RADIO

ESTABLISHED 1917

DESIGN, RESEARCH
PRODUCTION, OPERATION

★

FEBRUARY, 1943

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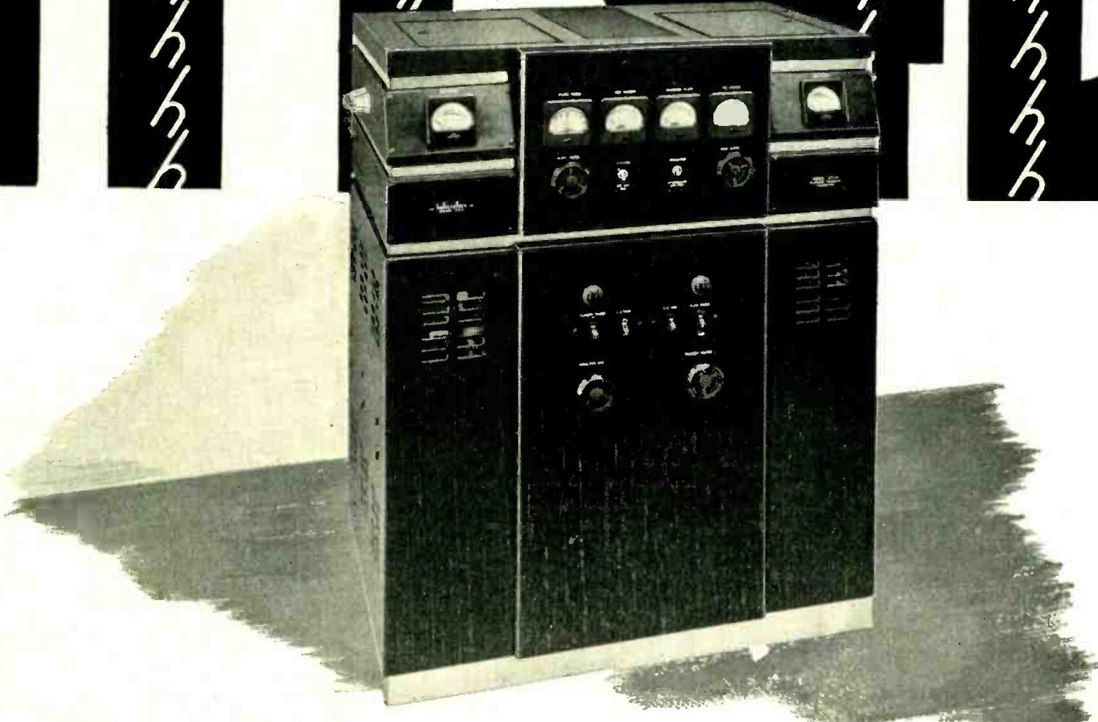

HERE is that high-powered rig you have always wanted to own . . . one that you can depend upon for peak operating efficiency. Hallicrafters have built into the HT-4B the resultant experience from years of engineering research.

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RADIO

Published by RADIO MAGAZINES, INC.

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COVER

Looking endwise into the corona ring system of a high-voltage pressure tank arrangement at the State University of Iowa. See article on page 15.

ARTICLES

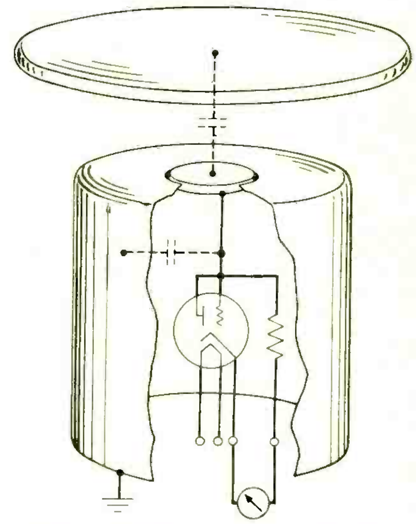
MISCELLANEOUS

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, 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.

TECHNICANA

RADIO-FREQUENCY VOLTMETER

★ Measurement of the high voltages encountered in radio circuits requires a potential divider because measuring instruments cannot take the full differences of potential. One method, outlined in the January 1943 issue of the *Bell Laboratories Record*, is to connect a large and a small capacitance in series across the voltage and measure the drop across the larger capacitance. This drop can be made small by using a large ratio of capacitances, since the voltages of two condensers in series divide inversely as their capacitances.

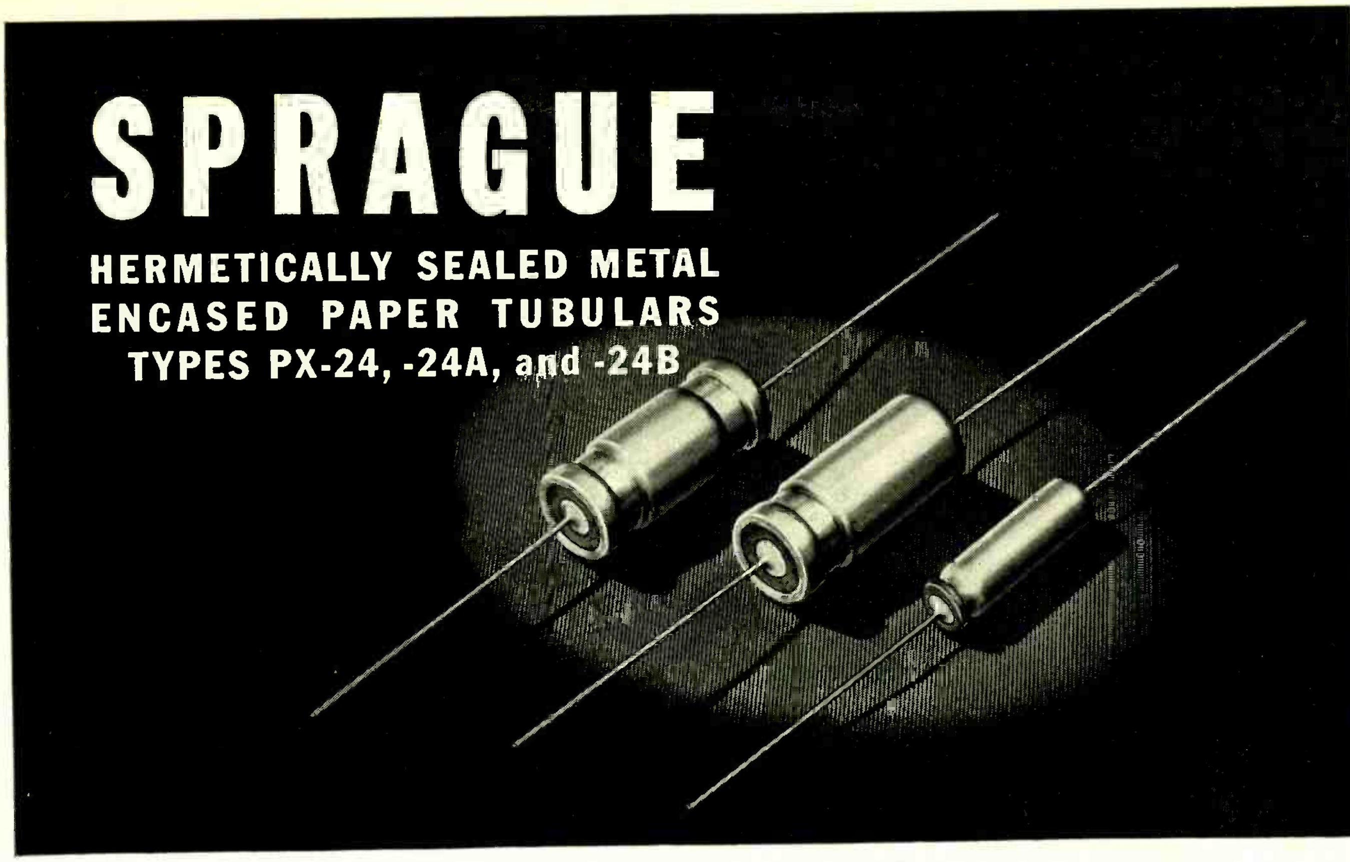


Radio-frequency voltmeter circuit.

In the radio-frequency voltmeter shown here the top plate, which is

[*Continued on page 8*]

High-voltage r-f voltmeter.



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...and do them well!

SMALL—light in weight—hermetically sealed, and outstandingly sturdy, these Sprague Metal-Encased Paper Tubular Capacitors have proved eminently satisfactory for numerous blocking and by-pass applications previously assigned exclusively to molded mica units. Not only is this true as regards less critical "mica jobs," but also on more exacting applications where characteristics such as temperature-insulation resistance, voltage-capacitance, or temperature-capacitance are important considerations.

There remain, of course, certain applications where mica capacitors should still be used, and Sprague regularly produces large quantities of transmitting mica capacitors in a complete range of types and sizes.

Deliveries of both types are obviously dependent on prevailing priorities. Production facilities—especially on the Metal-Encased Paper units—are being steadily expanded, and Sprague engineers will gladly cooperate in determining the adaptability of these Capacitors to your requirements.

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Sprague offers a constant market for large quantities of critical materials. Present requirements include: 7/16" and 1/4" hex brass rod, free turning; 5/16" and 1/4" diameter brass rod, free turning; #22 gauge long ternes, 8# to 15# coating; 8/32" standard hex brass nuts; also ferrous and non-ferrous metals. Offers of these items in small lots or large will be reported upon promptly and AA1 Priorities supplied to cover purchases.

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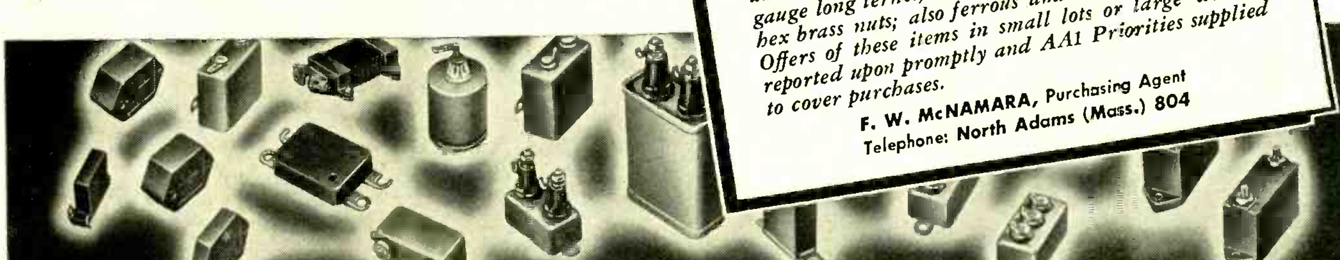


MANUFACTURERS OF A COMPLETE LINE OF RADIO INDUSTRIAL CAPACITORS AND KOOLOHM RESISTORS

TECHNICANA

[*Continued from page 6*]

about 3 inches in diameter, and the small metal disc concentric below it, form one capacitance. Distributed capacitance between this disc and the ground provide a much larger series capacitance whose potential can be conveniently measured. A vacuum tube rectifies the potential and a milliammeter in the tube circuit indicates the full voltage.

With this arrangement voltages up to 10,000 volts with frequencies up to 50 megacycles can be measured.

★

WOMEN AT WORK

★ The *Ladies' Home Journal* has been running a series of advertisements titled, "Never Underestimate the Power of a Woman!" And it seems now that the radio engineer and technician will have to take this warning to heart—for women are in our midst!

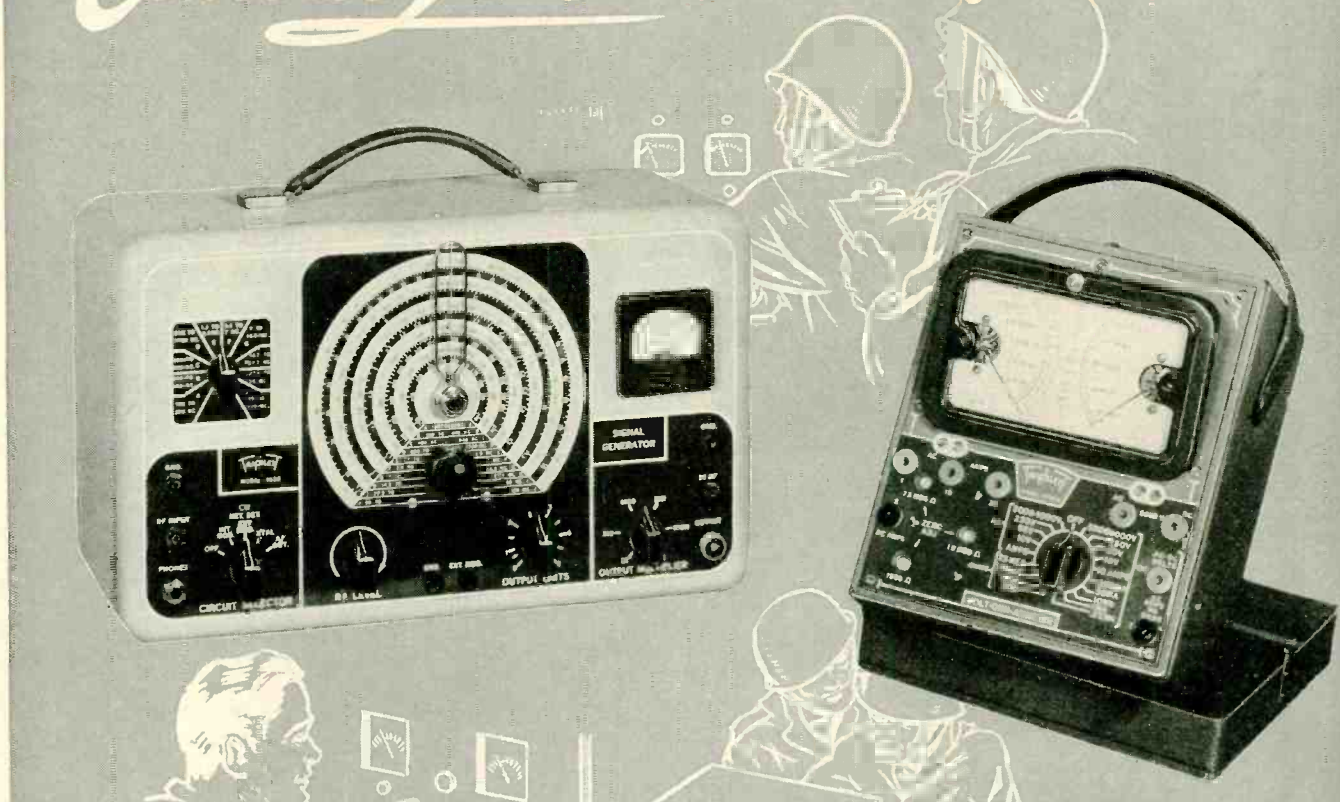
The Western Electric Company now has a large number of women doing "the man's work" of testing, calibrating and, in some instances, research. More recently, the Brown Instrument Company ran an advertisement in Philadelphia newspapers for "women college graduates to train for laboratory assistants, engineering aides and careers in research work," the last of which may chill the hearts of many males, by its implication of permanency. To make matters worse, Walter P. Wills, development engineer of Brown Instrument Co., states that just as women have shown that they

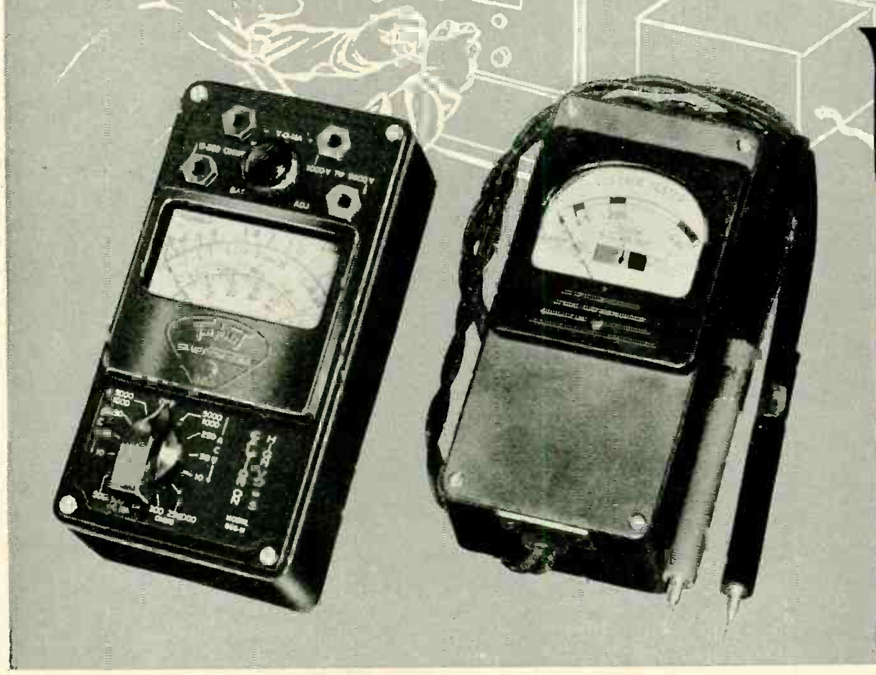
[*Continued on page 10*]

Irene Mele calibrating a standard resistance box at the Kearny Works of the Western Electric Company.

TRIPLETT

Combat Line TESTING EQUIPMENT





TRIPLETT

The Toughest Test in History

Miracles must be done in minutes in this war of mechanized movement. And Triplett Testers, built to the needs of war, are valued tools with America's armed forces on 22 fronts and on the seven seas.

Here are a very few of Triplett Combat Line Testers. There are many! Built for every tester job, they are different in adaptation to each specific purpose; unfailingly alike in precision performance rendered under the toughest test ever devised since the beginning of time.

When the last gun has been fired, the values of Triplett wartime experience will be evidenced by advanced technical superiority and by precision performance that might well seem miraculous today.

THE TRIPLETT ELECTRICAL INSTRUMENT CO., BLUFFTON, OHIO

A WORD ABOUT DELIVERIES

Naturally deliveries are subject to necessary priority regulations. We urge prompt filing of orders for delivery as may be consistent with America's War effort.

TECHNICANA

[*Continued from page 8*]

have greater aptitude at some production jobs than men, they also are better suited to certain laboratory assignments, especially those that require a great degree of patience.

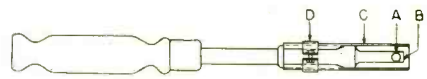
Possibly we will see in the post-war period, a Ladies' Section of the Institute of Radio Engineers, and Powder Rooms in the Engineering Societies Building.

★

SIMPLIFYING SMALL-WIRE SOLDERING

★ The job of soldering small wire connections is simplified at General Electric by making the iron stationary and dipping the connections into a small hole filled with solder near the tip of the iron.

