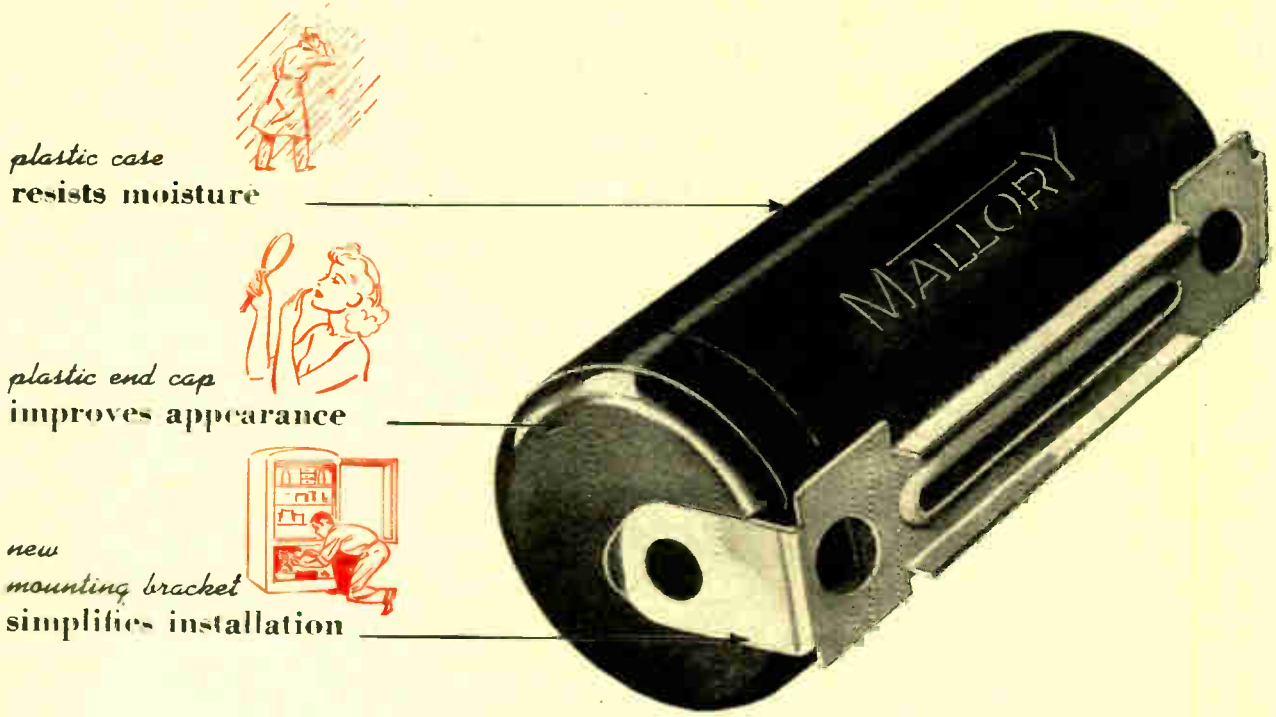
ELECTRONIC INDUSTRIES

CALDWELL-CLEMENTS, INC. ★ APRIL 1946

In This Issue

FM SYSTEMS ENGINEERING



Three "PLUS" Features of the Type "P" Mallory Motor Starting Capacitor

BETTER than the standard cardboard insulated aluminum can capacitor? You bet! Better in at least three different ways:

1. The moisture-proof plastic case eliminates all insulation difficulties.
2. The plastic end cap improves appearance—makes it unnecessary to use padding to prevent rattling.
3. The handy new mounting bracket speeds up installation—rules out the need of insulating tubes, metal end caps, grommets and other extra parts. Two screws mount this capacitor to the motor frame—*quickly and permanently!*

Available in all popular ratings. Mallory Type P Motor Starting Capacitors are interchangeable with standard aluminum capacitors in old style mountings. We will be glad to send you further information—and our engineers, as always, are ready to help with special problems.

Send for It Today!

Everything you want to know about Mallory AC Capacitors. Pictures, drawings, electrical characteristics.

P. R. MALLORY & CO. Inc.

MALLORY CAPACITORS

(ELECTROLYTIC, FILM and PAPER)

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

FM SYSTEM CHARACTERISTICS AND COMPARISONS

Point-to-Point Communication Services

1. Ability to reject to a substantial degree many forms of interference.
2. Transmitter tubes operate at full load at all times, approximately doubling the service area covered with a given power.
3. Low level power requirements in audio modulation circuits, permit lower battery drain in portable and mobile installations, less space and maintenance.
4. Greater signal-to-noise ratio permits louder signals at receiver in noisy locations.
5. No interference from other transmitters operating at same wavelengths if they deliver less than half the signal pickup from desired station.
6. Somewhat higher receiver cost.

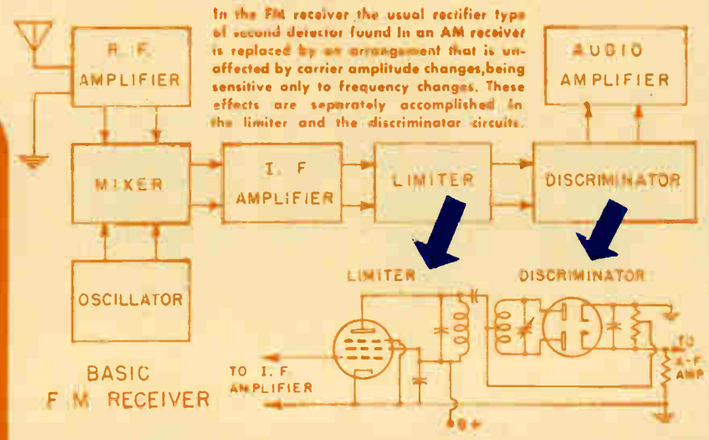
Broadcast Services

1. Ability to reject to a substantial degree many forms of interference.
2. Less economical of frequency spectrum than AM.
3. Somewhat higher receiver cost.
4. Inter-station howls, caused by carrier heterodyning, eliminated.
5. No limitation in fidelity of reception, beyond that due to receiving set capability.

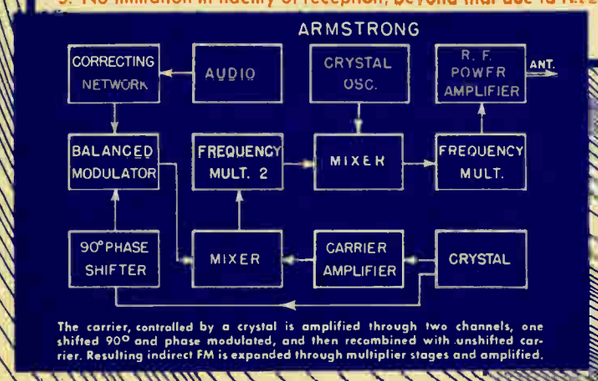
FREQUENCY MODULATION SYSTEMS

On this chart are shown basic principles, characteristics and features of the FM system which has so greatly increased in use, following extensive research work and developments, notably by E.H. Armstrong and associates.

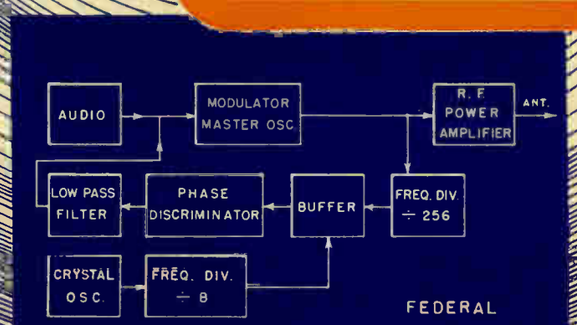
PREPARED BY ELECTRONIC INDUSTRIES



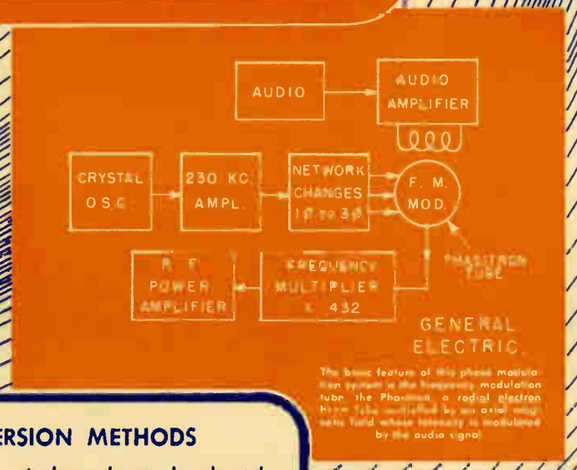
In the FM receiver the usual rectifier type of second detector found in an AM receiver is replaced by an arrangement that is unaffected by carrier amplitude changes, being sensitive only to frequency changes. These effects are separately accomplished in the limiter and the discriminator circuits.



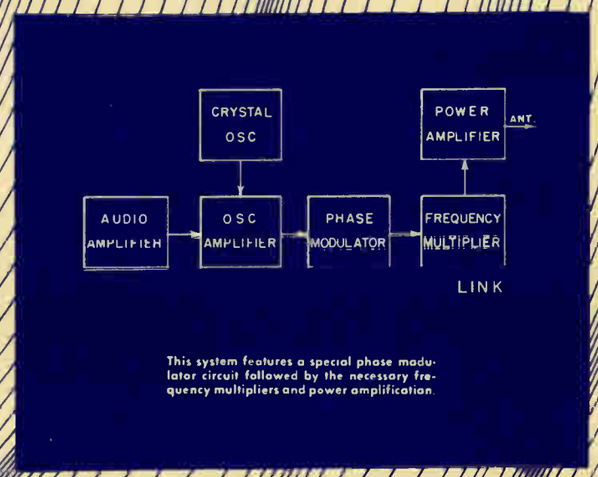
The carrier, controlled by a crystal is amplified through two channels, one shifted 90° and phase modulated, and then recombined with unshifted carrier. Resulting indirect FM is expanded through multiplier stages and amplified.



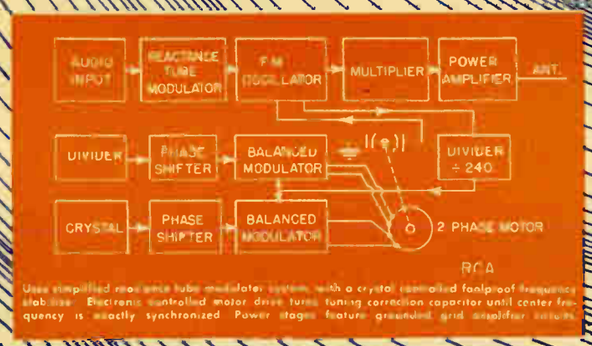
An all-electronic frequency stabilizer which compares the relative phase of a submultiple of the modulated oscillator frequency with that of a crystal. The resulting signal which represents a frequency shift is applied to a "Miller" effect correction tube.



The basic feature of this phase modulation system is the frequency modulation tube the Phasitron, a radial electron beam tube amplified by an axial magnetic field whose intensity is modulated by the audio signal.



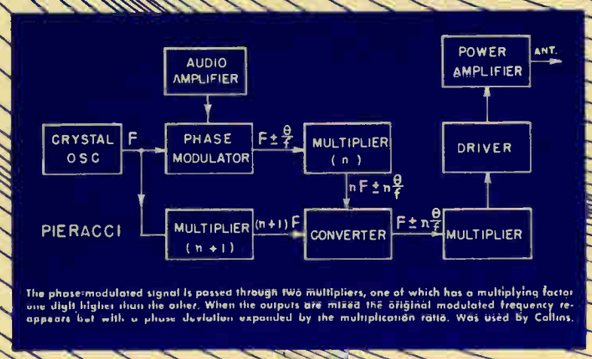
This system features a special phase modulator circuit followed by the necessary frequency multipliers and power amplification.



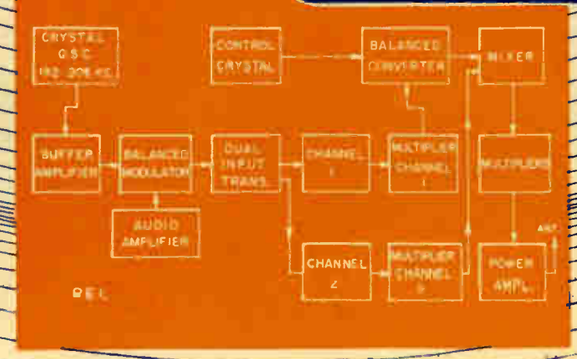
Uses simplified reactance tube modulator system, with a crystal controlled fool-proof frequency stabilizer. Electronic controlled motor drive turns tuning correction capacitor until center frequency is exactly synchronized. Power stages feature grounded grid amplifier circuits.

AM TO FM CONVERSION METHODS

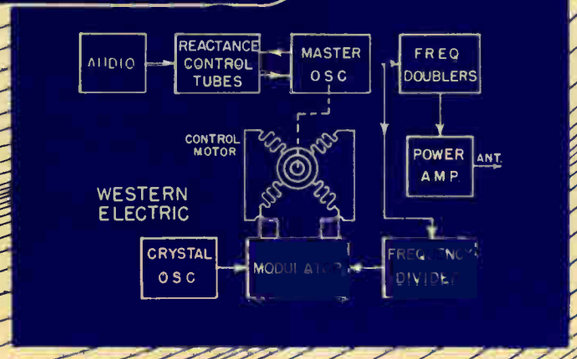
Many interesting arrangements have been developed to convert the usual amplitude variation obtained from a microphone into a frequency variation, and at the same time maintain the carrier at a constant median frequency. A few of the various systems developed for this purpose are outlined here.



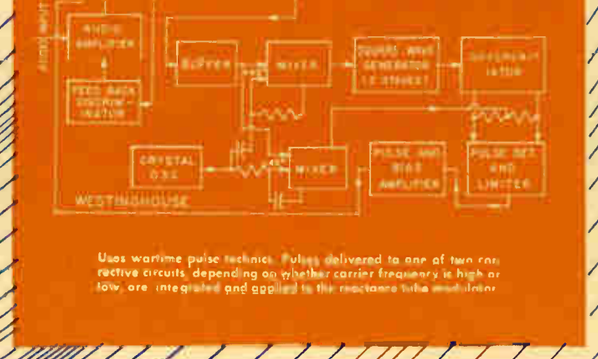
The phase-modulated signal is passed through two multipliers, one of which has a multiplying factor one digit higher than the other. When the outputs are mixed the original modulated frequency reappears but with a phase deviation expanded by the multiplication ratio. Was used by Collins.



The modulated carrier frequency from the master oscillator and a fixed frequency from a crystal controlled generator are applied to a mixer. The difference frequency is then step multiplied and amplified.



Reactance tube modulation system is used here with master frequency control accomplished by the electronic "watchman," a motor-driven tuning corrector applied to the master oscillator circuit.



Uses wartime pulse technics. Pulses delivered to one of two corrective circuits, depending on whether carrier frequency is high or low, are integrated and applied to the reactance tube modulator.

ELECTRONIC INDUSTRIES

Including INDUSTRIAL ELECTRONICS

★ IN THIS ISSUE APRIL, 1946 ★

FRONT COVER—REL 1 KW FM Transmitter ..... See page 4
EDITORIAL 61
FM SYSTEMS ENGINEERING (Color chart with this issue)
THEORY AND DESIGN OF DOUBLE-TUNED CIRCUITS—A. M. Stone and J. L. Lawson 62
NOMOGRAPH—FREQUENCY AND PHASE DEVIATION 69
NOMOGRAPH—FM DEVIATION 70
TWO-STUDIO CONSOLE 71
FEEDING COMBINED FM AND AM ANTENNA ARRAYS—Wilson Pritchett 72
FM SYSTEMS ENGINEERING—Ralph R. Batcher 75
CHART—FM BANDWIDTH VS. SWING 76
CHART—POINT-BY-POINT CONSTRUCTION OF FM WAVE—Josepha Zentner, Ph.D. 77
LARGER FM CARRIER SUPPRESSES SMALLER—H. Gregory Shea 78
DEFINING COMMON FM ENGINEERING TERMS 79
WHFM'S FM CONVERTER—K. J. Gardner 80
MOBILE RADIO SERVICE 84
HIGH FREQUENCY FM SIGNAL GENERATOR 86

TELE COLOR RECEPTION—Ralph R. Batcher 82
COLOR TELEVISION—Is It Ready To Adopt? 88
PRINTED CIRCUIT WIRING 90
TUBES ON THE JOB 92
MANUFACTURE AND USE OF GLASS BONDED MICA—D. E. Replogle 94
LABORATORY KEYHOLE 97
SURVEY OF WIDE READING 98
NEW PATENTS ISSUED 110

Washington News 102
News of Industry 104
Television Today 106
Personnel 138
New Bulletins 140
New Books Reviewed 150
What's New 112-114-167

ORESTES H. CALDWELL, Editor M. CLEMENTS, Publisher

EDITORIAL STAFF—Stanley P. McMinn, managing editor; Ralph R. Batcher, consulting editor; William Moulic, electronic theory and design; H. Gregory Shea, industrial engineering applications; Josepha Zentner, Ph.D., patents and foreign reviews; H. P. Yates, new products; Paul H. Hunter, instrumentation; E. T. Bennett, editorial records; Fred C. Hoffman, editorial production; Charles Dreyer, art director; Carl Buhrer, circuit diagrams; Roland C. Davies, 1290 National Press Building, Washington, D. C., Washington editor.

READER SERVICE—J. Cosin, H. Mirtel; data research, H. Kulik.

CIRCULATION—S. V. Spinetta, circulation director; subscriptions; list compilation: B. Gollub, M. Groening, B. Ruchaisky.

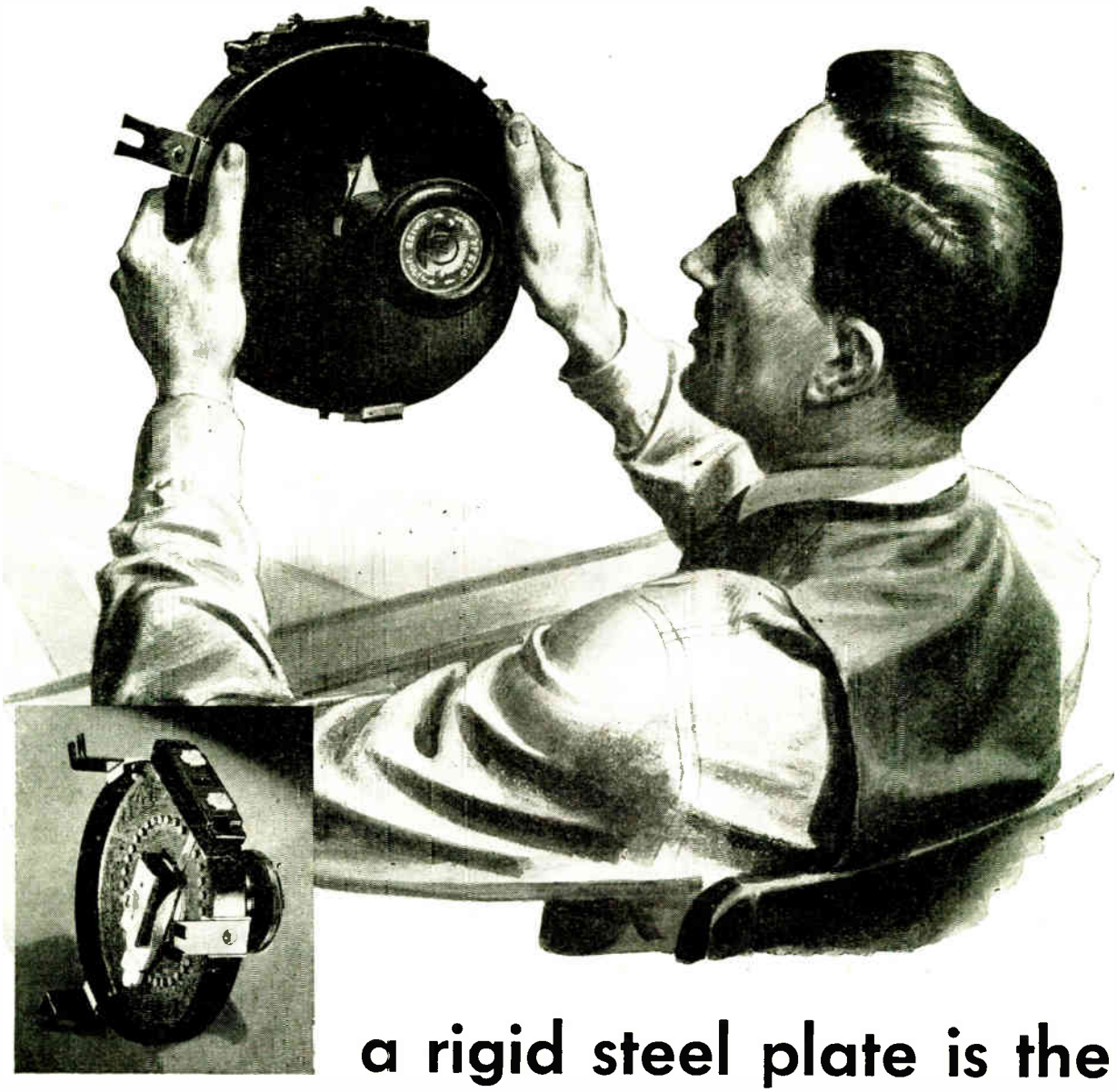
BUSINESS—M. H. Newton, business manager; John Samborn, sales manager; Richard Fitzpatrick, western manager; R. F. Willett, New England manager; Lee Robinson, district manager; C. J. Stillman; Ben Morris, promotion manager; N. McAllister, production manager; J. E. Cochran, make-up; W. W. Swigert, credit manager; W. Kenneth Reynolds, E. Callahan.

BRANCH OFFICES—Chicago 6, R. Y. Fitzpatrick, 201 N. Wells St. RAN. 9225; Cleveland 14, Kurt Groener, Citizens Bldg., 850 Euclid Ave., Main 8270; Los Angeles 14, Robert W. Walker, Walker & Minton, 403 W. 8th St., VAndike 9348; San Francisco 4, Eli C. Minton, Walker & Minton, 68 Post St., Sutter 5568.

CALDWELL-CLEMENTS, INC. — TEL. PLAZA 3-1340 — 480 LEXINGTON AVENUE, NEW YORK 17, N. Y.

Electronic Industries*, April, 1946. Vol. V, No. 4. Regular price per copy 35 cents. Published monthly by Caldwell-Clements, Inc., 480 Lexington Avenue, New York 17, N. Y. M. Clements, President; Orestes H. Caldwell, Treasurer. Subscription: United States and possessions, Mexico, Central and South American countries, $3.00 for one year; $5.00 for two years; $6.50 for three years. Canada, $3.50 per year; $5.50 for two years; $7.15 for three years. All other countries $5.00 a year. Entered as Second Class Matter, September 20, 1943, at the Post Office at New York, N. Y., under the act of March 3, 1879.

Printed in U. S. A. *Reg. U. S. Pat Off.



a rigid steel plate is the foundation of a GOOD RHEOSTAT

The first Ward Leonard Rheostats were built with a steel plate foundation. Its rigidity protected the insulating enamels, proved an excellent dissipater of heat and gave a substantial foundation for contacts, terminals and control members. Many of those early Rheostats are in active service today.

While the present day Ward Leonard Plate Type Rheostats have been modernized, made even smoother in action and offer many more steps of control in smaller diameters, they are still built on a rigid steel plate foundation.

With the wide range of types and sizes of Ward Leonard Rheostats you will find the one to meet your requirements—from the smallest electronic to the largest industrial application. Send for Rheostat Bulletins today.

Visit our booth No. 100 at the
RADIO PARTS AND ELECTRONIC EQUIPMENT SHOW
STEVENS HOTEL, CHICAGO, MAY 13 to 16

WARD LEONARD
RELAYS • RESISTORS • RHEOSTATS
Electric control devices since 1892

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

CML SERVES THE ELECTRONIC INDUSTRY

ROTOBRIDGE

CML 1500

CML 1100

CML 1110

CML 1200

CML 1420

Each of the CML units shown has been designed to perform a vitally needed service for manufacturers in the electronic industry. As a result, they are to be found in a host of plants—in laboratory and on the production line—contributing importantly to the efficiency of electronics.

ROTOBRIDGE..Mass Production Tester
CML 1100.....Power Supply Units
CML 1420.....Electronic Generator
CML 1200.....Stroboscope
CML 1500.....Megohm Meter

Write for Bulletins Today

COMMUNICATION MEASUREMENTS LABORATORY

120 GREENWICH STREET, NEW YORK 6, N. Y.

THE COVER

The REL model 518A-DL, 1000 w frequency modulated broadcast transmitter illustrated on the cover, permits operation on any selected frequency between 88 and 108 mc. Modulation is obtained by the phase shift principle, and the carrier frequency is stabilized in a dual-channel as developed by Maj. Armstrong.

The distinguishing feature of this method as compared to others is that the modulation of the frequency of the transmitter is accomplished without in any way affecting the frequency of the controlling oscillator. This is done basically by varying the amplitude of one of two currents that are phased at 90 deg. The resultant is consequently modulated both in frequency and phase. In order that the ultimate frequency deviation of the carrier shall be independent of the audio modulating frequency the program is passed through a corrector network, the response of which is inversely proportional to frequency.

Frequency stability

Two 200 kc crystal controlled frequency modulated currents whose deviations are instantaneously in opposite directions are obtained from a balanced modulator. The two are multiplied in frequency 81 fold in two separate channels. One of these is heterodyned to another frequency about 2 mc removed. This resultant and the output of the other multiplier channel are then beat together and their difference recovered. At this point all dependence of the output frequency of the transmitter on the original 200 kc oscillator is removed and its place is taken by the crystal oscillator at about 2 mc located in the modulator panel. The remaining frequency multiplication in the modulator is 48 fold and occurs in multiplier and output panels. The ultimate frequency stability of the transmitter, as the result of this arrangement is as though the carrier had not been frequency modulated and is therefore directly comparable to that of an AM transmitter at the same final frequency.

The power requirements of the REL unit is 3750 v-amperes for 1000 w output. Overall response is within 1 db from 50 to 15000 cycles at 25%, 50% and 100% modulation.

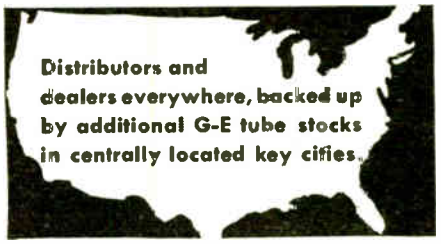
NOW you can obtain G-E electronic tubes, from smallest to largest—thyratrons, ignitrons, phototubes, high-frequency heating types, and others—out of distributor or dealer stocks *right in your area!*

A phone-call will bring G-E tubes to your factory door as fast as local delivery can get them there. No more machine shutdowns due to delays in securing replacements for old tubes that have given out! No more worry over whether new tubes shipped to you from a distant point will arrive in good condition!

Your G-E tube distributor or dealer is ready to supply you, at a moment's notice, with 100-percent operable new tubes out of freshly checked stocks-on-hand—tubes, moreover, covered by G. E.'s iron-clad performance warranty, which further guards your investment.

Contacting your nearby G-E tube supply source is insurance against unexpected time and production losses in your plant. It is a vital safety step you will be wise to take . . . at once! Phone your G-E distributor or dealer today. *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

The small thyratron at left, Type GL-502-A, has these anode ratings: peak voltage 1,300 v—peak current 500 ma—avg current 100 ma. . . . The large ignitron, Type FG-258-A, used primarily in welding control, has a kva demand of 2,400 with corresponding avg anode current 192 amp—max avg anode current of 355 amp with corresponding kva demand 800.



GENERAL ELECTRIC

162-E7-6650

FIRST AND GREATEST NAME IN ELECTRONICS

More Efficient Production — Better Finished Product

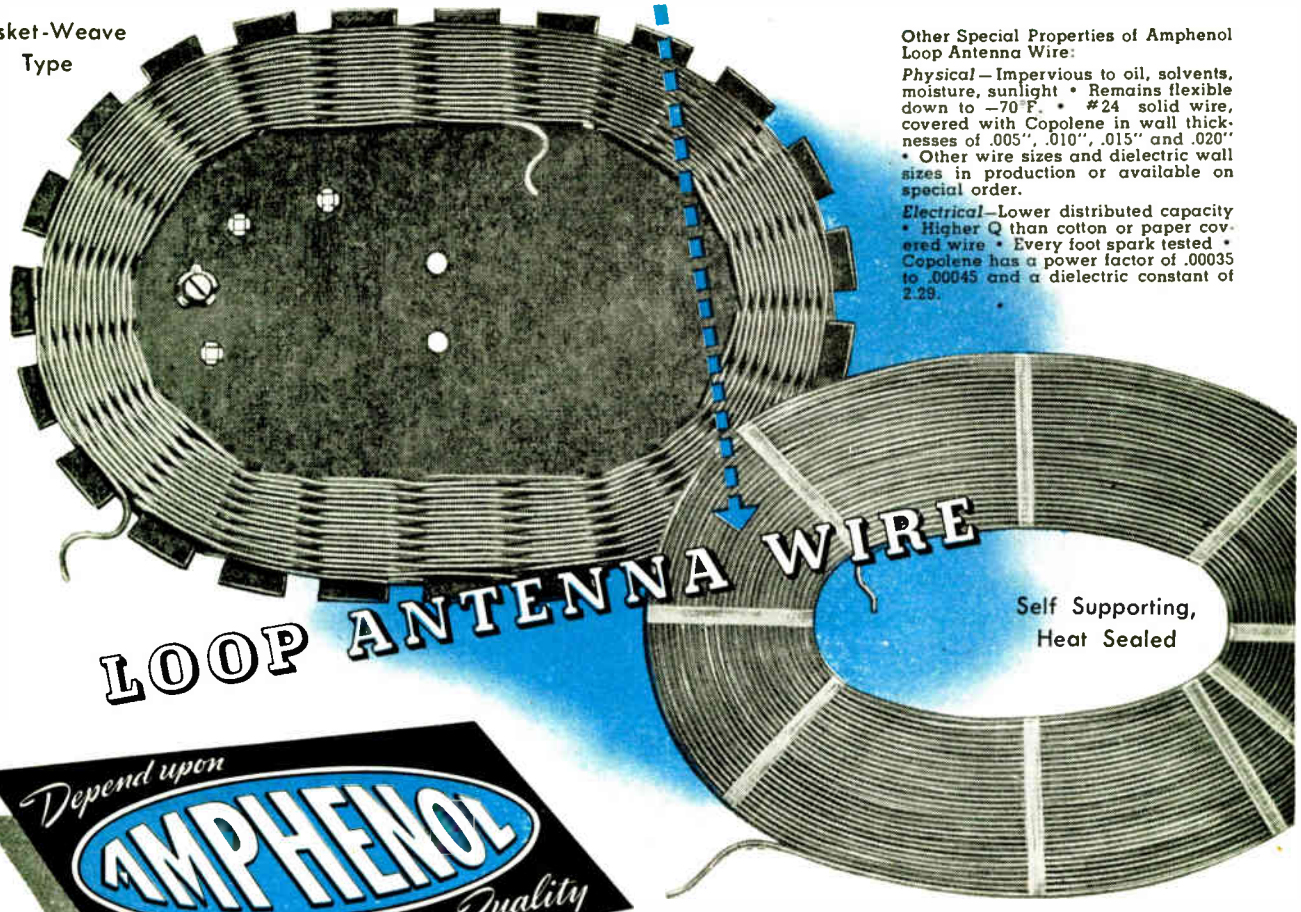
AMPHENOL

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

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

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

Basket-Weave Type



Other Special Properties of Amphenol Loop Antenna Wire:

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

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

LOOP ANTENNA WIRE

Self Supporting, Heat Sealed

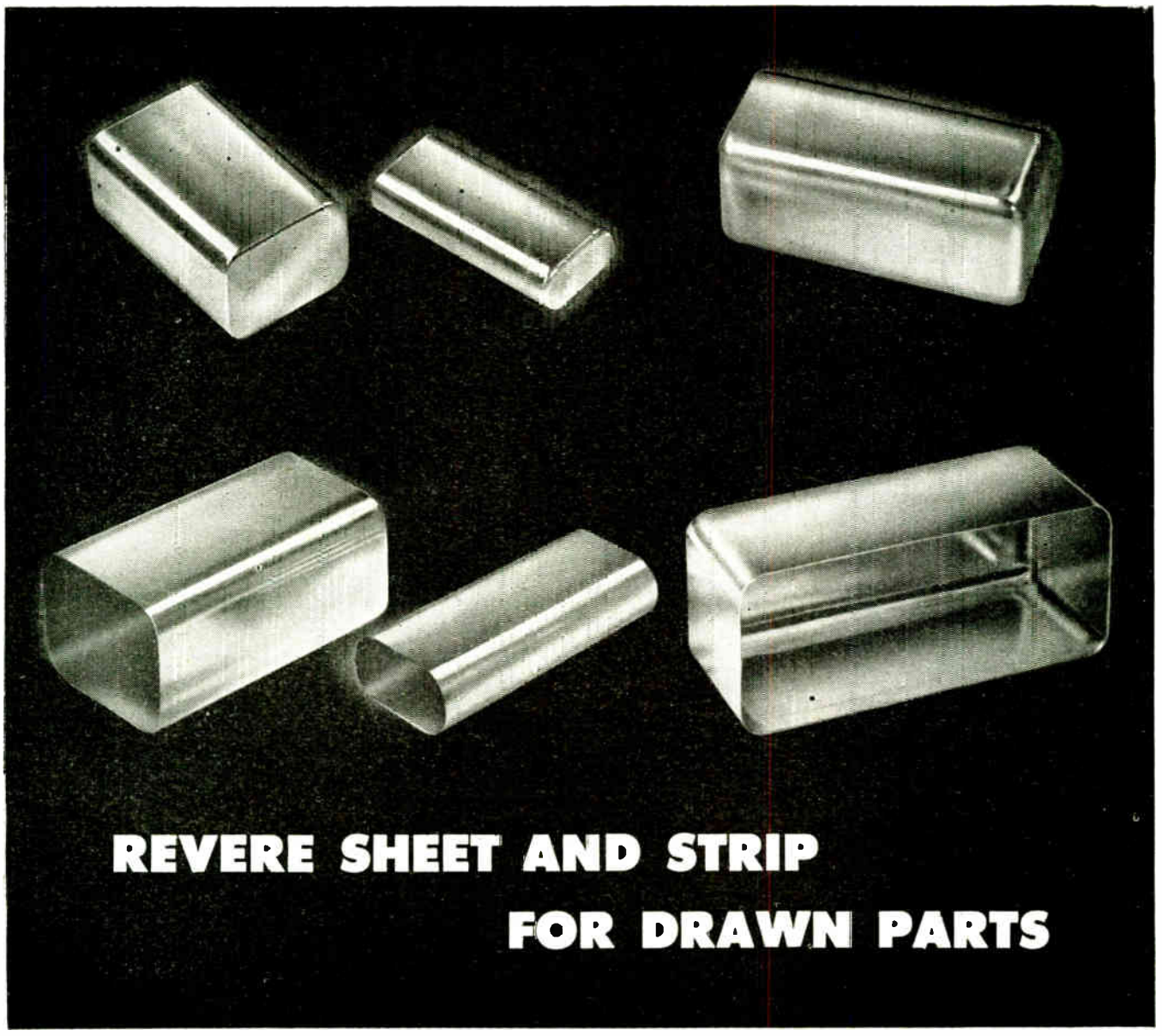
Depend upon AMPHENOL Quality

AMERICAN PHENOLIC CORPORATION

Chicago 50, Illinois

In Canada • Amphenol Limited • Toronto

COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS



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

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

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

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

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.

An example of Cinaudagraph Speaker Engineering—the fifteen-inch electra-dynamic speaker of Airean's Electranic Phanagraph, mast perfect af cammercial music machines.

There's a better

Aireon

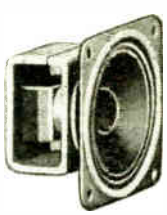
Cinaudagraph Speaker

for every electroaccoustical application

Aireon Cinaudagraph Speakers, Inc. has the facilities, experience and engineering ability to design and produce better speakers for any purpose. Whether it is a two-inch unit for portable radios, or a fifteen-inch for commercial phonographs, the same research, precision construction and superior materials are employed. Cinaudagraph PM Speakers use Alnico 5, the "miracle metal" which gives you four times the performance without size or weight increase.

In Aireon's scientific laboratories individual and special problems of electroaccoustical reproduction are under constant study, so that the finest, truest tonal reproduction may be combined with unusual stamina and long service life.

As a result, electronic perfection never before achieved has been incorporated in Cinaudagraph Speakers – for public address systems, radio, commercial phonographs and many special purposes.



Aireon Cinaudagraph Speaker for small radios – remarkable fidelity reproduction within a two-inch cone.

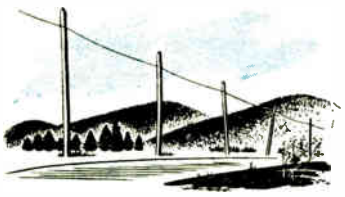
Cinaudagraph Speakers, Inc.

Subsidiary of Aireon Manufacturing Corporation

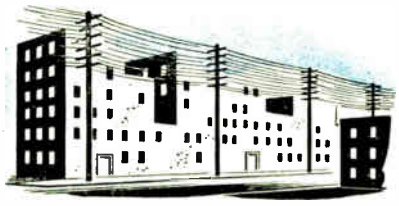
3911 SOUTH MICHIGAN AVENUE, CHICAGO

CINAUDAGRAPH SPEAKERS

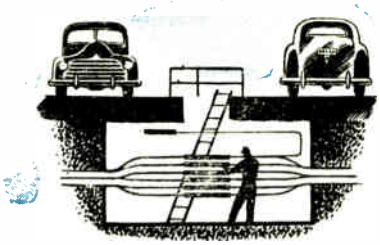
Why this team is a leader in VHF



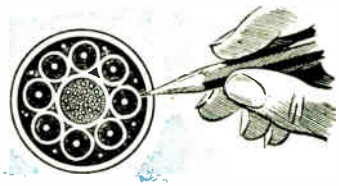
1. *First voice circuits were single iron wires with ground return. Frequency limitations, noise and high losses soon ruled them out.*



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

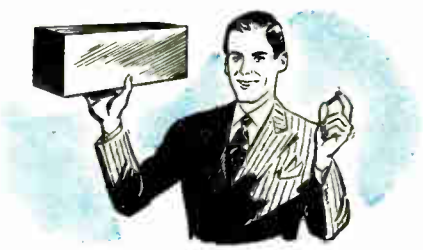


3. *Lead covered cable compressed many wire circuits into small space—took wires off city streets. But losses are prohibitive at very high frequencies.*



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

transmission



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

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

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

Continuing Research showed the way

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

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

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

What this means to YOU

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

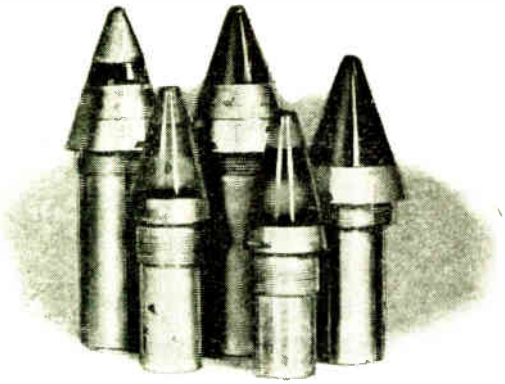
When your requirement dictates the use of VHF—in mobile communications, broadcasting, or point-to-point radio telephony—depend on Western Electric to supply the latest and best equipment for your needs.

BELL TELEPHONE LABORATORIES

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

Western Electric

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



They wanted a metal to pull an *Electronic Trigger*

In developing the Proximity Fuse, *Problem One* was to design a 5-tube radio transmitter and receiver small enough to fit into a shell nose. *Problem Two* was to engineer the unit to withstand physical shocks and strains never before encountered.

There was the smashing impact of the initial discharge. There was an accelerating force greater than 15,000 times gravity. There was the terrific centrifugal force imparted by barrel rifling.

Yet . . . aside from size, the tiny tubes that formed the "brains" of the fuse did not differ much from those used in home radios.

As in conventional tubes, most had elements of Nickel.

The low gas content of Nickel meant easy evacuation and no impairment of vacuum during use. *(An important feature with so little surface area available for "getter" action.)*

In addition, Nickel could resist deterioration in fabrication and withstand high evacuation temperatures without distortion.

Moreover, Nickel supplied all the required electronic and electrical properties.

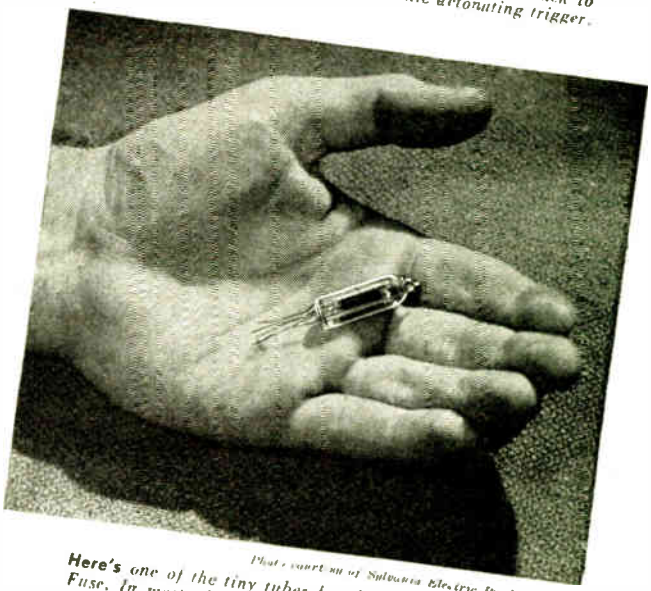
Finally, and of very great importance, Nickel could be worked in the extremely small sizes needed.

When you have a metal selection problem, investigate Nickel and high-Nickel alloys. They are workable metals offering a hard-to-find combination of properties for electronic applications. Write for the new "Inco Nickel Alloys for Electronic Uses" which gives you the data you want on the composition and characteristics of 13 Nickel alloys to solve electronic problems.

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

After leaving the gun, the Proximity Fuse begins to send out a tulip-like pattern of radio waves.

As target enters wave field, the waves are reflected back to the fuse where they release the electronic detonating trigger.



Here's one of the tiny tubes for the radio in the Proximity Fuse. In most of the tubes used, all elements are made of pure Nickel. Some tubes, depending upon design, use Nickel-molybdenum alloys in addition to Nickel.

Nickel NICKEL (INCO TRADE MARK) ALLOYS

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

*Reg. U. S. Pat. Off.

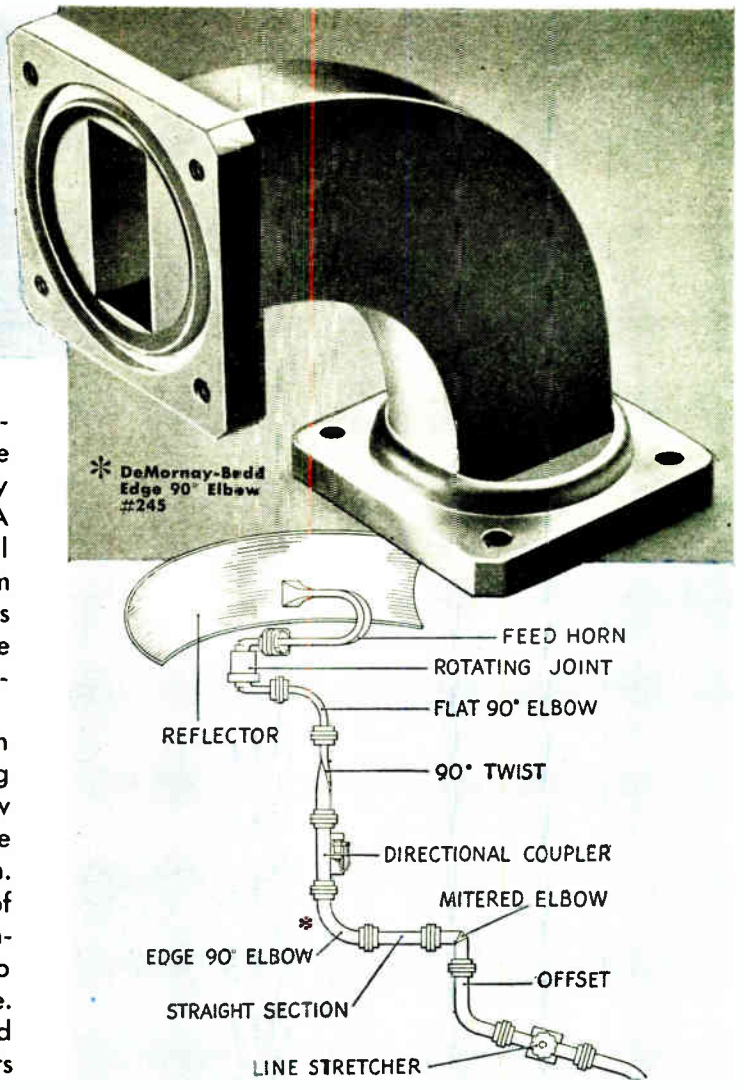
IMPORTANT FACTOR

in maintaining low standing wave ratio

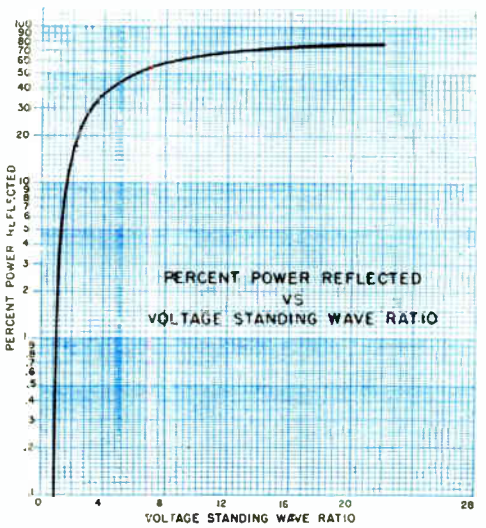
In all microwave transmission lines, it is important that the voltage standing wave ratio be kept as low as possible over the frequency range on which the equipment is operating. A high standing wave ratio means a loss of useful power because of the reflected power from the impedance mismatch. In addition, it causes a higher peak voltage in the transmission line thereby increasing the possibility of breakdown in the line.

The design and finish of an elbow have an important bearing on the voltage standing wave ratio. Impedance mismatches in an elbow can be caused by a change in the guide size due to improper bending or improper design. Discontinuities in elbows may be the result of improper bending techniques which cause indentations and other types of variations to appear on the inside wall of the wave guide. These irregularities change the impedance and result in a high standing wave ratio with its accompanying ills. Proper methods must be used in fabricating the elbow to prevent distortions which might result from bending the metal walls.

The design and manufacture of transmission line equipment is a specialty on which we have had vast experience in connection with wartime radar. We invite your inquiries, without obligation, on any of your transmission line problems.



Asterisk indicates position of Edge 90° Elbow # 245 in above plumbing arrangement. In addition to this standard part, elbows can also be supplied for any specific application requirement.



The curve shows the manner in which the reflected power increases with an increase in the voltage standing wave ratio. The curve is calculated from the following equation:

$$\% \text{ Power Reflected} = \left(\frac{\left(\frac{V_{max}}{V_{min}}\right) - 1}{\left(\frac{V_{max}}{V_{min}}\right) + 1} \right)^2$$

TALKIE SALE!

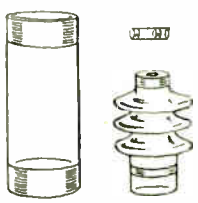
ONE thing we've learned during the war—almost every small electronic device should be able to work anywhere under any climatic condition. People are going to expect their personal walkie-talkies, plane radios, hearing aids, etc., to be as tough and durable as the stuff the industry developed for the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

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

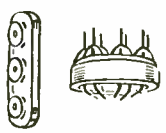
These Eyelet Terminals are another example of the breadth and versatility of Corning's line of electronic products. Some of them are pictured below with a brief description. Maybe they'll point to a possible solution for a problem that's been bothering you. If so, write, wire or phone The Electronic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

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

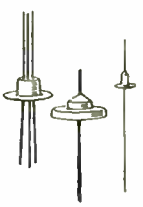
Metallized Tubes *for resistors, capacitors, etc. 20 standard sizes* $\frac{1}{2}$*" x 2" to* $1\frac{1}{4}$*" x 10". Mass-produced for immediate shipment.*



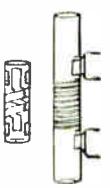
Metallized Bushings. *Tubes in 10 standard sizes,* $\frac{5}{16}$*" x* $\frac{25}{32}$*" to 1" x* $4\frac{7}{32}$*" in mass production for immediate shipment.*



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



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



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

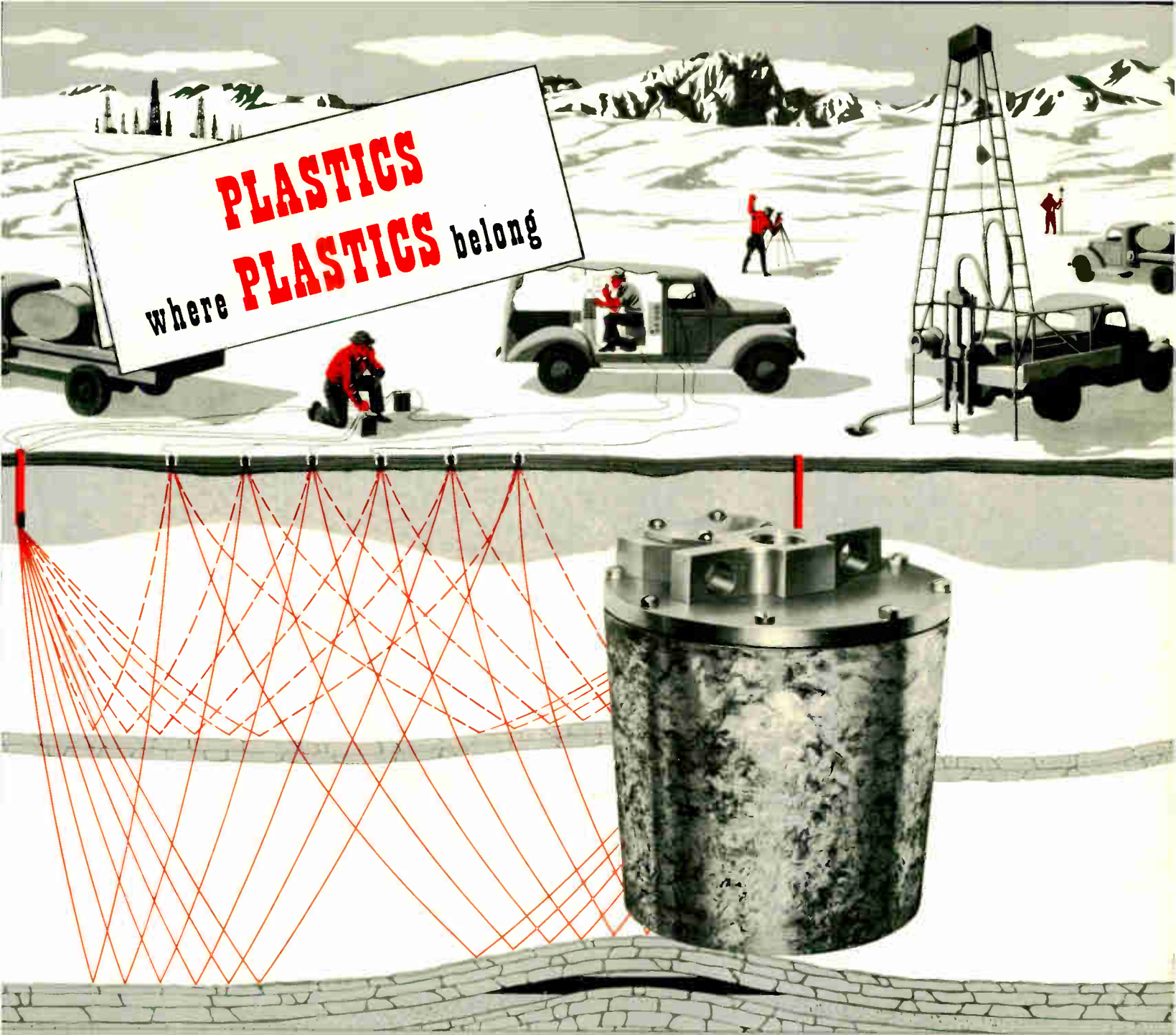
VYCOR Brand cylinders—*very low loss characteristics. Stands thermal shock up to 900°C Can be metallized.*

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

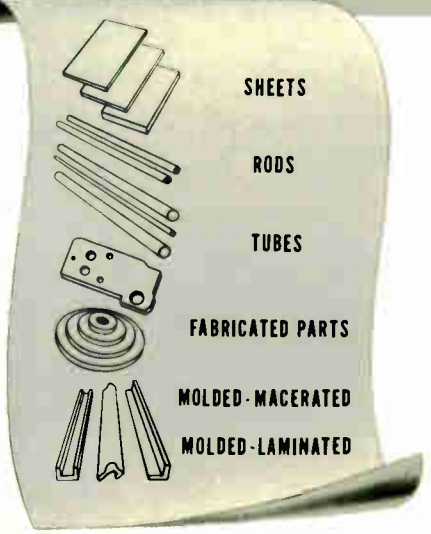
Electronic Glassware

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

CORNING REG U.S. PAT. OFF. PYREX REG U.S. PAT. OFF.



Using Corrosion Resistance, Ease of Machining



A NEW WAY to locate oil makes use of waves originating from a detonation of dynamite. Wave reflections are picked up by flower-pot-like "ears" strategically buried over the suspect area and seismographically recorded.

The pot or case, containing a sensitive electro-magnetic element, can be made of various materials. With Synthane, however, no special surface finish is required to resist corrosion. Synthane is also easily and quickly machined, and non-magnetic. In short, Synthane is *economically* better.

Is Synthane better for your job, too? Could be! Why not find out, preferably *before* you design? We're ready to help you with design, materials or completely fabricated parts.

SYNTHANE CORPORATION • 12 RIVER ROAD • OAKS • PENNSYLVANIA

SYNTHANE

SYNTHANE TECHNICAL PLASTICS • DESIGN • MATERIALS • FABRICATION

MAYBE IT'S TIME TO RECONVERT THINKING, TOO . . . .

By the time you read this, it's likely reconversion will be complete or nearly complete. *Plant* reconversion.

But before many a new product is born or an old product reborn, there will have to be a reconversion of thinking.

Some prewar notions about plastics and their limitations will have to be shelved, if they have not already been. Why? Because, even in the unspectacular technical plastics which we make, there have been important changes in resins and fillers. Low-loss and impact materials have been improved. Postforming of so-called thermosetting laminates is no longer a laboratory curiosity.

The old and erroneous habit of regarding plastics as ersatz materials has almost died out. Now it's the rule to use plastics where they rightfully belong, or not use them at all. As if to prove the point, there were so many legitimate uses for plastics during the war, plastics couldn't be spared for service as substitutes.

Reconvert your thinking about plastics? Yes! By all means go over every single part of your product or equipment to see where the advantages of plastics can be properly used to *your* advantage.

If plastics offer all the properties you want, or more than you want, at a more *economical* cost—considering labor, material, ease of manufacture, length of life, sales appeal, replacement expense, customer satisfaction—then use plastics.

Should our own type of plastics—Synthane—seem to answer your purpose, let us help you investigate the use, find the right grade of Synthane for the job, and—if you desire—fabricate the material for you.

The complete Synthane catalog is packed with helpful information. Before you forget, tear out the coupon and send for your copy now.

WRITE FOR IT TODAY

SYNTHANE

PLAN YOUR PRESENT AND FUTURE WITH SYNTHANE TECHNICAL PLASTICS • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

SYNTHANE CORPORATION, 12 RIVER ROAD, OAKS, PA.

Gentlemen:
Please send me without obligation the complete catalog of Synthane technical plastics.

NAME_____

COMPANY_____

ADDRESS_____ ZONE_____ STATE_____

CITY_____

MODERN ALCHEMIST

....producing the world's foremost resistance alloy!

Nichrome*

Unlike the ancient alchemist who unsuccessfully sought to create gold from base metals, this modern metallurgist is fusing nickel and chromium to produce Nichrome—the world's foremost heat and corrosion resistant alloy!

But it takes more than a balanced union of nickel and chromium to produce the superior properties of genuine Nichrome. For one, there is the all-important factor of exclusive Driver-Harris techniques. In every manufacturing and processing operation, from furnace to spool, exacting metallurgical controls and checks operate to assure the peerless and enduring qualities of Nichrome. These quality controls represent 46 years of continuous alloy research that have established Nichrome as the time-tested standard by which other electrical resistance alloys are measured.

Although there are other excellent nickel and chromium combinations, there *is only* one Nichrome . . . and it is made *only* by Driver-Harris . . . thus Nichrome is at once the registered Trade Mark and symbol of service and belongs wholly and solely to the Driver-Harris Company.

Nichrome is made only by

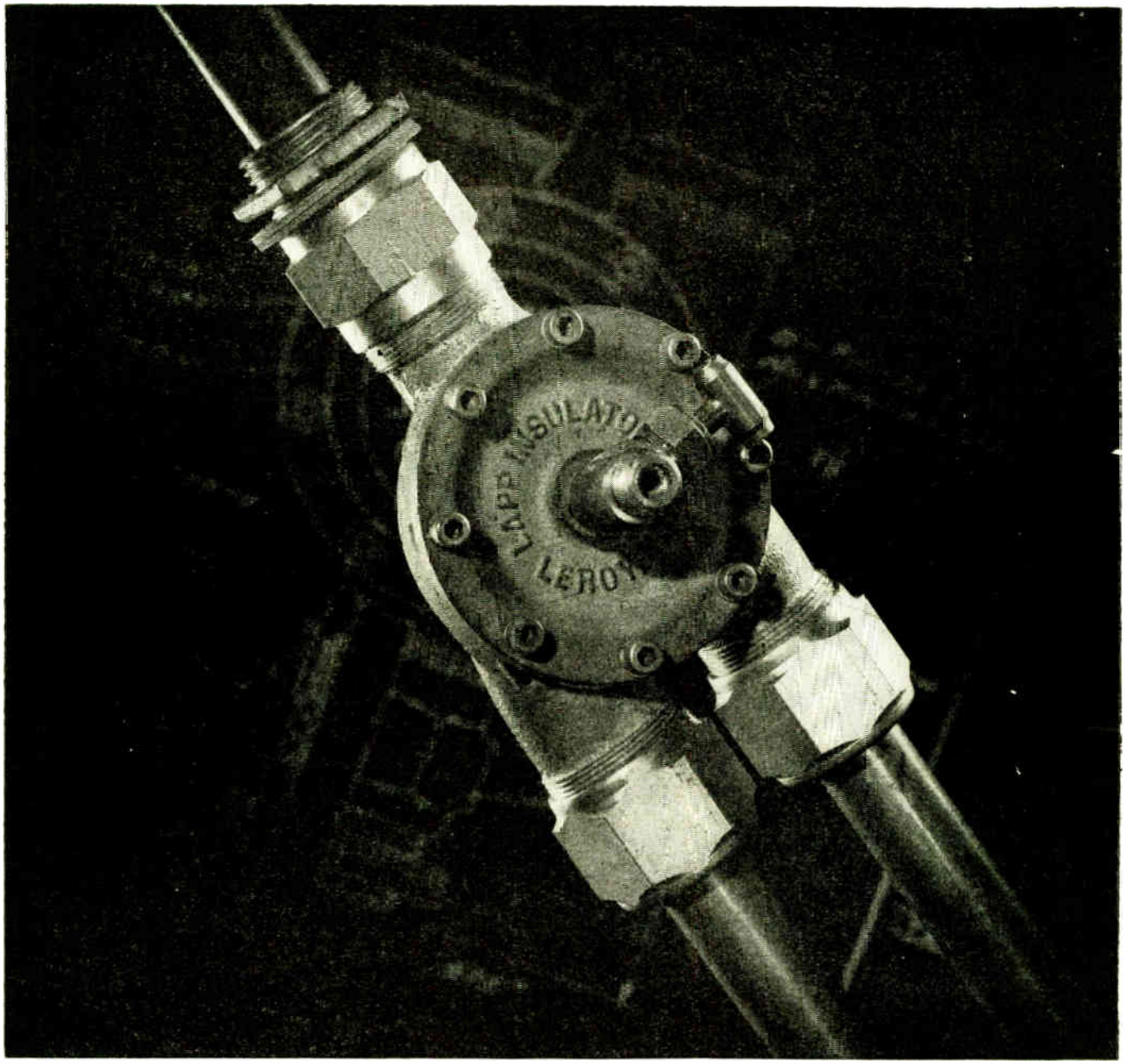
D H
SPECIAL PURPOSE ALLOYS SINCE 1888

Driver-Harris
COMPANY

HARRISON • NEW JERSEY

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

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



Electronic Parts: ENGINEERING AND PRODUCTION

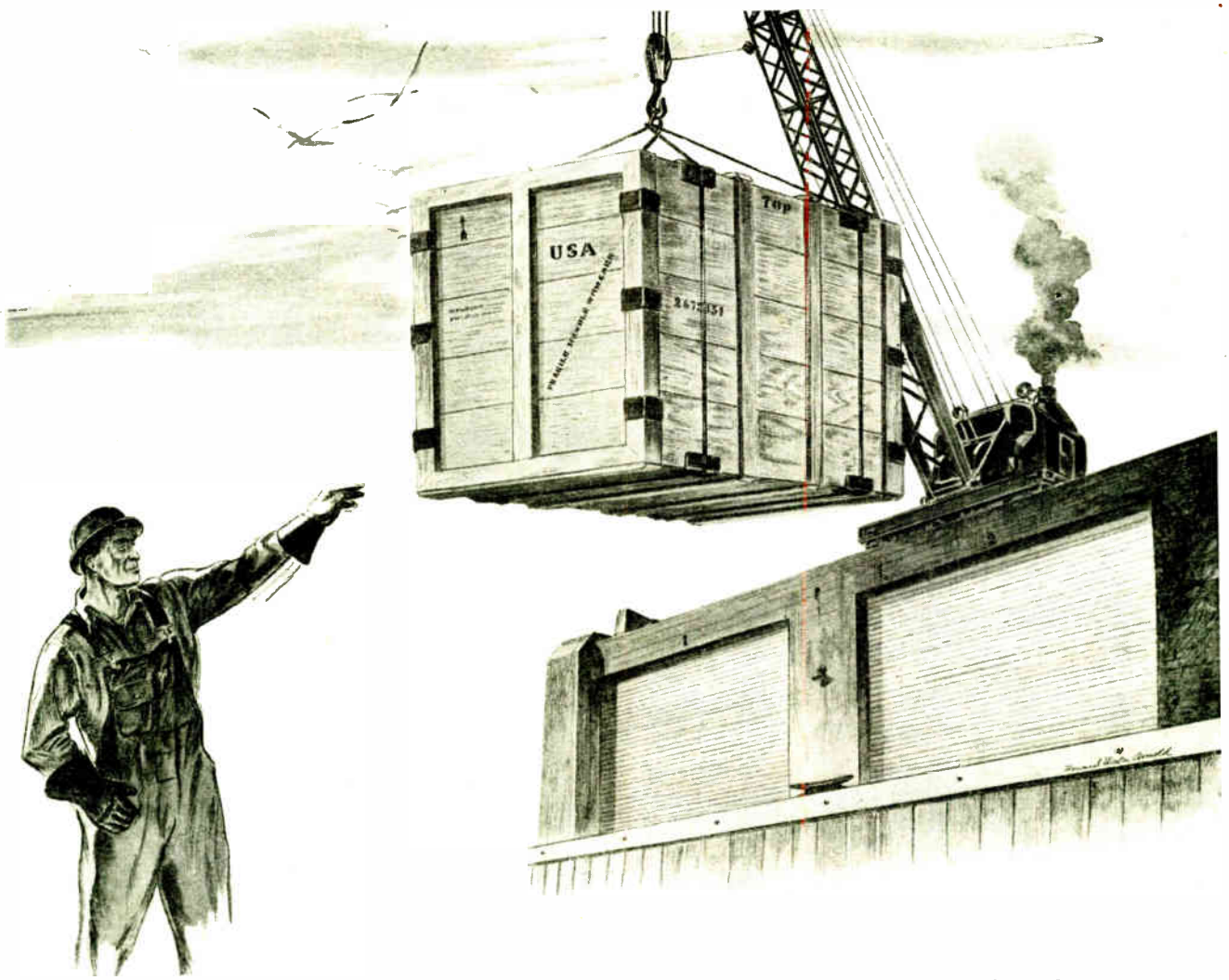
The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp



A machine shipped with a part *missing!*

. . . a part so important that without it the machine is incomplete.

Thousands of dollars have been spent to make this machine one of America's finest—in research, development, improvement and manufacture. Yet no one has considered the training of the man who is going to use it.

Many far sighted companies are now including with each product they manufacture a *complete* pictorial instruction manual and parts list — enabling the buyer to use the machine to best advantage.

Too often the manufacturer is blamed for a mistake actually caused by ignorance of the machine and its delicate parts.

Jordanoff Corporation places at the disposal of industry a highly developed training tool — **VISUAL EDUCATION** — an instructional method which, with the scientific application of pictures and text, simplifies the explanation of any product or process.

Our techniques in visual education are applicable to assembly, maintenance and repair manuals, personnel training books, parts lists and technical advertising.

Write for literature or ask for a representative.

JORDANOFF
CORPORATION

595 MADISON AVENUE • NEW YORK 22, N.Y.

SERIES 400

"SUPER-PRO"

TUNING RANGE .54-30 mc.

The "400" has high image rejection, high sensitivity, low noise level. It is designed for weak signal reception — puts new life in your 10-meter activity.

ASK THE MEN IN THE AACS WHO USE THEM . . .

The Series 400 postwar "Super-Pro" stands by itself, a leader in the field of communications. The reason of course is continual improvement in design through years of service under a wide variety of operating conditions. The people who know most about receivers choose "Super-Pros."

SEND FOR TECHNICAL DATA

THE SIGN OF QUALITY

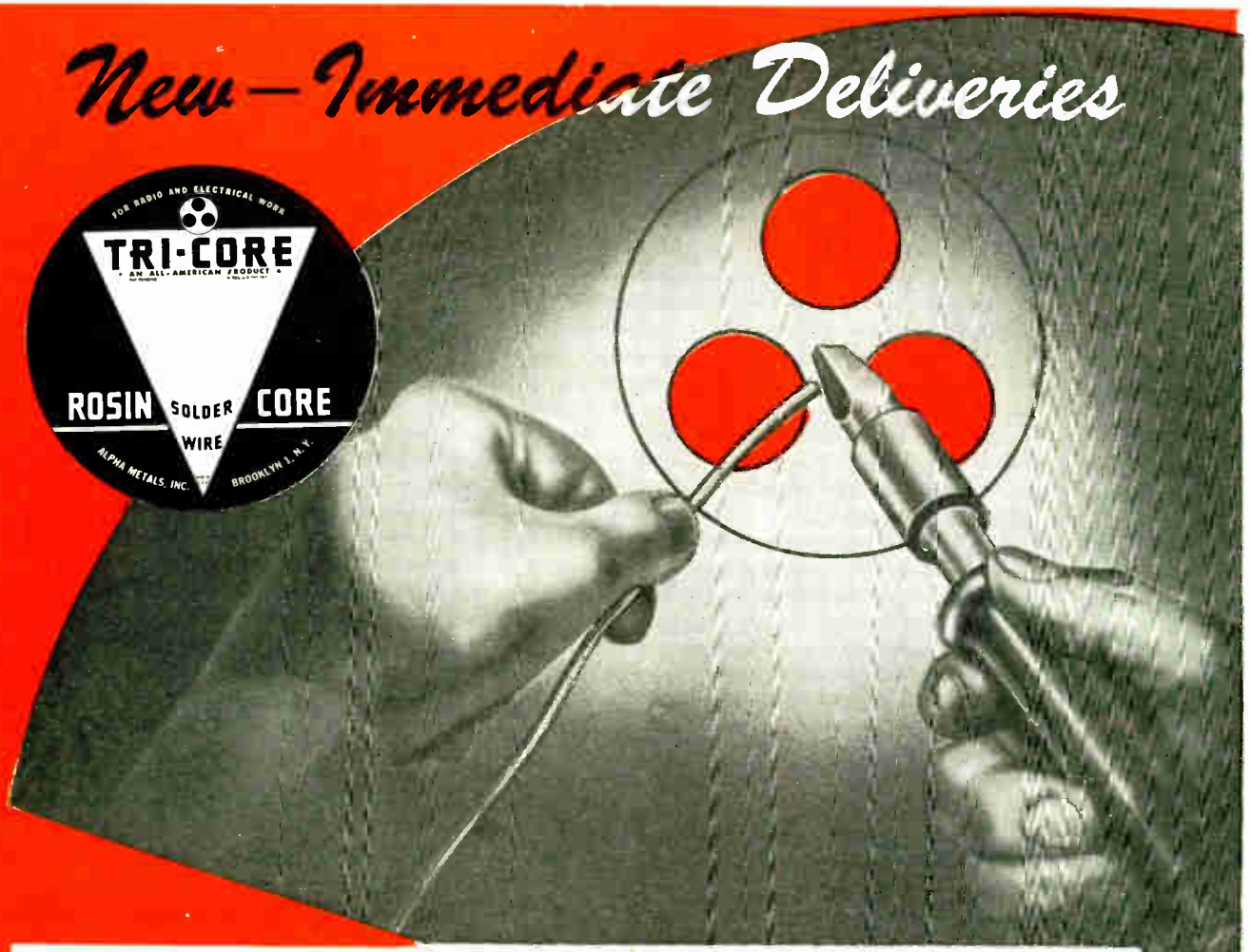
ESTABLISHED 1910

HAMMARLUND

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

MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

New—Immediate Deliveries



You Get More with TRI-CORE Solder

MORE... in faster, thorough fluxing. That's because Tri-Core's thinner walls make for instantaneous penetration of heat to the flux. Result—a continuous, free flow of high-grade, non-corrosive flux goes on the work before the solder melts.

MORE... in speedier production. Tri-Core's arrangement of three independently filled cores places them closer to the surface. That means that the solder melts faster. More work gets done in less time.

MORE... in measurable saving of tin. Tri-Core's faster melting gives you the results you'd expect of a much higher tin alloy content. Consequently, there's a definite and desirable saving in tin.

Alpha quality and high engineering efficiency is the result of our more than 40 years of research and experience in the manufacture of lead and tin products. TRI-CORE Solder exceeds A.S.T.M. Class A specifications and is available in all alloys, all flux percentage, all gauges.

