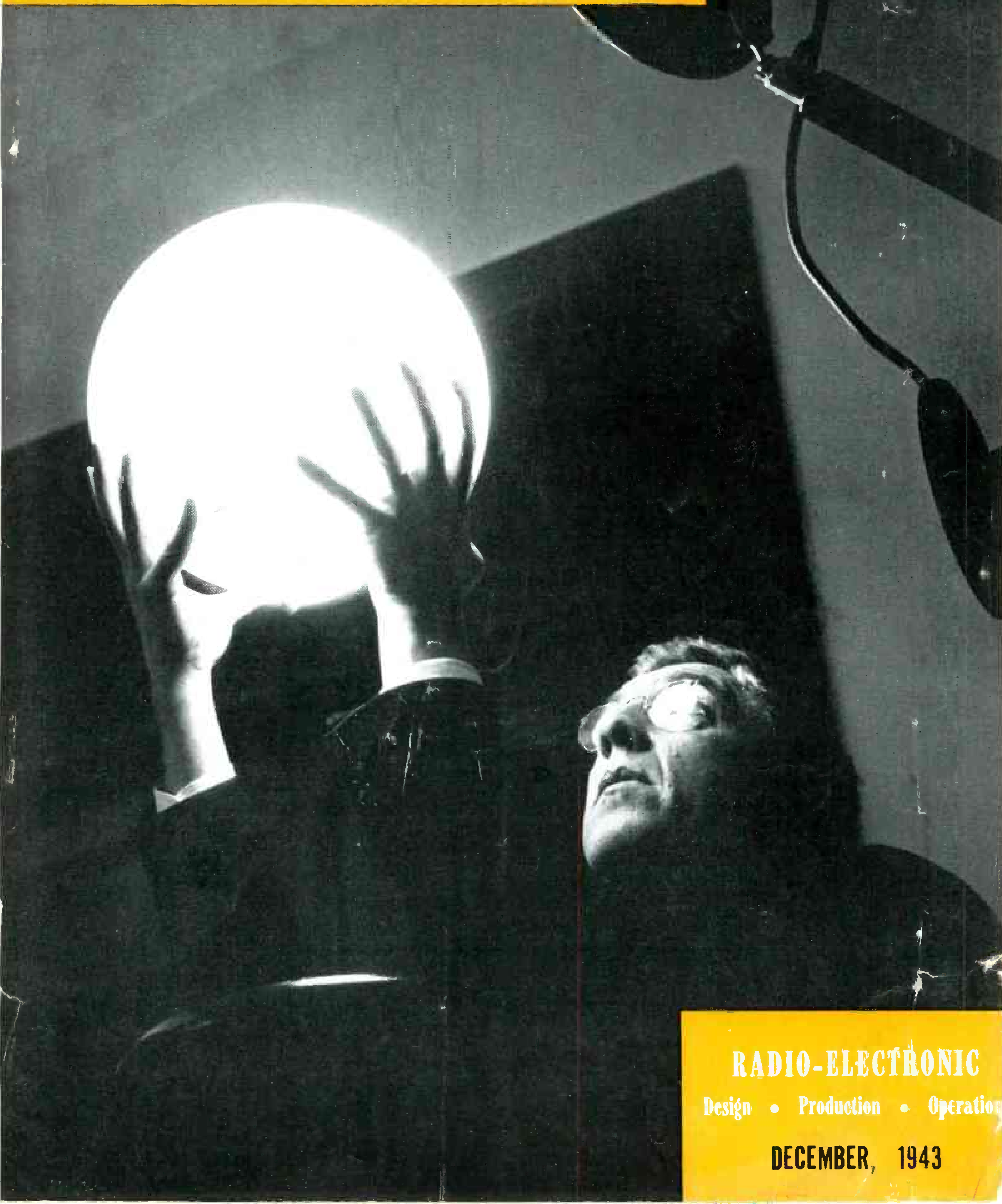
RADIO

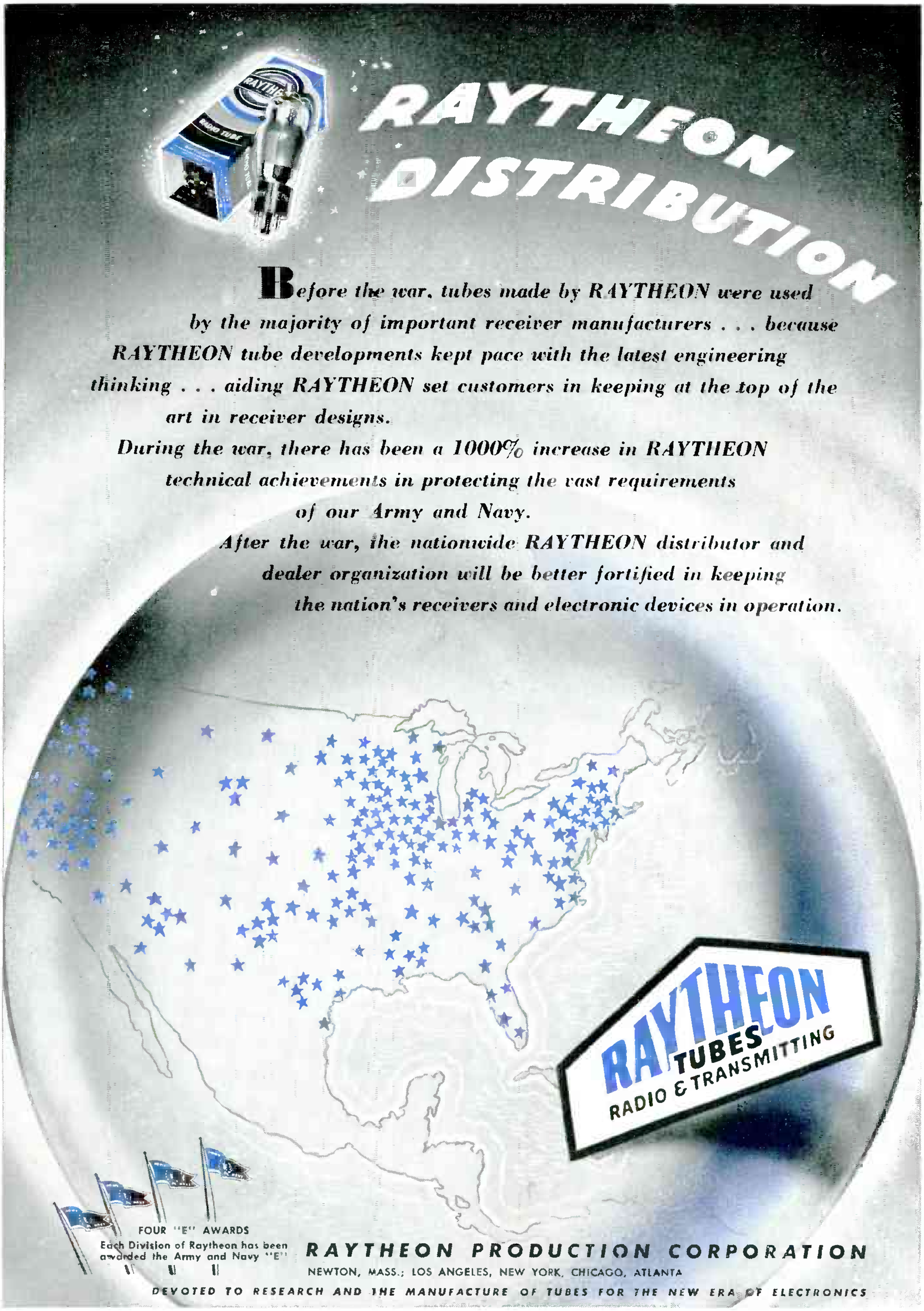
ESTABLISHED 1917



RADIO-ELECTRONIC

Design • Production • Operation

DECEMBER, 1943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Before the war, tubes made by RAYTHEON were used by the majority of important receiver manufacturers . . . because RAYTHEON tube developments kept pace with the latest engineering thinking . . . aiding RAYTHEON set customers in keeping at the top of the art in receiver designs.
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We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

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RADIO

Published by RADIO MAGAZINES, INC.

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Pacific Coast Representative:
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427 West 5th St., Los Angeles, Calif.

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NOTE: Because of wartime censorship restrictions, we must reserve the right to withhold from foreign subscribers any issue the regular domestic edition of which is not approved by the authorities for export without changes. In such cases subscriptions will be extended so that each subscriber will eventually receive the number of issues to which he is entitled.

◆

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DECEMBER 1943 **No. 287**

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COVER

Future possibilities can be foreseen from this ball of light, coated inside with phosphors and being energized by high-frequency radio waves from a pre-war diathermy machine. See page 10. (Photo courtesy Westinghouse.)

ARTICLES

MISCELLANEOUS

RADIO (title registered U. S. Pat. Off.) is published monthly at 34 N. Crystal Street, East Stroudsburg, Pa., by Radio Magazines, Inc., Executive and Editorial Offices at 132 West 43d Street, New York 18, N. Y. Subscription rates—United States and Possessions, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U.S.A. Entered as Second Class Matter October 31, 1942, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

EDITORIAL

NAVY RADIO DESIGN

★ The Bureau of Ships, Navy Department, considers the matter of simplicity of design in Navy radio equipment of increasing importance, and has brought this to the attention of the Design Branch of the Radio Division. The following memorandum, originally prepared for limited distribution, has now been cleared for general publication with the thought that a wider dissemination of the information will prove helpful to the war effort:

The Bureau views with concern the trend toward increasingly complex radio and allied electronic equipment. This tendency is objectionable because of:

(*a*) The large variety of slightly different components to be manufactured for initial production.

(*b*) The difficulties confronting servicing personnel in maintaining equipment.

(*c*) The astronomically large variety of components that must be carried in stocks throughout the world.

It is fully realized that, in part, the equipment complications arise in improvements intended to afford the Fleet equipment with improved operating characteristics.

It is also realized that electronics designers have been schooled for years, in particular, to strive for perfect performance from each circuit. Frequently this urge to reach perfection has resulted in assemblages of circuits that not only meet with overall performance characteristics desired, but also have a large margin of unuseable capacity.

The Bureau desires design supervisors be instructed to carefully examine each proposed design with a view to the ultimate production of the simplest possible, functionally satisfactory equipment.

A *few* examples of the questions that should be considered during such an examination are:

(*a*) Considering the overall performance desired, is this special component (transformer, capacitor, etc.) actually necessary or will the component now in production be really satisfactory though slightly less efficient?

(*b*) Considering the overall performance desired, and all of the resistors (or capacitors) used, of approximately the same size, as a block, would it be undesirable or impractical to use the same resistor value at all circuit points? Could the value be a standard one?

(*c*) Considering the overall performance desired, is it necessary to use so many different tube types? Or would it be desirable from a broad viewpoint to use fewer types, perhaps even at the expense of an added stage?

(*d*) Have the layouts and wire plans become complicated because of a desire for ultimate performance (particularly gain) from each stage, so that excessive overall performance has been obtained at the expense of ease of maintenance?

(*e*) On the other hand, are there components included that are marginal in design; that is, do the transformers, capacitors, etc., have a sufficient factor of safety against excessive current or voltage to insure trouble-free operation? Are tubes being worked beyond their ratings?

While it is fully appreciated that the problem posed is not easy, it is believed that in the forward rush of the war the virtues of simplicity are in danger of neglect. The Bureau has no desire at all to impair performance to secure pure simplicity, but it is not at all convinced that all present complexities are necessary.

The earnest cooperation of all design agencies will be appreciated. It is now thought that the result of such action will be better equipment for the ultimate purpose, which is victory.

SPACE LIGHT

★ In the "Technicana" department of this issue appears an item on a recent demonstration by Westinghouse engineers of fluorescent lighting by means of radiated energy from a generator of radio frequencies. The purpose of the demonstration was not to lead the audience into believing that any such form of illumination would become universal after the war—actually it was a sideshow to a much wider exhibition of lighting systems—but rather to indicate an approach to new possibilities. From that viewpoint it is an interesting subject, even though the stunt is old. What makes it of interest is the fact that we have today an assemblage of new ideas, methods and devices that may well transform an early discovery into a practical system for certain applications not now satisfied by the usual methods of illumination.

There is, of course, the problem of interference from the source of r-f energy. The solution to this might rest in the use of vhf generators of limited field strength and tightly beamed radiation. Such a unit, incidentally, could "turn on and off" lights by a change of "aim" from one lamp to another, or light a group of lamps by a widening of the beam.

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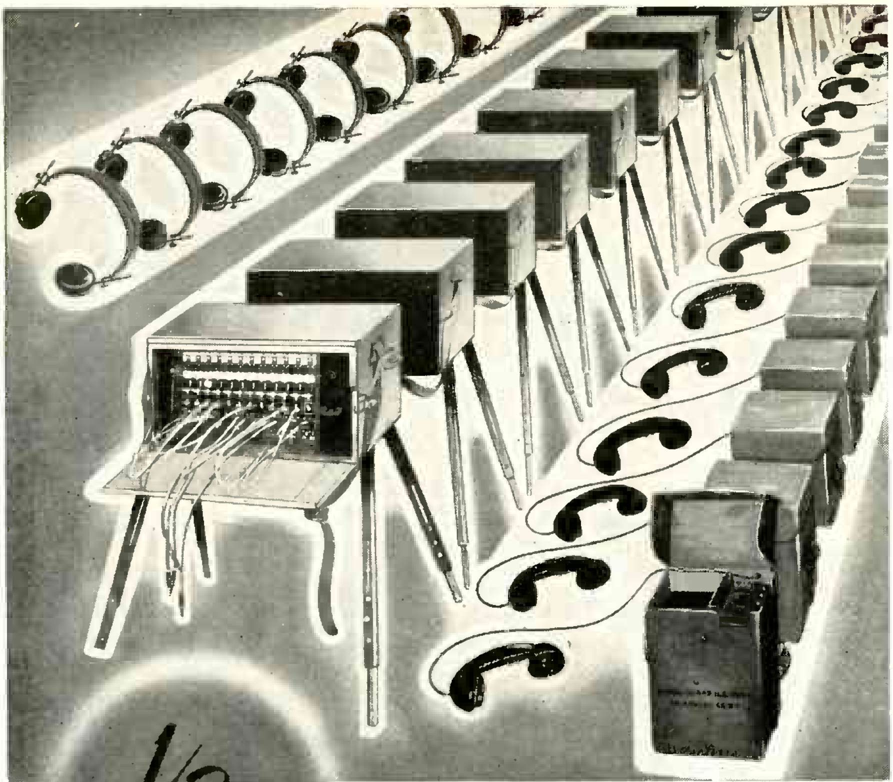

TECHNICANA

ONE-TUBE FREQUENCY DIVIDER

★ In most multivibrator circuits used for frequency division, at least two tubes are employed in the multivibrator and an additional tube is required to isolate the multivibrator from the output circuit load. In an article by Patrick F. Cundy in *Wireless World* for November, 1943, a method of accomplishing this result with a single tube is described.

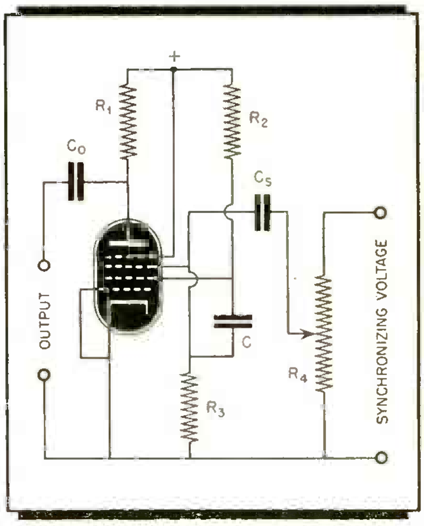

Fig. 1. Frequency-divider circuit.

As shown in *Fig. 1,* a Dow hexode oscillator circuit is employed, with the synchronizing voltage fed to grid No. 4. The amount of synchronizing voltage is controlled by the potentiometer R_4, and the coupling capacitor C_s is so chosen that its capacitance is approximately one-tenth that of C. The oscillation frequency of the uncontrolled multivibrator is determined by the time constant of the resistance and capacitance in the oscillating circuit, and by the tube parameters. By using a hexode, it is possible to utilize the electron-coupled plate circuit for external coupling purposes. Thus R_1 serves as the plate load and C_0 as the output coupling capacitor.

Other circuits, using oscillators of the "transitron" negative transconductance type, are likewise discussed.

ELECTRONIC VOLTAGE REGULATOR

★ An interesting compensated bridge circuit for electronic voltage regulation

[Continued on page 10]


A MITE IN SIZE . . . BUT A
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Precision crystals are performing a mighty job under the most trying battle conditions. But only the crystals that are microscopically clean can operate indefinitely. That's what makes crystals giants.
Crystal Products Company methods of exacting cleanliness in manufacturing procedures are unsurpassed. All crystal oscillators are guaranteed free from flaws, ghosts, inclusions —and are free from optical and electric twinning.
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TECHNICANA

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is described by F. Livingston Hogg in the November, 1943 issue of *Wireless World*. It is stated that this was originally presented by Lindenhovins and Rinia in the *Philips Technical Review*, Vol. 6, No. 2, 1941. It is claimed that this circuit limits the output voltage variation to less than .004 percent for an input voltage variation of 5 percent.

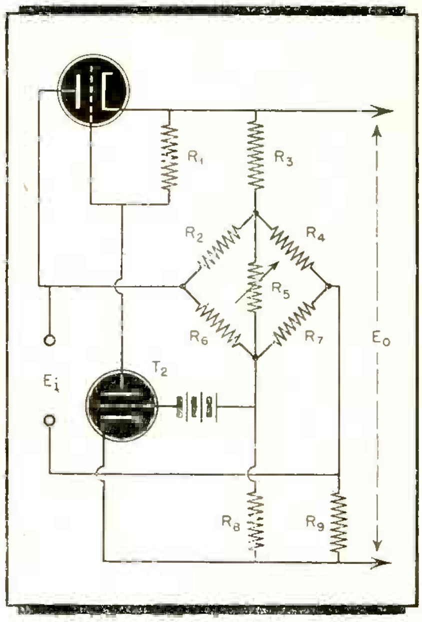


Fig. 2. Electronic voltage regulator.

The schematic circuit is shown in *Fig. 2*. In the bridge circuit, the following equations apply:

$$\frac{R_2}{R_3} = \frac{R_6}{R_8} = n\mu - 1$$

and

$$\frac{R_1}{R_3} = \frac{R_7}{R_9} = nSR_9 - 1$$

where

n = overall amplification of T_2
S = transconductance of T_1
μ = amplification factor of T_1

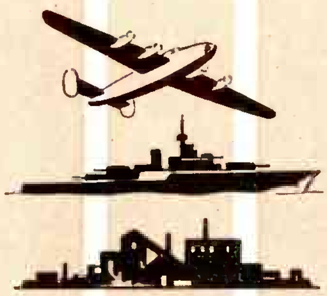
The resistor R_5 is adjusted to give the required output voltage.

RADIO POWER OPERATES LAMPS

★ The application of high-frequency radio waves to lighting homes, hotels and public buildings was recently demonstrated by Samuel J. Hibben, Director of Applied Lighting for the Westinghouse Lamp Division. Mr. Hibben showed how brilliant, vari-colored

[*Continued on page 12*]

A war Hero to Consider in Your Plans for the Future

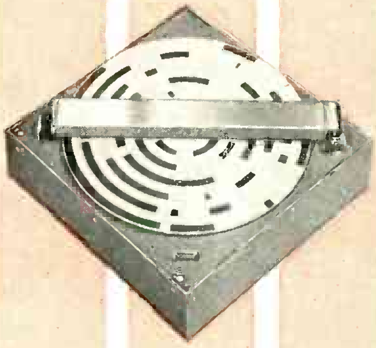


In a bomber over Berlin . . .

aboard a battleship in the far Pacific . . .

on the production lines of American factories . . .

AT EVERY WAR FRONT ELECTRONICS IS PLAYING A HEROIC ROLE



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TECHNICANA

[*Continued from page 10*]

fluorescent tubes could be fully lighted without being connected to any sockets or electrical wiring.

The generator used was a pre-war diathermy set, such as in general use by the medical profession. Mr. Hibben explained that far more powerful r-f generators are now serving in wartime radio and communications equipment and may bring about peacetime expansion of wireless power.

Light by radio.

Experimental lamps which consume less than an electric lamp, and which may be left burning night and day for such jobs as lighting house numbers and clock faces, were demonstrated. Among other types, one lamp was devised from two glass pie plates, showing that fluorescent lamps are not limited to tubular shapes. These have practical and decorative advantages for hotel halls and public buildings.

SKIATRON TELEVISION SYSTEM

★ The Scophony Corporation of America has developed a television system which is claimed to enable a definition of at least 1000 lines or more and a reduction of the band width required of at least 66 percent. This development, invented by Dr. A. H. Rosenthal, Director of Research and Development for SCA, is called the Skiatron Electron Opacity Television System.

The Scophony Skiatron receivers achieve these results by making fuller

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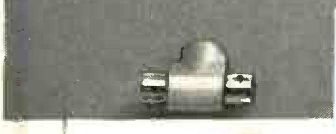

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TECHNICANA

[*Continued from page 12*]

use of persistence of vision and therefore require a much lower field frequency, about 20 per second or less. This should simplify television transmitter design and permit straight scanning instead of the present interlaced type. Further, it is expected that this development should make possible the establishment of six television broadcasting stations within the frequency range and geographical area where now only four may be located.

CATHODE-FOLLOWER FM CIRCUIT

★ A unique circuit for frequency-modulating an oscillator, incorporating a cathode follower to reduce the loading on the oscillator tuned circuit, is described in a note by F. Butler in the November, 1943 issue of the *Wireless Engineer.*

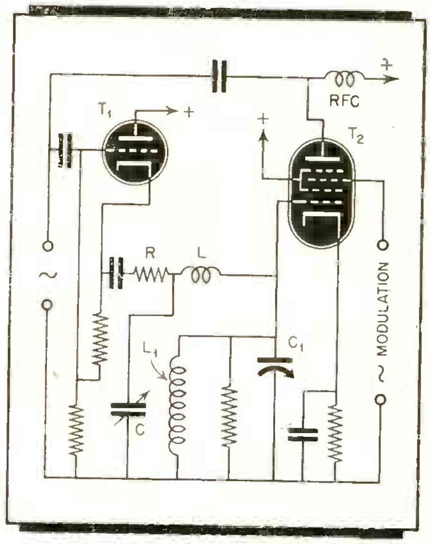

Fig. 3. Frequency-modulated oscillator.

In this circuit, shown in *Fig. 3,* it is also possible to employ fairly high values of capacitance and low values of resistance in the phase-shifting network. Thus R and C may be 5000 ohms and 50 $\mu\mu$f, respectively, to provide slightly less than 90° phase shift. The inductance L operates at resonance in conjunction with the tuned circuit L_1C_1. The latter is adjusted just off resonance to simulate a small capacitor, yet permitting the use of a tuning capacitance large in comparison with shunt stray capacitances.

FIXED COMPOSITION RESISTORS

★ For the first time, an agreement has been reached between manufacturers

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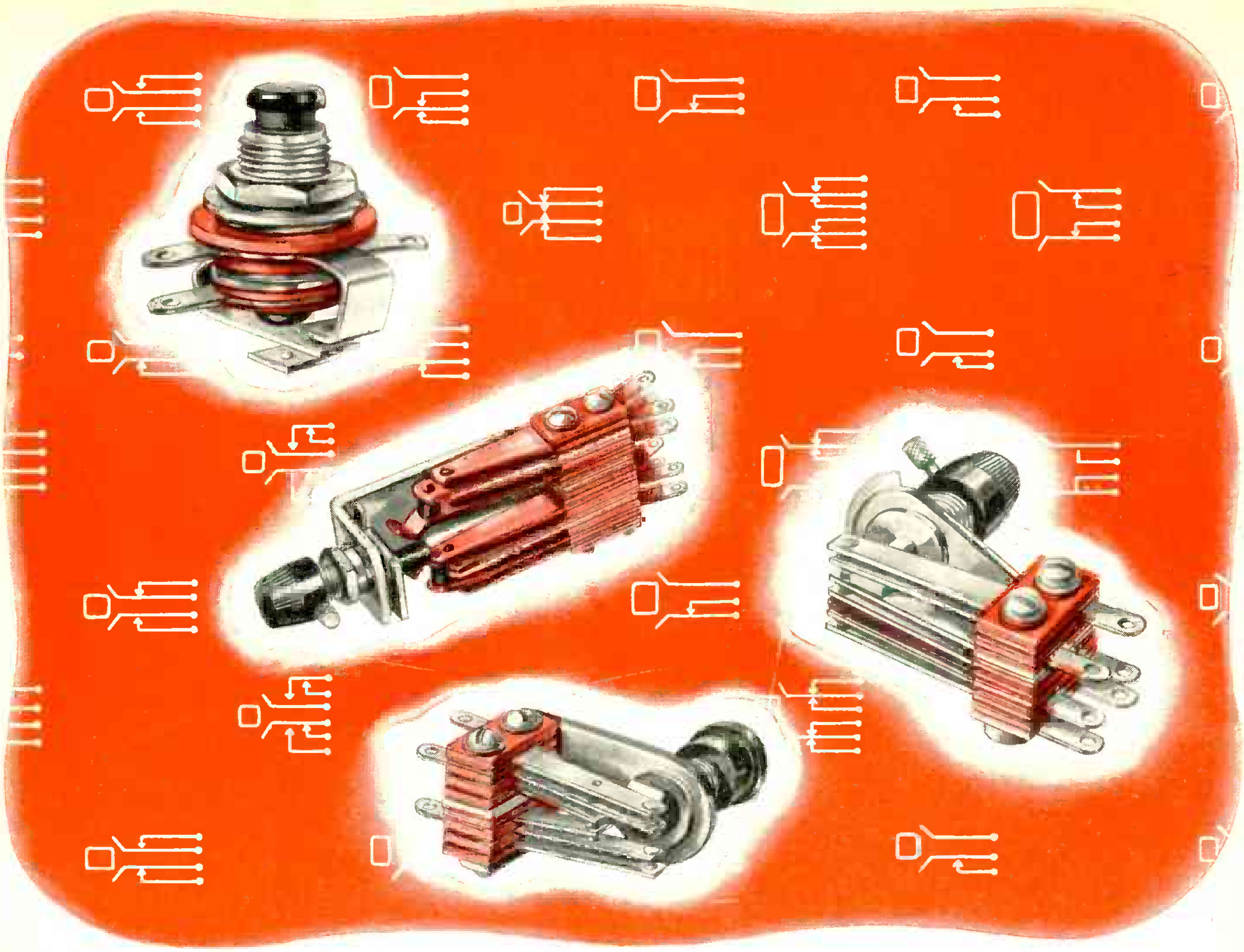

TECHNICANA

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and users of resistors as to just what the performance of general-purpose fixed composition, or "carbon," resistors should be. This agreement is set forth in a specification which has just been approved as a war standard (C75.7-1943) by the American Standards Association.

This specification covers fixed composition resistors suitable for use in all non-specialized applications in communications and electronic equipment. Performance requirements, test methods, standard dimensions and resistance values, and ratings for these resistors for the quality required by the Armed Forces are contained in this standard.

Designers of radio equipment are expected to utilize this standard as extensively as possible in order that maximum production may be had with a minimum waste of time and material, and in order to facilitate servicing of equipment in the field.

NEW COIL IMPREGNANT

★ Mineral oil was pressed into service by the RCA Chemical Engineering Section when it was found that the wax ordinarily used to impregnate radio coils would flow when too hot and crack or crystalize when too cold, all within the extremes of temperature at which these coils were required to function. Either failure would expose the winding to moisture, adversely affecting the electrical qualities of the coil.

The problem was solved by the development of a new impregnating agent, made from mineral oil and cumar resin, which will withstand both extremes of temperature without loss of its protective characteristics.

NEW SOLDER FLUX

★ Fluxing agents, such as rosin and zinc chloride, have been found unsatisfactory in many applications. While zinc chloride is a powerful flux, it tends to cause corrosion unless the soldered parts are thoroughly washed to remove the excess flux after soldering. Although rosin is free from this fault, it is not sufficiently active when used with such metals as steel.

Chemical engineers of the RCA Manufacturing Company have found that lavulinic acid, derived from common starch, is a much more active flux than common rosin. When blended with rosin, this flux can be used in

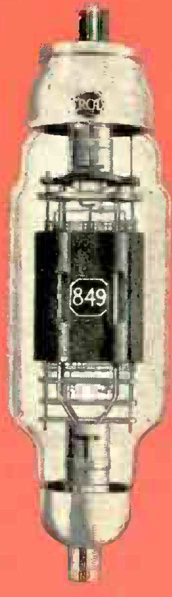
[*Continued on page 58*]

"Give Us Tubes That Last Longer"... Is The Cry

AND RCA ENGINEERS ARE DOING IT!

RCA
872-A / 872
Half-Wave Mercury Vapor Rectifier
$7.50

Replacing the 872 and 872-A, this new tube gives you better results for less money. A special alloy for the cathode base yields increased emission with lower tube drop, enables the tube to withstand larger surge currents without injury to cathode coating. And thermal efficiency has been greatly increased. Net result: better performance, longer life. (Note: RCA 8008 is a companion tube similar to type 872-A/872. The electrical specifications of each are identical. Type 8008 is equipped with heavy duty base and is particularly recommended for use in new equipment.) RATINGS: Filament Voltage, 5 volts; Filament Current, 7.5 amperes; Peak Inverse Voltage, 10,000 volts, max.*; Peak Plate Current, 5 amperes, max.; Average Plate Current, 1.25 amperes, max.
*For condensed-mercury temperature of 20-60° C.



