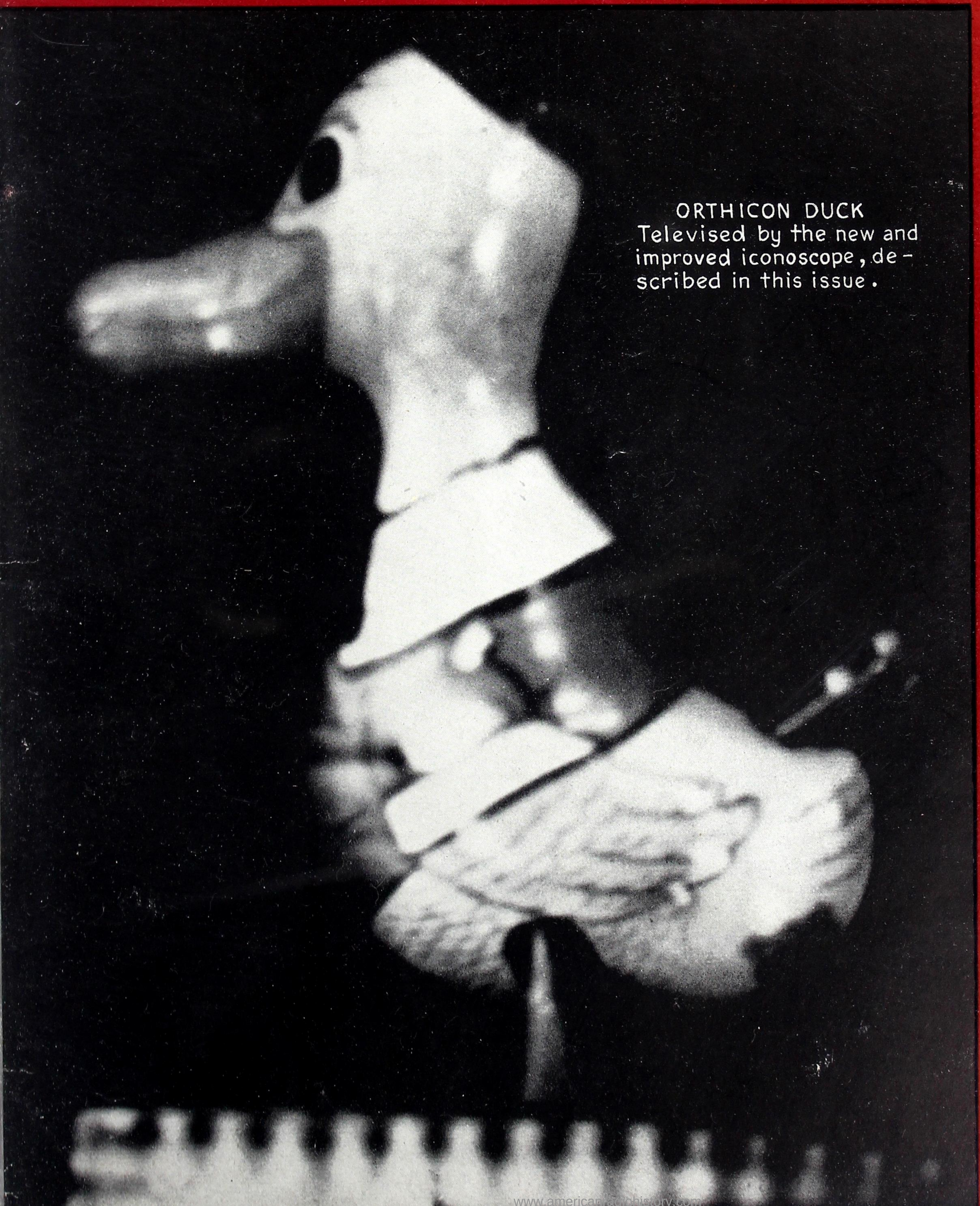
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



ORTHICON DUCK
Televised by the new and improved iconoscope, described in this issue.

JULY
1939

Price
50 Cents

McGRAW-HILL
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COMPANY, INC.

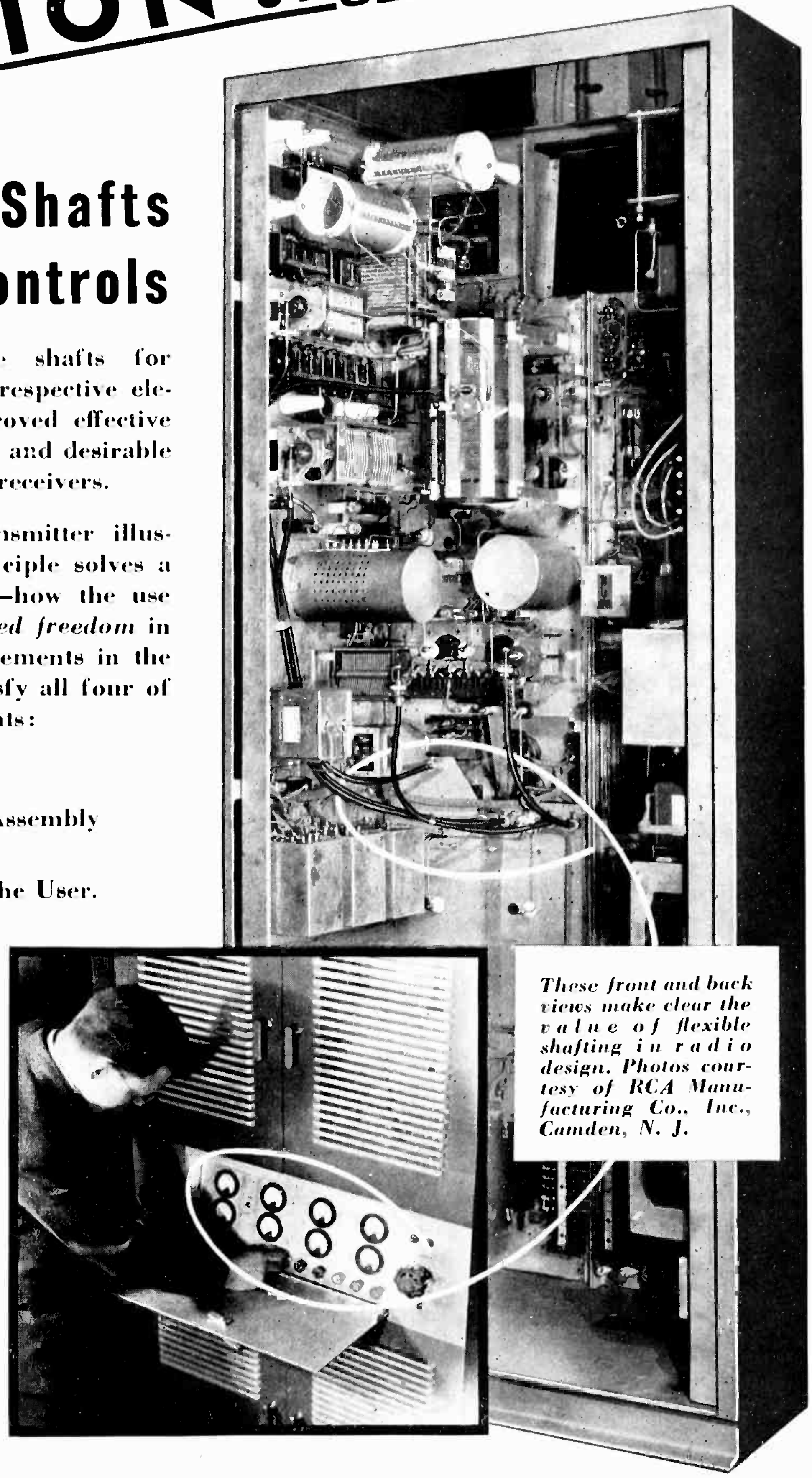
A good idea for TELEVISION engineers

... Use Flexible Shafts to simplify the controls

The principle of using flexible shafts for "Coupling" tuning knobs to their respective elements in the circuit, which has proved effective in radio equipment, is just as sound and desirable for TELEVISION transmitters and receivers.

The RCA Radio Broadcast Transmitter illustrated, shows clearly how this principle solves a number of vital design problems—how the use of flexible shafts permits *unrestricted freedom* in placing tuning knobs and circuit elements in the most advantageous positions to satisfy all four of the following important requirements:

(1) Circuit efficiency
(2) Easy and Economical Assembly
(3) Servicing Convenience
(4) Operating Facility for the User.



These front and back views make clear the value of flexible shafting in radio design. Photos courtesy of RCA Manufacturing Co., Inc., Camden, N. J.

ENGINEERING AID

Our full cooperation is offered to TELEVISION designers for working out the details of applying "Coupling" shafts to specific equipment. This cooperation involves no obligation—so consult us freely. As a preliminary, send for ENGINEERING BULLETIN 38 which tells all about S. S. WHITE flexible shafts for "Coupling." A request on your business letterhead brings you a free copy. Write for it—today.

S. S. WHITE

The S. S. White Dental Mfg. Co.

INDUSTRIAL DIVISION

Department E, 10 East 40th St., New York, N. Y.

A McGRAW-HILL PUBLICATION

electronics

RADIO . . . COMMUNICATION AND INDUSTRIAL APPLICATIONS OF ELECTRON TUBES . . . DESIGN . . . ENGINEERING . . . MANUFACTURE

ELECTRONICS, July, 1939, Vol. 12, No. 7. Published monthly, price 50c a copy. Subscription rates—United States and possessions, Canada, Mexico and Central American countries, $5.00 a year. All other countries, $6.00 a year or 24 shillings. Entered as Second Class matter, August 29, 1936, at Post Office, Albany, N. Y., under the Act of March 3, 1879.

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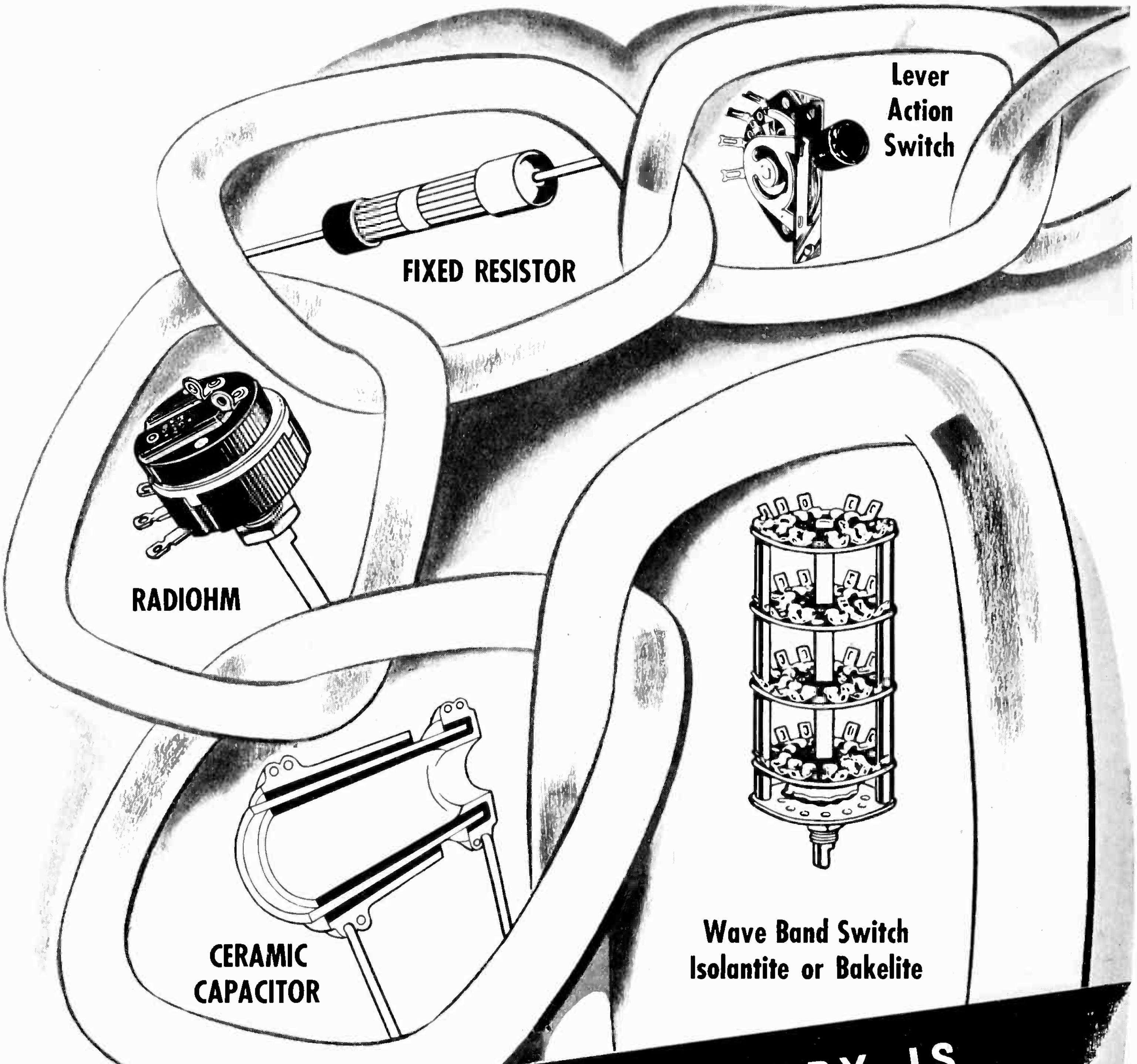


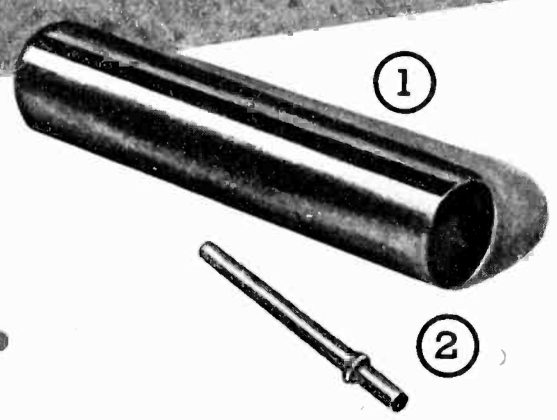
THE ELECTRONIC INDUSTRY IS LINKED WITH THESE FAMOUS PRODUCTS *by* CENTRALAB

New developments; some ephemeral and visionary; many sound and practical, are breaking on the horizon.

And today, as in the past, Centralab plays an important part in the electronic industry—in the designing laboratories of manufacturers — on the benches of experimenters — in the "trouble-shooting" service-man's kit and in tiny ham shacks. For wherever Quality, Dependability and Reliability count . . . there Centralab serves supreme. For sound or sight . . . CENTRALAB.

CENTRALAB DIV. of GLOBE-UNION INC., Milwaukee, Wis.

2 More Reasons why it pays to—
"GO RCA ALL THE WAY"



SUPERIMPOSED on the kinescope screen shown above you see the deft hands of an RCA expert assembling a video receiving tube. The anodes (1) and cathodes (2) of these high-fidelity tubes are fabricated by Superior . . . With other leaders in the field, RCA appreciates that the success of their equipment is dependent equally upon materials of uniform top-quality and outstanding technical skill . . . Superior Tube Co., Norristown, Pa.

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SEAMLESS TYPE	*OTHER TYPES*
CARBON STEELS	*Welded or Brazed and then Cold Drawn*
ALLOY STEELS AND TOOL STEELS	BUTTWELDED STEEL
STAINLESS STEELS	BRAZED STEEL
COPPER	*BRAWN "MONEL"
ALUMINUM	*BRAWN "INCONEL"
"INCONEL"	WELDRAWN STAINLESS
NICKEL	
"MONEL"	

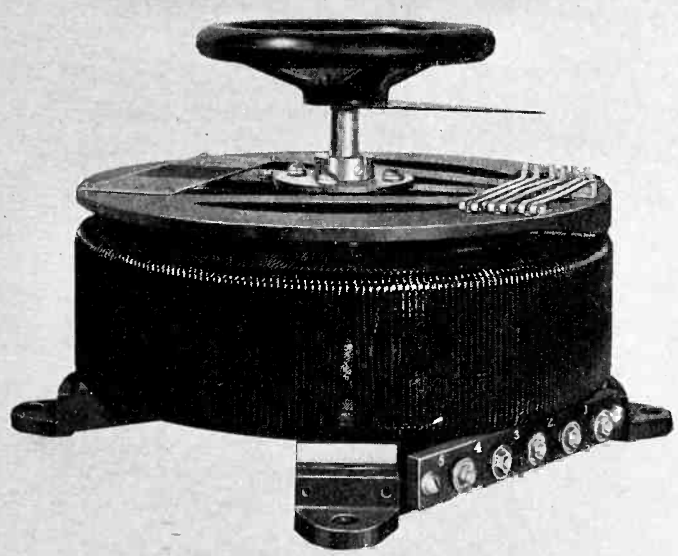
*U. S. Reg. Trademark

SUPERIOR TUBING

Two New VARIACS

5 kw and 7 kw

TYPE 50-A and 50-B VARIACS



DESIGN FEATURES

Laminated iron core . . . high-temperature Bakelite winding form . . . cast-aluminum brush support and radiating spokes . . . 6-brush contactor with phosphor-bronze springs and pigtails . . . cast-iron frame with four mounting holes for either table or behind-panel mounting . . . ¾ inch solid steel shaft with control wheel 7 inches in diameter . . . 340-degree rotation . . . dial engraved on both sides for two output voltage connections.

FOR controlling high power circuits, General Radio Company announces two new VARIAC autotransformers rated at 5 and 7 kva. These are in production with deliveries commencing shortly.

