETTS

NOW.. all electrical tubing insulation requisites with this exclusive varnish impregnant —

TURBOTUF

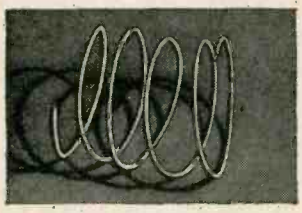
DAMAGED!
Illustration shows cracking of conventional insulating varnishes under bending stress

UNAFFECTED!
TURBOTUF withstands repeated 180° twisting and bending without trace of cracking

Non-cracking, non-peeling, non-chipping — whatever the angle of bend or twist!

A knock-out to usual insulation breakdown causes

NEW! TURBOTHERM Plastic Insulated Wire



Specialized in Gauge Nos. 18 to 30 stranded and solid conductor construction.

Bend it, crease it, twist it—subject it to any turn or bend—and you'll see that something new has been added to this quality insulation tubing and sleeving. TURBOTUF—an exclusive new development, constituting a genuine advance in the art, eliminates the hazard of cracking insulation, with subsequent wiring failure or service interruption.

Now when you specify TURBOTUF, you get these additional TURBOTUF advantages: increased, stabilized dielectric strength; higher temperature resistance; decreased moisture-absorption factor; unaffected by proximity to soldering heat; etc.

TURBO products include Flexible Varnished Tubing, Thermoplastic Insulated Wire known as Turbotherm, Extruded tubing, Saturated Sleeving, Fibrous Glass Tubing, Varnished Tapes and Cambrics, Mica and Mica Products. Write for free Specimen Board today.

WILLIAM BRAND & COMPANY

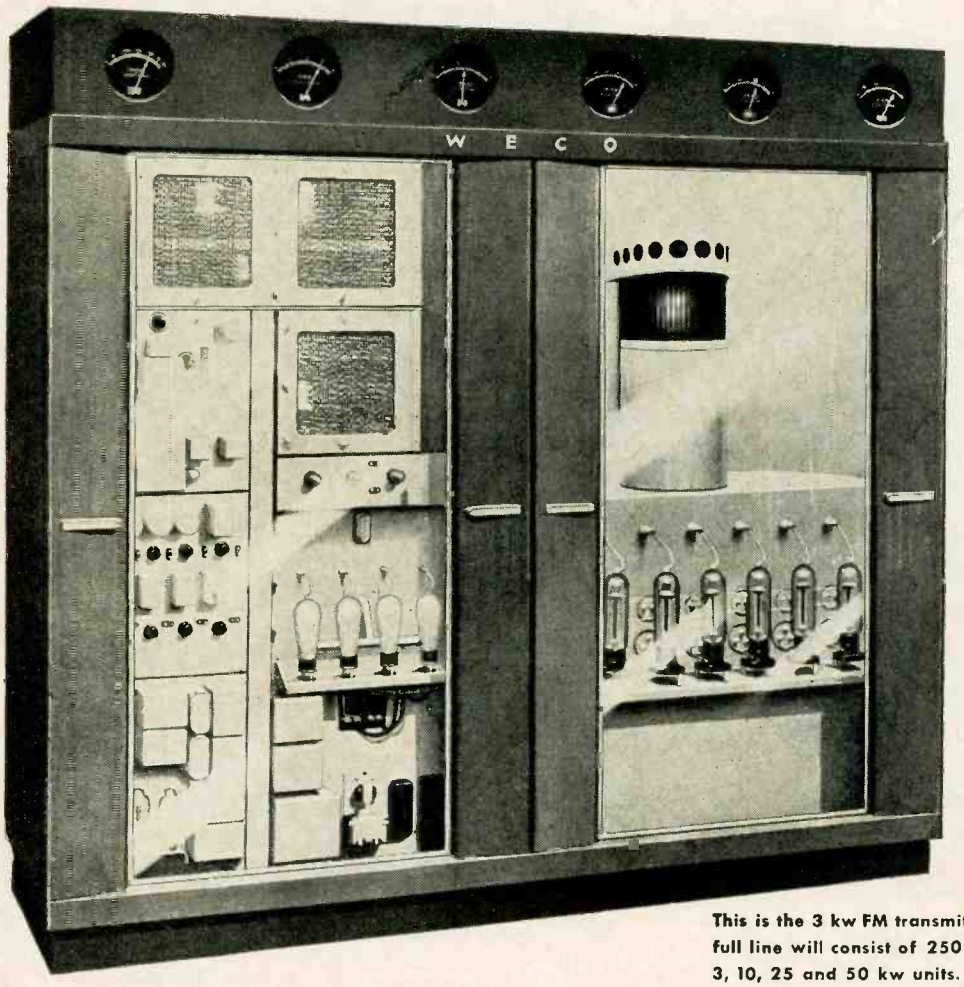
276 FOURTH AVE., NEW YORK 10, N. Y. • 325 W. HURON ST., CHICAGO 10, ILL.

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

TRANSVIEW design

. . . still another pioneering step in FM by

Western Electric



This is the 3 kw FM transmitter. The full line will consist of 250 watt, 1, 3, 10, 25 and 50 kw units.

Why you'll like it:

You'll like the full-length glass doors, which provide an unobstructed view of all tubes at all times.

You'll like the striking modern appearance—and the attractive station call letters.

You'll like the big, easy-to-read meters and the ease of access to components.

Most of all you'll like the *low* intermodulation, the *low* harmonic distortion and other features that put this new line of FM transmitters as far out in front in performance as in appearance!

— QUALITY COUNTS —

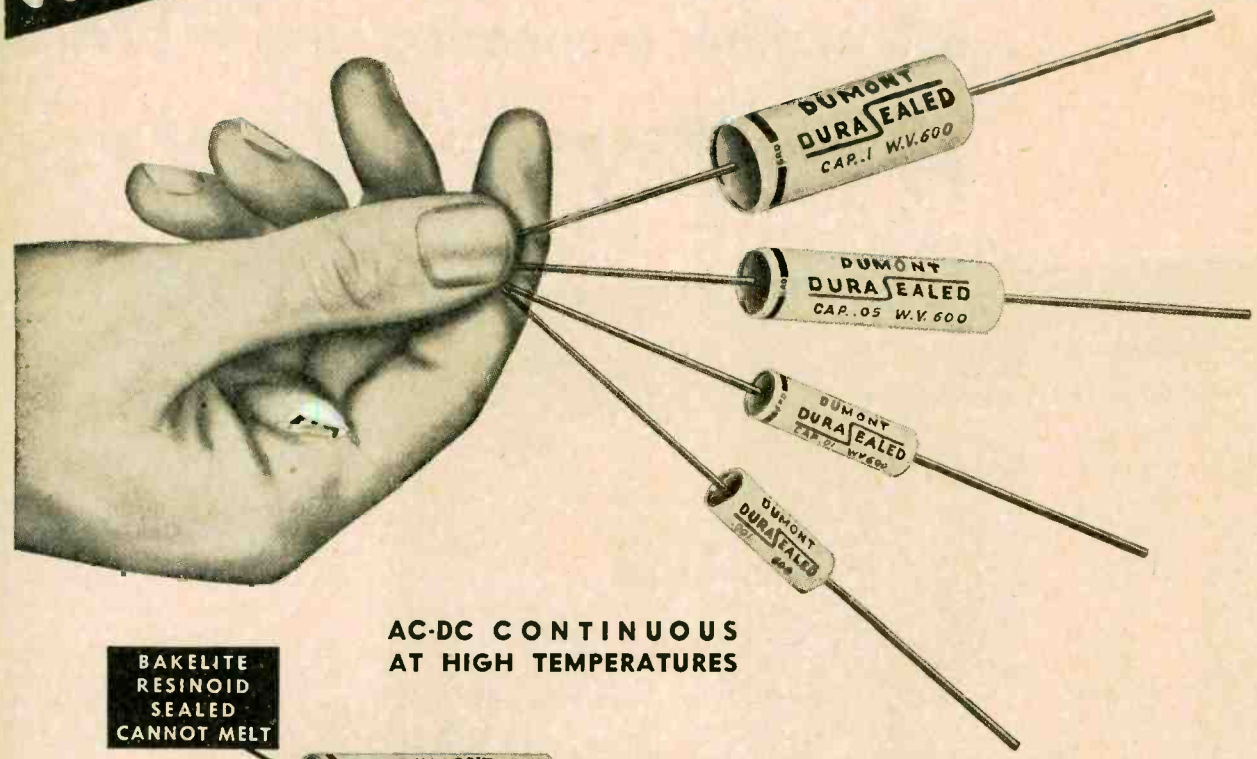
Since the very beginning of broadcasting, Western Electric has been noted for pioneering new ideas in transmitter design, which have later become standard practice in the industry.

Stabilized Feedback—the High Efficiency Amplifier Circuit—mounting all electrical components on a central vertical structure, achieving maximum accessibility—Synchronized Frequency Modulation are typical Bell Laboratories-Western Electric contributions.

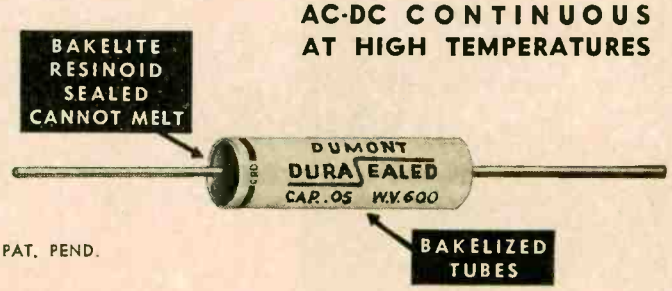
And today Western Electric's TRANSVIEW design FM line sets the pace for tomorrow! For technical information, talk to your local Graybar Broadcast Representative or write to Graybar Electric Company, 420 Lexington Avenue, New York 17, N. Y.

AT LAST!

SPECIAL WARTIME DEVELOPMENT NOW AVAILABLE FOR PUBLIC USE . . . TYPE P6 DUMONT *PAPER* CAPACITORS



AC-DC CONTINUOUS AT HIGH TEMPERATURES



PAT. PEND.

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

- ★ **HEAT PROOF**
- ★ **MOISTURE PROOF**
- ★ **LONGER LIFE**
- ★ **VACUUM SEALED**
- ★ **SOLVES SPACE PROBLEMS**

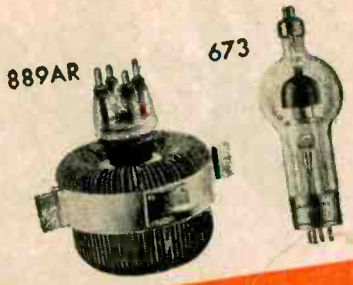
DUMONT ELECTRIC CORP.
MFR'S OF CAPACITORS FOR EVERY REQUIREMENT

34 HUBERT STREET NEW YORK, N. Y.

AMPEREX

ONE SOURCE · ALL TYPES

COMMUNICATION

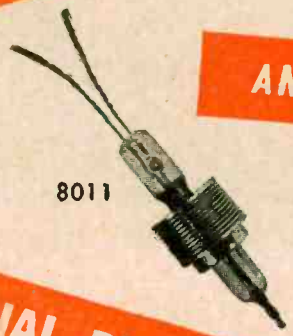


INDUSTRIAL

RECTIFICATION

ELECTRO-MEDICAL

AND ALL OTHER IMPORTANT TYPES



SPECIAL PURPOSE

Is it a special development for new equipment? Or a "standard" tube for replacements? A quarter century of creative research, precision manufacture and helpful service has given Amperex a unique position in the power tube field. This means a backlog of experience and forward-looking viewpoint which naturally translate themselves into tube performance, reliability and economy. Consult us — no obligation.

Write for: Catalog; Technical Rating and Data Sheets

AMPEREX ELECTRONIC CORPORATION

25 WASHINGTON STREET, BROOKLYN 1, N. Y., CABLES: "ARLAB"

In Canada and Newfoundland: Rogers Majestic Limited, 622 Fleet Street West, Toronto 2B, Canada

BACKED BY 36 YEARS OF *know-how*

HQ·129·X

"This morning I had a VK on phone, driving the S-meter completely off scale."

Another says, "Finest receiver on the market." Thus run the comments on the HQ-129-X. And why shouldn't they—thirty-six years of craftsmanship and research engineering back up every Hammarlund product.

see the HQ·129·X at your dealer's

HAMMARLUND

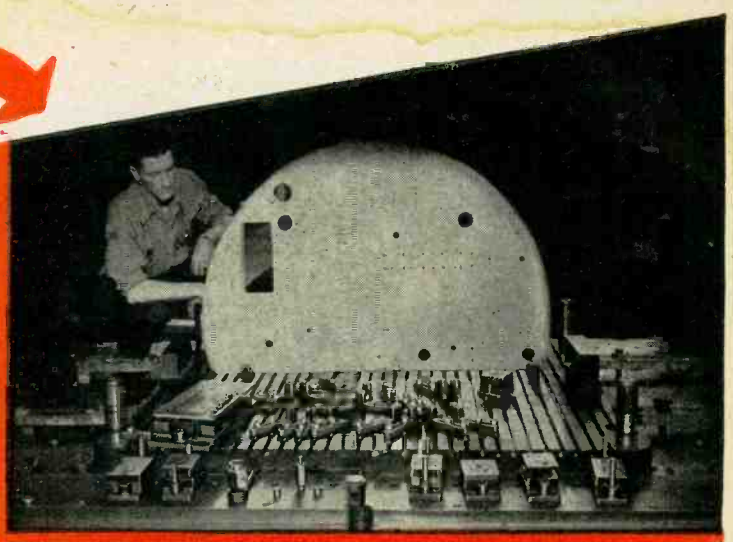
THE HAMMARLUND MFG. CO., INC., 460 W. 34TH ST., NEW YORK 1, N.Y.

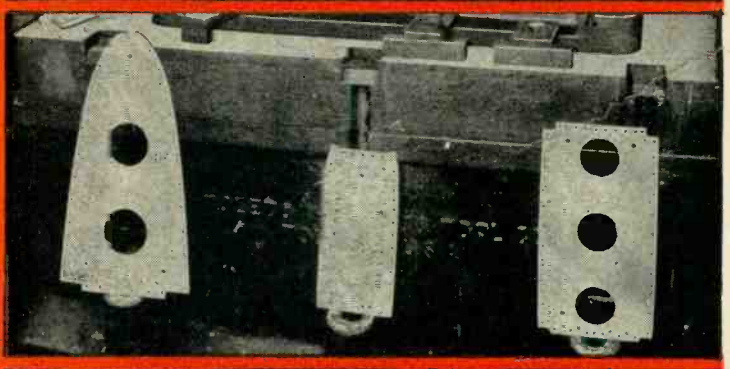
MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

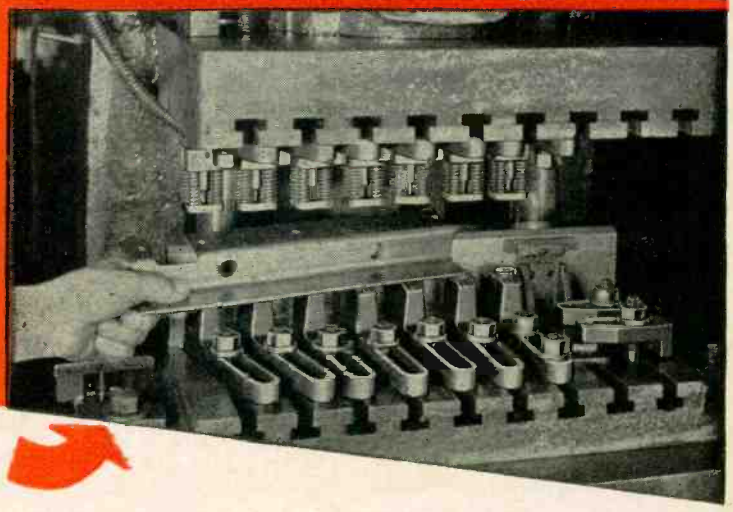
THE SIGN OF QUALITY

ESTABLISHED 1910

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







Re-use same WHISTLER ADJUSTABLE DIES in unlimited combinations

1. To Pierce Holes of any diameter from 1/32" up.
2. To Perforate Special Shapes.
3. To Notch Corners.

Save production time and reduce product costs by having Whistler punch and die units in your tool room.

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

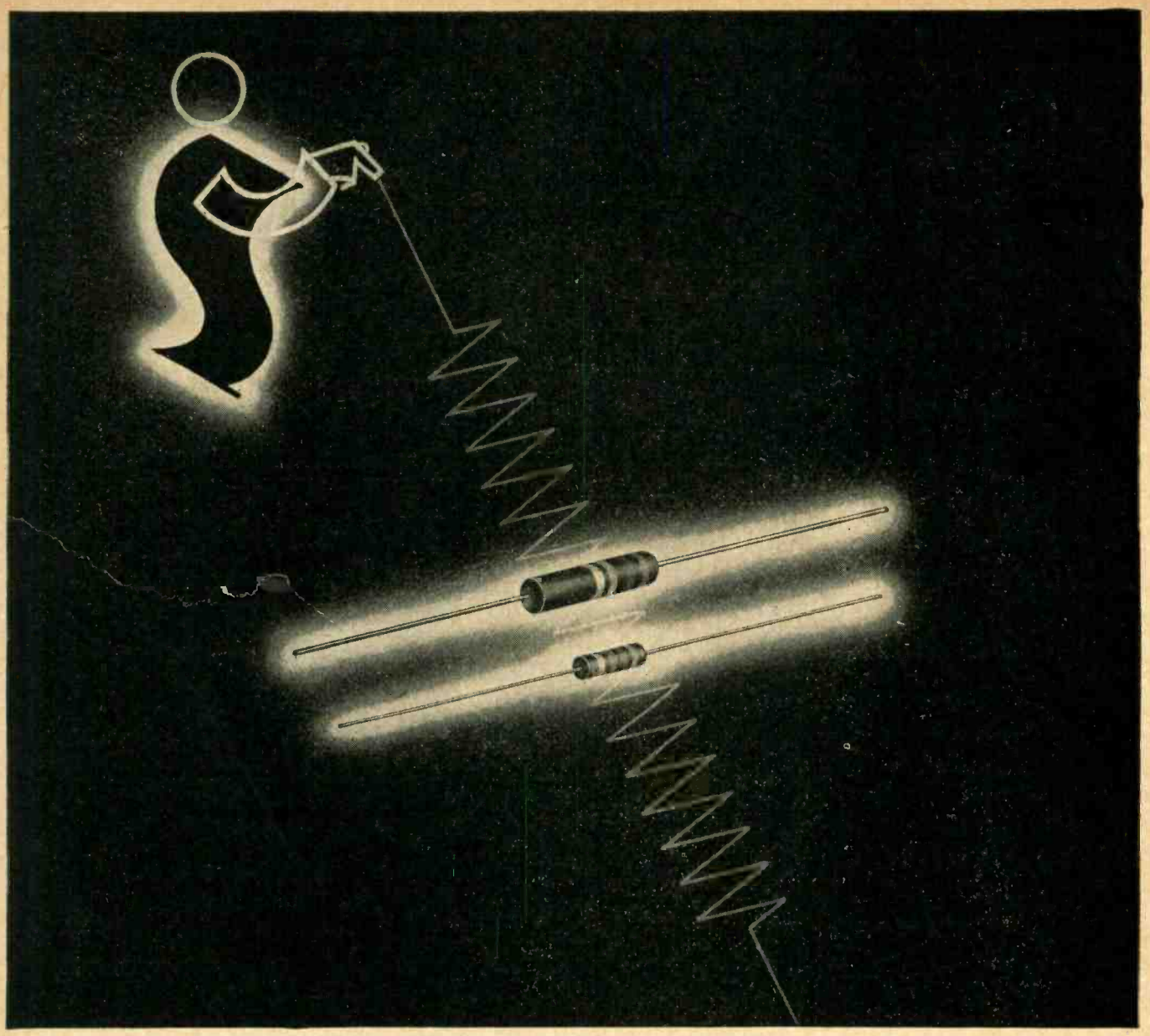
Now available from stock in a range of diameters up to 3", shipment can be made the same day your order is received. Special sizes, shapes, notching and group dies are made to order in a few days.

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

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

S. B. WHISTLER & SONS, INC.

752-756 MILITARY ROAD BUFFALO 17, NEW YORK



Fixed RESISTORS

You have seen resistor pictures before. Lots of them! Maybe you have even raised your eyebrows over diverse claims as to hair-splitting points of difference about resistor quality.

All we have to say is this:

Stackpole has long since proved its ability to make resistors to exceptionally high quality standards.

We don't claim any unsurpassed abilities or facilities for doing the impossible. We *do* claim to be fully capable of meeting your resistor needs — and to have the type of organization with which it is a pleasure to deal.

If you use reasonable quantities of fixed resistors up to 1 watt or variable resistors to almost any specification, Stackpole will welcome the opportunity to cooperate.

Ask for Catalog RC-6 — Stackpole Fixed and Variable Resistors — Standard, High-Frequency, Sleeve and Screw Type Iron Cores — Line Slide and Rotary Action Switches.

STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE

FIXED and VARIABLE RESISTORS—IRON CORES—SWITCHES

For an Extra Margin of

DEPENDABILITY
UNDER ALL OPERATING CONDITIONS

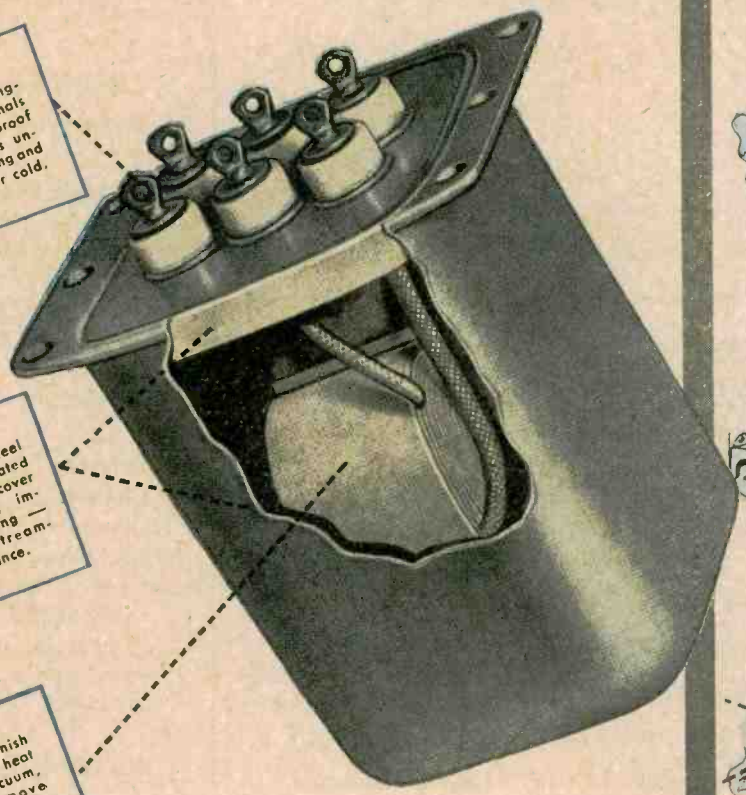
CASE TYPE

CHICAGO TRANSFORMERS
Sealed in Steel

Exclusive C. T. bushing-gasket seal at terminals is permanently proof against moisture, is unimpaired by soldering and by climatic heat or cold.

Seamless drawn steel case and C.T.-innovated "Deep-Seal" base cover provide a strong, impenetrable housing — rust-proofed, streamlined in appearance.

Coil is wax and varnish impregnated under heat and alternating vacuum, pressure, to remove moisture, prevent its re-entrance during assembly of unit.



Sealed AGAINST ATMOSPHERIC MOISTURE AND INDUSTRIAL FUMES

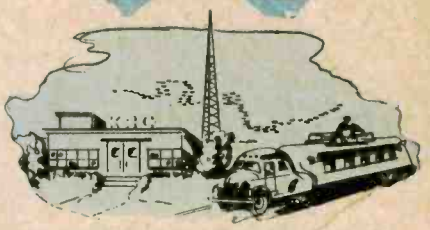
THUS ***Sealed*** AGAINST CORROSION OF COPPER COIL WINDINGS

STAY ***Sealed*** IN EXTREMES OF HEAT AND COLD!

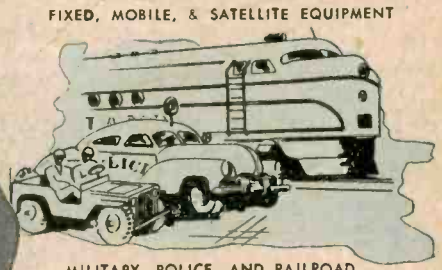
FITTED TO THE APPLICATIONS WHERE COMPONENT DEPENDABILITY IS ESSENTIAL TO

Avoid

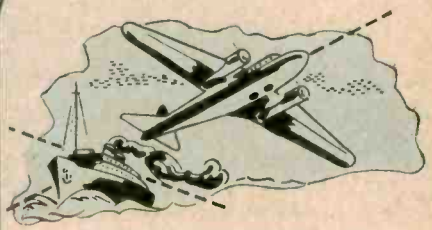
COSTLY MAINTENANCE
LOSS OF LIFE
DISRUPTION OF A VITAL SERVICE



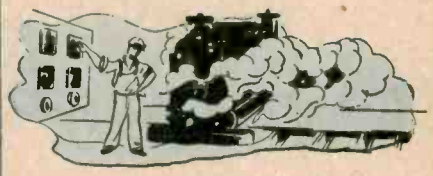
RADIO AND TELEVISION BROADCASTING
FIXED, MOBILE, & SATELLITE EQUIPMENT



MILITARY, POLICE, AND RAILROAD COMMUNICATIONS



ELECTRONIC NAVIGATIONAL AIDS FOR SHIPS AND AIRLINES



INDUSTRIAL CONTROLS

★ In these and many other transformer applications, economy, as well as efficiency, is best served by Chicago Transformer's *Sealed in Steel* construction.

Let its assurance of long-lasting transformer reliability help make your electronic product free of component replacements and expensive servicing regardless of adverse operating conditions.

CHICAGO TRANSFORMER
DIVISION OF ESSEX WIRE CORPORATION
3501 ADDISON STREET • CHICAGO 18, ILLINOIS

To avoid damage from Oxidation . . .

protect with NITROGEN

LINDE Nitrogen provides an ideal means of protection against oxidation and corrosion by air. For packaging dehydrated foods; for deaerating, processing, storing and packaging fats and oils of all kinds; or for providing an inert atmosphere, free of impurities, for the complete protection of practically any material susceptible to oxidation, use LINDE Nitrogen.

LINDE Nitrogen is 99.7% pure, but is also available bone dry and at higher purity for special applications. It is supplied as a compressed gas in cylinders containing 224 cu. ft. each, or in bulk in tank-truck and tank-car lots as a liquid which is converted into gaseous nitrogen as required. LINDE Nitrogen in bulk offers remarkable savings in cost and eliminates cylinder handling.

Write or call the Linde office nearest you.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

30 E. 42nd St., New York 17, N. Y. • Offices in Other Principal Cities

The words "Linde" and "Prest-O-Lite" are registered trade-marks.

LINDE has offices in Principal Cities

Eastern States
Baltimore, Md.
Boston, Mass.
Buffalo, N. Y.
Charleston, W. Va.
New York, N. Y.
Philadelphia, Pa.
Pittsburgh, Pa.

Central States
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Detroit, Mich.
Indianapolis, Ind.
Milwaukee, Wis.
Minneapolis, Minn.
St. Louis, Mo.

Southern States
Atlanta, Ga.
Birmingham, Ala.
Jacksonville, Fla.
Memphis, Tenn.
New Orleans, La.

Southwestern States
Dallas, Texas
Denver, Colo.
Houston, Texas
Kansas City, Mo.
Tulsa, Okla.

Western States
Butte, Mont.
El Paso, Texas
Los Angeles, Calif.
Phoenix, Ariz.
Portland, Ore.
Salt Lake City, Utah
San Francisco, Calif.
Seattle, Wash.
Spokane, Wash.

Linde HYDROGEN · NITROGEN · OXYGEN
ARGON · HELIUM · KRYPTON · NEON
XENON — Prest-O-Lite ACETYLENE

PAA

PAN AMERICAN

Orders Federal's FTR-3 Transmitter for "Ground-to-Clipper" Communication

DATA

Frequency Range — 2 to 20 Mc or 250 to 750Kc.

Power Output — Nominal rating, 3 Kw (2 to 20 Mc). Nominal rating, 2.5 Kw (250 to 750 Kc).

Types of Emission — Telephone and Telegraph.

Frequency Control — Low temperature-coefficient crystals for all operating frequencies.

Frequency Response — 300 to 4000 cycles, plus or minus 3 db.

Distortion — Less than 10% at 95% modulation.

Remote Control — Transmitter on-off, channel selection, push-to-talk, and keying may be performed by remote control.

Federal's Multi-Unit Equipment Offers Many New Advantages

PAN AMERICAN WORLD AIRWAYS—another famous user of Federal's ground-station radio transmitters—picks the FTR-3 for dependable flight contact with its huge modern "Clippers".

An FTR-3 multi-unit transmitter offers unique features for greater flexibility, simplified maintenance, easy accessibility and added safety. The complete transmitter consists of three basic sections—the RF unit, modulator unit and power supply unit. These separate units may be selected and combined in a single transmitter, to provide the operating characteristics needed for any job.

Each unit is mounted on rollers and can easily be drawn out for inspection or adjustment. Access to the back of the transmitter is therefore unnecessary, greatly reducing space requirements. Complete electrical and mechanical interlocks, as well as overload and overtemperature relays, give extra protection to both the equipment and the operating personnel. For complete information write today for Bulletin A-313.

Federal Telephone and Radio Corporation

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

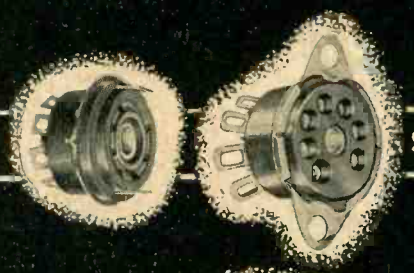
An IT&T Associate — Federal Telephone & Radio — FTR

Newark 1, New Jersey

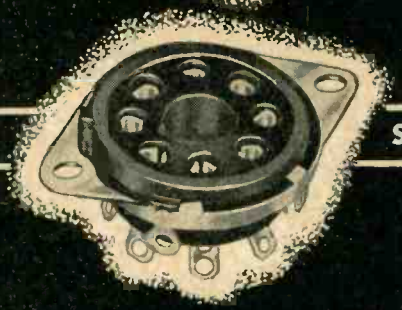
Franklin QUALITY *Sockets*

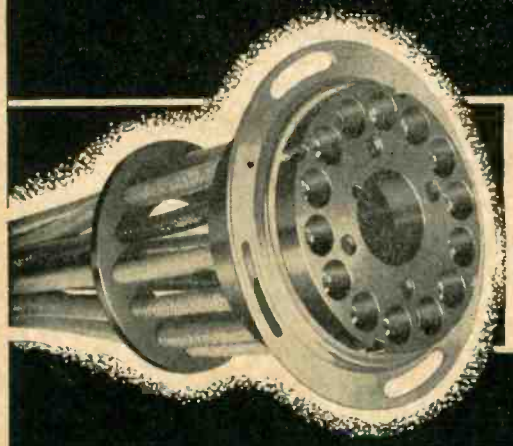
for Personal . . . Broadcast . . . Television Receivers

PERSONAL RECEIVERS — **SERIES 55A4 MINIATURE MOLDED**



BROADCAST RECEIVERS — **SERIES 60 MOLDED OCTAL**





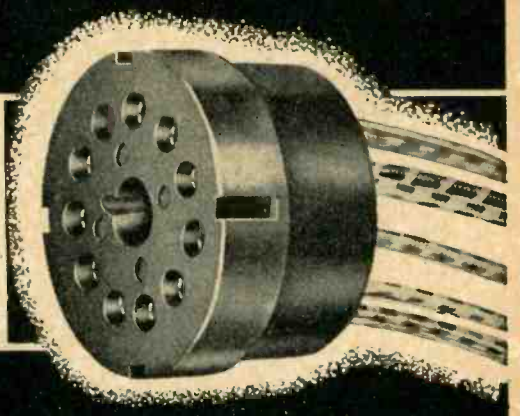
TELEVISION

ONE PIECE SOCKETS

DUO-DECAL

DIHEPTAL

MAGNAL



. . . and for general purposes, the Series 39 Socket, with patented bow spring action contacts (with or without a soldering tab to eliminate wiring to ground) is the favorite of all time. Automatically machine made, tens of thousands are being delivered to the radio industry to enable peak production of standard receivers. The millions in use give testimony to its being the favorite socket of pre and post war receivers.

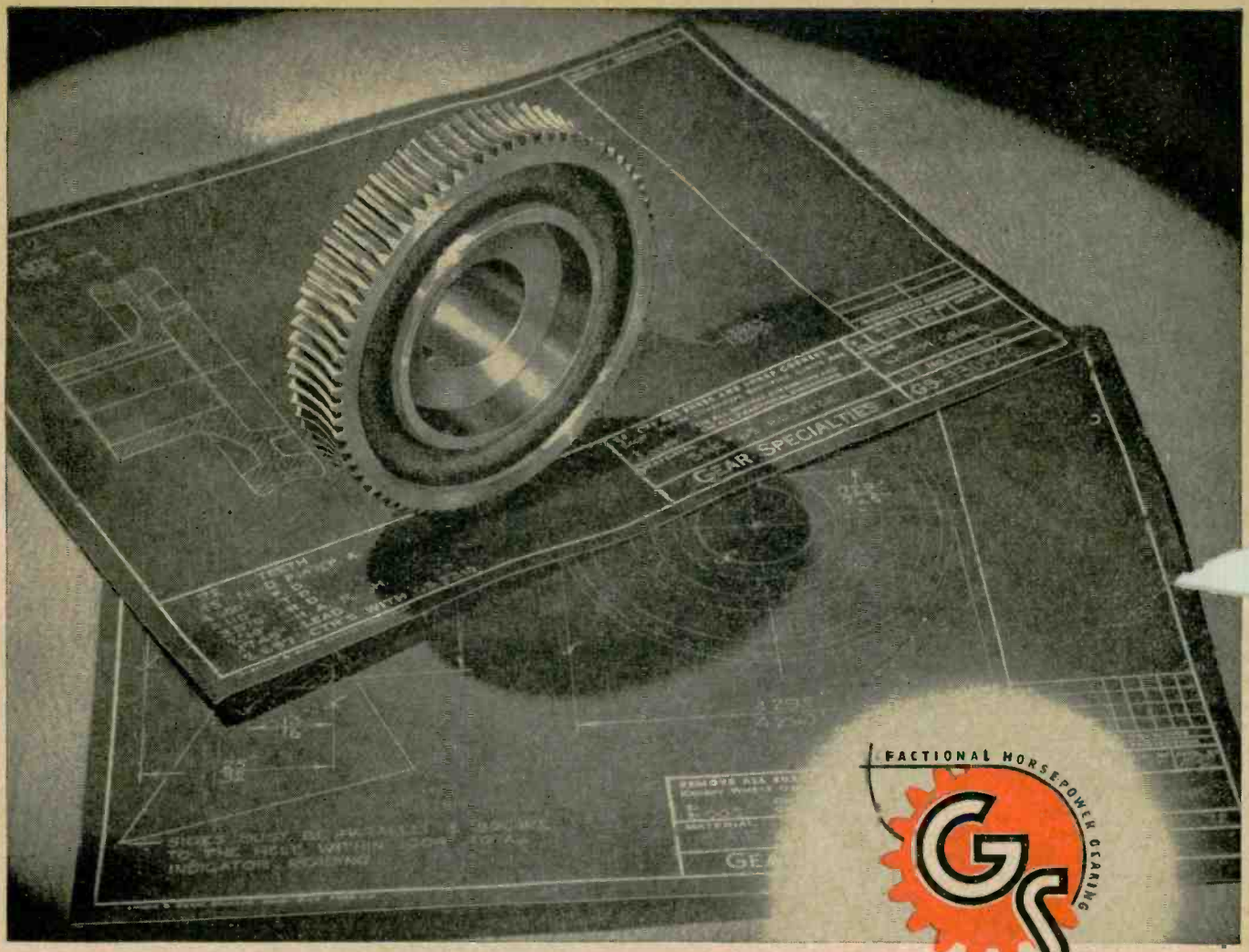
ELECTRONIC COMPONENTS

A. W. FRANKLIN MANUFACTURING CORP.

43-20 34th St., Long Island City 1, N. Y.

In California: A. W. FRANKLIN Mfg. Corp. of CALIFORNIA, 2216 West 11th St., Los Angeles 6, Calif.

SOCKETS • TERMINAL STRIPS • PLUGS • SWITCHES • PLASTIC FABRICATION • METAL STAMPINGS • ASSEMBLIES



CUSTOM-BUILT TO THE MOST *Exacting Specifications*

G-S SMALL GEARS are cut to extremely close tolerances. Each specification, however exacting, is executed and inspected with a degree of precision seldom equalled in small gear manufacture. Here, every facility has been provided for speedy, uniform quantity production: 1. Skilled engineers and designers; 2. Modern methods and machinery; 3. Trained operators; 4. Intensive series of inspections. 5. All operations under the constant supervision of *specialists*—men long experienced in producing Fractional Horsepower Gears exclusively. That's why G. S. Gears perform so smoothly and dependably for years, and that's why *each* G. S. Gear measures up to the same, exacting specifications. If Small Gears, from 12 to 96 d.p., are an important consideration in YOUR plans, for your own best interests, let our organization of specialists tackle the job! Consult with our engineers, or write today for a copy of the new G. S. catalog bulletin.

SEND FOR OUR 4-PAGE CATALOG

GEAR Specialties

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

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

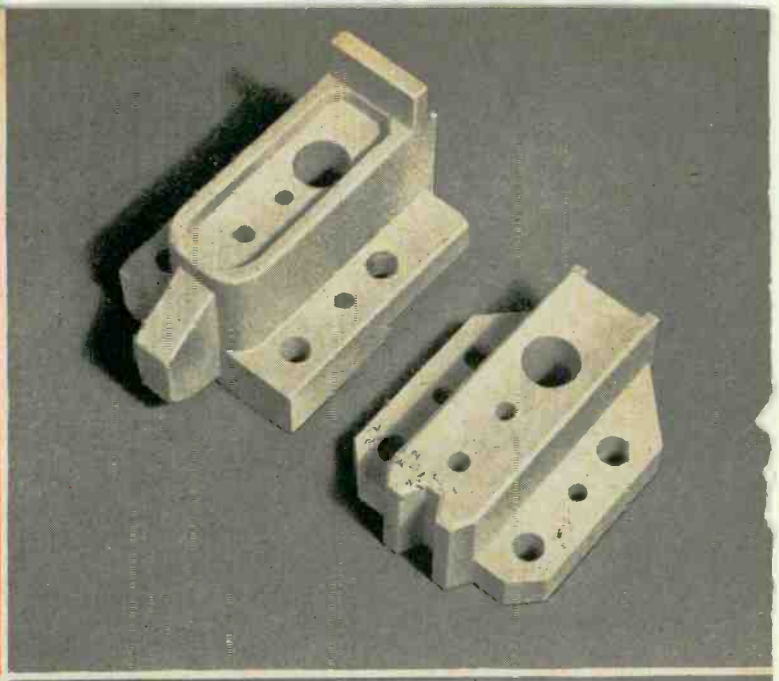
MEMBER OF AGMA

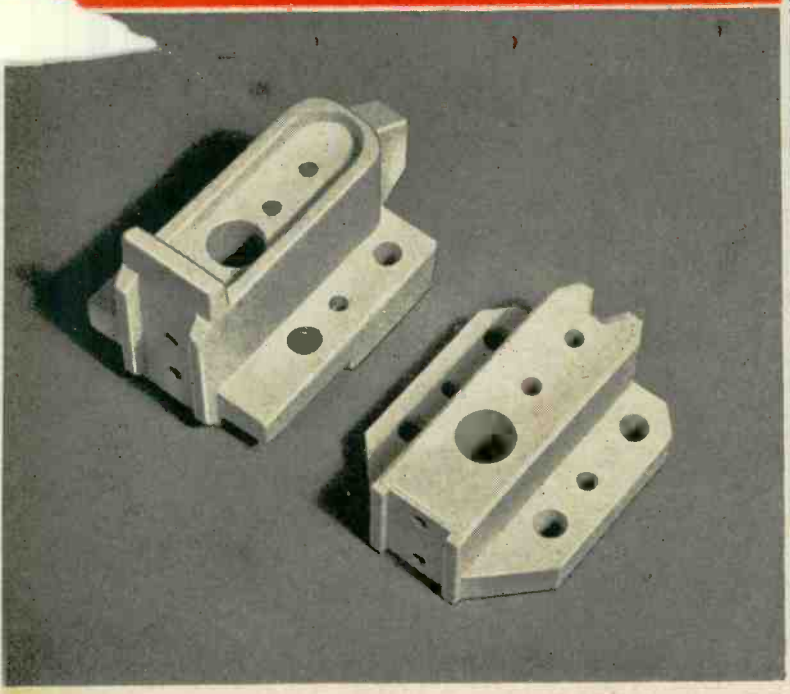
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

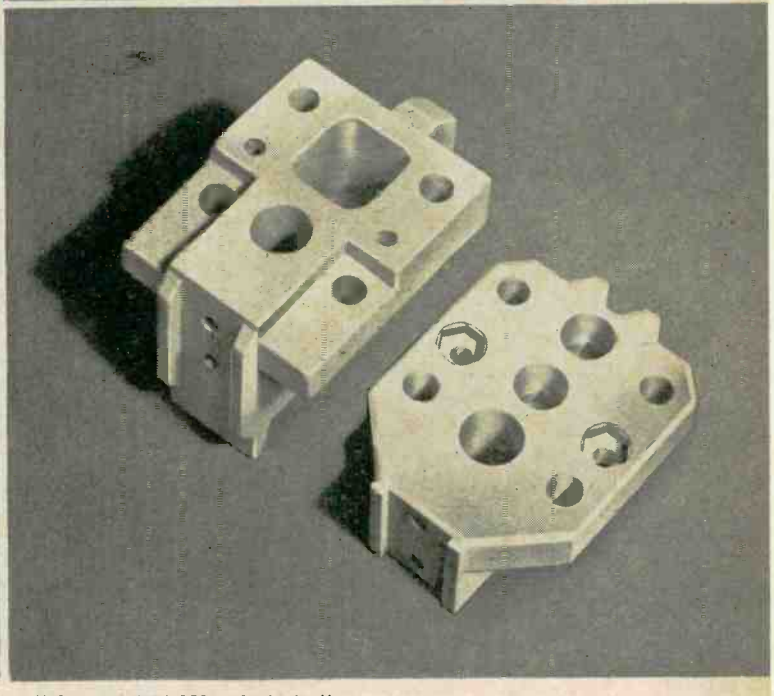
Redesign

IMPROVED PERFORMANCE

CUT COSTS 62%







Photographs courtesy JAMES R. KEARNEY CORP., St. Louis, Mo.

THE designing engineer who specifies ceramics knows exactly what is required, but the special knowledge and experience of the ceramic engineer frequently enables him to make design suggestions for low production cost.

Maximum efficiency and maximum production at lowest cost result when the designing engineer and the production engineer work together. The illustrations above show the results of such collaboration. The original and the final designs are shown in three perspectives.

Redesign of this part cut costs 62%. Maximum deliveries in minimum time were made possible. In addition, the customer said: "Your suggestions on redesign greatly strengthened this component, reduced its size and weight, and increased its utility."

American Lava Corporation engineers will gladly cooperate with you in developing your ideal design in AlSiMag custom made technical ceramics. In their 44th year of practical experience they offer production facilities and techniques that can be most valuable to any user of custom made ceramics.

NEW PROPERTY CHART—A new property chart giving the physical, electrical and mechanical properties of the more frequently used AlSiMag technical ceramic compositions will be mailed without charge on your request.

AlSiMag

Trade Mark Registered U.S. Patent Office

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE

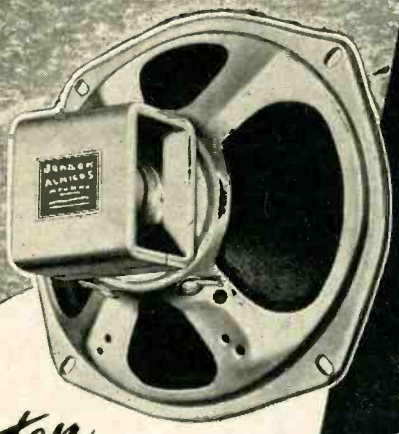
44TH YEAR OF CERAMIC LEADERSHIP

ENGINEERING SERVICE OFFICES:

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

Listen!

2 NEW Jensen Extended Range High-Fidelity PM SPEAKERS



These two Jensen speakers with *Alnico 5* PM design, provide excellent high-fidelity performance. Excellent as replacement and modernizing units for FM and television receivers, radio-phonograph combinations for studio monitoring, wired music, and for similar applications. Installed in Jensen *Bass Reflex** cabinets, they provide exceptionally high-quality reproduction with added octaves of bass response.

*Trade Mark Registered

Listen ...it's a Jensen SPEAKER

Model P8-SH (Superseding PM8-CT). A high-fidelity 8-inch *Alnico 5* PM speaker. Recommended for use with Jensen Model A-81 *Bass Reflex* cabinet. Maximum power handling capacity in speech and music systems, 6 watts. . . . Voice coil impedance, 6-8 ohms.

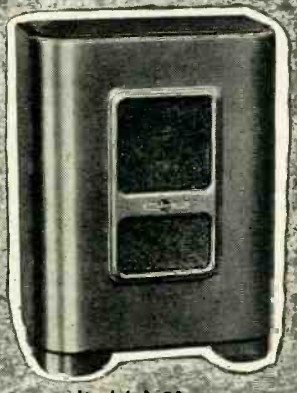
* *Standard Fidelity Model P8-S. Voice coil impedance, 3-4 ohms. Maximum power handling capacity in speech and music systems, 8 watts.*

Listen ...it's a Jensen SPEAKER

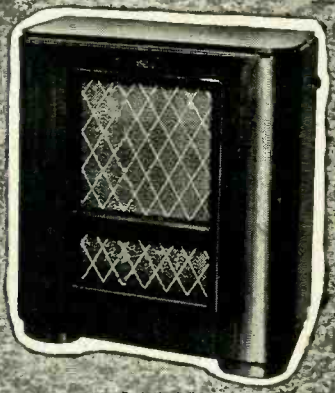
Model P12-SH (Superseding PM12-CT). A new 12-inch high-fidelity *Alnico 5* PM speaker. Designed for use with Jensen Model A-121 or Model D-121 *Bass Reflex* cabinets. Maximum power handling capacity in speech and music systems, 8 watts. Voice coil impedance, 6-8 ohms.

Standard Fidelity Model P12-S. Voice coil impedance 6-8 ohms. Power handling capacity in speech and music systems. 10 watts.

BASE REFLEX CABINETS



Model A-81—
for Model P8-SH speaker
Model A-121—
for Model P12-SH speaker



Model D-121—
for Model P12-SH speaker

Jensen SPEAKERS WITH ALNICO 5

Designers and Manufacturers of Fine Acoustic Equipment

JENSEN MANUFACTURING CO., 6607 S. LARAMIE AVE., CHICAGO 38, U. S. A.

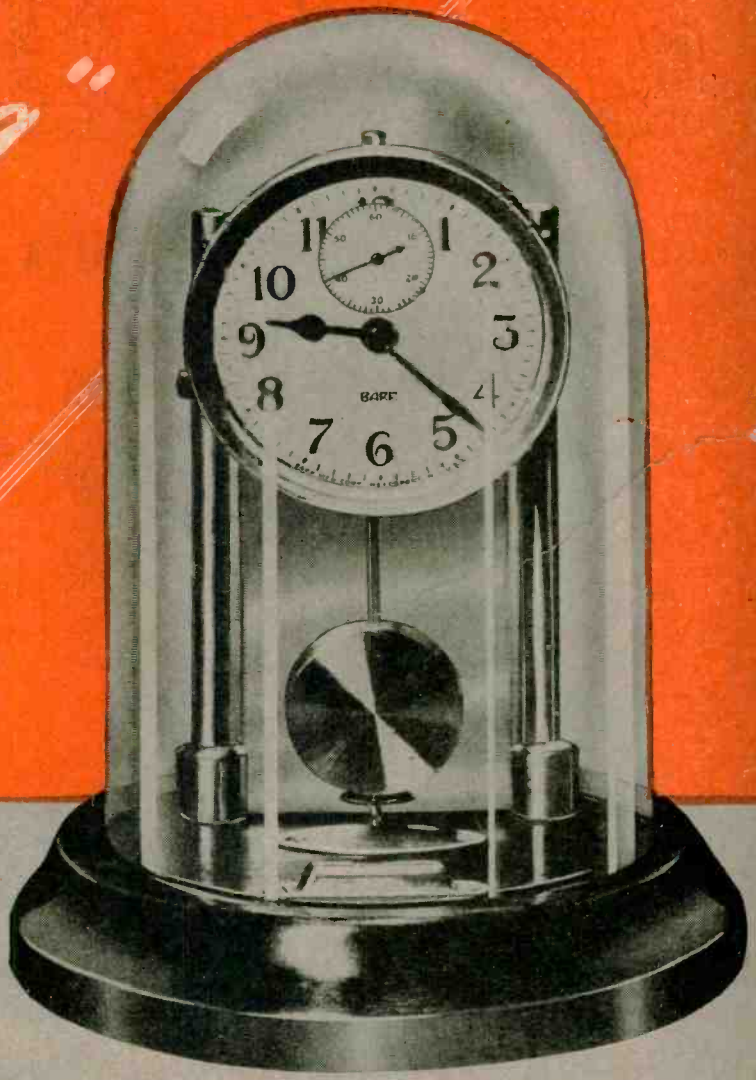
In Canada: Copper Wire Products, Ltd., 11 King St., W., Toronto, Ont.

This Modern *Miracle* Clock keeps

"In the Swing"

with

DRIVER-HARRIS NILVAR



GRANDFATHER'S CLOCKMAKER didn't worry about the effect of temperature on the length and arc of a clock's pendulum — a minute lost or gained didn't matter. Today it does — and today we have the alloy Nilvar.

Nilvar is a remarkable alloy which has identical microscopic length at widely varying temperatures. For that reason, Barr Manufacturing Corporation selected it for the pendulum of its new "miracle" Executive Clock which depends for its accurate operation upon the unvarying characteristics of the pendulum arc — at any temperature.

This unusual clock provides synchronous motor accuracy, yet operates from a self-contained power supply. In operation, as the pendulum momentum gradually lessens, its arc decreases until, at a pre-determined point a tiny weight is released which imparts fresh momentum to the pendulum. Thereupon the weight is instantly retrieved by a small-battery-energized electro magnet, in preparation for another cycle. No alloy but Nilvar could permit such critical pendulum arc control, for *Nilvar has the lowest T. C. of expansion of any alloy yet developed* — even lower than that of quartz.

Somewhere in your engineering or production operations — or in the operation of your product — the critical dimensional stability of Nilvar may help to solve a problem of long standing. Why not call on Driver-Harris engineers for their recommendations.

D H
SPECIAL PURPOSE ALLOYS SINCE 1919

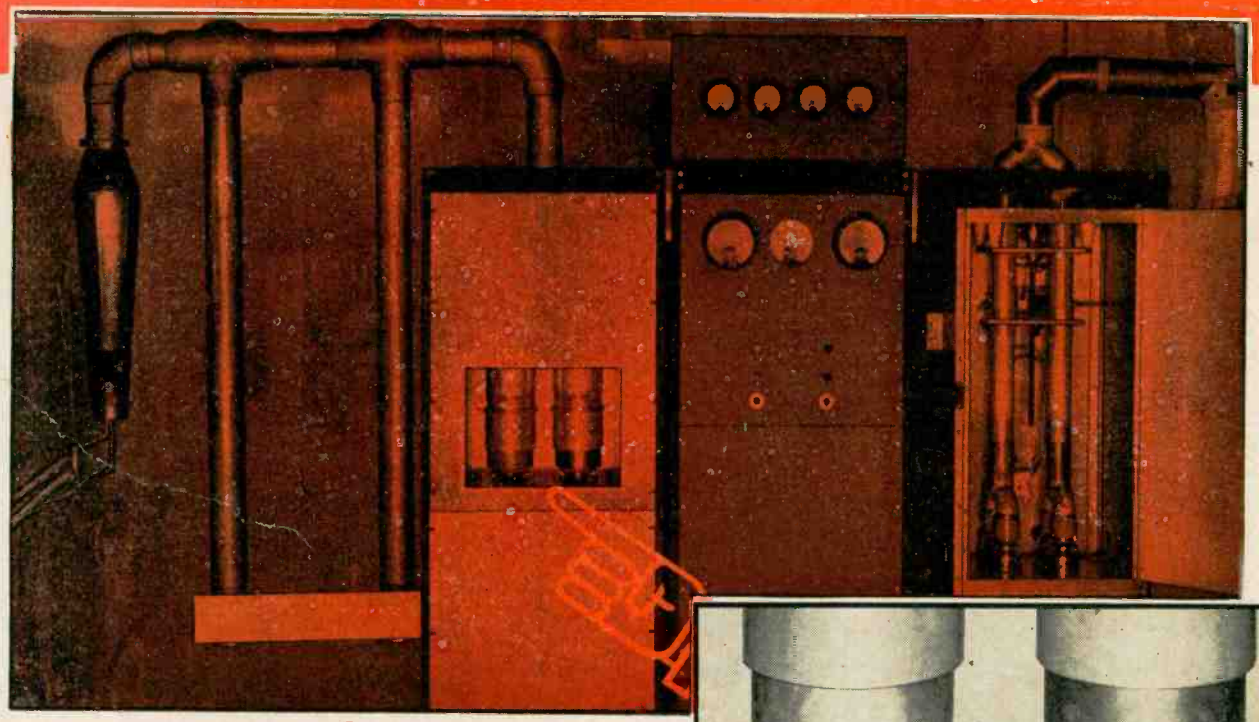
*Trade Mark
Reg. U.S. Pat. Off.

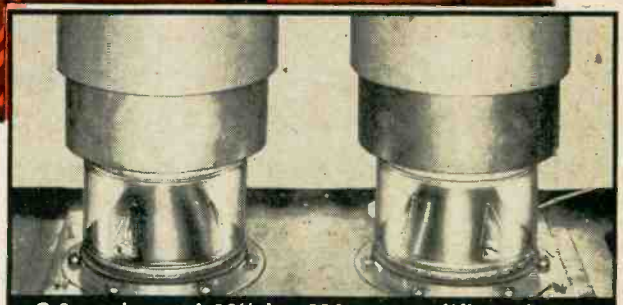
The B. GREENING WIRE COMPANY, LTD.
Hamilton, Ontario, Canada

Driver-Harris COMPANY
Exclusive Manufacturers of Nichrome
HARRISON, N. J.

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

COMPACT VERSATILITY for 10 KW at 110 MC





● Experimental 12½ kw 110 mc amplifier, above, and detail of Eimac 3X2500A3 triodes in final stage. Combination plate lines and air ducts simplify cooling.

Mounted in a 19-in. relay rack as illustrated above, two Eimac 3X2500A3 triodes are regularly pushing more than 10 kw of useful output power into a water-cooled load in the Eimac testing department. As measured, 12,500 watts is being delivered at 110 mc. The tubes are operating class C in a grounded-grid circuit, which requires no neutralizing and gives an apparent overall efficiency of 90 per cent. Circuit losses are reduced to a minimum by the use of low plate voltage. The 3X2500A3's deliver 12.5 kw at only 3500 plate volts.

So compact are the 3X2500A3 triodes (see inset closeup) that the entire final amplifier and driver can be housed in the equivalent space of two five-foot racks. The driver section, as shown at the right, provides 3 kw of driving power with four of Eimac's new 4X500A tetrodes in a push-pull parallel circuit. The low plate-voltage requirements of the 3X2500A3 also permit use of a common power supply for driver and amplifier.

Simple compact transmitter design is now made possible in the higher power brackets of the new f-m band. The Eimac 3X2500A3 offers a number of design advantages such as low driving power, low plate voltage, functional electrode terminations, and tool-less installation and removal. Write for full particulars.

EITEL-McCULLOUGH, INC., 1363E San Mateo Ave., San Bruno, Calif.
Export Agents: Frazar and Hansen, 301 Clay Street, San Francisco 11, Calif., U.S.A.

Follow the Leaders to

Eimac TUBES

BIG POWER IN A SMALL PACKAGE

EIMAC 3X2500A3 TRIODE

Besides the ability of a pair to produce 12½ kw of useful power output at 110 mc, the Eimac 3X2500A3 fills the bill for:

INDUSTRIAL HEATING . . . High power output at low plate voltage combines process speed and efficiency with safety to personnel. Low voltage is an additional advantage in tough industrial surroundings involving dust, dirt and moisture.

AUDIO AMPLIFICATION . . . Low plate resistance of the Eimac 3X2500A3 gives it excellent qualifications for use as a class-B modulator tube.

SUPERSONICS . . . Low voltage and high power with small driving power requirements combine to make an efficient and economical tube for application to low-frequency work as well as operation in the vhf region. This makes it just the tube for high-power applications in the supersonic frequencies.

Outstanding features of the Eimac 3X2500A3 triode include:

FILAMENT . . . Thoriated tungsten for high electron emission at low temperature and long useful life.

GRID . . . One hundred per cent useful grid area, with no interfering support structure. Grid wires specially treated by exclusive Eimac process exhibit suppressed primary emission for precise control and stability and controlled secondary emission for low driving requirements.

ANODE . . . External type with vertical-finned cooler of a size which facilitates combination of plate lines and air ducts, at the same time providing ample cooling without the need for either high air pressures or inconveniently large volumes of air. Sufficient cooling of the entire tube can be conveniently performed with only one blower. Low plate voltage gives high circuit efficiency, reduces power supply costs, minimizes operating failures by arc-over, and increases safety.

LEADS . . . Heavy cylindrical leads have low inductance and high current capacity. They make shielding easy and work well with coaxial lines. Tubes can be inserted and removed without tools.

GET FULL INFORMATION . . . Write for complete application data on the Eimac 3X2500A3 triode.

THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

EITEL-McCULLOUGH, INC.
1363E San Mateo Ave., San Bruno, California
Export Agents: Frazar and Hansen, 301 Clay St., San Francisco 11, California, U. S. A.

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

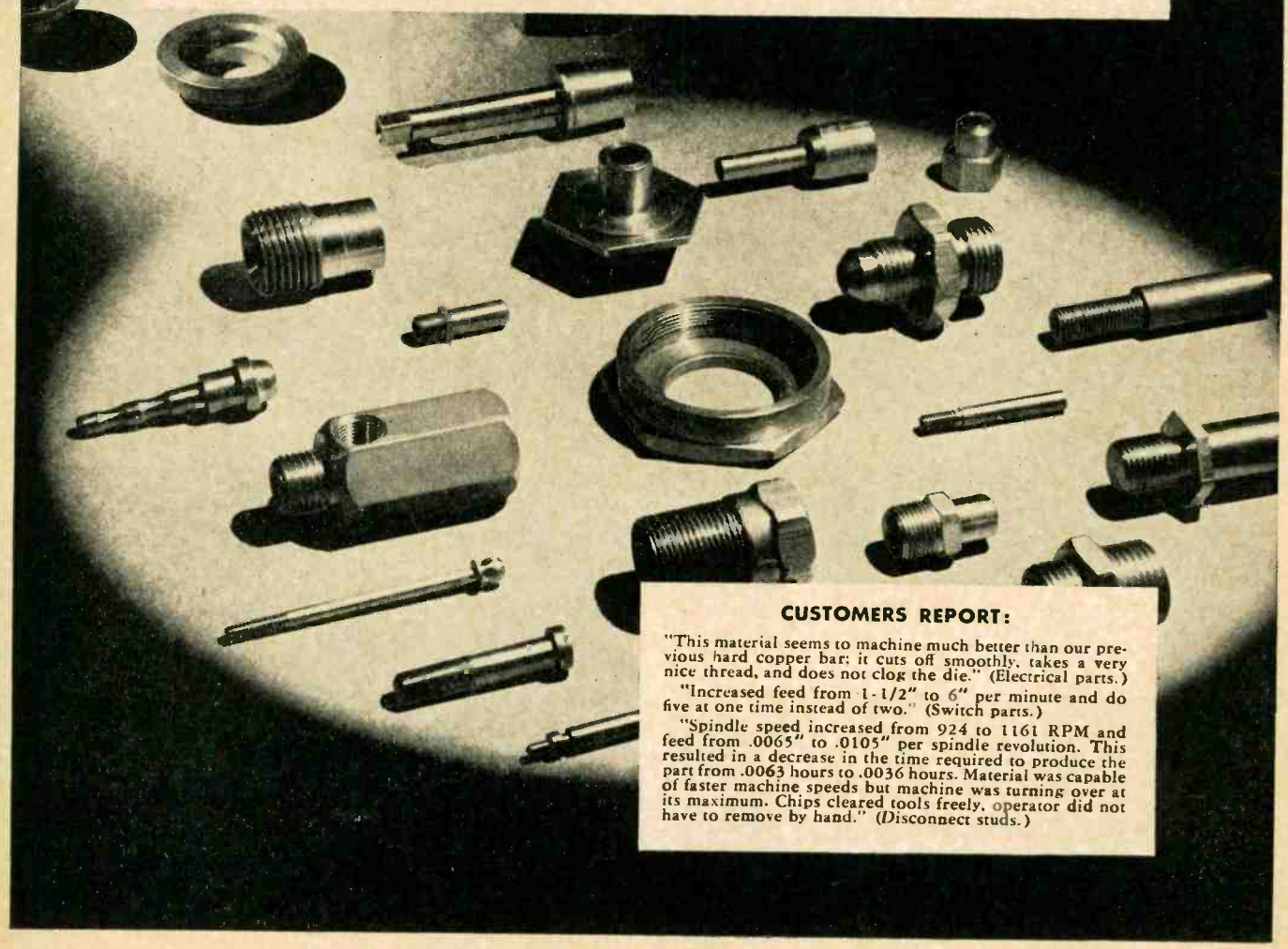
COPPER AND BRASS INCORPORATED

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.

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



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.)

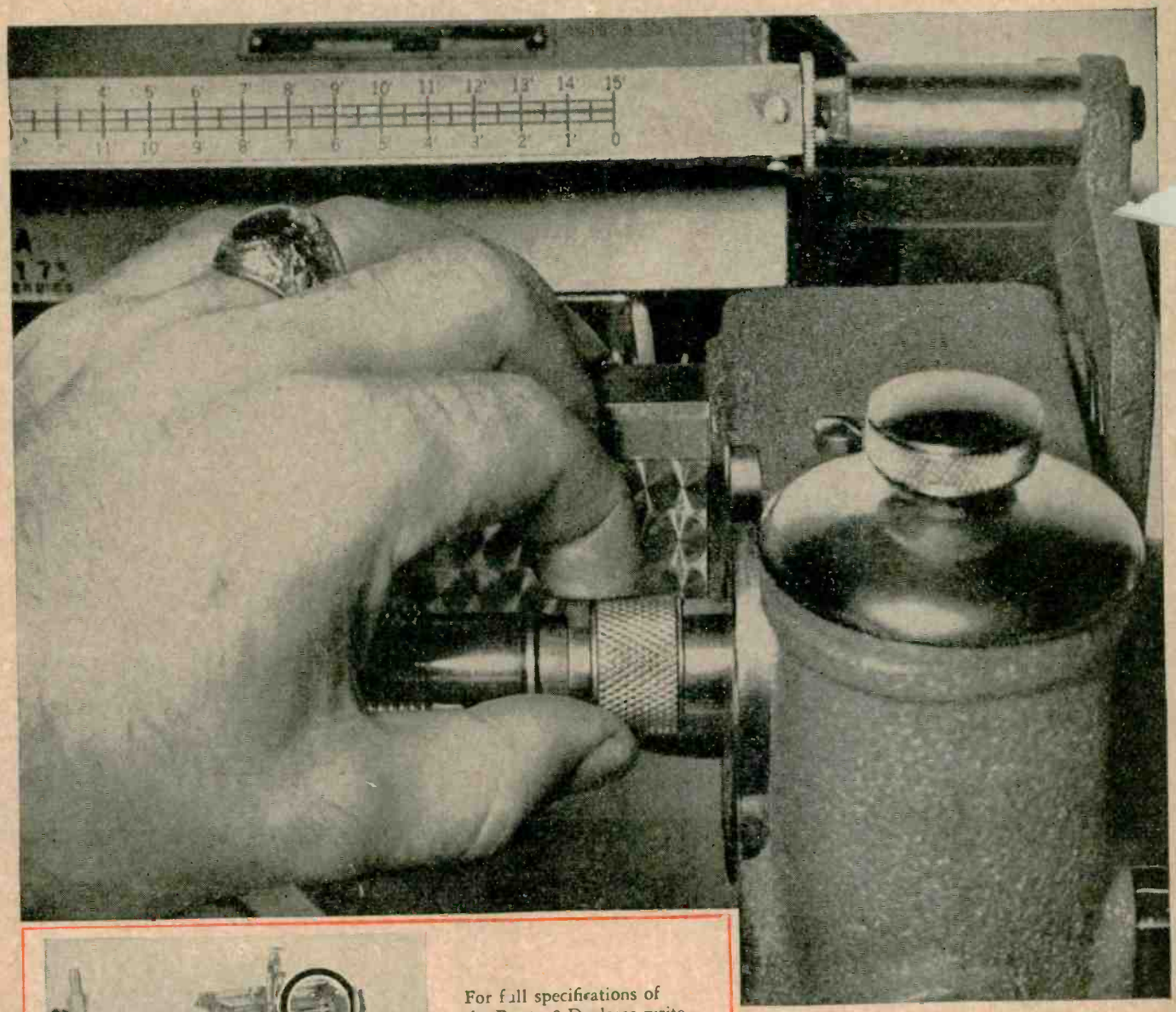
"Increased feed from 1-1/2" to 6" per minute and do five at one time instead of two." (Switch parts.)

"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.)

change pitch and direction almost instantaneously with the improved Presto 8-D Recorder

The Improved Presto 8-D Recorder is equipped with a reversing device for the feed screw. Result: Six feed pitches, inside-out *and* outside-in, using only one feed screw. This feed screw need never be removed from the recorder. Thus, changes in pitch and direction are accomplished within a matter of seconds.

The Presto 8-D Recorder is the easiest and most convenient machine to operate because of the arrangement of its controls and the cantilever overhead which saves lost motion in operation. Its unusually heavy construction assures high fidelity masters and instantaneous recordings.



For full specifications of the Presto 8-D please write Presto Recording Corporation, 242 West 55th Street, New York 19, N.Y. To insure future delivery within a reasonable time, we suggest you place your order now for immediate listing.

PRESTO

RECORDING CORPORATION

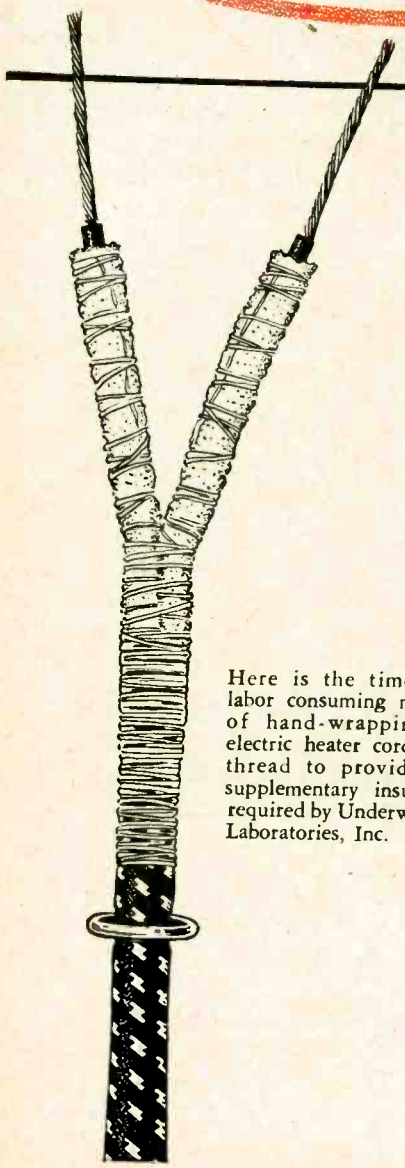
242 West 55th Street, New York 19, N. Y.

Walter P. Downs, Ltd., in Canada

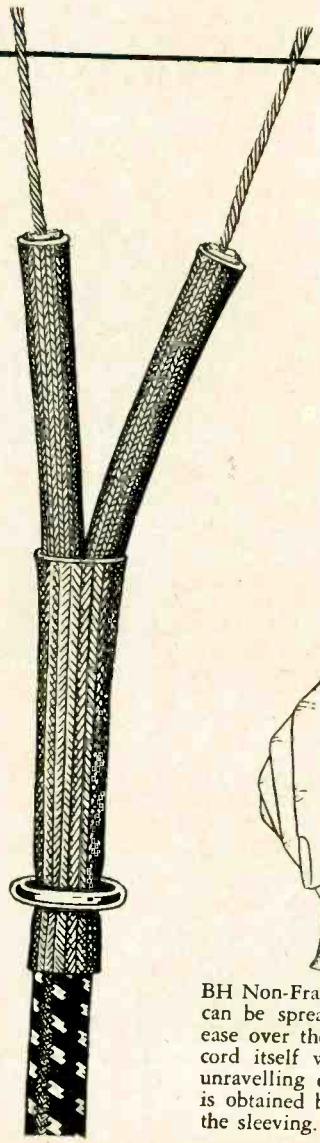
World's Largest Manufacturer of Instantaneous Sound Recording Equipment

Where heater cord is used and the temperatures on the braid within the appliance exceed 90° C, supplementary insulation is required over the braid.

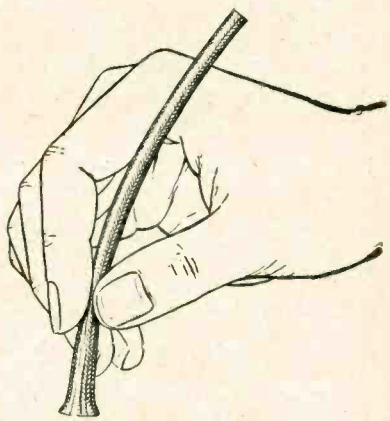
Underwriters' Laboratories, Inc.



Here is the time-and-labor consuming method of hand-wrapping an electric heater cord with thread to provide the supplementary insulation required by Underwriters' Laboratories, Inc.



Here is an electric heater cord with "pants" of BH Non-Fraying Fiberglas Sleeving, easily slipped over the leads and covered by a larger BH Fiberglas Sleeving. Saves minutes in the insulation of each cord. Approved by Underwriters' Laboratories, Inc.

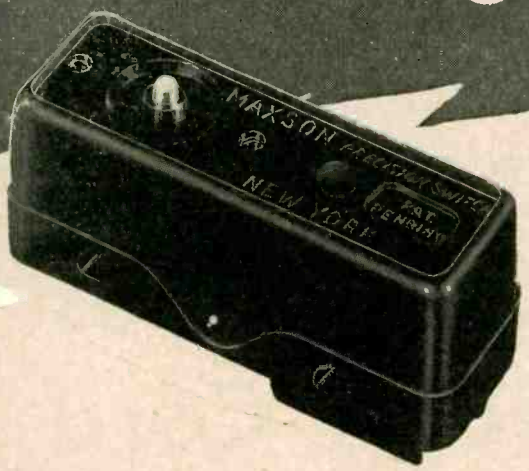


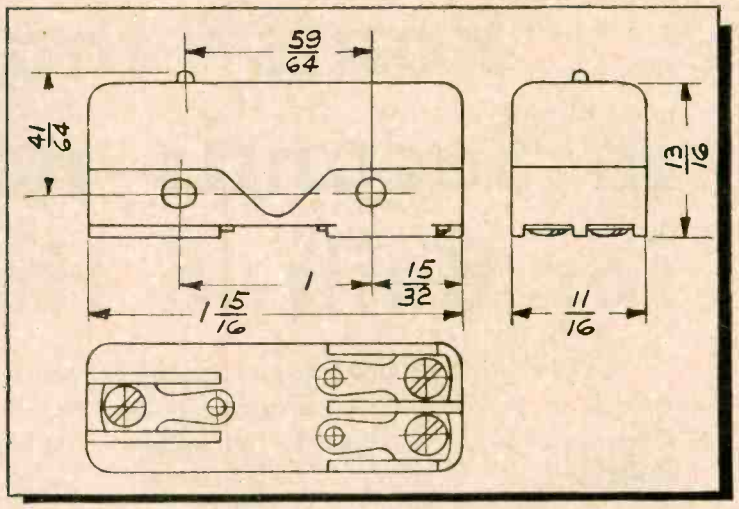
BH Non-Fraying Fiberglas Sleeving can be spread so that it fits with ease over the leads and the heater cord itself without any danger of unravelling or fraying. A snug fit is obtained by pulling the ends of the sleeving.

UNIMAX

PRECISION SWITCH

UNIFORM OPERATING CHARACTERISTICS

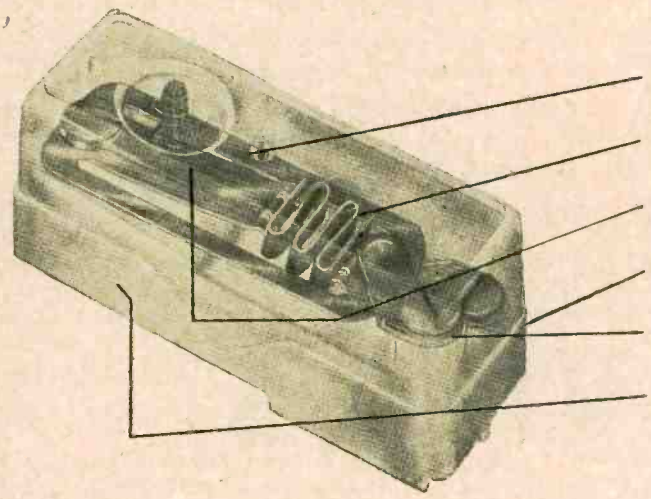




UNIMAX is a compact, snap-action electric switch embodying unique advantages that extend the utility of millibreak switches.

UNIMAX was designed to meet a recognized need for a switch with **uniform** performance characteristics and **maximum adaptability** to present and future applications. Mathematically calculated to provide the consistent uniformity of force and movement characteristics essential in mass production of precision apparatus, UNIMAX has been proved—over long periods and with thousands of test specimens—to confirm the mathematical predictions.

UNIMAX uniformity of mechanical characteristics simplifies production of precision apparatus by making possible the installation of switches without need for individual adjustment of associated apparatus. Run-of-lot switches are interchangeably usable both among units in any shipment or from several different shipments.



THESE DESIGN FEATURES

are planned for superior performance.

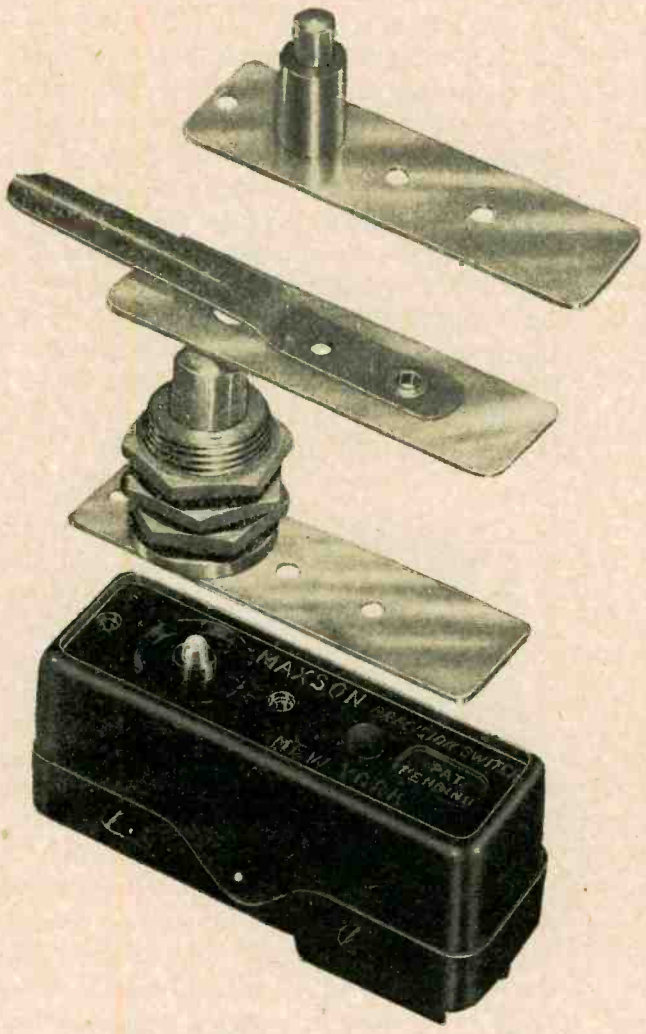
- **One-piece moving member** of heat-treated beryllium copper; tongue ribbed for maximum stability
- **Folded flat spring** exerts high contact pressure and produces instant traverse
- **Non-rotatable button** assures application of actuating force to same spot on tongue throughout life of switch
- **Molded phenolic case** permanently sealed together in assembly
- **Contacts of pure silver** laminated on copper; moving contact has low mass for minimum contact bounce
- **One mounting hole elongated** for convenience in production assemblies
- **Electrical ratings:** 15 amp. 125 volts; 5 amp. 250 volts; ½ H P, 115-460 volts 60 cycles; all units S. P. D. T.

UNIMAX SWITCH CORP.

UNIMAX
PRECISION SWITCH

MAXIMUM ADAPTABILITY TO VARIED USES

UNIMAX is new in name and in the advantages it provides, but it is not an untried product. It is a tested, original design of an old, established manufacturer. Designed to meet a need not satisfied by existing switches, UNIMAX is backed by an engineering organization with a reputation for reliability, resourcefulness, and broad experience. The capabilities of these mechanical, electrical, metallurgical, and chemical engineers are available for engineering all UNIMAX applications.



Maximum adaptability to diverse applications — obtainable, with minimum stocks, by virtue of removable, interchangeable, auxiliary actuators. This unique UNIMAX feature cuts inventories by allowing the basic switch to be adapted to varied uses by auxiliaries added in factory assembly or to be stocked separately. Further simplification of inventory results from the fact that every UNIMAX Precision Switch can be used for any of the three standard single-pole circuits.

UNIMAX SEPARABLE AUXILIARIES EXCEL BECAUSE

1. Each actuator—leaf or plunger type—is secured to a stainless steel mounting plate so that maximum strength is obtained.
2. The actuator assembly fits tightly in the molded recess in the top of the switch case thus strengthening the assembly.
3. All actuators are applicable to all switches and can be removed, re-installed, or interchanged without disassembling the switch or altering its operating characteristics.
4. The unique UNIMAX design affords flexibility of assembly and maintains the uniform accuracy of the basic switch for any type actuator.

New UNIMAX data will be issued for engineers interested in design and construction of apparatus requiring precision switches. Use the coupon to place your name on file for receipt of these data as released.

UNIMAX SWITCH Corporation
460 West 34th St., N.Y. 1, N.Y.

Gentlemen:
Please register my name for UNIMAX data sheets as issued. I am interested in the possible application of UNIMAX to _____

Title _____

Name _____

Company _____

Street & No. _____

City _____

State _____

A SUBSIDIARY OF
The W. L. MAXSON CORP.
460 WEST 34th ST., N.Y. 1, N.Y.

ELECTRONICS

Designers

ACCURATE TIME AND CURRENT CONTROL

for bench welders

To cut welding time on small-part fabrication, such as welding solid or stranded conductors to terminals, welding electronic tube elements, or other small parts, look into the possibilities of the Thyratron-controlled bench-or-tong, low-capacity spot welder.

These alert, accurate controls, with a suitable transformer, have recorded a two-to-one advantage over soldering and rivet fabrication. Because of Thyratron welding controls' accuracy and split-cycle response, rejects drop to a new low. They are designed for either 230v or 460v, 60-cycle operation, and are rated 77 amperes peak on a duty cycle not exceeding 10 per cent. Equipment for 50-cycle operation is also available. Write for Bulletin GEA-4175A.

ONE AND A HALF INCHES

of instrument accuracy

General Electric's 1½-inch panel instruments include direct-current, radio-frequency, and audio-frequency types, in both conventional and watertight construction. All feature the compact, internal-pivot element and Textolite cases; will withstand 50 G's shock, and are accurate to within ±2 per cent. The conventional, direct-current instrument is supplied self-contained for current measurements from 100 microamperes to 10 amperes and for voltage measurements up to 150 volts. For other requirements, combinations of instruments and accessories can be had. Write for Bulletin GEA-4380.

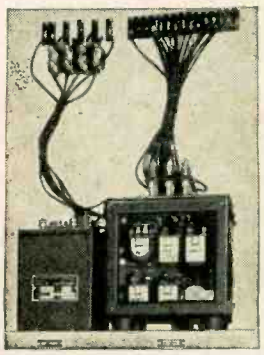
TERMINAL BOARDS *to cut wiring time*

There's less motion and more wiring speed when terminal boards are G-E Type EB-2. Strip the wire-end, insert it in the connector, tighten a screw, and the connection is made. Each of these solderless, pressure connectors will accommodate one No. 8 stranded conductor, two No. 12 stranded conductors, or three No. 12 solid conductors, all AWG.

Type EB-1 differs from EB-2 only in its terminals, which are the conventional washer-headed screw type. Both boards are molded from strong, long-lasting Textolite, both are available in 4-, 6-, 8-, and 12-pole sizes, and are equipped with marking strips. Covers are optional. Write for Bulletin GEA-1497A.

Fast Hook-ups that stay put

with FLAMENOL WIRE

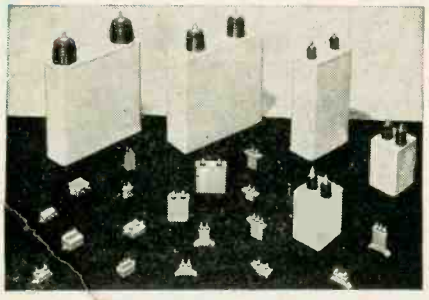


Flamenol hook-up wire's tough, plasticized-polyvinyl-chloride insulation strips clean, bends without cracking, and is available in seven different colors. Normally, it needs no bulky armor-braid for protection. As a result, Flamenol speeds up wiring operations on electronic apparatus, where voltages do not exceed 600. Flame-resistant, corrosion-resistant, non-oxidizing, and unaffected by most hydrocarbon solvents, mild acids and alkalies, Flamenol rarely needs either attention or replacing. Its glossy finish looks new, and stays that way. Write for Bulletin GEA-4352.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E COMPONENTS



NEW D-C PYRANOL* CAPACITORS

with new quality, sizes, ratings

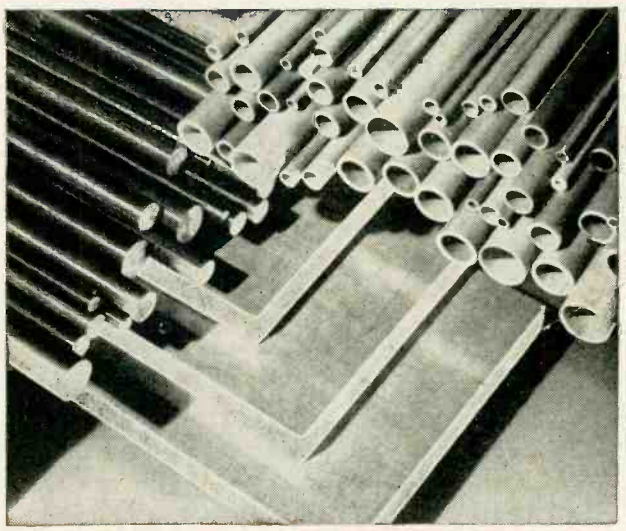
New materials, new manufacturing techniques and strict quality control, which were so important in the excellent records d-c Pyranol capacitors made during the war, are now incorporated into a new line of d-c Pyranol capacitors built to meet exacting commercial requirements.

This new line of d-c Pyranol capacitors has a broader range of sizes, ratings, and mounting arrangements, with characteristics that allow operation through the temperature range from –55C up to 85C, at altitudes as high as 7,500 feet. Sizes range from "bathtub" up to large, welded-steel case sizes, capacitance from .01 muf to 100 muf, and voltages from 100v to 100,000v. Write *Transformer Division, General Electric Company, Pittsfield, Mass.*

*Reg. U. S. Pat. Off.

MORE "KNOW" MEANS *better "do"!*

To help train new technical personnel, and make supervisory and production men's jobs mean more, G.E. offers this 12 part talking slide film, prepared to teach even non-technical personnel the elements of electronics. It comes complete with 12 slide films and records, 300 review books, instructor's manual and carrying case; price of the kit is $100. Call your local G-E office, or order direct from *Apparatus Dept., Sect. 642-13, General Electric Co., Schenectady 5, N. Y.*



FITS AND FIT FOR

any laminated-plastic job

Because it can be fabricated with machine tools into practically unlimited numbers of shapes, G-E Textolite sheet, tube, and rod stock adds flexibility to electronic apparatus design. Over fifty different grades – each with an individual combination of electrical, mechanical, chemical, and thermal properties – assures you that tube bases, coil forms, bus-bar supports and other components will be exactly right for your job. For additional information on G-E Textolite, write to *Plastics Divisions, Chemical Department, General Electric Company, Pittsfield, Mass.*

General Electric Company, Sect. A-642-13
Apparatus Department, Schenectady 5, N. Y.

Please send me

.....**GEA-1497A (Terminal Boards)**
.....**GEA-4175A (Thyratron Welding Controls)**
.....**GEA-4380 (Small Panel Instruments)**
.....**GEA-4352 (Flamenol)**

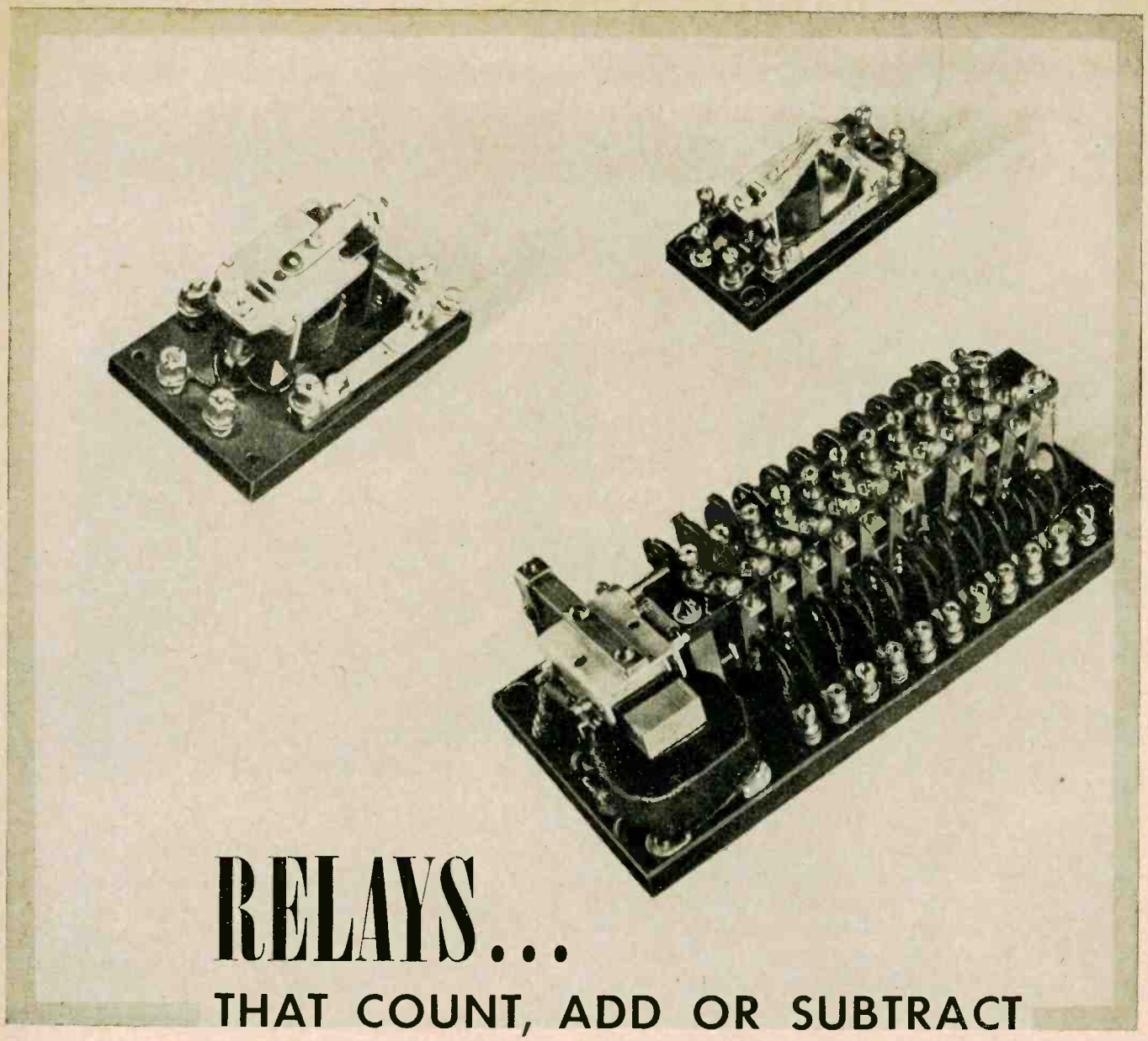
Note: More data available in Sweets File for product designers.

Name_____

Company_____

Address_____

City_____ **State**_____



RELAYS...

THAT COUNT, ADD OR SUBTRACT

. . . and have unfailing memories

Ratchet-type relays, another version of the popular Struthers-Dunn "Memory" Relay Series, are designed to supervise a control pattern for two or more circuits by successive impulses to a single operating coil. They are widely used for street railway safety signals, capacitor bank switching, single button control of reversing mechanisms, interlocking, and other operations requiring "memory" or "counting" supervision.

Also available with two operating coils for electrical re-set or "forward-and-reverse" stepping.

S-D
STRUTHERS-DUNN, INC.

5,327 RELAY TYPES

STRUTHERS-DUNN

STRUTHERS-DUNN, INC., Philadelphia 7, Pennsylvania

ATLANTA • BALTIMORE • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DALLAS
DENVER • DETROIT • HARTFORD • INDIANAPOLIS • LOS ANGELES • MINNEAPOLIS • MONTREAL
NEW YORK • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

THORDARSON

Transformers

A guarantee of Quality Performance Since 1895!

For over half a century Thordarson has been manufacturing the finest in transformer equipment. The oldest company in the field, it has pioneered many new developments, including the superior core and coil materials now used throughout its entire line. This vigorous policy of research and development, together with an unusually high standard of production, has made the name Thordarson a guarantee of quality . . . an assurance of trouble-free performance among engineers everywhere.

Thordarson's engineering staff and Thordarson's field men are prepared to assist you with your transformer problems. We are especially equipped to handle those types of transformers which require a high degree of engineering skill and which must be built to very rigid specifications. Send us complete details as to your requirements.

P. S. Deliveries aren't too bad these days, either!

ELECTRONIC DISTRIBUTOR and INDUSTRIAL SALES DEPT.

MAGUIRE INDUSTRIES, INCORPORATED

936 N. MICHIGAN AVENUE CHICAGO 11, ILLINOIS

EXPORT SALES DIVISION • SCHEEL INTERNATIONAL, INCORPORATED

4237-39 N. LINCOLN AVE., CHICAGO 18, ILL. U.S.A. CABLE ADDRESS — HARSCHEEL

depend upon

Mitchell-Rand

ELECTRICAL INSULATION HEADQUARTERS

SINCE 1889

WAXES and COMPOUNDS

. . . yes, you can rely upon Mitchell-Rand to supply the particular compound or wax to meet your specific requirement . . . and if in the extensive line totaling more than 3500 formulas, there isn't one which meets your conditions—then, Mitchell-Rand will create a compound embodying every quality required . . . an outstanding example of such special service is the development of EX 1257 Dipping and Impregnating Wax—just check the following specifications of the latest in Mitchell-Rand's large list of Waxes and Compounds:

Specifications and Test Data
M-R EX1257 Dipping and Impregnating Wax

Ring and Ball Softening Point	171 to 177° F.
Melting Point, UTD (Ubbelohde Method)	192 to 198° F.
Penetrations	32/200/60-8 to 10 77/100/5-6 to 8 115/50/5-10 to 12
Flash Point	500° F.
Specific Gravity at 60° F.	1.005 color tan
Viscosity, Saybolt Furol	at 250° F.—175 to 180 seconds at 275° F.—125 to 130 seconds at 300° F.— 90 to 95 seconds

FREE FOR THE ASKING

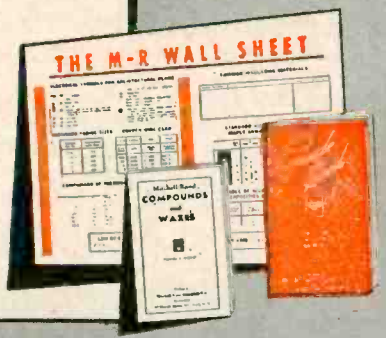
Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drill sizes, etc.

M-R COMPOUNDS

RESIST high voltage breakdown . . . salt spray atmosphere . . . humidity . . . cracking or flaking . . . acids and alkalis.
HAVE excellent flexibility . . . adhesive qualities . . . high cold flow . . . good thermal conductivity.

M-R WAXES

PENETRATE fibre . . . floss . . . bakelite . . . paper and cloth.
HAVE low viscosity . . . high surface tension . . . good electrical characteristics.
MORE THAN 3500 FORMULAS



No matter how difficult or involved your insulating and impregnating Wax or Compound problems are—bring them to Mitchell-Rand . . . the "Electrical Insulation Headquarters"

HEADQUARTERS FOR ELECTRICAL INSULATION — MR — FOR 50 YEARS

MITCHELL-RAND INSULATION COMPANY, INC.

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

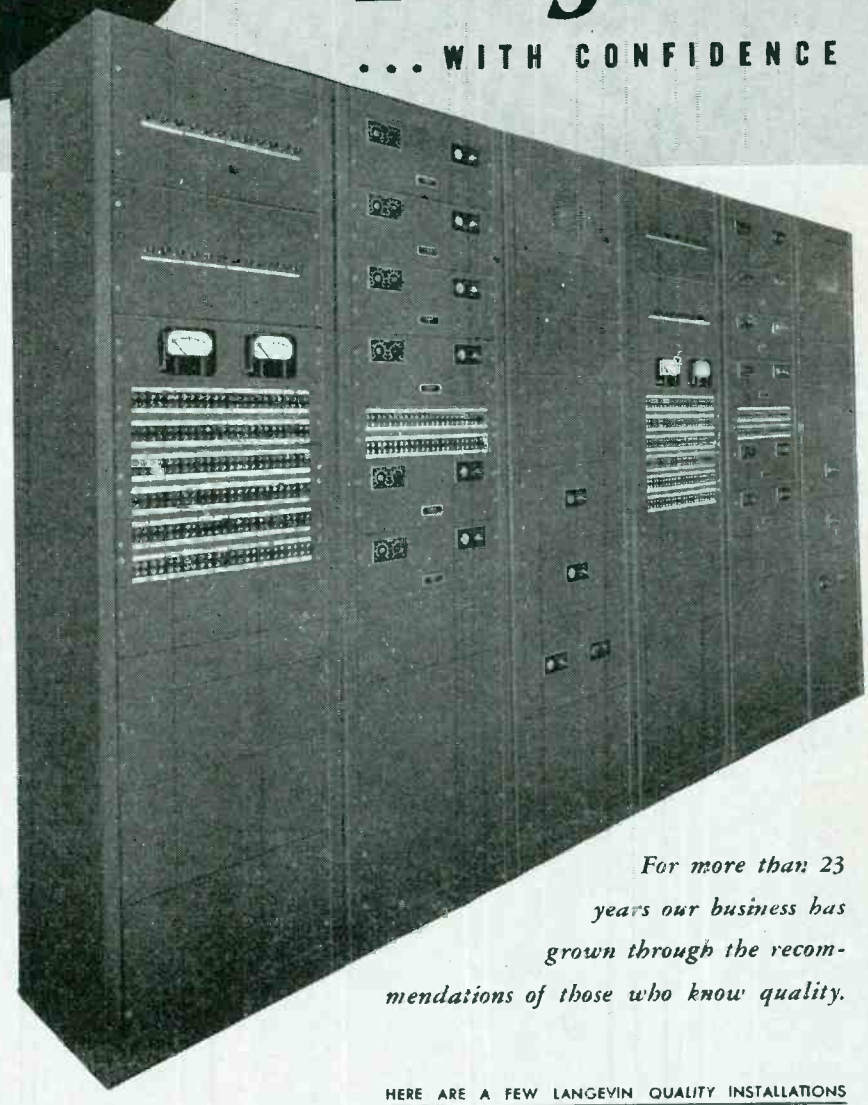
A PARTIAL LIST OF M-R PRODUCTS

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

SOUND SYSTEMS—?

RECOMMEND *Langevin*

...WITH CONFIDENCE



Representing the finest in audio systems engineering, a Langevin sound system combines three very important engineering components . . . carefully designed and built basic equipment . . . well thought out system design . . . and "on the job" engineering supervision.

In order to ensure continuous system performance, amplifiers that are built "to take it" are necessary. The versatile line of Langevin quality amplifiers fits this requirement. Parts are conservatively rated, chassis are constructed of 16 gauge rust proofed (zinc plated, Bonderized) steel with baked-on enamel finish; transformers are mounted directly to the chassis instead of being "floated" in their surrounding cans; and, most important, these amplifiers have high quality electrical characteristics—the uniform response and quiet, low distortion performance which provide excellent sound reproduction.

Designing a sound system to properly service an area requiring sound coverage is the specialty of the Langevin Systems Engineer. All the peculiarities of factory, office, auditorium, or athletic field construction are taken into consideration, and the facilities of the Langevin "custom built" department are brought into play to meet them.

Rounding out the Langevin service, is "on the job" engineering supervision providing the final follow through which ensures quality system performance.

For more than 23 years our business has grown through the recommendations of those who know quality.

HERE ARE A FEW LANGEVIN QUALITY INSTALLATIONS

Los Angeles Coliseum
California Pacific International Exposition at San Diego
Texas Centennial Exposition at Dallas
Rubber Bowl Stadium, Akron, Ohio
Madison Square Garden, New York, N. Y.
Statler Hotel Chain (Nationwide)
New York State Horse Racing Tracks
General Cable Company (4 plants)
United Nations (San Francisco; Hunter College; Lake Success, N. Y.)

Bring your sound problems to Langevin

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK, 37 W. 65 St., 23 · SAN FRANCISCO, 1050 Howard St., 3 · LOS ANGELES, 1000 N. Seward St., 38

New BRUSH MAGNETIC RECORDING TAPE AND WIRE OFFER *LOWER COST...UNIFORMITY...EXCELLENT FIDELITY*

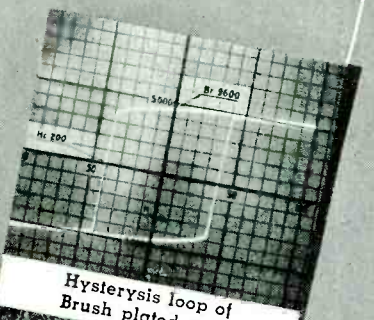
Outstanding Developments
Produced by Pioneer and Leader in this Field

BRUSH PAPER TAPE

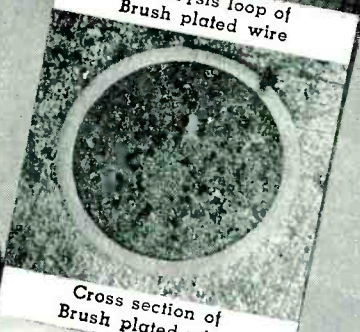
- Easy to Handle
- Extremely low-cost
- Can be edited . . . spliced
- Greater dynamic range
- Minimum wear on heads
- Excellent high frequency reproduction at slow speed
- Permanent—excellent reproduction for several thousand play-backs

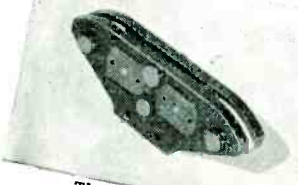
BRUSH PLATED WIRE

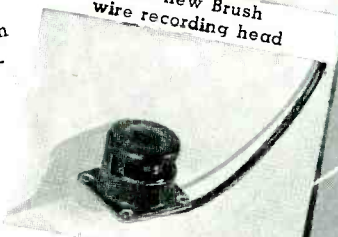
- Constant plating thickness assures uniform signal
- Correct balance of magnetic properties assures good frequency response and high level
- Excellent surface finish assures low noise and minimum wear
- Corrosion resistant
- Easy to handle—ductile—can be knotted



Hysterysis loop of Brush plated wire


Cross section of Brush plated wire


The new Brush wire recording head


The new Brush tape recording head

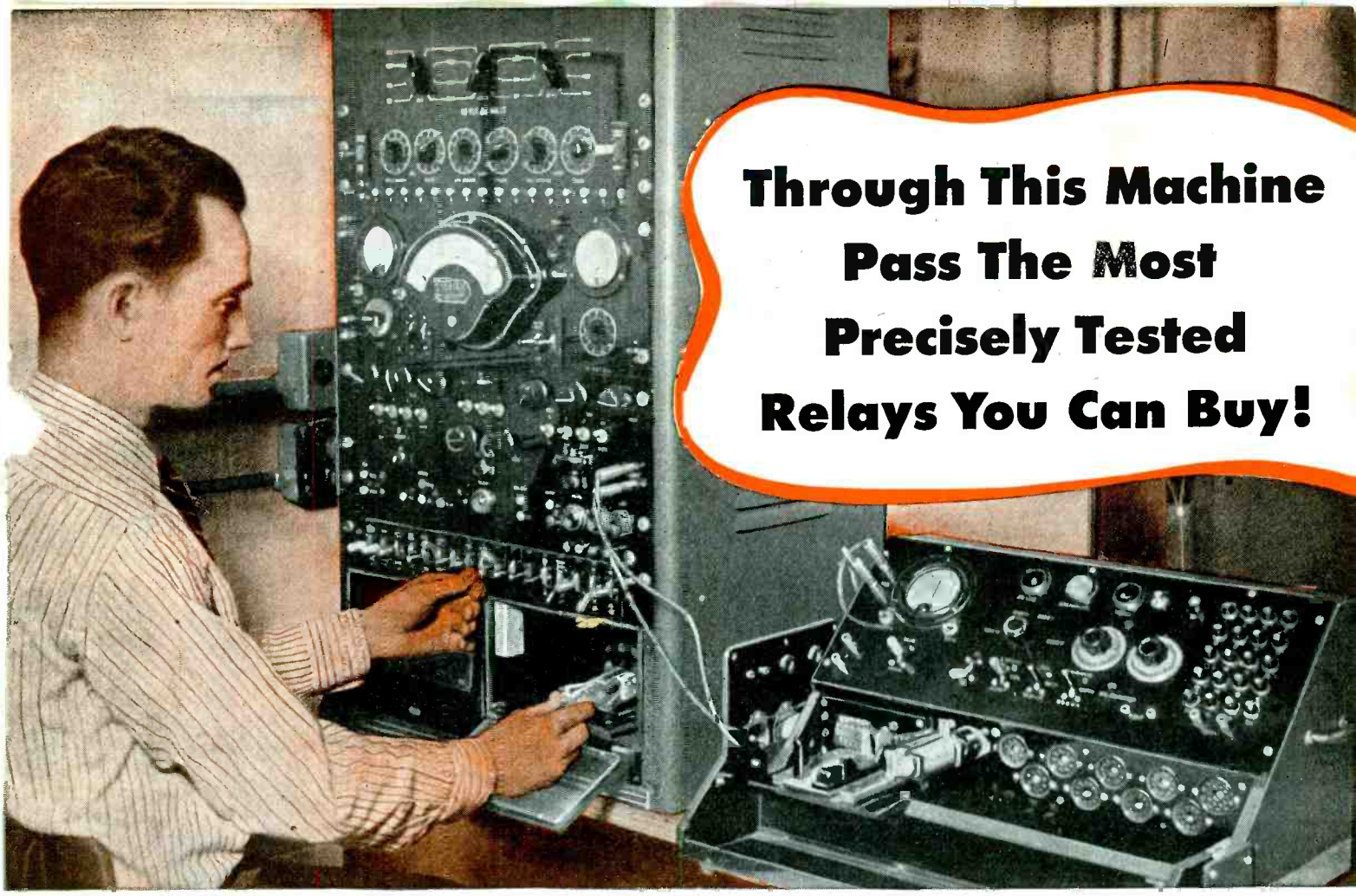
Vastly Improved Tape and Wire Recording Heads and Cartridges

Another important improvement made by Brush has been the development of very simply constructed, low-cost erasing, recording and reproducing heads. These are the very heart of the magnetic recording unit and the intensive research and development work done by Brush has resulted in decided improvements. Of principal interest are their excellent electrical characteristics, extreme simplicity of design to avoid trouble, and the "hum-bucking" characteristics which reduce the effect of extraneous magnetic fields. When required, the head cartridge alone (pole piece and coil unit) may be supplied for incorporation into manufacturers' own head structure.

These latest developments in magnetic recording equipment can now be obtained for radio combinations and other uses. Brush engineers are ready to assist you in your particular use of magnetic recording components.

THE BRUSH DEVELOPMENT CO.
3405 Perkins Avenue • Cleveland 14, Ohio

Write today for further information



Through This Machine Pass The Most Precisely Tested Relays You Can Buy!

Designed and built by Clare to "stand in" for YOU, this machine automatically compares the Clare "Custom-Built" Relay you ordered with the one you will receive.

Clare ingenuity in economically producing a relay "custom-built" to your exact specifications is also demonstrated in this unique Test Set which checks coil windings, resistance, breakdown and desired current and voltage to meet the exact demands of your specifications.