As shown by the drawing, the soldering iron can be fixed for use in this



manner by drilling a hole *A* into the tip *B*. A nickel steel tip will last longer than other types.

The drip and splash guard *C* catches surplus or drips of solder coming off the iron. It is made of 1/32-inch steel and is fastened to the iron with a hose clamp *D*.

★

MONITOR LOUDSPEAKER

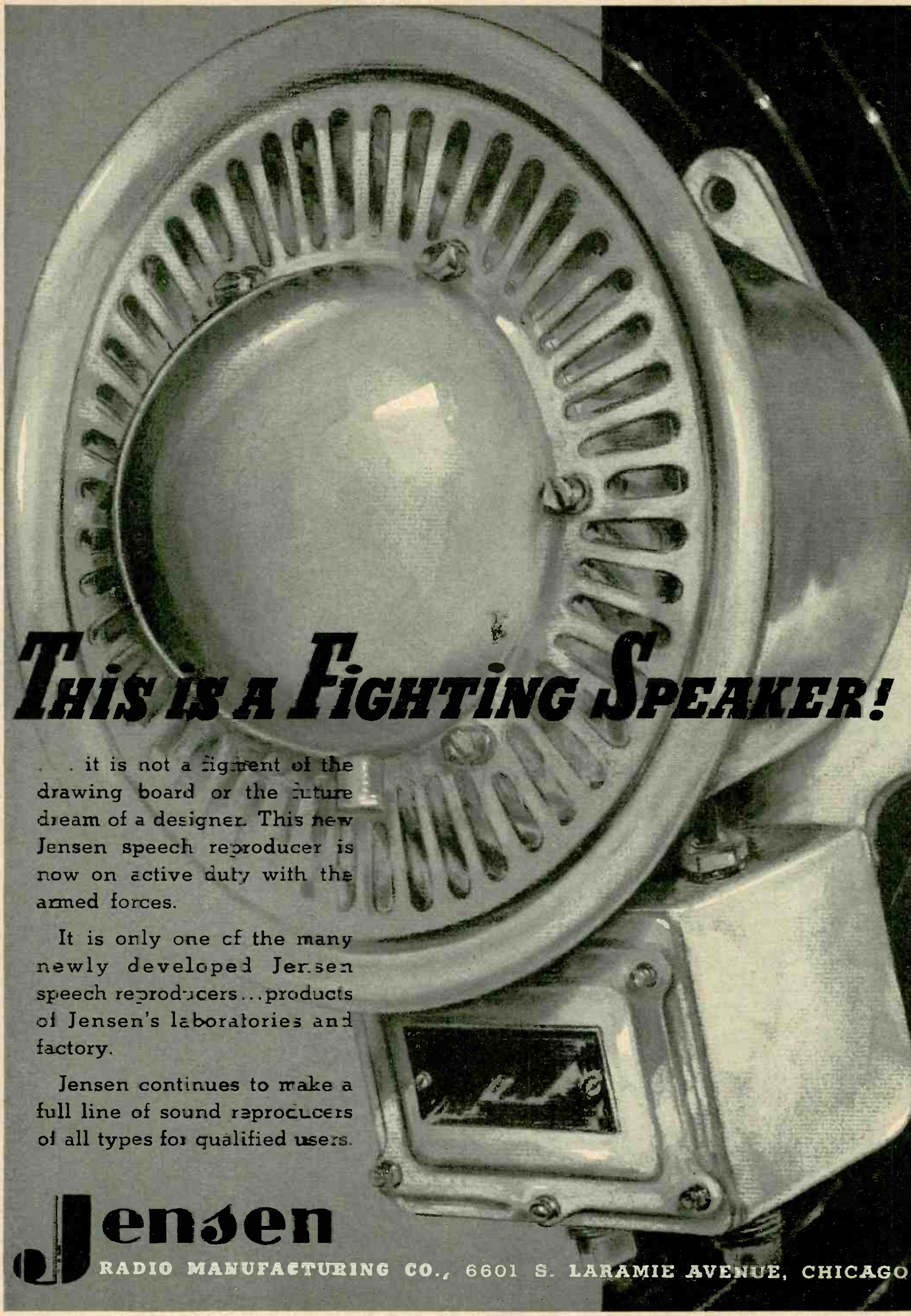
★ A single-unit loudspeaker employing a unique diaphragm construction has been designed by the General Electric Co., for use in broadcast stations for checking transmission quality. Stiffening the diaphragm with mica eliminated the ordinary 4000-cycle peak with subsequent cutoff and extended the high-frequency response to 9000 cycles. Good low-frequency response was maintained by using a very compliant diaphragm suspension and by mounting the speaker in a completely sealed wooden cabinet which eliminates the usual back wave.

★

SIGNAL-CORPS RESEARCH

★ Many are the means of communication devised and developed by engineers of the Signal Corps. Yet those in use now—excellent as is their performance—are far behind the new ones which are already emerging from the laboratory stages. And problems which existed in certain forms of operation

[*Continued on page 47*]


THIS IS A FIGHTING SPEAKER!
. . . it is not a figment of the drawing board or the future dream of a designer. This new Jensen speech reproducer is now on active duty with the armed forces.
It is only one of the many newly developed Jensen speech reproducers... products of Jensen's laboratories and factory.
Jensen continues to make a full line of sound reproducers of all types for qualified users.
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EDITORIAL

CIRCUIT VALUES

★ As brought to our attention by Cortlandt Van Rensselaer, the recent design of radio and electronic devices using high resistances of accurate value has outmoded the classical notation used for these circuit components. Heretofore the plan has been to use the symbol M for 1000 and Meg for 1 million ohms. Not only is Meg a cumbersome factor to include in the specification of many resistance values, but the similarity between the abbreviation M and Meg is sufficient to often result in confusion. The attempt to be consistent in the statement of resistance values has led many firms to specify all values in fractions of megohms. While it is true that this notation is less confusing than M and Meg, the numbers are still cumbersome when small resistances are specified.

A logical solution, he points out, and one which has been found to be wholly workable, is "to modify the old method by allowing the letter K to designate 1000, thereby opening the possibility of shortening the Meg symbol to M for 1 million. This is not an illogical proposal since the letter K is often used in engineering to signify 1000, and M 1 million. The resulting simplification is apparent."

Though it is customary in some quarters to express the values of resistors and capacitors through the use of exponents, the notation 5×10^{-4}, for instance, as the value of a capacitor is not satisfactory where the notation is to be resolved by radio maintenance men in civilian or military service.

For that matter, the entire system of circuit notation could stand revision and subsequent standardization. Since there are numerous ways of approaching the problem, the matter is open to discussion.

RADIOTHERMICS

★ The article "Heating of Wood With R-F Power", by John P. Taylor, in our January issue, provides but one small glimpse into the future of Radiothermics. It is a comparatively new branch of radio that holds untold possibilities. Quoting from a booklet recently issued by the Radio Corporation of America, "Radio waves may now be used to heat, dry, glue, stitch, anneal, weld and rivet; also to deactivate enzymes . . . Radio high-frequency 'furnaces' are a post-war prospect, and in them railroad ties can be seasoned quickly and 'cakes' of textiles dried uniformly. Even rubber may be radio 'cemented' to wood or plastic; cloth stitched and seamed by radio heat, metals hardened, plywood glued and fresh vegetables deactivated without loss of flavor or color." And any radioman who may wish to do a bit of imagineering can easily carry radiothermics into the realm of household appliances for heating and cooking.

As a commercial possibility, Radiothermics is on surer ground than such electronic devices as may be employed for the purpose of precise control, simply because it will take some time to educate the public, and industrialists, to the point where they will have confidence in equipment that can go completely haywire through such a simple fault as an open resistor or a change in the electrical value of a circuit component.

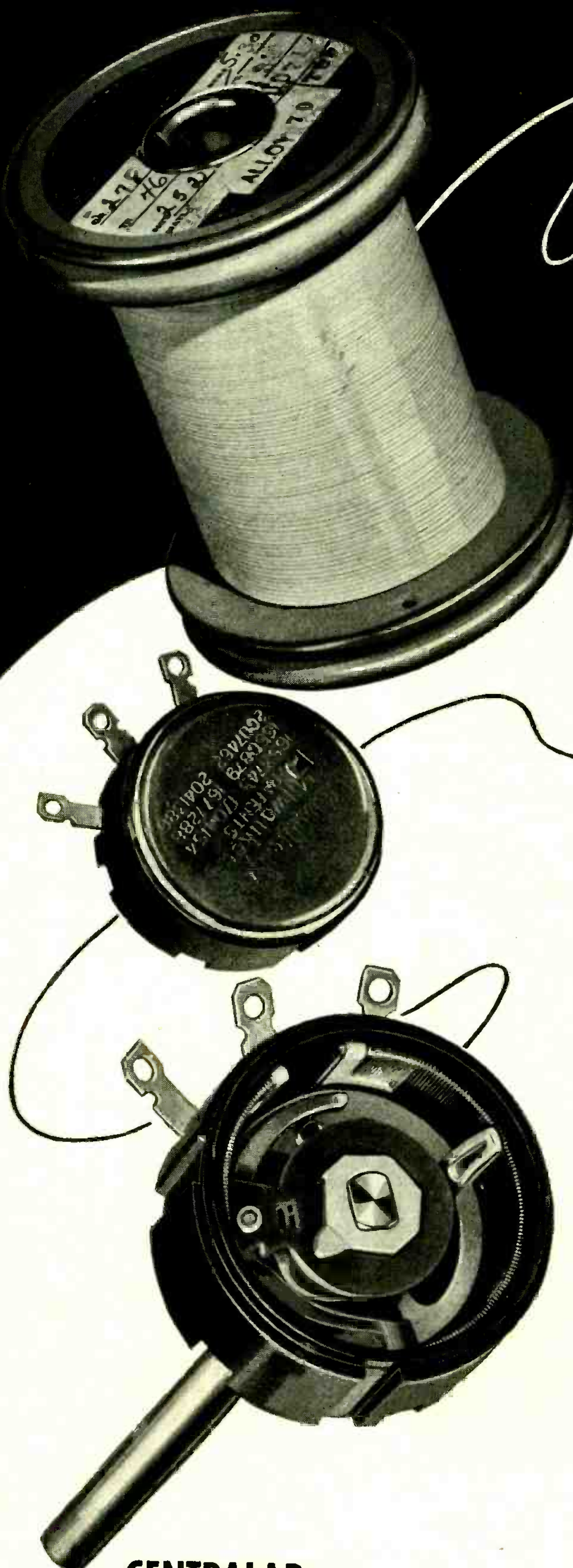
THE CASE OF THE MISSING PIECE

★ A recent article in the *New York Times* on the "books of etiquette" passed out to our soldiers bound for foreign countries, pointed out that these lessons in "how to behave when you reach —" are necessarily printed well ahead of time. Hence, if Germany had gotten wind of the fact that a book dealing with the customs of the peoples of North Africa was in preparation, our whole show would have been given away. Anyone can see, therefore, why the preparation of these books must be shrouded in secrecy.

It should be equally as evident — though it is not — that people, and particularly engineers and technicians, should not discuss outside of their own circles the characteristics of war devices or the theory underlying their operation, no matter how innocuous the data may appear to be.

Some time ago, a government agency took exception to an article prepared for *The Saturday Evening Post* on the grounds that, though most of the information contained in the article had been published at one time or another, it was unsafe to tie it up into one neat bundle, with none of the pieces missing. The editors of the "Post" saw the logic in that and refrained from printing the material in toto.

Most any scientific device can be likened to a jigsaw puzzle to the extent that the method of its operation may not be apparent at all if one segment of its basic theory of operation is left unexplained. We may assume, without being dramatic, that enemy agents pick up scraps of information here and there that provide a semblance of a complete picture. Do not place yourself in the position of unwittingly supplying an agent with the missing piece to any puzzle by talking out of bounds.—M.L.M.



Wire Wound Radiohms by Centralab

Our Army, Navy and Air Force is using electronic equipment in which Centralab Wire Wound Radiohms play an important part.

Available in single or tandem type . . . with or without switch . . . for use as potentiometer or rheostat . . . in resistance values up to 10,000 ohms. Total rotation 300°. Switch type requires 40° for switch throw. Linear taper only . . . rated conservatively at 3 watts . . . temperature rise of 100 ohm unit is 28°C. at 3 watts, 40°C. at 4 watts . . . with load carried over total resistor.

CENTRALAB: DIV. OF GLOBE-UNION, INC., MILWAUKEE, WIS.

HIGH-VOLTAGE CONTROL

V. J. YOUNG
New York University

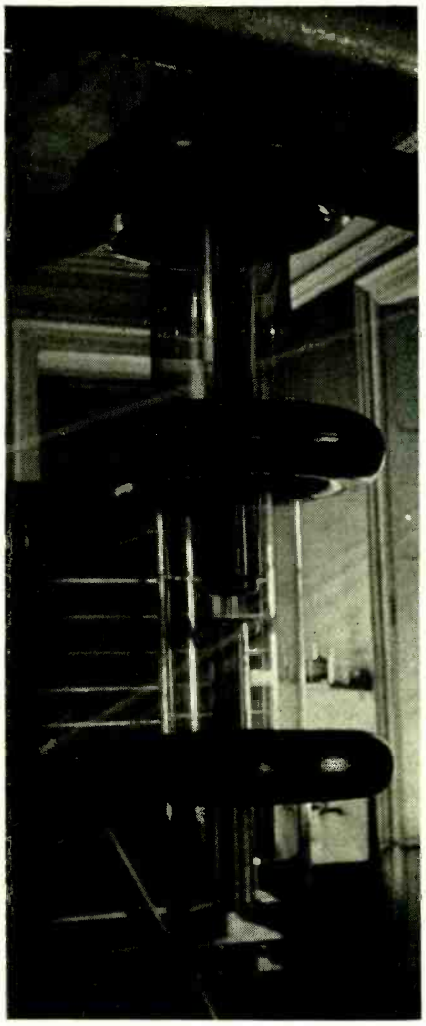
★ High voltages can mean almost anything from 2000 volts to 400 kilovolts, or even up to a few million volts. As far as the lethal qualities of the installation are concerned it makes very little difference. It is something like drowning in 10 feet instead of 100 feet of water. As a matter of fact voltages of 100,000 and more are probably somewhat less dangerous than 10-kilovolt potentials even though the two are capable of supplying the same amount of energy.

The electric field of really high potentials makes itself known while there is still time for you to change your mind about touching it. You feel it on your face and forearms; it tends to make your hair stand on end. For example, at the physics department of the State University of Iowa there is a 400-kv direct-current installation in open air. It consists of a simple vacuum-tube circuit designed to rectify and multiply the voltage of an oil filled transformer by a factor of four. There the electric field can easily be felt at a distance of three or four feet.

At the useful load the highest voltage appears on a metal box supported ten or twelve feet in the air on insulating legs made of a composition fiber. In this box at high potential are several small power supplies and a generator which is driven by a long insulating belt. The controls in the box are operated by long strings which terminate at a panel placed a conservative distance away. Ends of strings from these controls may be observed standing quite erect or pointing horizontally out toward the nearest wall. After a while you even learn that the output voltage can be estimated from the appearance of the string ends.

High Voltages in Radio

Both the Iowa installation and a very similar one at New York University, as well as a dozen others in various university laboratories both in the United States and abroad were built in 1935 or earlier. The physicist built up these sources primarily for his use in studying the central portion of the atom, but because of the moderately high voltages now being used in television and special military radio equipment, many of his construction problems are currently very pertinent. The ordinary cathode-ray 'scope with a 905 type tube may use one or two thousand volts; a tube such as the 912 used for the examination of transients may well use as much as 15 kv; commercial television receivers sometimes operate with 12 kv. A 10-kw frequency-modulated transmitter will use 7 kv on its plates and the largest transmitting tubes listed as standard items operate with as much as 20 kv. Furthermore, insulation must often be designed for twice these amounts to take care of the peak inverse voltage at the rectifier. X-ray outfits also make use of high voltage but are more easily handled because of the simplicity of the high-tension circuit. A tube such as is used in many doctor's offices will operate at only a few thousand volts, but large X-ray therapy machines even use potentials of 100 to 1000 kv.



Rectifier tower at New York University, showing string controls in foreground and stove pipe wiring.

Because of the economy of transmission of energy at high voltage, power companies use high-tension lines and occasionally, where space is not at too great a premium, actually operate at voltages as high as 800 kv. This is possible because the high voltage is alternating and thus obtainable from a transformer entirely sealed in oil. The leads are brought out on enormous insulators so as to keep the air path very large. Space is at more of a premium for laboratory and semi-portable apparatus and oil cases make the components inaccessible and add too much to the weight. Thus it is necessary to watch spacing very carefully and consider tricks to help out.

Points and Spheres

Two ten-inch spheres separated five inches in dry air will be insulated from each other much better than two points at the same distance. As little as 85 kv will cause a spark to jump between the points but the spheres will take 275 kv before breakdown occurs.

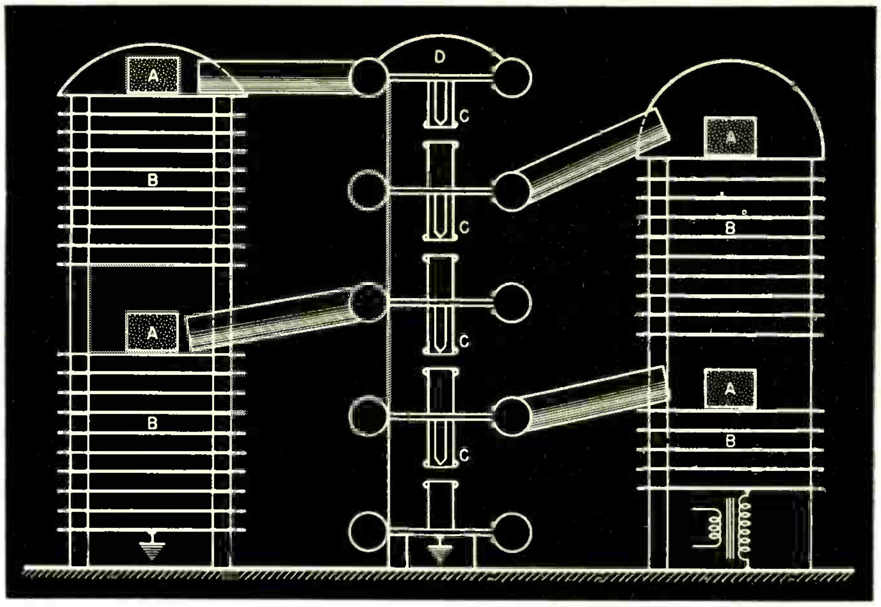


Fig. 1. Arrangement of the components in a 300-k.v. supply at New York University. A represents storage batteries for filament supplies; B, condensers made by series connecting units formed of three foot square window glass coated with foil on both sides; C, rectifier filaments and cathodes; D, high voltage point.