RCA
849
R-F and A-F Power-Amplifier, Oscillator, Modulator
$120

The real value that tube users get from many tube engineering improvements largely depends upon the manner in which the improvements are utilized in the overall designs. For example, the famous RCA zirconium-coated anode, used in the RCA-849, could have been applied primarily to the purpose of giving this tube a greatly increased rating. Or it could be utilized as RCA has done—to produce a tube which operated at a conservative rating, would yield a very considerable increase in the operating life of the tube. In these days, dependable performance, plus long tube life, is most needed. And that is exactly what you get with the long-service RCA-849. RATINGS: Filament Voltage, 11 volts; Filament Current, 5 amperes; Plate Voltage, 2500 volts, max.*; Plate Dissipation, 400 watts, max.*
*For Class C telegraph service.

RCA
828
Beam Power Amplifier
$17.50

High output with extremely low driving power is the big feature of RCA 828. And in addition, this tube needs no neutralizing in well-shielded circuits. In ICAS class C telegraph service, the 828 *will deliver* 200 watts with *only* 2.2 watts driving power! Conservatively operated at CCS ratings, the RCA 828 provides high safety factor and long life. Its high power-sensitivity saves vital materials by eliminating intermediate amplifier stages. Maximum frequency—30 mc at full rating; 75 mc at reduced rating. RATINGS: Filament Voltage, 10 volts; Filament Current, 3.25 amperes; plate voltage, 1250 volts, max.*; Screen Voltage, 400 volts, max.*; Plate Dissipation, 70 watts, max.*
*CCS rating for Class C Telegraph service.

RCA
833-A
Transmitting Triode
$76.50

An outstanding feature of this high-power air-cooled triode is its famous RCA zirconium-coated anode, permitting 44% more input and 53% more plate dissipation under CCS conditions than were possible with its predecessor, the 833. Designed for use as an r-f amplifier, class B modulator, and oscillator. This is one of RCA's most powerful glass-type triodes. Built for long life. RATINGS: Filament Voltage, 10 volts; Filament Current, 10 amperes; Amplification factor, 35; D-C Plate Voltage, 4,000 volts, max.*; Plate Current, 500 milliamperes, max. Plate Dissipation, 400 watts, max.*
*CCS rating with forced-air cooling for Class C telegraph service.

HOW TO REDUCE TUBE REPLACEMENTS
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Choose the Right Tube
second...
Treat Your Tubes Right

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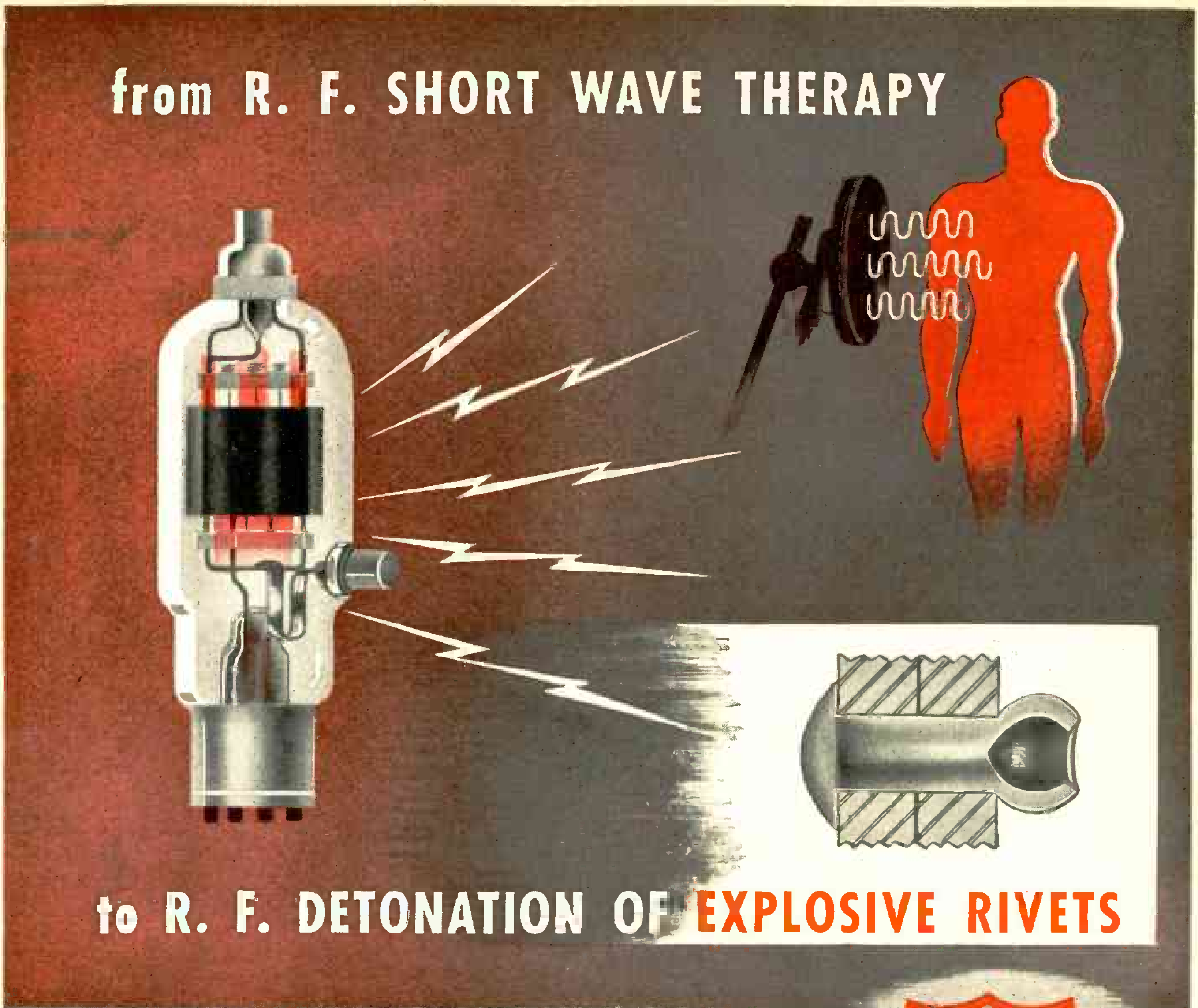
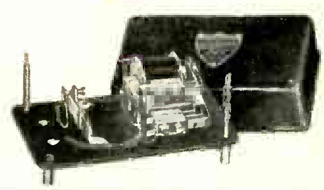
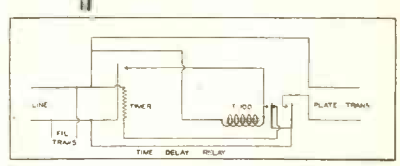


RELAYS BY GUARDIAN

From rebuilding human bodies—to riveting aircraft structures . . . from case hardening of metals to plywood glueing . . . wherever a tube is used, there you will usually find a relay. Oscillator tubes such as are used to generate radio frequencies in diathermy machines and detonators for explosive rivets usually require a "warm up" of 20 to 30 seconds to allow the tube filaments to heat. The Guardian Time Delay Relay T-100 is frequently used in applications of this type.

The time delay is adjustable for any period between 10 and 60 seconds and is accomplished by means of a resistance wound bi-metal in series with a resistor, not shown. The contact capacity of the T-100 is 1500 watts on 110 volt, 60 cycle, non-inductive AC. The power consumption of coil and time delay during closing of thermostatic blade is approximately 10 VA; after closing, 5.5 VA. Other types of relays commonly used in conjunction with oscillator tubes are the B-100 Break-In Relay for power supply control, and the X-100 Adjustable Overload Relay for power supply and tube protection. These and other R.F. relays are described in Bulletin R-5. Send for it. No obligation.





T-100 Time Delay Relay

GUARDIAN ELECTRIC

N-509 WEST WALNUT STREET CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

BOOK REVIEWS

BASIC RADIO PRINCIPLES, by Maurice Grayle Suffern, Captain, Signal Corps, U. S. Army. Published by McGraw-Hill Book Co., Inc., New York, N. Y. 271 pages. Price $3.00.

Captain Suffern has written this book to help those interested in obtaining a basic knowledge of radio fundamentals, and to aid in the training of radio servicemen and technicians. It is quite elementary in approach, and therefore will be of especial value to those who are entirely famiilar with radio parts and their applications.

Considerable space is devoted to radio components and, by showing side by side a pictorial view of each component discussed and its schematic symbol, the reader should more quickly learn to read schematic diagrams such as he will encounter in practical service work.

The book is substantially free from mathematics and, consequently, will be welcomed by those who wish to acquire an elementary knowledge of radio and electricity, yet lack any preliminary technical training. *J.H.P.*

★

TRAFFIC HANDBOOK FOR RADIO OPERATORS, by J. E. Kitchin. Published by Compass Book Co., P.O. Box 542, Ottawa, Canada. 163 pages. Price $3.00.

This textbook is intended for the use of students preparing for examination for Certificates of Proficiency in Radio in the Traffic Section of Canadian examinations.

Mr. Kitchin is a Canadian Radio Inspector and is accordingly well qualified to handle this subject. In addition, he has the ability to write clearly and concisely, so the book contains far more information than might be assumed from the number of pages. Furthermore, the writer confines himself strictly to his subject, all non-essential matter being eliminated.

We understand that this is the first book on the subject which has been presented. As such, it fills a definite need, and the author has done his job so well that it is difficult to see how it could be improved. *J.H.P.*

★

PATENT LAW, by Chester H. Biesterfeld. Published by John Wiley and Sons, Inc., New York, N. Y. 225 pages. Price $2.75.

This is a particularly timely book on a subject with which most research engineers and chemists are often confronted. So many new ideas and processes are now being developed in research laboratories that it behooves all who are working along such lines to acquire a degree of familiarity with the basic principles of the patent law in order that their work may be protected.

While the larger corporations have patent departments which can determine whether or not an idea is patentable, much of their time is wasted in considering developments which are obviously not patentable, and which would not have been submitted to them had the engineer some knowledge of the law. Other concerns, without patent departments, often waste considerable time and money procuring patents which are subsequently held invalid by the courts. The author states that 80 to 90 percent of the patents coming before the courts in recent years have been ruled invalid.

It is interesting to learn that patent law is not static; in keeping with the general increase in technical skill throughout the engineering fields, the courts are becoming more critical as to what constitutes invention. For this reason the author has omitted consideration of older cases where he feels they will not assist the reader in ascertaining present legal trends.

Among other topics, the author discusses invention and discovery, priority of invention, the patent application and prosecution thereof, interferences, infringement, licenses, ownership and shoprights, trade secrets and searches.

We feel that the information contained in this volume should be valuable to anyone doing original research or design work in the radio/electronic field. *J.H.P.*

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SHORT WAVE WIRELESS COMMUNICATION, Fourth Edition, by A. W. Ladner and C. R. Stoner. Published by John Wiley and Sons, Inc., New York, N. Y. 573 pages. Price $6.00.

In the latest edition of their well-known book, the authors have added a great deal of new material, including some 180 new diagrams. More attention has been devoted to ultra-short and microwaves, although, as the authors point out, war-time restrictions in England, as in this country, do not permit them to discuss many new and interesting developments. Despite this, there are 22 pages devoted to microwave oscillators of the magnetron and Klystron types. While there is only one page on dielectric wave guides, which is apparently considered quite hush-hush in England even though Lord Rayleigh pointed out their possibilities as early as 1897, the bibliography at the end of the chapter lists the outstanding articles by Barrows and Southworth on the subject.

After a few introductory pages, there is a short chapter on the history of the development of short waves. These are followed by two comprehensive chapters on the propagation of short and ultra-short waves. Chapters on feeders, antennas, push-pull and power amplifier circuits are then presented, after which oscillators, modulation circuits and reception problems are discussed. The treatment of quartz crystals is the most complete we have seen in any textbook.

The closing chapters cover commercial transmitter and receiver apparatus, and also high-frequency therapeutic equipment.

There is a considerable difference in the emphasis placed on many topics, as compared with their treatment in other books on the same subject, so the reader will often find here a more comprehensive discussion of many important subjects than in other similar sources. *J.H.P.*

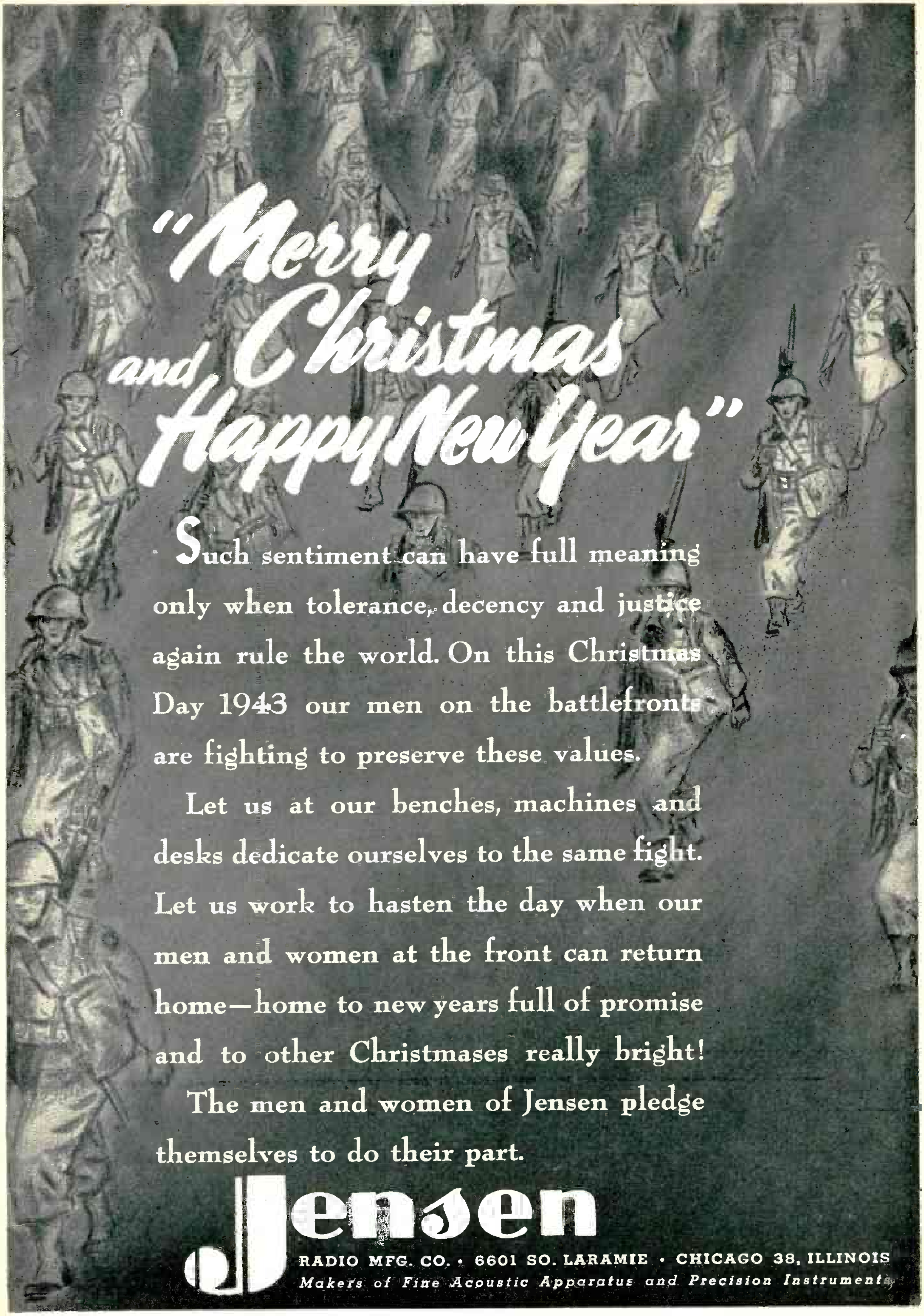
★

LABORATORY MANUAL IN RADIO, by Francis E. Almstead, Kirke E. Davis and George K. Stone. Published by McGraw-Hill Book Co., New York, N. Y. 139 pages. Price $.80.

This manual provides a series of carefully selected experiments designed to aid students in acquiring practical experience in radio laboratory work. The experiments included are the result of many years of experimentation to determine the most suitable laboratory exercises for beginners in radio, and have been used with marked success in many beginning classes of high-school students as well as for naval recruits.

The experiments described are grouped under the broad topics found in all textbooks rather than as separate disconnected exercises, and are planned so that students can work either individually or in groups. Only the simplest of equipment is required, most of which may be obtained from discarded radio receivers.

This book should prove particularly valuable to instructors in vocational training in radio and electronics.


"Merry Christmas and Happy New Year"
Such sentiment can have full meaning only when tolerance, decency and justice again rule the world. On this Christmas Day 1943 our men on the battlefronts are fighting to preserve these values.
Let us at our benches, machines and desks dedicate ourselves to the same fight. Let us work to hasten the day when our men and women at the front can return home—home to new years full of promise and to other Christmases really bright!
The men and women of Jensen pledge themselves to do their part.
Jensen
RADIO MFG. CO. • 6601 SO. LARAMIE • CHICAGO 38, ILLINOIS
Makers of Fine Acoustic Apparatus and Precision Instruments

THE BASIS OF MICROWAVE GENERATION

V. J. YOUNG
Engineer, Sperry Gyroscope Company

How the Fundamentals of Microwave Generation are Utilized in the Operation of Velocity-Modulated Tubes, Such as the KLYSTRON

★ If, in any radio transmitter, we follow the electrical energy from the power lines right through until it has been radiated from the antenna, there is some place in the path beyond which it is no longer fruitful to discuss the situation in terms of currents and voltages. Instead, it becomes necessary to describe the electromagnetic field. In ordinary broadcast and shortwave installations this point does not usually come until the antenna is reached. Antenna currents are measured and voltage curves are drawn. Much has been written about the necessary resonance of such transmitting antennas and about the distribution of electromagnetic radiation that may be expected from various geometric arrays, but quite a bit less has been said about the actual mechanism of radiation.

Microwave Transmitters

With microwave transmitters, the emphasis must usually be changed. Antennas are not just wires but, instead, are parabolic reflectors. Energy is not brought up to these radiating surfaces on wires but rather in a wave guide or in a coaxial line. The result is that the point in the energy path where it becomes more advantageous to consider electromagnetic waves is pushed right back to the microwave oscillator. To understand the operation of microwave transmitting tubes, such as the Sperry *KLYSTRON, it is necessary to cultivate a physical picture of electromagnetic waves and the way in which they originate.

At power line frequencies we are not ordinarily concerned with radiation because, with finite currents and reasonable separation of the conductors, the radiated energy is very small. In fact, if the special case of dipole radiation in which a single charge oscillates back and forth over a very small distance is considered, it becomes rather easy to calculate an expression for the total energy radiated as a function of the charge strength and the frequency. It turns out to be

$$\text{radiation} = (Q^2 f^2 / 6 \pi C^3) \text{ ergs per second}$$

where Q is the strength of the charge, f is its frequency of oscillation, and C is a constant equal to the velocity of light. Because of the squared term in f, radiation at low frequencies is very small. At microwave frequencies it has, until recently, been impossible to build efficient radiators because of the smallness of Q.

In this same dipole case we can calculate the electric and magnetic fields arising from the oscillating charge. It is found that in the region close to the charge, as measured in terms of wave

* Reg. Trade Mark of the Sperry Gyroscope Company.

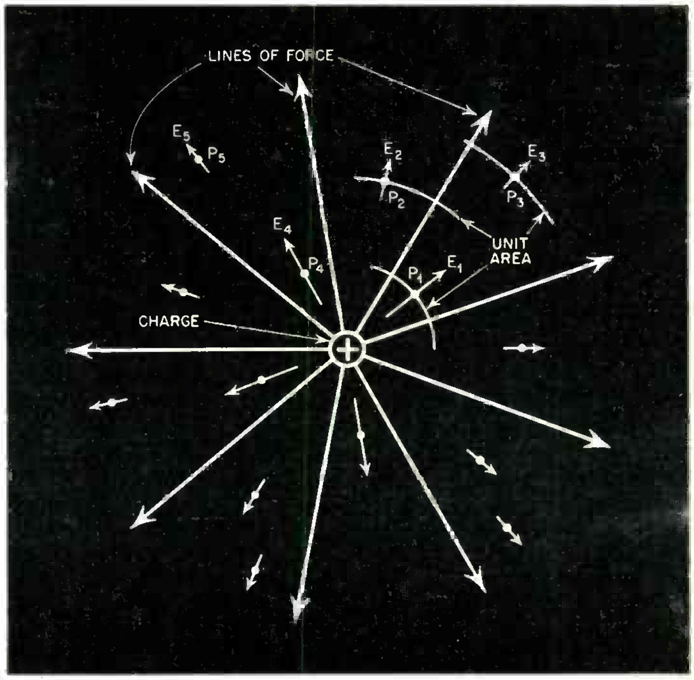


Fig. 1. The electric field arising from a stationary electric charge.

length, the fields become smaller with increasing distance at a more rapid rate than at greater distances. It is the strength of the field at these greater distances that gives rise to radiation, while the energy in the nearby field is reabsorbed by the charge as the direction of its acceleration reverses. This reabsorption of energy gives rise to the phenomenon of self-inductance.

Here, however, we are not so much interested in the field of an oscillating charge as we are in the more general question of how a moving charge interacts with an electromagnetic field. Some simple and rather general ideas can be easily developed concerning the way in which a moving charge causes fields. The action the other way, by which fields affect the motion of a charge, comes rather naturally into the picture from the definitions of the fields which are given.

Wave Trains

According to the electromagnetic theory any accelerated charge must radiate energy in the form of an electromagnetic pulse or wave train. If a charge initially at rest is set in motion or if, in motion, it is brought to rest, a single electromagnetic pulse is sent out. If the acceleration is such that the charge vibrates back and forth, or if continual acceleration is maintained as by the motion of the charge in a circular path, a train of waves is given out. When the charge moves back and forth along an antenna with acceleration and velocity such that it makes f complete trips per second, then a radio wave of frequency f is transmitted. This is true at all radio frequencies but is not strictly true at even shorter wave lengths, such as are encountered in light and X-rays. Even there the creation of the radiant energy is tied in with a picture of electrons in the atom which rotate in orbits and are thus accelerated. An added condition expressed by a more comprehensive theory, known as quantum mechanics, is necessary to explain atomic radiation. With phenomena which are large compared to atomic dimensions, this more complete theory reduces in such a way as to verify the simpler proposition.[1]

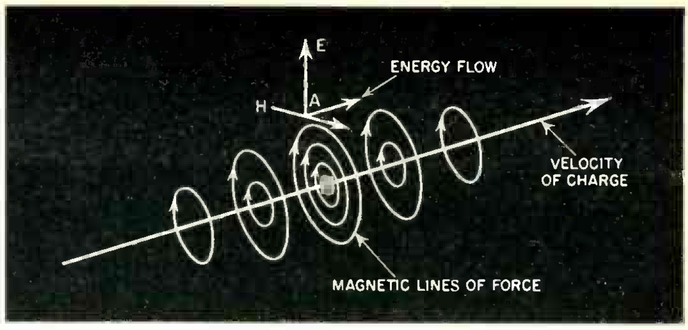


Fig. 3. Magnetic field of a moving charge showing that, in connection with the electric field, a Poynting's vector is generated which has no component outward from the wire.

Before we can go further we must next be sure of our ideas concerning the electric and magnetic fields themselves and how they exist around a charge under various conditions of motion. The electric field is a quantity that can be measured at any point in space by placing a known test charge at the point in question and noting the force exerted on it due to the attraction or repulsion of other charges in the neighborhood.[2] These neighborhood charges which determine the properties of the place where we put our test charge may be of two kinds. One kind is called free charge and as the name indicates, this kind is completely detached from charge of the opposite sign. The other sort is bound charge, which is always closely associated with equal and opposite charge. The portion of the force on the test charge due only to the free charge is a measure of the E field at the point. The whole force depending upon the arrangement of both the bound and unbound charge in the neighborhood measures the D field. In general, it is necessary to distinguish between these two electric fields. However, since we will restrict ourselves to free space where bound charge does not exist, the two will be equal and identical.

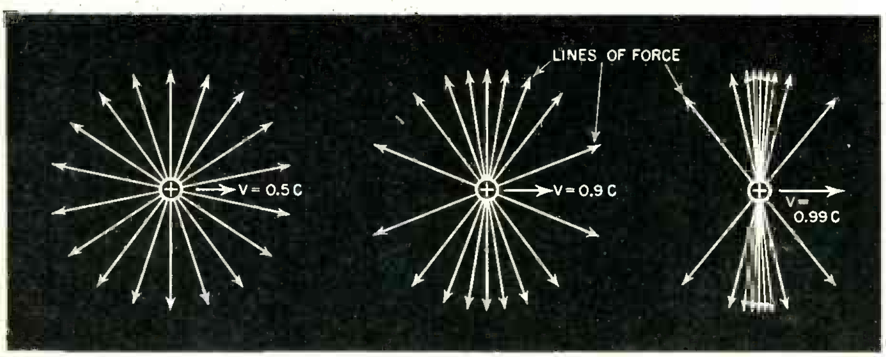


Fig. 2. Plots for the electromagnetic field about a charge for three translational velocities. The velocity of light designated by C is equal to 3×10^{10} cm per second.

Field of a Stationary Charge

In *Fig. 1*, the electric field is shown for several points in the neighborhood of a single stationary charge isolated in space. Actually, we are interested in knowing the value at all points in space. Since it is not practical to draw the vectors at even a large number of places, we ordinarily use a convenient method of mapping space with curves which are called lines of force. With such a map we can visualize the field at any point, even though the vector representing it is not drawn. The electric lines of force are so placed that tangents to them always show the direction of the field and the density of the lines indicates the magnitude of the vector. Hence, at P_1 in *Fig. 1*, the field is 4 units strong, since there are 2 lines per unit area density of force lines at that point. At P_2, the field has a strength of 2, since the density is only 1 line per unit area. At P_3, the field strength is 3/2, etc. A stationary charge has no magnetic fields at all associated with it.

When a charge moves in a straight line with a uniform velocity the electric field is usually very little different from that when it is stationary. It does take a finite amount of time for the test charge to feel the effect of attraction from the moving charge, so that at high velocity (greater than 0.5 times the velocity of light) the field is somewhat modified. In *Fig. 2*, the electric field in terms of force lines is shown for velocities of 0.5, 0.9 and 0.99 times the velocity of light. These modifications are not those which would be naïvely expected from simple reasoning which is based on the idea that, because of the transit time of the force line, a test charge at A feels a force dependent on the location of the moving charge at a slightly previous time. The reason for this is tied up with special relativity. According to that theory, an observer riding with the

[1] "Introduction to Modern Physics" by F. K. Richtmyer, McGraw-Hill Book Company.

[2] The test charge must be so small as to cause only a negligible shift of the charge generating the field.

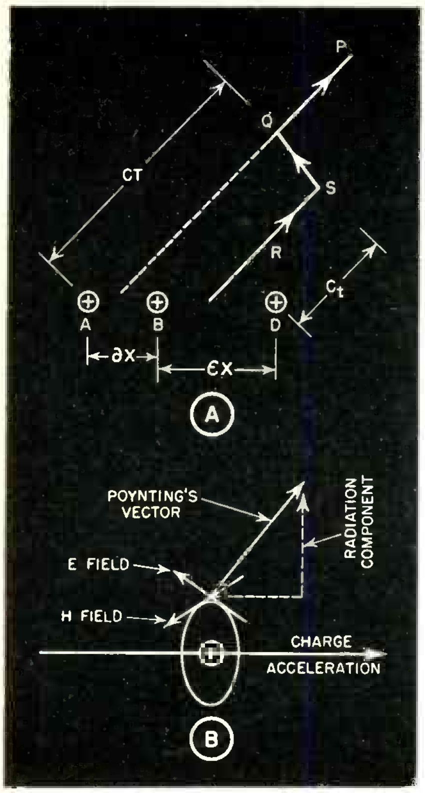


Fig. 4. In (A) the electric field arising from an accelerated charge is shown. The resulting Poynting's vector is depicted in (B) and indicates that a component of this vector points away from the path of the charge.

charge will see a stationary electric field and find the velocity of electromagnetic propagation to be the same in his frame of reference as that for a stationary observer. The satisfaction of these requirements calls for the fields as shown.

Actually, in all microwave generators now known, no such extreme velocities are encountered. Electric field patterns like the one shown for a stationary charge are always a very good approximation of the actual distribution, although because of the symmetrical nature of the relativistic change, it is clear that the conclusions we will draw are valid in any event.

Shown in *Fig. 3* are magnetic lines of force around a charge which is moving with constant velocity along a straight line. These show the magnetic field in the neighborhood of the moving charge in the same way as the electric lines of force show the electric field. The magnetic field, usually called the *B* or *H* field[3] is given a quantity which has a measurable value at every point in space and is hence really a property of space. To measure the magnetic field at a point such as *A* (*Fig. 3*), we may think of placing a very small test magnet at that point and orienting it until a maximum torque is required to hold it. The strength of the field can then be measured by that torque and the field direction obtained by releasing the test magnet and observing the direction in which the north pole points.

In the case shown in *Fig. 3*, the direction of the magnetic field can be determined by the right-hand rule usually used to show the magnetic flux around a current carrying wire. Here, the magnetic and electric fields move along with the charge. Poynting's vector showing the direction of energy propagation can be seen at any such point as *A* to indicate that the energy flow is in the space around the charge and moving in the same direction as the charge.[4] The direction of the energy flow is that of a right-hand screw when the *E* vector is rotated toward the *H* vector. It is specifically noticed in *Fig. 3* that there is no outward component of this flow. This confirms that a charge moving in a straight line with constant velocity does not radiate.