The general design follows that of the small VARIACS; a toroidially-shaped winding on a laminated iron core. Contact to the winding is made by a multiple-contact brush pigtailed to a terminal so that bearing contact resistance is avoided.

The new VARIACS have a number of unique design features which make possible the manufacture of these high power units with the same high efficiency of the popular Type 100 and Type 200 models, thousands of which are in use in the electrical industry. Particular care has been taken in the design of the new units to avoid the possibility of breakdown with the resulting damage to equipment consuming relatively high power.

The Type 50-A VARIAC is rated at 5 kva on a 115-volt circuit and can be connected to supply output voltages continuously adjustable from either 0 to 135 or 0 to 115 volts. The dial is calibrated directly in output voltage and is reversible for either output voltage connection.

The Type 50-B VARIAC is rated at 7 kva on a 230-volt circuit and supplies output voltages of either 0 to 270 or 0 to 230 volts. It, also, is supplied with a direct-reading reversible dial.

Both types are supplied in mounted models only (top photo).

TYPE 50 VARIACS

SPECIFICATIONS

	TYPE 50-A	TYPE 50-B
Load Rating:	5000 va	7000 va
Rated Current:	40 amp.	20 amp.
Maximum Current:	45 amp.	31 amp.
Input Voltage:	115	230 (tapped for 115)
Output Voltage:	0 to 135	0 to 270
No-Load Loss:	60 watts	75 watts
PRICE:	$100.00	$100.00

• ***Write for Bulletin 451***

GENERAL RADIO COMPANY CAMBRIDGE MASSACHUSETTS

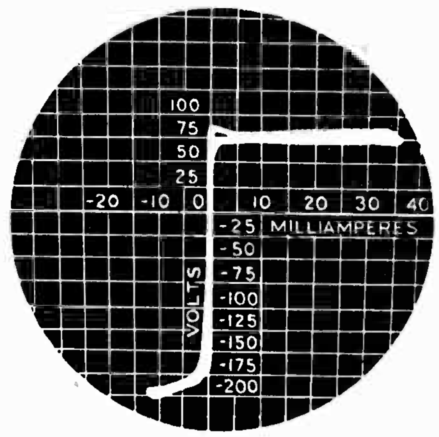
Do you NEED a faster, more sensitive relay?

Western Electric 313C Cold Cathode Tube operates on 5 microamperes in 1 millisecond

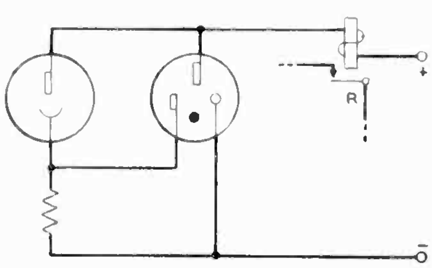
Because it has no moving parts the Western Electric 313C can operate at such speed... on such low current. This cold cathode tube is faster, more sensitive than *any* electromagnetic relay. It requires no cathode power or time in starting as does the thyratron. It's ideal for stand-by service.

The 313C can be used as a polarity detector to respond to either a positive or negative voltage. Hundreds of thousands of these tubes are now in this type of service in telephone bell boxes on party lines.

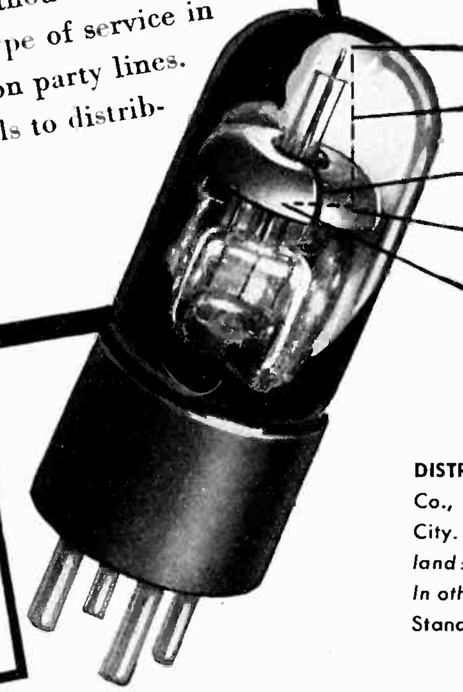
Write for full details to distributors listed below.



Current-voltage characteristics illustrating rectification property.



Photoelectric relay circuit using 313C cold cathode tube.



RATINGS AND CHARACTERISTICS:

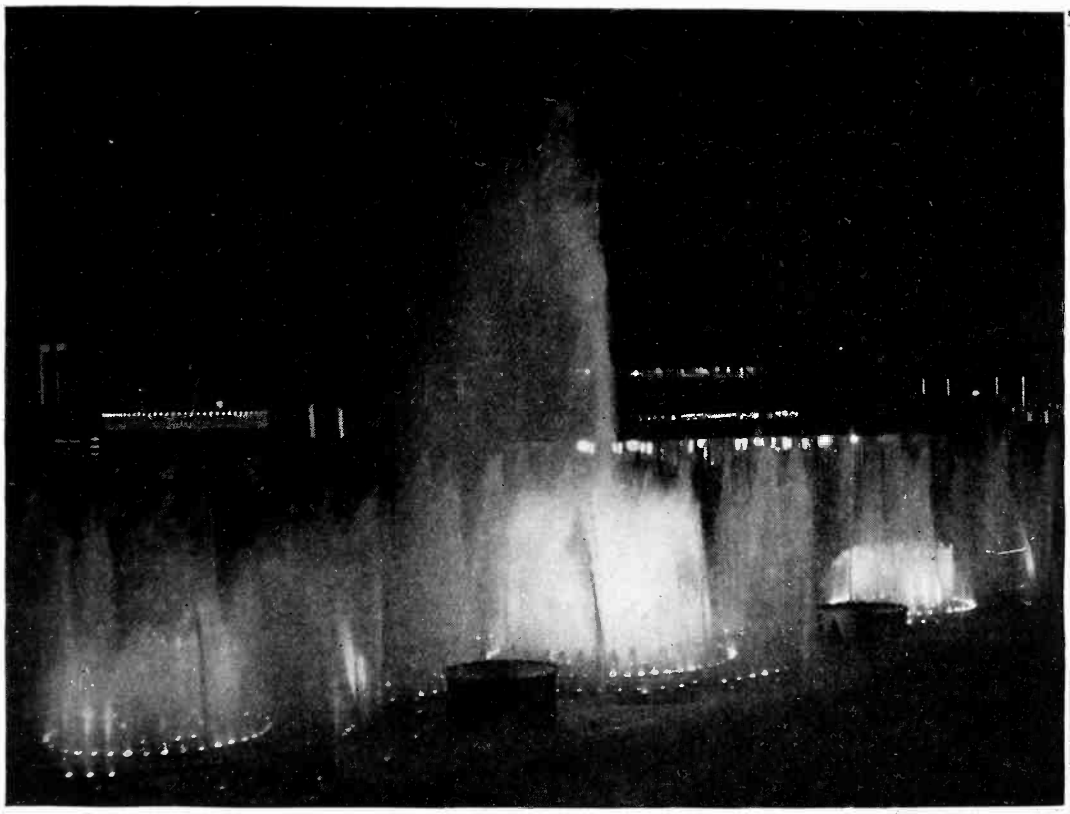
Maximum peak cathode current . . .	30 m.a.
Maximum average cathode current (average over 1 second)	10 m.a.
Control gap breakdown voltage . . .	70 volts
Control gap sustaining voltage . . .	60 volts
Main gap breakdown voltage	175 volts
Main gap sustaining voltage	75 volts
Deionization time	10 milliseconds

DISTRIBUTORS: Graybar Electric Co., Graybar Bldg., New York City. *In Canada and Newfoundland:* Northern Electric Co., Ltd. *In other countries:* International Standard Electric Corp.

Western Electric

ELECTRONIC EQUIPMENT

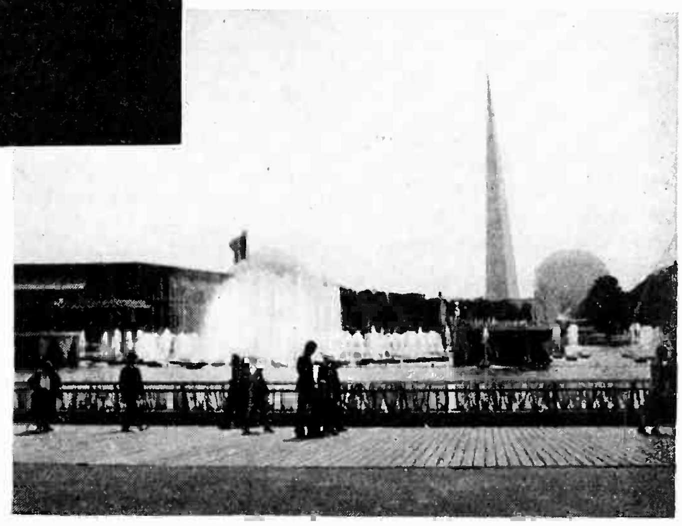
Distributed by GraybaR



● Night view of illuminated fountain display at Lagoon of Nations, New York World's Fair.

● A view of Lagoon of Nations in daylight with the Perisphere and Trylon in background.

● Sound, color, water, flame, smoke, light and fireworks combine to make the Lagoon of Nations display the greatest and most spectacular symphony ever produced.



AMERTRAN

Speaks to Crowds of 200,000 at the spectacular fountain display, Lagoon of Nations, New York World's Fair

DIFFICULT engineering problems are most frequently referred to firms who have proven ability along similar lines—to firms with the greatest accumulation of experience, knowledge and facilities.

Development of the greatest spectacle at the N. Y. World's Fair, the symphony of synchronized sound, color, water, flame, smoke, light and fireworks, which is presented nightly at the Lagoon of Nations to crowds numbering up to 200,000, required the active cooperation of engineers from many fields of endeavor to make it the outstanding success that it is. Not a minor part was the design of the 2000-watt sound system, and Bludworth, Inc., who was given this responsibility, called upon AmerTran to develop audio transformers for handling the large volume of sound with low distortion throughout the band of 28 cycles to 11 kilocycles.

Since the early days of radio, leading manufacturers, radio stations and recording studios have referred their audio transformer problems to AmerTran for solution. Let us submit data on equipment for your requirements.

Photographs courtesy Cinaudagraph Corp., Stamford, Conn.

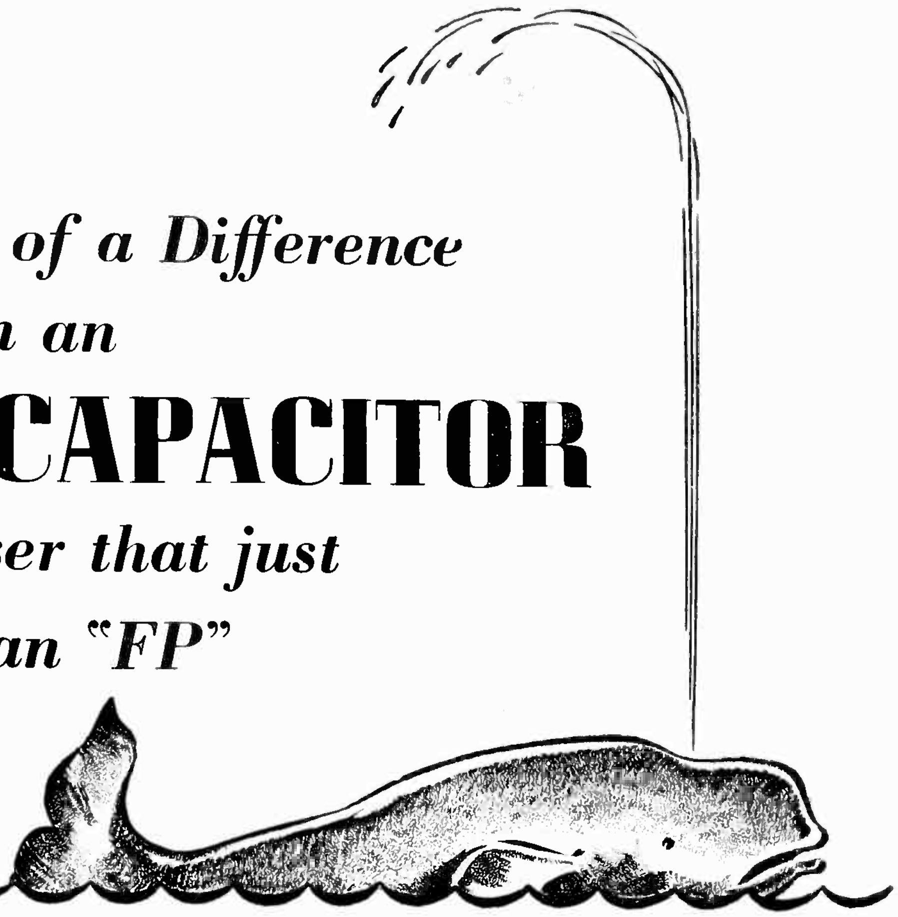
AMERICAN TRANSFORMER COMPANY

178 Emmet St., Newark, N. J.

●

AMERTRAN TRANSFORMERS

Manufactured Since 1901 *at Newark, N. J.*



There's a WHALE of a Difference between an

FP** (*Fabricated Plate*) **CAPACITOR

and a Condenser that just looks like an "FP"

**NOT etched Construction*

There's a difference in performance as wide as day and night *because* there is a difference in construction that isn't even comparable.

Mallory FP (*Fabricated Plate*) Capacitors are manufactured under an exclusive patented process developed as the result of months of research and experimenting, plus an investment involving an expenditure of over one hundred thousand dollars.

The characteristics and functioning of these capacitors is so decidedly superior that more than a million are now in use as original equipment . . . and millions more are scheduled to be used in the coming months.

It may be a sincere form of flattery to be imitated . . . but you should know that there is far more to a Mallory FP (*Fabricated Plate*) Capacitor than a modernized clean-cut compactness. There is no condenser, regardless of appearance, that will give you FP (*Fabricated Plate*) characteristics. If you want the ultimate in performance and savings . . . be sure it's an FP (*Fabricated Plate*) Capacitor.

P.R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA—Cable Address—PELMALLO

P. R. MALLORY & CO. Inc.
MALLORY

CROSS TALK

▶ **CATS AND DOGS** • • • Our London correspondent vouches for this modern application of scientific principles to communication.

By pumping a smell of cats into subterranean coaxial cables, British Post Office engineers have been able to trace leakages in the copper tubes that surround the conductors.

The cables run for 16 miles to the new transatlantic radiotelephone receiving station under construction near Rochester. Normally, a surrounding copper tube is pumped full of air to maintain a high electrical insulation. Leakages can put the station out of action.

When a gas smelling of cats was introduced into the tube a Labrador retriever taken along the route of the cable detected 14 leaks three feet or so under the surface. Wherever the dog attempted to dig repairs were found to be necessary. The taking up of two miles of cable was avoided by using this dog and cat-gas method.

Incidentally, in America Bell System engineers have made a new telephone cable with 4,242 separately insulated wires in it. Cable has same diameter (2⅝ inches) as its predecessor which had only 3,636 wires. This all came about by decreasing the thickness of the insulation around each wire from 34/1000 inch to 31/1000 inch.

▶ **VU-DB** • • • The following letter from H. A. Affel, Assistant Director of Transmission Development, Bell Laboratories is self explanatory.

"I was interested in the chart 'VU-DB Relationships' which appeared in the May issue of *Electronics*. In printing such a chart, however, I believe its limitations should be very carefully pointed out. A chart of this sort can, of course, apply only to sine wave measurements and the labels on the curves (e.g. 0 vu = .001 watts) are only true for sine waves.

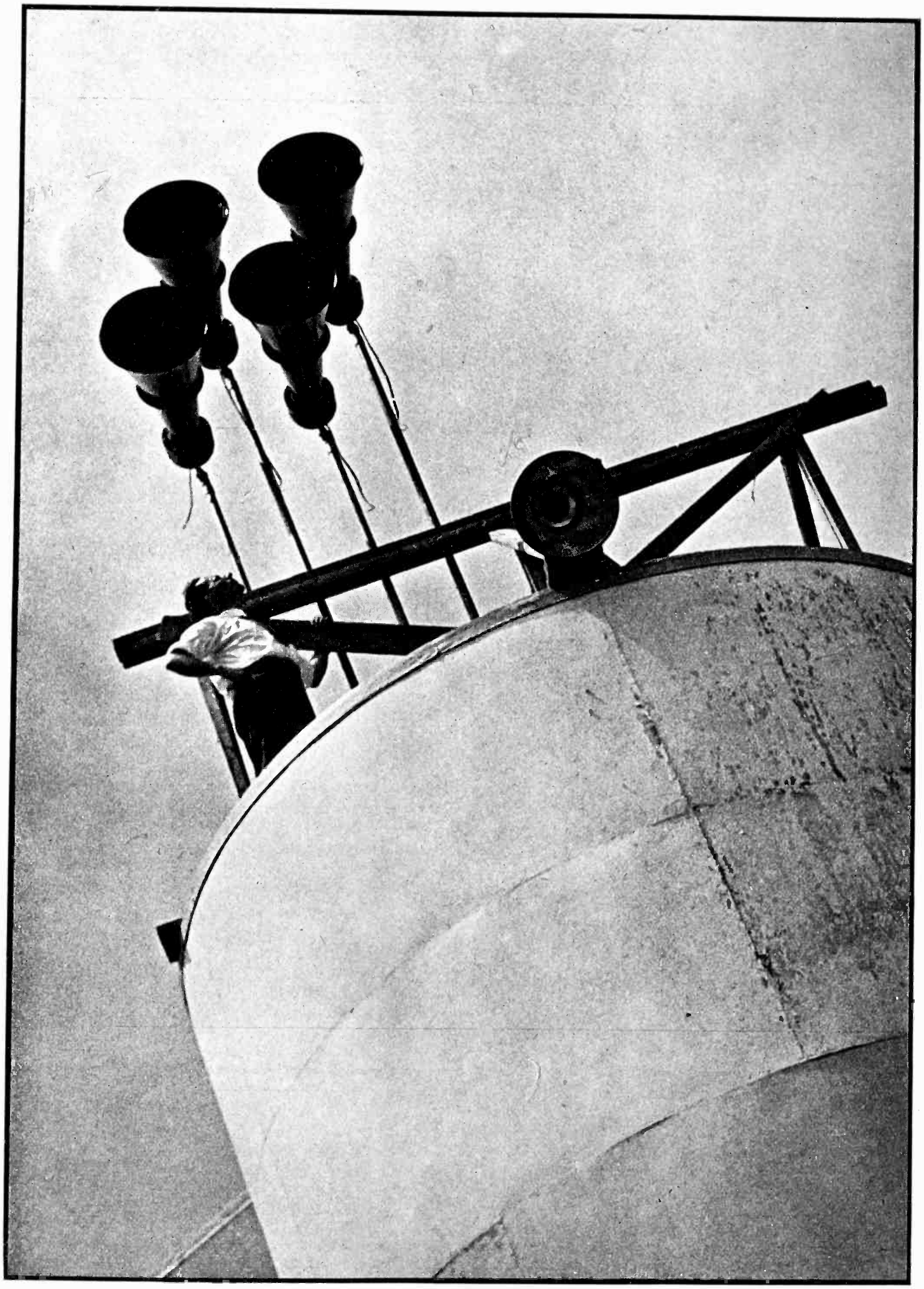
"The principal use made of volume indicators is to measure volume levels of speech and program waves. As pointed out in the article in your February issue by H. A. Chinn, R. M. Morris and myself, the reading of a volume indicator on such waves is determined as much by its dynamic characteristics as by its sine wave calibration. Different old type volume indicators calibrated on .006 watts may read on particular programs anywhere from 6 to about 12 db differently from one of the new standard volume indicators calibrated on .001 watts, where the chart leads one to expect a fixed difference of about 8 db.