It is not the voltage alone that dictates the insulation problem but rather the voltage and the geometry. These two requirements can be linked by talking in terms of the electric field. If a small test plate is located at various points between the charged spheres just mentioned, it will be found that the voltage to which corona charges the plate is just about proportional to the distance. That is, if 50,000 volts are applied to the gap, and if one sphere is taken to be at zero voltage, then one inch along the gap the plate will find 10,000 volts; two inches along 20,000, etc. We would then say that the electric field is approximately uniform, and has a value of 10,000 volts per inch.

With the points the situation is quite different. At only a short distance from the point at zero voltage, we would find nearly half the available voltage on the probe. The electric field will be very high in the neighborhood of the points and only a few volts per inch will be found in the central region. With either the spheres or the points it is a certain allowable value of the electric field which, when exceeded, will precipitate a breakdown.

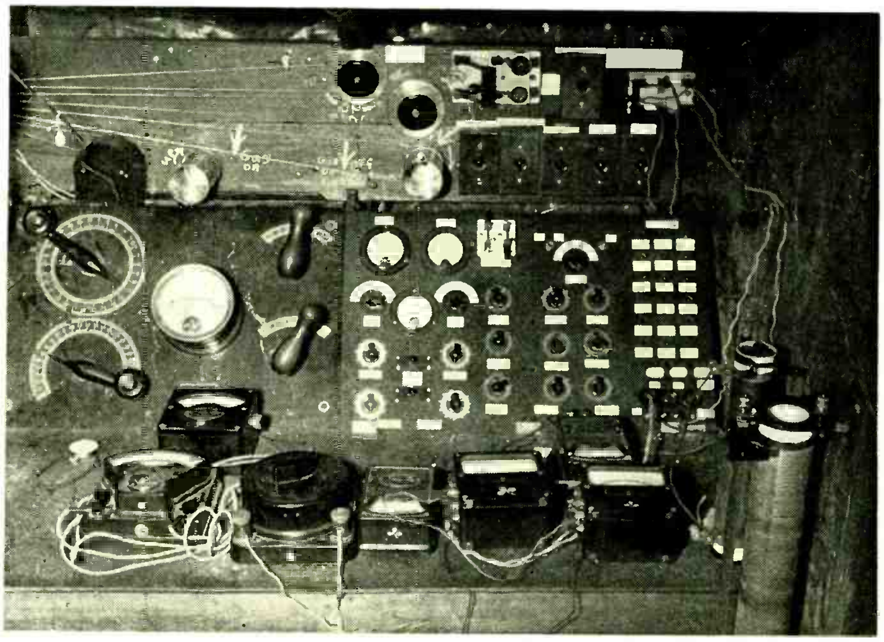
To avoid these high electric fields, which always appear at surfaces with small radii curvature, the Iowa and N.Y.U. systems were wired up with three- and five-inch stove pipe. See *Fig. 1.* Number eight wire is even far too small to avoid excessive corona from the high field at its surface. Built when rubber and gasoline were common and sealed off high voltage rectifiers were not, these systems had their rectifiers built in 20-gallon glass cylinders from the old gravity feed gasoline station pumps. The ends of the cylinders were closed off by steel plates and an inflated inner tube coated with colloidal graphite was mounted around each plate. The plates with their inner-tube shields then served as electrode connections. Filament leads were carried from isolated storage batteries by wires running inside the stove pipe. A charge looking at the assembly from another voltage saw only the smooth curved surfaces of the stove pipe or inner tube.

Housing High Voltage

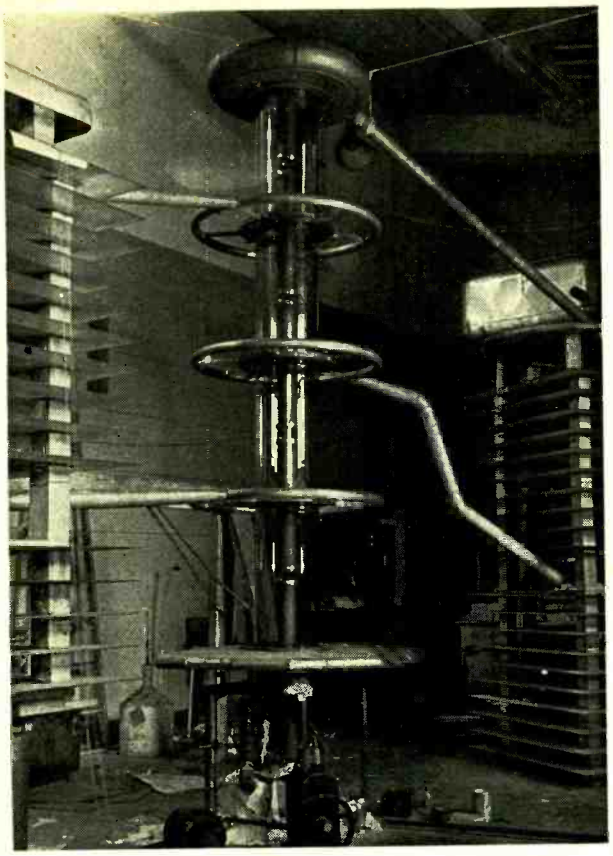
Even when surfaces are all kept to large radii of curvature, it is very difficult to house more than half a million volts in a room of modest dimensions. Even when the room is specially built and made very large, a practical limit is reached somewhere around a million volts. Above this, the apparatus is too large and small changes in humidity play too great a part in the operation.

The natural answer to this was to enclose the whole generator in a tank of some sort and hope that something could be done about the air which supported the unwanted discharge. The first idea, and again the natural one was to pump the air out of the tank and thus have the whole supply in a vacuum. This proved to be quite an impossible task. A good vacuum is the best of insulators but only a slightly poorer vacuum is even worse than air at atmospheric pressure. A glow discharge akin to those in neon signs takes place. Because of a need to frequently connect to the high voltage as well as make adjustments, it was very soon found impossible to use degassing methods suitable for good vacuums.

The opposite procedure of pumping air into the tank under pressure was very much more effective. Moreover, at the University of Wisconsin, where most of the early pressure insulation work was done, it was found that the addition of a gas such as freon gave still better results. In one installation a voltage of 3.5 million volts was ob-



Control panel inside the lead shack at the State University of Iowa installation.



Rectifier tower and condenser stacks at the State University of Iowa. Mechanical pump runs continually on diffusion pumps at the base of the tower to maintain the vacuum.

400-k.v. system with useful load in foreground as first built at the State University of Iowa. Framework in left corner is covered with lead to protect observer from X-rays.

tained by using an air pressure of 100 pounds per square inch. When ten pounds by weight of freon was added, 4.3 million volts could be obtained and with 15 pounds of freon it was possible to push the voltage up to 4.5 million volts before break-over occurred.

Fairly long cylindrical tanks are most commonly used. The high voltage point is then usually obtained at the center of the tank with perhaps the generating equipment running more or less along the axis of the tank to one end and the useful load again along the axis to the other end.

Two insulation problems then arise; first, along lengthwise supports to the ends of the tank and, second, across the air gap to the side walls. Spacing to the ends is usually quite ample if the leakage current which exists along the supports can be kept uniform throughout the length. On the other hand, if a certain segment of the path represents a sensibly higher resistance than the rest, charge will pile up across that piece, creating a local but very intense electric field and finally result in a breakdown.

Corona Rings

This situation is alleviated by surrounding the axial construction with equally spaced corona rings bent from aluminum tubing into the form of round hoops. See *Fig. 2.* A leakage current in the form of corona is then passed down these rings in enough strength to insure a uniform and equal field between each adjacent pair of rings. Appropriate rings are then tied to the apparatus along the axis of the tank so as to hold the components at proper voltages.

Insulation across the air gap to the curved surface of the tank is a somewhat different problem. Non-uniformity of the field is here caused only by the shape of the electrodes. Effectively the insulation problem is one between concentric cylinders. The inner cylinder is made up of the corona rings and the outer one is the tank. The field is strongest at the surface of the inner cylinder and when break-

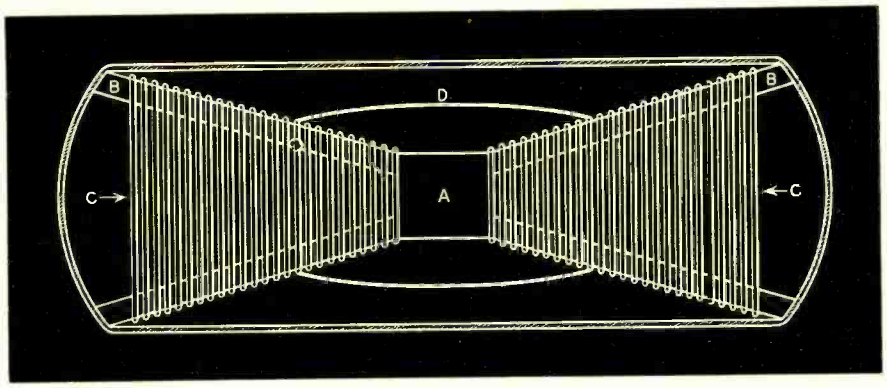
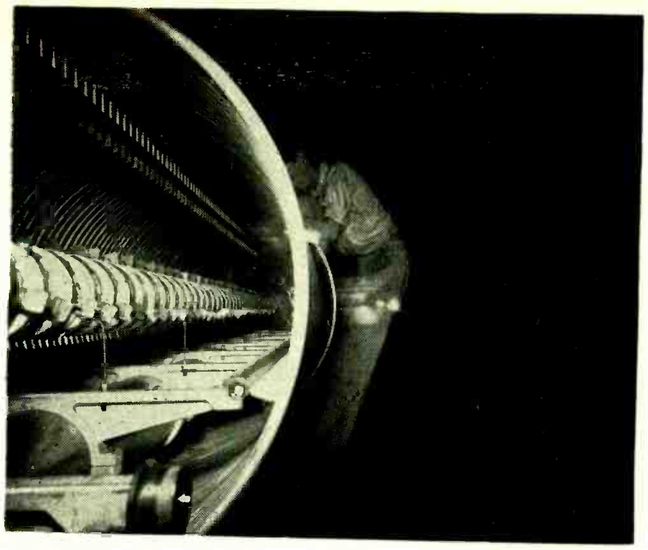


Fig. 2. Schematic cross section showing the insulation methods used in a typical tank-contained d.c. generator capable of several million volts. A is the high voltage electrode. B, longitudinal textolite members, supporting the whole assembly. C, corona rings to distribute the electric field lengthwise in the tank; and D, an intermediate shell to correct the field distribution between the high voltage elecrode and the wall of the tank. For 5,000,000 volts such a tank may be as much as 45 feet long and 10 feet in diameter.



A typical tank installed high voltage generator showing the insulating space between the corona ring system and the wall of the tank.

down occurs it will start there. This condition may be helped by inserting an extra metallic cylindrical shell midway between the two electrodes and connecting it to a voltage point on the corona-ring system somewhat more than halfway up to the potential of the center electrode. The number of volts per inch is then forced to be smaller in the central region and the field in the outer region is brought up more nearly to its limit.

Resistance in the sense that we usually think of it is of very little concern in high-voltage insulation. We must always work with gasses not easily ionized, liquids such as oil, or solids that have very high ohmic resistance. Any material able to conduct through itself more than a microampere or so immediately becomes hot and explodes or melts. Conduction resistance must always run up to hundreds or thousands of megohms. Except for the bugaboo of humidity we are rather concerned with avoiding fields which can actually rupture the insulation. In this connection, it is necessary to be wary when two different insulators are placed in series.

Capacitive Voltage Dividers

If, for example, two spherical electrodes 10 inches in diameter are placed 2 inches apart in dry air at standard pressure and temperature conditions, the gap will be found to be just about able to withstand 140 kv. With such large spheres closely spaced, the field is quite uniform in the gap and the 140 kv checks nicely with the dielectric strength of air often given in round numbers as 70 or 75 kv per inch. However, if a large piece of crown glass ½-inch thick is inserted in the center of this gap the situation is greatly changed and a spark breakdown will probably occur. This is true in spite of the fact that crown glass has a dielectric strength of about 90 kv per inch which is even greater than that of air. See *Fig. 3.*

In the simple case of two parallel plates with two dissimilar dielectrics, and neglecting the effect of the edges, we can understand the situation quite readily. These imaginary plates are a reasonable approximation to very large spheres. Thinking first of the boundary surface between the two dielectrics, we can see by symmetry that if the dielectrics are of uniform thickness, then the boundary must be an equi-potential plane. Thus we could insert a very thin sheet of metal along this surface without affecting the problem. As soon as we do this we realize that we have two condensers connected in series, with, for example, air and glass as their respective dielectrics. Since the condensers are in series their charge must be equal. This requires that

$$c_1 e_1 = c_2 e_2$$

where the subscript *1* refers to the air condenser and the subscript *2* refers to the glass condenser. Also

$$e_1 + e_2 = e$$

where e is the total voltage applied. Thus solving these two equations for e_1 and e_2, we get

$$e_1 = \frac{c_2}{c_1 + c_2} e; \quad e_2 = \frac{c_1}{c_1 + c_2} e.$$

Since the capacity of a condenser depends not only upon the geometry of the plates but also on a property of the dielectric measured by the dielectric constant, it is apparent that the voltage may divide so as to give the glass much less than its proper share to withstand. This in turn may cause a breakdown of the air whereupon the full voltage appears across the glass.

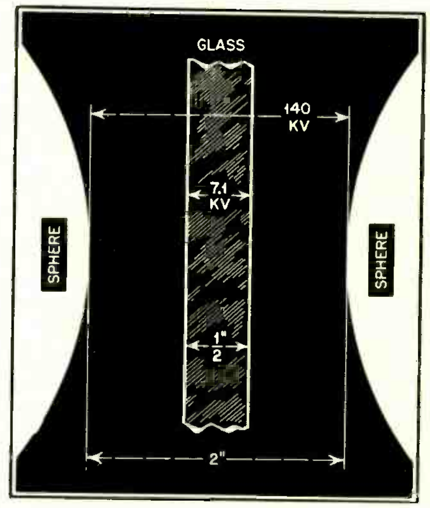


Fig. 3. Showing how voltage will distribute itself across air and crown glass in series. Because of the 6.2 dielectric constant of the glass as compared to unity, the air will be required to insulate for a disproportionately large part of the voltage. With constants shown, breakdown will probably occur. This is true even though 2 inches of air are alone enough to hold the 140 k.v.

BOOK REVIEWS

A-C CALCULATION CHARTS, by R. Lorenzen, 9 x 12, stiff cloth cover, 160 pages. Published by John F. Rider Publisher, 404 Fourth Ave., New York, N. Y. Price $7.50.

Engineers are generally annoyed by tedious computations; hence the large variety of special slide rules, monograms, charts, etc., that have come into being to reduce the time required for computation. When a number of essentially similar computations are to be made, the average engineer plots a curve or family of curves or calculates a table. Perhaps the engineer's mania for charts, curves, slide rules and tables lies as much in his dislike of routine as in his desire to save time. Certainly every radio engineer is many times plagued with routine computations of inductance, capacitance, reactance, admittance, conductance, susceptance, etc. "A-C Calculations" has as its purpose the reduction of effort involved in such computations.

The book, however, is not limited to radio-frequency calculation, but rather

[*Continued on page 43*]

NEW RADIO-RECEIVER STANDARDS

H. B. SMITH
Underwriters' Laboratories, Inc.

★ Recently, the November, 1942 edition of the Standard for Power-Operated Radio Receiving Appliances of Underwriters' Laboratories, Inc., was given approval by the American Standards Association and is now a recognized American Standard. This is the sixth edition of the Standard, superseding the edition of April, 1938, and it is the third edition of the Standard which has had ASA approval.

The Standard contains the Laboratories' requirements for power-operated radio receiving appliances for non-commercial use, designed to be employed on interior wiring systems in accordance with the National Electrical Code. The requirements, in so far as they apply, cover also television receivers, non-commercial or domestic phonographs, record players, recorders, and similar equipment.

The Laboratories' Work

The Laboratories' work on radio appliances is to determine that the fire and accident hazards involved have been reduced to an acceptable degree. Accordingly, such features as the size, shape, and general appearance of a receiver or its selectivity, sensitivity, fidelity, and the various refinements of control and station selection are not investigated; and there is, therefore, practically nothing in the requirements covering these items.

The requirements call for a substantial enclosure which will house all live or current-carrying parts involving fire or accident hazard, except cords or cables. Capacitors and inductors operating at a potential obtained directly from a metallic conductive connection to the power-supply circuit and involving fire hazards are required to be housed within a complete enclosure of noncombustible material. The area of openings for ventilation or other purposes is limited. The type of flexible cord for connection to the supply circuit is specified and provision is made for suitable bushings and strain relief in connection with the cord.

Material Requirements

The various materials used are required to be products which are recognized as suitable for the particular application; and accessories such as receptacles, lamp-holders, switches, etc., are required to be devices which comply with the Laboratories' requirements for those classes. Capacitors are required to present no undue fire or accident hazard. Substantial transformers with impregnated coils are specified, and definite limitations are placed upon the ventilating openings in transformer enclosures. Appropriate insulated conductors are required for all interior wiring, and spacings throughout a receiver are specified. Special attention is given to the accessibility and hazards of live parts. Fire and accident hazards are defined and provisions are made for the reduction of these hazards to an acceptable degree.

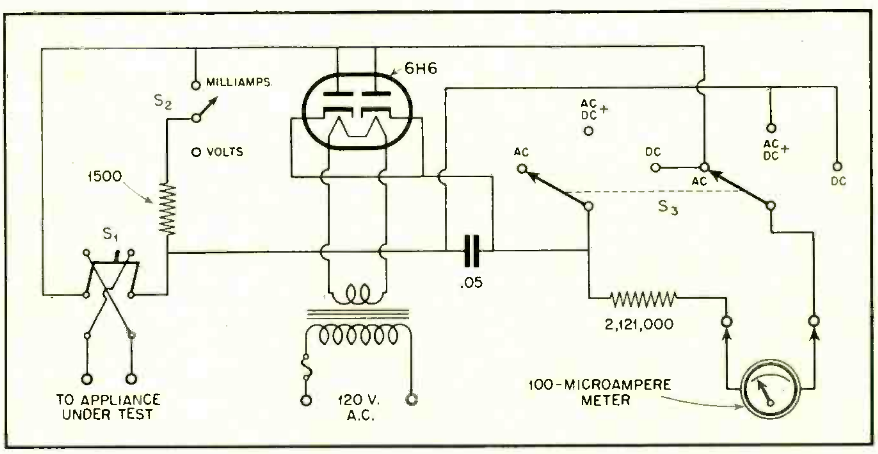
The complete investigation of a radio receiver consists of a careful examination of construction details to determine that the appliance complies with the above-mentioned requirements, and a comprehensive test program designed to insure the safe operation of the receiver under the conditions of actual service—including some of the abnormal conditions which are likely to obtain.