Effect of Acceleration

As we have seen, the electric field of a charge is ordinarily not much modified by constant velocities. When accelerations are present, however, the situation is changed. Referring to *Fig. 4A*, let us suppose that a charge *Q* is first observed at *A* and that it moves through the very short distance δx with an ever-increasing velocity. Let us further assume that after being accelerated to *B*, the voltage causing the acceleration is removed so that the charge continues with constant velocity through the small distance ϵx to the point labeled D. Now, if we consider what the field is like around the charge at the moment *D* is reached, we can see the effect of the acceleration. Representing by *T* the time it took our charge to travel the whole distance *AD*, then distant points such as *P*, which are farther from the charge than

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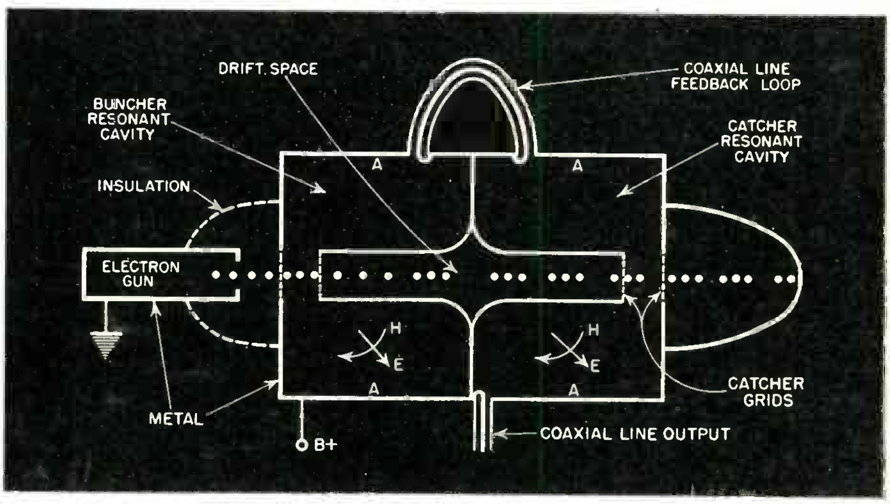


Fig. 6. Schematic diagram of a typical double cavity Klystron.

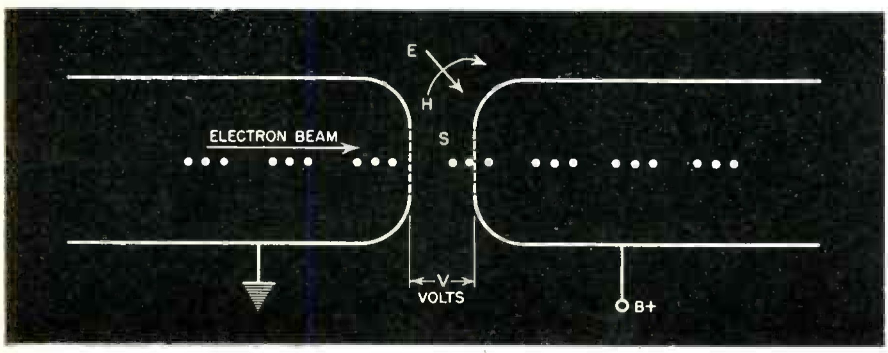


Fig. 5. The generation of a radio wave by the successive acceleration of bunches of charge. This is an alternative to the oscillation of a charge back and forth along an antenna.

[3] *B* and *H* bear somewhat the same relation to each other as do *E* and *D*. *H* represents the magnetic field arising from currents while *B*, called magnetic induction, is the field responsible for inducing voltage by its rate of change. *B* is dependent upon the magnetic properties of the medium as well as currents flowing in the neighborhood. In free space *B* is equal to *H*, so the distinction need not concern us here.

[4] Poynting's Vector in Wave Guide and Radiation Phenomena, RADIO, August, 1943.

The transmitter building, about 12 kilometers from the center of Rio de Janeiro. The right-hand side of the building is occupied by the shortwave transmitter, and a 25-kilowatt broadcast transmitter is located in the left-hand side.

"RADIO NACIONAL"

First Details of RCA 50-HF Transmitter by Which Brazil Speaks to the World

★ Technical and functional details of the RCA Type 50-HF international short-wave radio transmitter, built and installed by RCA for "Radio Nacional" of Rio de Janeiro, have just been released as the station concludes its first year of short-wave operation.

Dedicated "to the service of civilization, to the purpose of good neighbor relations, to the sacred cause of freedom," Radio Nacional's achievement since the new 50-kilowatt transmitter went on the air last New Year's Eve is attested in letters from persons who have received its programs in places as remote as Sweden, the Cape Verde Islands, Attu in the Aleutians, and other points around the world.

Eight Antennas Used

Two of the station's eight antennas located a few kilometers outside of Rio, are beamed to the United States; two more are beamed to Europe, one to Asia, and the remaining three are non-directional. Short-wave broadcasts are transmitted under the following identification calls: PRL-7, frequency of 9,520 kilocycles; PRL-8, frequency of 11,720 kilocycles; PRL-9, frequency of 17,850 kilocycles. Programs are in Spanish, Portuguese, and English.

The station's streamlined studios, housed on the 21st and 22nd floors of the building of the leading Brazilian daily newspaper, "A Noite," were completely equipped by RCA. There are three control booths for the seven studios. Equipment includes speech input equipment, racks, turntable, and recording equipment. In the main studio are fifteen Type 44-BX RCA velocity microphones, along with six of other types, with deluxe boom and program stands.

Of the same type as RCA 50-kilowatt transmitters in use at Leopoldville, in the Belgian Congo; at Brazzaville, in French Equatorial Africa, and elsewhere, Radio Nacional's transmitter was installed by the International Department of the RCA Victor Division through its subsidiary company, RCA Victor Radio, S. A., of Rio de Janeiro. John F. Dawson, RCA engineer, was installation supervisor.

Signs of the heightening importance of high-power international broadcasting led RCA to begin development of the 50-HF type of transmitter about a year before the attack on Pearl Harbor. Transmitters of this type are now being manufactured in quantity by RCA for the use of the United Nations in all parts of the world.

This view inside the building shows the front of the RCA 50-kilowatt international shortwave transmitter, with the console table, monitoring and measuring equipment, limiting amplifier, hum buck amplifier, and speech input equipment for emergency operations. Center door of transmitter enclosure leads to control compartment, inner doors on either side give access to the two radio-frequency channels, and the outer doors lead to the fronts of the exciter units.

Station Equipment

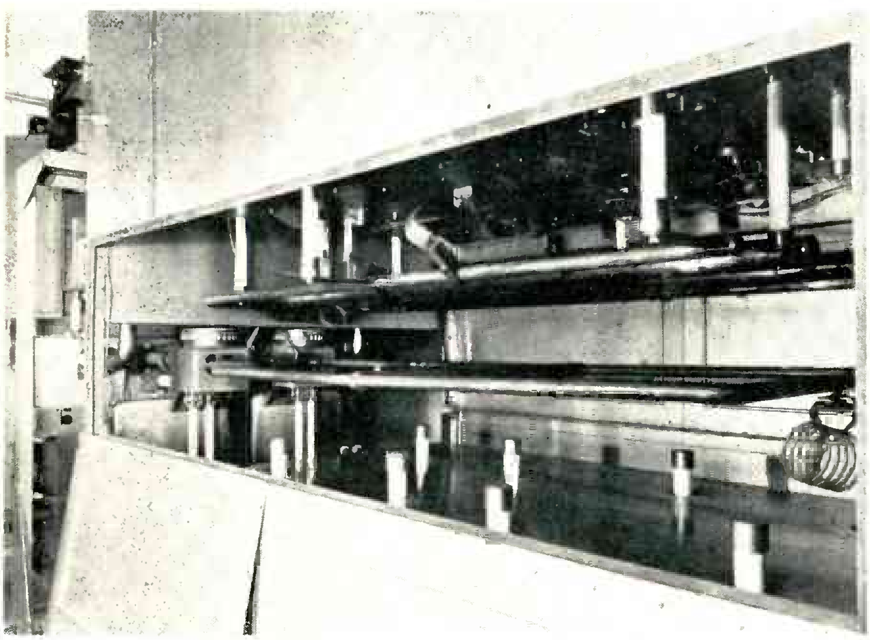
While the rectifier, audio, and control circuits of the 50-HF are similar to those developed for the RCA 50-E Broadcast Transmitter, the r-f circuits naturally vary to meet special problems and requirements of international broadcasting. Two complete radio-frequency channels are incorporated in the transmitter, for example, to facilitate quick setting up or changing of frequencies to any point in the range from 6 to 22 megacycles. Each r-f channel is contained in a separate compartment with separate interlocking systems, so that one may be entered for work while the other is in use.

A single power supply and a single modulator unit are situated between the two channels, so that they may be switched to either channel in no more than five seconds. The center door of the transmitter leads to the control compartment, doors on either side of this open into the two r-f compartments, and the farthest doors on each side lead to the fronts of the exciter units.

All control relays, contactors, and distribution switches are centralized on panels in the control compartment, the door to which is not interlocked, so that it may be entered during operation for the purpose of checking on the operation of the control circuits.

The d-c power from the 1.5-kv., 5-kv., and 10-kv. rectifiers may be switched to either of the radio-frequency units. An important feature of the rectifier circuit is the inclusion of a spare tube, the filament of which is kept heated during operation, with switching arrangements which make it possible to cut the spare into the circuit for immediate use in place of any one of the six regular tubes if one should fail. A bias rectifier on the modulator is the only additional d-c power supply required for operation of the complete transmitter.

All power switches and control and overload relays of the transmitter are centrally located in this compartment. Situated behind the middle door of the transmitter enclosure, the control compartment can be entered during operation of the equipment for check-ups on the control circuits.



Photograph shows tank and line coupling circuits of one of the r-f channels, with two RCA-880 tubes operating as power amplifiers. The modulator unit also uses two RCA 880's and modulates either one of the r-f channels. Tuning of these circuits is accomplished electrically by remote-control motors.

High-level Class B modulation of the 50-kilowatt carrier is provided. A cathode-follower driver, along with highly stabilized feedback circuits, provides low-distortion operation. The

[*Continued on page 44*]

OSCILLATOR FREQUENCY STABILITY

A. C. MATHEWS

An Analysis of the Causes of Oscillator Frequency Instability and Corrective Measures Which Have Proved Effective

★ The problem of oscillator frequency stability becomes more and more important as new services are added in the radio spectrum. Receivers must be capable of separating these stations with a high degree of accuracy and maintaining the received signal properly tuned for relatively long periods of time. This requires a high order of oscillator frequency stability.

The principal factors contributing to oscillator frequency drift can be divided into four parts. These are: 1. *Temperature;* 2. *Humidity;* 3. *Operating parameters;* 4. *Shock and vibration.*

1. TEMPERATURE

The effects of temperature variations are probably of greatest importance, since they are present under all operating conditions. Some services require working under ambient temperatures which may vary as much as 100°C. over a relatively short period of time.

Such variations in temperature can be compensated over a small frequency range by the use of a negative temperature coefficient capacitor. However, this would not be the proper approach since undoubtedly the drift would be due to several factors, and the amount of compensation necessary to accomplish the desired result would be excessive. Furthermore, as pointed out previously, compensation would only be correct over a narrow band of frequencies. Under these circumstances the problem must be approached more systematically. The drift due to each component must be segregated and studied separately.

As a starting point, the circuit layout should be studied. Components should be placed so that all leads are short and direct. Proper ventilation should be provided to prevent the heat radiated by the tubes from excessively raising the temperature of nearby components; thus the temperature vs. time curve will be more uniform and frequency compensation will be more effective.

The temperature of the tube usually stabilizes within the first 15 minutes of operation, while the other components may require an hour or more, depending upon their mass. A typical curve is shown in *Fig. 1.* Note the steepness of the curve during the first few minutes of operation. The first attempt at compensation would probably look like curve *B.* Here we have the same sudden rise at the start, but after about 15 minutes the drift no longer increases, the frequency then gradually returns to normal and remains substantially at this point during continued operation.

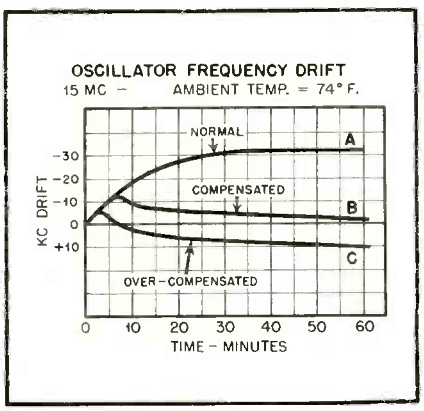


Fig. 1. Showing the effect of compensation and over-compensation of oscillator frequency drift.

It is fairly safe to assume that the drift encountered during the first few minutes of operation is due to the tube. This can be evaluated fairly accurately by operating the equipment until the frequency has stabilized and then quickly replacing the hot tube with a cold tube and noting the change in frequency as soon as operation starts. Of course, the cold tube base will have a slight cooling effect on the tube socket, but if the mass of the socket is large the results will be quite accurate. Once the initial tube drift has been determined a separate compensating capacitor can be employed which will offset this drift. The rapid heating of the compensator may be accomplished by using a separate heater element or by locating the compensator in a position so it will receive more heat directly from the oscillator tube.

With the tube drift accounted for and corrected, it is then possible to study the drift due to the other components.

Inductors

Probably the component responsible for the largest amount of drift is the inductor. Here it is necessary to consider such variables as the distributed capacitance, coefficient of expansion of the coil form and wire and the figure of merit, or Q, of the coil. In general the coil form should be of low-loss material.

Fig. 2 shows the relative drift of inductors wound on forms of different materials. The difference between the two curves will vary depending upon the percent drift of the coils as compared to the remainder of the circuit. It is shown that an inductor wound on a phenolic coil form will have more drift than a similar coil using a ceramic form. This is due to the change in distributed capacitance and the greater

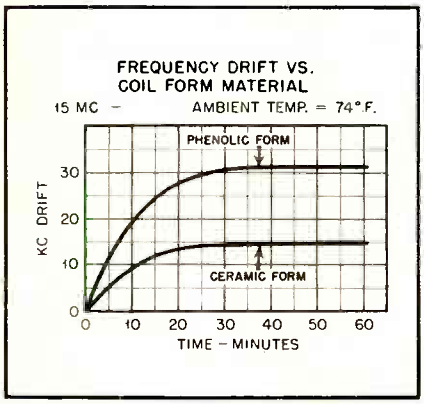


Fig. 2. Low-loss coil forms reduce frequency drift, as shown above.

coefficient of expansion of phenolic materials over ceramics. An inductor wound on a high loss factor material will obviously have a relatively high distributed capacitance. This will vary somewhat with temperature, thereby affecting the stability of the circuit in which it is used.

Effects due to the expansion of the coil form are rather complex in nature because the thermal coefficients of expansion of the diameter and of the length of the coil form are not usually equal. Variations due to the expansion of the wire must also be considered. It is very difficult indeed to design a coil wherein the expansions of wire and coil form balance both radially and lengthwise to give a zero change of inductance with temperature. Theoretically this may be possible; practically, however, it is inadvisable, due to production variations in the materials.

A more satisfactory way of increasing the frequency stability of an inductor is first, to decrease the dielectric losses and second, to reduce any physical changes due to temperature effects. Assuming the coil dimensions have been chosen such as to minimize the distributed capacitance, the next step is to use a low loss factor coil form. Maximum operating temperature and the coefficient of expansion of the material should influence this choice. The only other important factor we have not corrected is the variation due to the expansion of the actual wire used to wind the coil.

Consulting a table of the properties of metals we find that Invar or Nilvar has a coefficient of expansion of less than one part per million per degree centigrade as compared to 16 parts per degree centigrade for copper. Comparing the specific resistance, however, we find Invar and Nilvar to be quite high as compared to copper or silver. Due to skin effect at radio frequencies the current travels only in a small portion on the outside of the wire. The depth of penetration is a function of the frequency. This phenomenon can be taken advantage of in the design of temperature-stabilized inductors by plating a metal having a low specific resistance (such as copper or silver) on wire which is thermally stable. The plating thickness should be approximately 50 percent greater than the calculated skin depth for the lowest frequency desired. An inductor wound with this composite wire on a ceramic form will show a change of less than one part per million per degree centigrade.

Another design, which has been successfully used to stabilize inductors thermally, depends on a bimetal element to change the position of a shorted turn or copper vane. Still another method is to locate a powdered iron core on the end of a brass rod and insert the core into the coil in such a position that the expansion of the brass rod compensates for the change in inductance due to temperature variations.

Oscillator circuits which require a tickler coil may be improved by spacing the tickler coil from the secondary by means of polystyrene tape—or better still, by designing the tickler so that it is located inside the secondary, with as little dielectric material between windings as possible.

Capacitors

The percent frequency instability contributed by tuning capacitors is ordinarily negligible provided a good mechanical and electrical design has been followed. Points worthy of mention are: heavy end supports to prevent any twisting action when the plates are rotated; spacing between plates should be large; adequate rotor and stator supports; ceramic insulation; expansion of dissimilar metals which might affect the capacitance; ball-type bearings and the location of insulation out of strong electrostatic fields as far as possible. The effect of temperature vs. capacitance change measured on a well-designed tuning capacitor is shown in *Fig. 3*. A typical low-priced broadcast-type capacitor is shown for comparison.

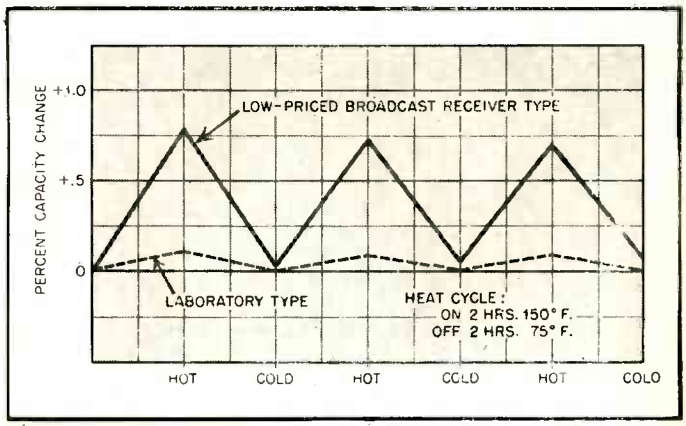
Negative compensating capacitors are of two types; titanium dioxide and bimetal. Because these capacitors are characterized by a negative thermal coefficient they have been used successfully to compensate for changes in circuit constants due to temperature variations. The titanium dioxide type have been by far the most popular because of their small physical size. Their compensation characteristic for some mixtures is not entirely linear over a wide temperature range (—40 to +70°C.). For variations of 40°C. within these limits they have proven entirely satisfactory in most cases.

Bimetal compensating capacitors are inherently large physically and the amount of compensation per degree of temperature variation is a function of the capacitance. This seriously limits their application.

Insulation and Insulating Supports

Wiring panels, standoff insulators and insulation on hookup wire have a very definite effect on the frequency stability of a tuned circuit. In general it is a function of the capacitance due to the material employed. Any design which minimizes the circuit capacitance should be favored, since capacitances due to insulation are quite likely to be a factor contributing to frequency instability. All high-poten-

Fig. 3. Indicating the degree of improvement in frequency stability which can be effected by careful receiver design.



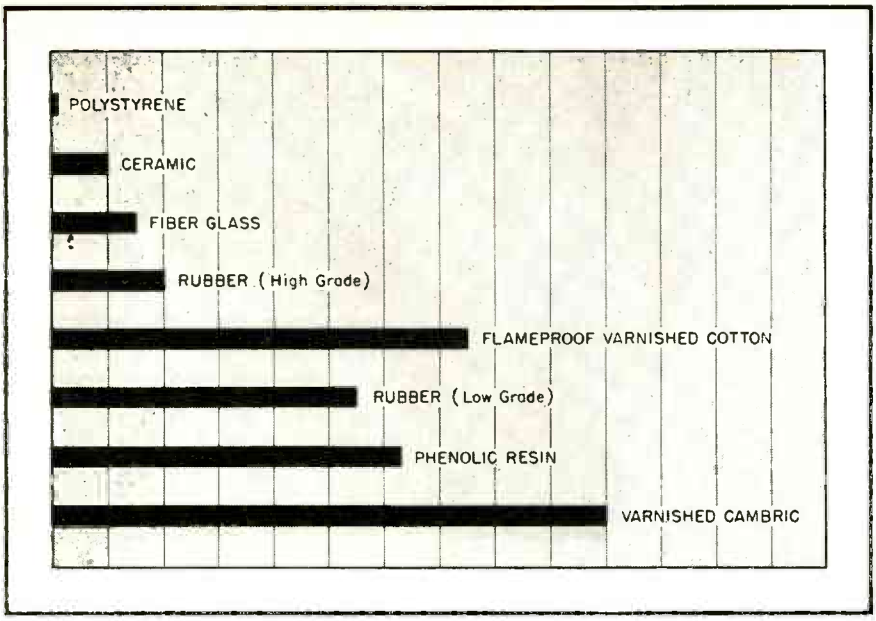


Fig. 4. The relative drift with different types of insulating materials for a given value of capacitance.

tial (r-f) leads should be short and as direct as practicable. Insulation should only be employed where it is impossible to support the wiring on ceramic standoff insulators. In cases where the lead must pass through a metal partition or chassis, the hole through which it passes should be of sufficient size to preclude the possibility of a short. Where space limitations do not permit large openings, ceramic feed-through bushings should be employed.

Phenolic insulation should be avoided, particularly in wave-band switches, terminal panels and coil forms, since this material "ages" over long periods of time when subjected to high temperatures. The results of tests on sample insulating materials showing the relative drift for a given value of capacitance are shown graphically in *Fig. 4.*

2. HUMIDITY

Humidity effects can be considered greater than those due to variations in temperature if good insulation is not employed. Components should be non-porous and possess a surface that does not easily wet. Even the slightest film of moisture has very good conductivity which obviously depreciates the value of the dielectric.

Unfortunately, some precautions taken to overcome humidity effects can seriously impair the operation, stability-wise, from a temperature standpoint. The wax impregnation of component parts to overcome high humidity conditions is not always the answer to the stability problem. In order to protect a component part from moisture by wax impregnation, it is necessary to apply a heavy coating (without pin holes) after the part has been thoroughly vacuum impregnated. A thin coat of wax is of little value, except on ceramic insulators, where it is used to help prevent formation of a film of moisture, because all commonly used waxes absorb water to a certain extent under conditions of high humidity. Once the moisture has penetrated the wax, it remains trapped for long periods of time, even under conditions of low relative humidity. Another objection to wax is that it adds additional dielectric losses to the circuit. If these losses were constant with temperature and time, they probably would not be too objectionable. However, the dielectric constant of wax is not constant with temperature. Volatilization of some of the constituents of waxes also usually occur when subjected to high temperatures over long periods of time.

Good humidity protection with a minimum of temperature instability can be obtained by treating the part with a polystyrene base varnish. This involves much more care and time than wax impregnation, but it has the advantage of adding less dielectric loss, absorbing practically no moisture and greater life.

Drift due to humidity can also be decreased by the use of desiccators such as silica gel. A small unit (about the size of a wet-type electrolytic capacitor) is available on the market for this purpose. They are provided with an internal heater so that it is only necessary to remove the unit when it needs refreshing and plug it into an ordinary power line receptacle. The internal heater will drive off the absorbed moisture and the unit is again ready for use. However, unless the equipment is nearly air-tight it will be necessary to refresh the desiccant quite often.

3. OPERATING PARAMETERS

The stability of an oscillator, neglecting changes in the constants of the frequency-determining circuit, is mainly dependent upon changes in the effective input and output impedances of the oscillator tube, the effective Q of the tank circuit, the harmonic content of the generated wave and the oscillator load. Variations in tube impedances are inversely proportional to the effective Q of the tank circuit. Therefore a low L/C ratio is desirable. This can be accomplished in two ways. The tank capacitance can be made large in comparison with the tube capacitance so that any change due to the tube is effectively swamped out, or the tube load on the circuit can be reduced by tapping down on the coil. Another method by which the frequency can be made substantially independent of operating parameters is by inserting suitable reactances in the grid and plate circuits and using a high resistance grid leak.[1]

Harmonics generated by the oscillator cross-modulate with each other and with the fundamentals to produce fundamental currents which are not in phase with the fundamental current due to normal operation. The resultant current affects the frequency of operation. Obviously, then, harmonics should be suppressed. Here again a high effective tank Q is desired since the impedance to harmonics will be at a minimum.

Since power-line voltages are not constant, and since a variation in the input voltage to the oscillator power supply will result in variations of the plate and heater potentials impressed on the oscillator, it is obvious that steps should be taken to overcome this difficulty. The power for the unit may be supplied either by a voltage-regulating transformer or a gaseous regulator tube may be employed to maintain constant plate voltage. A change in heater potential about the design center is not likely to cause serious trouble if the tube is not emission limited.

4. SHOCK AND VIBRATION

Shock and vibration can serious affect the frequency stability of an oscillator if the individual components

[1] Constant Frequency Oscillators — Llewellyn—*Proc. I.R.E.*, Dec. 1931.

and the complete unit are of poor mechanical design. This usually shows up as frequency modulation of the oscillator output signal. Special care should be taken in choosing components for the frequency-determining circuits. They should be mounted sturdily and as close together as practicable to provide short leads. Connections with right-angle bends are particularly susceptible to vibration and should be avoided if at all possible. The tuning capacitor should have a wide air-gap spacing with light plates and good bearings.

The effects of vibration can be minimized by the use of rubber cushionings in the form of shock mounts. For best vibration isolation, shock mounts should be placed in the plane of the center of gravity. Should this not be practical a compromise in the choice of the mount may have to be made to obtain the desired stability.

The load rating of a shock mount determines the load which it will carry for a predetermined deflection. Knowing the weight of the unit the proper size mounts are usually chosen to give a normal deflection under load of approximately 1/16 inch. To determine the percent of vibration transmitted through the shock mounts at any particular disturbing frequency it is necessary first to determine the natural frequency of the mounted assembly. This can quickly be found by the use of a vibration test table. Once this is known the percent of transmissibility may be calculated by the following formula.

$$\% \text{ vibration transmission} = \frac{1}{(F/f_n)^2} - 1$$

where F = disturbing frequency and f_n = natural frequency of the mounted unit.

Often the problem is not only to protect against simple vibration but also to protect against sudden shock. In such cases a compromise must be effected in choosing the proper mounting. Several types of shock mounts are available on the market so that no difficulty should be experienced in obtaining the proper type for a particular application.

Compensation

After all possible precautions have been taken to increase the frequency stability of an oscillator then, and only then, should the designer resort to methods of compensation. Fortunately, most component parts have a positive temperature coefficient so that a titanium dioxide capacitor can be used to correct the variations. Titanium dioxide capacitors are available with temperature coefficients ranging from 0 to -6.5×10^{-4} per degree Centigrade.

As mentioned previously, this type of capacitor does not have a linear characteristic curve over large ranges of temperature. Compensating capacitors should therefore be limited to a range of approximately 40°C. This can be readily accomplished by the use of a thermostat and a small ventilating blower. One disadvantage of such a system, however, is that the thermostat must be set at some point above the normal ambient temperature. Thus the equipment must first reach the thermostat temperature before any compensation is obtained. Care must also be taken properly to mount the blower to prevent an undue amount of vibration reaching the frequency-determination components of the oscillator.

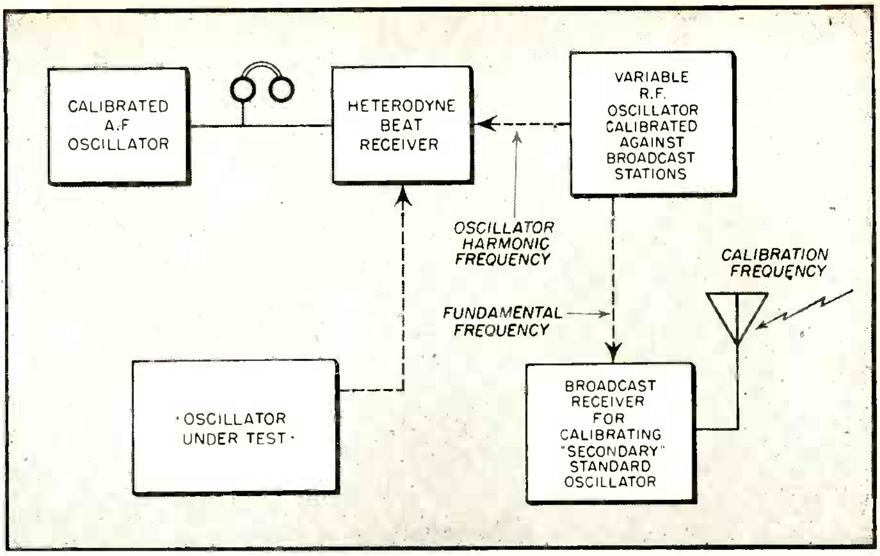


Fig. 5. Block diagram of a test setup for checking oscillator frequency drift.

Measurement of Stability

During the development of a stable oscillator, checks should be made on the components as they are designed. This can be accomplished readily by connecting the part to be tested in an oscillator circuit and then placing the component in a small oven, keeping the leads as short as possible. For best results the oscillator should be battery-operated to eliminate changes due to variation in line voltage. The oscillator should be adjusted to the frequency of a local broadcast station and a receiver used to pick up the heterodyne note. Once the test oscillator has been adjusted to zero beat with the station (this can be determined from the flutter of the received signal) the temperature of the heat box is increased and the change in the heterodyne beat note observed by comparison with a variable audio oscillator. The sign of the frequency drift may be determined at the end of the frequency check by tuning the test oscillator and noting which way it must be adjusted to obtain zero beat.

Broadcast stations are generally good sources of standard frequencies since they are required to maintain frequency to within 50 cycles of the assigned value. The higher power stations are usually within 10 cycles of their assigned frequency.

Assuming the individual parts have been checked and found satisfactory the next step is to mount them in the final chassis and case. When the frequency of the oscillator is within the broadcast band it is only necessary to repeat the above procedure against time. Should the oscillator frequency be below the broadcast band, harmonics of the oscillator under test may be used. However, if the oscillator frequency is above the broadcast band it will be necessary to employ a somewhat different technique.