Relays are our business. Clare engineering and manufacturing skills are entirely devoted to giving you the best built, most perfectly operating relay for the job you have. No precision methods of construction or testing which will assure this objective are overlooked. Clare reputation rides with the performance of every relay that bears our stamp.

That is why thousands of engineers in every branch of industry have learned to look to Clare "Custom-Built" Relays when new or unusual problems in the use of relays present themselves. They know Clare can give them a relay for their design . . . they never have to design to fit a stock relay.

Close at hand are Clare Sales Engineers ready to discuss such problems with you—to offer suggestions and set things moving for the design of a Clare "Custom-Built" Relay for YOUR application.

It will pay you to know all about Clare Relays. Our fine new Engineering Data Book will be mailed the day we receive your request. Drop a line today to: C. P. Clare & Company, 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY. *In Canada: Canadian Line Materials Limited.*

CLARE RELAYS

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

HEAT . . . COLD

. . . neither affects performance!

NEW

THYRATRON

GL-5545

For use where ambient temperatures range widely

With high peak voltage

high peak-to-average current ratio

stable dual-grid control

short heating time

GENERAL ELECTRIC's new GL-5545 Thyratron solves your problem of obtaining "climate-proof" performance from a control tube with high voltage rating. The inert-gas content which makes this possible, offers a second important advantage—no start-off time need be lost in bringing mercury vapor up to temperature.

Type GL-5545 was designed primarily for (1) 220-volt d-c motor control work, (2) use in separate-excitation ignitor circuits, (3) grid-controlled rectifier service. A high peak-to-avg current ratio (see ratings), as well as high peak voltage, mean unusual capacity to "do a job" under exacting conditions. Also, the grid design, with both control-grid and shields, cushions any grid effect from anode voltage surges, making for a stable circuit and more dependable tube behavior.

Sturdy construction parallels stout performance characteristics. The GL-5545's grid structure—supported both at top and bottom—is strongly braced to resist vibration and shock. Base is the large, heavy-duty type for solid mounting, and terminal pins are long, with ample contact area.

G-E tube engineers will be glad to discuss the application of this capable new GL-5545 Thyratron to equipment you now are designing. Phone or write your nearest G-E electronics office, or *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

RATINGS

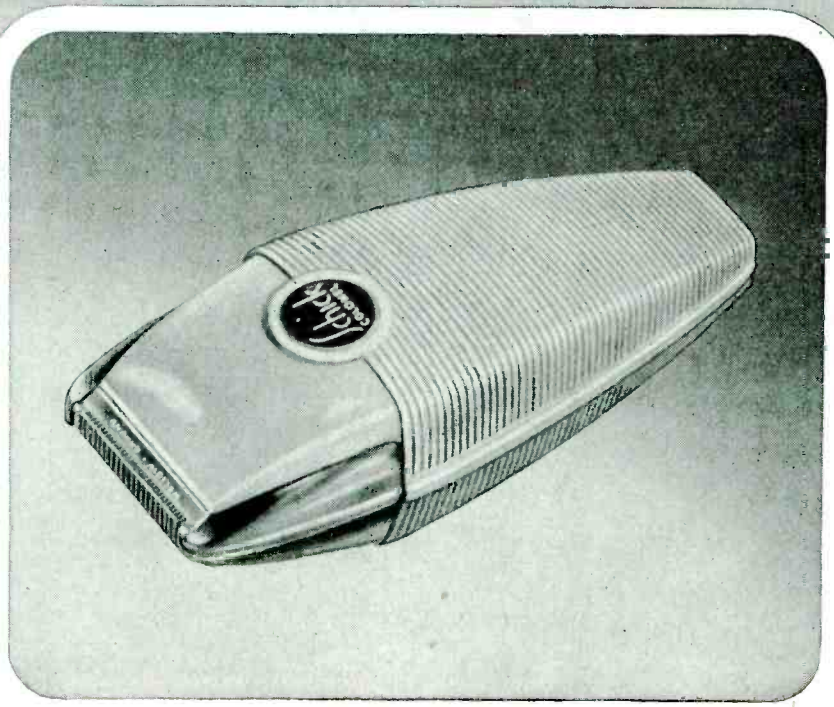
Filament voltage	2.5 v	Peak cathode current	80 amp
Filament current	21 amp	Avg cathode current	6.4 amp
Peak anode voltage, forward and inverse	1,500 v	Current averaging time	15 sec
		Ambient temp range	—55 to +75 C

GENERAL ELECTRIC

162-F2-6650

FIRST AND GREATEST NAME IN ELECTRONICS

SHAW-MOLDED FOR SHAVING COMFORT



Schick's Shaver has the smooth lines and sturdy construction that show sound plastics design and application, and is another molding achievement by Shaw in which materials and technique have been combined to help produce a top-notch product in plastics.

Five plastics components, produced from three different materials, are molded by the Shaw Insulator Company for the Schick Shaver. Each material was selected for specific properties essential to pleasing appearance, long life and trouble-free operation. Each mold was effectively designed and built. And the actual molding follows with the economies that can be effected by up-to-date presses and skilled personnel, guided by over a half-century of molding experience.

Shaw engineers can analyze your plastics problems and give you sound advice in the selection of any material and any molding process for the low-cost production of your plastics products. Shaw molding facilities can serve you today as they have served Schick, Incorporated for the last twenty years.

SHAW

SHAW INSULATOR COMPANY

MOLDERS QUALITY MARK ON MOLDED PLASTICS SINCE 1892

160 COIT STREET IRVINGTON 11, N. J.

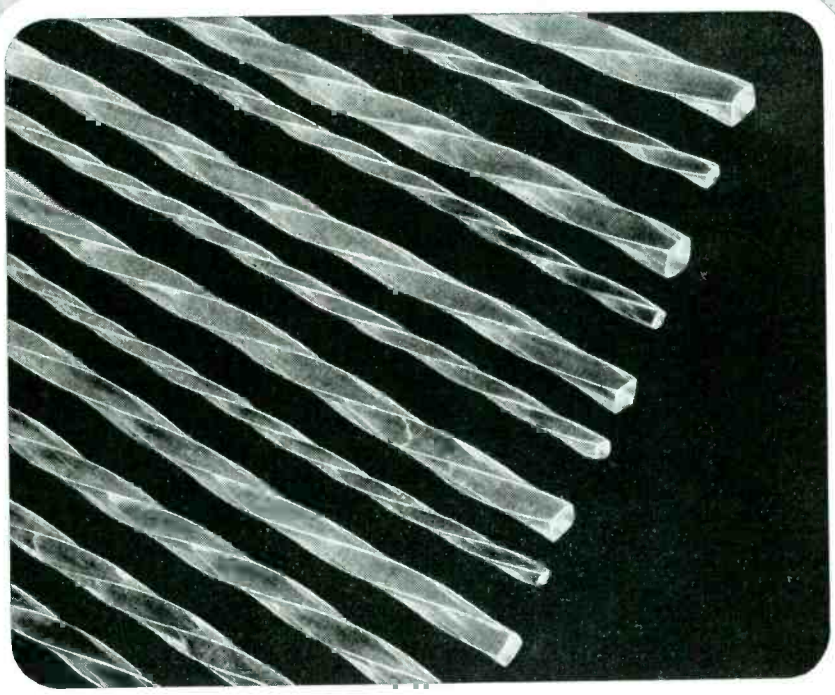
PLASTICS LITERATURE AVAILABLE

Shaw engineers have prepared a variety of literature, study of which might help you to a decision. Simply write a note about what phases of plastics especially interest you.

Or, you may prefer at once to call in a Shaw engineer, and present your problems for his study. This company's fifty-five years of plastics experience gives him a rich background from which you can draw.

Between the resources of Shaw and the Plax Corporation, Hartford 5, Conn., you can obtain assistance in almost all plastics methods and materials.

TWISTED SQUARE POLYSTYRENE ROD AVAILABLE



Plax is now producing square extruded polystyrene rod in twisted form. The striking appearance and unusual optical properties of the new shape make it ideal for displays, interior decoration and for creating special ornamental effects on table lamps, furniture, etc.

Unlike cut and twisted sheet, Plax twisted rod does not lose the twist when used where moderate heat is present but retains it to the softening point of the material itself.

Clear twisted Plax polystyrene rod is available for immediate delivery — colored rod on extended delivery. It may be had in thicknesses ranging from 1/8" through 3/4" in sixteenth-inch graduations.

WRITE FOR THIS POLYSTYRENE DATA

How to Machine Plax Polystyrene Products.
How to Use Coolants with Plax Polystyrene Products.
How to Cement Plax Polystyrene Products.
How to Polish Plax Polystyrene Products.
Notes on Design and Assembly of Plax Polystyrene Products.
Die-cut Parts from Plax Polystyrene.
How to Form Plax Polystyrene Rod.

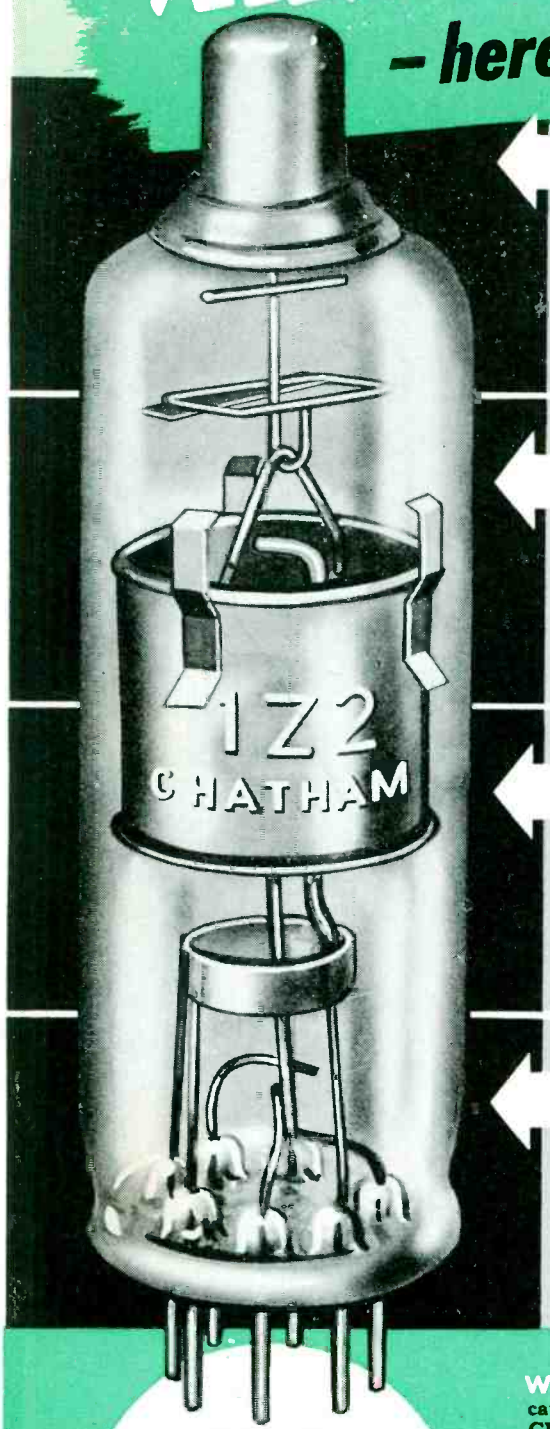
AND THIS PRODUCT INFORMATION

Data Sheets on Plax Cellulose Acetate, Cellulose Acetate Butyrate, Methacrylate, Polyethylene, Polystyrene and Ethyl Cellulose Products.
Article on Plax's Blown Products.
New special plastic shapes by Plax.

PLAX
FOR PLASTICS
NOT SUBSTITUTES···IMPROVEMENTS

133 WALNUT STREET ★ HARTFORD 5, CONNECTICUT

TELEVISION ENGINEERS – here's a LONG-LIFE 1Z2!



DESIGNED, BUILT, LIFE TESTED FOR LONG, DEPENDABLE SERVICE—

The CHATHAM 1Z2 incarporates all metal and glass construction that makes it possible to guarantee long service life under all operating conditians narmally encauntered in televisian service. Samples will be supplied to set designers to substantiate this claim.

PREMIUM PERFORMANCE . . . AT NO EXTRA COST—

Exclusive CHATHAM design features embadied in this 1Z2 permit higher peak voltages and laads than heretofore. These improved characteristics are the direct result of changes in structural design . . . which, at the same time, materially lower manufacturing costs.

CHATHAM IS TOOLED FOR IMMEDIATE VOLUME DELIVERY

CHATHAM production facilities make it possible, at present, to salicit inquiries regarding deliveries of the 1Z2. To insure meeting your requirements without delay, we suggest immediate investigation of the merits of this tube, in relation to your television circuit.

ENGINEERING COLLABORATION IN APPLYING THIS RECTIFIER—

Specialists in the solution of rectification problems, CHATHAM engineers offer complete cooperation in applying the 1Z2 to any projected or existing equipment design requiring a compact high voltage rectifier. This service, which has proved invaluable to many manufacturers, is offered without obligation.

OPERATING CHARACTERISTICS:

Max. D.C. Output Voltage—12,000 (25,000 inverse peak voltage)

D.C. Load—2 ma

Peak Anode Current—18 ma

Filament Voltage—1.25 Volts

Filament Current—265 ma

Bulb—Long Miniature—2 3/8" Long

WRITE FOR YOUR CATALOG TODAY— The new CHATHAM catalog contains complete information and technical data covering all CHATHAM rectifiers now available for prompt delivery. Included are high vacuum, mercury vapor and inert gas rectifiers and thyratrons. Many of the inert gas tubes operate in wide extremes of ambient temperature without the use of blowers, heaters or controls to regulate bulb temperature. Thus particular advantage is offered for relay stations, unattended transmitters and similar applications. For your free copy of this informative booklet, write on company letterhead today!

CHATHAM ELECTRONICS

475 WASHINGTON ST., NEWARK 2, NEW JERSEY

Radio Manufacturers!

NOW YOU CAN USE ALTEC LANSING SPEAKERS . . . AN ADDITIONAL MARK OF QUALITY, ANOTHER SELLING POINT, FOR YOUR FINE RECEIVERS.

THE ALTEC LANSING DIA-CONE SPEAKER

Model No. 600

When a radio manufacturer we know heard the famous Altec Lansing Duplex, his first words were: "You ought to design a speaker like this for my better receivers . . . at a price I can afford." And here it is . . . a popular priced speaker with a carry-over of Altec Lansing's premium priced features. This new model, No. 600, is a 12-inch edition of the Altec Lansing line. Now you can identify your finer receivers with Altec Lansing quality. Send for further technical information on the No. 600.

MODEL No. 600: Specially designed for better radio-phonographs. This Altec Lansing Dia-Cone Speaker incorporates a metal high frequency diaphragm and a 12-inch low frequency cone, coupled by a unique mechanical dividing network to a 3-inch voice coil of edgewise wound aluminum ribbon.

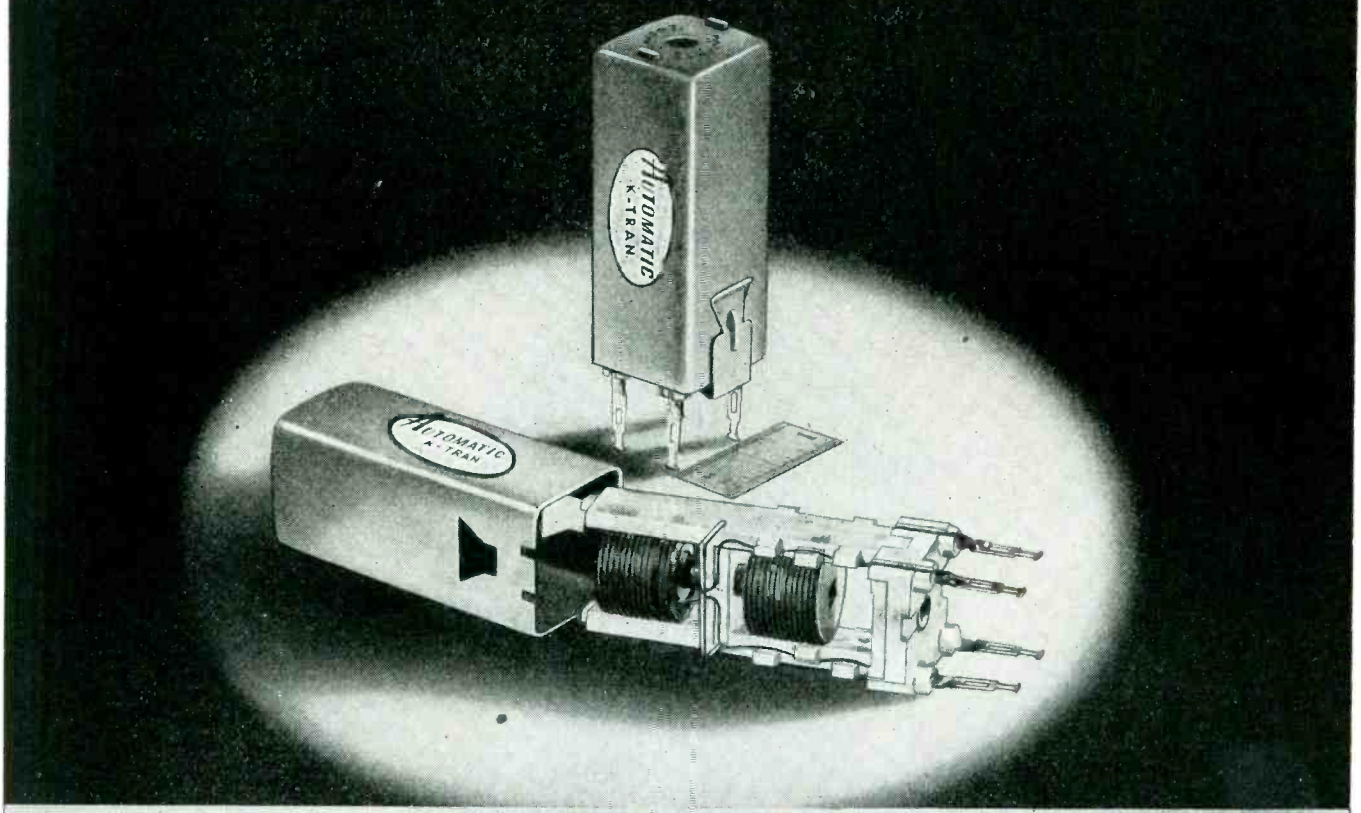
ALSO AVAILABLE IN 15-INCH DIA-CONE WITH A MULTICELLULAR HORN FOR HIGHER PRICED COMBINATIONS

"KEEP ADVANCING . . .

ALTEC
LANSING CORPORATION
1161 N. Vine St., Hollywood 38, Cal.
250 W. 57th St., N. Y. 19, N. Y.

. . . WITH ALTEC LANSING"

USE STANDARD PARTS—SAVE TIME AND MONEY



UNIVERSAL!

The Automatic K-TRAN is as standard as a resistor or mica condenser.

One of a few *standardized* types will meet almost any I. F. Transformer requirement in any radio set. Large stocks of a multiplicity of types are eliminated. Procurement problems on I. F. Transformers vanish. Shipments *from stock* eliminate months of waiting for material.

Use K-TRAN *throughout* your line!

AUTOMATIC MANUFACTURING CORPORATION

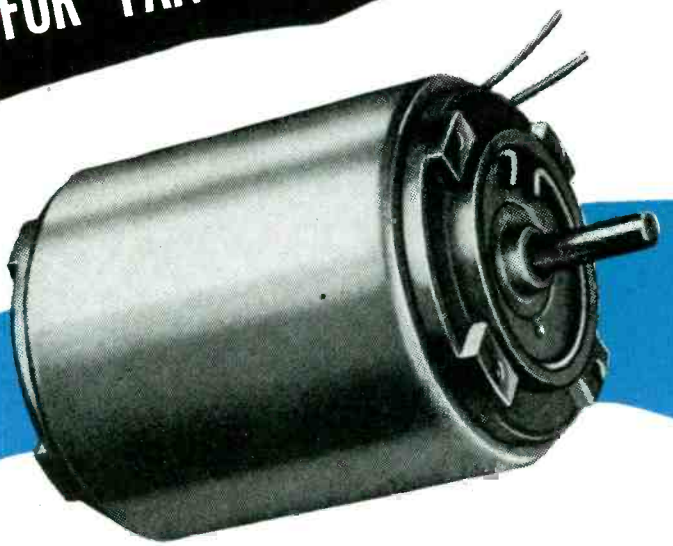
MASS PRODUCTION COILS & MICA TRIMMER CONDENSERS

900 PASSAIC AVE. EAST NEWARK, N. J.

NOW AVAILABLE . . .

FOR FAN AND AIR CONDITIONING APPLICATIONS

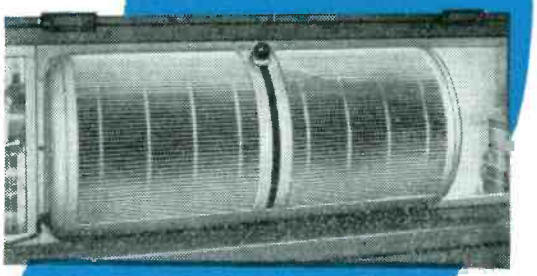
73 series



REX COLE, INC.
AIR CIRCULATORS

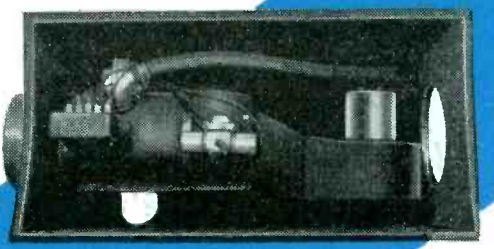
★ THREE STAR PERFORMERS FOR FAN APPLICATIONS . . .

TYPE NO.	TYPE	H.P.	SPEED
KP732L	Shaded Pole	1/30	1500
L731H	Capacitor	1/20	1600
L732G	Capacitor	1/15	1600



U. S. AIR CONDITIONING CORP.
WINDOW VENTILATORS

EASTERN AIR DEVICES motors have won wide acceptance for their efficient performance in fan and air conditioning units such as those illustrated. Their construction includes such desirable features as: replaceable "capsule" bearings, snap ring construction for easy disassembly, radically improved cooling means, insuring long life and quiet operation with minimum size and weight. Let us fit an E.A.D. motor to your application.



STEWART-WARNER CORP.
TRAILER HEATERS

EAD

EASTERN AIR DEVICES, INC.

585 Dean Street • Brooklyn 17, N. Y.

SANGAMO PAPER TUBULAR CAPACITORS

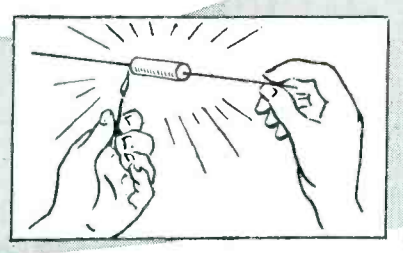
ARE NOW MOLDED IN PLASTIC

...just like micas!

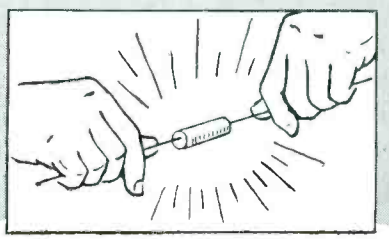
Paper Tubular Capacitors, molded in Thermo-Setting Plastic! Designed for use in all circuits calling for Paper Tubulars. Plastic Molding means no leakage. Capacity values remain more stable and moisture is completely sealed out. No wax to run at higher ambient temperatures. Smooth finish prevents catching dirt and dust. All in all, Plastic Molding assures longer life and lower power factor. Specify Sangamo Plastic Molded Capacitors wherever you use Paper Tubulars.

...try these tests WITH SANGAMO PLASTIC TUBULARS ....

WRITE NOW for the New Sangamo Capacitor Catalog for full information on the Sangamo Line.



NO WAX TO MELT....even heat as intense as is encountered in soldering, will not cause leakage in the case or at the lead joint.

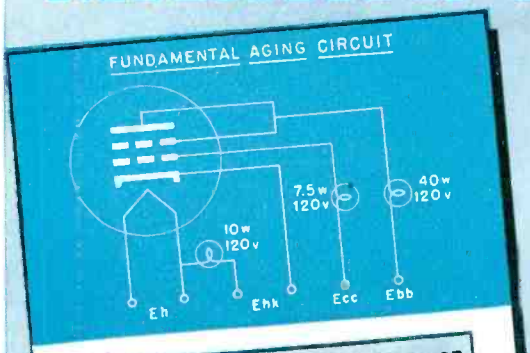


LEADS WILL NOT PULL OUT...Plastic Molding so tightly seals the leads in place, that under all conditions of normal use, leads will stay put.

SANGAMO ELECTRIC COMPANY SPRINGFIELD ILLINOIS

MAKING TUBES IS EASY..

If YOU KNOW HOW!

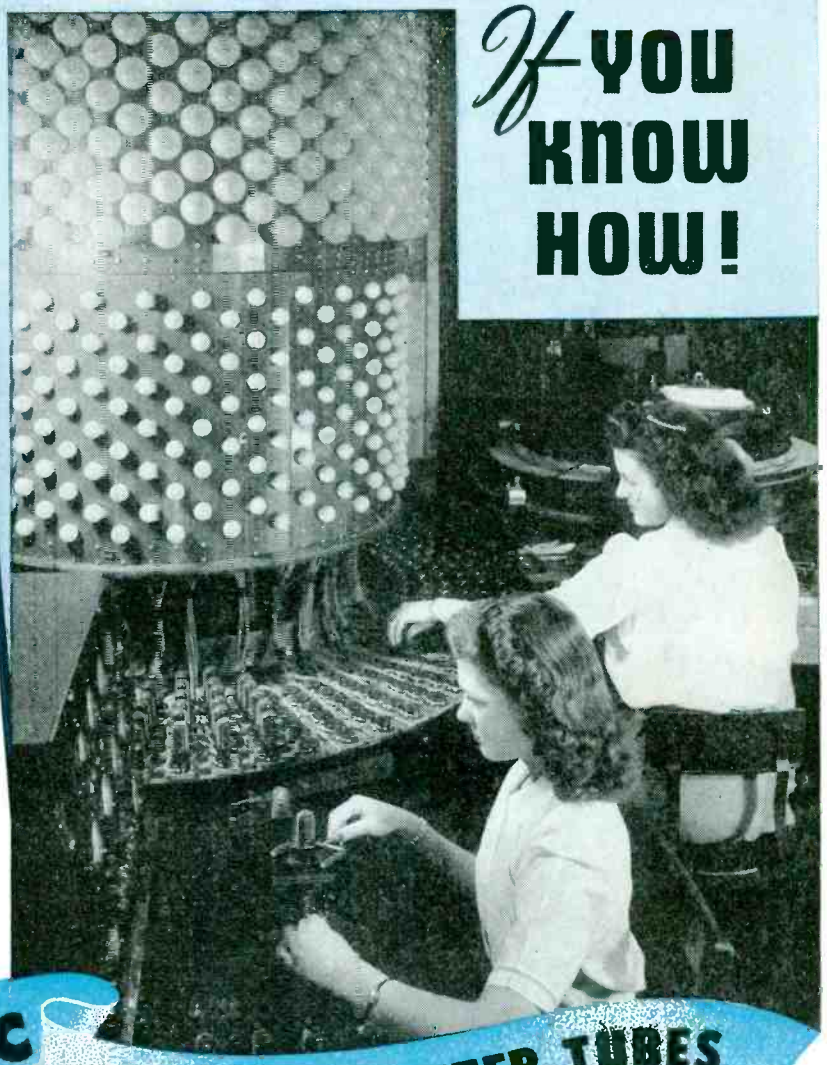


AGING SCHEDULE FOR HYTRON 50L6GT

Step	Minutes	Eh a-c	Ehk a-c	Ecc d-c	Ebb d-c
1	5	50	110	0	0
2	3	70	110	0	0
3	5	80	110	0	0
4	3	80	110	0	0
5	5	70	0	120	120
6	4	0	0	0	0
7	5	50	0	−10	120

Electrode potentials are varied as shown in the schedule. Actual voltages at the socket depend on currents drawn through the incandescent lamps used as economical, interchangeable current-limiting resistors.

Operations performed in seven steps are: (1) discovery of heater-cathode shorts (2) beginning of cathode processing to stabilize emission (3) further seasoning and burning off of h-k leakage (4) h-k potential increased to eliminate leakage (5) grid, screen, and plate potentials applied to complete de-gassification (6) cooling off period (7) normal potentials applied to pre-heat for test.



AUTOMATIC AGING FOR BETTER TUBES

Yes, radio tubes also must be "aged in the wood." Aging activates the cathode under accelerated life conditions, just before test. In the fundamental aging circuit shown, final seasoning and de-gassification stabilize characteristics in accordance with the carefully planned aging schedule.

Formerly tubes were plugged into long aging racks. An operator, equipped with the schedule and a timer, adjusted electrode potentials throughout the aging cycle. The human element resulted in errors of timing and switch manipulation.

Hytron's new automatic aging wheel minimizes human error. A motor drives a mechanically-indexing horizontal wheel on which 30 radial sections of 12 tubes each are slowly rotated. Brushes contacting commutator segments automatically apply electrode potentials. The wheel itself requires no operator. The final basing machine operator feeds the wheel. Tubes already pre-heated are removed by the test operator.

Other features of the aging wheel are elimination of needless handling, fast and steady pacing of the work, easy servicing, and readily interchangeable load lamps.

To you this automatic aging wheel means economical, more uniform tubes with stable electrical characteristics. Again Hytron know-how takes a forward step by making your tubes easier and better.

SPECIALISTS IN RADIO RECEIVING TUBES SINCE 1921

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY

-hp- 200B AUDIO OSCILLATOR

1. FAST—no zero setting required
2. STABLE—constant output, low distortion
3. VERSATILE—3 bands, wide frequency range

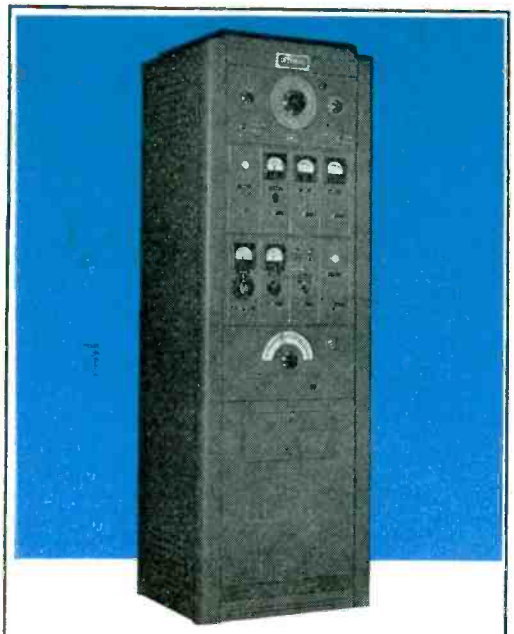
The model 200B *-hp-* Audio Oscillator brilliantly combines the virtues of coil-condenser and beat frequency types for swift, accurate operation under any condition. No longer are frequency zero settings necessary. Even during initial warm-ups, or line voltage variations as high as 10%, thermal frequency change is less than 2%. This high order of stability is maintained throughout the instrument's operating range—20 cps to 20 kc.

Model 200B supplies 1 watt or 22.5 volts output into a matched resistance load of 500 ohms and provides 25 volts on an open circuit. These outputs are constant within ±1 db between 20 cps and 15 kc. And distortion is limited to less than 1% between 35 cps and 15 kc.

This easy-to-operate audio oscillator has but three controls—main frequency dial (directly calibrated), a range switch selecting one of three frequency bands (with generous overlap) and a simple output amplitude control.

The versatile *-hp-* Model 200B is ideal for many uses—testing amplifiers, loudspeakers, transmitter audio responses; for modulating signal generators, driving ac bridges; or wherever a stable audio test signal is required.

The *-hp-* Model 200B Audio Oscillator is ready for early delivery—yours may be shipped from stock. Write or wire now for details.



Operadio makes 1500 tests per day with -hp- Oscillators

Operadio Manufacturing Co., St. Charles, Ill., uses three-band -hp- Audio Oscillators similar to the Model 200B, in over a dozen of their loudspeaker test racks. Fast-tuning -hp- oscillators make it possible for an inspector to check from 1000 to 1500 speakers a day on each of these units. This results in high-speed, mass production that meets the rigid specifications and close tolerances maintained in all Operadio products.

HEWLETT-PACKARD COMPANY
1341A PAGE MILL ROAD, PALO ALTO, CALIFORNIA

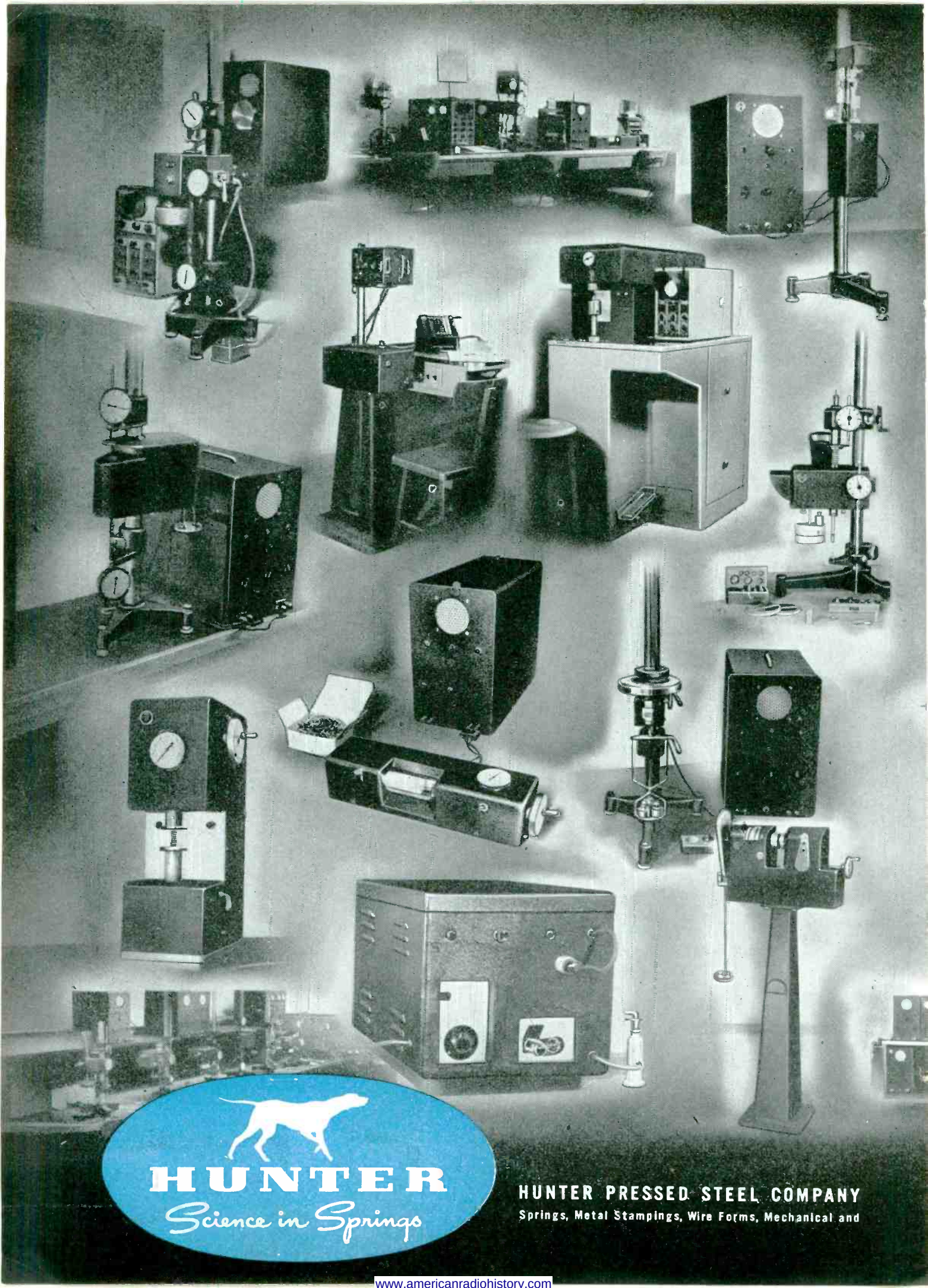
Power Supplies • Frequency Standards • Amplifiers • Electronic Tachometers
Frequency Meters • UHF Signal Generators • Square Wave Generators
Noise and Distortion Analyzers • Audio Signal Generators • Attenuators
Audio Frequency Oscillators • Wave Analyzers • Vacuum Tube Voltmeters

CONSTANT CAPACITANCE GAS-FILLED CONDENSERS...

As easy to tune as your home receiver, and once set, this gas-filled Lapp Condenser holds its capacitance under all conditions. No "warm up" required, no change in capacitance with change in temperature. As lump capacitance for service at high voltage and high currents, these gas-filled units save space, save power, and save trouble. Available in variable, adjustable, and fixed capacitance units. Condensers now in service range up to 60,000 mmf. (fixed), 16,000 mmf. (variable and adjustable). Current ratings to 500 amperes R.M.S., and voltage ratings to 60 Kv peak.

Lapp

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



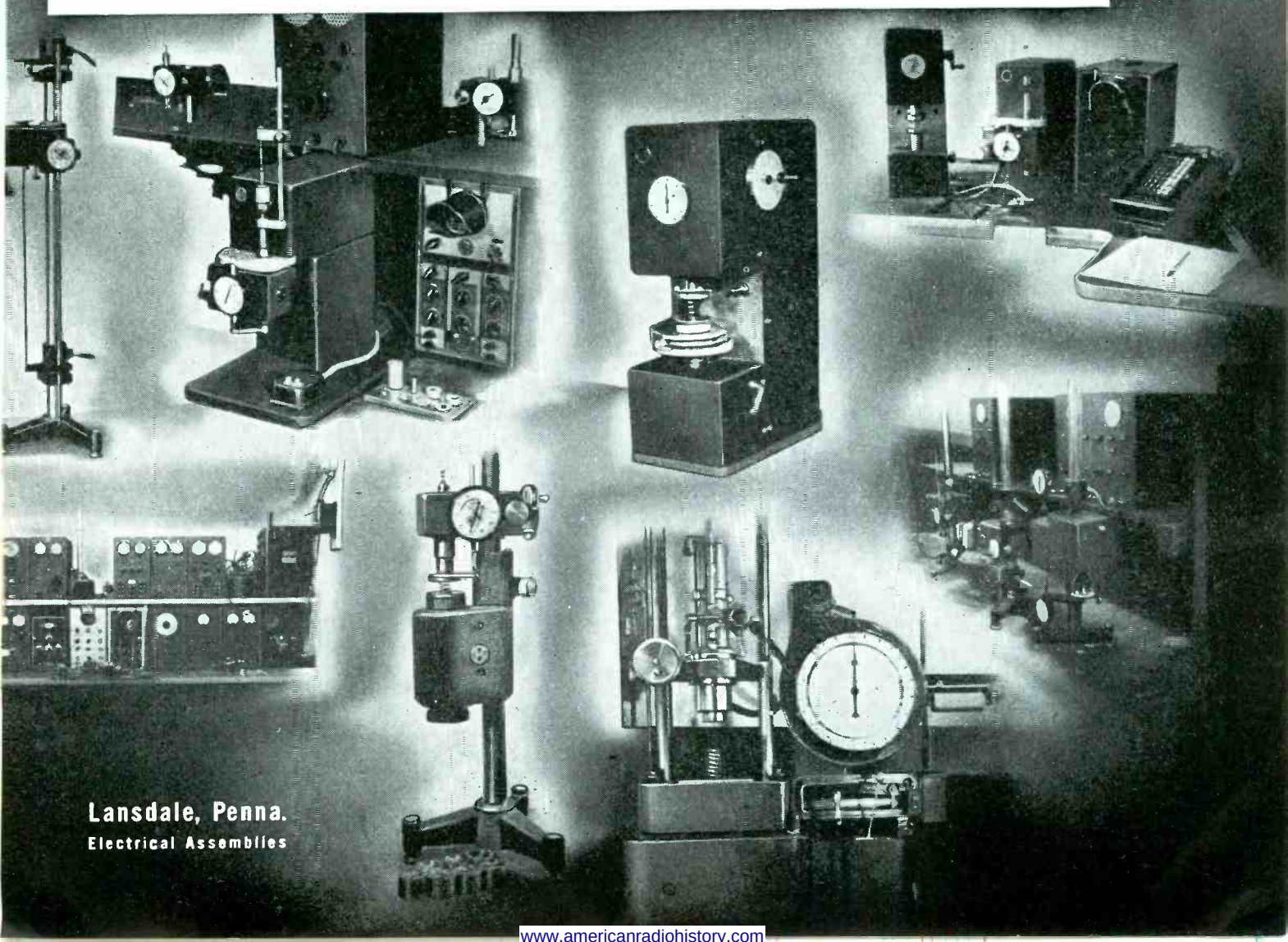
All this to test Springs?

PEOPLE who follow our advertisements or pop in on us at Lansdale often say, "Why so much equipment just to test a spring?" Good question!

Making and testing a few springs is one thing. Making and testing hundreds, thousands or millions of springs is something else again. A very different something else if you want the kind of springs that can breeze by close specifications.

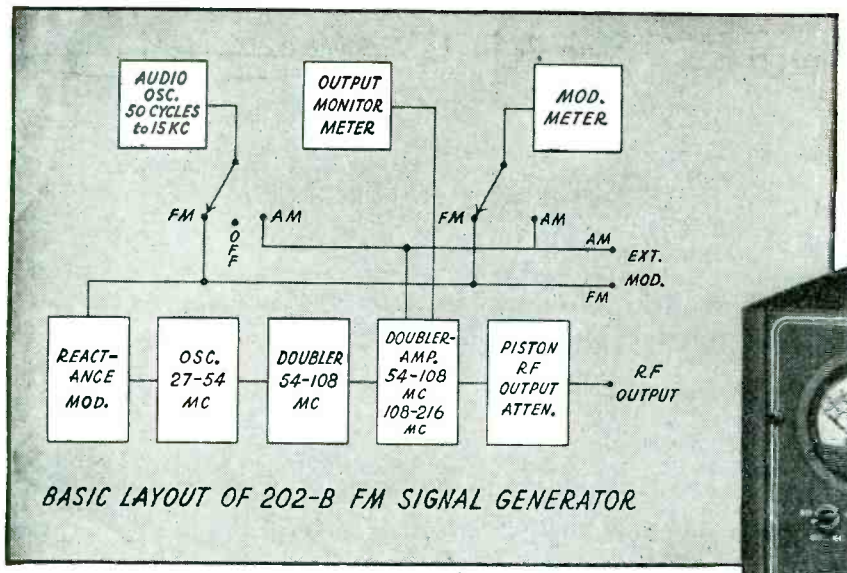
In order to implement our statistical control of quality (so effective in insuring better springs) . . . in order to give you springs that really meet tolerances and to *know that we know* they are right . . . we found it necessary to conceive, design and then even to build our own testing machines.

We show you a few of the machines on these two pages, some mechanical, some electronically operated.



Lansdale, Penna.
Electrical Assemblies

THE NEW FM SIGNAL GENERATOR



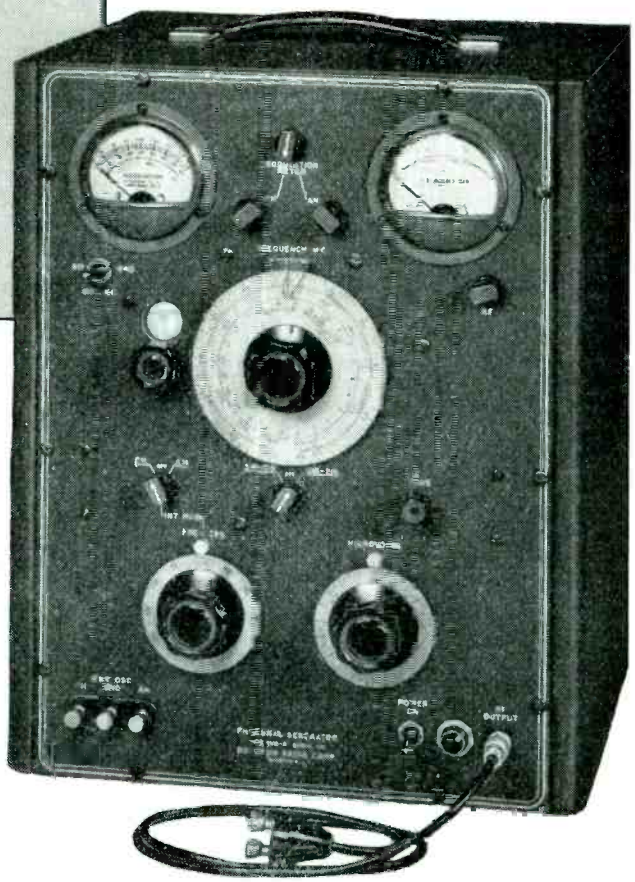
BASIC LAYOUT OF 202-B FM SIGNAL GENERATOR

Shown above in block form are the basic circuit elements of the new 202-B FM Signal Generator. The stage following the RF oscillator, in addition to doubling the oscillator frequency, prevents interaction between the output stage and the oscillator and modulator circuits. It also provides sufficient drive to saturate the output stage thereby minimizing unwanted amplitude modulation. The FM and AM modulating systems are independently monitored by a modulation meter which may be switched to indicate the degree of each type of modulation present.

Frequency doubling at the final stage is accomplished by changing the point at which the output tank coil is grounded, assuring stable and trouble free range switching.

FREQUENCY RANGE 54 to 216 MEGACYCLES

Model 202-B



THE Signal generator to help solve your FM problems

In response to widespread demands for a suitable FM Signal Generator to cover the new FCC frequency allocations, Boonton Radio Corporation now offers the Type 202-B FM Signal Generator to provide the utmost in performance. FM and television engineers will welcome the 202-B Signal Generator as *the* essential laboratory instrument for receiver development and research work.

Frequency coverage from 54 to 216 megacycles is provided in two ranges, 54 to 108 megacycles and 108 to 216 megacycles. A front panel modulation meter having two deviation scales, 0-80 kilocycles and 0-240 kilocycles, permits accurate modulation settings to be made.

Although fundamentally an FM instrument, amplitude modulation from zero to 50%, with meter calibrations at 30% and 50%, has been incorporated. This AM feature offers increased versatility and provides a means by which simultaneous frequency and amplitude modulation may be obtained through the use of an external audio oscillator.

The internal AF oscillator has eight modulation frequencies ranging from 50 cycles to 15 kilocycles, any one of which may be conveniently selected by a rotary type switch for either amplitude or frequency modulation.

The calibrated piston type attenuator has a voltage range of from 0.1 microvolt to 0.2 volt and is standardized by means of a front panel output monitor meter.

The output impedance of the instrument, at the terminals of the R.F. output cable, is 26.5 ohms.

Careful consideration has been given to the positioning of the main frequency dial and various controls, with modulation and output monitor meters located at eyelevel for maximum readability. Dimensions have been chosen to permit greatest economy of laboratory space. For complete details write for Catalog "D".

The design of this instrument was described on pages 96-101 of the November issue of ELECTRONICS. Reprints of this article are available upon request.

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

DESIGNERS AND MANUFACTURERS OF THE Q METER · QX CHECKER FREQUENCY MODULATED SIGNAL GENERATOR · BEAT FREQUENCY GENERATOR AND OTHER DIRECT READING INSTRUMENTS

ANTI-VIBRATION Littelfuses Longer Lasting, More Dependable Protection....Here's Why

Originally designed to withstand vibration, shock and other severe operating conditions encountered in aircraft applications.

Spring-and-Link element (5-ampere and lower) provides special protection for the delicate fuse element, offsets vibration. Short fusing section is soldered to beryllium copper spring as shown in illustration "B" above.

Mechanically depolarized elements, with 90 degree twist, are unresponsive to vibration from any direction and are used in larger amperages, as shown in Illustration "A" above. Special "gooseneck" formation at one end of fuse element prevents crystallization and cracking at the fusion point.

Complete assortment of ratings for small motors, relays and all industrial applications in which medium or high time lag protection coupled with anti-vibration and shock resistance qualities are major factors. In all such applications they will give you longer lasting, more dependable, more economical protection.

For complete information and prices on these and other Littelfuse quality products, send for Catalog No. 9 . . . just off the press.

A. 4 AG Littelfuse Series 411 Fuses. 10 to 40-ampere sizes for use on 32 volts or less. Glass enclosed.

B. 4 AG "Slo-Blo" Littelfuse Series 413 Fuses. 1 to 3-ampere sizes for use on 250 volts or less, and a 5-ampere size for use on 32 volts or less. Glass enclosed.

C. 4 AG Littelfuse Series 414 Fuses. 1 to 3-ampere sizes for use on 250 volts or less, 5 to 15-ampere sizes for use on 115 volts or less, and 20 to 40-ampere sizes for use on 32 volts or less. Bakelite enclosed, shatter-proof construction.

D. Finger Operated Fuse Extractor Post. A quick, safe and simple way of mounting and changing 4AG fuses. For front-panel mounting.

E. Pressurized, Finger Operated Fuse Extractor Post. Similar to above except for use at high altitudes in pressurized aircraft cabins, etc.

F. Same as "D," above, except for back-of-panel mounting.

For other Fuses, Mountings and Accessories send for Catalog No. 9

LITTELFUSE
4791 NORTH RAVENSWOOD AVE.

FIRST IN CIRCUIT PROTECTION

Incorporated
CHICAGO 40, U. S. A.

SLO-BLO-LITE • SWITCH-LITE • IGNITION-FRITZ • NEON INDICATORS • SWITCHES • CIRCUIT BREAKERS • FUSES, MOUNTINGS AND ACCESSORIES

is your net profit margin doing a disappearing act!

Magicians are mighty intriguing folk—in their place. But nobody, at any time or place, enjoys seeing his net profit margin do a disappearing act.

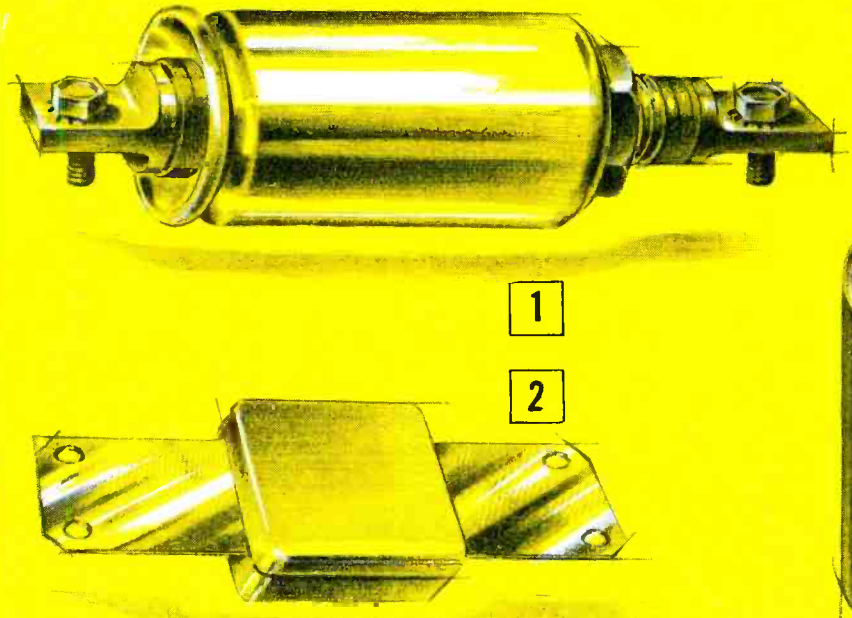
If product dependability is the life blood of your business; if lowered inspection costs, lowered service costs, and maintained production are determining factors in maintaining your profit margin — a consultation with our engineers will be to your advantage. The same specialized experience that in the past 37 years has resulted in the design and manufacture of over 250,000 different types of capacitors can be directed with equal efficiency to your specific needs. Typical examples of C-D capacitors designed for special requirements are shown below. Catalog of standard capacitor types available on request. Your specifications for types to meet your requirements are solicited.

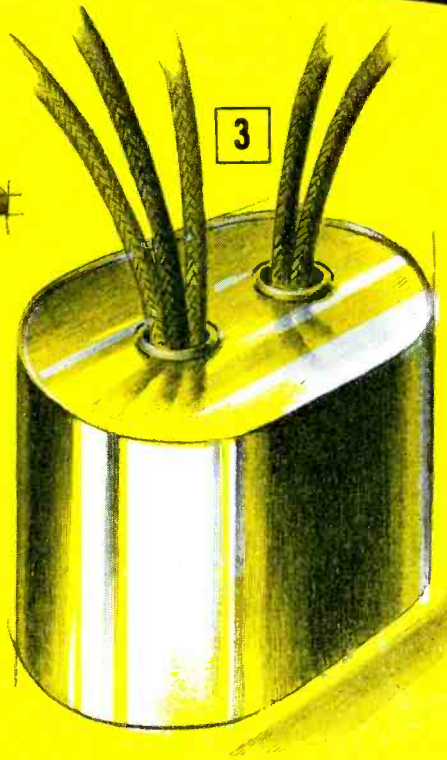
Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey. Other plants in New Bedford, Providence, Worcester and Brookline.

CORNELL-DUBILIER
world's largest manufacturer of
CAPACITORS

MICA • DYKANOL • PAPER • ELECTROLYTIC CAPACITORS

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





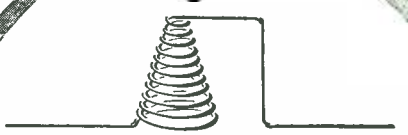
CAPACITOR #1 — A heavy-duty, hermetically-sealed, oil-filled and impregnated feed-through noise filter designed to meet the needs of an aviation application. Terminals with polnut assembly for either bulkhead or chassis mounting.

CAPACITOR #2 — This mica capacitor is molded in a low-loss phenolic case with strap terminals to pravide low impedance path of high frequencies. Designed for h-f by-pass circuits.

CAPACITOR #3 — An inexpensive, completely-integrated noise suppressor incorporating both inductance and capacitance in basic design. Assembly into parent equipment reduced to five operations where normally ten would be required.

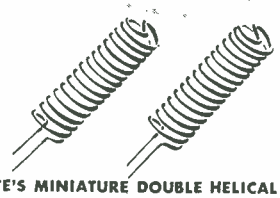
"We didn't know you could do that with Callite tube & lamp components"

CALLITE'S "M" SHAPED FILAMENTS *for high-power projection lamps. Employing a tungsten wire of .010" diameter wound on a .035 molybdenum mandrel for 55 turns per inch, its faster crystal growth produces interlacing crystals whose structure maintains the stability and non-warping property of the coil, thus withstanding elevated temperatures. Used for vacuum and incandescent lamps of high wattage and heat dissipation.*



CALLITE'S CONE-SHAPED TUNGSTEN FILAMENT. *This heater wire, .020" in diameter, is specially designed to produce lamp filaments that will maintain a constant lumen output because it permits very little distortion of the coils (despite their unusual pattern) during the life of the lamp. Used for special types of incandescent and gas filled lamps.*

CALLITE'S COILED-COIL HEATER. *Employs a .375 milligram tungsten wire heater wound on a .004 molybdenum mandrel for 800 turns per inch. The coil is then rewound on a .030 steel mandrel and skip turned every 68 t.p.i. Result: a highly efficient coiled-coil heater for miniature electron tubes with high emission properties equal in performance to larger envelope tubes.*



CALLITE'S MINIATURE DOUBLE HELICAL HEATER *for radar and microwave transmitting tubes. This molybdenum-tungsten alloy filament. .0048" in diameter and 133 mm. in length, is coated with aluminum. Evenly wound, of high tensile strength, good ductility and uniform resistance, this filament is particularly adaptable for high and ultra-high frequencies in restricted spaces.*

THE CALLITE COMPONENTS featured above indicate the kind of engineering ingenuity and production proficiency with which Callite serves the lamp and tube industry. For 26 years Callite has supplied standard and special shapes in every industry where lamp and tube components are used. The same ingenuity and flexibility of the Callite organization is at your command for any component problem requiring quick, efficient solution. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, N. J. Branch Offices: Chicago, Cleveland.

CALLITE TUNGSTEN CORPORATION CT

Callite

TUBE & LAMP COMPONENTS

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

write for **Catalog #156.**

OVER 26 YEARS OF PIONEERING IN TUNGSTEN METALLURGY

YOU GET A SQUARE DEAL AT OUR ROUND TABLE

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

These men make a detailed study of your special requirements. They plan, design and engineer the job with your needs and uses in mind. They determine the best manner of producing it, utilizing KARP'S superior equipment and facilities to your greatest advantage.

When your job is finished, it will be correctly designed for its application, handsome, rugged and built for long service life. You will have no costly problem of assembly . . . no need to spend additional time and labor on finishing touches. The job will be COMPLETE, ready for the installation of your electrical or mechanical operating parts with ease and simplicity. No matter how many units you order, every last detail will be absolutely uniform.

This custom service not only gives your product added value, but under KARP methods may often save you money.

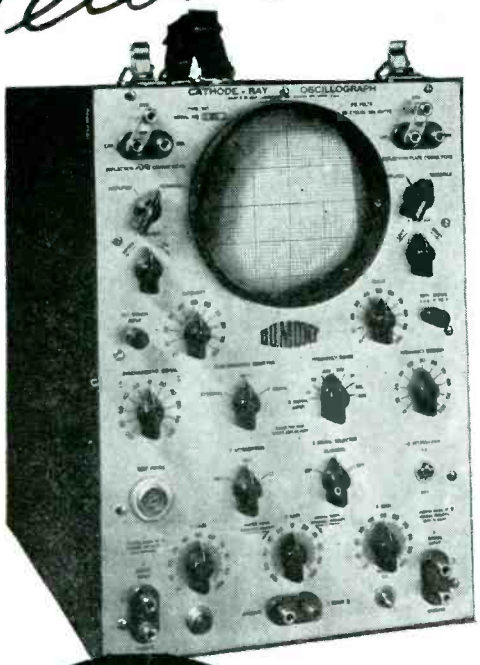
Consult us for cabinets, housings, chassis, racks, boxes, enclosures or any type of sheet metal fabrication.

Karp METAL PRODUCTS CO., INC.

Custom Craftsmen in Sheet Metal

124 - 30th STREET, BROOKLYN 32, NEW YORK

Television Problems?



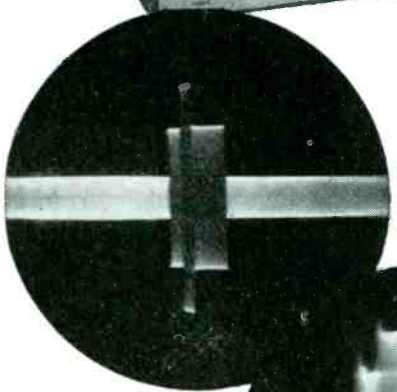
DU MONT Type 241 CATHODE-RAY OSCILLOGRAPH

Ideal for the observation of AUDIO, VIDEO and R-F signals...

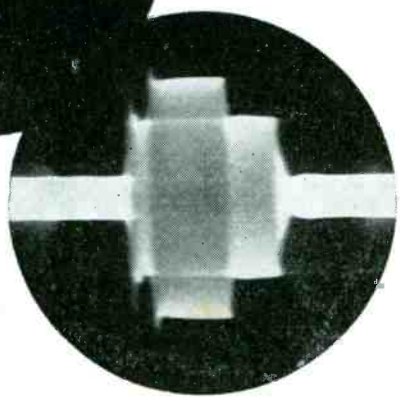
For unexcelled performance at moderate cost, the Du Mont Type 241 Oscillograph offers these outstanding features:

1. The Type 5JP cathode-ray tube with intensifier electrode for increased light intensity of the observed trace.
2. A vertical amplifier for study of signal frequencies up to 2 megacycles.
3. Direct connections (on front panel) to deflection plates for signals up to 60 megacycles without interaction between horizontal and vertical deflection plates.
4. Use as a modulation monitor over the standard broadcast band.
5. Examination of very short pulses in television transmitting and receiving equipment.
6. Brilliant, easy-to-photograph oscillograms through use of the Du Mont Type 5JP11 intensifier-type cathode-ray tube. Deficiencies in a television sync generator under test show up in the accompanying oscillograms taken on the Du Mont Type 241.

Literature on request.



Radio-frequency waveform of vertical sync pulse. Horizontal sweep frequency of the oscillograph set at 60 cps.



Radio-frequency waveform of horizontal sync pulse. Horizontal sweep frequency of the oscillograph set at 15,750 cps.

JUST ANOTHER REASON WHY DU MONT IS ALWAYS YOUR "BEST BUY"

DUMONT *Precision Electronics & Television*

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

TO EACH CUSTOMER FOR HIS SPECIFIC NEEDS

Unusual resistance to abrasion? High dielectric strength? Insurance of uninterrupted service in telephone communications? Each reel of Ansonia Ankoseal holds wire or cable earmarked for applications where it will do the best possible job. Our engineers can solve your cable problems.

THE ANSONIA ELECTRICAL DIVISION

ANSONIA, CONNECTICUT *of*

NOMA ELECTRIC CORPORATION

Original Recording For

BILLIONTH RECORD

. . . on **audiodiscs**

Recently in Camden, N.J., where the Victor Talking Machine Company was founded some 48 years ago, the billionth R.C.A. Victor Record was produced, thus marking a milestone in the history of the company, as well as the record industry.

For this history-making record, the Victor Division of the Radio Corporation of America chose two of John Philip Sousa's stirring marches, "Semper Fidelis" and "The Stars and Stripes Forever," played by the Boston Symphony Orchestra under the direction of Serge Koussevitsky. And for the discs, on which the original sound recording was made, they chose Audiodiscs.

For the original sound recording in the phonograph record and electrical transcription industries—for master discs used in processing—for sound recording and reproduction in radio broadcasting and motion picture studios—Audiodiscs hold a place of eminent leadership.

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

Export Department: Rocke International Corp., 13 E. 40th Street, New York 16, N.Y.

Audiodiscs manufactured in the U. S. A. under exclusive license from PYRAL, Paris.

they speak for themselves **audiodiscs**

The new EDISON thermal relay

...here's how it works

1. ELECTRICAL HEATER
(5 watts nominal up to 150 volts AC/DC) deflects bi-metal to actuate contacts.

2. CONTACTS
are rated at 6 amperes at 250 volts AC or 450 volts DC; under some conditions, s.p.s.t. normally open or closed.

3. MOVING CONTACT ARM
carried by heated bi-metal is a preloaded spring, which applies full contact pressure immediately. Action absolutely noiseless.

4. FACTORY-ADJUSTED SCREW
sets contact spacing for desired operating time — 5 seconds to 8 minutes.

5. COMPENSATING BI-METAL
maintains pre-set contact spacing and relay timing, regardless of ambient temperature.

6. "E" SPRINGS
braced between sturdy ceramic support and glass tube make assembly shock proof.

- **HERMETICALLY SEALED** in glass envelope, relay is tamper-proof, fully protected from dust, dirt, corrosion, or contact with outside air, with operation independent of altitude.
- **ARC-QUENCHING ATMOSPHERE** guarantees absolute minimum of contact fouling, pitting, or transfer; permits equal AC and DC ratings.
- **STANDARD RADIO TUBE BASE** 4-pin or octal.

Delay or timing is only one of its many uses

...what can this new Thermal Relay do for you?

IN ADDITION to protecting vacuum tubes by delaying plate voltage until cathodes are hot, the Edison Thermal Relay indicates or controls over- and under-current or voltage. It can do dozens of other jobs better and more cheaply than any other type of relay.

The Edison Thermal Relay carries relatively heavy AC or DC loads and prevents chatter when actuated by delicate controls.

The services of Edison engineers are available to assist you in working out your particular problems. A letter giving as much data as possible on the proposed use will receive prompt attention. Write Instrument Division, Thomas A. Edison, Incorporated, 23 Lakeside Avenue, West Orange, New Jersey.

THOMAS A. EDISON, Incorporated
Instrument Division, 23 Lakeside Avenue
West Orange, New Jersey

GENTLEMEN:

Please send me your Bulletin No. 3007X on the Edison Thermal Relay.

NAME_____

COMPANY_____

ADDRESS_____

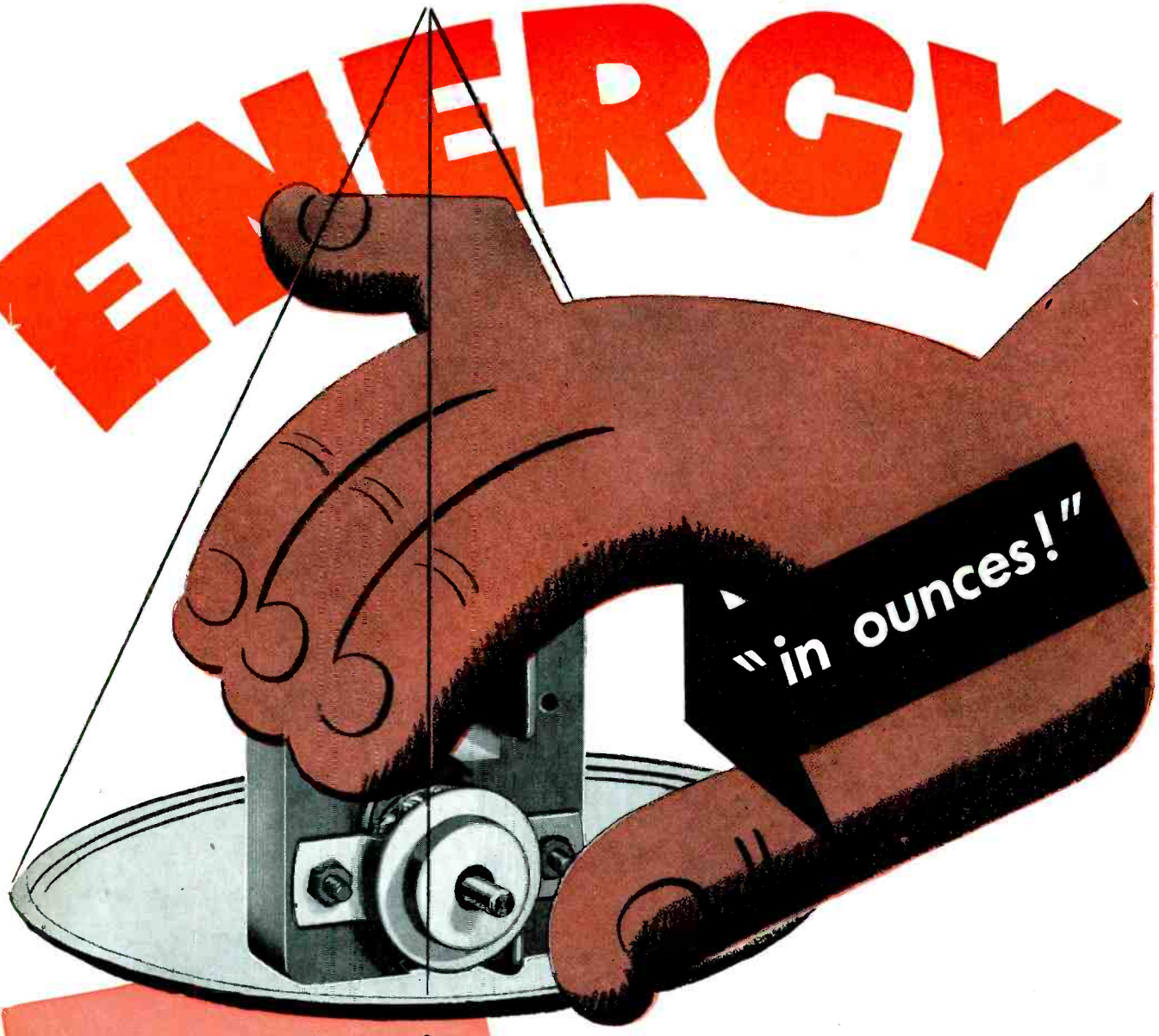
CITY_____ ZONE NO._____

STATE_____

Write for detailed descriptive bulletin #3007x.

AN EDISON CONTROL

ENERGY "in ounces!"



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!

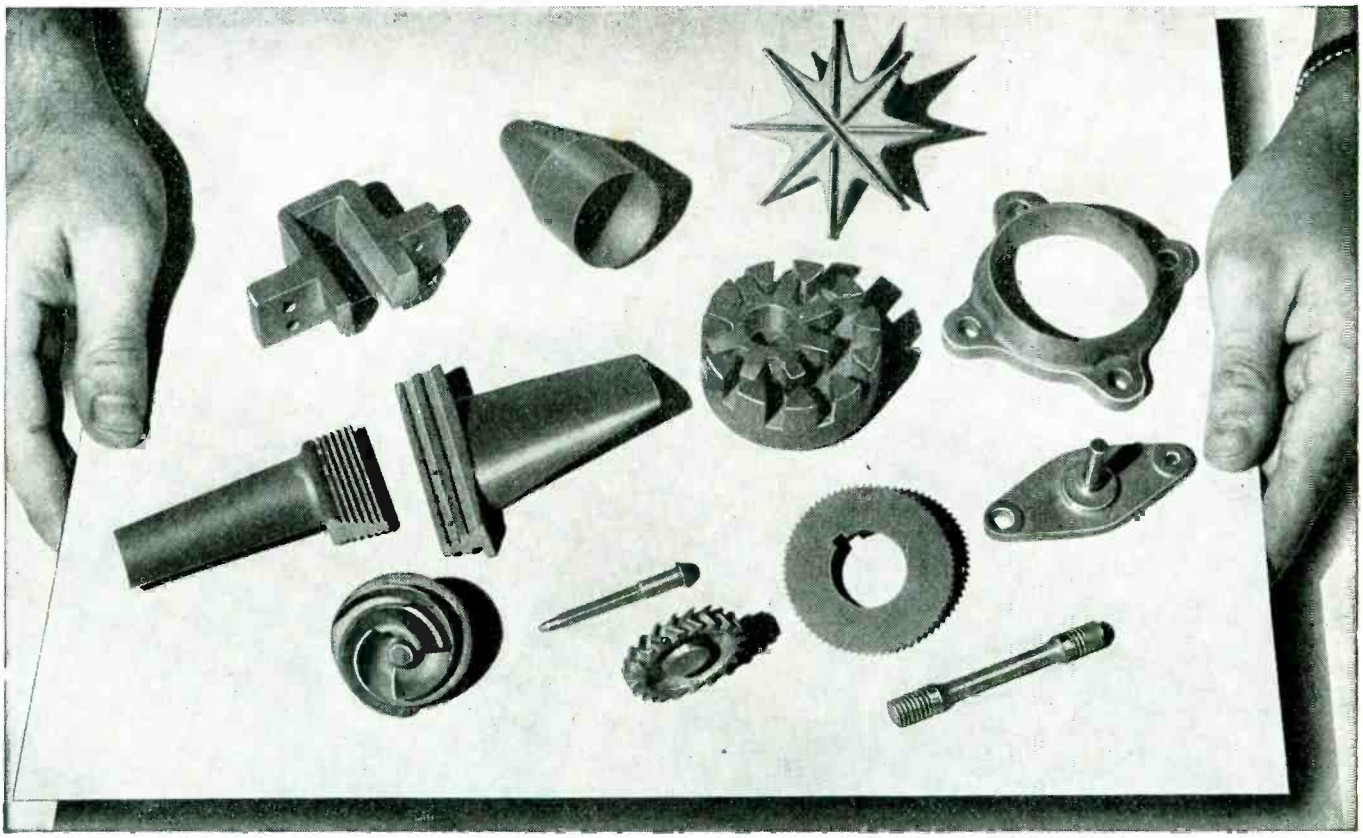
Alliance Powr-Pakt motors are mass produced. They can be built with design variations to meet special load and operating conditions . . . where motors rated from less than 1/400th h.p. on up to 1/20th h.p. are required.

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



CASTINGS . . . *but they were "machined" in the mold!*

Now—all the advantages of Monel, Nickel and Inconel—available in PRECISION CASTINGS

HERE'S another way to lick tough design problems . . . *precision castings of Monel, Nickel and Inconel.*

The new INCO Precision Castings Plant is now in operation . . . built and equipped after several years of pilot plant study, after thousands of experimental castings.

Check what this development means:

1 **Precision Castings of Precision Accuracy** — INCO precision castings are commonly made to tolerances of ± 0.003", and frequently to even finer tolerances.

2 **A Saving in Time and Money** — In general, INCO precision castings eliminate machining or other fabricating operations normally involved in making parts. This is particularly noteworthy where the design calls for intricate features and contours. INCO precision castings are delivered to you with a sand-blasted finish—and usually that's all the finishing these castings require before being assembled into the finished product.

3 **Broader Use for the INCO Nickel Alloys** — The flexibility of design permits the INCO Nickel Alloys to be used in shapes which frequently were neither economical nor practical to obtain as sand castings or by machining from forged stock or deep forgings.

4 **Dependable Source of Supply** — INCO handles precision castings as a mass production process . . . you can count on quick, steady production from INCO.

•

Perhaps an INCO Nickel Alloy precision casting is your answer to the need for faster production...for hardness, greater protection against stress, corrosion, high temperatures, wear and fatigue.

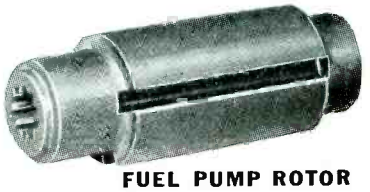
Let's go over your job together. Just send us a blueprint (or an actual sample). We'll be glad to work out all the information you want.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N.Y.

NICKEL (INCO TRADE MARK) ALLOYS

MONEL* • "K" MONEL* • "H" MONEL* • "R" MONEL* • "S" MONEL* • INCONEL* • NICKEL • "L" NICKEL* • "Z" NICKEL*

INCO PRECISION CASTINGS SAVE TIME AND MONEY

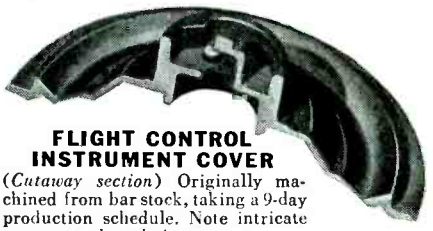


FUEL PUMP ROTOR

Would require a number of operations on several different machines. Note grooves on internal surface.

CLUTCH GEAR

Saved complicated machining. Also avoided at least one sub-assembly, i.e., force-fitting, welding or brazing the projecting key on small end.

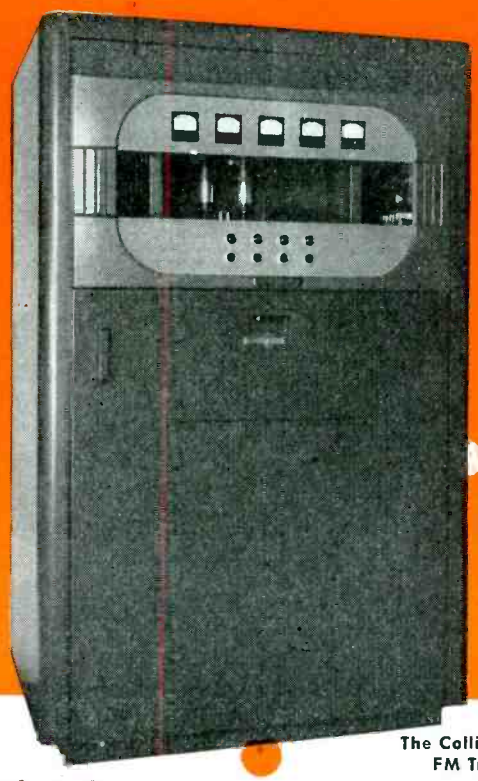


FLIGHT CONTROL INSTRUMENT COVER

(*Cutaway section*) Originally machined from bar stock, taking a 9-day production schedule. Note intricate recesses and studs in recesses.

Above parts are made of "S" Monel

1000 Watts of FM Broadcast Satisfaction



The Collins 732A 1kw
FM Transmitter

Collins FM transmitters are fully engineered in every detail. They reflect many years of successful experience in designing and manufacturing broadcast transmitters unexcelled in performance and reliability. Persons who attended the NAB convention in Chicago were noticeably impressed with the 732A on exhibition there.

What they saw:

RELIABILITY: They saw thorough design in every part of the equipment—Oversized components in all circuits—Personnel protection by means of electrical and mechanical interlocks—Overload protection—Proper ventilation. This transmitter is as substantial as it looks. Our engineers have the experience and know-how to design long and trouble-free life into radio equipment.

STYLE: The modern yet conservative exterior, with its three-tone gray finish, is attractive today and will be ten years from now. The beauty of Collins FM transmitters extends throughout the equipment. Chassis layout is symmetrical, roomy, and functional. Vertical construction and hinged chassis design provide utmost accessibility.

What they didn't see:

PERFORMANCE: They couldn't see the performance characteristics as measured in actual operation. Measurements show a carrier stability within ±200 cps. Distortion is less than 1.0%. The frequency response is within 1.0 db total variation from 50 to 15000 cps. The noise level is at least 65 db below 100% modulation.

Write for an illustrated bulletin. And remember that we can supply your entire equipment requirements.

FOR BROADCAST QUALITY, IT'S . . . COLLINS

COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA

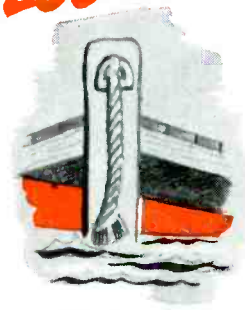
11 West 42nd Street, New York 18, N. Y. 458 South Spring Street, Los Angeles 13, California

5th among the features of DIEFLEX VARNISHED TUBING PRODUCTS is...

COMPLETENESS OF LINE

COMPLETE IMPREGNATION

FLEXIBILITY



NON-FRAYING

DIELECTRIC STRENGTH

GOOD PUSH-BACK QUALITY

THE use of Dieflex varnished tubings and sleevings offers a big advantage in production because the correct grade, color, and size can easily be chosen from the complete line available. Every piece of Dieflex tubing or sleeving is saturated with oleoresinous impregnating type baking varnish, and each one has the inherent advantages of extreme flexibility, smooth inside bore, and other excellent electrical and physical qualities illustrated on this page.

Dieflex tubing products are available with either a cotton or glass braided sleeving base to meet every insulating requirement. Available promptly from stock. Specify "Dieflex" to get the advantages of this superior tubing product.

DIEFLEX PRODUCTS LIST

MADE WITH BRAIDED COTTON SLEEVING BASE

- VTA Grade A-1 Magneto Grade Varnished Tubings
- VTA Grade B-1 Standard Grade Varnished Tubings
- VTA Grades C-1 and C-2 Heavily Coated Saturated Sleevings
- VTA Grade C-3 Lightly Coated Saturated Sleevings
- Heavy Wall Varnished Tubings and Saturated Sleevings

MADE WITH BRAIDED GLASS SLEEVING BASE

- VTA Grade A-1 Magneto Grade Varnished Fiberglas Tubings
- VTA Grade C-1 Extra Heavily Saturated Fiberglas Sleevings
- VTA Grade C-2 Heavily Saturated Fiberglas Sleevings
- VTA Grade C-3 Lightly Saturated Fiberglas Sleevings
- Silicone-Treated Fiberglas Varnished Tubings and Saturated Sleevings

SMOOTH INSIDE BORE

UNIFORMITY OF PRODUCT

ELECTRICAL INSULATION

Distributed by

INSULATION AND WIRE SERVICE

INSULATION MANUFACTURERS CORPORATION

CHICAGO CLEVELAND DAYTON
MILWAUKEE MINNEAPOLIS
DETROIT PEORIA

TRI-STATE SUPPLY CORPORATIONS

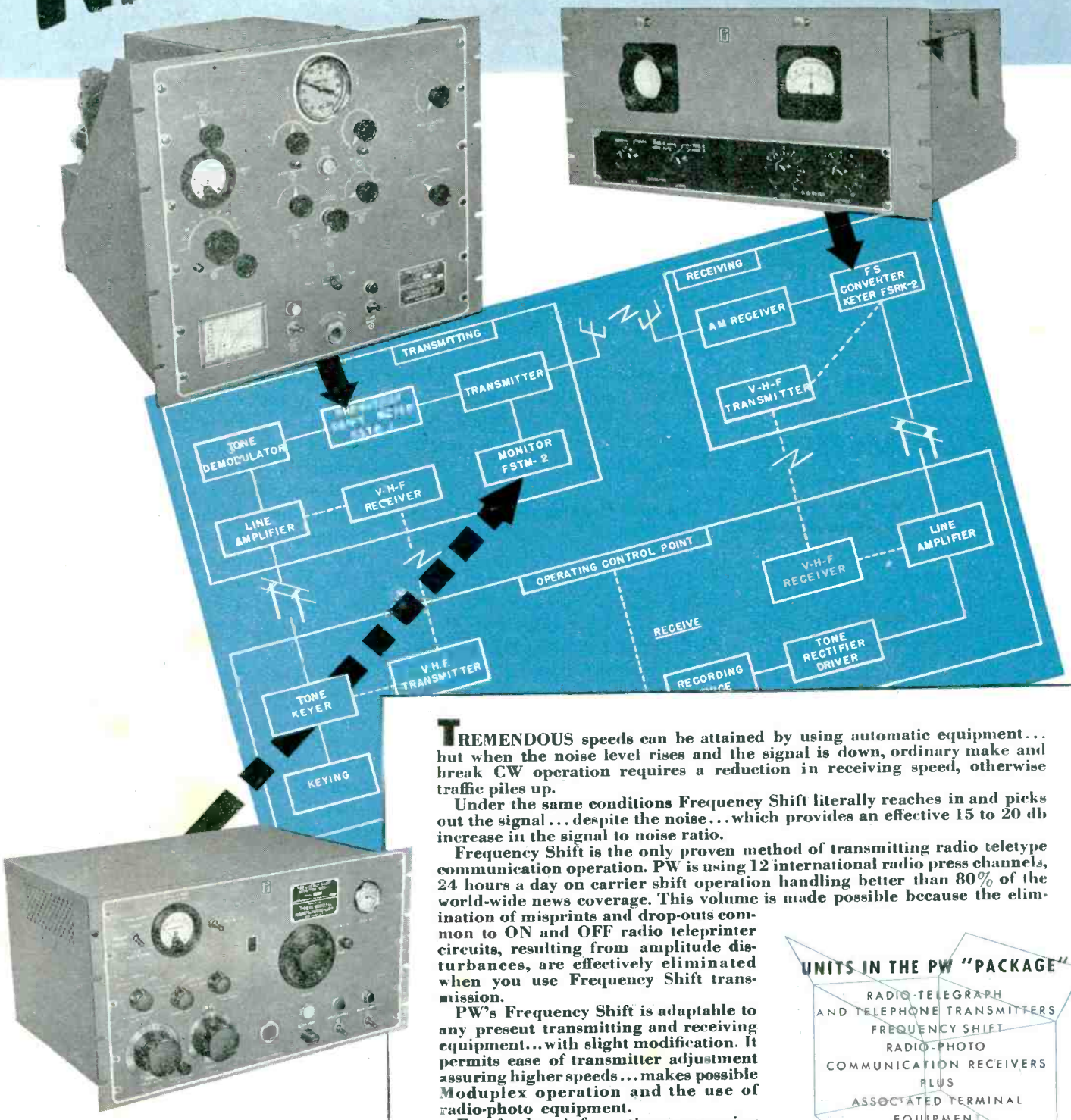
LOS ANGELES
SAN FRANCISCO
SEATTLE

INSULATION AND WIRES INCORPORATED

ST. LOUIS ATLANTA HOUSTON
DETROIT BLUEFIELD
BOSTON NEW YORK

NEW! PW "FREQUENCY SHIFT"

THE MOST DEPENDABLE RADIO-TELETYPE OPERATION *Known Today*



TREMENDOUS speeds can be attained by using automatic equipment... but when the noise level rises and the signal is down, ordinary make and break CW operation requires a reduction in receiving speed, otherwise traffic piles up.

Under the same conditions Frequency Shift literally reaches in and picks out the signal... despite the noise... which provides an effective 15 to 20 db increase in the signal to noise ratio.

Frequency Shift is the only proven method of transmitting radio teletype communication operation. PW is using 12 international radio press channels, 24 hours a day on carrier shift operation handling better than 80% of the world-wide news coverage. This volume is made possible because the elimination of misprints and drop-outs common to ON and OFF radio teleprinter circuits, resulting from amplitude disturbances, are effectively eliminated when you use Frequency Shift transmission.

PW's Frequency Shift is adaptable to any present transmitting and receiving equipment... with slight modification. It permits ease of transmitter adjustment assuring higher speeds... makes possible Moduplex operation and the use of radio-photo equipment.

For further information concerning Frequency Shift write Dept. 709 Press Wireless Mfg., Corp., Executive Offices, 1475 Broadway, New York 18, N.Y., USA

UNITS IN THE PW "PACKAGE"

RADIO-TELEGRAPH AND TELEPHONE TRANSMITTERS
FREQUENCY SHIFT
RADIO-PHOTO
COMMUNICATION RECEIVERS
PLUS
ASSOCIATED TERMINAL EQUIPMENT

Your installation is engineered from any combination of the above standardized PW units

PRESS WIRELESS

First in "Packaged" Communications Equipment

BUSINESS BRIEFS

By W. W. MacDONALD

When A New Column Bows it assumes an attitude that makes it equally easy for readers to administer a pat on one end or a kick at the other. We hope *Business Briefs* will merit the former, but in any event comment will be welcome.

This Monthly Stint stems from a growing conviction that while technical material is and always must be the engineer's bread-and-butter literature it would be profitable for the boys in the back room to know more about matters of current concern topside, particularly if they nourish an ambition to muscle into management.

The plan is to provide this information in capsuled form, and the following items represent our breadboard, or subject-to-design-change, stab at it.

Business Outlook for 1947 is considered good by most electronic equipment manufacturers contacted just before presstime, provided strikes in basic industries do not throw a monkey wrench into the works for everybody. Home radio makers hedge a little, say much will depend upon whether or not the market can be quickly cleared of the present glut of overpriced small sets.

Major Problems facing management include the inefficiency of labor and material shortages, two factors that hike costs and force factories to run the risk of pricing themselves out of the market. There is no certainty, but there does appear to be some hope of relief on both counts in the first half of the new year.

Surplus Equipment seen on a swing around several government warehouses leads us to believe that the stuff dumped on the market to date is just a drop in the bucket compared to what is coming. A lot of it will go to junkies as scrap but there is little assurance that they will break it up.

Gear finding its way into trade channels by any route will probably carry lower prices. Even so, we will stick our neck out to the extent of predicting little disturbance of the market for newly manufactured apparatus because many ultimate users already have a cellar full of fancy but not particularly useful gimmicks and will be more critical of what they buy from here on out.

Receiver Production broke all-time records in October, with 1,671,000 sets rolling off the lines. Last-quarter figures are incomplete but it appears that more receivers may have been produced in 1946 than in 1941, when 13,642,000 were made.

Dollar volume is another story, and not so rosy despite high prices because of the preponderance of small sets. But it is encouraging to note that production of radio-phonograph consoles rose from 105,000 in September to 125,000 in October and that sets having f-m facilities moved up from 17,500 in September to 23,800 in October.

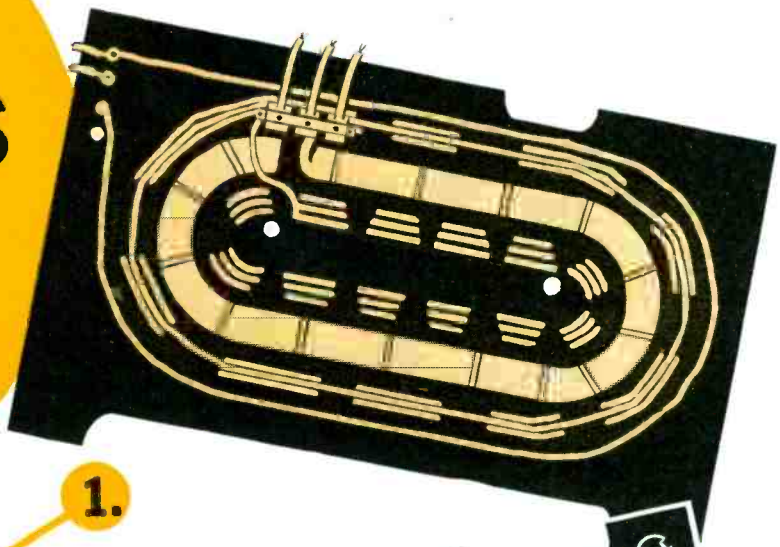
Broadcast Station Equipment shipped by RMA members in the first half of 1946, consisting of transmitters, studio accessories and antennas, totalled $1,758,573 in value. $395,511 worth was exported.

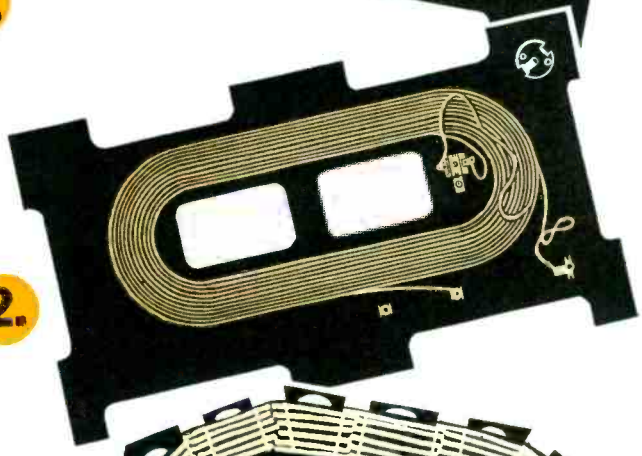
Of the domestic dollar volume on transmitters alone 63 percent was for a-m equipment, 19 for television and 18 for f-m.

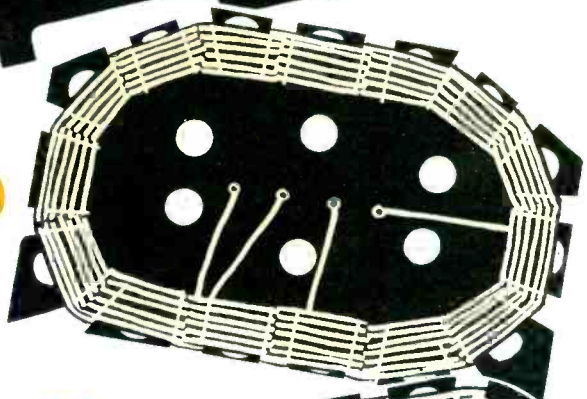
F-M Applicants appear to be specifying one of nine transmitter brands at the present time (please don't ask us which they are!), with less than two percent indicating that they plan to use composite gear. Manufacturers in a position to ship hot high-gain antennas with their transmitters are, it seems, in the driver's seat at the moment.

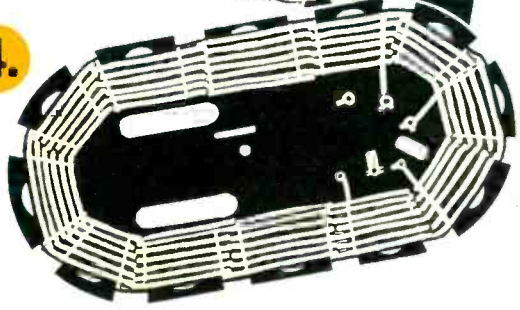
Over 90 percent of the paper work involved in filing an application is done by Washington consultants. How much they influence

Loop Antennas by Super









FOR IMMEDIATE DELIVERY

Standard Loop Antennas and Built to your Specifications

1. Multi-band combination loop Antenna and Radio Back.

2. Broadcast Loop Antenna and radio back combination with phone jack, outside antenna connection, aligning trimmer.

3. High Q Loop Antenna, polyethylene insulated wire.

4. Basket weave loop Antenna.

Also, I. F. Transformers, All-Wave Osc. Coils, R. F. Coils, Antenna Coils, and solenoid wound loop antennas

Standard types and to your specifications.

Super
ELECTRIC PRODUCTS CORP.

1057 SUMMIT AVENUE, JERSEY CITY, NEW JERSEY

applicants in the selection of transmitter brands cannot be precisely determined but it is known to be considerable.

Second Coming of Television, touched off at the TBA Conference in October, produced a raft of predictions. Frank Mansfield of Sylvania said 400,000 receivers could readily be sold in 1947. Ernie Vogel of Farnsworth thinks 750,000 to 1,000,000 would move this year if the industry could make them. Merlin Aylesworth estimates there might be 2,000,000 in use by the end of 1948. Joe Gerl of Sonora expects that 25,000,000 will be manufactured in the next decade.

Electronic Heating and diathermy are easily confused, sometimes with unhappy results. Stories about radio interference caused by medical apparatus are a dime a dozen and the tendency is to dump industrial gear into the same basket. Yet we have heard of no case in which induction apparatus has been responsible for widespread racket and know of only two authenticated instances in which noise from dielectric equipment achieved dx.

College Contracts with OSRD ran into fancy figures during the war, the take of 25 schools grossing over a million by mid-1945 totalling $335,000,000. Big six, among the many non-industrials easily earning their money were MIT, with approximately $117,000,000 on its books, Cal Tech $83,000,000, Harvard $31,000,000, Columbia $29,000,000, California $14,000,000 and Johns Hopkins $11,000,000.

Just how much of this work was electronic we cannot tell, but it is known that better than 55 percent of the business placed with industrial contractors by the Office of Scientific Research and Development was in our field.

British Production Capacity skyrocketed during the war and this plus plenty of uses for dollar exchange has prompted aggressive promotion of test equipment and

record players on our shores. Inquiry indicates that consumer interest is considerable, which is understandable in view of the fact that in one of these categories at least American manufacturers are just starting to roll out comparable high-quality gear.

Just how well the visitors will do when our own first team takes the field remains to be seen. Meanwhile, welcome brothers.

Army Appropriation for 1947 basic research in all fields is $70,000,000. Navy has earmarked $45,000,000. About 14 percent of the Navy nut will apparently be spent with the electronics industry. Army telleth not.

We have a list of firms to whom development contracts have already been awarded by both Services but they are naturally chary about telling who is doing what and how much.

Ham Licenses totalled 60,000 before the war. Approximately 7,000 more were issued during the shooting. There are about 75,000 now, and the FCC's hard-pressed personnel has just about caught up on renewals.

The rate at which new applications are coming in indicates a total around 100,000 two years from now. This is considerably under earlier predictions but it still represents one whale of a lot of brass-pounders.

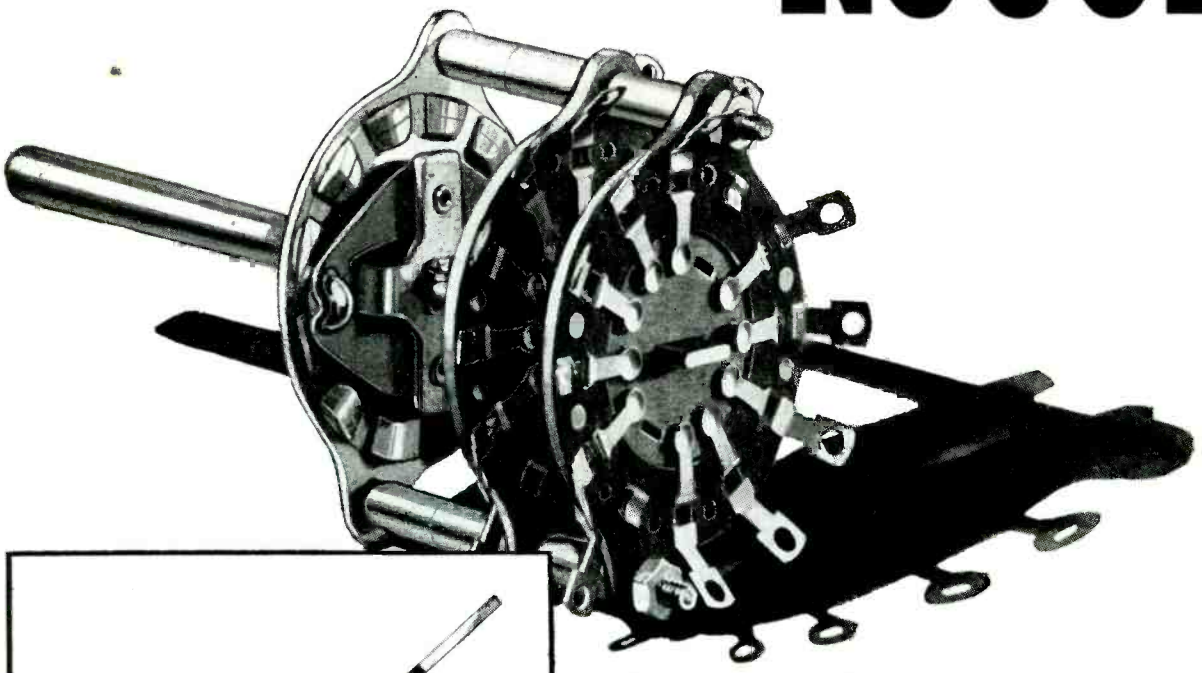
Factory Locations, figured out for those who have written in and asked where firms making electronic equipment, accessories and components are concentrated, are as follows:

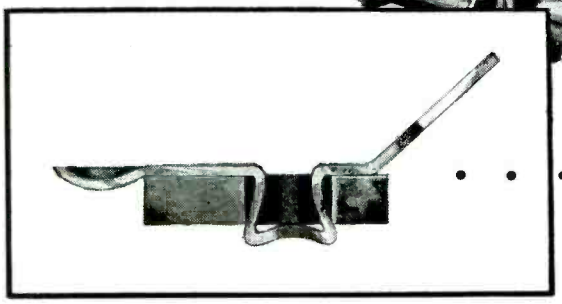
Middle Atlantic States 43.59, East North Central 29.62, New England 12.57, Pacific 7.35, West North Central 3.23, South Atlantic 2.24, East South Central 0.55, West South Central 0.55, Mountain 0.30.

Salaries paid design and development engineers by 12 eastern radio and electronic equipment manufacturers average $5,600. Production engineers get $4,100 and Juniors $3,000.

Attorneys practicing regularly before the FCC total 140.

WE MAKE THEM RUGGED





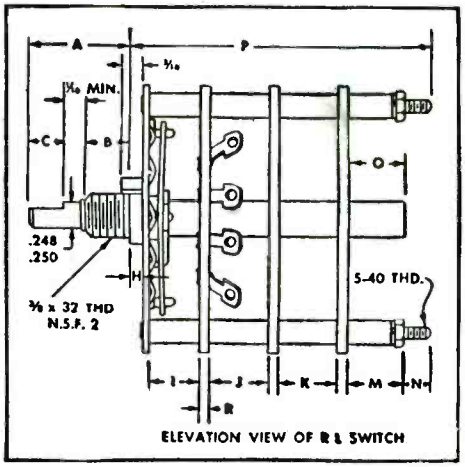
. . . the terminals feature two-point fastening!

This Mallory RL Switch, designed for low-power industrial applications, is known throughout the industry for its durability and dependable performance.

Notice how the terminals are fitted right into the stator—firmly held without rivets or staples. No chance of their wobbling loose! The terminals, in turn, are solidly built of spring brass material which is heavily plated with silver. Notice, too, the high lift and flexing ability of the terminals. That's to provide a self-cleaning action, insuring better electrical contact.

Contributing still further to rugged design are the stators of this RL Switch. They're made of heavy phenolic to provide good insulation and to withstand rough usage. Rotor contact slugs are of solid coin silver, common ground rings are of brass, heavily silver-plated: these features combine to assure long life.

The RL Switch offers from 1 to 6 circuits per section with 30 degree indexing—from 1 to 3 circuits per section when 60 degree indexing is used. RL Specification Sheets will give you more of the story. Send for them without obligation. Call on our engineers *any time* for extra help.



ELEVATION VIEW OF RL SWITCH

ASK FOR RL SPECIFICATION SHEETS

Printed on thin paper to permit blueprinting, these sectional drawings indicate standard and optional dimensions—make it easy for you to order production samples built to meet your requirements. Standard RL switches are obtainable from your nearest Mallory Distributor.

P.R. MALLORY & CO. Inc.

MALLORY SWITCHES

(ELECTRONIC, INDUSTRIAL and APPLIANCE)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CROSS TALK

►**SPEED** . . . C. W. Hansell, writing in the September "RCA Review", reminds us that the wideband relays now being readied for television may be used to transmit facsimile at unheard-of speed. He says "it is probable that all the channeling problems of the record communications services will be solved or bypassed by the introduction of page-per-frame facsimile message handling . . . In television it is normal practice to transmit 108,000 complete images, or pages, per hour." If such a system comes to pass, the telegram of the future may actually cost less when sent by day, when the coaxial and microwave relays are not engaged in networking television and hence may be devoted to "record communications." When will we see the microfilm recorder which photographs, in a thirtieth of a second, a single television frame filled with a dozen "day-rate" telegrams?

►**MOT** . . . A recent visitor has suggested a delightful phrase for the activity many top-flight engineers have been engaged in, for better or worse, in the introduction of standards and frequencies for f-m and television. Upstairs, downstairs, black, white, colored facts, fancies, and angles. He calls it "strategic engineering". Maybe our colleges should be teaching it. It seems to pay.

►**CITI-BAND** . . . Interest in the citizens radio band, 460 to 470 megacycles, has been revived by the recent release of the FCC proposing tentative rules and regulations to govern the new service. The Commission proposes to divide the band into three parts: 460-462 mc for fixed stations with 0.02 percent frequency tolerance; 462-468 mc for all classes of stations, including those with 0.2 frequency percent tolerance; and 468-470 mc for stations with 0.02 percent tolerance. This is a thoroughly constructive step, and one which may save the band from the progressive degeneration which has been predicted.

No one, so it seems, yet knows quite how to build a simple, small equipment for the citizens band with high-frequency stability. Lacking it, the band seemed doomed to intolerable interference in heavily populated areas. But to bar inexpensive equipment from the band would defeat one of the basic purposes for which it was set up, widespread public use in services not otherwise provided for in the allocation table. The Commissioners are wise in proposing to allow a reasonably slack frequency tolerance in the middle of the band, leaving the band edges for those services which can afford crystal-controlled equipment and need its more reliable performance.

Incidentally, the Commission is guilty of a masterpiece of understatement when it proposes that "the transmitting equipment shall be inherently incapable of operating at a power input of more than 50 watts" to the final stage. Very true, very true! In fact you can make it 15 watts,—and try and get it.

►**BUSINESS** . . . In this issue, (p.66) Bill MacDonald, Managing Editor of ELECTRONICS, begins a new column, "Business Briefs", intended to bring to our engineering readers a commentary on the production and distribution trends on which their, and our, livelihood depends. There was a time when engineers were not supposed to be interested in such matters. That was for "management". But engineers are, by and large, part of management today, and even the brand-new engineering graduate has been trained to appreciate that engineering effort must be placed along productive channels, if it is to be effective in adding to the common wealth. The new column, like the rest of our magazine, is intended for technical readers, but it has, we think you will agree, a new agreeable flavor. And Mac is just the guy to serve it, as his many friends in industry testify. He welcomes suggestions.

Two Systems of COLOR TELEVISION

A statement of the relative merits of the sequential color system shown by CBS and the simultaneous system demonstrated by RCA, from the standpoint of performance, required standards, and needed research

By DONALD G. FINK

RECENT INTEREST in the color versus black-and-white television controversy has centered on two color systems, demonstrated by the Columbia Broadcasting System and the RCA Laboratories.

The CBS system, which has been described at length in these pages[1, 2] is a typical example of the sequential method, in which images in the three primary colors are sent one after the other on a single r-f carrier. The RCA system, demonstrated recently and briefly described in these pages last month[3], is typical of the simultaneous method, in which images in the three colors are sent at the same time on three carriers. The sequential and simultaneous systems have been referred to as mechanical and electronic systems respectively but these are not significant designations, since either system can be operated electronically.

In preparation for the FCC hearing on color television which began December 9th last, the comparative merits of the two systems were studied by television specialists on committees of the Radio Technical Planning Board and the Radio Manufacturers Association. This article is a summary of their findings as revealed at the hearing, plus observations on economic factors not considered by the RTPB and RMA groups.

The Two Systems

The sequential system is characterized by the fact that the transmitted signal contains information about one primary color only at any instant of time, the three primaries following one after another.

The cameras thus far used with this system are of the mechanical type, i. e., they use a rotating disc carrying three color filters.