"The whole point is that 0 vu does not equal .001 watt or any other value of power, but is that level of a program wave which gives a reading of 0 vu on a standard volume indicator which is calibrated with .001 watt of sine wave power. A speech wave at a level of 0 vu has instantaneous peaks which are several times .001 watt and an average value of a fraction of that power. It is important to understand the philosophy that volume levels are not directly related to power, except in the rare case where a sine wave is being measured, but are, quite arbitrarily, merely the readings of an instrument which is calibrated and read in an agreed upon way.

"I wish to call your attention further to a definite error in the chart. One of the curves is based on a power of .0125 watt in 600 ohms. So far as I know, this value has never been used by anyone. Some of the broadcasting companies have, however, employed a calibration of 2.5 volts or .0125 watts in 500 ohms, for certain old types of instruments. On the average, although not on individual programs, these instruments so calibrated will read the same as certain other instruments calibrated with .006 watt in 600 ohms."

▶ **W2XBS** • • • In the middle of the Iams-Rose paper on the Orthicon at the New York IRE meeting in June, the loud speaker system began to spout a nice program from the NBC television station on top Empire State. In the McGraw-Hill building, people testing a Filmo projector have been astonished to get the same programs. Years ago, when WEAF was on top the Bell Labs at 463 West Street, it was lots of fun to open up the grid circuit of a repeater and to pick up broadcasts from the roof.

▶ **TALKING BOOKS** • • • On June 7, the President signed bill H.R.5136 enabling the Library of Congress to let contracts for the making of talking books for the blind to non-profit-making organizations rather than being forced by law to let these contracts to the lowest bidders for them. Since the American Foundation for the Blind, which produced the first talking book in 1934, and the American Printing House for the Blind operate on a non-profit basis, record quality should be such that the user of the record gets the maximum benefit and enjoyment from it. Large research organizations, such as the Bell Laboratories and RCA Victor, have aided in this work, publishers, authors and others have been paid only token royalties—all in the common aim of providing the blind with recordings of maximum value at lowest cost to the Government. There is no money to be made in this business because the volume is small. Therefore there seems little need for commercial concerns to compete with the non-profit groups on a price basis.



Sound . . . Experimental 100-watt loud speakers on test during early days of New York World's Fair construction. In spite of steam shovels and other noise making machinery, the battery covered an area of ½ mile radius

The Orthicon

A new and greatly improved form of the iconoscope uses low-velocity electrons for scanning, thereby avoids spurious signals, obtains storage efficiency ten to twenty times that of the iconoscope, and produces an output current linearly related to the light input

ON June 7th, Albert Rose and Harley Iams, of the RCA Manufacturing Company Research Laboratories at Harrison, revealed to the New York Section of the I.R.E. the details of a new developmental television pick-up tube which, in the opinion of your editors, is one of the most significant advances in television electronics since the advent of the iconoscope itself. The new tube's formal name is "Orthiconoscope" ("Orthicon" for short) from the Greek root ortho meaning "straight" and iconoscope for "image-viewer." The name derives from the fact that the curve between input light and output current is a straight line, in contrast to the similar curve of the iconoscope which is not linear. In photographic parlance the new tube is a "gamma-unity" device, whereas the gamma of the conventional iconoscope is in the neighborhood of 0.7. The new tube thus provides a more contrasty picture from a given subject than can the conventional pick-up tube.

The linearity of the device is but one of its advantages. By using low velocity electrons for scanning the mosaic image plate, the effects of secondary emission from the surface of the plate are made negligibly small. No spurious "dark-spot" signal is generated, and the uneven shading so troublesome in iconoscope pick-ups is thereby completely eliminated. Finally, and perhaps of greatest significance from the long range point of view, the storage efficiency of the new tube is substantially 100 per cent, compared with 5 to 10 per cent in the iconoscope. Ultimately, therefore, the new tube may be made to have an overall sensitivity 10 to 20 times that of the iconoscope.

The new tube has been under development for several years, and it combines a great many techniques which have appeared in other devices during that time. The radical difference, however, between the orthicon and all preceding forms of the iconoscope is the use of low-velocity electrons for scanning. This use has made necessary the development of a new technique of scanning, which combines the effects of a magnetic field and an electric field. This new deflection technique is a striking example of the practical application of low-velocity electron optics.

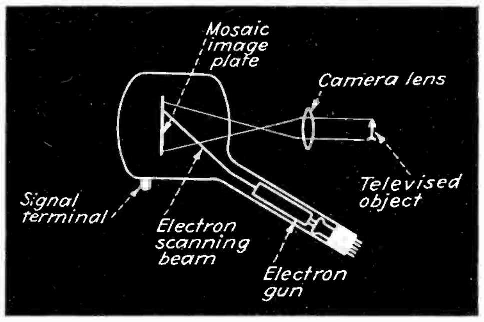


Fig. 1—Arrangement of the conventional iconoscope, now widely used as a pick-up camera tube

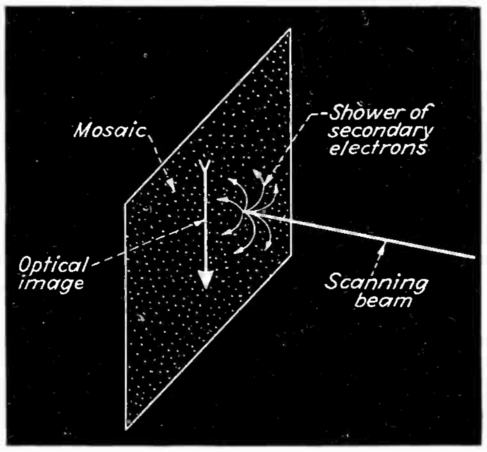


Fig. 2—When the high-velocity scanning beam hits the mosaic it generates a shower of secondary electrons which fall back on the mosaic, producing a spurious signal

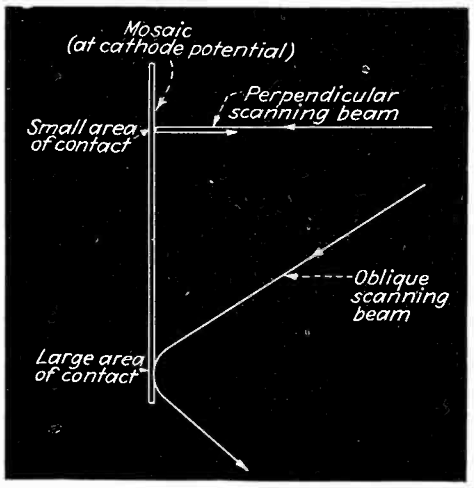


Fig. 3—When low-velocity electrons are used for scanning, defocussing occurs unless the scanning beam hits the mosaic perpendicularly

Before describing the tube in detail, it is worthwhile to list the specifications of the tube in its present experimental form: the tube is a cylindrical structure about 20 inches long and 4 inches in diameter. The image plate on which the optical image is focussed is located at one end of the tube and measures about 2 by 2½ inches. The picture resolution obtainable within this area exceeds 400 lines, and up to 700 lines has been achieved in some cases. These values equal or exceed the capabilities of the present television standards. The relationship between light input and current output is linear from zero light to the value of light which exhausts the beam current (about one microampere). The equivalent noise current due to a typical amplifier is about 2 to 3 thousandths of a microampere, whereas the maximum output signal current of the tube, under the same circumstances, is from 0.5 to 1.0 microampere. The maximum signal-to-noise ratio is accordingly from 300 to 500 times. The sensitivity of the present models is somewhat greater than that of the iconoscope.

To appreciate the advantages of the newly-developed tube, it is necessary to recall the operation of the conventional iconoscope and to show

how the use of a high-velocity scanning beam imposes limitations on the operation of the tube. These limitations were reviewed by Mr. Iams as follows: in the conventional iconoscope (Fig. 1) a mosaic composed of many tiny photosensitive globules is exposed to the optical image. The globules emit electrons under the influence of the light and thereby assume a positive charge in proportion to the amount of light falling on them. Since the globules are insulated from one another, the charge distribution so acquired cannot redistribute itself, but remains stored on the surface of the mosaic until the charge equilibrium is restored by the scanning beam. This beam is formed in an electron gun in a side-arm of the tube, is directed toward the plate and is deflected by electromagnetic deflecting fields to cover the plate in a pattern of interlaced scanning lines. The beam employed in the conventional iconoscope is accelerated to a velocity equivalent to about 1000 volts. The necessity of employing an electron velocity as high as this rests in the need for maintaining a sharply focussed beam which will retain uniform focus over the entire area of the mosaic, and which will excite a high level of signal current.

When the electron beam hits the globules of the mosaic its immediate effect is to liberate secondary electrons from them. The number of secondary electrons liberated depends, among other things, on the positive charge which the mosaic has assumed due to the photoelectric emission. In consequence the secondary electron current from the mosaic varies with the charge distribution induced by the optical image on the mosaic. The variations of this secondary electron current, when collected by the collector electrode of the tube, constitute the signal current from the tube. A common misunderstanding of the operation of the iconoscope is that the signal arises from variations of the beam current itself; that is not true since the impedance of the scanning beam is substantially infinite. Hence the secondary emission effect is of primary importance in the operation of the tube.

But, according to Mr. Iams, the secondary emission has other effects which are not desirable, and which in fact limit the operation of the

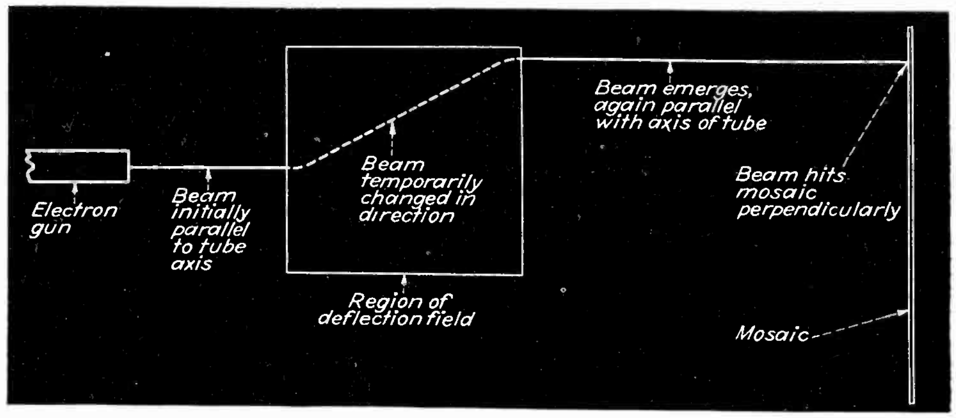


Fig. 4—To preserve the perpendicularity of scanning, the field deflects the beam temporarily. A combination of electric and magnetic forces is employed in the deflection system

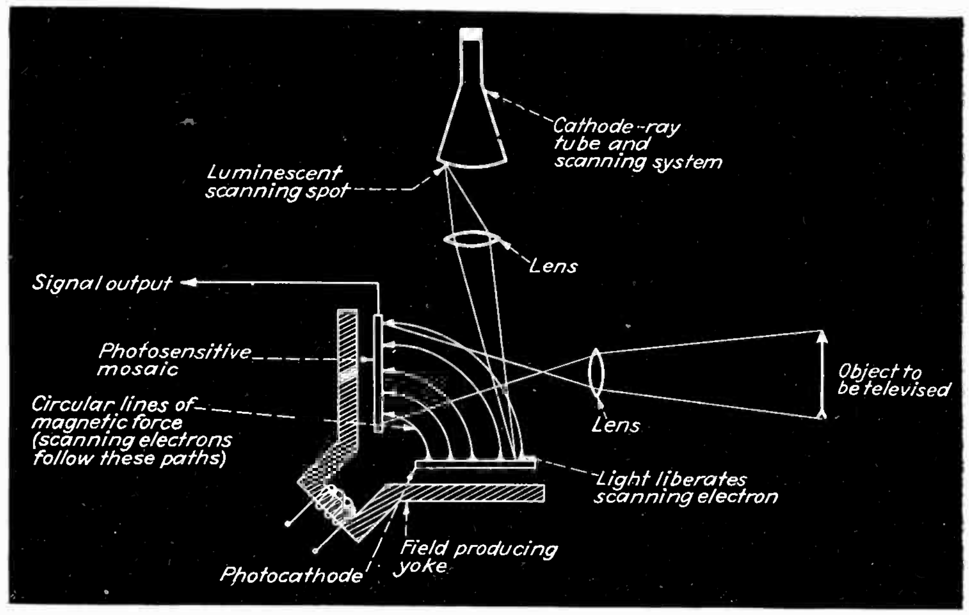


Fig. 5—An early system for obtaining perpendicular scanning employed a flying light spot focussed on a photocathode which liberated the scanning electrons

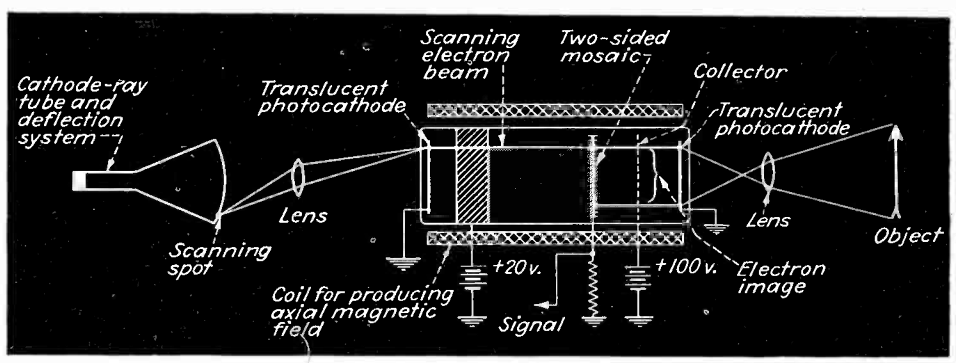


Fig. 6—Another developmental form of the tube used a two-sided mosaic, with image on one side and scanning electrons in the other. The flying spot of light was retained

tube. In the first place, there are more secondary electrons liberated than there are electrons received from the scanning beam, since the secondary emission ratio is greater than unity. But the mosaic plate is insulated, therefore on the average the number of electrons leaving it must equal the number gained. Accordingly only part of the secondary electron current can be collected; the remainder must fall back on the mosaic plate in a shower of electrons (Fig. 2). If the shower were perfectly uniform over the whole plate area, the only effect would be a loss of the distribution of stored charge. But the shower is not uniform, due in part to local irregularities in the secondary emission ratio on the plate, and due also to the effect of differences in the field existing at the plate surface. The shower of secondary electrons thus produces a random charge distribution which is superimposed on the regular charge distribution due to the optical image. The random distribution gives rise to a spurious signal, known as "dark-spot," which has no direct connection with the desired picture, and which has the effect of causing an unevenness in the background shading of the reproduced picture. A special shading-correction generator must be used to compensate for this spurious signal, and this generator must be controlled continually by an operator during each transmission. Even at best the shading-correction is not perfect, hence it is usual to notice a white "flare" at the edges of the picture.

The presence of the high secondary electron emission has still another undesirable effect. It produces a retarding field at the surface of the mosaic which inhibits the emission of the photoelectric electrons under the influence of the optical image. Therefore the photoelectric current is not saturated, but has a value roughly one-third of saturation. This reduces the possible output of the camera tube by the same factor, and accounts, in part, for the low photoelectric efficiency of the tube. The stored charge on the mosaic is, in addition, partially neutralized by the shower of returning secondary electrons, and this effect reduces the net photoelectric effect by another factor of three. The total output current is thus reduced by two factors of roughly three, and the output signal current is accordingly one-ninth what it would be if the photoelectric emission were saturated and there were no loss of stored charge. Accordingly, the overall efficiency of the conventional iconoscope is, on the basis of one-ninth the possible output, only 11 per cent. Actual measured values of efficiency range from 5 to 10 per cent.