A method frequently used is shown schematically in *Fig. 5.* An auxiliary oscillator whose frequency has been determined by heterodyning against a broadcast station or other reliable source is coupled to a receiver so that a beat note is obtained between it and the oscillator under test. It is simply a matter of tuning the oscillator under test to zero beat with the "secondary" standard and measuring the change in beat note against time by comparison with a calibrated audio oscillator. Frequent checks should be made of the "secondary" standard to insure that it has not drifted in frequency.

Much more elaborate methods have been described from time to time in various engineering publications, but with care the method described above is capable of very good results.

CLASS C AMPLIFIERS

CORTLANDT VAN RENSSELAER

The Principles of Class C Operation and their Application to the Design of Practical Amplifiers of this Type

FOREWORD

★ The purpose of this paper is to present that pertinent information which relates to the operation and design of Class C amplifiers. There is a general discussion of the voltage and current relations, which leads to a treatment of the exact method for determining the operating characteristics of any Class C amplifier. An attempt has been made to treat the subject fundamentals as completely as possible without including material related only indirectly to the subject. A bibliography of references to Class C amplifier analysis is included.

PART I

★ Vacuum-tube amplifiers are graphically analyzed with a set of curves known as static characteristics which relate grid voltage, plate voltage, and plate current. These may be plotted with any pair of the three parameters as axes. In the most familiar case, the curves are drawn for given values of grid voltage on axes of plate voltage and plate current. Such a set of static characteristics for a typical triode tube is shown in *Fig. 1*.

Class A Operation

To consider the operation of this tube, a d.c. plate voltage, E_b, and a grid bias voltage, E_c, are chosen such that the quiescent point, or point of static operation, is at A on the figure. Now if a sinusoidal grid voltage, e_s, is applied as shown, the instantaneous plate voltage, e_p, and the instantaneous plate current, i_p, will follow the excursions of instantaneous grid voltage — provided that the grid voltage does not increase beyond the static curve of zero grid voltage and does not exceed the value for cutoff of plate current. Under these conditions, the instantaneous values of grid voltage, plate voltage, and plate current are proportional and may be related by a straight line, $A''AA'''$, on the static characteristics. This line is known as the load line.

This condition, defined as Class A operation of a vacuum tube, is characterized by minimum distortion of the driving voltage as it is reproduced in the plate circuit, and by a low conversion efficiency of d.c. to a.c. power. A higher conversion efficiency may be obtained at the expense of distortion by extending the peak value of the grid voltage considerably beyond the limits stipulated in the last paragraph. For illustration of this condition, which is defined as Class C operation, *Fig. 1* has been reproduced in *Fig. 2* with a larger

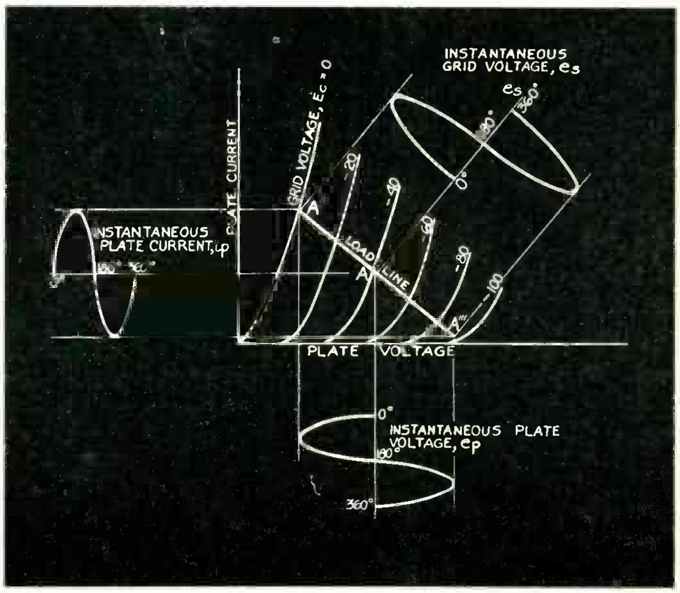


Fig. 1. Static characteristics and instantaneous voltages and currents for Class A operated 2A3.

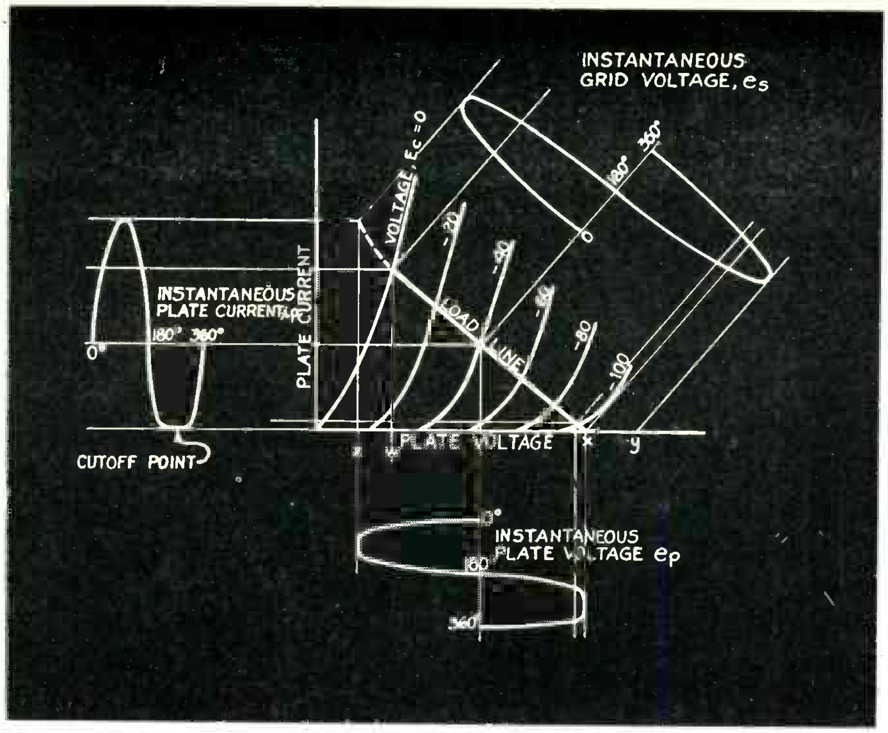


Fig. 2. Static characteristics and instantaneous voltages and currents for Class C operated 2A3.

value of instantaneous grid voltage. One should note that a distortion of the instantaneous plate voltage and plate current results.

Class C Operation

Between points *x* and *y* of the driving cycle in *Fig. 2,* the grid voltage is sufficiently negative to completely cut off the plate current. As a consequence, the plate current flows in cyclic pulses. From point *w* to point *z* of the driving cycle, the grid is at a more positive potential than the cathode. Therefore, some of the current which would normally be drawn from the cathode by the plate is diverted to the grid, resulting in a non-linearity of plate current with respect to driving voltage. A pulse of current will flow between the cathode and grid during this portion of each cycle.

In Class A operation of an amplifier, where grid voltage excursions are maintained within fixed limits, the d.c. power input to the amplifier maintains an average value equal to the d.c. plate voltage times the d.c. plate current at the quiescent point. However, when the driving voltage is increased for Class C operation, and the plate current is caused to flow in pulses, the average value of the plate current, and consequently of the power input, decreases, while the quantity of useful power converted by the amplifier increases. As a result, the efficiency of the amplifier is materially increased.

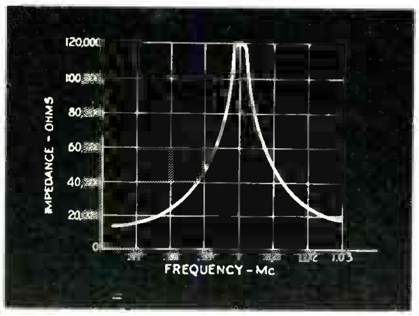


Fig. 3. Impedance of a parallel resonant circuit as a function of frequency.

A general criterion for vacuum-tube operation is that the output signal shall faithfully reproduce the input signal. It is obvious that the instantaneous plate voltage produced by driving the grid to a positive potential does not resemble the sinusoidal input voltage. Analysis will show that this distorted plate voltage is the sum of a number of harmonically related sinusoidal voltages, the most prominent of which is of the driving-voltage frequency. If a means is provided for selecting from this group of voltages the component of driving voltage frequency, the input signal will be reproduced in the output. This is accomplished by inserting a parallel resonant tuned circuit in series with the d.c. supply to the plate.

The impedance characteristic as a function of frequency for a parallel resonant circuit is shown in *Fig. 3.* One can see that such a circuit will short out a voltage of any frequency far removed from the resonant frequency of the circuit. For this reason, only a voltage of frequency near the resonant frequency of the circuit can be developed across it. Consequently the action of the parallel circuit on the plate voltage of the tube will be that of eliminating the distortion shown in *Fig. 2.*

It should be emphasized that this tuned circuit affects only the plate voltage. Plate current will continue to pulsate in the presence of the circuit since a parallel resonant circuit has little effect on the current which flows through it.

It is evident that an amplifier employing such a tuned circuit can function only at a single frequency. For this reason the Class C amplifier is used almost solely in the production of radio-frequency power.

Resonant Circuit

One may wonder how it is possible that a current flowing during only a portion of each cycle is capable of producing a continuous power output from the amplifier. An explanation for this likens the resonant circuit to a flywheel, which may be used to provide a continuous power from a pulsating source such as a gasoline engine. The more exact explanation considers the property of the inductance and capacitance of the circuit to store energy while the current pulse flows, and to release it when needed during the remainder of the cycle.

The circuit for a typical amplifier is shown in *Fig. 4.* A tuned circuit must be included in the grid circuit of the amplifier to maintain a sinusoidal driving voltage in the presence of grid current pulses. A cycle of the grid voltage, and another of the plate voltage developed across the resonant circuit have been plotted on a common time axis in *Fig. 5* with resulting grid and plate current pulses. The factors

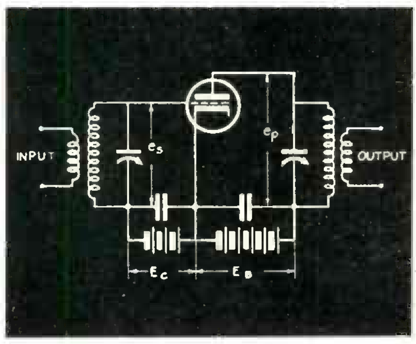


Fig. 4. Schematic diagram of typical Class C amplifier.

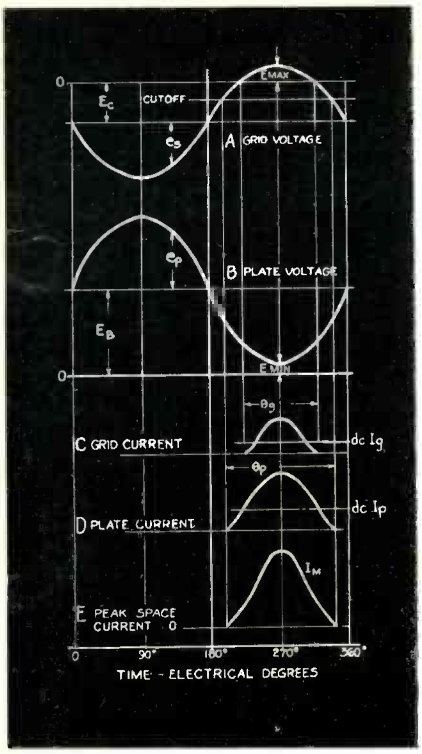


Fig. 5. Voltage and current relations in a typical Class C amplifier.

available for the analysis of the circuit of *Fig. 4* are shown in *Fig. 5.* They are:

1. E_c, d.c. grid bias voltage.
2. e_s, instantaneous value of sinusoidal grid voltage.
3. *Emax,* peak positive grid voltage.
4. E_b, d.c. plate supply voltage.
5. e_p, instantaneous value of sinusoidal plate voltage.
6. *Emin,* minimum instantaneous plate voltage.
7. θ_p, electrical period during which plate current flows.
8. θ_g, electrical period during which grid current flows.
9. I_g, d.c. or average grid current.
10. I_p, d.c. or average plate current.
11. I_m, peak space current.

The d.c. bias voltage, E_c, is impressed between the grid and cathode to maintain the quiescent point at a position which will allow the correct positive and negative excursions of grid voltage for Class C operation. The a.c. driving voltage, e_s, is superimposed on the bias voltage. The peak positive value that it attains over the cycle, *Emax,* is equal to the peak value of the driving voltage minus the grid bias. The voltage at the plate of the tube under static conditions is the d.c. supply voltage, E_b. During the cycle of driving voltage, the instantaneous plate voltage, e_p, increases to almost twice the d.c. supply voltage and decreases almost to zero. The minimum voltage reached by the plate over the cycle, *Emin,* is equal to the peak plate voltage minus the d.c. supply voltage.

The pulse of plate current flows during that portion of the cycle when the grid voltage is more positive than cutoff value. The interval of this pulse, θ_p, is expressed in electrical degrees. A complete cycle is 360 electrical degrees. The grid current pulse occurs during that portion of the cycle when the grid is more positive than the cathode. This pulse interval, θ_g, is of shorter duration than the interval θ_p. It is also expressed in electrical degrees.

The magnitude of the grid and plate current pulses averaged over an entire cycle yields the d.c. grid and plate currents, I_g and I_p. The sum of the peak a.c. grid and plate currents is equal to the peak space current, I_m. This is the maximum instantaneous emission to which the cathode is subjected.

Power Calculation

The calculation of power input, power output, and driving power for steady state operation requires that a means be available for determining the exact shape of the grid and plate current pulses. The most convenient method for determining pulse shapes is to plot them point by point from a straight load line of operation such as that in *Fig. 1.* However, the plate current, since it pulsates, is not a linear function of the grid voltage as is the plate current of a Class A amplifier. Consequently the load line will be curved on a graph with axes of plate current and plate voltage. But the plate voltage and grid voltage are proportional in a Class C amplifier. It is therefore possible to re-plot the static characteristics on axes of grid voltage and plate voltage with curves drawn for constant values of plate and grid currents. Such characteristics, called constant curves, are particularly well suited to this application.

The use of constant-current curves in Class C amplifier analysis was first proposed by I. E. Mouromtseff and H. N. Kozanowski (see bibliography). These curves are available for certain transmitting tubes. When unobtainable, they may be re-plotted point-by-point from plate-current, plate-voltage characteristics, which are available for all tubes.

A typical set of constant-current curves for a transmitting triode, with driving voltage, plate voltage, and current pulses properly oriented is shown in *Fig. 6.* One should note that in the practical application of the diagram, only the portion of this figure including the current curves would be required.

[*To be concluded*]

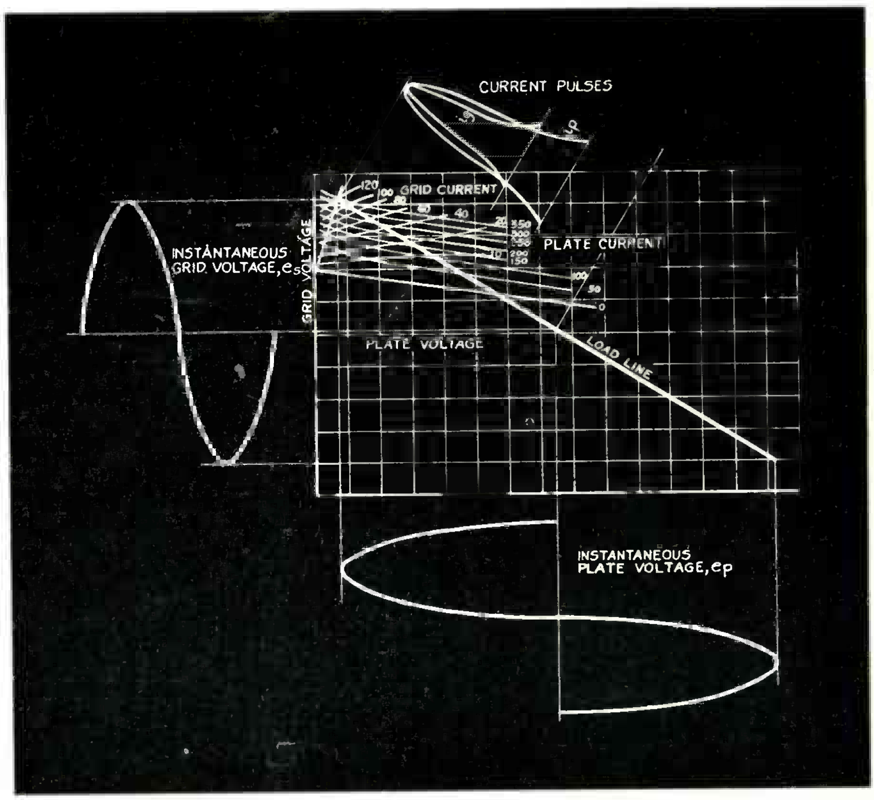


Fig. 6. Voltage and current relations on constant-current curves for a transmitting triode.

RADIO DESIGN WORKSHEET

No. 20—BRIDGE BALANCE ERROR; MUTUAL INDUCTANCE BRIDGE; UHF WIRE RESISTANCE

BRIDGE BALANCE ERROR

Problem: *Investigate the error in balance of a Wheatstone bridge due to stray impedances, such as stray capacitance of the ratio arms to ground.*

Solution: In the bridge circuit shown in *Fig. 1*, A and B are the fixed ratio arms, C the variable ratio arm, X the unknown arm to be measured, C_1 and X_1 the stray impedances.

If C and X are disconnected from the circuit, then the bridge can be balanced by adjusting C_1 or X_1. At balance we have for this condition:

$$A/B = C_1/X_1$$

C_1 and X_1 are often small variable capacitors deliberately inserted and adjusted in exactly this manner to balance out stray capacitances which might otherwise result in errors at balance.

Connecting arms C and X back in the circuit and rebalancing without disturbing the previous balance, we have at balance:

$$\frac{A}{B} = \frac{C_1C'}{C_1+C'} \times \frac{X_1+X}{X_1X}$$

where C' is the new value of this arm

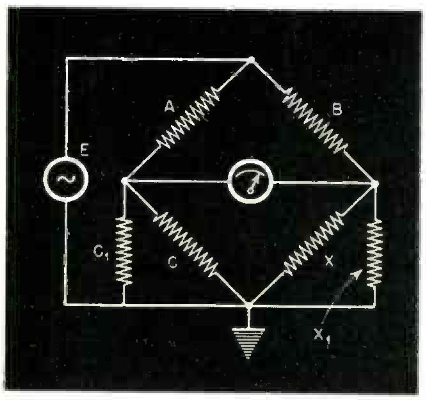


Fig. 1.

at balance. Reversing the arms X and C and rebalancing, we have:

$$\frac{A}{B} = \frac{C_1X}{C_1+X} \times \frac{X_1+C''}{X_1C''}$$

where C'' is the new value of arm C at balance. Eliminating C_1 and X_1 results in:

$$X = \sqrt{C'C''}$$

It is thus evident that by virtue of the three balances discussed above, the value of the unknown impedance X can be expressed in terms of C only and independently of the fixed ratio arms A and B. Assume (as is usually the case) that $A = B$ nearly. Then:

$$C'' = C\ (1+K)$$

Whence we have:

$$X = \sqrt{(C'')^2\,[1+K]} = C''\ [1+K/2]$$
approximately

if the constant K is very small compared to 1.

Now the original balance with C and X removed from the circuit is seldom pronounced due to the fact that C_1 and X_1 are usually very high impedances compared to A and B, with the result that a very small amount of energy is delivered to the bridge circuit. Consequently, an error in this balance may occur. To determine the extent of such an error, again assume $A = B$.

Solving the above equations for C_1 and equating yields:

$$X = \frac{2\,C'C''}{C'+C''}$$

which is independent of the original balance. Again let:

$$X = C'\ (1+K)$$

we find that:

$$X = C''\ (1+K/2)$$

From the above discussion it appears that the procedure of reversing arms C and X and determining the geometric mean value (i.e., square root of the product) of the two readings at balance will yield a value of the unknown impedance X which is independent of slight errors both in the stray impedance balance and in the fixed ratio arms. This is not only a conventional means of checking a unity-ratio Wheatstone bridge but is also valuable, even though the bridge arms are slightly out of balance, in arriving at a most probable value of the unknown impedance. The above derivation is intended to justify the method by showing that it yields accurate results.

MUTUAL INDUCTANCE BRIDGE

A common form of mutual inductance Wheatstone bridge, of which there are several well-known types, is illustrated in *Fig. 2*. In some circuits mutual inductances are balanced against each other, in others against a self-inductance or a capacitance. The circuit shown employs a mutual in-

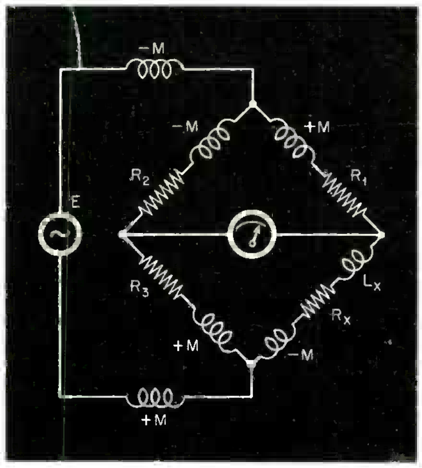


Fig. 2.

ductance to balance a mutual inductance.

At balance we have:

$$\frac{R_1+j\omega M}{R_2-j\omega M} = \frac{R_x-j\omega(L_x+M)}{R_3+j\omega M}$$

But:

$$R_1R_3+j\omega M(R_1+R_3)-\omega^2M^2 =$$
$$R_2R_x-j\omega(L_xR_2+MR_3)-\omega^2ML_x-\omega^2M^2$$

Whence:

$$R_1R_3-R_xR_3+\omega^2L_xM+j\omega M$$
$$(R_1+R_2+R_3+R_x)+j\omega L_xR_2=0$$

Equating real and imaginary terms results in:

$$R_1R_3-R_xR_3-\omega^2L_xM=0$$
$$-M(R_1+R_2+R_3+R_x)=L_xR_3$$

Whence:

$$L_x = \frac{R_1R_3}{R_2}\left[\frac{\dfrac{1}{R_2}+\dfrac{R_1+R_2+R_3}{R_1R_3}}{1+\dfrac{\omega^2M^2}{R_2^2}}\right]$$

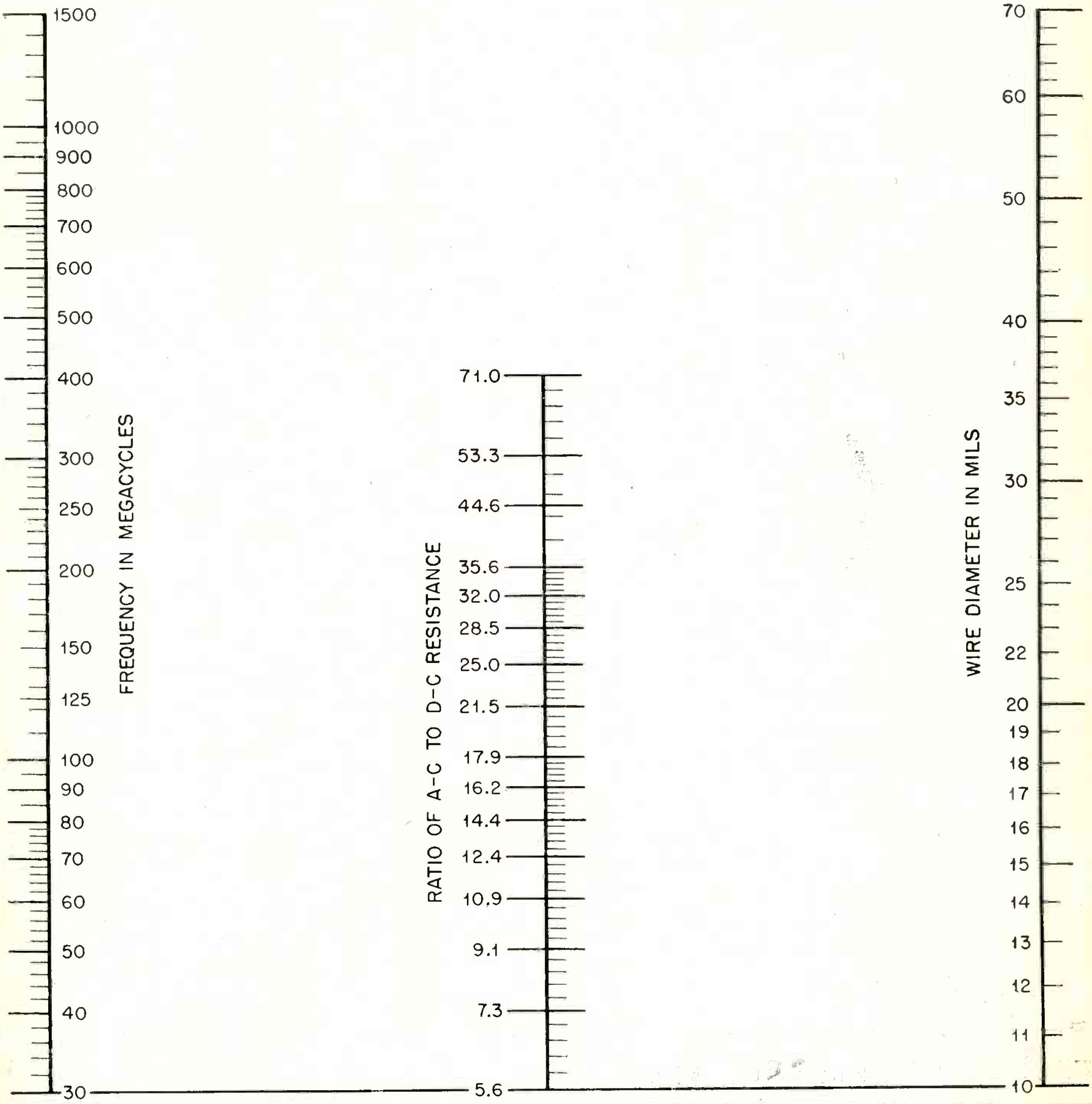
$$R_x = \frac{R_1R_3}{R_2}\left[\frac{1-\dfrac{\omega^2M^2(R_1+R_2+R_3)}{R_1R_2R_3}}{1+\dfrac{\omega^2M^2}{R_2^2}}\right]$$

[*Continued on page 34*]

H-F TO D-C WIRE RESISTANCE CHART

By R. G. MIDDLETON

This chart gives the ratio of a-c to d-c resistance of a copper wire whose diameter in mils is specified, when used at high frequencies. By laying a straight edge from the point on the frequency scale designating the frequency in megacycles at which the wire is to be used to the point on the wire diameter scale representing the diameter of the wire, the point of intersection on the center scale will show the ratio of the a-c to d-c resistance.



PRODUCTION SPEED-UPS

Mike Krafter, left, and Max Dose, of Zenith's punch press department, who have received awards for their suggestions on speeding or improving the production of war radio equipment. Thousands of others are aiding production by a display of American ingenuity.

CRYSTAL-HEATING OVEN

By JOHN M. GILLESPIE
Western Electric Co., Hawthorne Works

"Inasmuch as the method of heating the "DT" type crystals is inadequate, an improvement should be tried. I have designed and constructed a small electric oven, thermostatically controlled, which will give a more even heat than is obtained by methods now used."

The standard procedure was to heat the crystal under test to raise the temperature from minus 30 degrees Centigrade to plus 50 degrees, using small electrically heated blowers similar to hair-driers. As one requirement for the test was an even gradient, the blowers caused some trouble. Mr. Gillespie's oven was tried out and the model worked so successfully that orders were placed to equip all 200-kilocycle "DT" test positions with the new heater.

Adoption of Mr. Gillespie's oven is still incomplete, as a sufficient quantity have not yet been constructed. As indicated by trial of the model, better checks are being obtained and there is evidence that rechecks will be reduced materially.

The device consists of a small box made of sheet asbestos and provided with air vents in top and bottom. The front panel of the box is cut out to allow insertion of the crystal, which is held on a clip on the face of the test set, the box being of such dimensions as to permit its proper placement over the crystal under test.

Below the crystal position, and so placed as to allow air convection currents to bathe the crystal, are fixed two commercial type cartridge heating elements. A thermostat control is provided to regulate the temperature.

★

VACUUM-TUBE INSPECTION

By WILLIAM GOBLE
Radio Corp. of America, Harrison Plant

★ This concerns a mount short-checking device for midget tubes. Previously all mount shorts on these tubes were discovered after testing and the tubes discarded. Now, by a testing operation before seal and exhaust, the shrinkage items are discovered and a large percentage of these mounts are repaired and sent through as good tubes.

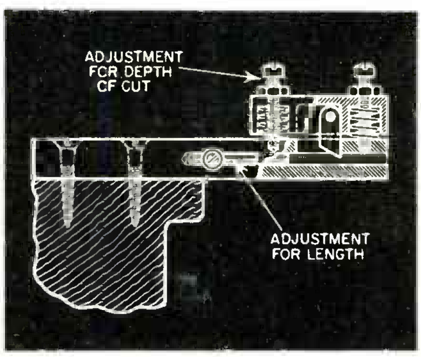
Yearly saving on improvement in overall shrinkage has been estimated as $8345. This figure means approximately 9500 extra tubes will be produced annually.

★

SHIELDING STRIPPER

By WALTER I. LINDALL
Submarine Signal Company

★ The old method of using scissors for removing the metal braid shielding from wire ends required one hour and thirty minutes to remove the shielding from 100 wire ends, or 55 seconds each.



Details of wire shielding stripper.

The accompanying sketch shows the details of an automatic stripper to accomplish the same purpose.

The time required for the same quantity with the improved stripper is 25 minutes, or 15 seconds each—a saving of 73% production time.

★

RADIOTHERMICS INCREASES PRODUCTION

★ Some war production operations have been speeded up by as much as 100 to 2500 per cent by the use of electronic devices for industrial heating, it was revealed by Henderson C. Gillespie of the RCA Victor Division, Radio Corporation of America, at the October meeting of the New York Electrical Society.