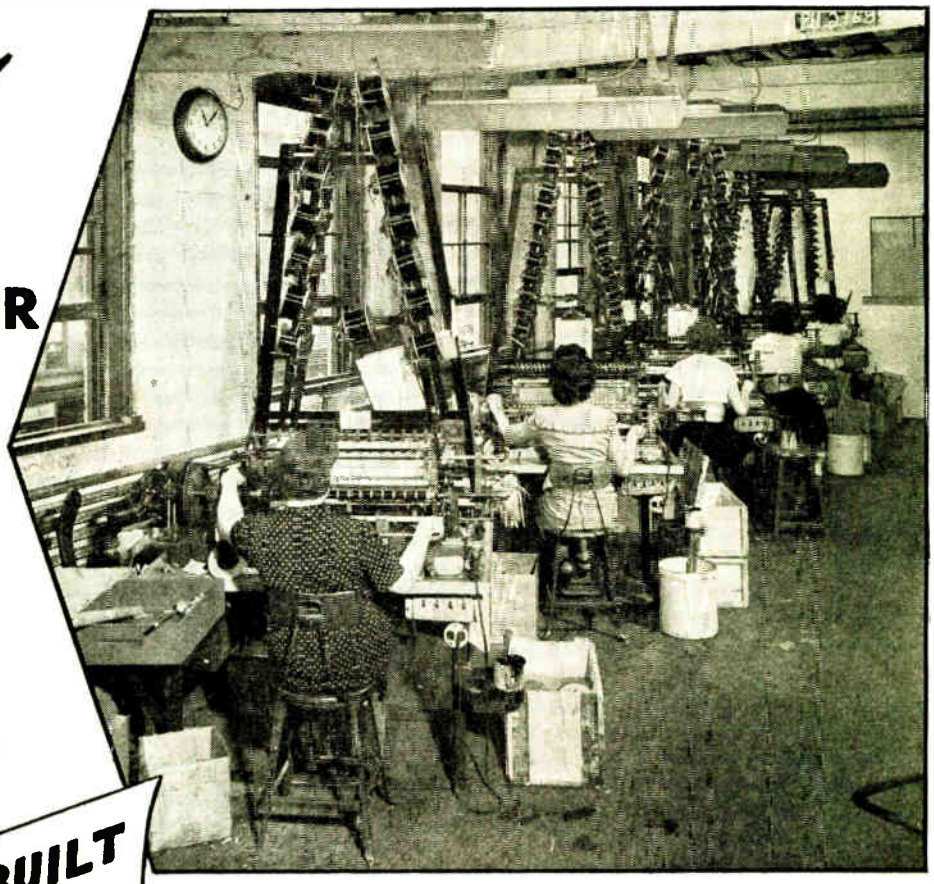
WRITE FOR BULLETIN AND ENGINEERING TEST SAMPLE

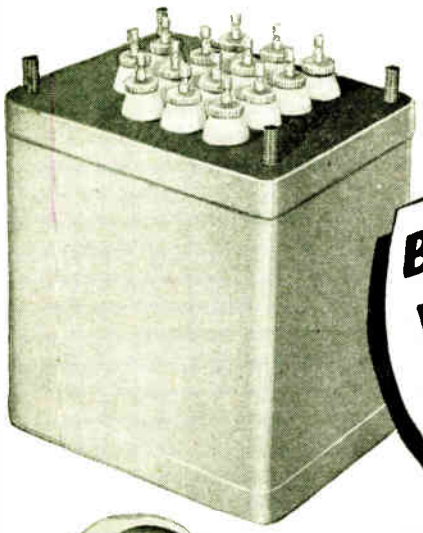
ALPHA METALS, Inc.

Single Core, Rosin and Acid Filled, Special Core Solder, Wire, Bar, Sheet, Preforms. Lead and Tin Products.

373 Hudson Avenue • Brooklyn 1, N. Y.

Every AmerTran Transformer *is* BUILT WITH CARE





BUILT WITH CARE

Advantages of multiple coil winding

Coil winding is an important phase of AmerTran Transformer construction. Use is made of high speed multiple winding machines (some of AmerTran design) capable of producing many coils at a time with exceptional uniformity. Care enters the picture in the precise control with which such elements as number of turns, tightness of layers and wire tension are maintained. Tight coils have fewer and smaller air pockets, and greater heat-conducting capacity. AmerTran coil winding methods add up to close conformity to specifications, uniformly excellent characteristics, and usually a consumer saving for a specific type and quality of transformer.

AmerTran Products:

Audio Transformers and Reactors. Modulation Transformers (to 500 KVA). Hermetically sealed Transformers. Plate and Filament Transformers. Filter Reactors. Wave Filters. High Voltage Rectifiers. Microphone and Interstage Transformers. Transtat A. C. Voltage Regulators. Other Electronic and Industrial Transformers.

AMERICAN TRANSFORMER COMPANY

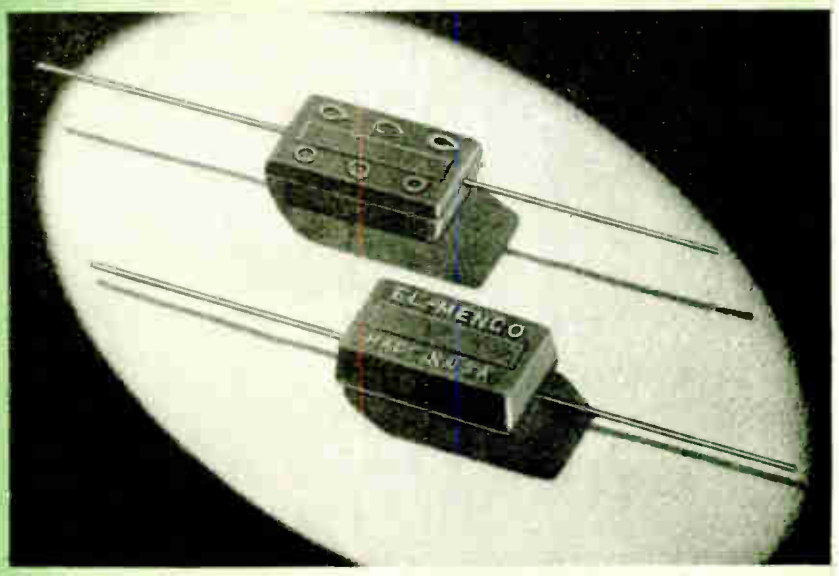
178 EMMET STREET
NEWARK 5, N. J.

AMERTRAN

MANUFACTURING SINCE 1901 AT NEWARK, N. J.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission

ISN'T IT SAFER . .



To use

These Time Tested Capacitors?

On the land, in the air and under the sea . . . in the steaming heat of the jungles and the sub-zero temperatures of the Arctic . . . El-Menco Capacitors proved to the men bent on Victory that they had what it takes.

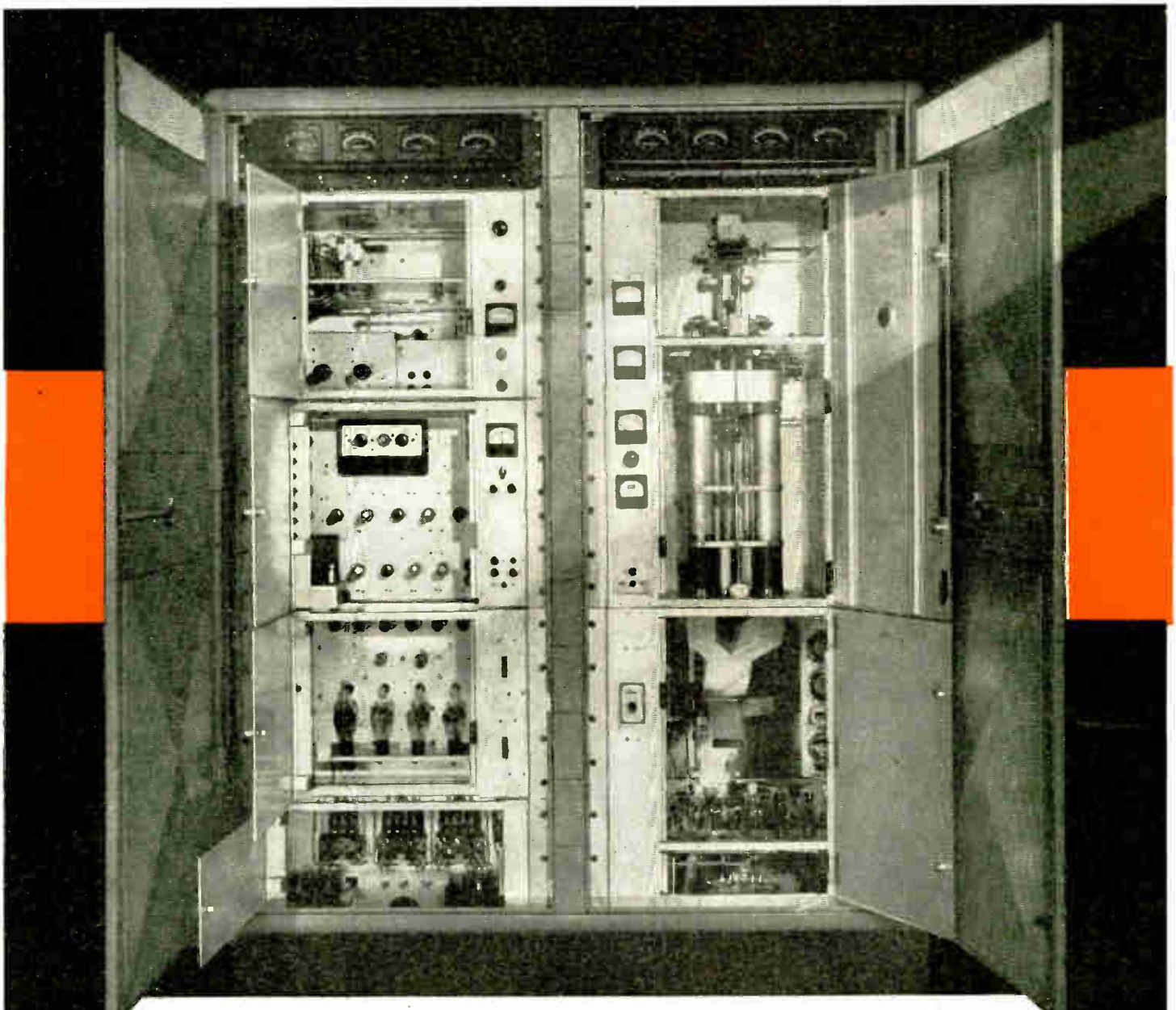
Electronics manufacturers will wisely choose these time-tested capacitors as further insurance for the success of their products . . . Write—sending us your specifications.

ELECTRO MOTIVE MFG. CO.
WILLIMANTIC, CONNECTICUT

ARMY NAVY

MOLDED MICA **El-Menco** MICA TRIMMER

CAPACITORS



6 DESIGN FEATURES THAT MEAN BIG NEWS IN FM

1. The circuits that stabilize modulation are completely isolated from the direct carrier path, allowing no variation in the quality of program transmission.

2. Improved method of direct frequency modulation and stability of the mean carrier frequency is accomplished by an all electronic system. No mechanical regulators to wear out of adjustment.

3. Mean carrier frequency is maintained within close limits of assigned channel, with an immediate and *automatic* control circuit employing a crystal oscillator.

4. Federal's "FREQUEMATIC" Modulator circuit has a greater dynamic range of modulation. No distortion over the entire range of modulation.

5. Utilizing a discriminator circuit, frequency of the master oscillator is stabilized to exactly that of a standard crystal through a method of frequency division. The unit has a spare crystal readily accessible for instant use.

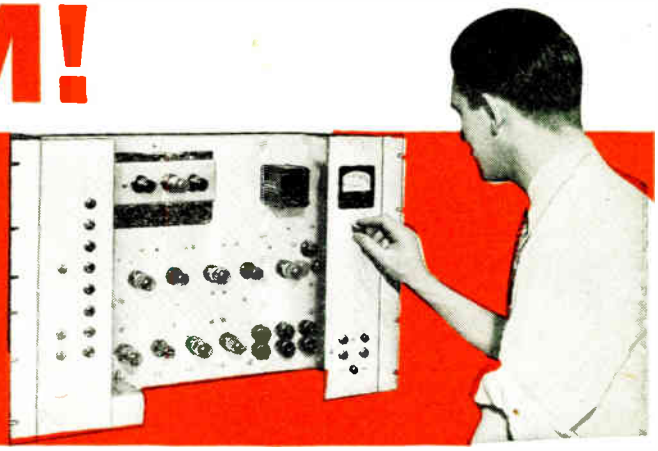
6. Frequency division is accomplished through multi-vibrator circuits with stable and rugged mechanical as well as electrical characteristics.

FEDERAL TELEPHONE & RADIO — FTR

Federal

HERE'S THE BIG NEWS IN FM!

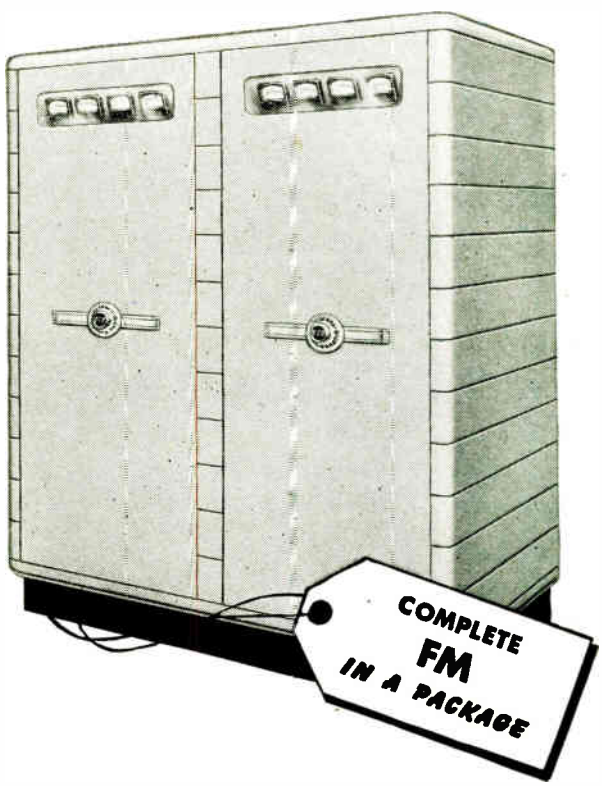
...it's FEDERAL's new "FREQUEMATIC"* MODULATOR



1—3—10 and 50 KILOWATT FM RADIO EQUIPMENT

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

*Trade Mark



Telephone and Radio Corporation

Newark 1, New Jersey

AN IT&T ASSOCIATE

Export Distributor:
International Standard Electric Corporation

OHMITE

RITEOHM PRECISION RESISTORS

Non-Inductive . . . Pie-Wound . . . 1% Accurate

NEW

½ Watt and 1 Watt Vacuum Impregnated Types . . . Hole in center for Through-Bolt Mounting . . . Equipped with Wire Leads or Lugs

Available from Stock . . . or Made to Order

OHMITE presents a *new* line . . . a *full* line . . . of finer precision resistors! Every type . . . every size . . . ready for every need! Each Riteohm is designed and built with all the specialized skill and experience that have made OHMITE units the standard in this field. However critical the application . . . consistent accuracy and reliability are assured. In these Riteohms, you get *time-proved protection against humidity, temperature and corrosion.*

Ideal for use in voltmeter multipliers, laboratory equipment, radio and electrical test sets, attenuation pads, and in electronic devices requiring *extremely accurate* resistance components.

AVAILABLE FROM STOCK in ½ watt and 1 watt units in a wide range of values, in various types of mountings and terminals . . . or made to order. Complete line of 6 different series includes non-inductive pie-wound vacuum impregnated units . . . single-layer wound vitreous enameled units . . . and non-inductive pie-wound hermetically glass sealed units. Some units are in a range of 0.1 ohm to 2,000,000 ohms. *Get full facts today!*

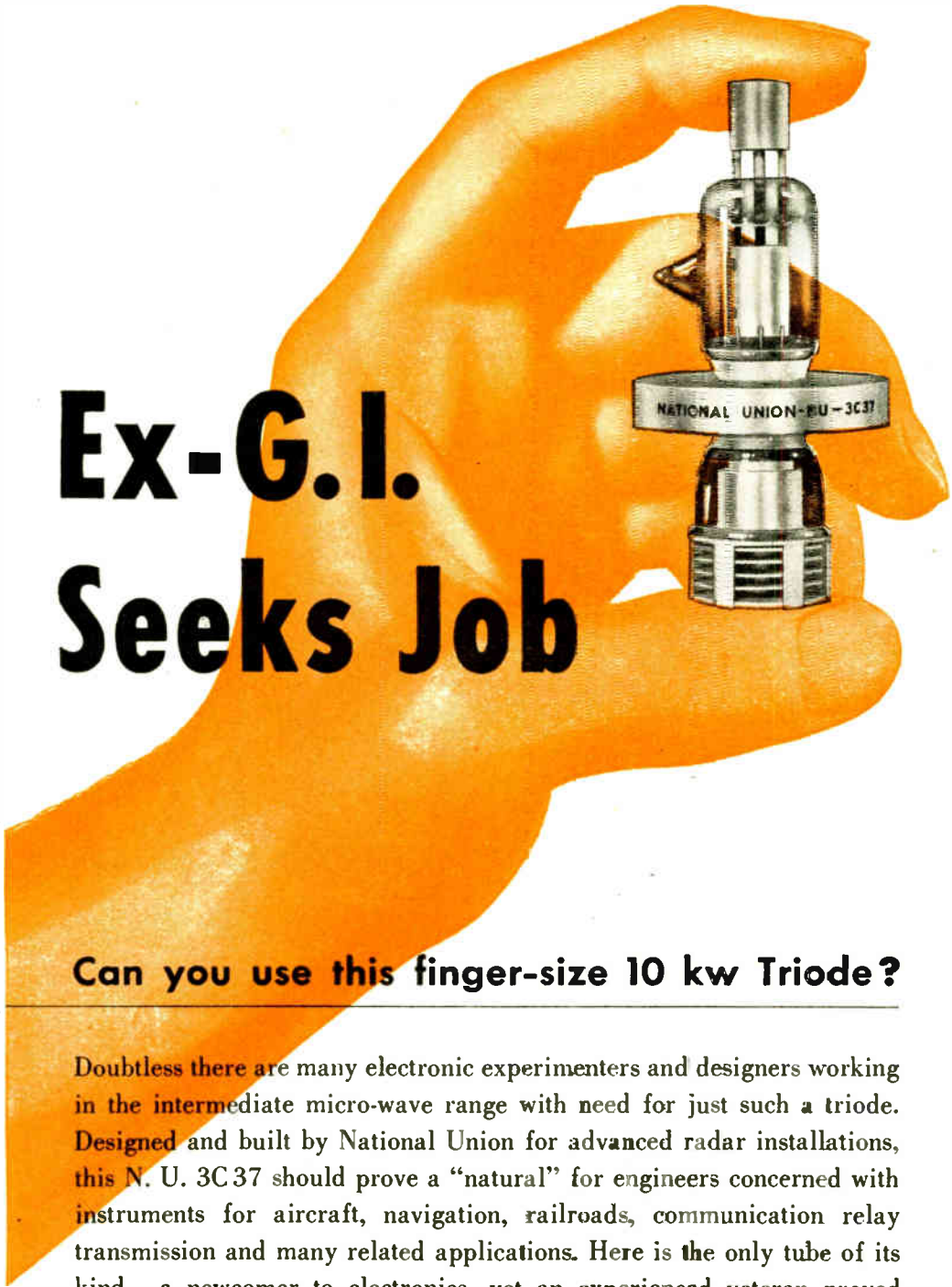
OHMITE MANUFACTURING CO., 4984 Flournoy St., Chicago 44, U. S. A.

Send for Bulletin No. 126

This handy Riteohm Bulletin makes it easy for you to select the exact units for your needs. Gives complete data . . . lists stock units and made-to-order units . . . includes dimensional drawings. Write for it now.

Be Right with **OHMITE**

RHEOSTATS • RESISTORS • TAP SWITCHES • CHOKES • ATTENUATORS



Ex-G.I. Seeks Job

Can you use this finger-size 10 kw Triode?

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

Qualifications of the N. U. 3C37

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

NATIONAL UNION
RADIO AND ELECTRON TUBES
NATIONAL UNION RADIO CORPORATION • NEWARK 2, N. J.

Just ONE of the large VISITRON family

Rauland Visitron Phototubes are the recognized leaders in the field of light-sensitive devices . . . uniformity, dependability and high sensitivity through the years have earned them that reputation. Whatever the application, sound-on-film, electronic control or television pickup, there is a *Rauland Visitron* Phototube available to do the job perfectly. Or, we can produce a specially designed tube to meet an entirely new application. Let the experienced *Rauland* engineers consult with you about your phototube requirements.

To be sure . . . specify *VISITRON!*

ALSO MANUFACTURERS OF DIRECT-VIEWING AND PROJECTION TYPE CATHODE RAY TUBES

RADIO · RADAR · SOUND **Rauland** ***COMMUNICATIONS · TELEVISION***

Electroneering is our business

THE RAULAND CORPORATION • CHICAGO 41, ILLINOIS

What has a miner's cap to do with invisible radiation?

When the flame of the old style miner's lamp grew dim, he knew that danger was lurking in the bowels of the earth.

Invisible radiation, as you know, has no such simple visual test. After the atom bomb was exploded in New Mexico, scientists dressed in protective clothing and equipped with proper testing equipment, checked the stray radiation still present. Heart of the testing equipment they used was a Geiger Counter electronic tube.

The Geiger Counter tube is a highly sensitive and dependable medium for the detection of weak forms of radiation. A new gas and quench combination has been developed for the tube, which makes it even more useful in industry.

This advancement made possible the introduction of the NORELCO Geiger Counter X-ray Spectrometer.

The NORELCO Spectrometer has many present and potential uses in industrial research. In addition, it has found application in production control through the analysis of materials before and during manufacture.

Through the use of the Geiger Counter X-ray Spectrometer and a graphic recording mechanism, the analytical procedure can be simplified. Many times just a single line on the graph can serve as a criterion for acceptance or rejection of a given material.

The application of the NORELCO Geiger Counter tube and the NORELCO X-ray Spectrometer to the problems of industry are further evidence of the Philips principle of wedding science and productive ability in the electronics field.

An organization with a background of over 50 years in electricity

Among the products of North American Philips are: Quartz oscillator plates, cathode ray tubes, industrial and medical x-ray equipment, fine wire, diamond dies, tungsten and molybdenum products.

Norelco
Reg. U. S. Pat. Off.

ELECTRONIC PRODUCTS

NORTH AMERICAN PHILIPS COMPANY, INC.

DEPT. D-4, 100 EAST 42ND STREET
NEW YORK 17, N. Y.

Comco — ready first with FM

is now first to have had equipment—

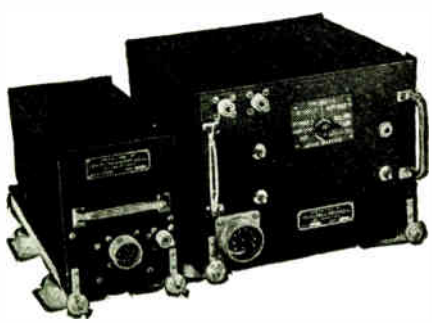
TESTED . . . BOUGHT . . . DELIVERED . . . INSTALLED

for

TAXICABS . . . RAILROADS . . . POLICE . . . TRUCK FLEETS

SOMEONE asked "Why is Comco so far ahead in the VHF Field". The answer is that we pioneered before the War in developing VHF aeronautical equipment and continued during the War manufacturing equipment in this field. Hence our circuits were perfected, our models were fully developed, and our production lines were set up, ready to deliver when the FCC allocated the new bands. Hence we very naturally led the field in offering practical working tests . . . and as these tests proved the effectiveness of our equipments, they were bought and are doing their job well in all these fields.

We will be glad to discuss your mobile-unit communication and control problems, by mail or in person.



Engineered for VHF mobile services for operation on 6, 32, 64 and 110 volts D.C. and 117 volts A.C. current. COMCO Model 172-T Transmitter provides 15 watts on 152-162 Mc band. Models for dual channel operation now available. Weight 12½ pounds.

COMCO Model 173-R Receiver provides extreme sensitivity with 1 watt audio output. Dual channel operation. Weight 7 pounds.

COMCO Model 189-FM Receiver mounted with a 3½" rack panel. Output 2 watts. Self-contained power supply. Dual channel models are available, if desired.

COMCO Model 170-FM Transmitter, built for continuous duty, full 50 watts output. Entirely self-contained with complete metering provided. 48" x 23" x 18". Dual channel operation and remote control units available.

Write for Complete Details

MANUFACTURERS OF RADIO & ELECTRONIC EQUIPMENT

COMMUNICATIONS COMPANY, Inc.

CORAL GABLES 34, FLORIDA

ML889A

Machlett improved design

provides longer life and better performance

The ML889A and ML889RA are outstanding examples of Machlett's ability to apply its time-tested and advanced techniques to tubes of standard design with resulting improvement in construction, performance and life. They incorporate the "know-how" that has made Machlett electron tubes demonstrably superior since 1897. Consider these advanced features that give you better tubes with longer and more uniform performance:

1. Heavy Kovar sections are used instead of the conventional and more fragile feather-edge copper seals. Result—greatly increased mechanical strength, lessening danger of breakage in handling and installation.

2. Filament and grid terminals are solid, continuous and of high conductivity copper. Contact surfaces gold-plated to minimize contact resistance.

3. Special grid and filament assembly reduces lead inductance, permitting safer operation as high as 50 mc. with full input and output.

4. Internal structure greatly strengthened, assuring constant and more uniform grid-filament-plate spacing.

5. One piece copper anode and shield assure uniform internal surface, permit maximum accuracy of assembly, provide complete shielding of anode seal and reduce difficult-to-outgas inter-faces normally found in tubes of this type.

6. All internal parts completely processed by Machlett's special techniques which prevent contamination and assure complete and permanent out-gassing.

7. Tube "pumped" by unique Machlett straight line, high voltage exhaust process assuring same high standards as characterize the Machlett line of high-voltage X-ray tubes.

• • •

These perfected tubes for high frequency heating and communications purposes constitute a further contribution by Machlett of quality, durability and long life to the electron tube art. Now available for initial installation and renewal purposes. For further details, write Machlett Laboratories, Incorporated, Springdale, Connecticut.

General Characteristics — ML889A

Filament Voltage	11 volts
Filament Current	125 amperes
Amplification Factor	21
Maximum Frequency for Full Power	50 mc.
Capacity, Grid to Plate	17.8 uuf.
Capacity, Grid to Filament	19.5 uuf.
Capacity, Plate to Filament	2.5 uuf.
Cooling	Water
Water	3-6 gals/min.
Air (ML889RA)	15 cfm.

At reduced power, may be operated at frequencies as high as 150 megacycles.

ML889RA, Air-cooled version of the ML889A, may be operated at full output at frequencies up to 25 megacycles, at reduced power up to 100 mc.

MACHLETT

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

Eimac TUBES

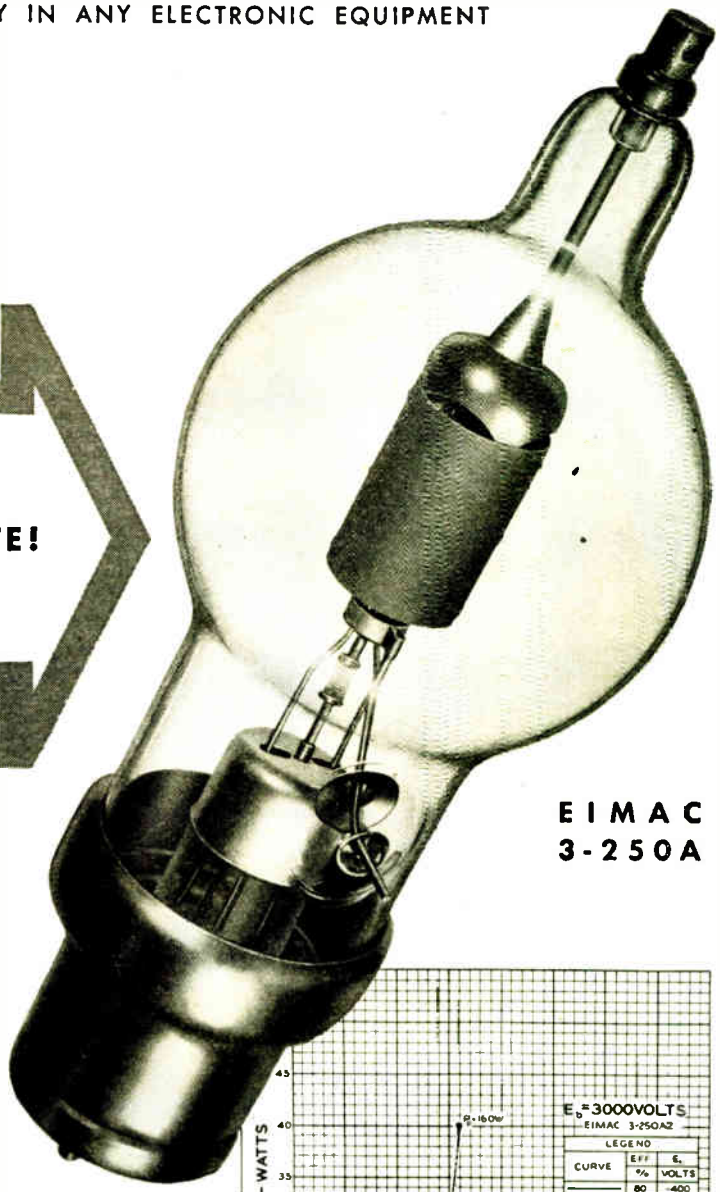
THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

NEW ELEMENTS IN THIS EIMAC TRIODE ADD MANY EXTRA HOURS PERFORMANCE

NEW **NON-EMITTING GRID!**

NEW **LOW-TEMPERATURE PLATE!**

NEW **FILAMENT STRUCTURE!**



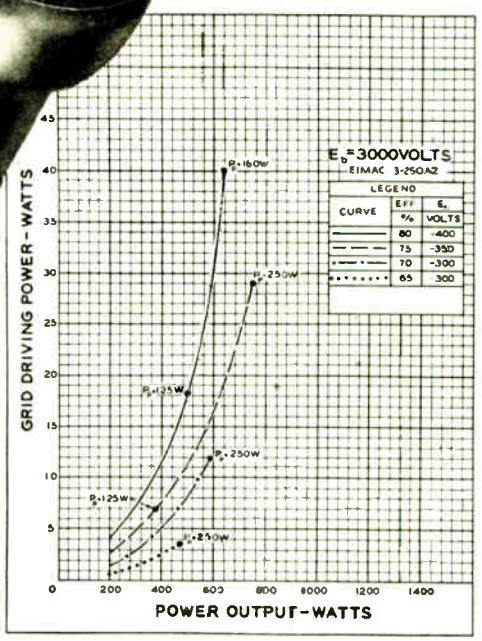
EIMAC 3-250A

Physically the new Eimac 3-250A triode is interchangeable with the old Eimac 250T. The new elements result in better performance and even longer life in a tube that has long been famous for its long life and stamina. This new tube is available in both low mu (3-250A2) and high mu (3-250A4) tube versions.

Its outstanding performance characteristics are exemplified by its low driving power requirements. For example, in R. F. Class C telegraphy, with 3000 plate volts on a single tube, the Eimac 3-250A2 (low mu) will deliver 750 watts output with only 29 watts (approx.) of driving power. (See chart.)

You can depend upon Eimac year in and year out for leadership in vacuum tube developments.* That's one reason why Eimac tubes are today, and have been for years, first choice of leading electronic engineers throughout the world.

**Ask your dealer to give you a copy of "Eimac Electronic Products" just off the press. Or write direct.*



Follow the leaders to

Eimac REG. U.S. PAT. OFF. TUBES

EITEL-McCULLOUGH, INC., 1211-H San Mateo Ave., San Bruno, California

Plants located at: San Bruno, Calif. and Salt Lake City, Utah

Export Agents: Frazar and Hansen, 301 Clay St., San Francisco 11, California, U.S.A.

ELECTRICAL CHARACTERISTICS

	3-250A2	3-250A4
Filament: Thoriated tungsten		
Voltage	5.0 volts	5.0 volts
Current	10.5 amperes	10.5 amperes
Amplification Factor (Average)	14	37
Direct Interelectrode Capacitances (Average)		
Grid-Plate	3.1 uuf	2.9 uuf
Grid-Filament	3.7 uuf	5.0 uuf
Plate-Filament	0.7 uuf	0.7 uuf

CALL IN AN EIMAC REPRESENTATIVE FOR INFORMATION

ROYAL J. HIGGINS (W9A10)...600 South Michigon Avenue, Room 818, Chicago 5, Illinois. Phone: Horrison 5948.

V. O. JENSEN, General Sales Co., 2616 Second Avenue, Seottle 1, Woshington. Phone: Elliott 6871.

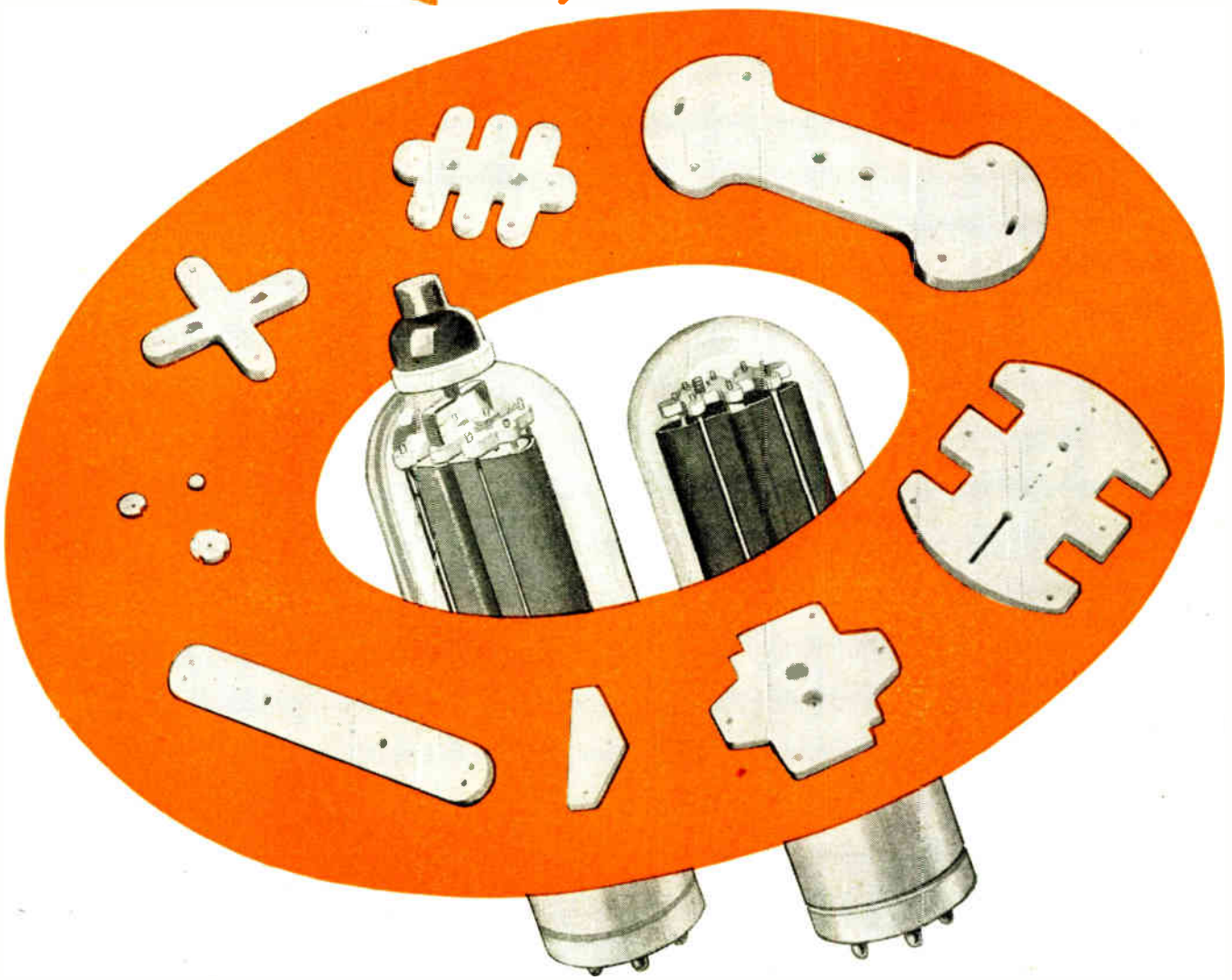
M. B. PATTERSON (W5C1)...1124 Irwin-Kessler Building, Dollos 1, Texos. Phone: Centrol 5764.

ADOLPH SCHWARTZ (W2CN)...220 Broodwoy, Room 2210, New York 7, New York. Phone: Cortlond 7-0011.

HERB BECKER (W6QD)...1406 So. Grond Avenue, Los Angeles 15, Californio. Phone: Richmond 6191.

TIM COAKLEY (W1KKP)...11 Beocon Street, Boston 8, Mossochusetts. Phone: Copitol 0050.

Precision Quality Control . . .



. . . A Year 'Round Feature of ALL

STUPAKOFF CERAMICS

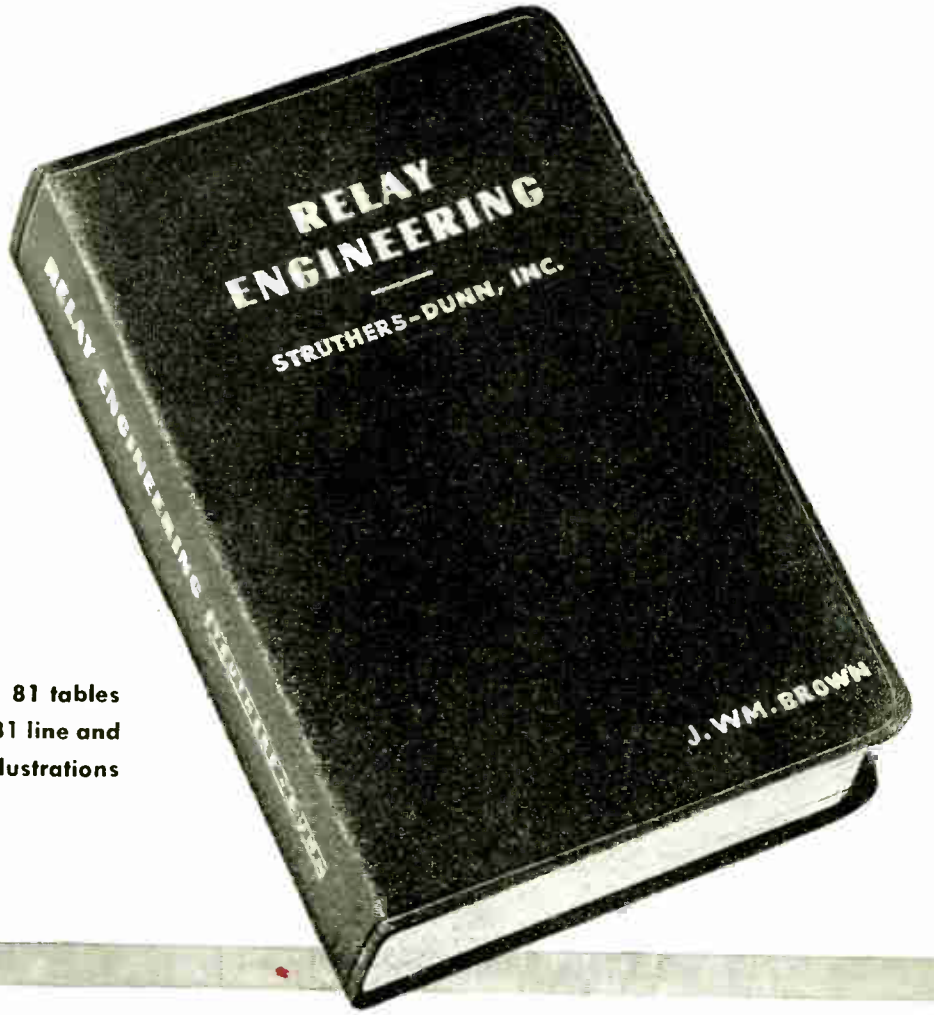
Stupakoff precision quality control gives you uniform, dimensionally accurate ceramic parts. By standardizing on STUPAKOFF products, you minimize production losses . . . gain assurance of maximum mechanical strength and maximum electrical protection.

The advantages of Stupakoff ceramics have been developed through years of engineering experience and research. Carefully selected and laboratory controlled materials, modern manufacturing facilities and constant inspection insure highest quality of finished products at all times. Specify Stupakoff—and be sure of the finest. *Write for Bulletin 245.*

EXPORT DEPARTMENT
13 E. 40th St., New York 16, N. Y.
Cable Address ARLAB all codes

STUPAKOFF

CERAMIC AND MANUFACTURING CO. · LATROBE, PA.



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

The handbook that tells you what you want to know about Relays and Timers

. . . Selection . . . Application . . . Use . . . Servicing and Maintenance . . . 640 pages . . . Handy manual size . . .
Have you gotten your copy? . . . Price $3.00

STRUTHERS-DUNN, INC.
1321 Arch Street, Philadelphia 7, Penna.

STRUTHERS-DUNN

5,327 RELAY TYPES

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

Callite tube parts

make General Electronics' power tubes extra rugged...

The DR575A is a heavy-duty, half-wave, mercury vapor rectifier manufactured by General Electronics, Inc. for use in induction heating apparatus. Here these tubes have proved their capacity to stand up under gruelling conditions for thousands of hours. Though rated at 15,000 volts inverse peak, they are tested at 25,000 volts—providing an overload factor in excess of 50%.

The rugged strength of the DR575A is built-in with Callite thoriated tungsten filament, "Kulgrid" leads and molybdenum rods. These Callite components permit higher operating temperatures with increased emission efficiencies.

Callite thoriated tungsten filaments contain the right proportions of tungsten and thoria to give the required electronic emission, plus the strength to withstand severe thermal shock and vibration. Callite's "Kulgrid"* is a stranded composite wire, having an inner core of copper bonded to a nickel sleeve, which does not oxidize nor become brittle at high temperatures. Callite's high purity molybdenum rod is known for its excellent working properties and complete freedom from oxidation.

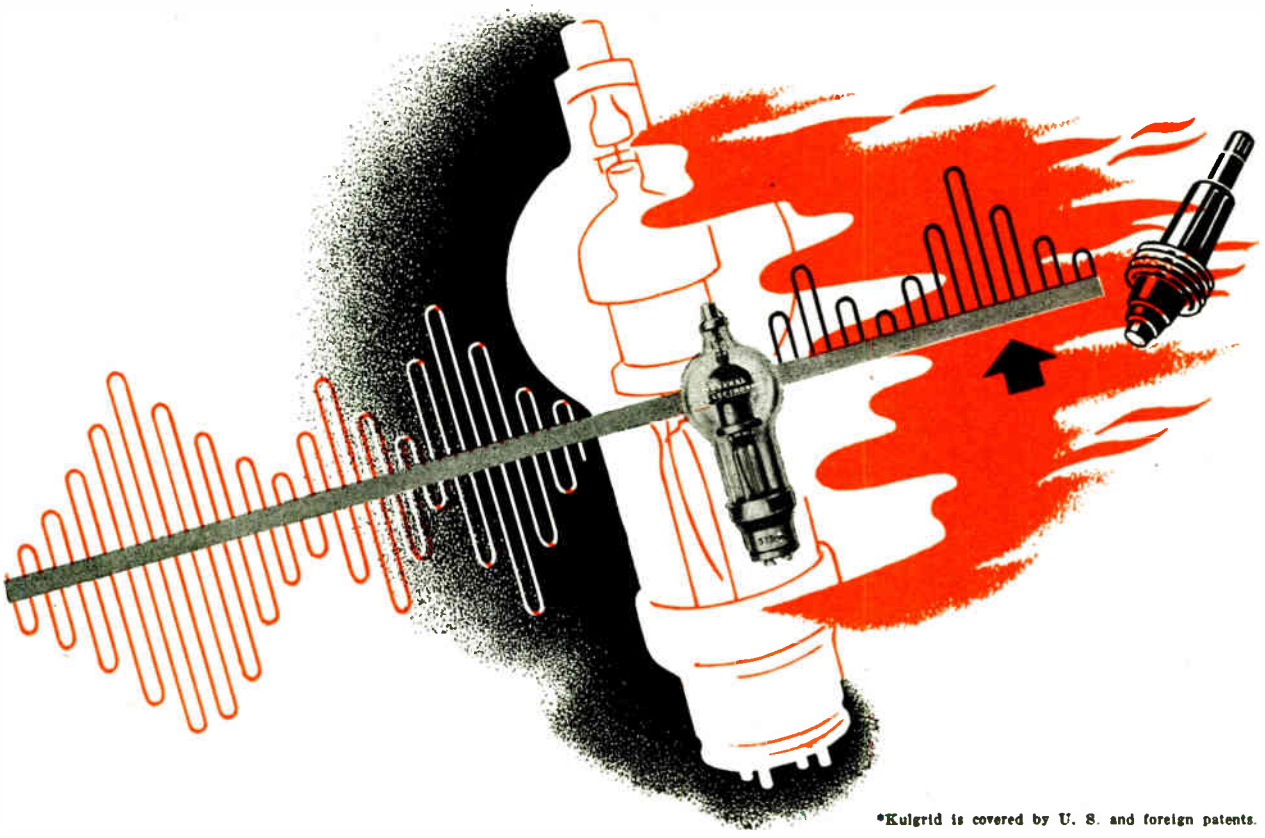
If you are striving for new highs in tube performance, investigate our specialized abilities and complete facilities for all kinds of metallurgical components. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey. Branch Offices: Chicago, Cleveland.

Callite *Tube components*

CALLITE TUNGSTEN CT

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

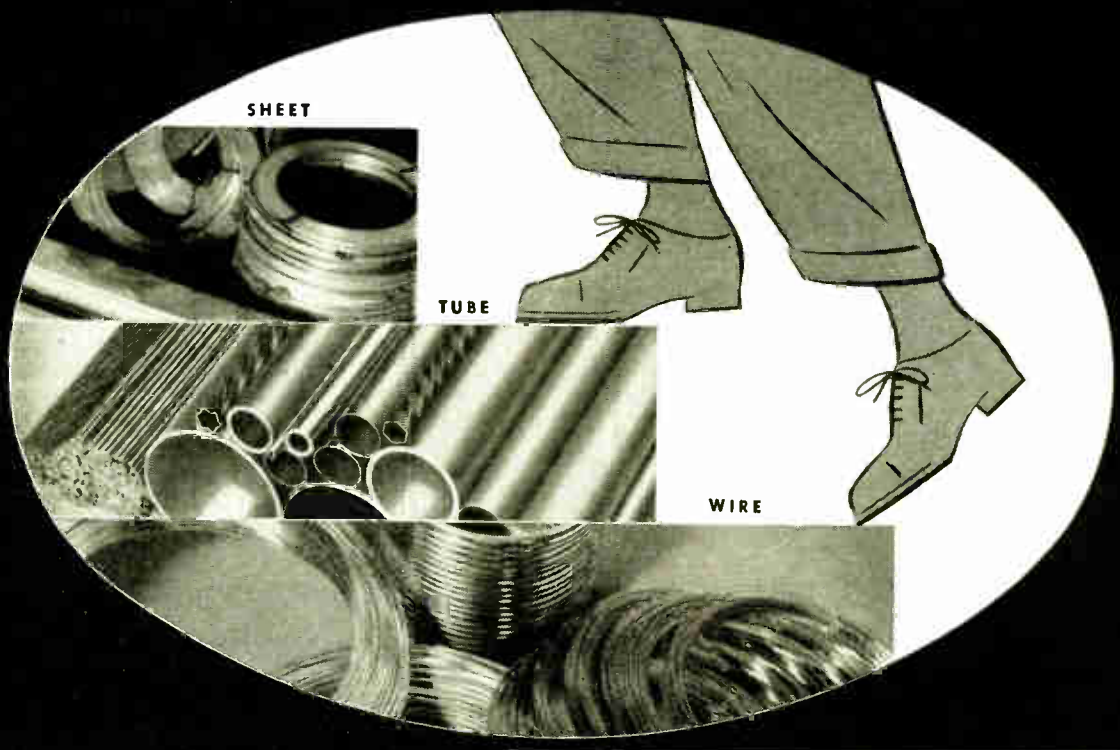
OVER 25 YEARS PIONEERS IN TUNGSTEN METALLURGY.



*Kulgrid is covered by U. S. and foreign patents.

3 Easy Steps

FOR SOLVING A METAL PROBLEM



General Plate

LAMINATED METALS

A few typical combinations produced by General Plate

S = SHEET W = WIRE T = TUBING OTHER Combinations on Request

	PLATINUM	PALLADIUM	GOLD	SILVER	ALUMINUM	BRASS	COPPER	BERYLLIUM COPPER	IRON	INVAR	STAINLESS STEEL	PHOS. BRONZE	MONEL	NICKEL	SILVER SOLDER	STEEL SAE 10-10	NICKEL SILVER
PLATINUM			SWT	SWT		SWT	SWT		SW	SW		SWT	SWT	SWT	SW	SW	SWT
PALLADIUM			SWT	SWT		SWT	SWT		SW	SW		SWT	SWT	SWT	SW	SW	SWT
GOLD	SWT	SWT		SWT	SWT	SWT	SWT	SW	SWT	SW	SW	SWT	SWT	SWT	SWT	SWT	SWT
SILVER	SWT	SWT	SWT		SWT	SWT	SWT	SW	SWT	SW		SWT	SW	SW	SWT	SWT	SWT
ALUMINUM			SWT	SWT		S	SWT										
BRASS	SWT	SWT	SWT	SWT	S				SW	SW	S	SW	SW	SWT	SWT	SWT	
COPPER	SW	SWT	SWT	SWT	SWT				SWT	SW		S	SW	SWT	SWT	SWT	SWT
BERYLLIUM COPPER			SW	SW													
IRON	SW	SW	SWT	SWT		SW	SWT			S	S	S	SW	SW	S		SW
INVAR	SW	SW	SW	SW		SW	SW		S		S	SW	S	S		S	SW
STAINLESS STEEL			SW			S			S	S			S	S			S
PHOS. BRONZE	SWT	SWT	SWT	SWT		SW	S		S	SW			SW	SWT	SWT	SW	SWT
MONEL	SWT	SWT	SWT	SW		SW	SW		SW	S	S	SW				SW	SW
NICKEL	SWT	SWT	SWT	SW		SWT	SWT		SW	S	S	SWT				SW	SW
SILVER SOLDER	SW	SW	SWT	SWT		SWT	SWT		S			SWT	S	S		S	SWT
STEEL SAE 10-10	SW	SW	SWT	SWT		SWT	SWT			S		SW	SW	SW	S		SW
NICKEL SILVER	SWT	SWT	SWT	SWT			SWT		SW	SW	S	SWT	SW	SW	SWT	SW	

General Plate Laminated Metals . . . sheet, wire and tube . . . provide many performance and economy advantages not found in single solid metals. These *permanently* bonded combinations of base metal to precious metal give you precious metal performance at a fraction of the cost of solid precious metal. Base to base metal combinations give special performance requirements not found in single base metals. Typical advantages include — better electrical performance, corrosion resistance, workability, ease of fabrication, ease of soldering, long wearing life and economy.

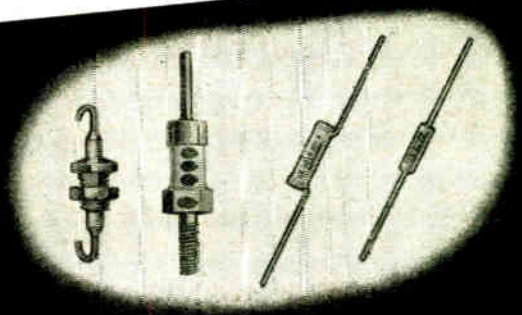
General Plate Laminated Metals will increase production and cut costs in such applications as electrical contacts, giant turbines, radar and radio tubes, instruments, chemical apparatus, mobile equipment.

Investigate General Plate Laminated sheet, wire and tube . . . wholly covered, inlaid, one side or both sides and stripe. Our engineers will gladly help you with your problems. Write for their services.

GENERAL PLATE DIVISION
of Metals & Controls Corporation
ATTLEBORO, MASSACHUSETTS

FOR FM RADIOS IT'S ERIE RESISTOR

Electronic Components and Products



FEED-THRU, STAND-OFF, PIGTAIL CERAMICONS

CINCH-ERIE PLEXICON TUBE SOCKETS
with built-in By-Pass Ceramicons

ERIE BUTTON MICA CONDENSERS

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

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

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

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

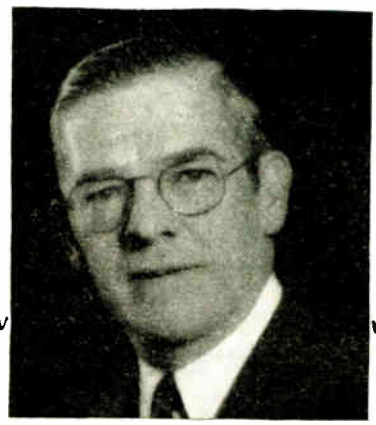
You can stake your reputation on these condensers for dependable use in tuned circuits, for by-pass applications, or as coupling condensers, in all FM applications. Write for complete details, giving desired operating characteristics.

Electronics Division
ERIE RESISTOR CORP., ERIE, PA.
LONDON, ENGLAND . . . TORONTO, CANADA

"TO ATTAIN STILL HIGHER STANDARDS OF SERVICE..."

"An asset in which the Nickel Plate Road takes great pride is the high standard of service which it renders to the shipping public. With its record for outstanding performance during the war years back of it, the Nickel Plate is looking forward to the utilization of new technological developments, such as radio and teletype, in order to attain still higher standards of service and usefulness."

President,
The New York, Chicago & St. Louis R.R. Co.



To fulfill completely its promise of increased rail efficiency, railroad radio equipment must be so designed that individual system units, such as transmitters, receivers, power supplies, and remote control units, will be readily accessible for inspection and quickly removable for service, replacement, or relocation.

Realizing the importance of these requirements, the Farnsworth Mobile Communications Division has engineered its railway communications equipment on the bases of *standardized design* and *unitized construction.*

Practical results from the application of these two engineering principles include the facts that—

(1) The basic components of Farnsworth systems, whether of space-radiating or inductive type, are *separate units,* which can be *quickly disassociated* from a system, either for maintenance or relocation.

(2) The same receiver, transmitter, or remote control unit is usable for wayside, mobile, or relay installations, thus providing *complete interchangeability* of basic equipment throughout any Farnsworth communications system.

(3) *Space-radio and inductive type* Farnsworth *units can be interchanged,* whether a part of mobile or stationary installations, and can be *readily utilized in combination* to meet varying railway operating conditions and requirements.

These are a few of the many engineering features incorporated in Farnsworth railway communications equipments to guarantee *maximum availability and flexibility with simplified, low-cost maintenance.* Farnsworth Television & Radio Corporation, Dept. EI-4, Fort Wayne 1, Indiana.

FARNSWORTH TELEVISION & RADIO CORPORATION

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • the Farnsworth Phonograph-Radio • the Capehart • the Panamuse by Capehart

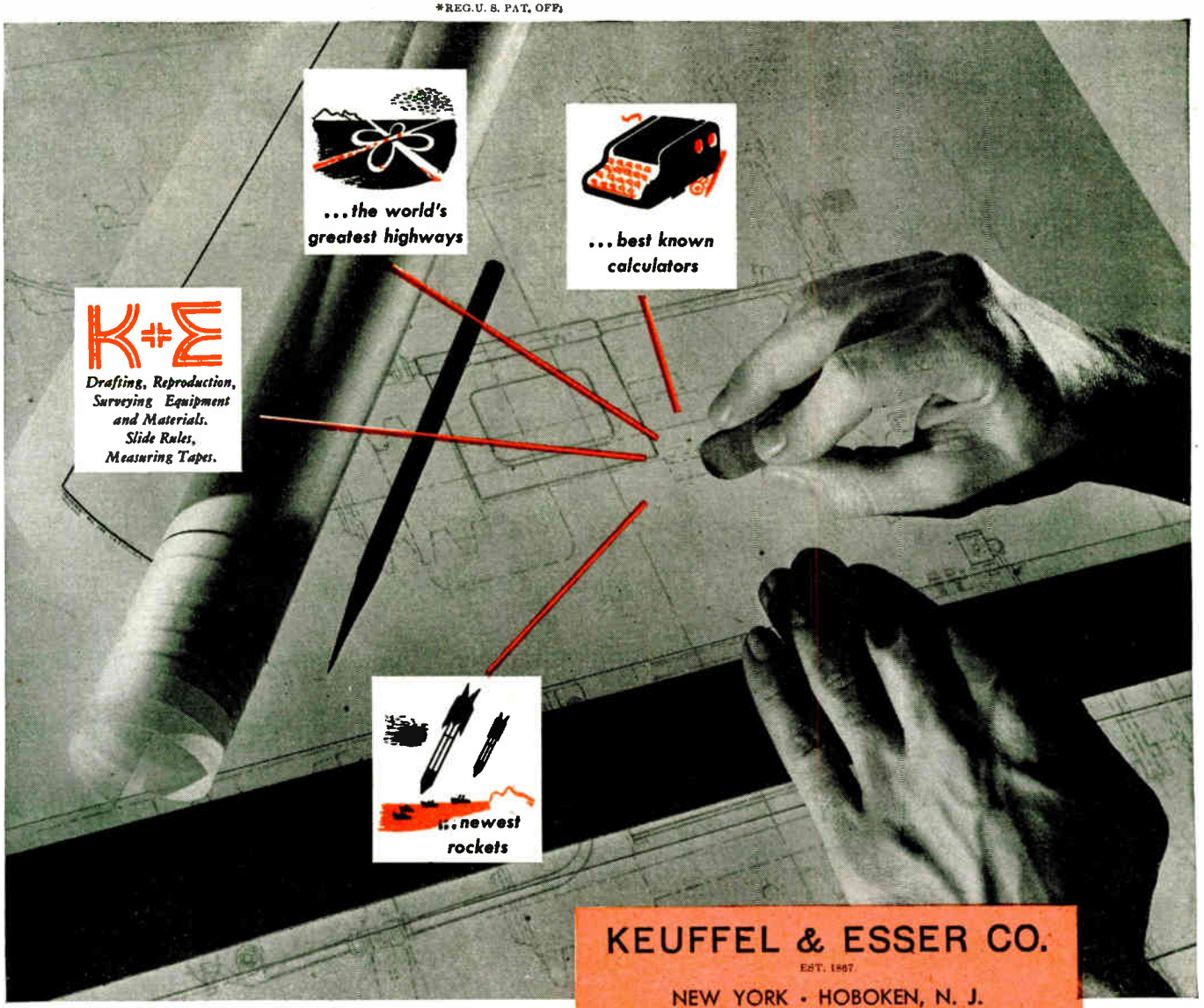
partners in creating

So clearly and unmistakably are draftsmen able to express their ideas on paper that their drawings have re-shaped the world. Through line, figure and symbol, draftsmen define the work to be done by the labor and machines of a nation. Assisting them to attain precision and clarity are drafting instruments that act almost as living extensions of their own hands...instruments that function figuratively as their partners in creating.

For 78 years Keuffel & Esser Co. drafting equipment and materials have been partners, in this sense, in shaping America, in making possible its swift-moving highway traffic, its speed in conducting business, its victorious might in war ...So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has materialized with the help of K & E. Could you wish any surer guidance than this in the selection of your own "drafting partners"?

You will find special advantages, for example, in PHOENIX* Tracing Cloth, which K & E has made almost "ghost-proof." Here is a cloth from which you can erase either pencil or ink lines without risking untidy "ghosts" on the prints, a cloth practically immune to stains from perspiration and water. You can even soak it in water for ten minutes at a time without harm! For further details about PHOENIX* Tracing Cloth, write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.

*REG. U. S. PAT. OFF.



STACKPOLE

GA MIDGET CAPACITORS

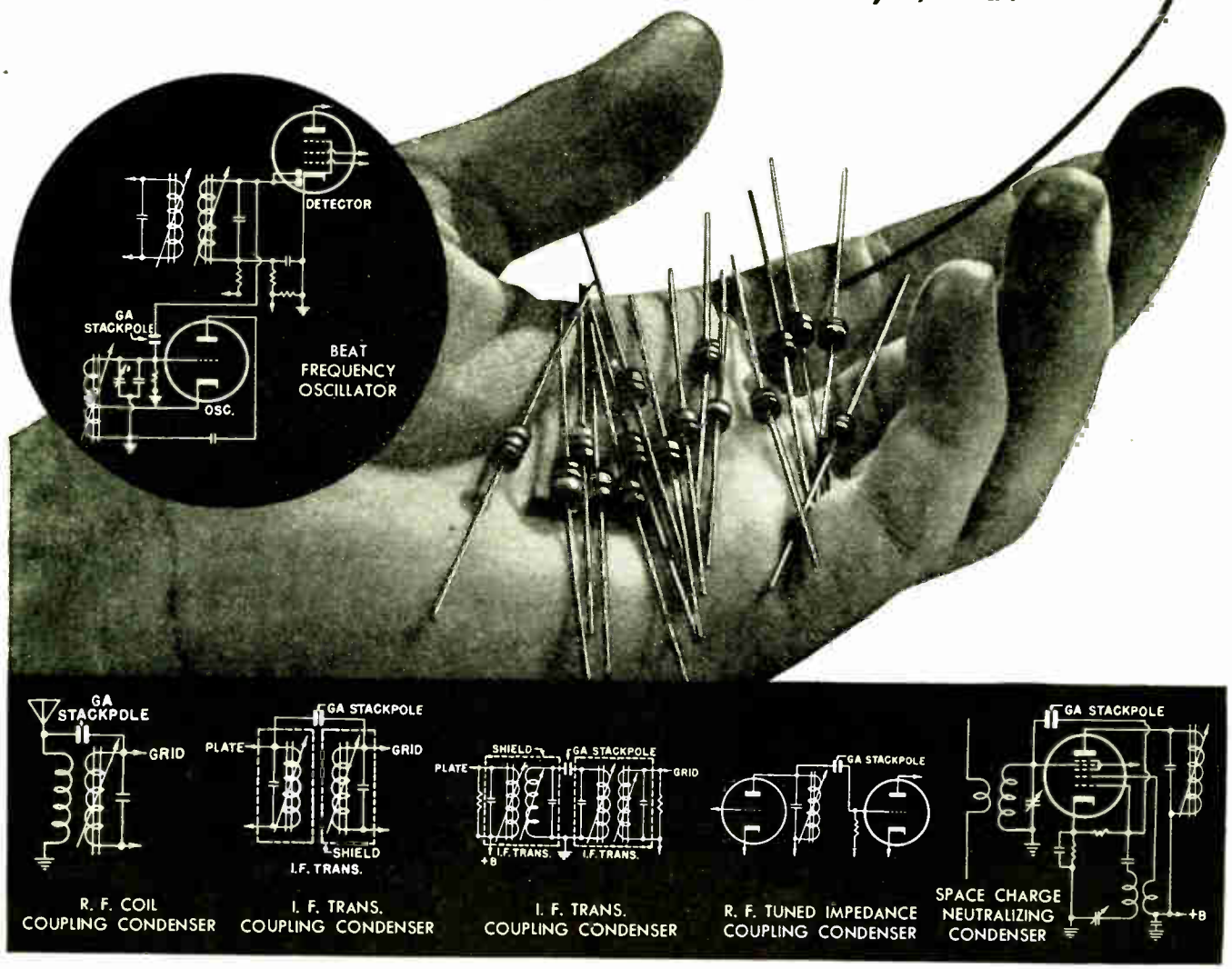
goodbye to gimicks!

Still twisting insulated wires together to form inefficient, makeshift "gimick" low value capacitors?

Stackpole GA Capacitors cost no more in the long run. Even more important, they bring you outstanding advantages in terms of greater stability, higher Q, better insulation resistance and higher breakdown voltage. In addition, they are mechanically superior and eliminate the undesirable inductive characteristic common to twisted wires. Sturdily molded, with leads securely anchored and tinned, they are widely used in circuits similar to those illustrated. Standard capacitors include 0.68; 1.0; 1.5; 2.2; 3.3 and 4.7 mmfd. with tolerances of ±20%.

Electronic Components Division

STACKPOLE CARBON COMPANY, St. Marys, Pa.



FIXED *and* VARIABLE RESISTORS • INEXPENSIVE SWITCHES

IRON CORES • COIL FORMS • POWER TUBE ANODES • BRUSHES AND CONTACTS • ALNICO II

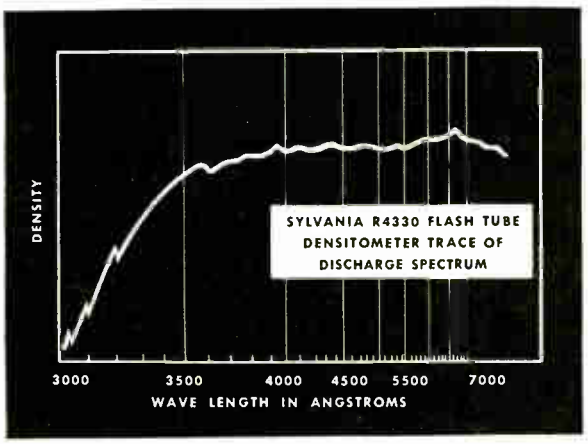
RHEOSTAT PLATES *and* DISCS • ANODES *and* ELECTRODES, ETC.

Photo Light Source 12,000,000 Peak Lumens

WITH THE SYLVANIA FLASH TUBE TYPE R4330

The Sylvania Type R4330 Flash Tube, used with suitable equipment, gives a brilliant flash of excellent photographic quality with a duration of only 1/5000 second.

A major application of the Type R4330 is in photography, where it permits taking exposures without the need for replacing flash bulbs. Its short flash duration "stops" motion, enabling the photographer to take sharp, clear pictures of moving subjects. Excellent color quality permits use with color film.



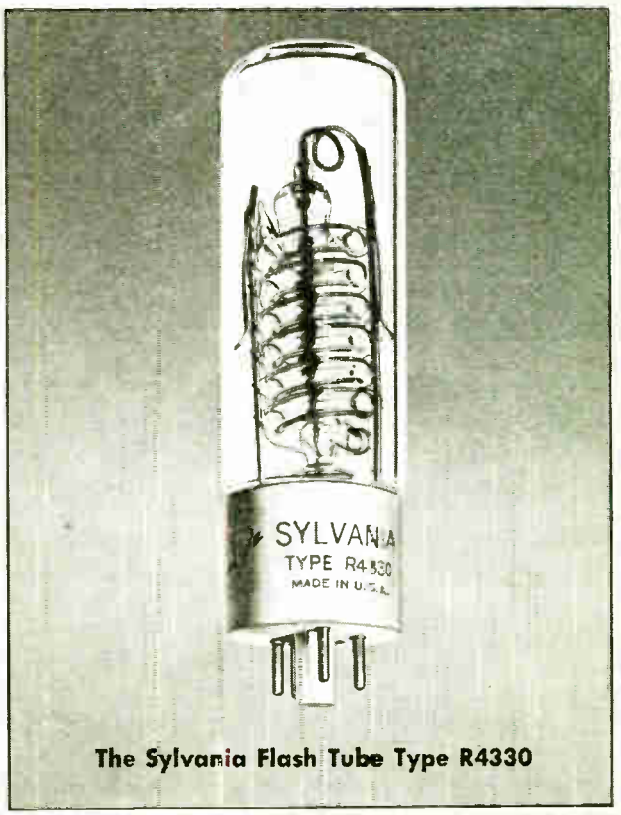
Each time the circuit switch is closed, the tube emits a single flash. Tube has a life of several thousand flashes.

Other uses of the R4330 are in beacons, obstruction markers, airport boundary markers and signaling devices.

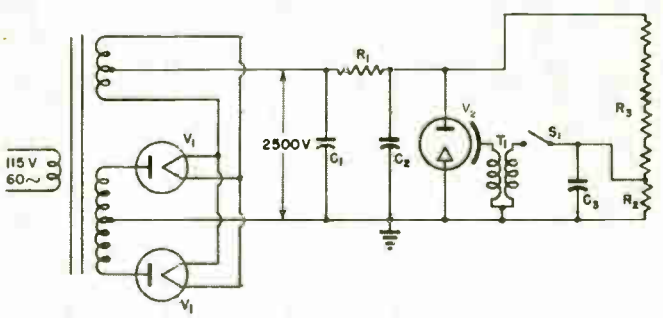
SYLVANIA STROBOTRONS

For observation of rotating or reciprocal motion under short-duration light pulses of controlled frequency, Sylvania Electric produces the SN4 and 1D21 Strobotrons — internally-triggered cold cathode tubes. In addition to their use in stroboscopic studies, both tubes may be utilized as electronic relays or controls.

You are invited to consult with Sylvania on specific applications of any of these tubes.



The Sylvania Flash Tube Type R4330



TYPICAL CIRCUIT DIAGRAM

R_1 500 ohms 100 watts	C_1 2 microfarads
R_2 150,000 ohms	C_2 32 microfarads
R_3 Consists of five 200,000 ohm resistors	C_3 1 microfarad
V_1 High voltage rectifier	T_1 Ignition coil
V_2 Sylvania R4330	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

RAYTHEON *Standardized*

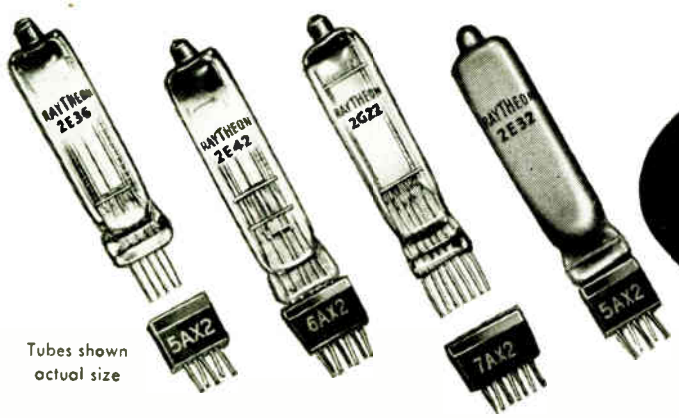
SUB-MINIATURE TUBES

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

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

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

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



Tubes shown actual size

RAYTHEON
MANUFACTURING COMPANY

Excellence in Electronics

RADIO RECEIVING TUBE DIVISION
Newton, Mass. • New York • Chicago

Let CLAROSTAT *Solve* your RESISTANCE PROBLEMS

Covers resistance range of 1 ohm to 999,999 ohms.