It follows that the advantage of

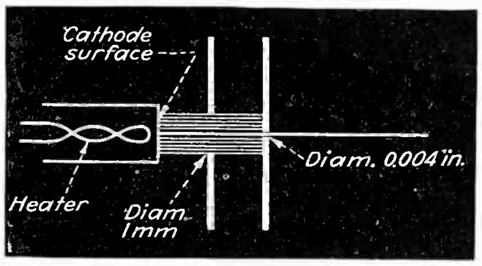


Fig. 7—In the present form of the Orthicon, this very simple electron gun is used

the iconoscope principle is severely reduced by the presence of the secondary electrons, although part of the secondary electron emission serves a useful purpose in developing the output signal current. In theory the iconoscope sensitivity, due to the principle of storing light in the form of a charge image, is multiplied by the number of picture elements in the image, or by from 100,000 to 200,000 times. In practice, only from 5 to 10 per cent of this increased sensitivity is realized. The new tube, on the other hand, permits an eventual realization of the full advantage of 100,000 to 200,000 times.

Getting Rid of Secondary Emission in the Orthicon

To improve on the conventional iconoscope, as shown by the authors, the indicated course of action is to get rid of the secondary emission (and thus obtain saturated photoelectric emission, no loss of stored charge and no spurious signal) and at the same time to substitute another agency for the secondary electrons in forming the picture signal. In the new tube, Messrs. Rose and Iams accomplish this result by using a scanning beam composed of low-velocity electrons. The mosaic target is maintained at the potential of the cathode of the electron gun. Consequently, the electron beam travels between two electrodes (the cathode and the mosaic) which have no difference of potential between them. Since the electrons start off at a very small velocity at the cathode, they must meet the mosaic with an equally small velocity. The low-velocity beam electrons, when they impinge on the mosaic, are in no position to excite secondary emission, and in fact no secondary emission effects have been observed. Furthermore the low-velocity beam electrons act as the agency for withdrawing the picture signal from the mosaic and conducting it to the collector electrode, whence it travels to the external circuit. The maximum value of the signal current is accordingly equal to the maximum value of beam current, which in the present experimental tubes is about one microampere. Passed through a 100,000-ohm load resistor, this output current is equivalent to a 0.1 volt output signal.

But the use of a low-velocity scanning beam is not without its difficulties. In the first place such low-velocity beams are very subject to deflection by stray magnetic or electric fields. In the second place, low-velocity beams are in general subject to severe defocussing if the beam does not hit the scanned surface directly at right angles. Thus, if the scanned beam hits the surface perpendicularly (see Fig. 3) and if the mosaic potential is the same as the cathode potential, the electron comes to rest at the surface, turns around and travels back toward the cathode directly away from the surface. The defocussing which occurs is due only to the emission velocity of electrons from the cathode. On the other hand, if the beam hits the surface at an angle as shown at the

Fig. 8—Method of obtaining "temporary" deflection (horizontal direction). The cycloidal motion (A) is obtained with electric and magnetic fields. The smoother motion (B) is obtained by employing a "fringing field" in the electric component

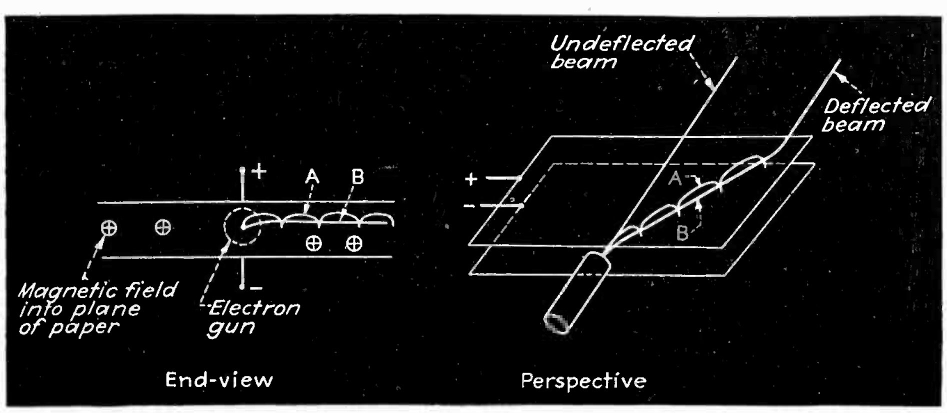
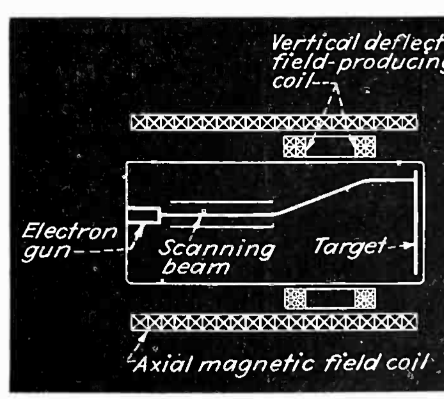


Fig. 9—Vertical deflection is obtained with a transverse magnetic field supplied by coils at right angles to tube axis



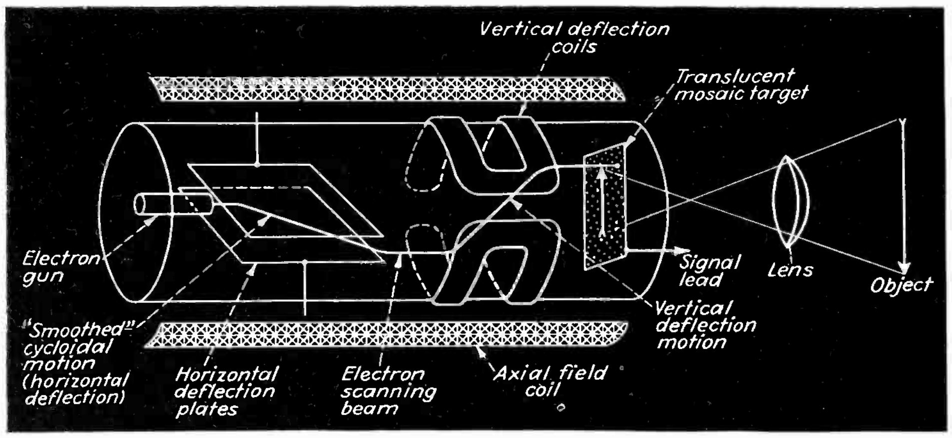


Fig. 10—The Orthicon in complete form. The deflection systems are shown in detail in Figs. 8 and 9. Note that the scanning beam hits the translucent mosaic at right angles

bottom of Fig. 2, the electrons "skid" along the surface tangentially and are reflected back toward the cathode at an angle equal to their angle of arrival. The point of contact of the electron with the surface is correspondingly ill-defined, that is, defocussing occurs.

To avoid this effect, it is preferable that the scanning beam impinge on the mosaic perpendicularly, no matter at what point in the scanning pattern. This precludes the use of conventional deflecting technique, in which the scanning beam is caused to scan the surface by the application of deflection forces which change the direction of the beam. In this latter case, the electron beam hits the outer edges of the mosaic at an angle.

To produce a method of scanning in which the beam maintains a perpendicular relation to the mosaic at all points, it is possible to employ a deflecting system which changes the angle of the beam temporarily. Thus, consider the scanning arrangement shown in Fig. 4. The beam enters the deflecting system as a stream of electrons from the gun. The deflecting system imposes a change in direction which persists only so long as the beam is within the deflecting field. Immediately after the beam emerges from the plates, it resumes its forward course and travels from the deflecting plates to the mosaic in a line parallel to the axis of the tube, and finally hits the mosaic perpendicularly.

To produce a deflecting system of this type in practice is not a simple job. Before it was successfully accomplished several preliminary attempts were made, using rather cumbersome apparatus. One of the early forms of the tube is shown in Fig. 5. The image to be televised is focussed optically on a mosaic plate as shown. At right angles to this plate is a photocathode which acts as the source of the scanning electrons. Focussed on this photocathode is an unmodulated spot of light derived from a conventional cathode-ray picture tube. This spot of light is deflected in the standard interlaced scanning pattern by a deflection system associated with the cathode-ray tube. Consequently the photocathode is scanned by the light beam and liberates electrons which arise from the photocathode in scanning formation. The electrons leaving the photocathode are guided to the mosaic by circular lines of magnetic force, which are produced by the iron yoke shown, energized with direct current. It is a principle of electron optics that electrons of low velocity, once started along a line of magnetic force will follow this line of magnetic force unless otherwise constrained. There being no other fields of force present, the low-velocity photoelectrons from the photocathode travel around the quarter circle until they reach the mosaic target. There they discharge the mosaic elements in accordance with the field distribution set up by the optical image focussed on the mosaic. The picture signal thereby produced is then taken from a signal coating on the reverse side of the mosaic. It will be noted that the scanning electrons are themselves produced indirectly by photoelectric action, that they impinge on the mosaic perpendicularly, and that they are of low velocity (their velocity when they hit the mosaic is substantially the same with which they were emitted from the photocathode).

Another evolutionary form of the tube, described by the authors, is shown in Fig. 6. Here a two-ended tube is used. At the right end a translucent photocathode has focussed on it the optical image to be reproduced. An image in electrons is thus formed and this image is focussed on a two-sided mosaic, where electron multiplication increases the effective charge and stores it. From the left-hand end of the tube another translucent photocathode is used to develop the scanning electrons. On this photocathode the image of the fluorescent scanning spot is focussed, from a cathode-ray tube which is deflected in the customary manner. The electrons leaving the left-hand photocathode travel toward the two-sided mosaic at low velocity and are guided thereto by the action of axial lines of magnetic force set up by the coil of wire external to the tube. These electrons scan the mosaic, hitting it perpendicularly at all points, and the video signal thereby generated is derived from the two-sided mosaic.

Both of the above described forms of tube operate satisfactorily but they require a great deal of auxiliary apparatus, which would be difficult to include in a camera housing of practical size. In addition, the detail of the picture depends on the size of the scanning spot developed by the auxiliary cathode-ray tube, and the size of this spot may suffer from the effects of halation, etc. when sufficient light is obtained from it to excite the desirable number of scanning electrons. Consequently, research was undertaken to devise a tube using a thermionic cathode (rather than a photoelectric one) for the scanning electrons.

The Present Developmental Form of the Orthicon

In developing a thermionic cathode type of tube, described by Dr. Rose, the first question was that of the electron gun. A very simple form was used, illustrated in Fig. 7. The cathode is a flat surface, directly in front of which is an aperature approximately one mm in diameter. This aperture defines a bundle of electrons, which is further reduced in cross-section by a pin-hole aperture (4/1000ths inch diameter). The positive potentials applied to the apertures are of low magnitude, so the beam is composed of low-velocity electrons, and the cross-section of the beam is narrow and well defined.

(Continued on page 58)

Applications of Copper Oxide Rectifiers

By LEO L. BERANEK
Cruft Laboratory, Harvard University

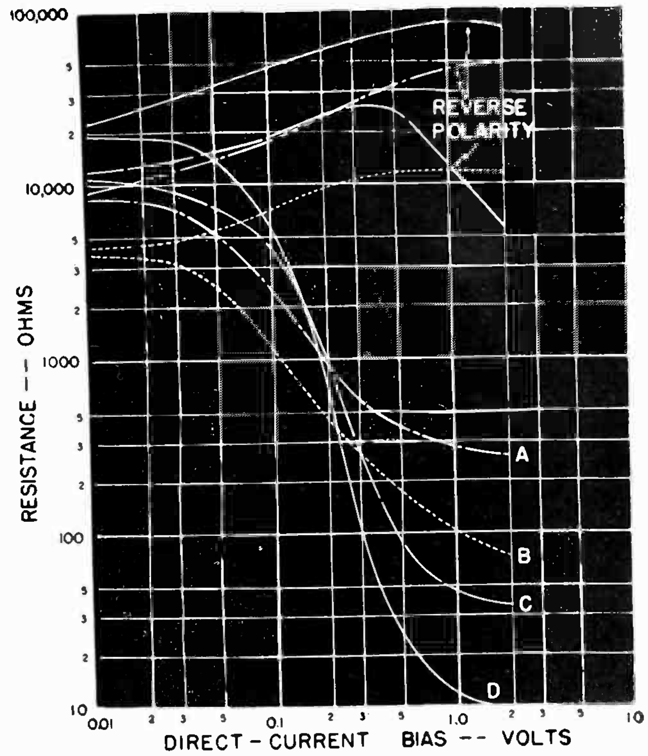


Fig. 1—Static characteristics of CuO rectifiers of four manufacturers

IN recent years improvements in manufacturing technique have made copper oxide rectifiers suitable for use at high frequencies, such as encountered in radio circuits[2] and carrier telephone systems[3, 4]. Although the voltage vs current characteristic of the copper oxide disc can be duplicated to a certain extent by vacuum tubes, certain definite advantages exist in favor of the former. For example, the discs are much smaller than an ordinary vacuum tube. Their electrical characteristics are permanent throughout their life and are free from variations which would occur due to change in supply voltages. Also, their life is long.

The copper oxide rectifying element proper consists of a copper plate or disc, one side of which is covered with a layer of cuprous oxide. On top of this is placed a thin layer of graphite which serves to prevent any counter-rectification at the interface between the cuprous oxide and the connecting electrodes. Over this layer a thin lead sheet is pressed, making contact with the uneven surface of the graphite. In practice these disc assemblies are usually mounted in stacks of two or more clamped tightly together to insure complete and permanent contact.

The current-voltage characteristic is determined by three factors: The purity of the mother copper, the oxygen content of the atmosphere in the oven during oxidation and, most important of all, the cooling technique employed. Thus it might be expected that units made by different manufacturers would have considerably different characteristics. This is clearly shown in Fig. 1, in which the static characteristics of four units of different manufacture[3] are shown. The resistance plotted is taken as the ratio of the bias voltage to the total resulting current. The resistance of a copper oxide disc varies inversely as the temperature. These variations are of the order of 4 to 8 per cent in the temperature range of 32° to 100° F. Humidity has also been shown[5] to be an important cause of long time variations in the characteristics. Circuits employing 3/16 inch diameter discs, commonly used as meter rectifiers and as elements in modulating circuits, should be operated so that not over three volts (peak) is placed across any one disc in the non-conducting direction and so that no current larger than 20 milliamperes flows in the conducting direction. These values can be exceeded somewhat for short periods of operation, but this may lead to accelerated aging.

Equivalent Circuit for A-C Response

The variational behavior (equivalent circuit for a-c response) of the copper oxide discs can be represented by a resistance in parallel with a capacitance. These are by no means constant, however, both being functions of frequency, bias voltage, and magnitude of the applied signal. Bridge measurements of the small-signal impedance were made on discs taken from "Varistor" units. Figure 2 shows the resistance and capacitance of a single disc plotted as a function of bias voltage. Consideration of the static characteristic curve for this disc shows that for values of E between 0 and 0.02 volts

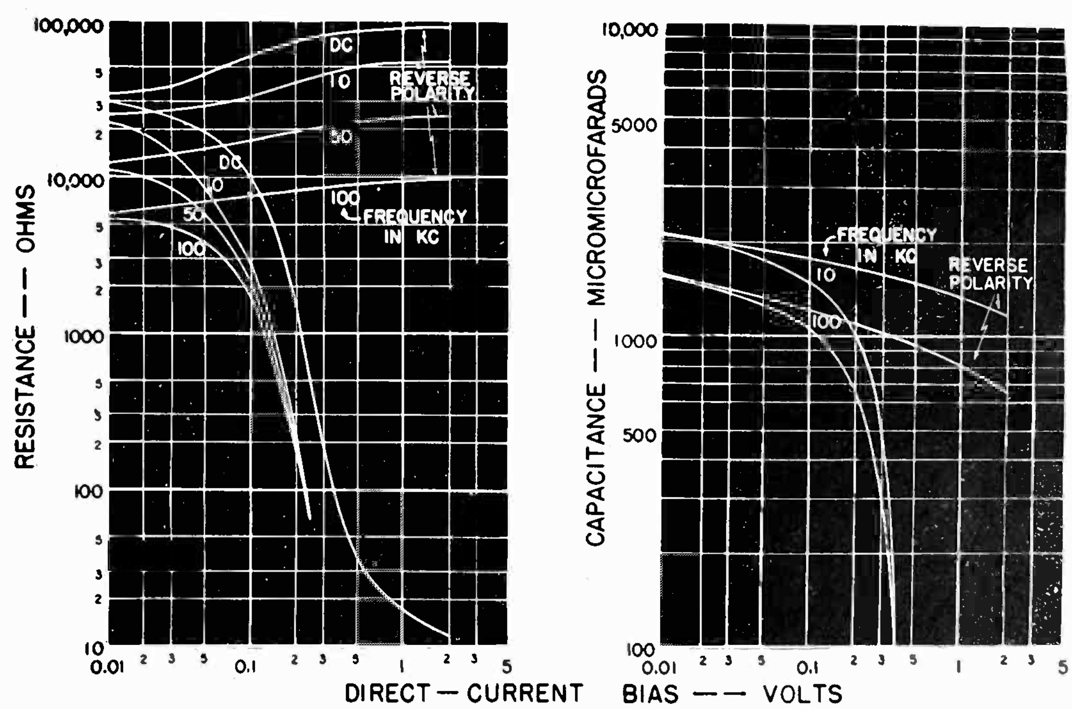


Fig. 2—Small-signal resistance and capacitance vs bias voltage of "Varistor" unit