To Be Checked by Tests

The features which are checked by means of tests include:

Power Consumption—A determination of wattage input, to insure that the power required to operate a receiver

[*Continued on page 49*]



For AC plus DC—Throw the reversing switch, S_1 to the position which gives the maximum reading.

(a) For current, the reading is in milliamperes (rms of the sine wave or 0.707 times the peak of the complex wave).

(b) For potential* in volts, multiply the reading by 1.5 (rms of the sine wave or 0.707 times the peak of the complex wave).

For AC Only—The meter readings are the same as (a) and (b). If different readings are obtained using both positions of the reversing switch, the average of the two readings is to be takn.

For DC Only

(c) For current in milliamperes, multiply the reading by 1.414.

(d) For potential in volts, multiply the reading by 2.12.

* If the potential measured is limited by a series impedance within the appliance, the reading of the meter is less than the open-circuit voltage; but under this condition, the impedance also limits the current leakage. As the series impedance approaches a capacitive reactance—i.e., as the parallel resistance component of the impedance becomes large—the AC + DC reading becomes less than the AC reading; but under this condition, the AC reading is a suitable measure of the open-circuit voltage.

PHASE AND FREQUENCY MODULATION

W. P. BOLLINGER
Radio Corporation of America

PART 1

★ Phase modulation and frequency modulation are so closely related to each other that if a clear understanding of one is gained, the other is more or less self-evident. For a physical conception of frequency modulation consider *Fig. 1.* This figure shows the r-f waveform for both an amplitude-modulated and a frequency-modulated carrier under various conditions of modulation. For simplicity, the r-f cycles are shown as having straight sides when in reality they are sine waves.

Amplitude- and Frequency Modulation

Line *A* represents the condition of no modulation where both signals have identical characteristics, being simply c.w. carriers. If we now apply modulation to these two carriers, their waveforms will be similar to the representation in line *B*. The amplitude-modulated signal has the amplitude of the carrier varied in accordance with the modulation without any change in the spacing between cycles, which means no change in the frequency of the carrier. However, in the frequency-modulated signal, just the reverse is true. Here the amplitude of the signal is constant but the spacing between the cycles does change, indicating a change in frequency.

Note that at a point on the frequency-modulated signal corresponding to the maximum positive crest of the amplitude-modulated signal, the spacing between cycles is largest. This means that the frequency is lowest at this particular point. Conversely, on the negative peaks, the spacing between cycles is a minimum, indicating the highest frequency at this point. Frequency modulation is then the varying of the frequency of a constant-amplitude signal in accordance with the modulating signal.

Now consider what occurs when the amplitude of the modulation is increased, as in line *C*. In the amplitude modulation case, the magnitude of the peaks and valleys of the r-f waveform have been increased. The condition shown will be recognized as 100% modulation. Likewise in the frequency modulation case, the cycles have been compressed and stretched considerably more than in line *B*. Since this compression and expansion represents frequency change, it is evident that the frequency deviation in line *C* is greater than that of line *B*. To our above definition of amplitude and frequency modulation, we may then add that in an amplitude-modulated signal, the magnitude of the amplitude variation of the signal is directly proportional to the amplitude of the modulation, while in a frequency-modulated signal, the magnitude of the frequency variation is directly proportional to the amplitude of the modulation.

The waves shown in line *C* point out one of the important distinctions of frequency modulation. Although the amplitude-modulated signal has reached its maximum undistorted modulation (100%), no such limitation is imposed on frequency modulation within the

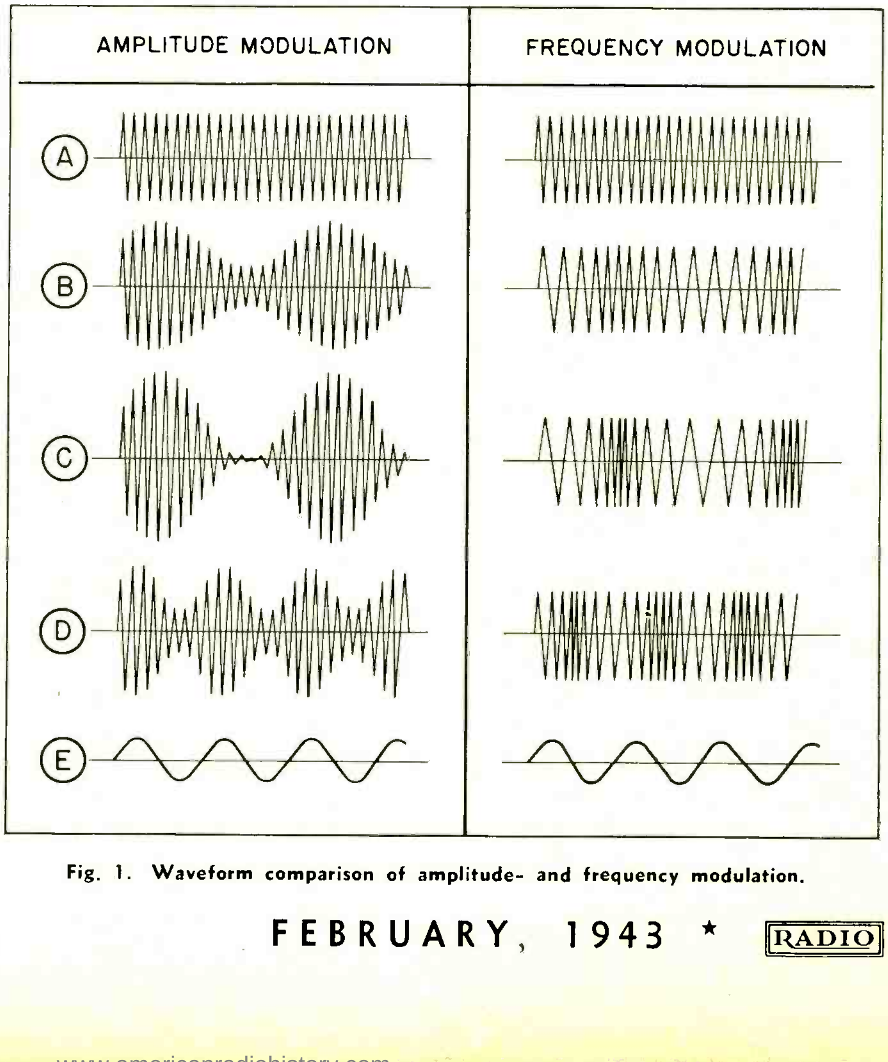


Fig. 1. Waveform comparison of amplitude- and frequency modulation.

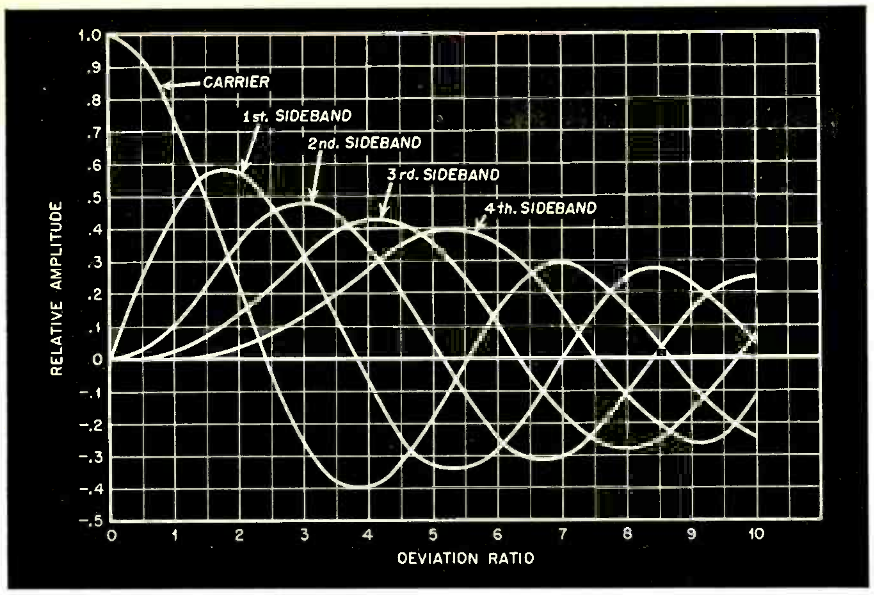


Fig. 2. Distribution of the components of an f-m signal.

practical limits of operation. Line *D* represents the condition of a higher frequency of modulation. Here in the amplitude-modulated signal the crests and valleys of the amplitude variation have been moved closer together, while in the frequency-modulated signal, it is the points of maximum compression and expansion of the r-f waveform that have been moved closer together. We can then say that in an amplitude-modulated signal, the number of amplitude variation cycles is equal to the number of modulation frequency cycles, while in the frequency-modulated signal the number of frequency variation cycles is equal to the number of modulation frequency cycles, all per unit of time. If both the amplitude and frequency modulated signals of line *D* are detected by their proper types of detectors, the outputs will be identical, as shown in line *E*.

Sideband Characteristics

The sidebands of amplitude and frequency modulation are, in general, quite different. In an amplitude-modulated signal two sidebands are present which are spaced either side of the carrier. The spacing between either sideband and the carrier is equal to the modulating frequency, and the amplitude of the sidebands is proportional to the magnitude of the modulation.

The frequency-modulated signal also has sidebands, but it may have a great many more than the two present in amplitude modulation. Like amplitude modulation, the sidebands are spaced from the carrier or mid-frequency and from each other by an amount equal to the modulation frequency. The amplitude of these sidebands bears no simple relationship to the magnitude of the modulation as in an amplitude-modulated signal, but varies as shown in *Fig. 2.* This graph shows the distribution of the carrier, or mid-frequency, and the sidebands as a function of the deviation ratio. The deviation ratio is defined as the maximum deviation of the frequency-modulated signal from its mid-frequency divided by the modulation frequency.

As an example, take the commercial frequency-modulated stations which have a maximum deviation of ± 75 kc from the mid-frequency. If this deviation were obtained with a 15-kc modulation frequency, the deviation ratio would be

$$75/15 = 5$$

It is easily seen then that the deviation ratio may become quite high if the modulation frequency is low and the full 75-kc deviation is maintained. For simplicity in *Fig. 2,* only the components up to the fourth sideband and deviation ratios up to ten are shown. The negative values on these curves simply means a reversal of phase.

Phase- and Frequency Modulation

Phase modulation can probably best be explained by reference to *Fig. 3.* The vector shown represents an r-f signal, and is rotating about its end, making one complete revolution for each r-f cycle. Our view may be likened to a stroboscopic picture of this rotating vector; that is, we get a short view of it once in every unit of time required for the vector to make a complete revolution. Since, by convention, the vector is rotating counter-clockwise, it can be seen that if the speed of the vector were increased slightly, our stroboscopic picture would show a slow motion of the vector in the counter-clockwise direction. Conversely, if its speed were decreased slightly, the vector would appear to move in the clockwise direction. If, then, the vector were observed to move first counter-clockwise, then reverse its direction and rotate clockwise an equal amount on the other side, and reverse its direction again; that is, oscillate between the two dotted vectors through the angle ø, it would be known that the vector was oscillating in its speed.

Note that even though the vector first speeds up and then slows down, its average speed would be constant regardless of the speed deviation. Since the speed of the vector represents a frequency, it is apparent that when this vector oscillates through the angle, ø, the frequency is being shifted either side of the mid-frequency point and the oscillation is, cycle for cycle, in direct accordance with the modulating signal. The oscillating vector then represents a frequency-modulated signal, but it also represents a phase-modulated signal; that is, the phase of the signal is being modulated through the angle ø. When the vector moves counter-clockwise, the phase is being advanced and when being moved clockwise, it is being retarded.

Where PM and FM Differ

Up to this point it is impossible to tell the difference between phase modulation and frequency modulation since both produce identical effects. The distinction between the two occurs when we consider the effects of various modulation frequencies. Referring again to *Fig. 3,* the speed of this vector indicates the deviation from the average speed and consequently indicates the frequency deviation. If then the angle ø is kept constant, as it is in phase modulation, but the number of oscillations the vector makes per unit time is increased, the speed of the vector and, consequently, the frequency deviation will be increased.

The following statements can then be made: In frequency modulation, the

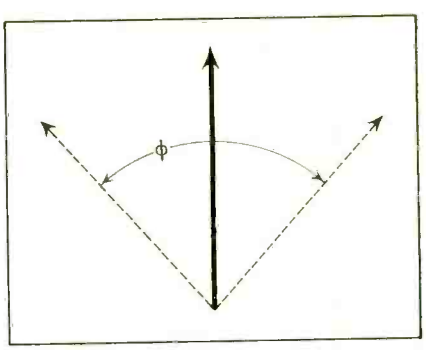


Fig. 3. A vector representation of a phase-modulated r-f signal.

frequency deviation is proportional to the amplitude of the modulating signal and is independent of the modulating frequency. In phase modulation, the phase deviation is proportional to the amplitude of the modulating signal, and is independent of the modulating frequency.

From the above discussion, it is apparent that with constant amplitude of the modulating signal, the frequency deviation is constant in frequency modulation but is directly proportional to the modulating frequency in phase modulation. Conversely, the phase deviation is constant in phase modulation but is inversely proportional to the modulating frequency in frequency modulation. From the standpoint of a receiving system then, the only difference between phase modulation and frequency modulation will be in the amplitude characteristics of each.

For example, if a receiver were intended for frequency modulation its audio output voltage would depend only on the frequency deviation of the signal and would be flat over the audio spectrum. If, however, this receiver were used for phase modulation, the output would have a rising characteristic with modulating frequency since the frequency deviation of a phase modulated transmitter is not only proportional to the amplitude of the modulating signal but is also directly proportional to the modulating frequency. To make this receiver operate properly on phase modulation, it would be necessary only to correct for this amplitude characteristic by making the audio system have an amplitude characteristic which is inversely proportional to frequency.

The same correction can be applied to the phase-modulated transmitter instead of the receiver, and so it is seen that all that is necessary to change a phase-modulated transmitter to a frequency-modulated transmitter is a network in the audio system of the transmitter which has an amplitude characteristic inversely proportional to frequency. In other words, it has a characteristic which drops 6 decibels per octave. Likewise, a frequency-modulated transmitter can be made to produce phase modulation by making the audio system have a characteristic which rises 6 decibels per octave.

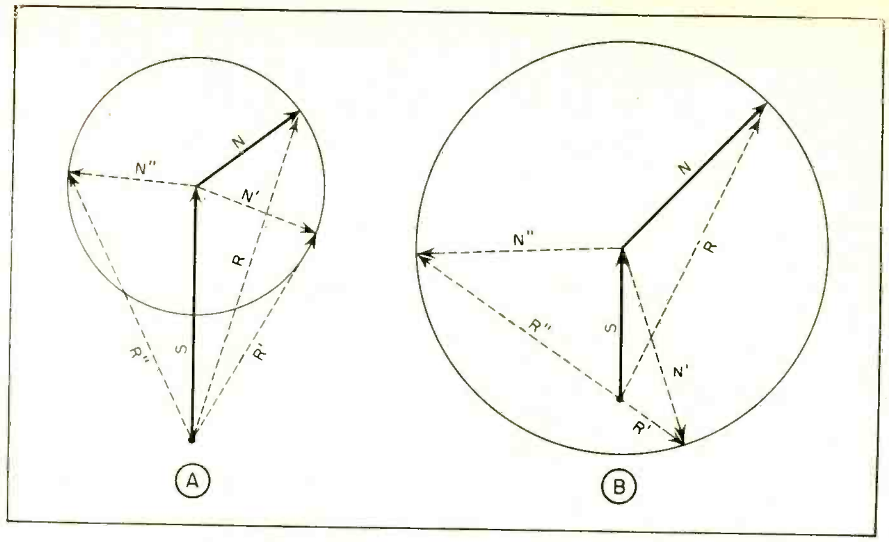


Fig. 5. Vector representations of f-m and noise signals.

Noise Reduction

It is possible to secure some reduction in noise in a frequency- or phase-modulated system by use of a limiter in the receiver which removes amplitude modulation caused by noise. A physical explanation of this is given in *Fig. 4*. In *A* of this figure is shown a frequency-modulated signal which is amplitude-modulated by a pulse of noise. If this pulse happened to occur at a time when the signal was deviated from its average frequency, the noise would be passed by the receiver. This will be better understood after the discussion of frequency-modulation detectors. The amplitude modulation which is present in *Fig. 4-A* can, however, be removed if it is passed through an amplifier which limits the output to *(a)* and *(a')*. The output would then appear as in *B* completely free from the amplitude modulation but still retaining the frequency modulation.

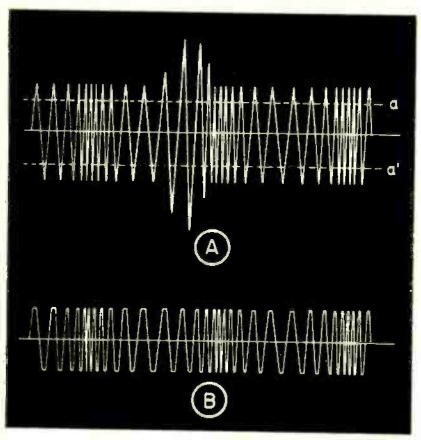


Fig. 4. An f-m signal under conditions of (A) noise and (B) limitation.

The frequency-modulation system is not completely free of noise disturbances, but has certain inherent limitations. Noise appears in a receiver as a pulse of r-f voltage, the frequency of this r-f voltage being equal to the mid-frequency of the receiver passband. Hence, if a signal is tuned to the mid-frequency, the signal and noise pulse will have the same radio frequency. The two voltages will then add as shown in *Fig. 5-A*, where *S* is the vector representing the desired signal and *N* represents the signal caused by the noise. The resultant, *R*, represents the combined signals and as can be seen is different in magnitude than the original desired signal. The phase between the signal and noise is determined purely by chance and depends only on when the noise pulse is introduced to the receiver with respect to an r-f cycle of the desired signal. An infinite number of combinations are then possible as in *N'*, *R'*, and *N''*, *R''*.

Now consider the case where the signal is not at the mid-frequency but is off to one side, as would be the case when the signal is being deviated to modulation, or when the receiver is not tuned properly. The signal and noise will not now have the same radio frequency but will differ by the amount of deviation of the signal. The two vectors shown in *Fig. 5-A* will not then assume any definite phase relation but will be continually changing. Since the noise vector now has a slightly different frequency and, hence rotational speed, from the signal, the noise vector will appear to rotate about the end of the signal vector, assuming all possible phase relations with it. The resultant *R*, *R'*, *R''*, etc. will then be a moving vector oscillating back and forth and also varying in its length or amplitude.