Introduction of radio-frequency heating through electronic devices to prepare compregwood propeller blades for molding reduced the time required for the molding cycle from seven hours to three. One electronic device stepped up the soldering of bases of radio capacitor cans from 100 cans an hour to 2,500.

In addition to soldering and the preheating of wood and plastics for molding, Gillespie said, radio-frequency heating applied through electronic de-

[*Continued on page 54*]

D.S.C., and S.C.C., and 12 to 36-gauge D.C.C. The rule is also engineered to indicate: *turns-per-inch* from 10 to 160; *inductance* from 0.1 to 15 microhenrys; *capacitance* from 3 to 1,000 micromicrofarads; *frequencies* from 400 kilocycles to 150 megacycles with equivalent wavelengths in meters.

Priced at 25c each from Allied Radio Corporation, 833 West Jackson Boulevard, Chicago 7, Ill.

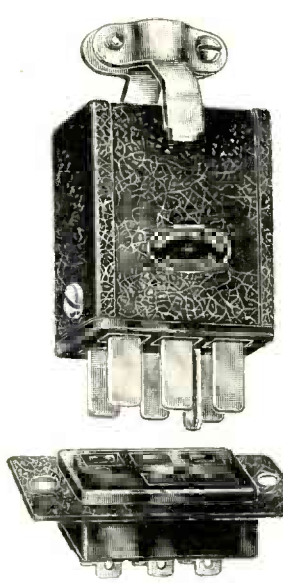
★

NEW JONES PLUGS AND SOCKETS

By increasing the leakage path and incorporating a new type of contact, the current characteristics of a new series of Multi-Contact Plugs and Sockets, designed by Howard B. Jones, has been materially improved. This new line is known as the #2400 Series and is interchangeable with their present #400 Series.

The Plug and Socket bodies are of BM120 Formula Bakelite moulded according to Navy Specifications 17P4, having high insulating qualities with maximum strength. Sizes range as follows: 2, 4, 6, 8, 10 and 12 contacts and are furnished with either a shallow bracket for flush mounting, deep bracket for recessed mounting or with metal cap with or without cable clamps. As both the Plug and Socket bodies are of identical size, they are interchangeable with either cap or bracket.

An entirely new type of socket contact has been developed. Four individual flexing surfaces make contact with each Plug prong. Due to the design, each segment makes positive contact over practically its entire surface providing increased contact area and smoother action. Projections on all four sides of the socket contact, as shown in the illustration, lock it into position when forced into the contact pocket and prevents any up and down movement whatever.



Both the Plug and Socket contacts are mounted into recessed pockets. Barriers surrounding the contacts greatly increase the contact to contact and contact to ground distance thereby increasing the voltage rating.

The Socket contacts are of phosphor bronze, silver plated. The Plug contacts are of brass ¼ x $\frac{1}{16}$" silver plated.

A shoulder extending around the face side of the Bakelite bodies presents a finished appearance when mounted in either a bracket or cap.

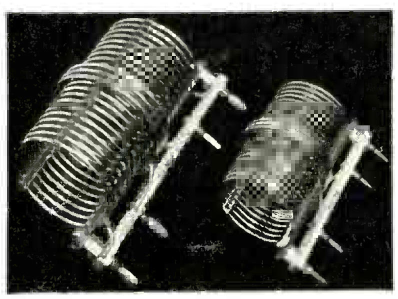
Thought was given to the present use of their #400 Series Sockets when this new series was developed, as a #2400 Plug will fit corresponding #400 Socket and #2400 Socket will fit corresponding #400 Plug.

Further information can be had by writing Howard B. Jones, 2460 W. George Street, Chicago 18, Illinois.

★

B&W COILS FOR RADIOTHERMICS

A broad assortment of standard coils for electronic heating applications, plus specialized facilities for the production of non-standard types, is offered by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.



Standard B & W heavy duty coils meet any electronic heating applications up to 1 kw. Of the well-known B & W "Air Wound" design (no solid winding form) these coils are light in weight, adaptable to numerous mounting arrangements, are exceptionally sturdy, and have low dielectric loss. Equally important, they are wound to uniform pitch, offer utmost design adaptability, and lend themselves readily to mechanical and electrical revisions in circuits that must be adjusted, or which are still in the experimental stage. Many special coils are also being produced regularly for electronic heating uses.

Catalog will be sent upon request to manufacturer.

★

G.E. INSULATION-RESISTANCE METER

A new electronic insulation-resistance meter for measuring the resistance of insulation in apparatus during the manufacturing process, thus revealing imperfections before the product leaves the factory, has been announced by the Special Products Division of the General Electric Company. The instrument is also desirable for checking the condition of insulation of apparatus in service, and for use in the laboratory for rapidly testing a wide range of production or experimental samples of insulating material.

The instrument consists of a conventional electronic rectifier, a Thyrite bridge circuit, and an electronic-tube voltmeter. It is available in two types. One

type has a scale calibrated from 1 to 50 megohms and measures resistance at 500 volts d-c; the other type has a 0 to 20,000 megohm total range and measures resistance over four different resistance intervals—from 0-5 megohms at 0-250 volts d-c and 5-200, 50-2000 and 500-20,000 megohms at 500 volts d-c. Any range may be quickly selected by a panel-mounted rotary switch.

The complete instrument is small, light in weight, and economical to operate. It is enclosed in a portable walnut case, the cover of which may be removed so that the instrument can be placed on a shelf or stand in full view of the operator. In addition, the well-illuminated dial permits the scales to be read easily even in poorly lighted locations.

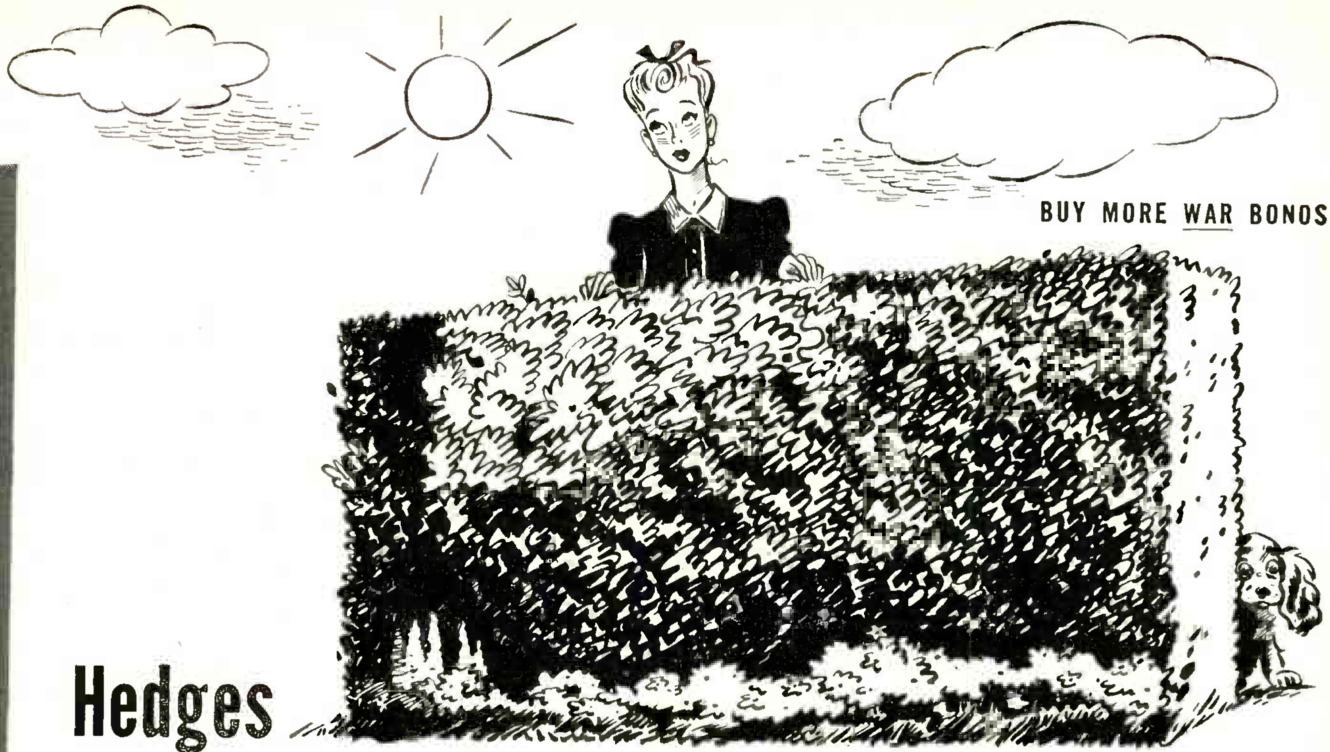
★

STRUTHERS-DUNN SNAP-ACTION RELAY

A new Struthers-Dunn Relay, Type 79XAX, is designed for a variety of electronic circuit applications calling for a highly sensitive unit having snap-action contacts. Contact pressure of this relay remains constant despite slow variations in the coil current in which it is connected. Then, when the coil current reaches a certain point, the contacts operate with a positive snap action.

The relay operates on as little as 10 milliwatts in its coil circuit, and is recommended for dozens of highly sensitive

[*Continued on page 64*]



BUY MORE WAR BONDS

Hedges

There are a number of requirements for new transmitter equipment which broadcast station managers, their engineers and consultants must always bear in mind.

1. The equipment must function in a manner consistent with FCC performance requirements.

2. The equipment must meet FCC safety requirements for the protection of operators.

3. The equipment design must include safeguards which effectively protect it from damage due to overload.

4. The equipment design must include maximum assurance against failure during broadcasting.

RCA provides these assurances—"hedges" against trouble.

From microphone to antenna, RCA offers the broadcast station *complete* equipment of coordinated design—assuring superior performance, maximum operating economy and convenience, and *definitely fixed responsibility*.

RCA Victor Division, RADIO CORPORATION OF AMERICA, *Camden, N. J.*

RCA

RCA BROADCAST EQUIPMENT

★ *RCA's line of apparatus includes more of the equipment necessary for the efficient operation of modern broadcasting stations than that of any other manufacturer.*

★ *RCA is the only broadcast equipment supplier manufacturing a complete line of measuring and test equipment.*

Q. & A. STUDY GUIDE

C. RADIUS

Methods of Overcoming Problems Associated With the Design of Program Transmission Lines

STUDIO EQUIPMENT—III

Program Transmission Lines

22. What is the purpose of a line equalizer? (IV-44)

23. Draw a diagram of an equalizer circuit most commonly used for equalizing wire line circuits. (IV-45)

24. Why is it generally unnecessary to equalize a short wire line program circuit? (IV-47)

25. Why are program circuits, using telephone lines, usually fed at a level of about 12 milliwatts? (IV-43)

Elements of a Telephone Line

In order to understand why telephone lines need to be equalized it will be necessary to state some facts regarding the propagation of electric waves along conductors of considerable length.

Telephone lines are used as a studio-to-transmitter link, and as a station-to-station link in network broadcasting.

In general two types of wire lines may be used: the open-wire line in which the two conductors may be separated by as much as 18 inches, and the cable pair in which the paper-insulated conductors are twisted together and are enclosed with other similar pairs in a lead sheath. Both types of line must be able to transmit audio frequencies from 30 to 8000 cycles with negligible distortion as far as the ear is concerned.

Lines of this nature are made up of continuously distributed parameters: series resistance *R*, series inductance *L*, shunt capacitance *C*, and shunt conductance *G*. *Figs. 3* and *4* give these constants for a mile of open-wire and cable respectively. For analysis at audio frequencies we may think of the line as being made up of recurrent networks of the type indicated in *Fig. 1*.

Characteristic Impedance and Reflection

If we measure the impedance, $Z = R + jX$, at the input terminals of a long line (several miles) we find that at audio frequencies the value of this impedance is practically independent of the termination, that is, of the load at the receiving end of the line. This impedance is known as the characteristic impedance, Z_o, of the line. The value of this impedance for the two types of lines is given in *Figs. 3* and *4*.

If a line is not terminated in its characteristic impedance, there is a discontinuity at the end of the line. Generally, the termination of the line is pure resistance. The wave travels along a line of impedance Z_o and then continues on in a purely resistive circuit. This is quite similar to the case of light traveling through air into water. At the surface where the light leaves one medium and enters another, some of the light energy is reflected. Similarly, in the case of the electric wave traveling along a line of impedance Z_o and continuing into a load of impedance Z_L, the ratio of the power received to the power that would be received on a smooth circuit, that is

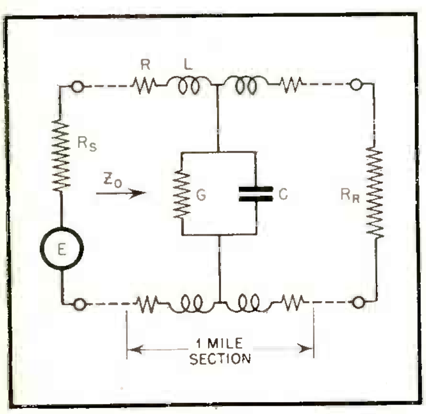


Fig. 1. Elements of a telephone line.

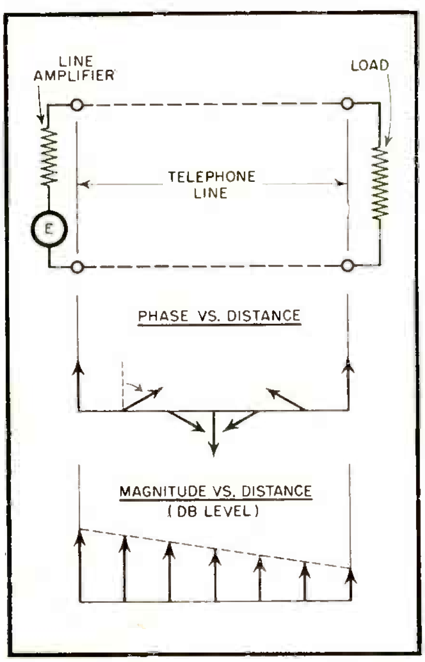


Fig. 2. Magnitude and phase of voltage.

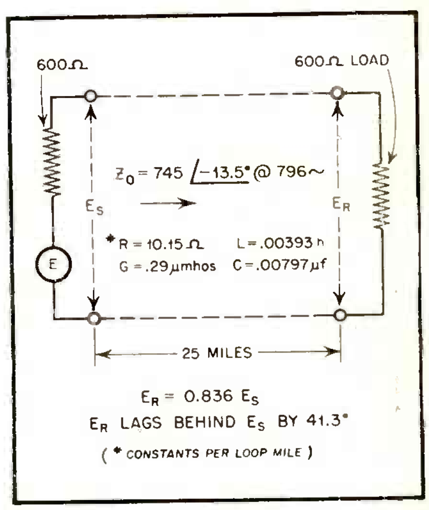


Fig. 3. No. 12 gauge open-wire line.

where $Z_L = Z_o$, is given by the formula

$$\frac{4\ Z_L\ Z_o}{(|Z_L + Z_o|)^2}$$

This is called a reflection loss. From *Fig. 3* it is apparent that two such losses exist: one at the junction of the line-amplifier and the telephone line, and the other at the junction of the telephone line and the load resistance. Using a 600-ohm output impedance of the line-amplifier at the studio and a 600-ohm input impedance of the low-level audio amplifier at the transmitter, the value of this ratio is very nearly unity at 1000 cycles. Hence, in this setup we can neglect the reflection losses due to the insertion of the telephone line between the resistive generator and resistive load.

Line Losses

If the line contained only series resistance and shunt conductance, all frequencies within the audio range would be attenuated by the same amount, the magnitude depending only on the length of the line.

The existence of series inductance and shunt capacitance both produce a voltage across the load at the receiving end which lags behind the impressed voltage at the sending end; that is, the maximum values occur later than they would if the line contained only *R* and *G*. The voltage wave has been slowed down or we can say that the velocity of propagation has been reduced. This phenomenon is a function of the frequency. If the maximum values of a 1000-cycle and 5000-cycle sine wave occur at the same time at the input of 25 miles of No. 19 cable they will be separated by 220 degrees at the end of the line. This is equivalent to saying that the 5000-cycle wave reaches the end of the line 0.28 milliseconds after the 1000-cycle wave. For lines used in connection with radio broadcasting this is not a source of noticeable distortion.

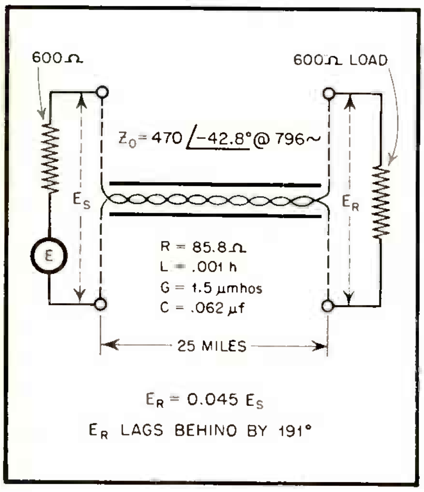


Fig. 4. No. 19 gauge cable line.

It is troublesome, however, in the case of long loaded lines used in telephonic communication where the velocity of propagation is very low and must be corrected with a phase-correcting network. *Fig. 2* indicates the rotation of the voltage vector as a function of the distance along the line.

Since the series reactance increases and the shunt reactance decreases with increasing frequency, the higher frequencies will be attenuated more than the lower frequencies. This is indicated by the solid line in *Fig. 5*. Between 500 and 5000 cycles there is an increase in the attenuation of somewhere in the order of 50 percent. Unless corrected, this loss seriously impairs the quality of transmission. In the case of open-wire line, atmospheric changes may noticeably alter the line response.

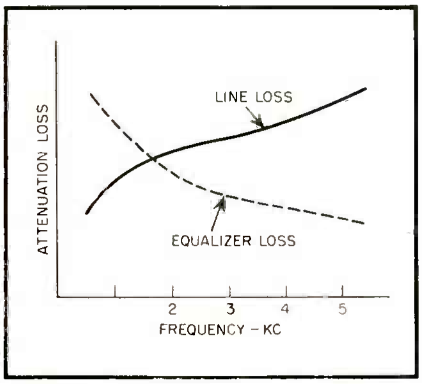


Fig. 5. Line and equalizer loss.

For all practical purposes then, the insertion loss produced by placing several miles of telephone line between the amplifier output and the load is primarily the attenuation loss caused by the impedance elements of the line.

Equalization

In open-wire and short cable lines the amount of attenuation distortion to be corrected is relatively small. In these cases a parallel resonant circuit, with a resonant frequency slightly above the highest frequency to be equalized, can be placed across the receiving end of the line as shown in *Fig. 6*. With proper adjustment of the series resistance *R* the attenuation-frequency characteristics can be made complementary to the line characteristics that produce the distortion. The loss of the line plus that of the equalizer will be substantially the same for all frequencies in the transmitted band. See *Fig. 5*.

In the low-frequency region where the equalizer produces substantial loss there will be a change of circuit impedance of sizeable value. This causes increased reflection losses and definitely limits the use of this simple equalizer.

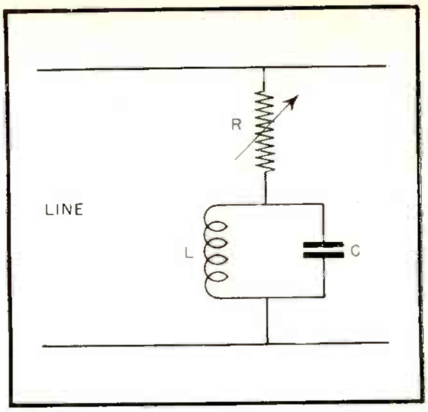


Fig. 6. Two-terminal shunt equalizer.

To equalize for relatively large amounts of attenuation distortion, a somewhat more complex equalizing network, in the form of a bridge T structure, may be used. This equalizer is designed to have a constant impedance over its entire frequency range. See *Fig. 7*.

Equalization by attenuation is best done at the receiving end of the line. This results in a more favorable over-all signal-to-noise ratio. Some broadcast stations have resorted to equalization by predistortion in which the line amplifier response is adjusted so that it is the inverse of the telephone line response. This increases the amplitude of the signal fed into the line. An excessive increase in the level of the energy fed into the line increases the strength of the magnetic field about the line and adjacent parallel circuits may be disturbed. This condition is known as crosstalk. By limiting the signal fed into the line crosstalk possibilities are greatly reduced. An excessive signal may also overload the repeater amplifiers on the long lines.

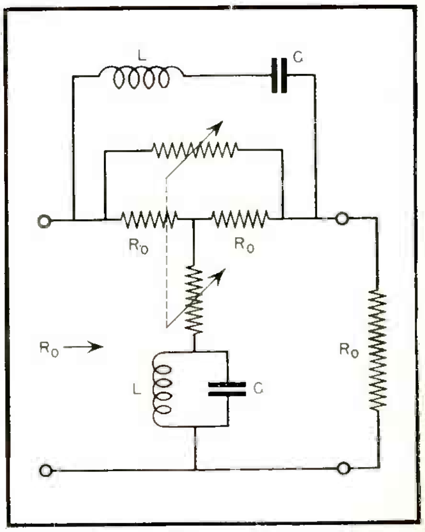


Fig. 7. Schematic diagram of a constant-resistance bridge T equalizer.

Dunlap and N. Rohats—*Electrical Engineer*, Vol. 62, May 1943, pages 231-234.

High-Speed Cathode-Ray Oscillography—J. H. Bryant and M. Newman—*Engineering*, Vol. 155, March 26, 1943, pages 241-242.

Measurement of Torsional Vibrations—R. Stansfield—*Inst. Mech. Eng. Journal & Proceedings*, March 1943, pages 175-193.

Measuring Coil Characteristics Without an Impedance Bridge — H. D. Brailsford — *Electronics*, Vol. 16, May 1943, pages 86-88.

Cathode-ray Oscillograph—Morris & Henley—Instruments Publishing Co., 1936.

Cathode-Ray Oscillographs—J. H. Reyner—Pitman, 1939.

The Cathode Ray Oscillograph in Radio Research — Watson-Watt, Herd & Bainbridge-Bell—His Majesty's Stationery Office, London, 1933.

The Cathode Ray Tube at Work—J. F. Rider — John F. Rider, Publisher, New York.

A Cathode Ray Frequency Multiplier—N. C. Jamison—*Physics*, Vol. 2, April 1932, pages 217-224.

Memoirs sur L'Étude Optique des Mouvements Vibratories — M. J. Lissajous — (Notes on Optical Studies of Vibrations) —*Annales de Chimie et de Physique*, Vol. 51, pages 147-157.

Wave Form Examination with the Cathode Ray Oscillograph—N. V. Kipping—*Electrical Communications*, Vol. 3, July 1924, pages 69-75.

Primary Radio Frequency Standardization by the Use of the Cathode Ray Oscillograph—G. Hazen and F. Kenyon—*Scientific Papers of National Bureau of Standards*, No. 489, Vol. 19, May 22, 1924, pages 445-461.

Improved Cathode Ray Tube Method for the Harmonic Comparison of Frequencies —D. W. Dye—*Proc. Phys. Soc.*, London, Vol. 37, 1925, pages 158-168.

Frequency Measurement with the Cathode Ray Oscillograph — F. J. Rasmussen — A.I.E.E., Vol. 45, November 1926, pages 1256-1265.

Frequency Measurements with Cathode Ray Oscillograph—F. J. Rasmussen—*Bell Lab. Record*, Vol. 4, April 1927, pages 281-284.

The Harmonic Comparison of Radio Frequencies by the Cathode Ray Oscillograph —T. S. Rangachari—*Exp. Wireless*, Vol. 5, May 1928, pages 264-6.

The Super-Position of Circular Motions —T. S. Rangachair—*Exp. Wireless*, Vol. 6, April 1929, pages 184-193.

A Method of Frequency Measurement with the Cathode-Ray Oscillograph — L. A. Wood—*Review Scientific Instruments*, Vol. 3, July 1932, pages 378-383.

Frequency Comparison with Cathode Ray Oscillograph — C. B. Fisher — *Electronics*, November 1933, pages 310-311.

Contronto di Frequenze Mediante Oscillografo a Raggi Catodici—S. Centineo—(The Comparison of Frequencies with the Cathode-ray Oscillograph)—*L'Electtrotec*, Vol. 20, December 25, 1933, pages 854-858.

Discussion of Lissajous Figures, *RCA Application Note No. 36*, 1934.

A Cathode-Ray Wavemeter for Decimeter and Centimeter Waves—Mong-Kang Ts'en —*Scientific Papers of National Research Institute of Physics*, Academia Sinica (Shanghai, China), Vol. 1, No. 6, March 1935, pages 1-17.

Cathode-ray Tubes and Allied Tubes — Technical Series TS-2, RCA Radiotron Company, 1935, pages 75-85—Bibliography.

Simple Circuits for Oscillographic Frequency Comparisons — B. Kurrelmeyer — *Review of Scientific Instruments*, Vol. 7, May 1936, pages 200-201.

Circuits for Oscillographic Frequency Comparison—H. J. Reich—*Review Scientific Instruments*, Vol. 8, September 1937, page 348.

Notes on the Calibration of Oscillators by Means of a Cathode-Ray Oscillograph—F. O. Roe—*Electrotechnics*—No. 13, September 1940, pages 59-62.

Tracing Two Characteristics on a Cathode Ray Oscilloscope—Millman & Moskowitz —*Electronics*, Vol. XIV, March 1941, page 36.

Versatile Oscilloscope — W. E. Gilson—*Electronics*, Vol. XIV, December 1941, page 22.

Cathode-Ray Frequency Modulation Generator — R. E. Shelby — *Electronics*, Vol. XIII, February 1940, page 14.

Improved Cathode Ray Oscilloscope Design—W. A. Geohegen—*Electronics*, Vol. XIII, November 1940, page 36.

Tube Used as Aircraft Instrument Indicator — *Electronics*, Vol. XIII, March 1940, page 36.

An Optical Harmonic Analyzer—H. C. Montgomery — *B.S.T.J.*, Vol. XVII, July 1938, page 406.

An Audio Frequency Response Curve Tracer—J. B. Sherman—*Proceedings IRE*, Vol. 26, No. 6, June 1938, page 700.

Cathode-Ray Engine Pressure Measuring Equipment — H. J. Schrader — *RCA Review*, Vol. II, October 1937, page 202.

Oscillographic Tube Characteristic Curves —H. M. Kozanowski and I. E. Mouromseff—*Radio Engineering*, Vol. XV, No. 1, January 1935, page 16.

The Cathode Ray Oscillograph—W. F. Diehl—*Radio Engineering*, Vol. XV, No. 6, June 1935, page 10.

A-F Band Response Oscilloscope — S. Bagno and R. Posner—*Radio Engineering*, Vol. XV, No. 6, June 1935, page 19.

The Cathode-Ray Oscillograph — J. B. Johnson—*B.S.T.J.*, Vol. XI, January 1932, page 1.

Braun Tube Hysteresigraph—J. B. Johnson—*B.S.T.J.*, Vol. VIII, 1929, page 286.

Extending the Usefulness of the Oscillograph in Circuit Testing—I. H. Gerks—*Bell Lab. Record*, Vol. VIII, No. 9, March 1929, page 352.

The DuFour Cathode-Ray Oscillograph—I. E. Cole—*Bell Lab. Record*, Vol. V, No. 5, January 1928, page 141.

Frequency Measurements with the Cathode-Ray Oscillograph—F. J. Rasmussen—*Bell Lab. Record*, Vol. IV, No. 2, April 1927, page 281.

The Cathode-Ray Oscillograph and Its Application in Radio Work—L. M. Hull—*Proceedings IRE*, April 1921, page 130.

"RADIO NACIONAL"

[*Continued from page 25*]

modulator unit proper uses two RCA-880 tubes, the same type as used in the power amplifier.

There are four crystal positions in each r-f channel. The crystal oscillator is followed by a doubler, three intermediate stages, and a driver stage using two RCA-827-R air-cooled Radiotrons. Low-power intermediate stages are tuned and reset by means of tap switches and variable capacitors. Excitation ratios are controlled by capacity-dividing circuits. Adjustment is simplified by the lack of transmission lines for interstage coupling.

Cooling System

The power amplifier proper is made up in two units for easy installation. The front section contains the two RCA-880 power amplifier tubes with associated water insulating coils, variable tank capacitor, variable neutralizing capacitor, filament transformers, and air blower.

Cooling water is supplied directly to the tube jackets through short ceramic pipes of small cross-section, thus reducing radio-frequency power loss in the water to a negligible amount. A motor-driven variable tank capacitor is used for tuning over a small frequency range. It consists of a single hinged plate at ground r-f potential operating in conjunction with two differentially variable plates which are attached directly to the tube jackets.

The differential variation is utilized for balancing the plate currents of the two tubes in push-pull. Spurious frequency circuits are minimized by the lack of any inductance between the plates of the tubes and the capacitor plates. The same holds true for the fixed neutralizing capacitor plates which are attached directly to the tube jackets.

The Tank Coils

The rear section of the power amplifier unit contains the tank coils and output circuits. A rectangular coil made up of 1-inch copper pipe covers the frequency range from 6 to 14 megacycles. Two turns are required for the lower frequency range. The lower turn is variable by means of a motor-driven control so that the tank capacitor tuning range can be augmented by variable inductance as well.

Above 14 megacycles the 1-inch copper pipe is replaced by a hairpin-type

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Society Journal, Vol. 62, November 1940, pages 2919-22.

Mullard Cathode Ray Oscilloscope—*Engineer,* Vol. 169, May 3, 1940, pages 421-22.

Multi-channel Delay Unit—W. H. Marshall and S. A. Talbot—*R. Sci. Instr.,* Vol. 11, September 1940, pages 287-289.

Multiple Sweep System for Cathode-ray Oscillography — S. A. Talbot — *R. Sci. Instr.,* Vol. 11, September 1940, pages 289-291.