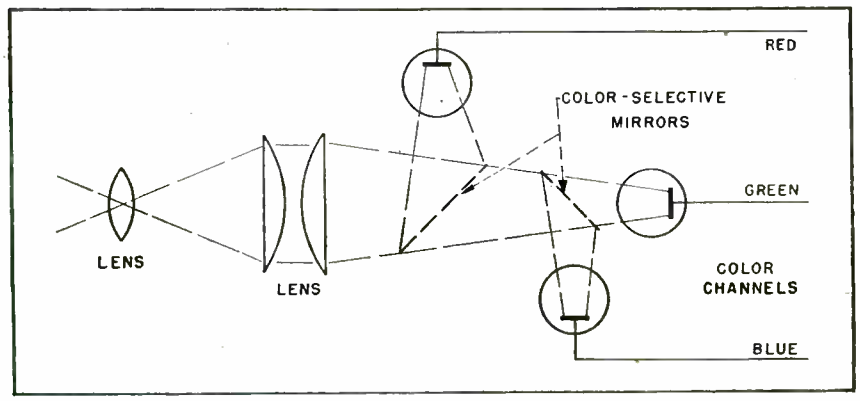


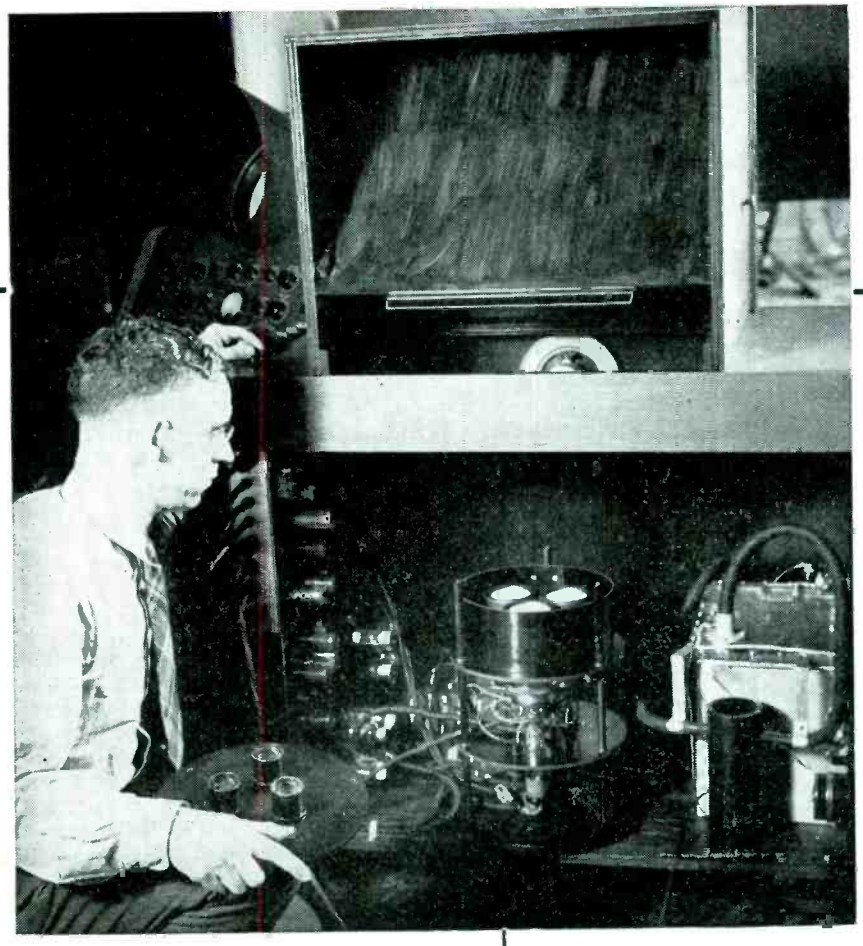
FIG. 1—Beam-splitting camera arrangement for deriving three colored images from color-selective mirrors. This type of camera can be used in either system, with the mosaics keyed sequentially or operating simultaneously

In place of the rotating disc, however, it is possible to employ a beam-splitting arrangement like the simultaneous-type camera, and three photosensitive elements (phototubes or mosaics), each with a different fixed color filter. The photosensitive elements may be keyed on and off in sequence, producing a sequential signal without using moving parts.

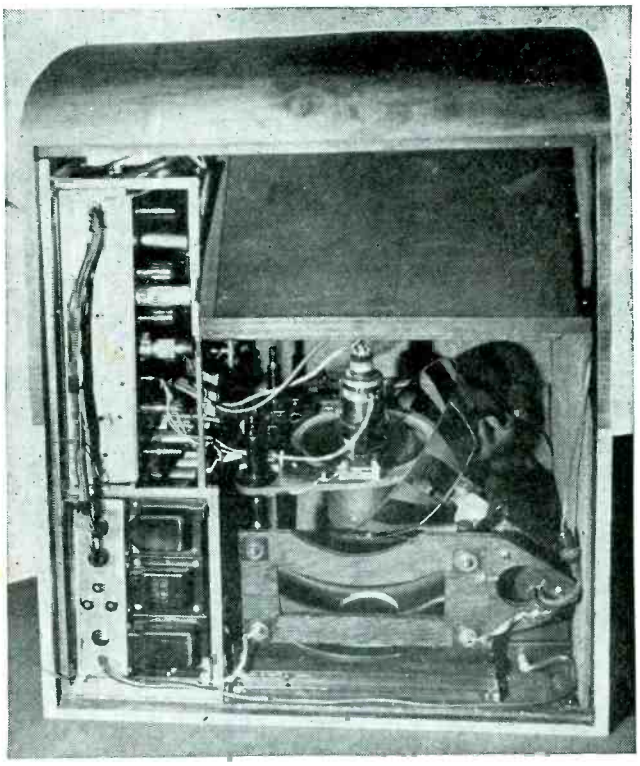
In the receiver the signal actuates a single cathode-ray tube in front of which rotates a synchronous color disc like the one used at the transmitter. Here, also, the mechanical disc may be replaced by three cathode-ray tubes, each fitted with a fixed color filter and arranged so that the images may be projected in register on a viewing screen. The c-r tubes are in this case keyed on and off in synchronism with the studio camera.

The simultaneous system uses three carriers or sub-carriers. The image is perceived either by three cameras, each with a different fixed color filter and each feeding a separate channel, or by a beam-splitting device, Fig. 1, which breaks the image into three colored images, each feeding a separate phototube or mosaic. In either event, three signals are generated simultaneously and are fed through three separate channels.

At the receiver, the three carriers are received separately either by employing three separate i-f amplifiers or by employing wave filters before the second detector,



Corresponding elements of sequential and simultaneous projection receivers. The CBS receiver (below) uses a single five-inch cathode-ray tube with a cup-shaped filter disc. The RCA receiver (at left) employs three separate three-inch tubes with projection lenses



and applied to three picture tubes, each fitted with a different fixed filter (or using colored phosphors). The three images are projected on a screen in register.

The simultaneous system is thus an electronic one, with elements like the elements of an electronic sequential system. The difference is that in the simultaneous system all channels are working at once, rather than one after the other as in the sequential system.

Different as the two systems may appear at first glance, they have many performance characteristics in common. Both are capable of rendering the same fidelity of color transmission, provided that the same color filters are used in each system. Both employ approximately the same bandwidth in the ether spectrum, since the sequential system requires one wide-band carrier while the simultaneous system uses three narrower carriers. Both are capable of about the same broadcast coverage, when operated in the same region of the spectrum, since

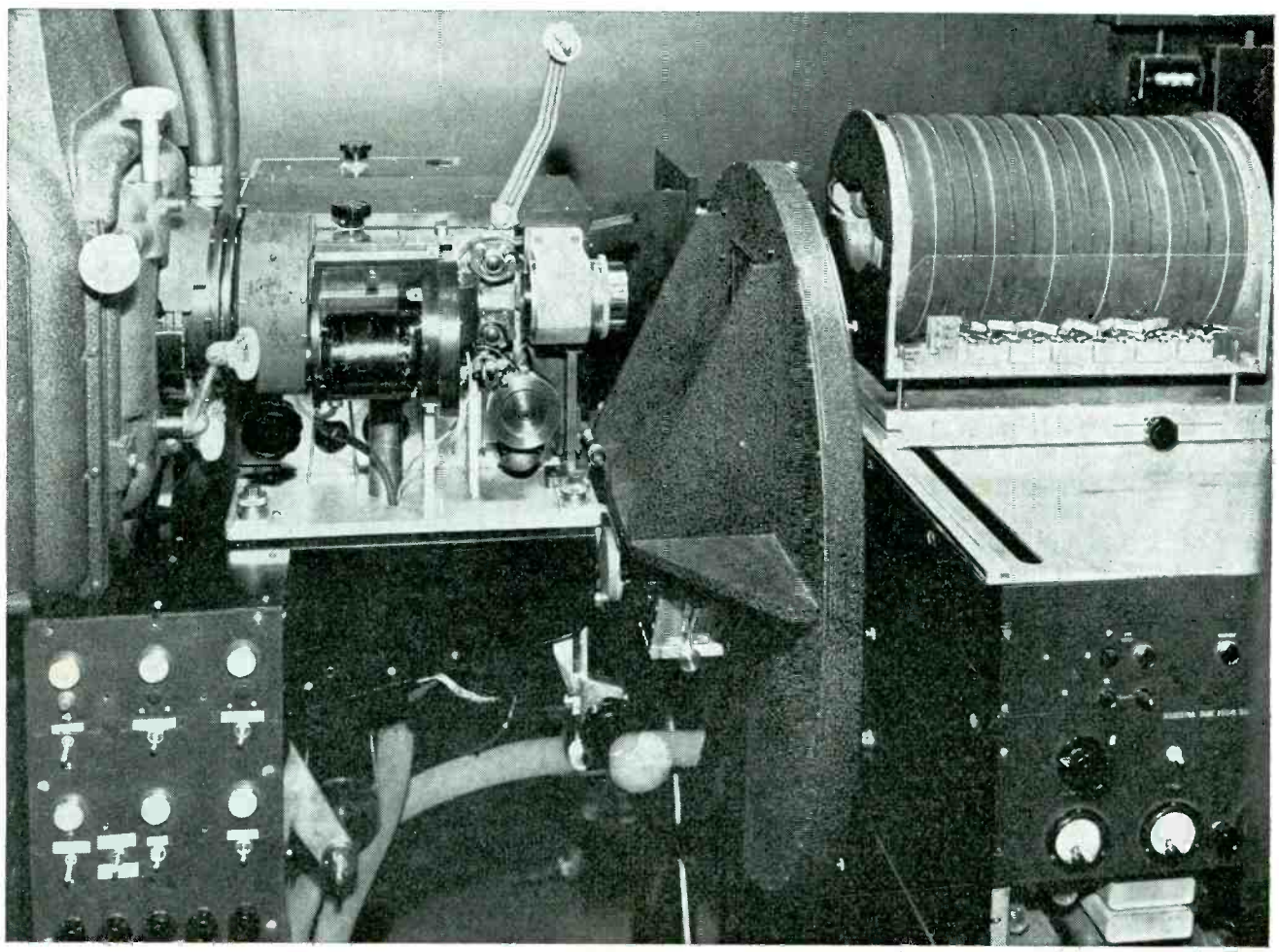
the separate transmitters of the simultaneous system can develop higher power over the narrower band, but only at the expense of using three sets of tubes. If all these tubes are combined (in a ring oscillator circuit, for example) in the single transmitter of the sequential system, they can provide approximately the same power over the wider band and hence produce equal signal strength contours.

Picture-Repetition Effects

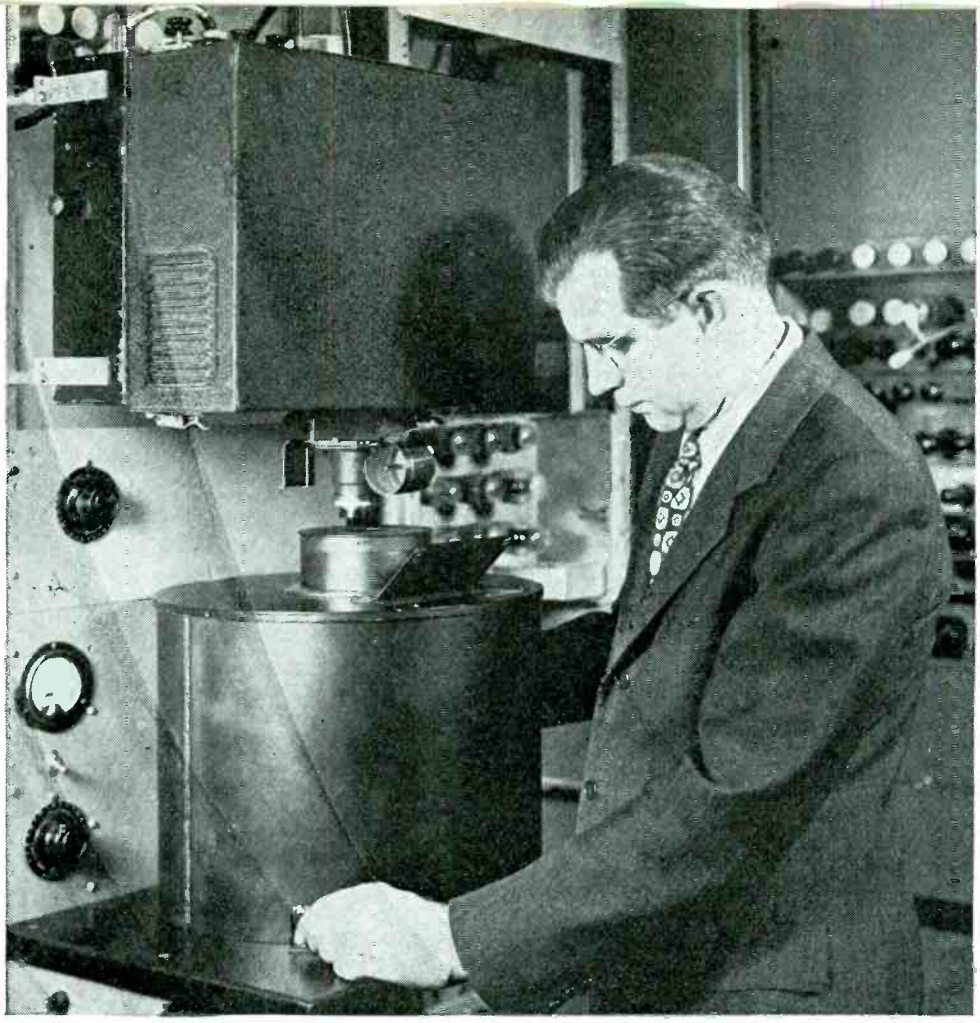
The two systems display different requirements when the picture-repetition effects (flicker, color break-up and color fringing) are considered. In the black-and-white system, the flicker problem has been attacked by setting the picture repetition rate at 60 fields per second (30 frames per second). At highlight picture brightnesses up to about 50 foot-lamberts (somewhat brighter than the brightest television pictures now available to the public, and high enough to be received satisfactorily in a well-lighted room), and when phosphors having normal decay rates are used, there is no apparent flicker in the black-and-white system. At higher brightnesses there is some doubt that the 60-field rate is high enough but it suffices for foreseeable needs.

In the sequential color system the flicker problem is complicated by the fact that the light from one color field must disappear substantially completely before the next color filter is positioned before the c-r tube. This implies the use of rapid-decay phosphors, and consequently higher apparent flicker. To overcome this tendency, and to assure smooth blending of the colored images, it is necessary to transmit the sequential color images at a field rate well above 100 per second. The rate originally adopted by CBS was 120 fields per second (40 color frames per second), and this was later raised to 144 fields per second (48 color frames). Since flicker is observable at brightnesses of 50 foot-lamberts or better with this rate, some engineers have urged that the field rate be set at 180 per second (60 color frames per second). In the latter case, the pictures are sent at three times the rate of the black-and-white images, and the bandwidth required is three times as great. It thus appears that the sequential system requires a video bandwidth of from 2.4 to 3 times the black-and-white figure, for a picture of equal objective resolution.

In the simultaneous system, the blending of colors is inherent and a much lower field rate is permissible. In addition, phosphors of slower decay may be used, and this



Corresponding film pick-up devices in the two systems. Below: CBS unit uses film projector (left), a color wheel (center), and a single image dissector pick-up tube (right). The RCA equipment (on right-hand page) uses a flying-spot raster scanner located below a housing containing a beam splitter with three multiplier phototubes



further lowers the flicker threshold frequency. Thus a rate of 60 fields per second in a simultaneous system may be expected to give flicker performance superior to that of a sequential system operating at 180 fields per second. Each of the three channels in the simultaneous system would have a bandwidth, for pictures of equal resolution, of 60/180 or one third that required for the sequential system. Under these conditions the total bandwidth required is the same in the two systems except that space for guard bands, to separate the three channels, must be allowed in the simultaneous system.

The other picture-repetition effects, color break-up and color fringing, are basically different in the two systems. In the simultaneous system, since all colors are presented continuously, there can be no color break-up as such, whereas in the sequential system break-up may be caused by movement of the eyes. Many observers, perhaps the majority, have a tolerance for color break-up, and it is not considered a serious factor in any event. Color fringing, the third effect, is also not present in the simultaneous system, but a similar effect due to lack of register among the three simultaneous images may be present. Hence the two systems are comparable in this respect.

Other Pertinent Factors

A factor of great importance in the progress of the art is the compatibility of color television standards with the present black-and-white standards. Here the simultaneous system has a clear advantage. If a simultaneous field rate of 60 per second is chosen, the scanning standards of each of the images are identical to the black-and-white standards. Hence the color images may be received, in black-and-white, on a standard present-day black-and-white receiver. This is done by using a frequency converter to tune the black-and-white receiver to the green image of the color transmission, which contains nearly all of the black-and-white values of the colored image.

The sequential system cannot be so accommodated to existing black-and-white standards. Thus the choice of the simultaneous system with a field rate of 60 per second would greatly ease the transition from black-and-white to color. Such a choice implies a total bandwidth (three simultaneous channels) somewhat greater than that for a 180-field sequential system, and considerably wider than that for a 144-field sequential system, which many consider to be adequate. Here, again, a situation exists which tends to place the two on a par. In the sequential system, since a single channel of fixed width is employed and all colors are scanned at the same rate, the same amount of information is necessarily sent in all three colors. Stated differently, if the bandwidth is chosen to accommodate the most detailed color, green, the same bandwidth is reserved to transmit detail in red and blue, despite the fact that less detail may suffice in the latter colors.

In the simultaneous system, on the other hand, the bandwidth provided for each color may be tailored to meet the detail requirements of the eye. It is well known in physiological optics that, except at very high brightness levels, the eye can resolve much less detail in a blue image than it can in an identical green image. Thus it is possible to restrict the bandwidth for the blue channel, and possibly to a lesser extent for the red channel also, without apparent loss of resolution in the color picture*. If this is done, and the extent to which it is possible has not yet been accurately determined, the bandwidth required for a simultaneous system will not exceed, and it may even be less than that required for a sequential system of the same resolution, even when guard-band space is provided in the former system.

Still another question is the relative ability of the two systems to pick up images directly from live subjects. Both systems have been demonstrated on film and lantern

* A similar saving of bandwidth might be achieved in the sequential system by scanning the colors at different rates, that is, allowing more scanning time for green than for red and blue, but this would introduce serious apparatus problems, particularly with respect to interlacing, color balance and flicker, and probably is not a practical procedure.

slides; no demonstrations have been given of live pickup with the simultaneous system. Until the latter event occurs, conclusions must be tentative. But it can be assumed that the register problem in the live-pickup simultaneous camera can be solved as satisfactorily as it has been in the receiver, and it may be expected that the performance will be about the same as regards color rendition.

In the sequential camera the mosaic must be completely discharged at the end of each color field (every 1/180th second in a 180-field system) to avoid carry-over of one color into the next. Since the storage time is thus reduced, the sensitivity of the sequential camera must inevitably be lower than that of the simultaneous camera, in which mosaic storage can be employed through the whole frame interval (comparably, 1/30th second). Whether or not this will prove an important advantage to the simultaneous system depends, of course, on the extent to which the producer uses dimly-lit scenes. The sensitivity of the image orthicon, which may be used in either color system, is so great that it may provide sufficient margin to give adequate performance in the sequential system with any light level likely to be encountered. Finally, it must be remembered that a sequential signal can be produced from a simultaneous camera by keying the color images in and out in sequence, so the most sensitive camera available could be applied to either system.

The above comparisons are based on equal resolution, that is, the same number of resolvable picture elements in the color picture produced by the two systems. To make full use of this resolving power, scanning aberrations must be minimized. Such aberrations are present in both systems.

In the sequential system, the frame rate is not synchronous with the 60-cps power source, even when operated at 180 sequential fields. Thus hum and spurious fields within the receiver must be carefully removed by filtering and shielding. In the 60-field simultaneous system, on the other hand, each image is synchronous with the 60-cps power source but the three images must be accurately registered one over the other on the camera and on the receiver viewing screen. It appears that with the use of a single deflection generator for all three c-r tubes, and with proper care in aligning and centering the beams, this effect may be minimized.

At the receiver one fundamental difference, and several less fundamental ones, appear in respect to the picture brightness. The fundamental difference arises in the fact that in the sequential system there is only one light source on at a time, operating sequentially with different colors, whereas in the simultaneous system three light sources operate at once. Hence, all other factors being equal, the simultaneous picture will be approximately three times as bright.

Received Picture Brightness

In the equipment thus far shown the brightness advantage of the simultaneous receiver is even more pronounced, because colored phosphors are used. Such phosphors generate far more light, from a given accelerating voltage, than does a white phosphor in conjunction with a colored filter (the average light loss of the colored filters is from 85 to 90 per cent). However, this is not a fundamental difference, since a sequential signal

Combined membership of the RTPB television panel and color television subcommittee which prepared evidence for recent FCC hearing. Seated at far end of table are D. B. Smith, chairman of RTPB Panel 6, and D. G. Fink, chairman of the subcommittee conducting color television studies. Others are, seated left to right, R. E. Shelby, NBC; W. E. Bradley, Philco; F. J. Bingley, TBA; Axel Jensen, Bell Labs; R. B. Dome, GE; Leonard Mautner, DuMont; G. L. Beers, RCA. Standing, left to right: H. G. Boyle, NA Philips; W. T. Wintringham, Bell Labs; P. J. Larsen, SMPE; P. C. Goldmark, CBS; E. M. Roschke, Zenith; A. Packard, Colonial; Curtis Plummer, FCC observer; J. E. Keister, GE; F. R. Norton, Bendix; A. A. MacDonald, Westinghouse; J. D. Schantz, Farnsworth; Pierre Mertz, Bell Labs; A. N. Murray, consultant; A. V. Loughren, Hazeltine; A. E. Newlon, Stromberg-Carlson; H. E. Kallman, Telicon; W. F. Bailey, Hazeltine; R. D. Kell, RCA; George Town, Stromberg-Carlson; J. D. Reid, Crosley; T. T. Goldsmith, Jr., DuMont; George P. Adair, FCC chief engineer, observer; H. G. Miller, Federal

can be used with three projection tubes with color phosphors, the tubes operating in sequence, in which case the sequential system would produce a picture one third as bright as the simultaneous system. But the three-to-one advantage of the simultaneous system cannot, it seems, be entirely eliminated.

The colored phosphors thus far used do not have equal luminosities so to secure proper saturation in the reds, a vernier optical red filter is added to the red tube. This limits the overall brightness of the system to about 50 percent of the value possible if an equally-luminous red phosphor were available.

Color Rendition

Color filters of the best type (those covering the widest area on the color triangle) can be employed at transmitter and receiver in either system, so both systems have the same ability to render color values. But if color phosphors are used in the simultaneous receiver this will be true only if the colors of the phosphors cover an equally large and similarly placed area on the color triangle. Furthermore, the color produced by the phosphor must be constant irrespective of changes in brightness.

Whether or not these requirements can be met is not known, but in view of the vastly improved control over phosphor characteristics, only minor losses are to be expected. Development of phosphors will assure bright projected pictures in the simultaneous system.

A proposal, affecting color rendition, has been made to reduce the flicker in the sequential system. This is to use primary color filters covering a somewhat smaller area on the color triangle (so-called low-flicker primaries) and having more nearly equal luminosities. These have been demonstrated by CBS and do reduce the flicker on a 144-frame sequential system so that it can be used at a brightness sufficiently high for viewing comfortably in a lighted room. The low-flicker primaries do not cover as large a region of the color triangle in the purple region and hence the rendering of purple tones is not as exact as with the standard primaries.

One final aspect of overall system performance, relating to r-f propagation, is the relative effect of multipath transmission. In the sequential system there is but one carrier, and the multipath effects (which are usually frequency-selective in appearance) are present, in effect, only once. In the simultaneous system there are three carriers, and the effect of multipath will be present in three separate groups of sidebands. Also since multipath effects depend on instantaneous carrier phase, and since the relative phases of the three carriers may vary, the multipath effects will presumably be different on the three colors. It might thus appear that multipath effects would be more serious in a simultaneous system. But such a contention is hard to support without a thorough field test.

Equipment Comparisons

In general, the sequential system may employ simpler equipment than the simultaneous, since only one camera, transmitter, antenna, receiver, i-f amplifier, and picture tube are required. The circuits throughout are wideband and therefore somewhat more expensive than a single narrowband circuit, but there is only one of them.

In the simultaneous system, three photosensitive surfaces or tubes are required in the camera each with associated amplification and modulation channels. A single wide-band transmitter modulated jointly by the carriers or sub-carriers might be used. At the receiver a joint r-f amplifier stage may be used and even a joint i-f amplifier. But somewhere in the receiver, either in the i-f amplifier or before the second detector, separation of the three carriers must be performed. Thereafter individual video amplifiers and separate picture tubes for each color are required. Also, for the present at least, there seems to be no adequate method of combining the simultaneous colors except by the projection method, which implies an optical system of high aperture and also requires high intrinsic brilliance on the c-r tubes.

All these factors point to an expensive receiver, compared to a direct-viewed sequential receiver. However, the price of a sequential *projection* receiver might not be substantially less than the simultaneous projection receiver, since the same projection system is required, and the synchronous motor-driven filter disk involves costs not present in the simultaneous equipment. Beyond these generalizations it is difficult to predict costs failing actual production of comparable receivers.

Summary

From the foregoing analysis it appears that the sequential and simultaneous systems offer equal promise in many respects. Both can provide good color rendition, free of flicker provided suitable standards are chosen. Such standards would entail about the same bandwidth requirements and coverage potentialities. But the inescapable conclusion is that one system or the other must be adopted; they are not compatible with one another.

If a color television system is to be a logical extension of the black-and-white system, the simultaneous system offers greater promise, but the equipment costs of this system will probably be greater, at least initially. Perhaps the greatest objection to the simultaneous system, so far as can be seen at present, is the difficulty of producing an inexpensive direct-viewing receiver.

Finally there are many questions which can best be answered by tests, in the laboratory and in the field, concerning propagation effects and the ultimate requirements of picture brightness and associated flicker phenomena. Coincidentally with this test program, new devices can be expected to appear which will show clearly the relative trend of costs, which in the long run must determine the extent to which either system can be used by the public.

References

(1) Color Television on Ultrahigh Frequencies, ELECTRONICS, p 109, April 1946.
(2) Where Color Television Stands, ELECTRONICS, p 104, May 1946.
(3) All Electronic Color Television, ELECTRONICS, p 140, December 1946.

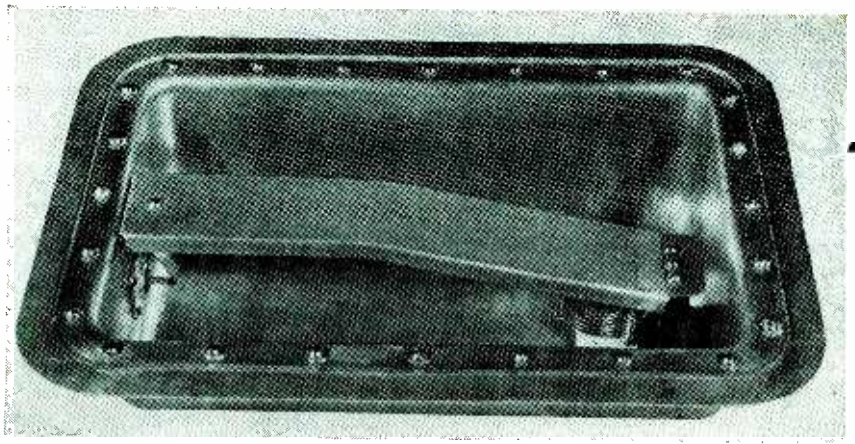


FIG. 1—The final antenna design for 75-mc marker-beacon service

Cavity

By HARVEY KEES
and
FAY GEHRES

Electronics Research, Inc.
Evansville, Ind.

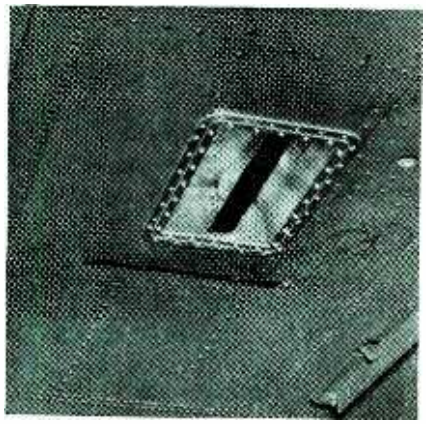


FIG. 2—The antenna recessed into the belly of a DC-3 airplane

HIGH-SPEED modern aircraft have complicated the problem of airborne receiving antenna design. Conventional open-wire aerials are not acceptable on many new airplanes because of their wind resistance and the accompanying precipitation static. The purpose of this article is to describe a recessed or "cavity" antenna designed to minimize wind resistance, and to give an account of some of the problems involved in its development.

The antenna, Fig. 1, has very little drag, as can be seen from the photograph of Fig. 2, showing it on the belly of a DC-3 airplane. It was designed primarily for 75-megacycle marker beacon reception, and is intended as a replacement for conventional open-wire half-wave antennas six feet long.

The antenna is essentially a shunt-excited element 9 inches long, mounted in a cavity 3 inches deep by 6 inches wide and 10 inches long. The element is tuned to quarter-wave resonance by an adjustable top-loading capacitor.

Flights in Douglas and Beechcraft airplanes over the Evansville, Terre Haute and Indianapolis *Z*-markers show the antenna will deliver 3 to 6 millivolts to a 50-ohm load at 1,000 feet. Maximums of 55 to 85 millivolts were observed across a 50-ohm load at 1,000 feet over the four Indianapolis fan markers.

Development

At the start of the cavity antenna development it was arbitrarily decided to try a cavity 18 inches long, 12 inches wide and 4 inches deep. A number of different element sizes and shapes were tested in this cavity, until finally a first experimental design was adopted, having an antenna element 16 inches long and 4 inches wide.

It was desired to use the antenna with a 50-ohm concentric transmission line to the receiver, but it was found that the series impedance at the base of the antenna element was in the order of only a few ohms. Shunt connection to the element proved to be a good means of obtaining the required impedance match.

Figure 3 shows two means of connecting a 50-ohm transmission line to the antenna element. The upper diagram shows a conventional-shunt-feed system at the base of the antenna, while the lower diagram shows a shunt-feed connection at the top end of the antenna. Both systems give the same electrical results.

Ground tests indicated that the experimental antenna had 0.9 times the voltage gain of a half-wave dipole. In flight this experimental antenna performed so well that it appeared desirable to attempt a smaller design, and the antenna pictured here was finally obtained. A comparison of the experimental and final-design antennas is interesting.

The volume of the final model cavity is approximately one-fifth that of the experimental model. The bandwidth to the three-to-one standing-wave ratio points for the

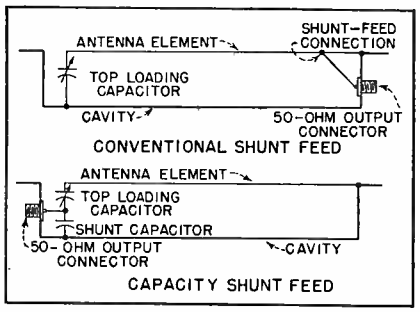


FIG. 3—Two methods of matching a 50-ohm concentric line to a quarter-wavelength receiving element. The system shown in the lower diagram was used

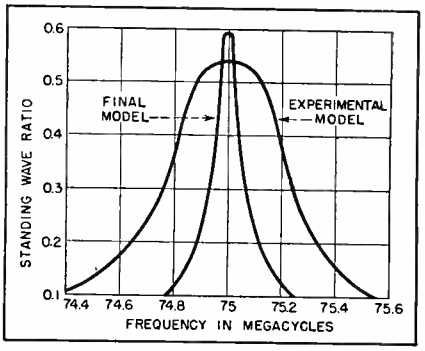


FIG. 4—Selectivity curves for an early experimental model cavity antenna using a fairly large element and the final compact design

Aircraft Antenna

A small, shunt-excited receiving element placed within a cavity which can be recessed into the body of an airplane performs well in 75-mc marker-beacon service and nearly eliminates wind resistance and precipitation static

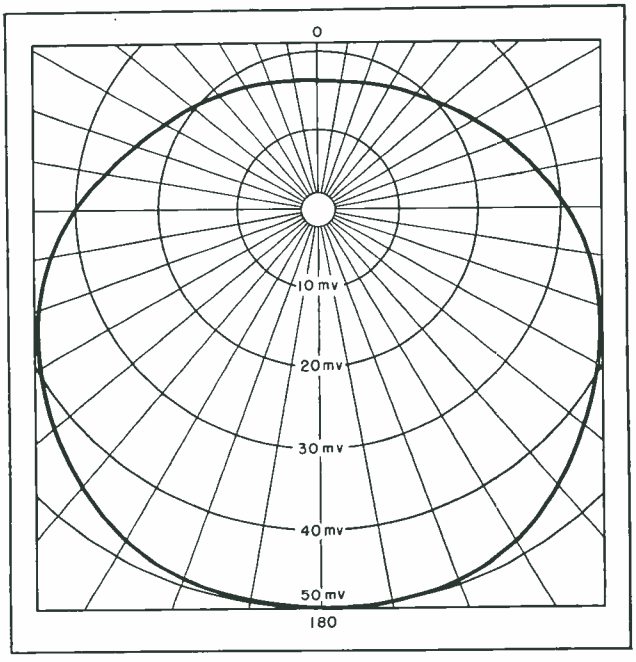


FIG. 5—Pattern of the final design at right angles to the line of flight. The line of flight is into the printed page

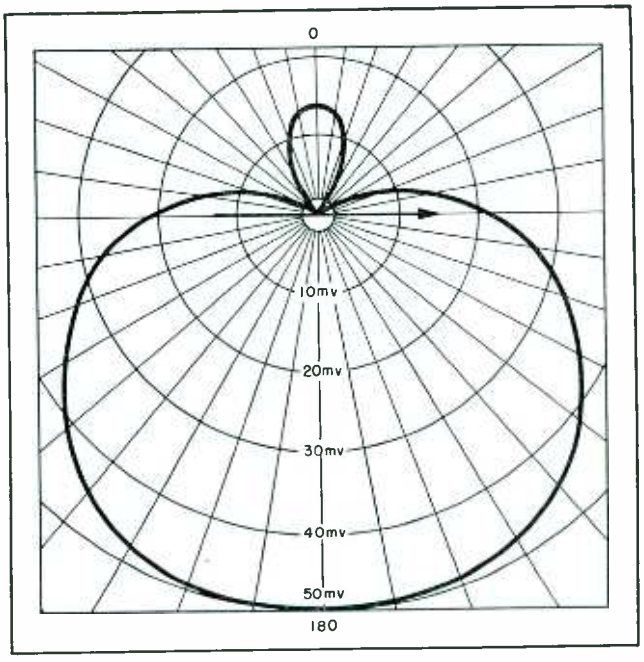


FIG. 6—Pattern of the final design in the line of flight. Line of flight indicated by the arrow

latter was approximately 440 kilocycles compared with 120 kilocycles for the former. Selectivity curves for the two antennas are given in Fig. 4. The sensitivity of the larger experimental model was twice that of the final design.

The selectivity curves indicate that the Q of both antennas is very high. It is so high for the final antenna that air dielectric capacitors have to be used for top loading, and a capacitor of this type with a large minimum capacitance is employed to obtain bandspread tuning.

Performance

Temperature tests on early models showed a frequency drift of approximately 200 kilocycles over a temperature cycle of 100 F to −50 F. This drift was reduced to within 25 kilocycles at 75 megacycles by installation of a bimetallic rotor plate on the top-loading capacitor.

Some care in the mechanical design of the cavity antenna is necessary to obtain sufficient stability. However, shake table, temperature, and humidity tests indicate that adequate stability can be obtained without great difficulty.

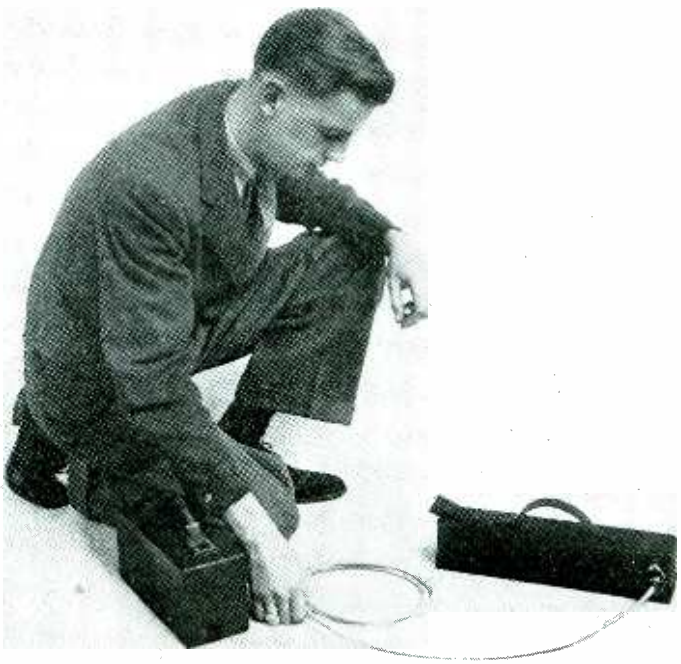
The bent antenna element in the cavity was adopted to reduce the effects of rain and other extraneous material on the face of the antenna. With the design shown, the output is reduced approximately one db when a heavy stream of water from a garden hose is directed across the face.

Figures 5 and 6 show the directional characteristics of the final antenna, mounted on a 4 by 8-foot ground plane.

Theoretical considerations indicate that cavity antennas act somewhat like corner-reflectors in which some of the gain is cancelled by resistance losses. It appears that the main price paid for a reduction in physical size is a decrease in bandwidth. A general conclusion to be drawn probably is that where large bandwidths are not required, the physical size of most conventional antenna systems can be reduced appreciably—to the point where resistance losses become important.

Modern GEIGER-MULLER COUNTERS

By A. GRAVES
Director of Research
Alltools Ltd.
Brentford, Middlesex, England



Typical counting apparatus. The G-M tube is mounted in the probe unit at the right, which plugs into the amplifier and counter

WITHIN recent years the need for the detection and counting of atomic particles has greatly increased, in the field of pure physics as well as applied physics. The greater proportion of this need has been satisfied by the Geiger-Muller tube, used with suitable counting circuits.

When low-intensity sources are being measured, care is necessary to ensure that the observed increase of count, above the background count, is real and not just a probability variation. For example, if the average background count is 80 per minute and a count is taken over 5 minutes, the total is 400 counts. The probable error is roughly the square root of the number of counts taken and hence is ± 20, or ± 5 percent. Thus, on a 5-minute count, any variation cannot justifiably be treated as real unless it is at least 10 percent greater than the background measured. (The background may be 5 percent low and the count 5 percent high). For a 20-minute count, however, the probable error drops to 2.5 percent. The longer the count, the less is the probable error.

From the above considerations it might appear desirable to have a low background count. In general, however, in reducing the background count we must reduce the effective area of the counter, and it therefore responds to a correspondingly smaller number of the particles being counted. In certain cases, where the solid angle of radiation is limited, a distinct advantage can be obtained by a smaller effective area and some form of window. Background counts as low as 10 (or even 5) per minute are not at all difficult to obtain, while still retaining the essential features of the G-M tube.

Tube Theory

All methods of measurement of radioactivity are based on ionization processes, whether the instrument is a Wilson cloud chamber, an ionization chamber, or a Geiger-Muller or similar counter. The difference in action between the G-M counter and the others lies in the fact that the response of the instrument is equal for all particles or photons, whereas in the case of all the others the response is largely proportional to the energy of the particle or photon.

The passage of an alpha or beta particle, or a gamma photon, leads to the ejection of an electron from the cathode surface or from a molecule of the gas in the G-M tube. The liberated electron is drawn to the highly positive anode, colliding with gas molecules in its path and thus liberating further electrons. This process becomes cumulative and is further added to by the action of photons emitted when the gas atoms return from excited states to ground states. The tube is thus behaving as a triggered amplifier, triggered by the incoming particle or photon.

This so-called avalanche process must not be allowed to continue indefinitely, and is made to collapse upon itself either by the admixture of some suitable polyatomic vapor such as alcohol, which has a quenching action, or by some external circuit which causes the voltage to drop below the operating voltage of the tube.

The ideal G-M tube is one which signals the passage of all particles by producing pulses of the shortest possible duration, and of the minimum amplitude compatible with ef-

Increased commercial utilization of radioactive isotopes has brought corresponding improvements in G-M tubes and counting equipment. The circuit of a new combination mechanical counter and electronic integrator is given

ficiency. A tube of such a type will be able to respond to events separated by 10^{-5} second, and should have an extremely long life as the passage of current has been reduced to the minimum for each operation.

Circuit Analysis

The circuit of a typical modern Geiger-Muller counting apparatus is given in Fig. 1. The high-voltage supply for the G-M tube is obtained by a voltage-doubling arrangement using two dry-disc rectifiers and a smoothing circuit, with a rheostat in series with the primary winding of the power transformer for voltage control. The bleeder consists of a suitable meter M_1 in series with a 6-megohm resistor. Since operating conditions vary from tube to tube, this voltmeter is a precaution against damaging the tube by application of too much voltage. The negative high-voltage supply also uses a metal rectifier, and the positive supply uses a type 80 tube in a conventional full-wave circuit.

Extinction tube V_1 is in a normal Neher-Harper circuit. For optimum operation, the bias of V_1 is adjusted by means of P_1, so that the tube is just cut off. In this condition a slight increase of voltage of the cathode of the G-M tube, due to an ionizing particle entering the tube, causes current to flow in V_1, thus causing the voltage across the tube to fall considerably (due to the large anode load R_3). The effect is cumulative and the extinction of the G-M tube is hastened. While many tubes are of the self-extinction type, some are designed for use with extinction circuits. Even with self-extinction tubes, an extinction circuit is often advantageous.

The negative pulses from the G-M tube are taken from the anode of V_1 and sent through C_2 and a grid resistor R_7 to the grid of V_2. Thus, in the absence of a pulse, the grid of V_2 is held at cathode potential by R_6 and R_8. The arrival of a pulse at the grid cuts off the current in V_2, resulting in a positive pulse at the anode of V_2.

Cutoff bias for V_2 is only about minus 2 volts, and consequently all negative pulses of amplitude greater than 2 volts give the same output from the anode. Since the pulse amplitude from a G-M tube (especially when used with an extinction circuit) is almost invariably considerably greater than 2 volts, this arrangement results in a satisfactory amplifier limiter.

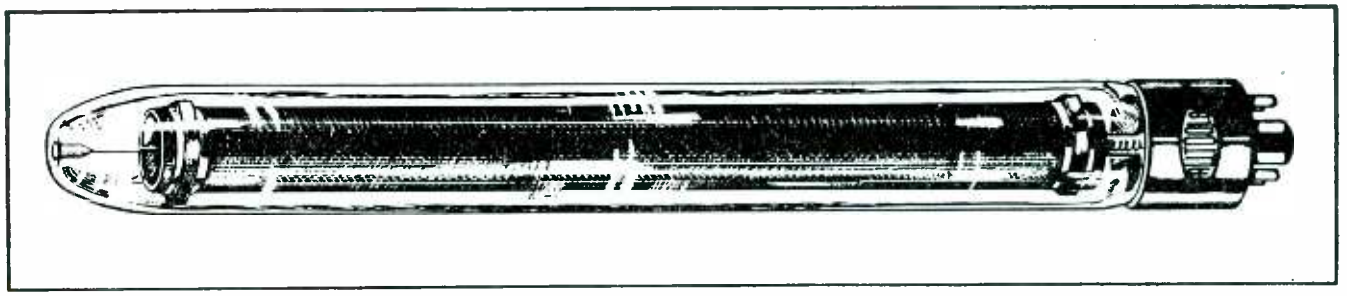
Tube V_3 serves different purposes, depending on the position of switch S_1. The central position of S_1 disconnects this tube entirely, blocking the circuit. In both of the other positions of S_1, transformer T_1 is in the circuit. This transformer feeds a phone jack to provide an audible indication of counting, useful in determining threshold voltages and in ensuring that no considerable number of counts are missed by the multivibrator circuit due to too high a rate of count.

When S_1 is over to the left, V_3 acts as a straightforward amplifier with the grid biased by means of R_{23} and R_{24} and with an anode load R_{11}. Negative pulses are then fed through C_5 to the grid of V_4 to trigger off the multivibrator circuit formed by V_4 and V_5.

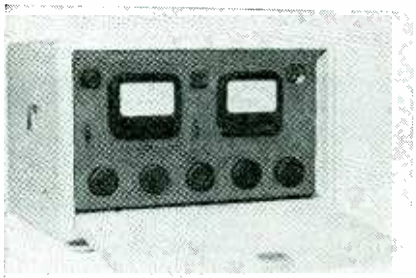
In the absence of pulses, V_4 passes a predetermined current. Power tube V_5 is biased beyond cutoff by the resistance chain R_{27}, R_{28}, and P_3, and thus no current flows through this tube.

When a negative pulse arrives at the grid of V_4, this causes less current to flow in V_4 and hence the anode voltage rises. This rise of voltage is fed through C_6 and R_{17} to the grid of V_5. Thus current commences to flow in V_5, and the drop of voltage at the anode is fed back through C_7 and R_{16} to the grid of V_4, causing still less current to flow in this tube and increasing the voltage charge on the anode of V_4 and the grid of V_5. The whole process is cumulative and ceases when V_4 is cut off. The current through V_5 must be sufficient in amplitude and duration to operate the electromagnetic counter used.

The duration of the current in V_5 is largely determined by the time constant of C_7, R_{16}, and R_{15}, which is made much shorter than that of C_6R_{18}. After a count, C_7 discharges through R_{15} and R_{16} and the grid potential of V_4 climbs towards its original voltage. This initiates



Modern Geiger-Muller tube as used in physical, industrial, and biological research



Combination integrator and mechanical counter for use with G-M tubes. Meter at left indicates rate of count directly, and meter at right indicates voltage being applied to G-M tube. In between meters is electromagnetic counter that indicates total count

cumulative action again, and the circuit quickly returns to its original stable state with V_4 on and V_5 cut off.

With this circuit the limit to the speed of counting is definitely fixed by the counter itself since the times required to build up the various voltage charges around the circuit are negligible.

When switch S_1 is over to the right, the integrator is in the circuit. The high-voltage supply for V_3 is then obtained from point A on the resistance chain formed by R_{32} and P_5. The anode load of V_3 (neglecting R_{32}) is then C_{20} in parallel with one of the resistors R_{35}, R_{36}, R_{37}, and R_{38}.

When S_1 is over to the right it also applies high voltage to V_6 through R_{31} and meter M_2. The grid of V_6 is fed directly from the anode of V_3 (neglecting T_1). When no pulses are being fed to the grid of V_3, the current in V_6 is determined by the setting of P_5 and the potential of the grid (tied to the anode of V_3).

When positive pulses arrive at the grid of V_3, each one causes a pulse of current through V_3. This current is pumped out of C_{20} during the on period of the pulse and the charge builds up again during the off period. The rate of buildup is determined by the value of C_{20} and by the resistance in parallel with it. If the pulses are sufficiently frequent the grid of V_6 adjusts itself to a new steady voltage, the current pulses being smoothed out by C_{20} and R_{35}. The voltage at the grid is such that the current leaking through R_{35} (or R_{36}, R_{37}, or R_{38}) to restore the charge on C_{20} equals the average current being pumped out of C_{20}.

This reduction of potential of the grid causes less current to flow through V_6 and hence through the meter. The greater the rate of arrival of pulses at the grid of V_3, the greater is the mean current flowing out of C_{20} and the greater will be the voltage drop across R_{35} to allow this to flow. The current through V_6, which is dependent upon the grid-to-cathode voltage, will thus be a measure of the rate of arrival of pulses at the grid of V_3. The meter in the anode circuit of V_6 therefore indicates the counting rate.

Since an increase in the counting rate results in a decrease of current, the meter reads backwards. The meter used in the apparatus is calibrated from 100 to 0 from left to right, and must be set to zero (extreme right of scale) before a count is taken.

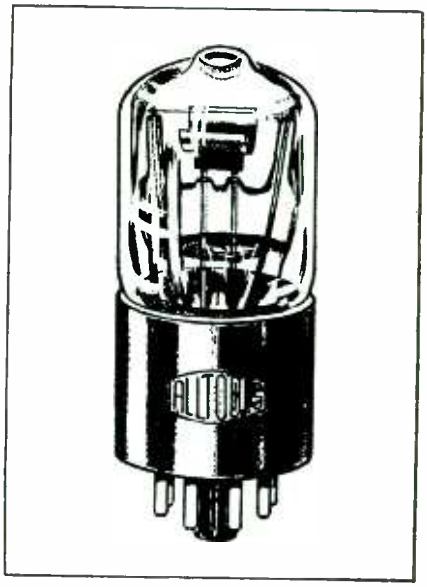
Using the Counter

With only the background count present, P_5 is adjusted until the meter reads zero. When a count is taken the deflection decreases and, by comparison with a standard source, a quick measure of the count is obtained. It is advisable to get the same deflection on the meter in both measurements and compare the strengths of the two sources by means of their distances from the counter. The inverse square law relates counts to distance.

Switches S_2 and S_3 give a choice of eight different sensitivities for use with different power sources.

The integrator is most useful for fast rates of counting, for under this condition the efficiency of the smoothing circuit is greater and the current pumped out of C_{20} is nearer to a continuous flow. For low counting rates, the needle becomes unsteady and consequently accuracy is lost.

The apparatus as a whole therefore provides two alternative methods of counting. The time taken to operate the mechanical counter sets an upper limit to the counting rates for which this method can be used. The highest-speed counter readily available will count at a rate of 16 per second (960 per minute). Since a G-M count is a count of random events, for absolute accuracy none of these must occur within $\frac{1}{16}$th second of each other. The randomness of the events reduces the actual rate of counting which can be measured with accuracy. With one of the counters mentioned above the upper limit for accurate counting is about 600 per minute.



Geiger-Muller tube having low background count as required for x-ray spectrum analysis

With the integrator, the slowest rate of counting is dependent upon the duration of the pulses, the time constants of the circuits, and the meter itself. This last factor makes calculation of the slowest rate rather complicated, but it is of the order of 100 per minute. There is thus a good overlap between the two methods.

The integrator method is, of course, less accurate than the mechanical counting method. If accurate high-speed counting is required, scaling circuits must be introduced. For the purposes for which this instrument was designed these were not considered necessary.

Typical Applications

There are many interesting present-day applications of G-M tubes and counters. One that is now increasing rapidly in importance is the measurement of samples and specimens of radioactive isotopes produced for sale and distribution.

Some very interesting work has been done in the field of tracer work recently, apart from such obvious uses in biology as tracing processes in glands, digestive tracts, and the blood stream. By painting parent wireworms with a radium varnish, then following their daily movements and measuring worm concentrations in different areas, much information can be obtained as to the habits of these destructive creatures. The same applies to other migrating insects and pests.

By introducing a radioactive tracer into a fertilizer and following, over a period of time, the movement of the tracer, information can be obtained concerning the precise action of the fertilizer. It has also been possible recently to introduce tracers into seeds themselves, which aids the study of plant growth or of mutations. Hypodermic methods may also be employed.

Danger of contamination by the radioactive elements used in some types of luminous paints makes periodic examination of the workers essential. Much of this work is done in England by the National Physical Laboratory, Teddington, using one of the counters described and some of the G-M tubes shown.

Where an element is found as a mixture of isotopes, one or more of which is radioactive, the concentration of a solution containing this element may be determined with the aid of a G-M tube and counter. For example, potassium is found as a mixture of K_{39} and K_{40}, the latter being present in the proportion 0.012 percent and emitting a B ray. It has been found possible to estimate the strength of K solutions very well by measuring the B radiation from the solution, using suitable B-sensitive G-M tubes and counters and comparing the results with those obtained from a solution of known concentration.

A G-M counter can be used in determining the age of the oldest igneous rocks by an assessment of the percentage proportion of uranium to its decay products in any radioactive minerals found. An analogous application is prospecting, not only for uranium ores but also for other minerals which are likely to be found in the same formations, such as lead, copper, cobalt, and silver. Conversely, the presence of any of these ores may indicate a probability of uranium ores.

In studying products of the carbon pile, the cyclotron, or other processes for obtaining synthetic radioactive materials, one of the short cuts in routine work is to establish the decay rate or half-life period of the element or compound under observation. This means that a series of counts is taken over a period of time. The reduction in the rate of counts indicates the decay rate. A simple result like this can only be reliable if each disintegration is signalled by a single pulse of very short duration and constant amplitude. Of all the instruments available the G-M counter is the most suitable for the purpose.

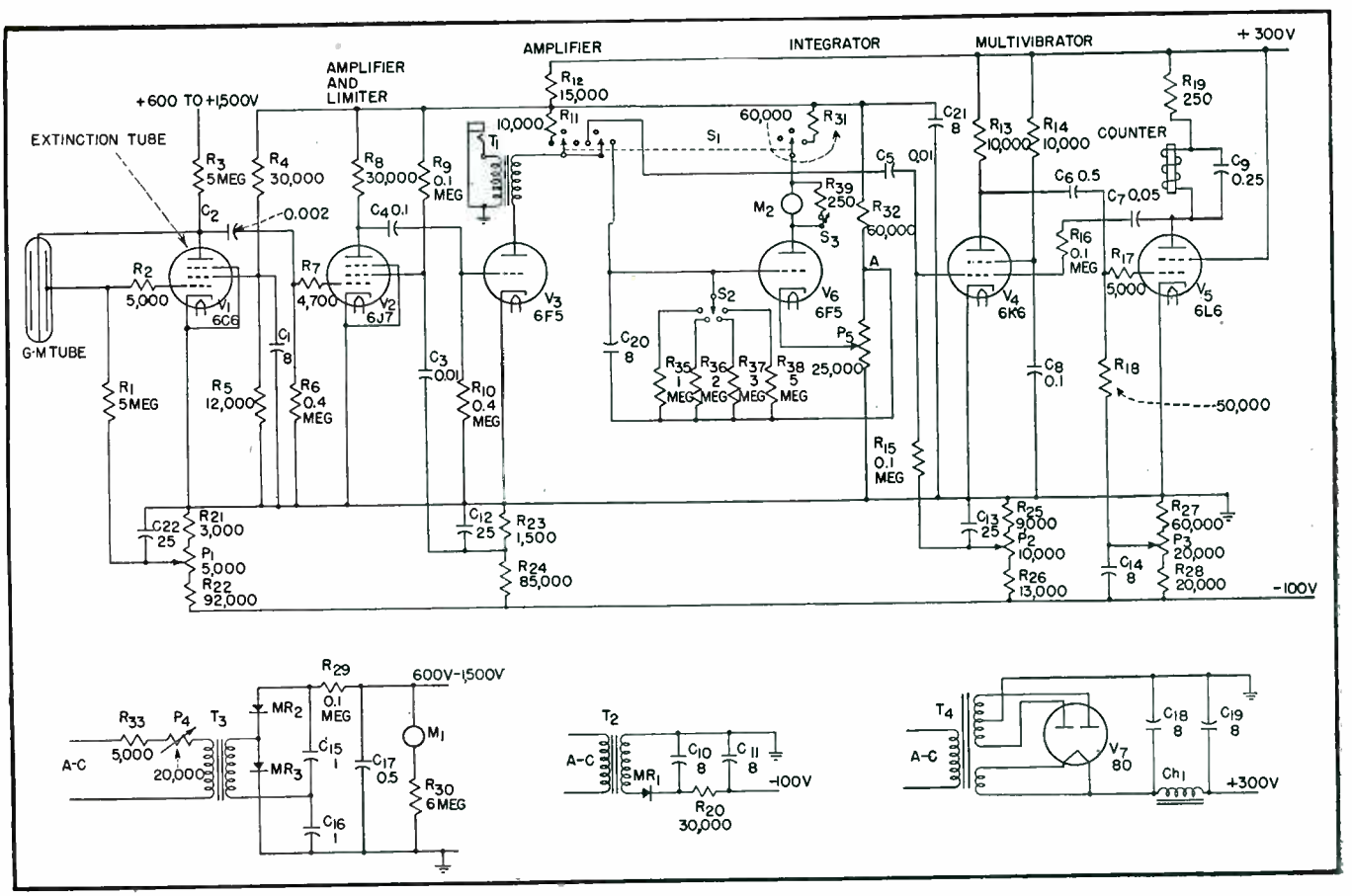
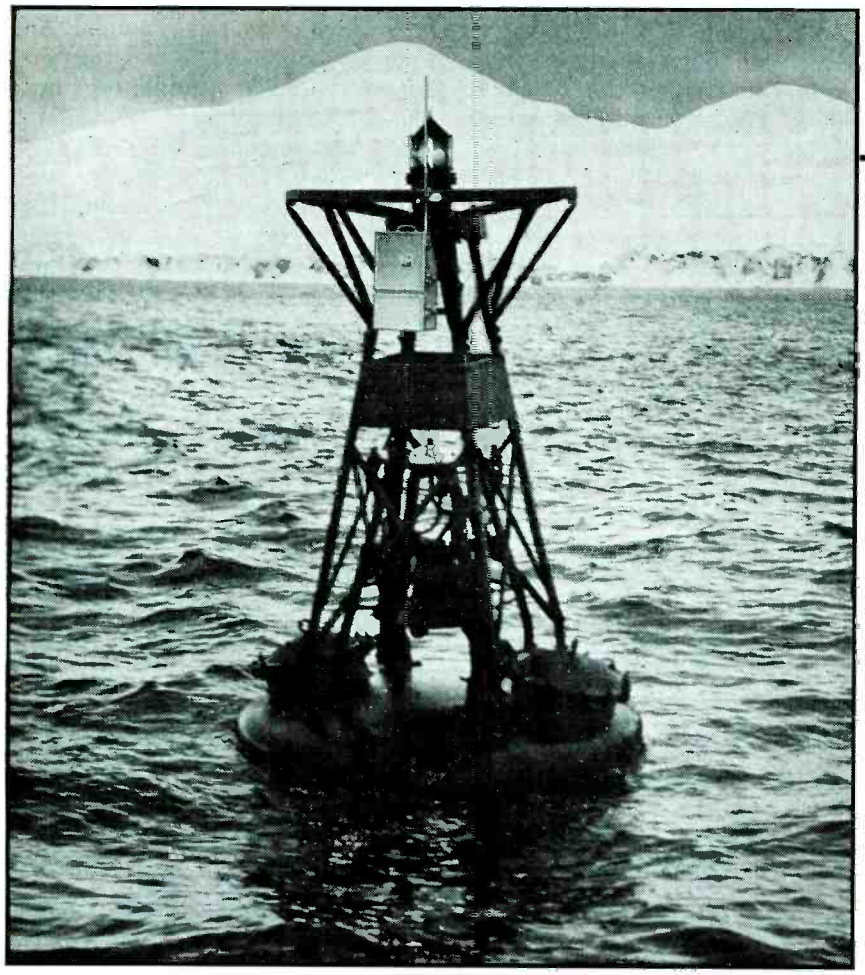


FIG. 1—Counting circuit providing two alternative methods of counting. With switch S_1 at the left, mechanical counting is provided over a range of 0 to 600 counts per minute. With S_1 at the right, pulses are integrated and the counting rate is indicated directly on a meter for high-speed counting, with the minimum count for accuracy being about 100 per minute



Installation in Massacre Bay, Attu. Weatherproof receiver housing and its vertical antenna can be seen near top of buoy. Normally unattended for up to a year at a time, these buoy lights were turned off by radio during the war upon approach of enemy ships

By A. F. HOPKINS, JR. and F. A. B. SMITH

Senior Airways Engineer
Civil Aeronautics Administration
Washington, D. C.

Radio Engineer
U. S. Coast Guard
Washington, D. C.

ANRAC is a term coined by the United States Coast Guard from the phrase Aids to Navigation Radio Control. This development, recently declassified, is a vhf radio remote control for quickly blacking out lighted harbor buoys in case of enemy approach.

Such buoys are equipped with lanterns illuminated by acetylene gas or electricity, and normally are allowed to function unattended day and night for approximately twelve months. Then they are completely reserviced and made ready for another year of operation. During the war, buoys and unattended fixed lighted aids to navigation were equipped in a number of the larger harbors on the east and west coasts of the United States, Aleutians, Hawaii, Midway, and other Pacific bases.

Military Requirements

The military requirements for promptly extinguishing lights on aids to navigation called for the application of radio devices under unusually severe marine conditions. Specifically, it was required that the buoy radio equipment including self-contained battery supply weigh not over 75 pounds, be easily attached to standard buoys, have sufficient sensitivity to operate reliably at distances of seven to ten miles with reasonable transmitter power, and extinguish the lights as soon as possible. Furthermore, it was important to provide security from enemy control and from accidental operation by mechanical shock, static, or interfering radio signals.

Probably no marine device suffers such complete exposure as a buoy anchored in deep water. In addition to continuous exposure to atmospheric elements—sun, wind, rain, snow, sleet, and ice—the buoy is constantly buffeted by the sea and seldom free of salt water spray. Thus a radio device installed on a buoy must be watertight and corrosion resistant. It must operate satisfactorily in the heat of direct rays of the sun and in the cold of winter, and it must not fail because of the constant motion of the buoy, which may become violent in heavy seas.

A harbor blackout system consisted of one or more control stations located so as to give an effective coverage of the area in which the lighted buoys were located. The control station equipment on shore consisted of a keying device and vhf transmitter to broadcast the coded signals. On the buoys were installed receivers responsive to these coded signals, and either electric relays or electrically-operated gas valves (depending on whether the buoys were lighted by electric or acetylene lanterns).

Coding System

The heart of the control system is a torsional-type selective relay having a permanent-magnet armature retained in a normal position by a hair spring. Upon application of pulsed d-c to the field windings, the armature vibrates rotationally

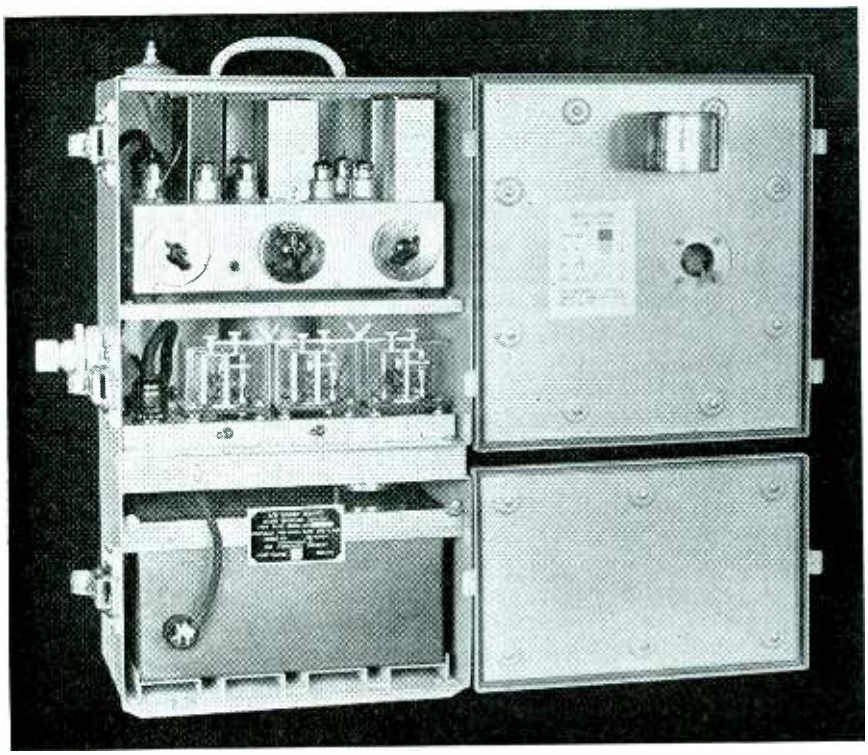
CONTROLLED BUOYS

Acetylene or electric lights on offshore buoys are turned on and off by special receiver employing frequency-selective torsional relays, in response to signals from vhf shore transmitter employing two supersonic subcarriers pulsed at different rates

(like a motor reversing itself continually) when the applied pulses have a rate equal to the natural frequency of the armature. With a current change of 1.2 milliamperes, the oscillation reaches sufficient amplitude in approximately two seconds to close a pair of contacts momentarily. These contacts are connected in a circuit to operate the relay or valve controlling the light. Four pulse rates are available for use in the range 10 to 16 cycles per second, and the torsional relay will discriminate between pulse rates as close as one cycle per second apart.

Normally, only two torsional relays are required, operating in the output circuit of a receiver, one being for the ON function and the other for the OFF function. For security purposes, however, operation of two torsional relays simultaneously was required to turn the lights on and one to turn them off, it being essential to get the lights off quickly and highly important that they not be turned on by the enemy. This was accomplished by transmitting two subcarriers, each pulsed at a different rate, the subcarriers being separated by the receiver filters and the pulses by the torsional relays. Normally, audio tones would be used for subcarrier frequencies, but in this equipment two supersonic frequencies between 20 and 30 kilocycles were used for added security.

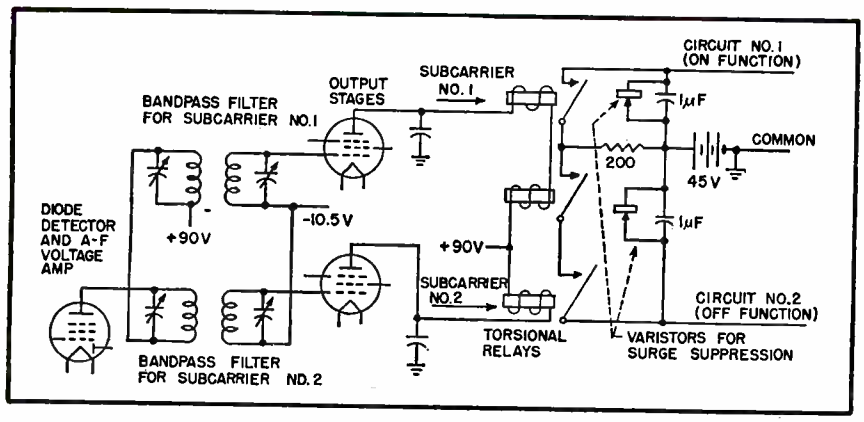
Impulse keying unit used at shore station



Radio receiving control of system, with cover opened to show superheterodyne receiver in top compartment, three torsional relays below it, and battery in lower section

With the two subcarriers transmitted simultaneously at different pulse rates, a casual listener might hear only a faint audio beat interrupted at a continually varying rate as the pulse frequencies went in and out of phase periodically. These sounds would be definitely deceptive to any one attempting to interpret the coding aurally.

An important feature of the system is that it is practically immune to false operation by radio noise and other signals, due to the double selection feature. Subcarrier frequencies and pulse rates must be accurately transmitted to cause the desired operation. Furthermore, the double selection feature provides a large number of coding combinations which can be changed readily. As an example, the signal to turn the lights on might consist of the radio carrier modulated simultaneously at 22 and 28 kc, the 22-kc signal being interrupted at 11 cps and the 28-kc signal being in-



Special audio output circuit of superheterodyne receiver used on buoy, showing connections for the three torsional relays developed by Wallace and Tiernan Co.

terrupted at 15 cps. The 22 and 28-kc subcarriers would be separated in the receiver by filters and fed through two rectifying channels to operate two torsional relays, one resonant at 11 cps and the other at 15 cps. Since the output contacts of the torsional relays were connected in series, it was necessary for both torsional relays to operate simultaneously to turn the lights on.

Control Station Equipment

The control station equipment consisted of a 50-watt vhf communication transmitter conventional in design except for its modulation capability, which extended up to 30 kc, and an impulse keying unit. A coaxial-type vertical antenna was connected to the transmitter through a concentric copper transmission line. This line was not pressurized with nitrogen, but instead was equipped with a desiccator which operates with air at atmospheric pressure.

The impulse keying unit provides the necessary coding impulses for the transmitter. Two electron-coupled oscillators with permeability-tuned coils generate the two subcarrier frequencies. A synchronous motor drives four cams actuating snap-action switches to provide four interrupting frequencies. A vibrating-reed meter allows a constant check on the line frequency.

To provide accurate pulse frequencies, an internal 60-cycle power oscillator is included. In case of deviation beyond one-quarter cycle in the commercial supply frequency, the synchronous motor is switched over to the internal 60-cycle source, which can be adjusted to exact frequency against the meter. This oscillator contains an unusual circuit which stabilizes the frequency under conditions of wide variation in input voltage. This is done as follows: Plate supply voltage is fed through a high resistance to the iron-core oscillator coil. Variations in plate voltage vary the magnetizing current of this inductor and thereby its inductance. This causes a change in frequency opposite that caused by the direct effect of the plate voltage variation, and the circuit is adjusted to closely balance out such change.

Code Combinations

For the nontechnical operator, four arbitrarily marked panel switches allow transmission of any one of three pre-set ON signals or the universal OFF signal. Four switches concealed beneath a removable panel allow setting up any one of twelve code combinations of subcarrier and interrupting frequencies for each of the three ON channels, and any one of eight combinations for the OFF channel. This system provides the means for dividing the buoys in a given control area into three groups which can be turned ON individually as desired, leaving the remaining groups unlighted. However, the OFF signal extinguishes all three groups at once, thus meeting the military requirement for quick blackout in emergency. All control station equipment, except the antenna, was installed in duplicate for reliability.

The buoy receiving control is a unit complete with a quarter-wave antenna, receiver, and dry battery. The receiver is a conventional superheterodyne design with a special audio output circuit incorporating the torsional selective relays. In order to obtain extended operation between battery changes, a low-drain electric motor-driven timer turns the receiver on for five seconds every two minutes. Thus the battery supplies plate and filament power only thirty hours per month on an intermittent basis. The timer motor draws an average current of two milliamperes at 7½ volts. The nominal receiver sensitivity is 10 microvolts with fresh batteries and 50 microvolts with batteries at cut-off. Low-drain tubes are used to obtain maximum battery life.

Control Relay on Buoy

The control relay for operation of the electric buoy is separately contained in a waterproof box and attached to the buoy in a suitable location to control the lighting circuit. Because of the intermittent contact afforded by the torsional relays and the necessity for conserving battery power, the control relay had to be latching as well as low-drain. This relay is a magnetic holding type requiring approximately 25 ma at 18 volts applied to either of two coils as needed to open or close the main contacts. An electrically-operated gas valve was designed for attachment to the flasher and burner assembly in the lantern of acetylene buoys. This acetylene relay is a mechanical latching type.

Other Applications

Applications of the system are being extended to the control of other unattended aids to navigation not required in operation continuously, such as fog horns and electric bell strikers. By eliminating the security features, the coding system can be simplified and a larger number of control functions are feasible.

The proven reliability of the system of remote control described here and its simplicity of operation may well be considered in future applications of radio remote control.

Constant-Gain Knock Pickup Amplifier

Cathode-follower input, special feedback circuit, and simplified phase inverter stage provide flat frequency response from 8 to 20,000 cycles with a gain of 160,000 for portrayal of knock patterns of internal combustion engines on a cathode-ray oscilloscope

By RICHARD P. KREBS and THOMAS DALLAS

Aircraft Engine Research Laboratory
Cleveland, Ohio

THE VISUAL DETECTION of knock in an internal-combustion engine by means of a piezoelectric crystal pickup, cathode-ray oscilloscope, and associated amplifier has been used extensively in fuel rating and engine testing.[1, 2] If quantitative measurements of the severity of the knock are to be made, however, one of the first requirements of the system is an amplifier whose gain is constant over a wide range of frequencies, independent of line voltage.

As a first step in quantitative detonation measurements, the amplifier herein described was built at the Cleveland laboratory of the National Advisory Committee for Aeronautics. This amplifier has a high-impedance input, flat frequency response from 8 to 20,000 cycles, a gain of 160,000, and sufficient voltage output to drive a 5-inch cathode-ray tube. The circuit is given in Fig. 1.

Cathode-Follower Input

The input section of the amplifier is a cathode-follower tube, which is an impedance transformer. In reproducing cylinder pressures good fidelity demands a long time constant for the input circuit.[3, 4] Under operation at reduced plate and filament voltages, the cathode follower has an input resistance of at least 50 megohms; moreover, it has reasonably constant gain under line voltage variation.

The wide range of frequencies covered by the combined knock and pressure waves makes it necessary to have an overall frequency response from 8 to 20,000 cycles per second, flat to within ±10 percent. Resistance - capacitance coupled amplifiers are used for the two amplifying sections. To obtain constant gain and to aid the frequency response, plate-to-cathode negative feedback is employed in the first amplifying section (two

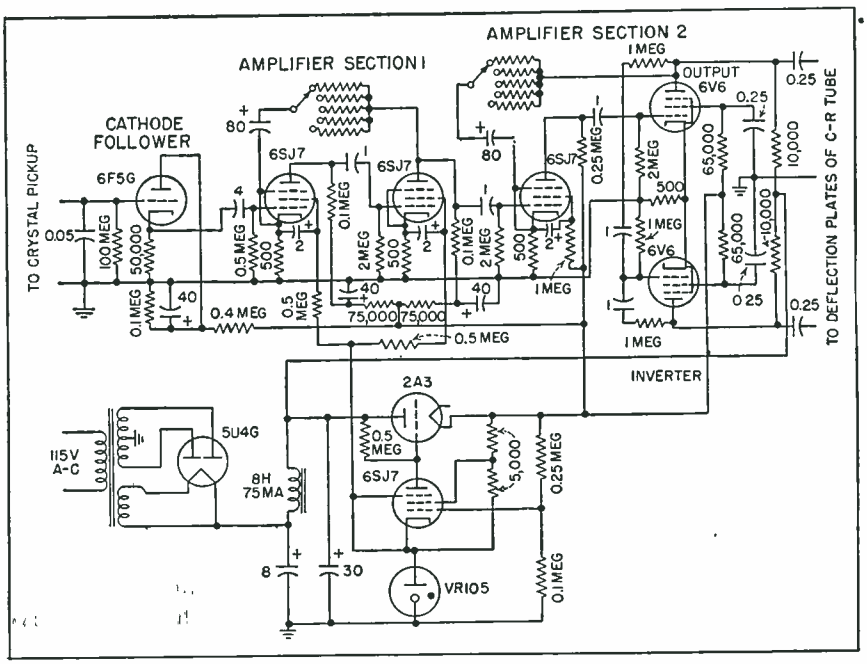


FIG. 1—Circuit diagram of constant-gain knock-pickup amplifier

6SJ7 tubes) and in the second amplifying section (a 6SJ7 tube and a 6V6 tube). The amplifier gain is controlled by changing the amount of feedback in these sections by means of five-position switches to give the following ten different gains:

Switch Position	Gain Section 1	Gain Section 2
1	10	200
2	25	240
3	60	300
4	150	350
5	400	400

In the above table, the gain of the cathode-follower tube is included in Section 1 and the gain of the inverter tube is included in Section 2. The values of the five resistors connected to each step switch are chosen to give the specified section gains. The overall gain, which is the product of that for the two sections, therefore ranges from 2,000 to 160,000 in 25 steps.

Feedback in Amplifier

From the standpoint of keeping the hum level at a minimum in a two-tube resistance-coupled amplifier with plate-to-cathode negative feedback as in Fig. 2, it can be demonstrated that reducing R_4 rather than increasing R_3 is the preferable method of reducing gain. The output from the two tubes may be considered as resulting from three voltages: the signal e_s and the hum e_1 and e_2 developed in the plate circuits of the two tubes. The basic equations are

$$e_1 + \mu [e_s - R_3(i_1 + i_3)] = i_1(R_1 + R_3 + r_p) + i_3R_3 \quad (1)$$

$$e_2 + \mu(e_1 - i_1R_1) = -i_2(R_2 + r_p) - i_3r_p \quad (2)$$

$$e_2 = -i_2R_2 + i_3R_3 + i_3R_4 + i_1R_3 \quad (3)$$

where μ is the amplification factor and r_p is the plate resistance of the tube.

Representative values for two 6SJ7 tubes are $\mu = 800$, $r_p = 1{,}000{,}000$ ohms, $\beta = 0.01$, and $R_1 = R_2 = 100{,}000$ ohms, where β is $R_3/(R_3 + R_4)$, the negative feedback factor. The gain for the signal voltage e_s may be considered constant if β is held fixed, regardless of the absolute values of R_3 and R_4, because a reduction in gain of the amplifier without feedback of 67 percent results in a change of gain of only 5 percent with feedback.

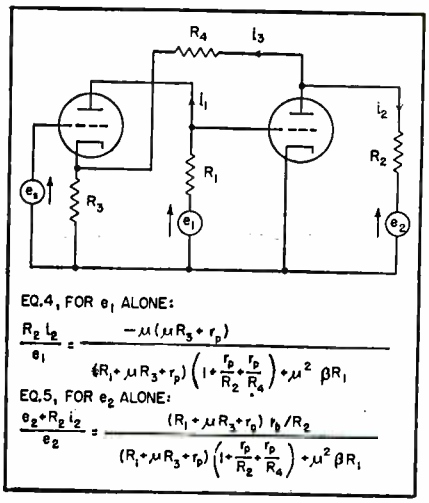


FIG. 2—Alternating-current functional diagram for two-stage amplifier with feedback

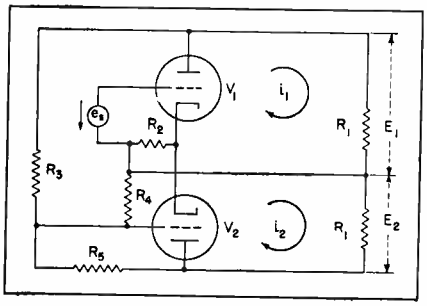


FIG. 3—Alternating-current functional diagram for stabilized inverter system

In the analysis, for simplicity, the signal voltage may be considered zero and the effects of e_1 and e_2 studied separately. Assume that $\mu + 1 = \mu$ and that $R_3 << R_4$. The output for e_1 alone is then given by Eq. 4 in Fig. 2, and the output for e_2 alone is given by Eq. 5 in Fig. 2. The following table presents the left-hand side of Eq. 4 and 5 for four different values of R_3 and corresponding values of R_4:

R_3 (ohms)	R_4 (ohms)	Gain for e_1	Gain for e_2
100	9,900	1.12	0.015
500	49,500	1.63	0.022
1,000	99,000	2.12	0.028
3,000	297,000	3.94	0.051

The table shows that the smaller R_3 is made (keeping β constant), the smaller the components of e_1 and e_2 will be in the output.

Simplified Phase Inverter

The usual method of obtaining phase inversion in a resistance-coupled amplifier having a driver and an output tube is to use an additional driver tube and output tube for the inverter circuit and to supply part of the voltage from the grid of the first output tube to this driver grid. Because of the feedback, the hum-to-signal ratio is lower at the plate of the first output tube than at the grid, and as a result, the inverter phase will have a higher hum-to-signal ratio than the original output tube. Since the increased hum was objectionable for the inverter section, a new circuit was developed for this application. Although it has only one tube, the highly necessary constant-gain feature derived from negative feedback is still obtained.

In the simplified version of this inverter circuit, shown in Fig. 3, let

$$R_3 >> R_1 \text{ and } R_5 >> R_1 \quad (6)$$

The negative feedback voltage will be βE_2, where

$$\beta = \frac{\dfrac{R_3 R_4}{R_3 + R_4}}{R_5 + \dfrac{R_3 R_4}{R_3 + R_4}}$$

$$\text{Also, let } m = \frac{\dfrac{R_4 R_5}{R_4 + R_5}}{R_3 + \dfrac{R_4 R_5}{R_4 + R_5}} \quad (7)$$

The following equation is written from the equivalent circuit of V_2 in Fig. 3, in which μ is the amplification factor and r_p the plate resistance of V_2 and other values are as indicated in the circuit:

$$\frac{i_2}{i_1} = \frac{E_2}{E_1} = \frac{\mu m R_1 + R_2(\mu + 1)}{r_p + R_2(\mu + 1) + R_1(\mu\beta + 1)} \quad (8)$$

If $\mu >> 1$ and $\mu\beta >> 1$, and the gain without feedback $\alpha = R_1 g_m$, where $g_m = \mu/r_p$, then Eq. 8 reduces to

$$\frac{E_2}{E_1} = \frac{mR_1 + R_2}{R_2 + \beta R_1 + \dfrac{1}{g_m}} \quad (9)$$

If through the use of a cathode capacitor $R_2 = 0$, Eq. 9 becomes

$$\frac{E_2}{E_1} = \frac{\alpha m}{1 + \alpha\beta} \quad (10)$$

The condition for perfect phase inversion can be established from Eq. 9 or 10 by letting $E_2 = E_1$, or

$$m = \beta + \frac{1}{\alpha} \quad (11)$$

Since Eq. 11 comes directly from

Eq. 9, perfect inversion is independent of R_2. However, the use of R_2 gives additional stability and minimizes mismatch between V_1 and V_2.

Representative values for the two 6V6 tubes of this phase-inverter application, using a plate voltage of 250 and a current of 20 milliamperes, are $R_1 = 10{,}000$, $1/g_m = 375$, $\mu = 240$, $R_2 = 500$, $r_p = 90{,}000$, $\alpha = 26.7$, and $R_4 = 1{,}000{,}000$.

Also, with $\beta = \frac{1}{3}$ from Eq. 11 and 7, it is found that $m = 0.371$, $R_3 = 0.797$ megohm, and $R_5 = 0.888$ megohm. A check on the usefulness and accuracy of the various equations can be made by substitution of these representative values. The values obtained for the ratio E_2/E_1 are 0.990 with Eq. 8, 0.988 with Eq. 8 ($R_2 = 0$), 1.000 with Eq. 9, and 1.000 with Eq. 10. Inasmuch as the variation of the ratio is about 1 percent, the use of the simplest expression (Eq. 10) for calculation of the voltage ratio E_2/E_1 is adequate. This likewise demonstrates the adequacy of Eq. 11, which comes directly from Eq. 10, as the determining condition for perfect phase inversion.

The above application demonstrates that odd values of R_3 and R_5 result from the application of Eq. 11. Since $\alpha\beta >> 1$, Eq. 11 can be modified to give the simple result, that

$$m = \beta \text{ or } R_3 = R_5 \qquad (12)$$

In compliance with this result, if the grid network (R_3, R_4, and R_5) is simplified to three 1-megohm resistors, β and m become $\frac{1}{3}$ and the voltage E_2 is only 10 percent less than E_1.

Inversion Efficiency

Figure 4 shows the variation of the inversion efficiency E_2/E_1 with the feedback factor β, which is the condition established by Eq. 12. The data for the curves were obtained from Eq. 10, which is valid only if μ is greater than approximately 40 and r_p is large compared to R_1. Because the maximum practical value of β is of the order of 0.5, these curves indicate that α should be greater than 20 before Eq. 10 is used.

Figure 4 may also be used to calculate m for perfect phase inversion if α is known. If β is chosen arbitrarily the ratio E_2/E_1 with $m = \beta$ is found from the appropriate curve of Fig. 4. If β is divided by the value of E_2/E_1 taken from the curve, the result is m for perfect phase inversion.

The minimum input signal of 1 millivolt made imperative an equivalent input background noise less than 100 microvolts. Hum in the amplifier was greatly reduced by insulating the transformer shell from the chassis with Bakelite strips, by using a filament potentiometer, by shielding the input stage, and by using negative feedback.

Overall Gain

Figure 5 gives the overall gain of the amplifier for different positions of the feedback control switches. The amplifier frequency-response characteristics are flat within ±10 percent from 8 to 20,000 cycles per second. The amplifier operates satisfactorily down to 2 cycles per second and up to 70,000 cycles per second.

Except for the highest gain of 160,000, overloading of the amplifier is not evidenced at output voltages up to 200 volts rms or 560 volts peak-to-peak.

For all settings of the feedback controls, the gain increases about $\frac{1}{3}$ percent for every 1 percent increase in line voltage. It is assumed that the increase in gain with increase in line voltage is a result of the change in characteristics of the first cathode-follower tube. This tube operates at a low filament voltage in a region where small changes in filament heating power will greatly affect the mutual conductance of the tube.

The hum and background noise in the amplifier is very low, varying from an equivalent input signal of 24 microvolts at the minimum gain of 2,500 to 17 microvolts when the gain is 160,000.

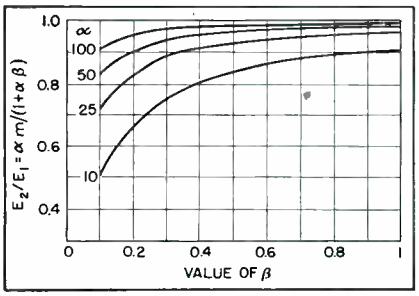
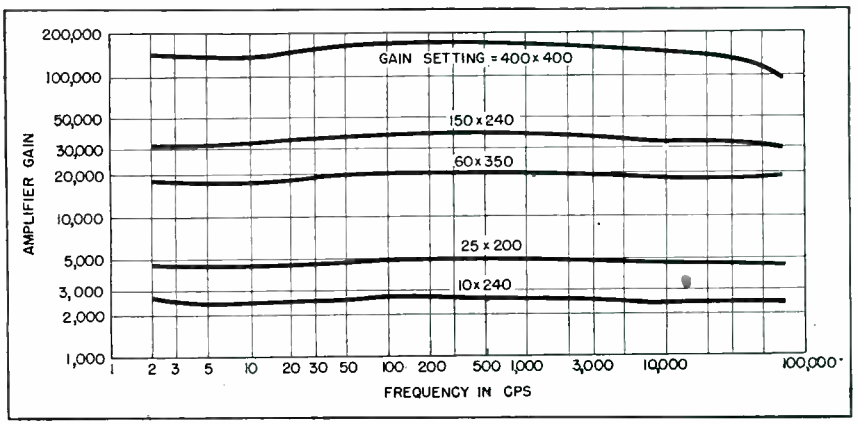


FIG. 4 — Measure of inversion efficiency E_2/E_1 as a function of β for various values of α, when $m = \beta$, tube amplification factor μ is greater than 40, and plate resistance r_p is large compared with load resistance R_1

FIG. 5—Amplifier gain as function of frequency for various positions of feedback controls is shown graphically below



References

(1) Lee, Dana W., The Effects of Engine Speed and Mixture Temperature on the Knocking Characteristics of Several Fuels, TN 767, NACA, 1940.

(2) Sanders, Newell D., Effect of Fuel Vaporization, Inlet-Air Temperature, and Fuel-Air Ratio on the Knock Limit of Isooctane, NACA ARR, 1942.

(3) Schroder, H. J., Cathode-Ray Engine-Pressure Measuring Equipment, *RCA Review*, 202-212, Oct. 1937.

(4) Head, J. W., Electronic Engine-Pressure Indicator, ELECTRONICS, p 132, Jan. 1945.

OVERMODULATION
Without Sideband Splatter

By adding this balanced-modulation circuit to an a-m phone transmitter, modulation in excess of 100 percent can be produced without causing adjacent-channel interference. The technique permits communication modulators to operate at high average level

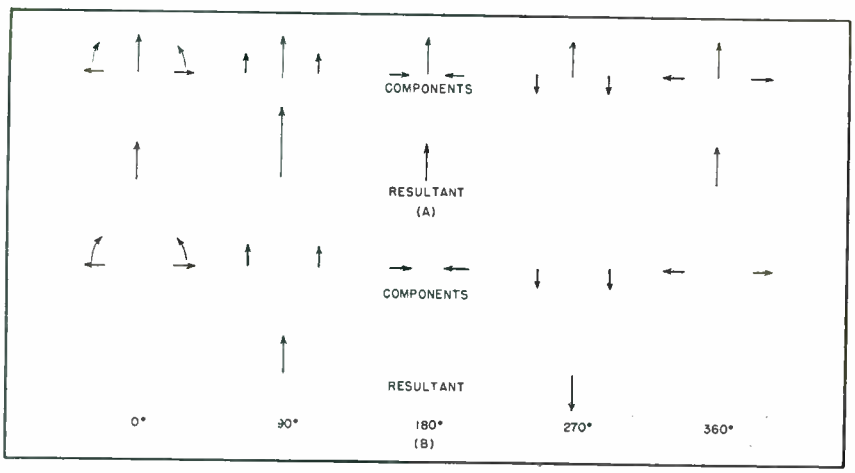


FIG. 1—Vector diagrams for (A) 100-percent amplitude modulation with carrier and (B) 100-percent modulation with fully suppressed carrier show that the resultant signal in the latter case reverses phase as a consequence of the modulation

IN OPERATING an amplitude-modulated radiotelephone transmitter in communications or broadcast service it is always desirable to keep the average percentage of modulation as high as possible in order to increase the energy in the intelligence-bearing sidebands. In this way a louder-sounding and hence more reliable signal is delivered to the receiver. However, the average percentage of modulation may only be increased until overmodulation begins to occur on the program peaks, for the waveform distortion caused by overmodulation clipping is rich in harmonics, and the corresponding sidebands spilling over into adjacent channels may interfere with adjacent-channel services. Yet in the case of speech, when the gain is adjusted to prevent overmodulation on peaks, it is found that the average percentage of modulation is distressingly low.

The circuit described in this article offers a simple means of increasing the average percentage of modulation of amplitude-modulated phone transmitters above 100 percent without causing adjacent-channel interference due to sideband splatter. Accompanying this increase in modulation percentage is a certain amount of distortion which will be noticed in receivers tuned to such a signal. However, it is unlikely that this distortion, occurring as it does only on peaks, will degrade speech intelligibility appreciably unless the percentage of modulation exceeds 100 by a very large amount.

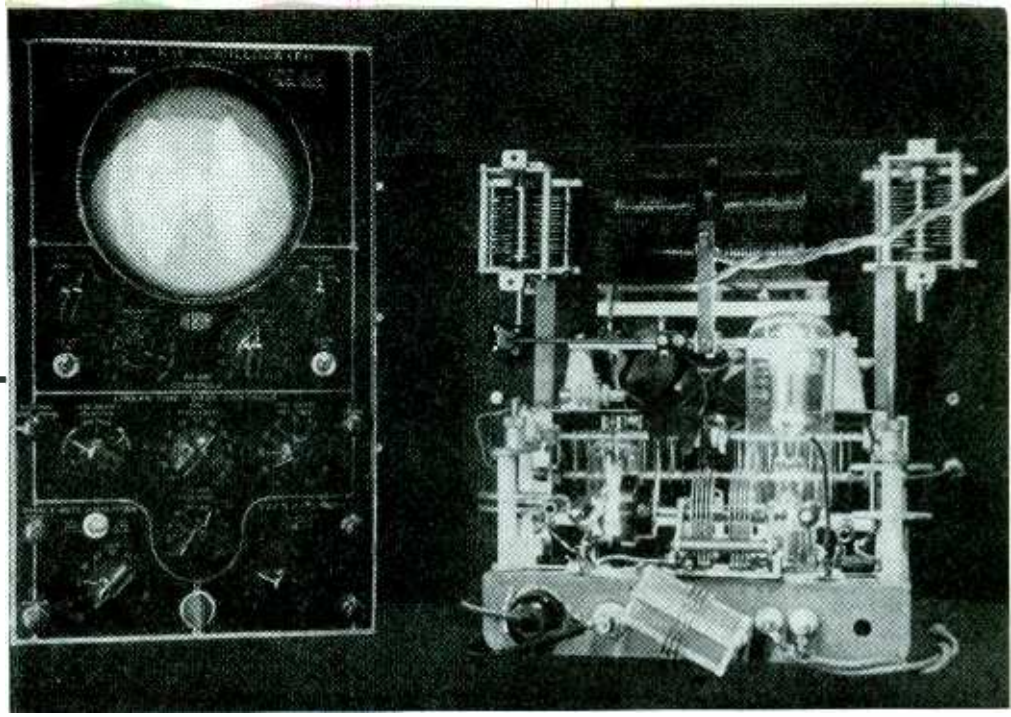
The circuit can be readily incorporated in existing plate-modulated phone transmitters, both single-ended and push-pull, having more audio power available than that required for 100-percent modulation. Installation of the circuit requires relatively few components. For radiophone service where intelligibility rather than fidelity is important, the system makes possible a saving in total primary power consumption and in class-C amplifier tube capacity for a given sideband power output. This advantage is obtained even though the bandwidth required for transmission is maintained at the absolute minimum.

Peak Limiting and Volume Compression

Various ways of increasing the average percentage of modulation have been suggested. One method is to alter the dynamic range of the original program material in such a way that the weak passages are made louder and the loud passages made weaker; known as volume compression. Another method is to introduce peak limiting devices which limit the maximum possible excursion of the audio signal fed to the transmitter. The two systems will increase both the average percentage of modulation and the intelligibility of a signal, at the expense of a certain amount of naturalness which is lost when excessive compression of the dynamic range or distortion due to clipping occurs.

In the case of the peak chopper, there is the disadvantage that the clipped waveform, if allowed to modulate the transmitter directly, contains harmonics capable of causing just about as much adjacent-channel interference as if the clipping had been caused by overmodulation itself. If these harmonics are removed by a low-pass filter, the waveform is no longer clipped at a fixed level, and overmodulation is no longer prevented.

By
OSWALD G. VILLARD, JR.
Acting Assistant Professor
Department of Electrical Engineering
Stanford University
Stanford University, Calif.



Experimental class-C balanced modulator used to produce modulation greater than 100 percent employed an HK-154 of about 50 watts plate dissipation for the modulator and an HK-54 of about 25 watts plate dissipation for the suppressor. A typical modulation envelope is shown on the oscilloscope. Circuit is shown in Fig. 3

Where splatter and adjacent-channel interference must be avoided, it is clear that peak chopping is not particularly practical.

If proper care is taken in their design, peak-actuated volume compressors can be made to prevent momentary overmodulation on peaks, without perceptibly increasing the bandwidth of the audio signal as a result of the distortion which occurs during the transient changes in gain. The only limit to the advantages to be derived from their use as a means for increasing the average percentage of modulation is the loss in naturalness—and eventually intelligibility—which results when weak sounds are amplified much more than loud sounds (unless, of course, a proportionate volume expansion is introduced at the receiver, but such systems of communications where volume expansion at the receiver is possible will not be considered in this article).

Another method of increasing the average percentage of modulation of an amplitude-modulated radiophone transmitter, which in effect allows the percentage of modulation to exceed 100 without causing any adjacent-channel splatter whatsoever, is to increase the power in the sidebands beyond the level produced by 100-percent modulation. It will be seen that this method, used in conjunction with volume compression, makes possible a still further increase in intelligibility over that obtainable by means of volume compression alone.

Briefly, the proposed system allows the ratio of sideband to carrier power to exceed one-half (the condition corresponding to 100-percent modulation) without permitting any distortion of the sidebands to occur. This condition of operation might be called

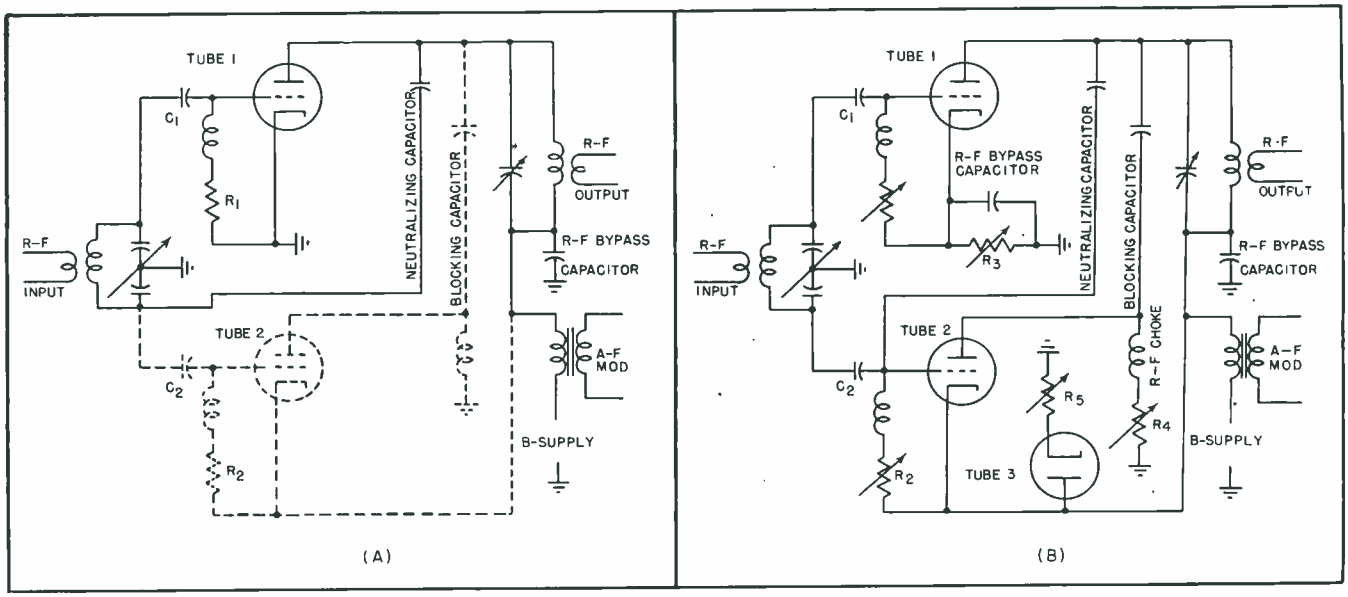


FIG. 2—(A) Additions to conventional class-C modulated amplifier to produce phase reversal of the carrier on overmodulation peaks are shown by dotted line. (B) To bring the two circuits into balance, variable resistors are added. Adjust either R_1 or R_2, or R_3 or R_4, one or the other pair but not both, until equal r-f outputs at a given plate voltage are obtained. Adjust R_5, reversing polarity of tube 3 if necessary, until tubes 1 and 2 present the same load impedance to the modulator

"double sideband reduced carrier," which would be analogous to the "single sideband reduced carrier" systems now in widespread commercial use.

Figure 1A shows the familiar vector diagram of an amplitude-modulated wave, 100-percent modulated. Figure 1B shows the same wave with the carrier removed but with the sidebands unchanged. It is possible to remove the carrier without altering the sidebands in any way; then, because the sidebands have suffered no distortion, there can be no splatter. Figure 1B could, for example, represent the double sideband output of a balanced modulator in which the carrier had been suppressed.

It is important to note that the resultant of a pair of a-m sidebands taken by themselves is a wave of the same frequency as the carrier, but changing in amplitude and also in phase, as shown in Fig. 1B. During the positive half of the audio-frequency modulating cycle, the resultant varies from zero to a maximum and back again; during the negative half cycle, the resultant follows a similar change in amplitude but with the phase of the carrier voltage reversed. This change in phase may be considered to be part of the normal a-m modulating action. When the resultant of the two sidebands is in phase with the carrier, we have phase addition and upward modulation; when the resultant is 180 degrees out of phase, we have phase cancellation and downward modulation.

Modulator Circuit

If we cause the amplitude and phase of a radio-frequency wave of the carrier frequency to vary in the same manner as the resultant of the two sidebands discussed in the preceding paragraph, we will have a means for producing a double-sideband carrierless signal. In practice this can be done in the following way. Two class-C amplifiers are fed from the same modulator in such a way that one produces output during positive half cycles of the modulating voltage, while the other produces output during negative half cycles. If one class-C amplifier is excited by a radio-frequency voltage 180 degrees out of phase with the excitation fed to the other, and both amplifiers work into a common output, we have the required condition of operation. The basic circuit is shown in Fig. 2A.

The portion of the circuit drawn in with a solid line is simply a conventional grid-neutralized single-ended class-C amplifier stage. The portion drawn with a dotted line represents the additional equipment needed to convert this stage into a double-sideband generator. For the moment, we will assume that the B-supply is shorted. It will be seen that tube 1 will produce r-f output during the positive half cycles of modulation, while tube 2 will produce r-f output of the opposite phase during the negative half cycles. If the output of the two tubes is properly balanced we will have the desired double-sideband output.

It will be noted that this circuit is nothing more than a species of balanced modulator. If the modulation transformer had been provided with a center-tapped secondary, and if the center-tap of this winding had been bypassed to ground and the ends connected through shunt-feed r-f chokes to the plates of the class-C amplifier stages, the circuit would have been recognized at once as one of the standard variations of a balanced modulator. The only real difference between the two cases lies in the method of connecting the supply voltages to the two class-C amplifier stages.

We are accustomed to think of balanced modulators as consisting of identical tubes or rectifying elements, which is, of course, the normal arrangement when double-sideband carrierless output is desired. But there is no reason why the carrier must be completely suppressed; it can, in fact, be present in any desired amount without disturbing or distorting the sidebands in any way. In order to make our balanced modulator produce double-sideband reduced-carrier signals, it is only necessary to insert d-c in the desired amount by means of the B-supply. In fact, for a given modulator a-c voltage output, which fixes the amplitude of the sidebands, we can make the ratio of sideband-to-carrier voltage (and also the percentage modulation) in the final r-f wave anything we would like—from something much less than one up to infinity—by simply adjusting the amount of injected d-c and thus setting the amplitude of the carrier.

Need for Balancing the Modulator

Of course, when a carrier is added to the sidebands in this way, the tube supplying the carrier will handle more power than its mate, which is called upon only to supply sideband energy. In the application of the circuit of Fig. 2A to over-

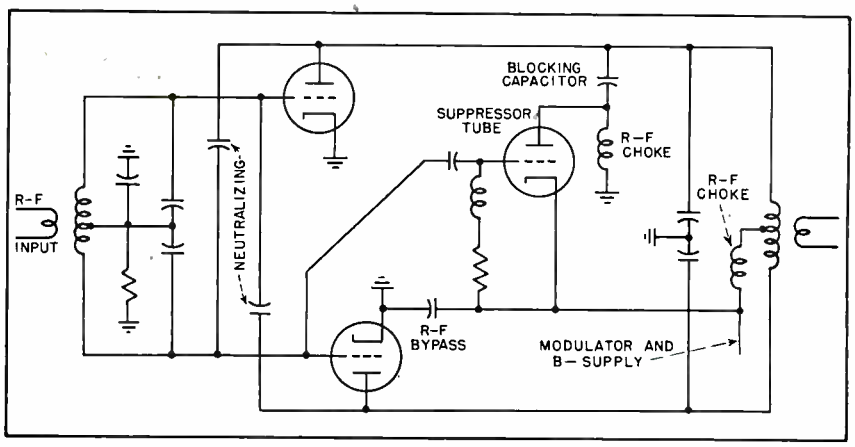


FIG. 3—Addition of splatter suppression circuit to push-pull modulated amplifier can be done simply. Balancing controls are not shown; see Fig. 2B

modulation splatter suppression, tube 2 will not, in general, be identical to tube 1, and consequently it is of interest to consider how a modulator consisting of two dissimilar tubes can be brought into balance. The circuit of Fig. 2A lends itself nicely to a consideration of balanced modulator operation in terms of familiar class-C amplifier concepts.

The curve of r-f output voltage versus plate voltage for a class-C amplifier stage is very nearly a straight line beginning at the origin and possessing a slope slightly less than unity. This characteristic comes about because the peak r-f voltage across the tank circuit of an adequately excited class-C amplifier is always very nearly equal to the plate supply voltage. The difference between these two voltages is, of course, the voltage required to draw the pulse of plate current through the tube. The magnitude of this voltage difference, assuming constant plate load impedance, is controlled to a first approximation by two factors—the angle of plate current flow and the amplitude of the grid driving voltage. Increasing either, within limits, will tend to increase the amplitude of the fundamental-frequency component of the plate current pulse, and thus increase the voltage drop at fundamental frequency across the tuned plate tank circuit.

The amount by which the slope of the r-f output voltage versus plate voltage curve is less than unity is roughly proportional to the magnitude of the instantaneous plate voltage required to draw the plate current pulse, and this magnitude is dependent on the angle of plate current flow and the amplitude of the grid driving voltage. Consequently, if we have two class-C amplifiers whose r-f output versus plate voltage curves we wish to match, or stating it another way, whose slopes we wish to make equal, to a first approximation it is only necessary to vary the grid bias or the driving voltage of one amplifier until its performance matches the other. This equality is the condition we wish to achieve in

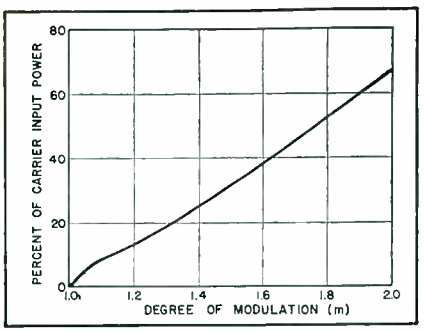


FIG. 4—Average power input to suppressor tube is shown as a function of degrees of sinewave modulation

the balanced modulator of Fig. 2A. Modulating voltages of from zero to maximum positive should produce r-f outputs of exactly the same magnitude from one amplifier tube as modulating voltages from zero to maximum negative produce from the other.

Another, somewhat more wasteful way of accomplishing the same result would be to add resistance in series with the supply voltage lead of whichever class-C tube is found by experiment to have the r-f output versus plate voltage curve of greater slope.

However, matching the slopes of the output curves does not guarantee that the two class-C amplifier tubes will then each present exactly the same load impedance to the modulator. It is entirely possible that the two tubes may produce equal r-f outputs at the same magnitude of d-c plate voltage, but at the same time draw differing d-c plate currents. The modulator will then be working into one value of load impedance during positive half cycles, and another during negative half cycles. Unless the effective output impedance of the modulator has been reduced by some means (such as negative feedback) to a very low value, positive and negative half-cycles of output voltage will have differing amplitudes and distortion will result.

Method of Producing Balance

A difference in load resistances can easily be eliminated by measuring the d-c voltage-current ratios of the two class-C tubes at a given plate voltage, and then in effect connecting a resistance in shunt with the plate supply leads of that tube having the higher ratio. The added resistance should be of a value such that the parallel combination of this resistance and its associated class-C amplifier presents the same load resistance to the modulator as the other class-C tube considered alone.

In the case of the double sideband generator circuit that we have been discussing, both tubes are effectively connected across the output of the modulator at all times; consequently the equalizing resistance must be connected to the circuit through a diode in such a way that this resistance is effectively present in the circuit only during positive or negative half cycles of modulation, as the situation may require.

Figure 2B is similar to Fig. 2A but with various balancing controls included. Resistors R_1 and R_2 are, of course, the grid leak resistors normally present in the circuit. (Use of grid leak bias is desirable from the standpoint of improving the linearity of the modulation characteristic.) Resistors R_3 and R_4 represent two alternative points of connection of amplitude balance controls. Resistor R_5 illustrates a way of connecting the load impedance balancing resistor. It should be emphasized that both R_3 and R_4 will not be needed. Only one resistor will be required, once the proper point of connection has been determined.