This amplitude variation can be removed by a limiter in the receiver, but note that phase modulation and hence frequency modulation are also present. Since the receiver is intended to receive frequency modulation, this component of the noise cannot be discriminated against. The situation becomes much worse when the noise amplitude becomes greater than the signal am-

[*Continued on page 43*]

RADIO DESIGN WORKSHEET

NO. 10—A.F., R.F. CIRCUITS; OPTICAL PATHS

POWER TO MULTIPLE LOADS

Problem 1: *It is sometimes desirable to supply power from an audio amplifier to two or more loads, each at a different impedance and each requiring a different but known power. To accomplish this, transformers of the proper ratio may be connected each to its separate load and with their primaries in series across the amplifier output. Derive the general expression for the transformer impedance ratio to find each of a number of loads.*

Solution: First let us take a simple example in which we wish to furnish 8 watts of power to a 15-ohm load, and 4 watts to a 500-ohm load from a single amplifier, as generally shown in *Fig. 1.* It is well known that if two resistances are connected in series across a source of power, that the power absorbed by each will be directly proportional to its resistance. Thus, if one resistance is twice as large as the other it will absorb twice as much power. Therefore it follows that the primary which is to absorb 8 watts must present twice the impedance to the line as the one which is to absorb 4 watts. To simplify the problem, transformer losses are assumed to be zero. The losses in well-designed transformers are low so that the error introduced by this assumption should be less than 10 percent.

Assume the amplifier output impedance R_0 is 500 ohms. Obviously the series impedance of the two primaries must be 500 ohms. Assume from *Fig. 1* that transformer (1) is to absorb 8 watts and transformer (2) is to absorb 4 watts. Then:

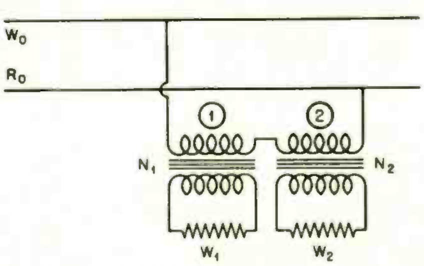


FIG. 1

$$Z_1 = 2Z_2$$
$$Z_1 + Z_2 = 2Z_2 + Z_2 = 3Z_2$$
$$Z_1 + Z_2 = 3Z_2 = 500$$

whence:

$$Z_2 = 500/3 = 167 \text{ ohms}$$

and:

$$Z_1 = 2Z_2 = 334 \text{ ohms}$$

From which it follows that the impedance ratios of the two transformers will be:

For Trans. (1) $N_1 = 15/334$ imped. ratio
For Trans. (2) $N_2 = 500/167$ imped. ratio

From this we can easily deduce the impedance ratios of any number of series transformers. Let N represent the ratio of the secondary to the primary impedance. Thus $N_1, N_2, N_3 \ldots N_K$ represents impedance ratios of any finite number K of series-connected transformers. It is obvious the N varies in accordance with the ratio of available power to absorbed power. It is also evident that N varies in accordance with the ratio of secondary impedance and line impedance. For the case of transformer (1), it seems reasonable to expect that:

$$N_1 = \frac{R_1}{R_0} \times \frac{W_0}{W_1}$$

Substitution yields:

$$N_1 = \frac{15}{500} \times \frac{12}{8} = \frac{1}{22.33} = \frac{15}{334}$$

$$N_2 = \frac{R_2}{R_0} \times \frac{W_0}{W_2} = \frac{500}{500} \times \frac{12}{4} = \frac{1}{0.3} = \frac{500}{167}$$

From which we may conclude that for the general case:

$$N_K = \frac{R_K}{R_0} \times \frac{W_0}{W_K}$$

It can be assumed that for ordinary cases the losses of all transformers will be essentially equal. If this is the case, then the power loss resulting from K transformers will be the same as if only one transformer having the same loss as one of the series transformers were to deliver the amplifier power to one load. Whence a more exact expression would be:

$$N_K = \frac{R_K}{R_0}\left(\frac{W_1 + W_2 + W_3 + \ldots W_K}{W_K}\right)$$

which is the general expression required.

PARALLEL RESONANT CIRCUIT

Problem 2: *Establish the relations, in a parallel-resonant circuit such as Fig. 2, between inductance, capacitance and resistance, for which the impedance looking into the circuit will be a pure resistance independent of frequency.*

Solution: The impedance of parallel-resonant circuits is equal to the product of the two arms divided by their sum.

Whence:

$$Z = \frac{(R_1 + j\omega L) \quad (R_2 + 1/j\omega C)}{(R_1 + j\omega L) + (R_2 + 1/j\omega C)} \qquad (1)$$

From the well-known relation for complex circuits we know that:

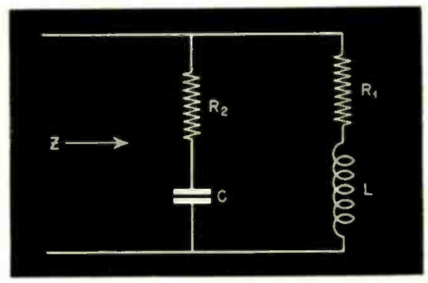


FIG. 2

$$\frac{A + jB}{C + jD} = \frac{AC + BD}{C^2 + D^2} + j\frac{BC - AD}{C^2 + D^2} = R' + jX'$$

from which we have from (1):

$$R' = (R_1 + R_2)(R_1R_2 + L/C) + (R_2\omega L - R_1/\omega C)(\omega L - 1/\omega C) \div (R_1 + R_2)^2 + (\omega L - 1/\omega C)^2 \qquad (2)$$

and:

$$X' = (R_1 + R_2)(R_2\omega L - R_1/\omega C) - (R_1R_2 + L/C)(\omega L - 1/\omega C) \div (R_1 + R_2)^2 + (\omega L - 1/\omega C)^2 \qquad (3)$$

If impedance Z of the parallel combination is to be a pure resistance, independent of frequency, obviously X must be zero. Equating the numerator of (3) to zero we have:

$$(R_1 + R_2)(R_2\omega L - R_1/\omega C) = (R_1R_2 + L/C)(\omega L - 1/\omega C)$$

or:

$$\omega L(R_2^2 - L/C) = 1/\omega C(R_1^2 - L/C)$$

This relation will hold if:

$$R_1 = R_2 = \sqrt{L/C} \qquad (4)$$

Substituting the values of (4) in (2) we find:

$$Z = R_1 = R_2 = \sqrt{L/C}$$

This arrangement has met extensive use in line equalizers.

[Continued on page 24]

CAMPBELL BALANCE EQUATION

Problem 3: *Set up the equation of the Campbell Balance from the following observations.*

Solution: If two inductance coils are placed in such position that there is magnetic coupling between them, an

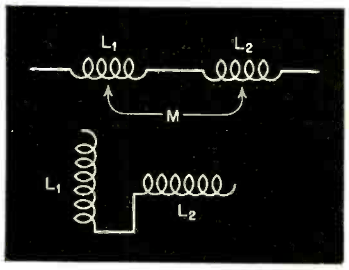


FIG. 3

increase or decrease in the combined inductance of the combination results, due to the mutual inductance. This is illustrated in *Fig. 3.* Thus the total series inductance is: $L_1 + L_2 \pm 2M$

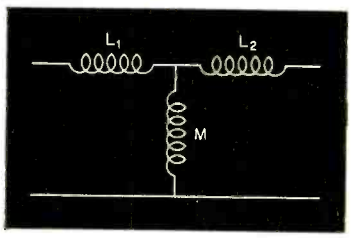


FIG. 4

where M may be positive or negative, finite or zero. Since the mutual inductance is common to the two circuits, it may be represented schematically as in *Fig. 4.*

The Campbell Balance makes use of this fact by resonating M with a capacitor C, as shown in *Fig. 5.*

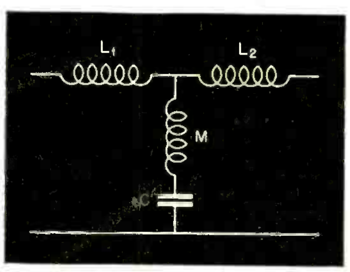


FIG. 5

When C and M are in resonance, the loss is infinite since it constitutes a short circuit. Actually, in practice, the loss is not infinite but is always large. This is sometimes used to boost the loss of filters at a specific frequency.

At resonance:

$$2\pi f M = 1/2\pi f C$$

Whence

$$C = 1/4\pi^2 f^2 M$$

DETERMINING OPTICAL PATH

Problem 4: *Determine the maximum optical path between two points at heights H_1 and H_2 above a plane spherical earth.* (Fig. 6).

Solution: Referring to *Fig. 7,* assume radius of earth $= R =$ 4000 miles. Then

$$H_1 = R - (R+H_1)$$

Since R is approximately equal to $R+H_1$ then:

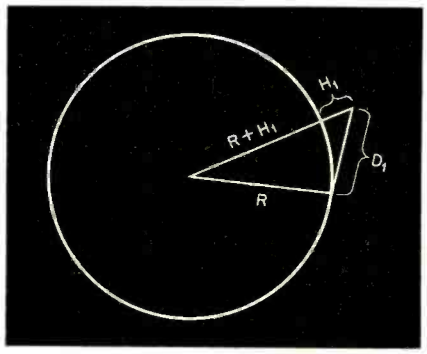


FIG. 7

$$(R+H_1)^2 - R^2 = D_1^2$$

$$[(R+H_1)+R]\ [(R+H_1)-R] = D_1^2$$

$$(R+H_1)-R = \frac{D_1^2}{(R+H_1)+R} = \frac{D_1^2}{2R}$$

very closely

Whence $H_1 = D_1^2/2R$

Whence $D_1 = \sqrt{2RH}$, approx. $=$

$$\frac{\sqrt{2}\ \sqrt{4000}}{\sqrt{5280}}\sqrt{H_1} = 1.22\ \sqrt{H_1}$$

If D_1 and R are in miles and H_1 in feet. Whence:

$$D_1 + D_2 = 1.22\ \sqrt{H_1} + 1.22\ \sqrt{H_2}$$

This formula may be applied to microwaves or other very short radio waves if refraction and diffraction can be neglected. Actually, ultra-high-frequency waves do bend around the surface of the earth, but the rate of attenuation increases much more rapidly beyond the optical horizon. *Fig. 8* and *Fig. 9* are curves relating D and H. In *Fig. 8* the square root of H_1 is plotted against the square root of H_2 with optical path $D_1 + D_2$ as a parameter. Thus if H_1 and H_2 are equal, for a 30-mile range from each tower to point of tangency, we have $\sqrt{H_1} = \sqrt{H_2} = 24.4$ miles, and $H_1 = H_2 = 24.4^2 = 595$ feet.

Fig. 10 is a somewhat more useful curve, with D plotted as a function of H. Here we find directly that a 30-mile range means a tower height of 595 feet.

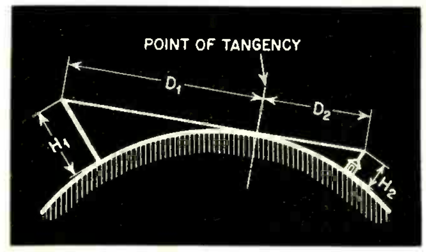


FIG. 6

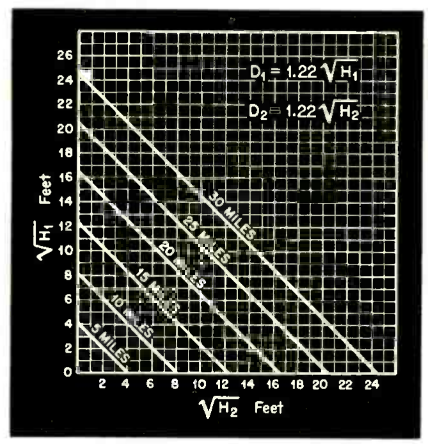


FIG. 8

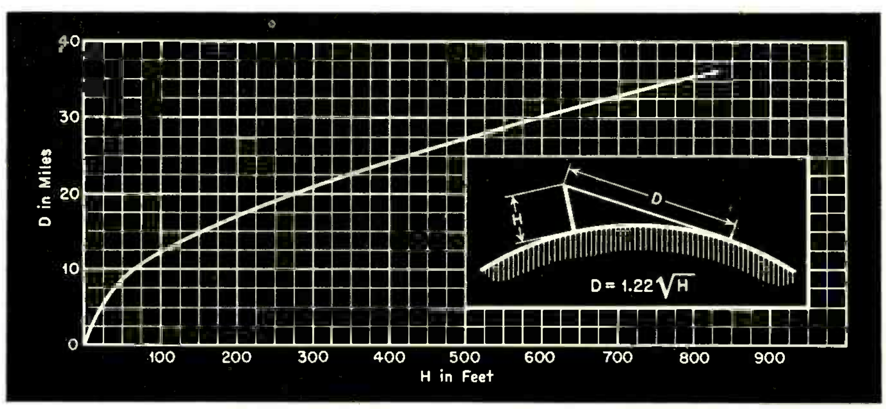


FIG. 9

Echophone Model EC-1 6 tubes, 3 bands. Tunes from 550 kc. to 30 mc. Beat frequency oscillator. Bandspread logging scale. Self-contained speaker. Electrical bandspread on all bands. AC/DC. 115-125 volts. ECHOPHONE RADIO CO., 201 EAST 26TH ST., CHICAGO, ILLINOIS

ALARM AND COMPARISON CIRCUITS FOR

REFERENCE FREQUENCY EQUIPMENT

F. R. DENNIS
Bell Telephone Laboratories

★ In the designing of new reference frequency equipment*, every precaution has been taken to insure the constancy of the various supplies, both in frequency and level. Since these frequencies are used for standardizing purposes it was felt desirable to provide an alarm system that would give immediate indication of any appreciable deviation from the nominal frequency. This function is served by the frequency-checking bay, which may also be used for determining at what primary frequency the trouble first appears.

Reference Bays

Two reference frequency bays are provided; and both are operated continuously. Since there is very little likelihood that any trouble would affect the frequency of both bays alike and at the same time, it is possible to use the difference in frequency between their outputs as an indication of constancy. So long as the frequencies do not differ by more than a very small amount, it may safely be assumed that each is operating at its correct value. The frequency-checking bay provides a continuous comparison of the two frequencies, and also is arranged to give both visible and audible alarms should the difference exceed a very small amount. In addition, arrangements are included to compare the frequency from either of the frequency generators with the standard frequency from the Bureau of Standards, which is sent out over Station WWV.

Each of the basic 100-kc oscillators maintains its frequency constant to within one part in ten million for long periods of time; and it was decided to have the alarm operate when the difference between the two 100-kc frequencies was as much as 2 parts in ten million. At 100 kc, however, a deviation of 2 parts in ten million is only 1/50 of a cycle, and it is difficult to design an alarm circuit to operate on such a small difference. It seemed preferable to raise the basic frequency to some higher value before determining the difference. Since the basic oscillators were also to be checked against the 5000-kc signal from Station WWV, it was decided to raise their frequencies to 5000 kc for comparison in the checking circuit.

[*Continued on page 28*]

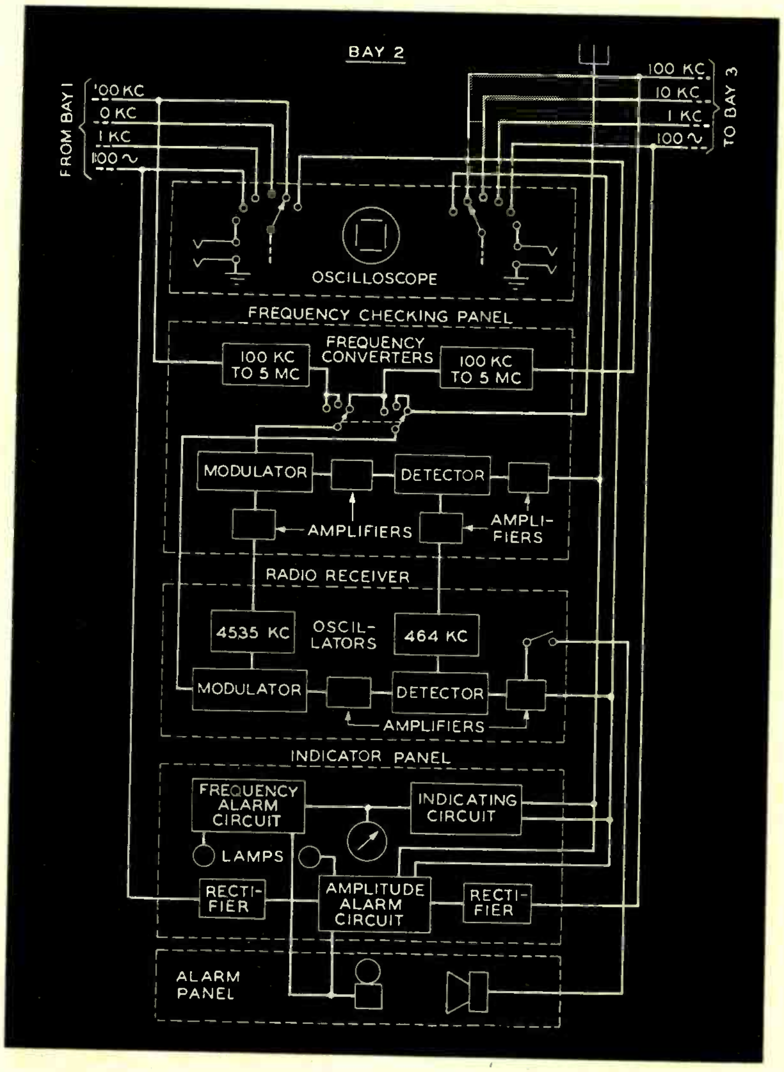


Fig. 1. Circuits of checking bay - bay 2 in the actual line-up.