Oscillographic Method of Measuring Positive Grid Characteristics—O. W. Livingston — *Proceedings IRE,* Vol. 28, June 1940, pages 267-268.

Oscillographic Technique for Measurements in a Network Analyser—D. M. Myers and W. K. Clothier—*Institute E.E. Journal,* Vol. 85, November 1939, pages 639-645.

Panoramic Reception: All Stations on Dial of Receiver may be Indicated Simultaneously on Cathode-ray Oscilloscope; Suited to Radio Navigation—*Electronics,* Vol. 13, June 1940, pages 14-15.

Radio Tube Solves Oscillograph Problem *Electrical World,* Vol. 113, May 18, 1940, page 1552.

Some Recent Developments in Impulse-Voltage Testing—C. M. Foust and N. Rohats—*Electrical Engineer,* Vol. 59, May 1940, pages 257-262.

Trapezium Distortion in Cathode-Ray Tubes—B. C. Fleming-Williams—*Wireless Engineer,* Vol. 17, February 1940, page 61.

Ultra - High - Frequency Oscillography; Electron Optical Spectral Analysis of Oscillations; Lissajous Figures—H. E. Hollman — *Proceedings IRE,* Vol. 28, May 1940, pages 213-219.

Vector-Response Indicator—B. D. Loughlin—*Electrical Engineer,* Vol. 59, June 1940, pages 355-357.

Visual Alignment Generator; Frequency-modulated Signal Generator—H. R. Myer —*Electronics,* Vol. 13, April 1940, pages 39-41.

Adapting a Commercial Cathode-Ray for Direct-coupled, Single-sweep applications —S. A. Talbot—*R. Sci. Instr.,* Vol. 12, February 1941, pages 100-101.

Application of an Electromagnetic Indicator to Internal Combustion Engine Problems—C. S. Draper, J. H. Lancor and L. Davis—*Journal of Aeronautical Sciences,* Vol. 8, November 1940, pages 7-16.

Bureau of Standards New High-speed Cathode-ray Oscillograph—O. Ackermann —*Instruments,* Vol. 14, July 1941, pages 205-266.

Cathode-ray Oscillograph; Type 208—Allen B. DuMont Labs—*R. Sci. Instr.,* Vol. 12, January 1941, pages 38.

Cathode-ray Oscillograph with Rotating-Drum Camera—E. G. Downie—*Electrical Engineer,* Vol. 60, November 1941, pages 984-986.

Combination Vacuum Tube Switch for Double-Trace Cathode-Ray Oscillograph-Audio-Amplifier and Mixer — H. K. Hughes and R. F. Loch—*R. Sci. Instr.,* Vol. 12, April 1941, pages 183-187.

Decimetric-Wave Oscillography; Abstract —Ganswindt and Pieplow—*Wireless Engineer,* Vol. 18, August 1941, pages 342-343.

Dynamic Balancing of Small Rotors by Means of the Cathode-Ray Oscillograph—A. Raspet and R. A. McConnell—*Electronics,* Vol. 17, August 1941, pages 70-71.

Electronic Switch and Square Wave Oscillator—J. R. Cosby and C. W. Lampson —*R. Sci. Inst.,* Vol. 12, April 1941, pages 187-190.

Lightning to the Empire State Building—K. B. McEachron — *Electrical Engineer,* Vol. 60, September 1941, pages 885-890.

Electronic Switch for the Simultaneous Observation of Two Waves with the Cathode-ray Oscillograph—H. J. Reich—*R. Sci. Instr.,* Vol. 12, April 1941, pages 191-192.

Methods for Determining the Restriking Characteristics of Power Networks Whilst in Service—C. Dannatt and R. A. Polson—*Journal IEE,* February 1941.

Photography of Cathode-Ray Tube Traces —H. F. Folkerts and P. A. Richards—*RCA Review,* Vol. 6, October 1941, pages 234-244.

Technique for Tube Data; Taking Tube Characteristics as Trace on Screen of Cathode Ray Oscilloscope—C. C. Street—*Electronics,* Vol. 14, October 1941, page 50.

Three-Beam Tube for Three-Phase Studies —*Electronics,* Vol. 115, April 5, 1941, page 1181.

Anomalous Dispersion of Dipolar Ions—H. O. Marcy and J. Wyman, Jr.—*Journal of American Chemistry Society,* Vol. 63, December 1941, pages 3388-3397.

Application of Oscillograph to Determination of Cooling Rates of Quenched Steels —C. R. Austin, R. M. Allen and W. G. Van Note—*American Society for Metals*—Vol. 30, September 1942, pages 747-773.

Application of Cathode Ray Tubes—B. Dudley — *Electronics,* Vol. 15, October 1942, pages 49-52.

Auxiliary Circuit for Cathode-Ray Photography — H. C. Roberts — *Electronics,* Vol. 15, September 1942, pages 59-60.

Cathode-ray Method of Wave Analysis—V. O. Johnson—*Electrical Engineer,* Vol. 60, December 1941, page 1032-1036.

Cathode-ray Oscillograph Delayed Single Sweep Circuit—W. E. Gilson—*Electronics,* Vol. 15, March 1942, page 65.

Cathode-Ray Oscillograph for Frequency Comparison — *Electronics,* Vol. 15, April 1942, page 94.

Cathode-ray Oscilloscope Impedance Comparator—V. Salmon—*Electronics,* Vol. 15, February 1942, page 54.

Direct Measurement of Lightning Current —J. W. Flowers—*Franklin Institute Journal,* Vol. 232, November 1941, pages 425-450.

DuMont Giant Demonstration Oscillograph Type 233, *R. Sci. Instr.,* Vol. 13, February 1942, pages 85-86.

Electrical Characteristics of Stroboscopic Flash Lamps—F. M. Murphy and H. E. Edgerton — *Journal of Applied Physics,* Vol. 12, December 1941, pages 848-855.

Flexible Sweep Circuit and Deflection Amplifier for Cathode Ray Oscillographs—W. A. Geohegan—*Electronics,* Vol. 14, December 1941, pages 38-39.

Giant Cathode-Ray Screen for Demonstrations—*Product Engineering,* Vol. 13, February 1942, page 112.

Injector-valve Motion Studies by the Cathode-Ray Oscillograph—H. M. Fuller —*Diesel Power,* Vol. 20, July 1942, pages 582-583.

Measurement of Torsional Vibrations—R. Stansfield—*Engineering,* Vol. 154, August 28, September 4, 1942, pages 178-180, 198-200.

Modern Cathode-ray Oscillograph for Testing Lightning Arresters—E. J. Wade, T. J. Carpenter, and D. D. MacCarthy—*Electrical Engineer,* Vol. 61, August 1942, pages 549-553.

New Instrument for Analyzing Electric Transients — N. Rohats — *General Electric Review,* Vol. 45, February 1942, pages 121-122; *Electronics,* Vol. 15, May 1943, page 78.

Portable High - Frequency Square - Wave Oscillograph for Television—R. D. Kell, A. V. Bedford and H. N. Kozanowski—*Proceedings IRE,* Vol. 30, October 1942, pages 458-464.

Recording Machinery Noise Characteristics—H. D. Brailsford—*Electronics,* Vol. 15, November 1942, pages 46-51.

Six - Trace Cathode - Ray Micro - Oscillograph—Von Ardenne—*Wireless Engineer,* Vol. 19, May 1942, pages 231-232.

Surge Propagation — T. F. Wall — *Engineering,* Vol. 153, April 17, 1942, pages 301-302.

Ten-Megacycle Oscilloscope—J. O. Edson —*Electronics,* Vol. 15, February 1942, page 72.

Time Bases — O. S. Puckle — *Inst. Elec. Eng. Journal,* Vol. 3, June 1942, pages 100-119.

Ultra-fast Oscillograph—E. J. Wade, T. J. Carpenter and D. D. MacCarthy—*Science,* Vol. 96, Sup. 10, July 3, 1942.

Use of the Oscillograph for Testing Fuel Injection—P. H. Schweitzer—*Automotive Industry,* Vol. 86, January 1, 1942, pages 26-30.

Wave-form Circuits for Cathode Ray Tubes—H. M. Lewis—*Electronics,* Vol. 15, July 1942, pages 44-48.

Electronic Circuit for Studying Hunting —M. J. DeLerno and R. T. Basnett—*Electrical Engineer,* Vol. 61, December 1942, pages 603-606.

New Frequency - Comparison Circuit for the Cathode-Ray Tube—G. H. Rawcliff—*Journal IEE,* Vol. 89, Part 3, December 1942, pages 191-194.

Oscillograph Speeds up Training of Electrical Instrument Mechanics—M. D. Jackman—*Instruments,* Vol. 16, February 1943, pages 64-65.

Rapid Non - destructive Material Testing with the Cathode-Ray Oscilloscope—W. A. Knoop, Jr.—*Instruments,* Vol. 16, January 1943, pages 14-15.

Servicing Resistance Welding Controls—B. L. Weller—*Electronics,* Vol. 16, January 1943, pages 78-81.

Surge Testing — C. M. Foust — *General Electric Review,* Vol. 45, November 1942, pages 629-632.

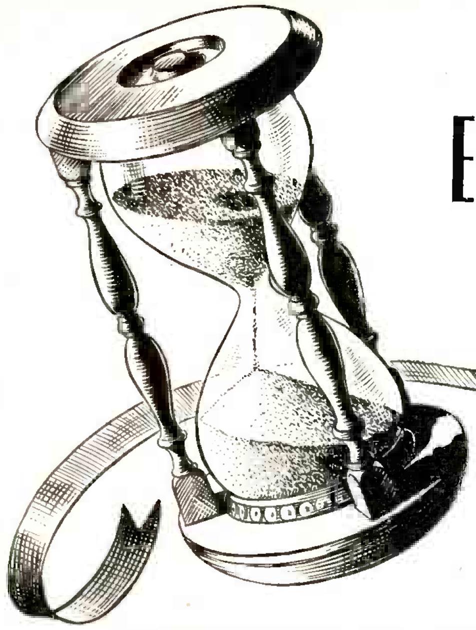
Tracing Valve Characteristics, Using the Cathode-Ray Oscillograph — G. Bocking, *Wireless Engineer,* Vol. 19, December 1942, pages 556-563.

Insulation Testing of Electric Windings—C. M. Foust and N. Rohats—*Electrical Engineer,* Vol. 62, April 1943, pages 203-206.

Radio - frequency Operated High - voltage Supplies for Cathode-ray Tubes—O. H. Schade—*Proceedings IRE,* Vol. 31, April 1943, pages 158-163.

Cathode - Ray Oscillograph Applied to Long-time Switching Transients—G. W.

[*Continued on page 44*]



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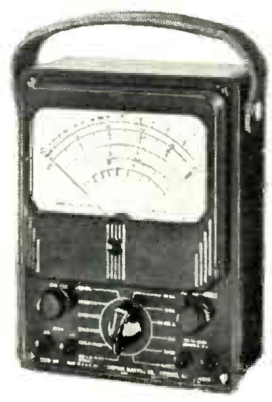

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13—CATHODE-RAY OSCILLOGRAPHS

Low Voltage Cathode Ray Oscillographs—Johnson—*BSTJ*, November 1922.

Low Voltage Cathode Ray Oscillographs—S. J. Crocker—*American Journal of Science*, Vol. 45, 1919, page 281.

Low Voltage Cathode Ray Oscillographs—E. S. Weber—*Elec. World*, Vol. 45, 1918, page 608.

Improvements in Cathode Ray Tube Design — Zworykin — *Electronics*, November 1931, page 188.

Elimination of Distortion in Cathode Ray Tubes—A. B. DuMont—*Electronics*, January 1935, page 16.

UHF Distortion in Cathode Ray Tubes—R. M. Bowie—*Electronics*, January 1938, page 18.

The Deflection of Cathode Rays in Multiphase Fields — H. E. Hollmann — *Elek. Nach. Tech.*, Vol. 15, November 1938, pages 336-341.

Four-Beam Electron Tube of High Writing Velocity—A. Biglke—*Arch. F. Elektrotech.* Vol. 33, February 15, 1939, pages 108-110.

New Investigations on Cathode-Ray Oscillographs—A. Thoma.—*Funktech. Monatsheft.*, No. 10, October 1938, pages 313-316; No. 11, November 1938, pages 329-331.

Electrostatic Deflection in Cathode-Ray Tubes with Non-parallel Deflecting Plates—Flechsig—*Elek. Tech. Zeit.*, Vol. 60, July 1939, page 798.

Ultradynamic Overcontrol of Cathode-Ray Tubes — Hollman — *Hochfrequenz. und. Elektroakustik*, Vol. 52, October 1938, pages 125-129.

Luminescent Materials—H. W. Leverenz and F. Seitz—*Jour. App. Phys.*, Vol. 10, July 1939, pages 479-493.

Cathode-Ray Amplifier Tubes — *Electronics*, Vol. 12, April 1939, pages 9-11.

Experimental Demonstration of Phase Focusing—L. Mayer—*Zeit, f. Tech Phys.*, Vol. 20, No. 2, 1939, pages 38-42.

Wave Energy and Transconductance of Velocity Modulated Electron Beams—W. C. Hahn—*General Electric Review*, Vol. 42, November 1939, pages 497-502.

Recent Improvements in the Design and Characteristics of the Iconoscope—R. B. Jones and W. H. Hickok—*Proceedings IRE*, Vol. 27, September 1939, pages 535-540.

The Image Iconoscope—Harley Iams—*Proceedings IRE*, Vol. 27, September 1939, pages 541-547.

The Image Dissector—C. Larson and B. C. Gardner—*Electronics*, Vol. 12, October 1939, pages 24-27, 50.

The Electrostatic Electron Multiplier — V. K. Zworykin and J. A. Rajchman—*Proceedings IRE*, Vol. 27, September 1939, pages 558-566.

Contrast in Kinescopes—R. R. Law—*Proceedings IRE*, Vol. 27, August 1939, pages 511-524.

Cathode-Ray Engine Indicators Have Advantages; Diagrams Taken Simultaneously on the Same Diesel Engine with Zeiss-Ikon and Standard-Sunbury Instruments—P. H. Schweitzer—*Automotive Ind.* 80, May 15, 1939, pages 612-613.

Cathode Ray Tube Photography — T. A. Rogers and B. L. Robertson—*Electronics*—July 1939, pages 12-19.

Determination of Phase Angle by Cathode-Ray Oscillographs—F. de la Chard. *Inst. Elec. Eng. Journal*, Vol. 83, November 1938, page 681.

Determining Natural Modes of Vibration of Structures—H. C. Hayes and E. Klein—*Engineer*, Vol. 166, December 16, 1938, pages 682-3.

Electronic Wattmeter; Its Use in Delineation of Power Wave-Forms—I. E. Rosenzweig—*Elec. Review* (London), Vol. 125, August 11, 1939. page 192.

Engine Indication with the Cathode-Ray Oscillograph; Abstracts. J. G. Williams—*Power Pl. Eng.*, Vol. 43, May 1939, pages 304-306; *Automotive Industry*, Vol. 80, January 1939, pages 50-51.

Fixed-Focus Electron Gun for Cathode-Ray Tubes—H. Iams—*Proceedings IRE*, Vol. 27, February 1939. pages 103-105.

Impulse Testing; Using Cathode-Ray Oscilloscope Equipment—G. J. Siezen—*Wireless Engineer*, Vol. 16, August 1939, pages 391-399.

Measuring Diesel Engine Performance; Siemens-type Oscillograph — *Power Pl. Eng.*, Vol. 43, September 1939, pages 577-578.

Multi-Channel Oscillograph Amplifier — F. C. Williams and R. K. Beattie—*Wireless Engineer*, Vol. 16, March 1939, pages 126-133.

Oscillograph Design Considerations—G. R. Mezger—*Proceedings IRE*, Vol. 27, March 1939, pages 192-198.

Piezo-Electric Indicator. for Internal Combustion Engines and Other Devices—*Engineer*, Vol. 167, February 3, 1938, pages 152-153.

Portable Cathode-Ray Oscillograph—J. G. Kearby—*Radio*, Vol. 22, November 1939, pages 30-32.

Recurrent-surge Oscillographs, and Their Application to Short-time Transient Phenomena—K. J. R. Wilkinson—*Inst. Elec. Eng. Journal*, Vol. 83, November 1938, pages 663-672.

Use of the High-Vacuum Cathode-ray Tube for Recording High-speed Transient Phenomena — D. I. McGillewie — *Inst. Elec. Eng. Journal*, Vol. 83, November 1938, pages 657-662.

Admiralty Cathode-ray Oscillograph Engine Indicator—F. D. Smith, E. H. Lakey and H. Morgan—*Inst. Mech. Eng. Journal & Proc.*, Vol. 39, April 1940.

American Apparatus, Instruments, and Instrumentation; Electrical and Electronic Instruments—R. H. Muller, *Ind. & Eng. Chem. Anal.*, Vol. 12, October 15, 1940, pages 587-588.

Basic Principles in the Design of Cathode Ray Oscillograph Engine Indicators—F. D. Smith—*Inst. Mech. Eng. Journal & Proc.*, April 1940, pages 48-56.

Build this Modern Oscilloscope — R. P. Turner—*Radio*, Vol. 23, May 1940, pages 31-33.

Cathode-Ray Alphabet Machine—A. W. Friend—*Electronics*, Vol. 13, June 1940, page 40.

Cathode-Ray Oscillograph as a Means of Demonstrating Elliptically Polarized Light—L. R. Steinhardt—*Journal Optical Society of America*, Vol. 30, May 1940, pages 226-228.

Cathode-Ray Oscillographs; a Battery-Operated Power Unit—R. E. Burgess—*Wireless Engineer*, Vol. 17, July 1940, pages 296-297.

Cossor Oscillograph—*Engineer.*, Vol. 169, May 17, 1940, pages 451-2.

Dortstellung Abklingender Schwingungen als Stehendes Bild auf der Kathodenstrahlröhre—J. Czech. *V.D.I.*, Vol. 84, February 3, 1940, page 83.

Differential Amplifier with Oscillograph as Detector of Discharges in Insulation — *Engineer*, Vol. 169, April 5, 1940, pages 320-321.

High-frequency Generator Calibration; to Obtain the Time Axis of a High-Voltage Cathode-ray Oscillograph—C. J. Tirk and P. H. McAuley—*Electrical World*, Vol. 113, February 24, 1940, page 606.

High-Gain D/C Amplifier for Bio-electric Recording — H. Goldberg — *Electrical Engineer*, Vol. 59, January 1940.

High Voltage Cathode-ray Oscillograph—A. C. Hall and J. M. Coombs—*R. Sci. Instr.*, Vol. 11, October 1940, pages 314-320.

How and Why of the Oscilloscope — E. Lovick — *Radio*, No. 23, January 1940, pages 29-30.

Lightning Recording Instruments; Oscillographic and Photographic Equipment—J. H. Hagenguth—*General Electric Review*, Vol. 43, May 1940, pages 195-201.

Measurement of the Conductance of Electrolytes; the Use of the Cathode-Ray Oscillograph as a Detector—G. Jones, K. J. Mysels and W. Juda—*American Chem.*

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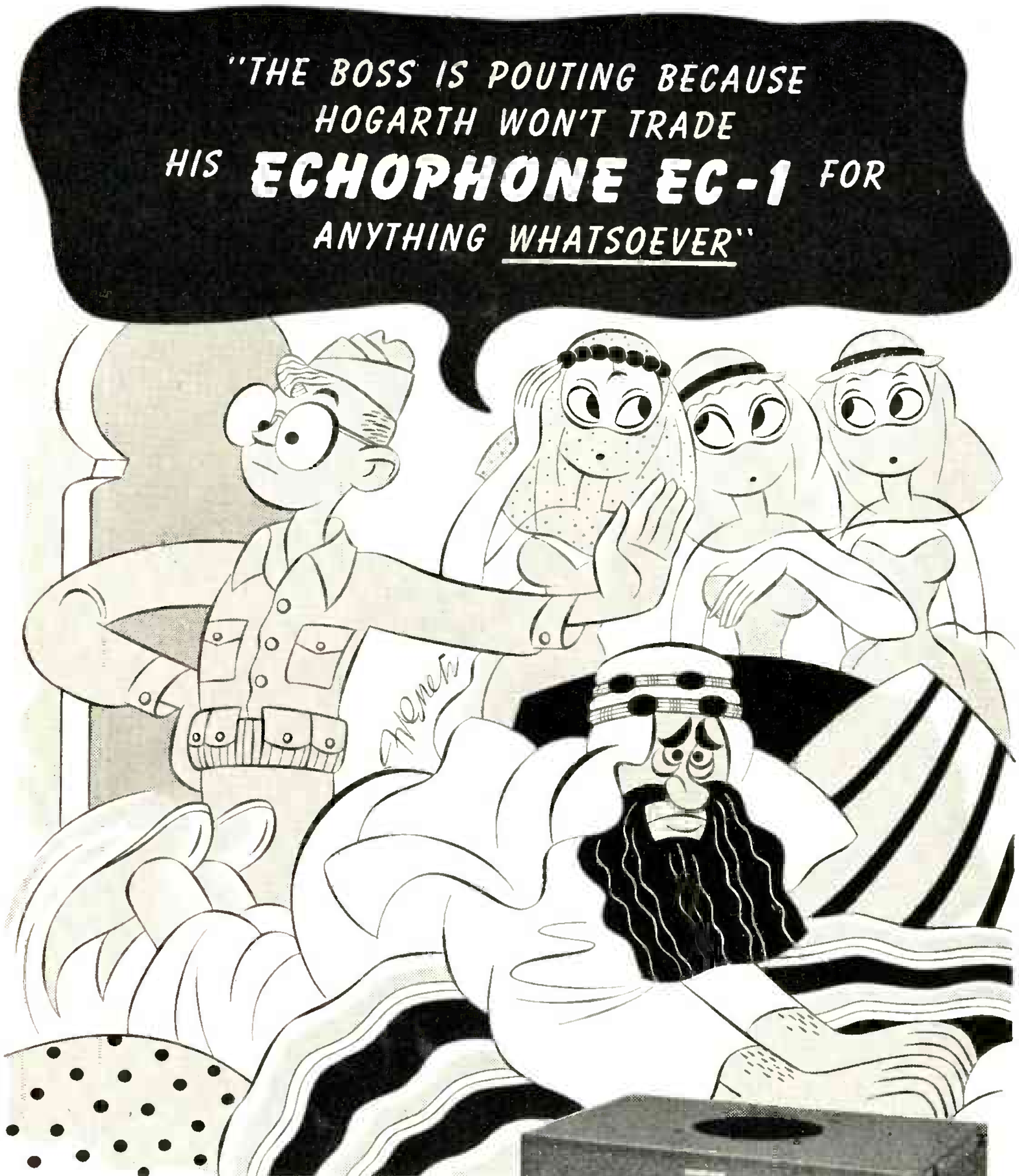

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(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on three bands. Electrical band-spread on all bands. Beat frequency oscillator. Six tubes. Self-contained speaker. Operates on 115-125 volts AC or DC.

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NEW PRODUCTS

ANNULAR SOUND DISTRIBUTOR

The Langevin Company, Inc., of 37 West 65th Street, New York City, has just announced a new type of Annular Sound Distributor, Type L-360. This distributor utilizes a different principle of sound distribution in that it combines molecular reflection and collision instead of collision alone as in other speakers.

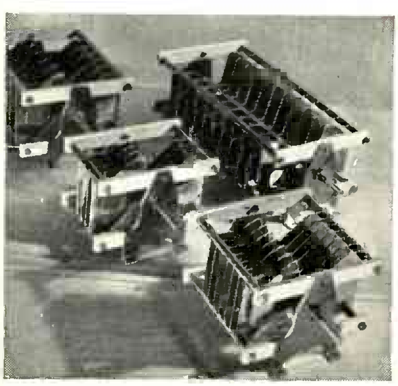
The use of this principle results in a uniformity of sound distribution both as to frequency and power over a horizontal plane of 360 degrees and a vertical plane of approximately 40 degrees. The Type L-360 Distributor is 23 inches in diameter with an over-all height of 25 inches. It will safely handle power input of 20 watts when equipped with Jensen U-20 Drive Unit. Bulletin on request, from manufacturer.

★

B&W TYPE CX VARIABLE CONDENSERS

A broad line of heavy-duty variable air condensers eminently fitted for electronic heating applications is being offered by Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.

Known as B & W Type CX Variable Condensers, these units are of sturdy, unconventional design offering many advantages for heavy-duty applications. Features includes perfect electrical design symmetry and built-in neutralization coupled with extreme mechanical durability. Their construction also lends itself admirably to the built-in mounting of standard inductors in such a way that lead lengths and resulting lead inductance are reduced to an absolute minimum.



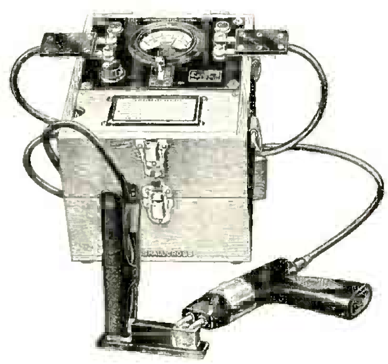
B & W Type CX Variable Condensers are available in almost any required capacity for electronic heating use up to 5 kw, 12,500 volts. Engineering Data Sheet sent upon request to manufacturer.

★

NEW SHALLCROSS TEST SETS

Two new Shallcross Low-Resistance Test Sets, Type 645 (Army range) and Type 653 (Navy range) include all popular features of previous models with the added convenience of complete portability and greater freedom, ease, and speed of operation.

The Test unit containing the meter, batteries, switches, control, etc., is supported comfortably and conveniently in front of the operator by means of adjustable shoulder straps. Bond or contact resistance measurements as low as .0001 ohm can then be made, simply by attaching the fixed clamp to one side of the bonded surface, then touching the hardened points of the Pistol Grip Exploring Probe to the other side.



Both hands are free at all times to adjust and operate the instrument. The weight of the Pistol Grip Exploring Probe is reduced to a minimum by incorporating the meters, batteries, etc., in the cabinet suspended from the operator's shoulders.

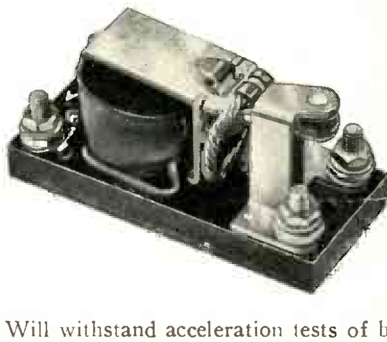
In addition to their widespread use in testing aircraft bonding, these Shallcross Sets are unexcelled for testing railroad bonds, radio equipment, contact resistance of relays, circuit breakers, switches, and various others. They make bar-to-bar resistance measurements on commutators as simple as making a voltmeter reading.

Type 645 (Army range) is 0.005 and 0.5 ohm full scale. Type 653 (Navy range) is 0.003 and 0.3 ohm full scale.

A copy of the Shallcross Low-Resistance Test Set catalog describing these and other popular models will be sent upon request to Shallcross Mfg. Company, Collingdale, Pa.

STRUTHERS-DUNN SHOCKPROOF RELAY

Designed for airplane use where utmost precaution must be taken against unintentional operation of contacts, the Struthers-Dunn Type 17AXX relay meets and exceeds all specified requirements for this type of unit.



Will withstand acceleration tests of better than 90 gravitational units—or from eight to ten times the G-rating of ordinary relays.

Despite its rugged construction, the relay is small in size, and light in weight. Units of this type are regularly supplied with series coils for any direct current, or with shunt coils for use on 12- or 24-volts d.c.

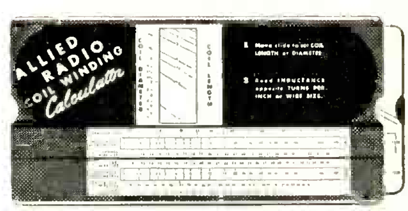
Full details on Type 17AXX may be obtained from the manufacturer, Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

★

NEW COIL-WINDING AND RF RESONANCE CALCULATOR

Allied Radio Corporation, Chicago, announces the release of a new slide-rule type rapid calculator, permitting quick and accurate determination of inductance, capacitance, and frequency components of series or parallel tuned r-f circuits as well as inductance, turns-per-inch, wire type, wire size, coil diameter and coil length for single layer-wound solonoid type r-f coils.

All values, in either case, are found with a single setting of the slide and are accurate to within approximately 1% for coils ranging from ½ inch to 5½ inches in diameter and ¼-inch to 10 inches in length. All possible combinations within these limits are shown.



Wire types and sizes include 11 to 35-gauge plain enamel, 11 to 36-gauge S.S.C.,

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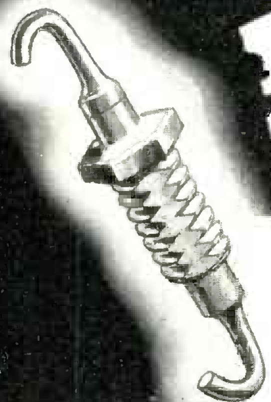
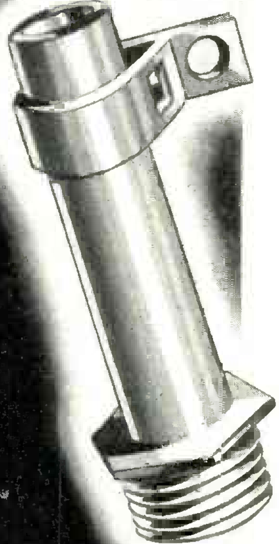
Centralab offers



Type 817-001 55MMF ± 10%
Neg. Temp. Coefficient
— .00052 MMF/MMF °C
Test voltage is 2000 V. D. C.
working voltage 1000 V. D. C.

Type 817-002
Mechanically as above
Capacitance 1.5 MMF ± 20%
Sketch is TWICE actual size.