So far nothing has been said about the effect of the double sideband generator tube on the neutralization of the original class-C amplifier. Inspection of Fig. 2A will show that if tube 2 has the same grid-plate capacitance as tube 1, the tubes will neutralize each other and no neutralizing capacitor such as the one shown will be needed. If the effective grid-plate capacitances are not exactly equal, as will almost invariably be the case when stray circuit capacitances are taken into account, a neutralizing capacitor may have to be connected between the plate leads, which are in parallel for r-f, and the grid of one tube or the

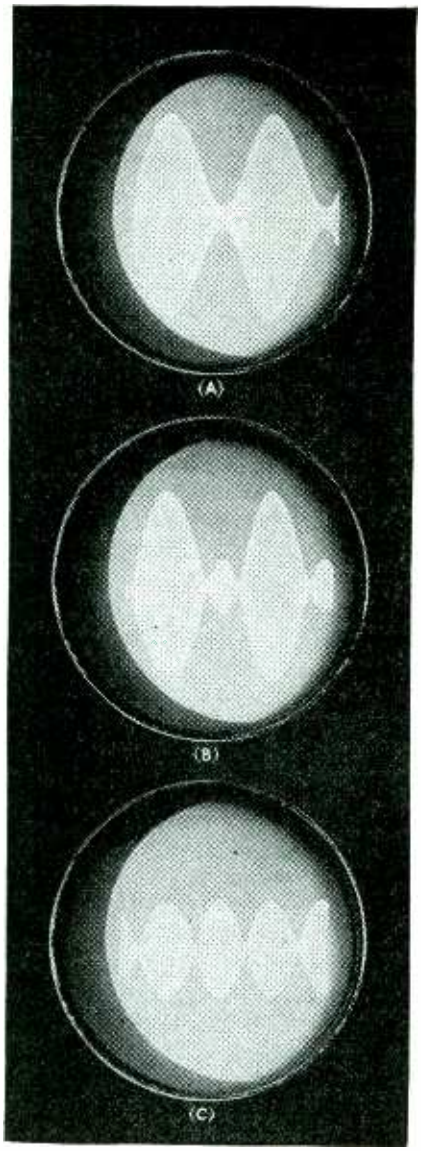


FIG. 5—Oscillograms show various degrees of modulation, including overmodulation, obtained with the suppressor circuit

other in order to make the neutralization perfect.

The circuit of Fig. 2A is correct when the effective grid-plate capacitance of tube 2 is less than that of tube 1. For the reverse situation, the plate connection of the neutralizing capacitor remains the same, while the grid connection should be made to the grid of tube 1.

Phase Shift in Grid Circuits

A word needs to be said at this point concerning the possibility of undesirable phase shift in the grid circuits of the two class-C amplifier tubes. Referring to Fig. 2A, note that grid coupling capacitors C_1 and C_2 will normally be so designed that their reactance at the operating frequency is very low compared to the equivalent shunt resistance of the grids of the two tubes at the positive peak of the grid driving cycle. Yet the reactance of these capacitors at the highest modulating frequency should be equal to at least twice the resistance of the grid leaks (neglecting, in the interests of simplicity, the effect of the r-f chokes), for good linearity of modulation.

In view of the extremely low shunt resistance which the grids may represent when driven well into the positive region of operation, it may not always be possible to prevent a certain amount of phase shift in the coupling circuits. If the two tubes are dissimilar, with differing grid driving requirements and differing grid impedance characteristics, the phase shifts in the two grid circuits may not be the same and the two tubes may not be driven exactly 180 degrees out of phase.

Unfortunately, the phase of the voltage in the grid circuits at the positive crests of the grid driving cycle directly determines the phase of the steady-state r-f voltage across the common plate tank circuit. The remedy is to equalize the time constants of the two grid circuits at the crest of the driving cycles, which can be done by varying the capacitance of one or the other of the coupling capacitors or by connecting a low resistance in series with the grid of whichever tube displays the lowest grid impedance at the positive crest of its driving cycle.

Fortunately, in most practical cases the phase shift through the coupling capacitors will be negligible; phase correction in the grid circuit will only be found to be necessary in the case of low-carrier-frequency, high-fidelity transmitters when widely dissimilar tubes are used.

Exactness of balance, both as regards phase shift and relative amplitude, can be easily checked by applying equal d-c plate voltages to both tubes simultaneously, and noting the presence or absence of r-f voltage of the fundamental frequency in the common plate circuit. This check should be made at a number of different supply voltages.

One other point is worthy of mention. Examination of Fig. 2 will show that tube 2 is shunt fed in both grid and plate circuits, and a low-frequency parasitic oscillation can be expected as a matter of course unless the r-f choke in the plate circuit is given a much larger value of inductance than that in the grid circuit.

Modifying Existing Equipment

On the basis of the foregoing discussion it is not difficult to see how almost any plate-modulated radiotelephone transmitter can be converted into a double-sideband generator for the purpose of suppressing adjacent-channel interference due to overmodulation. When the percentage of modulation is low, we have normal class-C modulated amplifier performance, with only tube 1 conducting. However, when overmodulation occurs, and the instantaneous plate potential of tube 1 becomes negative with respect to ground, tube 2 comes into action and produces an undistorted sideband output corresponding to the negative modulation peaks which would otherwise have been clipped off. Because there is no distortion, no adjacent-channel interference is generated.

The splatter-suppression circuit can readily be added to existing transmitters provided, of course, that sufficient reserve audio power is available. It will be seen that the number and the cost of the added components is not very great. The only possible complication is the filament supply for the suppressor tube, which must have high-voltage insulation and a low capacitance to ground. However, standard rectifier filament transformers meeting these requirements are not hard to find.

The splatter-suppression circuit can be added to push-pull class-C r-f amplifiers just as easily as it can be added to single-ended ones. Reference to Fig. 3 will make this clear. The tube labelled Suppressor Tube performs the same functions as tube 2 in Fig. 2. The circuit is in

all other respects that of a conventional push-pull amplifier. From the standpoint of r-f, the suppressor tube is connected between the grid of either one of the push-pull tubes and the plate of the other. The main point is that, when overmodulation occurs and the common plate-voltage lead becomes more negative than ground, causing the suppressor tube to come into operation, the suppressor tube must deliver to the tank circuit r-f which is 180 degrees out of phase with that supplied by the push-pull tubes when the common plate-supply voltage lead is at a positive potential.

Splatter-Suppressor Power

The splatter-suppressor tube need not have large plate dissipation capacity. Because tube 2 conducts only during the modulation peaks, the average power dissipated at its plate will be small. Consequently, a small, inexpensive tube can be used, provided one is selected with adequate insulation and adequate peak emission.

For a sinewave modulating waveform, the average power input to the splatter-suppressor tube can be calculated in the following way. Power input to the suppressor tube, expressed as a percentage of the carrier power input, is $0.278\ m\alpha$ for sinewave modulating voltage, where α expressed in degrees is the angle whose cosine is $1/m$, and m is the modulation factor (defined as the difference between the maximum and average envelope amplitudes divided by the average amplitude.)

A plot of this relation is given in Fig. 4. The actual power dissipated at the plate of the suppressor tube is, of course, the product of the total input times the efficiency of the suppressor tube as a class-C amplifier. Especially in the case of complex modulating waveforms, such as speech and music, it will be found that the power dissipated by the plate of the suppressor tube is relatively small for reasonable degrees of overmodulation.

It should be evident that use of the above splatter-suppression circuit will not prevent distortion at the receiver when the transmitter is modulated in excess of 100 percent. Some representative oscillograms will make this clear.

System Fidelity

Figure 5 illustrates the patterns obtainable. In all three figures the modulator output voltage is constant, and only the d-c plate input to the larger of the two class-C tubes was varied. Figure 5A shows the familiar modulation envelope pattern obtained when the percentage of modulation is less than 100 percent. In Fig. 5B the effective percentage modulation is now in excess of 100 percent, and the suppressor tube is beginning to make its contribution. In Fig. 5C the d-c or carrier power input has been reduced virtually to zero and we have very nearly a pure double-sideband output. In this particular setup, the two class-C load impedances presented to the modulator were not balanced, and time did not permit of any attempt to reduce the distortion present in the output of the laboratory modulator below the level shown. However, the oscillograms serve to illustrate the basic idea of the system, and the results obtained were in full agreement with expectations.

Figure 6 shows the trapezoidal patterns corresponding roughly to the conditions of adjustment illustrated in Fig. 5.

When a signal as much overmodulated as the one shown in Fig. 5B is demodulated by a wideband conventional receiver using a linear detector, a badly distorted replica of the original sinewave will be obtained. However, it should be borne in mind that any sideband clipping caused by the selectivity of the receiver circuits will reduce the effective percentage modulation of the incoming signal and thereby reduce the distortion.

Sideband clipping will, of course, normally be noticed only on the higher audio frequencies, 1,000 cps and above. In communication circuits where quality of reproduction is not important, it may be possible to put this effect to some practical use. Considerable high-frequency preemphasis at the transmitter could be followed by high selectivity

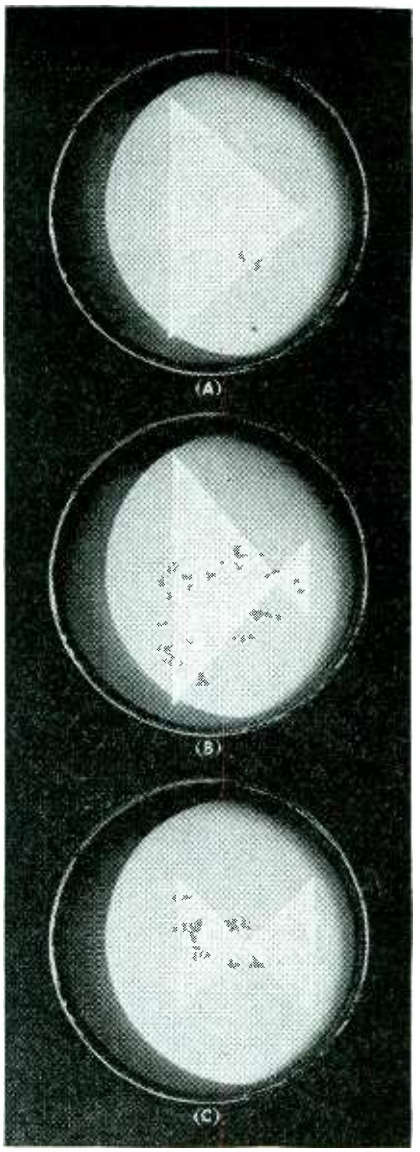


FIG. 6 — Corresponding trapezoidal patterns show the percents of modulation represented by oscillograms of Fig. 5

at the receiver, such as that obtainable with the conventional crystal filter. If high-frequency program peaks were then strong enough to overmodulate, receiver selectivity could easily be made sufficient to reject the excess sideband energy, thus leaving a signal at the second detector which was modulated less than 100 percent and hence undistorted. The chief practical difficulty with this arrangement is that most of the energy peaks in speech occur at frequencies below 1,000 cps. However, when overmodulation did occur at any frequency, it would not produce sideband splatter because of the carrier phase reversal of the suppressor tube.

STANDING

By HEINZ E. KALLMANN
Consultant
New York, N. Y.

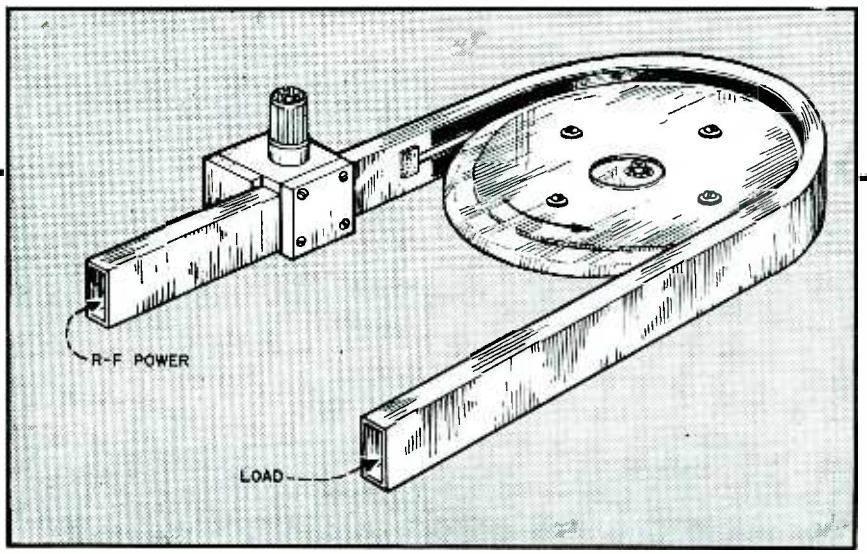


FIG. 1—Measurement probe (left of center) and eccentric dielectric rotor which dips through a slot in the U-shaped wave guide when driven by a small motor. This insertion of a dielectric gives the effect of alternately stretching the guide to a greater length and returning it to its original dimension

THE meter to be described is an automatic standing wave detector of moderate accuracy designed for quick and simple operation in situations such as production tests and adjustments of microwave equipment. It has proved helpful in a survey of the effects of various parameters on the matching of a waveguide transition. The study was typical of the many cases where only the standing wave ratio is wanted, not the position of the maxima and minima. In this device the problem is simplified by providing a constant and matched source of microwave power. It is then only necessary to know the difference between the maximum and minimum amplitude, which is proportional to the amplitude of the reflected power. If a mechanism periodically moves the position of the standing wave detector probe past the position of the maxima and minima or vice versa, then a peak-to-peak voltmeter fed by the detector will yield readings directly proportional to reflected voltage E_r. With a given input E_0, the meter may be calibrated in voltage standing wave ratio, η_v, from $\eta_v = (E_0 + E_r)/(E_0 - E_r)$.

Standing wave minima are spaced at intervals of half a guide wavelength λ_g; relative movement of the probe and minima by at least $\lambda_g/2$ will thus insure that at least one maximum and one minimum are passed by the probe wherever they happen to be in relation to the position of the probe. To assist the performance of the peak voltmeter circuit, however, it is preferable to increase the relative movement of the probe and standing waves from one-half guide wavelength to two or more guide wavelengths.

Transmission Line Stretcher

To simplify the design of the microwave components, the probe is mounted in a fixed position and its electrical distance from the load varied by means of a periodical line stretcher, in this case a strip of low-loss dielectric periodically dipped into the guide through a slit in its top wall. Insertion of a dielectric is equivalent to an increase of the guide width, thus reducing the guide wavelength λ_g. The arrangement used for a guide of 0.5 x 0.25-inch outside dimensions is sketched in Fig. 1; it offers a long taper of the dielectric in a small space. The guide is bent, in the E plane, to U shape with an outside diameter of 2½ inches. A central slit 0.092 inch wide is cut along the curved inside part of the U. Into this slit dips the edge of a circular polystyrene disk, 0.075 inch thick, which is mounted 0.10 inch off-center on the spindle of a small 30-rps motor (not shown). The configuration of a U-shaped guide and circular disk makes a very slim taper,

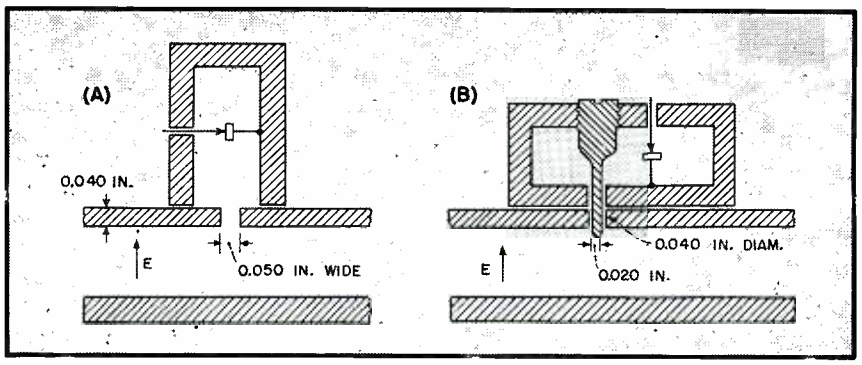


FIG. 2—Probe and crystal detector for measuring magnitude of power reflections. At (A) the crystal is coupled by means of an E-plane tee, whereas at (B) a coaxial coupling and wire probe are employed

This paper is based on work done for the Office of Scientific Research and Development under contract OEMsr-262 with the Radiation Laboratory, Massachusetts Institute of Technology.

WAVE METER

The power reflections caused by mismatch at the junction of waveguide components are measured automatically by a device which gives a direct meter indication of the standing wave ratio

minimizing the discontinuities and thus the reflection; bevelling of the dielectric disk further minimizes the discontinuities. When the motor rotates, the eccentric rim of the polystyrene disk periodically penetrates the center of the U guide nearly to the opposite wall and is withdrawn to the edges of the slit.

The sketch of Fig. 1 shows strips of lossy material, such as conducting rubber, cemented along the edges of the slit to absorb radiation through it and also small pieces of lossy material, such as molded polyiron powder, wedged into the ends of the slit. The latter are needed to absorb slot waves, spurious standing waves set up between the two edges of the slit as on a balanced line.

The main limitation to the accuracy of the meter is imposed by reflections from the point where the dielectric dips into the waveguide. Direct reflection of oscillator power at this point is observed as residual standing wave ratio even if the load is perfectly matched. Furthermore, waves reflected from an unmatched load are reflected forward again at this point. Second reflections at the load interfere constructively or destructively with the first ones, dependent upon the distance between line stretcher and load. The larger the mismatch at the line stretcher, the more does the observed standing wave ratio vary around the proper value. Oscillator mismatch that might affect the accuracy of the measurement is usually kept low by padding.

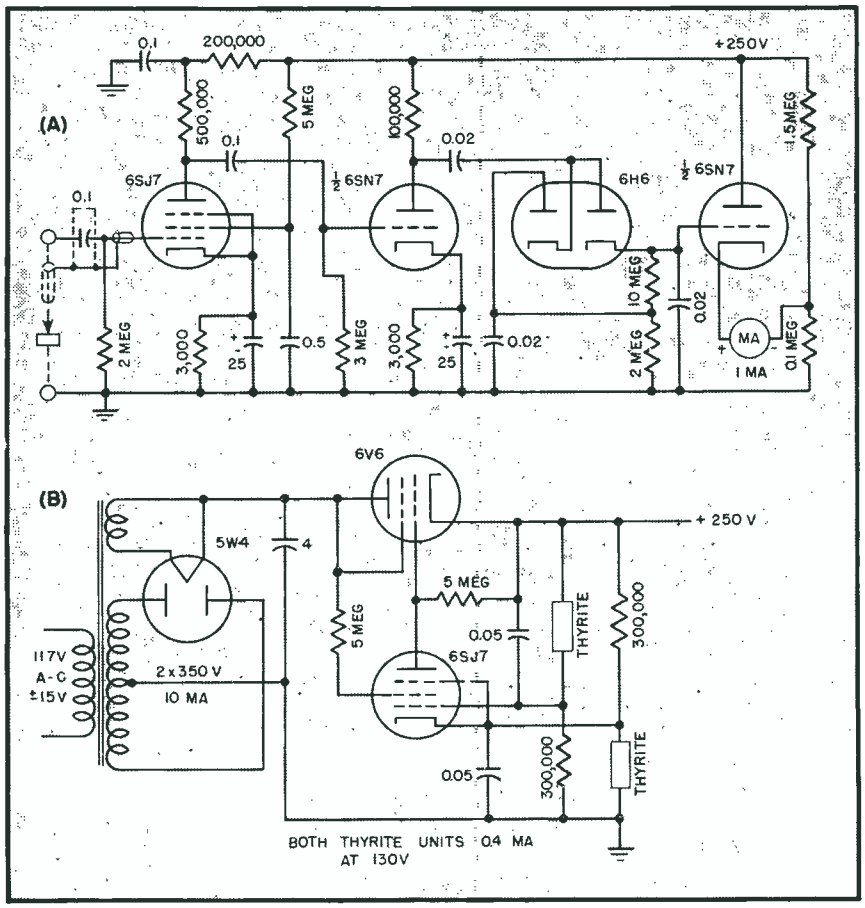


FIG. 3—Fundamental standing wave meter circuit diagram (A) and Thyrite bridge regulated power supply (B) used to operate the unit

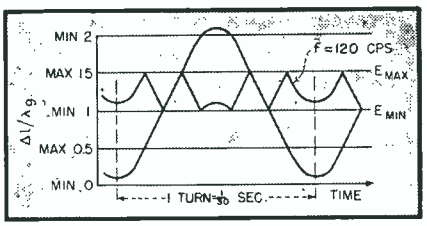


FIG. 4—The effect of changing line length as indicated by the signal at the probe. Rounded peaks occur when the line stretcher reverses its action

Crystal Detector

The probe is placed immediately before the line stretcher. It couples a crystal detector to the waveguide with about 15 db attenuation, assuming a power level of about 1 milliwatt at this point of the guide. The crystal may either be coupled in by an E-plane tee with a slot 0.050 inch wide across the whole width of the 0.040-inch guide wall, as shown in Fig. 2A, or by means of a coaxial coupling between the main and a short auxiliary guide consisting of a 0.020-inch wire probe in a hole 0.060 inch in diameter, as in Fig. 2B. The coupling should be nondirectional, but imperfection in this

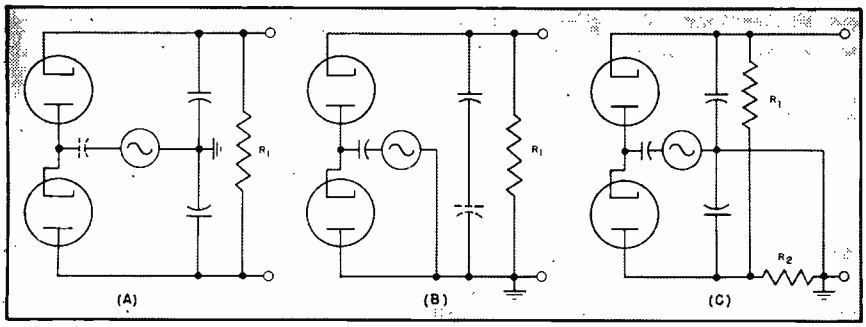


FIG. 5—Voltage-doubler rectifier circuits. At (A) is shown a full-wave doubler, with a half-wave circuit at (B). The circuit at (C) combines advantages of both types

respect will not affect the result.

The crystal detector is operated substantially without load. It can be shown that under this condition and for the relatively high power level in this device, it acts as a linear detector.

Indicator Amplifier

The amplifier and voltmeter circuit are shown in Fig. 3A. All plates are fed with about 250 volts, with very low ripple, from a regulated power supply (Fig. 3B) employing a Thyrite bridge; total current drawn is 3 milliamperes, exclusive of that for the microwave oscillator. The first amplifier stage, a pentode, and the second stage, a triode, provide about 70 db gain in a conventional audio-frequency design; the response extends low enough to minimize phase distortion at 30 cps. The amplifier feeds into a voltage-doubler rectifier employing a double diode.

The reading of the meter is unaffected by the distance of the load only to the extent that its rectifier circuit approximates a perfect peak rectifier, that is, one whose output is independent of the shape and spacing of the peaks. In particular, loading of the rectifier is undesirable since it affects mainly the shape of the peaks. To minimize this effect, very high load resistances are necessary which entail long time constants and slow meter response and whose insulation is difficult. To ease these requirements without sacrifice in accuracy, the following steps were taken.

Instead of the required minimum of a half guide wavelength, the line was stretched periodically by two or more guide wavelengths. The effect is illustrated in Fig. 4 where the sine-shaped curve represents the change of line length Δ_l/λ_g as a function of time t for one turn of the motor in 1/30 second. Since the change extends over two whole guide wavelengths, the signal at the probe will then be the same as if the amplitude had changed about four times as often back and forth between one minimum and the next maximum with the average frequency f approximately equal to 120 cps, as shown in the zigzag curve of Fig. 4.

Round peaks occur in the zigzag curve whenever the line stretcher reverses its action; their height depends on whether this happens near a maximum or minimum, or in between—that is, on the position of the load. The sharp peaks of the zigzag curve, on the other hand, are unaffected in height and shape by the position of the load. The larger Δ_l/λ_g, the more sharp peaks are interposed between each two round peaks and the less will the response of an imperfect peak voltmeter be affected by the varying height of the latter. It can be seen that deformation of the U-shaped guide or of the circumference of the polystyrene disk merely affects the spacing of the sharp peaks but does not affect their number or their height.

Rectifier Circuit

There are two main forms of the voltage-doubler rectifier, the full-wave doubler of Fig. 5A and the half-wave doubler of Fig. 5B. Both yield the same output—twice the peak-to-peak voltage. They differ in that the former draws energy evenly from both the positive and negative peaks of the supplied oscillations, but does not permit of both single-ended input and output without the help of a transformer; the opposite is true for the half-wave doubler.

The circuit of Fig. 5C was developed by combining most of the relevant advantages of both Fig. 5A and Fig. 5B. It differs from that of

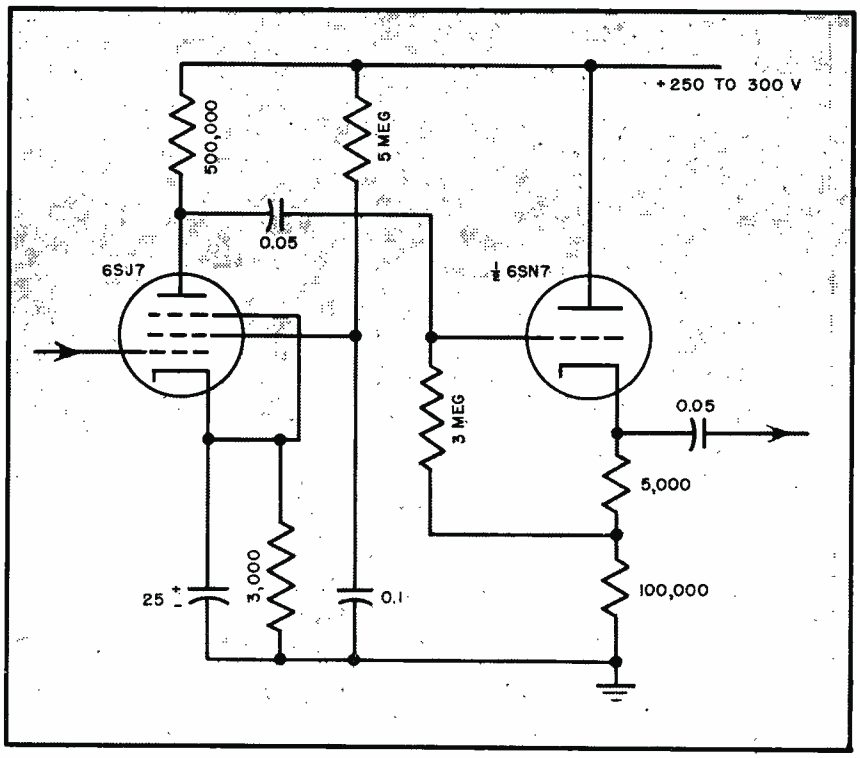


FIG. 6—Improved amplifier to replace the single stage shown in Fig. 3. Low impedance output is obtained with the cathode follower

Fig. 5A only in that one output terminal is grounded through resistor R_2 which is too large to affect the operation of the rectifier circuit. The new circuit has single-ended input and output; it still yields fully twice the peak-to-peak voltage for any load resistance which is large compared with $R_1 + R_2$. It provides approximately even loading of both the positive and negative peaks as long as R_2 is large, and offers a distinct improvement in the accuracy of the standing wave meter. In the circuit of Fig. 3, this voltage-doubling rectifier employs a value of 2 megohms for R_1.

Two further refinements tested and used in more elaborate equipment were not needed in the simple unit here described. The second amplifier stage in Fig. 3 was replaced by the two stages shown in Fig. 6. Replacing the amplifier triode by a pentode increases the sensitivity by about 20 db without reaching the limits of instability or circuit noise. In addition, this amplifier stage was coupled to the voltage-doubler rectifier via a cathode-follower stage with the low output impedance of $1/g_m$ approximately equal to 500 ohms so that the deformation of the voltage peaks due to rectifier loading was further reduced.

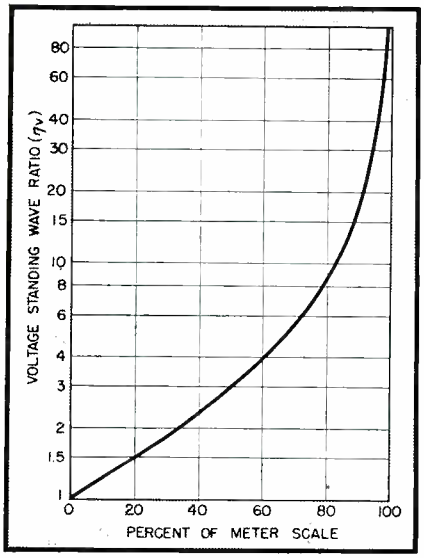


FIG. 7—Calibration of the meter dial in terms of voltage standing wave ratio

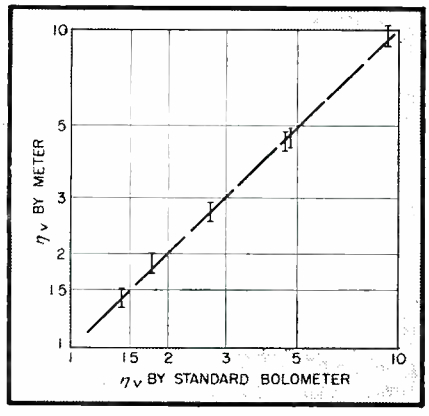


FIG. 8—Voltage standing wave ratio observed on the meter in comparison with measurements by means of a standard bolometer. Vertical lines indicate the spread of the readings

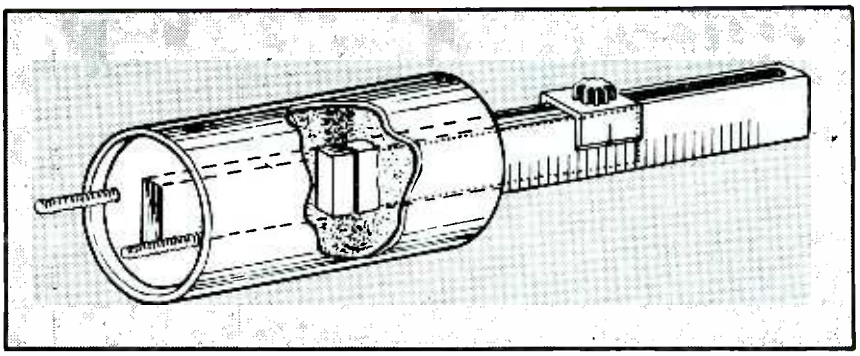


FIG. 9—Artist's drawing of an adjustable standing wave ratio load used in calibrating the meter as shown in Fig. 8

The output of the voltage-doubler rectifier is of the order of 100 volts for full scale, but is of such high impedance that direct measurement with a d-c voltmeter is undesirable. It is, therefore, transformed down to a more convenient impedance level by means of a cathode-follower tube. Due to the degenerative resistance of 0.1 megohm in its cathode circuit, the plate current of this triode is strictly proportional to its grid potential, with an effective mutual conductance of 10 micromhos. A bleeder resistance from B + to its cathode holds the standing plate current to cutoff.

Any meter system with a sensitivity of 1 milliampere for full scale deflection may be used. Its scale is calibrated according to the curve of Fig. 7; voltage standing wave ratio $= (1 + E_r)/(1 - E_r)$, if full scale (100 percent) is to indicate an infinite ratio. The detector characteristic, amplifier, and rectifier may all be assumed as linear.

Comparison With Bolometer

The calibration thus computed was checked for various loads against a standing wave detector employing a standard bolometer, with results as in Fig. 8. A load with a standing wave ratio adjustable from 1.02 to greater than 70 was built, as shown in Fig. 9, consisting of a choke-type metal plunger movable in a high-loss waveguide, molded of polyiron powder. A slotted-section line stretcher inserted between this calibrated load and the matchmeter was varied and the variations in the meter readings noted. Short lines straddling the expected straight line are marked in Fig. 8, indicating the range of these variations. The deviations never exceed plus or minus 10 percent of the correct standing wave ratio and, in most cases, are much less. The error is typical for reflections between line stretcher and load; it seems low considering that there were two choke-flange joints and that the polystyrene disk of the tested instrument did not even have a bevelled edge.

Circuit Elements not Critical

The assumption of a linear overall characteristic was thus confirmed. Changes in gain with aging have thus no influence on the calibration provided it is set to full scale for $\eta_v = \infty$. Adjustment may equally well be made by control of the input power or by a voltage divider (not shown) in place of the grid resistor of the first amplifier stage.

No tuned or frequency-sensitive parts are used. All circuit components are of standard type and tolerance. The instrument as described can easily be built into an 8-inch cube using standard components. No more space is needed even if the microwave oscillator is included, fed from the same power supply.

Electronic

Electronic position pickup, showing two-phase winding on a circular disc mechanically linked to a piezoelectric crystal. The disc is mounted in close proximity to an instrument pointer equipped with a small permanent magnet. There are no moving parts

IN MANY MODERN industrial instrumentation installations it is necessary to read sensitive measuring instruments at a substantial distance from the point of measurement to enable satisfactory centralized control. Reading of these remote instruments requires some form of telemetering.

We had such a problem some time ago when we were required to transmit the position of the sweep hand of a sensitive aircraft altimeter to a remote receiving station. Since the amount of torque which could be taken from the sensitive altimeter hand without deflecting it in excess of our tolerances was less than two milligram millimeters, the altimeter sweep hand could not be used directly to operate a variable resistance.

We decided to place a small magnet on the sensitive sweep hand and then pick up the orientation of the resulting magnetic field externally. This fitted in well with the design of the sensitive altimeter since it is a sealed instrument and the use of magnetic coupling eliminated the need for sealing glands. To insure freedom from influences of the earth's magnetic field it was necessary to make the field of the pointer magnet at least one hundred times as strong as the earth's field at the point of measurement, so that any mutual effects would be less than one percent. This was not a severe limitation.

Since we had decided to use electrical phase angle as the method of transmitting the pointer position from one location to another, it was necessary to employ a pickup having voltage output which shifted in phase as a function of the motion of the sweep pointer on the altimeter. To insure linearity of calibration it was also necessary that the phase shift be linear with motion of the pointer, the two following each other degree for degree.

Basic Principle

Figure 1 is a drawing of the basic position-pickup device which was converted for this use. It is a form of earth-inductor compass with which we have experimented and consists, as shown, of an armature mounted on a piezoelectric crystal of the type used in conventional phonograph pickups.

The armature is made of three laminations of 0.014-inch silicon steel two inches long and one quarter of an inch wide. The laminations are wound with several turns of Formex wire. The function of the armature is to couple an external magnetic field and to transmit this couple to the piezoelectric crystal. The crystal, which is ground to be sensitive to torsional moments, produces a voltage output which is a function of the rate of change of the couple between the magnetic field of the armature and the earth's field.

The magnetic field of the armature lies along its axis, as shown by the line *AB*. Line *CD* represents the orientation of the external magnetic field. The couple produced is proportional to the product of the strengths of the external magnetic field and of the magnetic field of the armature, and the sine of the angle θ between them. When the two fields are coincident with each other the sine of θ becomes zero and the couple becomes zero.

In the operating device the armature coil is excited with alternating current so that the couple is continually varying due to the reaction between a steady external field and a field which is varying sinusoidally. This continuously varying couple produces an alternating torsional moment on the crystal which varies in amplitude as a function of the sine of θ, and which varies in phase depending upon whether θ lies between 0 and 180 degrees, or 180 and 360 degrees. The phase of the couple does not vary continuously, but shifts through 180 degrees as θ goes through 180 and 360 degrees. Substantial moments may be produced in this manner, producing outputs from the crystal in excess of one volt.

The pickup may be connected to any suitable electronic or magnetic amplifier and servo and will then keep itself oriented with the external field. Such an arrangement is shown in Fig. 2. While this would be suitable for an earth-inductor compass, it would be too cumbersome for an instrument pickup.

Practical Variation

The variation shown in Fig. 3 was employed in the instrument under discussion. It may be seen that the armature mounted on the crystal is circular instead of rectangu-

Pickup with plastic hood, facilitating mounting over the glass face of an instrument

Position Pickup

A modified earth-inductor compass, comprising a piezoelectric crystal and an armature energized by a-c, provides an output voltage that shifts linearly in phase as a function of an instrument pointer on which a small permanent magnet has been mounted

By DAVID WILLIAM MOORE, JR.

Engineer in Charge
Fairchild Camera and Instrument Corp.
Jamaica, N. Y.

lar, and wound with a polyphase winding. This may seem to be a relatively minor change, but the effect produces a pickup much more flexible and more suitable for our application, and for any application requiring the reading of a very sensitive measuring instrument.

As in the previous example, the crystal is of the piezoelectric variety, and is sensitive to torsional moments. The armature is wound with a two-phase winding so that a uniform continuously rotating magnetic field can be produced. This rotating magnetic field reacts with any external magnetic field and produces a continuously varying torsional couple with this external magnetic field. The important point is that the phase of the continuously varying torsional couple with respect to the current exciting the two-phase winding is a direct function of the orientation of the external magnetic field with respect to the circular armature of the device described.

Line *AB* represents the continuously rotating magnetic field. Line *CD* represents the stationary external field. Because the magnetic couple between these two fields will vary as the sine of the angle θ between them, it is apparent that the phase of this couple will be a function solely of the orientation of the external magnetic field *CD*. This couple is transferred directly to the piezoelectric crystal, so the voltage output of the crystal will faithfully follow the couple. It will have a phase relationship to the current exciting the two-phase winding on the circular armature which is a direct function of the orientation of the external magnetic field. Thus any change of the orientation of the external magnetic field, caused by a change in sweep pointer position in the application under discussion, will result in a change in phase of the output of the piezoelectric crystal.

Because the crystal operates on force rather than upon any measurable motion, the position pickup has no moving parts. Also, it will reflect no load back upon the external field, which is very important when this field is produced by a small permanent magnet mounted on the pointer of a sensitive instrument.

For a given external magnetic field strength the voltage output of the crystal is constant, and varies in phase continuously as it is rotated with respect to the external field. If it is connected to an oscilloscope and simply rotated in the open the phase of its output voltage may be seen to continuously change as a result of the varying couple with the earth's magnetic field.

At the time this pickup was built and tested experimentally there were no high-output crystals which did not deteriorate badly at temperatures above 110 F. This precluded use of the pickup in the telemetering equipment described in an earlier article[1], but since then we understand that crystals as sensitive as Rochelle salt have been developed that will withstand high temperatures and not go to pieces.

REFERENCE

(1) Moore, David William, Jr., Continuously Variable Radio Remote Control, ELECTRONICS, p 112, Nov. 1946.

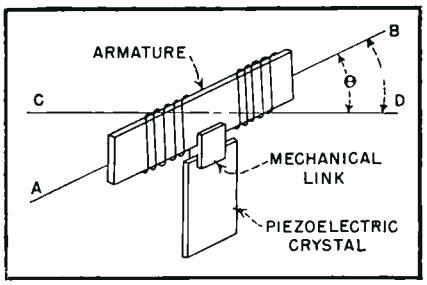


FIG. 1—Sketch illustrating the basic principle of operation. Line *AB* indicates the magnetic field of the armature. Line *CD* represents the orientation of an external magnetic field

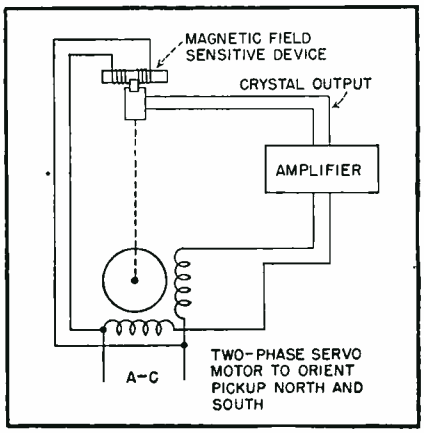


FIG. 2—Schematic showing a method by which the simple pickup illustrated in Fig. 1 may be used in conjunction with an amplifier and a servo motor to keep itself oriented with respect to an external magnetic field

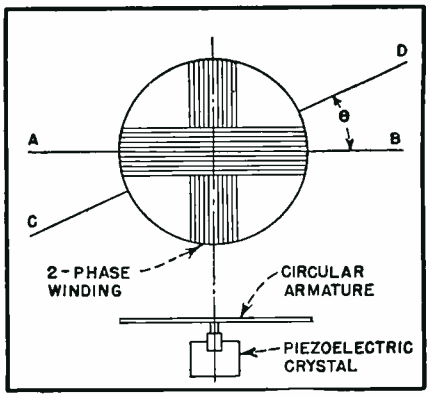


FIG. 3—Modification of the basic pickup design, employing an a-c energized two-phase winding on a circular armature, as employed in the electronic position pickup discussed in the text

Carrier - Difference

By R. B. DOME
General Electric Company
Bridgeport, Conn.

These components comprise the entire television sound system, except power amplifier tube. The system operates on present FCC black-and-white standards

SEVERAL PROPOSALS have been made in the past for the use of a common amplifier channel for sight and sound in a television receiver. Such a system would simplify the receiver, and render its operation free from the disturbing effects of local oscillator hum frequency-modulation and frequency drift. Most of these proposals are based on some form of multiplex[1, 2, 3] wherein the sound signals modulate the picture carrier during the horizontal blanking interval when no picture information is being transmitted. These methods may be classified as time division systems of transmission of intelligence, since the receiver employs a time-gated amplifier which opens only during that portion of time devoted to the transmission of sound.

Time division methods of sound transmission are weak for two reasons. The first is that the amount of power devoted to sound is relatively small which means that the signal-to-noise ratio will not be adequate over as long a range as if more average power had been used, and secondly, failure of the gated amplifier to synchronize properly in noisy locations means a further decrease in average signal-to-noise ratio.

The disadvantages of time division systems may be overcome by the use of a frequency division system with simultaneous transmission of picture and sound signals exactly as in the manner used today in black-and-white television in the frequency bands between 44 and 216 megacycles. There is nothing very complicated about such transmissions. The video signal modulates continuously one carrier frequency with amplitude modulation while the sound signal modulates continuously another carrier frequency with frequency modulation. A conventional receiver arrangement has been commonly used in the past. The local oscillator beats the two carrier waves down to two intermediate frequencies. Here the receiver is split into two i-f channels, a wide one for the picture, and a narrow one for the sound. Separate second detectors are employed: a simple rectifier for the picture, and a discriminator-detector for the sound.

The objections to this type of receiver are: (1) Frequency modulation of the local oscillator at power frequency rates, if present, will show up in final detection as an unwanted component. (2) If the local oscillator frequency drifts excessively with warm-up or with changes in line voltage, the signal at the discriminator may wander so far away from the balance point that the signal may become noisy or distorted or even entirely lost. (3) The system is subject to microphonics in that the movement of oscillator tube elements or oscillator circuit elements may produce frequency modulation which is detected along with the desired signals.

Another type of receiver, which may be used to receive these simultaneous transmissions, makes use of the frequency difference between the picture and sound carriers. The carrier-frequency-difference receiver does not depend on any precise local oscillator frequency for its successful operation. Instead, the high frequency which is finally to be detected is the difference between the picture and sound carrier frequencies. In black-and-white television in the channels between 44 and 216 mc, this frequency difference is 4.5 mc, as set by the FCC standards.

The receiver is constructed along fairly conventional lines. There is only one i-f channel. This is broad enough to pass both picture carrier and sound carrier plus the necessary sidebands of each carrier. In order that the wave applied to the second detector be dominated by the picture i-f carrier so that it can successfully demodulate the sound i-f carrier, it will generally be necessary to provide some attenuation for the sound i-f. This may be done by means of absorption trap circuits coupled to the i-f coils. A pair of such circuits with the proper Q's and couplings will result in an i-f response characteristic which is characterized by a shelf several hundred kilocycles in width with its center about the mean sound i-f. Figure 1 shows the frequency response characteristic of a typical i-f. The shelf height should be comparable to the minimum level expected for the picture carrier. If, for example, the picture transmitter does not modulate downward to any point below 15 percent of the voltage difference between peak of the synchronizing signals and zero, the receiver slope will reduce this to 7.5 percent since the picture carrier should be halfway down the slope, and hence, if the sound carrier amplitude is equal to the black level of 75 percent, the shelf should be in the

Reception of Television Sound

Use of a common i-f amplifier for sight and sound signals, an important new development in television receiver practice, reduces costs, eliminates local oscillator tuning and drift difficulties

order of 7.5/75 or one tenth of the maximum height of the i-f response.

With this treatment to the input to the second detector, the sound carrier will appear to the picture carrier as just another sideband so that in the detector output there will be found, in addition to the video frequencies, a 4.5-mc signal frequency-modulated with the sound. The 4.5-mc wave will be amplitude-modulated to some extent by picture modulation, but this may be easily removed by the employment of suitable limiter circuits at a later point in the receiver. The amount of amplitude modulation present in the wave depends upon the ratio of the amplitude of the two carriers at the second detector and is given by the following equation to an accuracy of better than one percent

$$e = \frac{a\,mE_1E_2}{[m^2E_1^2 + a^2E_2^2]^{1/2}}\left[1 + \frac{3\,a^2m^2E_1^2E_2^2}{64\,[m^2E_1^2 + a^2E_2^2]^2}\right] \quad (1)$$

where mE_1 is amplitude of picture i-f, and aE_2 is amplitude of sound i-f.

To show graphically how e is affected by the picture modulation factor m, let aE_2 be assigned a value of 1.0 and mE_1 assigned a range of values from 0.1 to 10. The resulting output e is then shown in Figure 2. It will be observed that as mE_1 decreases from 10 to 1 the value of e decreases from 1.0 only to 0.715. Thus the limiter has only to remove some 30 percent total modulation from the wave and not 100 percent.

Figure 3 illustrates this effect in a different way. At Fig. 3A is shown the picture modulated wave with a minimum modulation of 15 percent of the peak of the synchronizing pulses. Figure 3B shows the frequency modulated sound carrier having a level of 7.5 percent of synchronizing pulses. At Fig. 3C is shown what the 4.5-mc wave looks like as a result of the wave at Fig. 3A demodulating the wave of Fig. 3B. It will be noted that there is very little left for the limiter to do.

The whole output of the second detector may then be amplified by the usual video amplifier. Thus the video and sound channels are still common. Separation of sound and picture may be made at the conductor leading from the video amplifier to the picture tube, as shown in Fig. 4. A transformer has its primary 2 connected between the final video amplifier tube 3 and the picture tube 4.

The primary circuit 2 is tuned to the difference frequency of 4.5 mc. This tuning will prevent that frequency from appearing as picture modulation on the cathode-ray tube screen. At the same time it will provide a circulating current of considerable strength in the primary. This current is sufficient to induce a 4.5-mc wave in secondary 5, which is tuned to 4.5 mc. The secondary is connected to a tube 6 which serves as a limiter-amplifier to feed discriminator-transformer

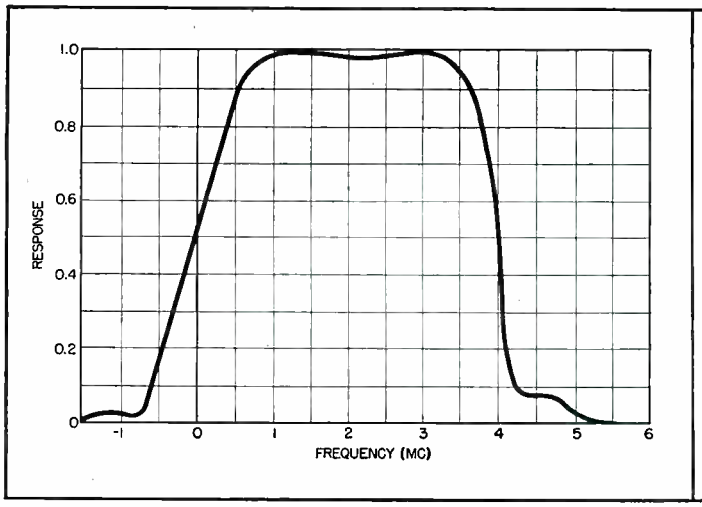


FIG. 1—Typical i-f passband for carrier-difference receiver. The sound carrier at 4.5 mc is attenuated by the plateau at the base of the curve

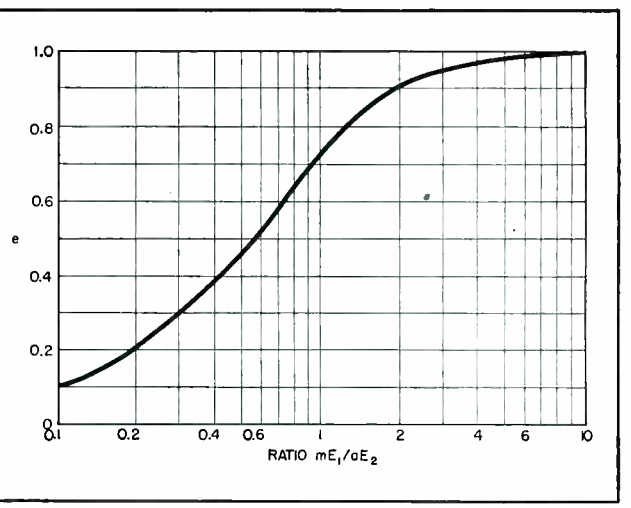


FIG. 2—Ratio of sight and sound carriers at input to second detector, as affected by the amplitudes of both signals. When picture carrier predominates, little limiting is required

7 and balanced-detectors tube 8 and tube 9. These tubes detect the frequency modulation present on the 4.5-mc wave and the resulting audio output is fed to audio amplifiers and to a loudspeaker for translation into sound. Another limiter tube may be added prior to tube 6 if cascade limiters are desired.

Thus a very simple receiver is effected which uses but few tubes and circuit components for sound and which has important improved characteristics over the conventional receiver. A nominal amount of drifting of the local oscillator frequency is of no consequence because the 4.5-megacycle frequency has been determined by quartz crystals at the transmitters and this difference frequency is held accurately to within ± 5 kilocycles. Hum modulation or microphonics in the local oscillator cannot affect the sound signal because any change in the sound i-f is accompanied by an equal change in the picture i-f so that the difference frequency is undisturbed by any variation of local oscillator frequency.

A receiver incorporating the circuit shown in Fig. 4 has been in operation in Bridgeport, Connecticut, some 52 airline miles from New York television stations, and has proved very stable and reliable in performance. Push-button or selector-switch tuning is possible without re-adjustment of the local oscillator because of the wide range of permissible variation in local oscillator frequencies. If the receiver is provided with a local oscillator tuning adjustment, it can be operated by unskilled personnel with ease because no special effort is needed to tune in the sound. In actual operation, towards one end of the tuning control the picture fades due to lack of sufficient picture carrier while at the other end of the control the sound fades due to lack of sufficient sound carrier. The operator thus can tune for a clear picture, a feature heretofore unavailable in conventional receivers where the sound channel must always be accurately tuned in and the resultant picture must be accepted as is.

Operation of the television picture contrast (gain) control does not appreciably affect the audio signal level because the limiter tends to apply a constant level to the balanced detector. The picture will be considered far too dim for use long before the sound fades to half strength.

This receiver has performed well on two of the three New York stations from the beginning. On the third station the performance was at first poor on account of video modulation being present along with the sound. This disturbance was traced to frequency or phase modulation of the picture carrier by the video modulating signal. This condition has now been corrected to a great extent by the station so that acceptable sound is now obtainable. This brings out one of the requirements of the transmitters for successful application of this system to general usage.

Requirements at Transmitters

Any phase or frequency modulation on the picture carrier in this system is directly transferred to the 4.5-megacycle beat frequency and ultimately detected. It is therefore important to place a limit on the amount of frequency modulation permissible on the picture carrier. Since the peak frequency deviation of the sound carrier frequency has been set at ±25 kilocycles, the limit on the picture transmitter should be about ±100 cps maximum, which corresponds to a modulation of ±0.4 percent or 48 db below 100-percent modulation on the sound transmitter. The fact that two out of the three transmitters in New York had been adjusted for practically no phase or frequency modulation even before the personnel knew what use was being made of their signals indicates that any transmitter can be so adjusted.

Another transmitter requirement is that some picture carrier must always be present. This is necessary in order to detect the sound carrier continuously. The present standards read that the transmitter shall be capable of modulating down to 15 percent of peak synchronizing level on maximum white. The standard may be modified to read "at least to 15 percent but not greater than 10 percent for downward modulation".

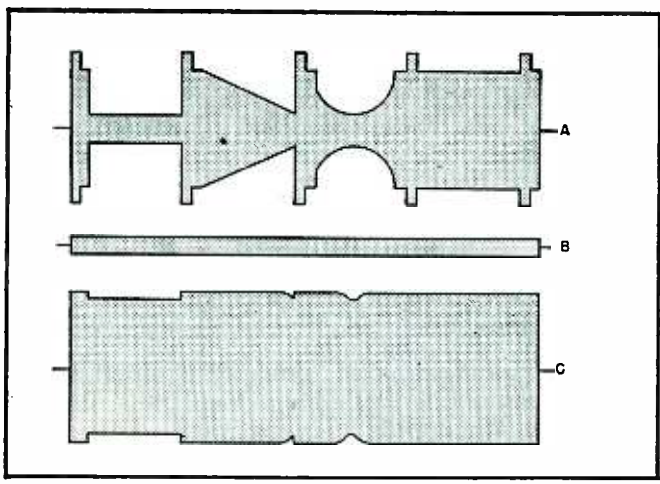


FIG. 3—Modulated sight carrier (A), sound carrier (B), and combined f-m carrier showing slight amplitude modulation (C)

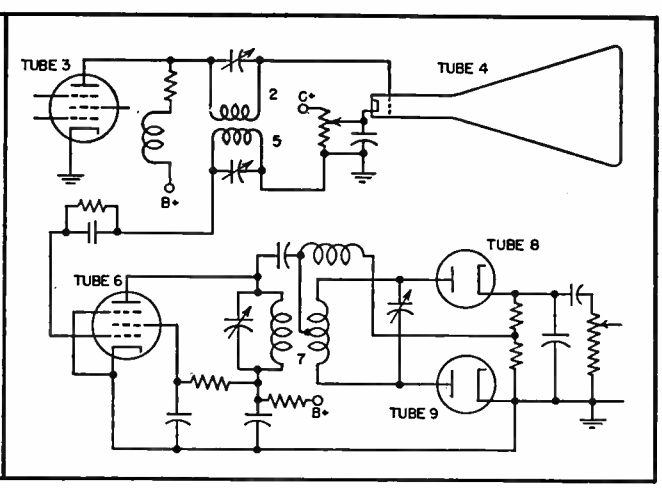


FIG. 4—Schematic of the carrier-difference sound system. The f-m sound carrier is taken directly from the picture-tube grid

This change will provide a 10 percent safety zone perfectly adequate for the system's operation.

It is recommended that the peak deviation of the sound transmitter be increased to ±40 kilocycles from the present ±25 kilocycles. This will aid in masking any inadvertent frequency modulation present on the picture carrier.

Signal-to-Noise Ratio

The signal-to-noise ratio of the system described may be calculated in terms of the conventional system and will be found to vary depending upon the average brightness of the picture. The equation is

$$\frac{S}{N} = \left(1 + \left[\frac{E_2}{mE_1}\right]^2\right)^{-1/2} \quad (2)$$

where E_1 is maximum amplitude of picture carrier, E_2 is amplitude of sound carrier and m is modulation factor of picture carrier. Thus for an all "white" picture, assuming $m = 0.17$, $E_1 = 1$ and $E_2 = 0.707$,

$$\frac{S}{N} = \left(1 + \left[\frac{0.707}{0.17}\right]^2\right)^{-1/2} = 0.234 \quad (3)$$

For an all "black" picture, assuming $m = 0.75$, then

$$\frac{S}{N} = \left(1 + \left[\frac{0.707}{0.75}\right]^2\right)^{-1/2} = 0.73 \quad (4)$$

And for an average picture $m = 0.49$, so

$$\frac{S}{N} = \left(1 + \left[\frac{0.707}{0.49}\right]^2\right)^{-1/2} = 0.566 \quad (5)$$

Thus, assuming optimum tuning of the conventional receiver, on the average the signal-to-noise ratio will run about 5-db lower than the conventional system; but in the long run, it actually may run better than the conventional system because drifting of the local oscillator may easily throw the conventional system well off the balance point on the discriminator characteristic, so that not only noise but audio distortion may be produced in considerable amplitude to degrade the otherwise excellent performance obtainable with precise adjustment.

Picture-Carrier Phase Modulation

Even though the picture carrier is cleared of spurious frequency modulation at the transmitter, reception with the picture carrier on the slope of the receiver i-f response characteristic will cause the picture carrier to take on a modulation of its phase angle as a result of unequal amplitudes of symmetrical sidebands.

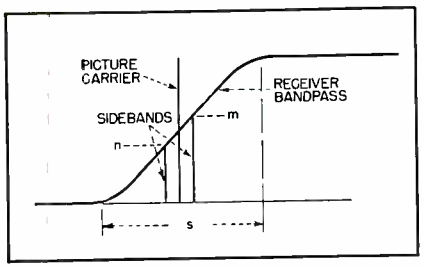


FIG. 5—Symmetrical picture sidebands of unequal amplitude, produced by slope of receiver bandpass characteristic, cause slight phase modulation, but the resulting disturbance is negligible

In Fig. 5 is shown a carrier wave placed half way down the receiver slope. An upper and a lower sideband are shown for a picture-modulation frequency lying in the audible frequency range. It will be noted that due to the slope, the upper sideband will have an amplitude m and the lower sideband an amplitude n. If the total frequency band of the slope be denoted by s, then it can be shown that the maximum possible phase angle modulation of the carrier wave (when the minimum picture level is 10 percent of the amplitude at synchronizing signal peaks) is

$$\phi_{max} = \tan^{-1}\left[\frac{\frac{1.68a}{s}\sin 2\pi at}{1 + 0.84\cos 2\pi at}\right] \quad (6)$$

where a is the picture modulating frequency

It is evident that as a approaches zero, negligible phase angle modulation will occur, but as the frequency increases, the phase angle modulation may become significant. The worst possible case occurs at 15,000 cps. If therefore a be assigned a value of 15,000 and s a value of 1,500,000, the phase angle will oscillate between the limits of plus 0.032 radians, when $2\pi at =$ 140 deg, and minus 0.032 radians when $2\pi at = 220$ deg.

On the sound transmitter, the equivalent phase modulation of 25-kc deviation for 15,000-cps modulation frequency is 25,000/15,000 or 1.66 radians. Therefore the spurious signal will be 0.032/1.66 = 0.0193 of maximum audio output. But since 75 microsecond deemphasis is used, this spurious 15,000 output is multiplied by a factor of 0.147, and hence the resultant audible level is $0.0193 \times 0.147 =$ 0.00275, which is 51 db below 100-percent modulation. If the sound transmitter deviation is increased from 25 kc to 40 kc, an additional 4-db reduction would be obtained, or the 51-db figure would become 55 db. In a similar manner, phase modulations at other frequencies may be calculated and are summarized in Table I. Since these levels are far below the usual residual hum and noise levels of even a good receiver audio amplifier system, it may be concluded that spurious responses due to incidental phase modulation are quite negligible.

Table I—Noise Introduced by Receiver

Picture Modulating Frequency in cps	Spurious Responses Below 100 percent Modulation in db	
	25-kc Deviation	40-kc Deviation
1,500	76	80
2,500	69	73
5,000	61	65
10,000	55	59
15,000	51	55

Conclusion

The author recommends that the Radio Manufacturers' Association propose to the Federal Communications Commission that the standards for the picture transmitter be modified so as to permit the carrier-frequency-difference system of sound reception to be used. Such standards would in no way make obsolete present receivers which employ two i-f channels and hence no hardship case will arise, yet it would open the door to a wider field of receiver distribution through lower costs, more reliable performance, simpler operation, and greater public satisfaction and acceptance, all of which are the ultimate aims of this development.

References

(1) Kallman, H. E., Audio and Video on a Single Carrier, ELECTRONICS, p 39, May 1941.

(2) Fredendall, G. L., Schlesinger, K., Schroeder, A.C., Transmission of Television Sound on Picture Carrier, *Proc. of I.R.E.*, p 49, Feb. 1946.

(3) Lawson, D. I., Lord, A. V., Kharbanda, S. R., A Method of Transmitting Sound on the Vision Carrier of a Television System, *Institution of Electrical Engineers*, p 251, July 1946.

Radio Control For MODEL BATTLESHIP

Continuous control of drive motor, rudder, and guns on battery-powered ten-foot model of U.S.S. California is achieved by carrier interruption and use of five subcarrier frequencies in connection with a narrow-deviation 1,800-kc f-m transmitter

A RELATIVELY UNUSUAL application of electronics is the radio control of a model battleship, incorporating the following features:

(1) Continuous control of the model's rudder from a steering wheel at the transmitter.

(2) Control of the model's drive providing instantaneous selection of forward, reverse, and off.

(3) Means to control the rotation of the forward pair of turrets, with instantaneous selection of the direction of rotation.

(4) Circuits permitting firing of four of the model's secondary guns, and all twelve of the turret guns.

(5) Means for simulating shipboard noises on the model, such as the sound of shipboard call systems, sirens, air raid alarms, and the like.

The 10-foot model is propelled at a top speed of approximately five miles per hour by four screws driven from a single twelve-volt motor through a gear box. The turrets and rudder are driven by smaller motors, and the guns are triggered by solenoids acting directly on their firing pins. The secondary guns fire .22 calibre blank cartridges, and the turret guns .38 calibre blank cartridges. Power for the model is provided by two six-volt automobile storage batteries connected in series.

Control System

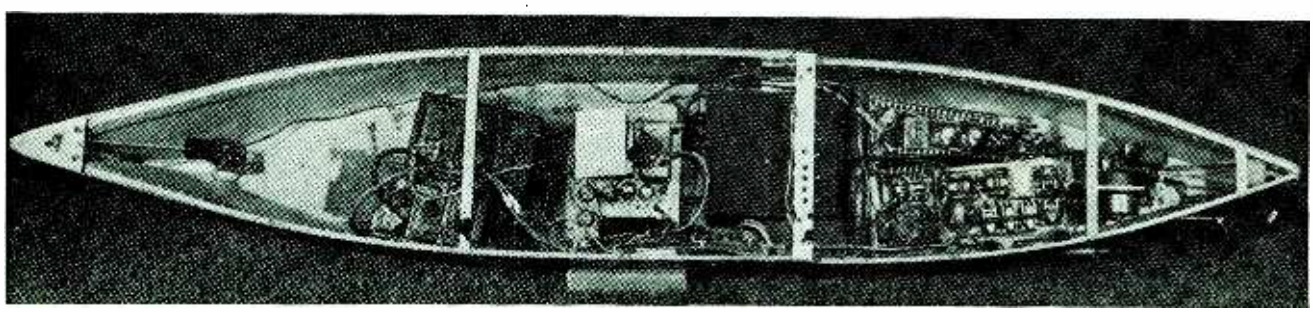
The control signals necessary to operate this mechanism are transmitted by a small, narrow-deviation frequency-modulated transmitter operating on a carrier frequency in the neighborhood of 1,800 kc. Three types of signals are used:

(1) Random variations of the carrier frequency over a total range of approximately 10 kilocycles by means of a trimmer capacitor in the oscillator circuit. The capacitor is geared to a wheel on the control box, and the frequency deviation produced by varying the capacitance is used to control the operation of the model's rudder.

(2) Audio-frequency modulation of the carrier by a reactance-tube modulator acting on the oscillator. The reactance-tube modulator is driven through a mixer tube by a pair of audio-frequency oscillators. The oscillators may be operated simultaneously or singly, as desired. The constants of the first oscillator can be switched to permit it to generate a frequency of either 300 or 650 cycles. These subcarrier frequencies are used to control the main drive motors. The constants of the second oscillator can be switched to make the oscillator frequency 1,390, 3,000, or 950 cycles. The 1,390 and 3,000-cycle subcarriers control the direction of turret rotation, while the 950-cycle carrier is used to control the advance of an 11-position stepping switch used to fire the guns, operate an indicator light, and connect a loudspeaker into the audio system of the receiver for the simulation of shipboard sounds.

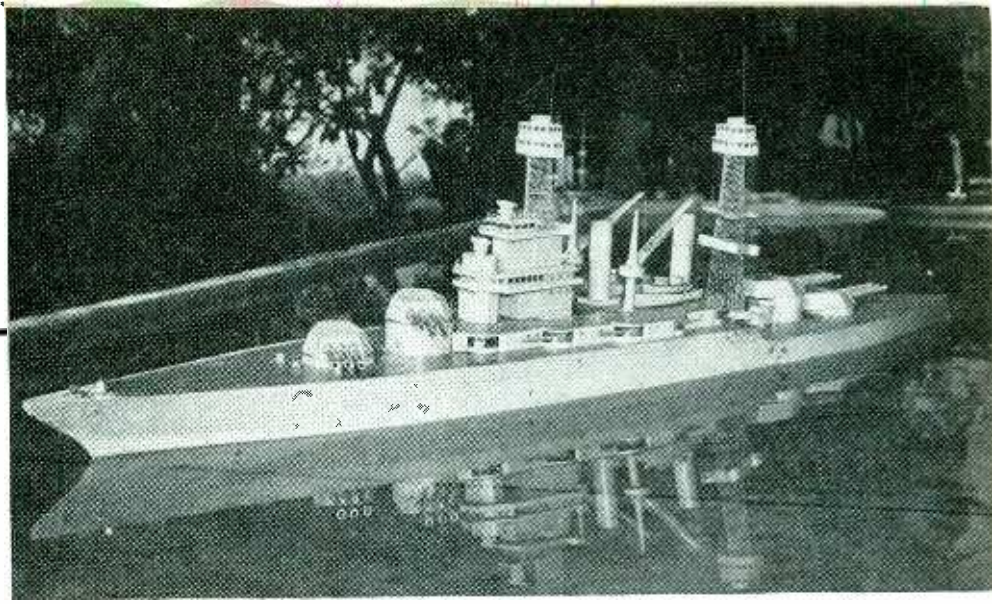
(3) Momentary interruption of the carrier frequency by breaking the plate supply of the oscillator. This signal is used to home the stepping switch just mentioned. Breaking of the carrier also opens the power supply to the main drive motor for the duration of the break, reducing the probability of runaway should the transmitter fail or the model sail out of operational range.

A microphone may be switched



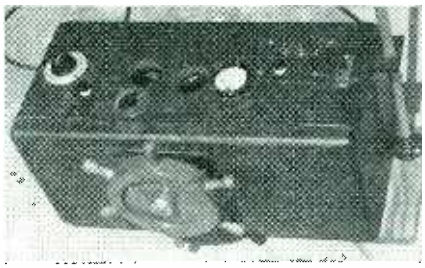
Hull of model, showing radio remote control equipment. Two 6-volt storage batteries serve as primary source of power, while a 90-volt battery provides C bias for the polarity-sensitive output stage

By G. C. FITZGERRELL
Los Angeles, California



Model of U.S.S. California, owned by H. E. Bixby of Glendale, California and equipped with radio control by the author of this paper. Principal dimensions are: Length 10 feet; beam 20 inches maximum; draft 8.25 inches; freeboard 5.75 inches; weight loaded is 410 lb; top of antenna is 34.7 inches above water line

into the modulator system, thus permitting the operator to transmit speech and other sounds to the model. When a loudspeaker is connected into the audio system of the receiver, the transmitted speech may be heard from the model, or the subcarriers may be heard and used in simulation of shipboard sounds.



Control box, with transmitter inside, transmitting antenna at right

If the loudspeaker is not connected in the receiver output the operator may, as a stunt, operate any one of the five subcarrier-controlled channels by whistling the appropriate frequency into the microphone. Operation of a subcarrier-controlled channel by a whistled note requires some practice since both the amplitude and frequency of carrier modulation are factors in determining which operation will occur. A signal of excessive amplitude will spill over and operate an adjacent channel, even though it is of the correct frequency.

Transmitting Elements

The reactance-tube modulator elements and the electron-coupled oscillator in the transmitter circuit are fed from a voltage-stabilized source to minimize drift, as shown in Fig. 1. The buffer stage and plate circuit of the electron-coupled oscillator are left untuned to simplify tuning procedures. The various audio-frequency subcarriers are supplied by switching *LC* components in the grid circuits of simple negative resistance oscillators. Subcarrier modulation amplitudes are controlled by potentiometers in the oscillator outputs.

An eight-foot aluminum rod may be coupled to the 6L6 final amplifier when an operating range of more than a few feet is desired. A loading whip and inductance are coupled to the top of the rod to increase its radiating efficiency.

The transmitter as a whole is encased in a hardwood cabinet with a six-inch steering wheel brought out the front. A calibrated dial used to gage the position of the model's rudder is visible through an opening in the top of the cabinet.

On the cabinet is a three-position telephone-type toggle switch used in lieu of an engine room telegraph. In the FORWARD position the carrier is frequency-modulated by a 650-cycle note and the model's forward drive is actuated. In the REVERSE position, 300-cycle frequency modulation of the carrier takes place, and the model's propeller drive is reversed. In the OFF position, the carrier is unmodulated and the model's drive is not actuated.

A knob on the cabinet actuates a three-position switch used to control rotation of the model's pair of front turrets. In the right position of the knob the carrier is modulated by a 3,000-cycle subcarrier. In the left position the carrier is modulated by a 1,390-cycle subcarrier.

When the knob is in its central position the turrets are at rest. With the knob in this center position the carrier may be frequency-modulated by the 950-cycle subcarrier used to advance the stepping switch. The selector is advanced by pressing a pushbutton on the control box. A similar button is used to break the transmitter carrier and thus to home the stepping switch.

Receiving and Selecting Elements

The control and voice signals are received on the model by a modified National FB-7 receiver with a Foster-Seeley discriminator in the output of the i-f amplifier, the circuit for which is given in Fig. 2. In the discriminator output the three types of control signals are separated from each other. The subcarrier and audio-frequency components of the discriminator output are amplified by a pair of pentode amplifiers with their grids connected in parallel. One of these tubes has a dynamic loudspeaker connected in its plate circuit, and the other feeds a bank of five tuned circuits, each circuit tuned to one of the five subcarrier frequencies. Each of these tuned circuits feeds a triode biased beyond cutoff, functioning as an overbiased plate detector. Each triode has a sensitive relay connected in its output. The sensitive relays connected in the output of the 300 and 650-cycle channels operate a pair of mechan-

ically interlocked relays that control the main drive motor. The mechanical interlock prevents the short-circuit that would result if both the forward and reverse relays were accidentally turned on at the same time. Similarly the 1,390 and 3,000-cycle channels operate through a pair of mechanically interlocked relays to control turret rotation. Maximum turret excursion is controlled by limit switches.

The sensitive relay in the output of the 950-cycle channel is used to advance a stepping switch. The stepping switch consists of a magnetically operated pawl and ratchet mechanism which advances a pair of ganged but electrically isolated wiping contacts. Each contact is moved forward by the ratchet mechanism over a series of ten contacts. The ratchet stop mechanism may be released, when desired, by a second magnet, allowing a spring to return the wipers to a zero or homed position. In this case the relay controlling the homing action is actuated by interrupting the carrier.

Operation of Stepping Switch

The actions controlled by the stepping switch and associated circuits are as follows:

SWITCH POSITION	ACTION CONTROLLED
0	Home
1	Disconnect subcarrier-controlled channels and connect loudspeaker
2	Fire first secondary gun
3	Fire second secondary gun
4	Fire third secondary gun
5	Fire fourth secondary gun
6	Fire forward turret
7	Fire second turret
8	Fire third turret
9	Fire aft turret
10	Turn on indicator light

The two stepping switch wipers are fed independently. The feed of wiper *A* is directly from the battery, but wiper *B* is fed from the battery through the back contact of a slow-release relay. The coil circuit of this slow-release relay is opened for the duration of each 950-cycle control signal by a pair of contacts held open by the pawl mechanism of the stepping switch. If the pawl is held down for over half a second the slow-release relay feeds current through its back contacts to the *B* bank of wipers, and hence on to the circuit of the contact on which the wipers are resting. Thus, to energize any one of the circuits controlled by bank *B* of the stepping switch requires not only that the wipers be moved to the appropriate position, but that the final impulse used to actually move the wiper into position be over a half-second duration.

For an example, suppose it is desired to move the wipers from the zero position to the number three position. The operator sends two short impulses and then maintains the third for over half a second. In practice the last impulse is maintained until the gun fires.

Loudspeaker and Homing Relays

The loudspeaker relay is operated by the No. 1 contact on bank *B* and is electrically locked in place by a feed from the No. 1 contact on bank *A*. If the stepping switch is in the homed position a long pulse will move the wipers to first position and operate the loudspeaker relay. The loudspeaker is then connected, and the five tuned channels are disconnected. The loudspeaker is kept on by the electrical lock-in, despite the fact that the 950-cycle channel which controls selector advance is disconnected by the action of the loudspeaker relay.

With the loudspeaker connected, the operator may transmit speech and other frequencies simulating shipboard sounds without tripping the subcarrier-controlled channels. When the stepping switch is homed the electrical lock feed through No. 1 contact of bank *A* is broken, allowing the loudspeaker relay to return to normal position. The loudspeaker is disconnected, and control of the subcarrier-operated channels is restored.

The sensitive relay controlling the homing action is fed from a triode that is normally maintained beyond cutoff by a negative potential picked from one leg of the discriminator. When the carrier is cut the negative potential is removed and plate current flows. The sensitive relay is closed by the plate current, and its contacts operate the solenoid homing the stepping switch. A lamp connected to the contacts of this relay indicates when the carrier is off. The contacts of the sensitive relay also energize the coil of the power relay whose contacts break the main drive motor feed for the duration of carrier interruption. This action is not objectionable, since only a momentary break is needed to home the selector. The circuit supplies a simple automatic stop in the event of transmitter failure.

Contact 10 on bank *A* turns on a small indicator light that is most used with loaded guns. So long as the operator can see the small indicator lamp at the masthead burning he knows that the selector is at the end of its travel, and not resting on any of the gun circuits. When the operator is ready to fire the guns the selector is homed and then advanced at once to the gun circuit to be fired. When the circuit operates, the selector is at once advanced again to position 10 to minimize the possibility of accidentally firing a gun, unless the operator wishes to fire another bank of guns immediately.

Rudder Control

The rudder control circuit differs fundamentally from the other controls in that it permits precise positioning of a remote unit by the control operator. This precise positioning is accomplished by deviating the mean carrier frequency of the transmitter and incorporating a motor-driven frequency control unit in the receiver, which automatically tunes the receiver to each new frequency selected by the operator of the transmitter. The same motor that retunes the receiver also drives the rudder. Therefore, within limitations imposed by the sensitivity of the equipment, there is a discrete rudder position for each carrier frequency selected.

The d-c component of the discriminator output provides the cues for the operation of the automatic frequency control unit. If the receiver is tuned precisely to the frequency emitted by the transmitter, the average output of the discriminator is zero. If the receiver is tuned to a higher frequency than the transmitter, then the average output of the discriminator is negative, and if the receiver is tuned to a lower frequency than the transmitter the average discriminator output will be positive.

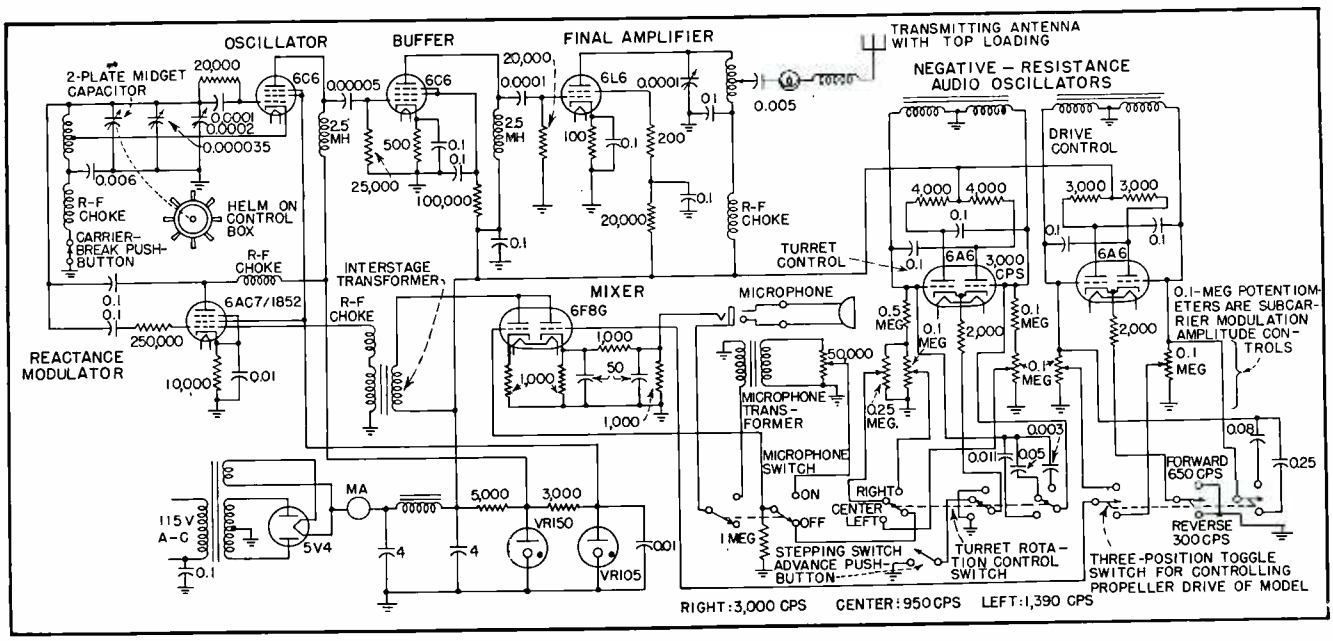


FIG. 1—Circuit of narrow-deviation f-m transmitter used in control box on shore

This d-c component of the discriminator output is separated from the subcarriers by a low-pass filter, and is then injected into a polarity-sensitive amplifying system with a pair of sensitive relays in its output. One of these sensitive relays is tripped when a positive potential is applied by the discriminator, and the other is tripped by a negative potential.

The sensitive relay operated by a negative potential operates a power relay that causes the steering motor to rotate in such a direction as to increase the capacitances in the receiving circuits. This action steadily reduces the frequency to which the receiver is tuned, until the receiver is once more in alignment with the transmitter (until the discriminator output falls to zero). This rotation also turns the rudder to port. The sensitive relay controlled by positive potentials from the discriminator causes motor rotation which decreases the capacitances in the receiver circuits and conversely causes the rudder to turn to starboard. Thus the transmitted frequency controls the position of the rudder and the frequency to which the receiver is tuned.

Electrodynamic braking is used to prevent overtravel of the steering motor and to minimize the possibility of hunting.

Sensitivities are so adjusted that a minimum change of approximately 300 cycles is needed to produce a change in rudder position. This 300-cycle dead zone is adequate for the electrodynamically braked motor to stop, makes it unnecessary to resort to more elaborate antihunt arrangements, and provides about thirty discrete rudder positions. By consulting a calibrated dial the remote operator can position the rudder within a few degrees. This is a far more accurate control than is usable in steering the model, since in general the operator notes only relatively large deviations from course, and consequently must use large rudder corrections to set the model once more in the desired direction.

Operation of Rudder

When the rudder is in the center position a pilot lamp blinks out on the model. This out indication of the lamp may be used by the operator to check and correct oscillator drifts. The steering wheel is set to the zero or center position by consulting the calibrated dial at the transmitter. If the indicator lamp does not blink out, the transmitter frequency is shifted slightly with the zero trim until the indicator lamp blinks out. The zero trim consists of a trimmer capacitor in parallel with the steering variable capacitance and the main tank capacitor. It will be found in practice that drifts are negligible if the initial alignments between wheel and rudder are made after a ten-minute warmup period.

It should be noted that the heater of the receiver oscillator tube is connected in series with a similar tube used as a ballast resistor. This was done because there was no six-volt equivalent of the 2.5-volt tube used in the original receiver. In addition this arrangement permits running the heaters at a slight overvoltage, effectively saturating filament emission and minimizing the effects of falling battery voltage. Use of an additional tube rather than a series resistor greatly reduces the period the oscillator has to be warmed up for reasonable stability. The oscillator plate supply was stabilized by a VR150 to minimize the effects of falling battery voltage and variable dynamotor loading.

Polarity-Selective Amplifier

The polarity-selective amplifier circuit mentioned in connection with the rudder system merits some special consideration. Basically it consists of a special balanced modulator input, single-stage amplifier, and double polarity-sensitive output stage, the whole so adjusted that plate current flows in one output tube when a positive signal is applied to the input grid, and in the other output tube when

a negative signal is applied to the input grid.

The balanced modulator converts the d-c input signals into a proportionate a-c signal that is more conveniently amplified and, in addition, indicates the polarity of the input signal by the phase of the a-c output. The balanced modulator as used differs from the conventional balanced modulator circuit in that an input signal is injected into only one of the input grids, and only alternating current is applied to the modulator plate circuit. Alternating current alone is used in the plate circuit to reduce the number of components necessary in the modulator stage.

The grid not used for signal injection serves to balance the modulator. The modulator is balanced with zero input. The potentiometer connected to the balancing grid is adjusted to the point producing minimum modulator output. If the point of minimum output lies at either extreme of the potentiometer, the modulator tubes are reversed in their sockets and the potentiometer is again adjusted for minimum output. With the modulator thus properly adjusted, a positive input to the modulator grid will cause an output signal of one phase, and a negative input will cause an output signal differing in phase by 180 degrees.

The modulator output is amplified by the second stage and is fed through the pushpull grid transformer into the phase-sensitive output stage. The two tubes of the output stage are biased to cutoff by a negative grid supply. The plate circuit is supplied with alternating current from the same small inverter that supplies the plate potential for the balanced modulator. Normally, then, neither of the output tubes will draw current. When alternating current appears in the grid circuit of the output stage, the tube whose grid is going positive during the positive pulse of the inverter will draw current. The output grid that is going positive during the positive inverter pulse will, of course, depend upon the polarity of the balanced modulator input. Thus a positive input causes one output relay to operate, and a negative input causes the other output relay to operate.

The small capacitances connected across the modulator plate transformer and across the grid transformer of the last stage serve two functions. They bring the normal peak of the transformer nearer to the 50-cycle frequency at which the inverter operates, thereby increasing the effective gain of the amplifier and causing it to discriminate against random noise created by the inverter brushes. More important, the capacitances are trimmed so as to compensate for phase shifts that would otherwise occur in the amplifier, thus making the signals at the grids of the output stage either in phase or 180 degrees out of phase with the po-

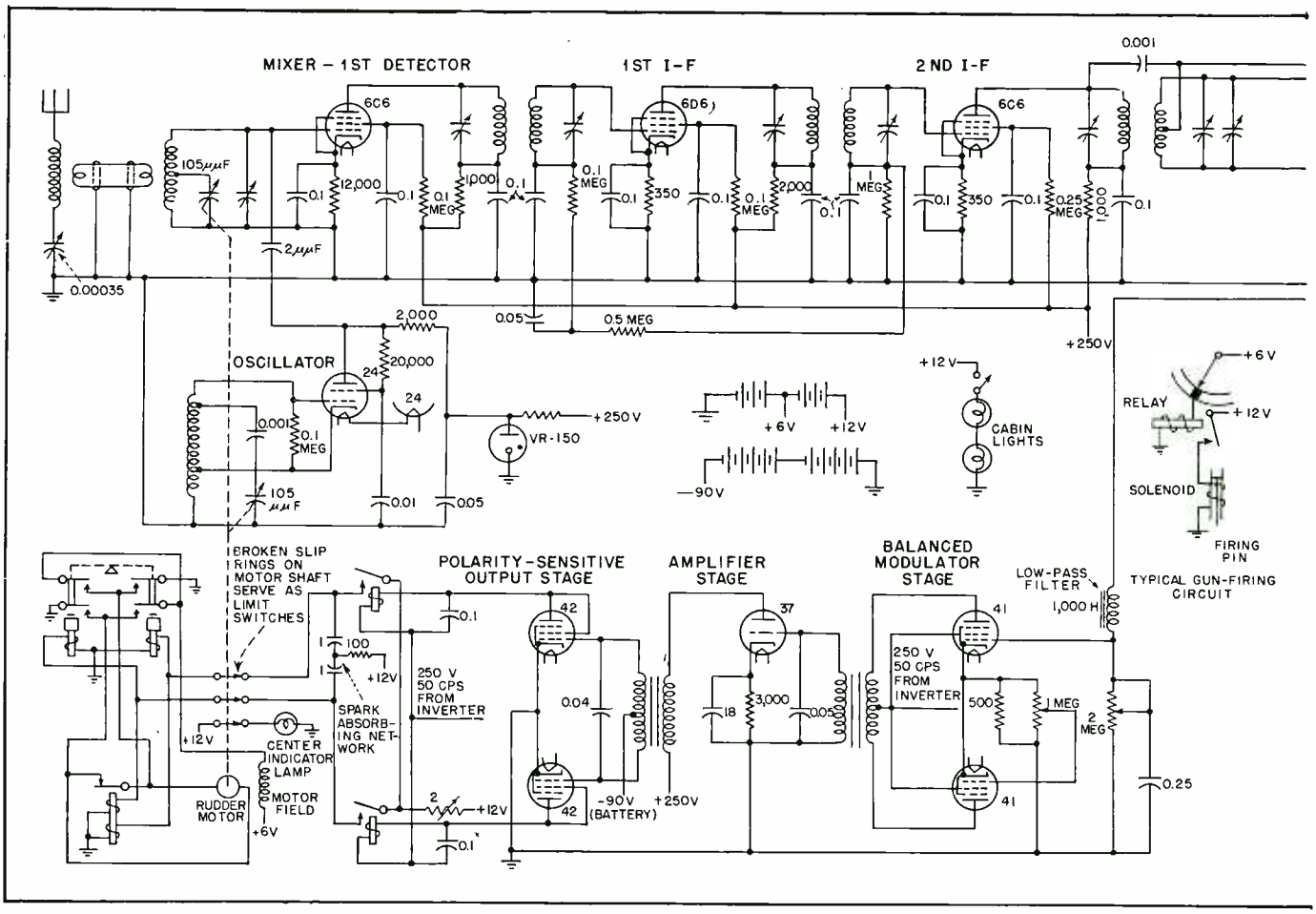


FIG. 2—Receiver and control circuits used in model. All gun-firing circuits are identical to that shown at left of selector switch. The elaborate series of manual switches provided in the boat to check operation and make adjustments has been omitted for simplicity

tential applied to the plates of the output tubes.

The electronic components in the model are grouped into two units. The receiver chassis contains the tuner, subcarrier channels, and the carrier-controlled channel used to home the stepping switch. A separate chassis contains the polarity-sensitive amplifier, inverter, and two dynamotors used to supply the receiver and amplifiers. On the same chassis are the pentode that feeds the loudspeaker and the voltage-regulating tube used to stabilize the oscillator plate voltage. The sensitive relays and the power relays are mounted on two separate panels.

The tuning mechanism of the receiver is coupled to the rudder drive mechanism by a shaft and a pair of gears.

The antenna used on the model consists of a single wire led from the stern forward over the tops of the two masts and down into the bow through an insulator. A loading coil and trimming capacitor located at this point are used to resonate the antenna to the mean transmitter frequency. Coupling is made from this loading coil into a two-turn link which feeds a twisted-pair shielded transmission line leading to the receiver, where coupling is made by means of a similar link into the grid coil of the first detector. The mast tops are bakelite rods which serve as insulators.

Installation and Operation

The power supply of the model consists of two six-volt automobile storage batteries connected in series, with most of the six-volt elements in the load distributed equally between them. A few six-volt relays are run in series with a resistor from the twelve-volt source, so as to permit a slightly higher operating voltage. This expediency provides positive relay operation even when the battery potentials have fallen.

Switches have been provided for manual operation of the controlled circuits. These are used for check-out prior to radio operation.

For operation, the transmitter and receiver are turned on and allowed to warm up for ten minutes. During this period the relay circuits are generally checked for operation with the manual controls mentioned above, after which the rudder and steering wheel are brought into alignment by adjusting the zero trim. Control from then on consists simply of turning the wheel and manipulating the two switches and pushbuttons used to key five subcarriers and break the main carrier. The system is rapid and simple in operation.

Special thanks are due to George Smithson and to Norma Carr for their assistance in the completion of the model and preparation of diagrams. This article was written with the permission and help of the owner of the model, Mr. H. E. Bixby.

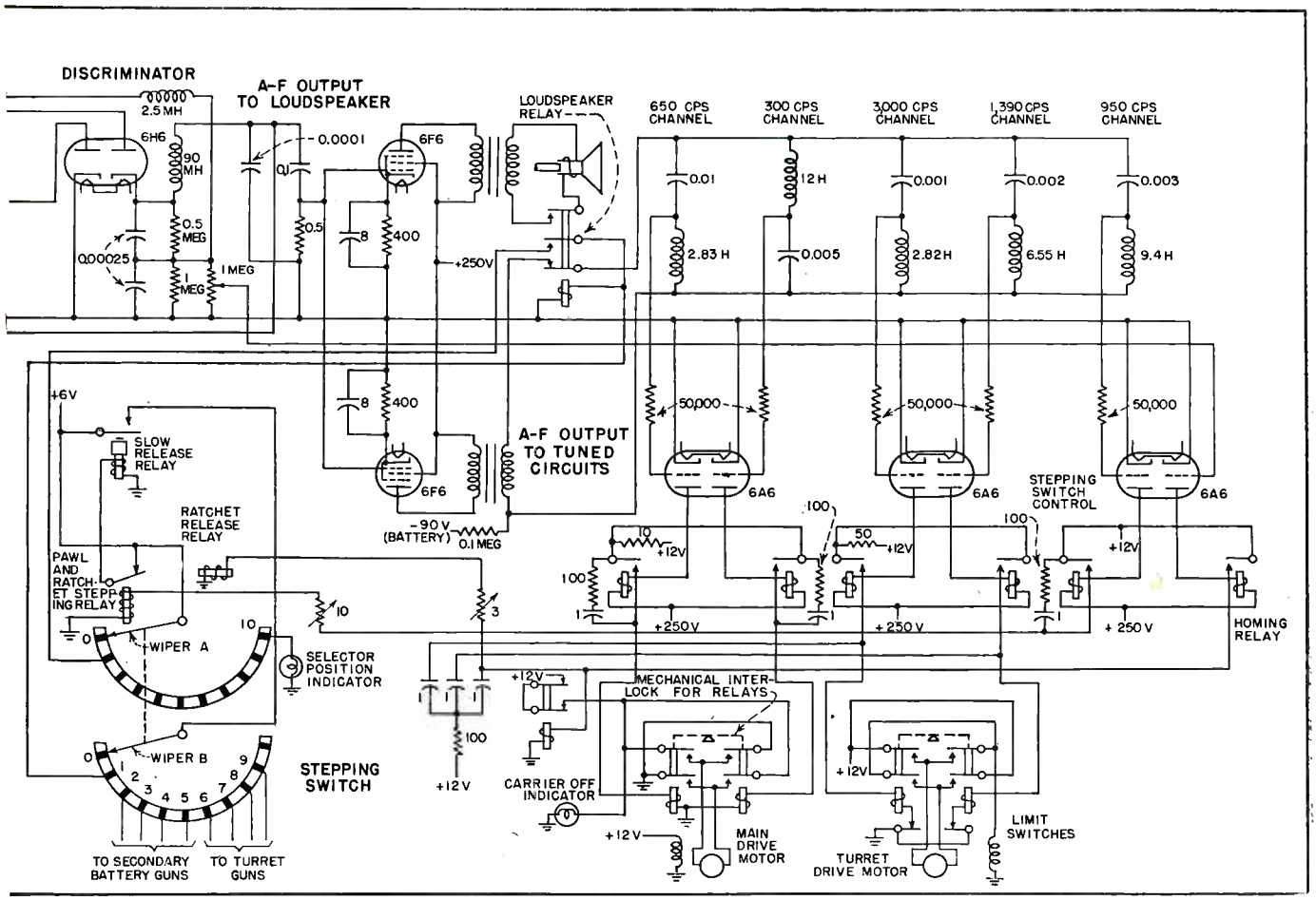


Plate supply voltages are obtained from two 6-volt dynamotors, not shown, each delivering 250 volts at 50 ma d-c, while an inverter delivering 250 volts at 50 cycles serves the phase-sensitive rudder amplifier circuits

Three-Band VARIABLE

Versatile pre-equalizer provides gain or attenuation adjustment in one-db steps independently in the low-, high-, or mid-frequency bands of the audio spectrum. Applications include recording, rerecording, sound system compensation, and broadcast station equipment

By L. D. GRIGNON

Development Engineer
Twentieth Century-Fox Film Corp.
Beverly Hills, California

THE variety of corrective networks used in audio equipment is due to the great number and extent of required corrections and to the difficulty of adequately and rapidly analyzing undesirable features in the signal being transmitted, recorded, or reproduced. In designing a single equalizer of sufficient flexibility to meet the diverse requirements usually encountered, one must decide what frequency characteristics are to be used, particularly if the total number of units is to be minimized.

The material which follows describes a suitable equalizer system which has been found easier to use and more effective for the purpose intended than any of the many types previously employed by the writer. In addition to this description, brief design information is given so that others may modify the circuits shown to suit particular conditions.

Characteristics

Experience with sound systems and in recording indicates that the majority of desired corrections exist in either or both the low or high ends of the frequency range. Intelligibility must be maintained at all times and, since this is most easily accomplished by emphasizing the mid-spectrum frequencies, a means must be provided to perform this function. Conversely, suppression of the mid-band can frequently be used to make harshness more tolerable, provided intelligibility is not degraded.

An important operating feature, too frequently excluded from corrective network design, provides that the 1000-cycle insertion loss shall not change appreciably as changes in the response characteristic are introduced. A few moments of operation with a network having this feature are sufficient to prove the point. Further, if the network is arranged so as to be inserted in various circuits, it must introduce no insertion gain or loss.

Accepting the above fundamentals, the unit was designed so that low- and high-end emphasis or suppression are in discrete steps achieved by a shelf effect arranged to shift the frequency of one-half loss or gain further toward the extremes of the signal band or nearer the mid-fre-

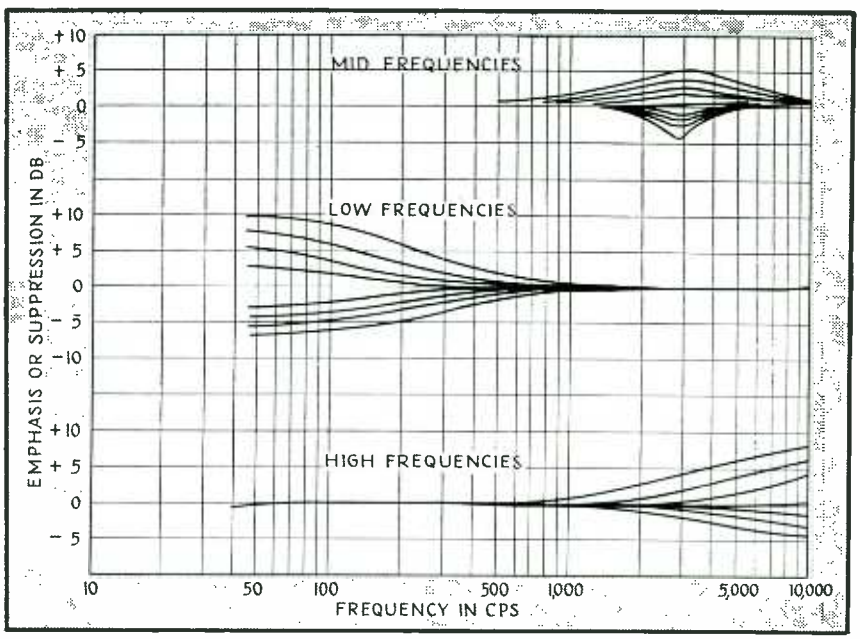
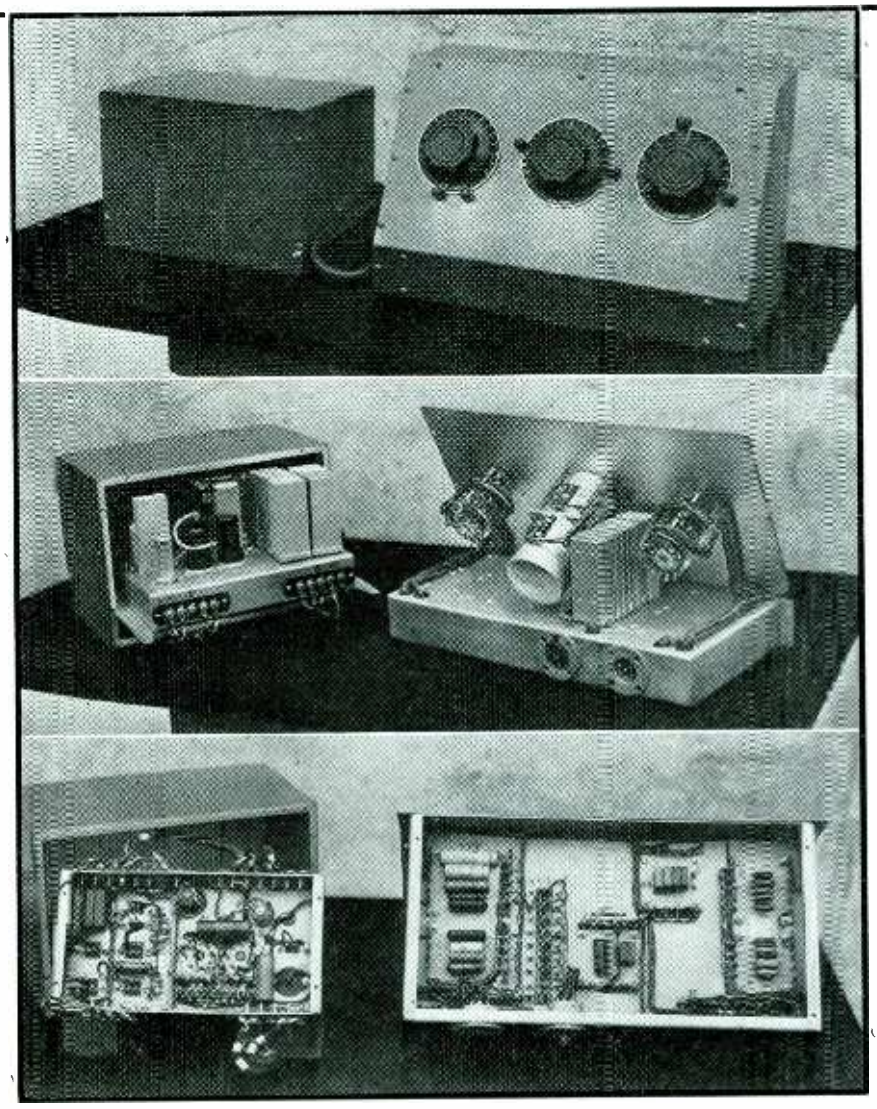


FIG. 1—Representative frequency characteristics obtainable with the three-band variable equalizer. Combining three curves, one from each group, gives the over-all response

EQUALIZER



Front, rear, and bottom views of two-stage amplifier (left) and control unit (right) of equalizer system. Values of control capacitors are changed in pairs by the selector switches on each side of the ganged attenuator for the mid-frequency band

quencies, thereby affecting the normal circuit characteristics only to the extent required by the necessary correction. (This differs from the usual manner in which only the slopes of the characteristic are changed, the hinge frequency remaining fixed.) Maximum suppression is 4 to 6 db, maximum emphasis is 8 to 10 db, and the change between steps is approximately 1 db, measured at 100 cps and 7,000 cps.

Mid-frequency correction is a maximum at 2,750 cps and is variable in steps of ½ db up to a total of 5 db suppression or emphasis. Frequency characteristics obtainable by the networks are shown in Fig. 1. Any combination of low-, mid-, and high-frequency responses can be obtained. Insertion loss of the system of networks can be made zero by a suitable choice of fixed attenuators.

Suppression at any of the three bands is introduced by rotating a control in a counter-clockwise direction from a normal setting and emphasis is applied by rotating the same control from the normal setting in a clockwise direction. In either case, suppression or emphasis is made progressively greater as the control is manipulated further from normal. As suppression or emphasis is introduced into any of the three frequency bands, the insertion loss at 1,000 cps does not vary more than 1 db.

Dial stops, which are readily adjustable, are provided on each control to permit pre-setting or to provide limits.

The system may be inserted into a circuit without affecting normal transmission, manipulations or usage and, as previously specified, volume corrections need not be made simultaneously with equalization, although under some circumstances, particularly when low-end corrections are applied, there will be an apparent level change.

Mid-Frequency Section

Two constant-impedance networks are used for mid-frequency control. One is a suppression network of the required shape and fixed in amount at the desired maximum; the second is an emphasis network connected in series and variable in equalization by an amount equal to the sum of the maximum amounts of desired suppression and emphasis. At an intermediate point in the setting of the

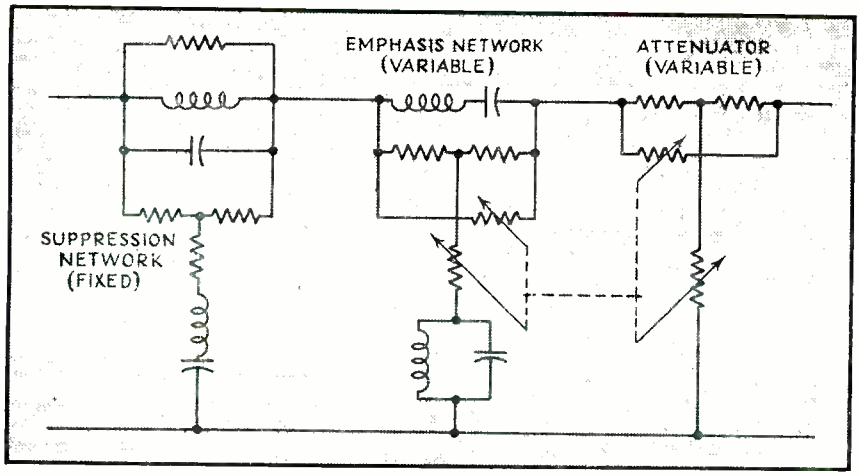


FIG. 2—Mid-frequency equalizer network

variable attenuator the frequency characteristics of the two networks are inverse and the net applied frequency correction is zero.[1]

To maintain constant insertion loss at all correction settings, a second variable attenuator having a 10-db maximum is mounted on the same shaft with the correction network attenuator, connected in series with the other two networks, and mechanically arranged to maintain the total attenuator loss at 10 db. The circuit as described above is shown in Fig. 2.

Feedback

Having introduced a loss of 10 db by the introduction of the mid-frequency networks, it is necessary to use at least 10 db of gain to maintain zero insertion loss. By providing amplification of greater than 10 db, low- and high-frequency correction can be realized by negative feedback.[2, 3]

The fundamental equation pertaining to negative feedback is

$$\text{Net gain} = A/(1 - KA) \qquad (1)$$

where A is voltage amplification without feedback and K is the ratio of input feedback voltage to the output voltage. Examination of this equation discloses that a two-fold change in K will nearly provide 6 db change in gain, provided that the product KA is sufficiently large. Further, by selecting the proper value for KA, the slope of the gain change can be adjusted to a maximum of approximately 6 db per octave when simple reactive combinations are used. However, when K varies with frequency because of reactive elements in the circuit, the phase angle around the feedback loop must be considered when computing resulting frequency characteristic changes.

Figure 3 depicts a two-stage amplifier with parallel feedback from the second plate circuit to the input cathode resistor. Feedback factor is determined by the ratio of Z_1 to $Z_1 + Z_2$. If either Z_1 or Z_2, or both, are made a function of frequency, as they are in Fig. 3, the frequency characteristic of the amplifier will vary accordingly.

Low- and High-Frequency Section

Low- and high-end suppression or emphasis can be controlled by capacitor-resistor combinations such as are shown in Fig. 3. With a suitable choice of resistors, capacitors, overall gain without feedback, and feedback factor the specified frequency characteristics can be obtained by increasing or decreasing C_1, C_2, C_3, or C_4 in discrete steps, as follows:

Low-end suppression: Decrease C_1
Low-end emphasis: Decrease C_3
High-end suppression: Increase C_4
High-end emphasis: Increase C_2

Capacitors C_1 and C_3 are connected into the circuit with a single switch which is arranged to maintain C_1 constant while C_3 is being decreased to produce low-end emphasis and, conversely, C_3 is held constant as C_1 is decreased to give low-end suppression. Capacitors C_2 and C_4 are switched in the same manner except that either is held at the minimum value while the other is increased, in steps, to obtain high-end emphasis or suppression.

So that the feedback path does not adversely shunt the plate-cathode branch of the output tube, it is desirable to keep the minimum impedance of the path about twice the nominal plate impedance of the output tube. At first thought, such a relatively low-impedance path may seem unduly small, but in use the effective plate impedance is considerably lowered by the feedback factor and by the fact that as the path impedance is lowered to achieve equalization, plate impedance is likewise lowered. Obviously, there must be a limit and R_7 serves the purpose.

Because of the foregoing facts, large values of A (Eq. 1) are used, amounting to a voltage gain of 350 (measured without bypass on R_2) exclusive of input and output transformers. With the particular coils used, the over-all gain is 50 db, which is then reduced by the no-equalization feedback to 30 db. The greatest change in net gain is then from 24 db to 40 db, leaving 10 db minimum feedback to insure stability and maintenance of characteristics.

Circuit Details

Theoretically, a two-stage amplifier with only resistive feedback cannot oscillate even though very large values of KA are used. In practice, this is modified by phase shifts within the amplifier due to coupling, bypass, and stray impedances so that care must be exercised in design to minimize such effects. A satisfactory solution, when reactive elements are included in the feedback path as in this application, results when the amplifier is flat in frequency characteristic within two db from 20 to 20,000 cps and has no abrupt changes in gain.

The approach to the design of a corrective amplifier such as shown in Fig. 3 naturally depends upon how many types of correction are to be supplied and the order of magnitude.

The design approach for the unit being described will be used as an example.

First, determine the slopes of the gain changes to be obtained, keeping in mind that simple resistor-capacitor networks have a maximum reactance change of 2 to 1 for a corresponding frequency change and may be limited to less than this ratio by choice of configuration. Assuming a given tube complement, the cathode resistor of V_1 is determined within certain limits and the minimum feedback impedance can be determined, since the difference in gain estab-

lishes the maximum sum of desired suppression and emphasis.