★

Each decade dissipates up to 225 watts. Greenohms (wire-wound cement-coated power resistors) used throughout. Glass-insulated wiring.

★

Six decade switches on sloping panel. Direct-reading in ohms.

★

Maximum current per decade: 5, 1.5, .5, .15, .05 and .005 amp.

★

Attractive frosted-gray metal case. Etched black-and-aluminum panel. Dual binding post terminals for left and right-hand duty.

★

Grille at bottom and louvres at side for adequate ventilation. Baffle plate protects switch mechanism against internal heat.

★

13" long; 88½" deep; 5¾" high. Weight, 11 lbs.

★

Moderately priced for general use. Many of these instruments in daily use today. Prompt delivery.

★

★ Literature on request . . .

★ With this unique Power Resistor Decade Box, Clarostat solves your resistance problems *under actual working conditions.*

No calculations required. No guesswork. No extensive experimentation. Here's a *power resistor* decade box. It can be introduced in any circuit or for any application. It provides the correct resistance value *under actual working conditions,* at the mere twist of the knobs. The resistance value that works best is then *read directly off the dials.*

Simple. Practical. Time-saving. Yet moderately priced. This instrument soon pays for itself—and continues to pay handsome dividends year after year. Typically a Clarostat solution of our resistance problems.

CLAROSTAT

Controls and Resistors

CLAROSTAT MFG. CO., INC., 285-7 N. 6TH ST., BROOKLYN, N. Y.

Export Division: 25 WARREN STREET, NEW YORK 7, N. Y.

Cable Address: SIMONTRICE, NEW YORK

G-E LAMINATED PLASTICS

FABRICATED TO YOUR SPECIFICATIONS

YOU GET ACCURATELY FINISHED PARTS MADE OF THE RIGHT MATERIAL READY FOR THE JOB

G-E Textolite sheets, tubes and rods are fabricated in an almost unlimited variety of sizes and shapes, and the General Electric Company has the necessary equipment to do this rapidly and economically—lathes, saws, shears, punches, hobs and mills . . . . even specially designed machinery to speed up and lower the cost on large production runs.

And because there are over 50 grades of G-E Textolite to select from, each having an individual combination of properties—electrical, mechanical, chemical, thermal—you get a grade that fits your needs.

Correctly machined and made of the right material for your application, you can be assured that when G-E Textolite fabricated parts reach you they will do the job.

Let us know your requirements. Write to Section T-2, General Electric Co., Plastics Divisions, One Plastics Ave., Pittsfield, Mass.

G-E Textolite tubing is shown being threaded to exacting mechanical and electrical specifications for radio coil forms.

G-E TEXTOLITE IS SUPPLIED IN THE FOLLOWING FORMS:

Sheets, Tubes, and Rods	Molded Laminated Parts
Fabricated Parts	Post-Formed Laminates
Nameplates	Translucent Laminates

Low-Pressure Molded Parts

CD-46-T2

"everything in Plastics"

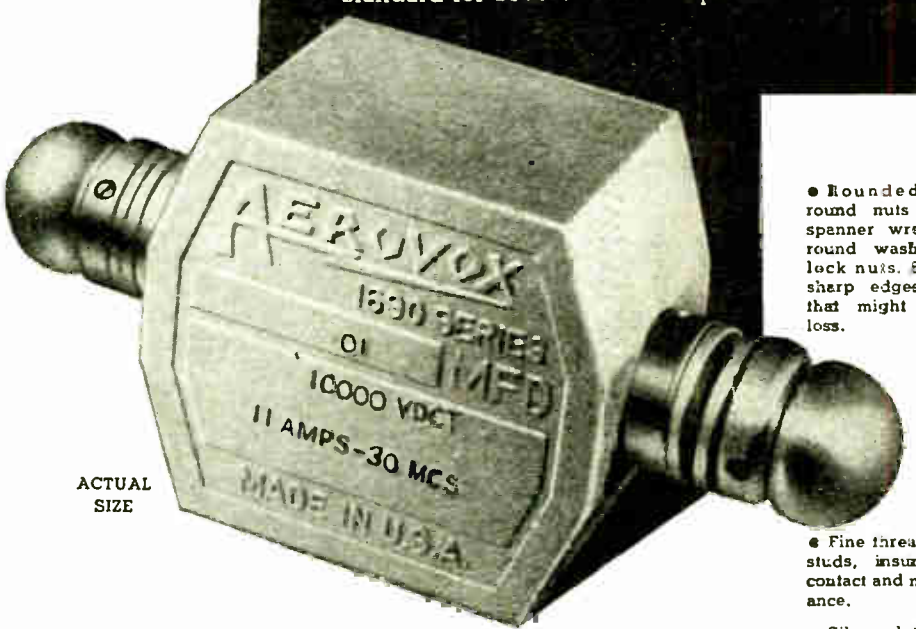
GENERAL ELECTRIC

STRAIGHT-LINE FEED
. . . Low Residual Inductance
. . . Higher Resonant Frequency
AEROVOX SERIES 1690
Mica Capacitors

● The brand new Aerovox Series 1690 molded-in-bakelite mica capacitor is intended specifically for circuits where inductance must be kept at a minimum. It is designed for least possible residual inductance, low r.f. losses and lower r.f. resistance and impedance. What's more, it provides increased KVA ratings for given capacitor sizes.

Such units can be advantageously applied as blocking capacitors in transmission lines; as tank capacitors for high-frequency oscillators; as by-pass capacitors for ultra-high-frequency currents; and as coupling or by-pass capacitors in induction-heating circuits.

Exceptional compactness for given KVA ratings; exceptionally-low-loss operation; ability to withstand constant duty and heavy overloads—for these and other reasons this latest Aerovox development marks a new performance standard for severe-service capacitors.



ACTUAL SIZE

Featuring . . .

● Rounded hardware—round nuts tightened by spanner wrench supplied; round washers; spherical lock nuts. Elimination of sharp edges and corners that might cause corona loss.

● Fine threads for terminal studs, insuring maximum contact and minimum resistance.

● Silver plating for all conducting members, minimizing skin resistance.

● Body of XM or yellow low-loss bakelite molded about mica section for thorough sealing and extreme ruggedness.

● Mica section of carefully selected mica and foil. Designed for straight-line path for ultra-high-frequency currents.

● Several times the size of the well-known Series 1650 bakelite-molded transmitting capacitors. Dimensions: 2⅜" w. x 2⅛" d. x 1⅜" h., and 4¾" overall between rounded terminal tips.

● Available in ratings up to 20,000 volts D.C. Test, or 10,000 volts operating. Capacitance values up to .001 mfd. at the highest voltage rating.

● *Interested? Write for detailed information. Meanwhile, submit that capacitor problem for our engineering collaboration.*

AEROVOX capacitors

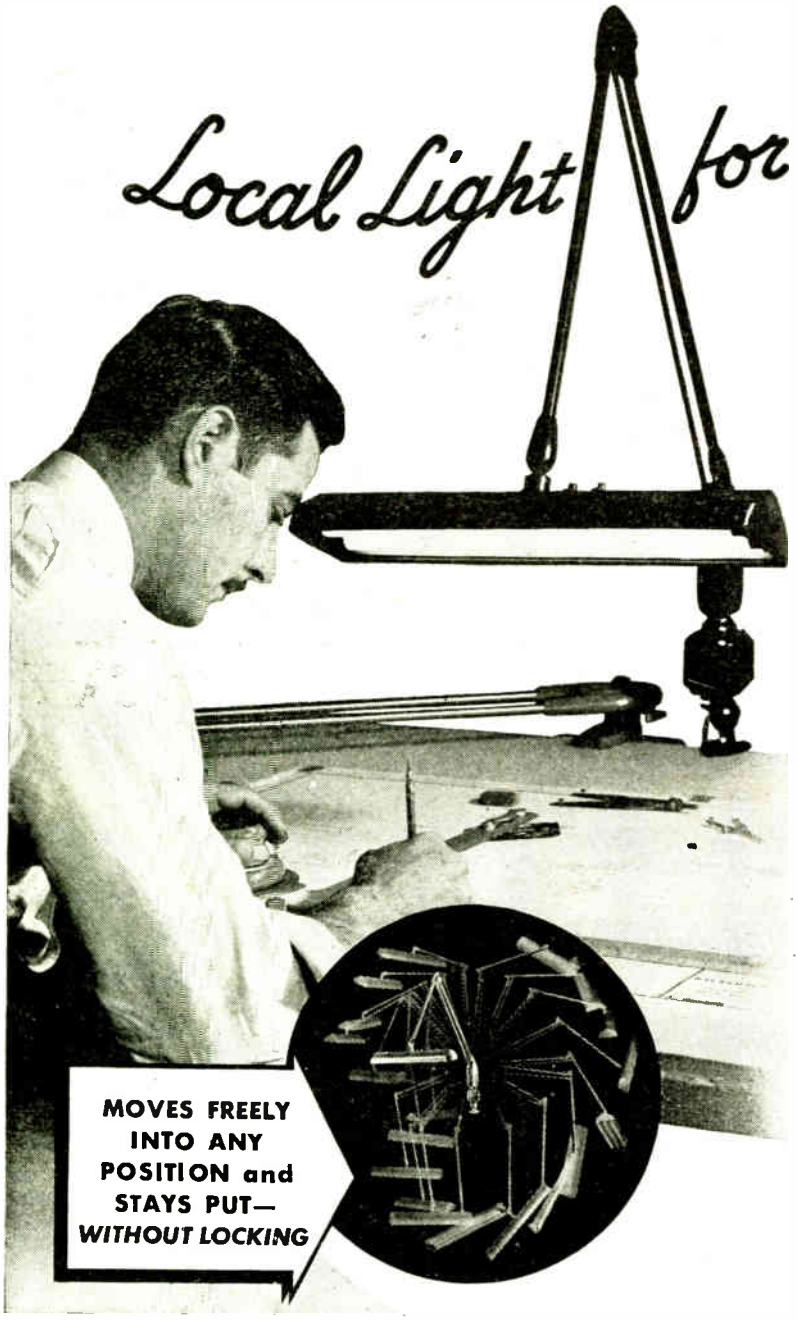
FOR RADIO-ELECTRONIC AND INDUSTRIAL APPLICATIONS

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

SALES OFFICES IN ALL PRINCIPAL CITIES • Export: 13 E. 40th St., New York 16, N. Y.

Cable: "ARLAB" • In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.

Local Light for Better Sight . . DAZOR ALONE Floats!



There's no margin for error in such critical tasks as precision machining, fine inspection, bench and assembly work. And none in drafting, accounting, bookkeeping. These jobs—and many others—demand straight seeing!

Use local light for better sight . . . Dazor *Floating* Lamps. For Dazors bring all-around *flexibility* to individual working areas, giving users full control over both the location and intensity of illumination.

A touch of the hand does it—*floats* the lamp to virtually any position where it *stays put* without further attention. This freedom of movement results from the *floating arm,* an exclusive patented Dazor development.

An investment in Dazor *Floating* Lamps will come back to you many times in higher worker efficiency and morale, in the quality and quantity of work produced, in the prevention of errors, accidents and waste.

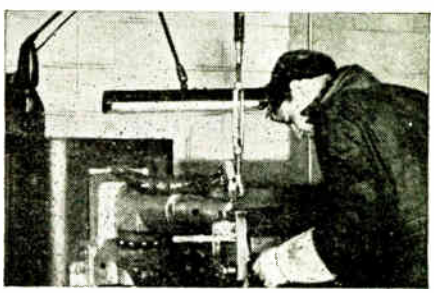
Phone Your Dazor Distributor

. . . get from him the full Dazor story, application assistance and an on-the-job demonstration. Your distributor's name, if unknown to you, can be secured by writing to the Dazor Manufacturing Co., 4483 Duncan Ave., St. Louis 10, Mo.

IN CANADA address inquiries to Amalgamated Electric Corporation Limited, Toronto 6, Ont.

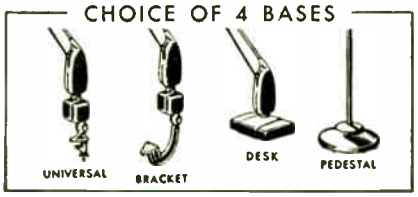
Precision machining is made easier, more certain with precise Dazor lighting.

Controlled Dazor lighting helps this dispatcher control train movements.



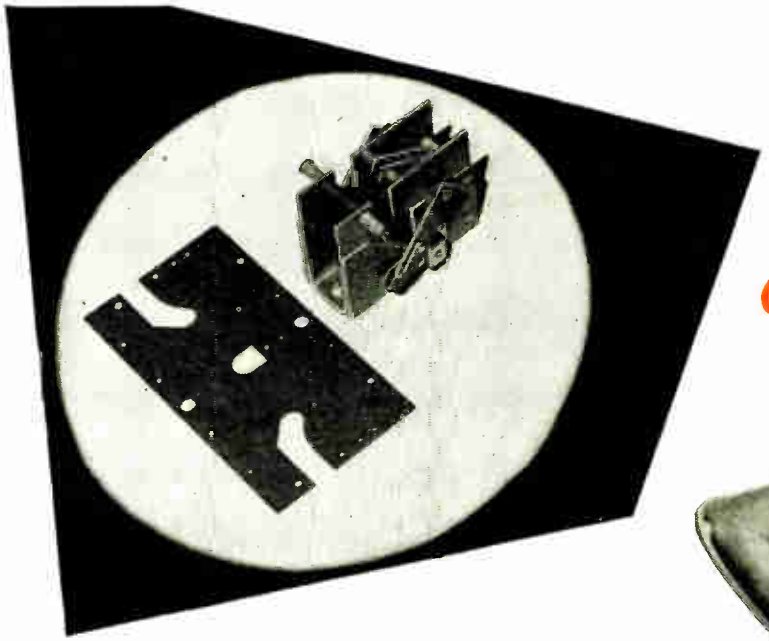
Intense Dazor illumination is here directed exactly where welder needs it.

CHOICE OF 4 BASES



DAZOR *Floating* LAMPS

FLUORESCENT *and* INCANDESCENT



Shapely

Post-Formed Phenolite chassis for high voltage circuit breaker. All holes and cut-outs are punched in the flat blank (*foreground*) before post-forming in channel shape. Use of Phenolite chassis in place of metal eliminates insulation of each separate part of assembly.

POST-FORMED PHENOLITE*

shapes profitable production and new products

There are opportunities for you in Post-Formed Phenolite—the laminated plastic that simplifies production and offers countless new applications for profitable-selling products!

Economical to produce, Post-Formed Phenolite parts are made in a matter of minutes. Practically any shape or form may be obtained simply by heating the sheet material a few seconds, then forming in low-cost wooden molds with standard press equipment. No sanding or "flash" removal is necessary. Fabrication may be done before or after forming.

Phenolite is extremely light in weight (about ½ that of aluminum); yet it has remarkable mechanical and impact strength. It possesses good machinability . . . is an excellent electrical insulator . . . resists heat and moisture . . . is resistant to abrasion . . . and is not affected by solvents and oils.

Find out some of the many ways in which this versatile material can be used. Write for full information and the assistance of one of our trained engineers.

NATIONAL VULCANIZED FIBRE CO.

OFFICES IN PRINCIPAL CITIES

WILMINGTON, DELAWARE

*FORMABLE THERMOSETTING SHEET MATERIAL

Ends your search for a versatile
HARD AS DIAMOND CERAMIC

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

Centralab
ERL
Division of GLOBE-UNION INC., Milwaukee

PRODUCERS OF


Ceramic Trimmers
Bulletin 695

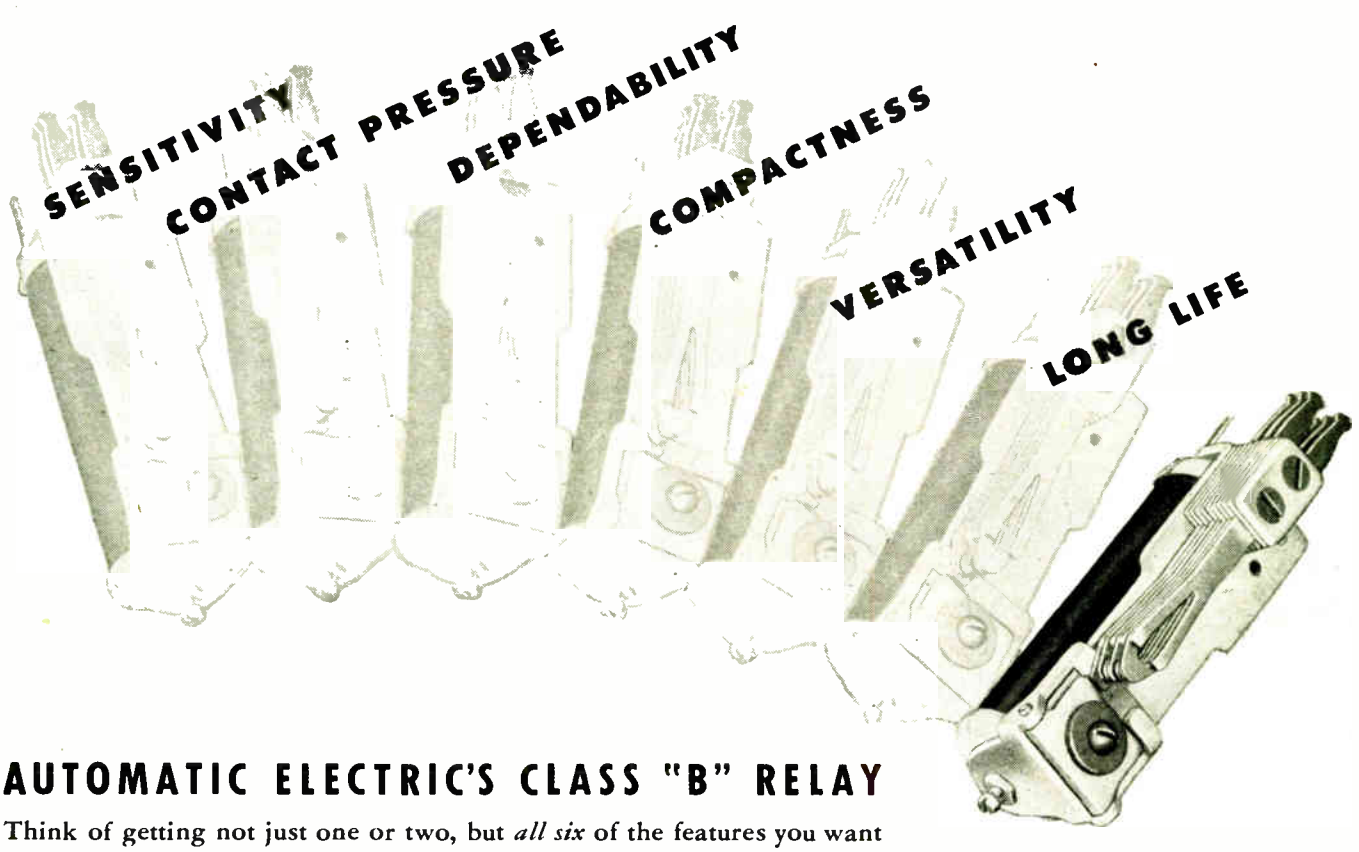

Variable Resistors
Bulletin 697


Tubular Ceramic
Capacitors
Bulletins 630 and 586


Selector Switches
Bulletin 722


Ceramic High Voltage Capacitors
Bulletin 814

All THESE FEATURES IN THIS ONE GREAT RELAY



AUTOMATIC ELECTRIC'S CLASS "B" RELAY

Think of getting not just one or two, but *all six* of the features you want —combined in one relay! That's the new Automatic Electric Class "B" relay. It's a leader in every detail of design and construction—a relay to meet the most exacting service requirements, in a wide range of relay applications.

Because relay users know a good thing when they see it, our entire production for many months has already been spoken for. But you'll find the Class "B" relay well worth waiting for, with its unique combination of design details:

Independent twin contacts for dependable contact closure... efficient magnetic circuit for sensitivity and high contact pressure . . . unique armature bearing for long wear under severe conditions . . . compact design for important savings in space and weight. Made for coil voltages to 300 volts DC and 230 volts AC, with capacities up to 28 springs;. also with magnetic-shielding cover, when desired

The Class "B" relay, and many others, are shown in Catalog 4071. Write today for your copy.

Relays by

AUTOMATIC ELECTRIC

AUTOMATIC ELECTRIC SALES CORPORATION
1033 WEST VAN BUREN STREET • CHICAGO 7, ILLINOIS
In Canada: AUTOMATIC ELECTRIC (CANADA) LIMITED, TORONTO

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

"KNOW-HOW"

The superiority of **WARD** Antennas reflects the "know-how" gained through many years' experience devoted to the exclusive manufacture of precision-built antennas. **WARD'S** excellence in this field has won the high favor of America's auto dealers, manufacturers, and motorists. All products bearing the **WARD** name are the finest in modern design, materials and craftsmanship, and can be counted upon for their consistent trouble-free performance. That's why **WARD** is "first choice" in antennas for all automobile and home radio applications.

World's Finest for Car and Home...
Combining Precision and Streamlined Beauty

Only WARD gives you all These Dominant Plus-Features

- Easy One Man Installation
- Patented Fluid Type Anti-Rattle Construction
- Positive Silver-to-Silver Contacts
- Extra Heavy Triple Chrome Rust-proof Plating
- Top Section, Stainless Steel
- Heavy Admiralty Brass Tubing
- Hi-Q Detachable Low Loss Lead-ins with Polyethylene Insulation and Vinylite Covering
- Complete with all Fittings and Conversion Kit for Torpedo Bodies
- Smooth Action Telescoping Sections
- 100% Shielded

WARD "HiQ" *Antennas*

THE WARD PRODUCTS CORPORATION
1523 EAST 45th ST., CLEVELAND 3, OHIO
EXPORT DEPT.—C. O. Brandes, Mgr., 4900 Euclid Avenue, Cleveland 3, Ohio
IN CANADA—Atlas Radio Corp., 560 King Street, W., Toronto 1, Ont., Canada

What Do You Want in a Relay?..
CLARE Will "Custom-Build" It
...Exactly

● Clare puts the designer in the driver's seat. Clare Relays permit a flexibility of plan unheard of with ordinary relays.

The secret? There isn't any. It's just that Clare "custom-building" makes it possible for you . . . with the utmost economy . . . to have a relay exactly suited to your specific requirements.

Clare doesn't design and manufacture a new relay for you from the ground up. There would be no economy for you in that. Clare "custom-building" selects the proper combination of Clare features for the job and includes them in a standard basic frame that is ideal for the requirement at hand.

Clare "custom-building" is a method of construction. It permits a wide range of contact ratings . . . five different contact forms or any combination of them . . . either flat or hemispherical contacts which may be of rare metals or special alloys . . . coil windings to match the circuit and application.

Clare Relays are built for applications where precise performance, long life and dependability are prime requisites. Thousands of users attest to the value of Clare Relays and the Clare "custom-built" principle.

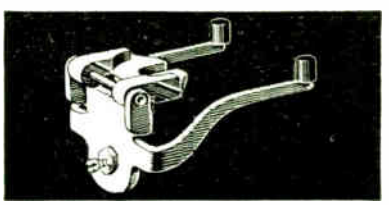
To "custom-build" a relay for you Clare engineers must know all the facts surrounding the requirements. Clare has sales engineers in all principal cities to show you how Clare "Custom-Built" Multiple Contact Relays are the effective answer to modern design problems.

Send for the new Clare Engineering Data Book with its full information on the full line of Clare Relays and allied control apparatus. Address: C. P. Clare & Company, 4719 West Sunnyside Avenue, Chicago 30, Illinois. Cable address: CLARELAY.

Contacts are welded to nickel silver springs by a special process. May be of precious metals or alloys in 12 different standard or special types and sizes.

Coil core of a.c. relays is of thin laminations of silicon steel, riveted together. This reduces hysteresis and eddy current losses, gives large amount of power with small heat losses.

High voltage spring pile-up insulators of special heat-treated Bakelite. Have minimum cold flow properties, low moisture absorption content. Permit punching without cracks or checks.

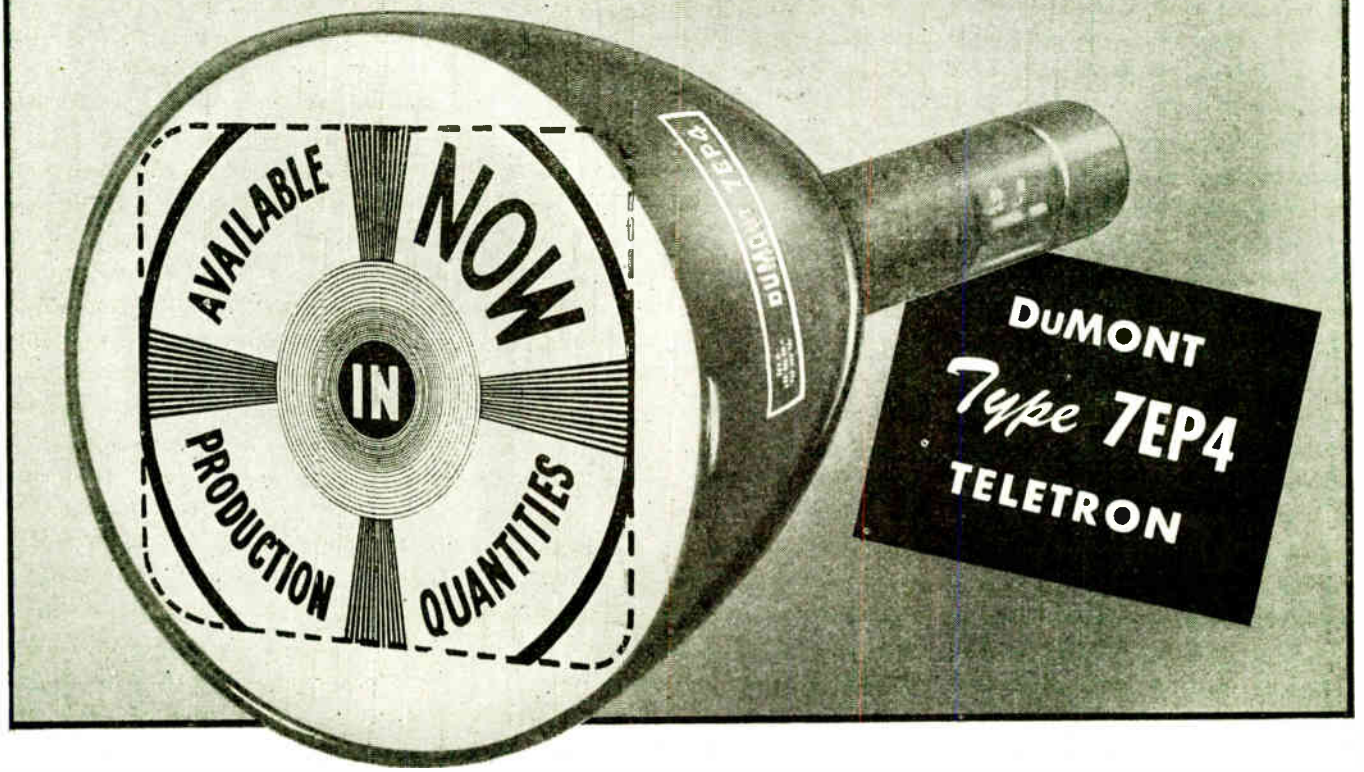


Double arm armature assembly with stainless steel shaft, operating in a marine brass yoke. Heelpiece, core and armature assembly of magnetic metal.

CLARE RELAYS

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

AMERICA'S *inexpensive* 7" TELEVISION RECEIVER TUBE



HERE'S HOW THE DuMONT TYPE 7EP4 HELPS KEEP RECEIVER MANUFACTURING COSTS AT ROCK BOTTOM:

1. Simplicity of the tube design assures low-cost production
2. Low operating voltage requires simple, low-cost power supply
3. Inexpensive but adequate all-phenolic magnal base cuts down socket costs
4. High deflection sensitivity; exceptionally good light output
5. Special DuMont "Eye Comfort" soft-quality screen
6. Stellar performance that "sells" receivers to a mass market...and at a profit

LET DuMONT'S REPRESENTATIVE PROVE THIS IS YOUR "BEST BUY!"

DUMONT *Precision Electronics & Television*

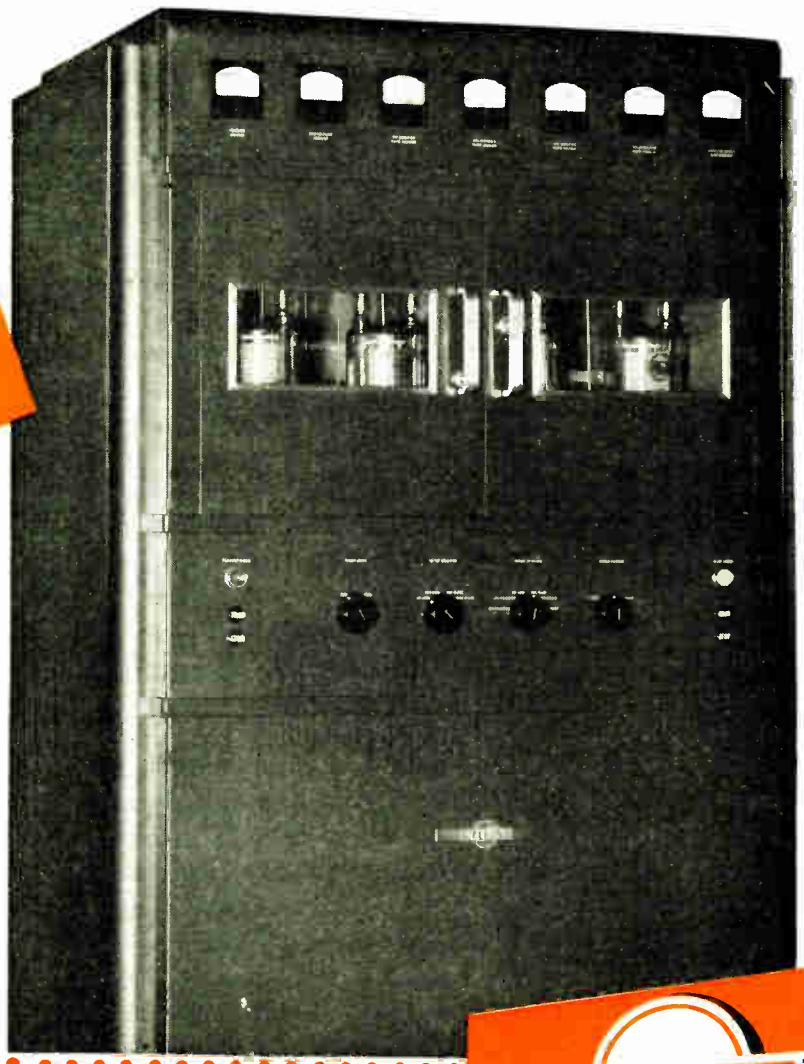
ALLEN B. DuMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

More output per dollar input!

The highly efficient output network of the Collins 20K AM broadcast transmitter contributes materially to its high operating economy and reliability. Efficient transfer of power from final amplifier to antenna calls for less power input, and therefore less power dissipation in circuit elements. Lower operating cost, greater dependability, and longer component life are the results of ingenious coordination of circuit design, components, and tubes.

Audio frequency distortion, noise level, and audio frequency response are within FCC high fidelity requirements. Stabilized feedback constantly safeguards these excellent performance characteristics under widely varying operating conditions.

Complete metering and motor tuning provide control over all circuits. Power change-over from 1000 watts to 500 watts is instantaneous. Write for further information. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.



FOR BROADCAST QUALITY, IT'S . . . .

COLLINS

ELECTRONIC INDUSTRIES
Including INDUSTRIAL ELECTRONICS

O. H. CALDWELL, EDITOR ★ M. CLEMENTS, PUBLISHER ★ 480 LEXINGTON AVE., NEW YORK (17), N. Y.

FM—Keep It Pure!

Inherently, frequency modulation can provide the most perfect broadcast reception. Its freedom from static and from background noise, and its wider fidelity range render it an ideal medium for public service. We deplore, therefore, any move that may ever be made to degrade FM by diminishing or eliminating its outstanding merits of noise suppression.

These are the great qualities that make FM the splendid "plus-broadcasting" it is.

Real vs. Shoddy

If in any quarter the aim is to produce quantity and cheapness—merely "sets that will receive FM," without embodying FM's great advantages of noise-elimination, a great loss will be suffered by the public and the radio industry. Some producers, fortunately, will always continue to hold high the standards of FM's full potentialities. Such lines should profit richly as the trade and public come to understand the difference between the real and the shoddy.

Engineer in Business

Radio engineering groups should give attention to augmenting members' earning powers as well as their technical information. Thus, the Los Angeles IRE section recently held a session on "The Engineer in Business for Himself."

Appropriate subtopics discussed were: "Proprietor, Partner or Corporation," "Protection of Your Ideas and Rights," "Relations with City, County and State," "Taxes," and "Ethics and Customer Relations."

May other groups follow LA's lead!

Aiding the Handicapped Vet

Each of us appreciates the obligation we individually owe to the returning war veteran. Our indebtedness goes much deeper for those with physical handicaps who are trying to re-establish themselves as producing workers. In many such cases, after short specialized training, supposedly handicapped workers often become even more expert and more productive than normal employees.

This problem also offers a particular challenge to the electronic industry. How quickly can we provide simplified controls for the production equipment now installed in the plants of America. Physical handicaps will not be such hurdles if a lathe can be run from a small control panel, if gaging can be done with audible signals, or delicate adjustments set-up with a sturdy lever.

Electronic controls have a bigger job than ever in reconverting America!

Better Traffic Signals

Radio men have been trying to pound home to railway and roadway traffic experts the fact that radio-control technic will be of great value to the railroad and automotive industries, particularly in supplementing existing traffic signals of the visual type. For such old-fashioned signals in effect, can "speak" only several words, "stop", "go", and "caution". These signals cannot convey the detailed information which is required in emergencies. And, when visibility is obscured, they cannot effectively perform their functions.

In Emergencies and Bad Weather

By the use of radio circuits, however, full information may be transmitted by voice signals, right into the interior of mobile units, regardless of weather conditions. This means a great gain in operating effectiveness.

Since such installations will contribute to public safety, as well as to the establishment of new industries, with resulting increased employment, every radio engineer should count himself a missionary in this effort.

Railroad and traffic signals can become one of the most important of the electronic industries.

Sent You as a Supplement to this Issue— ***In Colors; 16 by 11 inches***

Chart of Frequency Modulation Systems

Diagramming the basic principles, characteristics, and features of FM transmitters and receivers

THEORY AND DESIGN OF

By A. M. STONE and J. L. LAWSON
Radiation Laboratory† M.I.T.

Analysis and exact solution of shunt-fed, double-tuned networks permitting application to wideband circuits

● The transfer of electric voltage, current, or power from one place to another is a problem which has long plagued the circuit engineer. In most cases the characteristic needed in a suitable transfer circuit, or transformer, can be rather easily obtained by the simplest means, but where efficiency of transfer over a wide frequency range is required more complicated transformers must be used. The construction of a transformer having two resonant meshes, commonly referred to as a double-tuned transformer, has involved certain design formulas which apparently have been solved only for limiting cases. A complete solution for such a transformer does not exist, to the authors' knowledge, yet the widespread use of the circuit demands a complete understanding of the design formulas.

Transformers of more than two meshes have been used occasionally, but the complete design equations for such transformers are incredibly laborious. The double-tuned transformer represents a good compromise type, one which is neither too complex to understand nor as inefficient as the simpler single-tuned type. In this article a complete solution for the double-tuned transformer is presented, together with illustrations of the use of the derived formulas and charts. The solution has been restricted in two ways; only the shunt-fed circuit is calculated, and the coupling between meshes is adjusted for transitional or "flat-flat" response. More will be said about these conditions later; they represent conditions which are normally imposed in most practical cases.

In the more usual sense, and as we shall discuss it here, a coupling circuit will be considered to be simply a network composed of passive elements inserted between a generator or source and a transmission medium or receptor. Furthermore, the elements of this network will be presumed to be linear and non-radiating.

In general, where the source and receptor possess reactances, i.e., usually shunt capacitances, and where, as is most common, the transfer of voltage over a band of frequencies must be accomplished, the simplest coupling circuit is the single-tuned circuit. In Fig. 1 is shown a typical single-tuned circuit used as an interstage coupling element. It is a two-terminal unit used to produce output voltage (the grid voltage of tube 2) due to input current (plate current of tube 1). By means of adjustment of the inductance L, in relation to the tube and wiring capacitance C, effective voltage transfer will occur in the neighborhood of

$$\omega = 1 \div \sqrt{LC}$$

where $\omega = 2\pi x$ frequency. How narrow or how wide the region of voltage transfer is depends on R. Unfortunately for many applications, a wide bandwidth—low R—is accompanied by a distinct loss in voltage transfer.

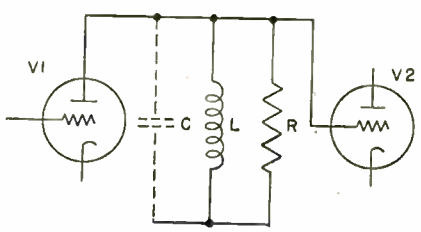


Fig. 1—Two-terminal single-tuned circuit

More efficient coupling circuits than the single-tuned exist. The output voltage from the network can be made higher, for a given bandwidth. It is beyond the scope of the present article to penetrate deeply into this question, but it may be remarked that coupling circuits in the form of infinite section filters can be shown theoretically to offer the best gain-bandwidth product. (1). But these are impossible to make, are often critical, and the better approximations are expensive, difficult of design, and often impractical. Furthermore, in many applications their phase response is inadequate. Hence it has been more and more customary to make use of the advantages of the double-tuned circuit over the single-tuned. This carries one well along the road toward the most advantageous coupling element, without too great a sacrifice of simplicity of design.

Double-tuned circuit

Perhaps the next most complicated, yet worthwhile, circuit after the single-tuned is the double-tuned network shown in Fig. 2. Here two single-tuned stages are mutually coupled inductively. The network is a four-terminal one: the pairs are, respectively, the input and output voltage terminals and duality between the two is insured by the linearity of the circuit elements.

Why is the double-tuned circuit, with its added complexity, preferred to the single-tuned circuit? There are a number of reasons.

1. The gain-bandwidth product can often be improved by a factor of 2. In multiple stages this improvement can be vital in wideband receivers.

2. Again in multiple stages, say n, the overall bandwidth* is decreased in proportion to the 4th root of n, whereas in single-tuned stages it decreases in accordance with the 3rd root. For eight stages, the improvement

†This paper is based on work done for the Office of Scientific Research and Development under Contract OEM sr-262.

(1) W. W. Hansen, J. Appl. Phys., 16 528, 1945.

*Bandwidth always refers to the separation of the 3 db points—i.e., the points where the power is 0.5 the maximum.

DOUBLE-TUNED CIRCUITS

in the overall gain-bandwidth product from this factor alone is about 1.5.

3. The selectivity is much improved over that of the single-tuned stage. That is, the sides of the bandpass curve are much steeper as the frequency departs from resonance. At the same time, near resonance, the top of the bandpass curve can be made much flatter than in the case of the single-tuned circuit.

4. The transient response of the double-tuned circuit need not be significantly worse than the single-tuned circuit. Overshoots in the output voltage in response to square wave input voltages can be held to a very few percent. The phase response is therefore almost linear over the bandwidth.

5. While a pair of staggered single-tuned stages can be made to have the same shape of response as one double-tuned stage, greater efficiency is obtained by the use of the latter, particularly if many stages are cascaded. Furthermore, when single stages are required, e.g., to couple from a tube to a line, there is no convenient way to make use of the staggering principle.

In spite of the fact that double-tuned stages have been very widely used in the past, there has been to our knowledge no complete theory covering its design and use. The double-tuned circuit has represented a good compromise between the complexity of analysis and desirability of response—that is, approximate calculations could be made rather easily. The mere fact that approximations have had to be used in the past indicates why circuits still more complex (and hence probably more desirable for certain applications) have scarcely ever been attempted.

This present article will present the results obtained from an exact solution of the double-tuned circuit. (It should be emphasized that whenever really wideband circuits, bandwidths of the order of the center frequency, are a requirement, in television, in radar, and the like, the narrow-band solutions are inapplicable. Circuits calculated on this approximate basis are often very far in error indeed.) As we have stated, the solution to be presented has been restricted to the case where the double-tuned circuit is shunt-fed, because most often in practice one has to deal with constant-current generators having shunt capacitance. The series-fed circuit is amenable to the same kind of analysis, but the details have not yet been carried out.

The practical application and the solution of the double-tuned circuit are facilitated by the recognition of certain equivalence relations. Not only does this ease the analysis but it is often extremely convenient in the construction of circuits to be able to use one of the equivalent, but physically different, forms of the circuit.

It is easy to show that the four-terminal T-network of Fig. 3 and the four-terminal π-network of Fig. 4 are completely equivalent to the double-tuned circuit of Fig. 2. This equivalence demands only relations among the inductances, and hence is a practical one.

These relations are:

Double-tuned to T:

$$L_1 + L_3 = \lambda_1 \qquad \lambda_1 - M = L_1$$
$$L_2 + L_3 = \lambda_2 \qquad \lambda_2 - M = L_2$$
$$L_3 = M \qquad M = L_3 \qquad (1)$$

Double-tuned to π:

$$\frac{\lambda_1\lambda_2 - M^2}{\lambda_2 - M} = l_1 \qquad \frac{l_2 l_3 + l_1 l_2}{l_1 + l_2 + l_3} = \lambda_1$$
$$\frac{\lambda_1\lambda_2 - M^2}{\lambda_1 - M} = l_2 \qquad \frac{l_2 l_3 + l_1 l_2}{l_1 + l_2 + l_3} = \lambda_2$$
$$\frac{\lambda_1\lambda_2 - M^2}{M} = l_3 \qquad \frac{l_1 l_2}{l_1 + l_2 + l_3} = M \qquad (2)$$

T to π:

$$\frac{\lambda_3}{L_2} = l_1 \qquad \frac{l_1 l_3}{l_1 + l_2 + l_3} = L_1$$
$$\frac{\lambda_3}{L_1} = l_2 \qquad \frac{l_2 l_3}{l_1 + l_2 + l_3} = L_2$$
$$\frac{\lambda_3}{L_3} = l_3 \qquad \frac{l_1 l_2}{l_1 + l_2 + l_3} = L_3 \qquad (3)$$

where λ_3 is defined by

$$\lambda_3 \equiv L_1 L_2 + L_1 L_3 + L_2 L_3 \qquad (4)$$

The coefficient of coupling,

$$k, \text{ is given by } k \equiv \frac{M}{\sqrt{\lambda_1\lambda_2}} \qquad (5)$$

Fig. 2—Double-tuned network using inductive mutual coupling

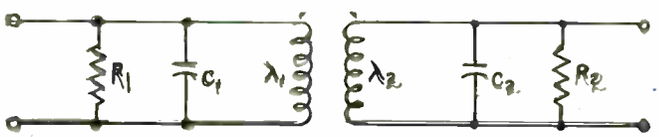


Fig. 3—Four-terminal T equivalent network of double-tuned circuit

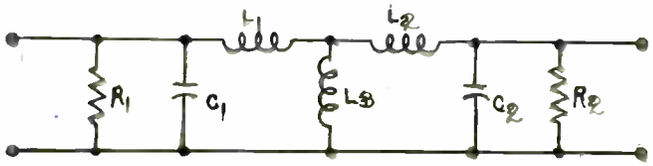
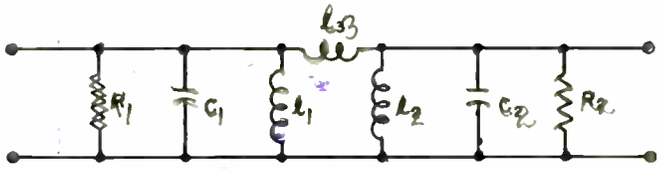
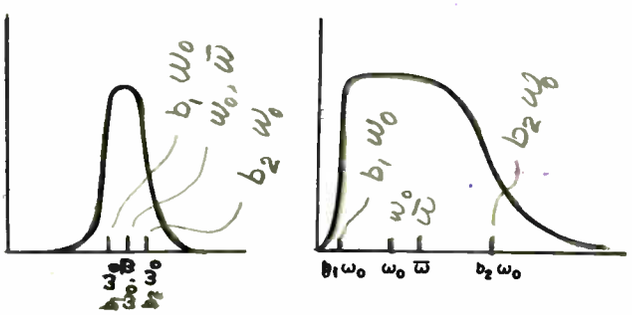


Fig. 4—Four-terminal π equivalent network of double-tuned circuit





(a) High-Q case (b) Exact low-Q case

Fig. 5—Flat-flat double-tuned resonance curve for low-Q and high-Q

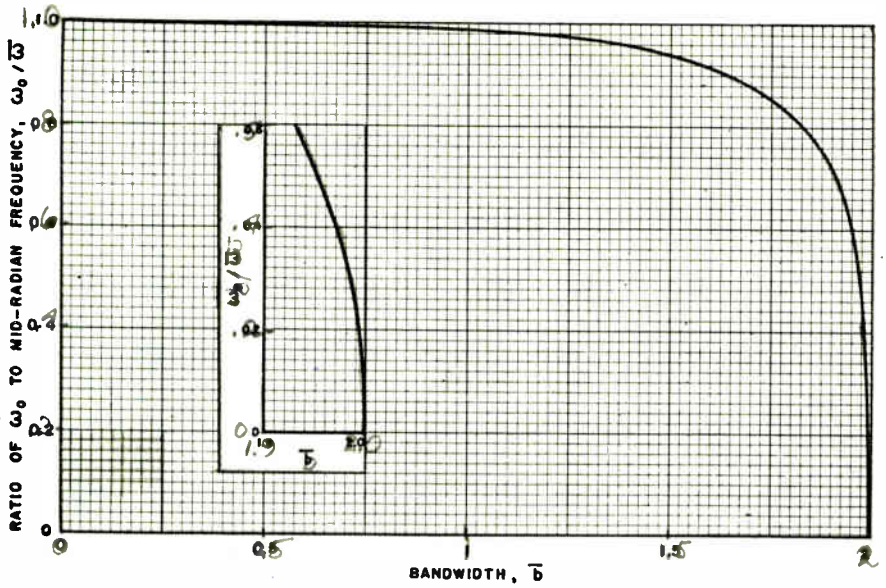


Fig. 6—Ratio of w_0 to the mid-radian frequency $\bar{w}$ as a function of the exact bandwidth $\bar{b}$

There is one further characteristic of the double-tuned circuit that has not yet been discussed here. By varying the strength of the coupling between the two meshes, one can achieve different types of bandpass curves, single-peaked, double-peaked, "flat-topped," etc. Nevertheless, for a great many applications one's interests are best served by making the curve as flat as possible over as large a frequency range as possible. When this is done we have what is called "transitional" or "flat-flat" coupling. See Fig. 5. The curve is so flat that only the fourth derivative of the ratio of output to input power† vs. the frequency has a value different from zero in the neighborhood of geometric band center.

This type of coupling is usually preferred over, for example, so-called "critical coupling" because: (1) a more advantageous gain-bandwidth product is achieved; (2) the tuning within the flat region of the frequency domain becomes obviously less critical; (3) the narrowing effects of cascading stages are less damaging; (4) the phase characteristic is good enough so that transient response is adequate for most applications.

When the Q's of the individual meshes of Fig. 2 are reasonably high—say, exceeding unity—an additional type of equivalence can be indicated. In what follows will be found certain approximate solutions, valid in the high-Q cases. These approximations to the exact solutions apply to the series-fed circuit as well. This requires that, if r is the resistance in series with the primary inductance, then the series-fed and shunt-fed circuits are approximately equivalent, if

$$rR = Q_1^2 \qquad (6)$$

where

$$Q_1 = \frac{\lambda_1 \omega_0}{r} = \frac{R}{\lambda_1 \omega_0} \qquad (7)$$

and ω_0 is the approximate center frequency.

With this in mind, in the next section will be presented design charts which apply to "flat-flat" double-tuned stages (or their equivalents) when shunt-fed — for example, from the plate of the pentode.

Design formulas and charts

The exact solution for the inductances to be used in the shunt-fed double-tuned circuit to achieve "flat-flat" coupling will now be written down. It is convenient to introduce the primary and secondary dissipation factors, α_1 and α_2, defined by

$$\alpha_1 = \frac{1}{R_1 C_1 \omega_0}; \qquad \alpha_2 = \frac{1}{R_2 C_2 \omega_0} \qquad (8)$$

It will be immediately recognized that the α's are merely the reciprocals of the Q's of the individual meshes. It can be shown that

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_0^4}$$

$$\lambda_2 = \frac{1}{C_2 \omega_0^2}\left(1 + \frac{\alpha_2^2}{8} + \frac{3\alpha_1^2}{8}\right)$$

$$\lambda_1 = \frac{1}{C_1 \omega_0^2}\left(1 + \frac{\alpha_1^2}{8} + \frac{3\alpha_2^2}{8}\right) \qquad (9)$$

$$L_3 = (\lambda_1 \lambda_2 - \lambda_3)^{\frac{1}{2}}$$

$$L_2 = \lambda_2 - L_3$$

$$L_1 = \lambda_1 - L_3 \qquad (10)$$

while the solution for l_1, l_2, and l_3 follows from Eq. (3). The solutions for the inductances is complete once the primary and secondary resistances and capacitances are specified, plus one additional quantity, ω_0. The quantity, ω_0, it may be stated, is the radian frequency at which the bandpass curve has its maximum value. It is only in the high-Q approximation (narrow bandwidth relative to the center frequency) that ω_0 is actually the center radian frequency.

All that the formulas in Eq. (9) can do is to ensure that with the physical quantities so related, one will obtain a "flat-flat" resonance curve. But nothing as yet has settled what the center frequency of the resonance curve will be, nor what the bandwidth will be. To anticipate, these will be essentially determined by the choice of the α's, and we will now turn to the method for their determination.

In the design of these transformers, one is usually given the arithmetic center frequency and the bandwidth desired. Let the former be denoted by $\omega/2\pi$ and the latter by $\bar{b} \dfrac{\omega}{2\pi}$. For example, for a 15 mc bandwidth arithmetically centered at 30 mc, $\omega = 2\pi \times 30 \times 10^6$ and $\bar{b} = 15/30 = 0.5$. Hence $\bar{b}$ is the value of the bandwidth in terms of its center frequency. We require relations between these two quantities and the as yet unspecified ω_0, α_1, and α_2 in Eq. (9). No analytic relationship is available. It is important to note that the loading-bandwidth relations do not depend on the center frequency, but only on the relative bandwidth $\bar{b}$. The value of α is the same for a 1 mc bandwidth centered at 2 mc as for a 15 mc bandwidth centered at 30 mc. In Fig. 6 is plotted ω_0/ω *vs* $\bar{b}$, and in Fig. 7 is plotted α *vs* $\bar{b}$ where $\alpha \equiv \alpha_1 + \alpha_2$.

In order to use the charts, one calculates $\bar{b}$ from the desired bandwidth and center frequency; $\bar{b}$ obviously has a value between 0 and 2. From Fig. 6 the ratio ω/ω_0 can be read, and thus ω_0 is determined. From Fig. 7 the necessary value of α is read. Note that the loading (i.e., α_1 and α_2) may be apportioned in any way between the two meshes so as to obtain the required total dissipation factor. However, gain-bandwidth consideration (see Table

†The reader will recognize this ratio as the square of the absolute value of the transfer impedance of the network.

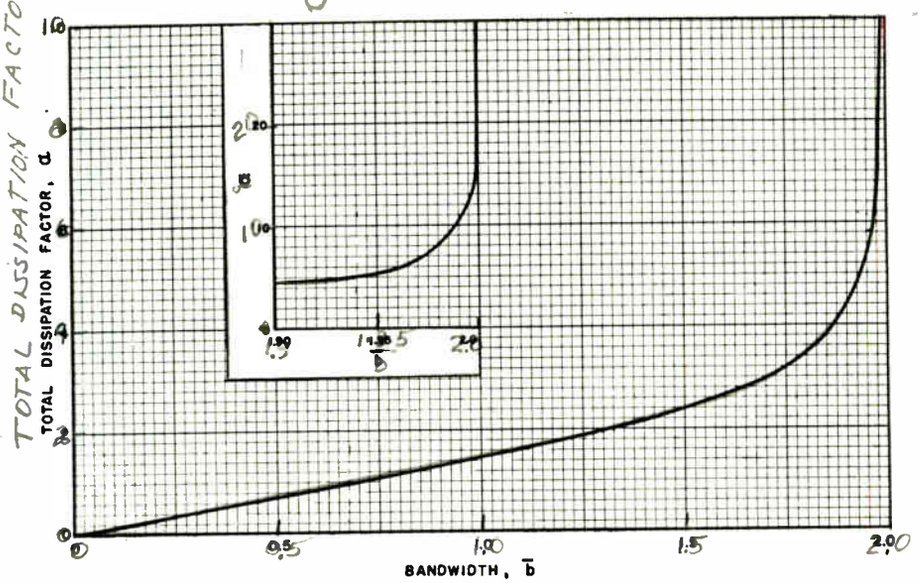


Fig. 7—Total dissipation factor α as a function of the bandwidth $\bar{b}$. Note: $\alpha \equiv \alpha_1 + \alpha_2$

I) usually will dictate either primary loading ($\alpha_2 = 0$) or secondary loading ($\alpha_1 = 0$). Or, it may happen that the particular circuit may be unavoidably loaded arbitrarily on one side or the other, or both.

At any rate, with ω_o, α_1, and α_2 determined from the charts and the division of the loading, the solution of the circuit is now complete. All we need do is calculate the L's, calculate the necessary R's (the C's are assumed given, although some cases may require their adjustment, as is shown later), and insert them in the network. When this is done one will obtain a flat-topped resonance curve for the transfer impedance of the network, with the center of the curve exactly where desired, and with a width between half-power points again exactly as prescribed.

Gain-bandwidth considerations

Bandwidth alone does not exhaust the desiderata for a coupling circuit. Equally important is the gain that can be achieved with a given bandwidth.

It would carry us too far afield to develop the equations leading to the gain-bandwidth product of the double-tuned circuit. It will be more useful to discuss this in terms of the improvement factor, F, which is a measure of the superiority of the gain-bandwidth product of the double-tuned circuit over that of the conventional single-tuned circuit.

For convenience two cases are considered: (1) the high-Q case, where the ratio of center frequency to bandwidth is very high; and (2) the low-Q case where the converse is true. Actually an error of only a few percent is involved, if the dividing line between the high-Q and low-Q cases is put at a ratio of center frequency to bandwidth equal to unity.

In both cases the factor F contains in it a term equal to

$$(C_1 + C_2)/\sqrt{C_1 C_2}$$

twice the ratio of the arithmetic to the geometric mean values of primary and secondary capacitances. This ratio equals 1 when the capacitances are equal and increases slowly the more unequal they are. In Fig. 8 is shown the quantity

$$\phi = \tfrac{1}{2}\frac{C_1 + C_2}{\sqrt{C_1 C_2}}$$

plotted as a function of C_2/C_1 or C_1/C_2.

The rest of the factor F is a numerical constant which depends on the case under consideration. If we write $F = h\,\phi$, then Table I gives the various values of h.

These values of h are rather curious. It will be noticed that a minimum improvement in gain-bandwidths product is a factor of 2 (when $C_1 = C_2$) for single-loaded circuits as wide as their center frequencies. This is in reality an enormous advantage when wideband circuits are required. Even the smaller factors in the other cases are of extreme significance. This will be most apparent when we discuss certain applications of these circuits.

TABLE I

Numerical coefficient, h, in improvement factor, F.

Single-loaded circuit, primary or secondary	
High-Q	2
Low-Q	$\sqrt{3}$
Equal loading on primary and secondary	
High-Q	$\sqrt{2}$
Low-Q	1

Approximate values

It is useful to have available in tabular form certain approximate expressions for the bandwidth and center frequency. These approximate expressions are surprisingly accurate even when the bandwidth is as wide as the center frequency. An error of not more than a few percent will be incurred in using these high-Q approximations and one rapidly incurs far less error as soon as the center frequency begins to exceed appreciably the bandwidth.

TABLE II

Approximate Values of Several Quantities

QUANTITY	HIGH-Q APPROXIMATION	LOW-Q APPROXIMATION
$\frac{\bar{\omega}}{\omega_o}$	1	$\frac{\alpha}{4}$
$\bar{b}$	$\frac{\alpha}{\sqrt{2}}$	2
$\frac{b_2}{b_1}$	$1 + \frac{\alpha}{\sqrt{2}}$	$\frac{\alpha^4}{16}$

In this table have been included values appropriate to the low-Q approximations (α_1 or $\alpha_2 \to \infty$) as well. Two additional quantities have been introduced. $\frac{b_2}{2\pi}$ and $\frac{b_1}{2\pi}$ are, respectively, the upper and lower half-power frequencies, both measured in units of $\omega_o/2\pi$. Their ratio is often a quantity of interest.

With the aid of Table II, the inductances in Eqs. (9) may be readily computed without the use of the charts. Only for high accuracy or for unusually wide bandwidths need the charts in Figs. 6 and 7 be consulted.

The mathematical solution of the shunt-fed double-tuned transformer or its equivalent which has just been outlined is exact. Due to conditions of physical realizability, however, it is necessary to select

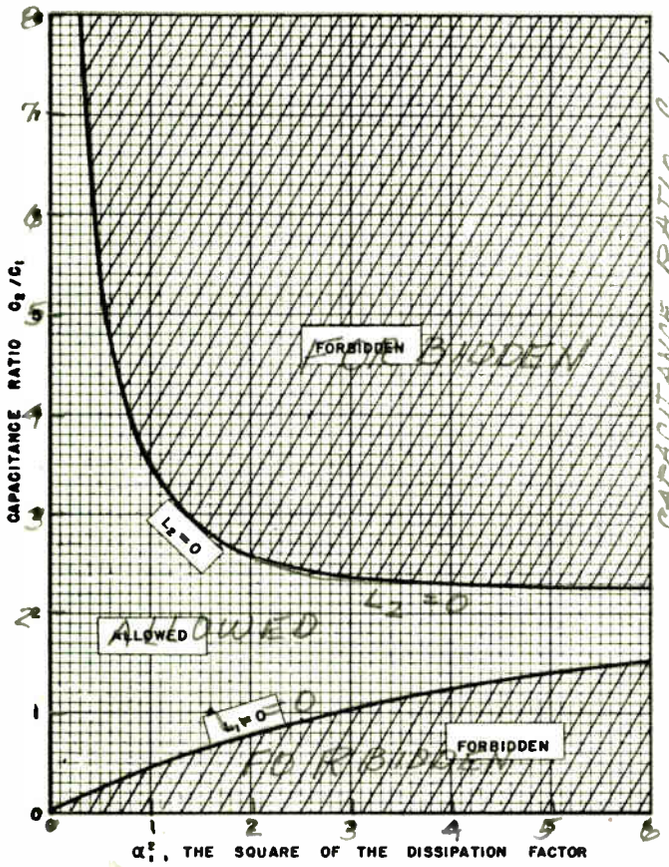


Fig. 9—Allowed and forbidden regions for C_2/C_1 as a function of α_1^2

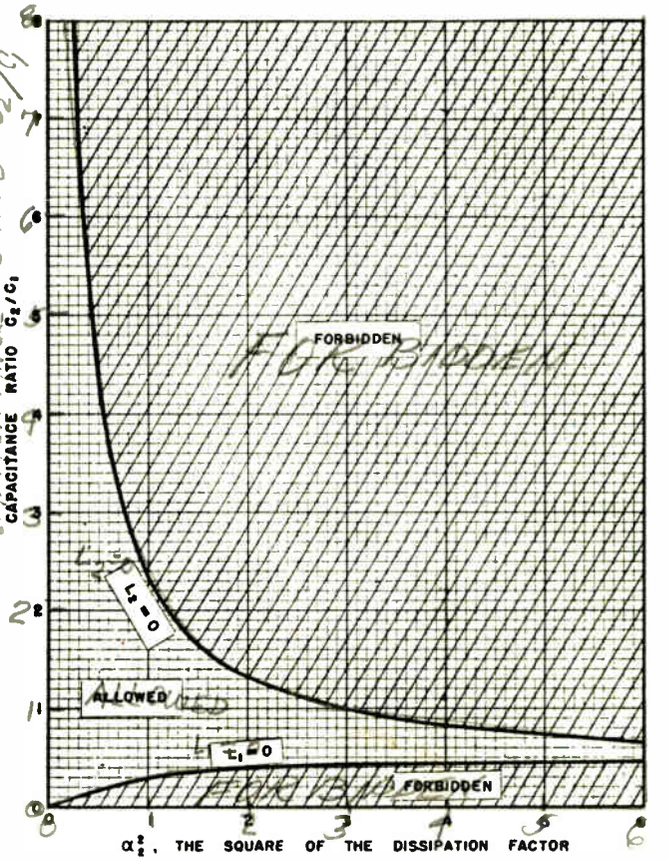


Fig. 10—Allowed and forbidden regions for C_2/C_1 as a function of α_2^2

only those solutions which allow real positive values for the inductances and for which the coefficient of coupling is less than unity.

The transformer solution has been stated, Eq. (9), but it is necessary to examine the coefficient of coupling, k. By definition

$$k^2 = \frac{M^2}{\lambda_1 \lambda_2},$$

from which the following equation may be derived:

$$k^2 = 1 - \frac{1}{\left(1+\frac{\alpha_1^2}{8}+\frac{3\alpha_2^2}{8}\right)\left(1+\frac{3\alpha_1^2}{8}+\frac{\alpha_2^2}{8}\right)} \quad (11)$$

where, as before, α_1 and α_2 are the dissipation factors of the primary and secondary, respectively. It can be seen that for any combination of dissipation factors λ_1 and λ_2 will be real positive inductances and the value of k will lie somewhere between zero and unity. Therefore, in principle, no restriction on the transformer circuit exists. Practical constructional difficulties, however, restrict the maximum value for the coefficient of coupling.

For the equivalent of T or π circuits it is necessary that L_1, L_2, L_3 and l_1, l_2, l_3 all be positive. If the equivalent T is physically realizable it can be shown that the equivalent π is also physically realizable. This can be done by noting the following relationship from Eqs. (3) and (9).

$$l_3 = \lambda_3/L_3$$

$$l_2 = \lambda_3/L_1$$

$$l_1 = \lambda_3/L_2$$

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_0^4}$$

Since λ_3 is always positive, values for L_1, L_2, and L_3 insure that l_1, l_2 and l_3 are all positive and therefore physically realizable. If any one of the quantities L_1, L_2, or L_3 is negative, then one of the quantities l_1, l_2, or l_3 will be negative. Therefore, if the equivalent T circuit is physically realizable the π circuit is also physically realizable and *vice versa*. It is only necessary therefore to investigate the restrictions which apply to one of the equivalent forms. For convenience the equivalent T circuit will be considered here.

From Eqs. (9) and (10) the following equations applying to the T circuit are:

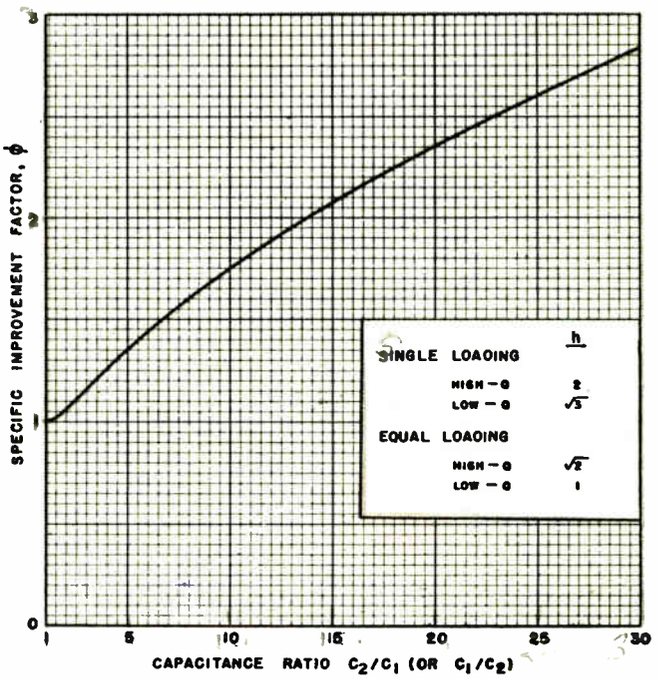


Fig. 8—Variation of the specific improvement factor Φ with the capacitance ratio C_2/C_1

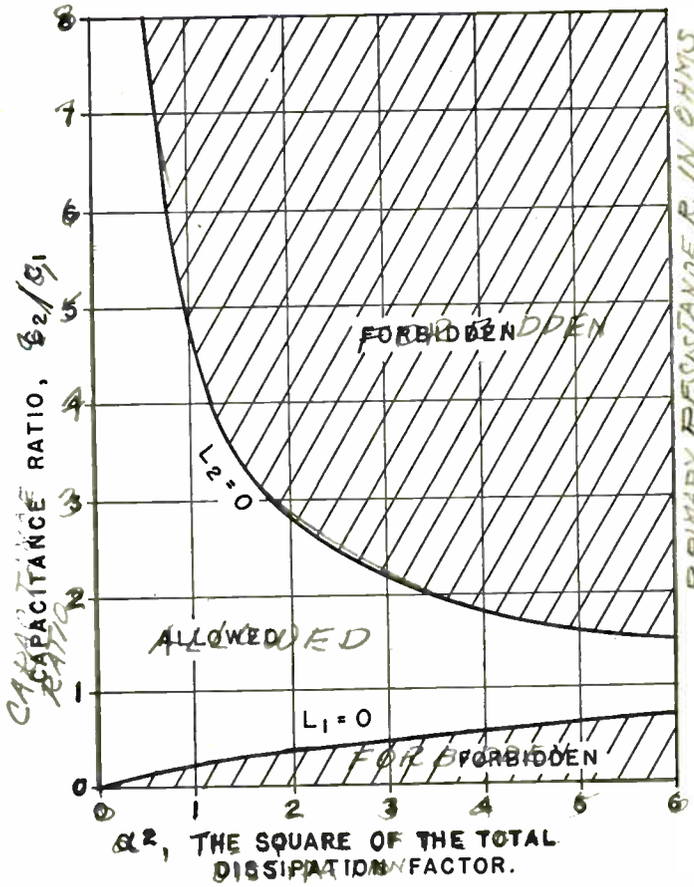


Fig. 11—Allowed and forbidden regions for C_2/C_1 as a function of α^2

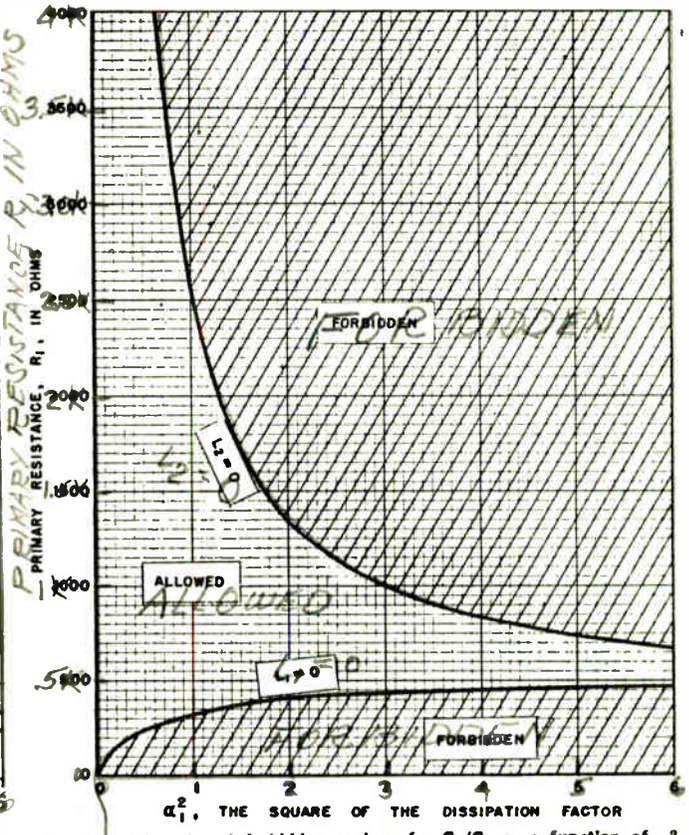


Fig. 12—Permissible regions for primary loading R as function of α_1^2

$$L_3 = \left(\lambda_1\lambda_2 - \lambda_3\right)^{\frac{1}{2}}$$

$$= \left[\frac{1}{C_1C_2\omega_0^4}\left\{\frac{\alpha_1^2+\alpha_2^2}{2} + \frac{3\alpha_1^4 + 10\alpha_1^2\alpha_2^2 + 3\alpha_2^4}{64}\right\}\right]^{\frac{1}{2}}$$

$$L_2 = \lambda_2 - L_3 \qquad (12)$$

$$L_1 = \lambda_1 - L_3$$

A positive real value for L_3 will always exist, and must be chosen for physical realizability.* However, L_2 and L_1 will not always be positive. It is convenient to write the conditions for the two cases separately:

(1)—L_2 positive. This will occur if $\lambda_2 \geqq L_3$, or if

$$\frac{1}{C_2^2\omega_0^4}\left\{1 + \frac{3}{8}\alpha_1^2 + \frac{1}{8}\alpha_2^2\right\}^2 \geqslant \frac{1}{C_1C_2\omega_0^4}$$
$$\left\{\frac{\alpha_1^2+\alpha_2^2}{2} + \frac{3\alpha_1^4 + 10\alpha_1^2\alpha_2^2 + 3\alpha_2^4}{64}\right\}$$

or if

$$\frac{C_2}{C_1} \leqslant \frac{64 + 16(3\alpha_1^2 + \alpha_2^2) + 9\alpha_1^4 + 6\alpha_1^2\alpha_2^2 + \alpha_2^4}{32(\alpha_1^2 + \alpha_2^2) + 3\alpha_1^4 + 10\alpha_1^2\alpha_2^2 + 3\alpha_2^4} \qquad (13)$$

The equality sign holds when L_2 actually becomes zero. Since this function is rather complicated, it is convenient to consider three special, but usually desired, conditions. The cases for primary loading ($\alpha_2 = 0$), secondary loading ($\alpha_1 = 0$) and equal loading ($\alpha_1 = \alpha_2 = \alpha/2$) are the following:

Primary loading:

$$\frac{C_2}{C_1} \leqslant \frac{64 + 48\alpha_1^2 + 9\alpha_1^4}{32\alpha_1^2 + 3\alpha_1^4}$$

Secondary loading:

$$\frac{C_2}{C_1} \leqslant \frac{64 + 16\alpha_2^2 + \alpha_2^4}{32\alpha_2^2 + 3\alpha_2^4} \qquad (14)$$

Equal loading:

$$\frac{C_2}{C_1} \leqslant \frac{64 + 16\alpha^2 + \alpha^4}{16\alpha^2 + \alpha^4}$$

These equations represent conditions which must be met by C_2/C_1 in order that L_2 be a positive inductance. These conditions are shown graphically in Figs. 9, 10, 11 in which the "allowed" region for C_2/C_1 is separated from the "forbidden" shaded region by the above equations in which the equality sign holds, i.e., $L_2 = 0$. The abscissa in these diagrams is α^2, the square of the total dissipation factor.