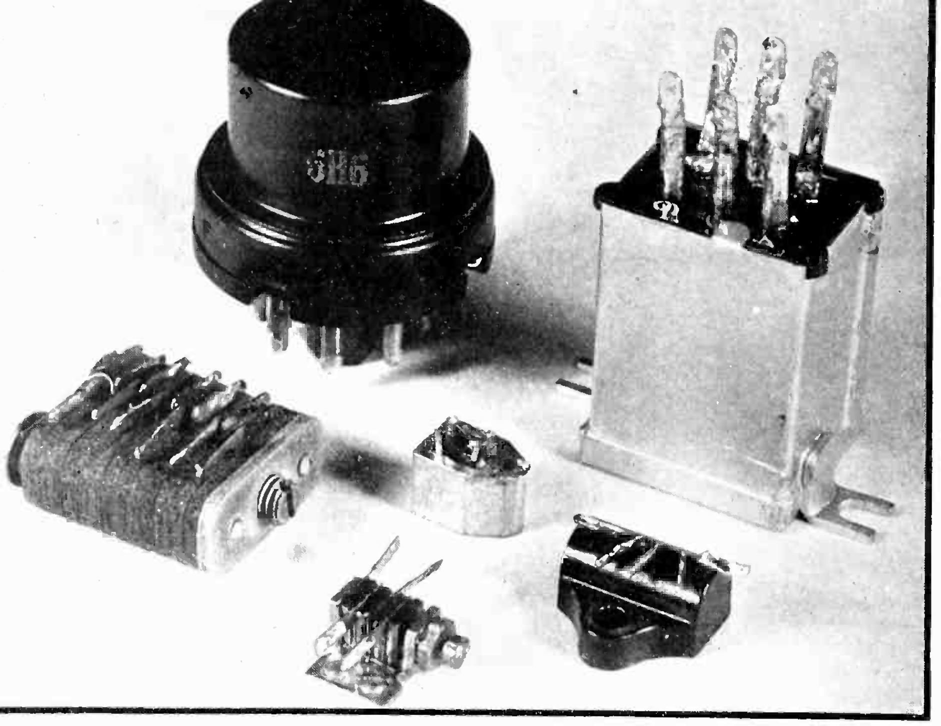
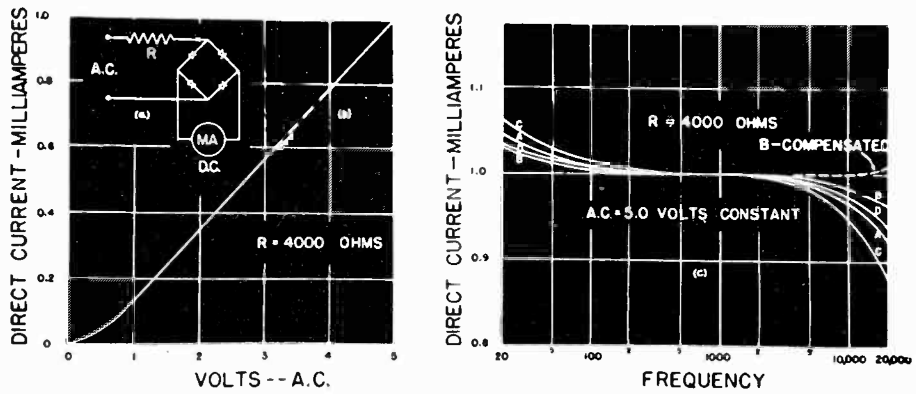


Fig. 3 — Typical CuO rectifier structures, sizes shown relative to 6H6 double diode

Fig. 4—Use of CuO discs in meter rectifier circuit



the current can be expressed by $I = aE + bE^2$; for $0.06 < E < 0.25$, $I = c(e^{kE} - 1)$; and for larger voltages I again becomes a linear function of E. This sort of characteristic is difficult to express mathematically, even when the shunt capacitances are neglected. It has been experienced that simple circuits using only one varistor can be most accurately treated for frequencies below 10,000 cycles by graphical analysis[6] of the static characteristic curves. Even this becomes unwieldy when several elements are used and more complex circuits can only be handled by mathematical approximations.

Application as Rectifier vs. Modulators

The applications of copper oxide rectifiers can be classified in two broad groups: First, as rectifiers to obtain a direct current bearing some relation to the applied alternating voltages and, second, as modulators or demodulators for frequency conversion. This paper will be concerned only with applications of the small 3/16-inch discs.

A familiar example is the a-c meter which uses a copper oxide disc as a rectifying element and a direct current milliameter as an indicator. Most common of all meter rectifier circuits is the simple bridge circuit shown in Fig. 4a. Its d-c vs. a-c applied voltage characteristic, as shown in Fig. 4b, is linear over the major portion of the scale except when the multiplier resistance is less than several thousand ohms. Figure 4c shows the direct current for a constant applied a-c voltage as a function of frequency for units supplied by four different manufacturers[5]. The falling characteristic on the high frequency end, commonly found in a-c meters, is due to the shunt capacitance mentioned before. This can be compensated by shunting the resistance R with a small capacitance. The best of the curves in Fig. 4c is shown in Fig. 5 as compensated by the addition of such a shunt condenser. The chief disadvantage of this circuit is that temperature changes directly affect its calibration. A circuit designed to eliminate this difficulty is shown in Fig. 6a. In this case the meter reads essentially peak voltage and hence is independent of moderate changes in the resistance of the oxide disc. The frequency characteristic, Fig. 6b, is largely dependent on the constants of the transformer and on the time constant of the parallel resistor and condenser. The low frequency droop can be raised by increasing the RC product, while the high frequency droop can be compensated as before by inserting a parallel resistor and condenser between the points 1 and 2. It is essential that rectifier units having high resistance in the non-conducting direction be chosen in order to keep the RC constant high.

A slightly modified form of the preceeding circuit is shown in Fig. 7a. It has been described by Tamm

Fig. 5—[illegible] rectifier output vs frequency, compensated by a shunt condenser. Subject to variation with temperature

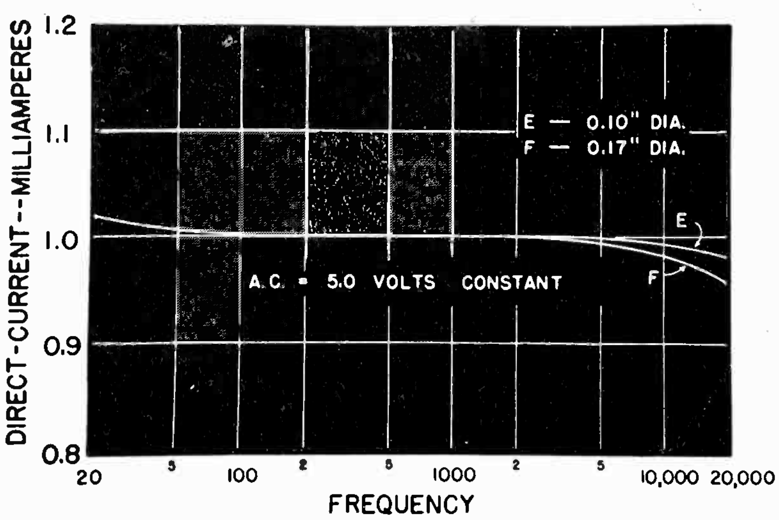
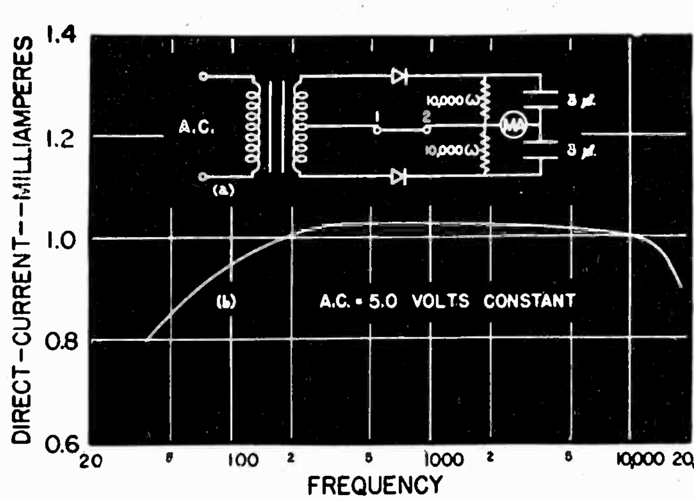


Fig. 6—Circuit devised to overcome variations with temperature. Peak values are indicated by the milliammeter



and Bath[3] and its properties have been further investigated in the Cruft Laboratory. In this circuit, if E_1 and E_2 are of the same frequency and if E_1 is at least three times as large as E_2, then the direct voltage measured across points 5 and 6 will be found to be directly proportional to E_1 and to the cosine of the phase angle θ between E_1 and E_2. The plot in Fig. 7b shows the direct voltage across terminals 5 and 6 vs θ with E_2 as a parameter, for the particular circuit constants of Fig. 7a. One application of this circuit which has been developed is its use as a power meter to measure the energy supplied by a single signal generator to a linear load. It can be used over the frequency range of sixty to five or six thousand cycles without the necessity for using vacuum tubes, thermocouples or any external supply voltage. In this case the voltage across the load is applied at terminals 1 and 2 (E_1) and a voltage proportional to the load current is connected to 3 and 4 (E_2). Since the direct potential across terminals 5 and 6 is not a linear function of E_1, it is necessary to insert an attenuator between the supply voltage and the terminals 1 and 2 and to reduce E_1 in all cases to one value, say 2.0 volts. Then if the scale of the direct current indicating instrument has been calibrated to read power directly for $E_1 = 2.0$ volts, it is only necessary to multiply the scale reading by the factor by which E_1 has been reduced.

Another feature of this circuit is that if the generator E_2 is replaced by a resistance and if a direct potential is applied at the terminals 5 and 6, then a voltage of the frequency of E_1 and having a magnitude directly proportional to the d-c bias will appear across this resistance. Two applications have been published[3] and are shown in Fig. 8. In (a) a direct current amplifier is shown whose stability is essentially that of the a-c amplifier. Variations of E_1 less than 10 per cent in magnitude will not effect the operation as long as the restriction that E_1 be greater than E'_2 by at least a factor of three is satisfied. In (b) a circuit is shown for measuring variations in the capacitance of a condenser. The magnitude of E_2 depends on the degree of unbalance of the bridge. In one application, C_1 is a pair of rollers placed on either side of a sheet of moving paper in a paper mill and since a d-c recording galvonometer is connected across the terminals 1-2, variations in paper thickness are recorded continuously as a function of time.

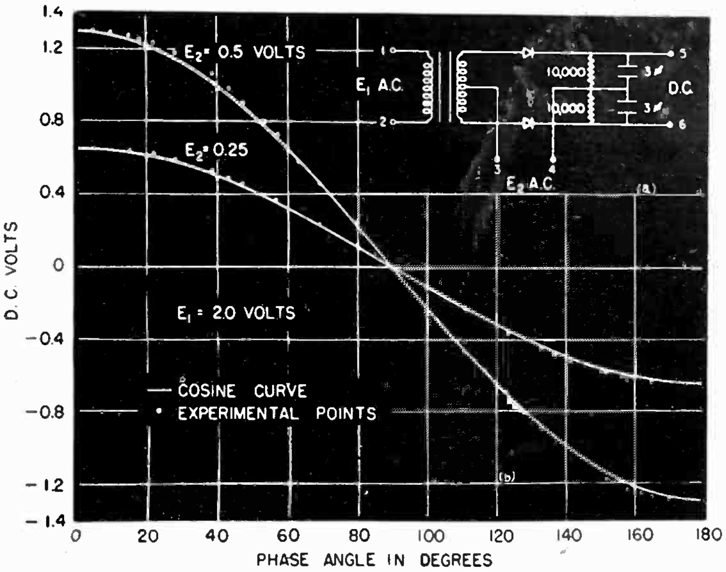


Fig. 7 — Modified form of circuit shown in Fig. 6, which has been used as a power meter in conjunction with a signal generator

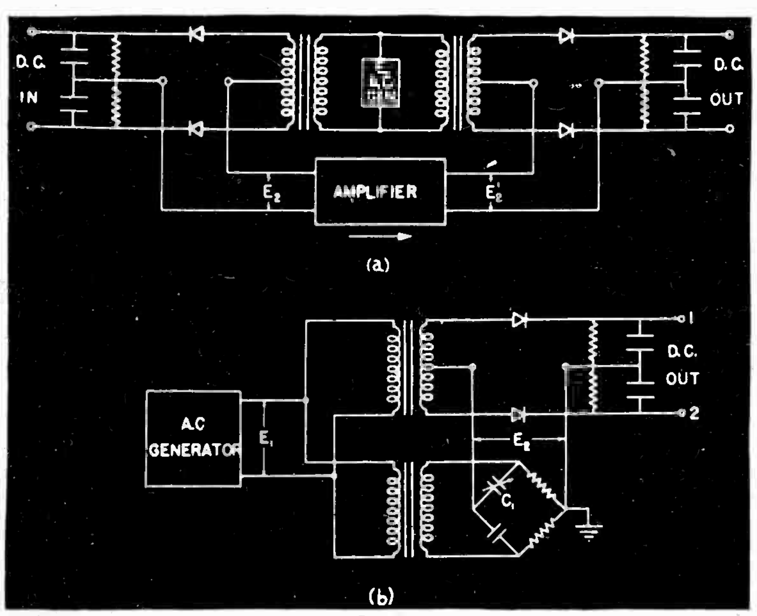


Fig. 8—Two applications of the compensated rectifiers: (a) a d-c amplifier and (b) circuit for measuring variations in capacitance

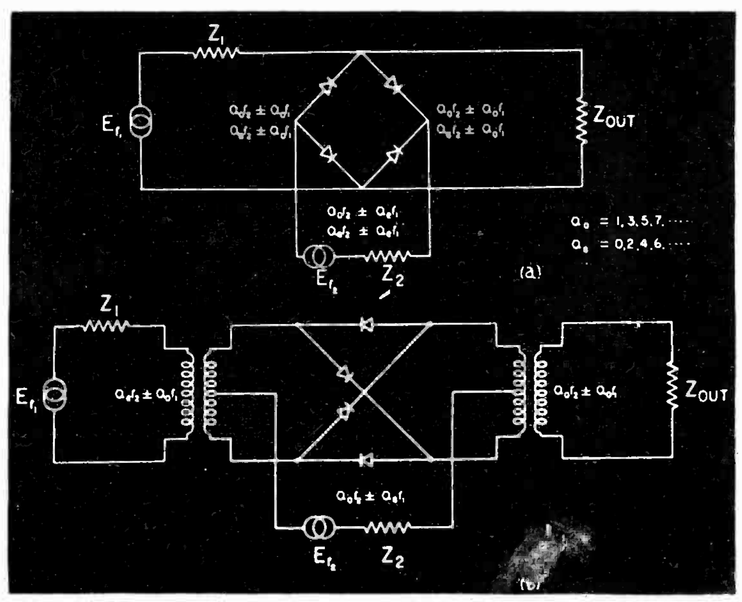


Fig. 9—Typical applications of CuO rectifiers to modulation in telephone service: (a) bridge circuit and (b) ring modulator

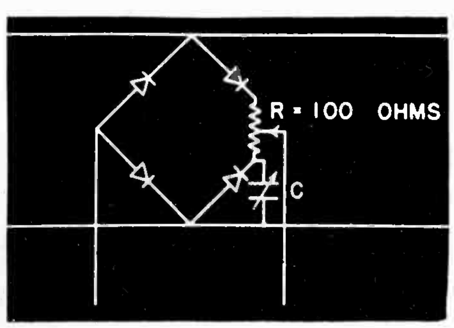


Fig. 10—Balancing circuit employed for attenuation of the carrier

Use as Modulators

Under the second class of applications, copper oxide rectifiers have

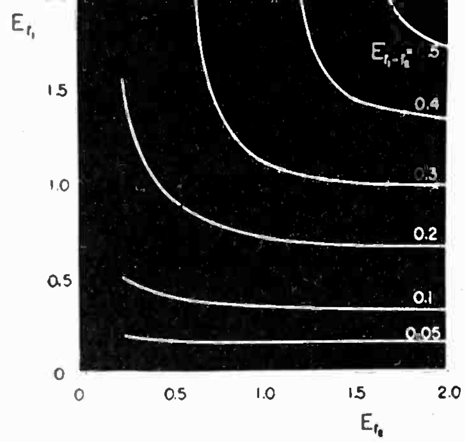


Fig. 11—Voltage levels for two carriers and difference frequency

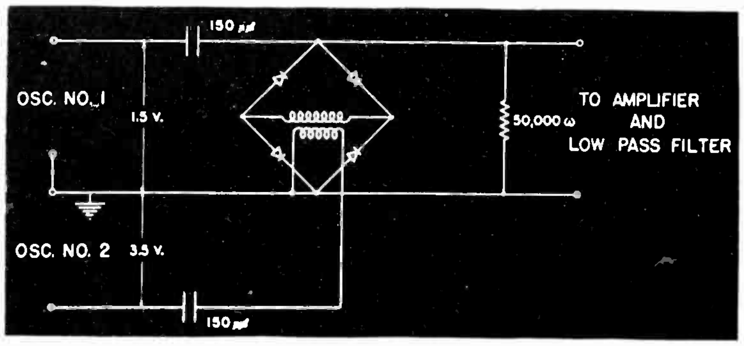


Fig. 13—Circuit for high difference-tone output

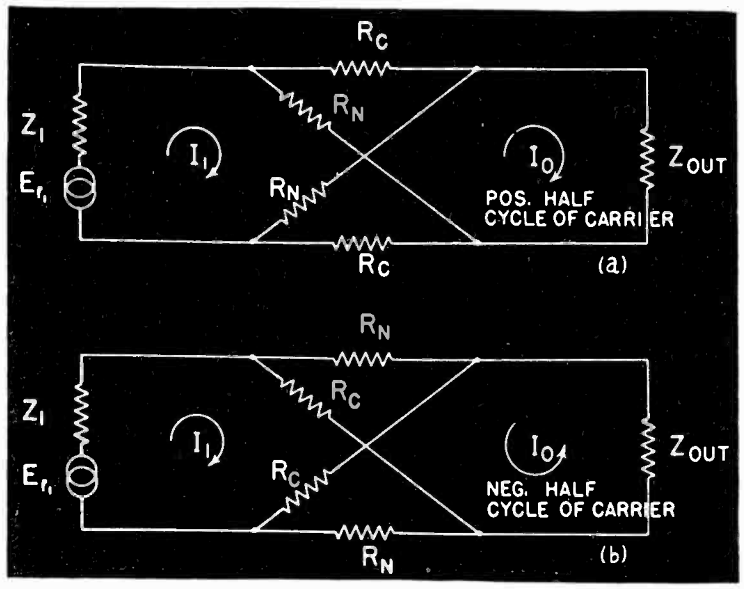


Fig. 12—Equivalent circuits for the ring modulator

found their widest use in carrier telephone systems as modulators and demodulators[8,9]. For this purpose, four rectifier discs are combined into either a bridge circuit, as shown in Fig. 9a, or into "ring modulators", as shown in Fig. 9b. The operation of the two is essentially the same, the difference lying in the number of frequency components that are desired or can be tolerated in the output circuit. It will be noticed that while a current component of frequency f_1 appears in the output of the bridge circuit, no current component of this frequency appears in the output of the ring modulator. Both circuits are similar to the van der Bijl type of vacuum tube balanced modulator in that the carrier is suppressed from the output circuit to a large degree. However, the copper oxide circuits excel because, due to the stability of their characteristics, a much higher degree of carrier suppression can be maintained. Even without special selection of the discs, the carrier amplitude will be reduced by thirty db in the output and with the balancing method shown in Fig. 10 carrier reductions of one hundred db can readily be obtained and reductions of sixty db can be maintained over long periods of time.