From all of these facts the product of KA and of each factor can be established. Obviously, there is more than one combination which will satisfy the conditions. Determination of the values of the capacitor-resistor networks can most easily be made by recourse to the charts of Di Toro.[4] Some trial values and computations are indicated. Note that the zero-equalization conditions are determined principally by R_7, R_3, R_4, R_5, R_1, and R_2 in Fig. 3 since both C_1 and C_3 are made large for this condition and C_2 and C_4 are made very small.

Once the approximate components are determined, the remainder of the work is best done experimentally.

Nominally, the blocking capacitor in the feedback path is made relatively large in order that appreciable changes in feedback phase angle, or reduction of the feedback factor, occur at very low frequencies where the amplifier gain is low and the stability requirements established by Black[2] and Bode[5] are met. The use of networks as described permits an appreciable reduction in the capacitances of the coupling capacitor and C_3 due to the reverse effects of C_1 which is made smaller than might be expected to accomplish the desired result. Proper proportioning of the capacitors maintains the feedback factor nearly constant over the useful frequency range when set for zero correction.

As previously mentioned, the amplifier at zero equalization gives a gain of 30 db which must be reduced to zero by attenuators. The system of networks is assembled as in Fig. 4 with these attenuators, three fixed and one variable (in the mid-frequency section), located so as to make the input and output essentially resistive.

Because the feedback network is not of abnormally high impedance the network controls can be placed in a separate unit which contains the two capacitor accumulator switches, the mid-frequency network attenuator with the compensating ganged attenuator, and the feedback network capacitors.

Due to the potential differences which gather on the switch contacts, there will be some noise unless these potentials are reduced by connecting resistors between adjacent switch contacts. These bleeder resistors can be made sufficiently low to reduce noise without seriously affecting the frequency characteristic. A further aid in maintaining low noise from the switches is the small difference in attenuation between steps.

The mid-frequency variable network has the usual characteristic of varying the frequency at which one-half attenuator loss occurs. As a result, the emphasis characteristic does not have the same shape as that obtained for suppression. The characteristic shown has been found satisfactory, but if this network were of the so-called constant B type as described by Miller and Kimball[6] there would not be the difference indicated.

Frequency characteristics do not change with tube replacement nor with a 10-percent change in plate supply voltage. Total noise, measured at the output of the system, is 87 db below 0.001 watt, which is sufficiently low to work into high-gain circuits for recording or rerecording. The minimum output capacity, including the output attenuator, is 8 db above 0.001 watt.

There has been some apprehension that feedback amplifiers with reactive networks in the feedback path are apt to be less stable and more susceptible to trouble than other conventional designs, but experience has shown that this is not the case. There has also been some aversion to the use of other than constant-impedance equalizers or additional amplifiers for frequency correction purposes, which has probably been due to ill effects caused by changing impedance conditions or poor transient response in such circuits. Both these faults are minimized in this system, as indicated by square-wave and intermodulation tests.

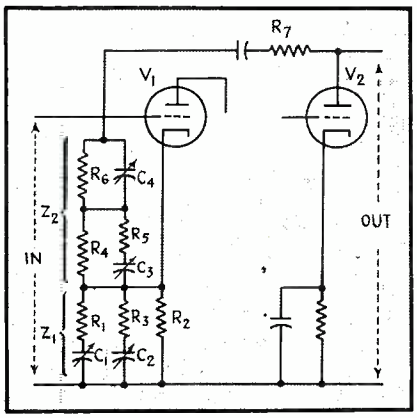


FIG. 3—Method of connecting resistors and capacitors in feedback path of two-stage amplifier providing low-frequency and high-frequency suppression or emphasis

References

(1) Design information on networks as described may be found in "Motion Picture Sound Engineering," D. Van Nostrand Co. Inc., New York, Chapter XVI.

(2) Black, H. S., U. S. Patent 2,102,670.

(3) Terman, F. E., "Radio Engineers' Handbook," McGraw-Hill Book Co., New York.

(4) Di Toro, M. J., Equalizer Design, ELECTRONICS, p 118, April 1944.

(5) Bode, "Network Analysis and Feedback Amplifiers," D. Van Nostrand Co. Inc., New York.

(6) Miller and Kimball, *Journal of the Society of Motion Picture Engineers*, 43, No. 3, p 187, Sept. 1944.

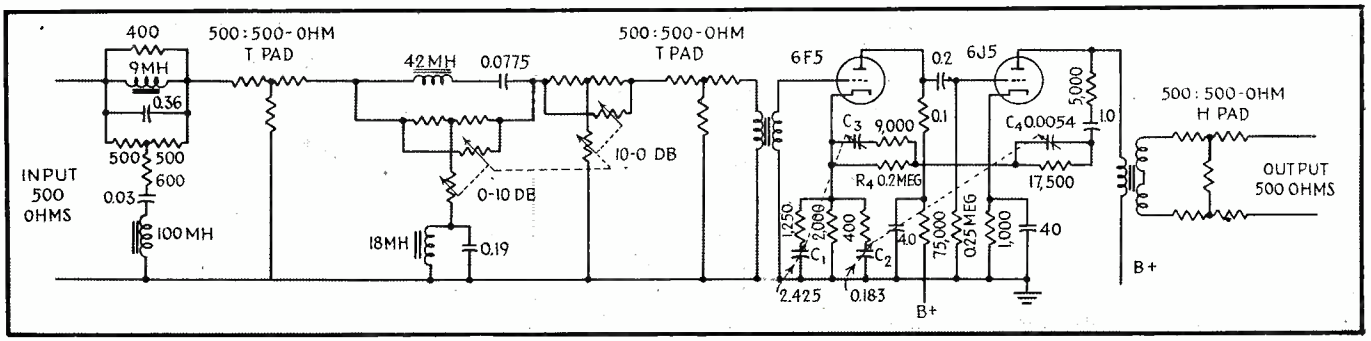


FIG. 4—Complete circuit of three-band variable equalizer. To raise lows, reduce C_3; to raise highs, increase C_2; to lower lows, reduce C_1; to lower highs, increase C_4. Fixed resistors shunting rheostats are 500 ohms each

Graphical Solutions

By HERBERT L. KRAUSS
Department of Electrical Engineering
Yale University
New Haven, Conn.

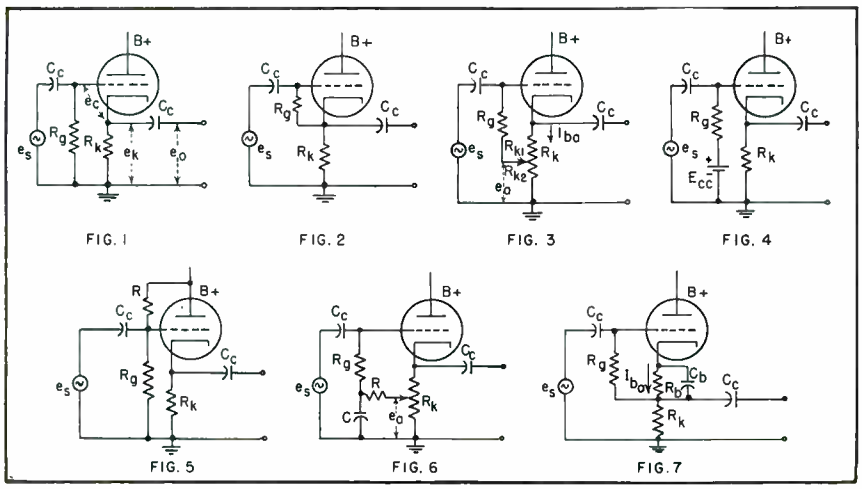


FIG. 1-7—Types of input circuits for cathode followers

THE LITERATURE contains a number of articles on cathode followers,[1-7] covering various aspects of their operation. Two methods of graphical solution have been presented.[4,7] The method which follows is thought to be somewhat simpler than the others, in that only the conventional family of plate characteristics for the tube and a load line are required. Special scales for cathode voltage and signal voltage must be determined for each value of load resistance, but this is not difficult after the quiescent operating point has been located. Once the signal-voltage scale has been provided, an analysis for voltage or power output and harmonic distortion may be made by conventional methods.

Assumptions

The load on the tube is assumed to be a pure resistance in all cases. Coupling and by-pass capacitors are assumed to have zero reactance; shunt capacitances due to tube elements, are assumed to have infinite reactance. Where transformers are used for coupling, they are assumed to be perfect, that is, to have zero winding resistance and leakage reactance, unity coupling, and infinite primary and secondary inductance with a finite ratio of transformation. For the sake of generality the source of signal voltage is assumed to be an amplifier stage which must be capacitance-coupled to the grid of the cathode follower. In some of the examples the circuit may be simplified if capacitance coupling is unnecessary.

Quiescent Operating Conditions

Figures 1 to 7 show common forms of the cathode-follower circuit, differing only in the method of obtaining grid bias. If high input resistance is required the circuits of Fig. 2 and 7 are best, because in these circuits the alternating voltage across R_g is $E_s - E_o = E_g$, the lowest possible value, and thus very little current will flow in R_g. On the other hand, in Fig. 1 the voltage across R_g is E_s. Since $E_g \cong 0.1\ E_s$ in many cathode followers, a given value of R_g will look approximately ten times as large to the signal source in the circuit of Fig. 7 as it would in that of Fig. 1. The circuits of Fig. 3 and 6 would give intermediate values.

To illustrate the graphical solutions for the quiescent operating points, the characteristics of a 6J5 tube will be used, with $R_k = 10{,}000$ ohms, and a plate supply voltage, $E_{bb} = 300$ volts. The steps in the solution are illustrated in Fig. 8. (1) Draw a load line with slope equal to $-1/R_k$ through the point E_{bb} on the plate characteristics of the tube. (2) For convenience in

Symbols

e_b = total instantaneous plate-cathode voltage
i_b = total instantaneous plate current
e_s = total instantaneous grid-cathode voltage
e_k = total instantaneous cathode-ground voltage
e_a = total instantaneous voltage developed across a portion of R_k, as shown in Fig. 3 and 6
e_s = total instantaneous signal voltage, applied between grid and ground
E_{co} = quiescent grid-cathode voltage
E_{ko} = quiescent cathode-ground voltage
E_{bo} = quiescent plate-cathode voltage
E_{cc} = bias supply voltage
E_{bb} = plate supply voltage
$e_g = e_c - E_{co}$ = instantaneous varying component of grid-cathode voltage
$e_o = e_k - E_{ko}$ = instantaneous varying component of cathode-ground voltage
I_{bo} = quiescent plate current
E_s = effective value of a-c signal voltage
E_g = effective value of a-c grid-cathode voltage
E_o = effective value of a-c cathode-ground (output) voltage
μ = amplification factor of the tube
r_p = dynamic plate resistance of the tube
R_g = grid leak resistance
R_k = cathode load resistance
R_{pp} = plate-to-plate load resistance of a push-pull amplifier
R_L' = plate load resistance of a transformer-coupled, single-tube amplifier, or = $R_{pp}/4$ for a push-pull amplifier

for Cathode Followers

Survey of cathode follower input circuits and a method of computing design data for the desired circuit from the conventional load line. Plate-loaded and cathode-follower amplifiers are compared. Several examples are given

computation, add a scale for e_k below that for e_b, using the relation

$e_k = E_{bb} - e_b$. (1)

(3) Locate the quiescent operating point ($e_s = 0$) for the particular circuit used. The method of doing this is indicated below for each of the circuits.

In Fig. 1 the grid is at ground potential under quiescent conditions. Thus $E_{co} = -E_{ko}$ (2) defines the quiescent operating point. From an inspection of the operating characteristics in Fig. 8 this is seen to occur approximately at the point where $E_{co} = -14$ volts, $E_{ko} = +14$ volts. It is labeled point A in Fig. 8.

In the circuit of Fig. 2, $E_{co} = 0$ because the grid leak connects the grid directly to the cathode. This gives the operating point indicated by B in Fig. 8. At this point $E_{ko} = 163$ volts.

The circuit of Fig. 3 gives an operating point that lies between those of the previous examples. The grid is at the potential E_{ao} above ground where E_{ao} is the quiescent value of e_a. The condition to be satisfied is that

$$E_{co} = -I_{bo} \times R_{k1} = -(E_{ko} - E_{ao}) = -E_{ko} \times R_{k1}/R_k$$

where $R_k = R_{k1} + R_{k2}$ (3)

As an example, suppose that the quiescent operating point is to be located where $E_{co} = -6$ volts, and $E_{ko} = 89$ volts. Then from Eq. 3, $R_{k1} = R_k (E_{co}/-E_{ko}) = 10{,}000 \times 6/89 = 674$ ohms, and

$R_{k2} = 10{,}000 - 674 = 9{,}326$ ohms. This gives the operating point labeled C in Fig. 8.

In the circuit of Fig. 4 the operating point may be chosen at will by adjustment of the bias voltage, E_{cc}. From inspection of the circuit it is seen that the condition

$E_{cc} = E_{ko} + E_{co}$ (4)

must be satisfied. If the operating point used in Fig. 3 ($E_{co} = -6$ volts, $E_{ko} = 89$ volts) is chosen, $E_{cc} = 83$ volts.

The operating bias for the circuit of Fig. 5 is obtained by means of the voltage divider R and R_g connected from B+ to ground. By proper choice of these resistors a quiescent grid-to-ground voltage of any desired value (equivalent to the E_{cc} of Fig. 4) may be obtained. Locate operating point as before.

The operating point for the circuit of Fig. 6 is determined in the same manner as that in Fig. 3.

For Fig. 7, $E_{co} = -I_{bo} \times R_b$ (5) If $R_k + R_b = 10{,}000$ ohms and operating point C is assumed, $I_{bo} = 8.9$ milliamperes and $R_b = 6/(8.9 \times 10^{-3}) = 674$ ohms. Thus $R_k = 9{,}326$ ohms. These results are the same as those obtained in Fig. 3. Since R_b is bypassed by C_b in Fig. 7, the a-c load resistance (R_k) is less than the d-c resistance ($R_k + R_b$). If R_k were to be kept at its previous value of 10,000 ohms, a new d-c load

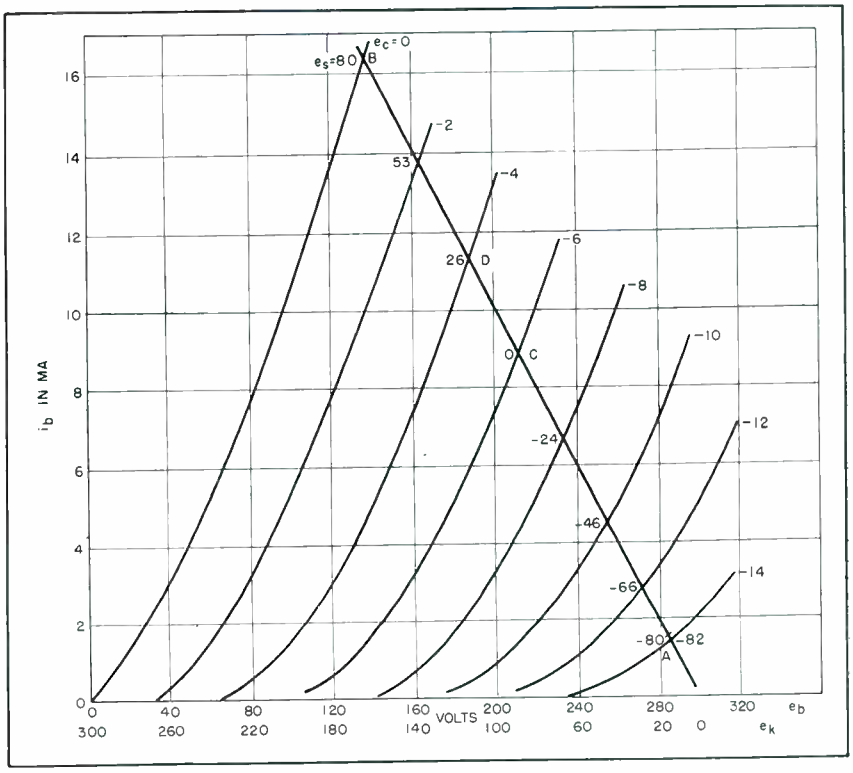


FIG. 8—A type 6J5 tube as cathode follower with R_k equal to 10,000 ohms and E_{bb} equal to 300 volts

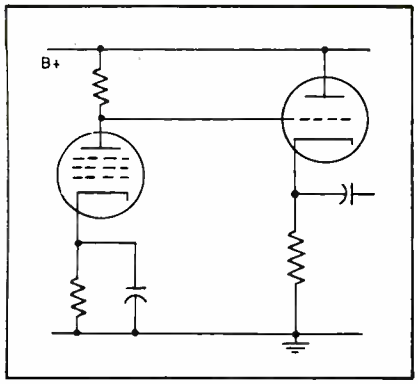


FIG. 9—A direct-coupled circuit

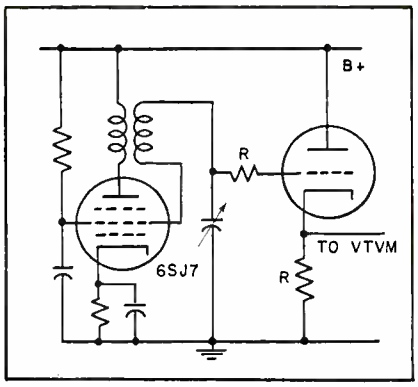


FIG. 10—Vacuum-tube voltmeter

line corresponding to $R_k + R_b$ would have to be drawn. If the a-c load line passes through operating point C the value of R_b may be found as before. The d-c load line would now pass through the operating point and the point $E_{bb} = 306$ volts. Thus the operating point may be selected on the a-c load line and the plate-supply voltage increased above the previously chosen value of 300 volts by the amount of the bias voltage. This correction, which would also apply to a plate-loaded amplifier with a cathode bias resistor, will generally be so small as to be negligible for all practical applications.

The choice of the operating point is governed by the same considerations as in plate-loaded amplifiers. If the point is too near $E_{c_0} = 0$ (point B of Fig. 8) the quiescent plate dissipation may be excessive or the grid may be driven positive and grid current caused to flow. If the operating point is too near the other end of the load line (such as point A of Fig. 8) nonlinear distortion is increased and the tube may be driven to plate-current cutoff with a relatively small signal voltage. Operating point C represents a good compromise since it allows large voltage swings in both directions with low distortion.

Dynamic Operating Conditions

Once the static load line has been found and the quiescent operating point located, the dynamic load line may be drawn through the operating point. The a-c load resistance will be smaller than the d-c load resistance whenever a load is connected between the output terminals of Fig. 1 to 7, or when a by-passed bias resistor is used, as in Fig. 7. In many applications the difference between these two load lines is negligible, and it is so assumed in the example which follows.

Using the load line in Fig. 8 and operating point C, the required signal voltage (e_s) is to be determined for various instantaneous operating points along the line. A convenient method consists of determining the amplitude of the signal voltage at each intersection of the load line and the tube characteristic lines. The instantaneous values of e_s may be found from the relation

$$e_s = e_c - E_{c_0} + e_k - E_{k_0} \qquad (6)$$

where E_{c_0} and E_{k_0} are the values at the quiescent operating point. The above equation is equivalent to the expression

$$E_s = E_g + E_o \qquad (7)$$

involving only the a-c components. Thus in Fig. 8 at point D, $e_c = -4$ volts, $e_k = 113$ volts, and $e_s = -4 - (-6) + 113 - 89 = 26$ volts. Other values for e_s are found similarly and are indicated in a scale along the load line. Once the scale has been determined for e_s, additional points on the scale may be found by interpolation where necessary. Because of the low distortion obtained in cathode followers, a linear interpolation of values of e_s between the points previously found is sufficiently accurate for most purposes.

Distortion Analysis

A sinusoidal signal voltage may now be assumed, and the output voltage or current may be analyzed for fundamental-frequency and harmonic components by the methods usually employed for power amplifiers.[8] It is important to note that the signal voltage (e_s) scale must be used for this analysis rather than the e_c-scale which is used for conventional amplifiers.

Using operating point C in Fig. 8 a signal amplitude of 80 volts is necessary to drive the grid to zero bias, at which point $e_k = 163$ volts and $e_o = e_k - E_{k_0} = 74$ volts. When

Table I

Fundamental-frequency power output and second harmonic distortion of a triode amplifier, plate-loaded and cathode-loaded. Triode-connected 6L6 tube with $E_{bb} = 255$ volts, $E_{cc} = -22.5$ volts, $\sqrt{2}\,E_g = 22.5$ volts

	Plate-loaded		Cathode-loaded		
R_L' ohms	P_o watts	Percent 2nd harmonic	P_o watts	Percent 2nd harmonic	$\sqrt{2}\,E_s$ volts
1,700	1.78	14.2	2.06	13.2	122.5
3,400	1.71	7.5	2.06	2.4	148.5
5,000	1.53	5.5	1.80	0.6	160.0

Table II

Triode-connected 6L6 tubes in push-pull, with $E_{bb} = 255$ volts, $E_{cc} = -22.5$ volts, $\sqrt{2}\,E_g = 22.5$ volts

	Plate-loaded		Cathode-loaded		
R_L' ohms	P_o watts	Percent 3rd harmonic	P_o watts	Percent 3rd harmonic	$\sqrt{2}\,E_s$ volts
500	3.72	0.41	3.75	0+	83
1,000	4.20	0.36	4.20	0+	114
1,500	4.02	0.23	4.02	0+	131

(In the push-pull amplifier R_L' is the equivalent load resistance presented to the composite tube, and is equal to one-fourth the plate-to-plate load resistance)

the instantaneous signal voltage is 80 volts negative (this point is indicated on the load line), $e_k = 17$ volts and $e_o = -72$ volts. Thus the amplitude of output voltage is nearly the same on the positive and negative half-cycles, indicating very little distortion. The voltage amplification of the circuit is: $A = \sqrt{2}\,E_o/\sqrt{2}\,E_s = 73/80 = 0.91$.

By contrast, if the circuit were operated as a plate-loaded amplifier with the same operating point and $\sqrt{2}\,E_g = 6$ volts, the corresponding values of amplitude of output voltage would be 74 for the positive half-cycle and −60 for the negative half-cycle, giving a fairly large percentage of second-harmonic distortion.

The conclusions to be derived so far are that the cathode follower has inherently low distortion because of its negative feedback; high input impedance which is advantageous if the previous stage is sensitive to loading; low output impedance desirable for driver-stage applications; but the disadvantage of requiring a signal input slightly larger than the output voltage.

Many useful applications of the cathode follower as a coupling stage between a high-impedance source and a low-impedance load or as a video amplifier stage have been cited in the literature.[1-7] The possibility of direct coupling to the grid of the cathode follower from the previous stage as indicated in Fig. 9 should be considered because it permits the elimination of the coupling capacitor and grid leak usually required. If the direct grid-to-ground potential of the cathode follower can be the same as the quiescent plate voltage of the previous stage, direct coupling should be feasible. Figure 10 shows another direct-coupled circuit which has been used successfully in our laboratory, where it was desired to make selectivity measurements on a tuned r-f amplifier stage. Since a diode-type vacuum tube voltmeter would cause appreciable loading of the tuned circuit, and a consequent reduction in gain and selectivity, a cathode-follower stage was inserted as shown. The screen grid of the 6SJ7 may be operated at 75 to 100 volts, which is a convenient range for the quiescent grid-to-ground voltage of the cathode follower. The resistor R was necessary in the grid lead to prevent oscillation of the cathode follower stage.[7] A value of R between 100 and 1,000 ohms is generally sufficient to prevent oscillation.

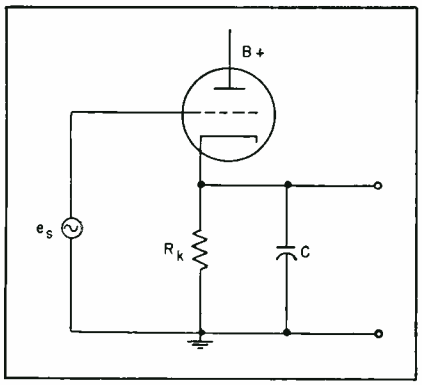


FIG. 11—A high-impedance detector circuit

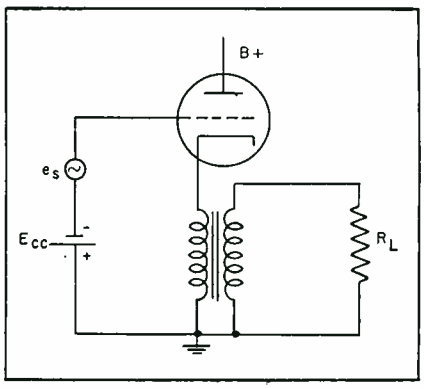


FIG. 12—A transformer-coupled amplifier

A-M Detector

The circuit of Fig. 11, with a high value of R_k and an r-f bypass capacitor C, will act as a detector for amplitude-modulated waves. The large value of R_k will cause the tube to be biased near cutoff under quiescent conditions. Thus the action is similar to that of a diode detector with the added advantage of high impedance presented to the signal source. The disadvantage of this circuit as a detector is that, no matter how high R_k is made, the bias voltage for the grid must be developed across R_k, and a negative signal equal to this bias voltage must be applied before the tube will cut off. Thus for small applied signals no rectification will occur. This difficulty can be avoided by applying enough direct voltage in the grid circuit to bias the tube to cutoff, but this is not always a convenient solution. The output voltage of this detector is positive with respect to ground, and therefore is not useful for avc purposes.

Because of the low output impedance of the cathode follower, it

Table III

Triode-connected 6L6 tubes in push-pull, with $E_{bb} = 255$ volts, $E_{cc} = -30$ volts, $\sqrt{2}\,E_g = 30$ volts

	Plate-loaded		Cathode-loaded		
R_L' ohms	P_o watts	Percent 3rd harmonic	P_o watts	Percent 3rd harmonic	$\sqrt{2}\,E_s$ volts
500	3.66	4.75	3.83	1.07	93
1,000	4.30	3.59	4.57	0.35	126
1,500	4.37	2.84	4.60	0.22	147
1,700	4.28	2.82	4.53	0.0+	154

Table IV

Triode-connected 6L6 tubes in push-pull, with $E_{bb} = 255$ volts, $E_{cc} = -37.5$ volts $\sqrt{2}\,E_g = 37.5$ volts

	Plate-loaded		Cathode-loaded		
R_L' ohms	P_o watts	Percent 3rd harmonic	P_o watts	Percent 3rd harmonic	$\sqrt{2}\,E_s$ volts
1,000	3.72	11.0	4.35	2.9	133
1,250	3.80	10.9	4.52	1.8	145
1,500	3.81	10.0	4.48	1.7	155
2,000	3.72	9.0	4.26	1.8	170

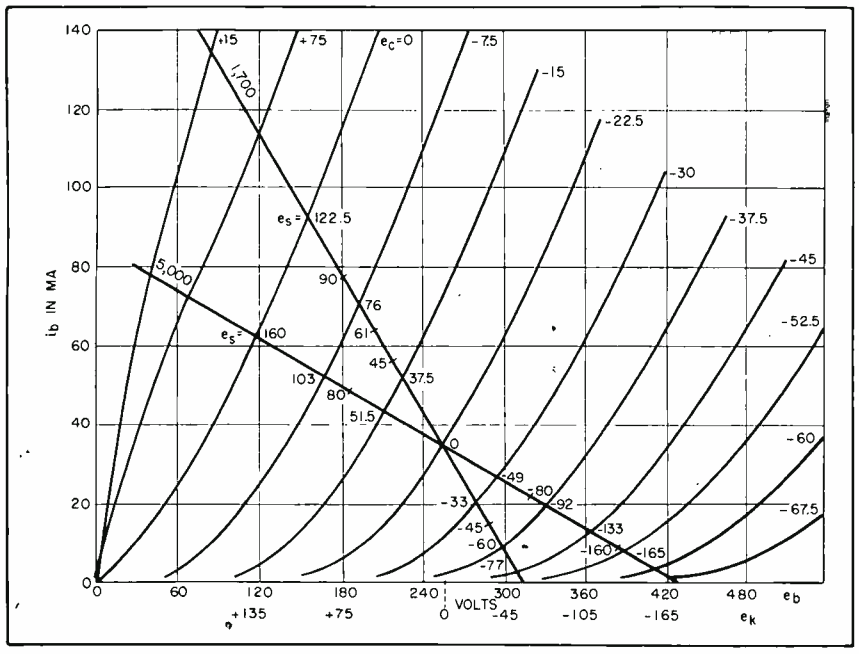


FIG. 13—A type 6L6 tube used as a transformer-coupled cathode-loaded power amplifier with R'_L equal to 1,700 ohms (upper curve) and 5,000 ohms. E_{bb} is 255 volts and E_{cc} is —22.5 volts

is sometimes useful as a power amplifier if the load impedance is subject to variation. The circuit diagram of a power amplifier with the load transformer-coupled into the cathode circuit is shown in Fig. 12. Although fixed bias is indicated, cathode resistor bias such as that used in Fig. 7 may be more convenient as long as the operation is restricted to class A. A graphical solution for the circuit of Fig. 12 is similar to that for a plate-loaded amplifier, except that scales must be provided for e_s and e_k as they were in Fig. 8. The quiescent operating point is determined from the plate-supply voltage and bias voltage exactly as it would be for a plate-loaded amplifier. Similarly, the slope of the load line is determined by the reflected load resistance (R_L') seen in the primary circuit of the transformer.

Figure 13 shows the graphical construction for a type 6L6 tube operated as a triode with $E_{bb} = 255$ volts, $E_{cc} = -22.5$ volts, and with load resistances of 1,700 and 5,000 ohms on the primary side of the transformer. A scale for e_k appears below the e_b-scale, and values of e_s are indicated along the two load lines. Note that $e_k = 0$ at the operating point; thus e_s is easily determined at any point along the load line from the relation

$$e_s = e_k + e_g \qquad (8)$$

Table I summarizes the results of calculations with three values of load resistance for both plate loading and cathode loading. The same grid-cathode voltage ($\sqrt{2}E_g = 22.5$ volts) was used in all cases, the corresponding values of $\sqrt{2}E_s$ being given in the table for the cathode-loaded amplifier. The fundamental-frequency power output and percent second harmonic distortion were calculated by the method given in reference number 8, with the assumption that harmonics higher than the third were negligible. Note that $r_p \cong 1{,}700$ ohms at the operating point—thus the values of load resistance used correspond approximately to $R_L' = r_p$, 2 r_p and 3 r_p.

For the 1,700-ohm load the cathode loading does not reduce the distortion appreciably below the value obtained with plate loading, because the signal amplitude is such as to cause the tube to be cut off during part of the cycle (i.e., $i_b = 0$ at $e_s = -90$ volts). If the signal amplitude is reduced to 90 volts ($=\sqrt{2}E_s$) with the 1,700-ohm load, $P_o = 1.31$ watts and the second harmonic distortion = 5.1 percent.

With the other values of load resistance the harmonic distortion is reduced considerably by cathode loading and the power output is increased about ten percent. In all cases the large values of signal voltage required for cathode-follower operation are a definite disadvange.

Push-Pull Power Amplifier

The circuit for the cathode-loaded push-pull power amplifier is shown in Fig. 14. An examination of the conditions to be satisfied for both quiescent and dynamic operation shows that they are identical with the conditions for a plate-loaded push-pull amplifier. The conditions are:

quiescent—$i_{b1} = i_{b2}$, $e_{c1} = e_{c2} = E_{cc}$, $e_{k1} = e_{k2} = 0$, and $e_{b1} = e_{b2} = E_{bb}$ (9)

dynamic—$\Delta e_{s1} = -\Delta e_{s2}$, $\Delta e_{k1} = -\Delta e_{k2}$, $i_{b1} - i_{b2} = i_d$; therefore $\Delta e_{c1} = -\Delta e_{c2}$, $\Delta e_{b1} = -\Delta e_{b2}$ (10)

In these relations the subscripts 1 and 2 refer to the two tubes of the push-pull circuit, and i_d is the net flux-producing component of current in the transformer primary. This current is defined in the conventional manner[9] so that

$$i_d \times N_p = i_2 \times N_s, \qquad (11)$$

where N_p is the number of turns on one-half the primary, and N_s is total secondary turns.

Since the conditions to be satisfied are the same for both cathode loading and plate loading, the graphical solution for plate-loaded push-pull amplifiers is applicable. A signal-voltage scale must be provided along the load line on the composite characteristics. Two 6L6

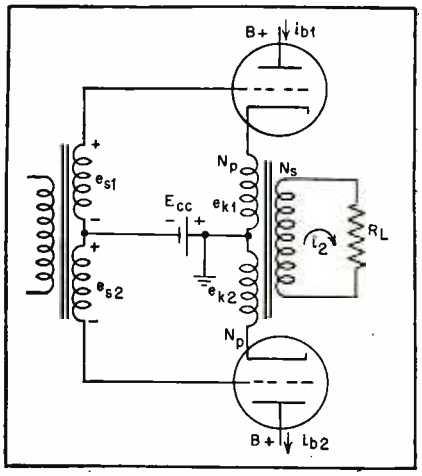


FIG. 14—A cathode-loaded push-pull power amplifier circuit

tubes, triode-connected, were used for this analysis. A comparison of fundamental-frequency power output and third harmonic distortion for plate-loaded and cathode-loaded amplifiers under various operating conditions is given in Tables II to V.

Conclusions

From the results of these calculations the following conclusions are drawn concerning cathode loading versus plate loading for power amplifiers:

The advantages in all cases of cathode follower operation are the high input impedance (with negative grid operation) and low output impedance. The latter is particularly desirable when the load impedance may vary with frequency and a constant load voltage is desired. The disadvantages in all cases of cathode-follower operations are the large signal voltages required and the possibility that the maximum allowable cathode-to-filament potential of the tubes will be exceeded under maximum output conditions. For the single-tube amplifier, cathode loading will increase the power output and reduce the distortion compared to plate loading, provided the signal voltage used for cathode-follower operation does not drive the tube to plate-current cutoff (see Table I).

If the distortion is low for the plate-loaded case (either single or push-pull tubes) cathode loading will not increase the power output appreciably (see Table II). This is logical since if the distortion were negligible, the instantaneous excursions along the load line would be exactly the same for either type of loading. If the distortion is high in push-pull plate-loaded operation, cathode loading will reduce the distortion considerably and may increase the power output by more than ten percent. (See Tables III to V.) The increase in power output occurs because the negative feedback with cathode loading acts to increase the amplitude of the fundamental-frequency current while reducing the harmonic currents. The value of equivalent load resistance (R_L') which gives maximum power output is approximately the same for both cathode loading and plate loading in each case considered. With a fixed operating point and fixed grid voltage amplitude this result would be expected, since the excursions along a given load line are approximately the same for both types of loading.

The internal impedance of a tube acting as a cathode follower is $r_p/(1+\mu)$.[10] If the Maximum Power Transfer Theorem is applicable, a load resistance equal to the internal resistance of the tube would give maximum power output. However, this theorem holds only for strictly linear operation of the tube with a constant voltage generated in the equivalent plate circuit, and thus restricts the grid swing to small values for the plate-loaded amplifier. This restriction is not so severe for cathode loading because of the reduced distortion. The equivalent generator for a cathode follower produces a voltage $\mu E_s/(1+\mu)$[10]; thus it is the signal voltage E_s that must be kept constant in this case rather than E_g, while the load resistance is varied to obtain maximum power output. This follows also from Shapiro's graphical solution[4] involving equivalent plate characteristics for the cathode follower, wherein the input signal is represented by the grid-to-plate alternating voltage which is identical with the E_s used here.

Although the above arguments are theoretically sound, certain practical considerations prevent operation of the cathode follower with load resistances comparable to $r_p/(1+\mu)$ in order to obtain more power output than is possible with plate loading. The plate power dissipation of the tube under both quiescent and dynamic conditions must not exceed its rated value. This will locate the operating point relatively low on the family of plate characteristics (see the operating point of Fig. 13, which is near the maximum-plate-dissipation point). Then for small values of R_L' the maximum allowable value of E_s (which will not produce grid-current flow or plat-current cutoff) will be quite small. With E_s limited to such a small value the power output will be less than the maximum value obtained with the load values and signal amplitudes noted earlier.

In conclusion it should be pointed out that this method of graphical analysis may also be applied to any amplifier that has combined plate and cathode loading, or for negative-feedback amplifiers. The scales for e_s and e_k would be determined in such a case by the amount of feedback voltage developed in the grid or cathode circuit. Once these scales are determined the analysis proceeds in the manner previously given.

Table V

Triode-connected 6L6 tubes in push-pull, with $E_{bb} = 255$ volts, $E_{cc} = -37.5$ volts, $\sqrt{1}\,E_g = 45$ volts (grid driven 7.5 volts positive)

	Plate-loaded		Cathode-loaded		
R_L' ohms	P_o watts	Percent 3rd harmonic	P_o watts	Percent 3rd harmonic	$\sqrt{2}\,E_s$ volts
1,000	6.27	10.7	7.37	2.2	169
1,250	6.34	10.2	7.43	1.8	181
1,500	6.35	9.2	7.39	1.5	196
2,000	6.08	9.0	7.00	1.6	215

Acknowledgment

The author wishes to thank Professor H. J. Reich and P. F. Ordung of the Department of Electrical Engineering, Yale University, for their helpful comments during the preparation of this paper.

References

(1) Reich, H. J., "Theory and Applications of Electron Tubes", McGraw-Hill Book Co., 2d Edition, p 164, New York 1944.
(2) Reich, H. J., Features of Cathode Follower Amplifiers, *Electronic Industries*, p 74, July 1945.
(3) Richter, W., Cathode Follower Circuits, ELECTRONICS, p 112, November 1943.
(4) Shapiro, D. L., The Graphical Design of Cathode-Output Amplifiers, *Proc IRE*, p 263, May 1944.
(5) Greenwood, H. M., Cathode Follower Circuits, *QST*, p 11, June 1945.
(6) Goldberg, H., Some Considerations Concerning the Internal Impedance of the Cathode Follower, *Proc* IRE, p 778, November 1945.
(7) Schlesinger, K., Cathode Follower Circuits, *Proc IRE*, p 843, December 1945.
(8) MIT Staff, "Applied Electronics", John Wiley and Sons, p 412, New York 1943.
(9) MIT Staff, "Applied Electronics", John Wiley and Sons, p 438, New York 1943.
(10) MIT Staff, "Applied Electronics", John Wiley and Sons, p 537, New York 1943

WAVEGUIDE DATA

Dimensions of rectangular copper waveguides covering the entire microwave spectrum in accordance with FCC frequency allocations, with cutoff frequencies, curves of attenuation and power-handling capacity for each size, and performance equations

By LEONARD E. SHERBIN

Chief Engineer
DeMornay-Budd, Inc.
New York, N. Y.

THE MICROWAVE FIELD has reached that stage of development where it is now desirable to standardize on various waveguide sizes. Since the physical dimensions of a waveguide determine the frequency range over which it can most satisfactorily operate, it is desirable that waveguide dimensions be standardized according to frequency allocations. This would avoid need for two waveguide sizes to cover a band of frequencies allocated to one service, as well as to obtain the maximum efficiency from a transmission line.

A number of systems for determining standards for waveguide sizes have been put forth, all of which are based upon the following factors: (1) To use as few waveguide sizes as possible; (2) To have the waveguides operate over as wide a band as is practical; (3) To choose the dimensions so that the inherent losses are as low as possible; (4) To standardize on waveguides having the highest possible power-carrying capacity; (5) To choose the waveguides with characteristics compatible with FCC frequency allocations; (6) To use waveguide sizes for which tubing is available; (7) To choose dimensions so that the waveguide has the necessary mechanical strength.

Cutoff Frequency

The cutoff frequency is that frequency below which a waveguide will not transmit any energy. That is to say, the wave will not propagate if it is below the cutoff frequency of the waveguide. This is borne out by the fact that the characteristic wave impedance is a pure imaginary quantity for frequencies below the cutoff frequency of a waveguide.

The attenuation in a waveguide below cutoff is a reactive attenuation. The waveguide looks like a pure reactance to the source and therefore the energy is reflected back from the waveguide. The action of a waveguide below cutoff is analogous to that of a high-pass filter below the pass band of the filter. The characteristic wave impedance for a transverse electric wave is

$$Z_{TE} = \nu_1 / \sqrt{1 - (f_c/f)^2} \qquad (1)$$

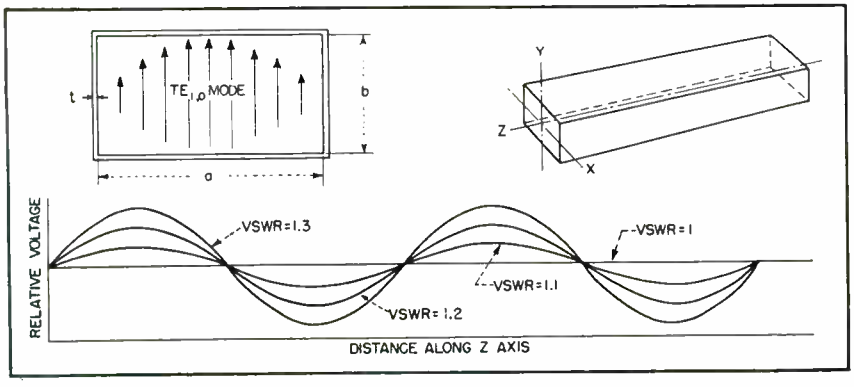


FIG. 1—End view of electric field distribution in rectangular waveguide, and curves showing voltage along longitudinal axis Z of a rectangular waveguide for various voltage standing wave ratios

where Z_{TE} = characteristic wave impedance for a transverse electric wave, $\nu_1 = \sqrt{\mu_1/\epsilon_1}$ = intrinsic impedance of the dielectric, ϵ_1 = dielectric constant, μ_1 = permeability, f_c = cutoff frequency, and f = frequency.

For values where $f_c > f$ the characteristic wave impedance is a pure imaginary and hence no energy can be propagated along the waveguide. When $f = f_c$ the characteristic wave impedance is infinite and for an ideal waveguide would represent a sharp transition from an imaginary characteristic wave impedance to a real one. However, for practical waveguides with imperfect conductors there is a small amount of phase shift below cutoff and some attenuation above cutoff. Above cutoff, practical wave guides have a real attenuation factor and a phase shift along the axis of the guide.

The above discussion shows the impracticability of using waveguides at frequencies below cutoff for the transmission of energy. At frequencies close to and just above the cutoff frequency for a given waveguide the attenuation-vs-frequency curve has a steep slope with a relatively high attenuation factor. This makes it undesirable to use waveguides in this region. The expression for the cutoff frequency for a transverse electric $TE_{m,n}$ or transverse magnetic $TM_{m,n}$ wave is

$$\lambda_c = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}} \qquad (2)$$

where λ_c = wavelength at cutoff, m and n are the subscripts for a given mode, and a and b are the inside dimensions for the wide and narrow sides respectively as indicated in Fig. 1.

For the $TE_{1,0}$ wave, which is the one used in practically all cases, Eq. 2 reduces to

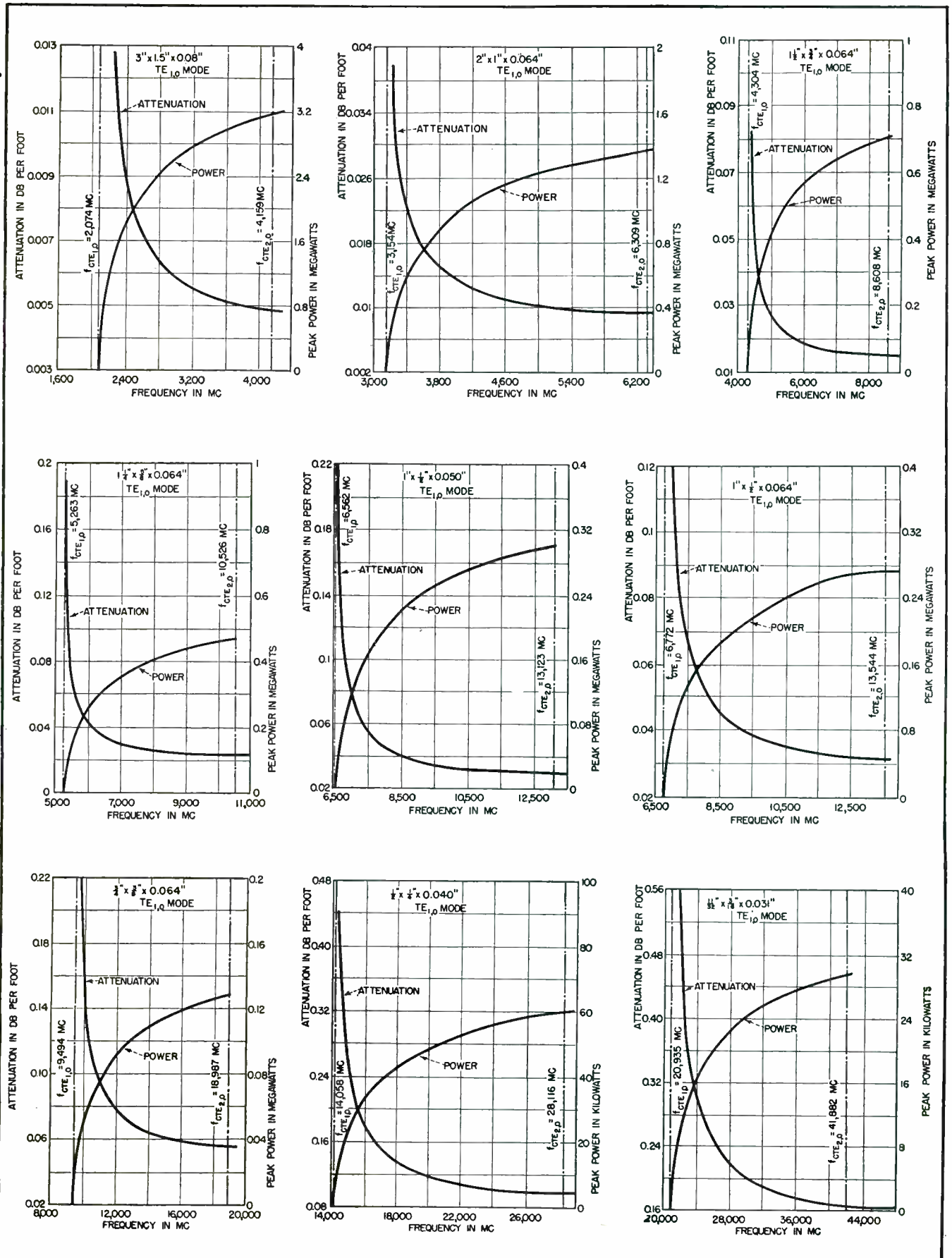


FIG. 2—Attenuation and power curves plotted against frequency for rectangular copper waveguides having the length, width, and thickness dimensions indicated. All operate in $TE_{1,0}$ mode. Two sets of curves for 1 x 1½-in. size show effect of wall thickness

$$\lambda_c = 2a \qquad (3)$$

This equation shows that for the $TE_{1,0}$ mode the a dimension of a rectangular waveguide is the only physical factor determining the cutoff frequency. The cutoff frequencies of the waveguides included in the various recommendations for standardization are given in Fig. 2.

Operation at Higher Modes

In order to operate a waveguide at its optimum efficiency the dominant mode is usually used. The dominant mode is the lowest-frequency mode that will propagate down the waveguide. The propagation of more than one mode in a waveguide is undesirable as it results in impedance mismatches for the various modes, along with reflections and the generation of spurious frequencies other than the desired one at discontinuities. If these spurious frequencies can propagate down the waveguide they will have many detrimental effects. This results in the loss of energy propagated down the waveguide, high standing wave ratios in the waveguide, and very inefficient transmission of the microwave energy.

Therefore, it is essential that the physical dimensions of a waveguide be so chosen that all modes, other than the desired one, cannot propagate. This places the limitation on the highest frequency at which a waveguide can be most efficiently used.

The $TE_{2,0}$ mode is the next higher mode that could be propagated. By simplifying Eq. 2 the cutoff wavelength for the $TE_{2,0}$ mode becomes equal to a. This places a limit on the highest frequency of the band for which a given waveguide is suitable.

In practice, the upper frequency limit is usually lower than the theoretical limit, so that moding difficulties are avoided. The lowest transverse magnetic wave which can exist is the $TM_{1,1}$ mode and since it occurs at a higher frequency than the $TE_{2,0}$ mode in the recommended waveguide sizes, there is no need to investigate further.

The b dimension is subject to compromise on many points. The larger the b dimension the lower the attenuation and the greater the power-handling capacity of the waveguide. However, there is a limit as to how large b can be made before difficulties are encountered with modes other than the dominant mode. The b dimension has to be such that it will not support any mode other than the $TE_{1,0}$. In practice the ratio of the b dimension to the a dimension is usually less than 0.5 to avoid any possibility of the waveguide supporting a mode other than the $TE_{1,0}$.

Power-Carrying Capacity

The maximum power that a waveguide can carry for the $TE_{m,0}$ mode is

$$P = E_{max}^2 6.63 \times 10^{-4} ab \left(\frac{\lambda}{\lambda_g}\right) \qquad (4)$$

where P = maximum power for the $TE_{m,0}$ mode in watts, E_{max} = maximum permissible voltage gradient, λ_g = guide wavelength, λ = free space wavelength, and a and b are waveguide inside dimensions in cm. This gives the theoretical power that a waveguide can handle if the voltage standing wave ratio is 1, and is valid for given humidity and air pressure conditions only.

The maximum field intensity occurs where the electric field is greatest. The greatest electric field is parallel to the narrow side (b dimension) in the center of the broad side (a dimension). Therefore, the b dimension limits E_{max} since it determines the field intensity at which a voltage breakdown will occur. The maximum power is proportional to the cross-sectional area ab of the waveguide and the ratio λ / λ_g.

A value of 15,000 volts per cm will be used in the calculations for E_{max}. This value has been arrived at empirically and is used by the Army and Navy in applying power ratings to waveguides. Any increase in voltage standing wave ratio will decrease the power-handling capacity of waveguides since the field intensity will then have varying values along the waveguide axis, with the maximum value of field intensity being greater than if the voltage standing wave ratio were unity. Any sharp corners, bends, twists, etc, would tend to lower the maximum power rating. Figure 1 shows (at upper left) the electric field distribution across a waveguide for the $TE_{1,0}$ mode, along with curves portraying the increase in peak voltage due to increasing standing wave ratios.

The graphs in Fig. 2 give the maximum power-carrying capacities under ideal conditions and assuming an E_{max} of 15,000 volts per cm for the $TE_{1,0}$ mode.

Attenuation

In a rectangular copper waveguide with air dielectric and for the $TE_{1,0}$ mode the attenuation is

$$\alpha_{copper} = \frac{0.01107}{a^{3/2}} \left[\frac{\frac{1}{2}\frac{a}{b}\left(\frac{f}{f_c}\right)^{3/2} + \left(\frac{f}{f_c}\right)^{-1/2}}{\sqrt{\left(\frac{f}{f_c}\right)^2 - 1}} \right] \qquad (5)$$

where α_{copper} = attenuation in db per ft for a copper waveguide for the $TE_{1,0}$ mode.

For metals other than copper, Eq. 5 must be multiplied by K, where K is equal to the square root of the ratio of the resistivity of the metal used to the resistivity of copper.

The values for attenuation in waveguides as obtained by measurements run somewhat higher than the values obtained by solving Eq. 5. This is caused by such conditions as variations in plating, impurities in the metal, dust, varying atmospheric conditions, and corrosion.

Curves of attenuation vs frequency are also given in Fig. 2 for various waveguide sizes, based on Eq. 5. These curves indicate that it is not desirable to operate a waveguide at frequencies close to cutoff. The attenuation is high in this region and decreases rapidly to the point where it is fairly constant. Also, wide-band operation in this region is undesirable as it would cause considerable distortion.

For narrow-band operation near cutoff the attenuation is so much greater that considerably larger transmitters would have to be used to obtain a comparable input to the antenna for most practical waveguide installations. In receiving applications the increased attenuation results in lower effective signal input to the receiver, thereby decreasing the signal-to-noise ratio and sensitivity of the installation.

Cinch IS THE STANDARD

Cinch Miniature Sockets are

ONE, TWO, THREE

. . . proven (1) *dependable* and *durable* under most exacting requirements of service in the foremost radio sets and electronic equipment . . . (2) *complete line* of miniature sockets, laminated and molded, and related parts, mounting straps, shields and bases for today's needs and in anticipation of tomorrow's requirements. Cinch coordinated and engineered the first complete line of one piece, ceramic and mica filled molded miniature sockets with shield and saddle, see illustration No. 9365.

. . . in production and (3) *available* on order.

MINIATURE SOCKETS

CINCH MANUFACTURING CORPORATION, 2335 W. Van Buren St., Chicago 12, Ill., *Subsidiary of United-Carr Fastener Corporation, Cambridge 42, Mass.*

ELECTRONIC HEATING REQUIREMENTS

By A. P. BOCK

Design Engineer
Westinghouse Electric Corp.
Baltimore, Md.

WHEN a substance is heated by induction or dielectric means, the power required to attain a given temperature rise at a given rate is a basic consideration. It depends directly upon the number of pounds of material, the specific heat, the number of degrees temperature rise, and inversely upon the number of minutes in which the heating is to be accomplished. Neglecting heat radiation and convection losses which are usually insignificant below 1,500 F, the pertinent power-temperature rise information is presented in a series of curves which are plots of

kw/100 deg F = 1.758 (lb/min) × specific heat (1)

In the graphs below a curve is drawn for each of a selected number of specific heats ranging from 0.04 to 1.0; two graphs being shown to facilitate accurate scaling for large or small amounts of material differing by a factor of 10. The dashed line curve represents the power needed to evaporate water and reads directly from the vertical scale in each graph. The evaporation curve is a plot of

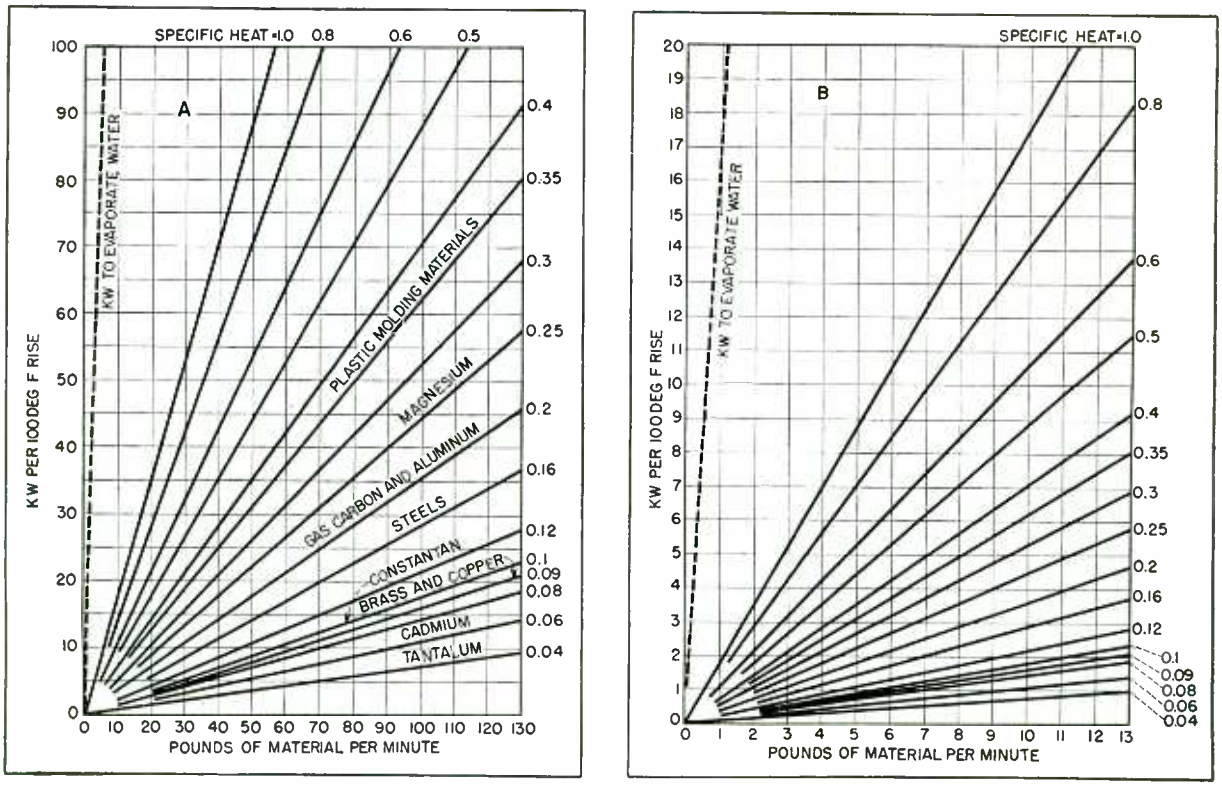
kw = 17.05 lb/min of water evaporated (2)

Examples

Suppose it is desired to heat 50 pounds of steel per minute from 50 F to 1,350 F. Using a specific heat of 0.16 a value of 14 kw per 100 deg rise is obtained from graph A. Then for 1,300 deg rise, 13 × 14 or 182 kw of thermal power is required.

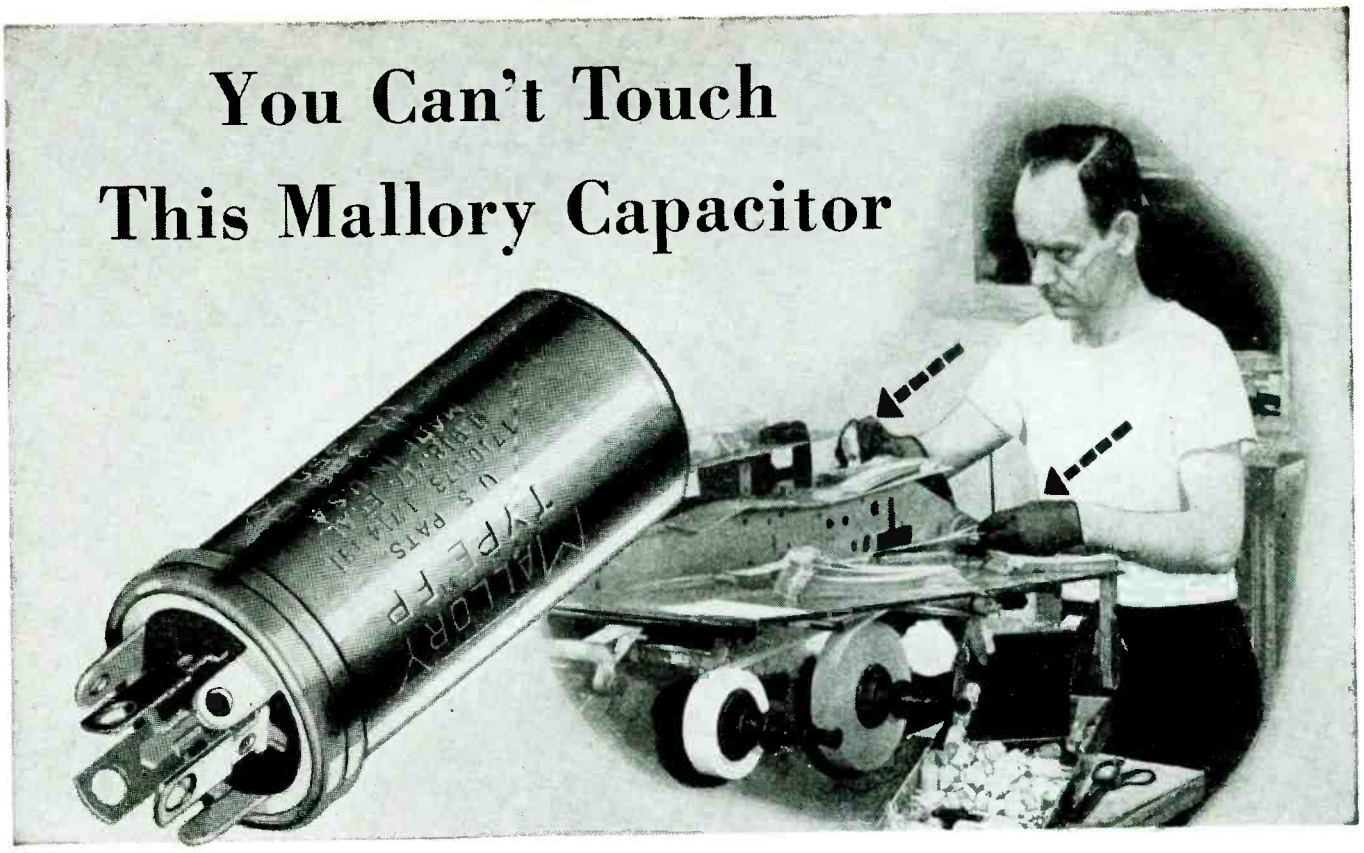
In another case, it may be desired to heat 10 lbs/min (dry weight) of preforms, such as general purpose molding compound, from 70 F to 270 F or 200 deg rise. Suppose this material contains 2 percent moisture, all of which will be evaporated by the time 270 F is reached. Using a specific heat of 0.35, a value of 6.1 kw per 100 deg rise is obtained from graph B. Then for 200 deg rise, 2 × 6.1 or 12.2 kw of thermal power is required to heat the dry material.

Two more factors of required power enter in owing to the moisture; raising 0.2 lb of water/min from 70 F to 212 F or 142 deg rise. Using a specific heat of 1.0 for water we have 0.35 kw per 100 rise or 0.5 kw for 142 deg rise. In evaporating 0.2 lb of water/min, the dashed-line curve of graph B indicates that 3.4 kw is needed. The sum of these products, then, totals 16.1 kw.



Thermal power versus heating rate for materials of various specific heats. The two graphs are identical except that the one at the right is used for more accurate results with small quantities

You Can't Touch This Mallory Capacitor



(that's true in more ways than one)

No other capacitor made today can touch the Mallory FP for quality or dependability. There are many reasons why this is so. Some of them originate in the extreme precautionary methods exercised at the Mallory plant.

Mallory technicians are aware, for instance, that salts (among other impurities) present a constant threat to the service life of electrolytic capacitors. That's why raw material impurities are kept to an absolute minimum—*actually at percentages equivalent to only a fraction of a part per million.* That's why too, at the Mallory plant, no human hand is allowed to come in contact with capacitor cartridges or their ingredients.

Hands perspire. Perspiration contains salt. *Therefore workers are required to wear rubber gloves.* A small detail, but an important one. "Mustn't touch" at the Mallory factory is still another reason why Mallory FP capacitors are used everywhere with safety and confidence.

Yours for the asking!

Everything you want to know about Mallory Electrolytic capacitors—types, sizes, electrical characteristics—even data on test measurements and mounting hardware!

P. R. MALLORY & CO. Inc.

MALLORY CAPACITORS

(ELECTROLYTIC, OIL and WAX)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

TUBES AT WORK

Edited by VIN ZELUFF

Method of Plotting Tracking Error

By E. B. MENZIES
Auckland, New Zealand

PLOTTING OF a tracking error curve is generally reckoned to be a more tedious procedure than the original calculations of correct oscillator inductance and padding capacitance.

A simple system for plotting tracking error has proved to have reasonable accuracy, and great flexibility. It is invaluable where it becomes necessary, in the design of superheterodyne coils, to make the small inductance changes necessary for perfect tracking.

It was proposed to wire the coils under test with their correct tuning and padding capacitors, and align them in the normal manner. A signal generator would be fed into the antenna coil (through the usual dummy antenna) and the frequency of the beat appearing in the mixer plate checked at various positions of the tuning capacitor, perfect tracking keeping the frequency of the beat more or less constant at the i-f frequency. The next step was to make the antenna coil produce its own signal at the frequency of the signal circuit by wiring it in an oscillator circuit, and do away with the signal generator input.

Thus, one section of the tuning gang tunes an oscillator at the signal frequency, and another section tunes the usual local oscillator. If these two are combined in the normal mixer circuit, we have a beat frequency in the plate circuit equal to the normal i-f. By beating this i-f signal with a signal of the same frequency from a signal generator, in a tube such as a 6L7, it is possible to listen with headphones in the 6L7 plate circuit to the tracking error.

The circuit is shown in Fig. 1. The antenna coil is wired in a Franklin oscillator circuit and the output of this signal-frequency oscillator is coupled to the signal grid

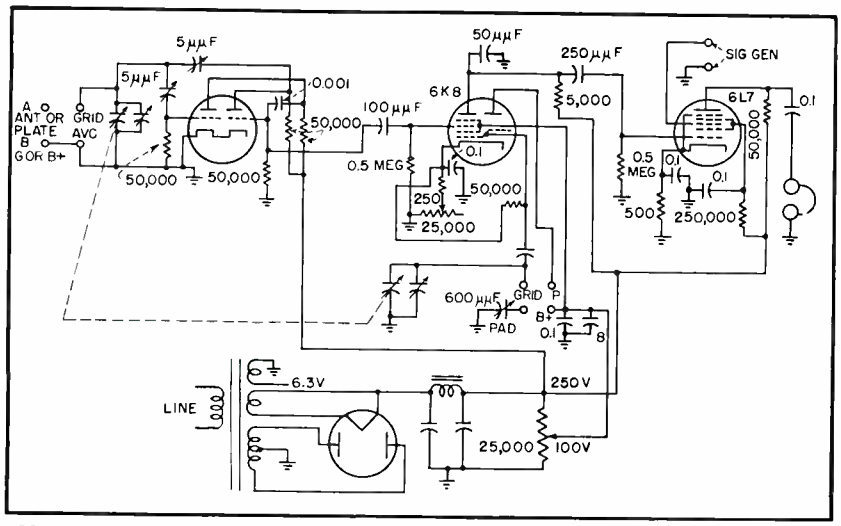


FIG. 1—Complete circuit for checking the tracking error in superheterodyne receivers. The coil terminals are lettered to indicate the corresponding connections in a typical receiver

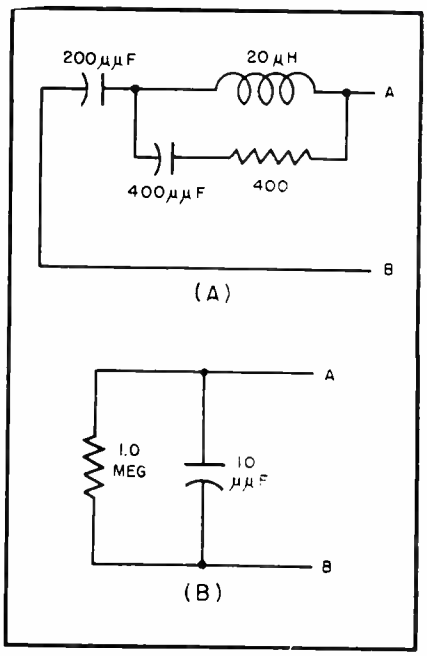


FIG. 2—Loading circuits for connection to the primaries of antenna and r-f coils

of the 6K8. The 6K8 oscillator circuit is normal. The i-f signal appearing at the plate is coupled to the injection grid of a 6L7 detector. The output of a signal generator, tuned to the i-f frequency, is fed into the other input grid of the 6L7, and headphones are connected in its plate circuit.

Mixer Output

Although the signal in the 6K8 plate circuit contains beats equal to the sum and difference of the signal and oscillator frequencies, as well as traces of both their fundamentals and their harmonics, in practice the amplitude of the difference frequency (normally used as the i-f) is so large compared with the beats from other harmonics, that these latter may be almost disregarded. A bypass capacitor in the 6K8 plate circuit removes some of the higher order harmonics.

A gain control in the 6K8 cathode circuit enables the operator to compensate for high signal oscillator output driving the 6K8 signal grid positive.

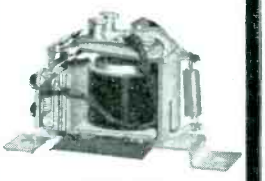
Fig 2A shows the constants required for loading the antenna winding. The free primary does, in most cases, show self-resonance at some point within the tuning range of the secondary. If there is self-resonance, and the coupling coefficient is of normal value, the

Relays BY GUARDIAN

FACTORY STANDARD WITH SPECIAL VARIATIONS

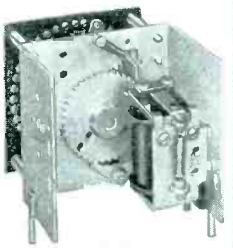
Series 500
Midget Relay

Use this relay where space, weight and maximum power delivery are primary factors. Sturdy. Offers many contact combinations. Maximum contact control capacity 8 amps. Fits in approximately 1½ cu. in. space.



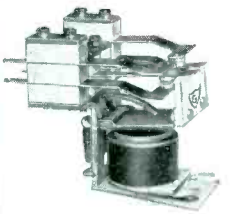
Series 150

Suitable where a small A.C. control relay is needed or if exposed to possible maladjustment. Equipped with "special" spring tension contacts which "make" before the armature fully completes its travel. Remaining armature movement is taken up by the contact coil spring insuring a firm, wiping contact.



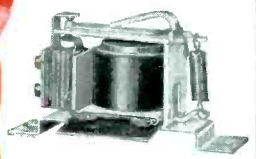
Series R Stepper

Three basic types for A.C. and D.C. operation: (1) Continuous rotation, (2) Electrical reset, (3) Add and subtract. For automatic circuit selection including automatic sequence; automatic wave changing on short wave transmitters; business machines; totalizers; conveyor controls, etc.



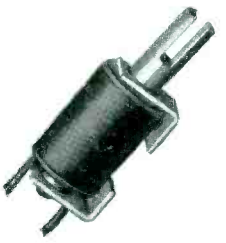
Series A-100
High Frequency

A1SiMag insulated, compact, low cost. For antenna changeover; break-in; hi-voltage keying; remote control of receiver and transmitter and other high frequency applications.



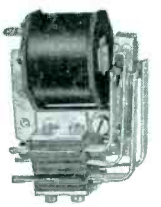
Series 120

A small, compact relay. An economical unit designed for control up to single pole double throw. Unique armature assembly prevents arcing. Low priced, yet high in quality and performance.



Series 1-A Solenoid

The series 1-A Solenoid by Guardian is one of numerous types for intermittent and continuous duty. Applications include valve control and operation; electrical locking; clutch and brake operation; material eject on; spray gun operation among others.



Series 40 A.C.
Laminated Relay

Designed to produce maximum output with minimum current input. Typical uses include control of call system bells; auxiliary for automatic radio tuning; remote control of fractional motors; safety devices; instruments; sound movie auxiliaries.

Guardian Switches

Switch assemblies by Guardian are unlimited, ranging from a single set of contact blades up to multiple stacks. The Guardian Featherub Switch shown is actuated mechanically. Operates on manual, roll-over or cam action. There are hundreds of others. Contact blades are obtainable in phosphor bronze, tinned to withstand salt spray test, or standard Guardian phosphor bronze.

Introducing a new product? Redesigning an established favorite? You may be thinking in terms of a "special" electrical control. Yet, a *basic* type Guardian Relay—Stepper—Contactor—Solenoid—or Switch Assembly (each adaptable to many variations) may meet your "special" control requirements with utmost efficiency. In such applications where *standard* Guardian units become "specials," the savings in time and money are substantial and you beat delivery schedules in the bargain. We urge you—study the *standard* Guardian units pictured and described above—there are many more fully illustrated in the Guardian Relay catalog giving complete operating details and variable contact data for each. Your copy is waiting. Write.

GUARDIAN ELECTRIC

1625-A W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

Feller

coupled reactance of the primary may shift the resonant frequency of the secondary appreciably. Figure 2B shows a loading circuit for the primary of an r-f coil. The 10-$\mu\mu$f capacitor has been included as being a reasonably close approximation to the output capacitance of most of the r-f pentode tubes in normal use.

A curve for normal oscillator tracking is shown in Fig. 3. In the case of a simple superheterodyne, we can assume that the original calculations called for the three points of perfect tracking as 600, 1,000, and 1,400 kc. These perfect tracking points show as crossovers on the curve.

Method

While it may be possible to position the 1400-kc crossover point correctly by adjustment of the parallel trimmers, and to position the 600-kc point by adjustment of the series padder, only correct oscillator coil inductance will position the 1,000-kc point correctly. The effect of too high an oscillator inductance is to make the two higher-frequency crossover points bunch together at the high-frequency end of the tuning range, and to make the tracking error large at the lower frequency end of the tuning range.

The procedure for taking a tracking error curve is quite simple. The antenna and oscillator coils are checked first. The signal generator is tuned to the correct i-f frequency and connected to feed the 6L7. As in normal alignment, the trimmer capacitors are adjusted at 1,400-kc, the padder at 600-kc, and the 1,400-kc point rechecked. The proper adjustment is indicated by zero beat in the headphones.

When the gang is tuned from the full-in to full-out position, if the oscillator inductance is correct there should be three points of zero beat, 600, 1,000, and 1,400 kc. At other than these points the beat note in the phones will vary in pitch with the position of the tuning capacitor.

The deviation from perfect tracking at any point may be measured by leaving the gang set at that point and retuning the signal generator for zero beat. It is possible to determine exactly the deviation in kilocycles from perfect tracking, and to tell if the oscillator signal is high or low in frequency. It is then a matter of minutes to plot a curve. With an intermediate frequency of 465 kc, a deviation of about 5 kc appears in order, particularly with a standard gang which would be almost certain to show some inaccuracy in itself.

The procedure in the case of an r-f coil is to remove the antenna coil, substitute the r-f coil, and leave all trimmers set as they are. When the r-f coil primary is loaded correctly, rotation of the gang should produce a similar curve, with little or no alteration of the antenna trimmer.

If the equipment is made so that coil connections can be easily and quickly made, then a tracking error curve can be made in a few minutes. The system has proved itself here in a practical way, and the accuracy would appear to be well within the limits of mass-production manufacturing tolerance.

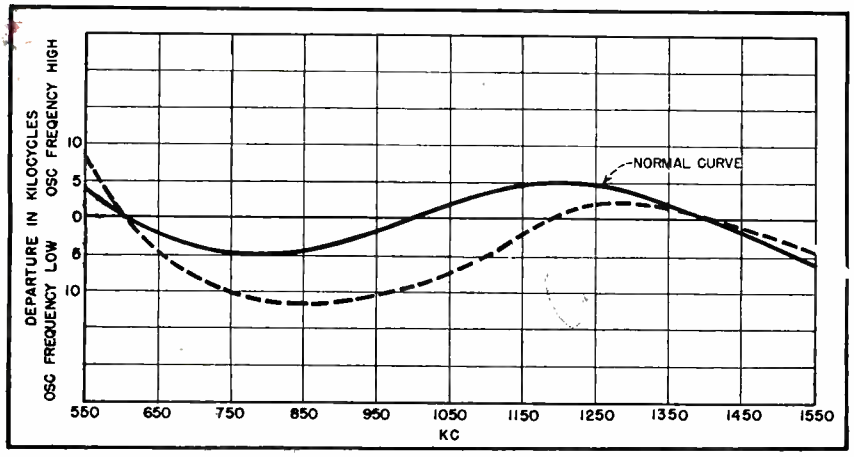


FIG. 3—Curves showing the departure of a receiver oscillator from perfect tracking. The dashed curve is that obtained when the oscillator inductance value is too great

Magnetron Modulation

AMPLITUDE MODULATION of a magnetron oscillator presents a number of difficulties, the most fundamental being the nonlinear relationship between the anode and output voltages. In practice, undesired frequency modulation is often the most serious defect and the General Electric Co. of Great Britain overcomes this in an experimental equipment by modulating the anode voltage with a signal having a square waveform and repeating at a frequency of 17 kilocycles so that the magnetron oscillates only during alternate half periods. Audio modulation is superimposed by varying the duration of the pulses of modulation.

In reception, a lowpass filter, which can be the human ear, converts the pulse-width modulation to amplitude modulation.

Hum-Reducing Circuit

BY ALVIN H. SMITH

Technical Supervisor
Station KSCJ
Sioux City, Iowa

THE CIRCUIT shown in Fig. 1 can be used to reduce carrier hum in a transmitter if the source of hum is 240 cps. It is particularly useful in transmitters having a Scott-connected two-phase filament supply and has been so applied in a five-kilowatt composite a-m broadcast transmitter at KSCJ.

The a-c output of the circuit in Fig. 1 is approximately 0.5 volt at 240 cps. This voltage may be fed into the audio circuits of the transmitter at any point desirable, observing polarity of leads for cancellation of hum, also ascertaining that other circuits are not adversely affected.

A bridging circuit across the transmitter a-f input terminals was used at KSCJ to insert the 240-cps a-c into the audio circuit, where after subsequent amplification and modulation, it acts to balance out the 240-cps component generated

NEW! Designed for FM!

TYPE 5530 with terminal arrangement for grounded-grid application, as in Western Electric 3 kw FM transmitter.

TYPE 5541 with terminal arrangement for grounded-plate application, as in Western Electric 10 kw FM transmitter.

Western Electric

Forced Air Cooled Transmitting Triodes

Designed by Bell Telephone Laboratories, these new triodes are tops in performance in the 88 to 108 megacycle FM band.

Their filaments are of thoriated tungsten—the most efficient emitter for power tubes of these ratings.

Their rugged construction—brazed and welded metallic joints, Kovar-to-glass seals, protected metallic vacuum "seal-off", and self-supporting filament structure—insures long dependable service.

Their terminal arrangements are designed for maximum flexibility of application. Tubes having identical electrical characteristics can be "factory tailored" with suitable attachments for special terminal requirements.

For further details: Call your local Graybar Broadcast Representative—or write Graybar Electric Company, 420 Lexington Avenue, New York 17, New York.

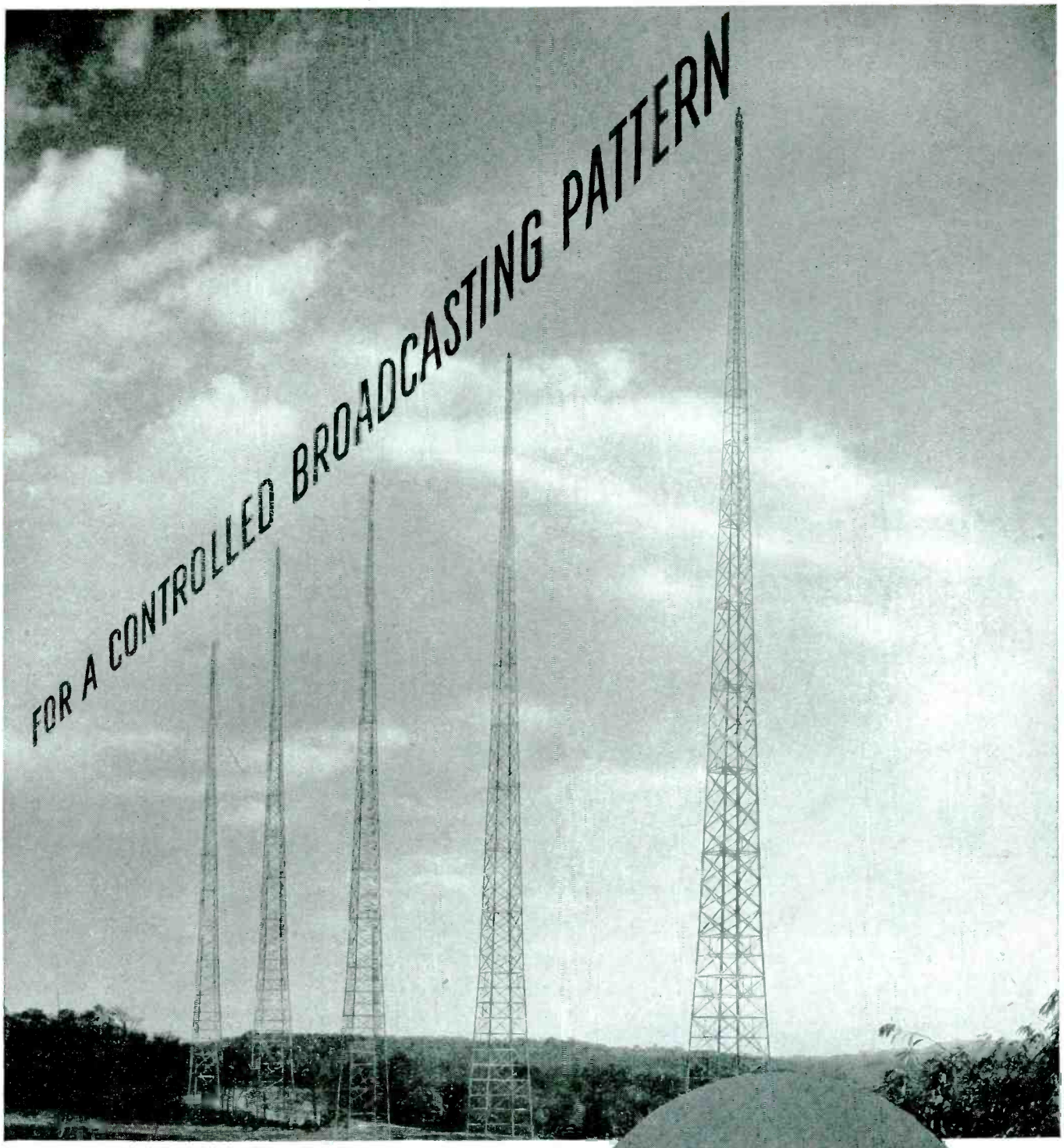
—QUALITY COUNTS—

	TYPE 5530	TYPE 5541
Filament—Thoriated Tungsten		
Filament Voltage	5 volts a-c	7.5 volts a-c
Filament Current	55 amperes	55 amperes
Amplification Factor	26	26
Maximum Ratings (Apply at frequencies up to 110 megacycles)		
Direct Plate Voltage	4500 volts	8500 volts
Direct Plate Current	2.25 amperes	3.25 amperes
Plate Dissipation	3 kilowatts	10 kilowatts
Interelectrode Capacitance		
Plate to Grid	*23.0 mmf	25.0 mmf
Plate to Filament	* 0.6 mmf	1.5 mmf
Grid to Filament	*20.0 mmf	21.0 mmf
Maximum Dimensions		
Height	7-11/16 inches	9-25/64 inches
Diameter	5-5/32 inches	8-1/32 inches

*Tube shielded as in grounded-grid operation

Western Electric

Distributed by GraybaR — OFFICES IN 92 PRINCIPAL CITIES



Pittsburgh's new 5,000-watt KQV station will shortly offer greatly improved reception to its expanding radio audience.

Facilitating their transmission to selected areas is this directional array of five 350 ft. vertical radiators, designed and erected by Blaw-Knox.

BLAW-KNOX DIVISION
OF BLAW-KNOX COMPANY
2077 Farmers Bank Building, Pittsburgh 22, Pa.

BLAW-KNOX
Antenna
TOWERS

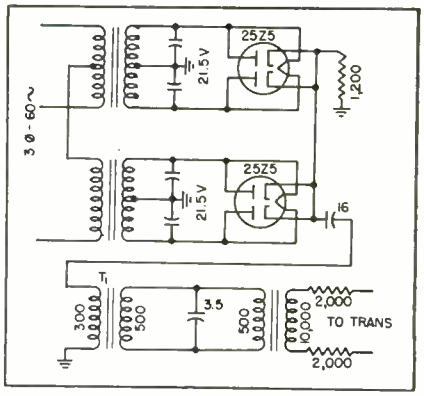


FIG. 1—Heaters and plates of the 25Z5 tubes are supplied by the same winding that feeds the 343A tubes in the transmitter

in the transmitter. This connection is shown in Fig. 1.

It is desirable to experiment with different values of capacitance, as resonance at 250 cps is desired in both the primary and secondary circuits of T_1. The wiring should be kept out of strong r-f fields. The ground connections should be made directly to the center taps on the filament transformers, rather than just any transmitter ground. These precautions are necessary in order to prevent r-f pick up which produces an undesirable a-f output in the 240-cps hum-reducing circuit.

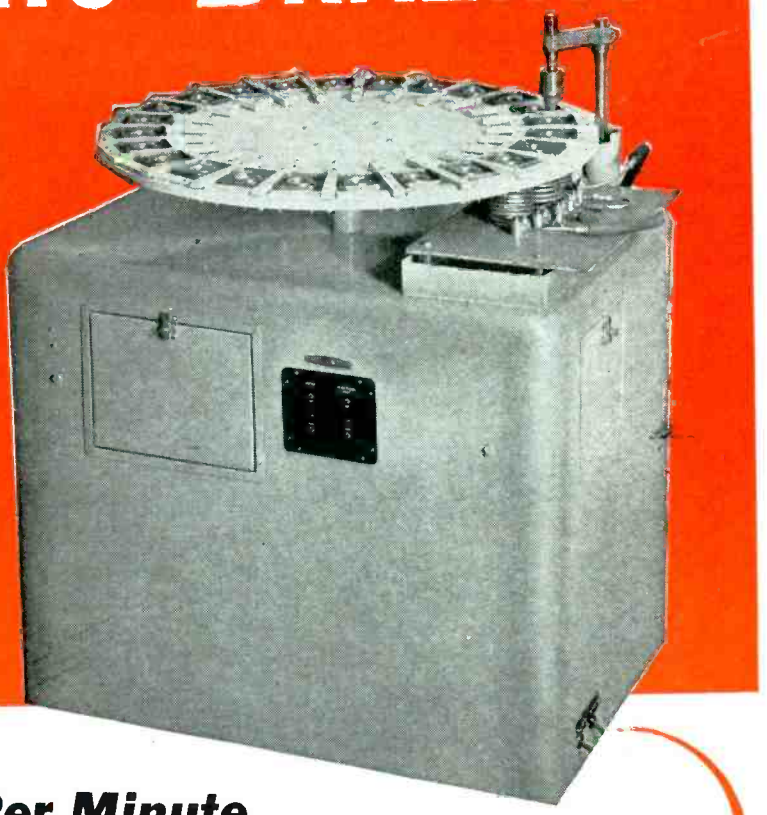
This circuit is largely self regulating as its input is taken from the power amplifier filament supply—both will increase and decrease together. The 25Z5 tubes must be matched for best results.

As pointed out by Loy E. Barton "Hum Compensator for Broadcast Stations," (*RCA Broadcast News*, Feb. 1935), the predominate hum frequency using a 60-cps supply is 240 cps. This fact was verified by the use of a General Radio sound analyzer.

With 14 db of inverse feedback in the KSCJ transmitter, the following readings were obtained, before the hum-reducing circuit was connected: at 60 cps, −68 db below 100 percent modulation; at 120 cps, −56 db; at 180 cps, −67 db; at 240 cps, −47 db; and at 360 cps, −60 db.

Using 14 db of inverse feed-back, the noise reading on a General Radio distortion and noise meter—used by many broadcast stations—was −41.5 db. A carrier noise reduction of 8.5 db was obtained with the hum-reducing circuit, giving a

ELECTRONIC BRAZING UNIT with 24 Station INDEXING Work Carrier



Delivers 5 Complete Assemblies Per Minute

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

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

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

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

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

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

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

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

Scientific Electric

Division of

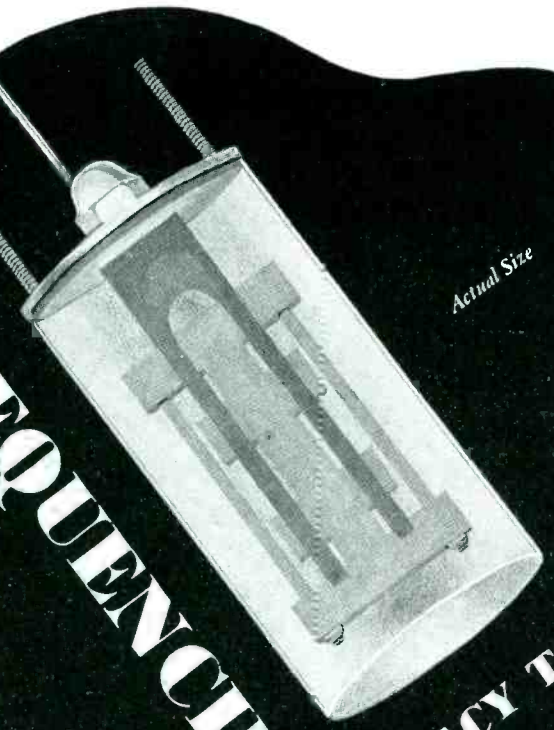
"S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

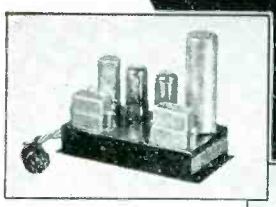
Manufacturers of

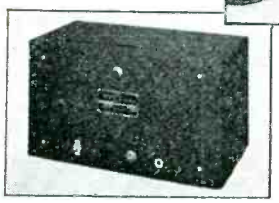
Vacuum Tube and Spark Gap Converters Since 1921

LOW FREQUENCIES



ACCURACY TO 1/1,000th of 1%





TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

Dist. of Western Electric & Watch Master Watch-rate Recorders

THE FINEST CORED SOLDER IN THE WORLD

AVAILABLE

Special
High Conductivity
RADIO ALLOY
90 tin/10 Lead

Our claim is a simple one. We believe that Ersin Multicore is the finest cored solder in the world. If you are not already familiar with our product, we believe it can be of special assistance to you in your soldering processes whether you are manufacturing 10,000 radio receivers or repairing one • Ersin Multicore is solder in the form of a wire containing 3 cores of non-corrosive Ersin Flux • You get a guarantee of flux continuity. The Multicore construction gives you extra-rapid melting. Combined with a super active Ersin Flux—**Exclusive with Multicore**—you enjoy a speedy and consistently high standard of precision soldering • Available in 5 alloys and 9 gauges. Please write for detailed technical information and samples.

ERSIN MULTICORE

U.S.A. Distributor: British Industries Corp., 315 Broadway, New York 7, N. Y. Canadian Distributor: Sni-dor Radioelectric Ltd., 445 Craig St. West, Montreal

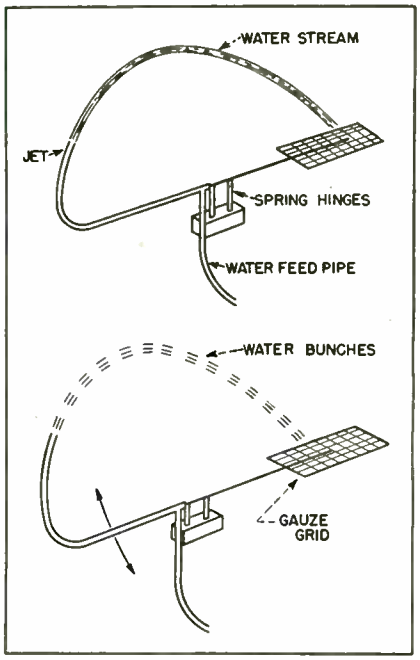
carrier noise level of −50.0 db. Tests indicated that the 240-cps component, for all practical purposes, was eliminated. From a listening standpoint this 8.5-db reduction is very pronounced, as 240 cps is readily passed by most receivers and the ear is fairly sensitive at that frequency.

Mechanical Klystron For Demonstration

A SIMPLE but excellent model illustrating klystron action is shown in the accompanying illustration.

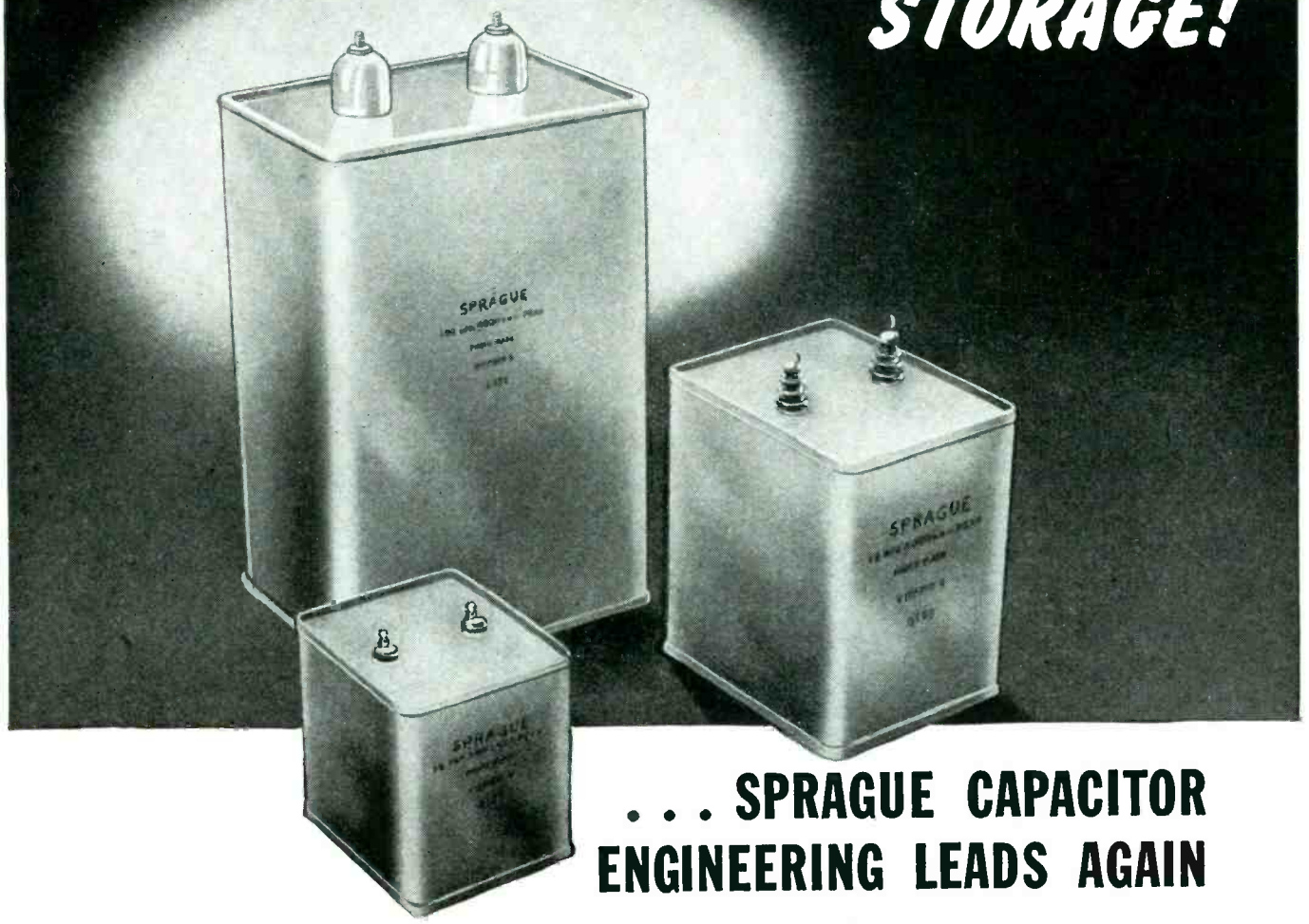
It consists of a balanced horizontal hollow arm mounted on two adjustable spring hinges representing the tunable resonator. At one end of the arm a piece of close-mesh gauze represents the catcher grid and at the other end is an almost vertical nozzle fed with water through the hollow arm and a flexible rubber tube. The whole arrangement resembles a pair of scales with the jet of water set to shoot up in the air and to impinge on the gauze as it falls.

Starting from rest, the random motion of the water breaking into globules produces sufficient agitation (corresponding to electronic



When the water stream starts flowing, it hits the gauze grid and starts the see-saw action. The result is spurts of water being thrown to the gauze grid much like the electron bunching in a klystron

PHOTOFLASH! ENERGY STORAGE!



. . . SPRAGUE CAPACITOR ENGINEERING LEADS AGAIN

Photoflash units for war applications used Sprague *VITAMIN Q Capacitors—*because only Vitamin Q Capacitors could withstand the severe service conditions encountered.*

Privileged to work with the inventors of photoflash photography from its early inception, Sprague engineers have contributed materially to its post-war development. Not only has the present line of capacitors impregnated with the famous and exclusive Vitamin Q dielectric established new standards of compactness, light weight and dependability for electric flash tube (photoflash) photography; equally important it paves the way for outstanding economies and greater efficiency for capacitors for flash welding and time control circuits where duty cycles other than photoflash conditions prevail.

GET THE FACTS!

PHOTOFLASH ENERGY-STORAGE DATA BULLETIN ON REQUEST

Write for Bulletin #3205. Contains specifications and performance data on Sprague Vitamin Q Capacitors —also helpful, up-to-the-minute information on photoflash problems.

SPRAGUE

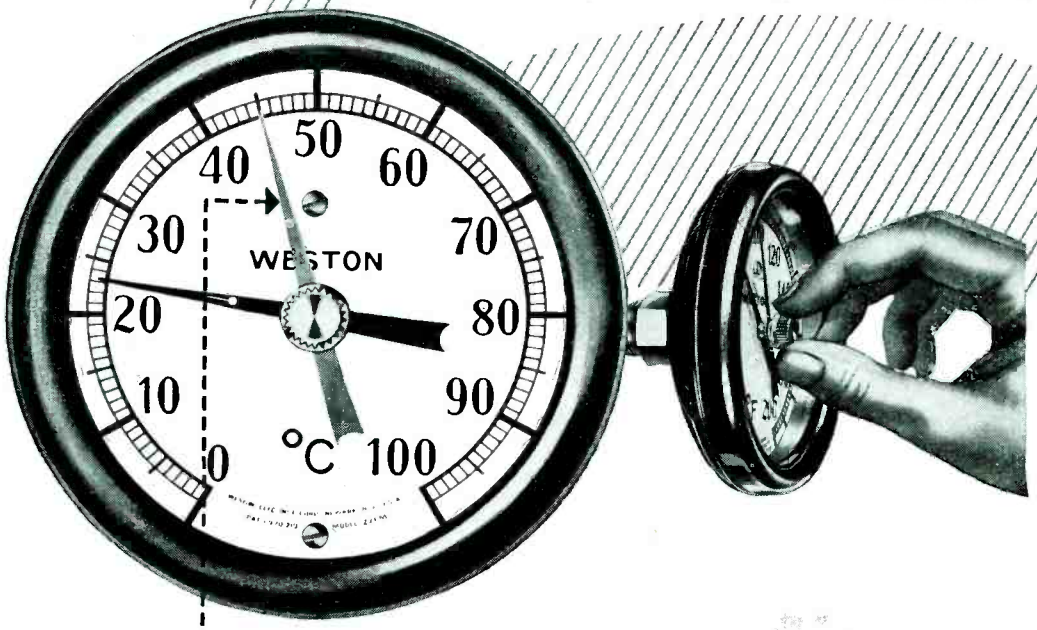
PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

SPRAGUE ELECTRIC CO., North Adams, Mass.

*Trademark Reg. U. S. Pat. Off.

NEW all metal WESTON

MAXIMUM-MINIMUM Thermometer



RED INDEX shows the highest or lowest temperature reached!

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

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

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

Weston *Instruments*

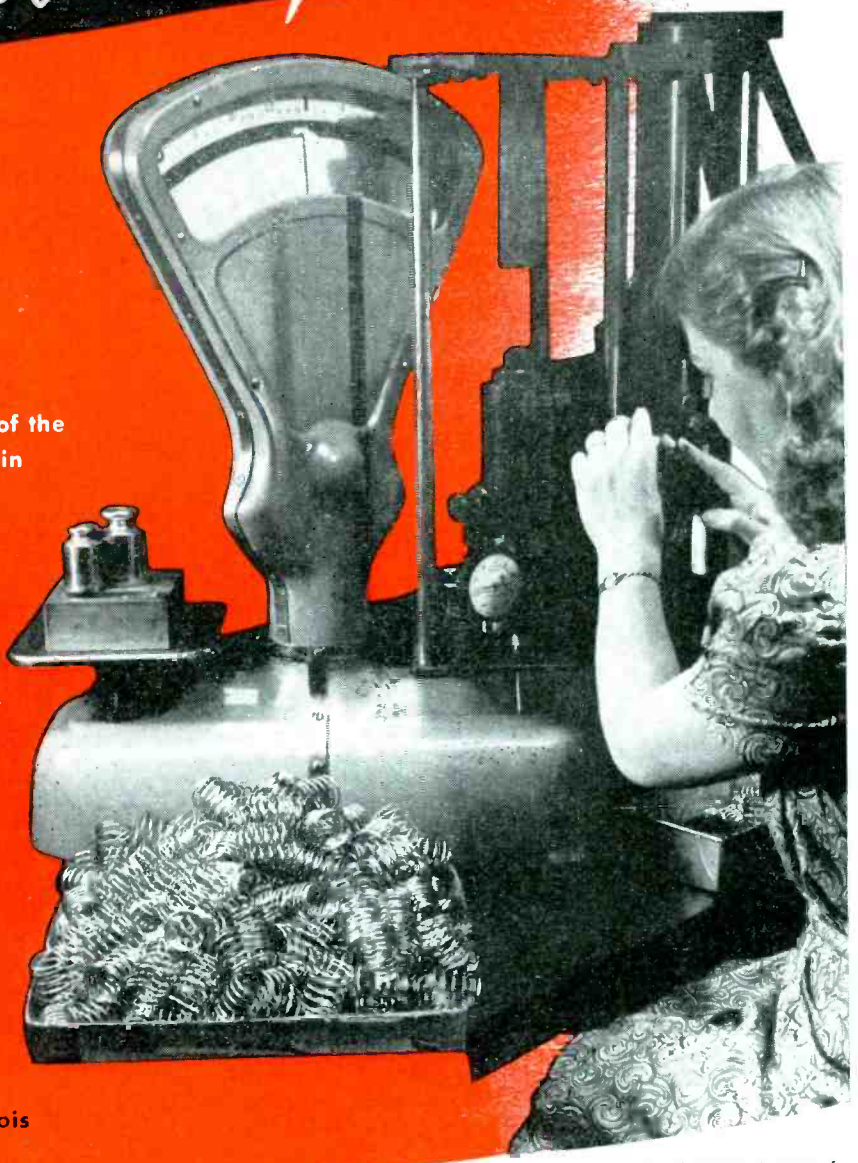
ALBANY • ATLANTA • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT • JACKSONVILLE • KNOXVILLE • LOS ANGELES • MERIDEN • MINNEAPOLIS • NEWARK NEW ORLEANS • NEW YORK • PHILADELPHIA • PHOENIX • PITTSBURGH • ROCHESTER • SAN FRANCISCO • SEATTLE • ST. LOUIS • SYRACUSE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

the uniformity of Accurate Springs

means lower ultimate cost FOR YOU!

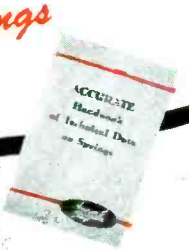
Ordinarily you don't speak of the uniformity of a batch of springs in the same breath with cost. But the two are really inseparable . . . variations in the size and shape of springs can cause the loss of dollars worth of assembly time . . . variations in load characteristics can result in unsatisfactory operation of the finished product.

Here at Accurate you'll find skilled springmakers and practical, experienced engineers . . . people who realize the importance of uniformity to you. Why not make it a point to discuss your spring problems with us. ACCURATE SPRING MFG. CO., 3830 W. Lake Street, Chicago 24, Illinois



Load testing is one of several controls exercised at Accurate.

Springs — Accurate Springs — Wire Forms • Stampings



Send for your copy of the new Accurate Spring Handbook. It's full of data and formulae which you will find useful. No obligation of course.

agitation) to initiate oscillation of the arm, providing that the jet velocity is correct. The jet then starts rocking with simple harmonic motion as the globules hit the gauze grid and so the water globules are modulated in velocity.

During one-half of the stroke, the water is accelerated and during the other half retarded, with the result that the drops bunch in a most striking manner and when the system is tuned correctly they hit the gauze on its downward path and so maintain oscillation. Thus, over one cycle more energy is given to the system than is absorbed by friction.

A model on these lines is particularly suited to explain klystron action as bunching is quite plain from the droplets of water in mid air and, when the jet velocity is incorrect (corresponding to improper beam voltage), the oscillations do not build up or even maintain themselves. The model described was built by the research laboratory of the British Thomson-Houston Co.

Carrier Failure Alarm

By Richard E. Thornton
Studio Engineer
Station KXYZ
Houston, Texas

This station has an auxiliary transmitter in the same location as the control room and studios, and it became a problem for the studio staff to efficiently employ the auxiliary transmitter when the regular five-kilowatt transmitter went off the air due to power failures and other emergencies.

The regular monitoring system in the control room was capable of being fed off the audio output of a monitoring receiver, but during bad weather and lightning storms was practically impossible to use for program purposes. Several procedures and systems were suggested but were not satisfactory. Upon several occasions the regular transmitter was off the air for several minutes before the studio operator was notified, due to unavoidable complications.

An alarm system was incorporated in the receiver itself, thereby reducing size of unit necessary, wiring, and simplicity. An RC com-

CONCENTRICITY...

For Uniform Transmission Characteristics in High Frequency Lines

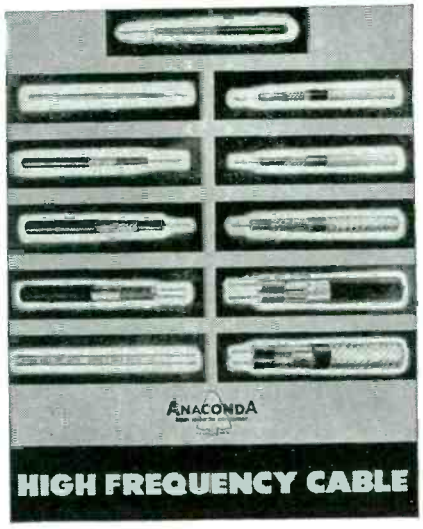
IN COAXIAL CABLES, more than in any other types, accurate relationship between the component parts is essential.

Concentricity and uniformity of conductors and dielectric join in Anaconda Coaxials to effectively fulfill the objectives of electrical designers.

Each type is specifically designed to serve best in the intended application. All electrical characteristics are held within close limits to uniform standards assuring accurate surge impedances.

In addition to manufacturing standard types of coaxial cables, Anaconda offers research and engineering facilities to meet needs for specialized types.