The above equations represent an upper limit to the ratio C_2/C_1. There is also a lower limit which can be derived, in which the conditions that L_1 be positive are investigated.

(2)—L_1 positive. This occurs if $\lambda_1 \geqq L_3$, or if

$$\frac{1}{C_1^2\omega_0^4}\left\{1 + \frac{1}{8}\alpha_1^2 + \frac{3}{8}\alpha_2^2\right\}^2 \geqslant \frac{1}{C_1C_2\omega_0^4}$$
$$\left\{\frac{\alpha_1^2+\alpha_2^2}{2} + \frac{3\alpha_1^4 + 10\alpha_1^2\alpha_2^2 + 3\alpha_2^4}{64}\right\}$$

or if

$$\frac{C_2}{C_1} \geqslant \frac{32(\alpha_1^2+\alpha_2^2) + 3\alpha_1^4 + 10\alpha_1^2\alpha_2^2 + 3\alpha_2^4}{64 + 16(\alpha_1^2 + 3\alpha_2^2) + \alpha_1^4 + 6\alpha_1^2\alpha_2^2 + 9\alpha_2^4} \qquad (15)$$

This again can be expressed for three special cases:

Primary loading:

$$\frac{C_2}{C_1} \geqslant \frac{32\alpha_1^2 + 3\alpha_1^4}{64 + 16\alpha_1^2 + \alpha_1^4}$$

Secondary loading:

$$\frac{C_2}{C_1} \geqslant \frac{32\alpha_2^2 + 3\alpha_2^4}{64 + 48\alpha_2^2 + 9\alpha_2^4} \qquad (16)$$

Equal loading:

$$\frac{C_2}{C_1} \geqslant \frac{16\alpha^2 + \alpha^4}{64 + 16\alpha^2 + \alpha^4}$$

These results are also presented graphically in Figs. 9, 10, 11 where the lower shaded region represents "forbidden" values of C_2/C_1 in order that L_1 be real.

*The negative solution, not physically realizable, is mathematically equivalent to the transformer with the output winding reversed.

Thus if C_2/C_1 is made to lie within the allowed region, as presented on the diagrams in Figs. 9, 10, and 11, then L_1, L_2, and L_3 will all be physically realizable and the equivalent T or π circuit can be made.

We may illustrate the principles just presented by some typical cases:

A.—*Video coupling transformer.* In a video amplifier one is interested in amplifying frequencies within a band whose low-frequency limit is perhaps 10 cycles and whose high-frequency end is a few mc. One can investigate the possibility of using the transitionally-coupled transformer or its equivalent as a suitable interstage coupling unit. It is convenient to calculate the dissipation factor and design frequency, ω_o, in terms of the upper and lower half-power frequencies which we may denote by f_2 and f_1, respectively. f_2 and f_1 are measured in cycles per second.

From Table II we see that

$$\frac{b_2}{b_1}=\frac{\alpha^4}{16}, \quad \text{or} \quad \alpha = 2\sqrt[4]{\frac{b_2}{b_1}} = 2\sqrt[4]{\frac{f_2}{f_1}} \qquad (17)$$

If $b \equiv b_2 - b_1$, the true bandwidth in units of $\omega_o/2\pi$, then it can be shown that the low-Q approximation gives $b \cong \alpha/2$. Thus

$$b = \frac{b\omega}{\omega_o} = \frac{\alpha}{2} \qquad (18)$$

Since b_1 is small compared with b_2, we may write

$$b \cong b_2 = \frac{2\pi f_2}{\omega_o} \qquad (19)$$

From Eqs. (17), (18) and (19) we obtain the relationship

$$\omega_o = 2\pi\sqrt[4]{f_2^3 f_1} \qquad (20)$$

Values of α and ω_o, determined by Eqs. (17) and (20), are substituted into Eqs. (9) and (10) from which the transformer constants may be derived.

As a specific case let us calculate the constants of a transformer which will couple from the plate of of a 6AK5 pentode into the grid of another 6AK5 pentode. In this case $C_1 = 4.5$ $\mu\mu$f and $C_2 = 7.2$ $\mu\mu$f. Let us further require that $f_2 = 10$ mc and $f_1 = 10$ cycles.

From Eq. (17): $\alpha^2 = 4 \times 10^3$

From Eq. (20): $\omega_o = 1.99 \times 10^6$

From Eqs. (9) and (10): $\lambda_3 = \dfrac{1}{C_1 C_2 \omega_o^4} = 19.6 \times 10^{-4}$

$$\lambda_2 = \frac{3\alpha^2}{8C_2\omega_o^2} = 52.65 \text{ henrys sec. inductance}$$

$$\lambda_1 = \frac{\alpha^2}{8C_1\omega_o^2} = 28.1 \text{ henrys pri inductance}$$

$L_3 = M = 38.5$ henrys mutual inductance

A transformer having these large values of inductance with distributed capacitance small with respect to C_1 and C_2 is clearly not a feasible arrangement in the present state of the art. However, the equivalent of such a transformer can be approximated in one of the derived forms, such as the T. In this case it is necessary to pay attention to physical realizability.

In order to calculate values of L_1, L_2, and L_3 it is necessary to use the exact value for C_2 as given by Eqs. (16) for primary loading.

$$C_2 = C_1\left\{\frac{32\alpha^2 + 3\alpha^4}{64 + 16\alpha^2 + \alpha^4}\right\} \text{ where } L_1 \text{ vanishes} \qquad (21)$$

Substituting this expression into Eqs. (9) and (10) one may derive:

$$L_2 = \frac{1}{C_2\omega_o^2}\left\{\frac{8}{8+\alpha^2}\right\}$$

$$L_3 = \frac{1}{8C_2\omega_o^2}\left\{\frac{32\alpha^2 + 3\alpha^4}{8+\alpha^2}\right\}$$

which for very low-Q ($\alpha \to \infty$) become:

$$L_2 \cong \frac{8}{C_2\omega_o^2\alpha^2} = \frac{1}{2\pi^2 C_2 f_2^2}$$

$$L_3 = \frac{3\alpha^2}{8C_2\omega_o^2} = \frac{3}{8\pi^2 C_2 f_1 f_2} \qquad (22)$$

Since there is no limitation to reducing f_1 to zero, we may consider the circuit under these conditions. Note that $R_2 = \infty$, $L_3 = \infty$, and $C_2 = 3C_1$. Readers will recognize the circuit as one known as series peaking, for which the design equations are the following:

$$R_1 = \frac{1}{4\pi C_1 f_2}$$

$$L_2 = \frac{1}{2\pi^2 C_2 f_2^2} = \frac{8}{3}R_1^2 C_1 \qquad (23)$$

This is a commonly used type of video coupling circuit. The product of gain and bandwidth of such a circuit may be computed, and the improvement factor, F, over a single-tuned (R-C video coupling) circuit may be obtained.

$$F = \frac{\sqrt{3}}{2}\frac{(C_1+C_2)}{(C_1C_2)^{\frac{1}{2}}} \qquad (24)$$

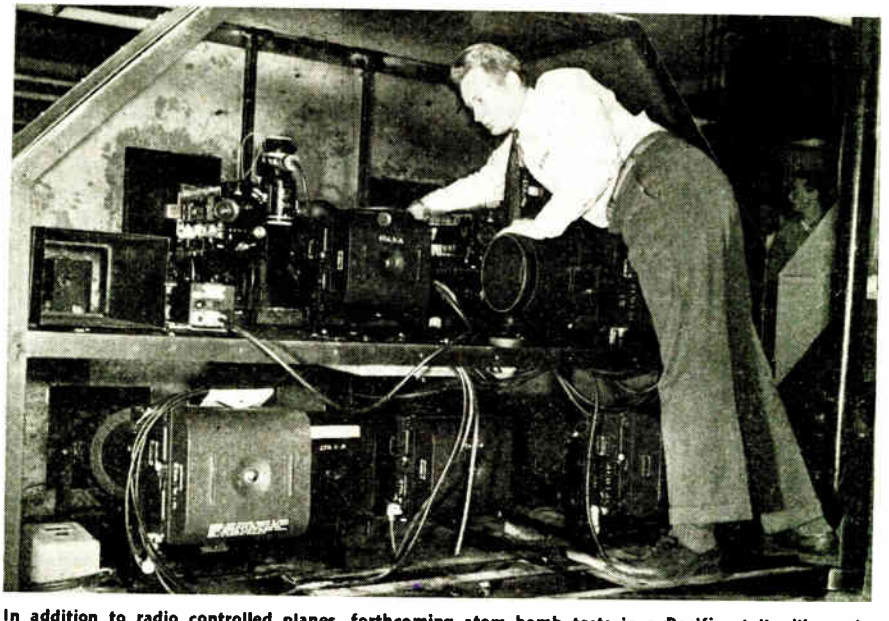
If $C_2 = 3C_1$, as indicated above, the improvement factor is just 2.

While the series-peaked circuit just exemplified has proved to be of considerable value, it represents only one type of video peaking. Other types may be more desirable. It is possible, in fact, to construct other circuits which have better transient response and gain-bandwidth product than the series-peaked circuit just described.

B.—*Interstage if coupling.* A double-tuned transformer or its equivalent makes a very satisfactory if interstage coupling unit. It is not

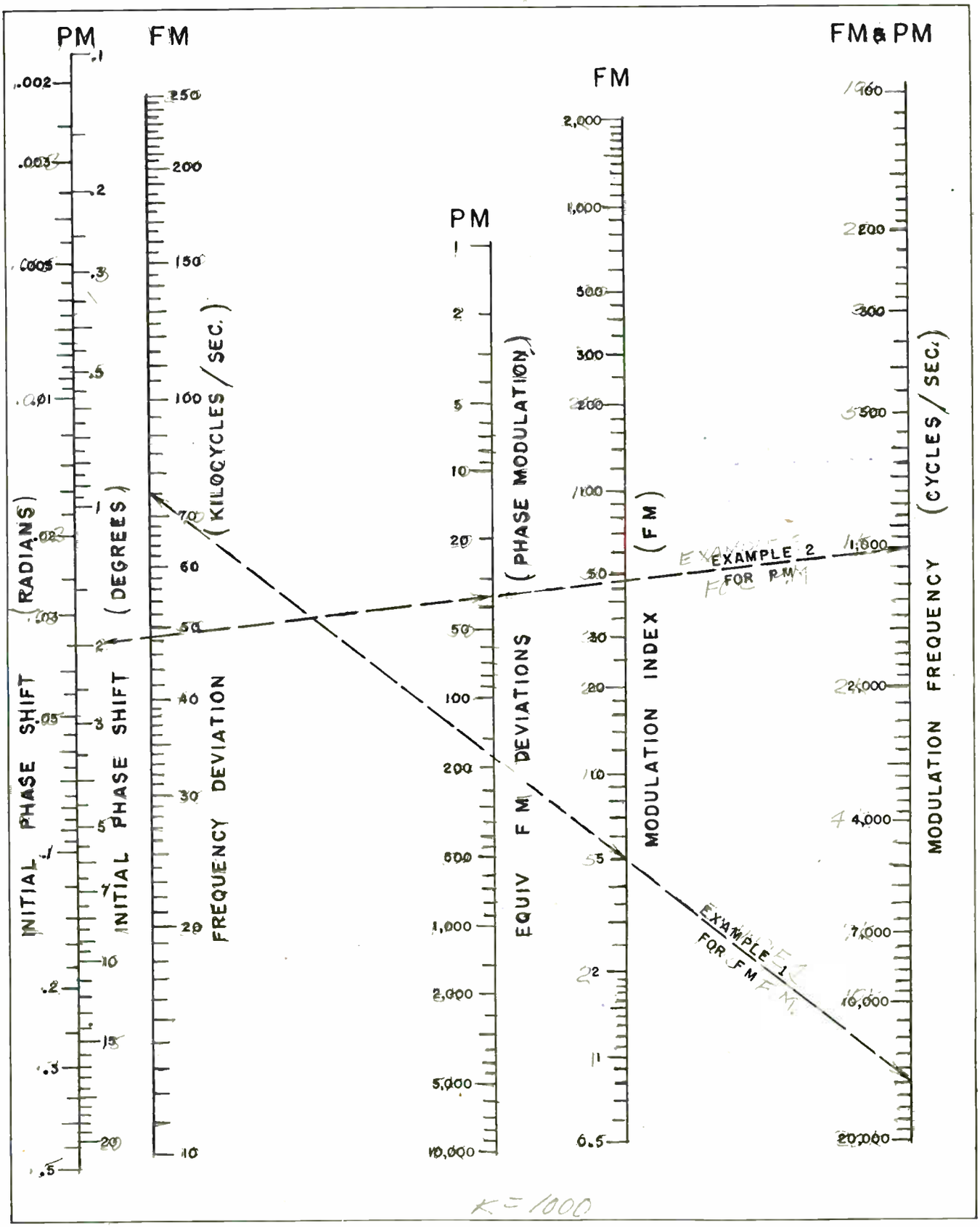
(*Continued on page* 123)

RADIO CONTROLLED CAMERAS FOR ATOM TEST



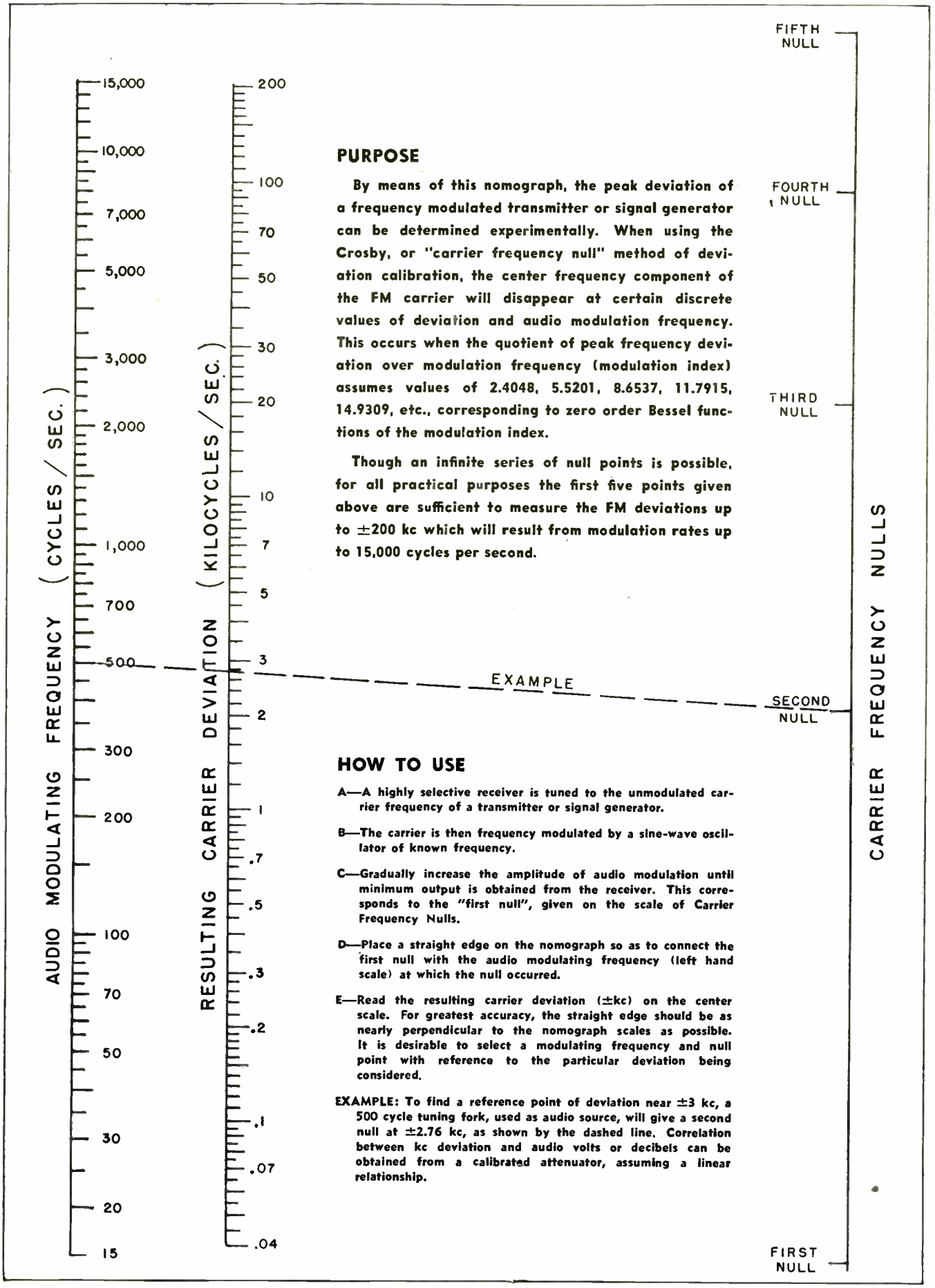
In addition to radio controlled planes, forthcoming atom bomb tests in a Pacific atoll will require radio controlled cameras. This is part of the equipment to be installed by Fairchild Camera and Instrument Corp., on a ring of steel towers around Bikini

FREQUENCY and PHASE DEVIATION



With this chart the modulation index of a frequency modulated signal, or the equivalent FM deviation of a phase modulated signal can be determined in either case on the center scales by the intersection of a line connecting the applied modulation frequency value on the scale at right, with either the phase shift or the frequency deviation scales at the left. EXAMPLE 1 for frequency modulation—15,000 cycles applied audio with a modulation index of 5 gives a frequency deviation of 75. EXAMPLE 2 for phase modulation —1.000 cycles applied audio with an initial phase shift of 2° gives an equivalent FM deviation of 35 cycles. Adjacent scales at extreme left permit use of either radians or degrees

NOMOGRAPH FOR FM DEVIATION



PURPOSE

By means of this nomograph, the peak deviation of a frequency modulated transmitter or signal generator can be determined experimentally. When using the Crosby, or "carrier frequency null" method of deviation calibration, the center frequency component of the FM carrier will disappear at certain discrete values of deviation and audio modulation frequency. This occurs when the quotient of peak frequency deviation over modulation frequency (modulation index) assumes values of 2.4048, 5.5201, 8.6537, 11.7915, 14.9309, etc., corresponding to zero order Bessel functions of the modulation index.

Though an infinite series of null points is possible, for all practical purposes the first five points given above are sufficient to measure the FM deviations up to ±200 kc which will result from modulation rates up to 15,000 cycles per second.

HOW TO USE

A—A highly selective receiver is tuned to the unmodulated carrier frequency of a transmitter or signal generator.

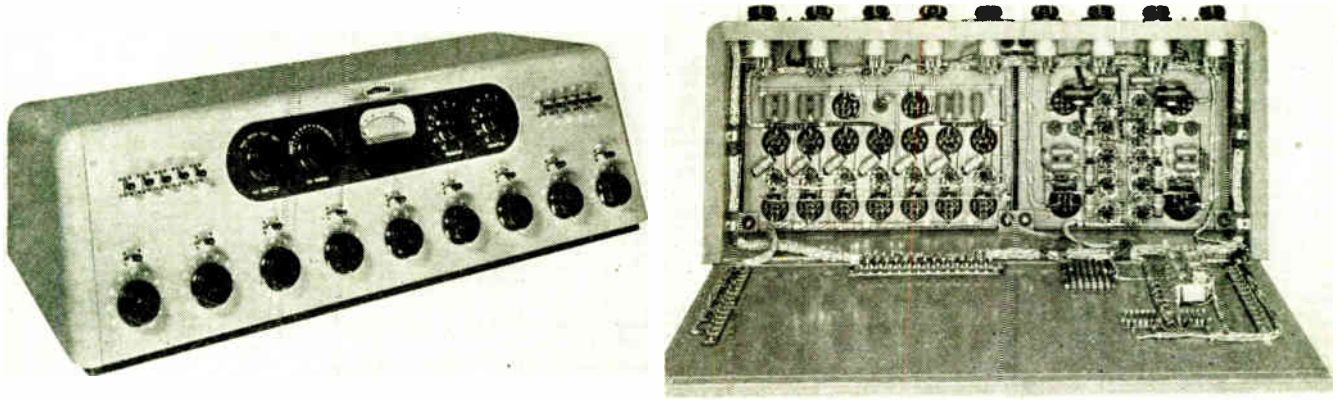
B—The carrier is then frequency modulated by a sine-wave oscillator of known frequency.

C—Gradually increase the amplitude of audio modulation until minimum output is obtained from the receiver. This corresponds to the "first null", given on the scale of Carrier Frequency Nulls.

D—Place a straight edge on the nomograph so as to connect the first null with the audio modulating frequency (left hand scale) at which the null occurred.

E—Read the resulting carrier deviation (±kc) on the center scale. For greatest accuracy, the straight edge should be as nearly perpendicular to the nomograph scales as possible. It is desirable to select a modulating frequency and null point with reference to the particular deviation being considered.

EXAMPLE: To find a reference point of deviation near ±3 kc, a 500 cycle tuning fork, used as audio source, will give a second null at ±2.76 kc, as shown by the dashed line. Correlation between kc deviation and audio volts or decibels can be obtained from a calibrated attenuator, assuming a linear relationship.



Two views of the Raytheon broadcast studio console, the front with its controls for two studios and for control room announce microphone, two transcription turntables and 14 incoming lines; and the back showing accessibility, method of wiring and the seven pre-amplifiers

TWO-STUDIO CONSOLE

Simultaneous auditioning and broadcasting from any combination of studios and other sources provided for

● Increasing demand for higher quality audio transmission requires apparatus having a wide response range. In addition such equipment must include a means for gaging the true quality of transmitted programs, especially in FM stations. The new model RC-10 studio console produced by Raytheon Mfg. Co., Chicago, has many useful features and provides a modern, compact, flexible, wide range speech input system adaptable for use in both AM and FM broadcasting.

In a typical installation, for example, the unit has facilities to handle two studios, a control-room announce microphone, two transcription turntables and 14 incoming lines. Provision is made for the simultaneous auditioning and broadcasting from any combination of the studios, turntables or remote lines.

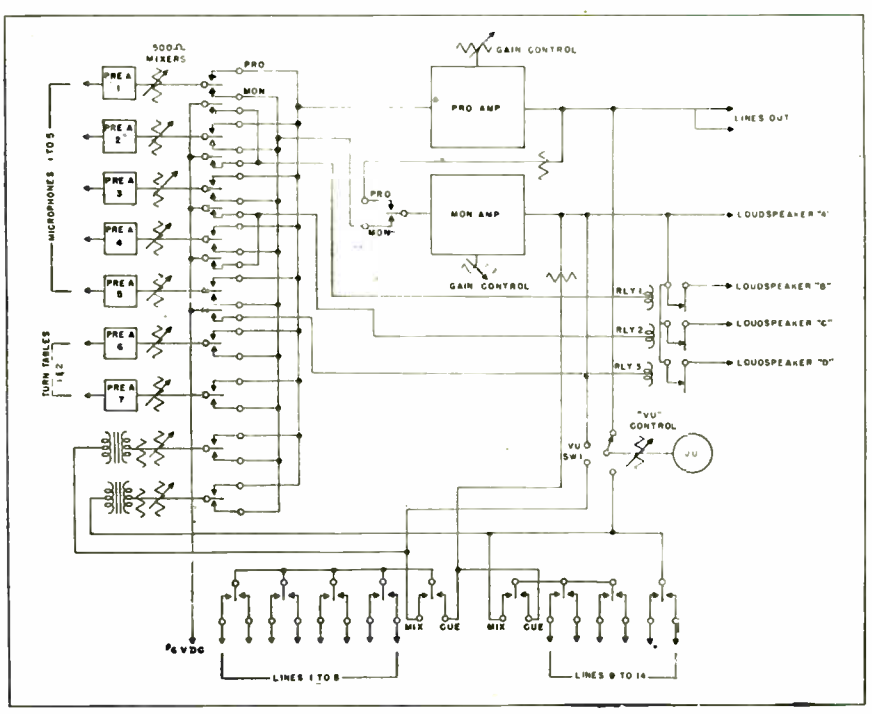
A single all metal console is used as a housing for the amplifying and control equipment. The dual power supply for the speech input console is mounted in a separate wall cabinet. The functions and arrangement of the various circuits are shown in the block diagram.

The console is made up of seven pre-amplifiers, one program amplifier and one monitoring amplifier. A nine-position mixer system is utilized to provide complete control of the seven pre-amplifiers as well as two remote circuits. Three-position lever action keys are used in the output of each mixer so that it may be switched to the input of the program amplifier for auditioning purposes. The five microphone switches are interlocked to three loudspeaker cut-off relays. This prevents operation of speaker B, C, or D in any studio where there is a live microphone, but facilitates cueing by allowing the performers to hear the close of the program preceding their own. Pre-amplifiers number 6 and 7 are normally used as transcription turntable input amplifiers. They may be used for microphone input use.

The program amplifier provides a high gain, low distortion, low noise level amplifier or feeding the transmission line to the transmitter location point. The monitor amplifier has a maximum output of approximately 8 watts. With the monitor input switch connected to the program output line through a

(*Continued on page* 129)

Schematic wiring diagram of the Raytheon console arranged to show the versatility of the unit and the manner in which various connections are set up with flip switches



FEEDING COMBINED FM

By WILSON PRITCHETT
Radio Engineer, E. F. Johnson Co., Waseca, Minn.

Basic types of circuits designed to eliminate possibility of shorting FM power or permitting crosstalk from AM feedback

● Installation of a frequency modulation antenna on top of a base-insulated standard broadcast tower antenna introduces the problem of feeding the FM power across the base insulator without short-circuiting the latter at the frequency or permitting the AM to pass back through the FM feed line to the FM transmitter and causing crosstalk at the FM frequency.

In addition, standard broadcast stations already in operation are required to submit data to the FCC regarding the effect of the FM antenna and associated equipment on the AM base impedance and field pattern. This is because the addition of an FM antenna may change the height or cross-section of the AM antenna. This alone may change the base impedance. The presence of the coupling circuit may also produce a change. Finally, erection of a tuning house very near the base may change the impedance. These changes in the base impedance of the AM tower may necessitate readjustment of the FM antenna feeding system.

Coupling schemes

In new installations of both FM and AM coupling equipment the impedance change can be incorporated in the design specifications of the AM coupling unit. Also both units can be placed in the same tuning house and for a certain type of circuit both units may use a common line to excite the two antennas.

Several possible methods of accomplishing this will be discussed together with their influence on both the AM and FM systems. Three basic types of circuits will be considered. The first two will be briefly described. The third circuit based on coupling schemes originated by A. Alford, has been commercially developed by the writer and will be treated in more detail.

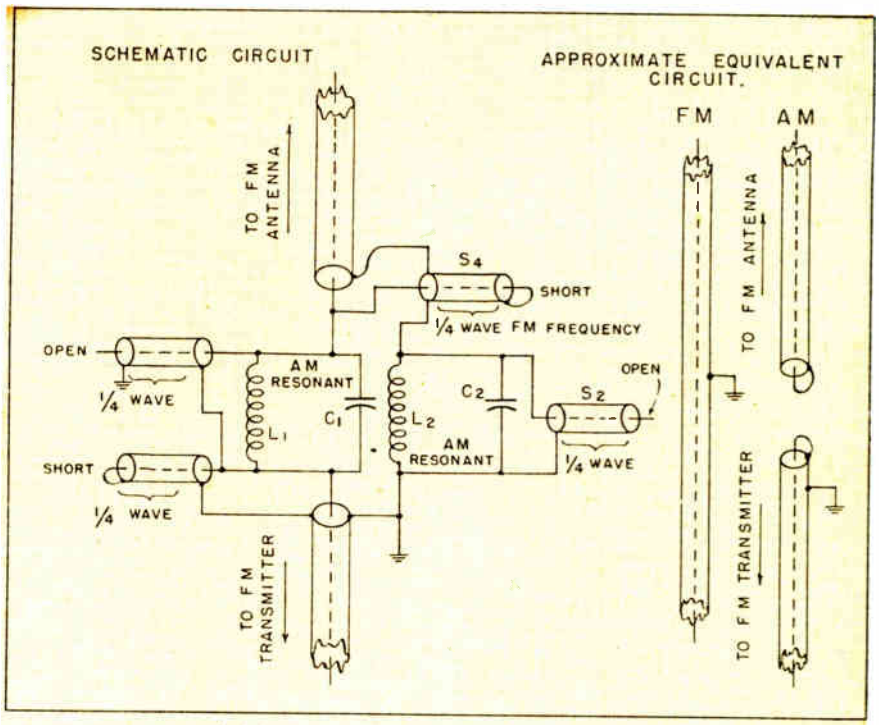


Fig. 1—Frequency modulation antenna coupler using quarter-wave lines at the FM frequency

The first method uses direct coupling of the FM line from the transmitter to the line passing up the tower by means of open-circuited and short-circuited lines ¼ wavelength long at the FM frequency.[1] Open-circuited ¼ wave lines are used to join the corresponding conductors of the FM transmission lines. A short-circuited ¼ wave line bridges the output end of the FM line from the transmitter to prevent AM power from passing back toward the FM transmitter. Inductors and capacitors form parallel resonant circuits at the AM frequency with the open-circuited lines across which they connect.

The sketches of Fig. 1 show a schematic circuit including the ¼ wave lines and their approximate equivalent circuits at the two frequencies of interest. Two modifications of the Taylor scheme are incorporated, namely, grounding the end of the external conductor of S_1, and adding short-circuited ¼ wave line, S_4, connected across the output line. The purpose of the ground on S_1 ¼ wavelength from its input end is to prevent its shell from behaving as a large admittance shunting the input line. The purpose of S_4 is to prevent the development of spurious voltages across the output line.

The second method carries the FM transmission line directly through a circuit offering a high impedance to the AM frequency. This is done by winding the FM line in the form of an inductor which is tuned to anti-resonance with a capacitor. Another method for obtaining the same result is to insulate the FM line for a distance up the AM tower equal to ¼ wave at the AM frequency. At this point the line is securely connected to the tower. Another modification which

[1]John P. Taylor, "FM Antenna Coupler", Electronics, August 1945, p. 107.

and AM ANTENNA ARRAYS

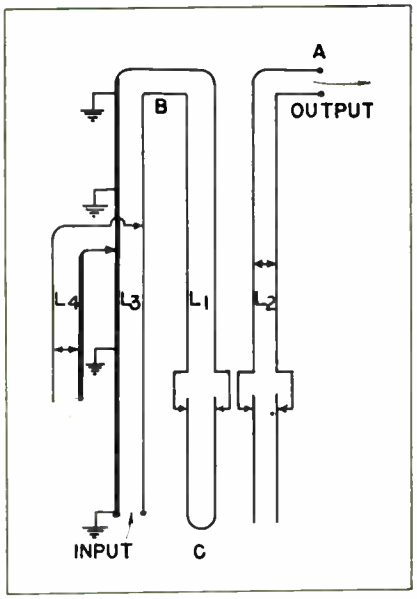


Fig. 2—Schematic circuit of FM antenna iso-coupler using coupled transmission lines

can be used is to carry the line out parallel to the ground a distance of ¼ wave and then ground it. Under certain conditions less than ¼ wave can be used and the line tuned to anti-resonance with a capacitor.

The limitation of this method is the attenuation present in a line of suitable size for winding. The disadvantages of the insulated line are the necessity for a line nearly ¼ wave long below the FM antenna and the cost of installation and maintenance of the insulation. These disadvantages are especially significant at the lower broadcast frequencies.

The third method makes use of a pair of electromagnetically coupled transmission lines.[2] The input section is fed from the transmitter and the output section is connected to the transmission line passing up the tower to the FM antenna. The spacing between the coupled sections is designed to withstand the voltage at the base of the AM antenna.

Adjustment of the section lengths and of the location of a shorting bar and an adjustable stub line provide means for making an impedance match with the line extending back to the transmitter. In addition, they permit elimination of stray FM fields about the coupling unit. Use of short-circuited coupling sections and a matching stub eliminate AM voltages across the FM lines. The system couples the FM lines and at the same time isolates the AM and FM systems. The sketch of Fig. 2 shows a schematic of the adjustable coupling sections, the matching sections, the adjustable stub and shorting bar.

This scheme has been applied in the production of a coupling unit shown in Fig. 3 and called an FM iso-coupler.

The coupling sections in the center are made from ⅞ in. O.D. copper tubing with adjustable ends. In Fig. 3, the tubing nearest the base plate is L_1 in Fig. 2 and is the input section which is connected to the upper end of the matching section (L_3) to the left. The tubing mounted farthest from the base plate is the output section (L_2 of Fig. 2) which connects to the FM transmission line passing out of the tuning house and thence up the tower. The adjustable short-circuiting bar in the output section is seen near the middle of the section.

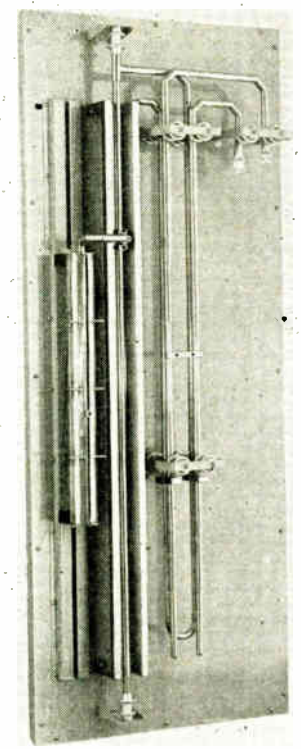


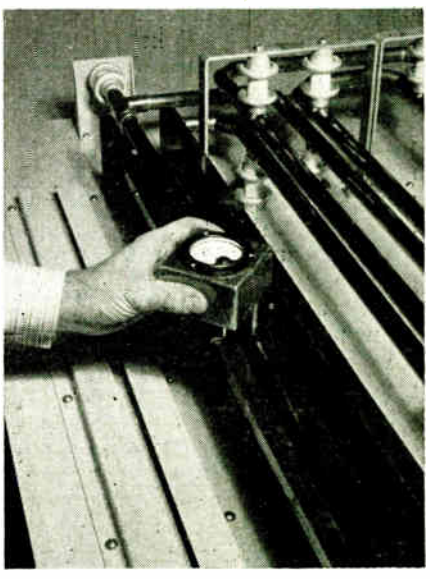
Fig. 3—Photograph of FM antenna iso-coupler showing coupled transmission lines, matching section and stub line

The matching section (L_3 of Fig. 2) consists of a ⅞ in. tube within a rectangular copper duct open on the top side. The dimensions of this section are such that it has the same characteristic impedance as that of the input line from the transmitter. The opening permits the adjustable stub line on the extreme left to be connected to the matching section at any point. The open construction of the matching section permits easy measurement of the standing waves before and after the stub has been connected and adjusted. The photograph (Fig. 4) shows the voltage standing wave ratio measuring instrument in place for measuring the standing wave ratio. All parts are mounted on the heavily copper-coated base plate as shown.

The area to the right of the output section in Fig. 3 provides space for mounting additional circuit elements that may be required in a particular installation. In existing installations an inductor for anti-resonating the capacitance introduced by the coupling unit is needed. This inductor is of the hollow copper tubing type to permit pressurizing the antenna line.

Five FM adjustments are possible as shown in Fig. 2. The only adjustment necessary is of the pressurized inductor connected between the shell of the antenna line and ground. Since the only purpose of the inductor is neutralization of the stray capacitance, it is adjusted after all FM adjustments are complete. The initial FM adjustments are made with the stub L_4 discon-

Fig. 4—Photograph of voltage standing wave ratio instrument measuring relative voltage at 100 mc on matching section of FM antenna iso-coupler



[2]Andrew Alford, "Coupling Networks in Radio-Frequency Circuits", Proc. IRE Feb. 1941, p. 55.

nected from the matching section L_3 and power off.

The lengths of the input and output sections, L_1 and L_2 are to be set to ½ wavelength at the operating FM frequency. Since in the design shown, the supporting insulators contribute approximately 3 mmf each of capacitance, loading the length is shortened as shown in Fig. 5. The distances are measured from the upper end of the duct at point B in Fig. 2 to the extreme lower end of the sections. The input section L_1 is adjusted to ½ wavelength so that its input impedance will be high. This high impedance prevents longitudinal excitation as an antenna by the small

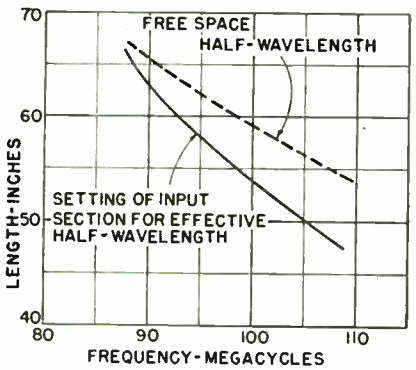


Fig. 5—Graph showing the effect of supporting insulators on effective half-wavelength of input section

voltage drop due to the unbalanced currents flowing at B. As a result the open end at C is practically at zero potential with respect to ground and no significant stray fields result.

The next adjustment is that of the shorting bar on the output section L_2. This is done with a small amount of FM power fed into the lower end of L_3 and with the antenna and its line connected to point A. If the antenna does not exactly match the line standing waves will be present and the impedance as seen from A may be different from the characteristic impedance of the line. The adjustment of the shorting bar on L_2 usually will locate it near the middle of the line. When the standing wave instrument indicates a minimum standing wave ratio as it is moved along L_3 the shorting bar adjustment is correct.

In practice the adjustment is rather broad with the higher load impedances at A resulting in placing the bar toward the open end. As a refinement, the length of the output sections may be changed very slightly with alternate adjustments of the shorting bar until a

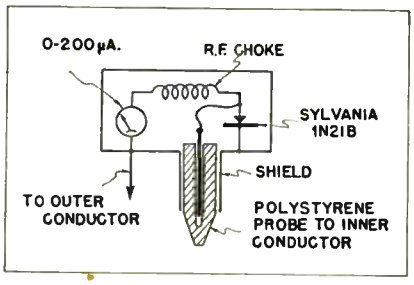


Fig. 6—Sketch of internal arrangement of voltage standing wave ratio instrument of Fig. 4

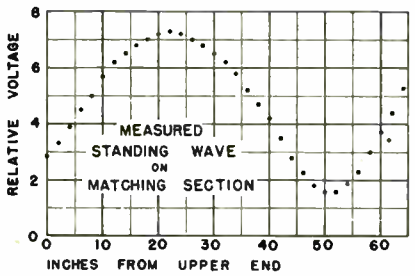


Fig. 7—Plot of relative voltage values of a standing wave measured on the matching section with VSWR instrument of Fig. 4

minimum ratio is obtained. Tests with the instrument shown in Fig. 4 show that a ratio from 2 to 4 will be obtained. In no case should the length of L_1 be changed once its adjustment is made for the FM frequency.

Standing wave rates

From the value of the voltage standing wave ratio (VSWR) and its location, the position of the stub L_4 and its short-circuiting plug may be determined.[3] A correction must be made for the stray inductance of the connecting lugs and amounts to about 7 in. of line. After these adjustments are made, a check can be made of the residual VSWR below the point where L_4 joins L_3.

A sketch of the VSWR instrument is shown in Fig. 6. The design of this instruments is such that its effect on the standing wave[4] is practically negligible as shown by the symmetry of a standing wave measured by it in Fig. 7. The values of the ordinates were obtained from readings in conjunction with the calibration curve of the VSWR instrument shown in Fig. 8.

The crystal has approximately a square law characteristic at the upper end as seen in Fig. 8 but its characteristic becomes almost cubic at the lower end. This effect permits detection of a small change in voltage. However, it becomes necessary to read the low deflections rather carefully.

Resistive dummy loads ranging from about 20 ohms up to about 400 ohms were connected across the output section at point A in Fig. 2 and power was fed at a number of frequencies within the present 88 to 108 mc FM band. It was possible to adjust the lengths and the position of the shorting bar on L_2 to yield a VSWR below 4 on L_3. Placement and adjustment of the stub line L_4 reduced the residual ratio to approximately 1.1 in the lower part of the matching section.

The input capacitance between point A and ground of Fig. 2 was 105 mmf with L_1 and L_2 extended for 88mc operation. A thermoammeter having a range up to 25 amperes was connected between point A and the output of a high power radio frequency source. The tests gave an initial spark-over between L_1 and L_2 at 18 amperes loading and a consistent final repeated spark-over at 21 amperes for a frequency of 2 mc. These spark-over currents correspond to about 19 and 22 kv peak between the output section L_2 and ground respectively.

Voltages of this magnitude are well in excess of any that will be found at the base of practical 50 kw tower antennas.

[3]F. E. Terman, Radio Engineers Handbook, p. 189.
[4]Altar, Marshall and Hunter, "Probe Error in Standing-Wave Detectors", Proc. IRE, Jan. 1946, p. 33.

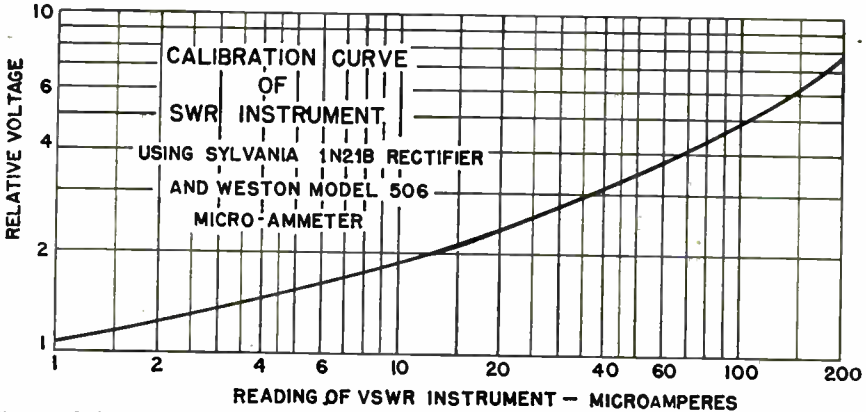


Fig. 8—Calibration of VSWR instrument of Fig. 4 showing characteristic of crystal rectifier

FM SYSTEMS ENGINEERING

By RALPH R. BATCHER
Consulting Editor, Electronic Industries

Analyzing the various commercial methods that have been developed to accomplish frequency modulation of an RF carrier

(See Systems Chart Supplement With This Issue)

● There are numerous types of FM circuits used in the transmitters developed for regular broadcasting service and for special two-way communication purposes, such as police radio, railroad services, etc. The general purposes of the circuit arrangements of some of these are listed on the chart in this issue.

The actual methods used to accomplish frequency modulation of the rf carrier, may be classified as (1) direct FM and (2) indirect FM (produced by means of phase modulation and its subsequent transformation to FM).

Direct FM is accomplished by a system consisting essentially of a self-excited oscillator, the operating carrier frequency of which may be altered simply by variation of the tank circuit constants. Examples of this method are used by the RCA, Federal, Westinghouse, Western Electric, etc., arrangements shown on the chart.

Center frequency stability

It is evident that although the momentary change in frequency may be quite large, it is necessary that the center or rest frequency be stabilized quite accurately, since any slow or permanent shift would result in an unbalance in the push-pull effects in the audio system in the receiver, with a consequent increase in the harmonic distortion. Thus two main problems are encountered in the design of a transmitter—producing the shift in frequency in accordance with the audio signal and maintaining a stable center frequency.

A common method uses a reactance tube modulator, which makes use of the frequency shift in a self-excited oscillator that occurs when any of its operating parameters are altered. Specifically, the oscillator tank circuit is altered a definite amount by reason of a change in a shunting impedance produced by the plate impedance of a pair of screen-grid modulator tubes. These tubes are biased in such a way that their combined plate impedance (the current in which is shifted in phase so as to simulate a reactance) will vary in accordance with any audio frequency voltage impressed on their grids. All of the factors in this system are set to produce a linear modulation of the oscillator frequency.

Reactance tube

In the reactance-tube modulation method a considerable frequency deviation can be obtained with good linearity and a comparatively small amount of frequency multiplication is needed to secure the desired frequency deviation of the transmitter carrier at the output terminals. As an illustration, one may consider the frequency deviation required in the master oscillator of an FM transmitter delivering 100 watts of power to an antenna system at a center frequency of 95 mc with a maximum frequency deviation of ± 75 kc.

Under these conditions, using the process of direct FM, the master oscillator could be conveniently adjusted to a center frequency of 5.277 mc followed by one doubler and two tripler cascade operated stages (total multiplication 18) to deliver a 95 mc output frequency to the power amplifier stage of the transmitter. In this case, a multiplication factor of 18 in the cascade stages between the master oscillator and the antenna or output circuit would require a master oscillator deviation of 75/18 kc or 3166.6 cycles for full "modulation".

Since it is essential that the center frequency shall not drift and cause interference with signals on adjacent channels, or require continuous retuning of the FM receiver, frequency stabilizing is needed.

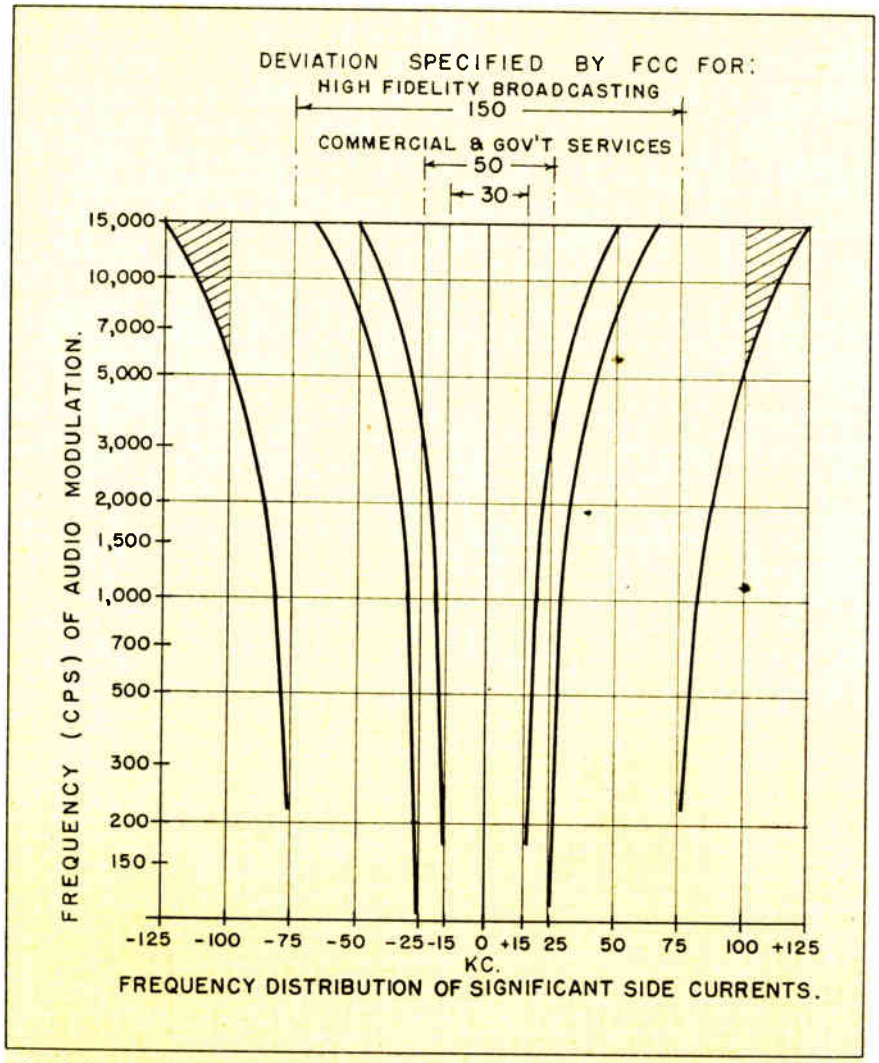
FM phase shift

The "indirect" or Armstrong method of producing FM, starts with a crystal controlled oscillator the output of which is directed along two paths to a heterodyne mixing circuit. One path is through a network which shifts the phase of the oscillator output by 90°, and then through a balanced amplitude modulation circuit which reproduces the sidebands while suppressing the actual carrier as generated by the oscillator. The second path is direct from the crystal oscillator to the mixer.

The combination of the two signals from the paths mentioned produces a resultant wave that is retarded and advanced in phase by a shift that may reach 30° from the median value. This method of modulation results in phase modulation. The frequency of the modulation signal has no part in this process except to determine the number of times per second this phase departure is made. Therefore, to transmit one amplitude cycle of a single tone, the carrier frequency will advance in phase from zero up to some other value, say 20°, drop back to zero and then go through a retardation of 20°, and back to zero. This excursion would be only 10° each way with a weaker tone and might be 30° with the strongest audio signal handled. It is usually found that a phase shift in excess of 30° creates non-linearity.

The process of conversion from phase modulation to FM requires a compensation in the amplitude of the audio input voltage if FM is to be produced having a constant ratio

FM BANDWIDTH VS. SWING



Actual bandwidths required for various swings of frequency in FM transmission are shown. Heavy lines enclose frequency space required for all Fourier analysis side currents whose amplitude is 1% or more of the signal. Where, for example, the 8th side current is over 1% and the 9th less than 1%, interpolated values have been used to keep the curves smooth. The cross-hatched portion shows the extent to which significant side currents fail to come within the 200 kc clear channels specified for broadcasting. Where 40 kc or 60 kc channels are allowed for police and point-to-point services the same effect may be seen by noting when the 15 and 25 kc swing lines cross the channel width lines.

of frequency deviation to volume over the audio range used. This is because the phase shift produced is proportional to the amplitude of the audio input signals that are applied to the phase modulator.

In pure phase modulation, the number of upper and lower sideband currents depends on the $\Delta\ \theta$ shift, and therefore only on the audio volume level. Thus a 50-cycle and 10-kc audio tone of the same amplitude will produce the same number of sideband currents. However, in the latter case, the upper and lower sideband currents will be 200 times further away from the center frequency than in the 50-cycle case. Thus the bandwidth required for PM changes as the audio frequency, while in direct FM the bandwidth is determined by the audio volume level only.

For this reason, a corrective network is applied to the audio circuits ahead of the modulator to provide an audio input amplitude which is inversely proportional to the frequency of that signal. This addition, called predistortion, is necessary to insure a constant transmitter frequency deviation over the entire frequency range of the audio input signal for a given audio level. Omission of the compensating network in the audio input circuits has the result of unduly emphasizing the higher audio modulating frequencies. The compensated PM (indirect FM) becomes equal in all characteristics to direct FM.

The RCA transmitters utilize a variation of the reactance tube modulation system with simpler multiplication and fewer tubes. The modulation circuit and the center frequency correction circuit are entirely independent. The latter is established by a motor-driven trimmer capacitor connected to the oscillator tank circuit. This motor has a two-phase winding operated by the amplified beat frequency signal obtained by heterodyning a subharmonic of the master oscillator frequency with the frequency of the standard crystal oscillator. The RCA radio frequency amplifier stages utilize the grounded grid system of connections which simplifies neutralization, permits greater tube output and has effective operating characteristics in the 100 mc range.

Stabilization control

The Federal Telephone & Radio Co. has disclosed an arrangement used in their transmitters that produces direct FM featuring an all-electronic center frequency stabilization control and modulator unit. The arrangement uses standard receiver type tubes and has only two tuned circuits. The resulting center frequency variance keeps well within the FCC limit. The method used compares the relative phase of the modulated oscillator with that of a crystal in a phase discriminator using submultiples of the oscillator frequency. A division of 256:1 by multivibrator stages reduces the maximum phase shift of 6100° at the master oscillator to 24° at the discriminator, keeping the system within the control range of the phase discriminator. The sinusoidal voltages applied to the discriminator result from passing the multivibrator voltages through a low-pass, high Q filter.

The rate of frequency deviation is not affected by simultaneous division of phase and frequency. The output of the phase discriminator is passed through a high impedance low-pass filter which permits only those frequency variations that are less than ten cycles to effect control. These voltage variations are applied to the grid of the modulator, which operates on the "Miller effect" principle. The frequency of the master oscillator is adjustable from 3.66 to 4.5 megacycles followed by sufficient frequency multipliers and amplifiers to reach the desired operating frequency and power. Federal is building transmitters of 250 watts, 1 kw, 10 kw, and 50 kw power output.

Modulation in the Western Electric transmitters is accomplished by

the reactance tube method. Automatic regulation of the carrier frequency is accomplished by an induction motor drive to the tuning capacitors in the modulated oscillator. The output of the reference crystal oscillator and the output of the frequency divider chain are combined in a motor control circuit. Inertia of the motor armature prevents motor response to rapid variations at the modulating frequency.

A rotating electric field set up in the motor whenever the carrier and reference frequencies differ, causes the motor to rotate in a manner which will correct the master oscillator frequency.

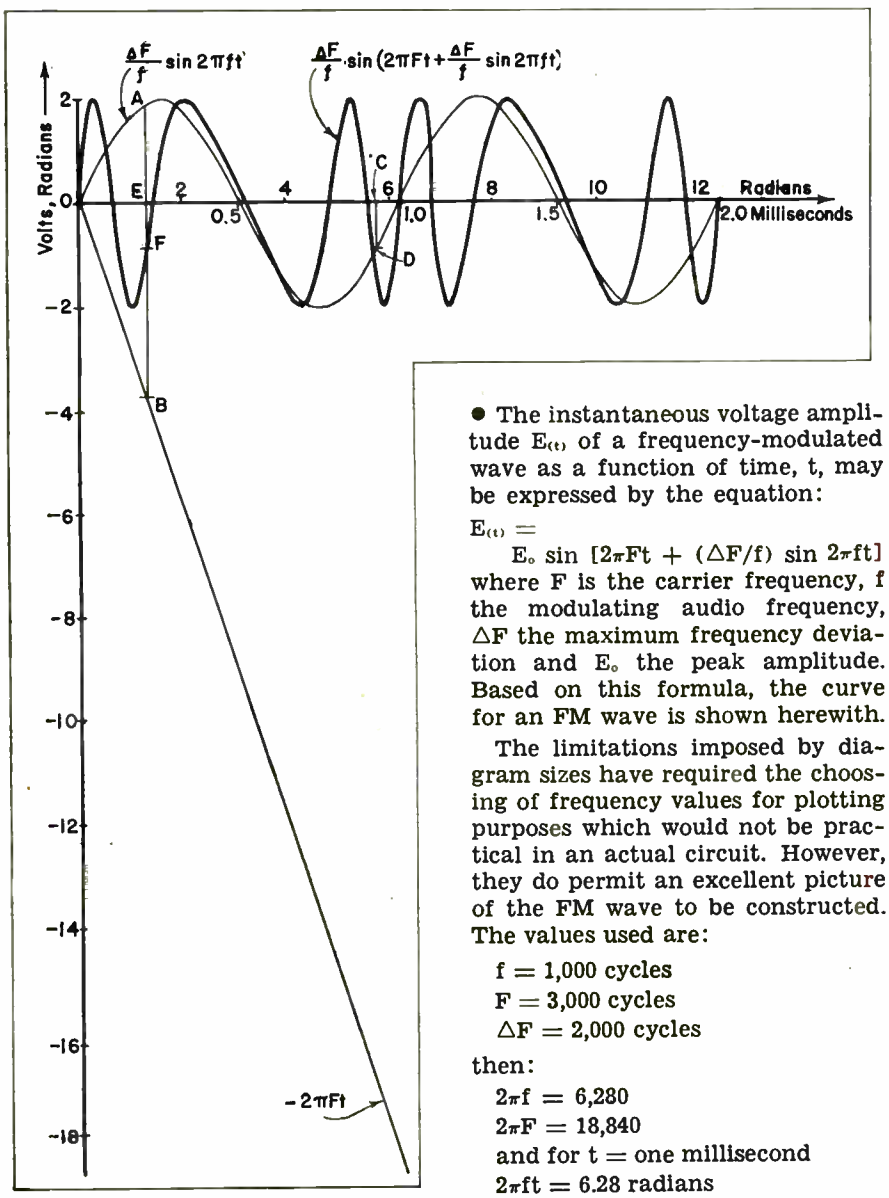
In a particular example for a carrier frequency of 99.3 mc, the reference crystal oscillator frequency would be 6060.79 cycles. Low frequency crystals of X-cut duplex (flexural mode) structure vary less than 25 cycles per megacycle for an ambient temperature range of 40° to 130° F. At the frequency of the required oscillator, the range of frequency variation is less than 0.15 cycle. Since the transmitter frequency is 16,384 times the crystal frequency, a total frequency variation of less than 2,457 cycles results. This being well within the FCC regulation of 4,000 cycles, temperature control of the crystal is unnecessary. Western Electric's transmitter line will include 1, 3, 10, and 50 KW power output equipments.

The frequency control system used in the Westinghouse transmitters is an adaptation of the pulsed circuit technic of wartime radar to FM broadcasting. A push-pull master oscillator operating at one-ninth of the carrier frequency, is modulated by the audio signal. The reference crystal oscillator is at 1/18th of the carrier frequency. The second harmonic of this oscillator is applied to two fixed phase shifting circuits to obtain two reference frequency signals 90° apart in phase.

The beat notes, which occur when the master oscillator operates above and below the carrier frequency, are

(*Continued on page* 130)

Point-by-Point Construction of FM Wave



Plot of frequency-modulated carrier constructed as outlined in accompanying text

● The instantaneous voltage amplitude $E_{(t)}$ of a frequency-modulated wave as a function of time, t, may be expressed by the equation:

$E_{(t)} =$

$E_o \sin [2\pi Ft + (\Delta F/f) \sin 2\pi ft]$

where F is the carrier frequency, f the modulating audio frequency, ΔF the maximum frequency deviation and E_o the peak amplitude. Based on this formula, the curve for an FM wave is shown herewith.

The limitations imposed by diagram sizes have required the choosing of frequency values for plotting purposes which would not be practical in an actual circuit. However, they do permit an excellent picture of the FM wave to be constructed. The values used are:

$f = 1{,}000$ cycles
$F = 3{,}000$ cycles
$\Delta F = 2{,}000$ cycles

then:

$2\pi f = 6{,}280$
$2\pi F = 18{,}840$
and for t = one millisecond
$2\pi ft = 6.28$ radians
$2\pi Ft = 18.84$ radians

The FM curve was constructed by the following steps:

1.) Draw the sine curve $y = (\Delta F/f) \times \sin 2\pi ft$. Care must be taken to choose equal radian scales for both x and y axis.

2.) Draw a straight line representing the function $y = -2\pi Ft$.

3.) To obtain the sum $2\pi Ft + (\Delta F/f) \sin 2\pi ft$ measure the vertical distance A—B between the sine curve and the straight line at any point E of the x-axis.

4.) We now require the value of the sine whose argument is the distance A—B. Having chosen abscissa and coordinate scales identical (see point 1) we may find this sine value by using the original sine wave curve. The distance A—B is laid off on the x-axis to obtain point C. The value of the sine at this point C, or the vertical height C—D, is the desired value of the function $y = (\Delta F/f) \sin [2\pi Ft + (\Delta F/f) \sin 2\pi ft]$ at the point E.

5.) Find point F by laying off distance C—D from E on a straight line parallel to the y-axis.

By basing the construction of the FM curve on the sine curve of amplitude $\Delta F/f$, the FM wave will be of this amplitude. Any desired amplitude can be obtained by appropriate choice of another basic sine wave not identical with the audio wave.

The graph illustrates the extreme irregularity of a frequency-modulated wave. In the particular example the FM wave is periodic with a period equal to the period of the audio wave. However, this is purely accidental and due to the choice of the carrier frequency as an exact multiple of the audio frequency.—J.Z.

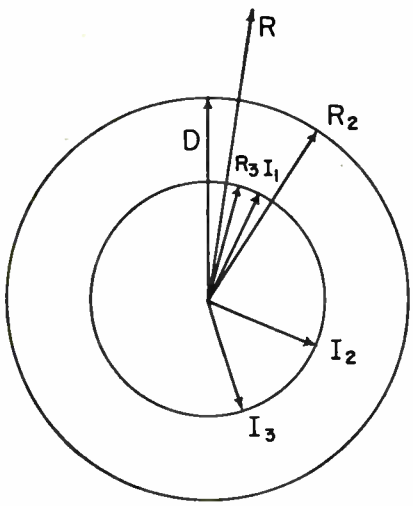
LARGER FM CARRIER

By H. GREGORY SHEA
Associate Editor, ELECTRONIC INDUSTRIES

A simple explanation making easily understandable the reason why a strong signal "takes control" of a receiver

• One of the important and highly useful features of FM is the ability of a receiver to reject to a high degree a weak carrier in favor of a stronger one. In AM sets, as is well known, two carriers of identical frequency or whose frequencies are within audio range interfere with each other in proportion to their respective signal strengths. Only sharpness of tuning can be depended on to discriminate between a wanted and an unwanted signal, and if the two are of the same or almost the same amplitude and frequency, no separation is possible.

The situation is quite different in an FM receiver. Two carriers of the same center frequency can be separated by a receiver provided only one of them has a greater amplitude than the other. The action causing this has been described quite at length in the literature[1].



Desired (D), interfering (I_1, I_2, I_3) and resultant vectors (R_1, R_2, R_3)

An interesting point however is this: Suppose an automobile with an FM set is traveling in a region where signals are available from two stations of the same center frequency and approximately the same amplitude. What happens to cause the receiver to discriminate between the two? If the stronger carrier becomes the weaker due to some cause such as fading, why will the receiver not receive both for a time instead of suddenly shifting from one to the other?

To understand this action, refer to Fig. 1 in which D is the desired signal vector and I is the interfering signal vector. While both vectors are spinning with their respective angular velocities, it is only the relative motion which interests us and so we can for the moment consider the vector D as fixed and the vector I as spinning at a rate determined by the frequency $F_D - F_I$, the difference between the two.

In the figure the resultant vector R, the sum of D and I has been drawn for three positions of I, labeled 1_1 I_2 and I_3. It may be seen that while I turns almost 180°, R swings about 30° toward the horizontal and then turns back, R_3 making a smaller angle with D than does R_2.

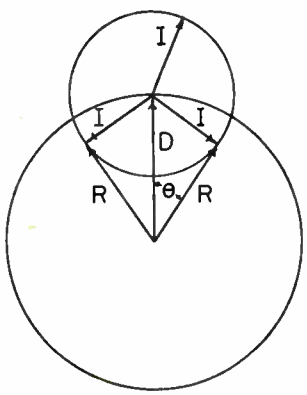


Fig. 2—Resultant phase flutters about D

This can be shown more conveniently by the diagram of Fig. 2 in which the vectors I have been drawn from the end of D instead of from the origin. In this figure, the extreme out-of-phase position of the resultant is shown to occur when R is tangent to the small circle.

The angle for which this occurs evidently is the angle whose sine is I/D. In Fig. 3 the size of the interfering vector I has been increased to the point where it is equal to D. The angle now fluctuates from +90° to —90° and the magnitude of R from D+I to 0. At this point the resultant vector R is about to shift from its oscilliatory motion about D to a rotary motion about D with an average angular velocity equal to that of I. This is shown in Fig. 4 where I has been drawn larger than D.

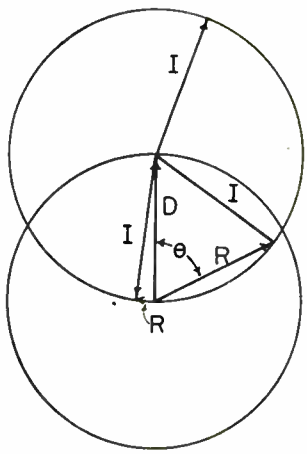


Fig. 3—As I increases, so does phase flutter θ

Fig. 4 has been rearranged in Fig. 5 by moving the small circle down so its center is on the edge of the I circle. That is, the vector D is drawn from the end of I instead of vice versa and it is seen that the result is the same as in Fig. 2 except that the circle positions have been reversed. I is now the vector about which the resultant R flutters in phase and to whose angular velocity R is tied. Hence the receiver, which always is actuated by the resultant, now in-

[1] "Interference Problems," John H. Bose, ELECTRONIC INDUSTRIES, April, 1945, pp. 91.

SUPPRESSES SMALLER

terprets the frequency fluctuations of the interfering signal I because it has become the larger.

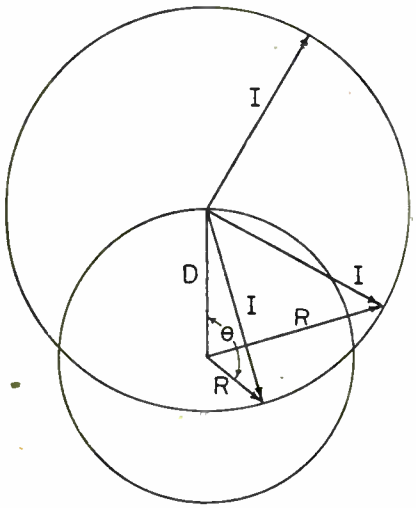


Fig. 4—When I exceeds D, R rotates

This can be shown analytically with great ease. Assume two carriers arriving with amplitudes D and I and angular velocities (Ω t) of A and B. Introduce the difference angular velocity C equal to A — B, whence B equals A — C. The resultant of the two carriers is D Sin A + I Sin B. Using the trigonometric formula for the sine of the difference of the two angles,

I Sin B = I Sin (A — C) .....(1)
= I Sin A Cos C — I Cos A Sin C
D Sin A + I Sin B .....(2)
= (D + I Cos C) Sin A — (I Sin C) Cos A

In equation (2) Sin A and Cos A represent the spin of the resultant at the same rate as the desired carrier D Sin A. As shown in Fig. 6, the quantities in parenthesis are the components of the resultant moving with angular velocity C with respect to D. Now, as long as D is greater than I, the quantity (D + I Cos C) remains positive at all times, never going below the center of the large circle. I Sin C alternates from positive to negative. The resultant R therefore phase-flutters back and forth about D.

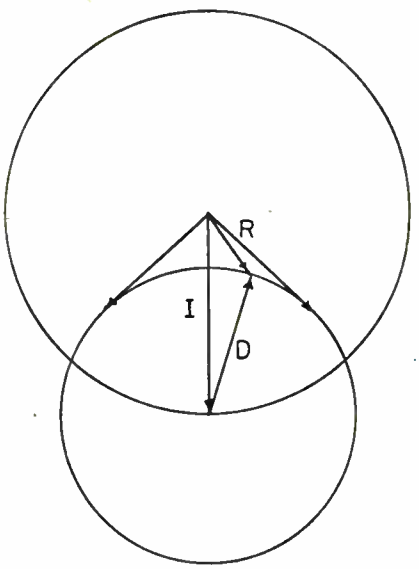


Fig. 5—Positions of D and I interchanged

When I becomes larger than D however, (D + I Cos C) alternately is positive and negative so that the resultant R spins around the center of the "D" circle with angular velocity C, D being still assumed to be fixed. However, since actually D is not fixed, the resultant

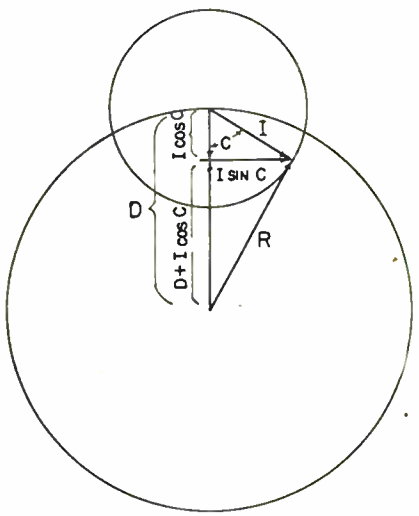


Fig. 6—Geometry of the various vectors

R is already going around at velocity A with the vector D, its resultant absolute angular velocity is the difference or A — C. This is equal to B and hence the resultant is now tied to B instead of A as previously. Hence the interfering carrier has "taken over" upon becoming larger and now suppresses the desired carrier.

DEFINING COMMON FM ENGINEERING TERMS

Antenna gain—The ratio of power radiated in a desired direction by a directive antenna to the radiation in the same direction by a non-directive antenna.

Center frequency—The frequency of the carrier of an FM wave before modulation. When a modulating signal is impressed on this carrier the instantaneous frequency varies constantly about this center frequency as a mean value.

De-emphasis — The reduction of loudness of high notes in a receiver. See Pre-emphasis.

Deviation ratio—The ratio of the number of cycles per second change in carrier frequency to the number of cycles per second of the highest modulating signal when the latter is at maximum amplitude. FCC rules for FM broadcasting permit a maximum of 75 kc deviation above or below center frequency. The loudness of the signal causing this is not prescribed and may vary with the broadcasting station. If the highest frequency signal used in modulation is 15 kc the deviation ratio is 75/15 or 5.

Discriminator—The tube and associated circuits in the FM set which changes frequency modulation to audio amplitude modulation. A number of circuits have been designed for this purpose.

Frequency deviation—The frequency shift each side of the mean carrier frequency. It is proportional to the amplitude of the modulating signal.

Frequency stabilization—Correction of carrier frequency drift.

Inter-channel interference — Interference with reception in one channel caused by radiations in nearby channels.

Limiter—A circuit used to prevent amplitude variations from reach-

(*Continued on page* 81)

WHFM'S FM CONVERTER

By K. J. GARDNER
Technical Supervisor
WHAM-WHFM, Stromberg-Carlson Co., Rochester, N. Y.

Engineering details of equipment and circuits which permit simultaneous transmission on 45.1 and 98.9 mc

• Since December 2nd WHFM's regular programs have been duplicated on 45.1 and 98.9 mc at 1 kw the higher frequency using a new antenna mounted atop the lower frequency turnstile. When FCC assigned a frequency of 98.1 mc, the best method of putting a stable signal there with the proper degree of modulation appeared to be to follow our existing REL transmitter with a new unit, and this is what we did.

In our existing transmitter, the phase modulated output of an "A" oscillator on 200 kc is multiplied to 12,800 kc, which frequency is fed into a mixer stage. A "B" crystal on a frequency of 5930.208 kc is doubled to 11,860.416 kc and fed into this same mixer stage. Here the difference frequency of 939.583 kc is selected and amplified and multiplied 48 times to give the final operating frequency of 45.1 mc ± 75 kc modulation at an output of 3 kw.

To arrive at a frequency of 98.9 mc with a frequency swing of ± 75 kc, it is apparent that the new transmitting unit should start off with another mixer stage combining the rf output from another "B" oscillator, which would govern the final frequency, tapped off from a point in the first chain of amplifiers with the required deviation.