Mathematically, an exact analysis of the operation of the modulator is exceedingly complicated. As is usually found in non-linear circuits, it is simpler to determine first the characteristics of the circuit experimentally and using that information as a guide, make simplifying assumptions in the mathematics which may lead to useful answers. In carrier telephone systems and in many other applications, a single side band is desired, that is, a component whose frequency is equal to either the sum or the difference of the signal and carrier frequencies. Furthermore, it is usually desired that the amplitude of this sum or difference frequency bear a linear relation to the amplitude of the impressed signal and that a minimum of distortion products be generated in the modulating process. Therefore, if, for the circuits of Fig. 9, certain reasonable generator and terminal impedances are selected, valuable information should be obtained from a contour diagram of constant $E_{f1 \pm f2}$ on the E_{f1} vs E_{f2} plane. Such a plot is shown in Fig. 11. From these contours it may be deduced that if E_{f2} is large in comparison to E_{f1}, then the sum and difference terms vary linearly with E_{f1} and are independent of E_{f2}. This is just the performance that is desired. Also measurements show that lowest harmonic distortion occurs under this condition. A similar result is obtained for the ring modulator.

When the carrier voltage is large in comparison to the signal voltage, then the resistance of the copper oxide discs will be controlled almost entirely by the carrier except during the very short time that it is passing through zero. As the carrier voltage passes through a cycle, pairs of the oxide discs become alternately conducting or non-conducting. This occurs in both types of circuits, but for purposes of analysis the ring modulator is more convenient. In this type, the equivalent circuits of Fig. 12 can be drawn for the two

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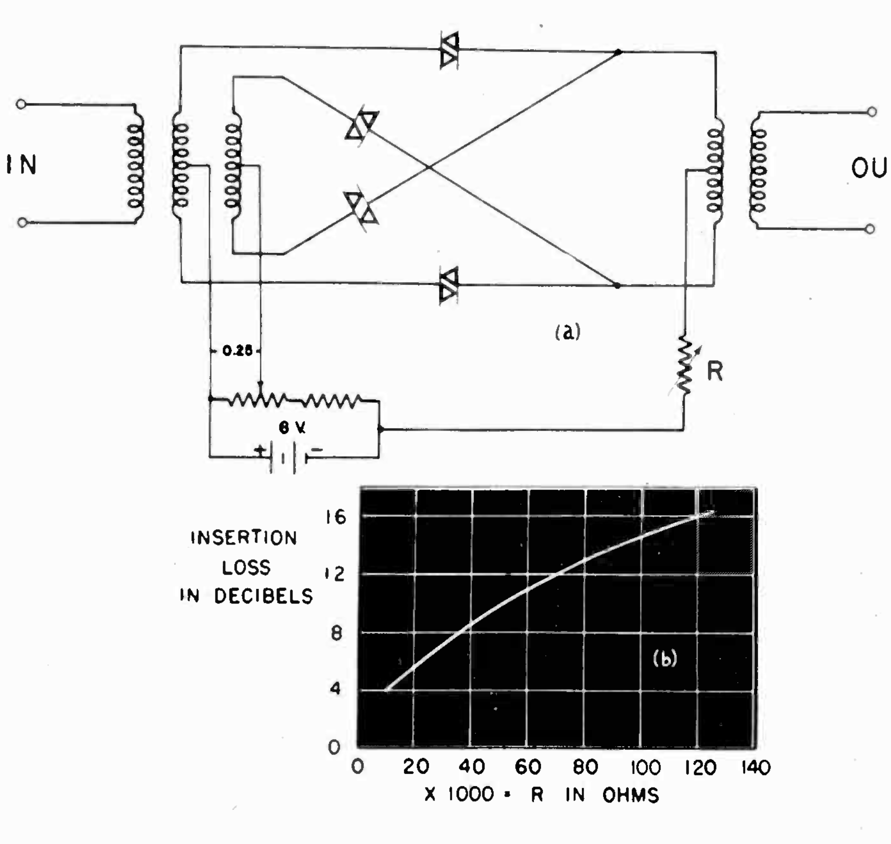
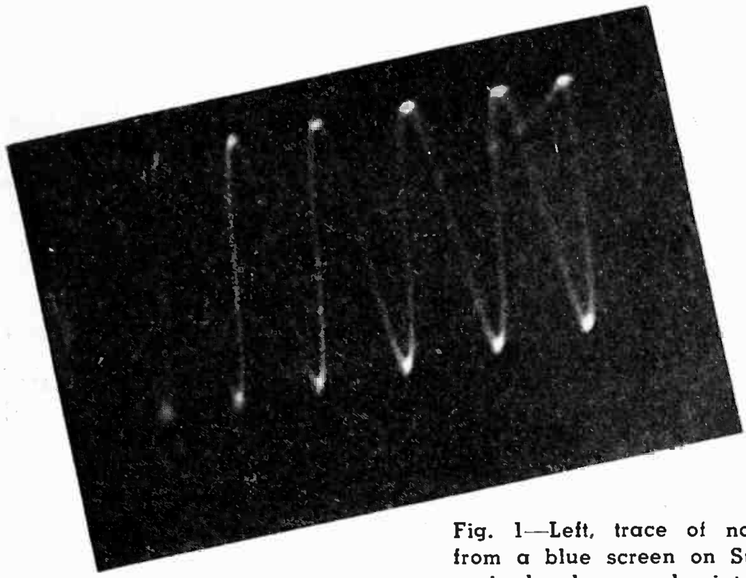


Fig. 14 — A variable-loss network using double rectifiers (See reference 10)



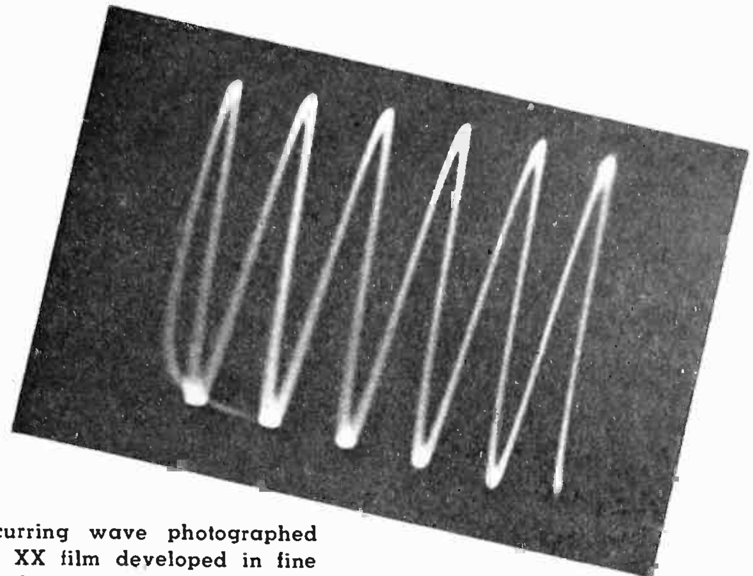


Fig. 1—Left, trace of nonrecurring wave photographed from a blue screen on Super XX film developed in fine grain developer and printed on high contrast paper. Used as basis for Table I. Fig. 2—Right, same except writing speed is one-half that of Fig. 1

C-R TUBE PHOTOGRAPHY

By T. A. ROGERS and B. L. ROBERTSON
University of Calif. *Shell Oil Co.*

THE increased use of the cathode ray oscilloscope in the study of transient or recurring phenomena has necessitated the application of photography in order to obtain a permanent record of the trace on the screen. The photography of cathode ray tube screen traces involves a number of problems, and attention should be given to: (1) the speed at which the electron beam travels across the fluorescent screen, (2) the spectral radiation characteristics of the cathode ray tube screen, (3) the aperture of the taking lens, (4) the spectral sensitivity of the photographic material, (5) the magnification at which the photograph is made, (6) the voltages applied to the electrodes of the cathode ray tube (and especially the second anode voltage), and (7) the developing conditions.

The writing speed, or the velocity with which the electron beam traces over the screen of the cathode ray tube, is of greater fundamental significance in discussing exposures than tables covering the general case of recurring phenomena because such tables are not applicable to the recording of single sweeps of nonrecurrent waves. The writing speed, on the other hand, is applicable both to recurring and non-recurring phenomena.

From the geometrical optics of a simple lens, it may be shown that the amount of light reaching the film for a given light source varies as $(1 + M)^2$ where M is the magnification. For full size photographs, $M = 1$, but more often the photographic image is smaller than the original so that $M < 1$.

The intensity of the trace on the cathode ray tube screen is roughly proportional to the second anode voltage, if all other electrode voltages are maintained constant, or is roughly proportional to the square of the control grid voltage if other electrode voltages are held constant. Thus, if proper exposure data is available for one set of known voltages, the exposure for other electrode voltage can be estimated.

Most developers are satisfactory for oscillographic photography. For films of normal size a high energy developer should be used and the film developed to maximum contrast in order to record maximum writing speed. On the other hand, if miniature negatives are used, in which the image must be considerably enlarged, a fine grain (low energy) developer may be required, although this will reduce the writing speed which can be recorded satisfactorily.

It now remains to determine the maximum writing speed for which satisfactory traces are obtained. In some experimental work to determine this speed, a three inch cathode ray tube was operated at normal conditions, and a 5000 cycle sine wave from a beat frequency oscillator was impressed on one set of plates and a sweep voltage on the other set of plates. For such sinusoidal traces, the displacement from the reference axis is given by

$$s = 0.5\ A \sin\ (2\ \pi\ ft)$$

where A is the peak-to-peak amplitude and f is the frequency of the voltage. The writing velocity of the electron beam is the time rate of change of the displacement, or

$$V_w = ds/dt = A\ \pi\ f \cos\ (2\ \pi\ ft)$$

which is a maximum for $\cos\ (2\ \pi\ ft) = 1$.

Using these relationships, a series of exposures were made. The image on the film was that which satisfied the minimum requirements for projection printing on a contrast paper. The writing speed was then determined from the size of the image, the frequency of the wave and the aperture of the lens system. The results of this experimental work are shown in Table I which gives the writing speeds for several films for two different kinds of screens, with normal operation of the three-inch oscilloscope and a lens aperture of $f/3.5$. The writing speeds should not be regarded as being absolute. They are given as representative, approximate values determined from many photographs and serve to show results which may be normally expected.

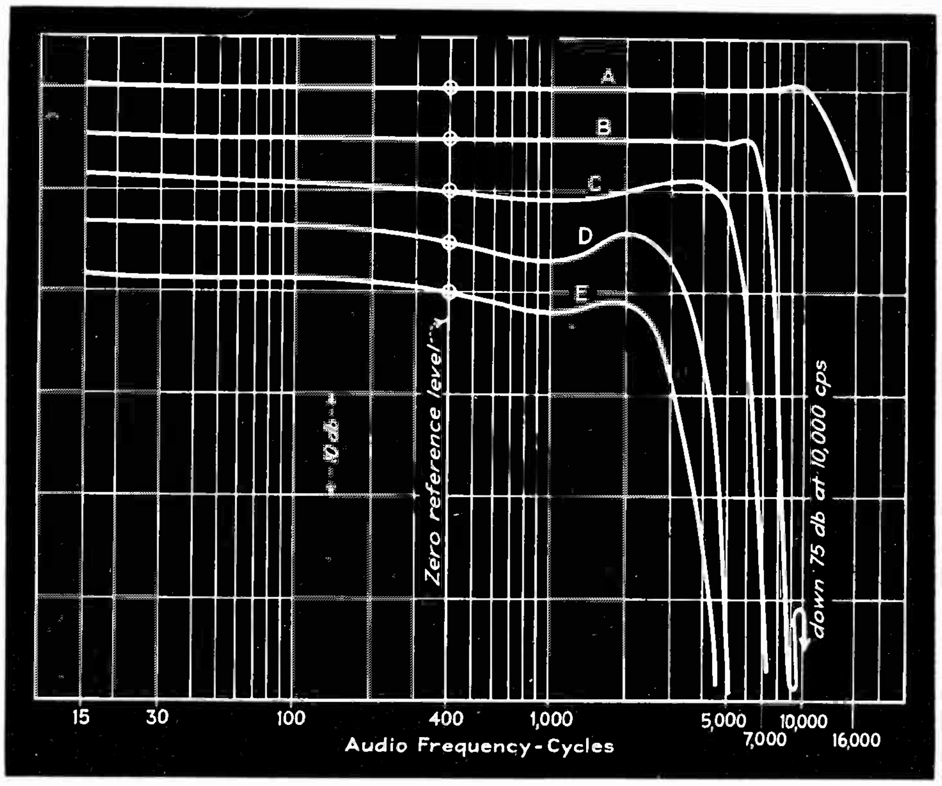
Table I—Writing Speeds for Oscilloscope Traces*

Film	Writing Speed in mm/sec. Green screen	Blue screen
Eastman Super XX	47,000	125,000
Agfa Ultraspeed	22,000	60,000
DuPont Superior	14,000	37,000

*This table is prepared for normal operation of three inch oscilloscope, a lens aperture of f/3.5, with films processed in fine grain developer.

HIGH QUALITY

In an effort to enable the radio listener to interpret music and other sounds normally, as if he were in the studio or concert hall, Lincoln Walsh has designed and constructed the high quality radio receiver described in this article



Audio response curves measured from antenna input to voice coil. Curve A is the wide-band response, curve B is the response with the variable i-f transformers and low-pass audio filter adjusted to eliminate a moderate amount of interference. Curves C, D and E are the curves for increasing amounts of interference

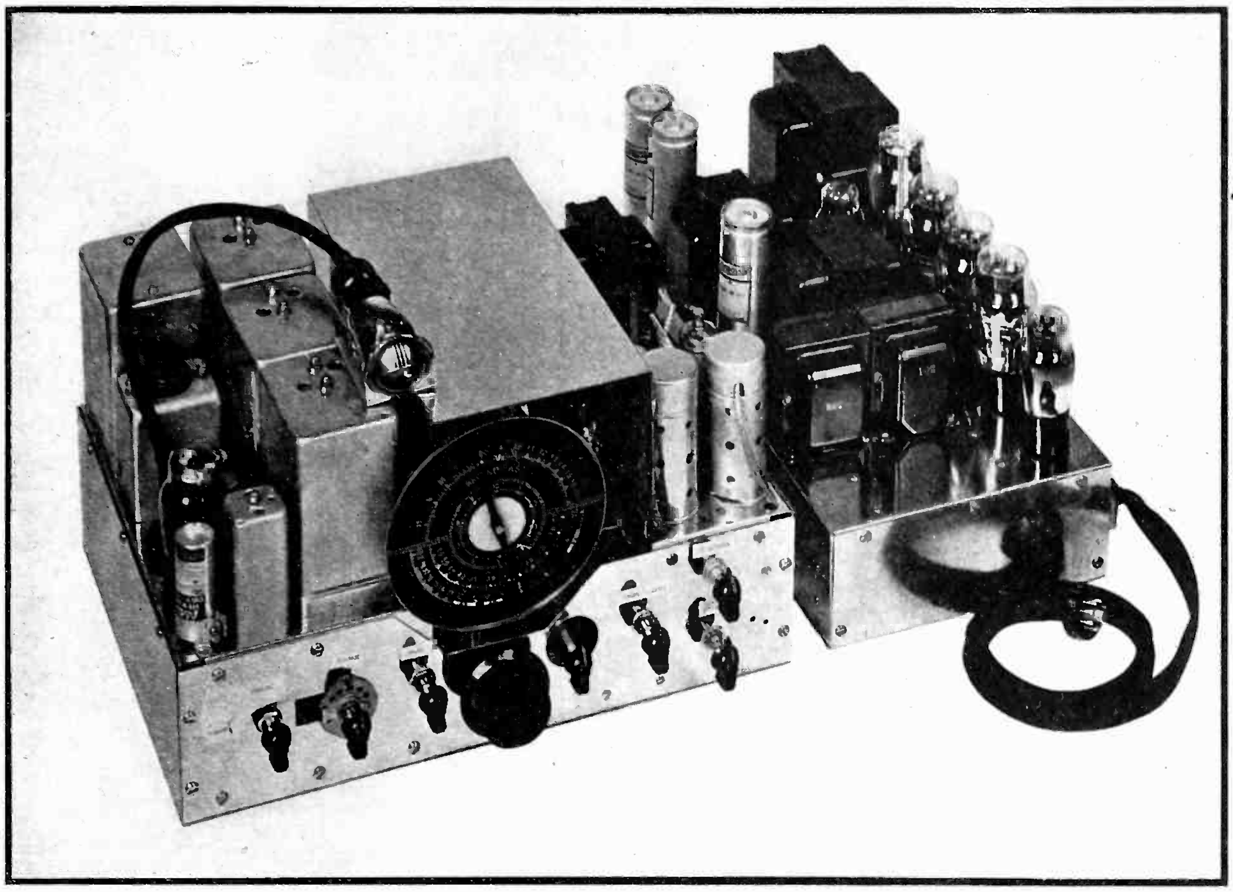
ONCE upon a time a radio engineer, who attended a symphony concert, said, "I didn't like it because the music was too high pitched. The violins were too tinny and the horns too brassy. On the low end of the scale," he continued, "there were some very low notes which didn't belong there." This tale is not as fantastic as it sounds (actually, it is true) because most of the radio receivers available today reproduce music in such a manner as to give a new and poorer interpretation to music.