45306



ANACONDA
from mine to consumer

ANACONDA WIRE & CABLE COMPANY

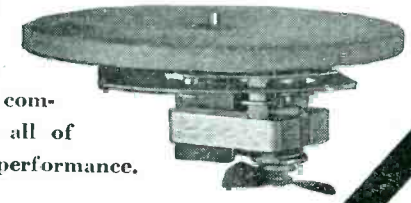
GENERAL OFFICES: 25 Broadway, New York City 4
Subsidiary of Anaconda Copper Mining Company
CHICAGO OFFICE: 20 North Wacker Drive 6 • Sales Offices in Principal Cities

Write for these useful, new folders containing characteristics of Anaconda high-frequency coaxial cable and television lead-in lines. Address: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

- PRECISION WIRE WOUND RESISTORS
- WHEATSTONE BRIDGES
- RADIO & ELECTRONIC TEST EQUIPMENT
- RADAR ASSEMBLIES

Eastern Electronics Corp.

PHONOGRAPH TURNTABLE UNIT The need at this time for large quantities of phonograph turntable assemblies has prompted us to quickly design and tool up for the immediate production of this item. Engineers will find this compact turntable meeting all of their requirements for performance.



PERFORMANCE: — Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

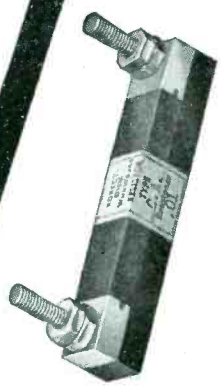
QUIETNESS: — Is assured by full-floating rubber motor mountings and rubber cushioned drive. Permanent freedom from turntable wobble is guaranteed by an extra rigid turntable, an extra long bearing and precision machining of these parts.

RELIABILITY: — The motor is fan-cooled and will operate continuously with an exceptionally low temperature rise. All bearings are of ample size and are provided with self-lubricating features.

Type C
Maximum resistance 500,000 ohms.

Type A
Maximum resistance 1,000,000 ohms.

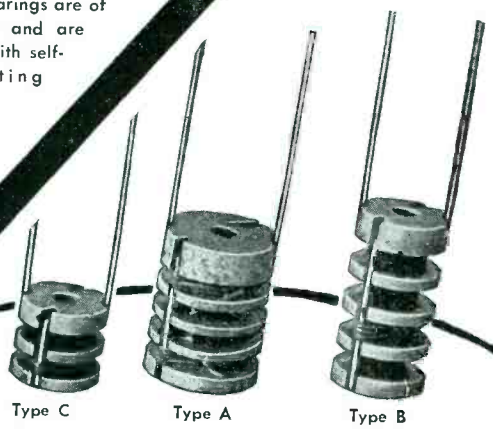
Type B
Maximum resistance 1,000,000 ohms.



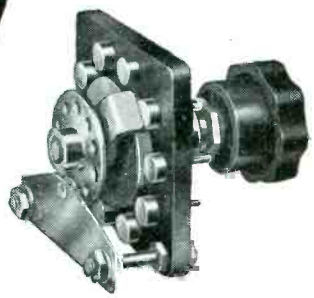
Type XM
Instrument resistance shunt .1 ohms or lower. 25 watts.

★ ★ ★

We will make special resistors to any value or tolerance.



Type C Type A Type B



ROTARY SELECTOR SWITCH

Designed for use where low contact resistance and mechanical sturdiness is required. Its construction insures long wear with low contact resistance of less than .001 ohm. May be arranged to have several sections to obtain multi-polar switching.

Well suited for precision test instruments; shunt ammeters, thermo-couple types, Wheatstone Bridges, and similar devices.

Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

New York Sales Office
Turney & Beale
215-05 27th Ave.
Bayside, Long Island, N.Y.
Tel. BA 9-8958

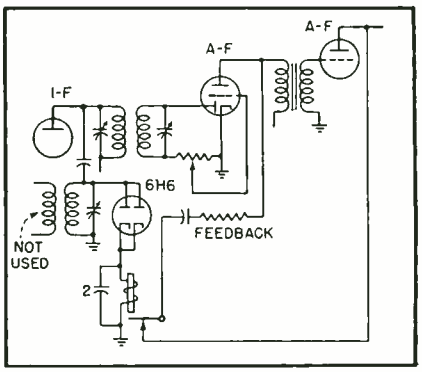
Chicago Sales Office
Bauman & Bluzat
2753 West North Ave.
Tel. Humboldt 6809

Boston Sales Office
11 Pemberton Square
Tel. Capitol 2425

J. E. Oliphant and Company
505 Uhler Building
Marion, Ohio

Toronto Sales Office
C-H Engineering Co.
137 Wellington St. West
Toronto, Canada
Tel. Adelaide 5366

bination was used between the output transformer and the plate of the first audio stage, so that the feedback level would be appreciably more than monitoring level. The output of the receiver speaker, with carrier on, was not enough, however, to impair monitoring on the regular master control room speaker. In this way, the receiver may be tuned and audio level set satisfactory to the operator on duty. As long as the carrier is on, static-free monitoring off the transmitter bus is accomplished. If, for any



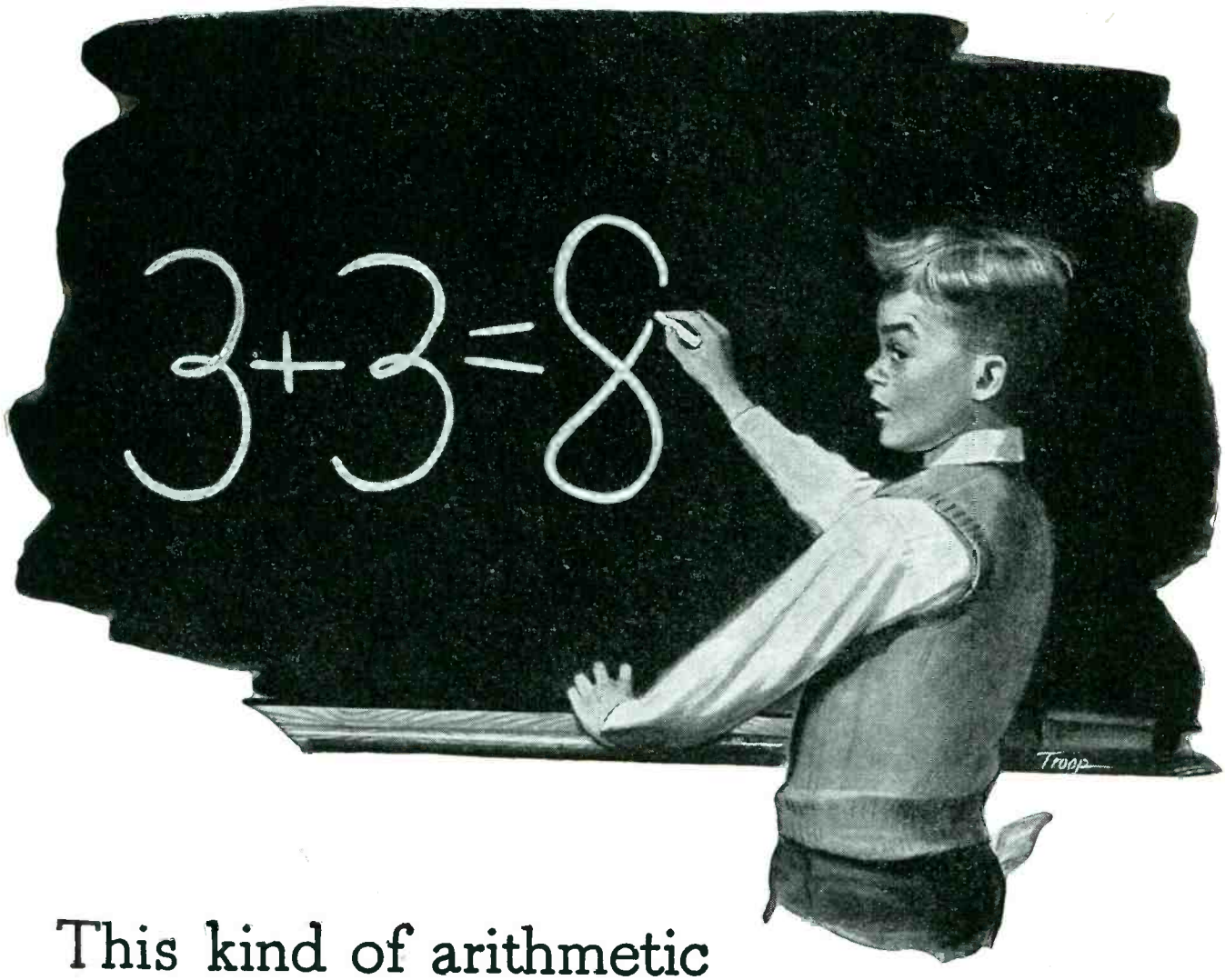
Simple additions to the circuit of a monitoring receiver form a carrier failure alarm

reason, the carrier ceases, the relay switches in the feedback circuit, and the resulting tone signal overrides any level that the monitor may be feeding to master control.

Circuit

An extra i-f transformer was coupled to the plate of the last i-f stage through a small coupling capacitor. The secondary of the added unit was tied to the plates of a H6 and a sensitive relay inserted in series with the cathodes of the 6H6, as shown in the diagram. A one-ma relay performs admirably. A capacitor was tied across the relay winding to prevent chatter due to modulation.

Adjustment of the unit is not critical. The carrier is applied to the antenna input terminals of the receiver and the r-f gain advanced on the receiver to a point slightly beyond that necessary to actuate the relay. This advance is necessary due to the fact that slightly more current is required to reset the relay when the carrier comes back on after a dropout than is necessary for initial adjustment. The i-f transformer is tuned to resonance



This kind of arithmetic may put Johnny through college

Here's how it works out:

$3 put into U. S. Savings Bonds today will bring back $4 in 10 years.

Another $3 will bring back another $4.

So it's quite right to figure that 3 plus 3 equals 8 . . . or 30 plus 30 equals 80 . . . or 300 plus 300 equals 800!

It will . . . in U. S. Savings Bonds. And those bonds may very well be the means of helping you educate your children as you'd like to have them educated.

So keep on buying Savings Bonds—available at banks and post offices. Or the way that millions have found easiest and surest—through Payroll Savings. Hold on to all you've bought.

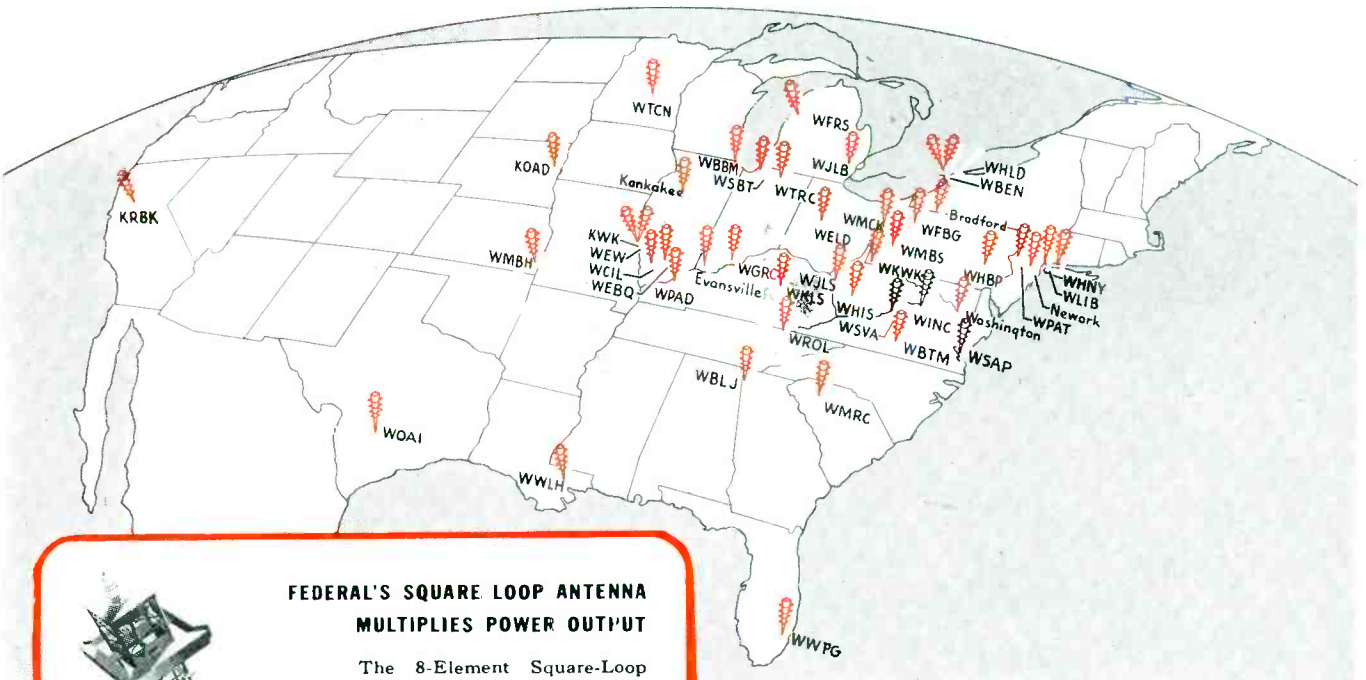
You'll be mighty glad you did . . . 10 years from now!

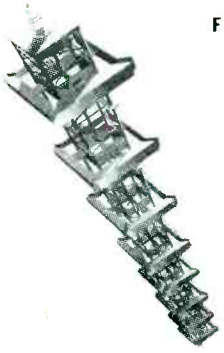
SAVE THE EASY WAY... BUY YOUR BONDS THROUGH PAYROLL SAVINGS

Contributed by this magazine in cooperation with the Magazine Publishers of America as a public service

With Leading Stations from Coast to Coast

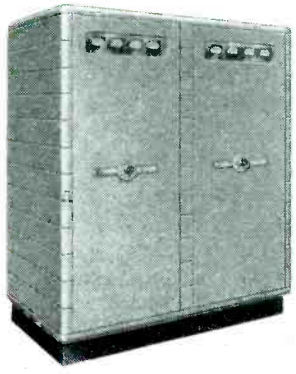
it's FM by Federal





FEDERAL'S SQUARE LOOP ANTENNA MULTIPLIES POWER OUTPUT

The 8-Element Square-Loop Antenna – an outstanding Federal development – gives your FM station an effective radiated power more than eight times that of the transmitter rating. A single adjustment per loop tunes for any frequency from 88 to 108 mc. Complete antenna and rugged supporting tower are designed to withstand heavy winds and icing loads.



FEDERAL FM TRANSMITTERS FEATURE "FREQUEMATIC"* MODULATOR

The "Frequematic" modulator – an exclusive feature of every Federal FM transmitter – assures outstanding fidelity and mean carrier stability. Simple all-electronic circuits with standard receiver tubes simplify initial alignment and reduce maintenance expense. Holds center frequency within .001%. Signal-to-noise ratio reduced to 5600-to-1.

*Trade Mark

TODAY, station operators everywhere look to FM for finer broadcasting. And they look to Federal for the finest in FM. Already, Federal equipment is on the job in major FM stations throughout the country—setting new records for performance and dependability.

Remember that FM by Federal means complete equipment—and complete service, too. For Federal can supply your entire transmitting system, from microphone to antenna—all components precision engineered and designed to work together. And Federal will see the job through until your station is *on the air*. Factory-trained engineers will supervise installation, tune the equipment, and instruct your personnel in its operation and maintenance—all without extra charge. For complete information, write today to Dept. B-213.

Federal Telephone and Radio Corporation

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

An IT&T Associate — Federal Telephone & Radio

Newark 1, New Jersey

by means of maximum reading on a 0-5 ma meter in series with the cathodes of the 6H6.

Since installation, there have been no failures of the alarm and it has saved quite a bit of otherwise lost broadcast time.

Pulse Detector as Noise Limiter

A METHOD of c-w reception without noise has been demonstrated in several cities around the country by Don L. Hings, vice-president of Electronic Laboratories in charge of research.

Called a pulse detector, the equipment consists of a six-tube unit that is attached to a conventional communications receiver. Its circuits operate to prevent noise from entering the audio stages of a receiver and when a c-w signal is received, it allows a local audio oscillator to feed the loudspeaker and reproduce the keyed signals. Essentially it distinguished the difference between the decaying waves of noise and the continuous waves of a desired signal.

The pulse detector functions somewhat inversely to the usual methods of continuous wave reception. The detector circuit is limited by a low-impedance gating circuit, which dissipates energy during the short-circuiting interval. As a result, the detector load circuit receives the lower amplitude of decaying waves at the low gating level and no wave form exists on the detector load circuit during the c-w interval.

The decaying waves, developed from general noise or even from conversion noise in the receiver, are amplified, limited and rectified and the relatively constant d-c component, unless interrupted by a continuous wave at the detector, is used as bias to control a balanced amplifier that is excited by the tone generator.

Operating values are generally set on the receiver so that gating occurs with approximately one microvolt of input signal. Anything in excess of this has no detrimental effect. Consequently, automatic volume control, noise limiting and beat-frequency oscillators are not required in this system of continuous-wave reception.

Speed Nuts*

Give You More Assembly Advantages

Than Any Other Nuts, Regardless of Price

PREVENT VIBRATION LOOSENING

SPEED NUTS prevent vibration loosening because they provide a *double* spring-tension lock that *absorbs* vibration instead of merely *resisting* it. Insures a tight attachment for the life of the product.

SPRING TENSION RESILIENCY

In the assembly of porcelain enamel, plastic or glass parts, SPEED NUTS provide the tension necessary for a tight assembly, yet are sufficiently resilient to prevent damage due to expansion and contraction, vibration or shock.

APPLIED FASTER

SPEED NUTS put wings on your assembly lines because they start easier, pull down faster and no wrench is required to keep them from turning. Made also for use with coarse-thread sheet metal screws, requiring fewer turns to tighten, for still faster application.

ELIMINATE LOCK WASHERS

You can boot lock washers out the window, for SPEED NUTS are self-locking. They cut both material and handling costs. Because of their wide bearing surface, SPEED NUTS also can eliminate the use of spanner washers.

SELF-RETAINING

Many types of SPEED NUTS lock themselves in screw-receiving position for "blind" location assembly, eliminating expensive welding, riveting or clinching operations.

PERFORM MULTIPLE FUNCTIONS

Like a one man band, many special types of SPEED NUTS perform multiple functions, replacing two or more parts. SPEED NUT prongs can be incorporated in almost any shape or form to do the job easier and faster.

LOCK ON UNTHREADED STUDS

"Push-On" SPEED NUTS need only be pushed over rivets, nails, tubing, or unthreaded studs to lock parts so securely, you can't wrestle them off. Costly threaded inserts, drilling and tapping are eliminated—molding costs reduced—assembly speeded up.

WILL NOT CLOG

Having no threads, SPEED NUTS cannot clog with paint. No assembly delay for re-tapping threads. This is particularly important where SPEED NUTS are permanently attached to parts for blind assembly.

WILL NOT "FREEZE" TO THREADS

Having no threads, SPEED NUTS will not "freeze" to rusting bolts. They can be easily removed at any time for servicing or replacing. You'll save the repair men a lot of cussing.

WEIGH LESS

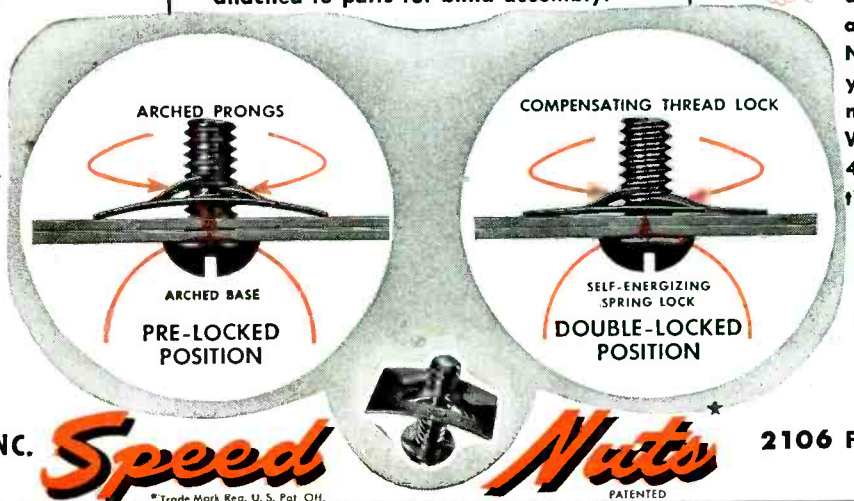
Because they are made of sheet metal instead of bar stock, SPEED NUTS are in the "featherweight" class compared with threaded nuts. By eliminating lock and spanner washers and other unnecessary parts, weight is reduced still further.

MINIMIZE SHIPPING DAMAGE

SPEED NUTS give you free insurance against shipping damage. They provide a resilient lock that defies loosening and prevents cracking of enamel and glass. With SPEED NUTS, your products will reach your customers in perfect condition.

SEND TODAY

We're not fooling about these advantages. They are very real and worth-while as any SPEED NUT user will tell you. Rush your assembly problems to us now, giving complete details. We'll show you which of the 4000 shapes and sizes will do the trick for you.



IN CANADA:
Wallace Barnes, Co., Ltd.
Hamilton, Ontario

IN ENGLAND:
Simmonds Aerocessories, Ltd.
London

IN FRANCE:
Aerocessoires Simmonds, S. A.,
Paris

IN AUSTRALIA:
Simmonds Aerocessories, Pty. Ltd.,
Melbourne

TINNERMAN PRODUCTS, INC. Speed Nuts* PATENTED 2106 Fulton Road, Cleveland 13, Ohio

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

FASTEST THING IN FASTENINGS . . . MORE THAN 4000 SHAPES AND SIZES

INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Color Matching Frit

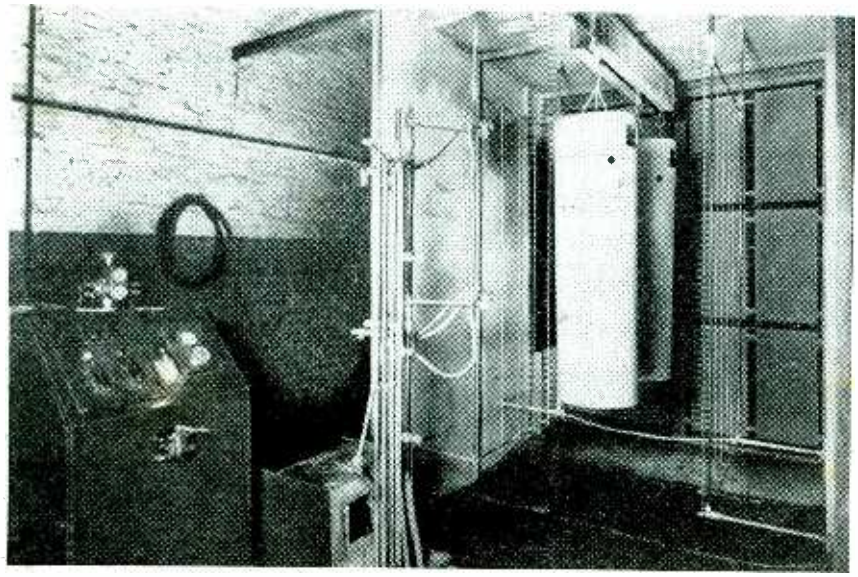
PEMCO CORPORATION, Baltimore, simplifies the matching of porcelain enamel and glass colors and provides a constant quality control check with a G-E recording photoelectric spectrophotometer. It is expected to save from two-thirds to three-fourths of the time needed to match colors at Pemco, as compared to former methods.

The company manufactures porcelain enamel and glass colors and "frit", the raw material of porcelain enamel before it is fused to metal, and must frequently produce colors to match samples sent in by customers. Before adoption of the spectrophotometer the technique was visual comparison. This technique was difficult and often inaccurate, because under certain lighting conditions two colors may appear matched to one person and mismatched to another.

An operator makes a test with the G-E spectrophotometer. The instrument measures and records curves of over two million shades of color

A library of over 1,000 color curves of known composition, representing every porcelain enamel and glass color produced, has been established since installation of the instrument. When a customer submits a sample color, it is analyzed by spectrophotometry and the resulting color curve is matched as closely as possible with one of the curves in the library. An experienced color mixer knows what ingredients must be added to make the curves, and the colors, match perfectly.

ELECTROSTATIC PAINTING



Paint particles, sprayed at water heater casings, are distributed uniformly by the electric field between vertical rods charged by Ransburg Co. equipment

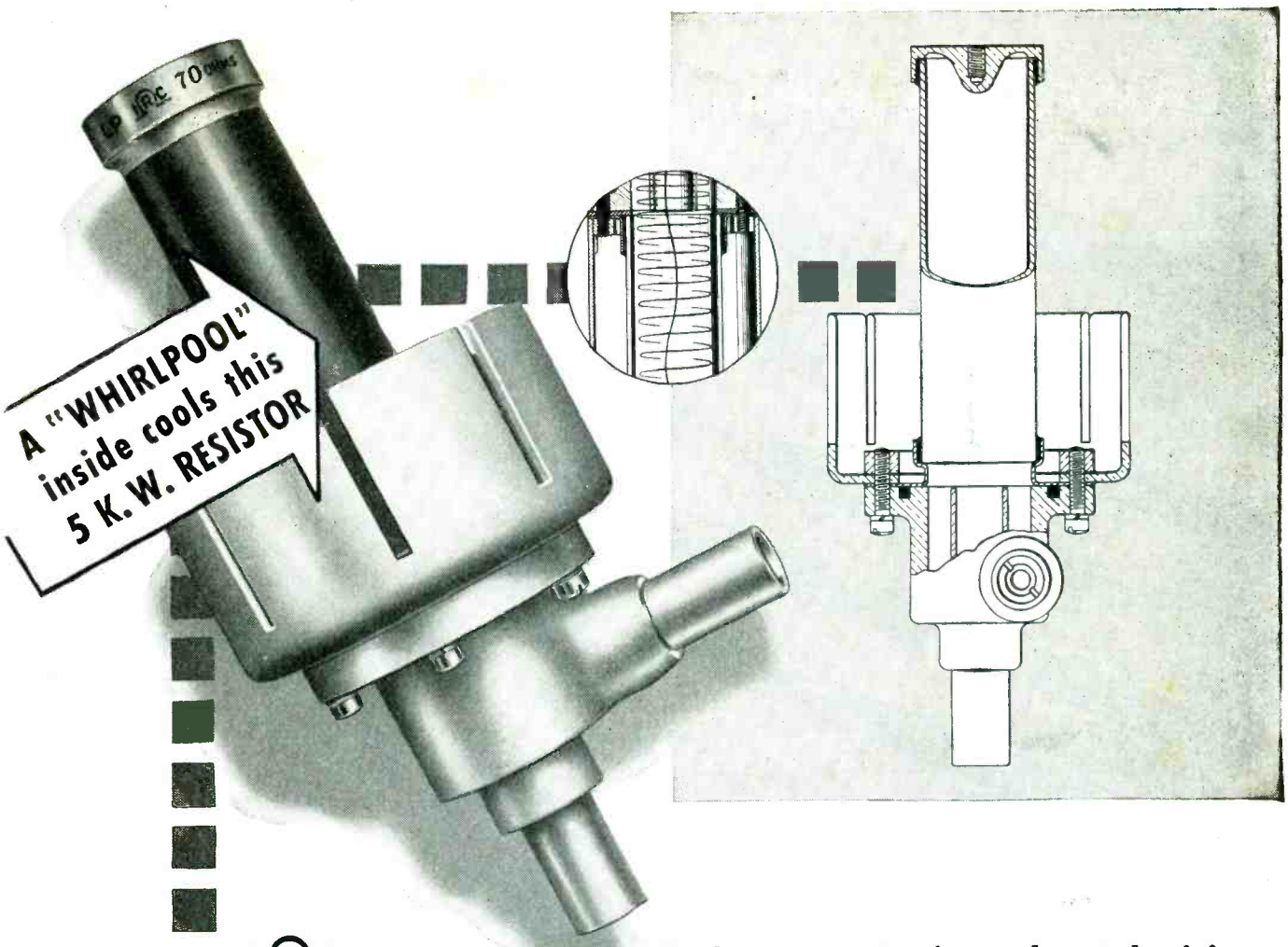
Vacuum-Tube Acceleration Pickup

CAPABLE of measuring accurately the rapidly changing accelerations to which various parts of an airplane are subjected in flight, a new electronic tube has been developed at the National Bureau of Standards under the direction of Dr. Walter Ramberg. It is proving useful in such applications as the measuring of accelerations in portions of the body of "dummy" pilots and living subjects when subjected to critical acceleration during crash landings or seat-ejections from jet-propelled airplanes.

The tube contains a fixed, indirectly heated cathode with two plates, one on either side, and elastically mounted to deflect in response to acceleration normal to the plane of the plates. The deflection causes a change in plate current proportional to the acceleration and such changes in current are recorded on an oscillograph.

The elastic plate mounting gives a fundamental frequency of about 800 cps, so that the tube can record accelerations with frequencies up to 200 cps. So far, 95 of the tubes have been built and tests conducted at the Bureau on the latest type tubes have proven them to have the desired natural frequency with an output proportional to acceleration normal to the plates. For an acceleration of the order of 10 times gravity the output is of sufficient magnitude to record directly on a standard oscillograph without an auxiliary amplifier.

Computation of the fundamental frequency of the plate structure for bending normal to the plate was done by treating the structure as an elastic system with a concentrated mass at the center of gravity of the plates and distributed masses



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.

PREFERRED FOR PERFORMANCE · IRC · FIXED & VARIABLE RESISTORS

SHORT DELIVERY CYCLE

Fittings are now carried in stock. Resistance elements are made to order for range and tolerance.

For specific engineering information contact your IRC Sales Engineer or write Dept. 1-A.

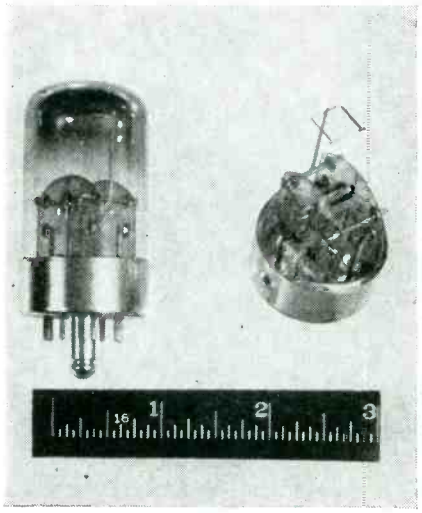
INTERNATIONAL RESISTANCE CO.

401 N. BROAD ST., PHILADELPHIA 8, PA.

In Canada: International Resistance Co., Ltd., Toronto, Licensee

in the supporting wires, which are subject to flexure and torsion by the vibration of the plate normal to its plane. The diameters and lengths of the wires were computed to give a fundamental frequency in this mode in the range of 750 cps. The natural frequencies of vibration in other modes were estimated to be much higher.

To determine the fundamental frequency experimentally, the pickup was connected into a Wheatstone bridge with a cathode-ray oscilloscope, and the pickup tapped with a pencil or finger. The output on the oscilloscope was matched against the output of an audio oscillator at a known frequency. The tubes tested had certain disadvantages. The zero, or reference point, tended to drift gradually with time for most of the tubes and a warming up period of about 15 minutes was required to reach equilibrium. However, these disadvantages may not be serious in recording rapidly changing accelerations over a short period of time.

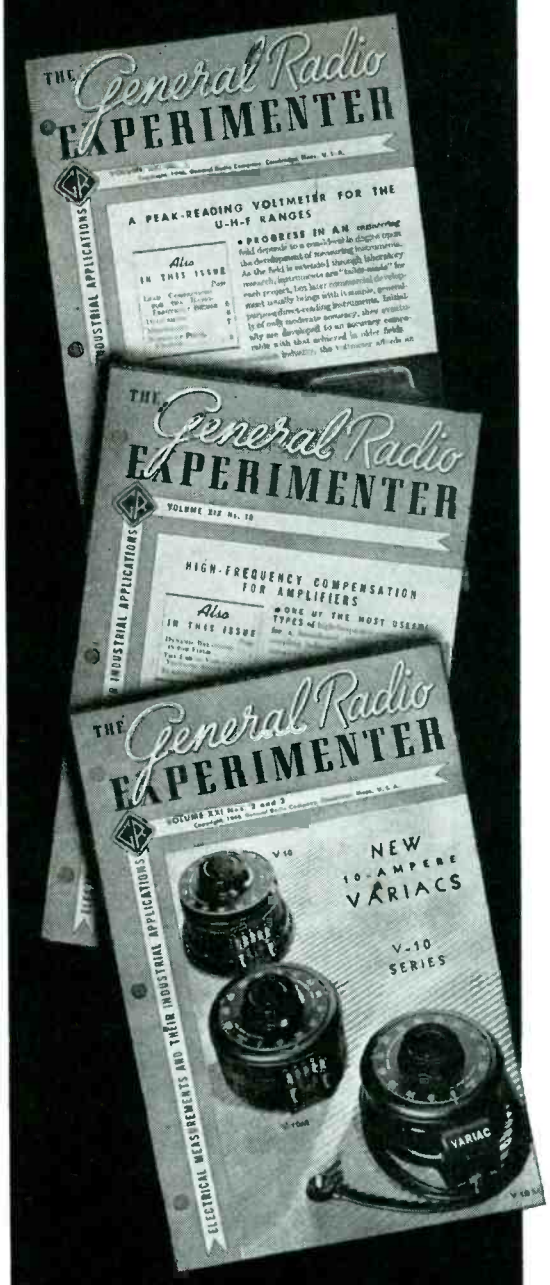


The vacuum-tube acceleration pickup consists of a fixed, indirectly heated cathode with elastically mounted plates, one on either side, as shown at right

For applications in which the high output, high natural frequency, high capacitance, and linearity are useful, the advantages may outweigh the disadvantages of zero drift, warming up time, high power consumption (about 7 watts for tube and Wheatstone bridge) and the need of filtering to remove natural frequency response.

The high capacity of the pickup is advantageous in recording accel-

Do YOU Read the G-R EXPERIMENTER?



● The General Radio *Experimenter* is sent WITHOUT CHARGE each month to scientists, engineers, technicians and others interested in communication-frequency measurement and control instruments. It has been published continuously since 1926. Each month it contains eight pages of articles describing new G-R instruments, new ways of using G-R equipment, and numerous applications of a general engineering nature.

Included in recent issues have been articles on such subjects as: peak-reading u-h-f-voltmeter; output systems of signal generators; new VARIACS; multiple photos with the Microflash; measuring lateral motions in a rotating system; new amplifier and null detector; constant waveform frequency meter; series and parallel components of impedance; improved megohmmeter for a-c operation; a light source for microsecond photography, etc.

To be placed on the mailing list to receive the *Experimenter* regularly, merely fill in, clip and mail the coupon below; or supply ALL of the information requested . . . a post card will do.

MAIL NOW! PLEASE FILL IN COMPLETELY

TO: General Radio EXPERIMENTER, 275 Mass. Ave., Cambridge 39, Mass.
Enter my COMPLIMENTARY subscription to the G-R EXPERIMENTER.

Name (print) . . . . . Company Name . . . . . .

Company Address . . . . . .
Street City and Zone No. State

997

Type of Business . . . . . Your Title . . . . . .

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 950 N. Highland Ave., Los Angeles 38

erations over a wide range and in preventing damage from sudden high accelerations. The linearity of the pickup permits the filtering out of high-frequency response, regardless of amplitude, and produces a record proportional to acceleration.

Electronic Magnetometer

By JACOB H. RUBENSTEIN
Recordchanger Inc.
Binghamton, N. Y.

THE SOLE PURPOSE of any magnetometer is to measure the direction, strength or changes in the lines of force of a magnetic field. The magnetometer to be described has high sensitivity and simplicity through the use of a specially designed pickup array as the detecting element, combined with a vacuum tube oscillator.

Due to its compactness, it should find unusual application in industry for remote indication or operation without mechanical coupling, by using the magnetometer to detect a change in position of a permanent magnet attached to an object whose motion is to be measured, particularly when the object whose motion to be measured is inaccessible.

For clarity, the magnetometer is described in the application for which it was originally developed, to determine the strength and direction of the earth's magnetic field.

The heart of the instrument is a pickup head shown in Fig. 1 with

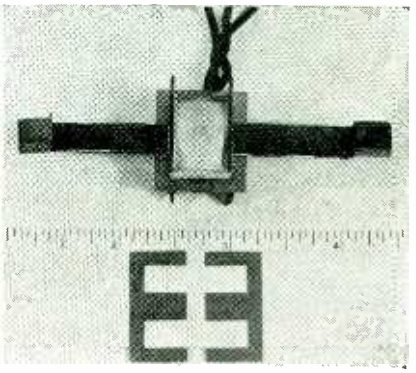


FIG. 1—Details of the head and, below, the two laminations of the core

an inch rule for size comparison. It contains an exposed view of the two-lamination shell-type inductance core.

Figure 2 is a schematic of the head in its associated circuit. The

LOOKING FOR A HIGH PRECISION RECTIFIER?

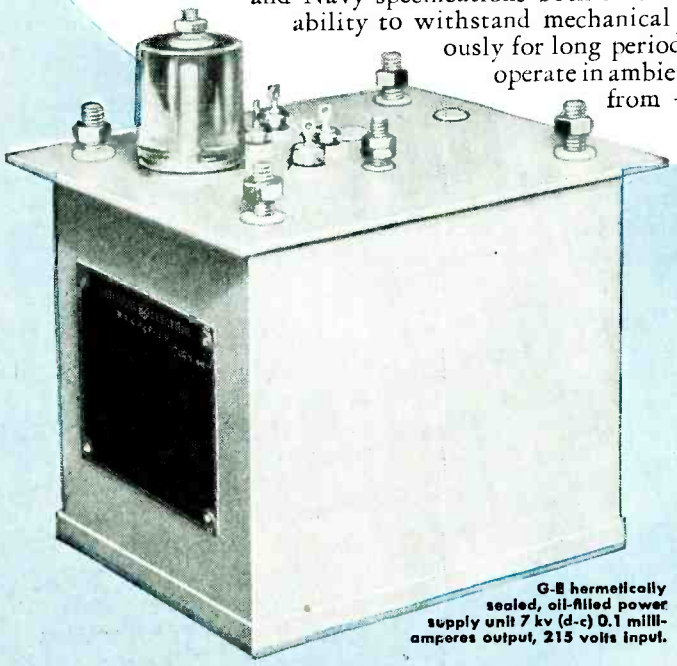
This one has Regulation Accuracy to
3.5% of 0.1 *Milliamperes Load*

LOW-CURRENT, HIGH-VOLTAGE D-C POWER SUPPLY IS COMPACT, LIGHT IN WEIGHT—HAS PREVIOUSLY UNOBTAINABLE FEATURES

These new small, light-weight a-c to d-c power supply units are especially built for precision work. They have a number of highly desirable features which make them suitable for supplying the high potential necessary for cathode-ray tubes, television camera tubes and radar indicator scopes, electron microscopes, and other jobs where unusually low regulation, light weight, and small size are primary considerations.

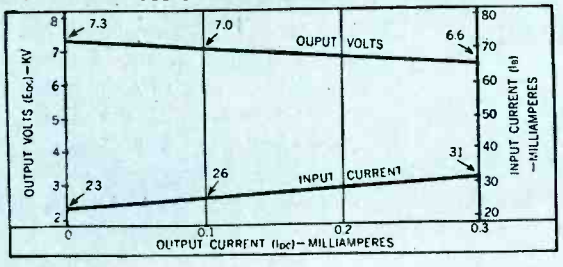
The unit shown here (Cat. 8317502) will supply 7 kv at 0.1 milliamperes d-c output. The regulation does not exceed 3.5% per 0.1 milliamperes load, and 15% at 0.5 milliamperes maximum load. The ripple on the output voltage is less than 1%. This unit is manufactured for 215 volts, 10,000 cycles, a-c input. An additional pair of terminals is provided to supply 45 volts a-c when 215 volts are applied to the input terminal.

This completely self-contained hermetically sealed rectifier will meet Army and Navy specifications both in the matter of design, and as to its ability to withstand mechanical shock and operate continuously for long periods of time. It is designed to operate in ambient temperatures ranging from −40 C to +60 C.



G-E hermetically sealed, oil-filled power supply unit 7 kv (d-c) 0.1 milliamperes output, 215 volts input.

INPUT CURRENT TO OSCILLATOR AND OUTPUT VOLTAGE VS. OUTPUT CURRENT TO LOAD



Has these Features

- **Precision stability**
- **Light weight (8 lb)**
- **Small size (6 by 6 by 7 in.)**
- **Selenium elements**
- **Only one high-voltage terminal exposed**
- **Filter has low energy storage**
- **Readily mounted**
- **Oil filled for strength**
- **Hermetically sealed**
- **Can be used as tank circuit of an audio oscillator***

*An unusual feature of this unit is that it may be used as the tank circuit of an audio oscillator. The input terminals are connected to the plate circuit. The 45-volt output terminals are connected as the grid feed back. The oscillator tube normally used is a 6V6. The operating frequency is 10,000 cycles.

GENERAL ELECTRIC

401-44-5155

GENERAL ELECTRIC COMPANY *Apparatus Dept.,* **Section 401-44, Schenectady 5, N. Y.**

Gentlemen:

- *Please submit quotation on.....Cat. No. 8317502 rectifiers, as illustrated.*
- *Please submit quotation on.....rectifier units, similar to Cat. No. 8317502, designed to meet the attached specifications.*

Name.....

Organization.....

Address.....

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

head consists of the tapped inductance L wound around the two laminations, the composition of the lamination is of high-mu metal, such as "MU" metal, permalloy and others. The elongated pieces extending from the closed core are also of high-mu metal. These elongated pieces are called "antennas" because they act as magnetic flux collectors. At the end of each antenna is a small permanent magnet. These are arranged in series-aiding relation to each other.

This head is the detecting element of the magnetometer, the rest of the circuit shown in Fig. 2 need not be in the magnetic field to be

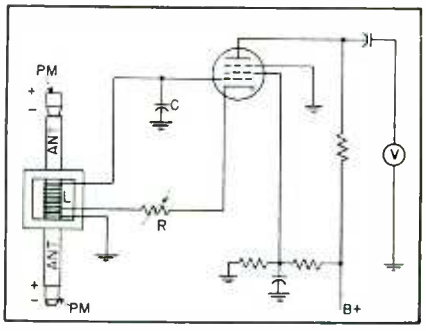


FIG. 2—Basic oscillator circuit used in the magnetometer

measured and may be in any convenient location, some distance away if desired.

Oscillator Circuit

The circuit of Fig. 2 is a form of electron-coupled oscillator. Fig. 3 shows a curve of the output voltage of the oscillator versus the magnetizing force in ampere turns applied to the oscillator coil core.

The output voltage of the oscillator is a function of the degree of coupling between the primary and secondary of the oscillator coil which in turn is a function of the permeability of the core of the coil, and from the curve it is seen that the mu of the core varies sharply in certain portions with the applied magnetizing force.

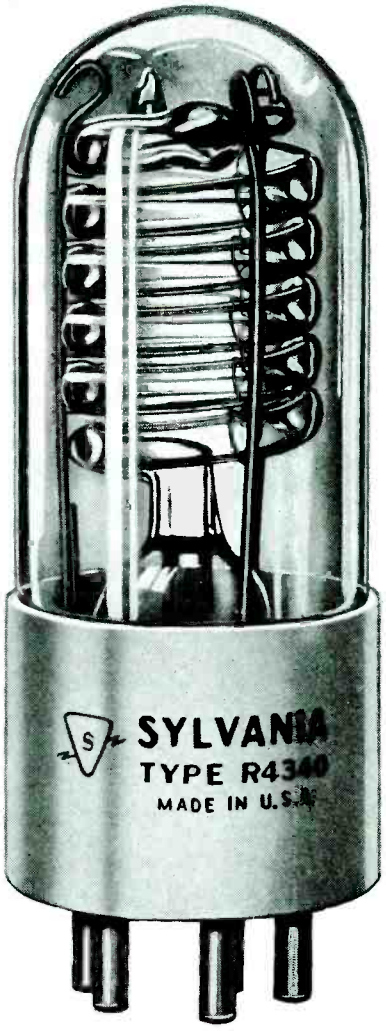
Examination of the steep portion of the curve shows that a large change in the mu of the core takes place for a small change in the flux through the head. All the head flux except a small leakage passes through the core, so that the density there is much higher than it is in the antennas because of its smaller cross section.

For proper design the average

SYLVANIA'S R4340

Electronic Tube for photographic purposes

FLASHES 30,000 TIMES!



Gives "DAYLIGHT" Flashes of 12,000,000 Peak-Lumens, 18,000 Lumen-Seconds

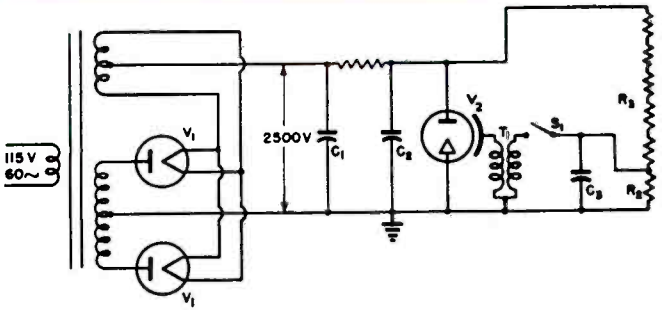
The Sylvania Type R4340 Flash Tube, used with suitable equipment, gives a brilliant flash of excellent photographic quality with a duration of only 1/1250th second.

A major application of the Type R4340 is in newly developed electronic flash units for photographic purposes. The R4340 will deliver more than 30,000 flashes before replacement is necessary.

Its short flash duration "stops" motion, enabling the photographer to take sharp pictures of moving subjects. Excellent color quality permits use with color film.

See your Sylvania Distributor for full details, or write for descriptive folder, address below.

TYPICAL CIRCUIT DIAGRAM



R_1	500 Ohms, 100 Watts	V_1	High Voltage Rectifier	C_2	120 Microfarads
R_2	150,000 Ohms	V_2	Sylvania Flash Tube R4340	C_3	1 Microfarad
R_3	Consists of five 200,000 Ohm Resistors	C_1	2 Microfarads	T_1	Ignition Coil
				S_1	Trip Switch

SYLVANIA ELECTRIC

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

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

mu of the head should be at point *A*, while the mu of the core is at point *C*.

Between points *B* and *C*, the slope of the curve is very steep and hence a relatively small increase in flux density beyond *B* will cause a large decrease in mu of the core, with correspondingly large decrease in coupling, resulting in a large drop in the reading of the voltmeter *V*.

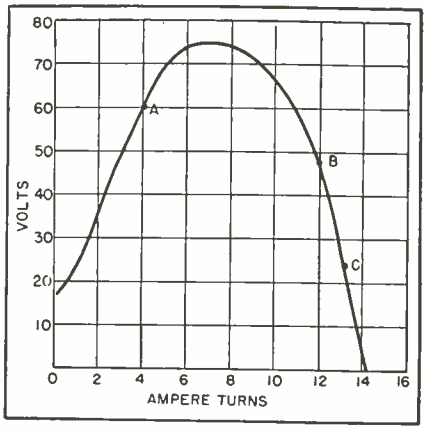


FIG. 3—Voltage output of the oscillator plotted against ampere turns of the oscillator coil

To bias the core to its most sensitive position to external flux changes, such as point *C* on the curve, magnets are introduced at the antenna ends instead of dynamic flux. This addition provides the needed constant value of magnetic flux to the antenna and to the oscillator core. The positioning also serves to increase the sensitivity of the magnetometer by extending the interaction of the head with the surrounding magnetic field over a larger area.

Both *R* and *C* of Fig. 2 are capable of shifting the operating point on the steep portion of the curve. Increasing *C* or decreasing *R* shifts the operating point towards *B*. These controls are used in conjunction with the flux fields of the magnets to bring about the desired slope and operating point on the curve. The sensitivity is also a function of the amount of metal in the center leg of the core.

Thus a small change in the strength or direction of the magnetic field in which the head lies causes a steep change in the permeability of the core of coil *L*, which in turn changes the coupling between the two sections of the coil,

ADJUSTABLE OVER WIDE TEMPERATURE RANGE*

A thermostat's range of temperature settings should not limit its applications . . . its range should be wide enough to permit a great variety of settings in accordance with individual product or process requirements. Its design should also permit temperature settings to be changed readily. The Fenwal THERMOSWITCH Control is available in standard models with temperature ranges of −100° F. to +400° F. or +100° F. to +600° F., and it may be calibrated at any point within these wide ranges merely by turning the adjusting screw to the desired setting. This wide selectivity of temperature setting is especially advantageous where large increments of change in the thermostat setting are required. Temperature control or detection in a variety of applications may be had by stocking just two standard THERMOSWITCH Controls of any desired model.

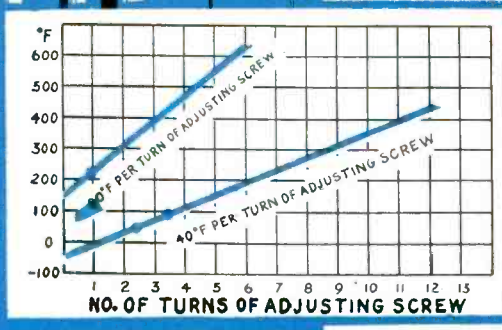
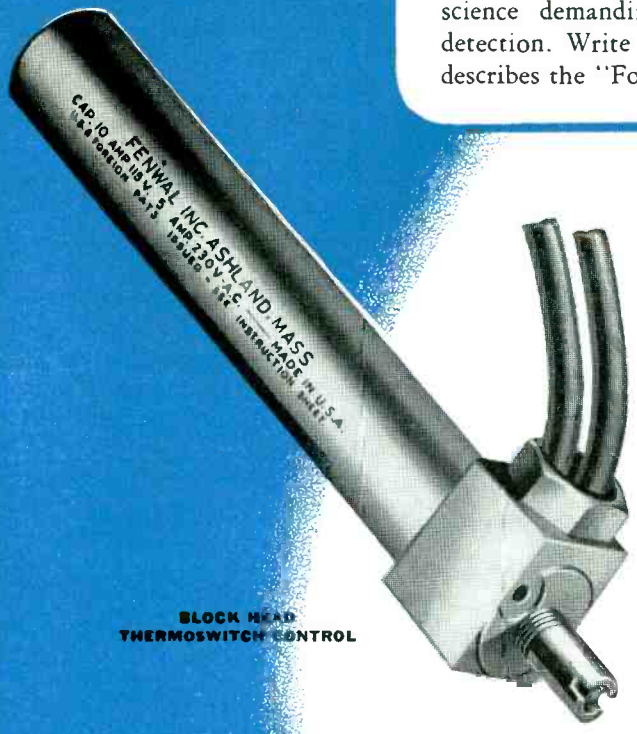


Chart shows the change in temperature setting corresponding to the number of turns of the adjusting screw of the THERMOSWITCH Control. For special requirements, the slope of the curve can be changed with special thread ratios.

Wide range of temperature adjustment is only one of many advantages that make Fenwal THERMOSWITCH Controls desirable for every branch of industry and science demanding precise, trouble-free temperature regulation and detection. Write for your copy of the Thermotechnics Booklet which describes the "Fourteen Facts in Fenwal's Favor."



BLOCK HEAD THERMOSWITCH CONTROL

FOURTEEN FACTS IN FENWAL'S FAVOR

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

*#10 OF THE "FOURTEEN FACTS IN FENWAL'S FAVOR".

Fenwal

FENWAL INCORPORATED

43 PLEASANT STREET

ASHLAND MASSACHUSETTS

Thermotechnics for Complete Temperature Regulation

and as a final result, the reading at *V*.

Amplifier

For anomalie measurements an additional stage of amplification brings the sensitivity of the magnetometer into the single-digit gamma range (a gamma is 1×10 to the -5 oersted).

The sensitivity and output of the oscillator alone are illustrated in Fig. 4. This curve shows voltage

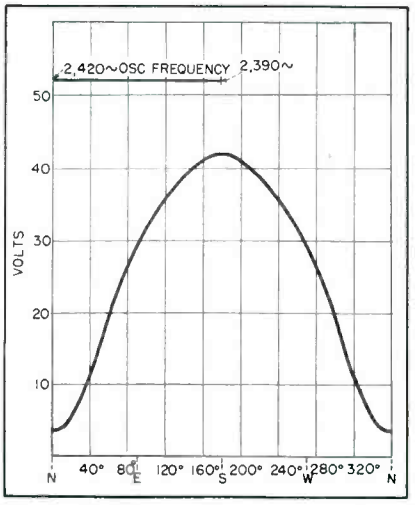


FIG. 4—Oscillator voltage output plotted against magnetic bearing. The horizontal intensity was 0.165 oersted

output plotted against horizontal magnetic bearing and was obtained from an experimental portable model whose circuit is shown in Fig. 5. The second tube is a current amplifier to operate the output milliammeter.

The curve of Fig. 4 would show a steeper slope with a recommended 90 volts on the oscillator plate. There is an oscillator frequency change of 30 cps from North to South.

With this circuit, magnetostriction effects, the changes in magnetic properties accompanying mechanical stresses, are very promi-

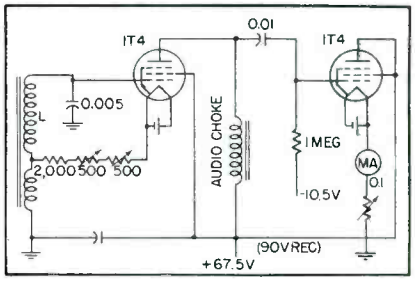
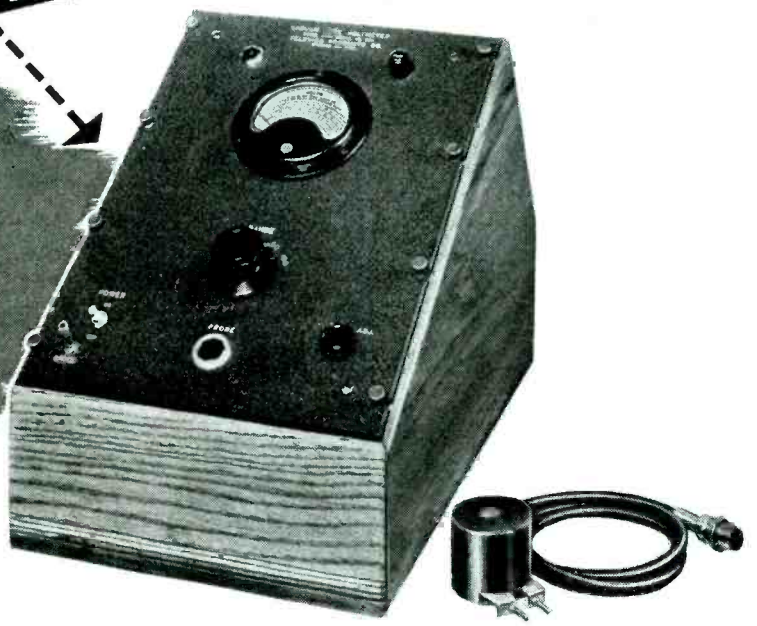


FIG. 5—Circuit of two-tube portable instrument useful for investigating magnetostriction effects. Coil *L* contains 5,000 turns, tapped at 500 turns

new! improved!

VACUUM TUBE VOLTMETER SERIES 200A



- **high impedance triode input**
- **high sensitivity on AF and RF**
- **stabilized zero setting**

Facts . . . Figures that Make Televiso's *New* Series 200A a *BETTER* Vacuum Tube Voltmeter . . .

High impedance input, high sensitivity and zero adjustment stabilization are the prime requirements in a vacuum tube voltmeter for use in modern electronic and industrial manufacturing. Televiso's new Series 200A combines these three qualities to an unusual degree. It is a direct reading instrument with a full scale sensitivity of .5 volt for use at audio *and* radio frequencies. Readings as low as 100,000 microvolts are accurate. Only one zero adjustment is needed for all ranges. The instrument covers the radio frequency range to 500 megacycles, is linearly responsive to the low audio frequency range of four cps. and useful to two cps.

The new Series 200A is the result of years of testing and research. Stray capacitances and detuning effects are reduced to a minimum by bringing the input connections of the voltmeter close to the circuit to be measured. Connections can be made directly to the measured circuit by wires or by a contact clamping fixture for production work. It has an external probe to which connections can be soldered, or binding posts that can receive wires or banana plugs.

The input tube is a triode plate circuit rectifier type in which the input voltage is rectified under full wave, square law operating conditions and indicates rms values.

The rear storage compartment of the instrument contains a source of calibration voltage equal to five rms volts ± 2%, making possible continuous checks on calibration accuracy.

Range: 0-150 volts AC in 5 ranges. Full-scale ranges are .5 volt, 2 volts, 15 volts, 50 volts and 150 volts. The 150-volt range may be extended to 1500 volts by means of a type 10:1 capacitive divider available on special order.

Accuracy: Accuracy is ±2% of full scale on all ranges on sinusoidal voltages. Middle scale accuracy is within 5% on all ranges.

Dimensions: Length, 17.5"; width, 11.5"; height, 12.5"; panel, 30° slope.

Guarantee: The instrument is fully guaranteed for a period of two years against defective material and workmanship.

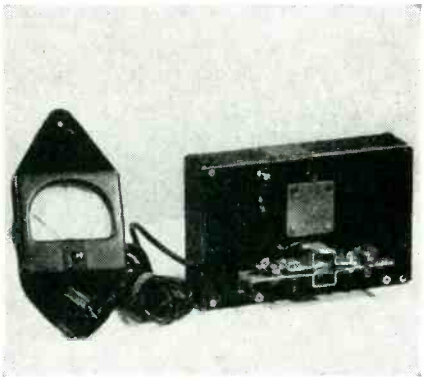
Like all Televiso measuring instruments, the new Series 200A vacuum tube voltmeter is a model of modern design and construction—assuring dependability and extreme accuracy over extended periods of time. Cabinets are copper lined to prevent extraneous radio frequency fields from affecting readings. The panel is of caustic dipped aluminum, flat black painted with a fine baked enamel finish.

Write for Bulletin 32 for complete details

Price $170.00 F.O.B. Chicago. Deliveries from stock

Televiso
PRODUCTS CO.
7466 IRVING PARK ROAD
CHICAGO 34, ILLINOIS

nent and easy to demonstrate through the use of long thin antennas. Retentivity can be accentuated and demonstrated through the use of multiple laminations in the antennas. For magnetic measurements with an absolute minimum of retentivity, the antenna may be dispensed with entirely. The proper amount of magnetic



Portable magnetometer. Tubes and batteries are contained in the cabinet at right

flux is introduced directly to the coil core and the sensitivity is more than ample.

The permanent magnets may also be dispensed with, if the antennas are made long enough to collect enough flux from the earth's field to bias the core to the desired operating point on the curve of Fig. 3.

FLASHLIGHT FOR BLIND

Movie cameraman Joe Walker demonstrates his visual aid. A flashlight illuminates the scene; returning light beams are focused by a lens onto a photoelectric cell. Modulation of the beam is accomplished in one experimental model by an oscillator and by a motor-driven fan in another. Change in the audio tone produced is heard from a small earphone or a built-in loudspeaker

"you can get VARNISHED INSULATING PAPERS of every type — at IRVINGTON"

Standard Irvington Varnished Papers

- Condenser Tissue
- Kraft Paper
- Bond Paper
- Red Rope Paper
- Saturated Kraft
- Asbestos Paper

When the "spec" reads *varnished paper insulation*, investigate the properties of Irvington's products. Many thicknesses of six varnished papers — made standard by general use — are available.

Base papers are carefully selected for low acidity, uniformity in thickness, tensile strength, and tear resistance. To these base stocks are applied Irvington-formulated insulating varnishes which provide high dielectric strength as well as resistance to heat, oil, and moisture. The varnish film is smooth and free from pin holes.

Write for generous test samples of the Irvington varnished insulating papers listed below.

TYPE	COLOR	RANGE OF THICKNESSES
Condenser tissue	Yellow	.00075" to .002"
Kraft paper	Yellow & Black	.00125" to .020"
Bond paper	Yellow	.0015" to .006"
Red Rope paper	Yellow	.007" to .015"
Saturated Kraft	Yellow	.004" to .005"
Asbestos paper	Yellow	.010" to .032"

IRVINGTON

Varnish & Insulator Company

IRVINGTON 11, N. J.

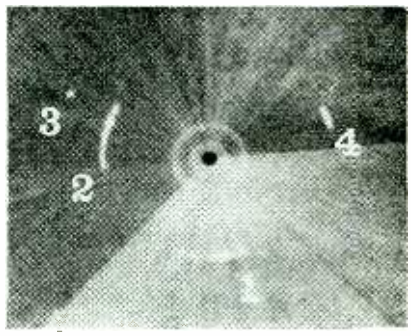
THE ELECTRON ART

Edited by FRANK ROCKETT

Meteors Detected By Radar

METEOROLOGICAL ionosphere research and radio wave propagational studies are being conducted with the aid of radar techniques operating at very high and ultra-high frequencies. As a part of these studies the meteor shower from October 7-12 that accompanied the passage near the earth of the comet Giacobini-Zinner was observed by scientists of the National Bureau of Standards and others here and abroad.

Observations were made on 107 mc using 25 microsecond pulses at 400 pps with a peak power of 100 kw. The antenna was oriented at an azimuth of 315 degrees and an elevation of 45 degrees. Meteors themselves are generally too small to reflect appreciable radio energy; however, in passage through the atmosphere they heat it so hot that it ionizes. It is this ionized trail that reflects the radio waves. The frequency that will just be reflected by an ionized gas is proportional to the square of the density of ions. Thus, although 100-mc used by the Bureau of Standards would penetrate the ionosphere, it was reflected by meteor tracks. However, 600 to 1,000 mc used by the Army Signal Corps for similar measurements was not reflected by either the ionosphere or the meteors. Thus the strength of meteoric ionization can be estimated.



Four echoes from meteor trails displayed on a ppi. Radar provides altitude as well as azimuth and elevation positions of meteors from one observation and can be used during daytime and overcast; it is thus far superior to optical observation

The bursts observed on the old, lower-frequency f-m band coincided with appearances of meteors. Some evidence indicates that E-layer ionization is generated by meteors. For these reasons more detailed measurements of the effects of meteors are being made so that communicational and navigational services can be assigned frequencies best suited to their needs.

RADIO CONTROL GOES HAY WIRE

Wired for radio, this plow can be remotely controlled to run a straight furrow, turn left or right, and raise or lower the plowshare. Radio signals transmitted on 60 meters from the truck are received at the tractor which pulls the plow. The signals control pneumatic servomotors that operate the plow. The farm tractor, developed by Tractors Ltd. in cooperation with the British government, is undergoing field tests

Frequency Modulator

By GEORGE G. BRUCK

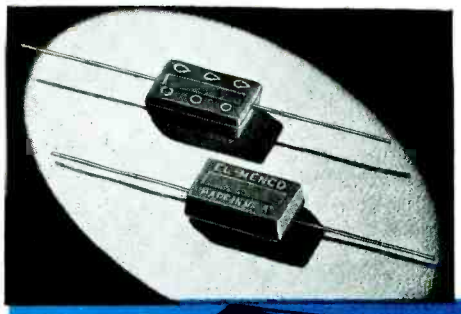
Farmingdale, N. Y.

A NEW METHOD for obtaining frequency modulation combines several components of a frequency modulator into one unit. The usual reactance-tube frequency modulator comprises a (1) reactance tube, or tubes if push-pull, (2) double diode demodulator, and (3) inverse feedback loop for linearity and mid-frequency control. These three units can be combined into a single unit giving the circuit of Fig. 1. In the composite circuit the control discriminator is working on the oscillator frequency, not on a lower frequency.

Circuit Behavior

Disregarding L_2 and C_2 the circuit acts as a class-C Hartley oscillator. As such, each grid receives one impulse every cycle. Relatively high grid resistances limit peak grid voltages practically to cathode potential.

At resonance the vector potential across L_2 and C_2 is at right angles



El-Menco Capacitors need no introduction to the Electronics Industry... this message is to let you know we're in there pitching every minute to help you with your problems... Send us your specifications on micas and trimmers, and if it's humanly possible, we'll make them for you.

We Really Know How.

Foreign Radio and Electronic Manufacturers communicate direct with our Export Department, at Willimantic, Connecticut for information.

The Electro Motive Mfg. Co., Inc.
Willimantic, Connecticut

MOLDED MICA **El-Menco** MICA TRIMMER
CAPACITORS

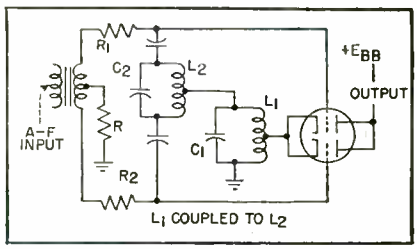


FIG. 1—Frequency modulation is produced by this simple circuit

to the one across L_1 and C_1, thus, although each grid receives one impulse per cycle, these two voltages are phased differently. Figure 2A shows the vector diagram for the case of perfect resonance. There are two plate current pulses per cycle, one advanced by the same angle that the other is retarded relative to the phase condition of the tank circuit of L_1 and C_1. The circuit is in equilibrium when the tube is oscillating at resonance.

If an a-f voltage is applied in push-pull to the two grids through R_1 and R_2, it alternately increases and decreases the angle of flow on either side of the tube. The contri-

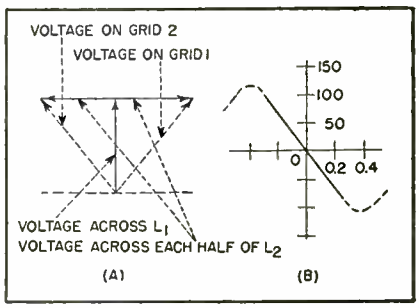


FIG. 2—(A) Grid voltages are symmetrically displaced in phase by action of resonant circuits of Fig. 1. (B) Application of a-f as shown in Fig. 1 produces frequency modulation. Values on coordinates show magnitudes that can be expected

bution on either side of the tube towards the total plate current thus has its phase shifted back and forth, resulting in frequency modulation.

Simultaneously, a voltage is established across R_1 and R_2 that tends to counteract the modulating voltage, thus providing negative feedback. The voltage-frequency characteristic of the circuit is therefore essentially independent of tube characteristics, depending only on the discriminator curve of L_1C_1 and L_2C_2 shown in Fig. 2B.

Design Considerations

The system works best if coupling between L_1 and L_2 reduces the

phase shift in the primary to zero in the neighborhood of resonance, which is accomplished with 0.50 transitional coupling. Choosing L_2 three to four times L_1 will give best results. If coupling is too high, the circuit can oscillate at either of two distinct frequencies, both different from the resonant frequency of L_2 and C_2. If coupling is too low, the frequency of oscillation becomes dependent on both circuits, whereas it should, for optimum performance, depend only on L_2 and C_2.

Amount of feedback is controlled by the magnitude of R_1 and R_2. If very little feedback is desired, R_1 and R_2 are replaced by r-f chokes, which must be identical to avoid differential phase shifts.

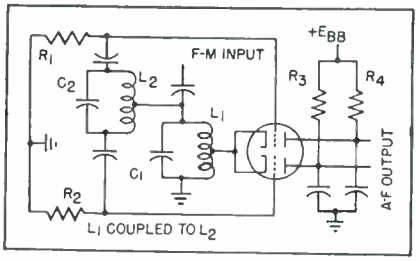


FIG. 3—Modification of the circuit of Fig. 1 gives an f-m discriminator

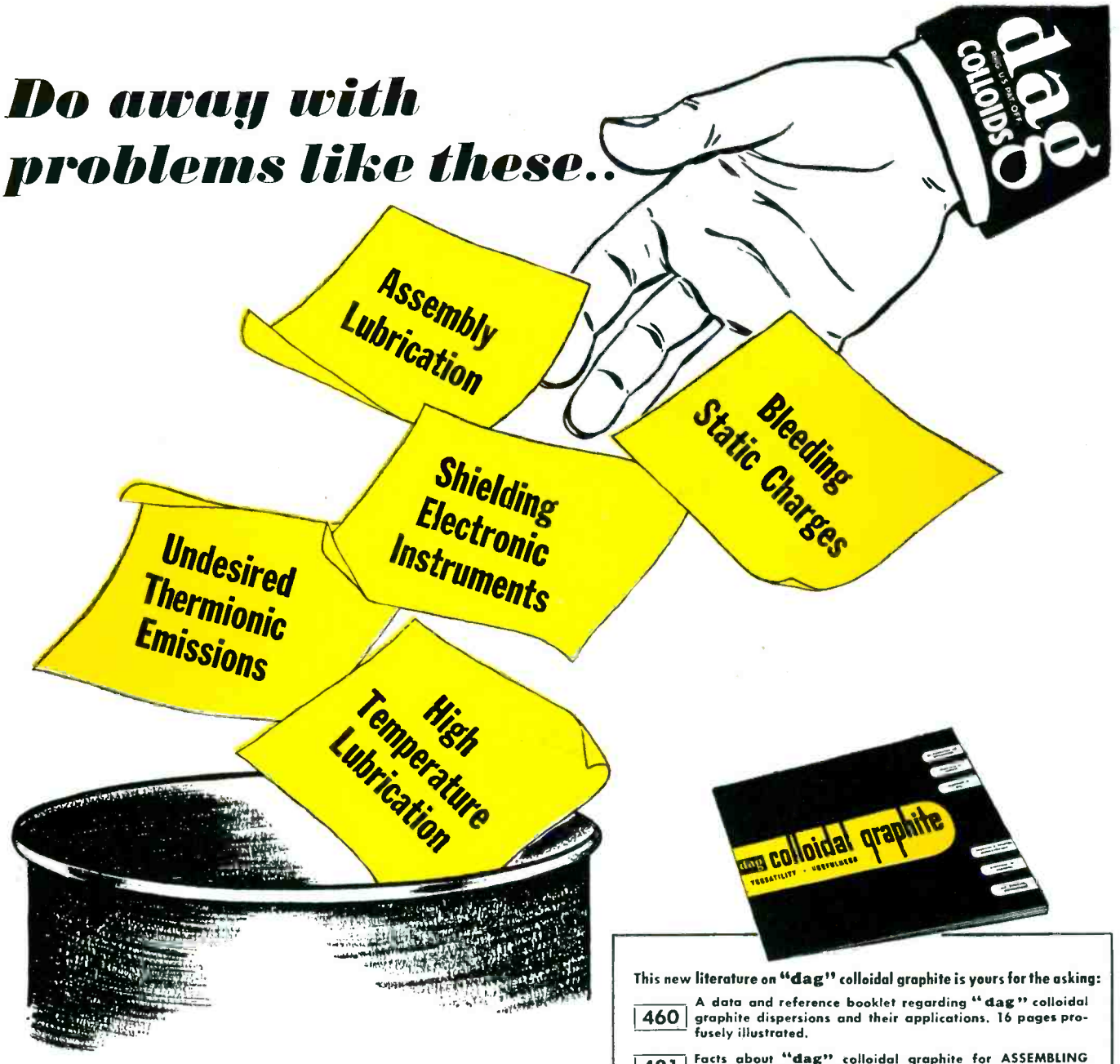
Output is obtained by inserting a parallel resonant circuit in the plate lead at the point marked on Fig. 1. The circuit lends itself particularly well to recovery of higher harmonics in the plate circuit and can be used as a frequency-multiplying driver stage. Although the fourth harmonic is the highest that can usually be obtained at the output, in one circuit operating at about 10 mc the output was 78 mc. Such an arrangement will give full frequency deviation with only a carbon micophone in the primary of the modulation transformer.

The same or a very similar circuit can be used as an f-m phonograph pickup. For reception, the circuit can be operated as a discriminator as shown in Fig. 3 wherein it also acts as limiter, amplifier, and squelcher. It is essentially an oscillator that falls in step with the incoming signal. Audio frequency is recovered in push-pull from the two plates.

Development of Electron Accelerators

ATOMIC RESEARCH, industrial radiography, and medical therapy

Do away with problems like these..



A lot of headaches around the plant can be tossed into the discard when you use dispersions of **dag** colloidal graphite. Dispersed in several fluid carriers **dag** colloidal graphite has such versatility that few plants can afford to be without it. So if you have problems like those listed above, consult with an Acheson Colloids service engineer about the **dag** colloidal graphite dispersion for your specific needs.

ACHESON COLLOIDS CORPORATION

PORT HURON, MICHIGAN

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

460 A data and reference booklet regarding "**dag**" colloidal graphite dispersions and their applications. 16 pages profusely illustrated.

421 Facts about "**dag**" colloidal graphite for ASSEMBLING AND RUNNING-IN ENGINES AND MACHINERY.

422 Facts about "**dag**" colloidal graphite as a PARTING COMPOUND.

423 Facts about "**dag**" colloidal graphite as a HIGH TEMPERATURE LUBRICANT.

431 Facts about "**dag**" colloidal graphite for IMPREGNATION AND SURFACE COATINGS.

432 Facts about "**dag**" colloidal graphite in the FIELD OF ELECTRONICS.

ACHESON COLLOIDS CORPORATION
PORT HURON, MICHIGAN, DEPT. A-5

JMLcoA-NN1

Please send me without obligation, a copy of each of the bulletins checked.

460 ☐ NAME_____

421 ☐ POSITION_____

422 ☐ FIRM_____

ADDRESS_____

423 ☐ CITY_____ ZONE_____ STATE_____

431 ☐ OUR PRESENT OIL SUPPLIER IS_____

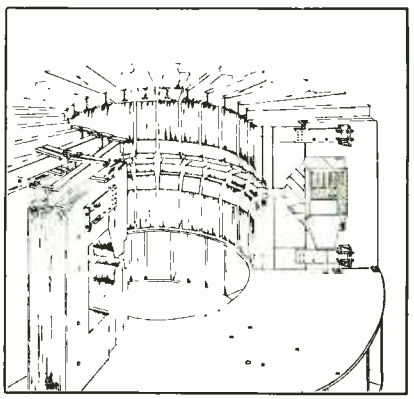
(Lubricants containing "**dag**" colloidal graphite are available from major oil companies.)

432 ☐

make use of high-velocity electrons either directly or to produce x-rays. In atomic research, internal nuclear forces and dimensions are inferred from disintegrations produced by electron beams or x-rays. These disintegrations produce neutrons and leave the atoms radioactive, both results being useful. For such disintegrations to be produced, the incident energy must exceed the very large binding forces of the particle to be ejected. Thus physicists have sought methods of generating high-velocity electrons, beginning with direct accelerators, then the cyclotron, the betatron, the synchrotron, and, most recently, the racetrack. These developments have paved the way for improved industrial radiography and extended the utility of medical x-ray therapy.

Potential Gradient Accelerators

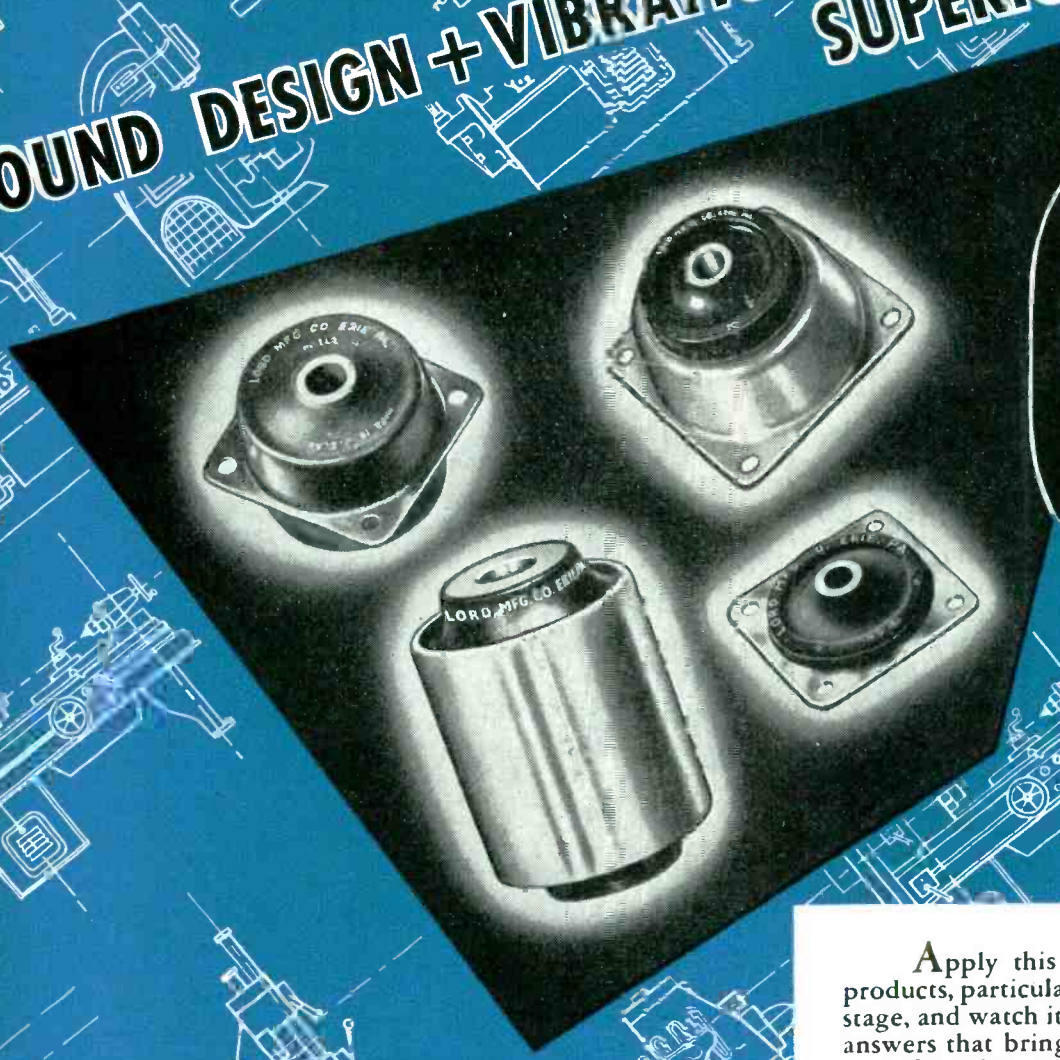
The simplest method of accelerating electrons is by means of a potential gradient, such as is used in all vacuum tubes. High voltages



Synchrotron at Massachusetts Institute of Technology will produce 300 mev electrons from an orbit of one meter radius and a field of 10,000 gauss. The magnet, designed jointly by the staff of MIT Laboratory for Nuclear Science and Engineering and engineers of the transformer division of Allis-Chalmers Mfg. Co., will weigh 55 tons

for these linear, potential accelerators are obtained from electrostatic generators or inductors. The accelerators are limited by the length of the path (over which the electrons are accelerated) that can be conveniently built and the potential gradient that can be maintained along that path without arcing. Electrons can be accelerated by this method to energies between one and five million electron volts (mev). Medical and dental diagnostic x-ray equipment and industrial radiographic units for sections thinner

SOUND DESIGN + VIBRATION CONTROL = SUPERIOR PRODUCT



LORD
BONDED RUBBER
Shear Type
MOUNTINGS

Apply this simple formula to new products, particularly while in the blueprint stage, and watch its uncanny magic develop answers that bring a better product, lower manufacturing costs, and increased sales. Isolation of vibrational stresses frequently enables redesign for lighter weight, increases life of bearing surfaces, and protects vital parts.

Best of all, you will find the answer to your search for quicker and easier sales. Customers are enthusiastic when they find your usual high quality of performance coupled with new, *SMOOTHER* operation. Noise and vibration—the principal causes of industrial fatigue—no longer take their toll of efficiency and accuracy. Vibration Control cushions the nerves of industry.

For best results, bring your vibration problems to Vibration Control Headquarters. The service of LORD Vibration Engineers is yours for the asking. Write today for a vibration analysis of your new products.

LORD MANUFACTURING COMPANY, ERIE, PA.

FIELD OFFICES { New York, N.Y. Detroit, Mich. Washington, D. C. Chicago, Ill. Burbank, Cal.
Canadian Representative: Railway & Power Engineering Corp., Ltd., Toronto, Canada.

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

than half a foot use these methods.

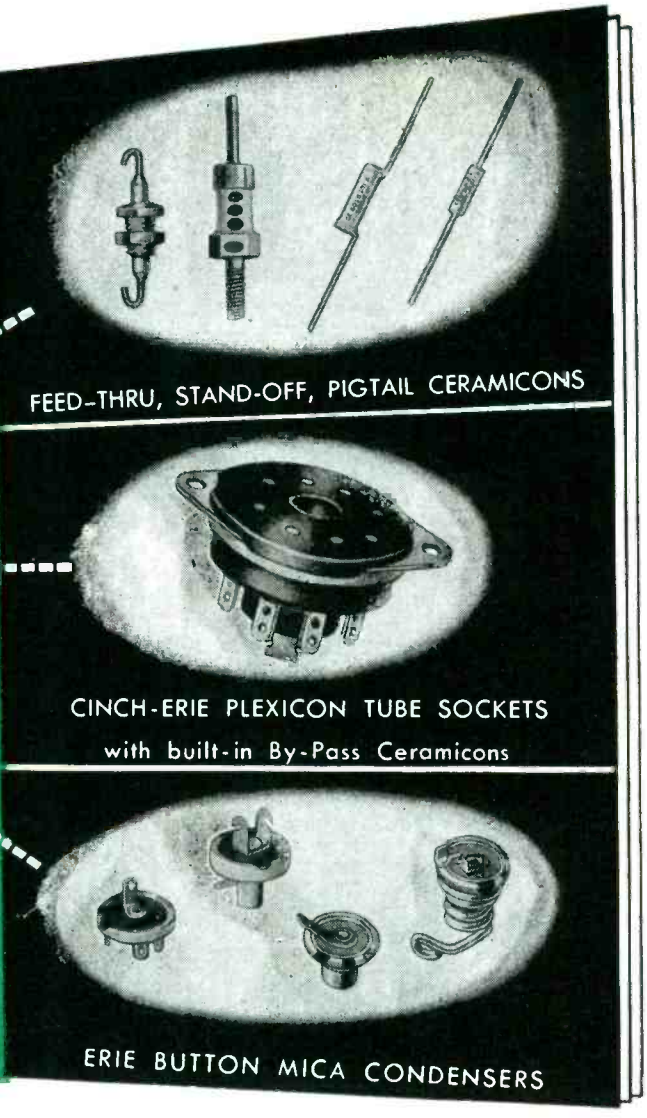
To avoid the complications of producing and insulating high potentials, the cyclotron was devised. The electron is made to follow a circular orbit by being projected perpendicularly to a uniform magnetic field. A potential gradient is established tangential to the electron's orbital path, usually by a radial gap in the electrostatic shield surrounding the plane of the path. Thus the electron receives

Betatron installed at the Army Ordnance Department's Picatinny Arsenal for studies of heavy munitions and machinery develops 20 mev x-rays. Operation is semi-automatic for use by nontechnical operators doing production line inspection. Engineers at Allis-Chalmers Mfg. Co., manufacturers of this betatron, have found that steel is most readily penetrated by 20 to 30 mev x-rays.

an acceleration each time it passes through the gap. Repeated accelerations from one small potential are used to produce accelerations greater than those possible in the linear accelerator. Usually the gap extends across a diameter of the orbit so that the polarity of the accelerating potential must be changed twice for each electron revolution; the potential from an r-f oscillator is used, the frequency being adjusted so that the electron receives an acceleration each time it passes the gap. Any charged particle can be accelerated in the cyclotron, hence it has been used in atomic and nuclear research.

As the velocity of a particle increases, its mass also increases. The period of revolution of an electron in a cyclotron (given by $T = m/eB$ where $m = m_e/[1 - (v/c)^2]^{1/2}$ is the relativistic mass of the electron, e is the charge of an electron, v is its velocity, and c is the free

FOR FM RADIOS IT'S ERIE RESISTOR



Electronic Components and Products

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

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

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

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

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

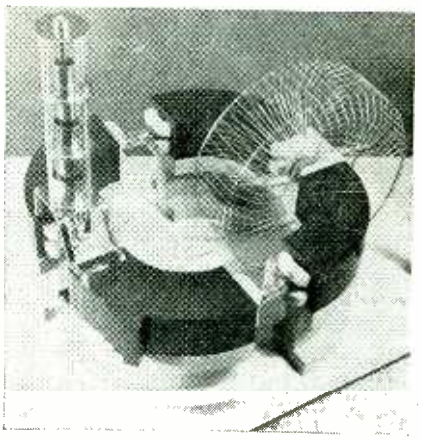
Electronics Division
ERIE RESISTOR CORP., ERIE, PA.
LONDON, ENGLAND . . . TORONTO, CANADA

Portion of a radiograph of a three horsepower, explosion proof, squirrel-cage induction motor shows industrial possibilities of 20 mev x-rays. Point source permits large direct magnification of image. Cone of x-rays becomes narrower as higher voltages are used to produce them. Exposure time was only one minute with motor four feet from the betatron

space velocity of electromagnetic waves) increases as a consequence of the increase in mass so that the high-speed electron will arrive at the gap too late to be accelerated by the r-f field. However, if either the r-f is lowered in frequency or the magnetic field is increased with time, conditions for acceleration of the electron as it crosses the gap will be restored. This phase correction of the cyclotron is the basis of the synchrotron, which can accelerate electrons to such high velocities that they lose energy by direct radiation.

Induction Accelerators

The great drawback to cyclotrons and synchrotrons is that they re-

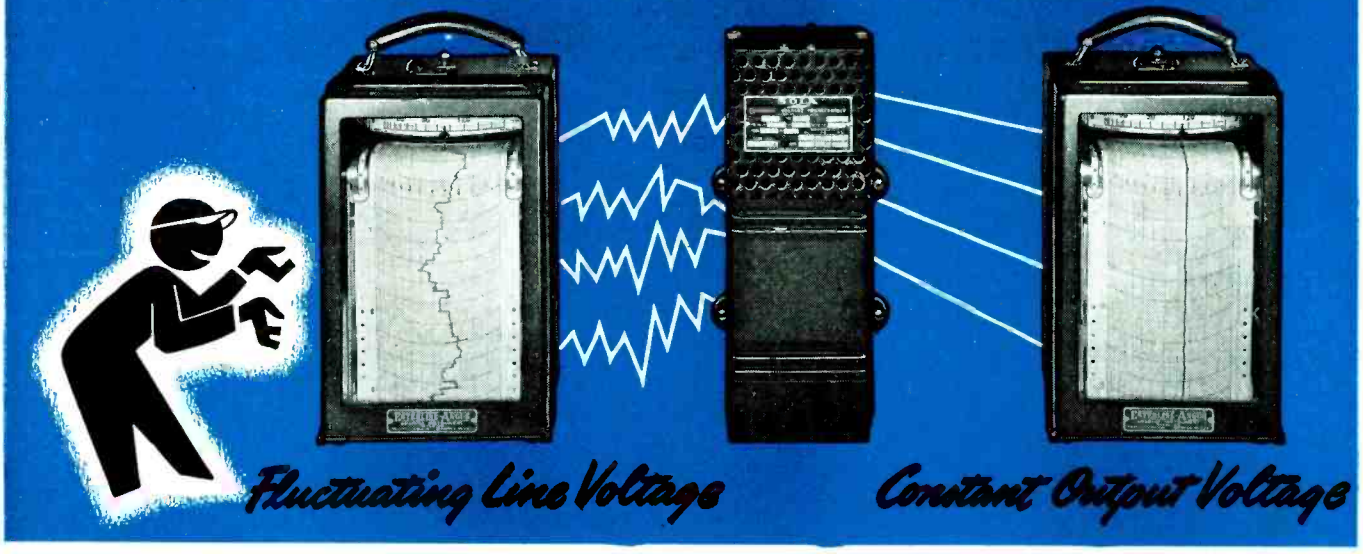


Racetrack modification of synchrotron designed by the staff of University of Michigan for Naval research in subnuclear phenomena at Applied Physics Laboratory of Johns Hopkins University will develop 300 mev electrons; it weighs 15 tons. Electrons are first linearly accelerated to 0.5 mev in the 15 foot high column to the left

"WHEN EQUIPMENT IS STILL IN THE BLUEPRINT STAGE...

AND VOLTAGE VARIATIONS MAKE YOU RANT AND RAVE

...LET A SOLA 'CV' MAKE THAT VOLTAGE BEHAVE"



It may look good on paper . . . and perform superbly under regulated laboratory voltages, BUT . . . when it encounters the *unstable* voltages that are available to your customers, what happens—

—to costly filaments and tubes?
—to precision parts?
—to sensitive, balanced circuits?
—to over-all efficiency?
—to customer good-will?

The operating voltage you specify will never be consistently available unless you make provision for it. That can be done most economically and satisfactorily by including an automatic, self-protecting SOLA Constant Voltage Transformer as a "built-in" component of your equipment.

There are many standard models in SOLA Constant Voltage Transformers that have been specifically designed for built in use. They are being successfully used today by many manufacturers of electrically energized equipment who have *guaranteed* the availability of constant rated voltage. May we make a recommendation for your equipment?

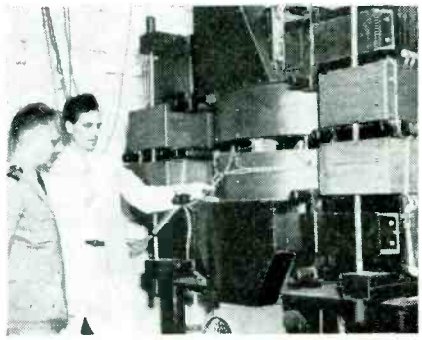
Write for Bulletin DCV-102 ... Here is the answer to unstable voltage problems.

SOLA *Constant Voltage* **TRANSFORMERS**

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

Manufactured in Canada under license by FERRANTI ELECTRIC LIMITED, Toronto

quire large, heavy magnets. An entirely different approach to the problem of electron acceleration, avoiding the need for such large magnets, is to utilize the induction principle of transformers, which is done in the betatron. The technique is to produce an increasing magnetic flux linking the orbit of the electrons. Because there is acceleration as long as the magnetic flux is changing in the same direction,

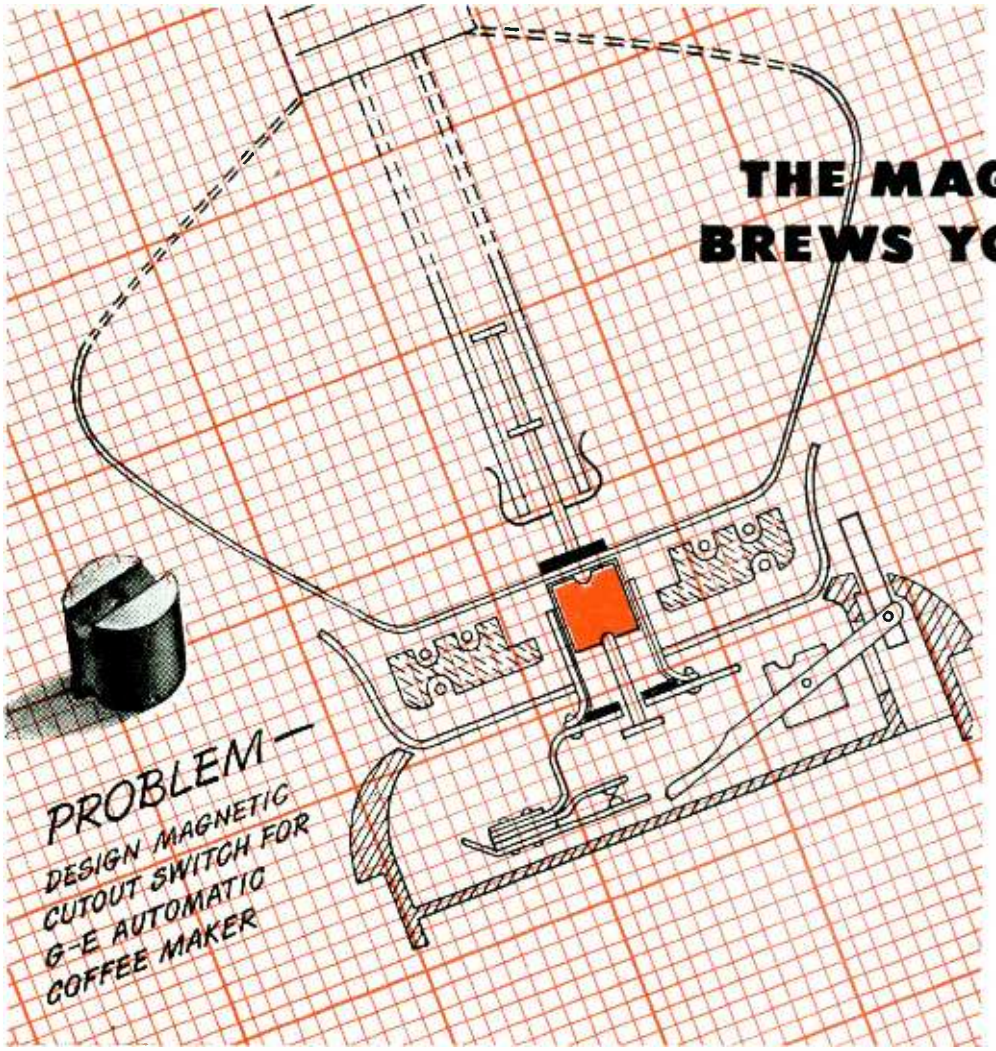


Transformation of mass to energy, as accomplished in atomic fission, was first produced by means of high-speed electrons. Such fission is most effectively produced by 20 mev x-rays, but higher energy rays produce other reactions. For example, energy is converted to mass when very high energy x-rays pass close to the nucleus of an atom; the ray vanishes and an electron and positron pair appear. The transformation is, however, not permanent for the positron quickly unites with an electron producing new radiation. Dr. H. C. Pollock, General Electric Research Laboratory scientist, and Capt. R. D. Conrad, USN, Director of the Planning Division, Office of Naval Research, are inspecting a 70 mev synchrotron being built for Naval research. First peace-time use of atomic energy will be for ship propulsion, second for heating cities from a central plant

there are no phasing problems. Acceleration is more dependent on the rate of change of magnetic flux than on the flux density, so the magnet need not be large. It is necessary, however, to so shape the magnetic field that the electrons will follow an equilibrium orbit. As the electrons go faster the radius of their orbit ($r = mv/eB$ where r is orbit radius, and the other symbols are as before) would increase, but by so arranging the magnetic field that the increase in flux density at the orbit just offsets the effects of the increased flux linkages accelerating the electron, a stable orbit is obtained. Electrons are readily accelerated to 20 mev. The betatron is used industrially for radiographing metal sections several feet thick.

To further reduce the amount of iron required in the betatron, a

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS



THE MAGNET THAT BREWS YOUR COFFEE

The heart of the G-E Automatic Coffee Maker is a tiny but powerful sintered ALNICO 2 magnet. At precisely the right moment, it shuts off the current and the coffee is ready! Pressing the button raises the magnet to the position shown, where it is held by attraction through glass to the nickel disc at the bottom of the siphon tube. When enough pressure is developed, boiling water surges up the tube, pulling the disc assembly with it. Its top magnetic support gone, the ALNICO magnet drops and opens the contact switch.

G.E.'s precise quality control methods used throughout magnet production, plus accurate testing and rigid inspection insure you of receiving magnets of the highest uniform quality for your application.

Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. The large group of sintered and cast ALNICO alloys has been augmented by the lightweight, non-metallic mixture, VECTOLITE, and by the ductile permanent magnets, CUNICO, CUNIFE and SILMANAL. From such a wide choice of materials, you may now find a magnet better suited for your application or a material which will make possible new designs heretofore impractical or impossible.

General Electric engineers, backed by research and application experience, have acquired years of "know-how" in selecting the best permanent magnet material and properly designing magnets for thousands of products. These engineers are at your service.

For detailed information about G-E permanent magnet materials, fill out and return the coupon to *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

PERMANENT MAGNETS

GENERAL ELECTRIC

CD 47-JA1

ELIMINATE YOUR MAGNET SUB-ASSEMBLY PROBLEMS

Consult General Electric for the design and manufacture of carefully calibrated permanent magnet sub-assemblies, ready for your final product. G-E magnet sub-assemblies will benefit you in the following ways:

- *Eliminate your assembly line rejects.*
- *Eliminate calibration problems in your factory.*
- *Eliminate cost of production and testing equipment.*
- *Eliminate breaking and chipping losses on brittle magnetic materials.*
- *Eliminate expense of shipping special trays for semi-finished magnets.*

We shall be glad to send you additional information about G-E permanent magnet sub-assemblies upon request.

METALLURGY DIVISION
CHEMICAL DEPARTMENT
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

Please send me your bulletin, GES-3337A, "Permanent Magnet Materials."

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....

ELECTRON ART (continued)

direct current can be used to bias the iron core. Furthermore the synchrotron and betatron can be combined to accelerate electrons to the 100 mev level. The advantage of combining the synchrotron with the betatron is that the synchrotron offers the possibility of repeatedly accelerating electrons a great many times, thereby obtaining velocities that would only be possible in the betatron were the magnetic field to increase rapidly for a long time, reaching impossible flux densities. The advantage of combining the betatron with the synchrotron is: In the synchrotron as most conveniently used for accelerating electrons, the magnetic field strength is increased, which in addition to holding the period of revolution constant, changes the orbital radius. The magnet is therefore called upon to supply a field across a wide annular ring. By using betatron action to accelerate electrons to tens of millions of electron volts, the width of the annular ring over which magnetic flux must be provided is narrowed.

A further modification, presented here in chronological order of its inception although it belongs logically with the cyclotron type of accelerator, is the racetrack accelerator. Four straight sections are inserted between quadrants of the radial track of a synchrotron. One section contains a cavity r-f accelerator, another provides space for electron injection and for the target, and the others improve the stability of the electrons in their orbit. The construction permits efficient use of the iron and exciting power of the magnet, allows an injection chamber and accelerating cavity to be built in magnetically field-free spaces so that they can be built of iron to provide magnetic shielding at these critical regions, and leaves the entire path within the magnetic field clear of obstruction, such as the target, so that proper flux gradients can be produced.

Medical Research

Measurements of the effects produced by electron beams from a 20 mev betatron indicate possibilities of curing ten percent more cases of cancer than is possible by other techniques. Tests at Michael Reese

. . . our greatly increased production on Simpson Model 260 makes it available to you NOW at your jobber's

The Simpson 260 is easily the world's most popular set tester for television and radio servicing. You cannot touch its precision, its useful ranges, or its sensitivity in any other instrument selling for the same price or even substantially more.

It has been a long time since we have been able to produce enough 260's to meet the demand, because the 260 has consistently out-sold every other remotely similar test instrument. The reason is simple: it out-performs and out-values them all. Simpson advanced engineering and unyielding standards of quality and precision manufacture enable it to *stay* accurate under conditions ordinary instruments cannot survive.

Incidentally—production on other Simpson instruments is clearing, too. We feel confident that it will not be long before you can buy those Simpson instruments you have waited for.

Ask your jobber for the Simpson 260—he has it now!

SIMPSON ELECTRIC COMPANY
5200-5218 W. Kinzie St., Chicago 44, Ill.

Simpson

INSTRUMENTS THAT STAY ACCURATE

SIMPSON 260, HIGH SENSITIVITY SET TESTER FOR TELEVISION AND RADIO SERVICING

Ranges to 5000 Volts—Both A.C. and D.C.
20,000 Ohms per Volt D.C.
1000 Ohms per Volt A.C.

At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. The practically negligible current consumption assures remarkably accurate full scale voltage readings. Current readings as low as 1 microampere and up to 500 milliamperes are available.

Resistance readings are equally dependable. Tests up to 10 megohms and as low as ½ ohm can be made. With this super sensitive instrument you can measure automatic frequency control diode balancing circuits, grid currents of oscillator tubes and power tube, bias of power detectors, automatic volume control diode currents, rectified radio frequency current, high-mu triode plate voltage and a wide range of unusual conditions which cannot be checked by ordinary servicing instruments. Ranges of Model 260 are shown below.

Price, complete with test leads.....$38.95
Carrying case $5.55

Volts D.C. (At 20,000 ohms per volt)	Volts A.C. (At 1,000 ohms per volt)	Output
2.5	2.5	2.5 V.
10	10	10 V.
50	50	50 V.
250	250	250 V.
1000	1000	1000 V.
5000	5000	5000 V.

Milli-amperes D.C.	Micro-amperes	Ohms	
10	100	0-1000	(12 ohms center)
100		0-100,000	(1200 ohms center)
500		0-10 Megohms	(120,000 ohms center)

(5 Decibel ranges: —10 to +52 DB)

ASK YOUR JOBBER

Hospital indicate that high-energy electron beams are more effective than x-rays. The electron beam is brought out of the betatron through an iron tube inserted tangentially to the orbit.

In the case of x-ray treatment of tumors, dosage that can be delivered to malignant cells is limited by the radiation that adjacent healthy tissue can tolerate. In treating surface tumors, a nondirectional x-ray source is placed very close to the area being treated. Intensity of radiation is thus high at the cancerous tissue but decreases rapidly beyond it. However, when treating internal cancers such advantage cannot be taken of the decrease of radiation density with distance. The treatment must be limited to such dosage as will not harm intervening healthy tissue through which the x-rays must pass.

To destroy cells, radiation is used to produce ionization within them. Using an electron beam projected through the cells to produce ionization has several advantages over using x-rays. There appears to be a critical velocity at which maximum ionization is caused. A high-speed beam of electrons can be projected through healthy cells with little harm, but by the time the beam reaches the malignant cells the electrons will have slowed down

Micro second exposure time makes possible x-ray study of high-speed effects on material and personnel ,such as deformation of football at kickoff. Instead of using high-voltage electrons to produce very penetrating x-rays, high currents are used to produce intense radiation. Potential gradients of 10 to 100 million volts per centimeter are used to produce cold-cathode field emission. High arc currents vaporize cathode, forming a vapor cathode of metallic ions that emits 1,000 amperes. Tube operates at 300 kilovolts, 960 amperes for one microsecond intervals; x-rays penetrate one inch of steel. Equipment made by Westinghouse is small because high voltage is applied so briefly that an air arc has insufficient time to strike

Uniform purity and top quality of Schweitzer Insulating Papers are assured by the innumerable quality controls and tests throughout the manufacturing process. Designed for paper or electrolytic capacitors, coils, transformers and other insulating purposes, these papers are supplied in thicknesses ranging from .00025" to .004".

SCHWEITZER PAPER CO.

182 Cornelison Avenue, Jersey City, N. J.
Plants: Jersey City, N. J., Mt. Holly Springs, Pa.
Research Laboratories and New York Office:
Chrysler Building, New York 17, N. Y.

SPECIALISTS IN THIN GAUGE INSULATING PAPERS

to their optimum ionizing velocity, and will emerge from the tumor with too low a velocity to cause further damage. The 20 mev electron beam from a betatron penetrates 10 cm of tissue with maximum ionization between 7 and 8 cm. There is another phenomena that also acts to make the technique useful. The susceptibility to destruction by ionization is highest in cells undergoing fission. As malignant cells are dividing more actively than normal cells, they are more likely to be destroyed than other cells.

Self-Regulating Field Excitation for Magnetrons

By H. C. Early and H. W. Welch
Radio Research Laboratory
Harvard University
Cambridge, Mass.

Stable magnetron operation can be obtained by utilizing the anode current as excitation for the magnetic field, instead of using a permanent magnet or a separately excited electromagnet. The volt-ampere characteristic of the magnetron can be made to correspond to a constant power curve over a significant part of the operating range, or to optimum modulating conditions.

Series Magnet Connection

Using a series connection of field and anode circuit, adjustment of anode voltage is less critical and the tuning range for fixed voltage is greater than for constant magnet excitation. In experimental circuits

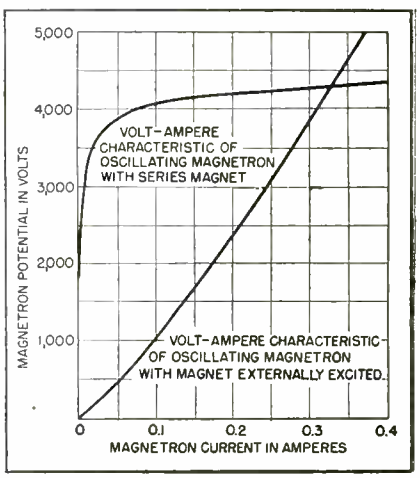


FIG. 1—Comparison of oscillating magnetron characteristics. (Labels should be reversed)

Impromptu Discussions about Miniature Tubes

"This New Year stuff makes you kind of think of the changes and improvements that are taking place. Now that we are working so much more with miniatures I don't know how we ever got along without them. Take the Tung-Sol 35W4 power rectifier that replaces the old 35Z5GT.

"You know this tube was designed especially for series heater operation in five or six tube ac/dc receivers. The 35W4 is a good job . . . no other rectifier will give you all its features. Heater voltages add up . . . you don't need to throw away power in line cords, ballast tubes, or resistors. And for rectification efficiency... say, the 35W4 will make an ac/dc receiver perform just as effectively on dc as on ac power. Since you must have a pilot light, the tapped heater circuit of the 35W4 gives you a fool-proof system which minimizes lamp surges yet gives good illumination.

"High ambient temperature is another point. You have to consider it in regard to its effects on the rectifier as well as other circuit components and on fire underwriters standards. The 35W4 can tolerate an ambient as high as 150° C. This, of course, fits in with the compactness of the resulting equipment. The smaller the tubes, the closer all parts are assembled hence the higher the temperatures.

"The use of two 35W4's is perfectly practical for voltage doubler applications. At 117 volts input, a full-wave doubler delivers 100 ma. at 230 volts to the filter input or 100 ma. at 210 volts with the half-wave doubler. Think what this means in terms of power output in 'transformerless' ac power amplifiers! When you have a circuit demanding up to 4.5 amperes peak current for very short intervals look into the 35W4 . . . there go the whistles, Happy New Year—Everybody!"

TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY
Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York
Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

it is possible to put the tube into oscillation at low power, observing tube operation before applying full power. The oscillating state of a magnetron with series excitation rises uniformly with applied power instead of suddenly for fixed excitation, as shown in Fig. 1. Parasitic oscillation at low anode voltages or oscillation at abnormal modes is avoided. In addition, the high inductance of the magnet winding can be used in the anode power supply filter, and the output power can be controlled by a single Variac in the input power line.