Mixer stage

The first step was to provide the new mixer stage with 12,800 kc, completely isolated from the modulator unit. This was done by tapping off energy at the 6,400 kc point, and running it through an isolation stage which also doubled to 12,800 kc. Now at this point, we have an rf voltage containing the proper modulation. Working back from 98.9 mc, the output of the mixer stage must be on a frequency which when multiplied by 48, not only arrives at the assigned carrier frequency, but also contains the necessary ± 75 kc swing. This dictates that the output of the mixer stage should be on 2060.417 kc.

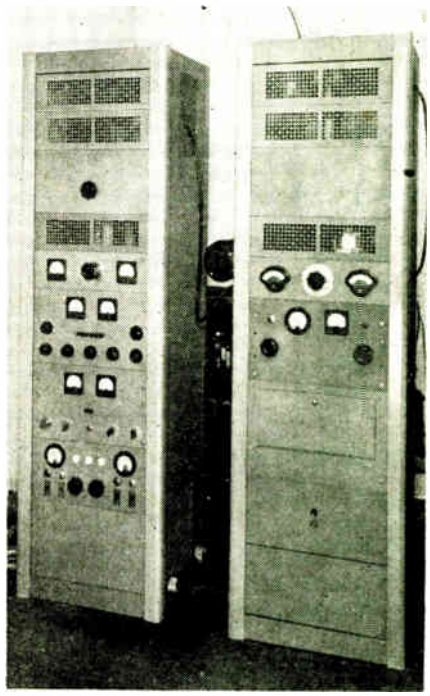
To obtain the new "B" oscillator frequency, subtract 2060.417 from 12,800. The result is 10,739.583 kc. Since we will use one doubling and isolating amplifier, divide this frequency by 2. The result then is 5369.7915 kc for the oscillator. The quartz crystal decided upon was a Bliley variable air gap in a BC46 oven. Adjustment of the air gap allows the transmitter to be placed exactly on 98.9 mc.

Amplifier chain

Following the mixer stage is a chain of amplifiers and doublers which build the power up to approximately 10 watts on a frequency of 32.966 mc. At this point the rf is fed into a pair of push-pull HK257B tubes which triple the frequency to 98.9 mc, and which are capable of producing approximately 60 watts of power.

The plate circuit of the tripler stage is tuned by means of a parallel bar tank circuit. Great care was exercised to maintain symmetry to ground resulting in exceptionally fine stability in this stage. A coaxial link coupling circuit a half-wave length long, transfers energy into the parallel bar grid tank of the final amplifier. The final power amplifier consists of two Eimac 4-250A tetrodes, which are operated with a power input of 1,500 watts, and whose dissipation is slightly under the rated dissipation, resulting in an output of approximately 1 kw. Great care was taken to obtain mechanical and electrical symmetry in the final stage, to obtain efficient operation.

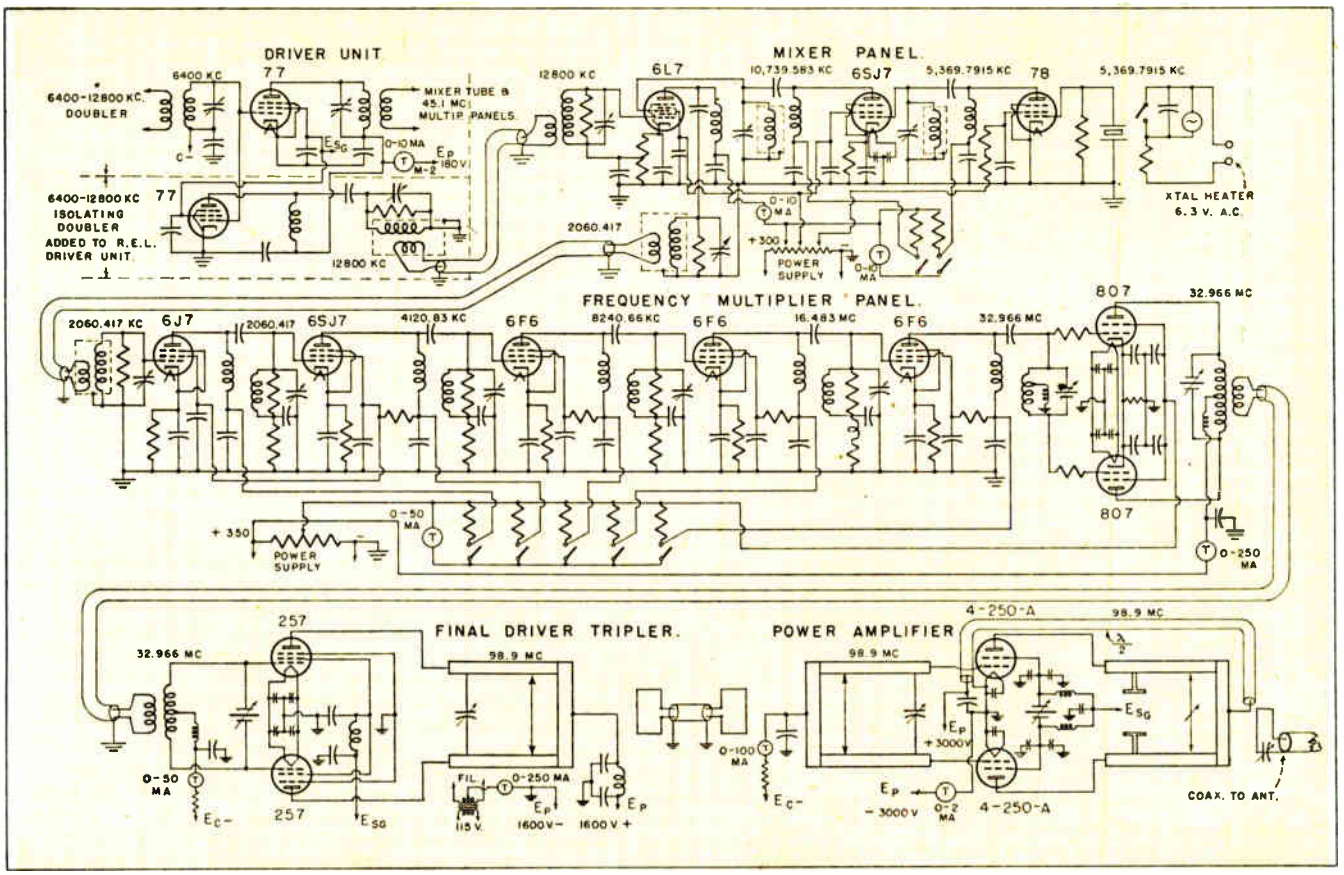
Two important steps were taken to insure maximum stability over a wide tuning range. First, the screens were fed through separate radio frequency chokes, and then by-passed through condensers which series resonated out the inductance of the screens. A trimmer condenser was used for fine adjustment. This resulted in the screens being effectively grounded at 98.9 mc.



Left unit contains oscillator-multiplier equipment and HK257B tripler. Two bottom panels contain power supply; oscillator mixer system is in third panel, multipliers in the fourth, remainder of panels being devoted to triplers. Right bay holds the power supplies and controls for the final

Insuring stability

The second precaution was to feed the plate voltage to the center of the plate tank through a half-wave length polyethylene concentric line, which was tied directly to the two filaments at the bottom end. This effectively placed the "cold" end of the plate tank at ground potential. The modulated rf output was then coupled through a tuned coil to a 7/8 in. gas filled line which in turn connects to the antenna system.



Complete wiring diagram of the original driver and the new units and final amplifier which have made it possible for WHFM to broadcast FM programs on two bands simultaneously. For the higher frequency band a new antenna was mounted above the existing antenna for 45.1 mc

DEFINING COMMON FM ENGINEERING TERMS

(Continued from page 79)

ing the discriminator (2nd detector). FM waves even though sent out at constant amplitude usually become somewhat amplitude modulated by noise, undesired carriers etc., before being received. This AM must be removed to prevent distortion.

Modulation index—The ratio of the frequency deviation to the modulating frequency for any signal being considered.

Phase deviation—The time integral of frequency deviation. If the frequency increases 10 kc in the time of one cycle of a 200-kc carrier the new frequency will have gained a phase lead over the old frequency amounting to .5 x 10 - kc/200 kc x 360 deg. or 9 deg.

Polarization—One of the simplest electromagnetic wave consists of an electric field whose lines of force are vertical, and a magnetic field whose lines of force are horizontal, both being at right angles to the direction of propagation. This constitutes a vertically polarized wave. If the electric field and the magnetic field are interchanged the wave is said to be horizontally polarized. More complex waves are possible.

Pre-distorter—Circuit used in the indirect FM system to make the signal current amplitude inversely proportional to the signal frequency. This is necessary because the modulator circuit is a phase modulator rather than a frequency modulator. By thus predistorting the signal the output of the phase modulator is a true FM signal.

Pre-emphasis—The boosting of loudness of high notes over low notes in a transmitter to equalize signal to noise ratio over the audio frequency band.

Reactance tube modulator—A tube and circuit used to change amplitude modulation to frequency modulation by variation of the plate circuit reactance in step with changes in the amplitude of an impressed signal.

Squelching—Eliminating noise reception when no signal is present. As shown elsewhere in this issue, reception of one signal by an FM set tends to prevent reception of any other signal or of noise. If no signal is present, however, a roaring sound will be heard unless a squelch circuit is incorporated to shut off the receiver at such time.

Time constant—75 microseconds—The standard set by the Federal Communications Commission for pre-emphasis (which see). A common means of emphasizing high tones is to put a condenser and a resistance in parallel in the grid circuit of an amplifier. As the condenser passes high tones more readily than low ones, the desired effect is produced. The amount of pre-emphasis is determined by the values of resistance R and capacity C used. Either one can be varied, and as long as their product is the same the effect on the circuit will not change. This product is called the time constant and is the value which makes the exponent —t/RC unity in the expression ϵ raised to the power (—t/RC). As is well known this is the function connecting the instantaneous and final values of a transient in an RC circuit.

TELE COLOR RECEPTION

Experimental test and program material now on air is creating interest among television engineers to study system problems

• As a result of the activity in color television a number of engineers have expressed interest in setting up a receiver.

As a whole, there are no problems encountered in a color television receiver at 400-500 mc frequencies so difficult of solution that ordinary television practices or those that have been encountered in radar and guided missile television systems will not prove useful. At present there is only one station on the air at frequent intervals in New York, but other installations are under way in Chicago and elsewhere, using the same principles. This simplifies the technic of reception somewhat, although later, when a number of stations are sending simultaneously or in locations where strong signals at the image frequency are found, much greater attention must be paid to the front-end selectivity. Better rf amplifier tubes, useful in the 500-700 mc range, would certainly be worth while, and they may be forthcoming later.

In setting up a color receiver an experimenter can go at the system gradually, first getting the signal handled correctly, which brings in the color picture as black and white, and then adding the synchronized disc.

Existing black-white and color systems do not conflict or overlap. They have two separate spectrum bands, different scanning systems, and different antennas which prevent any possibility of an economical form of combination set. Thus each system seems to be on its own.

While the main handicap for placing the color system on a commercial basis is the lack of system standards, this in reality affords greatest opportunities for the engineers, especially those in the Metropolitan New York area, to work in a field that is just beginning to become important. Many consider that the main thing is to get started immediately and build a set that will pick up the "color" signals from CBS. The receiver is not excessively intricate, especially

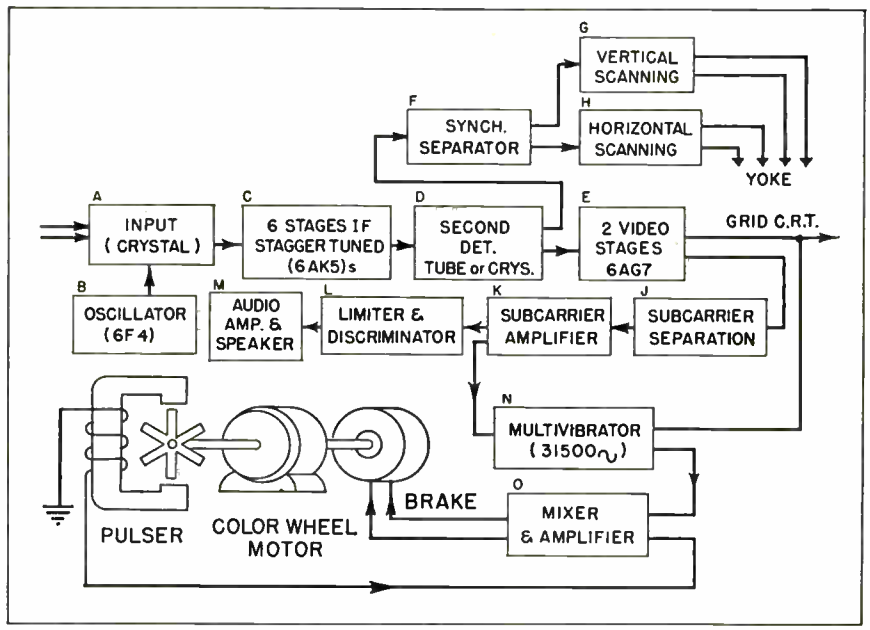


Fig. 1—Diagram of a 500 mc color receiver, similar to that used during CBS demonstrations

if a modest diameter of screen is selected—a 5-in. or 7-in. tube.

CBS engineers are naturally unable to give out circuits that are "guaranteed" to be the simplest and most effective possible because all their work has been of an experimental nature without much regard to ultimate manufacturing costs. However, it is possible to report a few suggestions on setting up a 490 megacycle color receiver.

The sooner experiments are made by independent, responsible persons the more valuable will be the data collected for correlating into the system standards.

CBS color system

Carrier.—The high operating frequency materially affects the range. An effective radiated power of 20 kw is obtained by reducing high angle radiation. Since a half wave dipole is only around 12 in. long—two 6 in. rods, it is necessary in order to secure pickup and directivity comparable to that of a simple dipole in the lower television band to use a parabolic reflector or a multiple array.

As is well known, the effectiveness of the highest frequencies in communication systems depends on utilizing the antenna gain factor. The gain of an antenna is the ratio of its peak power output in one direction only, to its average power output in all directions. In the case of extremely short waves, as, for instance, the 10,000 mc used in the recent RCA television tests with color the gain may be as high as 2,000. Since this gain is directly proportional to the area of the reflector and inversely proportional to the square of the wavelength, it is obvious that the gain increases rapidly with decreasing wavelength.

Other things being equal, the gain at 490 mc is about 36 times that for frequencies of 80 mc. On the other hand, very little pickup at all would be obtained unless these reflectors or multiple arrays are used. The reflector may be made of metal sheet, netting, screen or parallel wires or strips (an open-work grid). The strips function as cross-sections of wave guides, when the spacing between the strips (from center to center) is less than about one-third of the wavelength.

Sound Channel.—Another difference between the CBS color system

and the regular black and white is the system of transmitting the sound signal as pulses of frequency modulated subcarrier energy. 31,500 of these pulses are transmitted per second, having a subcarrier frequency of about 8 mc. Thus the sound channel is associated with four different frequency bands—(1) its own frequencies in the audio band, (2) the pulse frequency of 31,500 cycles, (3) the subcarrier frequency of 8 mc, and (4) the radio frequency carrier, circa 490 megacycles.

The sound subcarrier pulses are transmitted during the "back porch" portion of the sync. pulse. These frequency modulated pulses are separated out at the second detector or at one of the video stages, preferably the latter because of the increased gain. The separation can utilize resonance methods (at the 8 mc frequency) in combination with a "shutter" tube that opens up the audio channel at the termination of each blanking pulse of the horizontal frequency.

Each pulse (there are 31,500 per second) "samples" the momentary amplitude of the sound frequency. Assuming a 16% horizontal flyback interval the total sync. pulse duration is approximately 5 microseconds. It is possible to devote 50% of this time to the sound signal; this gives 20 cycles of an 8 megacycle signal in each FM pulse. This varies because, with FM, the carrier will differ with each pulse from that of the previous one, within, of course, the deviation limits. (± 600 kc.) One cycle of the audio signal will be represented by from several up to hundreds of these frequency modulated samples.

Fig. 2 shows a typical pulse selector that accepts FM pulses during the intervals after synchronization pulses appear. The screen of the tube is biased to cut-off except when a pulse (positive) from the horizontal flyback (with possibly a small added time delay) overrides this bias and permits the pulses to pass the following stage.

The demodulation comes after limiting in the usual manner. The audio system must be limited in frequency range to below half the line frequency (that is, to 31,500/2 cycles) by filters or other design expedients.

Since the frequency modulated 8 mc signals being produced by amplitude modulating the 490-megacycle carrier, the latter modulation would "unblank" the blanking pulse and superpose a number of white horizontal dashes on the video picture, an auxiliary blanking pulse must be applied to the picture tube to keep its modulation grid at cut off throughout the blanking interval. One arrangement for doing this is shown in blocks K and N in Fig. 1. The multivibrator N must be of the unsymmetrical type that remains in one mode of operation for the short interval of one FM pulse (about 5 microseconds) only. Its frequency of 31,500 cycles is synchronized from the second detector or from pulses from somewhere in the audio channel.

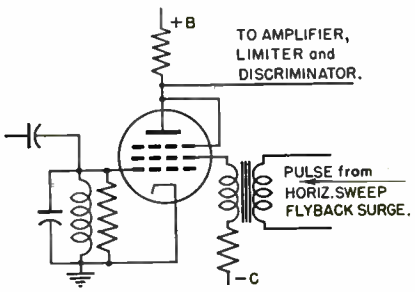


Fig. 2—"Shutter" tube separator for sound pulse recovery during intervals after sync

An alternate method is to amplify and to rectify a signal picked up from the FM subcarrier channel and to use the short pulses of dc so obtained to continue the cathode ray tube blanking.

It will be noted that, although the downward amplitude modulation may be at somewhat different actual frequencies during successive sync periods, the energy content of each blanking pulse is identical with the others, so that the superposition of the sound on the video will not upset the vertical sync pulses. Also since the horizontal sync pulse has already appeared before the FM burst takes place, horizontal sync is likewise unaffected.

Scanning Frequencies. — Vertical 120 cycle per second with the usual sawtooth wave shape. Horizontal frequency — 31,500 cycles also of sawtooth shape. The usual 2:1 interlacing system is retained, modified for color as follows: During first sweep 262.5 lines are transmitted in red covering the even lines, then 262.5 lines in blue, covering the odd numbered lines. Then the third vertical sweep covers the first series (even) lines again, this time in blue. In other words, there are:

1—262.5 even lines in red,
2—262.5 odd lines in blue,
3—262.5 even lines in green,
4—262.5 odd lines in red,
5—262.5 even lines in blue,
6—262.5 odd lines in green.

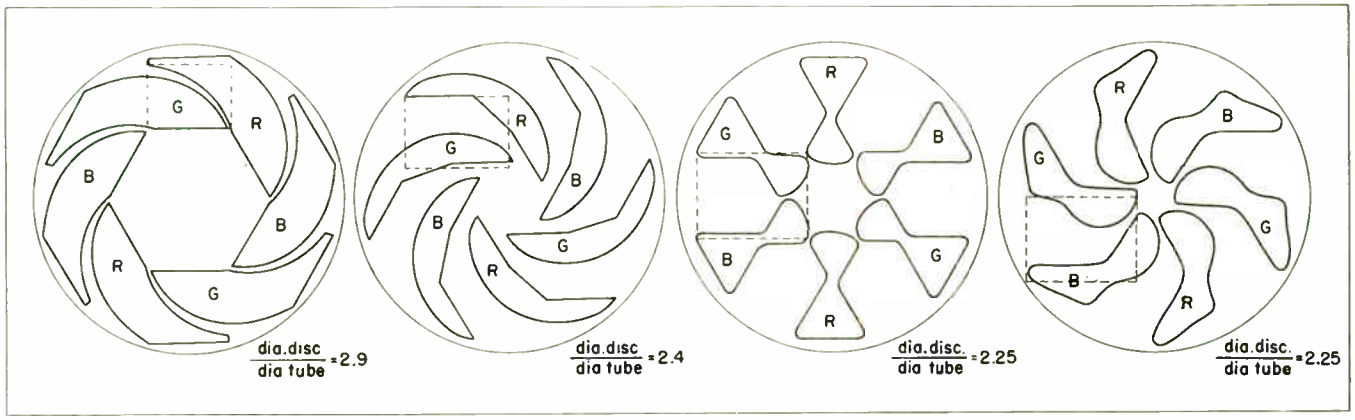
Thus there are six intervals, each 1/120 sec. long, required to produce a single frame.

A color distribution wheel rotating at 1,200 rpm synchronously produces the color synthesis at the receiver. A typical wheel shown in Fig. 3 may be of 1/16 in. plexiglas or lucite with the areas artificially stained or with films of appropriate color cemented on.

One might assume from the sequence table immediately above,

(*Continued on page 116*)

Fig. 3—Forms of color wheel filter segments. The second arrangement is a typical shape, although for convenience the trailing edges of segments can continue up to next sector if desired. These wheels rotate counter clockwise and are synchronized to turn at 1200 rpm

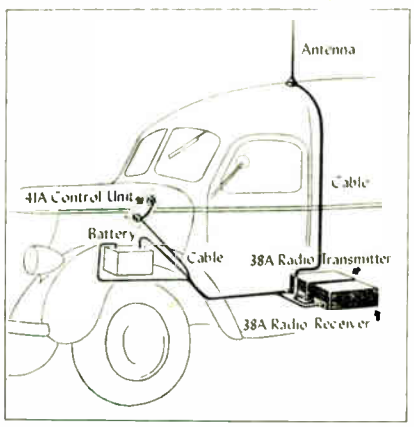


MOBILE RADIO SERVICE

Engineering details of FM "party line" telephone system being installed by AT&T for urban and highway vehicles

• Plans for the commercial trials of the recently announced mobile telephone service of the Bell Telephone System have progressed to the point where installations shortly will be commenced. It is expected that the principal users of this service will be commercial vehicles which can be re-routed or given important instructions while on the road.

Two branches of this service are recognized—the urban and the highway, and operating requirements may be slightly different. Due to the required reliability of a public service of this nature it is expected that the installation and monthly charges will be higher than for ordinary telephone service. In promoting this service the telephone company is definitely feeling its way and the early installations will be on an experimental basis.



Western Electric 38A transmitter and radio receiver as installed on a private vehicle

The apparatus for installation in the moving vehicle, be it car or truck, will be available from the telephone company on a rental basis. Also the company expects to supply specifications to those who are interested and a number of manufacturers are expected to produce equipment for sale. For its own equipment, the telephone company will be responsible for installation and servicing while subscribers who own their own equipment will have to make arrangements elsewhere.

Control unit, mounted under dash and housing switches, indicator lamp and call bell

At the present time, a few experimental sets have been manufactured by the Western Electric Co., and consist of an FM transmitter and receiver which can be installed out of sight with a telephone handset of the regular type mounted under the dashboard. The dashboard installation will incorporate an on-and-off switch with a pair of bull's-eyes, one to show that the power is on and the other used along with a bell to indicate when the vehicle is being called. The operator of the vehicle ordinarily will have the power on whenever the vehicle is in operation, so as to be able to receive a call at any time. With the power off, the set, naturally, will be inoperative.

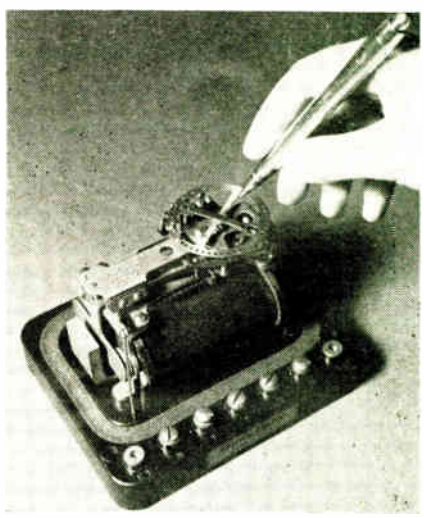
In view of the fact that some vehicles will want to be in the receptive condition all the time they are on the road it will be necessary for the vehicle to have a special large capacity battery and generator to replace the one supplied as original equipment. The drain of the transmitter on the battery is expected to be 35 amperes during transmitting intervals and that of the receiver 6 to 8 amperes. The receiver B voltage will be produced by means of a vibrator, while that of the transmitter will probably come from a dynamotor. In general, the antenna on the vehicle will be mounted on the roof, but highway units may have a side antenna to keep from hitting low bridges.

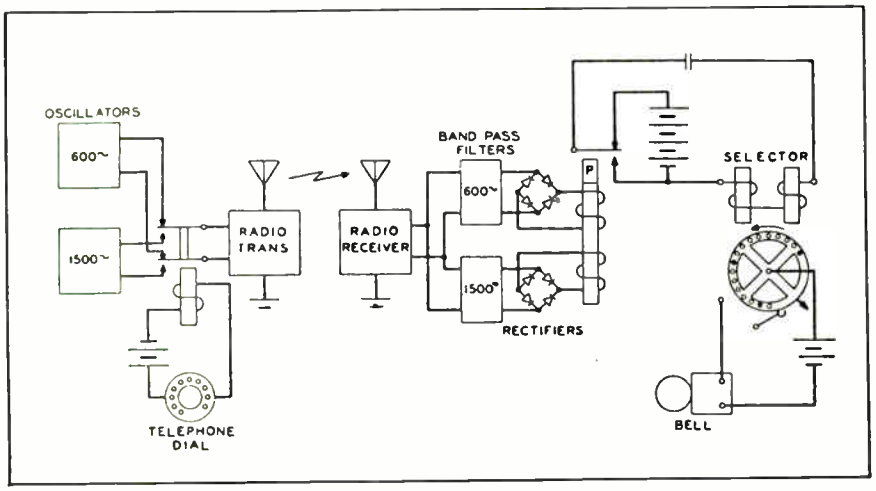
The service given will be a party line service and may extend to 100 cars on a single frequency. When the operator of the car wishes to call someone he will pick up the handset, listen to be sure the circuit is idle and if it is, press a push-to-talk button to call central. The connection can then be completed over the regular telephone lines to any desired point, local or long distance. On the other hand, when it is desired to call someone in a car, a coded ring consisting of a series pulses* will be put out by the central station.

These pulses will actuate a stepping relay in each of the cars on the "party line" which have their operating switch on. In these relays contacts are arranged around the circumference of a ratchet

*Harbor and Coastal Radiotelephone System —Anderson and Pruden—Proc. IRE April, 1939, pp. 251.

Close-up of pulsing unit which is heart of the system and permits selective calling





Block diagram of the complete mobile radio telephone system showing the manner in which the equipment has been designed to permit the selective calling of a particular vehicle

driven wheel in such a way that the proper code of pulses will result in only the relay of the called car closing the ringing circuit. This will ring and flash the "call" bull's-eye on the dash. Thereafter conversation will be in the normal telephone manner except that the automobile operator will have to use this push-to-talk button.

It is not planned to use loud speakers in this system as this would decrease privacy, increase noise, raise the required power level and otherwise complicate the installation.

Operating frequencies

It is expected that the urban service will operate on a frequency between 152 and 158 mc while the highway service will operate in the 30-42 mc band. A frequency deviation of 15 kc is planned for the urban frequency range and this would operate in a 60 kc cleared channel. The highway service will use a 40 kc channel. The usual telephone range of speech frequencies will be used. This means a spread in the neighborhood of 300 to 3,000 cycles.

The question of signal strength laid down in the operating area and signal-to-noise ratio is one for which no general figures can be given. However, the telephone company expects to lay down a field strength generally sufficient to give a good signal above the prevailing noise level in all areas covered. It is recognized, however, that blind spots may occur in which transmission or reception would be unsatisfactory or even impossible.

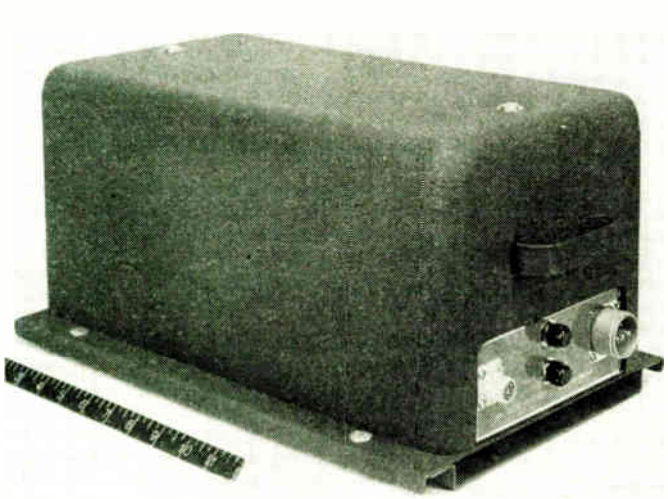
It is also recognized that the problems of interference such as from diathermy equipment or adjacent automobiles with bad leakage conditions in high tension electrical systems will be present. And as with any FM system should the interference carrier have an amplitude greater than that of the signal carrier, the latter will be eliminated. It is recognized that one of the characteristics of FM is that reception will be good for favorable signal-to-noise ratios, but will become bad if this ratio drops close to unity or below. The mobile units will have a power of about 25 w while the station transmitters, several of which may be used in a large metropolitan center, will have a power output of about 250 w.

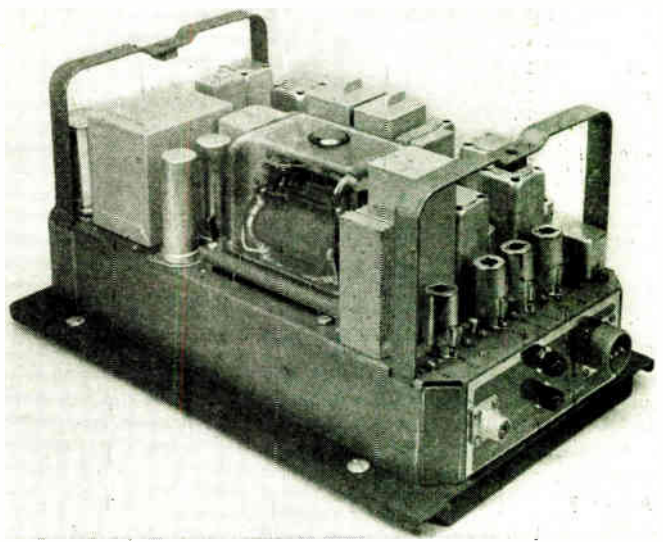
Classes of service

Three classes of mobile service are contemplated initially. (1) A general 2-way telephone service between any regular telephone and any mobile unit with a 3-minute initial period. (2) A special 2-way dispatch service between a particular telephone and specified mobile units. This would include a direct line from the dispatcher to the telephone central and a 1-minute initial period would apply. (3) A 1-way signalling service to mobile units to notify the operator to comply with prearranged instructions.

The first installation of the urban mobile telephone service will be made in St. Louis and it is expected that the service will be extended thereafter to cover more than 30 cities from coast-to-coast by the end of the summer of 1946. Some of these cities are: Philadelphia, Pittsburgh, Washington, Baltimore, Boston, New York, Newark, St. Louis, Chicago, Milwaukee, Cincinnati, Cleveland, Columbus, Detroit, Indianapolis, Oklahoma City, Dayton, Kansas City, Houston, Miami, Memphis, Atlanta, New Orleans, Ft. Worth, Birmingham, Dallas, San Francisco, Denver, Salt Lake City, Los Angeles.

The complete radio telephone receiver, which weighs about 40 lb., is shown at the left, may be mounted in any convenient location on the vehicle. At right is the transmitter with the cover removed showing the transparent plastic covered selector unit centrally mounted





HIGH FREQUENCY FM

Generation of standard signals from 86 to 108 mc for laboratory and production testing of FM receivers

● The future acceptance of FM broadcasting for home reception depends largely on recognition of the three major advantages of this type of transmission, namely:

(1) Higher signal-to-noise ratios,

(2) An extended audio frequency range,

(3) Lower distortion inherent to both transmission and reception.

To fully realize these advantages the testing procedure used for design and maintenance of FM receivers must have several unusual features. The most important item for laboratory and production line uses is the signal generator with its special characteristics:

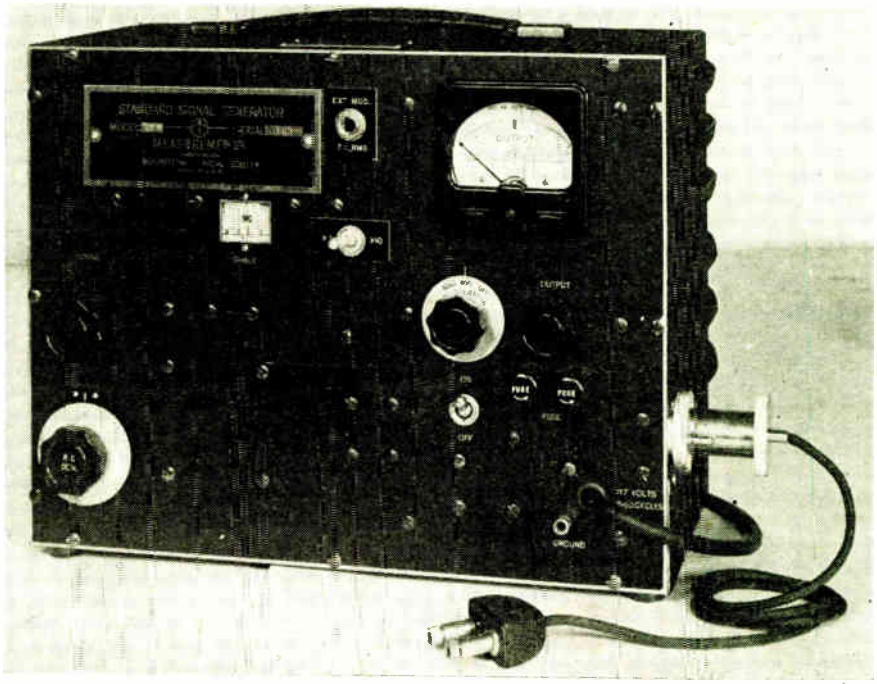
(1) A noise level from all sources at least 60 db below that of the desired signal output.

(2) A modulation characteristic inherently uniform from dc to 15,000 c/s (within 2 db).

(3) Distortion not exceeding 1% total harmonics when the test signal is frequency modulated 75 kc to either side of center frequency. The range and modulation capabilities must, of course, safely exceed the FCC requirements for transmission in the 86 to 108 mc. band. In this regard it may be of interest to examine the Type 78-FM signal generator that has just been developed by Measurements Corp., Boonton, N. J.

To attain these standards of performance considerable work was first done on equipment and methods of measuring and calibrating FM signals. It was decided to base all deviation calibration on the following sequence:

(1) Establishing a linear frequency modulation with respect to signal generator audio input by measurements using a laboratory standard FM receiver of special design. For this purpose a 30 mc if amplifier and discriminator was designed, using a silicon crystal mixer with two stages of amplitude limiting, followed by a balanced discriminator having a high degree of linearity over a range of ± 400 kc. After heterodyning the FM signal output against an unmodulated signal generator, used as local oscillator, this wide-band if channel easily accepts the maximum deviation of ±300 kc for which the Model 78-FM is designed.



Panel arrangement of a new portable FM signal generator for the 86-108 mc band

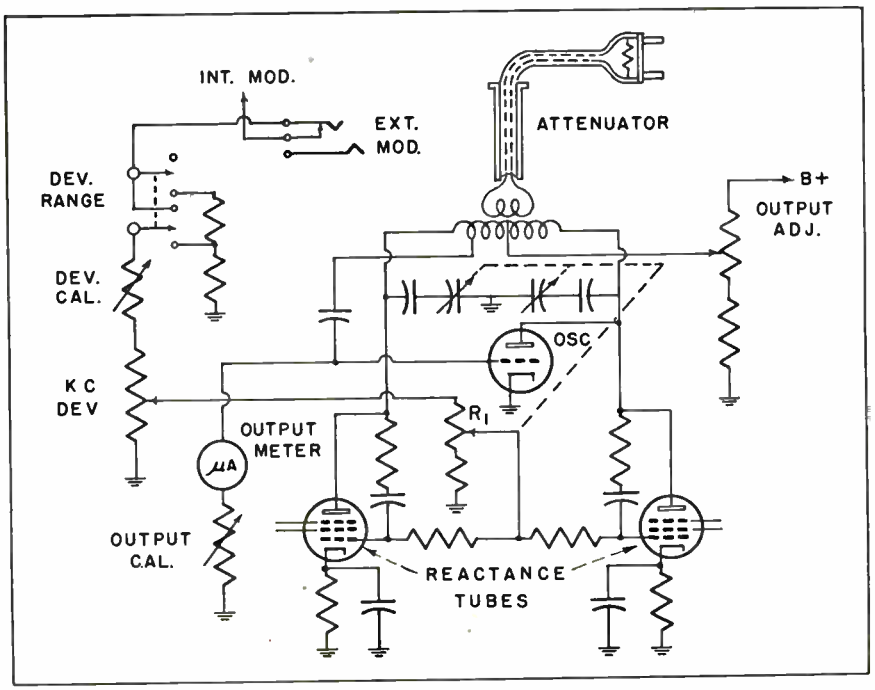
(2) The "carrier null" method of FM deviation calibration is next applied, using a tuning fork of exactly 3,466 c/s as modulation source. This frequency yields null points of center frequency when peak deviations of 8.335 kc, 19.132 kc and 30 kc are attained (see nomograph, page 70 of this issue).

(3) Having established a reference point (30 kc) of deviation, and knowing that deviation is linearly related to modulator input voltage, it is now possible to mark the "Deviation Dial" of the signal generator by applying known dc potentials to the input network of the frequency modulating circuit. The primary standard of dc voltage in this case is a Weston potentiometer and standard cell which is capable of establishing voltage values to an accuracy of one part in 10,000.

Since incidental amplitude modulation from the modified Colpitts oscillator used in this instrument was found to be less than 3% at a deviation of 100 kc, no amplitude limiter was considered necessary to assure uniform signal output. However, oscillator "stiffness" does vary with L/C ratio when tuning over the band, therefore it is necessary to adjust the level of input signal to the frequency modulator circuit in some way if the direct-reading deviation dial is to be accurate at any selected carrier frequency. Fortunately, a range of 86 to 108 mc represents a tuning ratio of only 1.3 to 1.

The response of the oscillator to quadrature currents introduced by the reactance tubes does not vary widely over this narrow tuning range and suitable choice of constants has caused this variation to be practically linear. Reference to the accompanying circuit diagram will show a variable potentiometer, R_1, mechanically coupled to the oscillator tuning capacitor. Factory adjustments provide for tracking this linear potentiometer to produce automatic compensation of the audio signal input to the reactance tubes. This maintains the level of actual frequency modulation to within 5% of the values shown by

SIGNAL GENERATOR



Basic circuit elements of the FM signal generator, showing mutual inductance attenuator

the directly calibrated deviation dial. A switch is provided on the panel, in order that one deviation dial can cover the two ranges of 0±30 kc and 0±300 kc.

Though an internal source of audio modulation at 400 and 8,200 c/s is provided, fidelity runs will require an external variable audio oscillator to deliver exactly 7 rms volts across the 5,000 ohms impedance of the external modulation input circuit. Relative deviation accuracy, when using an external source of frequency modulation, is ±5%, plus any error made in determining the magnitude of the external 7-volt level. Over-all transient response of the Model 78-FM is suitable for square wave modulation of the carrier signal. Square wave testing of FM receiver performance has been found to yield more information in less time than other methods.

The deviation dial may be used as a calibrated vernier frequency control by applying a dc potential of exactly 9.9 volts to the external modulation jack. This suggests a rapid method of selectivity measurement, since reversal of the dc polarity will shift the signal generator frequency above and below the center frequency by an amount directly indicated on the deviation dial.

Signal output is obtained from a transverse type mutual inductance attenuator calibrated directly in microvolts from 1 to 100,000. The attenuator tube will be seen in the accompanying photograph, attached to the output cable at the lower right, and partially withdrawn from the case. Across the innermost end of this tube a small coupling loop is mounted so as to lie opposite the center tap of the oscillator coil.

Movement of the tube varies the inductive coupling between oscillator and loop, and the capacitive component of coupling is effectively eliminated by locating the loop at the electrical center of the coil where the two out-of-phase capacitive fields tend to cancel. Careful termination at both ends of the attenuator and output cable system provides a uniform impedance of 17 ohms under all conditions. Reliable impedance characteristics are of special importance in an instrument intended for use as a standard of output voltage.

The meter marked "Output" in the photograph serves to monitor the signal amplitude by reading a reference value of oscillator grid current. This permits standardization of the oscillator performance at any frequency of operation.

In the 86-108 mc FM band, such problems as image rejection, adjacent channel interference and susceptibility to impulse noise have not, as yet, been thoroughly explored. The relation of all these factors to FM receiver design should be investigated in the laboratory before large scale production is attempted. The instrument described is one link in the chain of special instruments required for this purpose.

Operational Principles of Racon Equipment

Principles and operational methods of both radar and loran are pretty well understood, thanks to the wealth of material that military authorities have permitted to be published. Comparatively little has been made public regarding another cousin of these services which in the Coast Guard goes under the designation of racon.

The racon or radarbeacon is an electronic beacon designed to serve as an aid to aircraft navigation for such aircraft as are equipped with radar equipment. The essential difference between radar and racon is that, unlike radar, which depends upon a reflection of its own energy to determine the existence and position of an object, racon is made up of a receiver-transmitter combination which sends out a coded signal when actuated or triggered by a radar signal of the proper type. The aircraft or ship determines its range and bearing from the racon station as well as the identity and position of the racon by the presentation of the racon signal upon the radar scope. The outstanding advantage of this type of radar to aid navigation is that a single beacon in an area will suffice to enable navigation in any weather conditions if a ship is fitted with the necessary radar interrogating equipment, and at a much greater reliable range than with radar alone.

COLOR TELEVISION—

Why majority of industry, after study of CBS' proposed system, determines to go ahead with black-white as planned—while encouraging color experiments

• Among television men there is really no party-line of "black-white" vs. "color". Instead every responsible television executive and engineer we have talked with, is peering eagerly ahead to the eventual coming of color-TV.

But the issue today is whether the mechanical color - television proposed by CBS executives, if generally adopted, would not limit and hobble the widest development of future color-television—with all its ultimate possibilities of brilliance, size, fidelity and electronic color.

While several radio leaders express themselves enthusiastically about CBS color television, the preponderance of industry opinion seems to be that the best present course will be to:

1. Go ahead immediately with black-white television as originally planned.
2. Study and develop color television so that an adequate color-television system can be ready in 3 to 5 years.

Meanwhile, CBS is demonstrating to the press, radio manufacturers and broadcasters, and the public, a most enticing demonstration of color television. This, with post-war refinements, uses the same mechanical principle of rotating color screens as CBS exhibited before Pearl Harbor. Details of the uhf transmission and picture characteristics appear elsewhere in this issue.

CBS demonstrations

At CBS headquarters, visitors are first led into a luxurious semi-lit reception room where several minutes' wait assures adaptation of the eyes to night conditions. Then the audience files into the darkened viewing room, to see the 12-in. picture (10-in. direct-view tube, lens magnified).

An effective film program is shown, contrasting color with black-white, in presenting a variety of indoor and outdoor action sequences, including a football game in which color clearly distinguishes the uniforms of contrasting teams, in a way impossible with black-white.

In watching these color scenes of fast-moving action the visitor will detect none of the "barber-pole" effects of the earlier demonstrations of this same rotating color-wheel principle applied to color movies and color video. But engineers present remember that the CBS demonstration uses color films as the source of the program, and that so far as the television equipment is concerned, it is merely scanning a "still" picture at any moment! Hence the speeding ball or flying white horse has already been stopped by photography, and no color fringes are possible from the television-film scanner. Quite a different result is expected by engineer critics when the live color-pickup camera (which CBS promises soon) goes into action.

Screen intensity

Low intensity of the color picture seems to be one of the abiding drawbacks of the present CBS system. With large percentages of light being subtracted by each of the color screens, engineers point out that the mechanical color system is bound to be wasteful of the precious cathode-tube illumination. But even if higher screen intensities could be achieved, the 20-frame flicker (which is now not noticeable at low screen brightness) would appear annoyingly at higher illuminations and so spoil seeing. Hence CBS color seems doomed to low-intensity dark room effects—this in contrast with the brilliant illumination (20-ft. candles) of new postwar black-white screens.

Absence of "ghosts," usually so annoying in the metropolitan area of big buildings, is one of the striking advantages of uhf demonstrated during the CBS showing. With its receiving dipoles (little larger than two lead-pencils) mounted in a rotatable reflector

CBS COLOR TELEVISION

480-496 mc; 525 lines in red, blue and green. 20 complete pictures per second

ADVANTAGES

Greater attractiveness and interest
Better "seeing" through color contrasts.
Greater appeal to advertisers
Absence of wide-angle ghosts
Absence of color-fringes with film scanning
Purchasers would willingly pay 100% premium for color, same screen size
In million lots, color sets only 10-15% more costly than black-white sets (Goldmark)
Mechanical color relies on simplicity of wheel principle
Sound carried on same channel as picture
Color offers a powerful new selling appeal for industry

DRAWBACKS

Low illumination of pictures
Dark room used
Flicker at brighter intensity
Color fringes on fast moving objects with live pickup?
Ghosts from distant (narrow-angle) reflecting surfaces.
Line-of-sight path essential (to antenna or reflecting object)
Wood structures and foliage tend to block off reception
Attenuation of signal greater than on 50-90 mc.
Initial receivers expected to cost double black-white
Mechanical color system limits size, brightness and compactness of receiver
Mechanical-color sets may be useless on eventual electronic-color system
Mechanical-color wheels and drums are bulky; may tend to become noisy
Color networks not feasible with present coaxial equipment.
Present projection color pictures dim, flat and wasteful of light or cabinet space
Further field tests needed
No standards available. To adopt standards may take three years

Is It READY to ADOPT?

outside the 9th floor of the CBS building, the uhf color pickup can be taken from any of a number of reflections from nearby buildings. Without the reflector, ghosts would of course be plenty. But the sharpness of the receiving reflector enables clear ghostless images to be picked up, as different reflecting structures come into the line of the reflector.

Distance reception?

However, at receiver distances of 20 to 30 miles from the transmitter, where other city skyscrapers a mile or so away are also included in the sharp beam of the distant receiving reflector, ghosts transposed by an inch or so would be expected on the color-TV screen, as with black-white. Uhf does not seem to offer any solution of this most annoying form of ghost trouble for outlying viewers.

But suburban-rural video reception at 20 or 30 miles may not be practicable on the 500-mc band. For at such distances, whatever the height of the antenna structure, the blocking of the carrier waves by trees, buildings and foliage may shut off signals. One prominent television expert expects the service area of a 500-mc station to be only a quarter of that of present 50-mc television. However, one of the CBS technicians, using a homemade color-TV receiver, now reports getting good color pictures at his home 10 miles from the CBS antenna. And CBS executives point out that in cases where an owner's receiving antenna is below line-of-sight to the receiver, he can then swing around and focus on the reflection from some higher object beyond (that is, if any—for such elevated reflection sources seem scarce in suburban and rural areas over 15 miles from the transmitter).

Height of antenna is still desirable for 500-mc color, as for 50-mc black-white. In almost all residence locations, arrays of multiple small dipoles (perhaps 16 to 50) may be necessary for adequate pickup, since, in the last analysis, the energy received is proportional to the space spanned by the dipole tips. Hopes that uhf dipole arrays could be concealed inside shingle-roofed attics, are blasted by war experience that at these higher frequencies wooden structures are almost as opaque as metal; especially would this be true in rainy periods.

Color appeal and cost

Laymen and press people who watched the CBS demonstrations have testified that so great is the appeal of color, they would readily pay twice as much for a color-television set as for the same size screen in black-white. Interestingly enough, several experienced television engineers have independently computed for Electronic Industries, that a color set complete with color wheel, should be built in limited quantities for about twice the cost of present black-white sets.

Dr. Peter Goldmark, CBS engineer who is responsible for the CBS color experimentation, thinks that in million lots, color-wheel sets could be produced at 10% to 15% above black and white. (About 50 color receivers are now being built for CBS by GE at a reported cost of $3,500 each for direct-view sets, and $5,500 each for projection sets. These, of course, are experimental models, and such sets have no bearing whatever on future selling price of similar sets.)

The projection color set exhibited by CBS has a screen 22 in. wide, but the picture seems dim and pastel, being annoyingly faint and indistinct, even in the darkened room. Since only a colored-lantern-slide "still" was demonstrated on the projection set, one might infer that the serious light losses of the color-wheel precluded any film showing of moving scenes. This projection-set difficulty points up one of the objections to the CBS system, with its distinct limits to future sizes and brightness. Color wheels cannot be introduced into the Schmidt lens system without great light loss; alternative optical systems permit easy color interception, but introduce bulky cabinets.

Some visitors at the CBS demonstrations mention hearing the whirling color wheels; others did not detect or notice the sound of the moving parts. CBS executives declare that such wheels should introduce no problems after man's long mechanical history. Other engineers suspect that, in living rooms, wheels running at 1,200 rpm may tend to get noisy and out-of-balance with use, and also may introduce synchronism troubles when transmitter and receivers operate on different power systems.

CBS' purpose

In some quarters, CBS' motives in entering upon costly color-television demonstrations with avowedly no intention of building color sets or utilizing the system itself, are impugned as being intended only to block the 1946-47 introduction of black-white television (expected to injure radio broadcasting time sales). With CBS' present front-line position in standard

(*Continued on page* 118)

STANDARD BLACK-WHITE TELEVISION

44-88 mc, 525 lines, 30 pictures per second

ADVANTAGES

- **Now operating within reach of 16 millions population**
- **8000 sets have been built and used for years**
- **200,000 more sets planned for first post-war production year**
- **Standards accepted and approved by FCC and engineering bodies**
- **Direct-view sets as low as $200**
- **Projection sets $450 up**
- **Sixteen years of field tests culminated in present standards**
- **Many engineers have design experience**
- **Program people fully experienced**
- **Direct-view screens up to 20 in.**
- **Projection screen 16 x 22, up to full theatre size**
- **Screen brightness, 20 ft-candles**
- **Can be watched comfortably in normally lighted room**
- **Black-white operation will give excellent preparation for color**
- **Station sites, buildings, towers, etc. largely convertible to color**

DRAWBACKS

- **Pictures lack color for increased interest, fidelity and contrast**
- **Difficulty in distinguishing objects of equivalent shades**
- **Advertisers complain B-W does not do justice to attractively colored merchandise**
- **Line scanning frequency is too low to permit picture and sound on same channel and transmitter**

PRINTED CIRCUIT WIRING

Newly developed process of fusing connections on ceramic placques permits production of "two-dimensional" assemblies

• A new process, perfected for the radio proximity fuze, known as the "printing" of wired electric circuits complete with components, on a plate of steatite ceramic will make possible a reduction of size in radio, hearing aids, instruments and electronic control circuits never before dreamed possible.

Wiring is produced through the use of a silver paste printed or stenciled on the steatite ceramic and then fired at high temperatures to bond it firmly. In the same way suitable resistor material is sprayed through accurately cut and positioned masks or silk screened onto the same plate, and small, paper-thin, ceramic disc capacitors are soldered directly to the proper silvered leads. Finally, other components, such as tubes of the new subminiature type are then soldered directly to leads on the plate.

The simplicity of this procedure makes possible a unit that is inconceivably small, highly efficient, practical and easy to service. As time-consuming hand wiring, assembly and errors are eliminated by this high speed process, lower production and consumer costs can be visualized.

Fig. 1 shows the complete fuze with a direct comparison as to size, with a 6L6G radio tube.

Since the plaques as used in these fuzes called for the components to withstand a set back force of 10,000 times the force of gravity, the requirement of ruggedness led the engineers at Centralab Division of Globe-Union Inc., in cooperation with the National Bureau of Standards to the perfection of the process of circuits printed onto steatite ceramic plates.

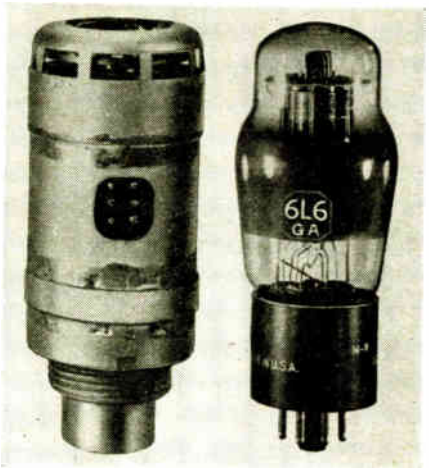


Fig. 1—Complete fuze, containing air-driven generator, transmitter, receiver, amplifier and control circuits, compared in bulk with standard type of 6L6 amplifier tube

Fig. 2—Photograph showing the comparative sizes of equipment as normally produced by conventional methods and the same circuit as produced by the newly developed "printing" process

To graphically show the reduction in size made possible by this printing method, Fig. 2 portrays a two-stage amplifier produced by conventional radio assembly methods compared with identical circuit produced by the new steatite plate method. In the photographs, Figs. 3 and 4, the top and underside of a 2-stage amplifier is shown. When they are compared with the wiring side of a conventional 2-stage amplifier chassis the neatness and compactness of the new method is striking. A diagram of the circuit used for both units is shown in Fig. 5.

The five distinct steps in the production of the ceramic plate amplifier are: 1. Fabrication of the steatite ceramic plate; 2. Printing or stencilling of circuit wiring on the steatite plate; 3. Spraying resistors through accurate masks, which size and position the resistors between proper silvered leads; 4. Attaching small, high dielectric constant, ceramic disc capacitors directly to the silvered wiring on the plate; 5. Soldering tubes or other required components to silvered lead holes provided in the ceramic plate.

The hardness of the steatite, after firing, closely approaches that of a sapphire, and it is impossible to perform any machining operations on it other than wet grinding with diamond wheels. As this is a slow

STEATITE CHARACTERISTICS

Thermal Coeff. of Expansion per degree Centrigrade	20-800°C 8.3 x 10^6
Modulus of rupture in lbs. per sq. in.	21,000
Dielectric constant	5.82
Dielectric loss factor at 1 kc	.40%
Dielectric power factor at 1 mc	.06%
Dielectric strength per mil thickness	247 v
Grade per American war standard C75.1-1943	L 5
Porosity of moisture absorption	0 to .005%
Color	White or Ivory

and costly procedure, it is performed only when extremely close dimensional tolerances are required.

The silver is applied to the steatite in the form of a paste composed of silver oxide or finely divided silver in combination with binders and solvents. The actual application or "printing" is done by means of the silk screen process. The screen is prepared using a photosensitive emulsion coated onto a fine mesh silk. The finer the silk mesh, the finer and more delicate a pattern can be produced. The screen, in turn, is stretched tightly on a sturdy wood or steel frame as in Fig. 6. It is possible to see the open paths through which the paste is forced through the fine mesh on the steatite with a neoprene bar or "squeegee."

The actual pattern of the screen is produced by preparing an accurate black and white transparency negative of the pattern desired. For example, the negative for a plaque handling the circuit of Fig. 5 is shown in Fig. 7.

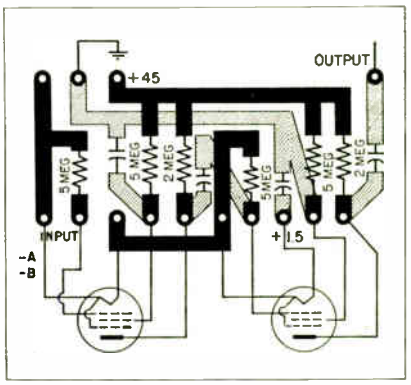


Fig. 5—Placque assembly for amplifier, using layouts of Fig. 3. Under face is wired as per cross-hatched strips, as at top of Fig. 7

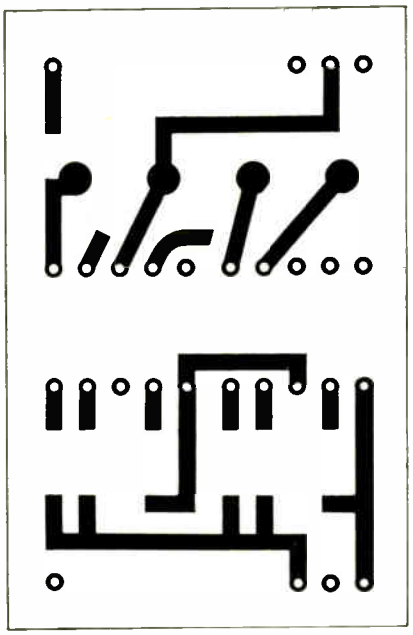


Fig. 7—View of the pattern on silk screen

After application of the silver paste to the ceramic the plates are placed in a furnace heated to 1300-1500° F. to burn off the solvent and binders, leaving the pure silver leads or wiring adhering to the steatite with a tensile strength of approximately 3000 lbs. per sq. in. For use in very ultra high frequency circuits, small circular or rectangular spiralled coils may be printed flat on the steatite surface by this method. Coils have readily been produced with Q's of 150-200 with

(*Continued on page* 120)

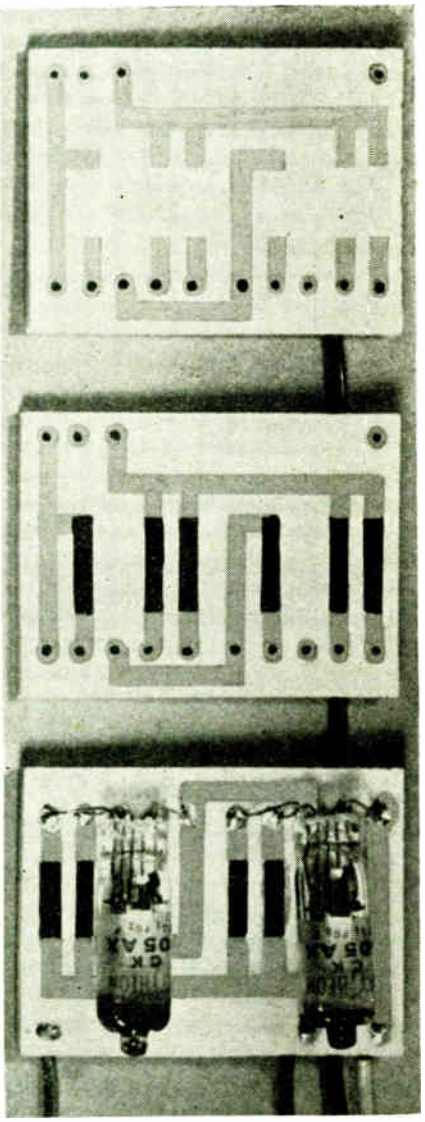


Fig. 3 — Above, various steps in processing the silver "printed" ceramic placques

Fig. 4—Bottom view of completed placque

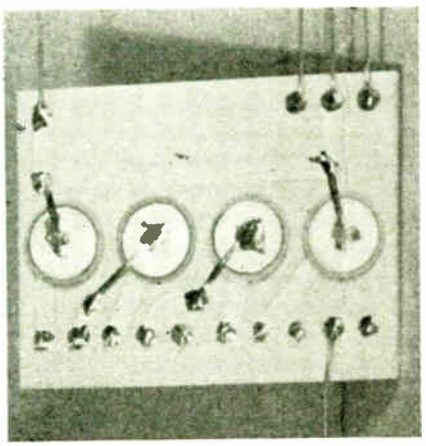
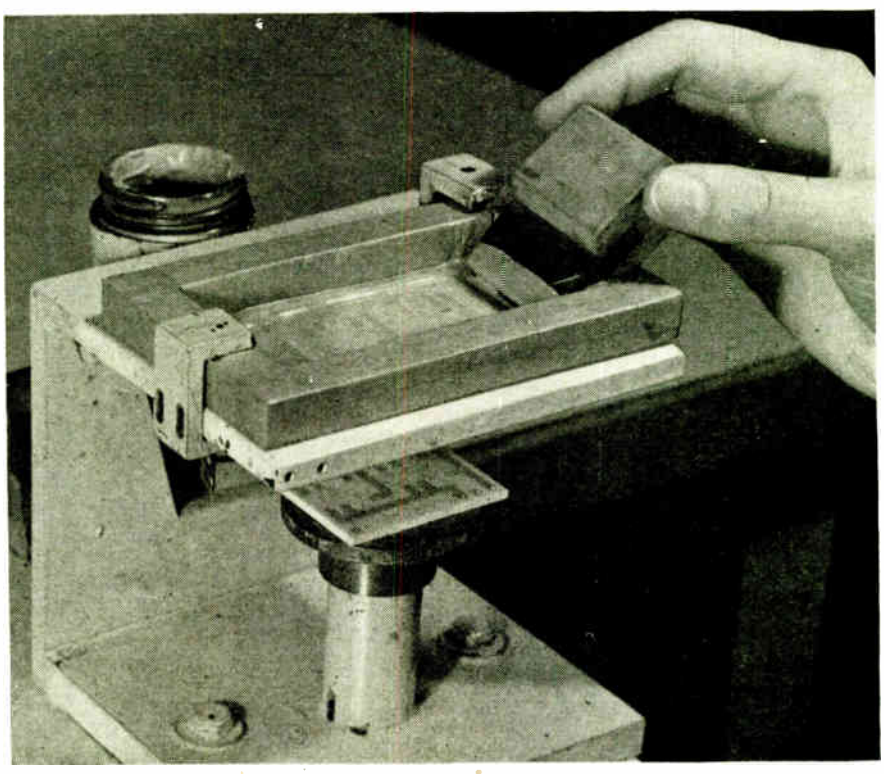


Fig. 6—The silk screen in use showing the silver paste, and neoprene bar or squeegee in use. The ceramic placque is raised by treadle to come into contact with the screen as shown



TUBES ON THE JOB

This unit refrigerates; cooks and serves individually wrapped hot dogs in 20 seconds

Electronic Weeny Cooker

A new automatic vending machine which keeps food products under refrigeration until they are cooked with dielectic heat has had its first commercial installation in New York. The unit handles frankfurters in rolls but additional models dispensing other types of hot food are a possibility in the near future. This new hot dog unit stands about 6 ft. high and occupies approximately 6 sq. ft. of floor space. It will operate from any ac outlet. The cabinet is divided into three sections. The bottom contains the compressor and mechanical equipment for the refrigeration unit. The top section houses three storage drums in which the cellophane wrapped frankfurters and rolls are kept at 45° F. until delivery to the electronic cooking equipment. The machine will hold 180 food units at one loading. A larger model is under construction to handle 300 units. The center partition of the cabinet contains the dielectric heating equipment, the power supply and the electric controls for the storage drum movement which delivers the food unit to the heating element and finally to the customer. The electronic heating circuits use only three tubes. The oscillator is a new tube especially developed for this equipment. After considerable experimentation, Aireon Mfg. Corp., Kansas City, Kans., which helped design and is building these machines, has found that an undisclosed frequency cooks the hot dog perfectly in 20 seconds without scorching the roll. The sandwiches are delivered at a temperature of about 170° F. Radio Chef, Inc., Chicago and New York, are planning installations at many factories, transportation terminals and entertainment centers.

Development work is being pushed on a coffee making machine which will make fresh coffee every time a coin is inserted and not simply measure out a cupful of coffee that has been brewed at some previous time.

Automatic Bean Sorter

In the plant of the Michigan Bean Co., Saginaw, Mich., electronic equipment is being used to pick up each individual bean, scan its color and then automatically sort it. The whole operation is many times faster and more accurate than was possible with human sorting.

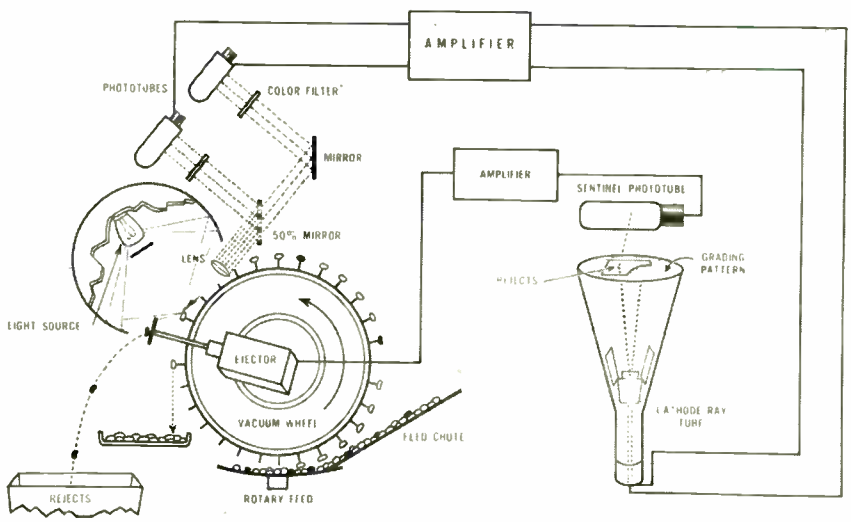
The beans are dropped on a rotary feed disc. At right angles to the face of this disc a revolving vacuum wheel is mounted. From the circumference of this vacuum wheel a series of hollow spoke-like tubes project, each of which pick up a single bean and holds it for the entire cycle of operation. During its travel cycle the bean passes under a light source, reflecting a certain precentage of this light into an optical system. The amount of light reflected depends on the physical conditions of the individual bean; if it is in satisfactory condition the skin is bright, glossy and firm. If the bean is in poor condition the surface is dull and dark.

Reflected light is picked up by two mirrors and serves as a control for the operation of two photoelectric lamps, one unit receiving the light after it has passed through a red filter and the second photoelectric lamp getting its beam through a green filter. The output of each of these lamps is amplified and then fed to one pair of deflecting plates in a cathode ray tube.

By masking off a pre-determined area on the CR screen for beam position indicating a good bean, a positive illuminated signal is established for all rejected beans. This rejected signal is used as a control for a third photoelectric tube, which in turn operates an ejector plunger. This ejector removes the bean from the holding tube on the vacuum wheel and drops it into a reject bin. All beans not removed by the ejector mechanism are deposited as good in container by breaking the vacuum in the hollow tube holding the bean.

The complete installation in Saginaw consists of eighty units each of which will sort 2,500 lbs., of Michigan Pea beans every 24 hours. The equipment was designed and built by Electric Sorting Machine Co., 410 44th St., S. W. Grand Rapids 8, Mich.

Schematic of bean sorting equipment; proportion of red and green light controls rejections



Measuring Time

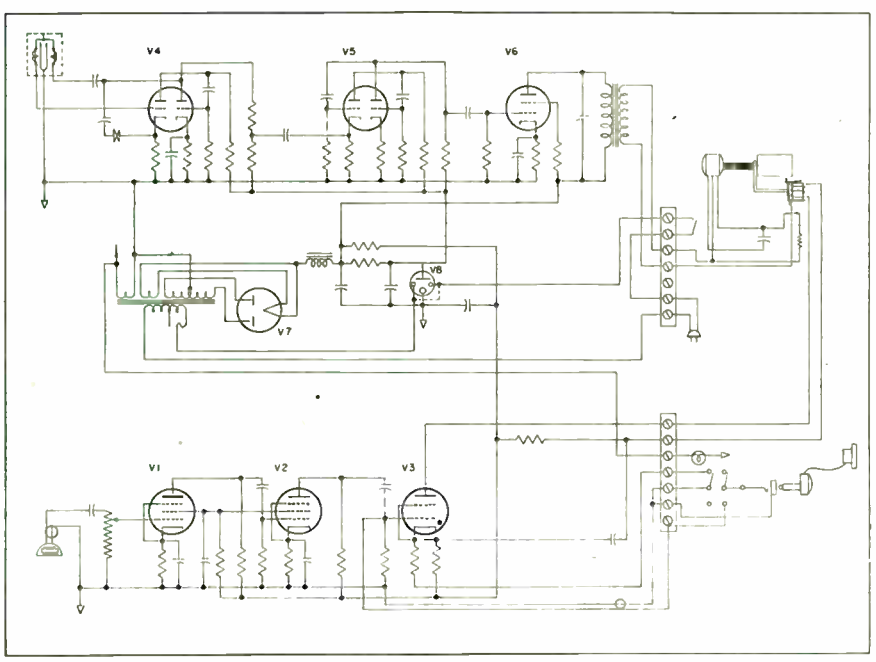
One of the many useful tools that the war has accelerated for the use of industrial research and design is the measurement and control of ultra-short time intervals. An interesting industrial job that tuned fork and electronic control engineering has done for a trade which formerly required a long apprentice and training experience, is the Watchmaster made by American Time Products, Inc., New York City. This watch rate recorder will plot on graph paper any incorrect adjustments or mechanical trouble of any watch. A 30 second test is long enough for an accurate diagnosis of trouble or to check adjustments.

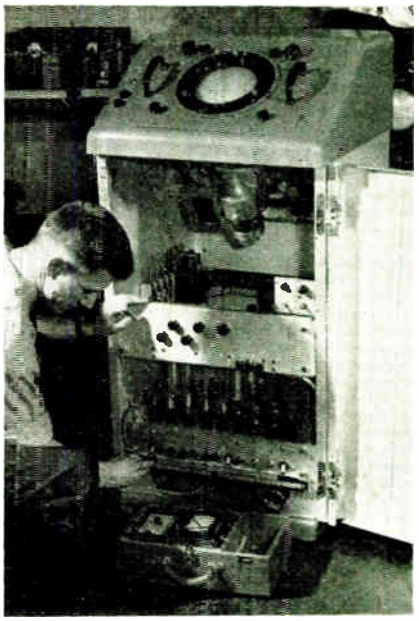
Test results are shown on drum in center

As will be seen in the schematic, the equipment consists essentially of two circuits; one picks up the tick of the watch through a microphone and after amplification is used as the control of a magnetically actuated stylus. The second circuit is pulsed with a special alloy compensated tuning fork and is used as a speed control of the motor driven graph cylinder which revolves at exactly five revolutions a second. The response accuracy of this fork is better than 0.001 per cent. Inasmuch as the average watch ticks five times a second and each tick operates the printing stylus, a watch that is in perfect adjustment prints an index line parallel to the guide lines on the graph paper. If a watch is running fast the index line will slope upward, if slow downward.

Not only will this electronic unit indicate running speeds but it will also print the reason a watch is not keeping correct time. The normal tick of a watch is a complex group of sounds each caused by the separate operating functions of the works. However, many of these individual sounds have no bearing on the performance of the watch so the entire group are resolved in the Watchmaster as a single recorded dot. If these dots in the index line are straight it would show that the watch under test was in good operating adjustment even if it was running slow or fast and needed regulation. If the index line is broken or ragged it is a signal that the watch has definite mechanical trouble. Each particular type of trouble affects the rhythm of the watch tick in a characteristic pattern. When this pattern is printed on the graph and compared to a standard set of index line trouble curves it provides an accurate guide to the cause of the trouble.