Type 814-078 300 MMF ± 10%
Neg. Temp. Coefficient
— .00075 MMF/MMF °C
Test voltage is 1400 V. D. C.
working voltage 500 V. D. C.
Sketch is TWICE actual size.

Two Types of
BUSHING MOUNTED CAPACITORS
for special applications

Both types are used in high frequency circuits where a capacity ground to the chassis and a "lead through" is desired.

The ceramic capacitor tube is plated internally and externally with silver and then with copper. The tube is snug fit in the brass bushing and the external capacitor plate is soldered to the bushing.

In types 817-001 and 817-002 the tinned copper wire is also snug fit inside the capacitor tube and is soldered to the internal plate.

We are equipped to produce other sizes and capacities where quantity need justifies the tooling of special parts.

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PRODUCERS OF VARIABLE RESISTORS . . . SELECTOR SWITCHES — CERAMIC CAPACITORS, FIXED AND VARIABLE . . . STEATITE INSULATORS

THEORY AND APPLICATION OF NOMOGRAPHS

R. G. MIDDLETON
Project Engineer, Templeton Radio Company

Explaining the Application of Nomographs to the Solution of More Advanced Problems

PART 2

★ In the last article we saw that mathematical operations which can be solved on a slide rule can also be solved on a sheet of semi-log paper with the aid of a straight-edge. These graphical solutions were seen to be elementary nomographic processes.

To derive more powerful methods for the solution of particular communication problems, we shall expand the principles already outlined to include logarithmic scales which are not of equal extent, and which are individually chosen for the purpose of solving some particular equation.

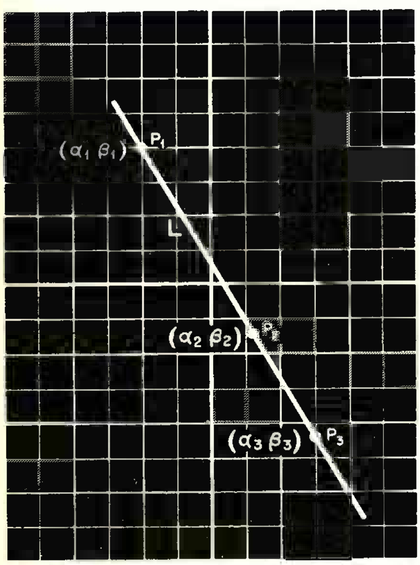


Fig. 6. The graph of a straight line in Cartesian coordinates.

In this article we shall employ the device of working most of the problem backward until we obtain a general relation which is directly applicable to all equations of a given form. After the general relations are established, these will subsequently serve for immediate construction of any nomograph for any similar equations.

Part 1 of this series showed how we could select three scales on a sheet of semi-log paper to obtain any product or any quotient with the aid of a straight-edge. Such a construction is

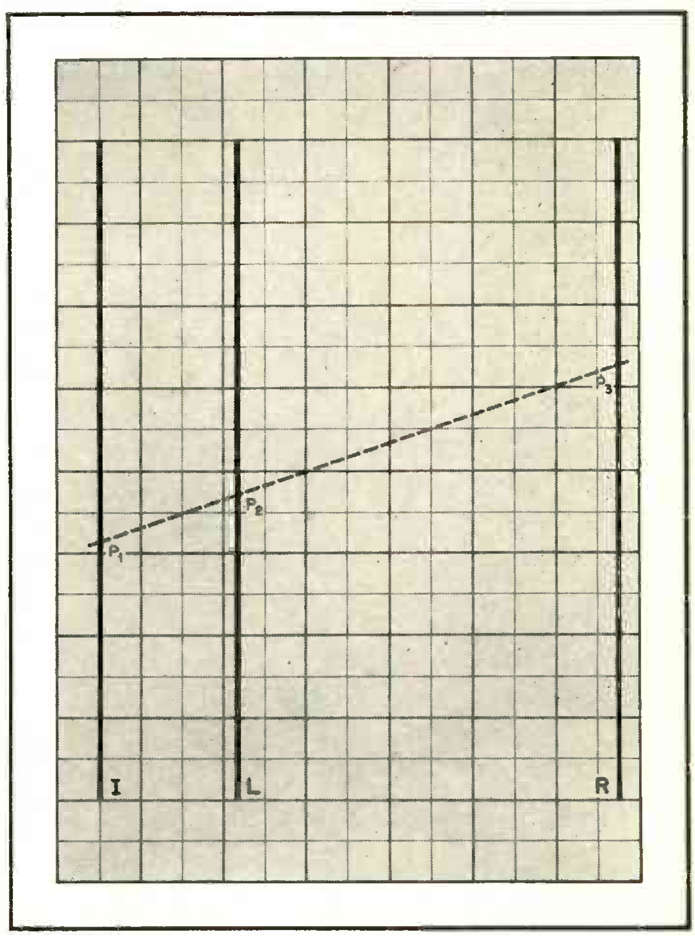


Fig. 7. A nomograph for a function of current I, inductance L, and resistance R.

nomographic since it may be applied to the simplest communication problems, such as Ohm's law:

$$I = E/R$$
$$\text{or, } E = IR$$

We noted likewise that the "product" scale for this particular nomograph consisted of the squares of the "factor" scale. It is useful to be able to construct such "product" scales graphically, and *Fig. 5* shows how this may be done after locating any two points (by direct calculation).

Construction

The construction is basically important, and should be noted carefully. Scale *A* may be termed the "factor" scale, and Scale *B* the "product" scale. We wish to obtain a rapid graphical construction for Scale *B*, whose values are the squares of Scale *A*. We do this by means of Scale *C*. Note that Scale *C* has a different length of cycle from Scale *A*; this absolute length is of no importance in the construction, and any logarithmic scale whatever may be used. Even the slide from a slide rule may be used to lay off the values.

But it is very important to connect the proper cycles before starting the graduation. In *Fig. 5* we have set up the construction by noting where 1 and 100 must strike on Scale *B*; we do this by squaring the 1 and the 10 of Scale *A*. Next we place the 1 of Scale *C* on the 1 of Scale *B*, and connect 100 of Scale *B* with the top or 100 point of the second cycle of Scale *C*. After drawing this one line, all other lines may be rapidly drawn in by means of a T-square and triangle. The immense utility of the construction is apparent from the figure; while it is a simple matter to determine where the squares of Scale *A* integers lie, it is a tedious matter to precisely locate 2, 3, 5, etc. on Scale *B*. It is still more tedious to precisely locate 1.5, 2.5, 3.5, etc.; but if the graphical construction is employed, all the necessary intermediate values may be struck in at once from lines to Scale *C*.

Since we are now able to construct logarithmic cycles of any desired absolute length, we are now in a position to derive more powerful methods of nomographic analysis. From this point forward, we shall construct nomographs in which no two scales have cycles of equal absolute length.

Working Formulae

It is now necessary to seek working formulae which correspond to conventional engineering formulae, and from which the desired nomograph may be

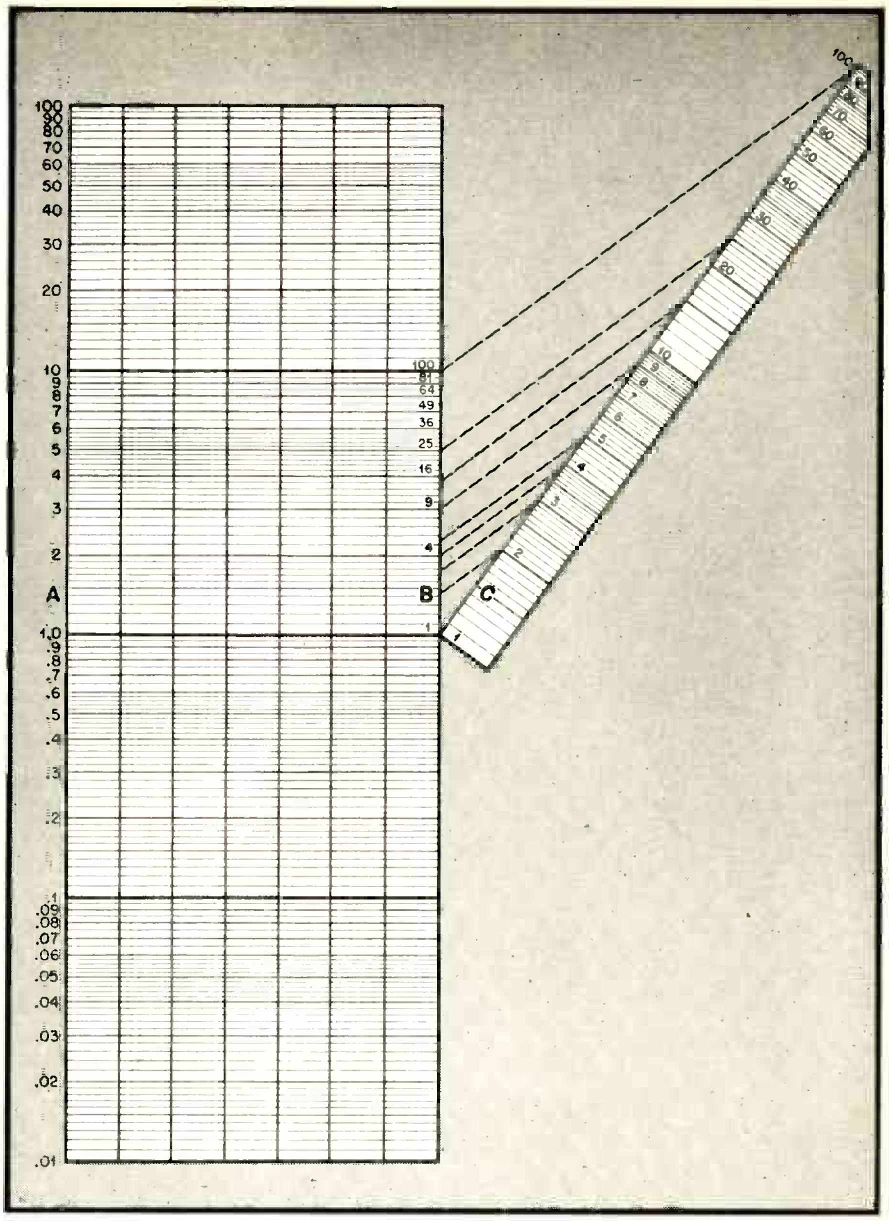


Fig. 5. This shows how to construct "product" scales graphically after locating any two points by direct calculation.

constructed with a minimum of effort.

Referring to *Fig. 6*, which shows the graph of a straight line in Cartesian coordinates, we may recall that if three points P_1, P_2 and P_3 lie on a straight line L, then their coordinates have a certain unique relation. If these coordinates are:

$$P_1 = \alpha_1,\ \beta_1$$
$$P_2 = \alpha_2,\ \beta_2$$
$$P_3 = \alpha_3,\ \beta_3$$

the determinant of the form:

$$\begin{vmatrix} \alpha_1 & \beta_1 & 1 \\ \alpha_2 & \beta_2 & 1 \\ \alpha_3 & \beta_3 & 1 \end{vmatrix} = 0 \quad \ldots\ldots\ldots (1)$$

may be equated to and must equal zero.

This determinant is "expanded" in the following manner:

$$\alpha_1(\beta_2 - \beta_3) - \beta_1(\alpha_2 - \alpha_3) + (\alpha_2\beta_3 - \alpha_3\beta_2) = 0$$

or:

$$\alpha_1\beta_2 - \alpha_1\beta_3 - \alpha_2\beta_1 + \alpha_3\beta_1 + \alpha_2\beta_3 - \alpha_3\beta_2 = 0$$

or:

$$\beta_1(\alpha_3 - \alpha_2) + \beta_2(\alpha_1 - \alpha_3) + \beta_3(\alpha_2 - \alpha_1) = 0$$

since the rules for expanding a nine-term determinant,

$$\begin{vmatrix} \text{I} & \text{II} & \text{III} \\ \text{IV} & \text{V} & \text{VI} \\ \text{VII} & \text{VIII} & \text{IX} \end{vmatrix}$$

is: $\text{I}(\text{V}\cdot\text{IX} - \text{VIII}\cdot\text{VI}) - \text{II}(\text{IV}\cdot\text{IX} - \text{VII}\cdot\text{VI}) + \text{III}(\text{IV}\cdot\text{VIII} - \text{VII}\cdot\text{V})$

Functional Nomograph

If we wish to construct a nomograph for a function of current I, inductance L, and resistance R, as shown in *Fig. 7*, we have seen that any three

[*Continued on page 59*]

THIS MONTH

NEW NAME IN INDUSTRY

A story which has been partially known to the Radio Industry has now been announced in its entirety by *H. L. Hoffman,* President of Hoffman Radio Corporation. Hoffman is a new name in the industry; the records of its key men and the companies that merged to form this new organization are not. The Mission Bell Radio Manufacturing Company, incorporated in 1932 by *H. G. Schmieter* and *P. L. Fleming* was one of the three major companies on the coast holding a direct RCA license for the manufacture of home receivers and combinations, and did a sizeable volume of production and sales in the Western market.

In 1941 re-organization took place to provide additional capital and trained personnel to plan an aggressive expansion program. At this time *H. L. Hoffman,* one of the West's leading merchandisers, became President, *P. L. Fleming,* former President of Mission Bell, Vice President, *W. D. Douglas,* Treasurer, and *G. G. Davidge,* Secretary, both having been active in distribution in the West.

In line with this expansion program, the company in 1942 acquired the Mitchell-Hughes Company and proceeded with the manufacture of Mitchell - Hughes radio-phonograph combinations.

In this acquisition Hoffman gained two of their top executives in the person of *W. S. Harmon,* Vice President in charge of Engineering, formerly Chief Engineer of Emerson Radio, and *R. McNeely,* Sales Manager, formerly Eastern Sales Manager for Gilfillan. This provides the company with a directorate whose combined experience totals more than 50 years in radio production and sales.

The new and re-organized company moved to new quarters at 3430 South Hill Street, Los Angeles, Calif., in July of 1942. New quarters provided three times the space formerly occupied. This space has been tripled recently with subsequent additions being planned. Hoffman Radio is a prime contractor for various types of communication equipment for practically all the military services.

★

G.E. FORMS CREDIT CORPORATION

The formation of the General Electric Credit Corporation, an investment company organized under the New York State Banking Law, has been announced by the General Electric Company. The new organization will broaden the scope of activities carried on since 1933 by the General Electric Contracts Corporation, and will include the business of the latter company which was principally financing the sale of consumer goods.

The main office of the new corporation will be at 570 Lexington Avenue, New York City, and branches will be operated in other principal cities.

The immediate function of the new investment company will be to provide financing for war construction and production work in connection with contracts which involve the use of products of General Electric and its associated companies, or parts produced by others for incorporation in such war products. In the post-war period the new company will not only provide financing for the purchase of consumer goods, but will also furnish increasing assistance in the purchase of other products of the company.

Harold Shevers, president of Espey Mfg. Co., receives "E" flag from Lt. Col. W. B. Brown. Presentation was made on November 5th.

Signal Corps repair depot in Iceland. Shown is repairman testing a Teletype machine after general overhauling. In background is a Hallicrafters SX-25 receiver used for the reception of vital information at the depot. (U.S. Army Signal Corps photo.)

★

ACTIONS BY FCC

COORDINATED SERVICE

The Commission has adopted a new Section 10.153 to require licensees of State Police radio stations to submit applications for, or contracts covering, similar service rendered by the licensees to municipal or county police organizations. The new Section 10.153 reads:

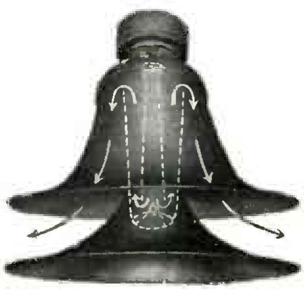
"10.153 *Coordinated Service*—Any applicant for an instrument of authorization who proposes to furnish a coordinated police radio-communication service to one or more municipalities, counties, or governmental agencies, *other than the applicant,* must make specific formal request for authority to furnish such service. Applications for such authority should contain a full and complete description of the service to be rendered, including information as to whether one-way dispatching service to mobile units or two-way radio-communication service is to be provided. Applications for authority to render coordinated service must be accompanied by duplicate copies, under oath, of all agreements relating to the service to be rendered. Such agreements must be in writing, must clearly set forth what service is to be rendered, and include a statement as to ownership,

[*Continued on page 52*]

A Safe Bet for Steady Sales

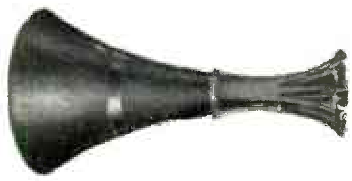
Left—MARINE SPEAKER; approved by the U. S. Coast Guard, for all emergency loudspeaker systems on ships. Re-entrant type horn. Models up to 50 watts. May be used as both speaker and microphone.

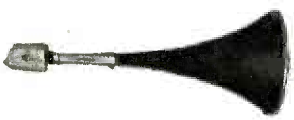
Right—RE-ENTRANT TRUMPET; available in 3½′, 4½′ and 6′ sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.



Left—RADIAL HORN SPEAKER; a 3½′ re-entrant type horn. Projects sound with even intensity over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

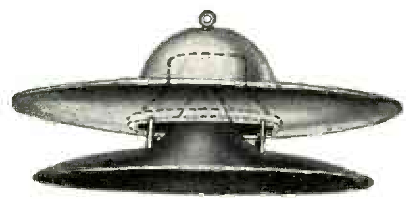
Right—AEROPLANE HORNS; super-powerful and efficient P.A. horns for extreme range projection. 9 and 4 unit Trumpets available.





Left—PAGING HORN; extremely efficient 2′ trumpet speaker for use where highly concentrated sound is required to override high noise levels. Uses P.M. unit.

Right—RADIAL CONE SPEAKER; projects sound with even intensity over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

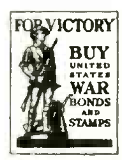


SEND FOR CATALOG

RACON, pioneer and world's largest manufacturer of loudspeakers, horns and driving units, is working at capacity filling diversified orders — speakers for Army, Navy, Maritime Commission and industrial use. Now we are planning ahead.

Practically all industrial firms are users, or potential users of some type public-address, paging or sound distribution system. Statistics prove that a properly planned sound system installation is a good investment which in time generally pays for itself.

RACONS have always enjoyed a steady, high sales volume. We believe they always will, for our products are the finest that money can buy, or engineering skill produce. Receiver units supplied with either metal or plastic diaphragms. RACON products generally cost less than competitive brands because a lower power-rated and lower-priced RACON will outperform higher power-rated units of other make. In other words, don't let catalog list-prices fool you. Basic costs and rated outputs are the prime factors worth considering. That's why leading soundmen prefer and specify RACONS, they are dependable—a safe bet for steady sales and satisfied users.



RACON ELECTRIC CO. 52 EAST 19th ST. NEW YORK, N. Y.

ZENDER SERVING W.P.B.

In addition to his duties as Chief Engineer and Sales Manager of Lenz Electric Manufacturing Company, Chicago, wire manufacturers, Mr. Ray Zender has been appointed Wire Consultant to the Radio section of the War Production Board on a "dollar a year" basis.

NEW PRODUCTS

[*Continued from page 48*]

vacuum tube applications, as well as in detecting overloads at low current levels. Its greatest field of usefulness lies in applications where current varies slowly between various limits, rather than quickly from zero to rated value.

Details on Type 79XAX will be supplied by Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.

★

HAYDON D-C TIMING MOTOR

Haydon Manufacturing Company, Inc., of Forestville, Connecticut, have announced a new type of d-c motor for timing applications on direct current.

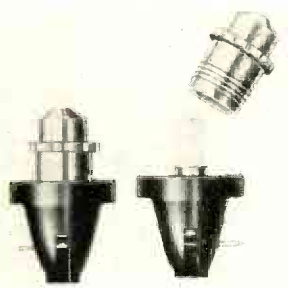
This is a normally running 6-volt motor with resistance wire calibrated at the factory for 12 volts, 24 volts, and other voltage applications. It is available with all the various output shaft speeds which the company now has in its a-c line of timing motors, these speeds secured through sealed-in lubricated gear trains. Speeds available will be from 900 r.p.m. down to one revolution per month.

Extremely consistent speed is obtained by the governor effect of an electrical eddy current drag built into the motor. A unique feature is the fact there is no arcing at high altitude operation and brush life is unusually long. The motor can be purchased with special lubricant for operation at extremely low temperatures.

This motor is entirely new in design, reversible, weighs approximately 6 ounces and operates on a current input of approximately 100 ma., no load. The motor, including gear reduction, measures only 2 7/16" high by 2 1/8" wide by 1 3/8" deep.

NEW G-E INDICATOR LAMP

A small molded plastic indicator lamp has been announced by the Specialty Division of the General Electric Electronics Department at Schenectady, N. Y. Special feature is a lock-on color cap which cannot be shaken loose and will not "freeze" to the base. As many as five circuits can be identified on one panel by the use of five different color caps — amber, red, green, white and blue.



The lamp is supplied ready for mounting. The base is mounted directly to the back of the instrument panel and the color cap is screwed into the base through the panel. A coil spring applies constant pressure to the base of the lamp bulb to maintain a good electrical contact. The lamp takes 6- to 8-volt bulbs.

Applications include radio transmitters, and any other equipment or control device where a glow lamp is needed to show that the device or circuit is on or off.

RCA DYNAMIC DEMONSTRATOR III

RCA's newest Dynamic Demonstrator, a practical circuit diagram designed for laboratory and classroom instruction in radio, is now in production and is available to schools and training classes on a priority basis, RCA Victor Division of the Radio Corporation of America has announced.

The Demonstrator embodies improvements in design and operation over two previous RCA models which have played a major role in the streamlined training of thousands of radio personnel suddenly needed in wartime.

Dynamic Demonstrator III is a complete, operative, six-tube superheterodyne radio receiver expanded on a plane surface so that all circuits and parts are readily visible and accessible for study. Its design is based on actual teaching experience and classroom requirements.

The Demonstrator is large enough for group study, presenting a visual comparison of schematic symbols and actual operating parts, since the parts are mounted beside their respective schematic symbols.

The RCA Dynamic Demonstrator is complete in itself and thorough studies of radio design, operation and radio servicing may be made without any additional equipment. However, the use of other instruments will extend the scope of study. A student of radio can obtain a more thorough understanding of the theory and operation of radio circuits by using the Demonstrator in conjunction with such RCA test equipment as the Chanalyst, Junior

"RADIO NACIONAL"

[*Continued from page 44*]

inductor of 2-inch copper pipe which serves to cover the range from 14 to 22 megacycles. A shorting bar on the hairpin is set at the proper point for the frequency desired.

The output tuning circuit uses inductors similar to the tank circuit and a motor-driven balanced variable capacitor to form a parallel tuned tank coupled to the plate tank. Output to a 300- to 600-ohm balanced transmission line is taken directly from the two hot plates of the variable capacitor.

Output Coupling

A motor-driven arrangement provides means for raising or lowering the complete assembly of output coupling coils and variable capacitors, thus allowing for a variation of output coupling without affecting either the output circuit or plate tank tuning. This feature allows for quick compensation during operation when sudden weather changes cause variations in the transmission-line impedance. All five motor tuning control keys are located on the front panel where the controlled effect can be noted on panel instruments.

A portable dummy antenna is included in the equipment and is particularly useful during initial adjustment on a new operating frequency. Capable of dissipating the full 75-kilowatt output from the transmitter (50 kw modulated 100%), it can be set up for any resistance between 300 and 600 ohms at any frequency between 6 and 22 megacycles.

PRODUCTION SPEED-UPS

[*Continued from page 35*]

vices, has proved its advantages in terms of improved products and savings of time, space and labor for case-hardening, annealing, and welding of metals, baking paint, tacking plywood, seaming thermoplastic fabrics, drying textiles, and other industrial operations.

By comparison with flames and other usual sources of heat for industrial processes, Gillespie said, radio-frequency heating is not only quicker but also permits closer control as to the area to be heated, provides more uniform heating, and for many processes is more efficient and more easily adapted to mass production methods.

The degree of control, he said, is illustrated by the fact that one end of a set screw can be brought to a white heat while the other end remains cool. This is an advantage, he pointed out, in the manufacture of many machine parts which function best if one portion is case-hardened while adjacent areas remain unhardened.

MICROWAVE GENERATION

[*Continued from page 23*]

CT, are unaffected by any of the motion until after the time of our final observation. In fact, this is true anywhere along the line *QP* simply because, although the field is propagated with the velocity of light and will travel a distance *CT* to *Q* during our observations, there has not been time for it to travel farther.

Similarly in *Fig. 4A*, during the time the charge moves with constant velocity, represented by *t*, the field extends out from the charge in the normal manner but, at the time of our final observation, it has only had time to travel a distance *Ct* to point *S*. Thus, in *Fig. 4A*, where we have drawn only one line of force, we know that line must be along *RS* and along *QP*.

[*Continued on page 56*]

the manipulation, we may expand this determinant; we will receive back $X^3 + XY - Z = O$. While we could use this determinant as a working determinant, it is obviously not "fitted" to the size of sheet we happen to choose. Therefore we must manipulate this determinant into working form. This manipulation will be illustrated in the next article.

THIS MONTH

[*Continued from page 52*]

WELSH NOW MOULDING

Wm. H. Welsh Company, of Chicago, are now doing compression moulding in addition to manufacturing speaker diaphragms. They are now in production on a large contract for plastic earphones for aircraft received from a large manufacturer in Chicago.

★

CLAROSTAT TO NEW QUARTERS

Marking another phase of its rapid expansion, Clarostat Mfg. Co., Inc., manufacturers of resistors, controls and resistance devices, has moved its general offices to 130 Clinton Street, in the center of Brooklyn, N. Y., close to the Borough Hall subway station. The firm's new 'phone number is Main 4-1190-1-2-3-4-5.

This latest expansion follows close on the opening of the third Clarostat plant last spring. All Clarostat plants are located in the Greenpoint section of Brooklyn.

★

NEW LITERATURE

NEW RELAY CATALOG

Several new types of relays, including a line of very small, lightweight and vibration-resisting relays for aircraft service, are shown in the 104-page Relay Catalog recently issued by Automatic Electric Company. Complete operating data and scale mounting drawings are given for these relays, and there are more than forty other types similarly treated. A double-page chart shows the important characteristics of each type, simplifying selection of the proper design for any purpose.

Also shown for the first time in this catalog are two desk microphones—a "carbon" and a "magnetic" type—especially adapted for use in airport control rooms and similar situations. Other items include stepping switches, keys, lamps and lamp holders, solenoids, counters, switchboard plugs, jacks and cords, and various types of microphones, headsets, and transmitter and receiver units for telephone and radio use.

Copies of this new catalog—No. 4071-D, "Relays and Other Devices for Electrical Control"—will be gladly sent on request. Address Automatic Electric Company, 1033 West Van Buren Street, Chicago 7, Ill.

★

"ELECTRONICS IN INDUSTRY"

A clear-cut exposition of the practical part electronics are playing in various industrial fields, as differentiated from the fanciful, "blue-sky" imaginings of some current writers, is graphically presented in a 44-page booklet just released by the RCA Victor Division of Radio Corporation of America, Camden, N. J. Profusely illustrated in color, and written in non-technical language, this booklet, "Electronics In Industry," is being made available to business executives, manufacturers, and industrialists in whose fields the science of electronics may find applications.

The plainly worded text and four-color illustrations dispel the mystery often associated with electronics by showing the workings of practical electronic devices now in operation in numerous fields in industry, government, education, and entertainment.

★

NEW STACKPOLE CATALOG

Just off press is the new 36-page Stackpole Electronic Components Catalog giving full details on Fixed and Variable Resistors, inexpensive Switches, and Iron Cores for a wide variety of electric, radio, and other electronic applications. Also included is a wealth of engineering information and data of interest to those dealing with items of this sort.

Particular interest attaches to the listing of Stackpole standard and high-frequency iron cores, this catalog representing the first assembling of complete information on these popular items. In addition to complete listings on the various types of Stackpole insulated and non-insulated cores, etc., the catalog contains helpful reactance charts as well as time constant charts for series circuits.

Other features include detailed listings, dimension diagrams, etc. of Stackpole's inexpensive lines of slide, line, and rotary-action switch; ⅓-, ½- and 1-watt fixed resistors, as well as variable resistors in standard and midget sizes for practically any radio, hearing device, or similar application.