Design of the field magnet is restricted. Minimum anode current and maximum flux required

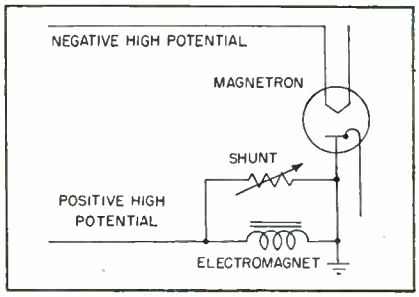
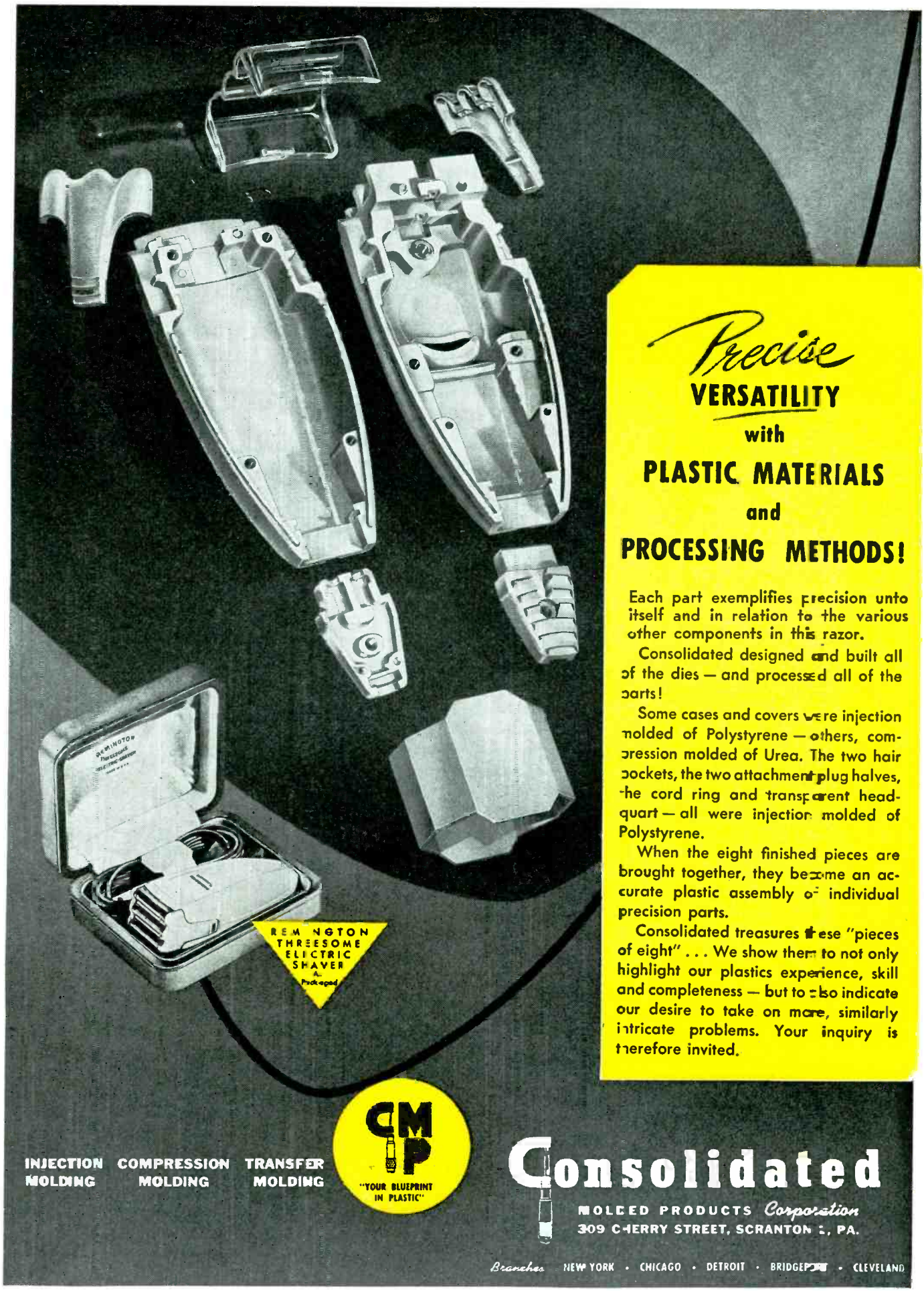


FIG. 2—Magnetron with series field excitation of its magnet

by the tube determine the amount of iron, thermal capacity, and number of turns of the magnet. If the magnet saturates, self-regulating properties of the circuit are lost.

The circuit can be connected as shown in Fig. 2. The magnet winding can be used in the power supply filter provided the plate transformer has low capacitance to ground. The anode block of the magnetron is at ground potential for convenience in providing water cooling. The shunt provides adjustment of the field to match the characteristic of the particular tube, or to control the output power.

Although a separate field excitation supply is unnecessary, the anode supply must provide the voltage drop through the magnet winding. A spark gap or Thyrite resistor across the magnet winding should be provided for protection of its insulation against voltage surges. The series magnet reduces effects of changing line voltage and power supply ripple. A combination of series and shunt field windings can be used to obtain a variety of characteristics. Thyrite resis-



Precise

VERSATILITY

with

PLASTIC MATERIALS

and

PROCESSING METHODS!

Each part exemplifies precision unto itself and in relation to the various other components in this razor.

Consolidated designed and built all of the dies — and processed all of the parts!

Some cases and covers were injection molded of Polystyrene — others, compression molded of Urea. The two hair pockets, the two attachment plug halves, the cord ring and transparent headquart — all were injection molded of Polystyrene.

When the eight finished pieces are brought together, they become an accurate plastic assembly of individual precision parts.

Consolidated treasures these "pieces of eight" . . . We show them to not only highlight our plastics experience, skill and completeness — but to also indicate our desire to take on more, similarly intricate problems. Your inquiry is therefore invited.

INJECTION MOLDING · COMPRESSION MOLDING · TRANSFER MOLDING

CMP "YOUR BLUEPRINT IN PLASTIC"

Consolidated

MOLDED PRODUCTS *Corporation*

309 CHERRY STREET, SCRANTON 2, PA.

Branches NEW YORK · CHICAGO · DETROIT · BRIDGEPORT · CLEVELAND

tors can be used for field shunts to further alter the overall magnetron operation. (Work reported herein was done at RRL under contract with OSRD, NDRC, Div. 15.)

French Microwave Telephone Circuit

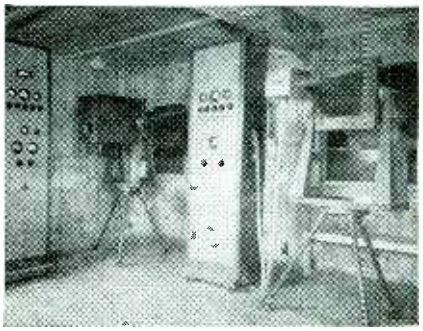
From McGraw-Hill World News

EQUIPMENT for microwave transmission of 12 simultaneous telephone conversations in both directions was put into operation last April between Paris and Montmorency, France. The equipment consists of separate transmitter-receiver pairs for each direction, one pair operating at nine centimeters, the other at ten; one uses horizontal polarization, the other vertical, and thus interaction between pairs is avoided.

Transmitter

The frequency-modulated transmitter that superimposes the twelve carrier-current telephone circuits spaced from 12 to 60 kc on the 10-cm radio carrier uses a velocity-modulated positive-grid tube. Modulation is accomplished by varying the anode potential, the tube having a nearly linear frequency-potential characteristic over a 20-mc range, more than used in the frequency modulation. The 5,000 volts on the anode is stabilized by counter-reaction against a standard battery, giving a frequency stability of one part in 100,000. Distortion in the preamplifier and modulator is reduced by local negative feedback.

Possible distortion in the frequency modulator is prevented by

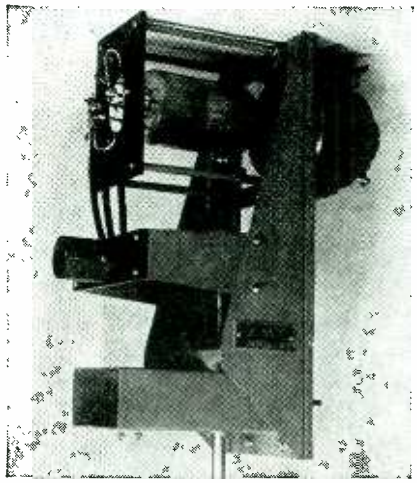


In the Montmorency station of the microwave telephone link, horn radiators are mounted on adjustable tripods allowing precise pointing laterally and in azimuth

a frequency compression technique. A portion of the transmitter output is demodulated and reinjected at the modulator in phase opposition to the existing modulation. In this fashion the frequency excursion of the transmitter is reduced and the linearity of modulation improved, provided the auxiliary circuit introduces no distortion. To make the auxiliary circuit linear, local frequency compression is used around it.

Receiver

The receiver also uses the principle of frequency compression to obtain a quality comparable to the best telephone wire circuits. A positive-grid local oscillator and diode converter are used; the latter has an especially flat filament to avoid differences in electron transit times. The converter feeds a wideband amplifier which in turn feeds



Positive-grid tube gives 30 watts output. Waveguide below tube couples into horn radiator. Frequency compression is used to reduce modulation distortion

a discriminator. To reduce distortion in the demodulator the output is used to frequency-modulate the local oscillator in synchronism to frequency variations in the incoming wave. This frequency compression also serves to make the receiver follow variations of the transmitter's center frequency.

A similar system for 24 telephone channels is being developed in New York by Federal Telecommunication Laboratory, IT&T affiliate of Laboratoire Central de Telecommunication which latter developed the equipment described above. For further details see: Le Cable Hertzien Paris-Montmorency, A-G. Cla-

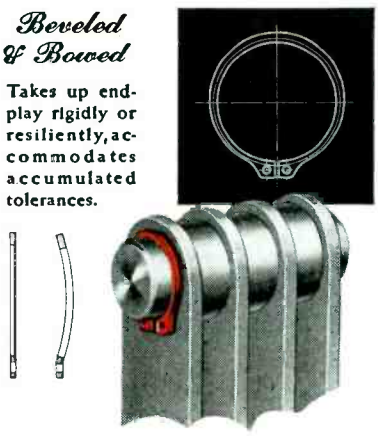
Precision fastening for any need: Waldes Truarc Special-Type Retaining Rings

Inverted

Provides uniform shoulder for curved abutting surfaces, for bearings with large corner radii.

Beveled & Bowed

Takes up end-play rigidly or resiliently, accommodates accumulated tolerances.



Self-Locking

Economical where thrust is moderate — holds fast, yet shaft requires no machining.

Interlocking

2-piece ring takes heavy thrusts, gives positive lock, secure against high RPMs.

*Crescent**

Snaps on radially where axial assembly is impossible. No special tools needed.

E-Ring

Variant of Crescent for small shafts; provides large, strong shoulder. Easily removed.

● There's a Waldes Truarc precision-engineered ring to answer every need. Truarc Retaining Rings give a never-failing grip because of their mathematically precise construction. No matter how demanding your specifications, it's a simple matter to refine your present designs to save material, machining and assembly costs. Waldes Truarc engineers will help you, will give your particular problem individual attention without obligation.

WALDES

TRUARC

TRADE MARK U. S. PAT. RE. 18,144 AND OTHER PAT. PEND.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

*U. S. PAT. 2,382,948

Waldes Kohinoor, Inc., 47-10 Austel Place
Long Island City 1, N. Y., Dept. 18-J

Please send Catalog No. 4 on Truarc Retaining Rings to:

Name_____

Title_____

Company_____

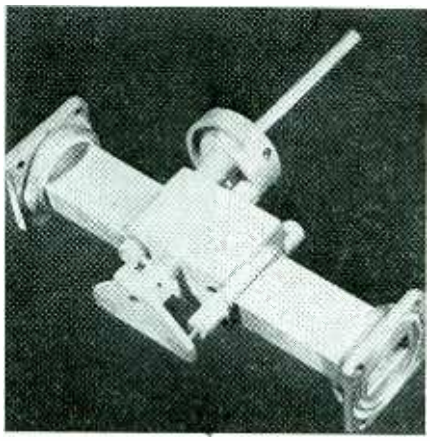
Address_____

City_____ Zone____ State_____

vier et G. Phelizon, Science et Vie, June 1946.

Metallizing Applications

DEPOSITION of thin layers of material from the vapor state has grown from a laboratory method of obtaining layers a few molecules thick to a versatile industrial technique. Glass attenuators for precision measurements of microwaves are made by metallizing glass. Thickness of the film is accurately gaged by measuring its conductivity during deposition. Research for the process was conducted at the Polytechnic Institute of Brooklyn (PB-6589, 47 p., Dept. of Comm.). Coaxial metallized glass attenuators and wave guide pads have been produced by the technique (PB-6588, 50 p., Dept. of Comm.). Using the same technique, precision metalized glass resistors for pulse circuits were produced. (PB-5186, 12 p., Dept. of Comm.).



Waveguide attenuator is built around a metallized glass resistance element

Samples for metallurgical testing are prepared by the vaporization process at the research laboratory of the Leningrad Electric Lamp Factory in Russia, where radio tubes are manufactured. To prepare alloys of all possible combinations of proportions of the constituent metals, the various alloying metals are heated to incandescence in a vacuum and the stream of particles emanating from them is made to mix on a screen to form what might be called an alloy spectrum. The technique offers an extremely fast method of preparing a range of alloys for study of their properties.

Communications Is My Business

"I'm a communications engineer. I'm engaged in the design, specification, purchase, installation, and operation of a wide variety of communication equipment ranging all the way from radio systems and units, public address and inter-communication systems, recording equipment, etc. to hearing aids and television.

Communications is a fast moving, highly competitive business. There's constant demand for innovation and improvement, and engineers must have at their fingertips up to date, authoritative information on all product sources as well as product specifications.

"That's why . . . **I use the BUYERS' GUIDE . . . why it's as indispensable as a slide rule to me as well as to every engineer in my field**

Mr. Manufacturer:

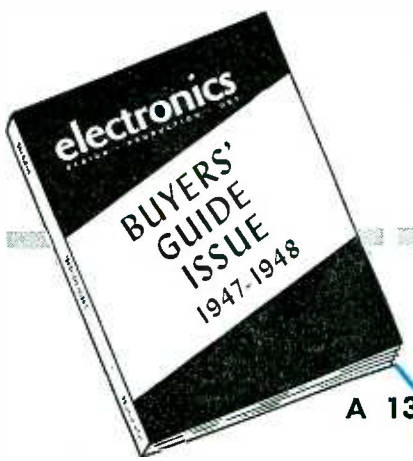
Your advertisement in the Buyers' Guide will be seen by over 29,000 subscribers and 120,000 pass on readers . . . a complete and select audience made up of the hard to reach men throughout industry whose function is the specification and purchase of electronic components, equipment, and allied products. Give these men the information they need to design-in and specify *your* products—in the ELECTRONICS Buyers' Guide.

THE BUYERS' GUIDE PROVIDES

the names and addresses of over 3000 companies making electronic components, equipment, and allied products. It contains a logical, easy-to-use, and detailed system of product classification that enables me to locate quickly all product sources. In addition, there are special features, graphs, tables, indices etc. . . . valuable day to day working tools for the engineer.

THE ADVERTISING CONTENT

supplies most of the information I need to examine, compare, and then design-in and specify components, equipment, and allied products. Manufacturers using the Guide for the presentation of complete catalog type copy on their full line of products perform a valuable service . . . save engineers like myself time and energy in thumbing through endless files and folders or writing to manufacturers for additional information."



A McGRAW-HILL PUBLICATION

electronics

BUYERS' GUIDE ISSUE

ABC • 330 WEST 42nd ST., NEW YORK 18, N.Y. • ABP

A 13th ISSUE • FREE TO SUBSCRIBERS • PUBLISHED EVERY JUNE 15th

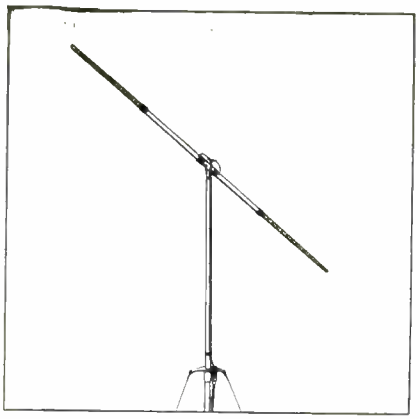
NEW PRODUCTS

Edited by A. A. McKENZIE

New apparatus, component parts, packaged units and allied equipment are described. Catalogs and manufacturers' publications are reviewed

Tunable Dipole (1)

KINGS ELECTRONICS, 372 Classon Ave., Brooklyn 5, N. Y. A new adjustable dipole that can be tuned for optimum reception of f-m, television, and airport frequencies will be available shortly. The dipole



arms are calibrated so that it is possible to repeat settings previously determined. All hardware and lead-in cable are furnished with the antenna kit.

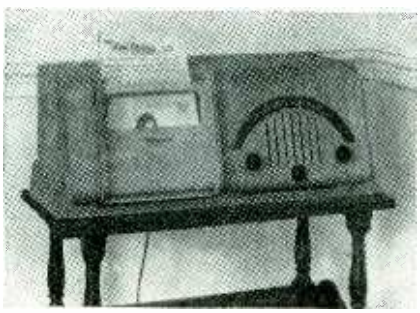
F-M Transmitter (2)

RAYTHEON MFG. CO., 7517 North Clark St., Chicago 26, Ill. Essentially, the new cascade circuit adds the phase shift of six receiver-type tubes to produce the required phase shift for noise-free high-fidelity modulation. This method is different from the frequency multiplication technique used in the original Armstrong system, and is said to result in an inherent lower noise level. Direct crystal control of the transmitter is possible without employing electromechanical frequency stabilizers. Frequency response is virtually flat from 30 to 15,000 cycles, distortion is less than 1 per-

cent, and the noise level is 65 db below 75-kc deviation from center. The 250-watt unit illustrated can also be used as a driver for either 1 or 3-kw amplifiers.

Facsimile Receivers (3)

FINCH TELECOMMUNICATIONS, INC., 10 E. 40th St., New York 16, N. Y. Facsimile receivers of several different types, including the table model illustrated, combine f-m broadcast reception with the recording mechanism for printing pictures at the rate of four 8½ x 11 pages every 15 minutes. Listeners in New York, Hollywood, San Francisco, Chicago, and Detroit have, or will shortly have facsimile broadcasts available for such receivers.



Thickness Tester (4)

BRANSON INSTRUMENTS, INC., Danbury, Conn. The Audigage is an interesting development in the line of equipment that uses ultrasonic frequencies for nondestructive testing of materials. The portable equipment, weighing only 14 pounds and powered by dry batteries, operates on the principle of reflection of a narrow beam of sound from the farther surface of a metal plate or pipe. In practice, a dial is turned until audio modulation of the ultrasonic oscillator

sounds loudest in headphones. The dial reading, calibrated directly in thickness of steel, can be converted easily to indicate thickness of other metals or glass. The instrument has a range corresponding to 0.09 to 4.0 inches of steel, with an accuracy of plus or minus 2 percent.

Thickness Gage (5)

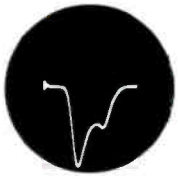
THE SHEFFIELD CORP., Box 893, Dayton 1, Ohio. The Measuray is an x-ray electronic comparator suitable for production measurement and control of materials moving at speeds of 5 to 5,000 feet a minute, metal sheets and foils or nonconducting plastics and paper. The apparatus does not touch the material gaged and movement or whip up and down between signal source and detector, within practical limits, does not disturb accuracy of

Now You Can SEE The Performance Of Your Circuits

With the

HAR-CAM
Visual Alignment
SIGNAL GENERATOR

The HAR-CAM Visual Alignment SIGNAL GENERATOR provides the swiftest and surest method for the adjustment and alignment of tuned circuits. With it the complete radio frequency response curve of any circuit under observation can be presented on an oscilloscope screen. Variations in circuit alignment can be accurately evaluated and necessary changes made in a matter of seconds — a far simpler, more precise method than the old technique of tuning for maximum audio or voltage output which often leads to improper alignment of I-F, discriminator or other circuits.



The HAR-CAM Visual Alignment Signal Generator instantly shows up the misalignment in the I-F circuit shown above.

With the assistance of the HAR-CAM Signal Generator, the performance of the circuit is easily and correctly adjusted.

SPECIFICATIONS

1. Linear frequency sweep deviation adjustable from zero to 900 kc peak to peak.

2. Vernier frequency control of 100 kc allows zero beat calibration of main tuning dial or for vernier frequency deviations, about main dial frequency setting.

3. Stable r-f gain control independent of frequency.

4. Five-step attenuator of r-f output giving over-all voltage range of 1 microvolt to .1 volt when used in conjunction with the gain control.

5. Output impedance, 1 ohm to 2500 ohms.

6. Phone jack for aural monitoring of zero beat calibration of main tuning dial.

7. Panel jack to feed linear sweep voltage to x-axis amplifier of oscilloscope, thus synchronizing the frequency sweep of the generator with the spot trace on the scope screen.

8. Voltage regulated supply for internal oscillators. Careful oscillator design to minimize drift.

9. Size, 7" wide, 9½" high, 10½" deep. Weight 18 pounds.

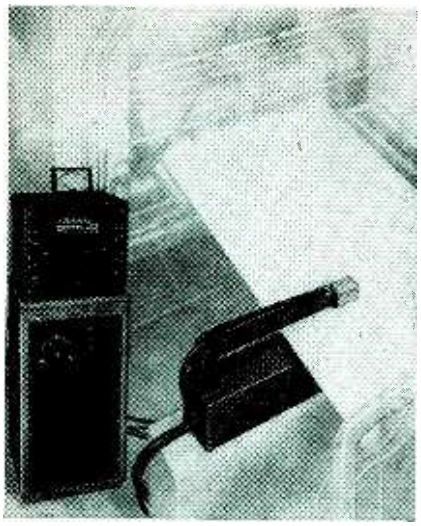
Write for Bulletin

HARVEY RADIO LABORATORIES, INC.

439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS

HAR-CAM
HARVEY OF CAMBRIDGE

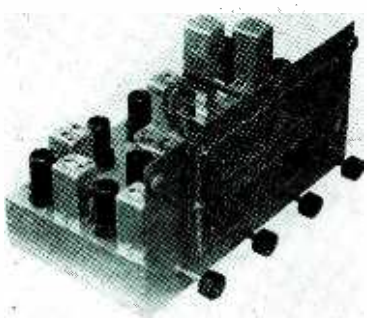
Typical HARVEY products: *Above left:* The HARVEY Marine Radio Telephone Model M-25; *center:* The HARVEY Regulated Power Supply 106 PA; *right:* The HAR-CAM Model MFT-25 FM Transmitter. Write for Bulletins.



measurement. Wall thickness of tubing can also be checked. All measurements are claimed to be within a tolerance of 1 percent of the thickness of the material gaged.

F-M and A-M Tuner (6)

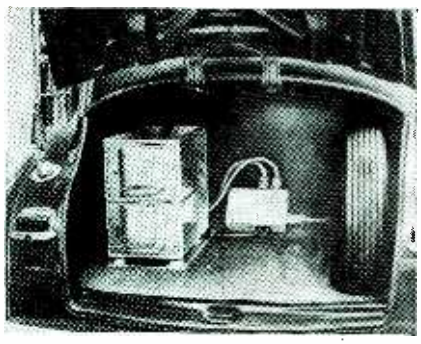
BROWNING LABORATORIES, INC., Winchester, Mass. A new f-m tuner covering 87 to 109 megacycles is combined with a-m circuits to tune the present broadcast band. Separate r-f and i-f channels are used for both bands. Cascade limiters are



provided for the f-m section. Provision has been made to utilize the new twin-lead 300-ohm cable for both inputs. Physically the tuner without power supply is 7⅜ inches high by 13½ inches wide, and requires a depth of 9 inches.

Mobile Radio (7)

KELLOGG SWITCHBOARD AND SUPPLY CO., Chicago, Ill. First models have been displayed of a new f-m mobile radio equipment designed to tie in



with radio service offered by the telephone company. The mobile receiver contains a selective signal circuit that responds to pulses sent out from the dial-operated central office transmitter. This system allows as many as 84 mobile units to be selected, one at a time, with all but the desired station locked out. A busy lamp makes it unnecessary to pick up the mobile handset to determine whether the circuit is in use. The handset is equipped with a push-to-talk switch that connects the f-m transmitter to the antenna and the dynamotor to the output tube. The equipment illustrated uses a drawer-type construction to facilitate servicing.

Dual-Channel Scope (8)

ELECTRONIC TUBE CORP., 1200 E. Mermaid Ave., Philadelphia 18, Pa. The model E-2G48 dual channel oscilloscope is a laboratory instrument comprising two separate operating channels that are connected to a dual-gun cathode ray tube. Obser-

vation of microsecond pulses containing frequency components up to 10 megacycles is possible. Timing markers are available. External connection to any of the deflection plates is possible and a trigger output is provided in each amplifier-control channel. The equipment has been designed with a view to making photographs of the phenomena displayed on the tube.

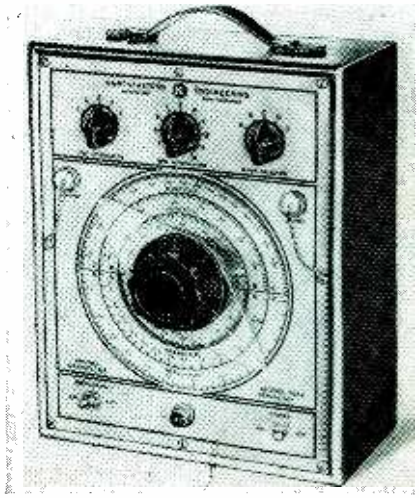
Geiger Counter (9)

VICTOREEN INSTRUMENT CO., 3800 Perkins Ave., Cleveland, Ohio. The model 337 counter control is a-c operated and supplies up to 2,000

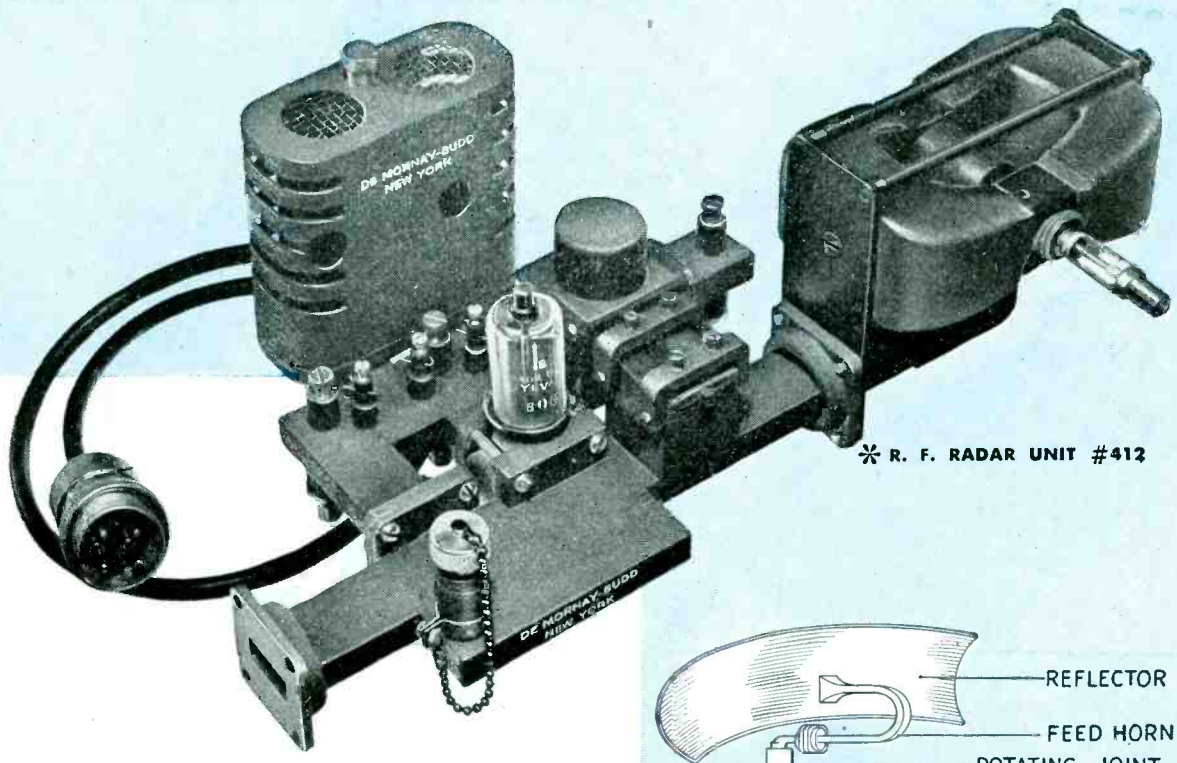
volts to the associated Geiger-Mueller counter tube. It scales counts by a factor of 64, although a scale of 8 can be used if desired. Provision is made for aural monitoring. An impulse counter is built into the front panel along with the operating controls.

Signal Generator (10)

NORTHEASTERN ENGINEERING, Manchester, N. H. The model 700A signal generator operates over the range 160 kc to 20 mc with fundamental frequencies supplied in five bands. Output impedance is 200 ohms with r-f output voltage of 0.1



PACKAGED R. F. RADAR ASSEMBLY ELIMINATES DESIGN HEADACHES



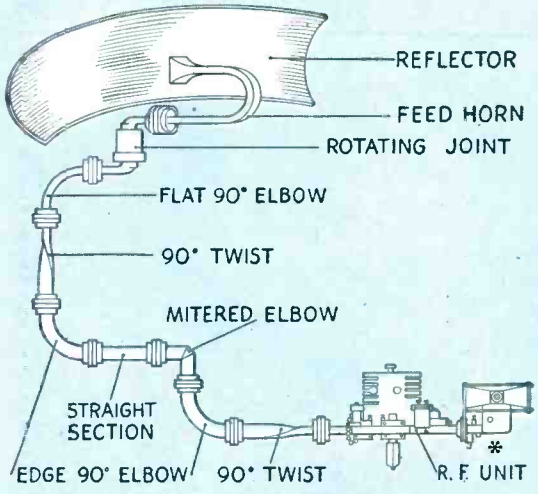
* R. F. RADAR UNIT #412

The DeMornay-Budd packaged R. F. Unit provides a complete R. F. assembly for microwave radar. It is now possible to obtain as standard items all the microwave R. F. components necessary in the fabrication of a complete radar—DeMornay-Budd Standard Transmission Line Components plus packaged R. F. Unit.

The R. F. Radar Unit is delivered complete and ready to operate. It is wired and contains all the necessary tubes and crystals. The unit uses a packaged magnetron capable of delivering 20 kw., peak power, at 9375 mc. Two type 2K25 local oscillator tubes are provided, one for receiver and A.F.C. and the other for beacon operation. A type 1B35 A-T-R tube, a type 1B24 T-R tube and the necessary type 1N21 crystals are included in the assembly. A 20 db. directional coupler permits accurate measurements to be made at any time with a maximum of convenience and safety.

Since the use of radar beacons is contemplated in the near future, the unit has been designed with a beacon cavity and crystal mount. The unit can be supplied without the beacon cavity and crystal mount and beacon local oscillator, and a termination supplied in their place so that it becomes a simple matter to convert to beacon operation when necessary.

NOTE: Write for complete catalog of De Mornay-Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.



R. F. Radar unit #412 (indicated by asterisk) used in conjunction with standard DeMornay-Budd transmission line components.

Write for catalog of standard bench test equipment.

DE MORNAY BUDD

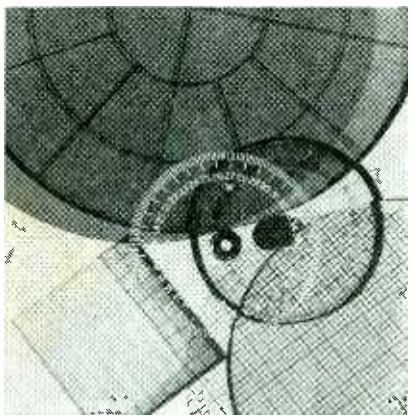
EQUIPMENT FOR 97% OF ALL RADAR SETS

DE MORNAY-BUDD, INC.
475 GRAND CONCOURSE, NEW YORK, N. Y.

volt rms. External modulation or 30 percent internal modulation at 400 cycles is provided. The unit weighs 14 pounds and measures 10 x 13 x 5 inches.

Engraved Dials (11)

AMERICAN PRECISION DIAL CO., 93 Massachusetts Ave., Boston 15, Mass. Plastic, glass, or metal dials can be engraved with circles up to 20 inches in diameter and with as many as 6,400 radial graduations



accurate to 2 minutes on 360 degrees by an automatic method that compares favorably in production cost with pantograph engraving.

Opinion Meter (12)

GENERAL ELECTRIC CO., Schenectady, N. Y. The composite opinion of groups as large as 120 can be measured by electronic casting of secret ballots. A hand-held individual station, connected by a flexible cord with the indicating meter, is set to the degree of positive or negative opinion held by the voter and the meter mechanism integrates the total expression of opinion. If voters wish to abstain an OFF button is pressed. The percentage of those not voting can be determined. Fifty-fifty opinions are eliminated, but the percentage so voting can also be determined.

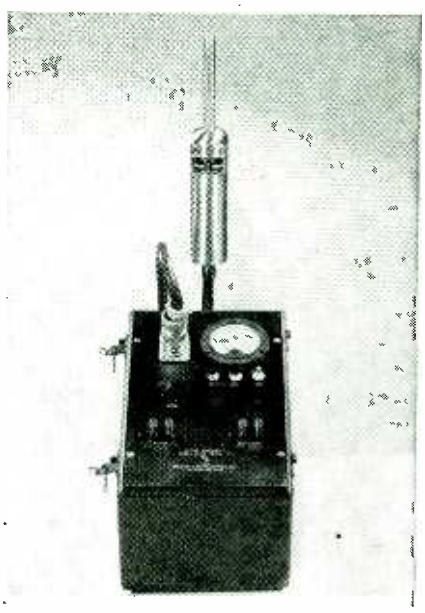
Combustion Safeguard (13)

COMBUSTION CONTROL CORP., 77 Broadway, Cambridge 42, Mass. The Fireye F18TS combustion safeguard has been improved to insure against damage resulting from flame failure and low boiler water

level. The photoelectric device that sees loss of flame operates an alarm and cuts off fuel. A probe in the water column is wired into the same control and alarm circuits.

Sound Pressure Measurement System (14)

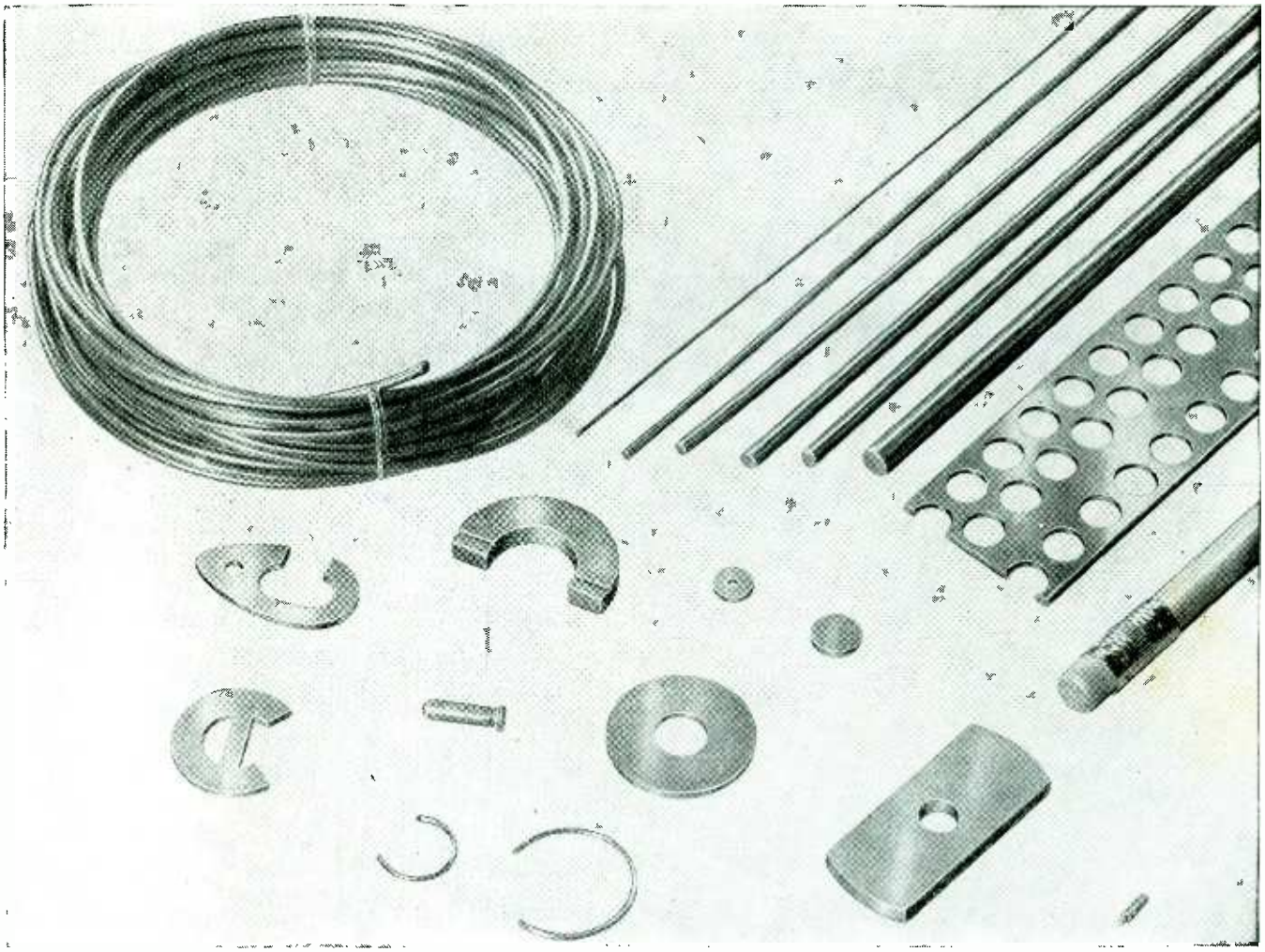
MASSA LABORATORIES, INC., 3868 Carnegie Ave., Cleveland 15, Ohio. The Model GA-1002 sound pressure measurement system is a precision electroacoustic device for making absolute measurements of sound pressure over the entire audible and early ultrasonic frequency range to about 40 kilocycles. The equipment comprises a Model M-101 standard microphone used with a shock-mounted preamplifier and 15-foot cable by which the probe assembly illustrated is connected to a battery-operated amplifier. A built-in calibrating circuit permits setting the gain to produce an output of exactly one millivolt per dyne per square centimeter sound pressure so that a conventional electronic voltmeter can be employed for direct reading of the pressure. Owing to the extremely high acoustic impedance and small size of the standard microphone, free field measurements can be more accurately made at high frequencies or inside confined spaces than has heretofore been possible. Shock pressures generated by explosions, engine exhausts and the like can be measured without damage to the equipment.



Midget Microphone (15)

KELLOGG SWITCHBOARD AND SUPPLY CO., 6650 S. Cicero Ave., Chicago, Ill. A midget microphone for meas-

PERMANENT MAGNETS MAY DO IT BETTER!



New Names in Permanent Magnet Materials
Made by Indiana Steel **CUNICO-CUNIFE-VECTALITE-SILMANAL**

Four new magnetic materials developed to widen and supplement the field of applications already stimulated by the cast and sintered Alnicos serve to emphasize the significance of correct design in the use of Permanent magnets. Due to their properties of ductility and machinability, Cunico and Cunife are especially adaptable in magnets of small size.

CUNICO is an alloy of copper, nickel and cobalt which may be cast, swaged, drawn, rolled, machined, punched or sintered in round, square or rectangular rods from ¼" to 1" in any cross-sectional dimension. It has a high coercive force and is well suited for magnets requiring a large cross-section in proportion to length.

CUNIFE is a copper, nickel, iron alloy which has directional magnetic properties and may be swaged, formed, drawn, rolled, punched, and machined. It has a high energy product in wire form up to ¼" diameter and its coercive force is comparable to that of Alnico.

VECTALITE is a sintered oxide which has directional magnetic properties, extremely lightweight and a very high coercive force. It has the unusual property of being non-conducting and has been satisfactorily used for rotor magnets in DC selsyns and tachometer indicators.

SILMANAL, because of its silver content, is relatively costly and, therefore, suited to special applications requiring a very high resistance to demagnetization in either AC or DC magnetic fields. It is ductile, malleable and machinable and may be produced in rods from 1/16" to 5/16" in diameter.

With these outstanding new additions supplementing a wide line of magnets, The Indiana Steel Products Company is equipped to furnish the exact type of permanent magnet to meet any production requirement. Our engineers invite you to consult them on your design problems. For complete information write for our free "Permanent Magnet Manual".

★ THE INDIANA STEEL PRODUCTS COMPANY ★

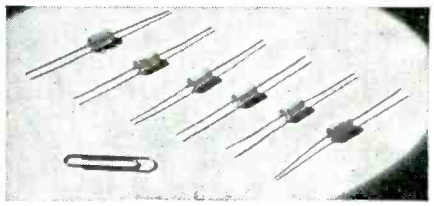
PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE * CHICAGO 2, ILL.

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910
PLANTS { VALPARAISO, INDIANA
STAMFORD, CONN. (CINAUDAGRAPH DIV.)

urement of sound pressures has now been made available after a long period of use in the laboratories of the manufacturing company. Response is minus 59 db referred to one volt per dyne per square centimeter, and is flat from 100 to 7,000 cycles within 1 db, or within 3 db from 60 to 10,000 cycles. Acoustic intensities of 1,200 to 1,400 dynes per square centimeter have been successfully measured.

Crystal Diode (16)

GENERAL ELECTRIC Co., Syracuse, N. Y. A new germanium crystal diode with a safe forward current of 0.05 ampere and a safe back voltage of 60 volts for radio and televi-



sion receiver applications has just been announced. Weighing several grams, with a body length of $\frac{23}{64}$ inch, the crystal has an interelectrode capacitance of approximately 0.2 micromicrofarad and a life performance of at least 3,000 hours.

Leak Detector (17)

VACUUM ELECTRONIC ENGINEERING Co., 316-37th St., Brooklyn 32, N. Y. The Veeco mass spectrometer leak detector is adjusted to cause a

electronics READER SERVICE . . .

TO BRING YOUR LIBRARY UP TO DATE ON

LITERATURE and NEW PRODUCTS

Manufacturers' Literature as well as further information on New Products described in this issue are important "working tools" for design and production departments. To make it easy to keep up to date, ELECTRONICS will request manufacturers to send readers the literature in which they are interested. Just fill out card as shown in the filled-in sample (right), *being particularly careful to write out in full all the information called for in each section of each card that is used.*

SAMPLE CARD SHOWING CORRECT FILL-IN ←

Write in circle number of item describing one item wanted → (14) Your Company Name Jones Mfg. Co. Address 3217 Lewis Ave. Chicago 13, Ill. Your Name Geo. Smith Your Title Chief Engineer ELECTRONICS, 330 W. 42nd St., N. Y. 18	Write in circle number of item describing one item wanted → (32) Your Company Name Jones Mfg. Co. Address 3217 Lewis Ave. Chicago 13, Ill. Your Name Geo. Smith Your Title Chief Engineer ELECTRONICS, 330 W. 42nd St., N. Y. 18
Write in circle number of item describing one item wanted → (37) Your Company Name Jones Mfg. Co. Address 3217 Lewis Ave. Chicago 13 Ill. Your Name Geo. Smith Your Title Chief Engineer ELECTRONICS, 330 W. 42nd St., N. Y. 18	Write in circle number of item describing one item wanted → (49) Your Company Name Jones Mfg. Co. Address 3217 Lewis Ave. Chicago 13, Ill. Your Name H. S. Towne Your Title Adv. Mgr. ELECTRONICS, 330 W. 42nd St., N. Y. 18

PLACE 1¢ STAMP ON CARD • DO NOT USE AFTER APRIL 1

HOW TO ORDER:

1. There are two postcards, each divided into four parts. Each of the four parts contains a box. You must write in this box the number that appears in this issue over the literature or new product item in which you are interested. Place one number only in each box.

2. Fill out completely (name, address, etc.) for each piece of literature or new product information you desire.

Do not say "same" in lieu of writing out full information called for when requesting more than one item.

3. This service applies only to literature and new product items in this issue. It does not apply to advertisements. Write directly to the company for information on its advertisements.

Careful and complete filling in of each portion of the card on which information is requested gives your request authority, and allows the manufacturer to whom we send your original request, the opportunity to address your copy correctly.

PLEASE NOTE:

In the event this copy of ELECTRONICS is passed along to other members of your company, please leave this sheet in for their convenience. This assures everyone in your plant the opportunity to fill in their requests. When the round is completed, cards can then be detached along perforated lines and dropped in the mail. Each individual request will be mailed by us to the company offering the information and for that reason must be completely filled out.

Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.	Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.
Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.	Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.
Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.	Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.
Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.	Write in circle number of item describing one item wanted → ○ Your Company Name.... Address.... .... Your Name.... Your Title.... ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.

An electronics service designed for

READERS and MANUFACTURERS

FOR THE READER...

ELECTRONICS fundamental policy has always been to supply its readers with all the pertinent and timely industry news. The ELECTRONICS Reader Service supplements this policy by offering the reader an easy and effective means of obtaining complete, up to the minute data on new products and of maintaining at his fingertips comprehensive, practicable information on "who's doing what" in the industry.

In every issue of ELECTRONICS there's complete coverage of the month by month development by manufacturers of new materials, components and equipment, as well as brief mention of all the important, new, manufacturers' technical pamphlets and catalogs. Some of these items will be of particular interest to specific design and plant engineers, buyers, executives and others of our readers. They will want to make further inquiry concerning the new products described or they will want to read and make a permanent part of their industrial library some of the manufacturers' literature and catalogs. ELECTRONICS Reader Service makes it easy for them to obtain in readily accessible and usable form the information they desire.

PLACE 1¢ STAMP ON CARD • DO NOT USE AFTER APRIL 1

Place 1¢ Stamp Here

ELECTRONICS

330 WEST 42nd STREET

NEW YORK 18, N. Y.

1-1-47

FOR THE MANUFACTURER...

ELECTRONICS Reader Service will also be welcomed by manufacturers who are desirous of placing the complete news of their product developments as well as their technical bulletins and catalogs in the hand of those members of the electronic industry... including design, electrical, and production engineers, researchers, physicists, executives, and buyers—who have a particular interest in, or represent a potential buying power for, their products.

Place 1¢ Stamp Here

ELECTRONICS

330 WEST 42nd STREET

NEW YORK 18, N. Y.

SUGGESTIONS FOR THE IMPROVEMENT OF OUR READERS' SERVICE ARE INVITED

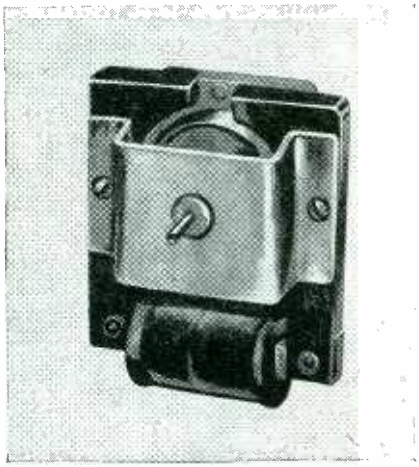
ELECTRONICS is constantly seeking new and improved ways of providing its readers with the news and information they want and need, and of assisting the manufacturer in effectively delivering his message to electronic markets. If you have any ideas for us, send them along. They'll receive prompt and grateful consideration.

1-1-47

meter deflection only when small amounts of helium are detected in the vacuum system to which the apparatus is connected. In practice, a small stream of helium is played over the apparatus suspected. If it is absorbed into the system, the detector gives immediate warning. The minute quantities of helium present in air do not affect operation. Nontechnical personnel can use the unit which is powered from 115 v, 60 cps lines.

Miniature Motor (18)

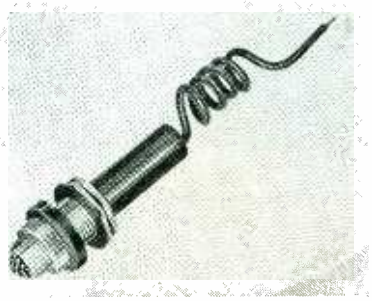
ALNI CORP., 10 E. 52nd St., New York 22, N. Y. A new miniature motor that can be operated on 30 milliwatts of power is now available for general use in operating



cam switches and small ventilator fans. The model 2000-2 illustrated weighs 2¼ ounces and measures 1¾ × 1¾ × ⅞ inches, is of the permanent magnet type, and operates on d-c.

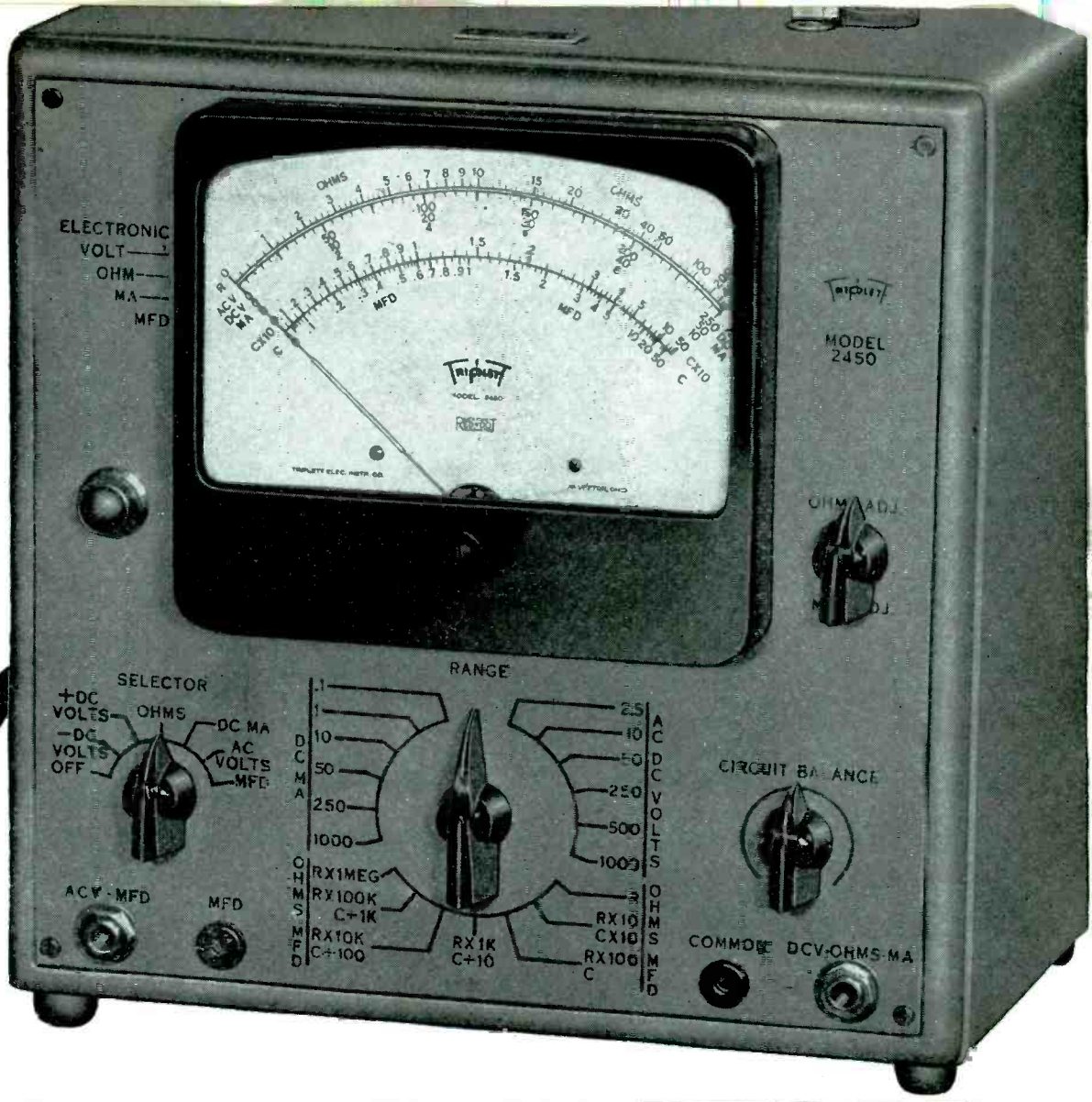
Blinking Pilot (19)

ENGINEERING ASSOCIATES, 380 Main St., East Orange, N. J. A new warning pilot lamp that blinks at a rate of 60 to 80 times a minute operates on 200 milliamperes. It can be used



Model 2450

ELECTRONIC TESTER



There's never been a tester like this!

Here's a tester with dual voltage regulation of the power supply DC output (positive and negative), with line variation from 90 to 130 volts. That means calibration that stays "on the nose"! That means *broader service* from a tester that looks as good as the vastly improved service it provides. And, together with its many other new features—including our Hi-Precision Resistor which outmodes older types—it means higher performance levels wherever a tester is needed. Detailed catalog sheets on request.

Highlights:

- 42 RANGES: DC and AC. Volts: 0-2.5-10-50-250-500-1000. DC MILLIAMPS: 0-0.1-1.0-10-50-250-1000. OHMS: 0-1000-10,000-100,000. MEGOHMS: 0-1-10-100-1000. CAPACITY IN MFD: 0-.005-.05-.5-5-50.
- LOAD IMPEDANCE: 51 megohms on DC Volts.
- CIRCUIT LOADING: Low frequencies. Circuit loading equal to 8 megohms shunted by 35 mmfd. High frequency circuit loading equal to 8 megohms shunted by 5 mmfd.

STANDARDS ARE SET BY TRIPLETT

Precision first ...to last

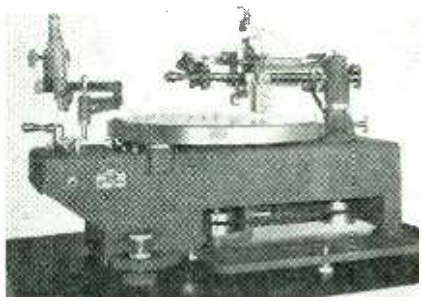
Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

on direct current circuits to 32 volts or alternating current up to 125 volts. External resistors are used to adapt to the different voltages. The unit mounts on any panel in a single 13/16 inch diameter hole. The housing is Bakelite.

Recording Turntable (20)

PRESTO RECORDING CORP., 242 West 55th St., New York 19, N. Y. The Presto 8-D recording turntable uses a heavy cast iron mounting base and table that can be mounted on a stand. An improved cutting head



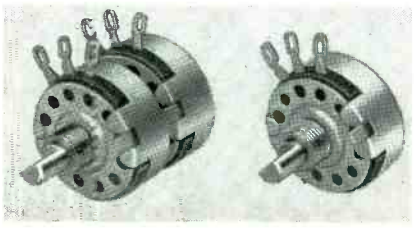
responds to frequencies between 50 and 8,000 cycles. Six different cutting pitches are immediately available by means of a belt adjustment. Changes in direction can be quickly made to provide inside-out and outside-in feed with a single screw.

Coin Television (21)

TRADIO, Asbury Park, N. J. Tradio-Vision is a new television receiver that can be installed in hotels or public places and operated by the insertion of coins. The equipments have a five or seven-inch screen,

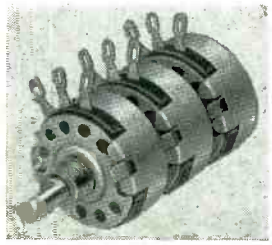
These Allen-Bradley Honeycomb Cartons

keep the fixed resistor leads always straight



TYPE J BRADLEYOMETERS
in 1, 2, and 3 section types

For continuously adjustable resistors—in 1, 2, or 3 section types—specify Type J Bradleyometers. They meet any resistance-rotation curve specification . . . and, being solid-molded, there is no change due to age or use. Furnished with line switch if desired.



You know how messy it is to pick fixed resistors from a pan of tangled units. No matter how carefully your operators work, resistor leads became bent.

But most serious are the loss of production and the irritation to assemblers when they fumble with tangled component parts. To avoid these problems, use Bradleyunit resistors. They come in handy honeycomb cartons that keep all leads straight.

And all leads are "differentially" tempered to prevent sharp bends near the resistor. Leads are quickly and easily formed to fit any spot in your chassis.

Bradleyunits are small in size but "tops" in load and life tests. Under continuous loads of 200% load for 100 hours, or under 100% load for 1000 hours, resistance change is less than 5%. Allen-Bradley Co., 110 W. Greenfield Avenue, Milwaukee 4, Wis.

A-B Quality

ALLEN-BRADLEY

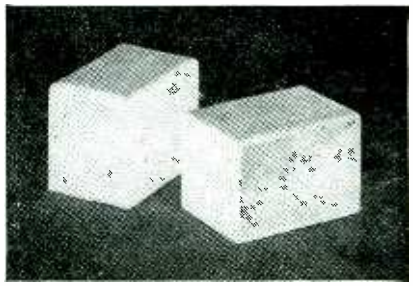
FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

500-line definition, and require 20 tubes. Overall size of the set is 16 x 9 x 8 inches.

Relay Covers (22)

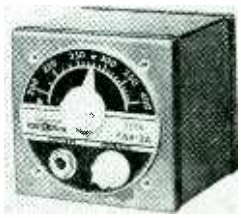
MASTER PLASTICS, INC., Wilmington, Delaware. Synvar Polyester resins combined with milled Fiberglas have been successfully used to make relay covers that have mechanical strength and temperature



resistance of more than 300 F. The methods and materials used in this case are applicable to similar enclosures when the required number of items is low.

Range Receiver (23)

BENDIX RADIO, Baltimore 4, Md. The type PAR-3 range receiver is a 4-tube superheterodyne with an intermediate frequency of 455 kc. It tunes between 195 and 410 kc and



operates from a 67.5-volt battery and one dry cell. The receiver weighs only 1.5 pounds and is contained in a 3⅛-inch cube.

Intercommunicator (24)

DALMO-VICTOR, San Carlos, Calif. The Dalmotron is a small, inexpensive intercommunication device claimed to be much more versatile than the conventional type. Among its unusual features is the ability in a six-station system to arrange two

FOR FASTER, MORE ECONOMICAL SOLDERING!

THE SOLDERING TOOL WITH *Automatic Feed*

At a touch of the trigger, stainless steel knives eject a measured amount of solder. A loading chamber in the handle provides housing for a 4-ounce reel of solder. For continuous, all-day production, solder may be fed through the EJECT-O-MATIC from large reels mounted on, or under, the bench. A special eyelet hole is provided for this purpose in the cover of the loading chamber. EJECT-O-MATIC Automatic Feed, with core solder, eliminates fussing with fluxes—makes soldering a one-hand operation — speeds production — assures neat, uniform joints. The 50, 75, 100 and 150 watt models are now available. Tips may be had in 6 different sizes and shapes.

Approved by Underwriters' Laboratories, Inc.

CONSIDER THESE BIG FEATURES

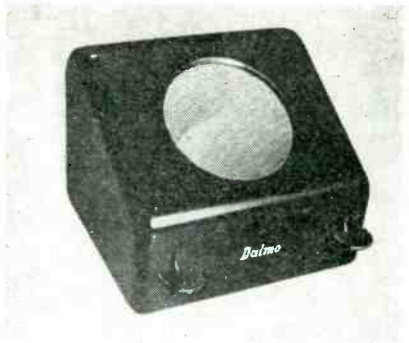
- Micrometer Control of Amount of Solder Ejected
- Anti-fatigue Balance—Light Weight
- Automatic Solder Retracting Feature—Prevents Melting of Excess Solder
- Cooling Vanes Dissipate Excess Heat
- Multi-clad, 400-hour Tip, no tinning, no filing
- One-hand Operation—Speeds Production
- Safety, Utility Base

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

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

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

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



separate two-way conversations while the rest of the system is open for paging.

Cements and Solvents (25)

JFD MANUFACTURING CO., 4117 Fort Hamilton Parkway, Brooklyn 19, N. Y. Radio cements, solvents, and carbon tetrachloride are now

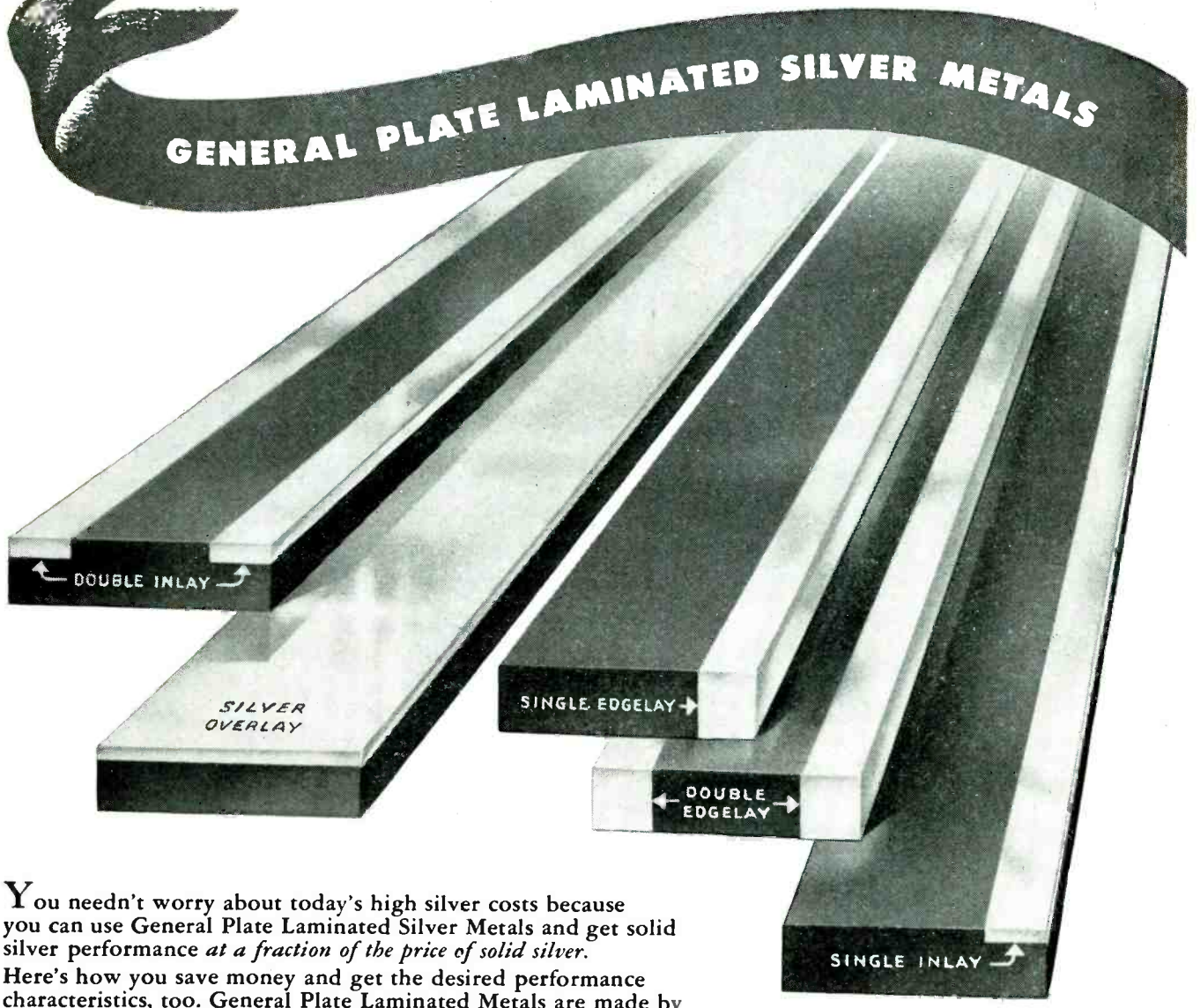
being packaged in 4-, 8-, 16-ounce, and gallon containers. A brush is attached to the metal cap of the cement containers.

Multimeter (26)

SYLVANIA ELECTRIC PRODUCTS, INC., 500 Fifth Ave., New York 18, N. Y. The type 134 Polymeter is provided with a probe utilizing the type 1247 proximity fuze type tube and can measure accurately up to 300 megacycles. Voltages up to 1,000 v d-c and 300 v a-c, direct current in the ranges 0 to 3 ma and 0 to 10 amp,

IT DOES THE JOB OF SOLID SILVER

Yet It's Yours at Low Cost...



You needn't worry about today's high silver costs because you can use General Plate Laminated Silver Metals and get solid silver performance *at a fraction of the price of solid silver.*

Here's how you save money and get the desired performance characteristics, too. General Plate Laminated Metals are made by permanently bonding thin layers of silver or other precious metals to thicker inexpensive base metals. Thus you get the precious metal performance at a cost slightly higher than the cost of the base metal.

Among the advantages of General Plate Laminated Metals, you get better electrical conductivity, high corrosion resistance, workability, ease of fabrication, better spring properties, long wearing life and structural and mechanical properties not obtainable with single solid precious metals.

General Plate Laminated Metals are available in sheet, wire and tube form with precious metal on one side, or both sides in practically any combination.

Investigate the advantages of General Plate Laminated Metals, today. Wire for information.

GENERAL PLATE DIVISION

of Metals and Controls Corporation

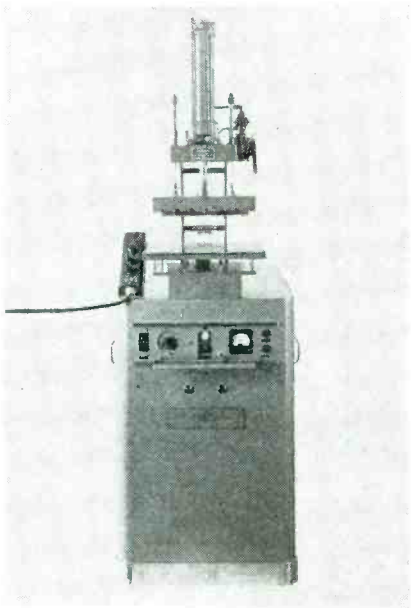
ATTLEBORO, MASSACHUSETTS

50 Church St., New York, N.Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, California; Grant Bldg., Pittsburgh, Pa.

and resistance up to 1,000 megohms can all be measured. The instrument operates from socket power and weighs 16 pounds. There are separate scale calibrations for resistance, d-c, a-c, and r-f measurements.

Plastic Sealer (27)

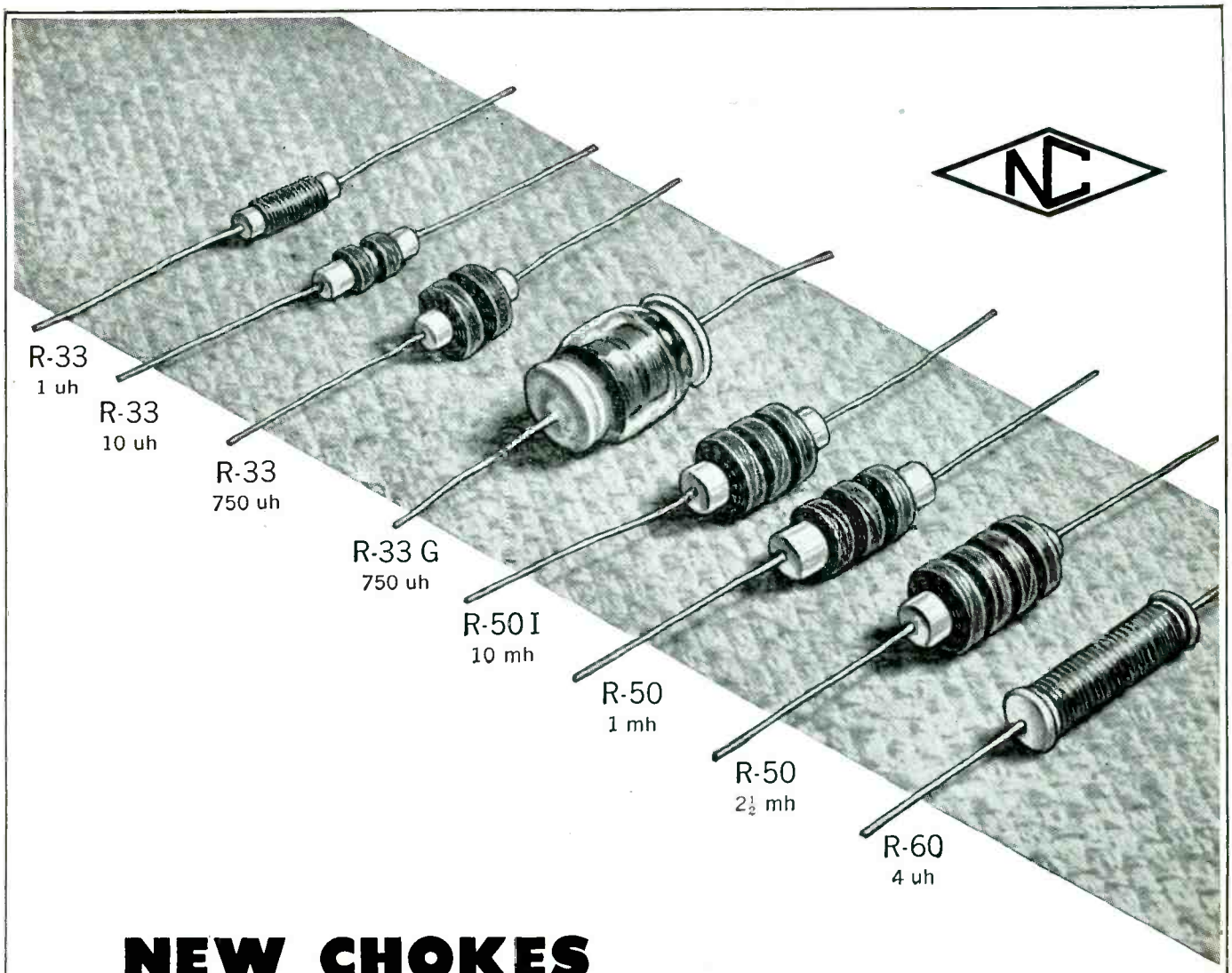
RADIO RECEPTOR CO., INC., 251 West 19th St., New York 11, N. Y. A new 2½ kilowatt dielectric sealer, type K-3-S, is completely self-contained. One of four types of sealing



press can be mounted on the top to form a complete thermoplastic welder for such substances as Koroseal, Saran, and Wataseal. Thicknesses from 0.002 to 0.040 inch in varying lengths can be handled successfully. A complete description is given in Bulletin 7005.

Crystal Oscillator (28)

BLILEY ELECTRIC CO., Erie, Pa. The type CCO crystal-controlled oscil-



NEW CHOKES

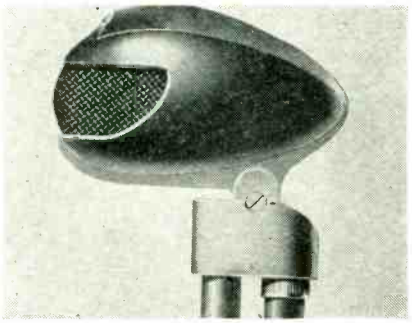
The enlarged line of chokes now offered by National includes many new sizes and types and provides units suited to specialized as well as standard applications. Many popular new chokes are illustrated above, including the R-33G which is hermetically sealed in glass. Other models cover current ratings from 33 to 800 milliamperes in a variety of mountings carefully planned for your convenience. These as well as old favorites like the R-100 are listed in the latest National Catalogue.

NATIONAL COMPANY, INC., MALDEN, MASS.

lator provides five of the most commonly used intermediate frequencies used in radio receivers, a 200-kilocycle signal for r-f alignment and a 1,000-kilocycle signal for shortwave testing. Other special frequencies can be added to the unit and selected at will. Audio modulation of the signals can be introduced as desired. Output can be varied from 0 to 15 volts. Power consumption is 17 watts and the equipment requires no warmup time.

Plastic-Cased Mike (29)

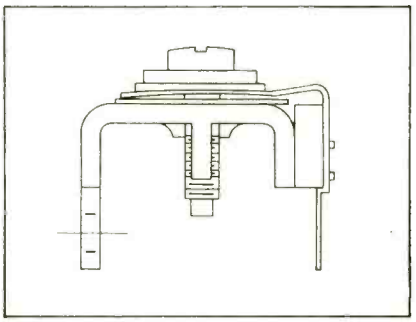
ST. LOUIS MICROPHONE CO., 2726 Brentwood Blvd., St. Louis 17, Mo. A new line of microphones called Colormikes is now being produced

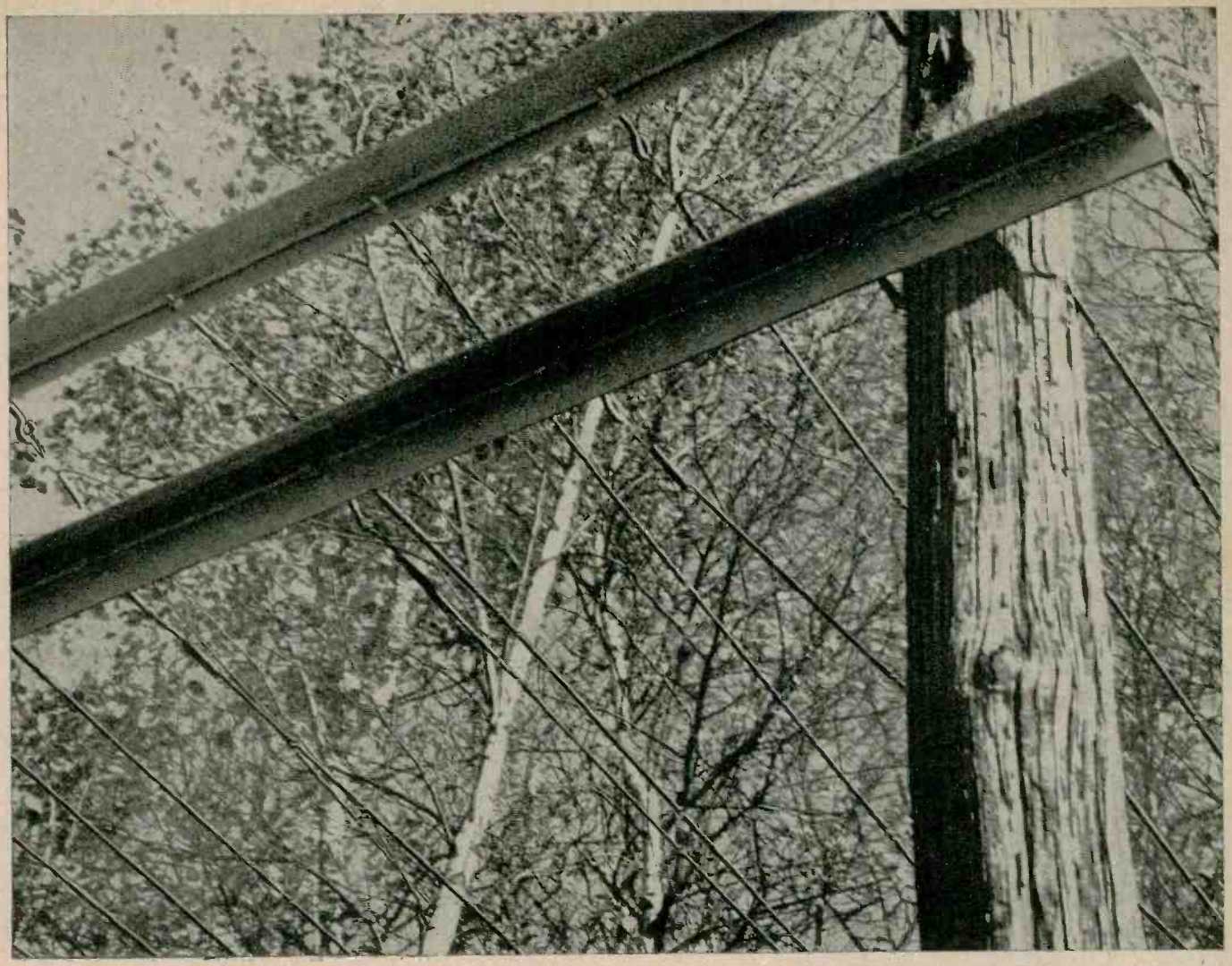


in colored plastic cases, with unbreakable diaphragms and Alnico V magnets. A variable-impedance output permits choice of 50 to 50,000 ohms for balanced line output.

Mica Trimmer (30)

LEAR, INC., Grand Rapids, Mich. Five new mica trimmer capacitors covering the capacitance range from 5 to 370 micromicrofarads have a minimum Q of over 200 at 1,000 kilocycles, and a leakage resistance of better than 2,000 megohms at a test voltage of 300 volts





Drop-wire undergoing abrasion tests in birch thicket "laboratory." Below, the new drop-wire, now being installed.

WE'RE GLAD THAT BIRCH TREES SWAY

The telephone wire which runs from the pole in the street to your house is your vital link with the Bell System. More than 17,000,000 such wires are in use.

The wire becomes coated with ice; it is ripped by gales, baked by sun, tugged at by small boys' kite strings. Yet Bell Laboratories research on every material that goes into a drop-wire—metals, rubbers, cottons, chemicals—keeps it strong, cheap, and ready to face all weathers.

Now a new drop-wire has been developed by the Laboratories which lasts even longer and will give even better service. It has met many tests, over 6 or 7 years, in the laboratory and in field experiments. It has been strung through birch thickets—rubbed, winters and summers, against trees, and blown to and fro by winds. In such tests its tough cover lasts twice as long as that of previous wires.

House by house, country-wide, the new wire is going into use. Wire is only one of millions of parts in the Bell System. All are constantly under study by Bell Telephone Laboratories, the largest industrial laboratory in the world, to improve your telephone service.

BELL TELEPHONE LABORATORIES

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

d-c. Screw adjustment of the capacitance is smooth and remains permanently set.

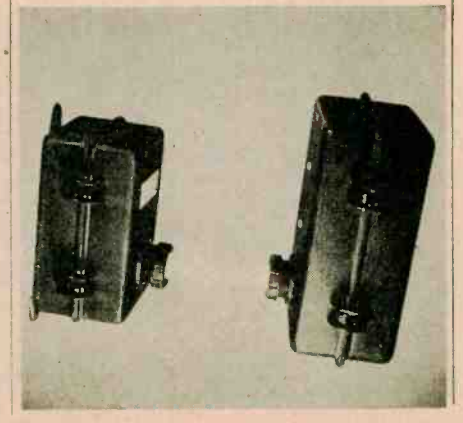
Transmitting Triode (31)

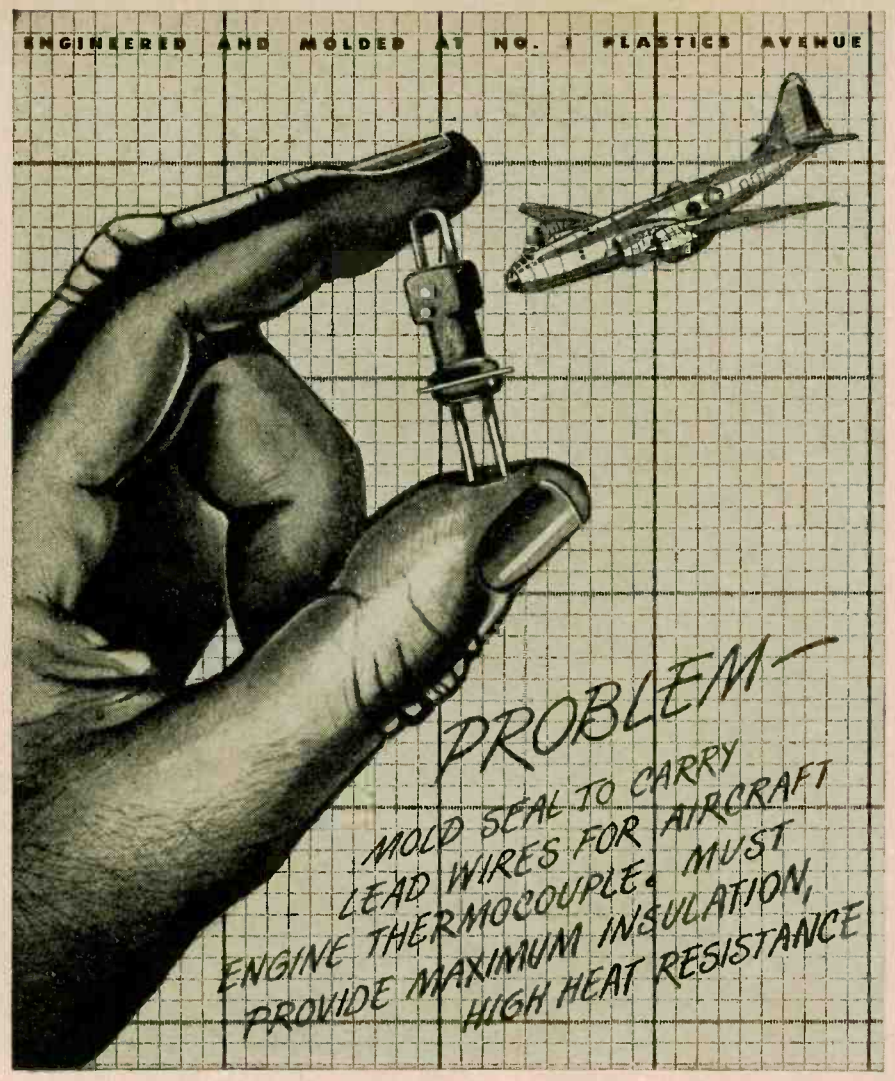
TAYLOR TUBES, INC., 2312 Wabansia Ave., Chicago, Ill. The type T-300 medium-power triode is similar in some respects to the type 204-A and is a direct substitute for types HF-300, KU-23 and DR-300 with some

few exceptions. Maximum operating conditions include plate voltage, 3,000 v; plate current, 275 ma; plate input, 750 watts; plate dissipation, 200 watts.

Smoke Control (32)

PHOTOSWITCH, INC., 77 Broadway, Cambridge 42, Mass. The type A20C photoelectric smoke indicator observes the density of smoke passing through a flue and signals when





When safety demands top protection—

INSULATE WITH G-E MYCALEX

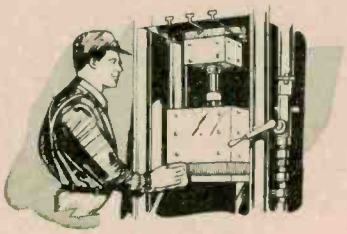
●In aircraft engines—where safety demands the finest insulating materials—this seal of General Electric mycalex assures excellent protection.

Maximum insulation resistance is needed between the two fine wires running through the seal. The gasket flange requires the same complete insulation. By bonding firmly to these inserts, General Electric mycalex gives the seal added strength, helps make it leakproof.

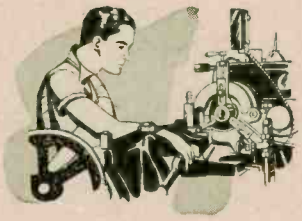
G-E mycalex is a gray, stone-hard material recommended for its high dielectric strength . . . low loss factor . . . heat resistance . . . toughness . . . chemical and dimensional stability. You may order it in standard rods and sheets, in fabricated parts, or molded to your own design. General Electric engineers, experts in the uses of this unique material, will help you apply it to your insulation needs. To get the complete story, send for the new bulletin, "G-E MYCALEX." Write to Section S-17, Plastics Divisions, Chemical Dept., General Electric Co., 1 Plastics Avenue, Pittsfield, Mass.

HOW THE G-E MYCALEX SERVICES CAN BENEFIT YOU NOW

You may order fabrication of sample G-E mycalex parts at surprisingly low cost. Test them yourself in your own equipment. Then, if you decide to specify G-E mycalex, your design can be converted to a molding process which permits speedy and economical production runs.



MOLDING SERVICE



FABRICATING SERVICE

Get This Unique Combination of Properties with G-E Mycalex

1. High dielectric strength
2. Low power factor
3. Prolonged resistance to electrical arcs
4. Chemical stability—no deterioration with age
5. Dimensional stability—freedom from warpage and shrinkage
6. Impervious to water, oil, and gas
7. Resistance to sudden temperature changes
8. Low coefficient of thermal expansion
9. High heat resistance

Samples Supplied on Request

GE MYCALEX

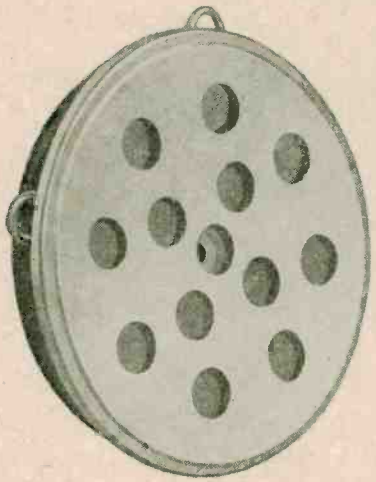
GENERAL ELECTRIC

CD47-M17

this density approaches values previously designated as the maximum to be tolerated. Supplementary equipment includes bells and graphical recorders.

Hearing Microphone (33)

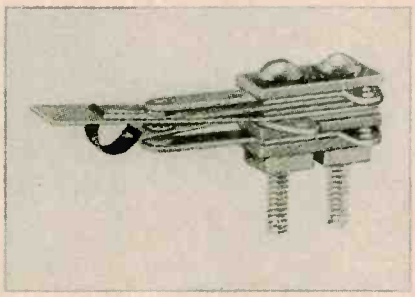
TIBBITTS INDUSTRIES, INC., Camden, Maine. A new ultrasensitive microphone for hearing aid use measures



1¼ inches in body diameter and is 3/32 inch thick. The model HA-30 unit uses a crystal element, protected by a guard grille.

Open Blade Switch (34)

ACRO ELECTRIC CO., 1316 Superior Ave., Cleveland 14, Ohio. A new two-pole snap-action switch operates with a movement differential of



1/16 inch. It is manufactured with single or double-throw contacts. Rated at 15 amp, 125 volts, a-c, the overall dimensions are only 2⅛ × 25/32 × ⅜ inches.

Calculator (35)

AMERICAN HYDROMATH CO., 145 West 57th St., New York 19, N. Y. The Calculaide frequency computer

Read why

INDUSTRY'S Fastening-wise LEADERS CHOOSE PHILLIPS SCREWS

INDEPENDENT STUDIES! AUTHENTIC! UNBIASED! Prepared by investigators from the James O. Peck Co., industrial research authorities, who talked with key men in top U. S. plants using Phillips Recessed Head Screws in product assembly.

"Assembly savings 50%" . . . "Breakage reduced 90%" . . . "Eliminate $40.-a-day spoilage." In their own words, America's best assembly men tell how they apply the proved advantages of Phillips Screws to speed driving, end driver skids, eliminate unsightly burrs, improve product appearance.

Each report is fully illustrated – a fact-jammed digest of modern assembly practice, information you never hoped to see in print, inside facts you would pay good money to get – now, FREE, to you.

12 Reports Now Ready

These reports have been offered as they were published throughout the year. If you haven't already sent for them, get all twelve now. Read them! Learn why, more and more, Phillips Screws spot the profit-planned products!

- HEYWOOD-WAKEFIELD . . .
- EMERSON RADIO . . . . . .
- SONOTONE CORP. . . . . .
- BENDIX APPLIANCES . . . . .
- PULLMAN-STANDARD . . . .
- SERVEL, INC. . . . . .
- OTIS ELEVATCR . . . . . .
- NORTON CO. . . . . .
- PITNEY-BOWES . . . . . .
- YORK CORP. . . . . .
- PIPER AIRCRAFT . . . . . .
- LIONEL CORP. . . . . .

Mail the coupon NOW!

PHILLIPS *Recessed Head* SCREWS

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

American Screw Co.
Atlantic Screw Works
Atlas Bolt & Screw Co.
Central Screw Co.
Chandler Products Corp.
Continental Screw Co.
Corbin Screw Div. of American Hdwe. Corp.
The H. M. Harper Co.
International Screw Co.
Lamson & Sessions Co.

26 SOURCES

Milford Rivet and Machine Co.
National Lock Co.
National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company

Phillips Screw Mfrs., E-13
c/o Horton-Noyes
2300 Industrial Trust Bldg., Providence, R. I.

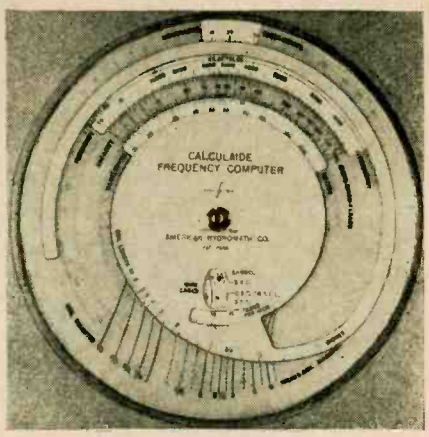
Send me the 12 Assembly Reports on Phillips Screws.

Name.....

Company.....

Address.....

.....



correlates, at one setting, natural frequency and wavelength of a circuit comprising an inductor and capacitor with the physical dimensions of the coil and the capacitance value of the capacitor. A frequency range from 400 kilocycles to 150 megacycles is covered. All scales appear on the same side of the computer.

Stripper Kit (36)

GENERAL CEMENT MFG. CO., 919 Taylor Ave., Rockford, Ill. Insulation of any wire from size 8 to 30

can be quickly stripped with the new Speedex 733-K kit. The basic tool has seven interchangeable blades and is packaged in a steel case.

Voltage Regulator (37)

SORENSEN & CO., INC., Stamford, Conn. Particularly applicable for aircraft use, the model D-500 a-c

MB PRECISION MINIATURE METERS

THERMOCOUPLE THERMOMETERS

For Example . . .

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

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

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

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

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

INSTRUMENT MB DIVISION

MINIATURE ELECTRICAL INSTRUMENTS FOR ANY PURPOSE

voltage regulator delivers output voltage in the range 110 to 120 volts with input voltage from 95 to 125 volts, 360 to 500 cycles. Regulation accuracy is 0.5 percent and harmonic distortion is less than 5 percent. The unit weighs 12.5 pounds.

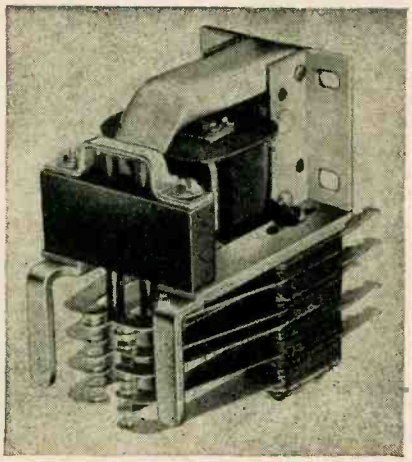
Transcription Console (38)

ROBINSON RECORDING LABORATORIES, 35 S. 9th St., Philadelphia 7, Pa. A new wooden cabinet with access

to turntable motors and storage space for recording accessories can be supplied with or without turntable chassis.

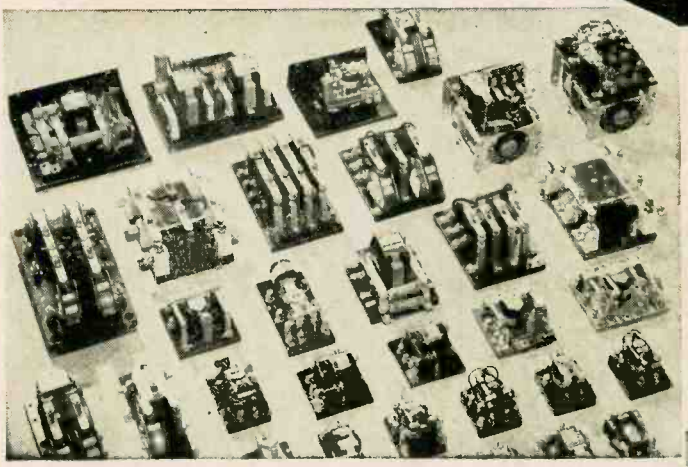
Multiple-Contact Relay (39)

AUTOMATIC SIGNAL DIVISION, Eastern Industries, Inc., 100 Regent St., East Norwalk, Conn. The AC2 multiple-contact relay used in vehicle-actuated traffic control systems is now available for general use. Insulation between individual contact springs and between any spring and ground is of the order of 300 megohms. Connections to coil and contacts are made at the rear so that



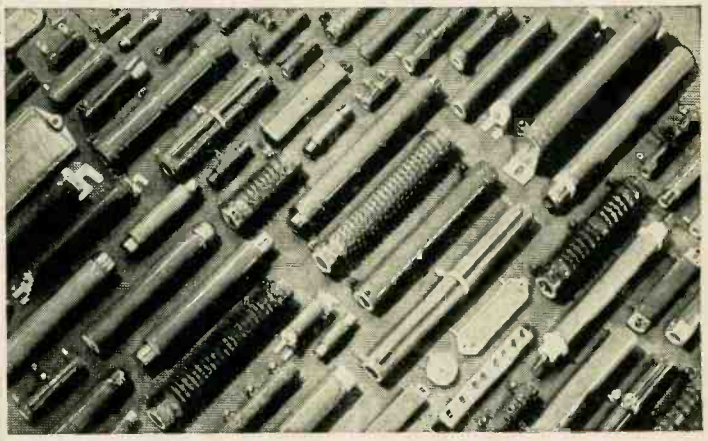
RELY ON THE LINE WITH THE RANGE THAT'S WIDE

You can find practically anything you want—in relays, resistors and rheostats—by selecting from the regular Ward Leonard line.



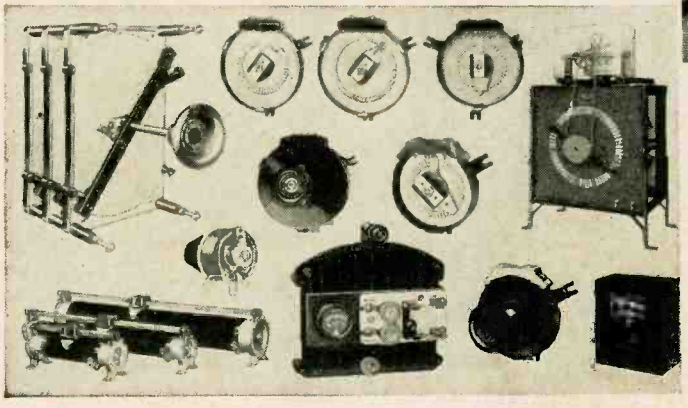
RELAYS

Crisp action, Durable construction. Low power consumption. Light, intermediate and heavy-duty types for sensitive, transfer, time delay, antenna change-over, break-in, and latch-in operation. *(Illustration at left)*



RESISTORS

Withstand heat, moisture, vibration, and other adverse operating conditions. Regular line includes wide range of types, sizes, ratings, terminals, mountings and enclosures. *(Illustration at right)*



RHEOSTATS

Operate smoothly. Durable contacts. Line includes widest range of sizes, tapers, and current ratings from tiny ring-types for radio to huge multiple assemblies for heaviest industrial use. *(Illustration at left)*

WARD LEONARD

Electric Control Devices since 1892

WARD LEONARD ELECTRIC COMPANY • 32 SOUTH ST. • MOUNT VERNON, NEW YORK

the relay can be vertically mounted on a panel. Coils for 115 and 12 volts, 60 cycles are standard. Various combinations of contact arrangement can be supplied.

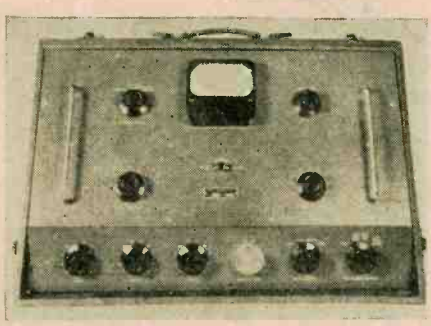
Plastic Capacitors (40)

AMERICAN CONDENSER CO., 4410 N. Ravenswood Ave., Chicago 40, Ill. The Amcon Little PL is a new small

capacitor in a molded plastic case for top chassis mounting. The units are 2⅛ inches high and have a diameter of 1⅛ inches.

Portable Console (41)

PRESTO RECORDING CORP., 242 West 55th St., New York 19, N. Y. The type 90-A portable console for recording consists of three preamplifiers, mixer, master gain control,



and recording amplifier. A selector provides various recording and playback characteristics. Flexibility of controls allows a free combination of functions so that the amplifier can feed both a public

SEAMLESS and WELDRAWN*

Stainless Steels • Alloy Steels
Carbon Steels • Nickel & Inconel
Monel • Beryllium Copper

Superior tubing *must* have what it takes, judging from the demands of the manufacturers of quality peacetime products. Many of these same manufacturers were engaged in production for the armed forces, where quality took on a new meaning—lives, many lives depended on it.

Quality can't be "just skin deep"—it must pervade the innermost parts of a product. Tubing usually loses its identity in end use—it very often is just a "line on a blueprint"—but a line or part that must perform as well as the costliest component in the assembly.

Choosing the proper analysis depends upon combinations of such properties as corrosion resistance, formability, machinability, high strength at high temperature and surface finish. Superior maintains tireless control of these factors as well as physical dimensions and tolerances, all of which contribute to tubing quality. Our ability to predict accurately the results to be experienced with any given analysis, is your assurance of enduring, faultless performance in production and end use.

Superior engineers and metallurgists are ready to help you choose the exact analysis for your product. Design with Superior tubing and be sure!

*Registered U. S. Trademark

THE BIGGER NAME IN SMALL TUBING **Superior**

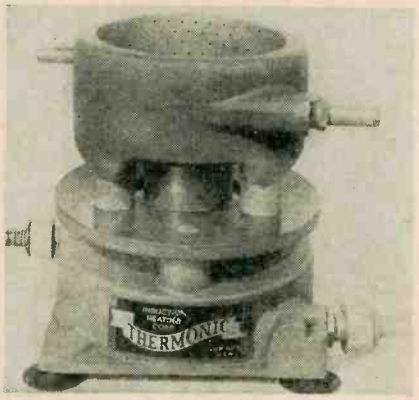
SEE OUR CATALOG IN SWEET'S

SUPERIOR TUBE COMPANY
Norristown, Pennsylvania

address system and record cutter. Incoming line programs can be combined with pickups or microphones. The equipment operates from socket power.

Heating Accessory (42)

INDUCTION HEATING CORP., 389 Lafayette St., New York 3, N. Y. A compact hydraulic rotary spindle



and quench ring combined in a single unit simplifies the handling and heat treatment of parts requiring rotation during the heating cycle and subsequent quenching in position.

Terminal Block (43)

CANNON ELECTRIC DEVELOPMENT Co., 3209 Humboldt St., Los Angeles 31, Calif. The new type Y6 terminal block for low-amperage circuits is made of phenolic plastic, fitted with side and foot brackets of steel and contacts of silver-plated brass. Six-contact units can be combined vertically or horizontally. Single or six-contact plugs can be inserted as desired. It is completely described in Bulletin Y6-1.

Moistureproof Speakers (44)

UNIVERSITY LOUDSPEAKERS, INC., 225 Varick St., New York 14, N. Y. The type MSR and MM-2TC loudspeakers are submergence and explosion proof. Electrical characteristics are similar but the type MSR has a 360-degree dispersion and is heavier than the MM-2TC which has 120-degree dispersion. These loudspeakers are suitable for use

A MIGHTY OAK

A TINY UNBRAKO SOCKET SET SCREW

Reg. U. S. Pat. Off.

Pat'd & Pats. Pend.

BOTH ARE TOWERS OF STRENGTH

You can't screw socket screws in or out, without a hex socket wrench,—so why not get our #25 or #50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.

In the electronics, radio and electrical manufacturing business these tiny "Unbrako" Socket Set Screws are like the mighty oak — their strength, and enduring quality are lasting. Their finely knurled cup points dig in and holds fast — regardless of the most chattering vibration. Though they be ever so tiny — they are made with the accuracy for which "Unbrako" Products are famous.

"Unbrako" and "Hallowell" Products are sold entirely through distributors.

Kits: Pat. Pend.

OVER 43 YEARS IN BUSINESS

Knurling of Socket Screws originated with "Unbrako" in 1934.

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 596 • BRANCHES: BOSTON • CHICAGO • DETROIT • INDIANAPOLIS • ST. LOUIS • SAN FRANCISCO

on docks, in railraod yards. in mines, powder mills, or flour factories.

Power Tetrode (45)

EITEL - MCCULLOUGH, INC., San Bruno, Calif. The new type 4X500A power tetrode is rated at 500 watts plate dissipation with operation at maximum rating up to 110 megacycles. The tube features low grid drive, controlled grid emission, high power gain and stability.

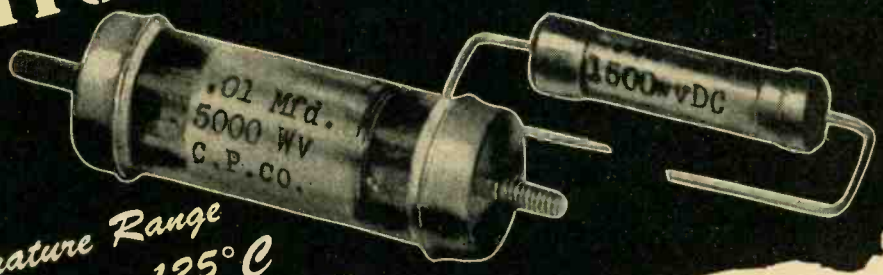
Line Fault Finder (46)

KENNETH W. JARVIS, 6058 West Fullerton St., Chicago, Ill. Two instruments with different ranges are now available for locating faults on power transmission lines. The location can be determined within an accuracy of 0.1 percent within 10 minutes after connecting the unit to a line that is open or shorted. The principle of operation is dependent upon resonance phenomena such that line current of the section

PLASTICON* ASG Silicone-Filled GLASSMIKES

1-3/8 x 3-1/2

FOR HIGHER VOLTAGES



Extreme Temperature Range from Minus 60° C to Plus 125° C

From 600 to over 30,000 Volts

Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.

Applications

- **For low and medium power coupling and bypass circuits where mica capacitors have previously been required**
- **Television and Oscilloscope Circuits**
- **Vibrator Buffer and Arc Elimination**
- **Geiger Counter and Instrument Capacitors**

Write for illustrated literature featuring our complete line of Glassmike Capacitors.

***PLASTICONS: Plastic-Film Dielectric Capacitors**

Order from your jobber: If he cannot supply you, order direct

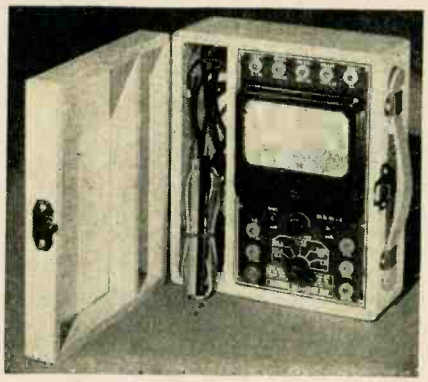
Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

under test is maximum at the resonant frequency of the section. A variable oscillator is geared in with a recorder to indicate the distance at which the fault lies as a function of resonant frequency. The smaller of the two units has a normal range of 100 miles on open wire line and the larger has a range of 250 miles.

Test Meter (47)

ELECTRONIC MEASUREMENTS CORP., 114 Liberty St., New York 6, N. Y. The Volometer Model 101 B illustrated is a volt-ohm-milliammeter with five d-c ranges up to 3,000



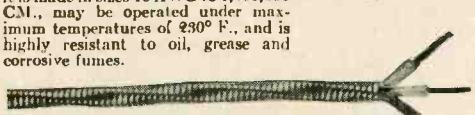
volts, four a-c ranges up to 1,200 volts, three d-c ranges to 600 milliamperes, and resistance ranges up to 20 megohms. The model shown, most expensive of the line, is priced at $24.95.

Literature

(48)
High-Frequency Melting. Ajax Electrothermic Corp., Ajax Park, Trenton 5, N. J. Bulletin 27 explains methods and equipment for induction heating and melting. The data is so presented as to facilitate proper selection of equipment for the job to be done.

(49)
Sound Equipment. Fairchild Camera and Instrument Corp., 88-09 Van Wyck Blvd., Jamaica 1, N. Y. A 24-page, plastic-ring bound catalog represents the complete line of cutter heads, pickups, studio recorders, portable recorders, and

The large cable illustrated to the right is Rockbestos A. V. C. Motor Lead and Apparatus Cable. Insulated with asbestos and varnished cambric, and covered with a heavy asbestos braid, it is made in sizes 18 AWG to 1,000,000 CM., may be operated under maximum temperatures of 230° F., and is highly resistant to oil, grease and corrosive fumes.



ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for temperature control systems, commercial gas burner safety pilot controls, signal and intercommunications systems. Its asbestos insulation and rugged steel armor assure trouble-free circuits. Sizes No. 14 to 18 AWG in two to five conductors with .0125", .025", or (.031" for 115 volt service) of felted asbestos insulation.

ROCKBESTOS A.V.C. 600 SWITCHBOARD WIRE
(National Electrical Code Type AVB)

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

A few of the 125 different wires, cables and cords developed by Rockbestos for severe or unusual operating conditions.

Your Products Will Never Die from "Hardening of the Arteries" if You Wire With ROCKBESTOS

WIRES, CABLES AND CORDS

It's costly in money and prestige to have "cripples" coming back for repair or replacement because of wire-failures. But you can go a long way toward eliminating this hazard by wiring with *permanently insulated* Rockbestos wires, cables and cords.

Rockbestos *impregnated asbestos* insulation — heatproof and fireproof — will never bake brittle, crack or flow and will not dry out with age. Furthermore, it will withstand corrosive fumes, oil, grease and moisture.

Among the 125 different Rockbestos types, you almost are certain to find the solutions to your wiring problems. Write for catalog or recommendations.

ROCKBESTOS PRODUCTS CORPORATION
443 Nicoll Street, New Haven, Conn.

ROCKBESTOS

The Wire with Permanent Insulation

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

other gear necessary for high-precision cutting of records. There is an interesting and well illustrated story on details of construction.