Precision tuning fork drives the graph-paper drum through rc amplifier at exact speed of 5 rps; amplified watch tick controls a gas-filled thyratron with recording stylus magnet in plate circuit





Radar receiver-indicator on City of Richmond

Peace-time Radar

The Old Bay Line's Baltimore-Norfolk night boat, City of Richmond, is now equipped with radar. This new Westinghouse equipment will provide navigational and anti-collision protection to the vessel on its regular 185-mile night run, regardless of weather conditions. Readings may be taken at three ranges. For close-in navigation an area four miles in diameter can be indicated in the seven inch viewing screen. The second range will cover an area sixteen miles across, while long range pictures will scan thirty-miles on all sides of the boat. The antenna, modulator and other rf units are mounted on the wheelhouse roof.

Reducing Baking Time

Infrared baking of electric coils has proven six to eight times faster than convection heating. In a time comparison made at an installation by the Fostoria Pressed Steel Corp., Fostoria, Ohio, the time required for proper coil baking in a convection oven was from 8 to 12 hours; Fostoria equipment reduced this time to 1 to 2 hours.

Steel Temperatures

Used with an electronic recorder, a new platinum thermocouple will measure the temperature of molten steel. Recorded temperatures can be made in less than forty-five seconds. This new high temperature recording equipment is manufactured by Brown Instrument Co., Philadelphia, Pa.

MANUFACTURE AND USE

By D. E. REPLOGLE
President, Electronic Mechanics, Inc.

Unusual combination of properties possessed by this insulating material make it useful in high frequency work

• Glass bonded mica, one of the newer insulators, has been used extensively during the war, particularly where low losses and strength were of prime importance. Its nature is unusual enough to warrant some description of its make-up and method of manufacture.

Were it found in natural form, glass bonded mica would most likely be classified as a metamorphic rock. Mica, which contributes its sterling value as an electrical insulator to this material, is itself one of the metamorphic rocks. It is an example of the extraordinary changes Nature effected with heat and pressure, clay having been the raw material.

Glass bonded mica comes closer in likeness to another metamorphic rock, quartzite, than it does to mica. Quartzite is composed of quartz grains cemented together by silica. If the words "mica grains" are substituted in this description for "quartz grains," we have a good description of glass bonded mica.

It resembles natural rock not alone in the inorganic materials which compose it and the process by which it is made. It has also unmistakably the appearance, the feel and the sound of stone—of an extremely dense, fine-grained, exceptionally hard stone. In color, it varies from a deep chocolate brown to light tan. Glass-bonded mica is also spoken of as "ceramic" material because, like the more readily identifiable ceramics, it is composed of inorganic earths fired to give stability to the final shape. Although a kinship does unquestionably exist, nevertheless an important difference distinguishes glass-bonded mica. This difference is in the manner of using pressure and heat in its manufacture. Pressure may be employed in the forming of ceramics, but it is not applied simultaneously with heat. In the making of glass bonded mica, on the contrary, the crux of the operation is when heat and pressure are combined to transform the raw materials into the final product.

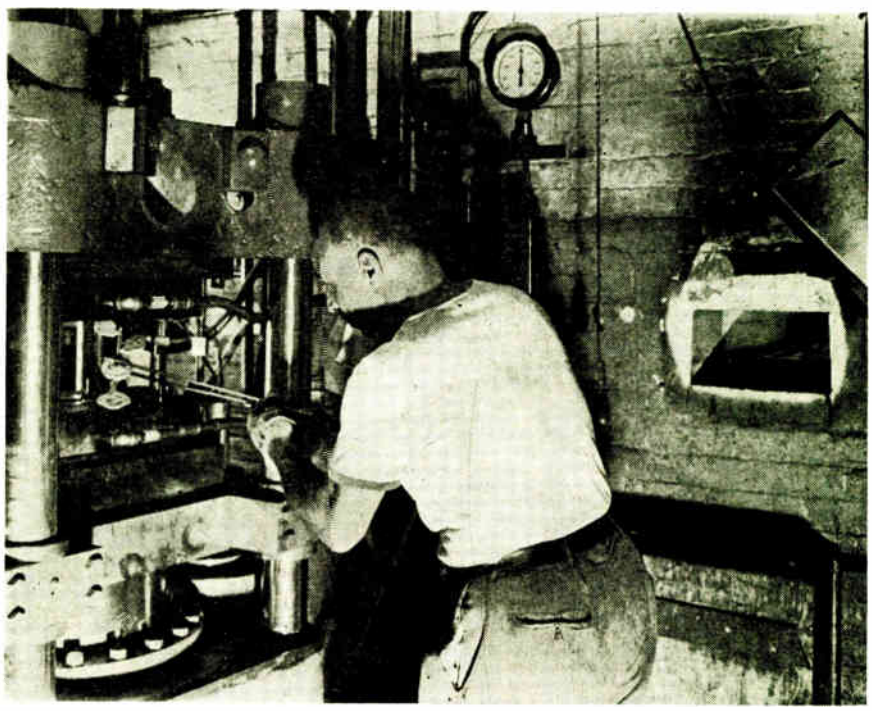
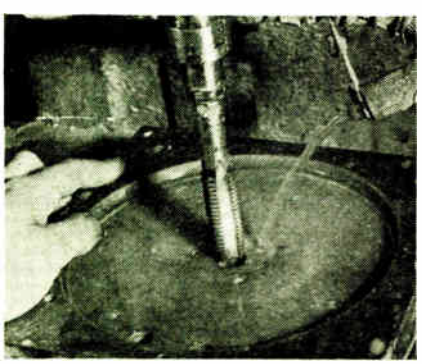


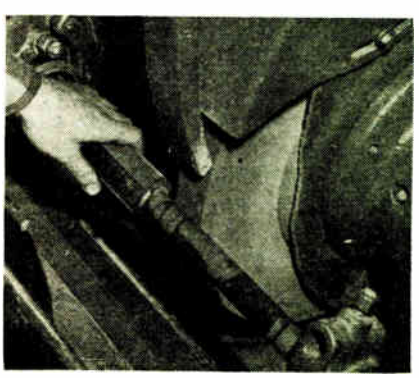
Illustration of molding process. Great heat and pressure are required to cause proper flow

Glass bonded mica, as it emerges from the manufacturing operation, looks like neither glass nor mica. In some ways, it behaves like neither, for it is a substance both of logic and paradox. Two of the finest insulators known are mica and glass. In view of this, it is logical that a compound of selected mica and special glasses should be a superb dielectric. Mica alone is subject, however, to splitting and flaking, and glass alone has always been associated with fragility. Yet, paradoxically, their union results in great mechanical strength. Furthermore, glass does not lend itself

Sheet of glass bonded mica being tapped with the use of water as coolant and lubricant



Excellent surface finishes and close dimensions can be obtained by cylindrical grinding



OF GLASS BONDED MICA

to conventional machining. Yet this synthetic stone can be cut, drilled, milled, tapped, ground and polished with virtually the same ease and to the same split-thousandth tolerances as the metals.

In addition, it can be molded into intricate shapes, bonded with metals in molding, is resistant to high temperatures and electrical arcs, and virtually impervious to water, oil and gases. From this it becomes clear why glass bonded mica has become indispensable in high frequency radio apparatus, electronic devices and ignition equipment.

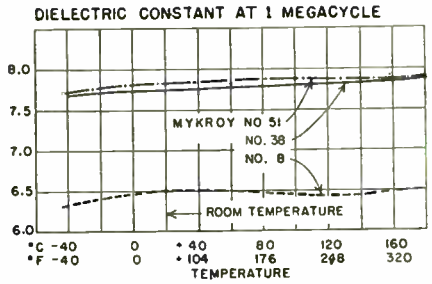
Its special virtue lies not in any one particular noteworthy quality. Rather, it is in the unsurpassed combination of valuable and useful properties it possesses. For the sake of brevity and simplicity, the leading insulating materials suitable for the same applications may be placed arbitrarily in three categories, (1) the ceramics, (2) the plastics, (3) the phenolic resins.

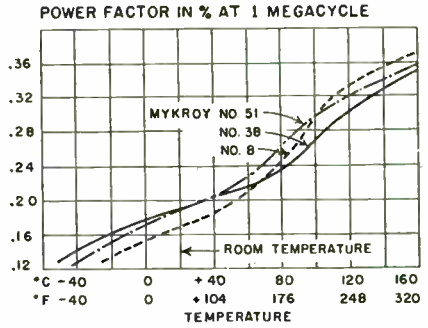
Steatite

In the ceramic group the steatites are the outstanding insulators. They have excellent electrical characteristics. They possess great resistance to heat, being able to withstand higher temperatures than glass bonded mica. They are strong mechanically and have rigidity. They may be molded into a variety of shapes prior to being fired.

A comparison of the electrical properties results in pretty much of a standoff. With respect to heat resistance, glass bonded mica will readily withstand prolonged exposure to temperatures up to 500-800 deg. F. without damage to its electrical, mechanical and physical properties. Higher temperatures are not generally encountered in radio or electronics work. Furthermore, at extremely elevated temperatures most ceramics lose their dielectric value and actually become conductors. Insofar as mechanical strength and rigidity are concerned, glass bonded mica compares favorably with steatites, being tough rather than brittle.

It has two important advantages over the steatites in molding. It can be molded to much closer tolerances, and it can be bonded with





Above: Change of dielectric constant with temperature. Right: Power factor versus temperature for three grades

metal in molding. The steatites, because of the extreme heat to which they are subjected in firing and the shrinking which occurs, are not molded in combination with metal. Inserts of metal must be added later. Glass bonded mica and metals on the other hand bonds so well that hermetic seals capable of holding 80 p.s.i. of hydrogen pressure are obtainable.

To overcome the shortcomings of porosity and roughness, glazing and impregnating with wax are accepted practices with steatites. Both at best are compromises. Glazes are liable to crack and craze, permitting grime to lodge in the cracks on the surface and impair insulating efficiency, and glazes do not themselves have the excellent electrical characteristics of the body they cover. Waxing introduces an organic material, with the weakness this implies in the presence of an arc and the tendency to pick up dust. Because glass bonded mica has such a dense, smooth surface, glazing and waxing are not necessary.

Polystyrene

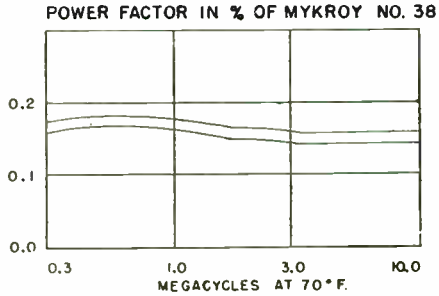
Among the plastics, the polystyrenes are probably the most widely exploited for electrical applications. The best polystyrenes boast of unusually low power and loss factors, approximating quartz in these respects. Dielectric strength is high. Mechanical strength of the polystyrenes, theoretically, is good, but the figures, impressive though they may be in print, do not tell the whole story. Cold flow is a serious problem with these materials. This shortcoming is intensified by mere warmth. Distortion from heat in the polystyrenes begins far below the boiling point of water, at temperatures ranging from 140 to 180 deg. F.

It is this inability to resist heat which makes the plastics so easy to mold. Glass bonded mica also molds well, but not because it is plastic, at low temperatures. In order to make it sufficiently plastic to flow under extremely high pressures, temperatures up to 1,800 deg. F. are required.

Phenolic resins

In the early days of radio, the phenolic resins performed yeoman service. In mechanical and dielectric strength the best types are excellent. With the advent of high frequencies, their high power factors and consequent high loss factors impaired their value in apparatus in which serious losses could

Variation of power factor with frequency



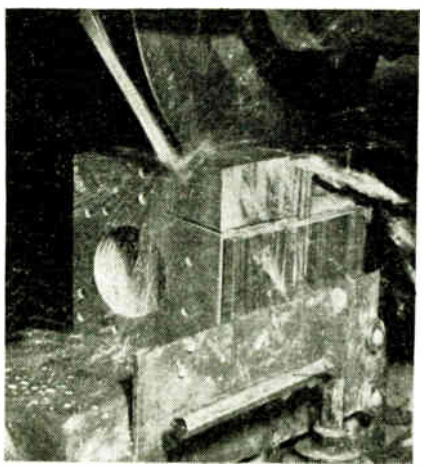
not be tolerated. The phenolics are also subject to cold flow and, being of organic origin, will carbonize under the heat of an arc. The phenolics furthermore are plagued by water absorption tendencies, whereas in glass bonded mica this is negligible. The phenolics — and other insulating materials as well, incidentally—require "tropicalizing" treatment to inhibit growth of fungi and molds in hot, humid climates. Glass bonded mica, it has been demonstrated by war-time ex-

perience, will not support the growth of fungi or molds and does not need "tropicalizing."

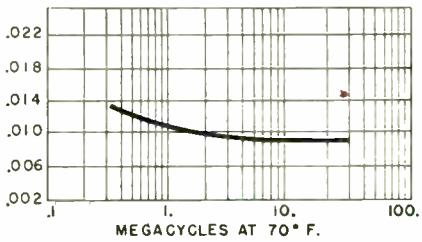
In the making of molded parts, the blended, finely-ground materials are formed into pellets, which vary in size according to the part for which they are intended. Some parts may be molded one at a time, others at the rate of 30 or more in a single operation. A pellet of average size is about as large and has about the same rectangular shape as a cake of everday toilet soap.

In small tunnel kilns, the pellets are heated to temperatures which may range up to 1,800 deg. F., depending upon the type of mix employed and the form desired. Upon reaching the correct temperature, a pellet is taken from the kiln and placed in the die. Again high pressures are employed. After the brief "dwell" the mold opens automatically, releasing the part. Controlled cooling is followed by the finishing operations.

The following machining directions are of interest to designers and processors. Any hacksaw or milling cutter will cut glass bonded mica. A hacksaw cuts easily but slowly. For fast work, a band saw with 10 to 12 teeth to the inch should be used and run at a speed of 1,400 rpm. Saws, however, quickly become dull and do not leave a smooth edge. The new speed type of band sawing or friction sawing is very satisfactory. A 12 in. diameter, 3/32 in. thick, No. 50 grit, grade 4-C Carborundum wheel, run at 3,600 rpm, will give a smooth surface, free from breaks or rough edges. A continuous flow of water is the best lubricant. Any high speed abrasive wheel operated dry can be used, but a somewhat rough edge may result. If a milling cutter is employed, 6 in. diameter by ⅛ in. thick side chip clearance saws are recommended and operated at a top spindle speed of 128 rpm. Cutting feed for ⅝ in. materials is 3½ in. per min. Large holes can be cut with a Carboloy fly cutter.



Sawing block by use of friction technic



Variation of loss factor with frequency

Drilling should be done with a firm, solid support beneath the glass bonded mica to prevent chipping when the drill breaks through. When the point breaks through, the piece should be turned over and the hole finished from the other side. A stream of water on the drill, or drilling under water is recommended. Drilling may be done dry, and a stream of air used to keep the hole free of dust and chips. High-speed drills may be used. Due to the abrasive quality of glass bonded mica, drills will dull rapidly and require frequent sharpening. Sintered carbide drills are an improvement as they will lessen the amount of sharpening required. Drills up to ¼ in. diameter should be run at 500 rpm. For drills ¼ in. to ½ in., the drill speed should be lowered to 250 rpm. Use 1 in. feed per min. for a ½ in. drill.

Holes should be tapped with a long lead tap. Both ends of the holes should be countersunk to prevent chipping.

Whenever possible, glass bonded mica should be shaped by grinding. The right grinding wheel, with plenty of water at the point of contact, will do the job quickly and leave a very satisfactory surface.

For honing, Carborundum machine hone No. 2F-6CF on a Patch Neguer machine running at 175 rpm will give satisfaction, while polishing can be done with a felt buff with powdered oxalic acid.

Aside from the usual requirements of molding practice, the following points should be noted:

Die draft taper—2 deg.
Minimum wall thickness—1/16 in.
Depth to diameter ratio for holes and slots—Preferably 1 or less.
Use rounded corners and edges.

Expansion coefficient of metal inserts should be similar to glass bonded mica. For tight seals use a metal with a slightly lower coefficient unless the metal goes around the insulator, in which case a higher coefficient is indicated.

PHYSICAL PROPERTIES	No. 8	No. 38	No. 51
Dielectric Constant (at 70 F., ASTM)	6.50	7.75	7.82
Power Factor (in %, ASTM)	.170	.190	.188
Loss Factor (in %, ASTM)	1.11	1.47	1.47
Dielectric Strength (volts/mil, ⅛" thick)	620	500	510
Hardness Mohs	3-4	3-4	3-4
Brinell	63-70	65-74	70-70
Modulus of Rupture (lbs./sq. in., ASTM)	16,100	19,900	18,100
Resistance to Impact (ft.-lbs., ASTM Charpy)	.10	.165	
Specific Gravity	2.75	3.47	3.87
Density (lbs./cu. in.)	0.099	0.127	0.140
Volume (cu. in./lb.)	10.08	7.87	7.15
Water Absorption (ASTM D116-42)	.035%	.024%	.058%
Color	Dark Brown	Golden Brown	Light Tan
Thermal Conductivity (BTU/sq. ft./1 in. thick/hr./deg. F.)	1.8	2.2	2.4
Thermal Conductivity (cal./sq. cm./1 cm. thick/sec./deg. C.)	.000620	.000758	.000827
Linear Coefficient of Expansion/deg. F. —100 F to +300 F	5.9×10^{-6}	6.0×10^{-6}	6.4×10^{-6}
+300 F to +700 F			6.6×10^{-6}

LABORATORY KEYHOLE

Current Research that Forecasts Future Electronic Developments

RADAR TO MEAN ALL-WEATHER FLYING— Remarkable developments of radar and other electronic aids for aviation during war were depicted by Army Air Forces, Civil Aeronautics Administration, and leading manufacturers in a unique five-day conference in Washington, attended by 300 to 400 persons. Aim of conference was to establish standardized system of electronic-radar air navigation aids for the United States, and then it is hoped, for the entire world. British Commonwealth greatly interested in program and had large number of observers at conference—later British expected to reveal their system, planning to American government and commercial interests at another round-table meeting. Conference was unanimous on one determination that present system of radio ranges and radio marker beacons would be replaced or supplemented by a complete system of radar control to mark the airline routes.

PRECISION TESTING—An electronically-controlled precision testing apparatus has been developed to check the performance of hydromatic airplane propeller governors. The governor which automatically adjusts blade pitch must be accurate within five revolutions per minute, or 0.02% at maximum speed. The new instrument is accurate within one revolution per minute and converts time, oil pressure and rpm into one set of comparable figures read from dials.

DUO-SPEAKER WITH RESONANCE—At Princeton, N. J. labs of RCA, Dr. Olson has been showing visitors newest duo-speaker. This consists of a large heavy 12-in. cone for low frequencies, in the center of which is a small cone about 3 in. in diameter radiating the high frequencies. The frequency response of this newly designed speaker is approximately flat from 60 cycles to 15,000 cycles. By regulating a resonant chamber in the rear of the cone the low-frequency response can be considerably accentuated if desired.

TELE ON WHEELS—Dr. T. T. Goldsmith of Allen B. DuMont Laboratories, Passaic, N. J., has equipped his 5-passenger sedan with a television set mounted in the rear seat, affording interesting data on interference, standing waves, and other 50-90-mc phenomena as he spins around Jersey. If he travels radially from the New York transmitters, the picture brightens and vanishes at fixed wavelength intervals; when moving tangentially this phenomenon disappears. Tele-set on wheels has also revealed critical nature of antenna location; moving car a few inches or feet gives surprising difference between excellent and poor picture reception.

COFFEE ROASTING—Electronic roasting of coffee beans is being studied. Preliminary results show that dielectric heating has a definite advantage in retaining a considerable percentage of the organic matter now driven off in the heating period in conventional roasting. To offset this advantage the initial equipment investment is higher than present type ovens. Continuing study is being made.

ATOM-BOMB TESTS TELEVISED — Plans for Marshall Island tests of atomic bombs scheduled for May will utilize two video transmitters set up on Bikini atoll, near site of explosions. Television receivers will be placed on the Navy's flagship and on press and observation vessels all 20 miles away. At these safe and remote viewing points, officers and scientists will study explosions by television, and the video screens will be filmed for Navy records and for newsreels.

TINY TUBES FOR HOME RADIOS are now subject of forward-looking researches, to use tube types developed for proximity-fuze. These sub-miniature tubes, each no larger than a pencil stub, are baseless and, in groups of four or more, would be soldered into a slug which could be slid into place in the set, facilitating tube replacement. Table sets might then shrink to cigarette-box proportions.

TELE FROM BLIMP—With Westinghouse preparing to transmit television and FM from Martin plane over Pittsburgh, GE has been experimenting with dirigible flying over Albany and other Hudson River points as relay link for television and FM.

GERMANIUM CRYSTALS—For use as a radio crystal, germanium requires very careful processing, according to procedures devised in the Purdue University laboratories, but it possesses striking advantages over silicon for some purposes and is silicon's equal in most other respects. Germanium crystals are in many ways declared far superior to conventional diode radio tubes, and can even serve as oscillator tubes. Though they can conduct a much larger current than ordinary diode vacuum tubes, they are small, require no heater, and can be wired into a circuit like a resistor.

HIGH VOLTAGE AT LOW COST—Television receivers requiring 6,000 to 30,000 volts for operation of either direct-viewing or projection type picture tubes use compact power supplies that rectify radio frequency voltages to obtain high dc output for low load currents. Filter capacitors on the order of 500 micromicrofarads are adequate, reducing size and cost as well as shock hazard. In quantity production these high voltage supplies may cost less than a power transformer alone, helping to lick another economic hurdle for the television industry.

NOTE: *Please don't ask us for more details about any of the foregoing. We present here all the information we have. As soon as we get more about any of these situations, full details will be printed in Electronic Industries. Our editors run across many interesting tips, leads, and rumors, both well-founded and baseless. We thought you would be interested in hearing about them, even if we can't give all the details or vouch for their authenticity. Editors.*

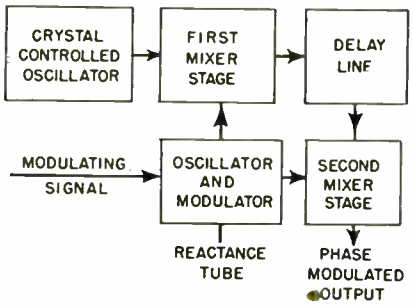
SURVEY of WIDE READING

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

Wide Phase Shift Modulator

D. Weighton (Wireless Engineer, London, December, 1945)

The frequency modulator represented in the block diagram includes a crystal-stabilized oscillator the output of which is heterodyned in the first mixer stage with a frequency - modulated signal derived from a reactance-tube modulator. The difference frequency is fed to a phase-shifting network, preferably a band-pass filter, which is required to have a linear phase-frequency characteristic, i.e., a constant time-delay independent of frequency over the beat-frequency range. The crystal frequency is restored in the second mixing stage by heterodyning again with the frequency - modulated signal and selecting the summation component by means of a filter.



Modulator for up to 90 radians phase shift

The performance of this circuit as to its frequency-modulation characteristics is studied in detail estimating the various effects causing distortion. It is pointed out that the reactance-tube modulator need not have high frequency stability. The maximum phase displacement produced by the system is approximately equal to $\phi\Delta\omega$, the product of the delay time, ϕ, introduced by the network and the maximum angular frequency excursion $\Delta\omega$ of the modulated oscillation.

The above approximation becomes less good for increasing modulating frequency and increasing delay time; this imposes a limit on the delay time. If a loss of one db at 10 kc/sec is admitted, the delay time ϕ should not exceed 26.4 microseconds. Another factor causing distortion is the non-linear relation between the frequency shift produced by the reactance-tube modulator and the impressed modulating voltage; harmonics will be present for large frequency swings. Based on previous investigations, a maximum frequency deviation of ± 75 kc/sec may be realized with less than 2% total harmonic distortion.

Combining this figure with the maximum permissible interval of the delay network, the maximum admissible phase shift produced by the system is $26.4 \times 10^{-6} \times 2\pi \times 75 \times 10^3 = 12.45$ radians. The last source for distortion considered is the difference in phase shift introduced by the time-delay network for different frequencies. It is estimated that the percentage harmonic generated in this process is equal to $3.125 \times \phi^2/n^2$, i.e., 3.125 times the square of the ratio of the delay time of the network to the number of network sections. The number of stages n required for a time delay of 12.45 radians, assuming a 1% harmonic content, may be evaluated from this relation to be 22.

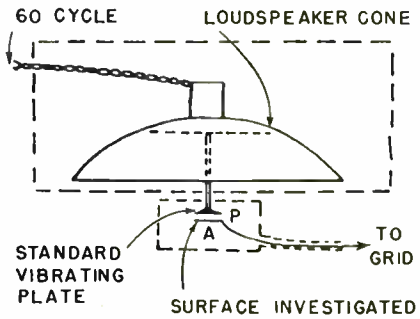
In practice a much larger phase variation than 12.45 radians may be utilized. A time-delay up to 50 microseconds could be introduced if an equalizer were inserted in the time-delay network. Further a frequency excursion of ± 300 kc/sec, instead of ± 75 kc/sec has been tried by the author without observing any undue distortion. These two figures result in a tentative estimate of $50 \times 10^{-6} \times 2\pi \times 300 \times 10^3 = 94$ radians phase shift; this would however, require a 167 section filter for a 1% harmonic distortion.

Measuring Contact Potentials

S. Rosenfeld and W. M. Hoskins (Review of Scientific Instruments, December, 1945)

In the course of an investigation concerning the phenomena of wetting it became necessary to measure the contact potential differences of the systems liquid-liquid and liquid-solid. A method previously developed by Zisman was modified and used.

Two conducting media whose contact potential difference is to be established are arranged to form the parallel plate capacitor A, P. The capacity of this capacitor is periodically varied by oscillating the standard-gold-plated plate P which is attached to a loudspeaker cone driven by a 60 cycle voltage. The surface under investigation constitutes the fixed plate of the capacitor. The generated ac voltage is amplified and indicated on an oscillograph.



Device for measuring contact potentials

If an equal voltage of opposite sign to the contact potential difference is impressed on the circuit, the oscillograph image changes from a sine-wave shape to a straight line. A type K Leeds and Northrup potentiometer was used for measuring the contact potential difference.

It was found that a conventional two - stage, resistance - capacitance coupled, high-gain voltage amplifier yields sufficient amplification to enable measurement of the contact potential difference to 1 millivolt. The two tubes used were a National Union Sound X/TRA 6J7 designed to give low microphonic values in the first stage and a RCA 6J7 in the second stage. Careful shielding had to be provided. Spurious effects when leaves are measured are avoided by use of nonpolarizing connections through a calomel half-cell.

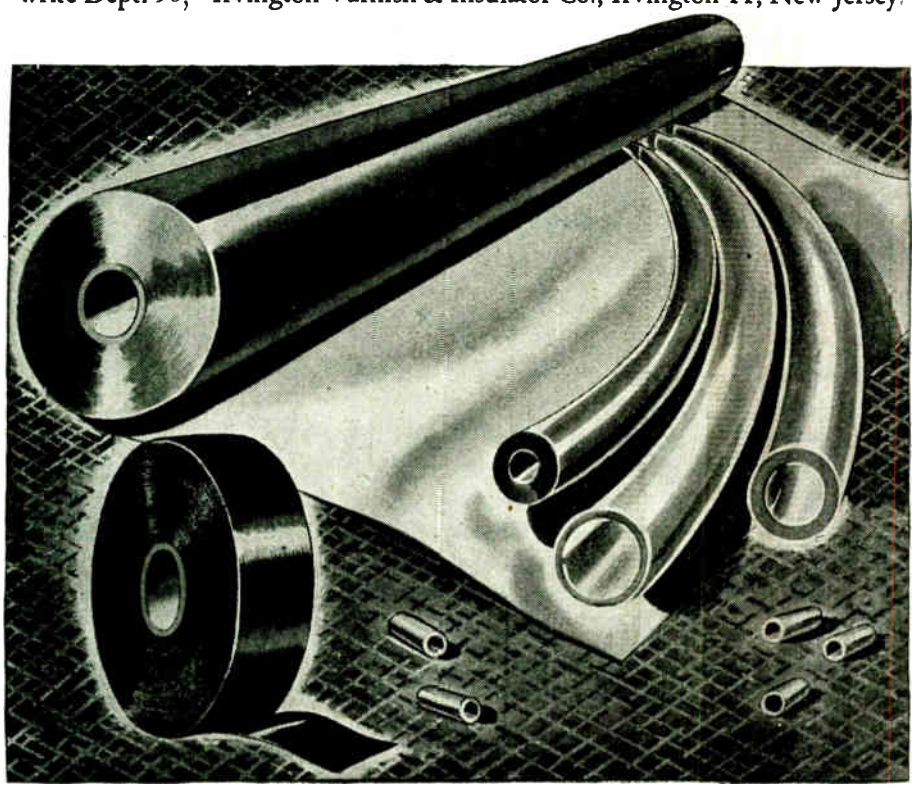
VARNISHED fiberglas Insulations

. . . that provide all the advantages of Fiberglas, *in fullest measure!*

It is the *varnish* and its proper application that endows Fiberglas insulation with that *extra* insulating protection.

To insure this *added increment* of protection, Irvington uses only carefully compounded insulating varnishes, scientifically applied to a Fiberglas base. In fact Irvington Fiberglas reflects the same exacting research and supervised production that has kept Irvington the leader in electrical insulation.

The varnished Fiberglas insulations you require in types, sizes and specifications, are all available at IRVINGTON. For samples, or full particulars, write Dept. 50, Irvington Varnish & Insulator Co., Irvington 11, New Jersey.



- CLOTH
- TUBINGS
- SLEEVINGS
- TAPE
- PUNCHINGS
- WIRE MARKERS
- SLOT

IRVINGTON VARNISH & INSULATOR COMPANY

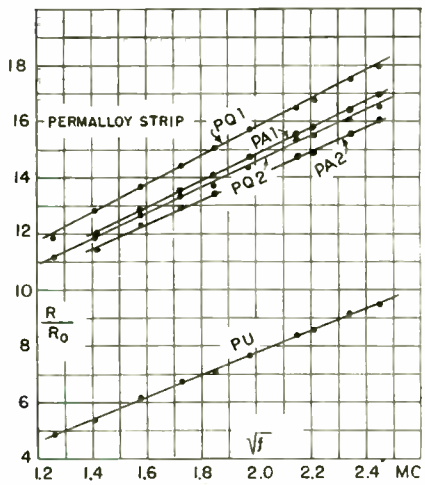
IRVINGTON 11, NEW JERSEY

RF Resistance of Iron Wires and Permalloy Strips

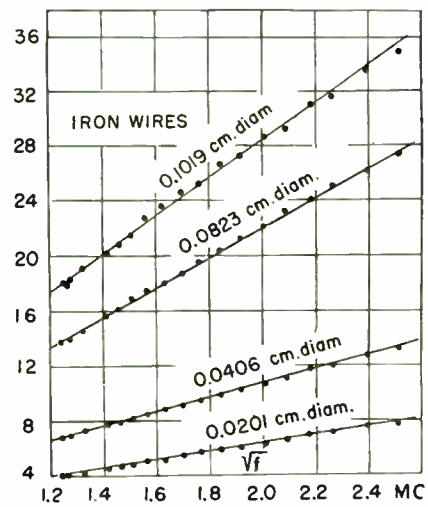
A. W. Smith, J. H. Gregory and J. T. Lynn (Journal of Applied Physics, January, 1946)

It is well known that the resistance of conductors increases with increasing frequency due to the skin effect. The ratio of R/R_o of ac to dc resistance of iron wires and permalloy strips was measured in the frequency range of from 1.5 to 6.0 mc per sec.

The voltage across a capacitor in a resonant circuit was measured with a tube voltmeter and the effect of the resistors to be investigated inserted in series was compared with standard resistances.



Resistance as function of sq. root of frequency



The permalloy tested had a composition of 78.5% nickel and 21.5% iron. Samples designated as PA-1 and PA-2 were annealed by heating in a closed furnace to 1000°C and cooled within the furnace over an eight-hour period. Samples designated as PQ-1 and PQ-2 were heated to 1000°C, but were withdrawn to cool quickly in the air when the temperature of the furnace had dropped to 600°C. The sample marked PU was not given any heat treatment.

In the two figures the results are graphically represented. The empirical equation of these curves is

$$R/R_0 = 0.4 + 1.57d(f\mu\sigma/10^3)^{\frac{1}{2}}$$

where d is the diameter of the wire in cm, R its resistance at the frequency f, R_o its dc resistance, and μ and σ permeability and conductivity respectively. These curves in conjunction with theoretical considerations indicate that the permeability of each specimen can be regarded as constant within this frequency range for small currents of a few milliamperes.

DC Beam-Cavity Oscillator

J. Marcum (Journal of Applied Physics, January, 1946)

The interchange of energy between a constant density electron beam and an oscillating electric field is studied; the electric field may be set up between grids connected to a cavity resonator. Under these conditions oscillations will be generated in the cavity provided the electron beam transfers energy to the electric field.

A partly graphical method for the solution of the problem is used and a chart is presented relating the various cavity and beam parameters and the operating frequency for ready evaluation of these quantities in a particular problem. A maximum efficiency of 17% is established.

FM Oscillator-Discriminator Circuit

A. Badmaieff (Journal of the Society of Motion Picture Engineers, January, 1946)

An apparatus was designed for conversion of mechanical vibrations into voltage variations. It may be used for the measurement or control of mechanical vibrations; its application to the testing of the frequency response of recording heads while cutting phonograph records is explained.

The vibrating system to be investigated is made to vary the position of the common plate of capacitors C_1C_2, thereby changing their capacitances in opposite sense. An electron coupled oscillator is formed by the cathode-control grid-screen grid section (K,G_1,G_2) and the tuned circuit (L_1,C_1), C_1 being the frequency determining element. The frequency-modulated oscillations supplied to the plate by electron coupling are detected in the discriminator circuit (C_2,L_2,D) which is tuned slightly off resonance with regard to the oscillation frequency.

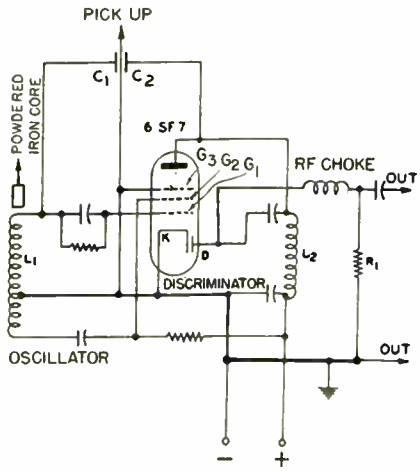


Fig. 1—FM oscillator and discriminator circuit

A voltage having an amplitude corresponding to the vibrations of the element under test will appear across output resistor R_1. This audio output of the oscillator-discriminator unit is amplified in a 6SJ7 connected as a triode and

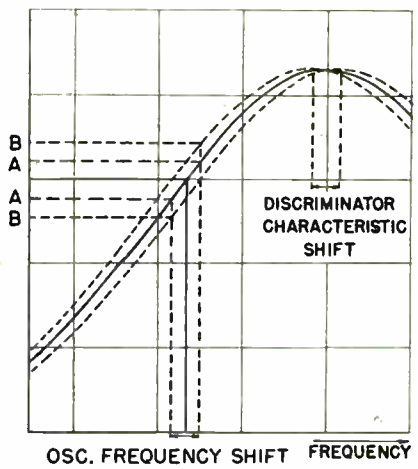


Fig. 2—Amplitude-frequency relation in Fig. 1

either measured with a tube voltmeter or made audible.

The oscillator frequency and the discriminator characteristic will simultaneously be displaced in opposite direction as the common capacitor plate moves. The operation of the system may be understood by inspection of the diagram in Fig. 2, where the heavy curve represents the discriminator curve for the center position of the capacitor plate and the two dashed curves are the discriminator characteristics for the extreme right and left positions of this capacitor. Simul-

(Continued on page 158)

WASHINGTON

★ ★ ★ Latest Electronic News Developments Summarized by *Electronic Industries'* Washington Bureau ★ ★ ★

FCC SPEEDS APPROVALS—Impetus to the construction of new broadcasting stations—standard AM, FM and television—is to be given by the Federal Communications Commission during April, when all five Commissioners will be in Washington after their field hearings. Promise of speedy decision during the coming month on the approximately 300 applications for new stations or improvement of existing equipment has been given by Acting Chairman Charles R. Denny, Jr.

SEE GROWING EQUIPMENT ORDERS—Approvals of the station construction plans loom as auguring a substantial flow of equipment orders to the manufacturers. In realization of the intense interest and value to the public of the new broadcasting media of FM and television, the FCC is bending every effort to implement authorizations in these fields. Likewise, in new non-broadcast radio services—aviation, radar, railroad, highway and urban mobile—the Commission has established special staff processes for speedy sanction of installation of equipment in these fields.

RECEIVER PRODUCTION SPEEDED; PRICING STILL HEADACHE—Even though the pricing "headache" still had to be ironed out in final form with the OPA by the radio manufacturers, particularly for components and materials in the higher-priced console and combination receivers, production in good volume, concentrated in the low and medium price sets (85% of them table models), has been reported to the Washington Government authorities as the prospect for the spring months. An upturn of shipment of radio receivers, approximately 500,000, occurred during January, but a falling off of production came in early February due to shortages of condensers, speakers, cabinets and tubes. This was alleviated somewhat in March.

FCC SURVEYS FM AND TELEVISION PRODUCTION OUTLOOK—The FCC has launched a questionnaire survey aimed to forecast the number of FM and television radio receivers and FM adaptors and converters to be produced in 1946. But the results of the Commission survey appear doubtful, since the manufacturing picture has been so clouded at present by the chain of circumstances tied in with price fixing and shortages of components and parts. Only end equipment manufacturers received the questionnaire. In regard to television receiver production, set manufacturing plans have the hazard of black-and-white versus color video. The FCC leadership has signified its desire to push lower-channel black-and-white television, but has just received a "$64 question" in the proposal of Columbia Broadcasting System to have standards for color video studied and promulgated in the near future.

TO PROCESS TELEVISION STATION GRANTS—In its program of launching television in various major metropolitan centers of the country, the FCC is giving first attention to the processing of television applications in cities where there are no stations. The first was Washington, where the applications of the Bamberger Broadcasting Service, Washington Evening Star Broadcasting Co. and National Broadcasting Co. were granted and action was deferred until oral argument on the Philco and DuMont video station assignments. The FCC, in its Washington proposed decision, gave special significance to the importance of a network owning a television station in the National capital. Hearings on the assignment of television channels in other large cities are slated to commence in Los Angeles and Chicago, while other centers will follow. The FCC visualizes around 100 video stations to be on the air by the end of this year.

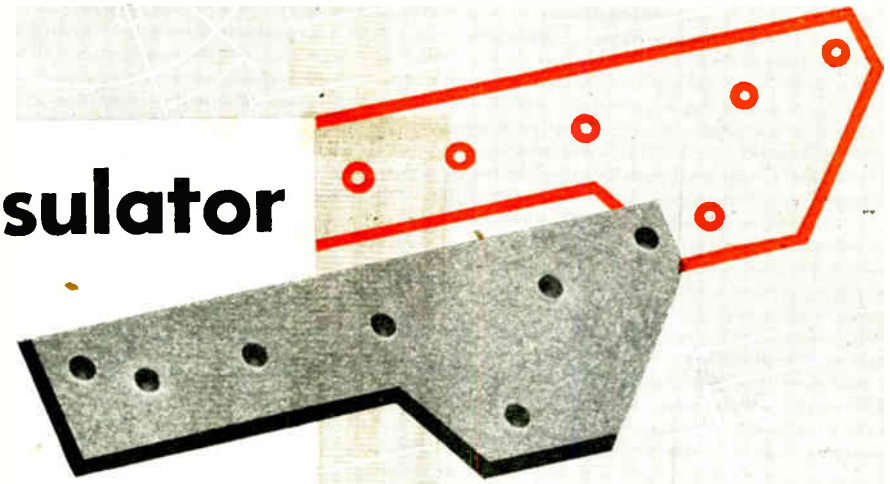
EDUCATIONAL FM POSSIBILITIES—Besides the large domain of commercial FM broadcasting, radio manufacturers have another substantial outlet for equipment sales in the educational FM broadcast service, for which twenty channels have been allocated, and which was launched for service by the Commission with the promulgation in early March of Rules and Regulations for educational station operation. Eventual FM outlook—4,000 to 5,000 commercial stations and around 800 educational stations, the latter estimated by U. S. Office of Education.

AVIATION RADIO-ELECTRONIC NAVIGATION AIDS RECEIVE CONCENTRATED ATTENTION—Aviation radio-radar-electronic aids are not being given much publicity in the daily press but promise a most fertile field for equipment production. Interest of manufacturers in this sphere was shown by attendance of 200 to 300 manufacturing, military and government experts at week-long session in Washington to devise plans for standardization of equipment for all-weather flying; meeting was under auspices of Army Air Forces Research and Development staff. Industry brought forth full plans for improvement of air navigation safety with variety of devices—Sperry's use of Klystron tubes; Federal Telephone and Radio's "Navar"; RCA's "Teleran"; Raytheon's radar developments; Hazeltine's "Lanac," etc. Important move in determining standard operating procedures of radio-electronic aviation devices for trans-oceanic flying was made during March at British-United States-Eire conference at Dublin.

National Press Building
Washington, D. C.

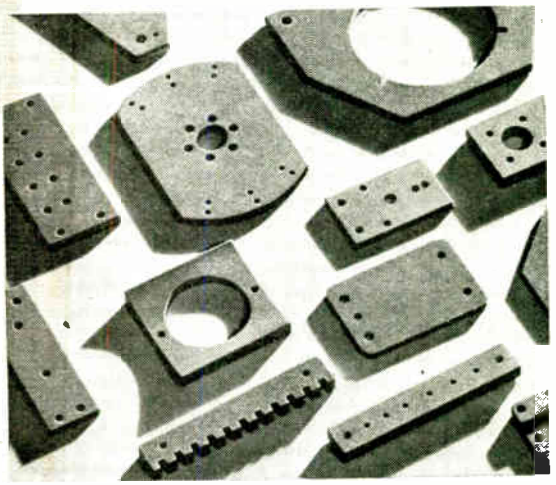
ROLAND C. DAVIES
Washington Editor

When insulator design calls for *Quick Action*



DEPEND ON MYKROY

PERFECTED MICA CERAMIC INSULATION



A representative group of parts fabricated in Mykroy to customer's specifications in our own plant. We have complete facilities to produce such parts in any quantities on rapid delivery schedules. Send us your specifications.

When time is of the utmost importance the ease and precision with which Mykroy can be fabricated into insulator parts makes it exceptionally useful to electronic and electrical engineers. Make those design changes on the spot . . . make them *quickly* and *economically* with Mykroy, for, here is a ceramic which can be worked in your own shop. Just transfer your design to the Mykroy sheet . . . then using conventional shop tools . . . produce the desired part by simple cutting, grinding, drilling, tapping and polishing techniques.

Because it has high structural strength and physical stability Mykroy can be machined to critical tolerances more readily than other types of ceramics. In addition, its electrical characteristics are of the highest order and do not shift under any conditions short of actual destruction of the insulation itself. This, plus excellent chemical and physical properties, makes it one of the best insulating materials ever developed for general and high frequency applications.

Get the full facts about this versatile dielectric now. Ask for a copy of the new MYKROY BULLETIN 102 which describes the new larger (19¼" x 29¾") sheet now available and call upon our engineers to help with your problems.

MECHANICAL PROPERTIES*

MODULUS OF RUPTURE	18000-21000psi
HARDNESS	Mahs Scale 3-4 BHN, BHN 500 K9 Load, 63-74
IMPACT STRENGTH	ASTM Charpy .34-.41 ft. lbs.
COMPRESSION STRENGTH	42000 psi
SPECIFIC GRAVITY	2.75-3.8
THERMAL EXPANSION	.000006 per Degree Fahr.
APPEARANCE	Brownish Grey to Light Tan

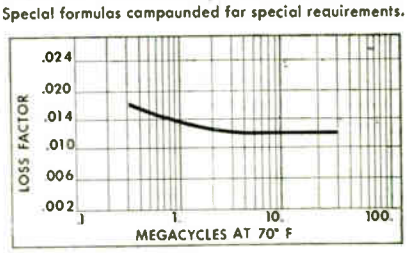
ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT	6.5-7
DIELECTRIC STRENGTH (⅛")	630 Volts per Mil
POWER FACTOR	.001-.002 (Meets AWS L-4)

***THESE VALUES COVER THE VARIOUS GRADES OF MYKROY**

GRADE 8. Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength.
GRADE 51. Best for molding applications.

Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. an standard Mykroy stack.

MADE EXCLUSIVELY BY

ELECTRONIC MECHANICS INC.

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

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

★ TELEVISION TODAY* ★

New Developments in the Video Field

Tele-Broadcasts Temporarily Quit

Except for WRGB in Schenectady all television stations have left the air temporarily and their engineers are wrestling with frequency changes. WNBT, NBC station in New York, returns on its new frequency (channel No. 4, 66-72 mc) on April 5. WCBW, CBS station in New York, shifts to new channel No. 2, 54-60 mc. The Du Mont station, WABD, which has been off the air for several months, expected to return to the air before March 15 on channel No. 5, 76-82 mc.

WBKB, Balaban & Katz station in Chicago, expected to resume operations on March 18 on channel No. 4, 66-72 mc, while the Philco station in Philadelphia, WPTZ, which has been off the air, will operate on channel No. 3, 60-66 mc.

Don Lee experimental station W6XAO will resume on channel No. 2, 54-60 mc, after reconversion, while the Television Productions, Inc., station W6XYZ, will return on channel 5, 76-82 mc. Both stations are in Hollywood.

WRGB in Schenectady, shifting to channel No. 4, 66-72 mc, remains in the same frequency it held previously and will continue operations.

Cut Tele Hours

For the time being there is to be no minimum requirement concerning the number of hours television stations must operate. FCC has let it be known that the previous requirement minimum of 28 hours a week has been waived until July 1 this year.

FCC Urged To License UHF Color Television

The Columbia Affiliates Advisory Board, representing 145 independently owned radio stations of the CBS network, has adopted a resolution calling upon the Federal Communications Commission to authorize commercial licenses for ultra-high frequency stations to transmit high-definition color television.

The resolution, which followed a demonstration of Columbia's color television on receivers suitable for the home, and a transmitter of commercial design, further stated:

". . . the interests of the broadcasting industry, as well as the interests of the American public, will be served by the early change from the standards of prewar television so as to take advantage of the increased knowledge of electronics and their commercial application."

Color Only—Zenith

There will be no black and white television receiving equipment manufactured by the Zenith Radio Corp., Chicago. The company has made public its intention of building nothing but high frequency receivers engineered for operation in the ultra-high frequency television band. The Zenith company operates television station W9XZV. It plans shortly to begin experimental transmission of color television pictures.

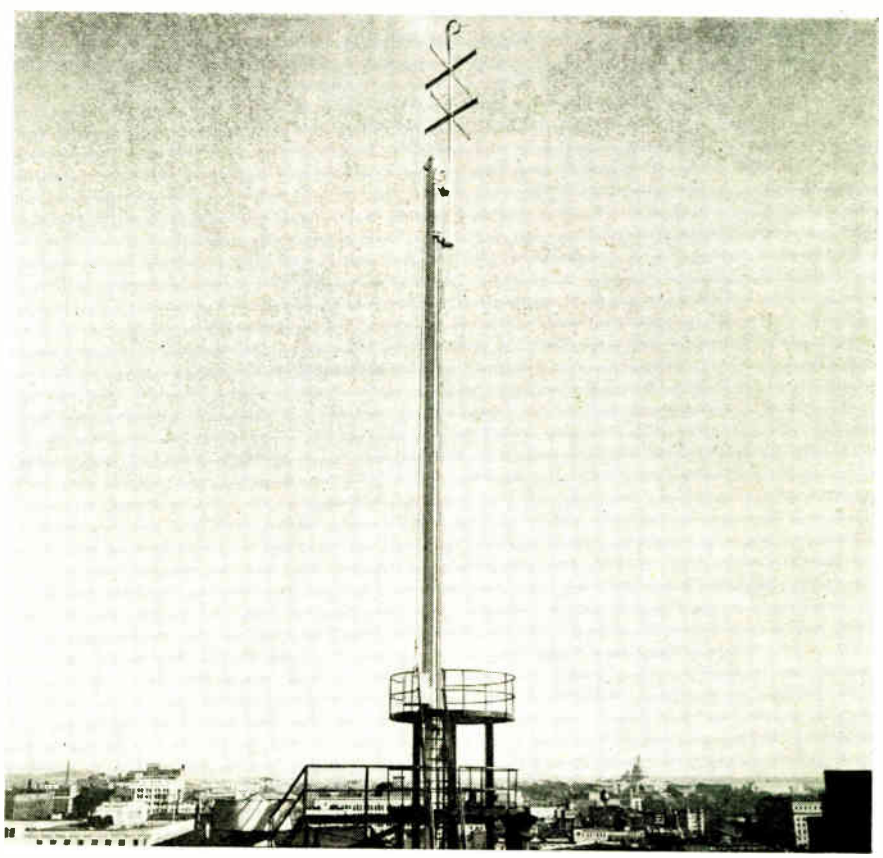
GE Tests Television Relaying From Blimp

General Electric engineers in Syracuse have been experimenting with television relay equipment installed in a blimp to determine the practicability of the idea and to check on the possibility of increased relay range of a station at varying altitudes.

The experiments are part of a broad General Electric research and engineering program which calls for the investigation of all methods of relaying—whether by ground or air "booster" stations—to arrive at the most economical and dependable system for the widest distribution of television and FM radio programs.

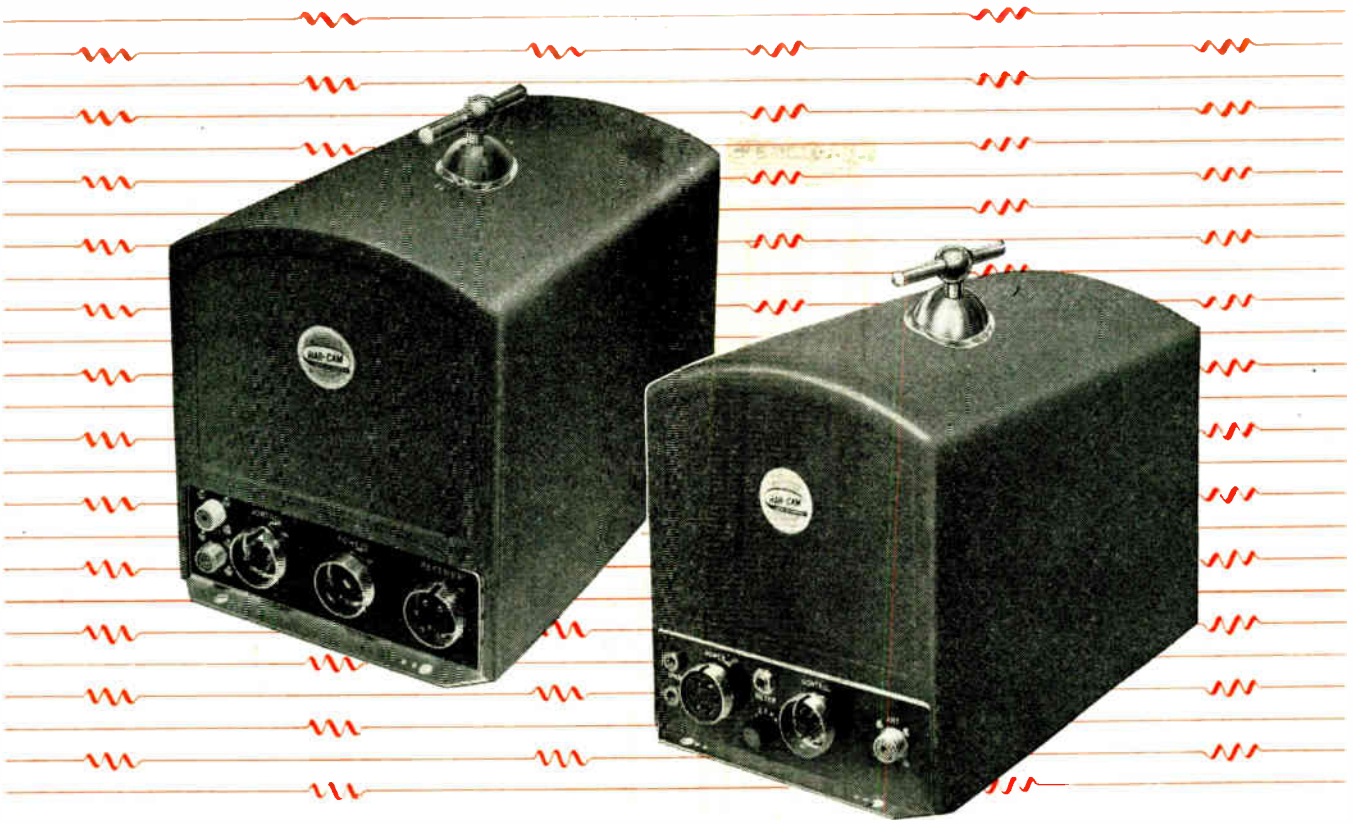
General Electric worked with Globe Wireless, Ltd., in the initial blimp relay tests, using a blimp of the Goodyear Tire & Rubber Co. The blimp was operated between Schenectady and New York City

(*Continued on page* 165)



DuMont's new two-bay broadband vertical turnstile antenna atop the Harrington hotel in midtown Washington, now being used for experimental video broadcasts. Array may be quickly raised, lowered

*Title registered U. S. Patent Office.



In Any Emergency, You Can Count on HAR-CAM Emergency Communications Equipment

HARVEY OF CAMBRIDGE Transmitters and Receivers team up to provide the most dependable and efficient two-way radio combination you can get. Here's why:

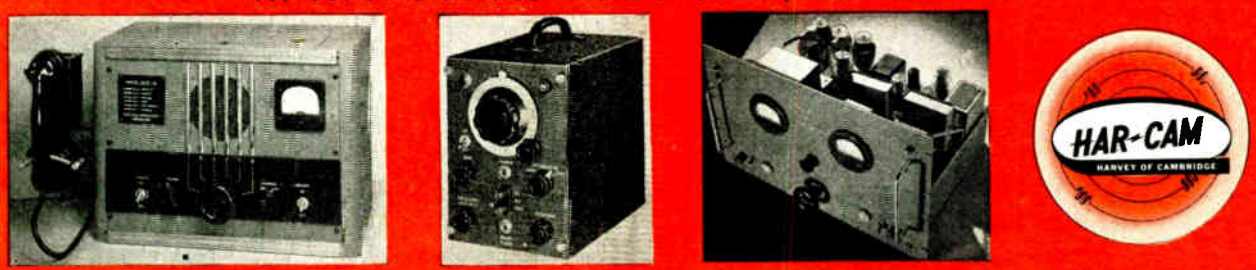
HARVEY OF CAMBRIDGE is one of the oldest manufacturers of two-way radio. Many of HARVEY'S initial installations are still considered standards of quality and performance. During the war, HARVEY OF CAMBRIDGE specialized in the development and manufacture of communications equipment — units that for obvious reasons had to be the last word in dependability and efficiency.

This combination of sound basic design and construction supplemented by the many important new and better communications developments mean HAR-CAM Transmitters and Receivers are now better than ever.

For complete information and specifications that will prove it beyond question, write for HARVEY Emergency Communications Equipment Bulletins No. 35 and No. 36.

HARVEY RADIO LABORATORIES, INC.

441 CONCORD AVENUE · CAMBRIDGE 38, MASSACHUSETTS



Typical HARVEY products: *Above left:* The HARVEY Marine Radio Telephone Model M-25; *center:* The HAR-CAM Visual Alignment Signal Generator Model 205 TS; *right:* The HARVEY Regulated Power Supply 206 PA. Write for Bulletins.

NEWS OF THE INDUSTRY

(Continued from page 104)

Peerless Electrical Products Co., as chairman; D. A. Marcus, general manager of the Electronic Specialty Co., as vice-chairman; and re-elected James L. Fouch, president of the Universal Microphone Co., treasurer. The officers automatically become members of the executive committee of the local council with four others also elected. The executive committee of the San Francisco and Los Angeles councils, seven each, thus become the board of directors for the statewide organization.

Los Angeles also selected the following to serve on the committee: George L. Carrington (Altec-Lansing Corp.); Robert Newcomb (Newcomb Audio Products Co.); L. B. Brittain (Brittain Sound Equipment Co.); with Howard Thomas, Jr. (Packard, Bell Co.), retiring chairman, making the seventh member.

RCA Victor Chicago Auto Radio Plant

The RCA Division of the Radio Corp. of America has leased a plant in the southwest section of Chicago to be devoted solely to the fabrication and assembly of automobile radio sets. Auto radios for General Motors are now being manufactured by RCA Victor at its Indianapolis plant. Transferring this operation to larger quarters at the Chicago plant and the installation of modern, straight-line assembly lines will provide RCA Victor with a substantial increase in productive capacity.

Ward Leonard Jersey Office

Ward Leonard Electric Co., Mount Vernon, N.Y., has established a branch office in the Industrial Office Building, Newark, N. J. It will be in charge of R. W. Vonasch as district manager.

Hastings Organizes Instrumentation Firm

Hastings Instrument Co., has been formed in Hampton, Va. and will specialize in research and the development of electronic instrumentation. Charles E. Hastings, formerly head of the instrument development section of the National Advisory Committee for Aeronautics, is chief engineer.

Electronics Section Added By Bustan

The National Bureau of Standards, Washington, has set up an Electronics Section to take up tube research and development work and the application of electronic circuits and radiation. Primarily, the purpose of the Section will be to broaden the scope of the ordnance development division work. The Section will be headed by Dr. Robert D. Huntoon.

Standards to 33,000 mc

Expanding its frequency standards service the Bureau of Standards, Washington, has set up frequency standards covering the microwave range to 33,000 mc. The new standards which will be available to industry are derived from the Bureau's national primary standard by a process of frequency multiplication, conversion and harmonic selection.

Marion Meter Policy

Marion Electrical Instrument Co., Manchester, N.H., has adopted a new guarantee policy covering its line of hermetically sealed indicating instruments. Hereafter instruments are to be unconditionally guaranteed for a period of six months. After this period Marion will replace any 2½ or 3½-in. instrument ranging from 200 microamperes upward for a flat fee of $1.50 regardless of whether the instrument has been overloaded, burned out or otherwise mistreated, provided the seal is unbroken. Same size meters with sensitivity greater than 200 microamps will be replaced for $2.50 under the same conditions.

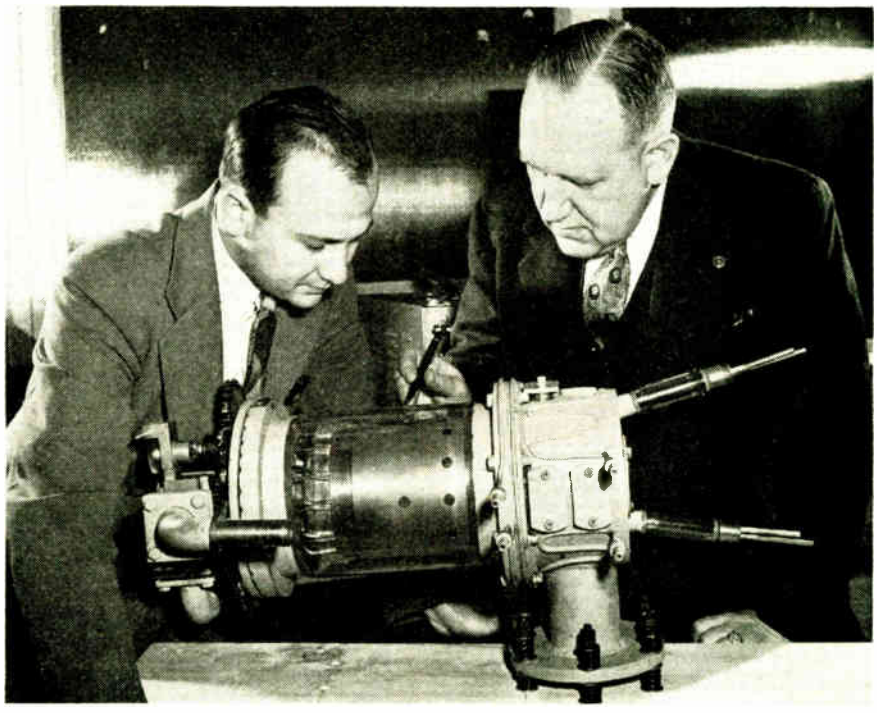
Ideal Drops Commutator

Hereafter it is to be Ideal Industries, Inc., instead of Ideal Commutator Dresser Co. Change in the name of the Sycamore, Ill., company has been made better to indicate the expanding character of its business. The change involves no alteration in management, personnel, location, manufacturing, or method of distribution.

P & B in Chicago

The Potter & Brumfield Sales Co. has been formed by the Potter & Brumfield Mfg. Co., Princeton, Ind., and will function as the Chicago sales office for the parent organization. The company manufactures relays, process timers and other electro mechanical equipment. The new organization will headquarter at 549 West Dashington Blvd., Chicago.

WORLD'S GREATEST MICROWAVE GENERATOR



Developed by Westinghouse Research Labs., this 500-lb. Resnatron, used in Allied radar jamming equipment, is heaviest and most powerful UHF tube ever made. Examining it are engineer Alfred Lattauzeo and E. J. Nauman, supervisor of Baltimore engineering laboratories

STUPAKOFF HERMETIC SEALS

meet exacting demands of
MODERN ELECTRONIC DEVELOPMENTS

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

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

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

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

*Reg U S. Pat. Off. Trade Mark No. 337962

STUPAKOFF

CERAMIC AND MANUFACTURING CO. · LATROBE, PA.

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

NEW PATENTS ISSUED

Amplifier

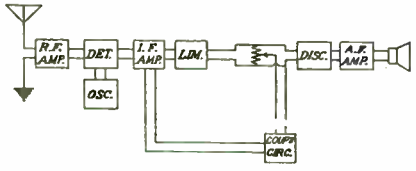
It is proposed to use several amplifying channels in parallel, each channel handling a predetermined section of signal amplitude. For example, if three separate channels are used, the first channel includes a stage which passes only the tops of the signal to be amplified, it is followed by an amplifier. The second channel rejects the top and bottom portions of the signal and amplifies only the center levels and the third channel is concerned with the low amplitude sections of the signal.

The signals are combined in a bridge circuit to give a resultant output representing the input in such a way that the different channels do not interfere but satisfactory energy transfer is obtained between each channel and the output circuit. This scheme permits improved efficiency because each amplifier may be operated at optimum condition as to applied input signal amplitude.

C. B. Fisher, (F) June 10, 1942, (I) July 3, 1945, No. 2,379,513.

Selective FM Receiver

The circuit was designed to increase the ability of an FM receiver to select the stronger of two signals covering parts of a common frequency band. Discrimination against the weaker signal is effective in the limiter circuit; its output contains comparatively more of the stronger signal relative to the weaker signal than does its input. The invention therefore suggests feeding back part of the limiter output to an intermediate frequency amplifier stage preceding the limiter. Amplitude and phase of the feedback line are controlled by adjusting the coupling circuit



to result in regeneration without causing oscillation. A signal can be received satisfactorily in the presence of an interfering signal of more nearly equal intensity than is possible without the feedback connection. Superregenerative feedback may be used.

The limiter circuit distorts the waveshape and has the effect of increasing the ratio of desired to undesired signal. The intermediate frequencies of the two signals traversing the limiter are not changed, also the two signals still carry each its original audio modulation. The selective effect occurs in the frequency swing; the swing of the weaker signal will be reduced in favor of that of the stronger signal provided two frequency modulated signals are considered. In other words, assuming the two signals had equal maximum frequency deviations at the input to the limiter, the maximum frequency deviation of the stronger signal will exceed the maximum frequency deviation of the weaker signal at the output of the limiter. The center frequency and the intelligence carried by each signal will remain unaffected. This constitutes a selective mechanism as the frequency deviation in FM may be compared to the modulation factor in AM. It will be seen that any amplitude modulation effects will be reduced in the limiter.

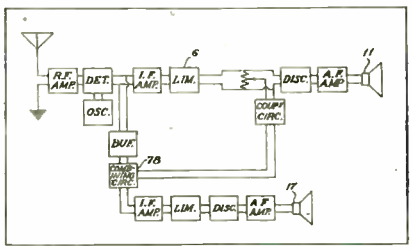
The regeneration, therefore, will be greater for the stronger signal increasing the effective desired-to-undesired signal ratio and decreasing the interference caused by the weaker signal.

R. M. Wilmotte, (F) December 26, 1941, (I) October 30, 1945, No. 2,388,200.

Separating FM Signals

This patent may be considered an extension of the invention described in the preceding patent No. 2,388,200.

The circuit is intended for the simultaneous or alternative reception of two or more frequency-modulated signals of identical or close carrier frequency. Limiter 6 pro-



vides an output where the stronger of the two signals dominates. A portion of this output is fed-back to the combining circuit 78 in such a phase and amplitude as to cancel this stronger component, leaving only the weaker component in the second channel feeding loudspeaker 17. The stronger signal is realized in loudspeaker 11.

R. M. Wilmotte, (F) December 26, 1941, (I) October 9, 1945, No. 2,386,528.

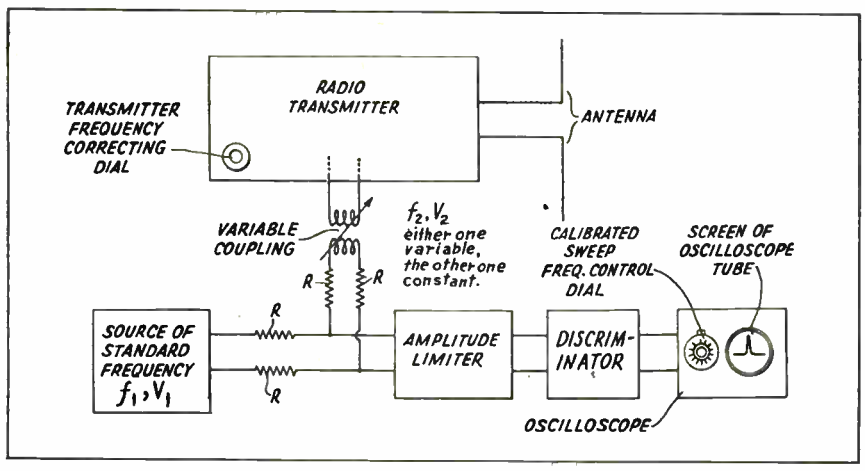
Use of Limiter Output of Two Similar Input Waves

When two currents of different frequency f_1 and f_2 and of slightly different amplitudes V_1 and V_2 are passed through an amplitude limiter, the resulting limiter output current has an amplitude R and a frequency f_3 approximately half way between f_1 and f_2. Fig. 1, p. 158, is a conventional vector representation of two currents, the one with larger amplitude, V_1, being represented by a constant vector, the other one, V_2, by a vector rotating with the difference frequency. The behaviour of the resultant current, R, may be visualized from the diagram.

The angle A_1 which is equal to $2\pi\ (f_2 - f_1)\ t$ represents the instan-

(*Continued on page 158*)

Fig. 4—Stabilizing transmitter amplitude by use of amplitude limiter scheme, page 160



Kodak

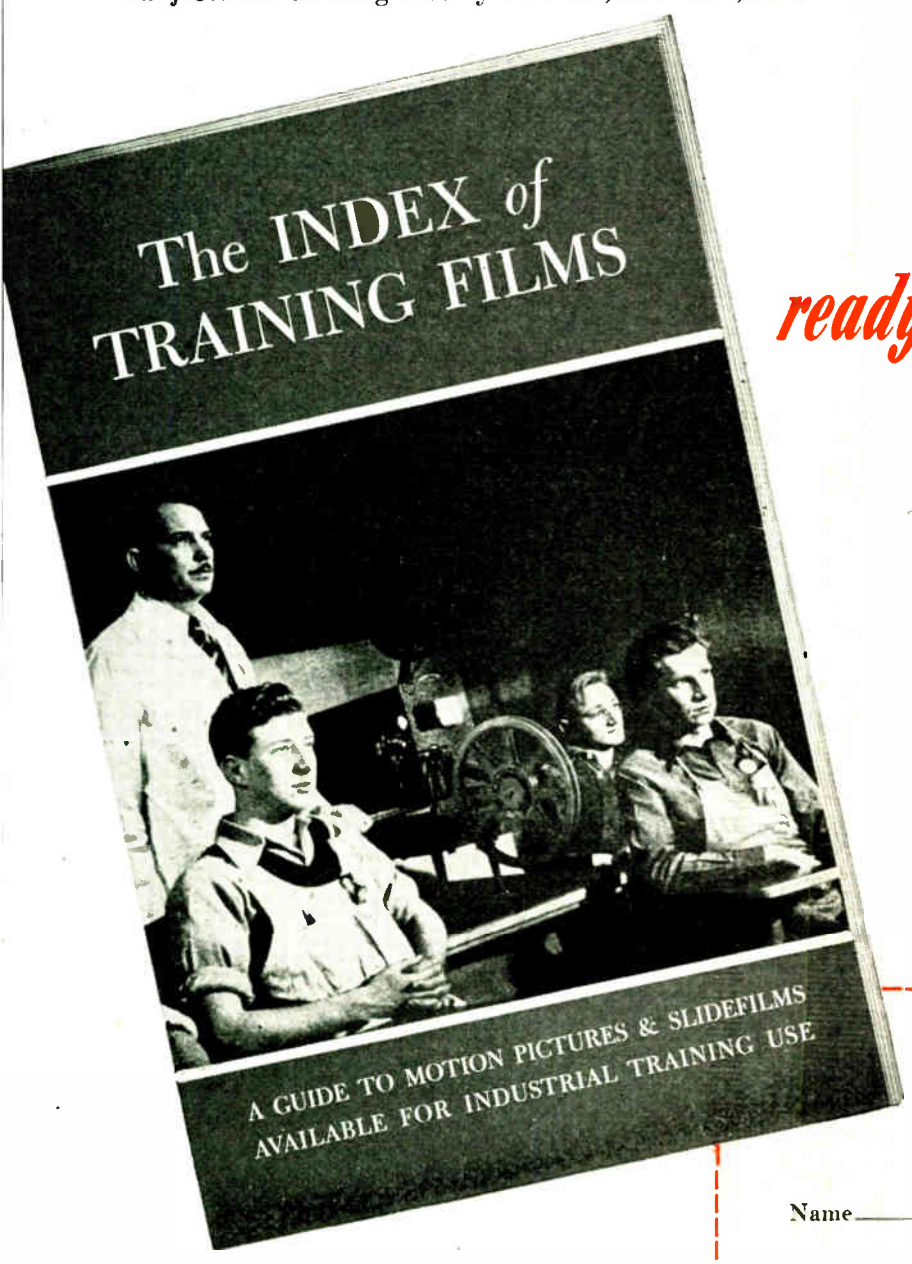
Free...to Makers of Electronic Equipment

You'd like to have *all* your training films made to order, of course. But if you can't manage to do this, you can still organize an up-to-the-minute training program by supplementing your own films with films made by others.