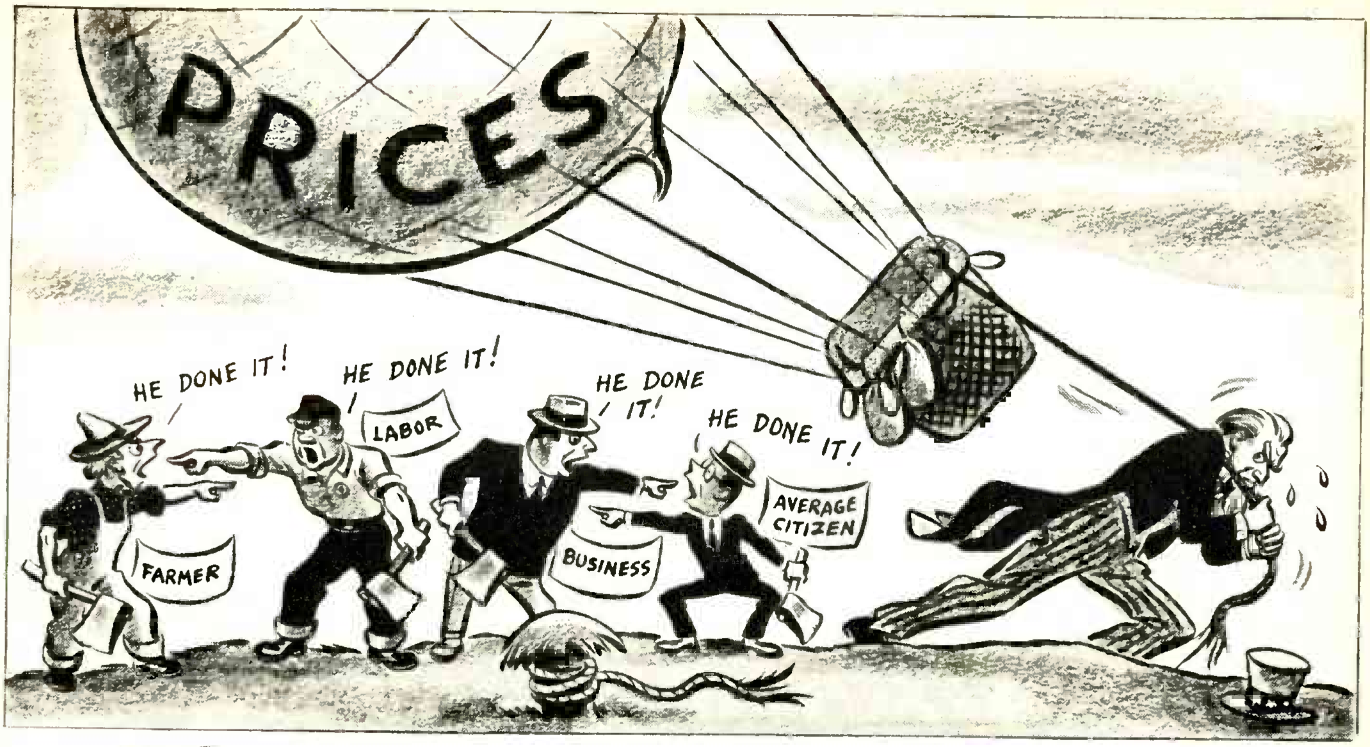
A copy of the catalog will be sent on request to The Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. Ask for Catalog RC6.

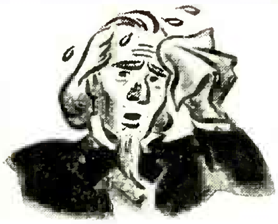
★

JAM HANDY CATALOG

A new type catalog-directory, classifying slidefilms and motion pictures, many of which are useful in radio technical training and salesmanship, is announced by The Jam Handy Organization, 2900 E. Grand Blvd., Detroit 11, Mich., and will be sent free of cost upon request to them. By a new system of indexing, cross-indexing, and classifying motion pictures and slidefilms, the user is enabled to quickly locate the subject wanted by a mere flip of the page. This saves time and labor otherwise spent in extensive film research work. Also, "previews" of each subject in the form of

[*Continued on page 62*]





Never mind "who done it"—pitch in and help get it down!

THIS IS YOUR UNCLE SAM talking—but I'm going to talk to you like a DUTCH uncle, to keep all of us from going broke.

Ever since the Axis hauled off and hit us when we weren't looking, prices have been nudging upwards. Not rising awfully fast, but RISING.

Most folks, having an average share of common sense, know rising prices are BAD for them and BAD for the country. So there's been a lot of finger pointing and hollering for the OTHER FELLOW to do something—QUICK.

The government's been yelled at, too. "DOGGONNIT," folks have said, "WHY doesn't the government keep prices down?"

Well, the government's done a lot. That's what price ceilings and wage controls are for—to keep prices down. Rationing helps, too.

But let me tell you this—we're *never* going to keep prices down just by leaning on the government and yelling for the OTHER FELLOW to mend his ways.

We've ALL got to help—EVERY LAST ONE OF US.

Sit down for a minute and think things over. Why are most people making more money today? It's because of the SAME cussed war that's killing and maiming some of the finest young folks this country ever produced.

So if anyone uses his extra money to buy things he's in no particular need of . . . if he bids against his neighbor for stuff that's hard to get and pushes prices up . . . well, sir, he's a WAR PROFITEER. That's an ugly name—but there's just no other name for it.

Now, if I know Americans, we're not going to do that kind of thing, once we've got our FACTS straight.

All right, then. Here are the seven rules we've got to follow as GOSPEL from now until this war is over. Not some of them—ALL of them. Not some of us—ALL OF US, farmers, businessmen, laborers, white-collar workers!

Buy only what you need. A patch on your pants is a badge of honor these days.

Keep your OWN prices DOWN. Don't ask higher prices—for your own labor, your own services, or goods you sell. Resist all pressure to force YOUR prices up!

Never pay a penny more than the ceiling price for ANYTHING. Don't buy rationed goods without giving up the right amount of coupons.

Pay your taxes willingly, no matter how stiff they get. This war's got to be paid for and *taxes are the cheapest way to do it.*

Pay off your old debts. Don't make any new ones.

Start a savings account and make regular deposits. Buy and keep up life insurance.

Buy War Bonds and hold on to them. Buy them with dimes and dollars it HURTS like blazes to do without.

Start making these sacrifices now—keep them up for the duration—and this country of ours will be sitting pretty after the war . . . *and so will you.*

Uncle Sam

KEEP PRICES DOWN!

Use it up • Wear it out
Make it do • Or do without

This advertisement, prepared by the War Advertising Council, is contributed by this magazine in co-operation with the Magazine Publishers of America.

electromagnetic waves start traveling back and forth between the electron beam and the wall *A*. At the times when the field is at the electron beam in the buncher, it generates a voltage between the buncher grids. This causes the electrons to be periodically accelerated as they move in this region. Thus, as the electron beam enters the field free space, called the drift space, some of the electrons have been accelerated and are traveling faster than others. These faster electrons then catch up with their slower contemporaries while crossing the drift space and reach the catcher grids in the form of bunches.

TECHNICANA

[*Continued from page 16*]

soldering steel parts without the necessity for subsequent washing, which is often impractical in many assemblies.

STEATITE RADIO INSULATORS

★ Approval by the American Standards Association of the American War Standard, Steatite Radio Insulators (C75.2-1943), makes available for the use of industry and the Armed Forces the second standard in a series of performance requirements for ceramic radio insulators.

The standard as a whole represents a specification suitable for the procurement of insulators by either radio prime contractors or by any individual branch of the Armed Forces.

The specification includes standard practices, requirements, manufacturing tolerances, and inspection procedures for the use of inspectors in both industry and the Armed Forces in determining the suitability of insulators. The standard drawings included show the equipment design engineer exactly what styles and sizes of insulators are available.

A useful and novel appendix has been included in this standard, in which are given design criteria as recommended by various insulator manufacturers and which have been found to be satisfactory by the other manufacturers represented on the task group which prepared the standard. This section should be particularly well adapted to assisting new personnel in radio design departments in that it explains what can be done with this particular form of insulation and gives the reasons for the specific requirements of the standard.

LUMINESCENT MATERIALS

★ Development of new and highly efficient luminescent materials by scientists in RCA Laboratories gives promise of opening new fields of activity in the postwar era, according to an article by H. W. Leverenz, which appeared in the October, 1943 issue of *Radio Age*, published by the Radio Corporation of America.

Mr. Leverenz points out that phosphors are unique in being able to convert electric power into white or colored light more efficiently than by any other known practical means. Also, they can store light for controllable time intervals from less than one hundred-thousandth of a second to more than twenty-four hours, and can instantaneously transform invisible radiations, such as cathode or ultra-violet rays, into visible light.

Possible uses for phosphors are stated to include intense light sources for sound recording and theater projection, inexpensive illumination of workplaces and homes by using phosphor crystals in fluorescent lamps, luminescent plastics to make night-time safer and more colorful, and phosphors emitting specific radiations for controlled treatment of living tissues and organisms.

SUPERSONICS TEST TIRES

★ A new device which tests rubber tires for flaws by means of supersonic waves has recently been demonstrated, as reported in *The Ohmite News*. The tire is placed in a trough of water and slowly rolled. The supersonic waves are transmitted through the water to the tire sides and a microphone picks up the waves passing through the rubber. As long as the rubber is solid the waves come through and a green lamp is kept lighted. If a flaw breaks the continuity of the waves, a red lamp is flashed.

★

CORRECTION

We regret that the vector potentials *E* and *H*, in *Figs. 1* and *4* of the article on "Maxwell's Equations in Microwave Reflections" in the October, 1943 issue, indicate a direction of propagation opposite to that shown. Also, in *Fig. 2-A*, the *E* vectors, and in *Fig. 2-B*, the *V* vectors, should be reversed.

USING NOMOGRAPHS

[*Continued from page 37*]

points P_1, P_2 and P_3, accessible to a straight-edge, will satisfy determinant (1). Now we must see what the relation of this working determinant is to a given equation in *I, L* and *R*. We perceive that α and β must themselves be functions which define the scale graduations of the *I, L* and *R* scales.

In other words, we shall work one step nearer the beginning by writing the terms of (1) in functional notation:

$$\begin{vmatrix} \phi(X) & \theta(X) & 1 \\ \phi(Y) & \theta(Y) & 1 \\ \phi(Z) & \theta(Z) & 1 \end{vmatrix} = 0$$

That the variables *X, Y* and *Z* are algebraic functions, such as X^2, 4.7 $(Y—3)$, or $9Z^{.5}$, etc., are indicated by ϕ and θ. Now,

$$\alpha_1 = \phi(X) \qquad \beta_1 = \theta(X)$$
$$\alpha_2 = \phi(Y) \qquad \beta_2 = \theta(Y)$$
$$\alpha_3 = \phi(Z) \qquad \beta_3 = \theta(Z)$$

and so it is clear that the point to mark "1" on the *I* scale is $\theta(1)$. It is also clear that substituting 2 for *X*, 3 for *X*, etc., will tell us how far up to go on the *I* scale to determine these points and mark them "2," "3," etc.

Now the nomograph in *Fig. 7* is of the type containing three vertical scales; it is evident that there is only one α, or $\phi(X)$ value, which is a constant C_1. Therefore, we must assign constants for the α functions in this particular type of nomograph. We see that the form will be:

$$\begin{vmatrix} C_1 & \theta(X) & 1 \\ C_2 & \theta(Y) & 1 \\ C_3 & \theta(Z) & 1 \end{vmatrix} = 0$$

and it immediately follows that whenever one of these constants is zero, it is indicated that that scale is coincident with the axis of ordinates.

We are now able to return to the beginning and derive the preliminary determinant from the engineering equation. Suppose that this equation is:

$$X^3 + XY - Z = 0$$

This equation may be written in the form of three simultaneous equations by letting

$$\Delta = Y \text{ and } \mathbf{T} = Z;$$

then $\Delta - Y = 0$, and $\mathbf{T} - Z = 0$, and $X^3 + \Delta X - \mathbf{T} = 0$

and, indicating the missing terms:

$$\Delta + 0 \cdot \mathbf{T} - Y = 0$$
$$0 \cdot \Delta + \mathbf{T} - Z = 0$$
$$X\Delta - \mathbf{T} + X^3 = 0$$

which may now be written in determinant form:

$$\begin{vmatrix} 1 & 0 & -Y \\ 0 & 1 & -Z \\ X & -1 & X^3 \end{vmatrix} = 0$$

Should we doubt the correctness of

Since it is surely continuous, we may connect S and Q and feel confident that the portion SQ shows us the effect of acceleration.

In *Fig. 4B,* the part of the field arising from the acceleration of the charge is redrawn on a larger scale, along with the magnetic lines of force and the resulting Poynting's vector. It is clear there, that the energy flow shown by that vector has a component which points outward from the path of the charge. This represents energy radiated out into space.

So far we have concerned ourselves only with the electromagnetic field arising from a single charge and have specifically pointed out that when the velocity of that charge increases, energy is radiated. Certainly this is true whether the charge is accelerated to the right or to the left and, if the charge oscillates back and forth as in an ordinary antenna, radiation occurs at regular intervals corresponding to each acceleration. The emission of such a train of pulses is referred to as a wave train and the oscillating charge is said to be radiating an electromagnetic wave.

The Bunched Electron Beam

In the Sperry KLYSTRON, the radiation of a continuous wave is obtained in a different manner. Instead of trying to keep a single charge constantly oscillating, which is manifestly difficult to do at the very high frequencies of the microwave region, a technique is used which requires acceleration in only one direction and secures the rapid repetition of the radiated pulses necessary to form wave trains by using a "bunched" electron beam. This is illustrated in *Fig. 5.* An electron beam consisting of groups of charges separated by space containing relatively little charge moves down inside a hollow electrode, through grids and the intervening space, into a second hollow electrode. Only in the space S do these charges receive acceleration and hence radiate out into space. Pulses of radiant energy are thus successively emitted for each bunch of electrons so that a radio wave is formed whose frequency is dictated by the constant velocity of the beam before acceleration and by the closeness together of the bunches.

Recognizing this possibility of generating radio waves, the problem of the KLYSTRON then becomes clear. It is to devise a vacuum tube which will supply such a bunched beam across the catcher grids and arrange an efficient method of collecting the radiated wave and transmitting it to the antenna where it can be sent out into space in accordance with a desired pattern. The way this is done in a standard two-chamber tube is shown in *Fig. 6.* The electron beam emerges from the electron gun traveling from left to right with a certain initial velocity. In some accidental way connected with the starting of the tube some bunching of the beam occurs so that, in the space between the catcher grids, successive bunches are accelerated and radiation pulses are sent out. The catcher cavity is of just the right dimensions so that these E and H waves travel out to the metal wall at A and are reflected back to the electron beam just in time to be strengthened and sent out again by the radiation from the next bunch. When this happens we say that the cavity is at resonance and the energy density in the catcher cavity builds up to a maximum. Energy can then be taken off in the coaxial line marked output.

Aside from concerning ourselves about how the first bunch is formed, we can also now easily understand how the bunching is maintained. In addition to the output coaxial line, a second coaxial fitting is connected to the catcher resonator. Through this some energy flows back to the buncher resonant cavity, which is geometrically just like the catcher cavity. Here, also,

[*Continued on page 58*]

large, vivid illustrations reproduced directly from the films themselves show you what you are going to get—in advance. The directory contains much detailed information—such as outlines of each subject and series, number of pictures on each slidefilm and in each series or Kit, and what type of projector is best suited to various radio training needs.

★

CALLITE TUNGSTEN ELECTRODES

Callite Bulletin No. 154, just issued, describes the application of Callite Tungsten Electrodes by atomic-hydrogen, helium and argon arc welding and gives complete data on the Callite Tungsten Electrodes available—their physical properties—dimensions and current range in amperes. Users of welding electrodes will find this bulletin extremely interesting and informative. Copies may be had on request to Callite Tungsten Corporation, 540 Thirty-ninth Street, Union City, New Jersey.

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NEW CENTRALAB BULLETINS

"Ceramic Tubular Capacitors" is the title of an engineers bulletin now being distributed by Centralab. Its eight pages contain tubular capacitor dimensions and capacity and color code charts besides general descriptive information. One section is devoted to an explanation of test equipment and controlled temperature compensation. It explains correlation methods and results of experiments. Send for your free copy of this bulletin by asking for Form 630 Revised. Centralab, Division of Globe-Union, Inc., 900 East Keefe Avenue, Milwaukee 1, Wisconsin.

No. 817-001 is the number of the bushing mounted capacitor now in current production at Centralab. It is a special type part used in high-frequency circuits where a capacity ground to the chassis and a "lead through" is desired. It is fully described with a dimensional illustration in Centralab's one sheet form 586. The back of the bulletin is devoted to engineering data on Centralab's 830 and 831 style Silver Mica Capacitors.

"A stable capacitor of compact size that is easily adjusted by means of a screw driver" . . . that is the general description Centralab gives of its Ceramic Trimmers, described in detail in its 8-page Bulletin 695 Revised. It goes on to explain the construction principle of the parts, and catalogs four styles in current large production giving the dimensions and specifications of each. Helpful drafting drawings and actual photographs round out this desirable source of information.

★

G. E. PRIMER ON ELECTRONIC TUBES

A 24-page nontechnical book titled "How Electronic Tubes Work" has been produced by the General Electric Electronics Department at Schenectady, N. Y. It is designed primarily for industrial engineers. Illustrated with 117 sketches and photographs, the book is a primer whose main emphasis is on how the electronic tube operates. The eight basic types of industrial electronic tubes and their uses are described. The book (GEA-4116) is available free on request to Dept. 6-215, Publicity Divisions, General Electric Company, Schenectady, New York.

★

G. E. PRIMER ON RADIO

A 68-page primer intended to help the beginner understand the fundamentals of radio has been produced by the General Electric Electronics Department. The book is the outgrowth of a training course in the radio prepared for people employed in nontechnical positions in the radio industry. The scope of the material is broad, with mathematical and engineering treatment on fundamental theory held to a minimum. Hence, the point of view of the practical serviceman has been adopted rather than that of the advanced engineer.

Copies may be obtained from the Advertising Division, Electronics Department, General Electric Co., Bridgeport, Conn., for 25 cents in coin.

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CANNON "AN" CONNECTORS

Cannon Electric Development Company, Los Angeles, has just issued a 10-page Supplement of latest information on Type AN Electrical Connectors. Supplement contains layouts of new insert arrangements, tabular matter and Special Plugs. Pages are in loose-leaf form to be used in current Cannon General Catalogs.

★

Appointments

SOLAR APPOINTS McKINLEY

J. E. McKinley, with offices at 401 North Broad St., Philadelphia, Pa., has been appointed sales representative for Solar Capacitor Sales Corporation in Eastern Pennsylvania, Maryland, and the District of Columbia.

★

R. H. MAYER JOINS TURNER CO.

The Turner Company, Cedar Rapids, Iowa, has announced the appointment of *Rollins H. Mayer* as electronic engineer in charge of research.

Mr. Mayer was previously connected with the Navy Radio and Sound Laboratory, at Los Angeles, where he was associate radio engineer, working under Dr. August Hund.

★

G.E. APPOINTMENTS

E. H. Fritschel has been named Sales Manager of Transmitting Tubes, and *H. J. Mandernach,* Sales Manager of Receiving Tubes in the Tube Division of the General Electric Company's Electronics Department, according to an announcement by *G. W. Nevin,* Division Manager. Both men are located in Schenectady, N. Y.

H. A. Crossland has been named Manager of Sales of the Receiver Division of the General Electric Company's Electronics Department, according to an announcement by *I. J. Kaar,* Division Manager. In this capacity, Mr. Crossland will be responsible for all sales matters of the division. For the present he will divide his time between Bridgeport, Conn., and Schenectady, N. Y.

R. P. Whitmyre has been appointed Assistant to *R. J. Bahr,* Purchasing Agent of the General Electric Company's Electronics Department. In this capacity, Mr. Whitmyre will assist Mr. Bahr in the general administration and co-ordination of purchasing and procurement activities for the department. He will be located at Schenectady, N. Y.

J. W. Whiteside has been appointed buyer in the Tube Division of the Electronics Department, General Electric Company, according to R. J. Bahr, department purchasing agent. His headquarters will be at Schenectady.

In this capacity Mr. Whiteside will be responsible for all purchases, including subcontracts for the division.

★

CANNON NAMES REPRESENTATIVES

To provide for better representation in various parts of the country where war production has opened new plants or greatly increased activity, and demand for Cannon's electrical connectors, *William V. Brainard,* Sales Manager, Cannon Electric Development Company, Los Angeles, California, has announced the following new engineering representatives:

E. B. Glenn, 801 Healey Bldg., Atlanta, Georgia; *Douglas H. Loukota,* 10 Light Street, Baltimore, Maryland; *Ray Perron & Company,* Little Bldg., Boston, Massachusetts; *H. M. Welch,* Crosby Bldg., Buffalo, New York; *George Sturman,* 712 Sixth Avenue S., Minneapolis, Minn.; *J. Tinsley Smith,* 108 17th Avenue S., Nashville, Tennessee; *J. W. Beneke,* St. Louis Agent for E. L. Melton, at 757 Arcade Bldg., St. Louis, Missouri.

★

C. A. PRIEST TO G. E. TRANSMITTER DIVISION

C. A. Priest has been appointed Manager of the Transmitter Division of the General Electric Electronics Department, Dr. W. R. G. Baker, Vice President in charge of the department, has announced. In this capacity, Mr. Priest will assume the responsibility for the operations of the Syracuse, New York, plant of the division, and will have his headquarters in that city. Mr. Priest was engineer of the Radio Transmitter Engineering Division at Schenectady, New York, before his new appointment.

control and maintenance of the equipment, and what charge or charges, if any, will be made for the service. Such agreements must run for a definite period of time and notice of the termination of such agreements must be given to the Commission not less than 60 days prior to cessation of service."

Earlier Test Periods

The Commission modified Section 15.75 to provide earlier week-day test periods for eastern/central time zones beginning and ending one hour earlier than the present periods. The revised Section will become effective ten days from date of approval by the Commission. The new time periods are:

Time Zone	Eastern	Central	Mountain	Pacific
Mondays	9-11 p.m.	8-10 p.m.	8-10 p.m.	7-9 p.m.
Wednesdays	9-11 p.m.	8-10 p.m.	8-10 p.m.	7-9 p.m.
Sundays	5- 7 p.m.	4- 6 p.m.	3- 5 p.m.	2-4 p.m.

All times given are local standard (war) time.

Portable Mobile Installations

The Commission adopted a new Section 10.115, effective Dec. 2, 1943, as follows:

"Section 10.115. *Portable-Mobile Installations in Private Vehicles* — No portable-mobile radio station licensed in the Emergency Radio Services may be installed or maintained in any vehicle, aircraft or vessel which is not owned or at all times controlled exclusively by the licensee unless special authorization for such installation has first been granted pursuant to proper application and showing of need therefor to the Commission."

★

SIEGEL, OF OHMITE, HONORED

David T. Siegel, founder and president of the Ohmite Manufacturing Company, Chicago, was elected to the board of trustees of Illinois Institute of Technology at the annual meeting.

Mr. Siegel was one of five new members named to the Institute's board, the others are: *Whipple Jacobs,* president of the Belden Manufacturing Co.; *Claude A. Kneupfer,* president and general manager of the General Engineering Works; *T. Albert Potter,* president of the Elgin National Watch Co.; and *Harold B. Smith,* president of the Illinois Tool Works. The Board of Trustees includes in its membership 56 industrial executives and professional men of the Chicago area. Siegel was elected as an alumni representative to the board, having been nominated by the Illinois Tech Alumni Association.

As a member of the board of trustees, Siegel will help formulate the governing policies of Illinois Tech, one of the nation's largest engineering colleges. The school was formed in 1940 by the merger of Armour and Lewis Institutes.

In addition to his newly-elected position on the Illinois Tech board of trustees, Siegel is a member of the Fixed and Variable Resistor Industry Advisory Committee of the War Production Board.

★

TEST REPORTS WANTED

To reduce the time element between the pilot stage and large scale production of a badly needed product, the Frederick Post Company wants one hundred users of Transparent Ammonia developed prints to confirm or disprove the laboratory and limited field tests of what appears to be a full step forward in this field.

The new Transparent, ammonia process, VAPO-vel has just passed months of testing for fading, keeping quality, stability of image and background, printing and developing speed, sharpness of image and the ability to pick up both strong and delicate detail.

Trial quantities will be furnished without charge with the understanding that a detail report will be made on the results of the tests.

If the comprehensive reports are favorable the original production facilities will be available to the one hundred companies participating in the tests.

For those who wish to make these tests just write the Frederick Post Company, Box 803, Chicago 90, Ill.

★

ARMY-NAVY "E" AWARDS

NEW AWARDS

THE ROLA COMPANY, INC.
2530 Superior Ave., Cleveland, Ohio

REEVES SOUND LABORATORIES, INC.
62 W. 47th St., New York, N. Y.

CHICAGO TELEPHONE SUPPLY CO.
Elkhart, Ind.

SCIENTIFIC RADIO PRODUCTS CO.
Council Bluffs, Iowa

ONE STAR

SOLAR MANUFACTURING CORP.
285 Madison Ave., New York, N. Y.

CLAROSTAT MANUFACTURING CO., INC.
285 N. 6th St., Brooklyn, N. Y.

SPRAGUE SPECIALTIES CO.
North Adams, Mass.

PRESS WIRELESS, INC.
Hicksville, L. I.

TWO STARS

RADIO CORPORATION OF AMERICA
Harrison, N. J.

GALVIN MANUFACTURING CORP.
4545 W. Augusta Blvd., Chicago, Ill.

BELMONT RADIO CORPORATION
Chicago, Ill.

HALLICRAFTERS COMPANY
Chicago, Ill.

THREE STARS

RCA VICTOR DIVISION, RCA,
Camden, N. J.

FOUR STARS

RCA VICTOR DIVISION, RCA,
Indianapolis, Ind.

UNIVERSAL MICROPHONE COMPANY INSTALLS NEW DEPARTMENTS

Universal Microphone Co., Inglewood, Cal., has installed two new departments. No. 10 will be composed of 35 company inspectors directed by Supervisor *John Nettleton.* Dept. 11 will be assembly line for T-45's, new Signal Corps lip microphone that fits on the upper lip and straps around the ears with bands.

★

CRYSTAL-MAKING IN MOVIES

"Crystals Go To War," a training film of Reeves Sound Laboratories, Inc., 62 West 47th Street, New York 19, New York, is an interesting Kodachrome sound film which illustrates and narrates the manner in which crystal oscillators, supplied for Airborne Radio, United States Army Signal Corps, are made.

The film is available on application by technical organizations, many of whom have seen it and found it very instructive as to mass production methods and from the standpoint of employee training.

★

AEE ELECTS OFFICERS

The following officers for 1944 have been elected by the Associated Electronic Engineers: President, *Frank H. Jennings,* LU No. 596; Vice-President, *Fred W. Huff,* LU No. 379; Secretary-Treasurer, *Alfred Kunze,* LU No. 306.

The Associated Electronics Engineers is composed of sound service engineers and inspectors having membership in the I.A.T.S.E. The aim of the organization is to promote the knowledge of electronics in their allied arts and to keep abreast of all new developments in the field.

Inquiries are invited from sound service engineers throughout the country. Address all communications to *Alfred Kunze,* Secretary-Treasurer, 6143 80th Street, Elmhurst, New York.

★

ALTMAYER WITH MEC-RAD

Mr. Franklin G. Gepfert, Chairman of the Board, announces the formation of Mec-Rad Division of Black Industries, 1400 East 222nd Street, Cleveland, Ohio, to manufacture the mechanical components of all types of radionic devices.

Mec-Rad Division is under the direct supervision of *John Altmayer,* Chief Engineer. *Theo. R. Finke* is development and production engineer. The major products of this division will be precision-type transmission lines and radiation components.

[*Continued on page 60*]

EVERYONE IS TALKING ABOUT THE NEW *Electro-Voice* ACHIEVEMENT

NICKNAMED THE "LIP-MIKE"

Officially known as the T-45, the

Electro-Voice DIFFERENTIAL MICROPHONE

is also affectionately termed the "Schickelgruber"

Developed by Electro-Voice engineers in close collaboration with the Fort Monmouth Signal Laboratory, the T-45 marks the beginning of a new era in which voice transmission is unaffected by ambient noise or reverberation. It accomplishes such complete suppression of background that speech from a battlefield or from the deafening interior of a moving tank is accompanied by hardly a trace of noise.

The "Lip-Mike" is a Differential Microphone designed to fit under a gas mask without breaking the seal — small enough to allow an Armored Force respirator to slide over it — and has been standardized for all Army Ground Forces.

- *Frequency response substantially flat from 200-4000 cps.*
- *Low harmonic distortion*
- *Cancellation of ambient noise, but normal response to user's voice*
- *Self-supporting, to free both hands of the operator*
- *Uniform response in all positions*
- *Usable when gas mask, dust respirator or oxygen mask is required*
- *Unaffected by temperature cycles from —40° F. to —185° F.*
- *Ability to withstand complete immersion in water*
- *Physical strength to withstand 10,000 drops*
- *Weight, including harness, cord and plug, less than 2 ounces.*

WHEN PEACE COMES, THERE WILL BE DIFFERENTIAL MICROPHONES OF MANY TYPES FOR CIVILIAN USES IN WHICH THESE ADVANTAGES WILL BE OF REVOLUTIONARY IMPORTANCE. THUS, ANOTHER WARTIME DEVELOPMENT WILL FIND ITS GREATEST VALUE IN THE COMING OF PEACE.

Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. · 1239 SOUTH BEND AVENUE · SOUTH BEND, INDIANA

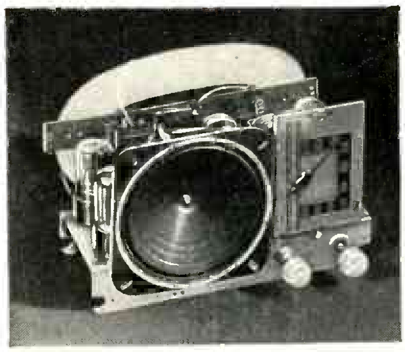
Export Division: 13 East 40th Street, New York 16, N. Y. — U. S. A. Cables: ARLAB

Voltohmyst, RF Test Oscillator, Beat Frequency (AF) Oscillator and the Cathode Ray Oscilloscope. The student can thus learn how to identify the nature and location of a fault existing in a receiver by methods employing maximum speed and accuracy.

★

ALLIED RADIO RECEIVER KIT

Allied Radio Corporation, Chicago, offers a modern radio receiver kit especially developed for illustrating theory and practices now being covered in basic or pre-induction radio training. It is now available to all schools and colleges conduct-



ing war training programs. This 5-tube kit permits progressive study of basic receiver subjects such as rectification, filtering, detection, r.f., i.f. and a.f. amplification, etc. The kit consists of all necessary parts, wire, hardware, solder, tubes, and speaker for the construction of a 5-tube a.c.-d.c. superhet receiver. Chassis is completely formed, punched and rustproofed. The only tools needed for assembly are screwdriver, pliers and soldering iron. Circuit includes features such as oscillator biased r.f. and i.f. stages, contact-potential biased audio stage, inverse feedback, automatic volume control, high capacity filtering, self-contained antenna, etc. Write Allied Radio Corporation, Educational Division, 833 West Jackson Boulevard, Chicago 7, Illinois, for free descriptive material and diagrams.

ADVERTISING INDEX