Wide band distortionless receivers will reproduce faithfully all sounds from the transmitter. However, with broadcast stations spaced 10 kc apart in the frequency spectrum, there are times when one station will interfere with the station on the adjacent channel. In metropolitan areas the signals from the strong local stations are free from interference a large part of the time and full advantage may be taken of the wide band receiver. But interference is often present, especially on winter evenings when transmission conditions are very good and the signals from distant stations are relatively strong and some means must be used to eliminate it as much as possible. The interference is of three separate and distinct types as follows:—1. 10 kc heterodyne whistle caused by the two carriers beating with each other. 2. Chatter, a high pitched, unintelligible sound caused by the desired carrier beating with the nearer side band of the adjacent channel carrier. 3. Crosstalk which is caused by the adjacent channel signal carrier beating with its own sidebands.

Elimination of Interference

Crosstalk can be removed only by narrowing the selective circuits and in this case variable band width i-f circuits are most convenient to use. The 10 kc whistle can be removed by the use of a 10,000-cps band-elimination filter, but in the receiver described, this is unnecessary because the whistle is removed by the chatter removal elements as is shown later. The method of removing the chatter is more involved and may best be shown by an example. Let it be assumed that the i-f band width has been narrowed for crosstalk elimination so that the signal is down 10 db at 10,000 cps and that the adjacent channel signal is one tenth as strong as the desired signal with both signals 30 per cent modulated. The Figure on page 22 represents the incoming signals and their sidebands at the detector. The desired signal, A, has a relative strength of 100 and its sidebands a strength of 15. The adjacent channel or interfering signal, B, has a relative strength of 3.33 and its sidebands, 0.5. For the purposes of this discussion the output of the detector is assumed to be proportional to the product of the carrier and sideband amplitudes. This is not strictly correct for a diode detector, but it approximates the actual condition. The relative amplitudes of the desired signal and the three types of inter-

RADIO RECEPTION



The receiver is contained in two chasses; the r-f and i-f units and first audio stage are in the left chassis and the audio power amplifier and power supply are in the right chassis. All controls and a heater transformer for the tuner tubes are mounted on the tuner chassis

ference under the stated conditions are as shown in Table 1. It has been shown by experience that the amplitude of the interference should be at least 60 db below the level of the desired signal. In this example, a

Table I—Amplitudes of the Desired Signal and Three Types of Interference

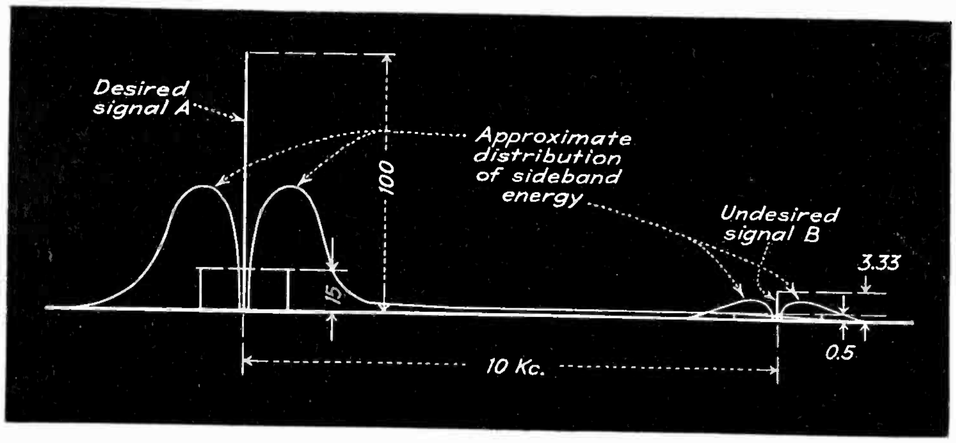
Desired Signal	—100×2×15=3000=0 db
Heterodyne Whistle	—100×33.3=333=—19 db
Chatter	—100×0.5=50=—36 db
Crosstalk	—3.33×2×0.5=3.3= —59 db

fairly severe case, the cross-talk is just about on the border line and something must be done about the chatter and heterodyne whistle.

Chatter may be described as inverted speech with a base frequency of 10,000 cps. Most of the energy of sound lies in the range of 100 to 2000 cps. Hence, most of the energy of chatter lies in the range of 8,000 to 10,000 cps. Therefore, the solution of the problem would seem to be to reduce the i-f half band width to between 7,000 and 8,000 cps and to reduce the audio response above 8,000 cps very rapidly so as to get as much fidelity as possible out of the desired signal. The 10-kc heterodyne whistle is also eliminated because the reduced audio response at 10,000 cps brings the level of the whistle well below the necessary —60 db level. If there is still interference under these conditions, the i-f band width must be narrowed still further and a lower audio cutoff frequency must be used.

After several years of experimenting with both t-r-f and superheterodyne receivers, it was concluded that the best way to get variable band width was to get it in the i-f circuits of the superheterodyne receiver. It is obtained by the use of i-f transformers of variable coupling in which the secondary coils of the three transformers are moved simultaneously by means of cams mounted on a shaft which also operates switches to change the cutoff frequency of the low pass filter used to reduce the audio response as mentioned above.

On the wide range position the transformers are at the point of maximum coupling with the first two overcoupled so as to give double peaks which are separated by about 35 kc. Mutual inductive coupling is used for three reasons: 1. The two peaks of the resonance curve will be of equal height only if no losses are introduced in the coupling reactance; inductive reactance is the only type of coupling which has no losses. 2. Mutual inductance is the only type of coupling which will move the peaks out from the center equally and will not vary the center frequency. 3. Any number of steps are possible. The resonance curve of the third transformer has a rounded top whose shape and width is varied by the variable coupling and the detector loading so as to be complementary to the curves of the first two transformers. This gives an overall resonance curve of the i-f system which is flat over a range of 32 kc which means the audio frequency response is flat to 16,000 cps. In the most loosely coupled position, the circuits are sufficiently undercoupled to get the maximum selectivity of which the i-f system is capable. Since the circuits are undercoupled, it is possible in this setting to align the i-f tuning condensers to a single peak with only a microammeter in the detector circuit and a source of 455 kc signal, even more accurately than by much more complicated methods as are now used in production alignment methods of overcoupled i-f systems.



Representation of the relative strengths of the desired and undesired signals and their sidebands. The energy of the sidebands is concentrated in the region between 100 and 2000 cps

Low Pass Filter

The low pass filter used in conjunction with the variable i-f band width to eliminate interference is of the Campbell type and consists of eleven elements. There are four series inductances, five shunt capacities, and two mutual inductances. The characteristic of this filter in position B is as follows:—

Frequency	Signal is down
Up to 7200 cps	0 db
8000	30 db
9000	50 db
10000	70 db

Experience has shown that it is desirable to vary the audio range in five steps. On the 7500 cps range, B, it is possible to receive signals as low as 100 microvolts without interference. Signals weaker than 100 microvolts can be received on the 5500 cps position, C, without interference and with quality considerably better than on a conventional receiver. For those conditions where high selectivity is necessary, such as high noise level or distant station reception, the 3600 cps range position, D, is used. For extreme conditions the 2500 cps range position, E, is used.

R-F System

The purpose of the r-f stage is primarily to reduce noise and the image frequency response. The r-f band width is wide enough to accomodate the widest i-f band and is of fixed width. The antenna circuit is double tuned and double peaked with the peaks separated by about 25 kc. The r-f stage is single tuned and single peaked and is made to have high resistance so that the peak will just about fill in the valley of the double peaked resonance curve of the antenna stage. The r-f system then has an overall resonance curve which is flat within one db over a band width of 25 kc, which will pass 12,000 cps without attenuation, and 16,000 cps will be down 6 to 8 db. Very little effort is spent to make the response flat to 16,000 cps because the transmitter characteristics of most stations drops off at about 11,000 cps. By reducing the 16,000 cps response by 6 db, it is possible to increase the r-f system gain by 3 db thereby decreasing the receiver hiss level by 3 db.

A-V-C System

The a-v-c system holds the detector voltage at 14 volts plus 0 minus 3 db over an antenna voltage range of two volts to 100 microvolts. The a-v-c consists of a diode fed thru a very broadly tuned transformer from a separate i-f tube. No delay is employed.

Elimination of Distortion

In a high quality system the speakers respond to frequencies up to 16,000 cps and will therefore respond to all audible harmonics. Hence, distortion in a high quality receiver is much more serious than in a conventional receiver. Distortion in the r-f and i-f tubes is minimized by operating them far below their capacities. Detector distortion is held as low as possible by operating the detector at 14 volts dc which is on the straight line portion of its characteristic and not so high that the second i-f stage overloads.

Any iron in the audio circuits will introduce a small amount of odd harmonics. The amount of harmonic increases with the hysteresis loss of the iron and decreases with increasing a-c flux density. Therefore, the audio circuit is resistance capacity coupled up to the input to the output stage. A special core steel having extremely low hysteresis is used and the high levels at which these transformers operate combine with low hyteresis to bring the distortion from this source to entirely negligible values.

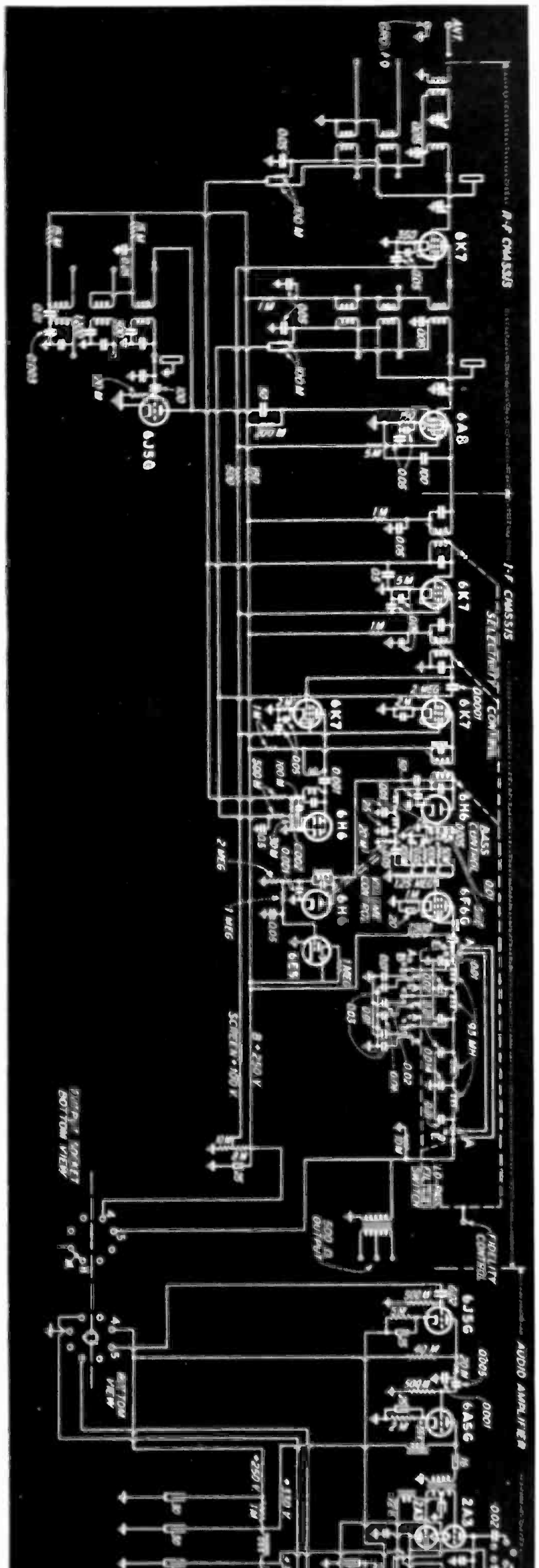
Low mu triodes are used throughout the audio stages for the reason that of all the tubes available for audio amplification, they have by far the lowest audible distortion. The audio amplifier operates over a range of 15 to 16,000 cps flat within one db and has an output of 15 watts with negligible distortion and 30 watts with very low distortion. It may seem that this is too great for homes. If an average power of three watts is desired and the incoming signal has an average modulation of 30 per cent and has peaks of 90 per cent, the peak power of the amplifier to reproduce the signal faithfully must be 9 times the average power required or 27 watts. Also, with a high quality receiver, it has been noted that there is a strong tendency to increase the volume to approximately the same loudness as in the original auditorium. Hence, a thirty watt amplifier is not much larger than the minimum required.

A pair of 2A3s in push-pull operating in Class A′ are the output tubes and are preceded by a 6A5G driver stage. A separate rectifier supplies fixed bias for the grids of the 2A3s. If for any reason the fixed bias should fail, a relay automatically switches the tubes to self bias and they will operate at reduced output. A feedback circuit is used to reduce the amplitude distortion at high levels. The driver stage, the fixed bias and the feedback are used so as to increase the effective output of amplifier. If it were operated without them it would have a power output of about ten watts with slight distortion. When the fixed bias is added the output is increased to fifteen watts. With fixed bias, the low impedance driver stage, and feedback in the circuit, the amplifier will operate at 30 watts or very close to its absolute peak power with slight distortion.

Speakers

Two speakers, one woofer and one tweeter, preferably mounted in a wall, are used. The woofer responds to frequencies up to about 8,000 cps and its resonance frequency is lower than 50 cps. The tweeter covers the range from about 5,000 cps to 16,000 cps, falling off slightly at 14,000 cps. It has been found to be better to have the two speakers overlap considerably in their frequency ranges instead of having a sharp transition point. It is necessary to have as large a baffle as possible so that the very low notes will be properly reproduced. Therefore, whenever it is possible the speakers are mounted in the wall.

Two speakers are used for the following reasons: In any speaker there are two sets of waves set up in the paper cone, one is longitudinal and one is lateral. As long as the rates of propagation of these waves are equal, the cone motion is essentially that of a piston, and this is the case at low frequencies. But at the higher frequencies, the longitudinal wave travels faster and reflects differently from the edge than the lateral wave, and therefore the motion of a given point on the cone is of a highly complex nature. To build one speaker covering the range from 40 to 16,000 cps in which all of these factors are properly controlled is substantially impossible in the present state of the art and it is better to build two speakers of different characteristics which supplement each other. There have been specially developed for this receiver, woofer and tweeter speakers of moderate cost which give excellent results.—C.W.



Circuit diagram of the high quality receiver with its audio power amplifier and power supply. The fidelity control changes the coupling of the variable i-f transformers and the cut-off point of the low-pass audio filter simultaneously. The first two inductances of the filter are loosely coupled and the second pair are closely coupled for extinction of the 10,000-cps whistle

Program Failure Alarm for Broadcast Stations

To give a positive indication of a program failure shortly after it occurs and to avoid giving false alarms during intervals for station identification or other reasons, the instrument described herein was constructed

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By HOWARD A. CHINN and ROBERT B. MOE
Columbia Broadcasting System

THE master control room of a modern network broadcasting station frequently has facilities capable of simultaneously transmitting eight or more different programs to outgoing program lines for distribution to radio stations in various sections of the country. Each of the outgoing radio lines is generally monitored by means of a volume level indicator and a loudspeaker.

Because of the many duties performed by the technicians in the master control room, it is not generally feasible to watch continually the volume indicators and dependence is largely placed on aural monitoring for checking outgoing programs. With several loudspeakers operating simultaneously, it is sometimes difficult to detect a failure of any individual channel. This is particularly true when a given program is being transmitted to more than one of the outgoing lines, as several monitor speakers are then reproducing the same program.