And that's where this new book, "The Index of Training Films," can help you. It lists—with hundreds of others—a wide selection of films on electronic subjects for training factory workers, salesmen, and trouble-shooters. Movies and sound-slide films cover electron-tube theory, circuits, electronic motor controls, resistance-welder control, phototube applications, and many other electronic topics.

This informative index describes and classifies outstanding films . . . tells which are free . . . which can be rented or bought, and for how much . . . and where to get them. For your copy, write . . .

Eastman Kodak Company, Rochester 4, New York



. . . a guide to ready-made Training Films

This new book lists 155 films on Electronics and related subjects which you can borrow, rent, or buy very reasonably

Mail This Coupon for Your Free Copy

Eastman Kodak Company
Rochester 4, New York

Please send me a free copy of the new book, "The Index of Training Films."

Name_____

Company_____

Street_____

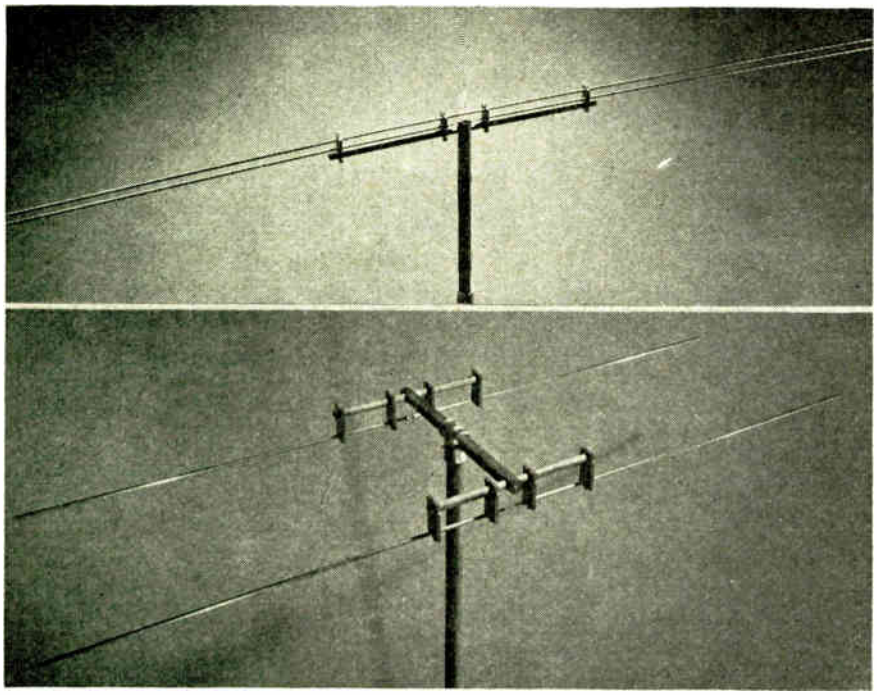
City_____ State_____

Training Films

—another important function of photography

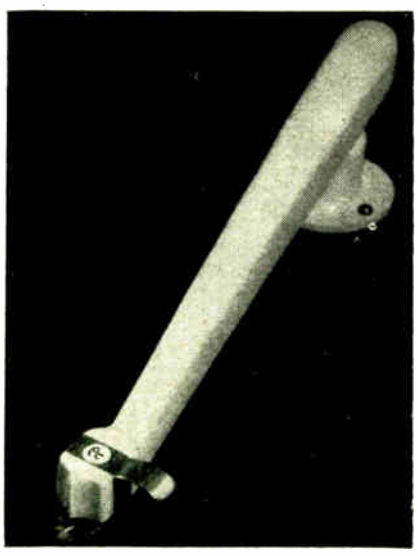
WHAT'S NEW

Devices, products and materials the manufacturers offer



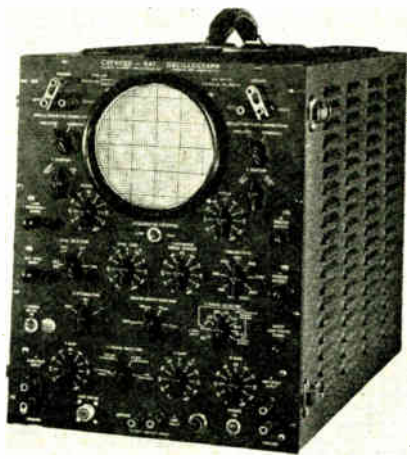
FM Antenna

Shur-Antenna—Mount, Inc., Sea Cliff, N. Y., has developed a versatile antenna for use on television, fm and hf amateur bands. The antenna has a number of tunable elements, such as adjustable spacing, adjustable length, impedance and polarization. The input impedance of the antenna is 282 ohms. —Electronic Industries



Pickup

A series of magnetic type reproducers for lateral records has been developed by Pickering and Crowe Audio Laboratories, Oceanside, N. Y. The pickups have virtually no frequency or harmonic distortion from 30 to 12,000 cps and will track any commercial record with a stylus pressure of 15 grams. A natural sapphire stylus is provided.—Electronic Industries

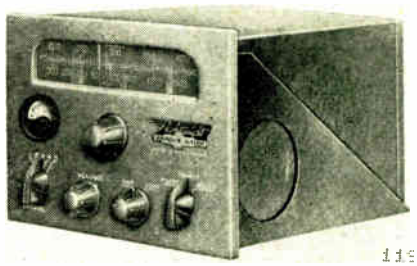


Oscillograph

The type 248 cathode ray oscillograph is a portable instrument designed for the accurate observation of microsecond pulses containing frequency components up to 10 mc. The instrument has been developed by Allen B. DuMont Laboratories, Inc., Passaic, N. J. It has a 5 in. cathode ray tube and contains such refinements as a timing oscillator, beam modulation amplifier and separate trigger pulse output. Operates from 115 v., 50-400 cycles ac.—Electronic Industries

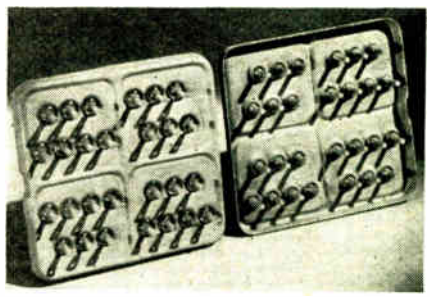
Mobile FM Transmitter

Harvey-Wells, Southbridge, Mass., is planning a mobile FM Transmitter with a power output of 15 watts and built-in converter power supply. It is controlled from a remote unit handset on the dashboard. Models are available to cover the frequency ranges 25 to 28 mc., 30 to 44 mc., 72 to 76 mc., and 152 to 162 mc.—Electronic Industries



Two-Way Communications Unit

The PATR-10 Flightphone radiotelephone equipment made by Bendix Radio, Baltimore 4, Md., weighs 7 lbs., including built-in power supply, shockmounts and range filter. The transmitter is provided with five crystal-controlled vhf channels, two of which are the standard frequencies for control towers and civil airways stations. The receiver covers a frequency range from 550 to 1500 kcs and from 200 to 400 kcs.—Electronic Industries



Hermetic Seals

Units which will enable electrical manufacturers to place leads for hermetically sealed items in any configuration have been perfected by the Hermetic Seal Products Co., Newark, N. J. The glass-insulated leads are designed to withstand severe temperature shocks without cracking. In demonstration the units were dipped in liquid air, and then immediately placed in boiling water. Minimum leakage resistance requirements are 5000 megohms but test results show the leads to have over 100,000 megohms.

Leads of .050 in. diameter in a ⅛ in. glass insulator will not break under a tension of 80 lbs. direct pull. Standard plugs and terminals will be available shortly to manufacturers.—Electronic Industries.

Flexible Waveguides

If microwave equipment requires movement, the "Waveflex" flexible waveguides manufactured by Titeflex Inc., 500 Frelinghuysen Ave., Newark 5, N. J., may be used. Waveflex is constructed of metal flexible tubing and has an electrically continuous wall. It is available in all standard waveguide band sizes and lengths.—Electronic Industries

Just Published the ELECTRONIC ENGINEERING HANDBOOK

NEW, original, authoritative, comprehensive—The *Electronic Engineering Handbook* is a working tool for every engineer interested in electronic developments and applications in the industrial or communication fields. Edited by Ralph R. Batcher, E. E., and William Moulic, the Handbook is written by some of the foremost men in their fields: men who have originated many of the techniques and applications they describe. Yet any engineer with a basic knowledge of electrical principles and simple circuits can understand and follow it with ease. You are invited to examine this outstanding Handbook in your own home or office.

"The Most Complete Book on Electronic Tubes and their applications, I have ever seen."

456 pages. More than 200 illustrations. Covers every important circuit and essential application.

"An outstanding job . . . deserves to be classed with the best texts on the subject. The industrial and communications applications are unusually well balanced." "I was amazed at the amount of useful material contained in this volume. The pioneering sections on high frequency heating and industrial sound applications are extremely well prepared." These are just a few typical comments from engineers who have found, in its pages, authoritative answers to current questions about electronic applications. Beginning with fundamentals, the Handbook proceeds, logically, to detailed discussions. Every important circuit, each essential application that requires picturization is *illustrated*. There are more than 200 charts, diagrams, special drawings and photographs. Bound in limp blue leatherette, the Handbook opens flat for convenience in use. The partial contents give you some idea of its scope. Nothing short of the book itself, can prove its day-to-day worth to you. Read it. Study it. See for yourself why outstanding engineers call The ELECTRONIC ENGINEERING HANDBOOK "amazing", "priceless". If, after 5 days, you feel that the Handbook is not worth much more than its modest price of $4.50, you may return it, without further obligation. But don't delay inspecting your copy. The present limited edition will go fast. Make sure of your copy by filling in and returning the coupon below *at once*.

CALDWELL-CLEMENTS, INC.
480 LEXINGTON AVENUE, NEW YORK 17, N. Y.

READ THESE PARTIAL CONTENTS

VACUUM TUBE FUNDAMENTALS:
Electronic Principles. Principles of Diodes. Principles of Multi-Element Tubes. Principles of Photo-electric Tubes. Cathode Ray Tubes. Special Purpose Tubes. Materials in Tube Construction. Vacuum Tubes as Circuit Elements.

ELECTRONIC CIRCUIT FUNDAMENTALS:
Principles of Rectification. Principles of Amplification. Low Frequency Amplifiers. High Frequency Amplifiers. Principles of Oscillators. Principles of Modulation. Principles of Detection. Cathode Ray Oscillographs. Relaxation Oscillators. Photo-electric Circuits. Electron Tube Circuit Application.

ELECTRONIC APPLICATIONS:
High Frequency Heating. Industrial Sound Systems.

VACUUM TUBE DATA:
Electronic Tube Data and Tables.

MAIL THIS NO RISK COUPON TODAY

Caldwell-Clements, Inc., 480 Lexington Avenue, New York 17, N. Y.

Send me The ELECTRONIC ENGINEERING HANDBOOK for inspection. If I am not completely satisfied, I will return it to you within 5 days. Otherwise, I will remit $4.50 in full payment.

( ) Payment enclosed. (Same money back guarantee.)

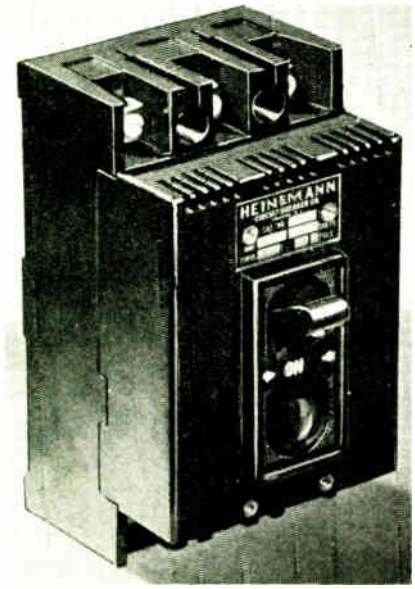
Name & Position .....

Company .....

Address .....

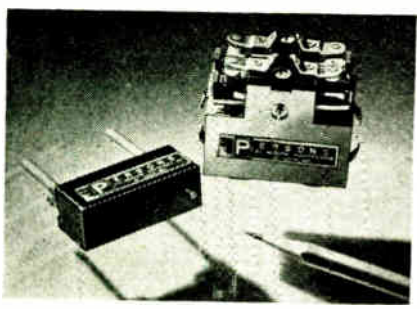
City .....State ..... Zone .....

EL446



Circuit Breaker

An addition to its line of general purpose circuit breakers in the 50 amp. frame size is a three-pole breaker with three trip units manufactured by the Heinemann Circuit Breaker Co., 137 Plum St., Trenton, N. J. The circuit breaker is designed for service on 120-230 v. ac or 250 v. dc, 50 amp. max. Continued overload opens the breaker in time inverse to the ratio of the current.—Electronic Industries

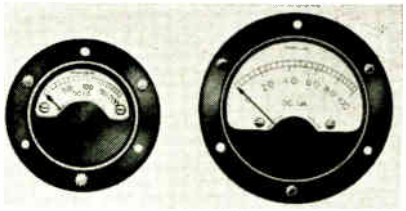


Snap-Switch

A high-capacity snap-switch adjustable to operate on feather touch force has been developed at Persons Control Div., Maguire Industries, 6301 Manchester Ave., St. Louis 10, Mo. The unit is the size of the small snap-switch installations and is designed to be free from chatter, have accurate adjustability and a long life.—Electronic Industries

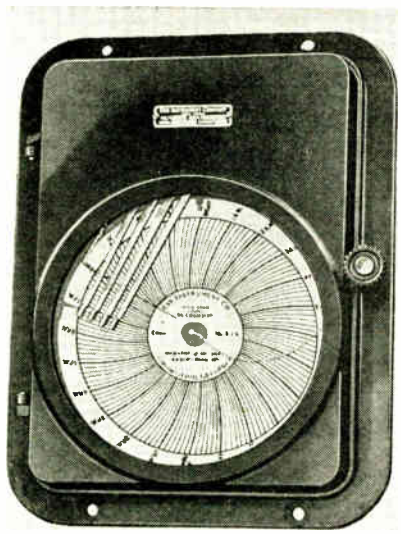
X-Ray Diffraction Tube

A chromium target x-ray diffration tube with a rating as high as that of the copper target tubes has been developed by General Electric X-Ray Corp., 175 W. Jackson Blvd., Chicago 4, Ill. This has been accomplished by electroplating the chromium on a copper backing. The new type is especially useful in experiments requiring the high resolution provided by chromium with its longer wavelength radiation. Increased heat loading is possible by an improved target construction, thus extending the useful life of the tube.—Electronic Industries



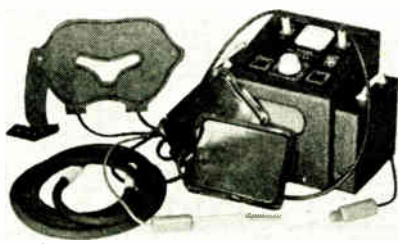
Miniature Instruments

A series of sealed miniature meters with an accuracy of 2% of full scale deflection is being made by the MB Mfg. Co., 331 State St., New Haven 11, Conn. The moving coil element of these instruments is only 1 in. in diameter and meets the AWS specifications. Two models are available in various ranges: No. 102 for 1 in. opening and No. 152 for 1½ in. opening.—Electronic Industries



Operational Recorder

A continuous record of "Time On" and "Time Off" of multiple operations including process timing is provided by an operational recorder manufactured by the Ess Instrument Co., Bergenfield, N. J. "Normality" of the processes is indicated by a circle traced on the chart. The instrument can be provided with up to six single or double acting pens and is available in 115- to 230-volt models.—Electronic Industries

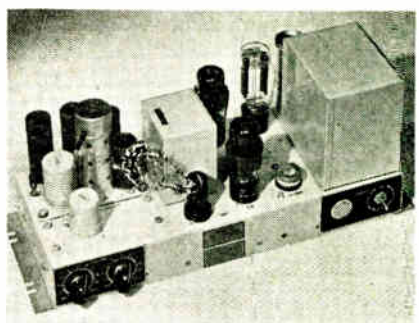


Diathermy Unit

A hf medical diathermy unit, the Anatatherm SW150, has been brought out by Miller Electro Research Laboratories, 3460 S. 16th St., Milwaukee 7, Wis. Operating on a frequency of 27.32 mc. it has a power output of 150 watts and consumes 350 watts on 110 v. ac line.—Electronic Industries

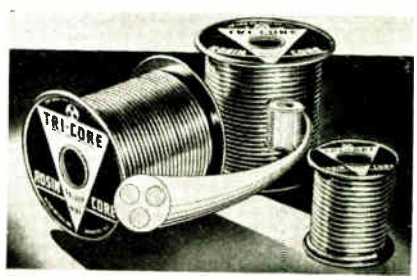
Electronic Heater

A dielectric heater with 2 kw output operating on a frequency of 27 mc is the first of a complete line to be manufactured by Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. The frequency of the unit can be varied through a wide range and heat sequence from 2 seconds to 20 minutes is controlled by an automatic timer. Preheating for forging and curing of plastics, gluing, drying, sterilization, processing and defrosting frozen foods are a few of the applications.—Electronic Industries



Sound Amplifier

A 20-watt medium to high gain master power amplifier type 108 has been developed by the Langevin Co. Inc., 37 W. 65th St., New York 23. Small input panels may be mounted and changed at will on the amplifier, thereby changing the overall gain with each different panel used. The unit is designed for high quality audio service, having a frequency characteristic better than ±1.5 db from 30 to 15,000 cps.—Electronic Industries



Rosin Solder

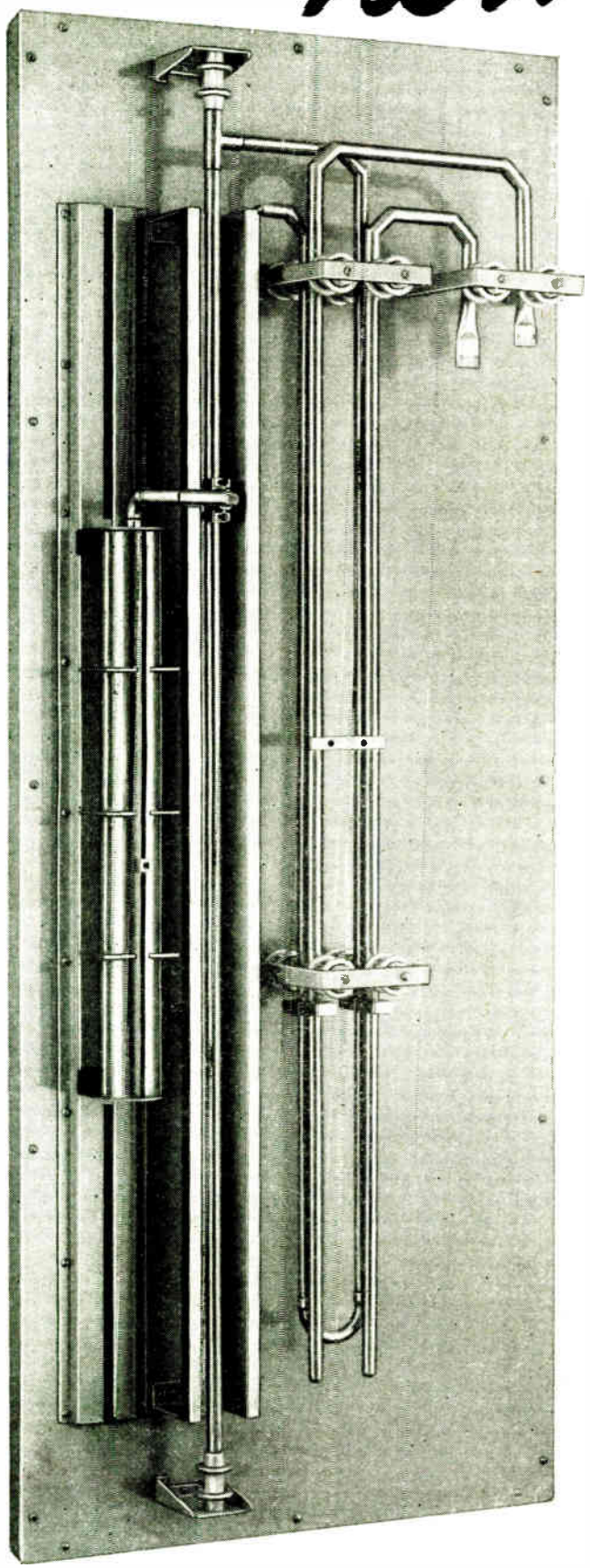
Alpha Metals Inc., Brooklyn, N. Y., has brought out Tri-Core solder, a solder with three independently filled cores of rosin flux. It is available in all alloys, flux percentages and gages.—Electronic Industries

(*Continued on page* 167)

new

FM ANTENNA ISO-COUPLER

By JOHNSON



For Feeding FM Antennas Supported on Base Insulated AM Tower Antennas

The Johnson Frequency Modulation Antenna Iso-Coupler isolates the AM and FM systems and properly couples the FM transmission line across the base insulation of the AM radiator.

Shown at left is a Johnson FM Antenna Iso-Coupler ready for installation in the tuning house. Although the Iso-Coupler is normally supplied in a specially designed cabinet, it is available for mounting in an existing tuning house or can be combined with Johnson AM Antenna Coupling equipment.

POWER RATINGS:
AM up to 50 KW FM up to 10 KW

FREQUENCY RANGES:
AM 550-1600 KC FM 88-108 Mc

FM LINE IMPEDANCE:
Unit is available for matching either 50 or 70 ohm lines from transmitter.

AM ANTENNA IMPEDANCE:
Provision is made for correcting the effect produced by the FM Iso-Coupler.

SHIELDING REQUIREMENTS:
Low Stray fields, no shielding of Iso-Coupler is required.

PRESSURIZING:
Provisions have been made for pressurizing the FM line through the Iso-Coupler.

ADJUSTMENTS:
All adjustments within frequency range are easily made. Adjustments are broad and stable.

The Johnson FM Antenna Iso-Coupler incorporates top quality materials: high conductivity copper tubing, grade L5 steatite insulators, and aluminum corona shields. The entire unit is of rugged low-loss construction. Available for use with this coupling unit or for any FM or television installation is Johnson V.H.F. COAXIAL LINE which has extremely low loss and reflection characteristics, yet embodies superior mechanical strength.

The complete line of Johnson Broadcast products includes: AM Antenna Coupling and Phasing equipment, Coaxial Lines, Tower Lighting Filters and Chokes, Pressurized Capacitors, Variable Capacitors, Inductors, Tube Sockets, R.F. Contactors and Current Transformers.

Write today for specific information.

JOHNSON
a famous name in Radio

E. F. JOHNSON COMPANY • WASECA • MINNESOTA

COLOR RECEPTION

(*Continued from page* 83)

that a succession of complete one-color picture are superposed—much like the three-color plate process of the printing arts, but this is not the case. In scanning a television picture everything is done by a single spot of light moving around in a hurry. Thus the color film sectors need only appear over the instantaneous location of the line in which the spot appears and over a certain area above this line to take advantage of the delay in the screen luminosity due to its phosphorescence. The greater the screen delay the larger must be the area of the colored sector. The decay does no harm if the color wheel is opaque at the time, but if the next color sector appears a false color mix is obtained.

Incidentally the sector shape of the colored films on the studio camera color wheel may differ radically from that of the receiver and depends upon whether a non-storage pickup tube (a dissector) or a storage type (one with a mosaic) is used. The latter tube presents more difficulties than the former because of the larger color sector areas needed.

Returning to the receiver system, the color sectors are usually not pie shaped, or rectangular or even regular. Several theoretically-shaped sectors for color wheels are shown in **Fig. 3.**

These curves cover approximately a 10% follow up area behind the scanned line, to take care of a certain amount of screen delay as mentioned above. It will be noted that a larger wheel is needed when its axis of rotation is directly below the axis of the cathode ray tube.

The matter of driving this disc at the proper speed calls for a synchronous motor, or a drive motor equipped with a phonic wheel to pull it into synchronism, or the synchronous brake.* Doubtless many will remember other expedients developed for driving the earliest disc television units with 60 lenses mounted around its edge!

In many cases a synchronous motor of the type with six salient poles milled in the periphery of an induction motor will suffice for locations served by the same power network.

Amplifier Channels.—In the CBS

*See Goldmark, Dyer, Pione, and Hollywood. Proc. IRE, April, 1942, page 179.

POSITIVE CONTROL

of Varying Power Supply

CASED MODEL

Raytheon Voltage Stabilizers

DELIVER OUTPUT VOLTAGE CONSTANT TO ±½%

FLUCTUATION of line voltage need not impair the performance of your electrical equipment. Such variations are easily corrected with magnetic-type, entirely automatic Raytheon Voltage Stabilizers.

Positive control is gained. Power supply is stabilized to ±½%. Reliability and accuracy of performance are effectively improved, *and at low cost.*

Investigate. Determine how positive control of line voltage can benefit your equipment. Our Bulletin DL-48-537 gives the detailed story. Write for it today.

Get These Principal Operating Advantages:

- **Control of output voltage to within ±½% of 115 or 230 V.**
- **Stabilization at any load within rated capacities.**
- **Quick response. Stabilizes varying input voltage within 1/20 second.**
- **Entirely automatic. No adjustments. No moving parts. No maintenance.**

RAYTHEON

Excellence in Electronics

RAYTHEON MANUFACTURING COMPANY

Industrial Electronics Division, Waltham 54, Mass.

demonstration receivers a crystal input mixer was used, connected to the incoming line and to a 6F4 tube oscillator. Since at present a single oscillator frequency only is needed, there being only one station on the air, a simple ultraudion oscillator circuit or a coaxial line arrangement that operates in the vicinity of 600 mc may be used. This is followed by six stagger tuned IF stages operating at 105 mc, a second detector (which might be a silicon crystal also) and two video stages using 6AG7 tubes. The latter are adjusted to cover 16 mc. A tap to the plate circuit of the first or second video stage picks off the 8 mc sound pulses as mentioned above.—R. R. B.

COLOR TELEVISION

(*Continued from page 89*)

broadcasting, critics say CBS could well afford almost any outlay to delay the coming of a competitive medium in which it would have fight anew for position.

Other gentler opponents of CBS' television policies assert that CBS is merely and generously seeking to aid the industry to shorten the loss period of introducing television, if the greater appeal of color can be used to accelerate the television boom!

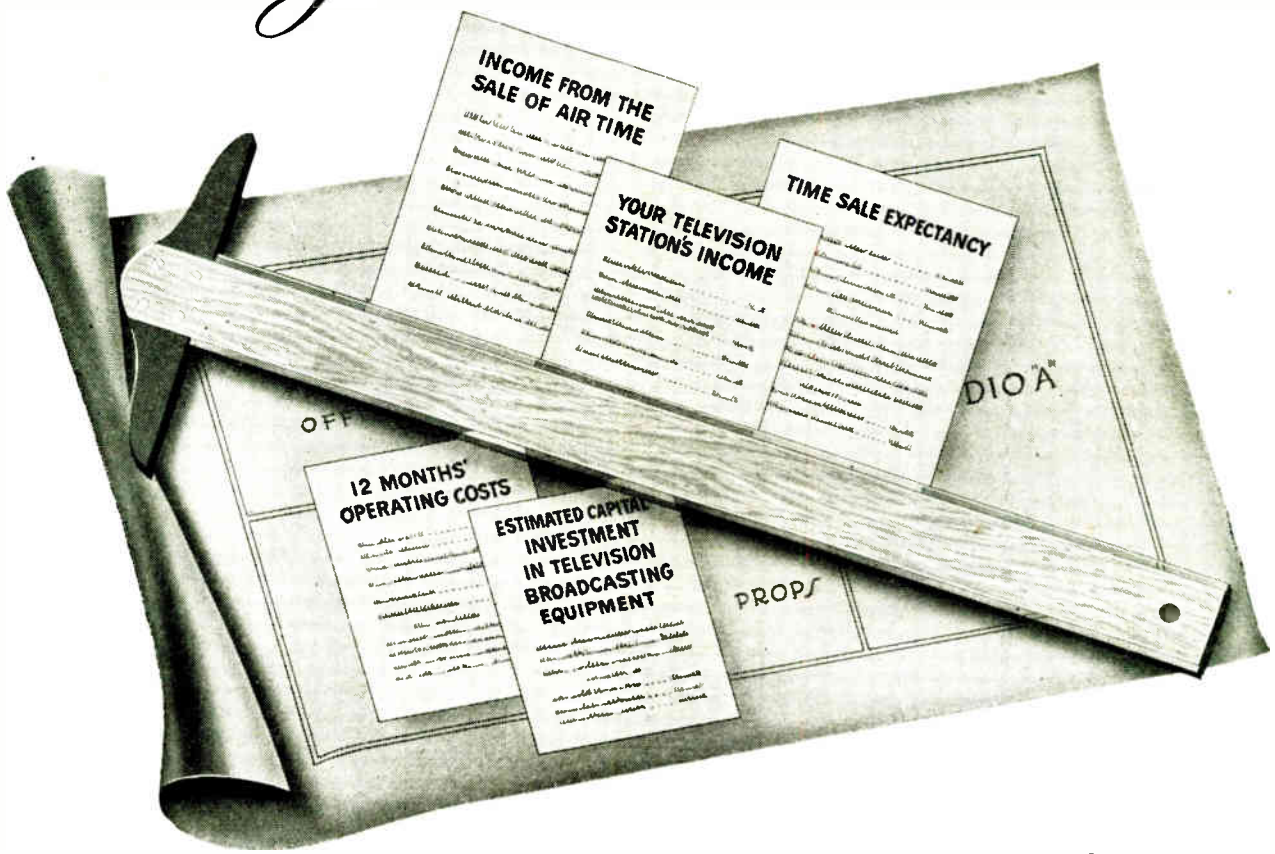
CBS officials insist that with industry cooperation, color-TV standards can be adopted by the industry and approved by FCC within six months, so that color would be ready to start by this coming Fall. But the majority of the radio industry, mindful of the 12 to 16 years which it has taken to refine and standardize black-white television, think that two to five years may be needed for the field tests and standards necessary to put any existing system of color television on a commercial basis.

Block real color possibilities

And still the question would be whether any such mechanical color-television system now attainable would not block future electronic color-television possibilities of daylight brightness, large screen, high speed movement, and even greater detail.

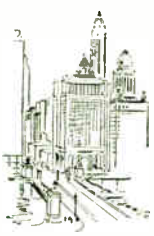
The majority of the television industry is therefore preparing to go ahead with black-white television in 1946, as earlier planned, and to get the fullest experience on

Planning YOUR TELEVISION STATION



. . . IS A JOB FOR DU MONT

NEW YORK



CHICAGO

LOS ANGELES

WASHINGTON

Four of the ten television stations now operating in the United States were built by the Allen B. Du Mont Laboratories, Inc. No other company has built more than one station. This fact speaks volumes.

It is especially important, too, since Du Mont's newest, most advanced television broadcasting equipment sets new standards of video quality and flexibility. Du Mont's 15 years of electronic and television "know-how" assure smooth, trouble-free efficiency at low operating cost.

If you are planning a television station, avail yourself of Du Mont's highly specialized television experience. Incidentally, we have published a down-to-earth booklet on "The Economics of Du Mont Television." We will be glad to send it to you—write on your firm's letterhead.

DUMONT *Precision Electronics and Television*

ALLEN B. DU MONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION WARD, 515 MADISON AVENUE, NEW YORK 22, NEW YORK

present standard lines. They feel that purchasers of black-white sets in 1946-47 can be assured one to two thousand nights' entertainment (three to five years' use), certainly the equivalent of the service expected by the average automobile buyer.

Experimentation needed

Meanwhile this industry majority wants to see the fullest experimentation with color by the CBS method and others. Indeed, leaders on both sides of the controversy have expressed approval of Electronic Industries' editorial proposal that CBS transmissions be continued at regular intervals from the New York Chrysler tower so independent experimenters can take part in this march toward video color. Adrian Murphy, CBS television vice president, has given assurance that his company will continue its color transmission on some future regular schedule. A second CBS color-TV transmitter has been announced for Chicago. There, also, Comdr. McDonald of Zenith will erect a station to conduct color-TV tests.

Television conservatives who propose to continue pushing black-white television recognize that the presence of color-tele demonstrations in New York, Chicago and possibly other cities, will have a confusing and braking effect on the public's enthusiasm for the new art. But they reason that with bigger and brighter black-white home screens soon to be available, black-white television sets will be demanded by the buying public as rapidly as the industry can supply them.

So black - white television is scheduled for immediate introduction as originally planned. But everybody is hopefully watching color-video experimentation, ready to embrace it at the moment when full color possibilities will not be stymied by the adoption of an interim color-video system.

PRINTED CIRCUIT

(*Continued from page* 91)

higher values obtainable if required.

A resistance range from 3 ohms to 200 megohms can be obtained by either varying the size or area covered, or by varying the proportions of the resistor ingredients. The electrical characteristics of resistors

. . . this greatest of test instruments has been tested into top ranking reputation

The Simpson 260 has out-sold and out-performed every other even remotely similar test instrument in the electronic and electrical fields ever since its introduction in 1939. Through the ensuing seven years, covering the War period, circumstances gave it a gruelling test for accuracy never visioned by its makers. It stands today as irrefutable proof that Simpson design and Simpson quality produce accuracy that *stays* in an instrument year after year.

The demand for the 260 from men who first used it in the Armed Services (in laboratories of 300 government agencies and universities, and on the battlefields the world around) has now been added to its enormous popularity among radio servicemen. The Simpson 260 is easily the world's most popular high-sensitivity set tester for television and radio servicing.

The basic reason for this out-selling and out-performing by the Simpson 260 is this: It out-values every other similar instrument in the field. You cannot touch its precision, its useful ranges, or its sensitivity in any other instrument selling for the same price or even substantially more.

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.....$33.25
Carrying case 4.75

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

produced to date have been excellent.

The capacitors, which can be seen as small discs on the ceramic plate, are actually ceramic condensors molded from high dielectric constant mixtures of titanium dioxide. These discs, varying from ⅛ to ⅜ in. in diameter, are from 20 to 40 mils thick. Capacity of these units varies directly with the area of silver on the faces and the thickness of the ceramic discs. Capacity can also be varied by the mixture of the high dielectric constant ceramic.

Dielectric constants of 40, 100, 1000 and 2000 are used in producing capacitors ranging in value from 6.5 to 2000 mmf. Higher dielectric constant materials than these mentioned are at present in the experimental stages.

Soldering methods

In soldering to metalized steatite the solder used must contain at least 2% silver in it to prevent further absorption of the silver from the ceramic. Use of regular commercial solder will "soak" the silver off the ceramic plate. A low temperature bismuth solder is used to fasten the ceramic capacitors to the proper silvered leads to prevent their fracture by the heat of normal soldering.

By this new method complete circuits can be produced at a high rate of speed and at the same time produce a unit of exceptional neatness, lending toward ease in checking circuits and repairs never before possible. This process makes each unit an exact mechanical duplicate of the original, consequently duplication of performance and stability is assured.

Centralab expects to cooperate with well established radio and hearing aid companies by the production of amplifiers, filters and control circuits, as small assemblies which can be plugged or wired into a main chassis. This will make possible replacement of entire circuits as easily and in the same manner that a tube is changed today. Another advantage is the tendency to discourage unwarranted tampering with the circuit. In short, this method will probably result in smaller, more compact, more reliable and easily serviced radio sets, which will enable standard radio and hearing aid manufacturers to speed their production with the end result of finer equipment at lower cost to the consumer.

DOUBLE-TUNED CIRCUITS

(*Continued from page 68*)

too complicated to calculate or adjust and gives considerably better gain than a single-tuned coupling unit. Likewise its transient response is satisfactory for most purposes.

Transformer constants

The rules for calculating the transformer constants have been given, and for bandwidths less than or comparable to the center frequency, the high-Q approximations can be used. Suppose that we wish to construct a transformer to be used between the plate of a 6AK5 pentode and the grid of a following 6AK5 pentode. For this condition C_1 is 4.5 $\mu\mu$f and C_2 is 7.2 $\mu\mu$f. Suppose further that we wish to have the circuit centered at 30 mc/sec with a bandwidth of 15 mc/sec. We now have to choose the type of circuit, whether it be primary-loaded, secondary-loaded, or loaded on both primary and secondary. The product of gain and bandwidth is best for a transformer loaded on one side only, and since secondary loading is generally considered more desirable (due to noise) than is primary loading, we will calculate the values for secondary loading.

$$\omega_0 = 1.38 \times 10^8,$$

$$\omega_0^2 = 3.54 \times 10^{16},$$

$$\omega_0^4 = 12.5 \times 10^{32}$$

From Table II

$$\alpha_2 = \frac{1}{\omega_0 R_2 C_2} = 0.707$$

so that $R_2 = 1043$ ohms.

(If exact values are desired, note that $b = 0.5$; from Fig. 7, $a = a_2 = 0.71$; from Fig. 6, $\omega = \omega_0$, very closely. Hence the more accurate value for R_2 is 1045 ohms.)

From Eqs. (9) and (10)

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_0^4} = 24.7 \times 10^{-12}$$

$$\lambda_2 = \frac{1}{C_2 \omega_0^2}\left(1 + \frac{\alpha_2^2}{3}\right) = 4.17 \times 10^{-6}$$

henries secondary inductance

$$\lambda_1 = \frac{1}{C_1 \omega_0^2}\left(1 + \frac{3\alpha_2^2}{8}\right) = 7.45 \times 10^{-6}$$

henries primary inductance

$$L_3 = M = \sqrt{\lambda_1 \lambda_2 - \lambda_3} = 10^{-6}\sqrt{31.1 - 24.7}$$

$$= 2.7 \times 10^{-6} \text{ henries mutual inductance}$$

This would require a coefficient of coupling

$$k = \frac{M}{\sqrt{\lambda_1 \lambda_2}} = 0.485$$

This transformer is fairly easy to construct, but it might be useful to use its equivalent T. The values are obtained from Eqs. (1):

$$L_2 = \lambda_2 - M = 1.47 \times 10^{-6} \text{ henries}$$

$$L_1 = \lambda_1 - M = 4.75 \times 10^{-6} \text{ henries}$$

$$L_3 = M = 2.7 \times 10^{-6} \text{ henries}$$

The equivalent π can also be computed from Eqs. (3):

$$l_1 = \frac{\lambda_3}{L_2} = 16.8 \times 10^{-6} \text{ henries}$$

$$l_2 = \frac{\lambda_3}{L_1} = 5.2 \times 10^{-6} \text{ henries}$$

$$l_3 = \frac{\lambda_3}{L_3} = 9.15 \times 10^{-6} \text{ henries}$$

T circuit calculations

As was pointed out in the previous discussion, the transformer can always be computed in this manner, but the equivalent T or π circuits may involve values of negative inductance. These are clearly not physically realizable. It is necessary to choose values of C_2/C_1 from Figs. 9, 10, and 11 which will give realizable values, or, if C_2 and C_1 are fixed, there is a maximum value to the bandwidth in terms of the center frequency. Since it constitutes an interesting and useful case, the bandwidth and constants of an interstage degenerate T unit can be calculated for 6AK5-to-6AK5 coupling. $C_1 = 4.5$ $\mu\mu$f, $C_2 = 7.2$ $\mu\mu$f, $C_2/C_1 = 1.6$. If we refer to Fig. 10 and examine the maximum value of α^2 which is possible ($L_2 = 0$) for the secondary-loaded case, we find $\alpha_2^2 = 1.55$ for $C_2/C_1 = 1.6$. We may therefore make such a transformer in which the bandwidth is 0.88 times the center frequency, and which is "simplified" in that L_2 vanishes. As an example we may desire a coupling unit centered at 30 mc whose bandwidth is 26.4 mc. The equivalent T circuit is calculated as follows:

$$\omega_0 = 1.88 \times 10^8,$$

$$\omega_0^2 = 3.54 \times 10^{16},$$

$$\omega_0^4 = 12.5 \times 10^{32}$$

$$R_2 = \frac{1}{\alpha_2 \omega_0 C_2} = 590 \text{ ohms}$$

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_o^4} = 24.7 \times 10^{-12}$$

$$\lambda_2 = \frac{1}{C_2 \omega_o^2}\left(1 + \frac{\alpha_2^2}{8}\right) = 4.67 \times 10^{-6}$$

$$\lambda_1 = \frac{1}{C_1 \omega_o^2}\left(1 + \frac{3\alpha_2^2}{8}\right) = 9.92 \times 10^{-6}$$

$$L_3^2 = (146.4 - 24.7) \times 10^{-12}$$

$$L_3 = 4.67 \times 10^{-6} \text{ henries}$$

$$L_2 = 0$$

$$L_1 = 5.25 \times 10^{-6} \text{ henries}$$

These are then the constants of a degenerate T coupling unit which is suitable for a wide band if amplifier. This degenerate T circuit is also a degenerate π circuit in which $l_1 = 0$, and will be recognized by readers as a so-called "L-section."

Coupling units

C.—*Intermediate-frequency Amplifier to Line.* It is often desirable to couple energy from an if amplifier into a transmission line whose characteristic impedance is about 75 ohms. Since single-tuned coupling efficiency is so poor for wide bands, it is useful to consider a double-tuned transformer coupling unit. This sort of transformer will be preferably a secondary-loaded transformer in which C_1 and R_2 are given, and in which the design may be made for a particular bandwidth centered at a particular frequency. For illustrative purposes let us calculate the constants of a transformer to couple from the plate of a 6AK5 pentode into a 75-ohm line or resistor over a bandwidth of 30 mc centered at 30 mc. For this case $C_1 = 4.5$ $\mu\mu$f.

$$\omega_o = 1.38 \times 10^8,$$

$$\omega_o^2 = 3.54 \times 10^{16},$$

$$\omega_o^4 = 12.5 \times 10^{32}$$

$$\alpha_2 = \sqrt{2},\quad \alpha_2^2 = 2,\quad C_2 = \frac{1}{\sqrt{2}\,\omega_o R_2} = 50 \mu\mu\text{f}$$

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_o^4} = 3.56 \times 10^{-12}$$

$$\lambda_2 = \frac{1}{C_2 \omega_o^2}\left(1 + \frac{1}{8}\alpha_2^2\right) = 0.705 \times 10^{-6} \text{ henries}$$

$$\lambda_1 = \frac{1}{C_1 \omega_o^2}\left(1 + \frac{3}{8}\alpha_2^2\right) = 10.99 \times 10^{-6} \text{ henries}$$

$$M = \sqrt{\lambda_1 \lambda_2 - \lambda_3} = 2.04 \times 10^{-6} \text{ henries}$$

This requires a coefficient coupling of

$$k = \frac{M}{\sqrt{L_1 L_2}} = 0.735$$

This coefficient of coupling is high enough so that construction of such a transformer is difficult. It is possible to construct an equivalent T transformer, provided one chooses conditions in such a way that the various constants are physically realizable. If we refer to Fig. 10, it can be seen that for $a^2 = 2$ the *maximum* value of C_2/C_1 is obtained when $L_2 = 0$. For this case $C_2/C_1 = 1.3$, and since $C_2 = 50$ $\mu\mu$f, C_1 must be 38 $\mu\mu$f. In other words, unless C_1 is as high as 38 $\mu\mu$f, it is *not* physically possible to make a T circuit which is the equivalent of the double-tuned transformer.

If capacitance is added to the primary, however, to raise C_1 to the proper value of 38 $\mu\mu$f, the T circuit may be used. The calculations for such a transformer are the following:

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_0^4} = 0.42 \times 10^{-12}$$

$$\lambda_2 = \frac{1}{C_2 \omega_0^2}\left(1 + \frac{\alpha_2^2}{8}\right) = 0.705 \times 10^{-6} \text{ henries}$$

$$\lambda_1 = \frac{1}{C_1 \omega_0^2}\left(1 + \frac{3\alpha_2^2}{8}\right) = 1.3 \times 10^{-6} \text{ henries}$$

$$L_3^2 = (0.918 - 0.42) \times 10^{-12}$$

$$L_3 = 0.705 \times 10^{-6} \text{ henries}$$

$$L_2 = 0$$

$$L_1 = 0.595 \times 10^{-6} \text{ henries}$$

Voltage gain

The gain-band width of this circuit, while substantially more than that of a single-tuned circuit, is distinctly less than that of the transformer previously described. The reason for this is the necessarily increased value of C_1. The gain in voltage from the grid of the if amplifier to the 75-ohm line is approximately equal to

$$\frac{g_m}{\omega_0 \alpha_2}\sqrt{\frac{2}{C_1 C_2}}$$

where g_m is the transconductance of the tube. The voltage gain of the transformer, therefore, will be 1.95, if a g_m of 5500 micromhos for the 6AK5 is assumed, while for the equivalent T circuit the gain will be 0.67. Thus the transformer is more suitable for use. It is to be

noted that the coefficient of coupling of the transformer is *not* dependent upon the value of C_1; the addition of primary capacitance will not reduce the required coefficient of coupling.

D.—*Input Circuit to If Amplifier.* It is sometimes useful to construct a double-tuned circuit for coupling energy from a relatively low-resistance generator into the grid circuit of an if amplifier tube. We shall consider the case in which the generator may be represented by a pure resistance with negligible reactance and in which the grid of the if amplifier tube may be represented by a pure capacitance with negligible loading. This is a condition which is frequently encountered when coupling a superheterodyne converter to an if amplifier.

Let us compute values for a transformer which is to couple a 400-ohm generator into the grid of a 6AK5 pentode with a bandwidth of 15 mc centered at a frequency of 30 mc.

$$\omega_0 = 1.88 \times 10^8,$$

$$\omega_0^2 = 3.54 \times 10^{16},$$

$$\omega_0^4 = 12.5 \times 10^{32}$$

$$\alpha_1 = \frac{\sqrt{2}}{2}, \quad \alpha_1^2 = 0.5$$

$$C_1 = \frac{1}{\omega_0 R_1 \alpha_1} = 13.3 \text{ mmf.}$$

This value of capacitance must be placed in shunt with the generator resistance, R_1, in order to secure the proper bandwidth.

$$\lambda_3 = \frac{1}{C_1 C_2 \omega_0^4} = 5.91 \times 10^{-12}$$

$$\lambda_2 = \frac{1}{C_2 \omega_0^2}\left(1 + \frac{3}{8}\alpha_1^2\right) = 4.56 \times 10^{-6}$$

henrys secondary inductance

$$\lambda_1 = \frac{1}{C_1 \omega_0^2}\left(1 + \frac{1}{8}\alpha_1^2\right) = 1.6 \times 10^{-6}$$

henrys primary inductance

$$M = \sqrt{\lambda_1 \lambda_2 - \lambda_3} = 1.35 \times 10^{-6}$$

henrys mutual inductance

$$k = \frac{M}{\sqrt{\lambda_1 \lambda_2}} = 0.484$$

The equivalent T can be computed.

$$L_3 = M = 1.35 \times 10^{-6} \text{ henrys}$$

$$L_2 = \lambda_2 - M = 3.31 \times 10^{-6} \text{ henrys}$$

$$L_1 = \lambda_1 - M = 0.25 \times 10^{-6} \text{ henrys}$$

The equivalent π can also be obtained.

$$l_3 = \lambda_3/L_3 = 4.37 \times 10^{-6} \text{ henrys}$$

$$l_2 = \lambda_3/L_1 = 23.7 \times 10^{-6} \text{ henrys}$$

$$l_1 = \lambda_3/L_2 = 1.78 \times 10^{-6} \text{ henrys}$$

As was pointed out previously, the transformer can always be computed in this fashion, but all cases considered will not yield physically realizable constants for the T and π circuits. It is of interest to investigate the regions of physically realizable constants for the T and π circuits. These are shown in Fig. 9 but we now have a relation between the bandwidth (represented by α_1) and C_1 and R_1. For a given bandwidth Fig. 9 shows an allowed region for C_2/C_1, and if C_2 is given (pentode input capacitance), this means a certain allowed region for C_1 itself. Since the bandwidth is specified, however, an allowed region in C_1 is tantamount to an allowed region in R_1.

It is of interest to show a sample chart of the allowed regions of R_1 as a function of α_1^2. Let us assume again that $C_2 = 7.2$ $\mu\mu$f. For this case, and if we use the results shown in Fig. 9, the allowed values of R_1 are shown in Fig. 12. It can be seen that for low-Q circuits the value of R_1 is rather limited, and a suitable match will not always be possible. Likewise, if the generator resistance, R_1, is fixed a maximum value of α_1^2 is found; therefore, the bandwidth of the coupling circuit is limited.

Engineers To Study Tube Developments

A symposium of "Wartime Developments in Radio Tubes" will take place on Saturday April 6th in the auditorium of the Engineering Societies building at 33 W. 39th Street, New York, under the arrangement of the New York Section of the IRE. Papers to be given include "Selected Topics on the use of Magnetrons" Hebenstreit (BTL), "Klystrons" Relson (Sperry), "Velocity Modulated Oscillators with Secondary Emission" Wang (Westinghouse), "Cyclophon" Grieg, Glauber and Levine (Fed. T. Labs), "Resnatron" Boggs (Westinghouse), "A New Miniature Tube" Lord (BTL) and "A Pulse Triode" Nergaard (RCA Labs). The two sessions will start at 9:30 A.M. and at 1:30 P.M.

STUDIO CONSOLE

(Continued from page 71)

pad, the monitor amplifier feeds loudspeaker outlets A, B, C & D. By connecting the monitor switch to the monitor section of the input switching keys, the amplifier operates as an auditioning amplifier. In the case of an emergency, the monitor amplifier can be used as a program amplifier. For such use it is only necessary to disconnect the loudspeaker circuits and reconnect the transmission line to the loudspeaker output terminals.

It is possible to switch 14 incoming lines to either of two remote mixing positions by means of the line switching keys. A cue from the output of the monitor amplifier may be fed to any one of the remote lines, except lines 13 and 14 which are reserved for network purposes. Talkback to adjacent studios or to remote line points is served through the monitor amplifier and switching facilities. If desired, headsets may be connected to the program, monitor or remote lines at easily accessible terminal board termination points located on the inside base of the console. Repeater transformers are installed in both the incoming line mixing positions.

Level indicator

An illuminated VU meter indicates the level at the output of the program amplifier and the monitoring amplifier. It also shows the level at the inputs of the two remote line mixers. Meter switching in these circuits is accomplished by the use of the VU switch located on the left side of the meter. The range of the meter may be extended by a meter multiplier. Twelve steps of 2 db per step are provided for this purpose and extend the range to +24 db.

A dual wall or relay rack mount power supply furnishes power. The power supply is made up of the two separate complete units. One supply energizes the program amplifier and the other is for the monitor amplifier. Power for the pre-amplifiers is obtained from either of the two supplies by means of a rotary switch located on the supply front panel. A dc supply operates the three 6-volt speaker relays which are mounted on the base of the console. Up to three additional relays may be energized from this supply.

The pre-amplifier input imped-

ance may be connected for 50,200 or 500 ohms. The remote line input impedance is 600 ohms. Each pre-amplifier consists of a single 6J7 type tube, transformer coupled to the mixer system.

The tube line-up of the program and monitor amplifiers is identical. Each amplifier consists of two 6J7 resistance-coupled stages and one 6SN7GT resistance-coupled driver stage for the push-pull 6F6 power output tubes. The output impedance of either amplifier is 500/600 ohms.

Feedback is incorporated in the line and monitor amplifiers by feeding a portion of the output voltage from the output plate back to the appropriate driver cathode through a resistor-capacitance network. The frequency response of either the line or monitor amplifier is flat within ±2 db from 30 to 15,000 cycles. Distortion is less than 1% from 50 to 7500 cycles on the line amplifier at an output level of +20 db.

The use of feedback further lowers the overall noise and hum level of the amplifier to a point where the signal-to-noise ratio at an operating level of +20 db is approximately 60 db.

FM SYSTEMS

(*Continued from page 77*)

out of phase with each other by 90° and are used to generate pulses. These pulses are thereby routed to two circuits, one circuit receiving pulses when the signal frequency is higher than the reference frequency, and the other receiving pulses under the reverse conditions.

An integrating circuit is arranged so that when a pulse appears on a particular one of these circuits, a definite charge is transferred into a storage capacitor. When a pulse reaches the other circuit, a charge of the same number of coulombs is released from the capacitor to the reference potential circuit. The voltage which appears across the capacitor is used to control bias on the reactance tube so as to correct the frequency of the master oscillator. This frequency control unit contains no tuned circuits, dividers, or locked oscillators.

Pieracci arrangement

A stabilized FM system (described in 1942 by Mr. R. J. Pieracci of the Collins Radio Co., Cedar Rapids, Iowa) also uses a low frequency

crystal oscillator as a stable radio frequency source. The RF energy from this oscillator is divided into two channels, one channel containing a phase modulator and predister producing a phase shift of θ/f radians when modulated. Both channels have a chain of frequency multipliers, but the multiplication factor in one of these chains is one digit greater than that of the other.

Consider the frequency of the crystal oscillator to be F, then the frequency at the phase modulator is $F \pm \theta/f$, θ being the phase shift. A series of "n" multipliers in the first chain raises this frequency to ${}_nF \pm {}_n\theta/f$ and in the second chain the multiplication raises the frequency to $F\ (n+1)$. When these two channels are heterodyned in a frequency converter, the original modulated frequency plus the multiplied phase deviation, or $F + {}_n\theta/f$ will be recovered. Any change in oscillator frequency is therefore nullified since the system is based on the mixing of the multiplied oscillator frequency with the multiplied modulated oscillator frequency in the converter tube. The system therefore acts as if the crystal were located directly at the converter tube. This circuit has been superseded of late.

Phasitron control

In the General Electric FM transmitter circuits direct crystal control of the carrier frequency is accomplished by the use of a special modulating tube the GL-2H21 called a Phasitron, described in the January 1946 issue of ELECTRONIC INDUSTRIES. (Page 78). This tube produces wide phase excursions in accordance with the audio frequency signals applied to the tube as an axial magnetic field. The audio response characteristic of the circuit produces wide-swing frequency modulation with only about 50 millwatts of audio power. The modulation coil that produces this magnetic field is controlled by a current flowing through the coil that varies inversely with the audio frequency, so that the phase shift of the output current decreases with increasing modulation frequency, giving direct frequency modulation in the output circuit.

About 35 volts of rf driving power from the crystal oscillator will suffice to operate a Phasitron, which is of a size and has the operating voltages of the same order as found in

regular receiving tubes.

In the Link system of indirect frequency modulation the output of an oscillator is connected to one grid of a double triode. The other section is used as a crystal oscillator. The plate circuit of this tube is untuned but is terminated in a high impedance rf choke. One triode section of this tube acts as a phase modulator. Radio frequency voltage is fed from grid to plate in two ways. One is direct grid-to-plate capacity and the other by the electronic amplification of the tube. Degeneration in the cathode circuit by means of a high ohm cathode resistor keeps the two voltages nearly equal and slightly less than 180 deg. out of phase. The magnitude of the electronically amplified voltage varies as the bias is varied by the audio input. The resultant is a current in the rf choke in the plate circuit which is varying in phase (and frequency).

Armstrong Answers FCC

Major Edwin H. Armstrong, commenting on the Federal Communication Commission's report of March 5 containing the reasons for the decision of January 23, when it denied the Zenith Radio petition to retain the low FM band, said:

"The Commission's report virtually admits that its Engineering Department has made one of the colossal mistakes of radio history. The statement 'There is nothing whatever in the present proceeding which vasts any doubt upon the ability of the FM stations in the 88 to 108 mc band to render a superior interference-free and static-free service over ranges of sixty miles, and perhaps in excess thereof' makes this quite clear.

"Of course the FM 100 mc band will go sixty miles. That was known eight years ago when I was developing FM on the only band available to me then, namely, the 117 mc band. But the question here involved is: Which is the best band? FM has demonstrated and is demonstrating every day that it will go over a hundred miles on the old band and cover two to three times the area of the new one. Why move it to where it will go sixty miles?

"The reason the Commission gave when it first moved FM was the superior rural service of the higher band, based on the theoretical calculations of a Commission engineer, K. A. Norton. Those calculations were disproved by Zenith's and the Commission's own measurements, but the Engineering Department

WE'RE HAVING A WONDERFUL TIME

MEETING OLD FRIENDS

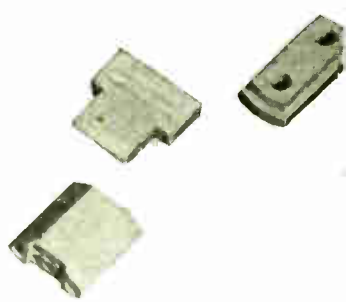
EVERY day old friends drop in to see us—familiar but long missed voices come over the phone—men back from strange lands, strange experiences.

Back home, back to the old job, the conversation swiftly turns to work. Pre-war dies and extrusion nozzles come out of the storage vault in perfect condition, ready for immediate production. Our men again produce pieces not made since before the war. Early designs, time tested and time proved, are being made in increasing quantities.

Most of our men are back too. Production is humming along at a pace even greater than the wartime speed which won American Lava Corporation employees five awards of the Army-Navy E. We're busy, but if you ever had tools at American Lava Corporation, they are still here, ready for your use, and somehow we'll take care of you.

Welcome home, it's great to see you back again.

Original Award July 27, 1942
Second Award February 13, 1943
Third Award September 25, 1943
Fourth Award May 27, 1944
Fifth Award December 2, 1944



AMERICAN LAVA CORPORATION
CHATTANOOGA 5, TENNESSEE
43RD YEAR OF CERAMIC LEADERSHIP

of the Commission has evidently chosen to ignore them to maintain a previously taken but now untenable position.

"In addition to the refusal to face the plain implications of the tests, the report is full of mistakes of technical facts which would be amusing were their effects not so serious to the public. These errors will be laid bare at the round table discussion on March 23 at the Broadcast Engineering Conference at Columbus, Ohio, which is sponsored by Ohio State University and the University of Illinois. It is now in order to challenge the responsible members of the Commission's engineering staff to appear at this Conference and substantiate the technical findings of this report, which will have a profound effect on radio history for years to come.

"Controversies concerning the laws of nature are never closed until the facts come out. The only way the facts in this situation can be suppressed is by shutting down the present 40 mc stations before the comparative performance of the two bands can be observed in actual practice by engineers and the public alike."

Armstrong Reduces FM License Fees

Further evidence of the growing popularity of FM radio is the revision of license fees announced by Major Edwin H. Armstrong, inventor of FM. This is a revision in transmitter licenses and follows the reduction made some time ago in receiving set licenses.

The original arrangements on transmitter royalties were made informally between Major Armstrong and the few pioneers in the manufacture of FM transmitters, with the understanding that when the volume of FM business increased, the license fees would be reduced. In accordance with this understanding, transmitter fees are now cut in half and a simplified form of license has been created.

As before, the license is issued to the broadcast station and the royalty based on the operating power of the station. It ranges from $150 for a transmitter with an operating power of 250 watts to $2,500 for a transmitter with an operating power of 50 kilowatts.

In the broadcast receiving set field, royalties have been reduced by approximately 20% from the pre-war rates, resulting in an effective current royalty rate of approximately 1% of the manufacturer's

New reference guide for Capacitors

TO assist you in properly meeting your capacitor requirements, Magnavox has prepared this handy reference guide. Specifications, accessory and technical data for the full line of Magnavox Electrolytic Capacitors are given in complete detail.

Magnavox Capacitors, produced expressly for the manufacturing trade, are built to meet severest operating conditions. Containers are standardized into eight sizes to simplify your design and assembly problems.

Economy in size and cost, long life, and efficient and trouble free operation are features Magnavox Electrolytic Capacitors can promise—and deliver. Mechanically, electrically and chemically they reflect years of research and experience. They have earned and won the confidence of the leading engineers.

Write today for this handy reference guide—and when you need the best in electrolytic capacitors—specify Magnavox. There is no substitute for experience! The Magnavox Company, Components Division, Fort Wayne 4, Indiana.

Magnavox
RADIO PHONOGRAPH

MAGNAVOX HAS SERVED THE RADIO INDUSTRY FOR OVER 35 YEARS

gross selling price or ½ of 1% of the price paid by the ultimate purchaser of the receiver. Major Armstrong has announced that he will continue to follow the policy of granting licenses to all applicants; will continue to waive royalties on FM broadcast stations operated by religious and educational institutions. Any veteran of World War II who proposes to operate an FM station and who will have a controlling interest in such station may defer the payment of royalty on an FM broadcast transmitter until he finds himself in a financial position to pay it. No additional royalty will be charged with respect to a replacement transmitter operating in the new band and with the same power.

In March, 1941, Major Armstrong offered to the War and Navy Departments the free use of his FM inventions for the duration of the emergency. At the same time he informed those Departments that he would grant to any Manufacturer designated by the Government a royalty-free license to manufacture FM equipment for military purposes. He followed the same course in Canada with respect to his Canadian patents. The royalty-free licenses in both countries are still in effect.

Tele Conference and Show Oct. 10-11

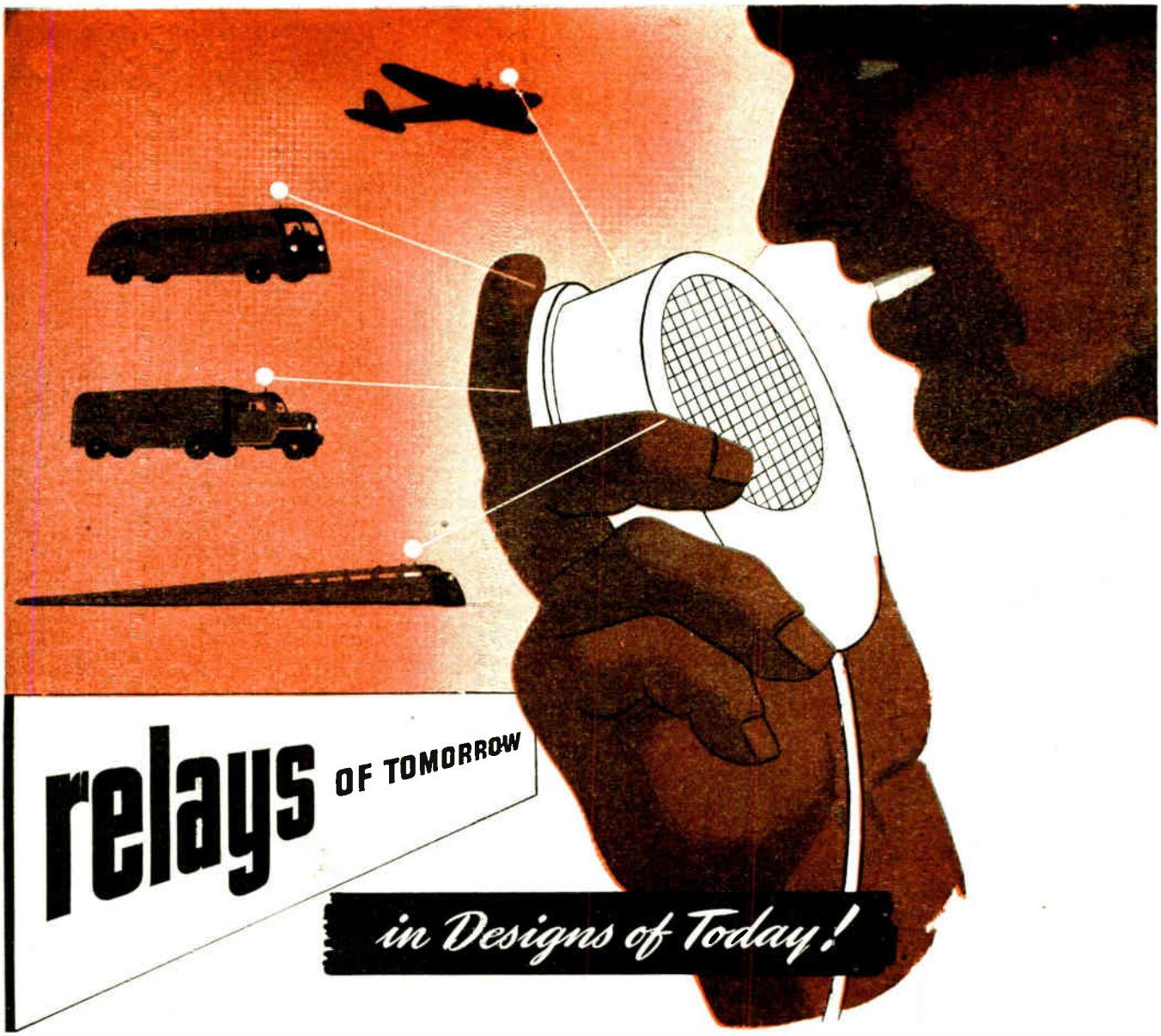
The first post-war television conference to be conducted by the Television Broadcasters Association, Inc., will take place at the Waldorf-Astoria Hotel, New York, on Thursday and Friday, October 10 and 11, 1946. Highlight of the two-day session will be the first exhibit of latest television equipment — receivers, transmitters, cameras and studio accoutrements—to be shown to the industry under one roof.

First FM Station For San Franciso

San Francisco is soon to have its first FM station. FCC has issued a construction permit to Associated Broadcasters, Inc., for a 40-kw station to be operated from KSFO's studios in the Mark Hopkins Hotel.

Electronic Incorporates

The Electronic Engineering Co., Chicago, has incorporated, hereafter will do business as Electronic Engineering Co., Inc. The company manufactures all types of transformers and electronics equipment.

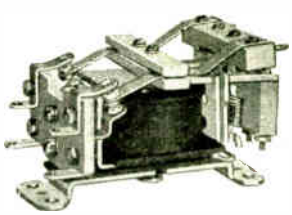


FOR COMMUNICATIONS IN TRAINS • TRUCKS • BUSES • PLANES...

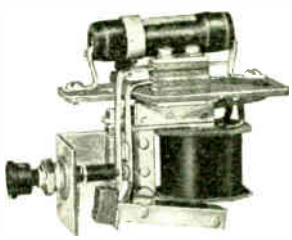
Relays BY GUARDIAN— years ahead of today— offer designers of two-way radios definite advancements which contribute to better long-life operation. This is especially evident with Guardian Relays and Switches used in two-way radios for trains, trucks, buses, planes.

For instance, Guardian's series 165-A Relay (A1 Si Mag insulated), for antenna changeover and break-in is small, compact, vibration-resistant. Laboratory tests with 2 normally open contacts prove series 165-A withstands vibration of 16.2 g.+ in both energized and de-energized positions. This is achieved by rugged overall construction and precise counterbalancing of the armature assembly. For H.F. and U.H.F. the series 165-A has a contact capacity to handle all required frequencies. Operates at temperatures ranging −65° to +160°F. and at altitudes from sea level to 50,000 ft. Truly, series 165-A merits a trial now! For V.H.F. antenna switching or keying try the war-tested Vacuum Switch Relay by Guardian.

Let us furnish cost-free information about the complete Guardian line of Radio Relays, also all Telephone Type Relays including the small Midget; and a special Switch used on push-to-talk circuits.



Series 165-A Relay



Series X-100 Relay

GUARDIAN ELECTRIC

1622-D W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

PERSONNEL

Nelson P. Case

Nelson P. Case, who has been chief engineer of the Hallicrafters Co., receiver division, has been promoted to chief engineer of the company. He joined Hallicrafters several months ago after two years as director of engineering design for Hamilton Radio Corp., New York, and was previously with Hazeltine for 13 years.

Garrard Mountjoy has been elected vice-president of the Electronic Corp. of America and will have charge of the organization's engineering. He was formerly director of radio research and development and director of the New York laboratories of Lear, Inc., has been head of the licensing consulting section of RCA License Laboratories and chief engineer of the Sparks-Withington Co., Jackson, Mich.

Garrard Mountjoy

Dr. Robert B. Jacobs

Dr. Robert B. Jacobs has been appointed to direct the physics laboratory of Distillation Products, Inc., Rochester, N. Y. He was previously engineer in charge of high vacuum development and research for the Kellex Corp.

Thomas C. Stephens has joined the research division of the Collins Radio Co., Cedar Rapids, Iowa. He goes to Collins from the University of Iowa, where he was an instructor in radio and electrical engineering, and a research engineer for the physics engineering development project.

Arthur H. Wulfsberg has joined the Collins Radio Co., Cedar Rapids, Iowa, as a member of the research division. He was formerly with Sylvania Electric Products, Inc., engaged in the design and production of radar and Loran equipment.

For your resistors for experimental work, pre-production models, pilot runs, and small production runs call upon your local IRC Distributor for prompt, intelligent service!

Announcing the IRC INDUSTRIAL SERVICE PLAN

now offered by over 300 IRC Distributors!

IRC Distributors from coast to coast are now able to give industrial users of resistors a new, extra service on all standard IRC products.

Under the new IRC Industrial Service Plan, your local IRC Distributor is building and maintaining adequate stocks of standard IRC units for many industrial requirements . . . and he can now fill your moderate-quantity orders, from stock, *at direct-factory prices!*

Take advantage of this new IRC plan, speed your reconversion and development by getting acquainted with your local IRC Distributor. If you do not have his name, your IRC Representative will be glad to recommend one or several in your vicinity, or write direct.

IRC Catalog No. 50 lists standard products stocked by IRC Distributors. *Send for your copy.*

DEPT. 2-D. 401 NORTH BROAD STREET, PHILADELPHIA 8, PA.

Edward F. Classen, Jr., has joined Radio Engineering Laboratories, Inc., Long Island City, in the capacity of sales engineer. He was previously connected with the Zenith Radio Corp. for ten years, will be associated with the REL midwestern representatives at 612 N. Michigan Avenue, Chicago, Ill.

Neal Turner has been appointed quality control engineer of the Hallicrafters Co., Chicago. He was formerly engineering sales manager for the RFC project in the Clearing, Ill. Hallicrafters plant.

Neal Turner

Maj. Frank R. Brick, Jr.

Major Frank R. Brick, Jr., has been appointed assistant to the president of Finch Telecommunications, Inc., Passaic, N.J. He has been associated with the organization for a period of ten years.

J. O. Ashton has joined the engineering staff of the National Electrical Mfrs. Assn. He is a radio engineering consultant and development engineer, was formerly associated with Dr. Palmer H. Craig, Dr. Lee de Forest and Dr. C. F. Burgess.

Harry E. Rice has been appointed assistant chief engineer of the radio division of Lear, Inc. He will have complete charge of production of home radio, aircraft radio and television and will make his headquarters at the Grand Rapids, Mich., office.