*New Reference Frequency Equipment, by V. J. Weber, *Bell Laboratories Record*, Nov. 1942, p. 73; A New Frequency Divider for Obtaining Reference Frequencies, by F. R. Stansel, *Bell Laboratories Record*, Dec. 1942, p. 27

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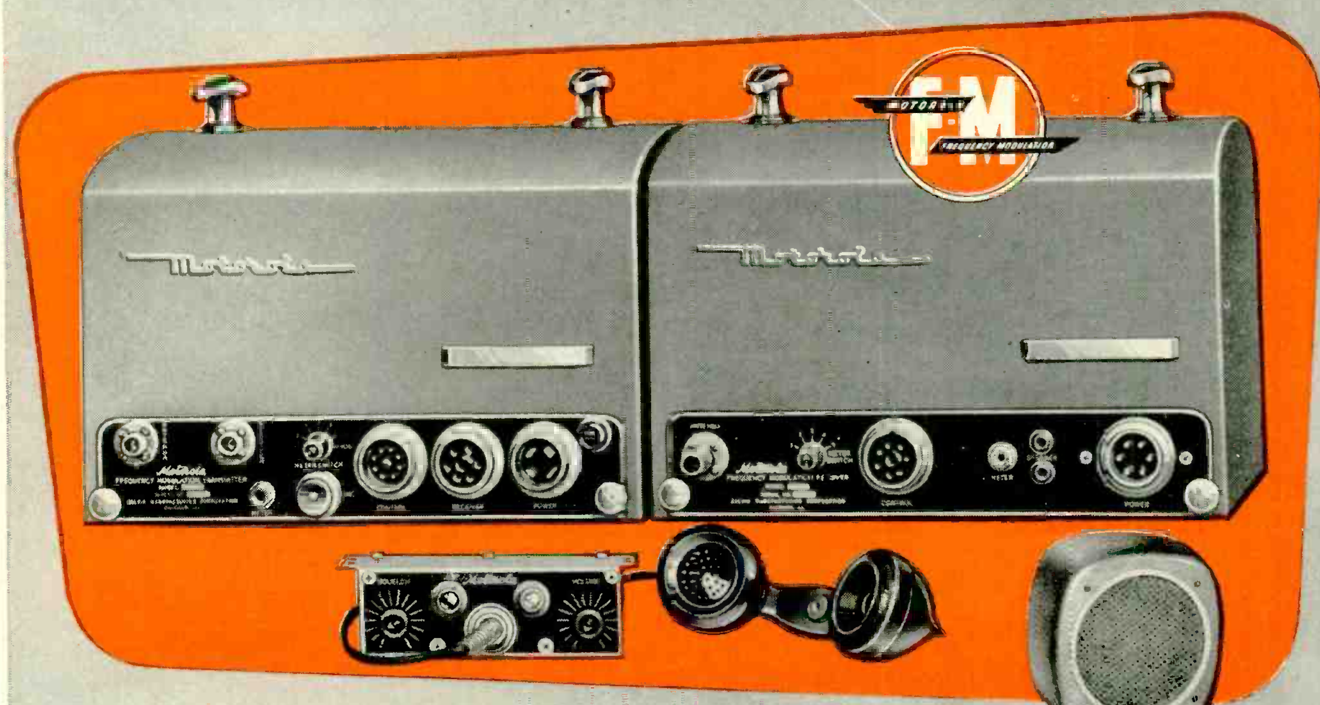

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A block schematic of the various circuits of the checking bay is shown in *Fig. 1.* These circuits are all on bay 2. Bays 1 and 3 are the reference-frequency bays. A tap from the 100-kc supply of each reference-frequency bay is brought to a 100-kc to 5000-kc frequency converter. Leads from the converters, as well as those from the antenna used for picking up the signal from WWV, are brought to a switch that permits any two of these 5000-kc sources to be connected to what are essentially two radio receivers supplied by common heterodyne and beat-frequency oscillators. The heterodyne ascillator is at 4,535 kc, and the modulation of this frequency with the 5000-kc input gives an intermediate frequency of 465 kc. This frequency, modulated with the output of the 464-kc beat-frequency oscillator, results in an audio output of 1 kc from each receiver. Since the same oscillators supply both receivers, the difference between the two output frequencies will vary only with variations in the two input frequencies; variations in the modulating frequencies will not affect it. These two 1000-cycle frequencies are carried to the indicator panel, where the difference is indicated, and gives an alarm if it exceeds a given amount.

Alarm Circuit

This alarm and indicating circuit is shown schematically in *Fig. 2.* The 1000-cycle outputs from the two receivers connect to the corners of a resistance bridge, which with the following vacuum tube acts somewhat as a modulator, and the usual sum and difference frequencies appear in the output circuit. A d-c meter in this output circuit will not respond to the sum of the frequencies or to any of the higher frequency products, but it will respond to the difference frequency: it will swing back and forth at the rate of the difference frequency. If the two 100-kc frequencies differ by 1/50 of a cycle, the two 5000-kc frequencies will differ by 1 cycle, and at the outputs of the two radio receivers, the two 1000-cycle frequencies will also differ by 1 cycle. Under these conditions, the meter pointer swings back and forth once each second, thus giving a direct indication of the difference in frequency between the two basic oscillators.

In addition to the meter, the control electrode of a cold-cathode gas-filled tube is connected to each plate circuit of *V7*. At some point in the difference-frequency cycle, depending on the adjustments of the circuit, each tube will become conducting because of the voltage on its control anode, and will pass current to an associated relay. One tube flashes just ½ cycle of the difference frequency after the other. The flashing of *V3*, for example, will operate relay *S2* through a back contact of relay *S3*, and the operation of *S2* lights lamp *L2*. When *V4* flashes ½ cycle later, the operation of *S3* through the front contact of *S2* will light *L3*. When *S3* operates, it momentarily opens the circuit of *S2*, and since the control voltage of *V3* is below the flash point at this time, *S2* will release, extinguishing *L2*. The release of *S2* momentarily opens the circuit of *S3*, but since the control voltage of *V4* is above the flash point, *S3* will not release. Lamps *L2* and *L3* thus alternately flash at the rate of the difference frequency, and give a continuous visual indication of the frequency difference.

To provide an alarm when the difference exceeds a certain amount, a connection is taken from the cathode

[*Continued on page 50*]

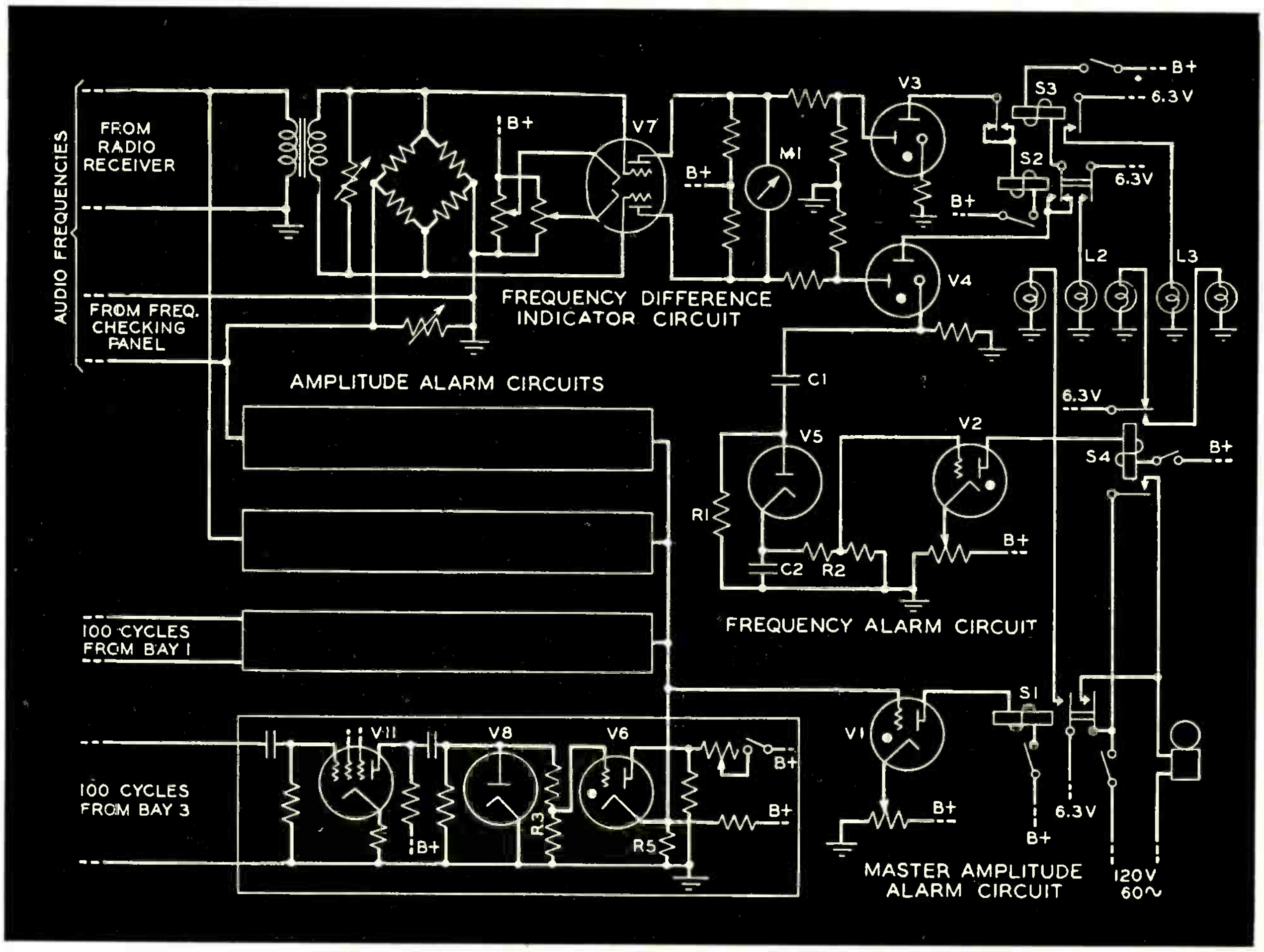

Fig. 2. Alarm and comparison circuit.

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VACUUM TUBES—3

TETRODES AND PENTODES

Tetrode Characteristics

31. Describe the physical structure of a tetrode electron tube. (II-127).
32. What is the primary purpose of a screen grid in a vacuum tube? (II-145).
33. What is the primary purpose of the screen grid of a tetrode? (V-63).
34. What is the meaning of secondary emission? (II-131).
35. What currents will be indicated by a milliammeter connected between the center tap of the filament transformer of a tetrode, and negative high voltage (ground)? (V-103).

In an ideal amplifier tube the plate should act only as a collector of electrons and not have any influence on the magnitude of the alternating current flowing in the plate circuit. (See Questions 18-22). Such a tube would have an I_p-E_p static characteristic as indicated in *Fig. 1* where a change in E_p does not produce an appreciable change in I_p.

To accomplish this, the function of the plate dealing with the control of the flow of electrons will have to be taken over by a fourth electrode, usually referred to as the screen grid, located between the cathode and the plate near the latter. See *Fig. 2*.

In order to function in this manner the screen grid must be maintained at a fixed potential (E_{sg}) equal to or less than that of the plate. It will then supply the electrostatic force pulling the electrons from the cathode to the plate. Because of its physical structure only a relatively small number of electrons strike its wires giving rise to a screen grid current. As the name implies, the screen grid effectively isolates the plate so that changes in its potential, due to the voltage drop across the load in the plate circuit, will not affect the flow of current from the cathode to the plate.

The "screening" or "shielding" effect of this screen grid can also be thought of in terms of reduced interelectrode capacity. This idea will be developed in a discussion on neutralization, to appear next month.

Since the plate potential changes by an amount equal to the a-c voltage drop across the plate circuit load, it is possible for the screen potential to exceed the plate potential. When this condition exists, the secondary electrons (secondary emission) knocked out of the plate by the high velocity primary electrons emitted by the cathode, will travel to the screen. The exact nature of this phenomena is indicated in *Fig. 3*.

As the plate potential (E_p) increases a point *A* is reached where the number of secondary electrons traveling to the screen exceeds the number of primary electrons traveling to the plate. The net current (I_p) therefore decreases as E_p increases from *A* to *B*. Under ordinary conditions current is directly proportional to voltage. Hence, this phenomena is referred to as "negative resistance." It is a detriment to amplifier action but is usefully employed in the dynatron or transitron oscillator. When the plate potential is increased beyond *B*, the secondary electrons begin to return to the plate. Above *D* secondary electrons are emitted in large number. Since the plate potential is higher than the screen potential the secondary electrons all return to the plate.

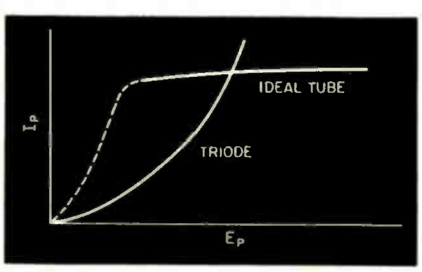

Fig. 1. Plate-current, grid-voltage characteristics of a triode as against an ideal tube.

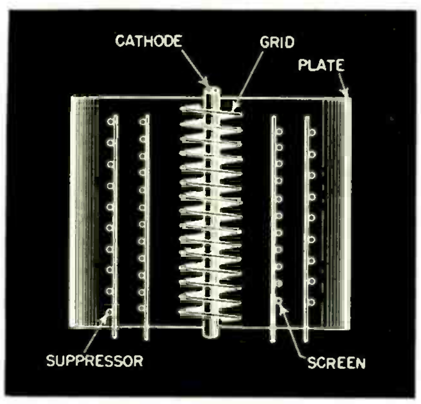

Fig. 2. Construction of pentode tube.

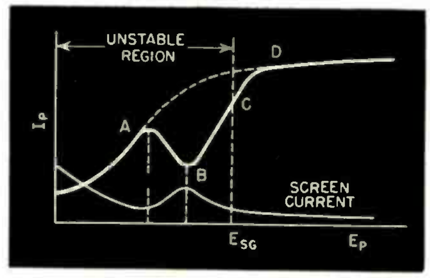

Fig. 3. Dotted line indicates elimination of secondary emission by means of suppressor grid.

Since the degree to which the plate current is controlled by the plate potential is much less in the tetrode than in the triode, the amplification factor is very high for the tetrode. For the original tetrode (24) the amplification factor is around 500. The small slope of the I_p-E_p curve indicates that the plate resistance is also large, around 0.5 megohm, which is generally speaking, a disadvantage.

A milliammeter connected between the center tap of the filament transformer and the negative high voltage (ground) will read both the plate and screen-grid currents.

Pentode Characteristics

36. What is the primary purpose of the suppressor (or cathode) grid in a multi-element vacuum tube? (II-146).
37. Describe the physical structure of a tetrode and a pentode on a comparative basis. (II-123).
38. Describe the electrical characteristics of a pentode, tetrode, and triode on a comparative basis. (II-124).

Because of secondary emission there is a relatively large unstable region, as shown in *Fig. 3*. If the effects of secondary emission could be eliminated, the I_p-E_p curve would follow the dotted line from *A* to *D*. This is done in the pentode or five-electrode tube. A third grid is introduced between the screen grid and the plate. This grid is connected to the cathode either internally or externally, and is sometimes referred to as the cathode grid. Because

[*Continued on page 48*]

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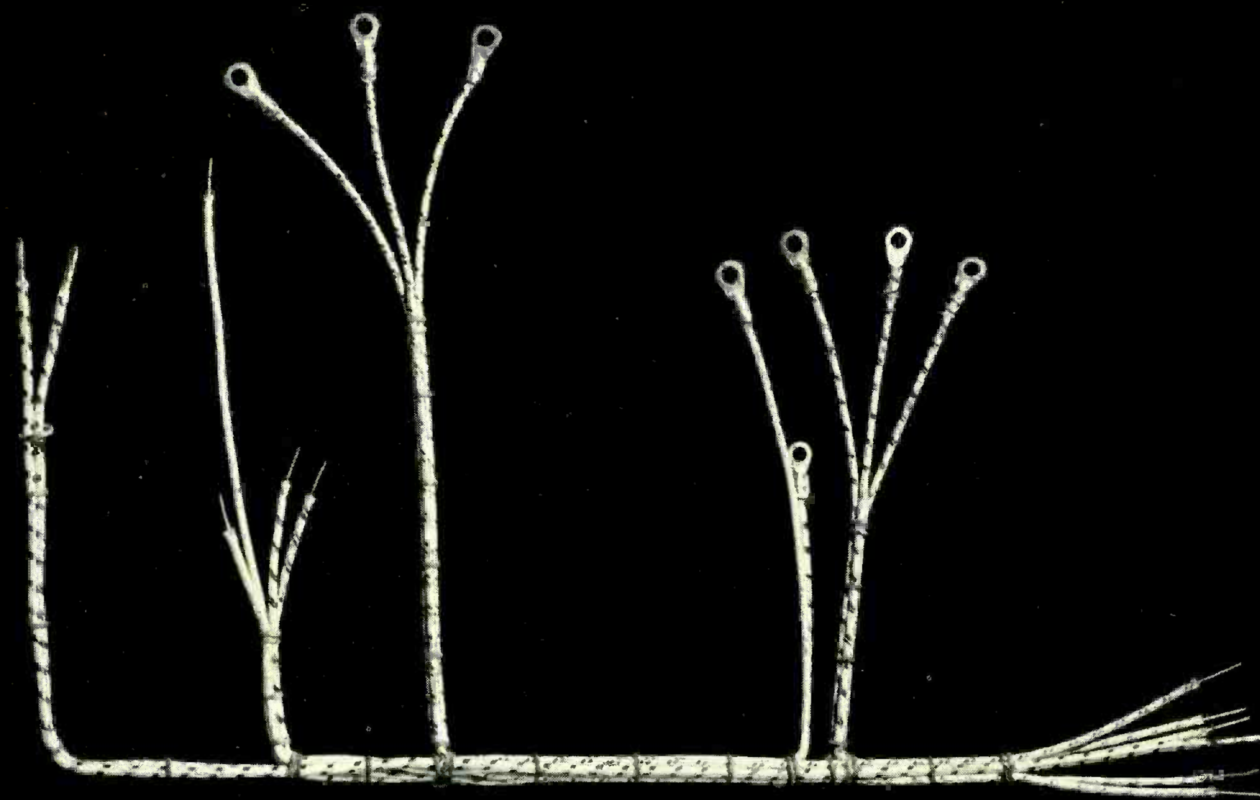

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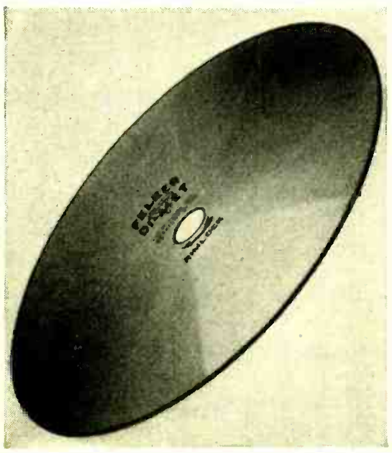

A folder giving additional details regarding these blades and their use, is available from the manufacturer upon request.

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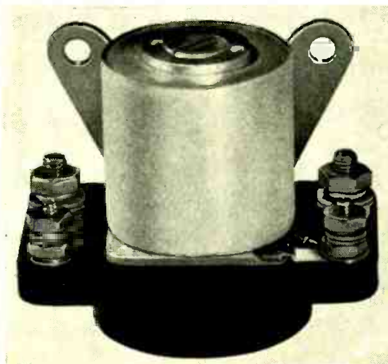
Among five types of approved solenoid contactor units announced by Guardian Electric Manufacturing Company, Chicago, the B-5 series illustrated, has a contact rating of 50 amperes continuous and operates on 24 volts d.c., producing a coil current of 210 milliamperes. It has double pole, single throw, normally open contacts. Weighs 11.2 ounces.