(50)

Hermetic Terminals. Cincinnati Electric Products Co., Carthage at Hannaford, Cincinnati, Ohio. A new 20-page catalog giving complete engineering data about Fusite terminals and HermetiCans also contains information on the company's automatic sealer.

(51)

Terminals. Patton-MacGuyer Co., 17 Virginia Ave., Providence, R. I. Forty pages are required to describe the more than 300 entirely different types of terminals for electric wires that this outfit is prepared to furnish. The latest catalog is just off the press.

(52)

Capacitors. American Condenser Corp., 4410 No. Ravenswood Ave., Chicago, Ill. Catalog A546 describes the company's complete line of dry electrolytic and paper dielectric capacitors.

(53)

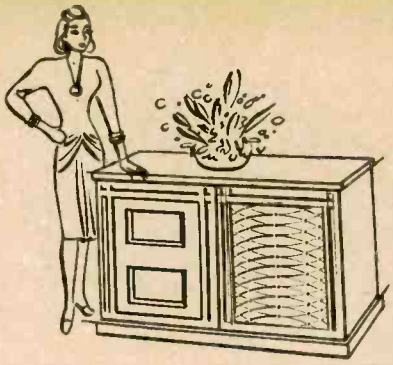
Variacs. General Radio Co., Cambridge 39, Mass. New continuously variable transformers and combinations for special or multiple-phase use are described in a new folder just issued.

(54)

Carbon Products. Speer Carbon Co., St. Mary's Pa. Catalog 25 is devoted primarily to brush grades, but dry-cell battery electrodes and filler, rheostat discs, and graphite power tube anodes are also covered in the 40-odd pages.

(55)

Connectors. Burndy Engineering Co., Inc., 107 Bruckner Blvd., New York 54, N. Y. A new 64-page illustrated catalog is offered free to those interested in electrical connectors for conductor sizes from No. 22 to 2,000 Mcm. Special tools for use with particular types of connectors are also described.



how to put your set in the "upstairs" class...

Four more manufacturers of phono-combinations, in the "upstairs" clique, are using Garrard record changers. That, in itself, is not good enough reason for Garrard to go into every phonograph and combination set built. A Garrard would hardly be at home in a six-tuber. But if you're striving for something ultra in your better combinations, Garrard is your changer.

With Garrard in your set, you give the dealer more to talk about; you please the customer who is willing to stretch a bit for technical perfection.

There are more than half-a-dozen reasons why Garrard will make your whole set easier to sell... more desirable to own. But perhaps it would be sufficient to mention that the Garrard changer has been chosen for these sets of unquestioned quality! SCOTT.....FISHER.....FREED · EISEMANN .....LONDON GRAMOPHONE.

PRECISE AS A WATCH

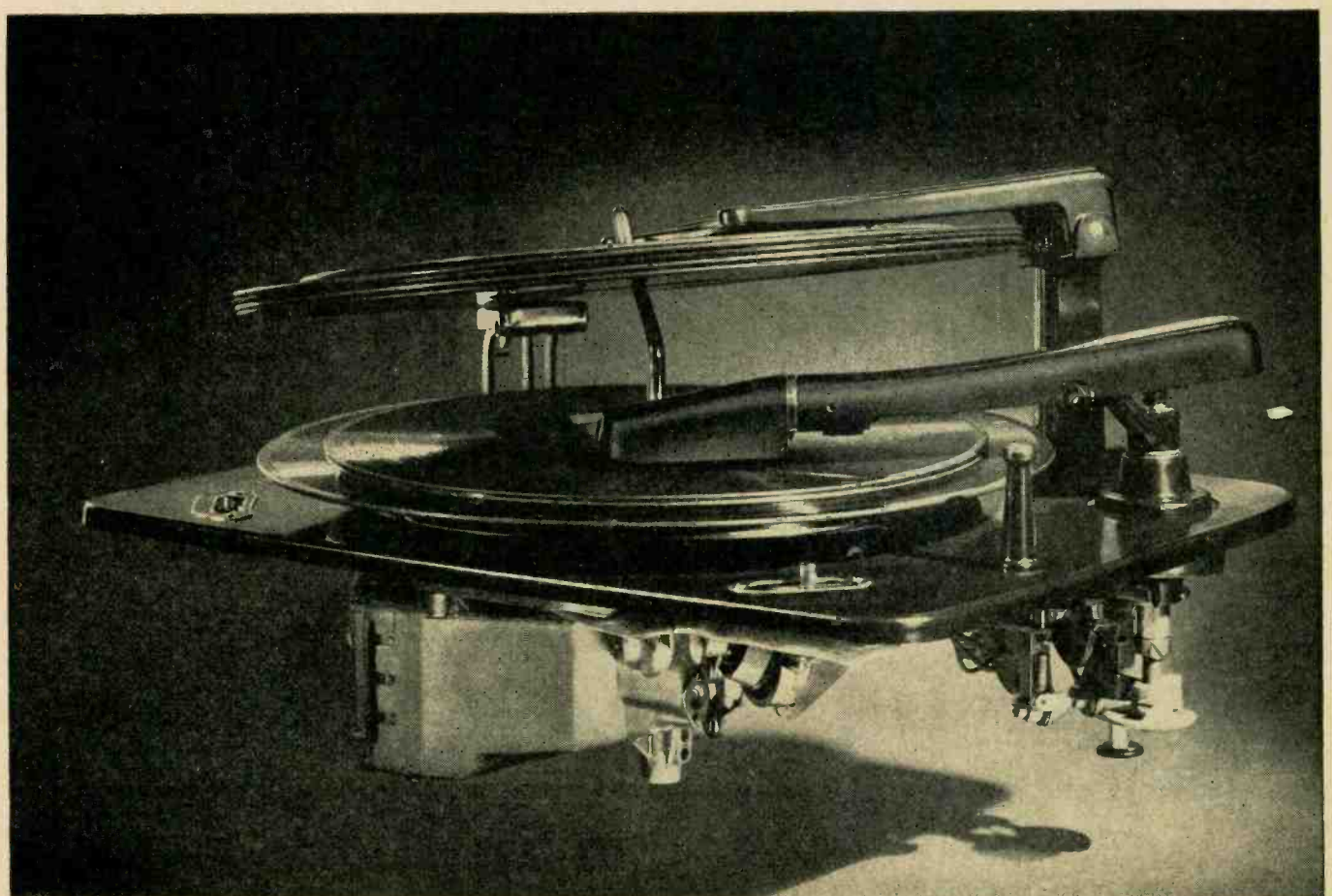
- speed-regulated, governor-controlled motor
- completely automatic mixing
- true-tangent, jewelled-pivot pickup arm
- exclusive non-slip spindle
- automatic stop
- heavy fly-wheel action built into turntable
- only one operating control necessary
- full swivel tone arm for changing needles
- kind to fragile records; no knives or trick spindle

... they ask for it by name ...

GARRARD

WORLD'S FINEST AUTOMATIC RECORD CHANGER

GARRARD IS THE ONLY CHANGER THAT BACKS YOU UP WITH A COMPLETE NATIONAL ADVERTISING CAMPAIGN IN CONCERT PROGRAMS AND IN LEADING HOME FURNISHINGS PUBLICATIONS. • GARRARD SALES CORPORATION • 315 BROADWAY, NEW YORK 7, N. Y.



for use with particular types of connectors are also described.

(56)
Flat Resistor Bulletin. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. A 4-page Bulletin C-1 gives characteristics of the type FRW power wire-wound resistors, together with information as to dimensions and stacking.

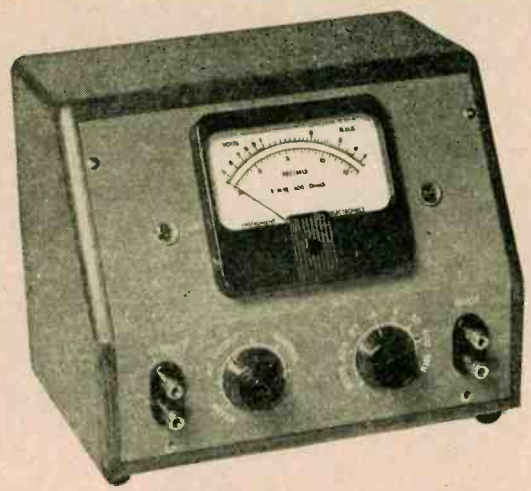
(57)
Propagation Predictions. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Prepared by the Central Radio Propagation Laboratory, National Bureau of Standards and issued November 1946, "Basic Radio Propagation Predictions for February 1947 Three Months in Advance" gives present world-wide predictions of monthly average maximum usable frequencies for the month in question. Starting with the July 1946 issue, these predictions have become available at 15¢ a copy or on a subscription basis at $1.50 a year (send no stamps).

(58)
Contact Springs. Gibson Electric Co., 8350 Frankstown Ave., Pittsburgh, Pa. Bulletin B-61 just issued describes their beryllium copper electrical contact springs and contact assemblies. Electrical and mechanical properties are included.

(59)
Sewing Machine. Union Special Machine Co., 400 North Franklin St., Chicago 10, Ill. Now in production is a plastic sewing machine or sealer that operates at a speed of 12 to 15 feet a minute. It is pictured in a recent pamphlet.

(60)
Variable Resistors. Technology Instrument Corp., 1058 Main St., Waltham 54, Mass. Precision variable resistors are announced in an 8-page pamphlet just released. The standard model, type RV3, is intended for use in experimental and laboratory gear. The laboratory model, type RVL3 is provided with a dial plate so as to be direct read-

LOGARITHMIC AC VOLTMETER
—WIDE BAND AMPLIFIER—



Advanced Design gives you a sensitivity and frequency response never before obtained.

No other Voltmeter offers all these advantages

- Range .0005 to 500 volts
- Frequency 5 CPS to 2.0 MC
- Logarithmic voltage scale
- Linear DB scale
- Input 2 Megohm 15 MMF
- Accuracy ±2%
- Stability ±1% 105 to 125 V.

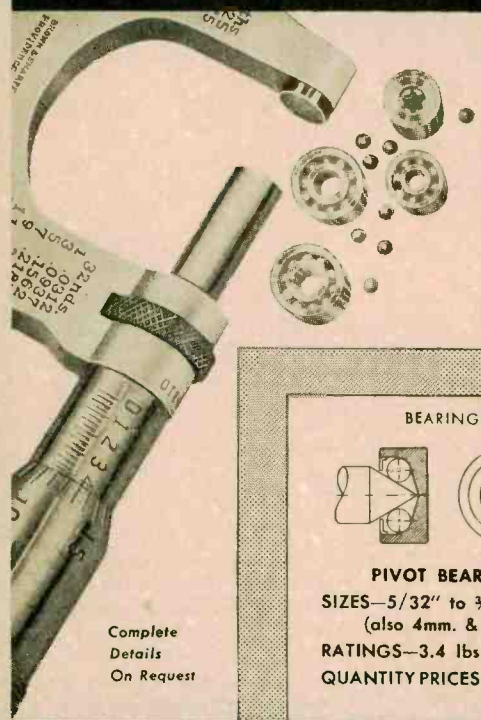
Ideal for Audio, Supersonics, Lower Radio Frequency Spectrum. Measures Stage Gain, RF and IF Amplifiers on Broadcast Receivers.

Write For Complete Information

Instrument Electronics

42-17A Douglaston Parkway **Douglaston, L. I., N. Y.**

INTRODUCING MICRO BALL BEARINGS



Complete Details On Request

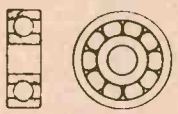
RADIAL AND PIVOT
...in Smallest Sizes

The first of their type ever made in the United States by modern methods of precision production.

Lowest prices on the industrial market for a first-quality product.

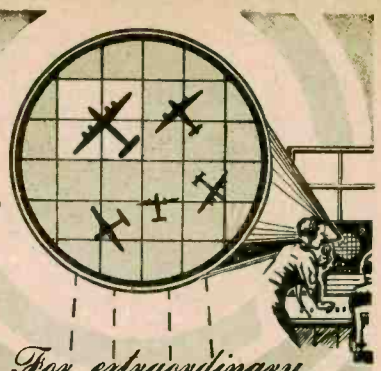
BEARINGS SHOWN TWICE ACTUAL SIZE

PIVOT BEARINGS
SIZES—5/32" to ⅜" O.D. (also 4mm. & 5mm.)
RATINGS—3.4 lbs to 22 lbs.
QUANTITY PRICES-From 16½c



RADIAL BEARINGS
SIZES—¼" to ⅜" O.D.
RATINGS—24 lbs. to 36 lbs.
QUANTITY PRICES—From 64c

NEW HAMPSHIRE BALL BEARINGS, Inc.
5 MAIN STREET • PETERBOROUGH, NEW HAMPSHIRE, U. S. A.



For extraordinary electrical performance

Use SILVER GRAPHALLOY*

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.
THE SUPREME CONTACT MATERIAL

in BRUSHES
for high current density ● minimum wear ● low contact drop ● low electrical noise ● self-lubrication

in CONTACTS
for low resistance ● non-welding character

GRAPHALLOY works where others won't! Specify GRAPHALLOY with confidence.

*A special silver-impregnated graphite

GRAPHITE METALLIZING CORPORATION
1055 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

ing in ohms to a high degree of accuracy. Among other interesting features is one that permits ganging these resistors in a self-supporting assembly.

(61)

School Sound. Radio Manufacturers Association, 1317 F St., N. W., Washington, D. C. School Sound Systems provides for the first time an authoritative guide, agreed upon by educators and manufacturers, for the use of radio equipment in the classroom. Single copies of the report are available from RMA.

(62)

Embossing and Drawing. S. B. Whistler & Sons, Inc., 748 Military Road, Buffalo 17, N. Y. A slick-paper 12-page booklet outlines the hydrodynamic embossing and drawing process for forming metal. The patented process and engineering advice on its use are offered.

(63)

Electric Bonding Machine. Singer Mfg. Co., 149 Broadway, New York 6, N. Y. Electric Bonding Machine 248-2 has been designed for high-frequency bonding of thermoplastics. In general appearance it closely resembles a modern high-speed sewing machine. At that point the resemblance ends. Read about it in a 6-page booklet.

(64)

Strain Gages. Hathaway Instrument Co., Denver 10, Colo. The type MRC-12 strain gage control unit will drive 6 separate galvanometers in a Hathaway oscillograph for strain recording over the frequency range 0 to 500 cycles per second. Seven pages of details appear as Bulletin SP 177.

(65)

Television Service. Television Associates, Inc., 190 North State St., Chicago 1, Ill. Studio illumination, titles, gadgets, kaleidoscopes and various services for the telecaster are available from this group that strives to serve the overall needs of television programming, transmission, and reception.

List of

ASBESTOS COVERED WIRE AND CABLE MANUFACTURERS

ASBESTOS COVERED CABLE

American Steel & Wire Co., Rockefeller Bldg., Cleveland, Ohio

Collyer Insulated Wire Co., 245 Roosevelt Ave., Pawtucket, R. I.

Rockbestos Products Corp., 313 Nicoll St., New Haven 4, Conn.

ASBESTOS COVERED WIRE

Accurate Insulated Wire Corp., 25 Fox St., New Haven 1, Conn.

American Steel & Wire Co., Rockefeller Bldg., Cleveland, Ohio

Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.

Austin Co., M. B., 108-116 S. Desplaines St., Chicago 6, Ill.

Boston Insulated Wire & Cable Co., 65 Bay St., (Dorchester), Boston 25, Mass.

Collyer Insulated Wire Co., 245 Roosevelt Ave., Pawtucket, R. I.

Diamond Wire & Cable Co., 128 E. 16th St., Chicago Heights, Ill.

General Cable Corp., 420 Lexington Ave., New York, N. Y.

General Electric Co., Appliance & Merchandise Dept., Bridgeport, Conn.

Habirshaw Cable & Wire Div., Phelps Dodge Copper Prod. Corp., 40 Wall St., New York, N. Y.

Hatfield Wire & Cable Co., 487 Hillside Ave., Hillside, N. J.

Hatheway & Co., 75 Montgomery St., Jersey City, N. J. (Sole distributors for Clifton Conduit Co. same address)

Okonite Co., Canal St., Passaic, N. J.

Rhode Island Insulated Wire Co., Providence 7, R. I.

Rockbestos Products Co., 313 Nicoll St., New Haven 4, Conn.

Roebling's Sons Co., John A., Trenton 2, N. J.

Rome Cable Corp., 330 Ridge St., Rome, N. Y.

Western Insulated Wire Co., 1151 S. Broadway, Los Angeles 15, Cal.

Westinghouse Electric Supply Co., Box 25, Wall St. Station, New York 5, N. Y. (Distributors)

ASBESTOS COVERED MAGNET WIRE

American Steel & Wire Co., Rockefeller Bldg., Cleveland, Ohio

General Cable Corp., 420 Lexington Ave., New York, N. Y.

General Electric Co., Appliance and Merchandise Dept., Bridgeport, Conn.

Rockbestos Products Corp., 313 Nicoll St., New Haven 4, Conn.

Roebling's Sons Co., John A., Trenton 2, N. J.

Rome Cable Corp., 330 Ridge St., Rome, N. Y.

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Beginnings of citizens' radio; new atomic lab; list of libraries getting OSRD reports; world telecommunications meeting; business news

New Production Record for Radio Receiving Sets

A TOTAL PRODUCTION of 1,670,444 radio receiving sets was reported by RMA member-companies for October, setting an all-time high for monthly output. Receivers with f-m facilities likewise attained a new high of 23,793 sets, but the output of television receivers slumped to 827 after its record of 3,242 sets for September. Radio-phonograph consoles continue to rise, reaching nearly 125,000 in October and thereby exceeding the prewar rate for this type of receiver. Other October breakdown figures from RMA are 1,128,616 for table models (not including battery sets), 153,800 for portables, and 170,000 for auto radios. The CPA estimate for October is 1,800,000 sets.

Citizens' Radio

TO ESTABLISH technical requirements for equipment to be used in the frequency band 460-470 mc allocated to the Citizens' Radiocommunication Service, the FCC has prepared for manufacturers and other interested groups a preliminary proposal intended to organize discussion and comment. Final specifications will be issued sometime after the Dec. 31, 1946 deadline for comments on the proposals.

The Commission proposes to assign no communication channels within the band, intends to keep to a minimum its rules and regulations governing the service, and will rely upon the 10,000-kc width of the band to provide reasonably interference-free operation in most parts of the United States.

To encourage use of better-class equipment while recognizing the relation between cost and frequency stability, the Commission proposes to license two types of stations:

Class A stations—permissible frequency tolerance of 0.02 percent

Class B stations—permissible frequency tolerance of 0.2 percent, with transmitters initially adjusted by the manufacturer to operate within 0.2 percent of the center-band frequency 465 mc; subsequent deviation from this adjustment in actual service would be permitted provided the emission is confined within the sub band 462-468 mc

To reduce interference encountered by those who can afford the

1946-47 RMA BOARD OF DIRECTORS

Directors of Radio Manufacturers Association for 1946 and 1947. Headquarters are at 1317 F St. NW, Washington 4, D. C.

At your command...at Magnavox

All the newest production and engineering techniques

THE history of every Magnavox electrolytic capacitor and loud-speaker is a story of painstaking research, engineering and development. Six acres of modern plant and equipment and our staff of trained engineers and designers, combine with thirty-five years of "know-how" experience to bring you the finest quality in component parts.

As the oldest and largest manufacturer of loud-speakers, Magnavox has achieved a breadth of experience equalled by no other radio manufacturer. Magnavox engineers and designers have all the necessaty experience and equipment to meet your specifications *exactly!* They stand ready to apply their developments to any of your component problems.

When you need loud-speakers, capacitors or electronic equipment, specify Magnavox—specialists in quantity production of quality components for the manufacturing trade. The Magnavox Co., Components Division, Fort Wayne 4, Ind.

Electrolytic Capacitor—*standardized into 8 container sizes to simplify design and assembly problems.*

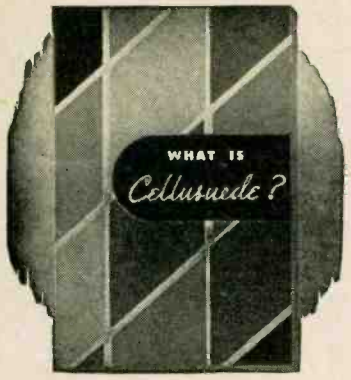
Electrochemical Department—*a capacitor processor keeps constant watch over the many controls in the aging room.*

Magnavox

has served the radio industry for over 30 years

SPEAKERS • CAPACITORS • ELECTRONIC EQUIPMENT

Booklet Tells How to Use *Cellusuede* FLOCK

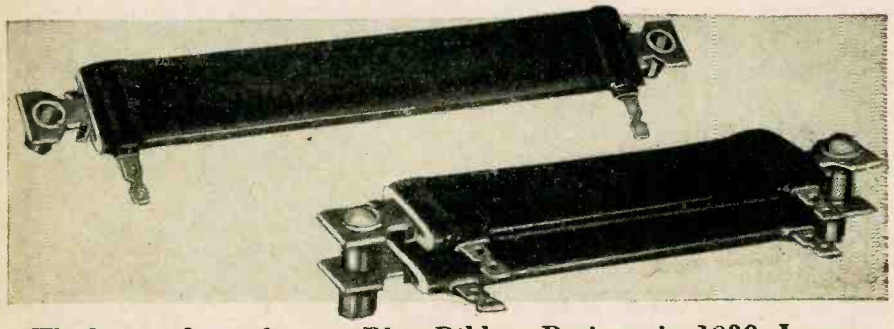


An interesting and colorful booklet on their product has been prepared for your information and convenience by the makers of Cellusuede Cotton and Rayon Flock. Brief, clear explanations give all the facts you'll want to know about this versatile coating material; what it is made of; how it is applied; how it can be used. In the pages of this booklet you may find the answer to one of your manufacturing problems. You will be interested, too, in the colorful and unique application of Cellusuede on the booklet cover. Write for your copy.

CP
Cellusuede Products, Inc.
ROCKFORD, ILLINOIS

Blue Ribbon

A NAME WELL-EARNED



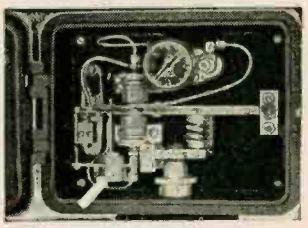
We designed our famous Blue Ribbon Resistor in 1939. It was the first flat or strip resistor in the field. Now there are others of similar type, but our Blue Ribbon still leads the field and still holds first place which its name signifies. It is compact, tough, and its remarkable performance offers you far more than just higher wattage ratings for unit space required. And our other resistors and rheostats offer you exclusive advantages also.

HARDWICK, HINDLE, INC. RHEOSTATS and RESISTORS
DIVISION OF
THE NATIONAL LOCK WASHER COMPANY
NEWARK 5, N. J. ESTABLISHED 1886 U. S. A.

Silicone News

DC SILICONES

DC Silicone Fluid affords greater sensitivity in temperature control



Photo, courtesy The Swartwout Co.

The Thermo Master Control and other control instruments made by The Swartwout Company of Cleveland have been redesigned and made even more sensitive through use of a damping device filled with one of the Dow Corning Silicone fluids (arrow). Previously no damping device was used because conventional organic fluids are subject to such wide changes in viscosity with temperature that they limit rather than increase the sensitivity of these carefully engineered instruments.

With the introduction by Dow Corning of Silicone Fluids unique among liquids for their flat viscosity-temperature slopes, low volatility, and thermal stability, the long standing problem of effective damping over a wide temperature range was solved.

The Thermo Master Control is widely used for regulating temperature in steam desuperheating involving temperatures ranging from 50° to 950°F. Ambient temperatures may vary from —40°F. to 150°F. Over such a wide temperature span, only silicone fluids remain sufficiently constant in viscosity to damp minor oscillations of the metallic control without lessening the sensitivity of such precision instruments.

For more information about DC Silicone Fluids available in several types for a wide variety of applications including use as liquid dielectrics and diffusion pump fluids, ask for catalog No. N 1-3.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Chicago Office: Builders' Building
Cleveland Office: Terminal Tower
Los Angeles Office: 634 S. Spring Street
New York Office: Empire State Building
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

more costly class A transmitters, it is planned to divide the available band as follows:

460-462 mc—class A stations at fixed locations exclusively
462-468 mc—class A and class B stations
468-470 mc—class A stations exclusively

Transmitter type-approval tests by the Commission would be made to determine ability to operate within the allocated band under all practical service conditions, to check maximum permissible power input, possible presence of superfluous emissions, and width of communication band. Since existing regulations specify that all radio stations must use the minimum amount of power necessary to carry out the communication desired, highly directive or beam antennas will be permitted on the premise that licensees will be cognizant of the statutory limitation on power.

All conventional types of emission are proposed to be authorized except A-5 (television), and even that would be authorized if a satisfactory showing is made as to the purpose to be served. It is believed that a maximum communication band of 0.2 mc will provide for all useful types of emission.

Transmitting equipment shall be inherently incapable of operating at a power input of more than 50 watts to the anode circuit of the tube or tubes supplying energy to the radiating system. Either a-m or f-m emissions would be permitted, with the percentage of modulation not exceeding 100 at any time for a-m. Tests for frequency stability would be made under any or all of the following test conditions:

(1) Gradual and sudden ambient temperature variations from 0 to 150 F.
(2) Barometric pressure variations corresponding to those from sea level to 12,000 feet above sea level.
(3) Relative ambient humidity from 5 to 95 percent.
(4) Atmosphere containing high saline content such as encountered on oceans.
(5) Movement of objects in the immediate vicinity of the equipment under test.
(6) Power supply voltage variations normally to be encountered under actual operating conditions.
(7) Length of test periods to be equivalent to those which will be encountered under the most severe conditions of operation for which the unit may be used.

New Atomic Power Laboratory

THE FOURTH in a projected nationwide chain of nuclear physics re-

search laboratories in the United States—a $20,000,000 institution to specialize in all phases of atomic power development—is to be built and operated for the government at Schenectady, N. Y., by General Electric Co.

The laboratory, to be designated the Knolls Atomic Power Laboratory, will be built around an atomic power pile of unstated size —second such projected uranium pile ever built primarily for creating atomic energy for peaceful applications. The other is to be at Oak Ridge, Tenn., where the world's first operating atomic-fueled power plant is to be set up. Dr. C. G. Suits, G-E vice president and director of research, will have general supervision of the Government laboratory and the nuclear study program. Responsibility for the atomic power pile has been assigned to Dr. Kenneth H. Kingdon, G-E physicist who was one of the early researchers in isolating U235.

Libraries Get OSRD Reports

NEARLY 2.5 MILLION copies of over 35,000 different scientific reports covering declassified war research projects of the Office of Scientific Research and Development are now being processed by the Library of Congress in preparation for distribution to leading libraries throughout the country where they will be readily available to the public. Libraries scheduled to receive the unrestricted reports are as follows: Brown University Library, Carnegie Library of Pittsburgh, Case School of Applied Science, Cleveland Public Library, Columbia University, Cornell University Library, Detroit Public Library, Duke University Library, Engineering Societies Library of the United Engineering Trustees, Inc., Georgia Institute of Technology, Harvard University Library, Illinois Institute of Technology, Iowa State College of Agriculture and Mechanic Arts Library, John Crerar Library in Chicago, Johns Hopkins University, Louisiana State University, Massachusetts Institute of Technology, New York Public Library, Northwestern University, Ohio State University Library, Princeton University, Purdue University

Library, Stanford University Libraries, University of California Library, University of Chicago, University of Cincinnati Libraries, University of Denver, University of Illinois Library, University of Kansas Library, University of Michigan Library, University of Minnesota Library, University of Missouri General Library, University of Nebraska Libraries, University of New Mexico Library, University of North Carolina Library, University of Pennsylvania, University of Rochester, University of Texas Library, University of Virginia, University of Washington Library, University of Wisconsin Libraries, Washington University Libraries, and Yale University Library.

Four permanent and complete collections of all reports have been assembled by OSRD. One will be sent to the National Archives, two will be reserved for the successor agency to OSRD, and the fourth will eventually go to the Library of Congress. The Army and Navy already have relatively complete sets.

World Telecommunications Meeting

AT THE MOSCOW Telecommunications Conference in September 1945, informal preliminary discussions by the five represented powers — United States, U.S.S.R., United Kingdom, France, and China —set the stage for a World Telecommunications Meeting beginning July 1, 1947. At that time the Telecommunications Convention of Madrid will be revised to provide for an entirely new structure of the International Telecommunications Union. It was agreed that the ITU should be affiliated with the United Nations Organization as a specialized agency.

Unanimous agreement was also achieved on a plan for setting up a Central Frequency Registration Board comprising five impartial and competent radio engineers, who would examine applications for new frequencies and determine whether the proposed station would cause interference with existing stations anywhere in the world. If it did not,

the frequency would be registered and thereafter protected from interference. If interference was likely the board would return the application and suggest selection of some other frequency. The board would have no authority to enforce its recommendations, however.

The Moscow Conference also agreed that there shall be called in the fall of 1947 a World High Frequency Broadcasting Conference to assign frequencies to short-wave stations all over the world and to establish an organization for facilitating interchange of broadcast programs between countries.

1947 Parts Show

DATES FOR THE electronic equipment show in Chicago, sponsored by Radio Parts and Electronic Equipment Shows, Inc., have been set for May 13 to 16 inclusive in 1947. Organization and sales meetings will be held May 11 and 12, with the keynote dinner for the entire industry scheduled for 7:00 p.m. on Monday May 12. The Exhibition Hall will open at 10:00 a.m. May 13 and remain open through May 16. Attendance will be confined to members of sponsoring manufacturers, their booth attendants, their sales representatives, and distributors, except that Friday May 16 is Open House Day during which radio servicemen, amateurs, engineers, and the general public will be admitted without registration.

MEETINGS TO COME

JAN. 23-26; SOCIETY OF THE PLASTICS INDUSTRY; technical papers and exhibit; Edgewater Beach Hotel, Chicago.

JAN. 27-31; ELECTRICAL ENGINEERING EXPOSITION; held concurrently with AIEE winter convention; 71st Regiment Armory, New York City.

JAN. 27-31; INTERNATIONAL HEATING AND VENTILATING EXPOSITION; Lakeside Hall, Cleveland, Ohio.

MARCH 3-6; IRE WINTER MEETING; Hotel Commodore, New York City,

with Radio Engineering Show at Grand Central Palace.

MARCH 22-27; WESTERN METAL CONGRESS AND EXPOSITION; Oakland Civic Auditorium, Oakland, California.

MARCH 31-APRIL 2; MIDWEST POWER CONFERENCE; Palmer House, Chicago; sponsored by Illinois Institute of Technology and directed by Prof. S. E. Winston.

MAY 13-16; 1947 CONFERENCE AND SHOW; Radio Parts and Electronic Equipment Shows, Inc., Chicago, Illinois.

BUSINESS NEWS

SENTINEL RADIO CORPORATION has consolidated all departments under

New Sentinel plant in Evanston

one roof in its new plant in Evanston, Illinois.

GALVIN MFG. CORP., Chicago, was awarded a Certificate of Appreciation by the War Department for its contributions to design and production of radio and radar equipment for the Army during World War II. The presentation was made to P. V. Galvin by Brigadier General C. H. Arnold and Major General H. C. Ingles. Motorola produced 341,529 units of ground forces radio equipment, 18,261 units of radar and beacon equipment, and over 35,000,000 piezoelectric crystal units.

AIREON MFG. CORP., Kansas City, Kansas has transferred radiotelephone production to a wholly owned subsidiary, The Aireon Radiotelephone Mfg. Co., which will move its entire operations shortly to a leased plant in the East. William A. Hahn of Baltimore, Md., president of Railway Radiotelephone and

Signals, Inc., will act as general manager.

RCA VICTOR DIVISION, Camden, N. J. has formed a large engineering group headed by Dr. Douglas Ewing to develop Teleran, a new air navigation system combining television with radar.

FARNSWORTH TELEVISION & RADIO CORP., Fort Wayne, Ind., recently staged an operational demonstration of railroad radio in the Dallas yards of Texas & Pacific Railway Co. Two-way communication was provided on three locomotives and three offices, using f-m equipment operating in the 152-162 mc band.

R. C. POWELL & CO., INC., 57 William St., New York, N. Y. has been organized for the development and marketing of electromechanical products.

OPERADIO MFG. CO., St. Charles, Illinois, now has branch plants operating in Dundee, Quincy, and Joliet, Illinois in addition to its two St. Charles plants. Decentralization was necessitated by shortages of both manpower and plant facilities in the immediate area.

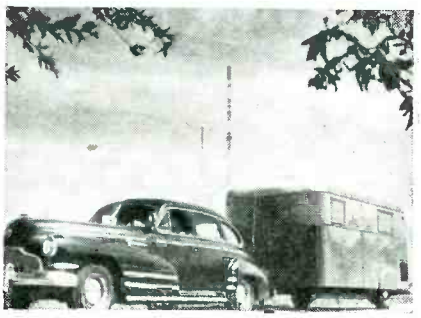
SOUTHERN CALIFORNIA WATER AND TELEPHONE CO. has started construction of a new building atop Mount Wilson, overlooking Hollywood, California, to provide communication service for the television and f-m broadcast stations now locating on this advantageous mountaintop site. Beaming of television programs from Hollywood to the transmitters will be achieved with microwave equipment using the new shielded lens antenna developed by Bell Telephone Laboratories. Cable facilities are also to be provided for television.

FMBI, an organization of f-m broadcasters, was formally dissolved at the NAB Convention in Chicago Oct. 21. Organizational meetings for a new group to be known as Frequency Modulation Association have already been held.

RCA AND NBC are providing television service in the press quarters for the United Nations General Assembly at Flushing Meadows, New York, for the convenience of newspapermen. NBC television camera-

men will operate the pickup equipment at the sessions. Without the television receivers, many of the reporters would be without direct contact with the action in the chambers.

GENERAL ELECTRIC CO., Syracuse, N. Y., is placing in operation eight mobile radio laboratories, each a



One of G-E's mobile radio communications laboratories now on the road

trailer equipped with testing and repair facilities for radio communication services and field strength measuring equipment for determining proper locations of transmitters.

PERSONNEL

JAMES L. MIDDLEBROOKS, who recently resigned as director of engineering for NAB, has been appointed chief facilities engineer for the American Broadcasting Co., succeeding Ben Adler.

BALTH. VAN DER POL, director of fundamental radio research for the Philips laboratories at Eindhoven, Holland, and president of the technical commission for the recently founded International Broadcasting Organization, conferred with scientists in the United States. On Nov. 13 he addressed the Cruft Laboratory staff of Harvard University on "The Fundamental Principles of Frequency Modulation".

ALFRED T. JOHNS has been named production manager of the Home Radio Division of Lear, Inc., Grand Rapids, Michigan.

ESTERLY CHASE PAGE leaves MBS Jan. 1 to return to private practice as broadcast consultant in Washington, with Earl Miner Johnson

taking over his post as engineering director of the Mutual network.

B. J. MILLER has been named chief of the recently organized Guided Missile Electronics Section of the National Bureau of Standards. Dr. Miller played an active part in research phases of the radio proximity fuze, and since Nov. 1945 has been working on electronic controls for guided missiles. Among activities under his guidance now is the Kingfisher Project, which is the advance development of the radar-guided BAT bomb.

B. J. Miller

H. L. Dryden

HUGH L. DRYDEN, associate director of the National Bureau of Standards, has been presented the Medal of Freedom for "an outstanding contribution to the fund of knowledge of the Army Air Forces with his research and analysis of the developments and use of guided missiles by the enemy." During the war Dr. Dryden directed the research and development program on guided missiles at the Bureau of Standards.

HECTOR J. DE FELIX, electronics engineering officer and Lieutenant in the U. S. Coast Guard for the past seven years, will be associated with W. N. Green in communications engineering practice in Porto Rico.

ALOIS W. GRAF, chairman of the Chicago section of IRE, has opened an office in Chicago for the practice of law in patent and trademark cases.

LESLIE G. THOMAS was elected vice-president in charge of manufacturing at Solar Manufacturing Corp., New York, N. Y. He was recently vice-president and works manager of International Resistance Co., Philadelphia.

NEW BOOKS

Inside The Vacuum Tube

By JOHN F. RIDER. *John F. Rider Publisher, Inc., New York* 16, *N. Y.*, 1945, 407 *pages*, $4.50.

Radio facts are presented in this book on such a basis that a high school junior or senior could well understand them. Innovations include reprinting of diagrams and graphs on subsequent pages so that they can easily be studied when the reader is referred to them, and the use of three anaglyphs—two-color drawings which appear in three dimensions when viewed by the two-color spectacles furnished with the book. Throughout the book are small illustrative sketches where electrons, atoms and ions are personalized and shown as small round imps with arms, legs, wings and antennae. This juvenile representation of negative imps running around the circuit or climbing through the grid wires will hardly appeal to all, but does often serve to make the subject matter a bit more familiar.

The treatment, beginning with the electron, its source and resultant movement under electrostatic force fields, is straightforward. More emphasis is placed on space charges and fields due to potentials on the tube elements than is usual in a book of this scope. Diodes are rather completely treated and form the basis for the triode treatment as well. The discussion on triodes covers five chapters and is adequately done, especially the explanation and construction of load lines as a means of determining operating conditions.

A chapter on tetrodes and pentodes is followed by one on the effect of cathode impedances. Short chapters on power amplifiers and miscellaneous tubes give mention to the general properties of such devices.

It is difficult for a reviewer to place himself in the position of a novice, and consequently the text seems over-simplified and repetitious. This redundancy may, to a beginner, be the real merit of the book. Numerous minor errors are apparent on careful reading but probably do no material harm. For

example, on p. 128; " . . the value of grid current caused to flow . . . . has been found that the lower the plate voltage, the less the grid current. This appears reasonable . .". Quite the contrary! A more serious error is the lack of any emphasis on the nonlinear characteristics of the tubes. Generally the nonlinear conditions are treated as exceptions to be ignored, and no basis is laid for detectors, rectifiers, oscillators, limiters, etc. This omission is probably part of the most annoying characteristic of the book, wherein it is stated many times and in many ways that the phenomena hinted at is much beyond the scope of the book and possibly the intelligence of the reader.

With these exceptions the book is well turned out and stands as one of the simplest of such simplified texts.—K. W. JARVIS

Communication Through the Ages

By ALFRED STILL. *Murray Hill Books, Inc., New York, N. Y., 201 pages, $2.75.*

THE AUTHOR OF "Soul of Amber" and "Soul of Lodestone" continues his exploration of 19th century technical literature, to bring forth another highly readable review of man's early gropings in search of scientific achievement. This time the goal is man's desire to communicate beyond range of his voice—a goal as yet unattained, in the author's opinion—because man has not yet learned to make words convey the exact intended meanings of his thoughts even in direct conversation.

The account begins logically with drums, fire, and smoke, covers 19th century and earlier uses of rays of light for signaling, then traces the beginnings of telegraphy with sparks of electricity and streams of electrons. Highlight of the entire book is the story of man's many attempts to achieve telegraphic communication across the Atlantic; after early failures of the Atlantic cable, work was actually started both in Russia and in Canada on a wood-pole telegraph line that would link U. S. with the capitals of western Europe. Successful laying of the new Atlantic cable in 1866

doomed this line to dormancy for three quarters of a century more, until the U. S. Army Signal Corps completed in Nov. 1943 a 2,000-mile overland telephone line paralleling the Alaska Highway.

Other chapters cover the beginnings of telephony, radio, and television, but the author's heart is with the 19th century and there are little but sketchy details of 20th century achievements in these fields. This is both understandable and commendable; no one book could begin to cover recent developments adequately, and it is much more interesting from a writing standpoint to probe into old books than try to make sense out of the hectic early days of radio. In retirement after serving for 21 years as professor of electrical engineering at Purdue University, the author is definitely enriching the literature of science with his streamlined historical anecdotes.—J. M.

Mathematical Aids for Engineers

By RAYMOND W. DULL, *Consulting Engineer. McGraw-Hill Book Co., New York, N. Y.*, 1946, 346 *pages*, $4.50.

WITH CONCISENESS approaching that of a reference manual, this sequel to the author's earlier "Mathematics for Engineers" presents elementary basic mathematical tools essential to higher mathematics. Illustrative examples show applications of the techniques to engineering problems created by developments of recent years. Topics covered include organic growth, organic decay functions, circles as tools, vectors, ray and string polygons, imaginary and complex numbers, hyperbolic functions, motions, impulse - impact - momentum equations, increments, images, and differential equations.—J. M.

Radio's Conquest of Space

By DONALD MCNICOL. *Murray Hill Books, Inc., New York* 16, *N. Y.*, 1946, 374 *pages*, $4.00.

Names, places, events and dates related to the development of radio communication have been collected by the author, divided into 30 convenient categories, then arranged

more or less chronologically within batches and tied together with smooth-flowing continuity to make up the 30 chapters of this book. One annoying but apparently unavoidable result of this technique is the abrupt flyback one, two, or more decades at the start of a new chapter after having come right up to the present at the end of the previous chapter.

Any attempt to cover even the communication aspect of radio within the confines of a 374-page book is foredoomed to leave many readers dissatisfied, because of the great number of developments clamoring for detailed attention. Because of the necessary omissions and the briefness of many citations, old-timers may find much to criticize here, but certainly the younger generation of radio enthusiasts will find the book stimulating.—J. M.

The Servicing of Television Receivers

Published by PHILCO CORP., *Philadelphia, Pa.*, 1946, 140 *pages*, $2.25.

This paper-covered 8½ by 11 volume looks and reads like one of the better maintenance instruction manuals published during the war for the purpose of indoctrinating Service personnel in radar and radio. From the first page, adequate type, clean cuts, and large, clear circuit diagrams are used to present simple, factual information of high value to the television receiver technician. Any possible severity in the presentation is relieved by a series of resistor-capacitor gremlins busily engaged, cartoon-wise, in demonstrating the "do's" and "don'ts" referred to in the text.

Although the television system and receiver are discussed in general terms, there are specific circuit drawings of a receiver, a trouble-cause-remedy chart, and an excellent series of illustrations of the cathode-ray tube display under various conditions of circuit failure.

Antennas, the greatest potential stumbling block between television studio and viewing public, have been well covered. If the answer to poor reception is not in the book, the service man can at least suspect a faulty antenna from the emphasis given the subject.—A. A. 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.

Physiology of Hearing

Dear Editor:

I am moved to write a criticism of the article, "Auditory Perception," published in the July 1946 issue of ELECTRONICS because of the damage to radio receiver design which may be caused by its appearance in so influential a journal, especially when sponsored editorially by your own brief laudatory statement on its initial page. You wrote that ". . . understanding of human hearing and its relation to various types of tone-compensating arrangements is an aid in evaluating and solving problems encountered in perfecting audio transmission and reproduction systems." While I quite agree with your statement in general, its application to the article in question seems to me unsound or at least premature.

Essentially, the difficulty, as I view it, is that Goodell and Michel do not really accept the ear as the basic perceptor of sound, so far as human hearing is concerned, but rather regard it as an imperfect instrument for which the good radio engineer should compensate. Whether the type of compensation they suggest is preferable to none has not been demonstrated.

Let us assume, for the sake of argument, that we have perfect electrical rendition of sound. This would mean that the microphone, substituted for the human ear at the site where we are accustomed to hear the sound to be rendered (the best seat in the orchestra, for a symphony), would, through a suitable transmitter, have converted the sound into an electrical form in which there was perfect reproduction in proper phase of its frequency components and their respective amplitudes.

At present, if the broadcasts of

CONTACTS

FOR THE FIELD OF ELECTRONICS

the New York Philharmonic Society are taken as an example, this assumption is not completely fulfilled, since the microphones are placed where no listener would want to sit. The result is that the intensity of reflected sound is reduced relative to the direct sound from the instruments, but, practically, this may be preferable because of the further reflections which occur on reproduction in the home. However, we make the assumption for purposes of discussion.

If the listener used a perfect receiver, one which converted back into sound without amplitude, phase, or frequency distortion the electrical signal, he would hear (assuming no reverberation) exactly what he would have heard if he sat where the transmitting microphone had been placed, provided the volume was adjusted to the same intensity. If he turns the volume lower, he will hear a different rendition.

Goodell and Michel, pointing to the shift in man's frequency-response curve as intensity is changed, would modify the receiver so that, when the volume is lowered, the sound is distorted in such a way that the human ear would then respond, despite the lowered intensity, as though the sound were still at the original intensity.

But this is quite unphysiological —quite different from normal ear function. If the orchestra were to play more softly (leaving out of consideration, now, the resulting change in the relative intensities of harmonics), the listener's hearing responds by shifting the emphasis of the lower notes, as shown in the frequency-response curves. This shift is expected, being characteristic of all sound heard by the listener.

If, artificially, the radio engineer enhances the treble, when volume is reduced, the listener will hear something different from what he is accustomed to hear at these sound levels. The musically trained listener, I suspect, would reject such compensation as distortion and would prefer the linear type of receiver.

It is at this point that I must admit that a matter of opinion has entered. It is my impression, as I have said, that the distortion sug-

PROFESSIONAL SERVICES

Consulting — Patents — Design — Development — Measurements

in

Radio, Audio, Industrial Electronic Applications

H. RUSSELL BROWNELL
Consulting Engineer

Specializing in Measurements & Testing Instruments & Techniques - Electrical - Electronic - Magnetic.

188 West 4th St. New York 14, N. Y.
Chelsea 2-4208

PAUL E. GERST & CO.
CONSULTING ENGINEER

Specialists in Electrical Product Design
El. Machinery, Apparatus & Applications
El. Appliances, Hi-Frequencies Apparatus
Electronics, Radio Communications

205 W. Wacker Dr. Chicago 6, Ill.

JOSEPH RAZEK, Ph.D.
Consulting Physicist

Electric and Mechanical Engineering Problems
Instruments and Control Devices Electronics
Specialists in Colormetry, Spectrophotometry and Industrial Color Control
Laboratory and Shop Facilities

202 Darby Road Llanerch, Pa.
Phone Hilltop 6910

EDWARD J. CONTENT
Acoustical Consultant

and

Audio Systems Engineering, FM, Standard Broadcast and Television Studio Design.

Roxbury Road Stamford 3-7459
Stamford, Conn.

C. M. HATHAWAY
Consulting Engineer

Research and Development
Product Designs
Tool & Methods Engineering
Pilot Manufacturing

1315 S. Clarkson St., Denver 10, Colorado

ARTHUR J. SANIAL
Consulting Engineer

Loudspeakers and Allied Devices

168-14 32 Ave. Flushing, N. Y.

DONALDSON ELECTRONICS LABORATORY
Research and Development

Shoran Radio Survey Consultant
Custom Built 'Scopes - Trick Circuits
Microsecond Sweeps - Microwave Systems
Industrial Applications

P.O. Box 1486 San Antonio, Texas

INDUSTRIAL DEVELOPMENT ENGINEERING ASSOCIATES
Engineering Consultants

Electronic Control, Motion Picture & Sound Equipment
Development—Design—Models

5874 College Ave. Indianapolis 5, Ind.

SENTINEL LABORATORIES

Electronic Instruments & Equipment. Custom designed and built to comply with your particular specifications

Industrial applications of Electronics and Electronic Laboratory Instruments our specialty

1019-23 Appletree Street Phila. 7, Pa.

STANLEY D. EILENBERGER
Consulting Engineer

INDUSTRIAL ELECTRONICS

Design—Development—Models
Complete Laboratory and Shop Facilities
6309-13—27th Ave.

Kenosha, Wis. Telephone 2-4213

RICHARD C. KLEINBERGER
Licensed Professional Engineer

Electronic Heating Applications

20 Cushman Road, White Plains, N. Y.

TECHLIT CONSULTANTS, INC.

Technical literature and art. Specialists in electronics. Instruction manuals, sales brochures, catalogues, isometrics, perspective, photo-retouching, schematics, wiring diagrams. Expert work at low cost. We have never missed a deadline.

140 Nassau Street New York 7, N. Y.

ELECTRONEERS
Electronic Consultants

Industrial - Communications - Medical

Write or phone for preliminary survey without charge.

489 Fifth Ave. New York 17, N. Y.
MUrray Hill 2-2492

MIDLAND ASSOCIATES
Consulting Engineers

Engineering Design & Development
Television Receivers—Technical Manuals
FM. Receivers—Test Instruments
A.M. Receivers—Special Problems
in all phases of Electronics

1959 Lunt Ave. Chicago 26, Ill.

RAYMOND M. WILMOTTE INC.

A Complete Engineering Service for the Application of Electronics to Industry

Consultation Design Construction

236 West 55 Street 1713 Kalorama Road N. W
New York 19, N. Y. Washington, 5, D. C.

ELM LABORATORIES
ELECTRONIC-MECHANICAL RESEARCH & DESIGN
Patented ELM Developments include

PREGRAME Automatic Radio Program Tuner, Famous "Gerty" Direction Finder Loop, Sealed Xtal Holder. Home Receiver Designs.

20 South Broadway Dobbs Ferry, New York
Phone Dobbs Ferry 4058

ALBERT PREISMAN
Consulting Engineer

Television, pulse Techniques, Video Amplifiers, Phasing Networks, Industrial Applications
Affiliated with
MANAGEMENT-TRAINING ASSOCIATES

3308-14th St., N.W. Washington 10, D. C.

PAUL D. ZOTTU
Consulting Engineer

INDUSTRIAL ELECTRONICS

High Frequency Dielectric and Induction Heating Applications, Equipment Selection, Equipment and component Design, Development, Models.

272 Centre St. Newton, Mass.
BIG-9240

THE CONSULTING ENGINEER

"By reason of special training, wide experience and tested ability, coupled with professional integrity the consulting engineer brings to his client detached engineer and economic advice that rises above local limitations and encompasses the availability of all modern developments in the fields where he practices as an expert. His services, which do not replace but supplement and broaden those of regularly employed personnel, are justified on the ground that he saves his client more than he costs him."

gested by the authors would be regarded as unnatural. However, it is possible that the ear and brain may interpret the resulting effect, not as distortion, but as the original sound heard at a higher intensity (nearer the one heard if one sat in the studio or hall) than the actual one.

I am not aware that this possibility has been explored and proven to exist. If it does, my own opinion, which doubts the actuality of this possibility, will have to be changed. But the burden of proof, it seems to me, most certainly rests on those who offer an innovation and proof is lacking in the paper in ELECTRONICS.

To my mind, the linearity of the receiver I referred to should be measured by comparing sound intensity where the listener is to sit with reference to the receiver, and the amplitude of the audio-frequency modulation of the radio signal. Thus, a linear receiver would almost certainly require bass boost, particularly at low levels, because of the relative inefficiency of electrical conversion into sound in this range.

To restate my objection—the job of the radio engineer is not to "improve" upon the ear unless he has demonstrated that the improvement will be interepreted by the listener as an actual improvement rather than as distortion. If we are to hear reproduced sound at different intensities from the original, verisimilitude, I believe, requires that the ear be permitted to hear it as though the original were at this lower intensity.

Actually, I doubt whether this is an important problem: the better the receiver, the louder it can be played with enjoyment until, I expect, the same intensity as the original sound will be the customary one and the problem considered by Goodell and Michel will have disappeared. They themselves indicate this goal: "True high fidelity would be indistinguishable from the original."

HAROLD LAMPORT
Research Associate
Laboratory of Physiology
Yale University School of Medicine
New Haven, Connecticut

THE MICROPHONE was invented in 1876 by Emile Berliner of Washington, D. C.

SEARCHLIGHT SECTION

POSITIONS VACANT

ASSOCIATE PROFESSOR Of Electrical Engineering. Education: M.S. degree in E.E. with specialization in Electronics. Teaching experience required. Industrial or military experience desirable. Salary $3200.00 to $3600.00 for nine months school year depending on age and experience. Write: Department of Electrical Engineering, North Dakota Agricultural College, Fargo, North Dakota.

INSTRUMENT ENGINEER—Young graduate electrical engineer well grounded in electronic work, radio and audio frequency and interested in applications to physical measurements. Position involving analytical studies, circuit analysis and design in support of an active instrument section of Flight Research Department. Replies will be held in strict confidence. Write Employment Office, Cornell Aeronautical Laboratory, Buffalo 5, New York.

ELECTRICAL AND Electronic Engineers—You are invited to investigate opportunities in electronics and electrical engineering at this Laboratory. We are organized as a department in a large college located in a Middle Atlantic State, and are engaged in research and development. Members of our research staff are appointed with academic rank. Some are teaching, although this is not a condition of employment. P-275, Electronics, 330 W. 42nd St., New York 18, N. Y.

$10,000 SALARY—A 20 year old electrical instrument company in New York area desires to permanently employ a reasonably young, preferably married, aggressive electrical engineer. Due to a death, the position of general manager will be open at a salary of $10,000 in three years. Electrical instrument experience preferred but not necessary. In reply give complete details of electrical, mechanical, office, design, drafting, writing experience and education. A small photograph to accompany first letter leading to personal interview. Starting salary commensurate with experience. P-276, Electronics, 330 W. 42nd St., New York 18, N. Y.

RESEARCH ENGINEERS — Progressive Midwestern Equipment Manufacturer located in attractive town of about 70,000 has opening for research engineers in the fields of powder metallurgy, high dielectric ceramics and glass technology applied to high vacuum tubes. University graduates with several years experience will find interesting activity in established laboratory at competitive salaries. Members of our staff have been notified. Apply P-277, Electronics, 520 North Michigan Ave., Chicago 11, Ill.

WANTED

Vacuum Tube Engineer

Position open for production process and design engineer. Must have experience in designing and processing of television tubes, phototubes and related electronic devices. Must be alert, aggressive and thorough, to work on expansion program. Permanent for right man. Midwest location. Salary open.

P-274, Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED

MATHEMATICIAN

Knowledge of electrical and mechanical means of solving equations. To work on computer development with New York City concern. Additional knowledge of servo systems desirable.

P-268, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED—ELECTRONIC ENGINEER

By development laboratory of fifty-year old manufacturing concern located in western New York. Graduate with several years experience in radar, navigation, fire control, servo or similar systems. Must have extensive knowledge of circuit fundamentals and be able to design circuit and apparatus for implementing broad new systems and to carry the work through prototype and pilot model stages.

P-269, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

TELEVISION ENGINEER

To be Service Manager for New York area by well-known manufacturer of Television Radio Receivers. Write giving experience and salary requirements.

P-270, Electronics
330 West 42nd St., New York 18, N. Y.

EMPLOYMENT SERVICE

SALARIED POSITIONS $2,500-$25,000. This thoroughly organized confidential service of 37 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Bixby, Inc., 278 Dun Bldg., Buffalo 2, N. Y.

POSITIONS WANTED

ELECTRICAL AND Mechanical Engineer. Post-graduate work in Physics. Twenty-five years in research and development of electrical, electronic and mechanical equipment, materials testing, specifications and quality control. Translating market requirements into sound engineering and manufacturing processes. Last seventeen years in consulting and executive capacities. Personnel policies and job evaluation. PW-278, Electronics, 520 North Michigan Ave., Chicago 11, Ill.

ELECTRICAL ENGINEER: Graduate with eight years experience in Seismograph, Acoustical and Electronics fields desires position in research and development of electronic equipment. PW-279, Electronics, 520 North Michigan Ave., Chicago 11, Ill.

ELECTRICAL ENGINEER, 4 years experience in servo-systems, radio and V.H.F. PW-280, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONIC INSTRUMENTS Engineer desires position in N. Y. C. area or western U. S. Age 27, single. Ph.D. degree. Four years experience in research, development and design of electrical and electronic measuring and control equipment. PW-281, Electronics, 330 W. 42nd St., New York 18, N. Y.

SENIOR RADIO-Electronics Engineer. B.S. in E.E. degree; 14 years of radio receiver (pre-war), radar, test equipment, and special devices, engineering and design, including experience as Chief Engineer. Interested in position as Engineer or in one providing business, production, or management experience. PW-283, Electronics, 330 W. 42nd St., New York 18, N. Y.

PRACTICAL ELECTRONICS Engineer: Experienced in Communications, industrial applications, geophysics. Research, design, production, service. West or foreign only. PW-286, Electronics, 68 Post Street, San Francisco 4, Calif.

FOR SALE

FOR SALE—Radio Sales and Service business in fast growing western city, Health and resort area. Well established doing both wholesale and retail service. Owner has other interests. FS-282, Electronics, 330 W. 42nd St., New York 18, N. Y.

NATIONAL DISTRIBUTION AVAILABLE

For Manufacturers who make products suitable for sale to Radio, Electrical, Electronic Jobbers and Industrials. We have a complete sales staff for national and export distribution. Reply with samples or description of product.

RA-228, Electronics
330 West 42nd St., New York 18, N. Y.

AVAILABLE JAN. 1ST.

Engineer & Sales Executive well acquainted top management, Chief Engineers Radio and Electronic Manufacturers Mid-West and East, open for sales managerial or regional representative position. Twenty years experience sales, engineering, laboratory work in Radio-Electronic field.

RA-284, Electronics
330 West 42nd St., New York 18, N. Y.

SALES ENGINEER

who can work with people and get things done, desires challenging opportunity—industrial sales or sales engineering—electronic equipment or components. Many contacts resulting from 14 years broad radio industry experience. E.E. and business education. Age 35. Married.

SA-285, Electronics
330 West 42nd St., New York 18, N. Y.

Broadcast Receiver Production Engineer

Production Engineer wanted by large Eastern radio manufacturer, to work directly with home radio manufacturing departments. Previous broadcast receiver production essential. In addition, must have good knowledge of radio circuits and theory. Write, describing experience, qualifications and salary desired.

P-271, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED!

MANUFACTURERS OF RADIO AND ELECTRONIC ITEMS who wish to build future sales volume or stabilize their business against a possible decline in domestic sales.

WAITING!

A highly profitable export market in all parts of the world. Established clientele with long history of satisfactory relationship.

Inquiries invited and references exchanged.

RA-288, Electronics
330 West 42nd St., New York 18, N. Y.

New England

SALES REPRESENTATIVE

Desires connection with high quality manufacturers in electronic fields.

Long experience in all phases of electronics.

MORRILL P. MIMS COMPANY

M. P. Mims, W5BDB/1

43 Leon St. Boston 15, Mass.

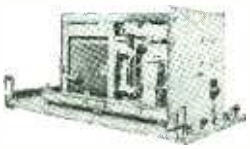
WANTED

To purchase or license patents on patentable ideas on Transformers.

Particularly interested in ideas pertaining to Transformers and reactors for use with fluorescent lamps.

Advance Transformer Company
1122 W. Catalpa Avenue
Chicago 40, Illinois

HI-POWER PARTS



POWER UNIT RA58-A $116

RA-58-A Hi-Voltage Power Supply

Ideal for breakdown insulation testing, or as a source of power for a pulse transmitter. This unit supplies continuously variable voltages between 500 and 15,000 volts DC at 35 ma. A voltage Doubler circuit using two 705a rectifiers and two 1 mf condensers is employed. BMS ripple voltage at maximum power is 6%. THIS UNIT OPERATES FROM 115 v/60c. Variable voltage is obtained by means of a Variac in the primary circuit of the high voltage transformer. Size is 21"x17½"x29" deep. Net weight 314 lbs.

PULSE AMPLIFIER

Signal corps type BC409. Designed for 115 volts. AC 60 cycles. Component parts worth several times the price of this unit. Slightly used. Following are a few of the items that make up the unit. 1—304TL (Eimac). 3—2 mfd. 4,000 W.V.xGE Pyranol condensers. 1—3200 volt 150 MA power transformer. 1—Variac 5 amps. General Radio type CU 200. 1—5 volt 26 amp. fil. transformer (for 304 TL). 1—2.5 volt 10 Amp. fil. transformer (5000 volt insulation). 1—1 mfd. 1000 volt GE Pyranol. 1—2 mfd. 1000 volt GE Pyranol **$59.50**

SANGAMO MICA CONDENSERS

F3L .0003 mfd 8000v list $29..... **$3.75**
F3L .0015 mfd 8000v list $31..... **4.00**

Sangamo G-4 .004 mf 20 kv (list $110) **$25.50**
Sangamo G-5. .006 mf 10 kv (list $87.50) **$19.50**
Solar type SX .0015 mf 3000v list $9.95 .75

HI-VOLT TRANSFORMER

AMERTRAN PLATE TRANSFORMER, 115 v—60-cycle primary. 6200 volt-ct-700 mil secondary. Size 11"x14"x10" **$39.95**

2.6 Hy 800 Ma Choke. Stud Terminals **$7.90**

½ WAVE RECTIFICATION XFMR 115v-60c/3200v @ 150 mils. MADE BY KENYON **$9.95**

NEW C.R. TUBES

Tube Type	Approx. List	Your Cost
3BP1	15.00	3.95
3FP7	27.00	5.35
5BP1	20.00	4.95
5BP4	27.00	7.95
5CP1	45.00	4.95
5CP7	48.00	6.00
5FP4	35.00	4.95
5FP7	32.00	4.95
5JP2	48.00	13.50
837	2.80	1.50
872A	7.50	2.45
705A	22.50	6.75
241B-WE	85.00	50.00
861	155.00	95.00

Sockets for 5CP1; 3BP1, & 5BP1 and similar types of tubes.....$ .95

All merchandise guaranteed. Mail orders promptly filled. All prices F. O. B. New York City. Send Money Order or Check. Shipping charges sent C. O. D. Send for Flyers.

COMMUNICATIONS EQUIPMENT CO.

131-E Liberty St., New York City 7, N. Y.
TELEPHONE WH 4-7658

JOBBERS-WHOLESALERS
QUANTITY-BUYERS!

MID-AMERICA'S UNBEATABLE LOW PRICES

DOUBLE Your Profits!

WHOLESALE ONLY!

Quantity buyers! MID-AMERICA has 70,000 square feet of warehouse space jam-packed with radio parts, electronic equipment, etc. Items at UNBELIEVABLY LOW PRICES—that will save and make you money. Listed below are a few samples!

Universal Output Transformer will match voice coil to any tube, single or push-pull. Strap mounting on 2⅛" centers. Size 2¼" high, 2" wide, 2" deep. Minimum order—100 **98c** each

AC-DC CHOKE 15 henry, 50 MA, 120 ohms DC resistance. Size: 1⅝" x 2" x 1½" Minimum order—50 **59c ea.**

ACORN TUBE SOCKET Low loss ceramic socket with rugged spring contacts for 954 and 955 tubes Minimum order—100 **$7.50** Per 100

SPEAKERS

5" Alnicko V PM Speaker with 4 ohm voice coil, less output transformer. Minimum order—100 **$1.37 ea.**

6" Alnico V PM Speaker with 2.15 Alnico V slug. Minimum order. 100 **$1.79 ea.**

PL-68 PLUG Jack Set with 4 ft. of 3-conductor rubber-covered cable with PL-68 plug on one end and 3-way open circuit jack, at other end. Minimum order—100 **15c** each

10 Watt RESISTORS — any ohmage — per size or assorted Minimum order—100 **$7.00** per 100

GUARANTEED

All items shown in this ad are guaranteed as rated by nationally-advertised manufacturers and are new, unused and in perfect condition.

Milliammeters—GE & Westinghouse 0-300 MA DC, 2⅛" flange, 2⅛" dia. body, 1½" deep. 0-20 MA DC, 2⅛" flange, 2⅛" dia body, 1½" deep. Both types with white scale, black markings (Minimum order each type—10) **$1.95 ea.**

RELAYS—Write for 12-page book illustrating more than 250,000 relays. 24c each, and up.

DYNAMOTORS—79c, and up! Write for complete listing of dynamotors. Our prices will 'shock' you!

APC CONDENSERS—8c each, and up! We have large quantities of unused APC condensers—all at ridiculously low prices! Ask for special condenser listing!

FREE CATALOG

TERMS: We extend usual credit to rated accounts. Others send 25% with order, balance C.O.D. All prices shown are f.o.b. Chicago warehouse.

MID-AMERICA Bargains

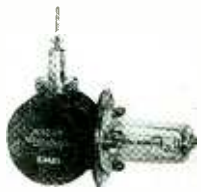
Mail orders and catalog requests to store address — Dept G-17

You ain't seen nothin' yet! Rush firm name and address for MID-AMERICA'S big catalog listing hundreds and hundreds of hard-to-get radio parts, transmitters, etc.—ALL AT UNBEATABLE LOW PRICES!

MID-AMERICA CO. Inc.

STORE 2412 S. MICHIGAN AVE. CHICAGO 16, ILL.
WAREHOUSE 2307 S. ARCHER AVE. CHICAGO 16, ILL.

3CM WAVEGUIDE COMPONENTS



Westinghouse type 2J32 (JAN.) just released. The 2J32 is designed for 10 cm. operation. Rated at 300 kw feet pulse power. Complete information supplied. Brand new, packed in individual protective cartons.

The 2J32 is listed at $200.
OUR PRICE $25.50
3J31's just received. One cm magnetron listed at $95.00 OUR PRICE..... $20.00
1B24 T-R tubes..... 2.98
3CM. Duplexer using 1B24..... $10.00
KLYSTRON oscillator tubes 2K25/723ab, designed for 3cm. operation. New. Packed individually. Listed at $38.00, reduced to $ 7.75
30 mc oscillator-amplifier with 2 6AC7's. Uses 723 a/b. Waveguide input, xtal detector. With 6AC7's $10.00
With 6AC7's and 723 a/b..... 16.50
Thermistor Beads (D-170396), for use with UHF and Micro-Wave Equipment (list @ $7.00) in separate sealed containers @ .95

3 CM WAVE GUIDE SECTIONS

Silver Plated Directional Couplers with 20 DB drop with:
A. Straight wave guide section 6" long....@ $3.95
B. 15° bend in wave guide 15"..... 5.90
C. 30° bend in wave guide 10" long 4.75
D. 90° bend in wave guide 15" long also 90° bend in coupler 6.50
E. Six-inch section silver plated wave guide with 90° twist 2.95
F. 2½ foot silver plated with 90° bend (2" radius) 5.50
G. 150° bend, with 90° twist 3½ radius with pressurizing ripple and coax coupler 3.95
2½ ft. wave guide sect. 3cm choke and cover 4.75
5 ft. wave guide sect. 3cm per foot 1.75

All merchandise guaranteed. Mail orders promptly filled. All prices F.O.B. New York City. Send Money Order or Check. Only shipping charges sent C.O.D.

COMMUNICATIONS EQUIPMENT CO.

131-E Liberty St., New York City 7, N. Y.
WH 4-7658

METERS
AND INSTRUMENTS

VOLTMETERS, AMMETERS, MICRO AMMETERS, OHMMETERS, FREQ. METERS
BRIDGES (Wheatstone), MEGOHMMETERS, RHEOSTATS, VARIABLE TRANSFORMERS, RELAYS

ELECTRO-TECH Equipment Co.

119 Lafayette St., New York 13, N. Y.

SURPLUS PARTS and EQUIPMENT

55,000 Sq. Ft. of Government-owned electronic parts and equipment. All material inspected and tested; backed by usual 90-day manufacturers' guarantee.

Sorry, no retail sales; all purchases against company orders only.

COMMUNICATION MEASUREMENTS LABORATORY

Central Agent for War Assets Adm.

DISPLAY ROOM: 350 W. 40TH ST.

Main Office: 120 Greenwich St., New York 6

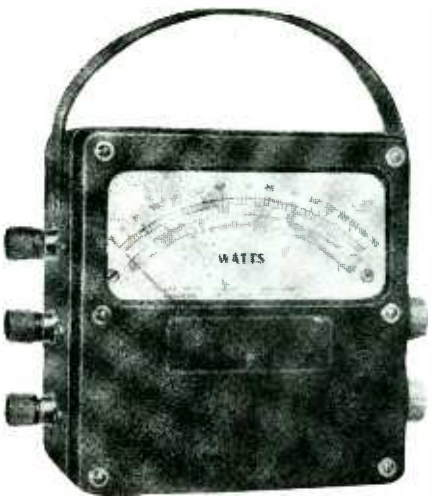
BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., Inc.
65-67 East 8th St. New York, N. Y.

PORTABLE A. C. VOLTMETER

Weston Model 433



0-150 volts, Accuracy within ¾" Hand Calibrated mirror scale 4.04" long with 150 scale divisions, knife edge pointer. Moving iron vane type completely shielded from external magnetic fields, Dim. 5"x6"x3½". Ideal for production control. Industrial testing and as laboratory standards. These meters are only slightly used and in perfect condition. They have been laboratory checked against Weston 326, Primary Reference Laboratory Standard and are within the accuracy guarantee of new instruments. (Full money back-guarantee if you are not completely satisfied) **The new List Price is $44.00. Your cost**

ONLY $19.00
F.O.B.-N.Y.

PORTABLE A. C. AMMETER

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, plush-lined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at **less than 50% of manufacturers list.**
Your cost **ONLY** **$12.50**

A. C. VOLTMETER

Westinghouse **"HA"** 5½" Square Case. Projection Mounted, 0-150 Volts, Accuracy within 1% 5" Scale with 30 divisions easily read at a distance. Ideal for production or any type of job where a constant critical line voltage must be maintained. **List Price $37.00. Your cost**

ONLY $14.50
F.O.B.-N.Y.

FREQUENCY METER

Westinghouse **"DY"** 4⅜" Round Case. Projection Mounted 50-70 Cycles 115 volts. Accuracy within 1%. The 3.6" Scale with 40 divisions is easily read from a long distance. Electric Dynamometer movement. Complete with external reactor. **List Price $97.00. Your cost**

ONLY $22.50
F.O.B.-N.Y.

Surplus New Panel Meters

All meters are white scale in round, flush, bakelite cases, unless specified otherwise. Add sufficient money on parcel post orders, excess will be refunded.

MICROMETERS

Marion, 2½", 200 microamp undamped mvt., spec. sc.....**$3.50**

W.E., 3½", concentric style, 0-200 microamp **$4.00**

G.E., Do-41, 3½", 0-500 microamp mvt. scale 20 K.V., comp with paper V-O-M.A. sc.....**$4.95**

D. C. MILLIAMMETERS

G.E., DO-53, 3½", square, 20 M.A..**$4.95**

Simpson 25, 3½", 5 M.A. movement Zero Right Scale—6 to 100 caption "DB" above 1 Microvolt.....**$3.00**

Weston, 3½", 0-1000 M.A.....**$4.50**

D. C. VOLTMETERS

G.E., DW-41, 2½", 15 volt Black scale, 15 markings, No Caption.....**$2.50**

W.H., NX-35, 3½", 15 K.V. comp. with 1000 r/v ext prec resist L.P....**$210.00**

Your cost **$21.00**

W.H., NX-35, 3½", 0-200 V, 1000 r/v **$5.50**

W.H., NX-35, 3½", 0-200 V, 1000 r/v mtd on 45 degree metal angle panel **$6.00**

Western Electric, 3½", Concentric Style, 0-75 volt D.C. 1000 r/v.....**$3.00**

W.E., 3½", 500 volt, 1000 r/v Concentric Style **$5.00**

RADIO FREQUENCY AMMETERS

Weston, 425, 3½", 0-500 M.A. R.F..**$7.50**

G.E., DW-44, 2½", O-1 A.R.F. Black scale **$3.50**

Weston, 640, 4½", Surf Mtd, 0-3 A.R.F. **$9.50**

G.E., DW-44, 2½", 0-4 Amps R.F. Black scale **$2.95**

W.H., NT-33, 2½", 0-9 Amps R.F. Black scale **$2.50**

A. C. VOLTMETERS

G.E., AW-42, 2½", 0-10 V.A.C.....**$3.95**

W.H., NA-33, 2½", 0-15 Volts A.C. Black scale marked 600-800 cycles calibrated for 60 cycles.....**$2.50**

W.H., NA-35, 3½", 0-130 volt A.C. BLANK scale except with a red reference mark at 115 volts.....**$3.00**

Weston, 517 2½", 0-300 Volts A.C..**$6.00**

G.E., AO-22, 3½", 150 volt.....**$5.50**

Weston, 517, 2½", metal case 0-150 Volts A.C., scale marked 400 cycles, accuracy within 3% on 60 cycle.....**$2.50**

A. C. AMMETERS

Weston, 476, 3½", A.C., 3 Ampere movement scale 0-120. Comes complete with external current transformer, by simply adding primary turns to the transformer any or all of the following ranges may be obtained 1.2, 6, 12, 30, 60 & 120 Amperes. Simple Wiring diagram furnished shows how to obtain any or all of these ranges....**$7.50**

SPECIAL METERS

Weston, 301 Power Level Indicator, 625 Microamp 1.2 volt A.C. mvt., self cont. rect., blank sc.....**$6.00**

Weston, 301, 3½", 0-150 V A.C. Rectifier Type, 1000 r/v A.C.....**$6.50**

J.B.T., 3½", Frequency Meter, 58-62 cycle, 5 reed.....**$4.00**

G.E., miniature, 1½", square, 1 M.A. 100 ohm mvt, 10 divis sc, bk sc.....**$2.75**

Marion, 2½", ring mtd "S" meter made for National Co. 1 M.A. mvt scale "1-9 S units 0-40 D.B. above S 9" **$3.50**

Selected Government Parts from Wells' Vast Stock!

MICRO SWITCHES

We can make immediate delivery of a wide variety of Micro-Switches, G.E. Switchettes, Acro, C-H and MU. Prices are well below the market. List upon request.

VOLUME CONTROLS

Send us your requirements on volume controls. Our stock consists of the most popular makes in values from 100 ohms to 5 megohms. New list ready.

BATHTUB CONDENSERS

All famous makes of oil-filled bathtub condensers are represented in our huge stock. Single and dual types range from .05 to 4 Mfd. at working voltages from 200 to 600. Write or wire for list.

All material is guaranteed to be of top quality and our prices always represent definite savings. Our engineering staff is qualified to suggest substitutions if necessary.

1717 West Madison St., Dept. E-1

Chicago 44, Illinois

WELLS SALES, INC.

SPECIAL BUY IN

TRANSFORMERS

PLATE TRANSFORMER

Value **$150**

SPECIAL **$39.95**

Immediate Delivery

6200 Volt CT—700 mils, 110 V. 60 Cy. tapped primary 2 KVA Amertran, size 11"x14"x10". Weight 150 lbs. Freight prepaid to any part of the Continental U.S.A.

We also carry a complete line of electronic and communication equipment. Send money order or check. Write for our latest bulletin 1 B.

Write or Wire to

NIAGARA RADIO SUPPLY CORP.

160 Greenwich St., New York, N. Y.

BOwlingreen 9-7993

FOR SALE

IMPREGNATOR

Barrett Centrifugal Impregnator 154-1 in original crates

Suitable for small wire wound coils or equivalent

STEVENS - ARNOLD CO., INC.

22 Elkins Street, So. Boston, Mass.

SURPLUS EQUIPMENT SALES

V.H.F. Connectors, type N, coaxial:
UG21U .. $.75 UG58U .. $.75
UG27U ..$1.00 M359 .... $.50

Televis'on Transformers, 115v 60 cps Sec. 5500v 3 ma, 2.5v 3a, 6.3v 1a $9.75

Measurements model 78B, R.F., Signal generator, 15-25 Mc and 150-230 Mc, good working order..... $45.00

3" Radar indicator scope, ID-93/APG-13A complete with 3 BPI and 9 tubes, black crackle finish case, new, 115V, 400 Cps..... $25.00

Radar receiver BC 406, 205 mc, 15 tubes, 115V, 60 cps..... $25.00

GE pyranol capacitors:

1 mfd, 15000 WVDC	$25.00
2 mfd, 4000 WVDC	5.00
.25 mfd, 4000 WVDC	1.00
.15 mfd, 4000 WVDC	1.50
.05 mfd, 1500 WVDC	.25
.05 mfd, 2500 WVDC	1.50

Button silver micas, 50, 400, 500 micro-micro'arad, 500 V. dc...10¢ each

IN 23 B diode crystals.....70¢ each

Write for bulletin

ELECTRO-IMPULSE LABS.

SHREWSBURY, NEW JERSEY

PRECISION

Sound Pressure Meter

Available

Almost new, in perfect condition. Consists of one Western Electric Microphone—Head 640-AA and all associate equipment. Ideal Instrument for acoustic research or precision production testing. Calibration chart and instruction book supplied, also drawings for various artificial ear couplers.

Price: $550.00 f.o.b. New York

For detailed information and Photo write to

FS-273, Electronics

330 West 42nd St., New York 18, N. Y.

FOR SALE

MICARTA PLATE

Westinghouse GR-219

64 Sheets 3/8" x 36" x 48"
45 Sheets 3/8" x 38½" x 48"
24 Sheets 3/8" x 25" x 36"

NORTHWEST PROCUREMENT & SALES

107 N. W. Couch St. Portland 9, Oregon

Immediately Available

Two Universal Coil Winding Machines, Type #84B (two coil machines) Complete with Motors. Perfectly New. Less than the former O.P.A. Price.

FS-272, Electronics

330 West 42nd St., New York 18, N. Y.

RECEIVER

HRO-5T; BRAND NEW

Includes 9 coil sets 50 to 430 Kcs, and 480 to 30,000 Kcs. Complete with tubes, two power supplies (110/220 volts A.C. and 6 volts D.C.), also spare parts and tubes.

Immediate Delivery. Price..$200.00 each

MASPETH TELEPHONE & RADIO CORP.

427 Flatbush Ave Ext., Brooklyn, N. Y.

MAGNETIC WIRE RECORDERS

Brand new, General Electric, model 20-N, 20-N-1. For 28 volt DC $89. Equipped for 110 volt AC $117. Extra 1 hour spools of recording wire $3. Recordings can be erased from wire any number of times. Includes instructions for simple change for playback through radio or amplifier. If you wish us to make change add $2 to above prices.

15% deposit required on C.O.D. orders.

INTERNATIONAL RADIO & SCIENTIFIC CO.

P.O. Box 18, Station G, Brooklyn 22, N. Y.

Special Values

Panel & Portable Meters

D. C. Microammeters:
50-100-200-500 microamps. High Resistance Voltmeters Vacuum Thermo-Couple Meters 3½" & 4½" Round & Rectangular

Multirange Portables:
readings from 10 microamps. full scale

Precsion Electrical Instrument Co.

146 Grand Street New York 13 N. Y.

SELSYN GENERATORS

5G, 6G, 7G. A.C. Motors 1/25, 1/40 H.P. 110 V. Other Surplus Equipment at Low Prices.

FS-287, Electronics

330 West 42nd St., New York 18, N. Y.

SLIDE RULE SHORT CUTS

Positive Location of the Decimal Point EASIER AC and DC calculations QUICKER NO OTHER SLIDE RULE TEXT LIKE IT 6 x 9 Inches; decorative cover 12 pt. type.

Second Edition—$1.50 postpaid

W. P. MILLER

536 F'' Street, San Diego 1, California

FOR PROMPT ANSWERS
to your business problems

The SEARCHLIGHT SECTIONS

(Classified Advertising)

American Machinist
Aviation
Business Week
Bus Transportation
Chemical & Met. Engrg.
Coal Age
Construction Methods
Electrical Contracting
Electrical Merchandising
Electrical World
Electronics
Engineering & Min. Jour.
Engineering News-Record
E. & M. J. Markets
Factory Mgt. & Main.
Food Industries
Power
Product Engineering
Textile World

For advertising rates or other information address

Departmental Staff

McGRAW-HILL PUBLISHING CO., INC.

New York, N. Y.

"TAB"

• NEW GUARANTEED — That's A Buy — ELECTRONIC PARTS •

DAVEN Attntr. "L" 5000rhm 0.5DB/10p....$1.45
DAVEN Attntr "POT" 50,000rhm 60DB/30pos 5.90
DAVEN attenuator "T" 600/600 30DB/10pos.. 4.95
DAVEN 13 circuit switch 2SPDT/3SPST/SP3P .79
FRIEZ BAROMETRIC Variable 140000ohm AS500045 ..... .97
Constant Impedance Rotary Beam Coupler..... 3.95
Pri. Transf 230V, Sec117/112/103/93V/7A....19.95
Auto tran GE 115/160/170/180V/1.95amp.... 2.05
10Hy100ma200ohm 95c; 10hy200ma100ohm..... 1.89
Hi-Imp S.C. Headsets with 8' cord & plug.... 3.25
S.C. Key with 6' rub cord & PL55 Plug..... .75
Resistor 1750ohm/25watt tapped at 7500, 3 for 1.00
Resistor 100000ohm/40watt, Two for..... 1.00
Kurman 1000cy hummer op6-8V DC ($9)..... .97

*½%, **5%, †10%.

1500	2000*	4000	4300**
7500	7950*	10000	15000
17000	30000†	75000	100000
140000	147000	166750	201000
229000	250000†	950000†	(Rest 1%)

"TAB" SPECIAL 3 for $1.00

Precision Wire Wound Resistors, IRC, Shallcross, Mepco, Inst. Res. Co., Ohmite for Meters, Bridges, Amplifiers.

250000	294000	314000	333500
353500	400000	402000	422000
458000	478000	THREE for $1.50	
500000	700000	THREE for $1.95	

1 Megohm 1% accy THREE for $2.45

Switch GE Toggle D.P.D.T. 3A/125V, 3 for....$1.00
Switch AH&H 10Amp/125V DPST Rotary ($5) .49
Switch AH&H 60A/600V, 250/125V Rotary... 1.00
Switch Burroughs 8CKT 15Amp/150V Rotary.. .49
Switch Multi-gang 2Pole/5Pos six gang ($7.50) 1.75
Switch Multi-gang 1Pole/11Pos three gang... .75
Switch Multi-gang 1Pole/11Pos two gang ($2.50) .59
Switch Multi-Ceramic 3Pole/3Pos two gang... .79
Switch Multi-Ceramic 2Pole/5Pos two gang... .89
Switch Multi-Ceramic 1Pole/12 Pos one gang... .89
Switch Multi-Ceramic 3Pole/3Pos two gang... .89
Switch Door Interlock GE 7460330-G4 ($1.50).. .69
TBY new Vibrapack & storage battery. Willard 4V/40AH; V'pack output 156V/30ma, 3V/375 ma, 1.5V/200ma, 7.5V/20ma & manual.....$9.95
WSTGHSE RECTOX FW Rect 12.8V/1.3 Amp. 3.40
Dynamic mike & transf to G new..... 1.95
Condenser WE oil 16mfd/400WVDC Two for... 2.45
Condenser oil 0.5mfd/600WVDC bathtub 5 for 1.00

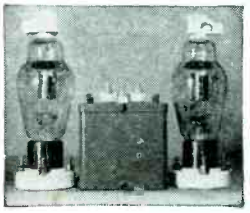
IF YOU DON'T SEE IT • • WRITE FOR IT • "TAB" CATALOG 99 IS FREE

Condenser GE Pyranol 1mfd/500WVDC 8 for..$1.00
Condsr oil 10mfd/600WVDC (2/2.5&5mfd) 2 for 2.50
Condsr oil Aerovox 20mfd/600WVDC (1-2-4-5-8mfd) 2 for 4.95
Condsr GE Pyr 3mfd/330VAC/1000WVDC 2 for $2.50
Condsr GE Pyr 15mfd/330VAC/1000WVDC each $2.95
Condsr Avx&Wst oil 2mfd/2000WVDC 2 for..... 4.25
Condsr Avx&Wst oil 3mfd/2000WVDC 2 for..... 5.00
Condsr GE Pyr 7mfd/660VAC/2000WVDC 2 for 7.00
Condsr oil 30mfd/600VAC/2000WVDC @..... 7.10
Condsr Wst Ineerteen 2mfd/5500WVDC @..... 10.00
Condsr Wst Ineerteen 2mfd/12500WVDC @.... 25.00
Condsr Wst Ineerteen 1mfd/25000WVDC @..... 75.00
Condsr CD oil TLA 2mfd/600WVDC 2 for ..... .79
Condsr Avx oil TLA 0.5mfd/1500WVDC 2 for.. 1.49

CRYSTALS NEW GUART'D IN FT243 HOLDERS ACTIVE OSCILLATORS, GOOD DOUBLERS & TRIPLERS. "BT" cut 2cys per deg C per Mc. Four for $3.00
6250 to 6750 (6MTR)
6797 to 6863 (11MTR)
7000 to 7425 (40, 20, 10MTR)
8333 to 9000 (6MTR)
OTHER FREQUENCIES AVAILABLE
Crystal Std 100kc ± 10cys....$7.20
Crystal Std 200kc ± 10cys.... 5.95
Crystal Std 5000kc 1.90
Dual socket CINCH Mica B', 2 for $.25

Condenser GE PYR .45 mfd/1000WVDC; 4 for..$1.00
Condsr oil bath-tub .05mfd/1500WVDC; 4 for.. 1.00
Condsr oil bath-tub 2X.1mfd/1500 WVDC, 3 for 1.00
Condsr GE Pyr 0.1mfd/2000WVDC, 2 for..... 1.00
Condsr Avx oil 0.1mfd/3000WVDC, each..... 1.25
Condsr Avx oil .03 mfd/7500WVDC, each..... 198
Condsr RF 25mmfd/10,000V wkg new 3 for..... .75
Condsr CD oil 6mfd/1500WVDC 2 for..... 4.50
Condsr .01mfd/1500WVDC tubular Ten for..... 1.50
Condsr. .01mfd/600WVDC molded type Ten for .95
Condsr .02mfd/600WVDC tubular oil Ten for.. 1.20
Condsr mica .01mfd/2500V ($3.40) 2 for..... 1.00
Condsr mica .001/8000V eff SOLAR ($36)..... 3.95
Condsr mica .00015/5000 AVX1950-406 ($29)... 3.49
Condsr mica .0003/10000 Sang G2 ($42)..... 4.50
Condsr mica .00015/20000 Avx1970-404 ($74)... 7.50
RF Choke 85MH HAMLUND ($3)..... .97
RF Choke 250MH HAMLUND ($4)..... 1.20
RF Choke 1MH/300ma National 3 for..... .90
Pulse Transf 0.4MUsec Horiz. BTO Television.. 1.49

Raytheon 8 6 6 A filament transformer 115V 60Cy PRI, 2.5VCT 11A sec and Two New GE 866A tubes ..$5.90 with Insltd caps & 224 sockets .. 7.00 Raytheon Transformer only ..3.25 Combination 872A Rectifiers, Transformer & Sockets new $12.00



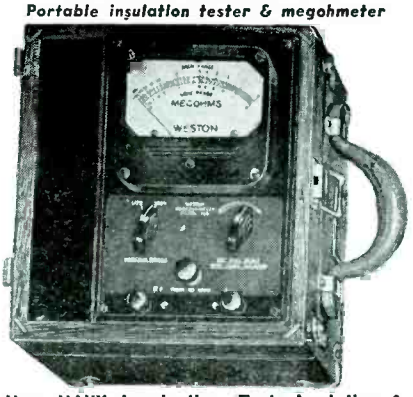
Hmtclly Cased choke 10HY/125ma/175ohm....$1.29
GE Dual 15HY/85ma choke cased H.V. insl... 1.49
WE ouncer Min PP/P to PP/G input KS9929. 1.20
EDISON Time Delay Relay 115V/10Amp..... 1.49
WE PP inpt & PP driver transfs 6V6/805..... 6.95
Kenyon Dynamic mike to Grid Transf..... 1.95
WE Dynamic microphone D-17334D-A..... 9.95

Transf Hmt'clly cased pri 50/800cy-80/115V Sec 1000VCT&300V/110ma, 6.3V/5V/3A. Three 6.3V/.65A, 6.3V/1.25A & Two H'cased chokes 10Hy/110ma & Two oil condsr 3mfd/330VAC/1000WVDC Pyranol & RK60/1641 Tube..$9.95

KENYON T-216, 115V/60cy, 1040VCT&80V/250 ma 5V/3A, 2.5VCT/3, two*6.3VCT/3A cased' 7.00
Transf 115V/60cy—5V/25amp H.V. insl. cased. 6.95
Collins choke 6Hy/1.2amp/12500Vwkg cased... 16.00
C'Ray fil 6.3V/2A, 2.5V/1.75A shielded HV.. 3.00
Bias transf 90, 80, 70Vatlamp Cased GE..... 2.95
MICRO Mu-Switch Leaf SPDT 15A/125V, Two 1.08

WESTON MODEL 796

Portable insulation tester & megohmeter



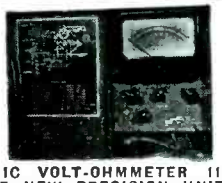
New NAVY termination. Tests insulation & resistance up to 200 megohms, test potential 350 to 500 VDC. Resistance 0-20-200 megohms .5 & 5 megohms center scale. 4" sq. 50 micromampmtr less batteries, test leads & carrying case (LP$100) $16.95 with carrying case $24.75: Parts for 500 V-AC supply $9.

Transf line to line 500, 333, 250, 200, 125 50ohms ± 1DB Cased Thermador mfgr..... 1.95
115V/60cyP, 1480V/50ma, 6.3V/1A, 5V/2A... 4.95
RF Choke 20MH/500ma Hamlund..... 1.25
Fil TR, 2.5V/1.75A, 6.5V/8A, 5V/3A, & RK60/1641 ..... 4.50

Baked

GR Variac 200CU/860 watt with D & K.$14.95
GR Variac 200B/170 watt..... 9.95
Transtat 88-132V./18.2 Amp.—110 V. inpt. 29.50
SOLA Constant Voltage Transf. 250 watt. 19.00
SOLA Constant Voltage Transf. Lab. 60 watt 15.00

Raytheon cased 840VCT/110ma, 540 VCT 21ma, 5V/3A, 5V/3A, 6.3V/1A, 6.3V/.6A, 115V 60 cy Pri & Two 10Hy/110ma hmt'cly cased chokes & oil condsr Two/2.5&5mfd..... 8.95
THERMADOR transf cased SC cont duty, PRI 200, 210, 220, 230, 240, 440V/50/60cys, Sec 3800VCT/6K/2.7amps ($365)..... 45.00

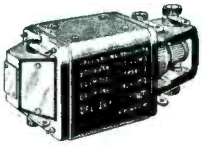


V	OHMS
0-3	1000
0-10	10000
0-30	100 M
0-100	1 Meg
0-300	10 Meg

ELECTRONIC VOLT-OHMMETER 11meg SENS SC. I-107-F NEW PRECISION UNIT SPECIAL $24.50. Additional VTVM Loctal tube ILE3/SP S.C. $1.45.
$2 Min. order FOB N.Y.C. Add Postage all orders and 25% deposit. WHitehall 3-3557. Send for catalog 300. Specialists in International Export, School, College & Industrial trade. Money Back Guarantee.

WE XTALS boxed sealed 1N21-22-23, 3 for.. $1.25
W. E. Crystal boxed sealed 1N26 UUHF-1CM. .54
IRC PRECISION 1KV/one meg½% Hmt'cly. 1.60
GE Meter 2½" B'C oncamp RF..... 3.95
GE Meter 2½" B'C fiveamp RF meter..... 3.50
GE Meter 2½" B'C one milliampmtr..... 2.95
GE DW41 2½" B'C 2000V/1000ohmsV & Mult. 8.95
GE DX1 Min. 1½" MTR Onema/100 ohms.. 2.95
WSTGHSE DUAL AN IND 200microamp..... 4.50
GE 2.5&25ma zero ctr Galvo 3½" B'C..... 3.95
SIMPSON ONE MA 3½" B'C Type 25..... 3.95
WESTON 476 SQ 3" B'C 15VAC ($10)..... 4.25
WESTON GE 10plus6DB 500/600ohm L..... 3.95
WESTON 301 meter 10KV/1000ohmsV & Mult 15.00

EICOR DC DYNAMOTORS NEW Gt'd overseas packed ANinsp. Hi-eff input 12V/8A or 24V/4A, output 275V/110ma & 12V/3A. SPECIAL EACH UNIT $1.95 OR Both units (2) with filter $3.49: Wgt. 9 lbs; 7¾" L x 2⅞"H x 4¼"W. Each unit conservatively rated. Can be used on 6V. ALNICO Field.



SC A27 Phantom Antenna new with manual contains MILLEN 12515 Variable Condsh. 150mmf/3000V & 2 W.L. plaque 12ohm/40W resistors, cont. in metal box, cables, clamps & spares "TAB" SPECIAL.$1.95
Control KIT type ABJ; 50tolmeg: 10 for.....$2.50
Condsr KIT Qty silvermicas; 50 for..... $2.00
Resistor KIT 100 BT½ & 1W; 50to2meg.....$2.50

SOCKET OCTAL Amphenol 78S micaB (18¢)
Spaghetti KIT assted sizes 60ft for.....$1.00
SOCKET LOKTAL MIP 88-8X (20¢) 20 for.. 1.50
SOCKET OCTAL CERAMIC 49SS-8 (45¢) 15 for 1.50
SOCKET OCTAL CERAMIC & SADDLE RING CINCH 10 for..... 1.50
SOCKET MAGINAL CERAMIC 49-SS1IL.. .49
SOCKET DIHEPTAL CINCH MICA B' ($5).. .49
SOCKET ACORN HAM'LUND UHS900 ($1.25) four for 1.00
SOCKET 4 PRONG JOHNSON 224 CERAMIC (80¢) 4 for.....$1.00
SOCKET 5 PRONG NATIONAL XC-5 CERAMIC (80¢) 4 for..... 1.00
SOCKET 50Watt GE HF AN INSP 2 for..... 1.30
SOCKET 304TL JOHNSON 213 ($1.80) each.. .85
SOCKET 929B JOHNSON 247 ($2.05) each... .49
SOCKET HUBBEL 15A/125V TWIST LOCK 7586 Five for..... 2.00
SOCKET MINIATURE BAYONET DIALCO 9S-3931-L90 each ..... .15

MFGR'S • • EXPORTERS • • DISTR'S ONE OR A CARLOAD BUY THE TAB WAY—THE PRICE IS RIGHT

G&P tube grips NATIONAL #8&24¼ & ⅜" caps 50 for $1.00
G&P tube grips ALDEN 92SL & lead wire 9/16 cap 20 for..... 1.00
LITTLE FUSES 3AG/250ma (LP25¢) 48 for.. 1.00
CORD SJ Hvy Duty Extension 16ft with Amphenol M&F plugs..... 1.00
Punched Chasis Two sizes fits R.R. 2 for..... 1.00
HEINEMAN 0322 Mag. Ckt. Breaker .010amp. .97
HEINEMAN 0322 Mag. Ckt. Breaker 3amp... .97
HEINEMAN 0322 Magnetic Circuit Breaker 8 & 25amp..... 2.95
HEINEMAN 0322 DP Magnetic Circuit Breaker 15amp..... 3.95
WESTINGHOUSE 3PH DE-10N Circuit Breaker 15A/600V 7.95
GE Adjustable temperature regulator switch CR2932-R1 ..... 7.95
AIR FILTER FIBERGLASS CART' 8 x 6½ x ⅞": 3 for..... 1.00
9002 JAN new boxed (2.25) 2 for..... 2.00

RCA 808 JAN-CRC New Gt'd, Fil 7.5V/4amp, plate 1500V/200 Watts Rated 140 watts output each "UHF" (List $7.75) "TAB" price $2.75@, 2 for $5.00.

GE & WST 807 JAN 2 for.....$2.50
GE & RAY 955 JAN 2 for..... 1.25
956, 957, 958A new & socket ea. 1.25
RCA 6AC7 JAN/BOXED new 4 for..... 3.00
872A new & socket, 2 for..... 5.75
6H6 Metal JAN Boxed, 2 for.... 1.35
6B8G JAN Boxed, 2 for 1.75
NU 2V3G JAN HV 16500V ($3.40) 2 for..... 1.50
GE 446A/2C40 Lighthouse tube ($12) 2 for.... 12.00
RCA 829B/3E29 JAN Boxed Gtd & socket.... 4.50

WE 307A RF PENTODE NEW (LP$13).....$5.95
WE 339A RF PENTODE NEW (LP$24)..... 6.95
WE 703A UUHF 20Watt/1000Mc's ($40)..... 5.95
WE 717A Door Knob tube new ($7.50)..... 1.95
2C26 JAN New UUHF (LP$5) Boxed..... 1.95
RX215 Raytheon new FW 500V/15amp..... 7.95
GE1641/RK60 new FW H.V. Rect ($2.75)..... 1.95
5BP1 or 5BP4 new gtd & socket, each..... 9.95
1625 JAN new beam (S'807) Boxed 2 for..... 1.30
RCA VR150 JAN new (LP$3.80) 2 for..... 1.90
RCA 30 Box JAN (LP$1.50) 2 for..... 1.10
RCA 1E7G JAN (LP$3.50) 2 for..... 2.50
RCA 6J4 JAN UUHF (LP$9) each..... 2.49
3A4 Tungsol JAN new (LP$2.30) 2 for..... 1.30
6AG5 JAN new boxed RCA (LP$3.20) 2 for... 1.50
6SN7 JAN new ($1.80) 2 for..... 1.60
5CP1 JAN & SOCKET $7.50: 3BP1 JAN & SOCKET 3.95

"TAB" • Dept. IE. Six Church Street, New York 6, N. Y., U.S.A. • "TAB"

INDEX TO ADVERTISERS

INDEX TO ADVERTISERS

Specify DAVEN

TRANSMISSION MEASURING SETS

To accurately measure transmission characteristics of audio systems and their components

These transmission measuring sets are accurately designed instruments for the measurement of the transmission characteristics of audio frequency communication systems. This equipment may be applied to measure gains or losses through amplifiers, repeaters, attenuating networks or communication lines without the use of laborious calculations, complex setups, or sensitive meters.

The sets shown here are sturdy compact units built to exacting specifications. Your further inquiry is invited. Technical questions will be answered by our Engineering Department.

TYPE 8A

A portable battery operated set . . . weight 14 pounds.

TRANSMITTING SECTION: Contains an internal oscillator, operating at a frequency of 1000 cycles. Output impedance is 600 ohms either balanced or unbalanced to ground. Output levels are 0 DBM* and —20 DBM*.

RECEIVING SECTION: Frequency response is ±0.3 DB from 30 to 10,000 cycles. Input impedance is 600 ohms terminating, and 6300 ohms bridging either balanced or unbalanced to ground. Will measure levels of —30 to +10 DBM* at zero VU meter indication, when terminating a line.

DIMENSIONS: 9⅜" high x 6½" wide x 12⅞" long.

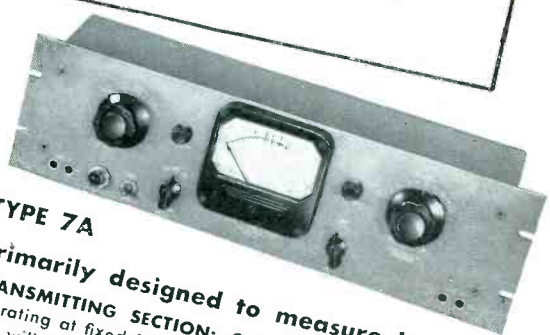
TYPE 6C

Primarily an instrument used for accurate gain and frequency response measurements. Must be used in conjunction with an external audio oscillator.

TRANSMITTING SECTION: Provides sending levels from —106 to +26 DB in steps of 1 DB for zero VU meter indication.

RECEIVING SECTION: Frequency response is ±0.3 DB from 30 to 17,000 cycles. Will measure levels of +4 to +42 DB in steps of 2DB for zero VU meter indication.

Input impedance is 600 ohms. Output impedance is 30, 50, 150, 200, 250, 500, and 600; 500 shunt and 600 shunt, either balanced or unbalanced to ground. Load impedance is 8, 15, 30, 50, 150, 200, 250, 500 and 600, either balanced or unbalanced to ground.



TYPE 7A

Primarily designed to measure losses.

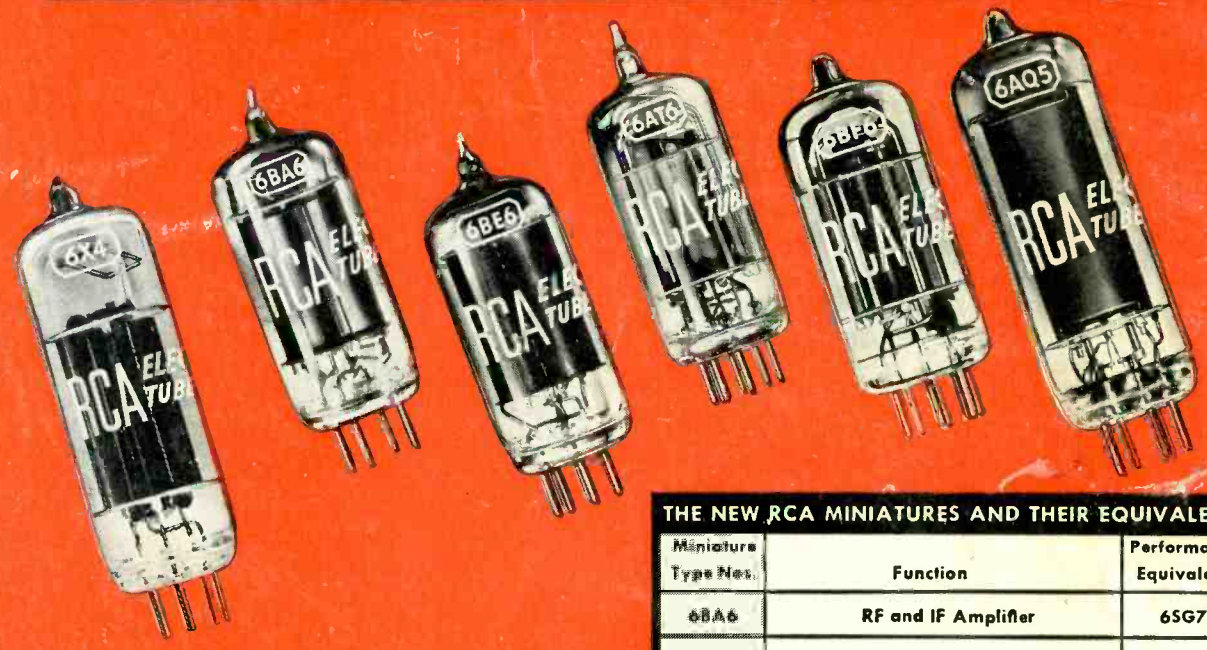
TRANSMITTING SECTION: Contains an internal oscillator operating at fixed frequencies of 500, 1000, and 2500 cycles and will provide output levels of —13, 0, +4, and +10 DBM*.

RECEIVING SECTION: Frequency response is ±0.3 DB from 30 to 10,000 cycles. Will measure levels of —30 to +10 DBM* at zero VU meter indication when terminating a line. Impedance is 600 ohms in both the transmitting and receiving sections.

* DBM is based on a reference of 1 MW into 600 ohms.

THE DAVEN CO.
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

A Complete Complement of RCA Miniatures for Auto Radio Receivers



THE NEW RCA MINIATURES AND THEIR EQUIVALENTS		
Miniature Type No.	Function	Performance Equivalent
6BA6	RF and IF Amplifier	6SG7
6BE6	Converter	6SA7
6AT6	Detector and High-mu AF Amplifier	6SQ7
6BF6	Detector and Medium-mu AF Amplifier	6SR7
6AQ5	Beam Power Amplifier	6V6
6X4	Full-Wave Rectifier	6X5

Small size and proved superior high-frequency performance of miniatures permit design of dashboard sets for broadcast and FM bands

RCA now has complete miniature complements for the design of auto receivers for both broadcast and FM bands. These tubes have the advantage of permitting considerably reduced receiver size, making particularly feasible the location of the receiver on the dashboard. For the FM band, they have the additional advantage of providing superior performance over most metal and glass types because of their lower inter-electrode capacitances, reduced lead inductance, and low-loss button-stem bases.

It is expected that the 6AT6 will be used in sets having a single 6AQ5 output tube, while the 6BF6 will be preferred as a driver for two 6AQ5's in push-pull, class AB operation. For receivers including the FM band, it is expected that the complements will be the same except for the addition of a 6AL5 miniature twin diode in the discriminator circuit.

RCA tube application engineers will be pleased to consult with you on the utilization of these or other RCA tube types in designs you now have under consideration. If you desire this service, or complete technical data on the miniature tubes illustrated, write RCA, Commercial Engineering, Section D-6A, Harrison, N. J.

RCA LABORATORIES
PRINCETON, N. J.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.

PROTELGRAM

LIFE-SIZE *more* LIFE-LIKE *Television!*

. . . from this 2½" tube

Chosen by these famous makers of quality projection TV receivers

ANSLEY • EMERSON
FADA • FISHER
PILOT • SCOTT
STEWART WARNER
INTERNATIONAL TELEVISION
BRUNSWICK

and others soon to be announced

PROTELGRAM is the result of nearly fifteen years of research by the world's greatest electronics laboratories. This scientifically designed, optically correct projection system makes possible, *for the first time,* a *life-size* distortion-free picture of nearly 200 square inches (20″ diagonal) . . . a more *life-like* picture without glare or eyestrain. And from a tiny long-life, low-cost picture tube!

PROTELGRAM is the answer to the public demand for a bigger, clearer picture that is easier on the eyes. It produces a better than 16″ x 12″ non-reflecting picture that fills a flat screen *all the way to the corners,* and permits wide angle visibility, fatigueless viewing from 5 feet or 50! Small size and light weight make possible compact consumer units. Write to Dept.TE-4, North American Philips Company, Incorporated, 100 East 42nd Street, New York 17, New York.

PROTELGRAM for **life-size,** more **life-like** television

Norelco

An Exclusive Development of

NORTH AMERICAN PHILIPS

Another RCA First...

. . . the economy of thoriated-tungsten filaments and improved cooling in high-power tubes

Here is unparalleled tube value . . .

Five new RCA tubes, ranging in power input from 1.5- to 150-kw, and successfully utilizing economical thoriated-tungsten filaments which offer marked savings in filament power and the cost of associated power equipment.

Five tubes with proved features of previous similar types. Two—the 5762 and 5786—have efficient newly designed radiators that permit the use of less expensive blowers.

Five tubes with improved internal constructions that contribute to their more efficient operation and longer service life.

These five new RCA tube types are "musts" for designers of broadcast, communications and industrial electronic equipment where design and operating economies alike are important considerations.

Forced-air-cooled assemblies and water-jacket assemblies are available for most RCA power tubes.

RCA Application Engineers are ready to consult with you on the application of these improved tubes and accessories to your specific designs. For complete technical information covering the types in which you are interested, write RCA, Commercial Engineering, Section 42DR, Harrison, New Jersey.

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.