R. M. (Rube) Coburn has been appointed sales manager of Panoramic Radio Corp., 242 W. 55th St., New York, manufacturers of Panoramic communication receivers.

Dr. Noel C. Jamison, research physicist, joined North American Philips Co. on January 2 as division chief in charge of electroacoustics. He was assistant professor of physics at Northwestern University until 1941 and then went to Harvard University to work under the auspices of the National Defense Research Committee.

proper application is as important as good workmanship

Accurate Service includes helping you select the right spring for your job —

Springmaking craftsmanship is important. But so is proper *application* of spring power. For example: A change in spring specifications may improve product performance, increase spring life, lower spring costs, or even shorten assembly time.

We, here at Accurate, recognize how important it is to apply spring power properly. What's more, we've the long and varied experience and the practical spring engineers necessary to help you use spring power efficiently and economically.

We have also, the spring craftsmen and modern facilities to make your springs the way they should be made. Find out for yourself. Accurate Spring Manufacturing Co., 3808 West Lake Street, Chicago 24, Illinois.

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.

SPRINGS • WIRE FORMS • STAMPINGS

Accurate Springs

Don Haines has been elected secretary-treasurer of the Chicago section of the Institute of Radio Engineers. He is a consulting engineer, was formerly Chicago field engineer for the National Union Radio Corp.

W. W. Watts has been made general sales manager of the engineering products department of RCA Victor Division. He has served as a colonel in the Signal Corps for the past three and one-half years. His headquarters will be in Camden, N. J.

Charles R. Denny has been named acting chairman of the Federal Communications Commission, taking the place of Paul Porter, recently placed in charge of OPA. Denny joined RCC four years ago as legal aide.

Charles R. Denny

Paul K. Povlson

Paul K. Povlson has been named vice-president and general manager of Maguire Industries, Inc. In his new position, he will supervise all manufacturing operations of the company, including those of subsidiaries. He has served since 1941 as vice-president in charge of production for the J. I. Case Co. of Racine, Wis.

M. J. Gross has been named manager of engineering for the General Electric X-Ray Corp., Chicago. He has been a member of the GE engineering staff since 1928 when he joined the GE research laboratory in Schenectady.

William G. Miller has been appointed manager of the headquarters manufacturing staff of the Westinghouse Electric Corp., Pittsburgh. He will be responsible for the manufacturing activities of the equipment, manufacturing engineering, production, quality control and wage incentive departments.

Philip I. Merryman has been appointed assistant to the director of the National Broadcasting Co.'s research department in New York. He will have charge of the planning and development division.

RAYTHEON'S NEW STUDIO CONSOLE

For AM or FM

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

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

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

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

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

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

Devoted to Research and Manufacture for the Broadcasting Industry

Compare THESE OUTSTANDING FEATURES WITH ANY OTHER CONSOLE

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

RAYTHEON

Excellence in Electronics

Allen D. Pettee has been appointed chief electrical engineer of the General Cable Corp. His headquarters will be at 420 Lexington Avenue, New York.

Emery B. Gebert has joined the Hungerford Research Corp., Murray Hill, N. J., in the capacity of chief powder metallurgist. He was formerly metallurgist for the Koebel Diamond Tool Co.

Carson M. Wheeler has joined the Amperex Electronic Corp. as chief engineer in charge of tube development. Previously he was connected with the Federal Telephone & Radio Corp., for more than ten years.

Carson M. Wheeler

Walter R. Jones

Walter R. Jones, for seventeen years associated with the Sylvania Electric Products, Inc., has been appointed chief engineer of the company's radio tube division. He was formerly general engineering manager for radio tubes and manager of the commercial engineering department.

P. B. Alger has joined the Sprague Electric Co., North Adams, Mass., in the capacity of application engineer. He was previously in charge of naval inspection work at the Stromberg-Carlson Buffalo, N. Y. plant.

Russell E. Kraft has joined Radio Frequency Laboratories, Inc., Boonton, N. J., as senior electrical engineer. Before the war he was communications engineer with the American Telephone and Telegraph Co., latterly has been connected with the design section of the Bureau of Ships.

California Plant For Sylvania Electric

Sylvania Electric Products Inc. has commenced construction of a new plant for the assembly of home radio receivers at Riverside, California for its wholly owned subsidiary, the Colonial Radio Corp., Buffalo, N. Y. Purchasing and engineering functions will be continued at the home offices in Buffalo.

NEW BULLETINS

Low Temperature Brazing

Handy & Harman, 82 Fulton St., New York, is distributing the latest issue of the "Low Temperature Brazing News" describing Sil-fos and Easy-Flo silver brazing alloys. The 4 page folder shows a number of applications of these low temperature alloys in industry and lists their advantages.

Crystals

Crystal Research Laboratories, Inc., Hartford 3, Conn., has issued an 8 page folder describing a complete line of mounted crystals. The bulletin contains photographs and descriptions of special crystals as well as a listing of standard crystals made to specifications.

Electrical Connectors

A revised edition of the Type "AP" Bulletin has been issued by Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Cal. The 12-page catalog lists five

THE FM EXPRESS IS ROLLING

. . . are you aboard?

As we write this, 53 FM stations are on the air. Another 323, granted conditionally, momentarily await the Washington green-light that starts them building. Additionally, 466 station applications are on the FCC docket.*

That's the current FM situation in a nutshell. But it doesn't tell all.

FCC Commissioner Paul A. Walker said recently: "Conservative estimates suggest that the number (of FM applicants) will approach 2,000 by 1947 as compared with only 950 standard broadcast stations now in operation."

Frank Mansfield, Sylvania Electric Products, wrote in the February FREQUENCY MODULATION that a consumer survey made by his firm indicated $600,000,000 will be spent in FM set sales in 1946-47-48.

Martin Codel, Publisher of FREQUENCY MODULATION as well as TELEVISION DIGEST AND FM REPORTS, conservatively estimates that $30,000,000 will be put into FM station equipment this year and next.

Thus speak men on the inside. What they say adds up to the top broadcast equipment sales opportunity today.

Are you telling your story to this market?

FREQUENCY MODULATION serves the men who do the buying. It is their magazine . . . the only one 100% for and about FM. It serves the seasoned AM broadcasters who seek new guidance in a new art; the hundreds of others who, with FM, are becoming broadcasters for the first time. It serves station owners, managers, chief engineers, program directors, consulting radio engineers, radio attorneys, government officials, equipment manufacturers and many others . . . a total circulation today of 16,000. For advertising rates and closing dates write to Edward Codel, FREQUENCY MODULATION, 103 Park Avenue, New York 17.

* March issue of FREQUENCY MODULATION with 10 page directory of FM station applicants free on request.

FREQUENCY MODULATION

100% for and about FM. Its credo: to bring ideas and inspiration to its industry, to give it cohesion, to interpret trends, to report happenings, and to help guide FM toward a useful and profitable existence.

plugs and three receptacle types, which, with six insert arrangements, make possible 48 different fittings. The series was originally designed for the Signal Corps, but has been used in many types of radio, telephone and sound circuits. The catalog includes an information section, exploded views, dimensional sketches, photos and application views.

Buying Guide

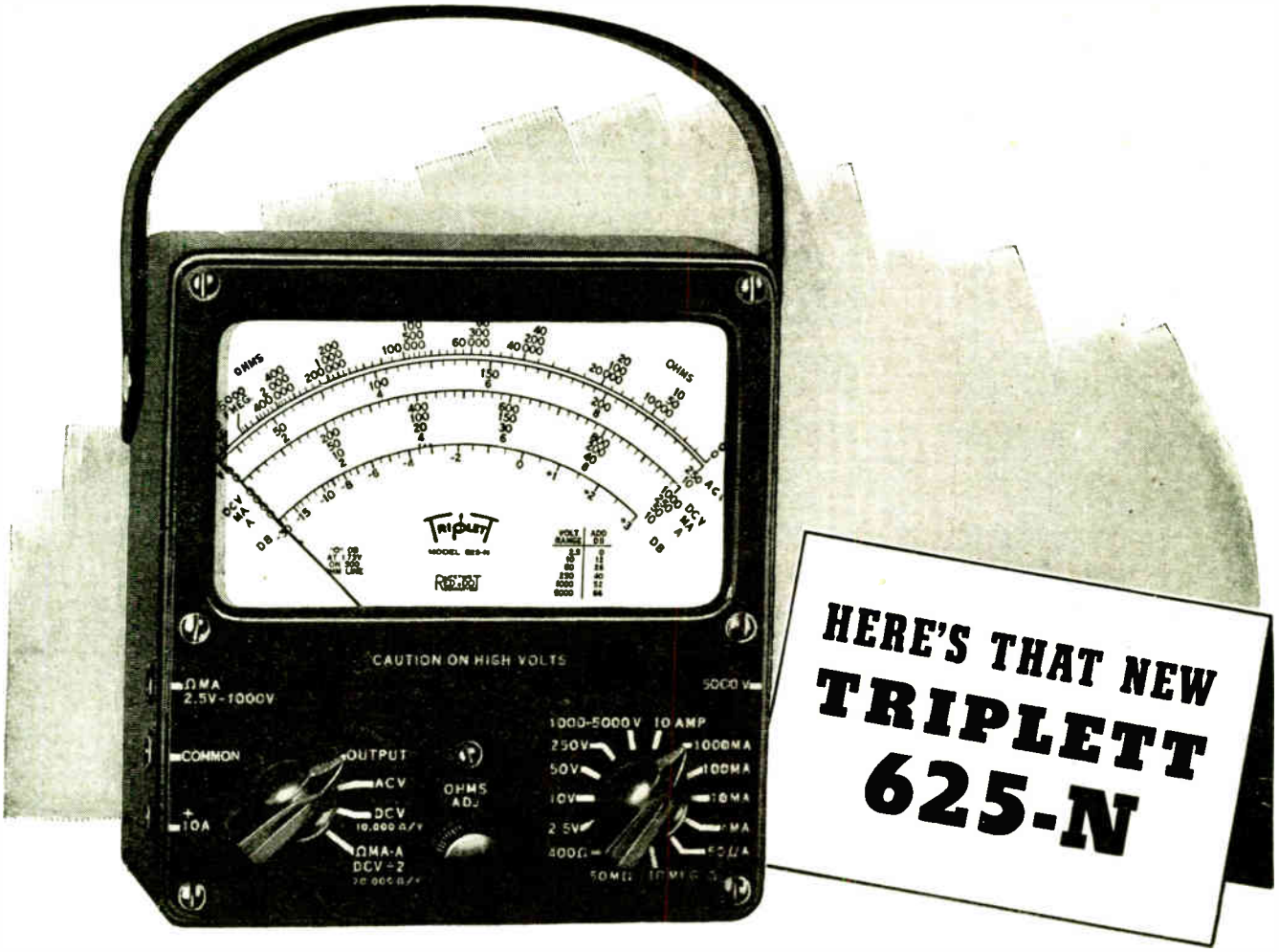
Allied Radio Corp., Chicago, has published a new 1946 buying guide. Emphasis is placed on industrial maintenance, research and production requirements as well as the needs of government agencies for radio and electronic supplies. Included are complete, detailed listings of tubes, test instruments, transformers, resistors, condensers, rheostats, relays, switches, rectifiers, tools, wire and cable, batteries, sockets, generators, power supplies, and other types of equipment in this field. All equipment is presented in organized sections with items indexed for easy reference. Public address and intercommunication units are listed for indoor and outdoor requirement, with ready-to-install systems for a variety of industrial applications. The sound equipment section also includes wide listings of microphones, speakers and other accessories. For training programs and experimental work there are a number of kits, manuals, and diagrams. A large technical book section covers leading publications on radio, electronics and electricity.

Lock Fasteners

The Simmons Fastener Corp., Albany, N. Y., has issued a new and revised catalog of its products. It includes the latest data and specifications on Quick-Lock, Spring-Lock and Lock-Nut fasteners. In 28 pages the catalog gives design and engineering information, dimensional sketches and installation instructions for these fasteners.

Electronic Tube Reference

A new reference booklet giving typical operating conditions and tube base diagrams for more than 450 types of electron tubes used in radio receivers and industrial electronic applications has been issued by Sylvania Electric Products Inc., Emporium, Penna. The booklet is useful for reference.



LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

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

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

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

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

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

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

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

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

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

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

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

Write for descriptive folder giving full technical details

Precision first ...to last

STANDARDS ARE SET BY TRIPLETT

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

NEW BOOKS

Radar, What Radar Is and How It Works

By Orrin E. Dunlap, Jr., published by Harper & Brothers, New York and London, 1946. 208 pages, $2.50.

This aim here is to give a popular version of radar so that the layman may appreciate its significance and realize the tremendous importance of science in the destiny of nations and of civilization. The text is a dramatic rather than technical representation of the achievement of radar. It is addressed to the layman and radio listener and reads like fiction. Performance, historical development and the part this comparatively new engineering branch played in winning World War II is described by numerous quotations of technical and military men. Future possibilities are pointed out.

Transmission Lines, Antennas and Wave Guides

By Ronald W. P. King, A.B., Ph.D., Associate Professor of Physics and Communication Engineering, Harvard University; Harry Rowe Mimno, E.E., Ph.D., Associate Professor of Physics and Communication Engineering, Harvard University, and Alexander H. Wing, E.E., Ph.D., Lecturer on Electronics, Harvard University, published by McGraw-Hill Book Co., New York City, 1945. 347 pages, $3.50.

This book has developed from the lecture notes of a special wartime training course given in the Graduate School of Engineering, Harvard University. However, the scope and the method of presentation of the material are not on a graduate level. Rather an attempt is made to provide necessary factual material and to develop a real understanding for the electromagnetic point of view without the use of higher mathematics. This attempt seems to have been unusually successful; rigor has not been sacrificed to simplicity but, where the mathematics is not included, the worded statements conform to the physical interpretation of electromagnetic theory. Over-simplification by analogues, frequently found in text books, is avoided. For example, where comparisons of different structures or circuits are made, precautions as to the limits of the similarity are included.

The first chapter on transmission lines derives the differential equations of the line, defines the vari-

ous terms used in transmission line theory, and then deals with the properties and applications of dissipationless lines, (impedance matching, stubs, etc.) Construction and use of the circle diagram is presented in a shortened version of A. H. Wing's article in the Journal of Applied Physics, August 1944, (reported in the April 1945 issue of Electronic Industries in the Survey of Wide Reading section). An interpretation of the general transmission-line equations follows.

Chapters II and III, dealing with antennas and ultra-high frequency circuits, respectively, include a qualitative introduction to general electromagnetic theory. Antennas as circuit elements, coupled antennas and transmission lines, as well as antenna arrays are studied. Properties of wave guides and cavity resonators are treated. The last chapter deals with wave propagation.

Introduction to Microwaves

By Simon Ramo, Ph.D., published by the McGraw-Hill Book Co., New York, 1945. 138 pages, $1.75.

Since a "frequency ratio of millions when compared with power frequencies and of thousands when

compared even with radio-broadcast frequencies makes microwaves fascinating and important" to commercial men and executives, who ask questions, this book well serves the purpose of a preface to the rather complex field of microwaves, especially since it is not "aimed to replace anything". Assuming a familiarity of the reader with power frequencies and lower radio frequencies, the book—in 15 "easy" chapters—establishes a link between the narrow concepts used at lower frequencies to the broader concepts of electro-magnetic theory necessary to include microwaves. An appendix listing a number of more formidable texts for further study is included.

RCA Review Resumes

The RCA Review, a technical journal of radio and electronic research and engineering published by the RCA Laboratories, Div. of Radio Corp of America, reappeared in March on a quarterly basis. The Review was suspended in 1942 as a consequence of wartime security regulations. RCA Review contains papers prepared by scientists, engineers and executives of RCA and its subsidiaries.

Open Amateur Band

Another band of frequencies has been made available to amateurs. Following a meeting on February 21 between all military services and members of the AARL, frequencies between 3,700 and 4,000 kc, inclusive, were turned back to the amateurs as of March 31. Operation is permitted only within the continental U. S., however, and includes class A phone between 3,900 and 4,000 kc. The remainder of the 80-meter band is expected to be opened before the end of the year. At the present time amateurs are permitted to use only the following bands: 28-29.7 mc; 56-60 mc; 144-148 mc; 420-430 mc; 1,215-1,295 mc; 2,300-2,450 mc; 5,250-5,650 mc; 10,000-10,500 mc; 21,000-22,000 mc.

Navy's Dow Promoted

Commodore Jennings B. Dow, USN, has been promoted and takes over an enlarged sphere of activities for the Government. During the war he headed the Electronics Division of the Navy's Bureau of Ships. He has now been given the official title Chief of Electronics in the Bureau of Ships.

John F. Rider Award

At a formal military ceremony held at Fort Monmouth in February John F. Rider, Lt. Col. Signal Corps (retired), was presented with the Legion of Merit medal. Part of his citation for the Legion of Merit decoration reads: ". . . rendered exceptional administrative service to the Signal Corps Publication Agency. . . . His ability to organize and effectively utilize available personnel materially contributed to the preparation, production and distribution of vitally needed technical manuals containing instruction for the installation, operation, maintenance and repair of signal equipment. From 26 November 1943 to May 1944, he planned and personally supervised the production of a backlog of 60 vitally needed technical manuals covering radar equipment already in theatres of operation but without adequate instructions for their installation, operation, maintenance and repair . . ."

Prince Honored

The 1945 Lamme medal of the American Institute of Electrical Engineers has been awarded to David C. Prince, vice-president, general engineering and consulting laboratory, General Electric Co., Schenectady. The award was made "for his distinguished work in the development of high voltage switching equipment and electronic converters".

Poly Opens Lab

Polytechnic Research and Development Co., Inc., 66 Court Street, Brooklyn, N. Y., has opened its consulting engineering laboratory coincident with a change in name from P. I. B. Products, Inc. The new corporate style has been adopted to better identify the expanded operations of the organization. Established during the war for the manufacture of microwave test equipment for the armed services, the company now makes available its research and development facilities in the field of applied physics for application to the technical problems of industry.

The organization is headed by Dr. H. S. Rogers, president of the Polytechnic Institute of Brooklyn and of the Brooklyn Chamber of Commerce, and is under the technical direction of F. J. Gaffney, formerly in charge of measurement and test equipment development at the MIT Radiation Laboratory.

Plastics Progress Report

A two-day meeting of operators interested in low-pressure molding and fabricating held at the Edgewater Beach Hotel in Chicago February 1 and 2, drew over 240 registrations and revealed keen interest in newly developed methods for producing plastic products of large size and contour.

The meeting, arranged by Society of the Plastic Industries, was under the joint direction of J. E. Stokes of Bakelite Corp., and Robert J. Brinkema, industrial designer. Highlights were the display of products; and a series of six talks given by leaders in this new phase of the industry.

The speakers and their subjects: William I. Beach, "Post Forming Developments During the War and Their Application to Peacetime Products"; John D. Lincoln, "Low-Pressure Molding During the War and Its Possibilities in the Future"; Egmont Arens, "Future Trends in the Low-Pressure Field"; William J. Connelly, "Present Trends of the Low-Pressure Industry"; Philip L. Rhodes, "The Naval Architect Looks to Plastics"; Roy B. Anderson, "Protective and Decorative Finishes for Low-Pressure Laminates".

British Amateurs Resume Operation

Radio amateurs in Great Britain have just received the all-clear from the General Post Office to resume restricted operation. Transmitting apparatus impounded in 1939, when the war started, is being returned and the reissue of transmitting licenses has commenced.

These licenses record several changes in conditions, the most fundamental being the official acceptance of amateur status (in the past the licenses have been for "experimental" stations not for "amateur" stations). This means that British amateurs will be able legally to operate within the exclusive international bands of 7 and 14 mc and that the traditional "Test" call may be replaced by the more common "CQ" call.

At present operation is restricted to the frequency bands 28-29 mc and 58.5-60 mc., but it is expected that the popular 7 and 14 mc bands will soon be released. Power inputs to the last stage of 100W are normally allowed and special application may be made for 250W permits. The Radio Society of Great Britain expects that radio experimenting will be more popular than ever (there were some 5,000 licensed amateurs in Great Britain before the war).

British Radio and Tele Licenses

The charge for radio receiving licenses in Great Britain which hitherto has been ten shillings ($2) is soon to be raised to one pound ($4) and another special license covering both sound radio and television is to cost two pounds ($8). These increases have been found necessary to fulfill the condition, laid down years ago, that the cost of all broadcasting services for home listeners should be met from the sale of receiving licenses. The general increase in costs during the last six years, and the improvement of facilities now to be undertaken, have largely accounted for the higher expense of broadcasting. At present two general programs, radiated on one national and a chain of regional transmitters, are available, and a third program of a more specialized nature is scheduled to start later this year.

The television service which, it is announced, will recommence in London on May 1st will require additional income which will, to some

THE FM EXPRESS IS ROLLING

. . . are you aboard?

As we write this, 53 FM stations are on the air. Another 323, granted conditionally, momentarily await the Washington green-light that starts them building. Additionally, 466 station applications are on the FCC docket.*

That's the current FM situation in a nutshell. But it doesn't tell all.

FCC Commissioner Paul A. Walker said recently: "Conservative estimates suggest that the number (of FM applicants) will approach 2,000 by 1947 as compared with only 950 standard broadcast stations now in operation."

Frank Mansfield, Sylvania Electric Products, wrote in the February FREQUENCY MODULATION that a consumer survey made by his firm indicated $600,000,000 will be spent in FM set sales in 1946-47-48.

Martin Codel, Publisher of FREQUENCY MODULATION as well as TELEVISION DIGEST AND FM REPORTS, conservatively estimates that $30,000,000 will be put into FM station equipment this year and next.

Thus speak men on the inside. What they say adds up to the top broadcast equipment sales opportunity today.

Are you telling your story to this market?

FREQUENCY MODULATION serves the men who do the buying. It is their magazine . . . the only one 100% for and about FM. It serves the seasoned AM broadcasters who seek new guidance in a new art; the hundreds of others who, with FM, are becoming broadcasters for the first time. It serves station owners, managers, chief engineers, program directors, consulting radio engineers, radio attorneys, government officials, equipment manufacturers and many others . . . a total circulation today of 16,000. For advertising rates and closing dates write to Edward Codel, FREQUENCY MODULATION, 103 Park Avenue, New York 17.

* March issue of FREQUENCY MODULATION with 10 page directory of FM station applicants free on request.

FREQUENCY MODULATION

100% for and about FM. Its credo: to bring ideas and inspiration to its industry, to give it cohesion, to interpret trends, to report happenings, and to help guide FM toward a useful and profitable existence.

plugs and three receptacle types, which, with six insert arrangements, make possible 48 different fittings. The series was originally designed for the Signal Corps, but has been used in many types of radio, telephone and sound circuits. The catalog includes an information section, exploded views, dimensional sketches, photos and application views.

Buying Guide

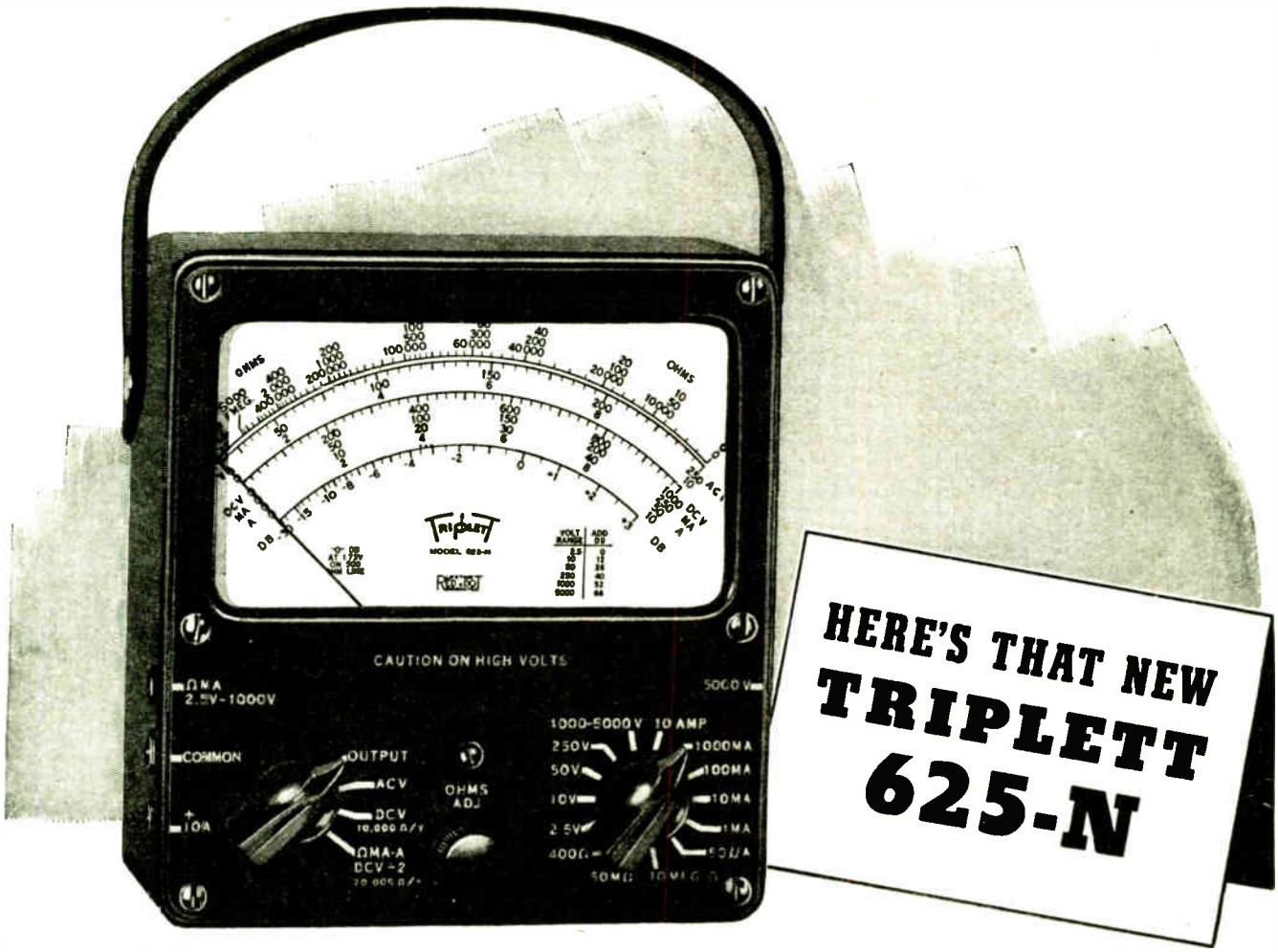
Allied Radio Corp., Chicago, has published a new 1946 buying guide. Emphasis is placed on industrial maintenance, research and production requirements as well as the needs of government agencies for radio and electronic supplies. Included are complete, detailed listings of tubes, test instruments, transformers, resistors, condensers, rheostats, relays, switches, rectifiers, tools, wire and cable, batteries, sockets, generators, power supplies, and other types of equipment in this field. All equipment is presented in organized sections with items indexed for easy reference. Public address and intercommunication units are listed for indoor and outdoor requirement, with ready-to-install systems for a variety of industrial applications. The sound equipment section also includes wide listings of microphones, speakers and other accessories. For training programs and experimental work there are a number of kits, manuals, and diagrams. A large technical book section covers leading publications on radio, electronics and electricity.

Lock Fasteners

The Simmons Fastener Corp., Albany, N. Y., has issued a new and revised catalog of its products. It includes the latest data and specifications on Quick-Lock, Spring-Lock and Lock-Nut fasteners. In 28 pages the catalog gives design and engineering information, dimensional sketches and installation instructions for these fasteners.

Electronic Tube Reference

A new reference booklet giving typical operating conditions and tube base diagrams for more than 450 types of electron tubes used in radio receivers and industrial electronic applications has been issued by Sylvania Electric Products Inc., Emporium, Penna. The booklet is useful for reference.



LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

DOUBLE SENSITIVITY D. C. VOLT RANGES

0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.

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

A. C. VOLT RANGES

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

OHM-MEGOHMS

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

DIRECT READING OUTPUT LEVEL DECIBEL RANGES

−30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES

0-50 Microamperes, at 250 M.V.

D. C. MILLIAMPERES

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

D. C. AMPERES

0-10 Amperes, at 250 M.V.

OUTPUT READINGS

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

ATTRACTIVE COMPACT CASE

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

LONG 5" SCALE ARC

For greater reading accuracy on the Triplett RED ● DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT

Greater ease in changing ranges.

Write for descriptive folder giving full technical details

Precision first ...to last

STANDARDS ARE SET BY TRIPLETT

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

NEW BOOKS

Radar, What Radar Is and How It Works

By Orrin E. Dunlap, Jr., published by Harper & Brothers, New York and London, 1946. 208 pages, $2.50.

This aim here is to give a popular version of radar so that the layman may appreciate its significance and realize the tremendous importance of science in the destiny of nations and of civilization. The text is a dramatic rather than technical representation of the achievement of radar. It is addressed to the layman and radio listener and reads like fiction. Performance, historical development and the part this comparatively new engineering branch played in winning World War II is described by numerous quotations of technical and military men. Future possibilities are pointed out.

Transmission Lines, Antennas and Wave Guides

By Ronald W. P. King, A.B., Ph.D., Associate Professor of Physics and Communication Engineering, Harvard University; Harry Rowe Mimno, E.E., Ph.D., Associate Professor of Physics and Communication Engineering, Harvard University, and Alexander H. Wing, E.E., Ph.D., Lecturer on Electronics, Harvard University, published by McGraw-Hill Book Co., New York City, 1945. 347 pages, $3.50.

This book has developed from the lecture notes of a special wartime training course given in the Graduate School of Engineering, Harvard University. However, the scope and the method of presentation of the material are not on a graduate level. Rather an attempt is made to provide necessary factual material and to develop a real understanding for the electromagnetic point of view without the use of higher mathematics. This attempt seems to have been unusually successful; rigor has not been sacrificed to simplicity but, where the mathematics is not included, the worded statements conform to the physical interpretation of electromagnetic theory. Over-simplification by analogues, frequently found in text books, is avoided. For example, where comparisons of different structures or circuits are made, precautions as to the limits of the similarity are included.

The first chapter on transmission lines derives the differential equations of the line, defines the vari-

ous terms used in transmission line theory, and then deals with the properties and applications of dissipationless lines, (impedance matching, stubs, etc.) Construction and use of the circle diagram is presented in a shortened version of A. H. Wing's article in the Journal of Applied Physics, August 1944, (reported in the April 1945 issue of Electronic Industries in the Survey of Wide Reading section). An interpretation of the general transmission-line equations follows.

Chapters II and III, dealing with antennas and ultra-high frequency circuits, respectively, include a qualitative introduction to general electromagnetic theory. Antennas as circuit elements, coupled antennas and transmission lines, as well as antenna arrays are studied. Properties of wave guides and cavity resonators are treated. The last chapter deals with wave propagation.

Introduction to Microwaves

By Simon Ramo, Ph.D., published by the McGraw-Hill Book Co., New York, 1945. 138 pages, $1.75.

Since a "frequency ratio of millions when compared with power frequencies and of thousands when

compared even with radio-broadcast frequencies makes microwaves fascinating and important" to commercial men and executives, who ask questions, this book well serves the purpose of a preface to the rather complex field of microwaves, especially since it is not "aimed to replace anything". Assuming a familiarity of the reader with power frequencies and lower radio frequencies, the book—in 15 "easy" chapters—establishes a link between the narrow concepts used at lower frequencies to the broader concepts of electro-magnetic theory necessary to include microwaves. An appendix listing a number of more formidable texts for further study is included.

RCA Review Resumes

The RCA Review, a technical journal of radio and electronic research and engineering published by the RCA Laboratories, Div. of Radio Corp of America, reappeared in March on a quarterly basis. The Review was suspended in 1942 as a consequence of wartime security regulations. RCA Review contains papers prepared by scientists, engineers and executives of RCA and its subsidiaries.

Open Amateur Band

Another band of frequencies has been made available to amateurs. Following a meeting on February 21 between all military services and members of the AARL, frequencies between 3,700 and 4,000 kc, inclusive, were turned back to the amateurs as of March 31. Operation is permitted only within the continental U. S., however, and includes class A phone between 3,900 and 4,000 kc. The remainder of the 80-meter band is expected to be opened before the end of the year. At the present time amateurs are permitted to use only the following bands: 28-29.7 mc; 56-60 mc; 144-148 mc; 420-430 mc; 1,215-1,295 mc; 2,300-2,450 mc; 5,250-5,650 mc; 10,000-10,500 mc; 21,000-22,000 mc.

Navy's Dow Promoted

Commodore Jennings B. Dow, USN, has been promoted and takes over an enlarged sphere of activities for the Government. During the war he headed the Electronics Division of the Navy's Bureau of Ships. He has now been given the official title Chief of Electronics in the Bureau of Ships.

John F. Rider Award

At a formal military ceremony held at Fort Monmouth in February John F. Rider, Lt. Col. Signal Corps (retired), was presented with the Legion of Merit medal. Part of his citation for the Legion of Merit decoration reads: ". . . rendered exceptional administrative service to the Signal Corps Publication Agency. . . . His ability to organize and effectively utilize available personnel materially contributed to the preparation, production and distribution of vitally needed technical manuals containing instruction for the installation, operation, maintenance and repair of signal equipment. From 26 November 1943 to May 1944, he planned and personally supervised the production of a backlog of 60 vitally needed technical manuals covering radar equipment already in theatres of operation but without adequate instructions for their installation, operation, maintenance and repair . . ."

Prince Honored

The 1945 Lamme medal of the American Institute of Electrical Engineers has been awarded to David C. Prince, vice-president, general engineering and consulting laboratory, General Electric Co., Schenectady. The award was made "for his distinguished work in the development of high voltage switching equipment and electronic converters".

Poly Opens Lab

Polytechnic Research and Development Co., Inc., 66 Court Street, Brooklyn, N. Y., has opened its consulting engineering laboratory coincident with a change in name from P. I. B. Products, Inc. The new corporate style has been adopted to better identify the expanded operations of the organization. Established during the war for the manufacture of microwave test equipment for the armed services, the company now makes available its research and development facilities in the field of applied physics for application to the technical problems of industry.

The organization is headed by Dr. H. S. Rogers, president of the Polytechnic Institute of Brooklyn and of the Brooklyn Chamber of Commerce, and is under the technical direction of F. J. Gaffney, formerly in charge of measurement and test equipment development at the MIT Radiation Laboratory.

Plastics Progress Report

A two-day meeting of operators interested in low-pressure molding and fabricating held at the Edgewater Beach Hotel in Chicago February 1 and 2, drew over 240 registrations and revealed keen interest in newly developed methods for producing plastic products of large size and contour.

The meeting, arranged by Society of the Plastic Industries, was under the joint direction of J. E. Stokes of Bakelite Corp., and Robert J. Brinkema, industrial designer. Highlights were the display of products; and a series of six talks given by leaders in this new phase of the industry.

The speakers and their subjects: William I. Beach, "Post Forming Developments During the War and Their Application to Peacetime Products"; John D. Lincoln, "Low-Pressure Molding During the War and Its Possibilities in the Future"; Egmont Arens, "Future Trends in the Low-Pressure Field"; William J. Connelly, "Present Trends of the Low-Pressure Industry"; Philip L. Rhodes, "The Naval Architect Looks to Plastics"; Roy B. Anderson, "Protective and Decorative Finishes for Low-Pressure Laminates".

British Amateurs Resume Operation

Radio amateurs in Great Britain have just received the all-clear from the General Post Office to resume restricted operation. Transmitting apparatus impounded in 1939, when the war started, is being returned and the reissue of transmitting licenses has commenced.

These licenses record several changes in conditions, the most fundamental being the official acceptance of amateur status (in the past the licenses have been for "experimental" stations not for "amateur" stations). This means that British amateurs will be able legally to operate within the exclusive international bands of 7 and 14 mc and that the traditional "Test" call may be replaced by the more common "CQ" call.

At present operation is restricted to the frequency bands 28-29 mc and 58.5-60 mc., but it is expected that the popular 7 and 14 mc bands will soon be released. Power inputs to the last stage of 100W are normally allowed and special application may be made for 250W permits. The Radio Society of Great Britain expects that radio experimenting will be more popular than ever (there were some 5,000 licensed amateurs in Great Britain before the war).

British Radio and Tele Licenses

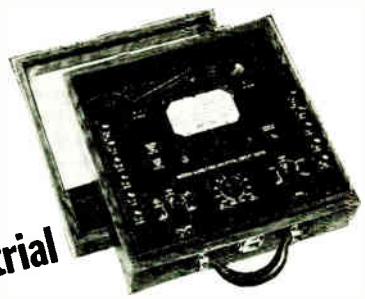
The charge for radio receiving licenses in Great Britain which hitherto has been ten shillings ($2) is soon to be raised to one pound ($4) and another special license covering both sound radio and television is to cost two pounds ($8). These increases have been found necessary to fulfill the condition, laid down years ago, that the cost of all broadcasting services for home listeners should be met from the sale of receiving licenses. The general increase in costs during the last six years, and the improvement of facilities now to be undertaken, have largely accounted for the higher expense of broadcasting. At present two general programs, radiated on one national and a chain of regional transmitters, are available, and a third program of a more specialized nature is scheduled to start later this year.

The television service which, it is announced, will recommence in London on May 1st will require additional income which will, to some

to Streamline ELECTRICAL TEST PROCEDURE

★ **the simplified AC CLAMP AMMETER**
(Model 633)

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



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

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

★ **the versatile SIGHT METER**
(Model 703)

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

For complete information on these, and other time-saving WESTON instruments write . . . Weston Electrical Instrument Corporation, 628 Frelinghuysen Avenue, Newark 5, New Jersey.

Weston *Instruments*

Albany · Atlanta · Boston · Buffalo · 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.

small extent, be met from the combined radio and television license. A still pattern and a sound tuning signal for testing purposes has been radiated from Alexandra Palace since February 1, and the question of the extension of television to the provinces is still being considered by the government television advisory committee. The transmission will operate on the same system and frequencies (Marconi-E.M.I., 41.5 mcs 45 mcs) as hitherto but minor technical improvements will be made.

Chamberlain Cited

A second Legion of Merit award has been made to a CBS man for war achievement. A. B. Chamberlain, chief engineer of the Columbia Broadcasting System, was cited for "breaking a tremendous design and production deadlock at a time when airborne radar equipment was urgently needed by the Fleet to combat enemy air action. Chamberlain served as assistant head of the Design Branch, Electronics Division, Bureau of Ships, from April to October, 1945. He had left CBS in May, 1942, for Navy duty as lieutenant commander. He returned to inactive status last December.

ELIMINATE

the Time Consuming

ELEMENTS

in Short Run Piercing

Don't stop long run jobs to set up for short run piercing jobs. A Wiedemann Turret Punch Press can do it with greater accuracy . . . at long run low cost.

Don't interrupt long run production to make 1 or 10 or 100 pieces of a kind, panels, chassis, outlet boxes, special gaskets, louvres, copper buss, and other pierced sheet metal parts. Use a Wiedemann!

A WIEDEMANN *Simplifies*

EVERY COSTLY PIERCING OPERATION

★ Layout time is completely eliminated or greatly reduced because of easily operated material positioning gauge tables . . . only one man is needed to handle the largest sheets in the press.

★ Conventional equipment takes 15 or 20 minutes to change punches and dies. With a Wiedemann, punches and dies operate on an easily rotated turret . . . a few seconds is all that is required to rotate turret from one punch to another.

★ 11 to 32 dies at your fingertips for instant piercing . . . all dies are locked into position by means of index pins after correct dies are located on turret.

★ No sheared punches or dies from inaccurate set-ups . . . holes are punched clean.

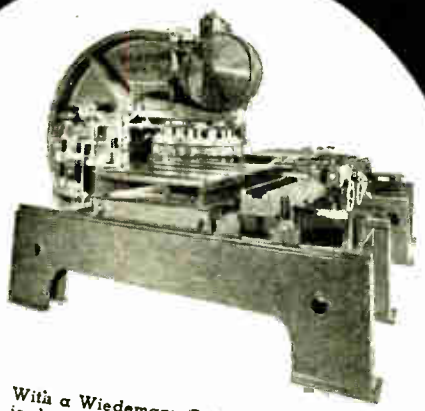
★ No waiting for die set-up man. A Wiedemann is always ready to run without tearing down any set-up.

★ Long run jobs can be started on your Wiedemann while production dies are being made.

Send today for Wiedemann Bulletin No. 92 to get the complete story of Short Run Piercing Economy.

WIEDEMANN MACHINE COMPANY

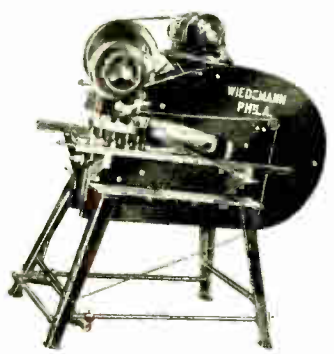
1833 SEDGLEY AVENUE
PHILADELPHIA
32, PA.



With a Wiedemann Type R-7, punching is done either directly from blue prints or from charts without any layout work being necessary, merely by turning two handwheels to obtain accurate X and Y coordinate settings.

This high speed positioning of material is accomplished on a ball bearing spacing table for sheets up to 50" wide by 100" long. Any point on sheets up to ¼" thick can be located under the punching station for piercing openings, or making louvres or knock-outs.

There are no stops to set . . . from 12 to 32 stations operate on an easily rotated turret for instant piercing. Changing from one punch to another is a matter of seconds - - - practically instantaneous.



The R-4P Power Driven Turret Punch Press is furnished with 12 punches and dies up to 1¼" diameter, mounted in a revolving turret. An accurate, positive indexing device locks the revolving turret, when the punch and die selected for use are located centrally under the ram. This locking and unlocking is done by a small lever shown on the side of the machine; this lever being interlocked with the clutch trip mechanism to prevent operation of the machine unless the turret is properly positioned and the index lever locked in place.

WIEDEMANN TURRET PUNCH PRESSES & GAUGE TABLES

WIDE READING

(*Continued from page* 100)

taneously with the discriminator characteristic the frequency of the generated oscillation, measured on the abscissa, is shifted in the opposite sense, the right-hand characteristic being applicable to the lowest frequency and vice versa.

It will be seen that the diode voltage output for extreme positions of the capacitor center plate is increased by the variations of the discriminator characteristic from the voltage difference between points A—A to the voltage difference between points B—B; it appears to be doubled. The dotted lines represent the variations of the oscillator frequency and its equivalent diode voltage output.

An effect similar to that in a push-pull circuit tends to eliminate distortion due to the non-linear frequency-capacitance relation in a tuned circuit, because the two capacitors are varied in opposite sense; this only holds if the two resonant sections are closely balanced. Further, as both sides of the moving plate have an effect of about equal magnitude, the movement has to be of only half the amplitude for a comparable sensitivity increasing the linearity of the system. The "push-pull" capacitor construction is described in detail.

Calibration curves indicate that a deflection of 0.003 inch results in a diode voltage of 2.5 volts; the deflection-voltage curve is linear within this range, the total harmonic content amounting to less than one per cent.

PATENTS

(*Continued from page* 110)

taneous phase difference between the two input currents; it is a linear function of time and may therefore be taken as a measure of time in plotting the phase and frequency of the resulting wave R. The angle A_2 which represents the instantaneous phase difference of the resulting current R with respect to the larger current V_1 is almost equal to half the angle A_1 most of the time. (If the two currents were of equal amplitude, the angle A_2 would be equal to $A_2/2$ at all times according to a geometrical law.) Therefore, the phase variation A_2 of the resultant current R with respect to the phase of the stronger current V_1 is also proportional to time over a large range of the

angle A_1 (see Fig. 2). This is equivalent to a constant frequency difference between these two currents, frequency being the derivation of phase with respect to time.

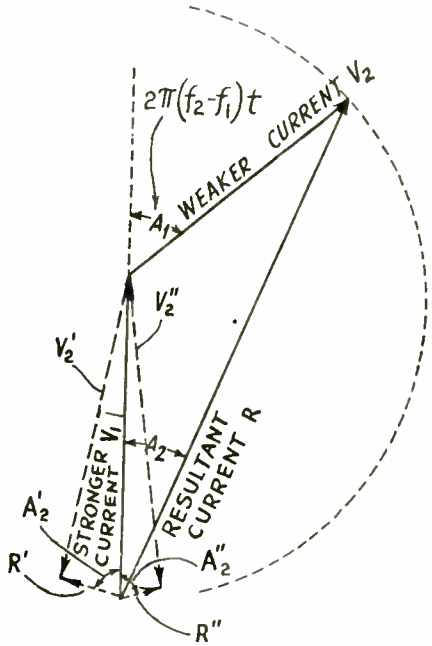


Fig. 1—Adding two nearly equal currents

However, at the instant of opposing phase of currents V_1 and V_2, A_2 changes its polarity within a very short period of time; it as-

sumes the values of almost plus 90 deg., A'_2, zero, and almost minus 90 deg., A''_2, in rapid succession, as will be realized when considering the dashed line section of Fig. 1. This sudden phase reversal corresponds to a momentary very great change in frequency.

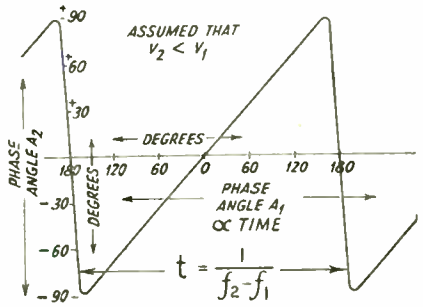


Fig. 2—Phase angle as function of time

The relative phase A_2 of the resulting current with respect to the stronger input current is plotted in Fig. 2 as a function of A_1 which is proportional to time. Fig. 3 illustrates the constant frequency f_3 during most of the time and the frequency shift occurring at the instants of opposing phases of the two input currents. The amplitude of the frequency shift pulse and its direction are such that the mean or carrier wave output frequency from the limiter is equal to f_1, the frequency of the stronger input current V_1. Therefore the momentary large frequency shift will be in a direction from the average frequency toward and beyond the frequency of the stronger input current V_1 and if the relative magnitude V_1/V_2 of the two input currents is reversed, the direction of the momentary frequency shift is also reversed. Consequently an extremely small change in relative amplitudes of the two input currents around the condition of equality will reverse the direction of the large peak frequency shift.

Mathematical analysis justifies the approximate findings derived by inspection of the vector diagram. It indicates that if two currents of almost equal amplitudes V_1 and V_2 and of different frequencies f_1 and f_2, respectively, are passed through a limiter, the peak frequency deviation D (see Fig. 3) of the limiter output current is given by the expression:

$$D = \frac{V_1 + V_2}{V_1 - V_2} \times \frac{f_2 - f_1}{2}$$

This equation gives a factor, multiplying the frequency difference $f_2 - f_1$ to obtain the frequency shift D, equal to 10 and 20 for V_2/V_1 values of .9 and .95, respectively, i.e. a doubling of the frequency shift for a 5 per cent amplitude change.

The direction of the frequency deviation reverses as either the dif-

ference in amplitudes, V_2-V_1, or the difference in frequency, f_2-f_1, changes sign, i.e. as the smaller current becomes the larger or the lower frequency becomes the higher frequency. It will be readily understood from the description of these phenomena that they may serve to indicate, measure or control relative frequencies or amplitudes of currents having slightly different amplitudes.

Fig. 4 is a block diagram of a frequency deviation indicator. Its operation is self-explanatory. If the amplitude ratio is maintained constant and close to unity, the curve on the cathode-ray oscillograph will be similar to that shown in Fig. 3. The direction of the peaks up or down on the oscilloscope screen, will indicate whether the transmitter frequency is above or below the frequency of the standard source, while the oscilloscope sweep frequency required to reproduce one cycle on the screen will be a direct measure of the frequency difference between transmitter and standard frequency source, as may be inferred from Figs. 1, 2 or 3. The peak amplitude also increases with increasing frequency difference.

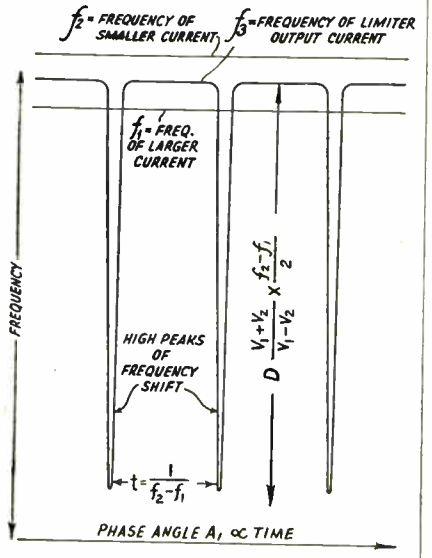


Fig. 3—Resultant frequency as function of time

Automatic control means provide a constant amplitude input to the limiter for varying transmitter powers. Alternatively, the standard frequency source output may be adjusted by the transmitter output so as to keep the current ratio V_2/V_1 constant. By replacing the cathode ray oscilloscope by rectifiers, combining their output differentially and using it to control the transmitter frequency, automatic frequency control may be achieved.

If in the diagram of figure 4 the amplitude V_2 varies while the frequency f_2 is constant, similar curves will be observed on the cathode ray oscilloscope screen. Therefore, amplitude variations may be observed

or controlled by a suitable adaptation of the above described apparatus.

Automatic volume control of keyed audio frequency current, difficult to achieve otherwise, may be effected with this system. Another application of the principle is the control of a switching system to use either the stronger or the weaker of two currents; this may usefully be employed to choose the stronger current in a diversity receiving system. Operation of a receiver of amplitude modulated telephone signals or of on-off telegraph signals is explained. It is also possible with a circuit involving the limiting procedure described to receive the two sidebands of a modulated signal but with a carrier suppressed and to reinstate the carrier at the point of reception.

C. W. Hansell, RCA, (F) April 18, 1941, (I) October 30, 1945, No. 2,388,052.

Horn Leaves Navy

Captain Charles W. Horn, USNR, who has been special assistant to the Chief of Naval Communications, has left Government service. He will enter private business as a consultant on technical radio engineering matters for clients in Mexico and other countries south of the United States border.

TELEVISION TODAY

(Continued from page 106)

over territory where GE and Globe Wireless will operate an experimental radio relay network. The network will carry FM radio, television, business machine reports and radio photos in a two-way operation.

Philco Develops New "Suitcase-Type" Camera

A new 35-lb. television camera and lightweight suitcase-type control equipment, so designed that a television crew can carry their studio with them and have it operating in a few minutes, has been developed by the Philco television engineering laboratories.

"A unique feature of this new equipment," reports Frank J. Bingley, chief television engineer of Philco, "is that several television cameras can easily be operated from a single portable master control unit. Also, these new cameras give us a clearer, sharper picture than the heavy and awkward prewar equipment.

Declaring that one reason for using this new lightweight video equipment at football games was to compare its performance with older, heavier television cameras, Bingley stated that the new camera outperformed prewar models by a wide margin. "It gave us brilliant television pictures, with better definition and detail," he pointed out. "The new equipment was particularly useful for the close-ups of

football action which have proved so popular with the television audience of Philco Station WPTZ in the Philadelphia area."

Bingley said that one reason for the improved picture quality obtained from the new camera is that it is designed to utilize the latest types of television camera tubes. Also, both the new Philco camera and its auxiliary units contain entirely new electronic circuits, including many advances based on wartime radar research.

Westinghouse Tests Stratovision Unit

Westinghouse Electric Corp. has been flight testing its Stratovision plan for broadcasting television and FM from airplanes. According to reports submitted to FCC which is monitoring transmissions, results have been fully up to expectations. A Martin plane carrying a 250-watt transmitter has been flown over Wilmington, Philadelphia and New York and at 25,000 ft. usable signals have been transmitted over an airline distance of 240 miles. Three channels are being used at various frequencies between 100 and 550 mc, one for FM, one for television and a third for communication incident to the test. Operation on three additional channels up to 2,000 mc has been authorized.

"WGHF" Undergoing Equipment Tests

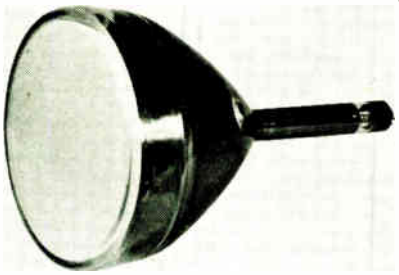
WGHF, the new FM-FAX broadcasting station located atop 10 East 40th street, New York City, owned and operated by Captain W. G. H. Finch, USNR, is now undergoing station equipment tests under the direction of Chief Engineer Herbert C. Florance. WGHF operates on a frequency of 99.7 mc.

Finch Honored by Truman

The president of Finch Telecommunications, Inc., Capt. W. G. H. Finch, USNR, has been awarded the Legion of Merit by President Truman for "exceptionally meritorious conduct in the performance of outstanding service for the Government of the United States." Captain Finch was Head of the Countermeasures Design Section, Electronic Division, Bureau of Ships, United States Navy.

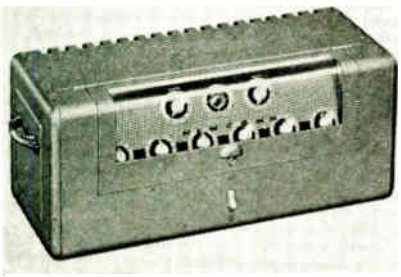
WHAT'S NEW

(*Continued from page* 114)



Cathode Ray Tube

A 10 in. direct viewing cathode ray tube has been developed by Rauland Corp., 4245 No. Knox Ave., Chicago, Ill. The tube uses electromagnetic deflection and focusing and permits a max. anode voltage of 12,000 volts.—Electronic Industries



Amplifiers

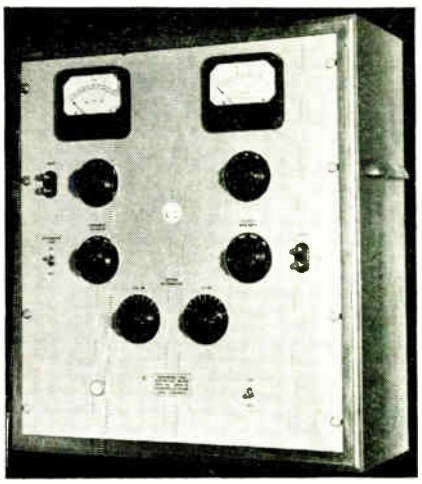
Newcomb Audio Products Co., Los Angeles, Cal., has developed the K-Series high quality amplifiers for PA systems. Ranging from 30 to 60 watts, the amplifiers have a flat frequency response within 1 db from 20 to 20,000 cps. They are provided with an overload indicator and have a choice of six different output impedances. Tonal balance is controlled by dual acting individual tone controls.—Electronic Industries

Amateur Transmitter

A 1000 watt amateur station in the form of a desk has been developed by Kluge Electronics Inc., 1031 N. Alvarado St., Los Angeles 26, Cal. The transmitter is designed for 5-band operation, has variable frequency control in each band and is for phone and cw. Built-in speaker, crystal-controlled frequency monitor and built-in clock are included. It can be operated on 110 or 220 volts.—Electronic Industries

Distortion Meter

Pickering and Crowe Audio Laboratories, Oceanside, N. Y., are manufacturing the model 502 intermodulation distortion meter, which shows two to four times as much distortion as the usual harmonic



method and agrees more closely with listening tests. The instrument measures distortion from 0.1 to 50% with 2% meter accuracy and provides test frequencies of 100 cps. and 7 kc. It consumes 100 watts at 110-120 v., 50-60 cps. ac.—Electronic Industries

Circuit Breaker

Aireon Mfg. Corp., Kansas City, Kans., has designed a circuit breaker for use in home electrical systems. The device has both overload circuit breaker action and manual "Off-On" switch. Models are suitable for ac and dc.—Electronic Industries

RMA Organizes Amateur Section

Radio amateurs, "the only hobbyists on earth who require a government license," now can look forward to the close cooperation and full support of the industry they helped establish. With "ham" activity at its all time peak and with the number of amateurs expected to number between 250,000 and 500,000 within a few years, the Radio Manufacturers Association has formed a new Amateur Radio Activities Section with William J. Halligan as chairman.

Its purpose is to act as a clearing house of information concerning new products needed by amateurs, to establish standards of good engineering practices relative to amateur radio equipment, and to work closely with the American Radio Relay League in the support of amateur radio in legislative and regulatory matters.

The section already has been fully organized into subcommittees dealing with five different phases of amateur cooperation. These include equipment, equipment parts, frequency and power regulations, promotional and development of amateur radio in foreign lands. Vice-chairman of the section is Frank Holstrom and committee heads are William A. Ready, Robert Almy, George Grammer, Walter Jablon and Robert Adams.

Motorola Tests 37, 73 and 160 Megacycles

For a week 160 mc signals have been climing hills, ducking around limestone quarries and sliding into deep valleys with the abandon widely claimed as the exclusive characteristic of the former low frequency FM band.

The test was carried out by Daniel E. Noble, general manager of Motorola's Communication Division, to answer some questions about the design of systems for channels in the new mobile bands, 72-76 mc and 152-162 mc. Extensive Motorola tests in the Chicago area, extending over many months, had established the superior characteristics of the high frequency channels in flat areas. There remained the question of what to expect in areas where hills and valleys would offer possible barriers to the high frequency carriers.

Three 250-watt transmitters, with antennas 100 feet above ground, were installed on the roof of the

ELECTRONIC INDUSTRIES

Advertisers, April 1946

	Page
Accurate Spring Manufacturing Co.	141
Aerovox Corporation	51
Aireon Manufacturing Corp.	8–9
Air-Track Manufacturing Co.	165
Allied Radio Corp.	170
Alpha Metals, Inc.	23
Altec Lansing Corp.	152
American Electrical Heater Co.	144
American Lava Co.	133
American Phenolic Corp.	6
American Television & Radio Co.	132
American Transformer Co.	24
Amperite	134
Andrew Co.	4
The Arnold Engineering Co.	116
Automatic Electric Sales Corp.	55
Barker & Williamson	140
The Benwood-Linze Co.	159
Bird & Co., Richard H.	151
Bogen Co., Inc., David	148
Brach Mfg. Corp., L. S.	150
Burke Electric Co.	142
Burstein-Applebee Co.	163
Caldwell-Clements, Inc.	105
Callite Tungsten Corp.	39
Cambridge Thermionic Corp.	170
Capitol Radio Engineering Institute	156
Carter Motor Co.	146
Cellusuede Products, Inc.	134
Centralab	54
Chicago Transformer Div. of Essex Wire Corp.	118
Clare & Co., C. P.	57
Clarostat Mfg. Co., Inc.	49
Cohn & Co., Sigmund	140
Martin Coleman	163
Collins Radio Co.	60
Communications Co., Inc.	34
Communication Measurements Laboratory	3
Conant Electrical Laboratory	122
Concord Radio Corp.	160
Cornell-Dubilier Electric Corp.	101
Corning Glass Works	14, 15
Coto-Coil Inc.	125
Cramer Co., R. W.	163
Creative Plastics Corp.	152
Crystal Research Labs., Inc.	154
Dalis, Inc., H. L.	146
Daven Co.	Cover 3
Dazor Manufacturing Co.	52
DeMornay-Budd, Inc.	13
Deutschmann Corp., Tobe	128
Driver-Harris Co.	19
Dumont Electric Co.	16
DuMont Laboratories, Allen B.	32, 59, 119
Eastern Engineering Co.	154
Eastman Kadok Co.	111
Eby Inc., Hugh H.	136
Eisler Engineering Co.	167
Eitel-McCullough, Inc.	36
Electrical Equipment, Inc.	168
Electrical Reactance Corp.	162
Electronic Developments Associates	113
Electronic Engineering Co., Inc.	142
Electronic Laboratories, Inc.	48
Electronic Mechanics, Inc.	103
Electro-Motive Mfg. Co.	25
Erie Resistor Corp.	41
Farnsworth Television & Radio Corp.	42
Federal Telephone & Radio Corp.	26–27
Frequency Modulation	147
General Electric	5, 31, 50
General Industries Co.	144
General Plate Division	40
Guardian Electric	137
Hammarlund Mfg. Co.	22
Harvey Radio Labs	107
Haydon Mfg. Co.	120
Heyman Manufacturing Co.	166
Illinois Condenser Co.	148
Indiana Steel Products Co.	58
Insuline Corp. of America	130
Irvington Varnish & Insulator Co.	99
International Nickel Co., Inc.	12
International Resistance Co.	139
J-B-T Instruments, Inc.	151
Jefferson Electric Co.	47
Johnson Co., E. F.	115
Jones, Howard B.	156
Jordanoff Corp.	21
Kahle Engineering Co.	138
Keuffel & Esser Co.	43
Kings Electronics Co.	136
Kinney Manufacturing Co.	123
Keerman Electric Co.	163
Lapp Insulator Co.	20
Lectrohm, Inc.	163
Machlett Laboratories, Inc.	35
Magnavox Co., Ltd.	135
Mepham Corp., G. S.	167
Mallory & Co., Inc., P. R.	Cover 2
Manufacturers Screw Products	164
Measurements Corporation	146
Millen Mfg. Co., Inc., James	132
National Union Radio Corp.	29
National Vulcanized Fibre Co.	53
Newark Electric Co.	159
North American Phillips Co., Inc.	33
Ohmite	28
O'Neil-Irwin Mfg. Co.	159
Palnut Co.	156
Par-Metal Products Co.	158
Patton-MacGuyer Co.	159
Permoflux Corp.	124
Plasticraft Products Co.	148
Premier Metal Etching Co.	160
Radio Corp. of America	Cover 4
Radio Receptor Co., Inc.	128
Radio Wire Television, Inc.	162
Rauland Corporation	30
Raytheon Manufacturing Co.	46, 117, 143, 165
Revere Copper and Brass, Inc.	7
Schauer Machine Co.	158
Selenium Corporation of America	164
Shur-Antenna-Mount, Inc.	166
Sigma Instruments, Inc.	168
Simpson Electric Co.	121
Small Motors, Inc.	169
Stackpole Carbon Co.	44
Stamford Metal Specialty Co.	164
Standard Piezo Co.	161
Struthers-Dunn, Inc.	38
Stupakoff Ceramic & Manufacturing Co.	37, 109
Sun Radio Co.	127
Superior Tube Co.	145
Sylvania Electric Products	45
Synthane Corporation	17, 18
TAB	166
Taylor Fibre Co.	126
Television Digest & FM Reports	153
Thomas & Skinner Steel Products Co.	169
Titeflex	129
Triplett Electrocal Instrument Co.	149
Victoreen Instrument Co.	160
Vokar Corporation	165
Vulcan Electric Co.	161
Ward Leonard Electric Co.	2
Ward Products Corporation	56
Webster Electric Co.	131
Western Electric Co.	10, 11
Weston Electrical Instrument Corp.	155
Wiedemann Machine Co.	157
World Radio Laboratories, Inc.	168
Wrigley Co., Wm.	138

Graystone Hotel in Bedford, Ind., one operating on each of the three test frequencies, 37, 73, and 161 mc. The 30-watt mobile unit on each frequency followed predetermined routes north, south, east and west for 40 miles, while data were recorded to show talk-back to central and talk-out to the mobile units. The three cars traveled more than one thousand miles each, with data recorded every few seconds. All three cars talked back to headquarters consistently out to 30 to 35 miles. When a deep valley and an intervening hill would stop the signals from the 161 mc car, the 73 mc and 37 mc signals stopped.

Addressing a group of Indiana Police Communication engineers at the conclusion of the tests, Daniel E. Noble stated: "The tests were not conducted to prove anything; they were made objectively with the purpose of answering questions about new band propagation in rough terrain. An examination of the data does not disclose a definite trend favoring one frequency over any other in the test group, but selected data will prove a performance superiority for each of the frequencies under test. This is further proof that any differences are largely marginal and purely academic. It would seem that in the Bedford area, the field strength differences introduced by terrain roughness are greater than field differences caused by the change in frequency. In flat terrain, the 37 mc signal will provide a greater range of communication than the higher frequencies, but at the cost of a very poor signal-to-noise ratio.

"The tests are significant to FM broadcasting. If tests in other rough terrain areas are comparable to the Bedford tests, the upper band to F Bedford tests, there can be no doubt about the wisdom of the FCC's decision to allocate the upper band to FM. I have consistently favored the upper band for FM broadcasting, although I expected some reduction in coverage in rough areas. The Bedford tests indicate that there will be no significant reduction in coverage even in the rough areas."

"Tomorrow Show" Shifted

Chicago's "Products of Tomorrow" exposition has been indefinitely postponed. It was scheduled to open in the Coliseum April 27. Postponement results from the cloudy production picture and the difficulty of predicting delivery dates of merchandise.

DAVEN POWER OUTPUT METERS

DESIGNED TO MEASURE POWER OUTPUT

- at fixed impedance and fixed frequency
- at fixed frequency and variable load
- at fixed load and variable frequency

ALSO

- to determine internal impedance or optimum load
- to measure insertion loss of a network
- to measure noise pick-up level
- to test band width, selectivity, fidelity, sensitivity

OP-182

Power Range: 0.1mw to 5 watts.
Impedance: 40 values, 2.5 to 20,000 Ω
Accuracy: ±5%.

OP-193-A — OP-193-B

Power range: 0.1mw to 5 watts.
Impedance:
OP-193-A — 18 values, 400 to 20,000 Ω
OP-193-B — 40 values, 2.5 to 20,000 Ω
Accuracy: ±5%.
Special Feature: Provision for use of headphone and/or meter.

The DAVEN OP Series Power Output Meters offer a selection of four models for measuring the effect of power and load on audio amplifiers, filters, oscillators and similar equipment, as well as for standard radio receiver tests. Types OP-182 and OP-961 are widely accepted for their wide flexibility, accuracy and durability. Types OP-193-A and OP-193-B are especially adapted for noise pick-up level work in testing radio receivers, where the use of headphones is desired. A special three-position switch enables use of headphones circuit, meter circuit or both simultaneously.

OTHER SPECIFICATIONS

INDICATING METER

Rectifier type AC, calibrated 1 to 50mw and 0 to 17 DB. Reference level 0 DB = 1mw.

METER MULTIPLIER

OP-182, OP-193-A, OP-193-B—Extend meter power reading, 0.1 to 100 X scale; DB reading, —10 to +20 DB in 10 DB steps.

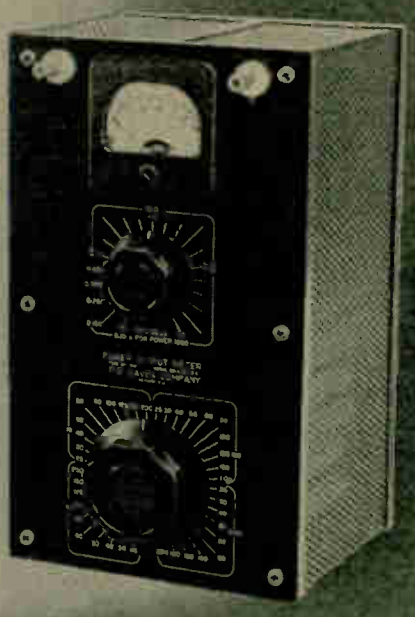
OP-961 — Extends meter power reading, 0.1 to 1000 X scale; DB reading, —10 to +30 DB, in 2 DB steps.

MOUNTING

OP-182 — Black metal panel, hand rubbed walnut cabinet, 12"x6"x6"

OP-961—Black metal panel, ventilated metal case, 12"x7"x6½".

OP-193-A, OP-193-B — Black bakelite panel, portable cabinet with removable cover, 13¾"x7¾"x5¼"



OP-961

Power Range: 0.1 to 50 watts.
Impedance: 40 values, 2.5 to 20,000 Ω
Accuracy: ±2%.

HAVE YOU A DAVEN CATALOG IN YOUR FILES?

THE DAVEN COMPANY
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

For table-model, console and large-screen television receivers

RCA now has available four new and improved Kinescopes of standardized type that meet practically all television receiver design requirements. These RCA-developed Kinescopes feature higher quality, longer operating life and far greater brilliance and definition than the prewar types. The use of high-volume precision equipment in their manufacture, coupled with RCA's extensive wartime experience in the design and mass production of cathode-ray tubes is reflected in the lower pricing of all four types.

RCA-5TP4: The RCA-5TP4 (5″ face) metallic film Projection Kinescope more than doubles screen brightness of 16″ x 20″ projected pictures. The "mirror-backed" screen also improves picture contrast and detail. Combined with the Reflective Optical System, the 5TP4 permits viewing at higher ambient light levels.

RCA-10BP4: The RCA-10BP4 with its 10-inch face is the star performer of the directly viewed line of Kinescopes. It is characterized by high definition and picture contrast 2 to 3 times greater than prewar types. Deflection and focus are accomplished magnetically. An outside conductive coating, when grounded, serves as a filter capacitor. The new, high-voltage Duodecal 7-pin base is used.

RCA-7DP4: The RCA-7DP4 Directly Viewed Kinescope is a compact tube with a 7″ diameter face particularly adaptable to table-model receivers. It incorporates the same features as the RCA-10BP4 but employs electrostatic focusing and a lower anode potential.

RCA-7GP4: Specifically designed for inexpensive table-model receivers, the 7GP4, also having a 7″ face, has exceptionally high deflection sensitivity, a high-efficiency screen and operates at a relatively low anode potential. Both deflection and focusing are accomplished electrostatically. The low-price and high-performance characteristics of the 7GP4 make it unusually attractive for receiver designs aimed at the mass market.

RCA Tube Application Engineers are ready to consult with you now on the adaptation of RCA Preferred Type Kinescopes to your television receiver design requirements. If you wish aid in the application of these or other RCA tube types, write RCA, Commercial Engineering Department, Section D-7D, Harrison, N. J.

COMPARATIVE SPECIFICATIONS

	5TP4	10BP4	7DP4	7GP4
Heater Volts	6.3	6.3	6.3	6.3
Heater Amps	0.6	0.6	0.6	0.6
Anode Volts*	27,000	10,000	8,000	4,000
Focus	Electrostatic	Magnetic	Electrostatic	Electrostatic
Deflection	Magnetic	Magnetic	Magnetic	Electrostatic
Deflection Angle	50°	50°	50°	
Raster Size (approx.)	2 3/4" x 3 5/8	6" x 8"	4" x 5 1/2"	4" x 5 1/2"
Bulb Dia. (max.)	5 1/8"	10 5/8"	7 5/16"	7 1/8"
Length (max.	12 1/8"	18"	14 7/16"	14 7/8"
Base	Duodecal	Duodecal	Duodecal	Diheptal
Fluorescence	White	White	White	White
Persistence	Medium	Medium	Medium	Medium

*design center maximum value

The Fountainhead of Modern Tube Development is RCA

TUBE DEPARTMENT

RADIO CORPORATION of AMERICA

HARRISON, N. J.