The B-5 Solenoid Contactor, like the balance of the series, is built to U. S. Army Air Force specifications and can be adapted from numerous applications of heavy current control in aircraft and other products.



Unit is said to resist acceleration and vibration over 10 times gravity, that it operates in any position and is so constructed that it may be disassembled with pliers and screwdriver. Metal parts are plated to withstand 200-hour salt spray test. Full details obtainable by writing to Guardian Electric, Dept. B-5, 1605 West Walnut St., Chicago, Ill.

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Jewels of smooth, colorless frosted black glass, with removable color disc or diamond cut (faceted) colored glass, are optional. The slip-fit bezel, holding the jewel, permits quick, easy removal of lamp from panel front. Metal parts are burnished cadmium plated, except the bezel, which has a highly polished chrome finish. Any double contact, candelabra sized bayonet base lamp with C7, G6, S6, or T4½ bulb size can be used.

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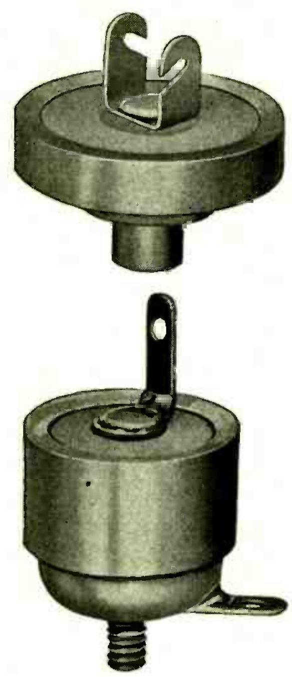

They are made in two sizes, basic type 1770 which is ¾" in diameter and basic type 170 which is 15/16" in diameter. Height of the units vary in accordance with capacity, the maximum height, excluding mounting stud and terminal is ¾".

Type 1770 is rated at 500 volts d.c. working and is available in any standard temperature coefficient from ±120 (P120) to —750 parts per million per

[*Continued on page 51*]

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[*To be continued*]

FREQUENCY MODULATION

[*Continued from page 22*]

plitude, as shown in *Fig. 5-B*. Here instead of the resultant simply oscillating back and forth it makes complete rotations as in *R, R', R''*, etc. This means that during noise pulses the resultant signal actually picks up or looses extra cycles, causing an instantaneous variation in frequency. This variation will be detected by the frequency-modulation receiver and will appear in the output as noise.

The vector diagrams of *Fig. 5* are not absolutely true indications of the actual case, because the noise vector has a varying magnitude. However, for simplicity, it is assumed to be constant and indicates the desired effects.

This is the first of three articles on the fundamentals of Phase and Frequency Modulation. Part 2 will appear in the March issue.

BOOK REVIEWS

[*Continued from page 18*]

to the solution of a.c. problems generally. It contains some 146 charts in two colors (red and green) and two black and white charts to be used as keys to find the proper chart to meet specific boundary conditions. In addition to the charts there are some nine pages of explanation of the use of the charts in network problems. A two-page introduction explains the general theory and use of the charts.

The charts are essentially patterned after that described by Slonczewski in the *Bell Laboratories Record* of November, 1931, and later amplified by Tolmie in the *IRE Proceedings* of September 1933. Half of the 146 charts are intended for computation of reactance or impedance and half for computation of susceptance or admittance. The charts are arranged in groups of nine, each group having the same frequency range but with ascending values of reactance or susceptance. Since the reactance or susceptance charts alone would not enable the determination of impedances or admittances directly, supplementary scales are printed on each page to permit of such computations. One chart is devoted to the computation of Q(= reactance/resistance) and another to the computation of phase angle.

Anyone at all familiar with a.c. theory can use the charts in this book with ease. The charts are well chosen and the explanation clear and logical. It is highly recommended to all radio engineers and others concerned with

any degree of circuit computations.—C.F.N.

★

RADIO CODE MANUAL, by Arthur R. Nilson, 5½ x 7½, flexible cover with ring binding, 174 pages, published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y. Price $2.50.

As an author, Mr. Nilson is well-known for his books "Practical Radio Communication" and "Radio Operating Questions and Answers", with J. L. Hornung as co-author. It is reasonable to expect, therefore, to find his "Radio Code Manual" an authoritative and seasoned work.

The book is divided into seven sections, these sections covering the learning of code; how to send; twenty radio code lessons; being your own code instructor; how to build code-practice apparatus; how to become a better operator; setting up and running a radio class, and how to get a restricted radiotelephone operator's permit. A comprehensive index is also provided.

The manual contains a number of innovations, one of the most helpful, from a psychological standpoint, being a table and a chart indicating the time required by the average student to attain various code speeds. The chart shows the disheartening "Plateau Period of Slow Learning" where many students become discouraged. Pointing up the fact that such a period in learning exists, and is common to most all students, is, in itself a means of helping the beginner pull himself through the interval where no apparent progress is (consciously) made.

The twenty code lessons—the real meat of the manual—provide the usual combinations of letters and numerals in groups having common code characteristics (and to be studied as groups). together with code-practice material built up around these groups. Subsequent lessons bring in the many abbreviations, etc., that are used in commercial radio, so that the student becomes familiar with them as he is picking up code speed. The final lessons contain code-practice material in the form of actual message forms, etc., as used in commercial radio communication.

The construction of a number of types of code-practice sets is covered in Part V, most of them simple enough to be made up from spare and junk parts, which is important nowadays. A really good homemade key is also described.

The ring binder permits the manual to be opened out flat at any page, which is a distinct convenience when the student wishes to use the code-practice material.

A fine book for anyone wishing to

learn the code and pick up commercial procedure at the same time.—M.L.M.

★

MATHEMATICS FOR ELECTRICIANS AND RADIOMEN, by Nelson M. Cooke, 6½ x 9¼, stiff cloth cover, 604 pages. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. Price $4.00.

Though one can gain a great deal from a study of mathematics as a subject in itself, infinitely more is to be gained if the study is in the channels of one's own field. Thus, though there are many excellent books on general mathematics, the radioman lacking a background of mathematics has a far better chance of grasping the subject if it is applied as a supplement to his knowledge of radio. "Mathematics for Electricians and Radiomen" more than meets this special advantage.

The framework of this book is similar to many student texts, in that problems are posed for the reader to work out at the conclusion of each chapter, and the answers provided in the back of the book. Moreover, the author has been generous in the number of practical examples and solutions he has provided, which are always of assistance to the student in determining the manner in which mathematical problems are tackled. Of further aid to the uninitiated, an appendix includes the meanings of mathematical symbols, such as $\cong$, $>$, $<<$, $\leqq$, etc., and the usual designations (in electrical and radio work) given to the letters of the Greek alphabet—"road signs" that are often meaningless to the beginner.

The book opens with chapters on arithmetic, then works into equations, the use of the slide rule, fractions, exponents and radicals, logarithms, trigonometric functions, vector algebra, etc., with interspersing chapters on such subjects as Ohm's Law as applied to series and parallel circuits, Kirchhoff's Laws, series and parallel a-c circuits, etc.

Radiomen short on mathematics but long on aspirations will find this book a mighty good stepping stone to a more useful life.—M.L.M.

★

RADIO SERVICING MANUAL

Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, announces the publication of a new pocket-sized manual, written by Major J. G. Tustison, U. S. Army Signal Corps, formerly electronics engineer with ERPI and Altec Service Corporation.

The booklet describes practical field-tested short-cut methods for servicing Electronic and Radio devices, with only the simplest equipment and tools. Many methods described are those used by our armed forces for servicing equipment in the field of operations.

Engineers will be interested in the application of principles for practical servicing of Radio and Electronic units without the use of complex test instruments. Service and maintenance men also will be able to apply many of the methods in their everyday work. This handy booklet includes color code information on resistors, condensers, power and audio transformers, i-f transformers, and speaker lead and plug connections. An additional feature is a conversion table of fractional inches to decimal and millimeter equivalents.

Copies of the publication are offered free to engineers, maintenance and servicemen who send in requests on firm letterheads.

TECHNICANA

[*Continued from page 10*]

are meeting defeat as rapidly as Rommel in Africa or the Japs at Guadalcanal.

Cold-Weather Batteries

Take batteries, for example. In cars, as the temperature goes down, the storage battery's output follows it. Less known is the fact that the chemicals which activate a dry cell become less and less active at low temperatures, being virtually inert at subzero temperatures—no lower than some of those encountered by members of our armed forces in Arctic outposts, or even in planes at high altitudes.

Several methods are being investigated for overcoming these handicaps, and one of the most interesting is the development of a new type of storage battery. This particular model, as reported by the Special Projects Section, will deliver an output at temperatures of minus 40° F.

The Ground Radio Section of the Ground Signal Equipment Branch is using a different approach to the problem of "B" supplies in certain American and British radio sets. This consists of the design of vibrator power supplies to replace the dry cells formerly used.

Still another method has been hit upon by the Meteorological Section of the Signal Corps General Development Laboratory at Fort Monmouth. There, "B" batteries sent up to the substratosphere in radiosonde equipment suffered from the effects of low temperature. The solution in this instance was a means of keeping the batteries at normal temperature regardless of the frigidity of their surroundings — and the solution was beautifully simple; the batteries are merely contained in a thermos bottle.

Solderless Terminals

Another study being conducted by the same branch deals with the use of solderless terminals on Signal Corps equipment. If adopted, these might save considerable time and labor expense in addition to saving solder, which uses a percentage of that precious metal, tin. Other factors affecting the use of such terminals are also being considered.

Standardization

Standardization is similarly receiving much engineering thought. The Standards Branch at the Signal Corps General Development Laboratory has appointed a member of the Standards Information Section to investigate the various uses of composition resistors, the important characteristics for each use, and the proportion of each use to total requirements. Reasons for this are that binding materials may differ in various resistors, that due to variations in design and construction, resistors of the same nominal rating are not always interchangeable, and so forth.

Mica capacitors, too, came in for their share of attention. The Branch released Standards Sheets on the American Standards Association Wartime Standards on Mica Capacitors. This standardization has been in work for some months, and many believe that it will prove to be the first step toward simplifying the process of design, manufacture, storage and issue of many components of Signal Corps apparatus.

Crystallography

Over at the Crystal Section, they have not only been busy grinding and testing crystals, but have started a series of lectures for training production and inspection personnel in the use of the special apparatus required in their work. Some interesting results have been obtained in a series of tests on various types of crystals, including Grade Zero-B and smoky quartz, both of which showed "excellent activity." In the former, the needles were virtually perpendicular to the surface of the crystals tested, and preliminary results indicated that when blue needle quartz is used, the needles must not be parallel to the major surfaces of the finished crystals. In the case of the smoky quartz, the blackest specimens available were employed to make crystals from 3 mc to 7.3 mc.

★

THERMAL RADIO

★ High frequency induction heat, used in a brazing operation on certain parts for war goods being produced at a General Electric plant in the east, has reduced the time for the operation from four minutes to forty seconds, and has eliminated the need for highly skilled workers to perform the work.

In use, the part to be heated is placed in a water-cooled, copper tubing coil and current is passed through the coil at frequencies in the order of 500,000 cycles per second. This current generates the pulsating magnetic field which heats the part. The intervening air, or parts of the human body which may be in the magnetic field, are, of course, not affected.

STUDY GUIDE

[*Continued from page 32*]

it is held at cathode potential which is always negative with respect to the plate, the secondary electrons are repelled, driving them back into the plate from which they were ejected by the primary electrons. This action suppresses all the effects of secondary emission, but does not suppress the primary emission. Greater output can be obtained from pentodes because the unstable region is removed.

Fig. 4 shows comparative values of the electrical characteristics of triodes, tetrodes, and pentodes.

Transmitter-Tube Faults

39. What are some of the possible indications of a defective transmitting tube? (III-94).

40. What are some of the indications of a defective vacuum tube in a transmitter? (VI-158).

41. What may cause a radio-frequency amplifier tube to have excessive plate current? (VI-157).

TUBE	g_m	μ	r_p
TRIODE	200 - 5000	10 - 100	800 - 150,000
TETRODE	400 - 4000	300 - 800	400,000 - 1,000,000
PENTODE	400 - 9000	70 - 1500	22,000 - 2,000,000

Fig. 4. Comparative values of triodes, tetrodes and pentodes.

42. What are some of the possible causes of overheating vacuum tube plates? (III-101).

43. What are some of the possible indications that a vacuum tube in a transmitter has subnormal filament emission? (III-95).

It is standard practice to periodically record currents and voltages on all tubes in a commercial transmitter. Abnormal readings will indicate either a defective tube or improper circuit adjustments which, if not corrected, may result in tube injury. A defective tube, if not burned out, will have either a low plate current if emission is low or a blue haze and/or high plate current if gas is present. Excessive plate current resulting in overheating of the plate may also be due to improper circuit adjustments; such as, insufficient bias, excessive excitation (a-c grid voltage), off-resonant tuning of the L-C tank in the plate circuit, excessive plate voltage, or improper neutralization. Below-normal plate current is usually a sign of subnormal emission if grid and plate voltages are correct.

Filament Adjustment

44. If the transmitter filament voltmeter should cease to operate, how may the correct filament rheostat adjustment be found? (II-100).

With proper plate voltage, grid voltage, and grid excitation, the filament rheostat may be set to deliver normal plate current.

Grid Bias Voltage

45. Given the following electron tube constants $E_p = 1000$ volts, $I_p = 150$ ma., $I_g = 10$ ma. and grid leak = 5000 ohms. What would be the value of the d-c grid bias voltage?

Since the bias is established by the flow of grid current through a grid leak resistor, the plate current does not enter into the problem.

$E = I \times R = (.010 \text{ amp.}) \times (5000 \text{ ohms}) = 50 \text{ volts}.$

Water-System Resistance

46. The 50-kilowatt output stage of a broadcast transmitter, having a final amplifier efficiency of 33 percent, has a plate current of 10 amperes. If the water cooling-system leakage-current meter reads 11 milliamperes, what is the resistance of the water system from plate to ground?

Power input = 50,000 watts/.33 = 150,000 watts.

Plate supply voltage = 150,000 watts/10 amp. = 15,000 volts.

Resistance = 15,000 volts/.011 amp. = 1,363,636 ohms.

The answer is correct if we assume that the plate voltage and plate supply voltage are equal.

RECEIVER STANDARDS

[*Continued from page 19*]

is not more than 5 per cent in excess of the marked rating on the appliance.

Leakage Currents—A determination of the currents which may flow from exposed or partially protected live parts. Such leakage currents are required to be held within safe limits.

Temperature—Operation of a receiver under normal conditions to determine that specified temperature limits on various materials and parts are not exceeded. Temperatures high enough to present any fire hazard and temperatures which would result in the deterioration of insulation or other essential nonmetallic material are not considered to be acceptable.

Dielectric Strength—A comprehensive check on the adequacy of the insulation and spacings throughout a receiver, with particular reference to the factor of safety over the potentials normally existing at various points.

Strain Relief—A 35-pound test on supply cords.

Abnormal Operation—Special tests on parts which are normally operated for limited periods of time, but which may be operated continuously under abnormal conditions. Pull-out tests on separable connectors. Short circuit tests on capacitors and cables.

New Features

Among the new features of the revised edition of the Standard are the following paragraphs relating to shock hazard, and a description and wiring diagram *(Fig. 1)* of a device with provision for input, line, and meter connections which has been found to be suitable for determining compliance of a radio receiver with the new requirements for voltages and corresponding leakage currents at exposed or partially protected live parts.

A current-carrying part which involves shock or fire hazard shall be spaced or otherwise suitably insulated for the voltage involved and suitably protected for the expected service.

Shock hazard shall be considered to exist at a live part in a circuit involving a potential of 125 volts or less in the following cases:

(A) At an exposed live part, if the open-circuit potential is more than 25 volts and the current with a 1500-ohm load is more than 5 milliamperes.

(B) At a partially protected live part, except as noted in paragraph 75, if the open-circuit potential is more than 35 volts and if the current with a 1500-ohm load is more than 15 milliamperes, with a maximum allowable a-c component of 10 milliamperes in any case.

REFERENCE FREQUENCY EQUIPMENT

[*Continued from page 28*]

circuit of *V4* to a small condenser *C1*. The other side of this condenser is connected to ground through a high resistance *R1*, and also through a rectifier. The charging current of *C1* passes through the rectifier to a much larger condenser *C2*. Since the rectifier passes current in one direction only, *C2* cannot discharge through it, and must discharge through the high resistance *R2*. A tap from this resistance is carried to the control anode of the gas-filled tube *V2*. When the discharge current of *C2* reaches a predetermined value, the voltage on the control grid will be high enough to cause *V2* to become conducting, thus passing current to relay *S4*, which sounds an alarm and lights a lamp. The voltage on the control grid of *V2* depends on the rate at which *C2* discharges, and this, in turn, depends on the rate at which it charges. This latter rate is proportional to the charge on *C1* times the rate, or number of times a second at which it is charged. Since *C1* charges once for each cycle of the difference frequency, the voltage on the control grid of *V2* is proportional to the difference frequency, and the circuit may be adjusted to operate the alarm at any desired difference frequency.

Output Level Alarm

An alarm is also sounded and a lamp lighted when the output level of any of the frequency outputs falls below safe values. Such a reduction in level of the 100-kc, or of the 100-cycle frequency of either of the reference-frequency bays, will cause sufficient potential to appear on the control grid of tube *V1* to cause current to pass and operate relay *S1*. This rings the bell and lights an alarm lamp as does the operation of relay *S4*. The use of the 100-cycle frequency gives an overall check on the system.

The amplitude alarm circuits associated with the four frequency supplies are essentially alike. Only that for the 100-cycle frequency from bay 3 is shown in *Fig. 2*. The input, after being brought to a suitable level, is impressed across the diode *V8,* which passes only the positive half cycles. The negative half cycles, flowing through resistance *R3,* bias the grid of tube *V6* sufficiently so that no current flows. Should the input level drop sufficiently, however, the negative bias on *V6* will be reduced enough to permit current to flow. This current, flowing to ground through *R5,* provides a positive bias for the grid of *V1,* which passes current and operates the alarm for all four amplitude alarm circuits the tubes corresponding to *V6* are grounded through *R5,* and the operation of any one or more of them will give an alarm.

Besides alarm and comparison circuits, the checking bay also carries the cathode-ray oscilloscope for comparing frequencies. It can be used for comparing the two 1000-cycle outputs from the radio receivers, or any of the four reference frequencies from bays 1 and 3. Jacks permit comparison, also, of frequencies from outside sources. Through these various provisions, the accuracy of the basic sources is under constant supervision; and any significant abnormality sounds an alarm.

NEW PRODUCTS

[*Continued from page 35*]

degree C (N750). Maximum capacity at zero temperature coefficient (NPO) is 1000 mmf and is approximately 7000 mmf in N750.

Type 170 is rated at 1500 volts d.c.

working. Maximum capacity in NPO is 400 mmf, and 1750 mmf in N750.

Erie Disc Ceramicons can be supplied in a wide variety of mounting studs and terminals. The design of these condensers is such that their resonant frequency is considerably higher than that of conventional condensers, an important characteristic for ultra-high frequency applications. The Disc Ceramicons are hermetically sealed, to provide maximum protection against humidity.

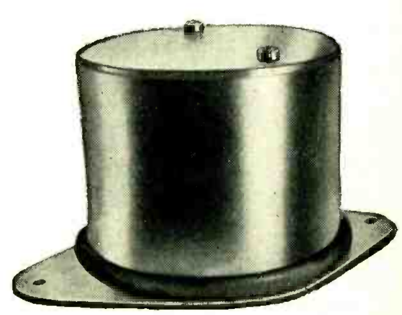
Copies of a data sheet showing various styles of available mounting studs and giving electrical characteristics of Erie Disc Ceramicons can be secured by writing Erie Resistor Corporation, Erie, Pennsylvania.

★

CRAMER TIME-DELAY RELAY

Designed specifically to furnish maximum protection to vacuum tube equipment under unusual and difficult operating conditions, a new time-delay relay has been developed by The R. W. Cramer Company, Inc. of Centerbrook, Connecticut.

Basically, the Type TD4 Time-Delay Relay consists of a synchronous motor-driven timer which delivers an accurately measured but completely adjustable time delay prior to activation of a switch mechanism. As such, it is ideal for controlling application of plate voltage to mercury-vapor rectifiers and other tube equipment.



The Type TD4 is designed for operating conditions which the ordinary time-delay relay cannot withstand.

The heavy steel base plate provided for mounting is zinc plated. The cover is zinc plated and has a black crackle finish enamel over the zinc. The joint between cover and base plate is sealed by a compressible gasket. The entrance for control cables is sealed by a special grommet and by a sealing compound.

The entire mechanism is, therefore, protected against dust, moisture and air with intent to eliminate any possibility of condensation inside the case. The wiring is protected against moisture by protective coating.

The relay provides the customary resetting action of its predecessors so that the full delay period is delivered in cases where circuits are re-energized after power interruptions of considerable duration.

In cases of momentary power failures, the ordinary timer resets completely. The Type TD4, however, holds the time actuated switch in operating position for about 3/10 second after all power is cut off. Interruptions of less than 3/10 second, however, do not cause resetting of the timer and equipment functions normally with power restoration.

In addition to protection against atmospheric conditions, the mechanism is designed to prevent opening or closing of the switch by heavy jarring or rapid vibration. This is a requirement for many industrial applications as well as for Marine and Military service.

★

"DURASHIELD" LAMINATED PLASTIC

Durashield is a laminated plastic which is meeting war demands for a satisfactory substitute for brass, copper, or bronze nameplates, tool checks, dial faces and similar marking plates on ships, machinery, and metal equipment of every kind. It is a product of Plastic Fabricators, Inc., 500 Sansome Street, San Francisco, California, and is built to meet minimum Navy requirements in the standard grade, and can be obtained in colors.

"Durashield is produced by a lamination process," explains Dan Danziger, Sales Manager of Plastic Fabricators, Inc. "To meet minimum Navy specifications, the center sheet upon which the wording is printed is an opaque cellulose acetate plastic, .010" thick. On each side of this is laminated a transparent acetate plastic, .020" thick, making a finished product measuring .050" thick. The transparent outside allows a clear vision of the directions, name, or whatever may be printed on the center and being laminated in a solid plate resists wear and remains a solid unit which successfully replaces the familiar brass, bronze, or copper plates heretofore used."

Another advantage of the new product is the fact that it can be die-cut, stamped, drilled, or otherwise made to conform to any specification as to size and shape. It is fire resistant, successfully withstanding temperatures of 200°F.

★

G. E. SPOT WELDING CONTROL

A new electronic half-cycle, synchronous control for the precise operation of resistance-welding machines has been announced by the General

Electric Company. Mounted in a protecting cabinet, the control is furnished in two types: the CR7503-A136, which also includes a welding transformer and is designed for bench mounting, and the CR7503-A133, which is without a transformer and is designed for wall mounting. Both types can be used either with tongs or with a suitable bench welder.

The control features a new tube, the easily replaced GL-415; a new circuit which makes higher-speed welding possible; and a simplified initiating circuit which improves performance and reduces maintenance. The new design also incorporates heat control by the phase-shift method. The heat adjustment is made by a dial mounted on the front of the cabinet.

The control facilitates the welding of tinned copper, steel, or alloy wires; of studs from 0.01 to 0.05 inch diameter to flat surfaces, with little or no indentation on the opposite surface of the metal; and the spot welding of unusually thin (less than 0.01 inch) pieces of stainless or mild steel, nickel, or silver to brass or bronze, with negligible oxidation or discoloration.

The control also makes possible the welding of low resistance joints which are unaffected by temperatures considerably in excess of 125 C, the point at which certain types of soldered joints weaken and often collapse. This results in the complete elimination of solder, with a corresponding saving of tin, and a saving of approximately 50 percent in time. Also, in many cases it greatly simplifies the problem of training new employees, since the technique of resistance welding is learned much quicker and with less waste of material than in the case of soldering.

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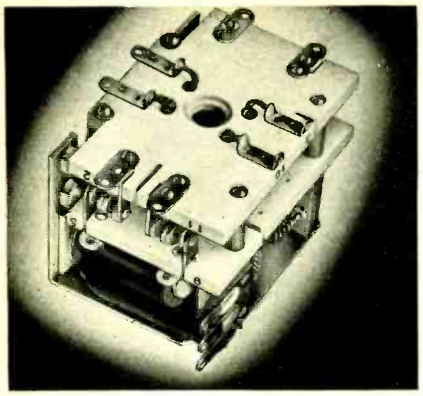
ALLIED AIRCRAFT RELAY

Allied Control Company's Model AK Relay is a high speed Keying and Break-In Relay for Aircraft Radio Equipment. It is compactly designed for high voltage, high speed and resistance to vibration. Its push-pull magnetic arrangement provides magnetic holding pressure on both transmit and receive contacts. One pole is equipped with two windings one of which is a holding winding connected directly across the battery supply. The other winding is connected in series with the single winding on the other pole and polarized so that when the circuit is completed through the key, the flux is neutralized on the holding or receive position pole and



the armature pulls up to the transmit position. Opening the key cuts off the bucking flux and the holding flux pulls the armature back to receive position.

The relay is completely balanced; its arms are equipped with anti-bounce features; it is magnetically held in both positions and does not rely on back spring pressure; it keys at 20 cycles; its contact rating is 1,000 volts at 30,000 feet, 20 megacycles; 4 pole double throw; it is insulated to sustain 10,000 volts at sea level; its standard models are in 12 and 24 volts d.c.; its wattage consumption is 5.5 in first position and 17.0 in second position; it withstands vibratory motion to better than 20 G.; all of its terminals are easily accessible; its insulation plate is of high pressure steatite; it is mounted with elastic stop nuts and its dimensions are 2 7/16 x 3½ x 2¼ inches; its weight is 17 ounces.

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THIS MONTH

POLICE RADIO ESSENTIAL

The inevitable loss of some police manpower to the armed services makes the need for two-way police radio communication vital in many communities never before having this service, according to responsible police officials who point out that one policeman with this equipment can do the work of four policemen without it. This was explained by D. L. Chestnut, General Electric electronics engineer in a talk on January 20 to the New Jersey section of the International Municipal Signal Association meeting at Harrison.

War-expanded responsibilities in hundreds of communities have put increased burdens upon these communities to maintain orderly and effective efforts in their local contributions to the total war program, the speaker explained. "An appreciable part of this burden falls upon the local police force," he said, pointing out that in addition to their regular duties these police agencies must help provide adequate protection to local war industries."

The amount of material required to produce enough essential two-way police radio equipment is "infinitesimally small" in proportion to the total military radio requirements, Mr. Chestnut said in explaining how the Federal Government has set up a radio reserve pool to take care of essential police requirements. During the first few months of 1942, it looked as though no more police radios would be available for the duration, Mr. Chestnut said. Law enforcement agencies and industry presented their problems to WPB which, after accumulating the facts, set up the "pool." Each of several manufacturers have been given an order by the Defense Supplies Corporation, a subsidiary of the RFC, to manufacture a specified quantity of "essential" two-way police radio equipment.

"Much freedom of action is allowed by WPB in the choice of radio equipment. Individual cities are permitted to proceed in substantially peacetime manner in the selection of the manufacturer from whom they wish to purchase," the engineer explained.

As a guide to law enforcement agencies needing new police radio equipment, Chesnut pointed out that they should (1) be sure that the need is vital; (2) select the equipment needed; (3) submit an application through the manufacturer to the War Production Board for this equipment, on a form which can be obtained from the manufacturer; (4) submit an application for construction permit to the Federal Communications Commission. The manufacturer will assist in filling out the necessary form.

The Federal Government, law enforcement agencies throughout the United States, and the radio manufacturing industry are united in full recognition that the first job is to produce the necessary combat equipment and material and get it to our troops, the engineer said, and are also united in a co-operative program to successfully solve an important "contributory problem," the supplying of essential police radio communication on the home front.

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A. J. CARTER, RMA FOUNDER, DIES

Services were held Wednesday, January 27, at Chicago for A. J. "Nick" Carter, president of the Carter Motor Company of Chicago, and a founder and former Director of RMA, who died suddenly at his home, Sunday, January 24, at the age of 60. Mr. Carter was among the organizers of the Radio Manufacturers Association, and for many years served on its Board of Directors. He was a pioneer in television, having promoted the first television exhibitions in Chicago in 1923-29. He was a Director on the first RMA governing board through 1924-25, and served on the Association's Board for several years thereafter.

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HAZELTINE SERVICE CORPORATION BECOMES HAZELTINE ELECTRONICS CORPORATION

The name of Hazeltine Service Corporation has been changed to Hazeltine Electronics Corporation, according to an announcement just made by Mr. W. A. MacDonald, President. This step follows completion of a program of plant expansion providing large additional facilities for electronics research and development.

"The tremendous growth in the use of electronic devices by the Army and Navy has greatly increased the responsibilities entrusted to the Hazeltine organization," said Mr. MacDonald. "Since the infancy of radio broadcasting Hazeltine has been supplying new principles, circuits, techniques and equipment, and Hazeltine developments today are playing an ever more vital part in helping to keep the United Nations superior to the enemy. With enlarged facilities in plant and personnel we can undertake solution of the most complex problems in electronics. Following the war, Hazeltine Electronics Corporation will be able to supply the public, through industry, with electronic marvels that can make life safer and happier for every one."

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DEATH OF I. R. BAKER SHOCKS RADIO WORLD

Camden, N. J., Feb. 10.—Members of the radio, television and electronics industries mourned today the loss of one of its best liked pioneers in death yesterday of Irvin Ray Baker, 39, of Haddonfield, New Jersey. Mr. Baker, who was formerly head of RCA's Broadcast Transmitter Sales and latterly was advancing the development of electronic applications to war industries, died at work (Tuesday, February 9th) of a cerebral hemorrhage.

Mr. Baker is survived by his wife, Eleanore, and a month old son, Robert Roland.

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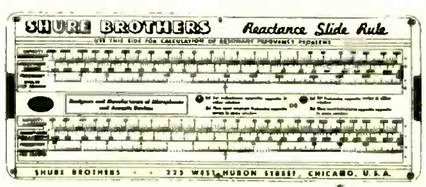
SHURE REACTANCE SLIDE RULE

A handy new Reactance Slide Rule that speeds up the solution of reactance and resonant frequency problems has been devised by Shure Brothers, designers and manufacturers of microphones and acoustic devices.

Radio and electrical engineers, physicists, radio servicemen, radio amateurs, teachers and students find this accurate Slide Rule useful in their every-day work. It saves time solving problems covering resonant frequency, capacitive reactance, inductive reactance, coil "Q," and dissipation factor.



On one side of the rule, resonant frequency problems are solved with one setting of the slide, using

$$\omega^2 LC = 1$$

with ranges of 5 cycles to 500 megacycles, .001 mmf to 1,000 mf, and .00001 mh to 10,000 henries.

On the other side of the rule, reactance, dissipation factor and coil "Q" problems are solved with one setting of the slide, using the following formulae:

$X_C = 1/2\pi fC$, $X_L = 2\pi fL$, $Q = 2\pi fL/R$, and $D = 2\pi fCR$.

The ranges on this side are 0.1 cycle to 10,000 megacycles, 1 mmf to 100 mf, and .001 mh to 100 henries.

This new Reactance Slide Rule is available at a nominal charge of 10c in coin or stamps to cover the cost of handling and mailing. Shure Brothers, 225 West Huron St., Chicago, Ill.

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"FORMEX" WIRE CATALOG

A 27-page catalog dealing with the properties, advantages, and available types of Formex Magnet Wire, has been issued by the General Electric Co., Schenectady, N. Y.

The wire has as an insulation a thin film of synthetic resin of the polyvinyl-acetal type.

The catalog, GEA-3911, is available upon request to the manufacturer.

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ACME TRANSFORMER CATALOG

In a special bulletin just issued, The Acme Electric & Mfg. Co. of Cuba, New York, lists standard specifications and mounting means of Audio Transformers, Driver Transformers, Interstage Transformers, Reactors, Microphone Input Transformers for airborne equipment and transmitter transformers and reactors for mobile equipment.

In addition to the specifications covering such units, a chapter is devoted to the explanation of transformer compounding. The manufacturer asserts that transformers sealed with the proper compound can operate at a lower temperature rise than ordinary air-cooled transformers, the secret being that certain types of compound have the quality to dissipate heat more rapidly than ordinary free air.

The manufacturers offer to send this engineering bulletin No. 159 to anyone interested in the production of equipment in which transformer units of this type may be included.

★

SYLVANIA TECHNICAL MANUAL

A new printing of Sylvania's 5th edition of the Technical Manual is now ready for distribution to Radio Technicians.

One section of the Technical Manual has been devoted to listing all new types of tubes released since the previous issue, and a section pertaining to panel lamps has also been added.

Plastic binding has been employed which allows the book to lie flat and remain open at whatever page is to be consulted.

The general arrangement of the technical data of the reprinted Manual remains the same, and index tabs are still supplied, glued and marked for easy installation on the proper pages.

The new revised Technical Manual sells for the pre-war price of 35c per copy, and may be secured from Sylvania Distributors or by ordering direct from Sylvania Electric Products Inc., Emporium, Penna.

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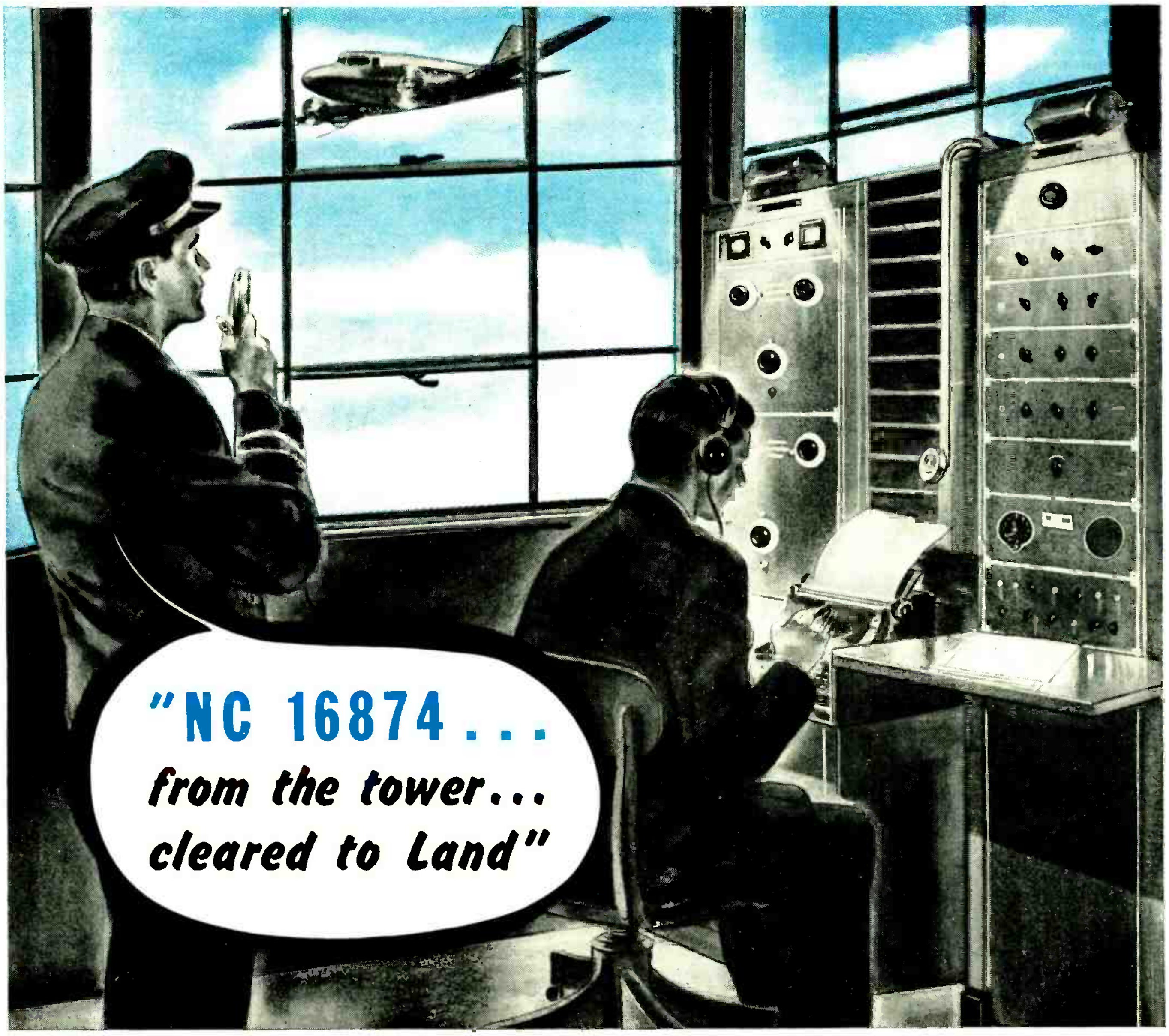
ADVERTISING INDEX


"NC 16874 . . .
from the tower...
cleared to Land"