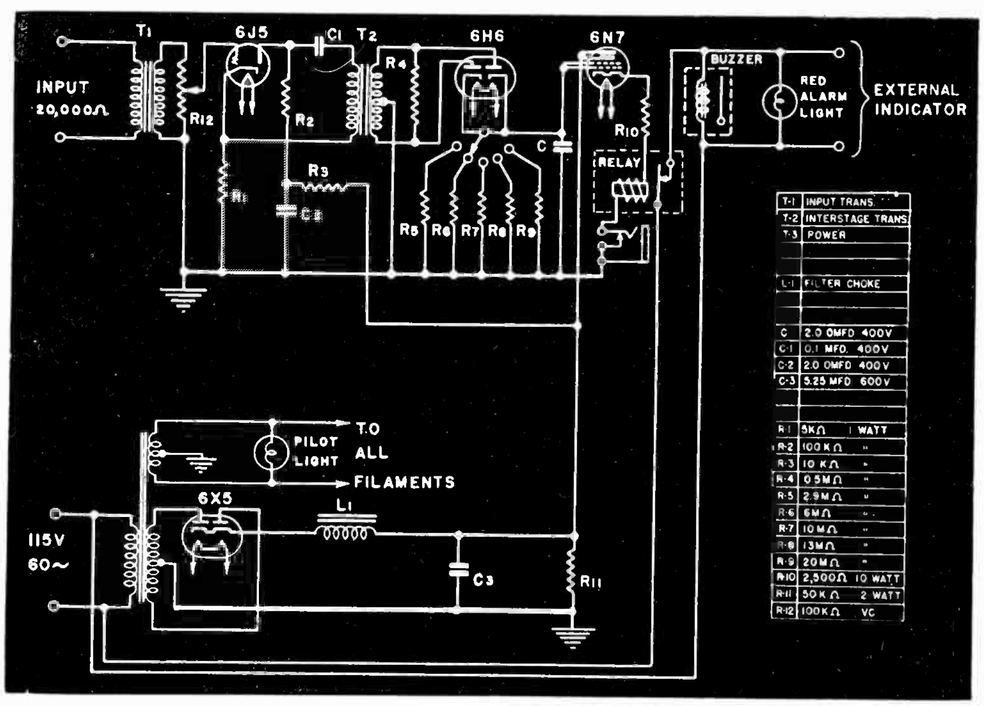
A study was therefore undertaken to determine the merit of the various means for avoiding unnecessary delay in the detection of a program failure. One of the experimental devices developed was designed to give an alarm a predetermined time after a program interruption occurred. It is believed that this unit may be of interest to others.

Description of the Alarm

The CBS experimental Program Failure Alarm is a program-operated relay which gives a visual-aural alarm when program fails on the line which the unit is monitoring. An adjustable time delay has been incorporated in the unit so it will not operate and give a false alarm during station identification intervals or during other short pauses in program continuity.

A schematic wiring diagram of the device is shown below. The first tube is a voltage amplifier which, besides providing considerable amplification, serves to isolate the following tube, a full-wave diode rectifier, from the program line. Such isolation is necessary in order to guard against the possible introduction of distortion on the program circuit.

A voltage, proportional to the amplitude of the program input level, is developed across an adjustable diode load resistor, R_5 to R_9, which is shunted by a fixed condenser, C. The time constant of this RC circuit determines the time delay of the alarm, consequently the load resistor has been made adjustable in steps (by means of a selector switch) in order to provide various time delays. Five time constants, giving delays of 10, 20, 30, 40 and 55 seconds, have been incorporated in the device. Obviously, if desired, the



Circuit diagram of program failure alarm. Variation in the time delay before the alarm operates is provided by the adjustable diode load resistor and condenser

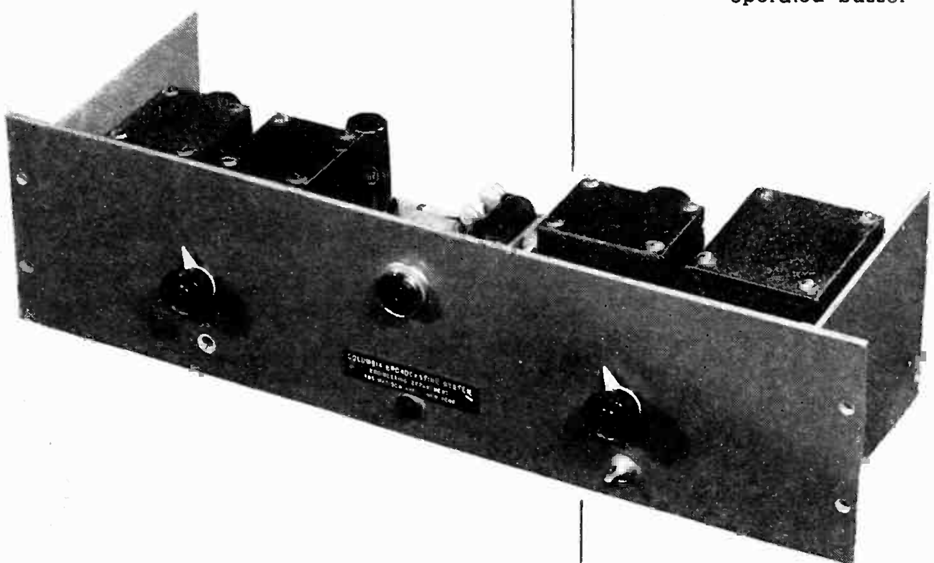
delay control could be made continuously variable by employing a variable resistor in place of the five fixed resistors.

The grid circuit of the relay control tube is connected across the time delay network. The grid of the control tube is biased, with no input to the device, to a point where approximately 2 ma of plate current flows. When audio input is applied, the voltage across the *RC* network reduces the negative bias on this tube and the plate current increases through the control tube and the alarm relay. When correctly adjusted, this plate current will reach a value of 20 ma on normal program peaks. This increased plate current actuates the relay and as long as audio input to the device is maintained, the relay remains energized. As is evident from the figure, the relay contacts are open when the relay coil is energized. Thus as long as the audio input is maintained, the alarm does not operate.

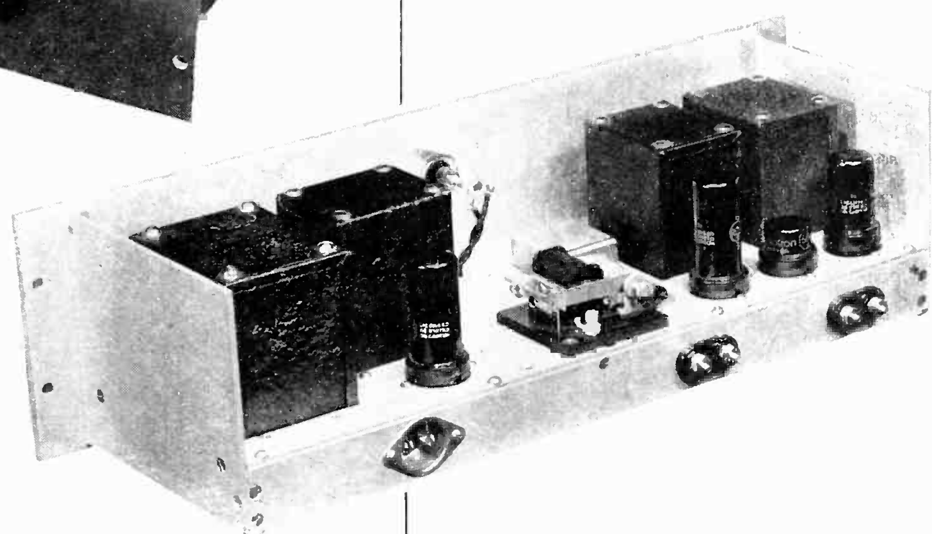
When the program input ceases, the condenser discharges slowly through the diode load resistor and the plate current of the relay control tube gradually decreases until it reaches a value of approximately 5 ma. At this point, the relay is released and the alarm operated. The alarm consists of a large red light and an a-c operated buzzer which has no sparking contacts to cause inductive interference in adjacent equipment.

A particularly important feature of the device is the fact that a tube failure or a filament- or plate-voltage failure within the device itself will operate the alarm. Thus, the device monitors its own operation and cannot become defective in operation without indicating the failure by means of an alarm.

The CBS Program Failure Alarm is completely a-c operated with self contained power supply. To permit mounting the units on a standard relay rack, they are built on standard 5$\frac{1}{4}$ by 19 inch duraluminum panels. Terminals are provided on the rear of the unit for audio input and for external visual indicator, if one is desired. The input impedance is 20,000 ohms so that the device may be bridged across existing program circuits.



The alarm is given by the large red pilot light in the center of the panel and by a sparkless, a-c operated buzzer



The unit is designed to operate on lines which carry a level of eight vu or higher. It is self-monitoring and a failure within itself will cause an alarm

Adjustment for Proper Operation

In order to obtain the correct time delay, upon initial installation, it is necessary to properly adjust the input circuit gain control. This is done by applying a test tone at normal program level to the line across which the alarm is connected. A milliameter is then plugged into the jack in the relay circuit and the current adjusted to 20 ma by means of the gain control on the front panel.

The unit described was designed to operate on lines carrying a level of +8 vu[1] or higher. If a unit is required for protection of a line carrying a lower volume level, an additional stage of amplification should be used. The time constants which have been given are based on tone input but it will be found that they hold quite accurately on program material where there are the usual 100 per cent peaks.

The alarm will operate if the level in the line falls to a value 20 db below the normal transmission level and remains at that level, or lower, for a length of time corresponding to the setting of the delay control. However, the alarm will immediately be turned off when the level rises to a value 12 db below the normal level. The Program Failure Alarm was designed to operate on 60 cycle, 115 volt lines. Changes in line voltage of $\pm$ 10 volts affect the time constant less than $\pm$1 second.

The unit illustrated above was used on an experimental basis for several months and found to be entirely satisfactory for the purpose in hand. It represents a specific application of several ideas, already disclosed on a broad basis, to a particular problem.

[1] Affel, Chinn, Morris: "A New Standard Volume Indicator and Reference Level," *Electronics*, Vol. 12, No. 2, February, 1939.

Lagoon of Nations Sound System

IN the Lagoon of Nations at the New York World's Fair is a spectacular display making use of water, fire, smoke, light and sound. Each evening just after dusk a prearranged show is given. Numerous streams of water, 1400 in number, are projected high into the air and are illuminated by many varicolored floodlights. At times large sheets of flame, dense masses of smoke and various kinds of fireworks join in the visual chorus. The entire performance is accompanied by a musical score.

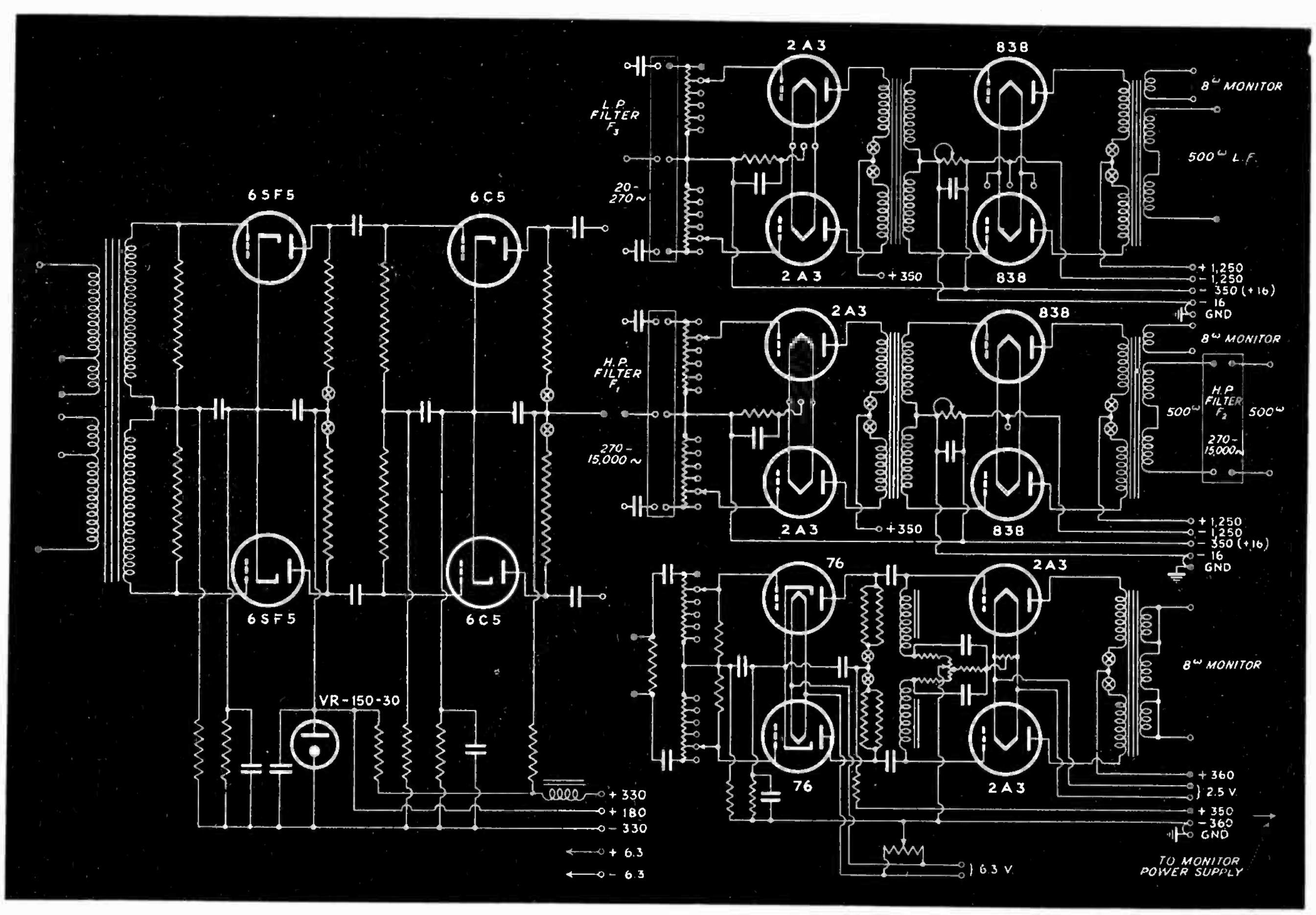
To maintain a common center of interest, the music must emanate from the center of the fountain. Obviously, an orchestra could not be located there and would not have the volume necessary to overcome the high noise level caused by the 1400 water nozzles, gas jets and fireworks and to cover the large crowds which witness this spectacle. So it was necessary to place several sound projector units near the center of the fountain and to design a high quality sound system of great enough power to cover adequately an audience of 100,000 people at an average distance of 250 feet.

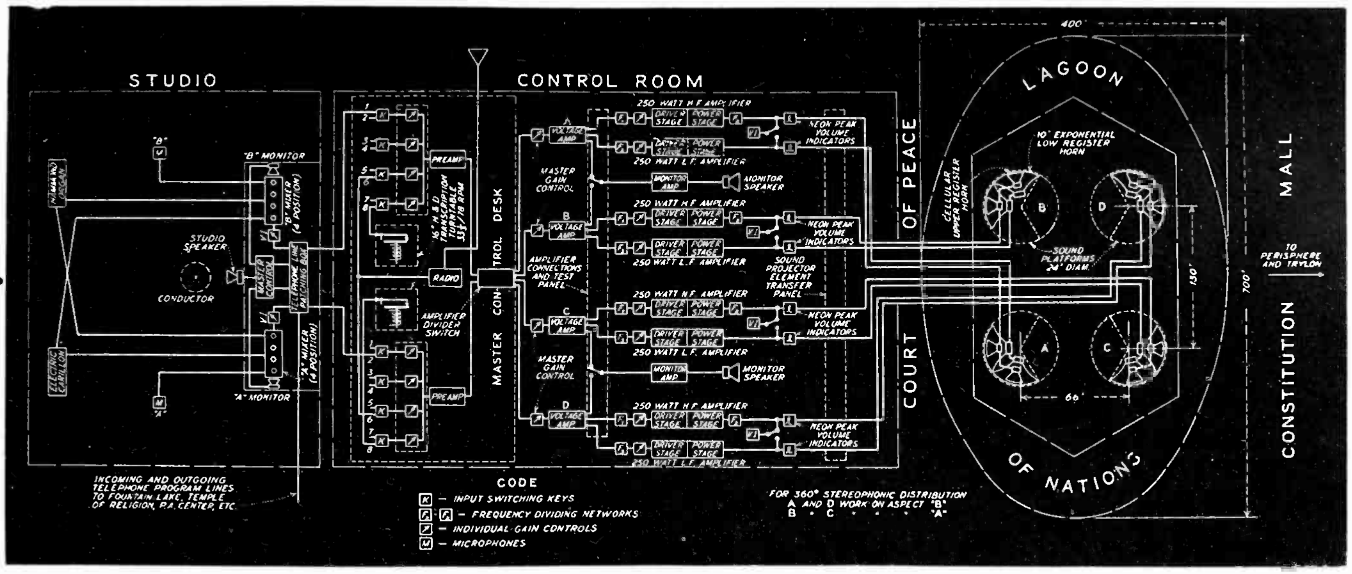
A specially designed high quality sound system was installed to transmit the music from a remote studio to the center of the fountain where it is radiated to the audience with 360 degree acoustic perspective and stereophonic distribution. Two Western Electric Cardiod microphones pick up the music, one for the right aspect of the orchestra and one for the left aspect. Each aspect has a separate channel up to and including the sound projectors. The sound is transmitted by means of special telephone lines, equalized to 11,000 cps, from the studio to the control room on top of the Roumanian Pavilion overlooking the lagoon. Each aspect is fed into a pair of 500 watt Bludworth amplifiers and then through 500 ohm lines to the appropriate sound projectors in the center of the lagoon. A total power of two kilowatts is fed into the speakers. This is great enough to overcome the very high noise level and to cover the large audience properly. The frequency range of the entire system is from 28 to 15,000 cps within two db and with less than three per cent distortion.

Four fireproof sound projector chambers or "igloos", each 24 feet in diameter and seven feet high, are located near the center of the lagoon in the midst of the water nozzles and gas jets. The major axis of the lagoon is 700 feet long and the minor axis is 400 feet long. The igloos are 130 feet apart on the major axis and 66 feet apart on the minor axis. There are two low frequency and four high frequency sound projectors in each igloo. The low frequency units are Cinaudagraph 27-inch-diameter cone loud speakers with divided exponential acoustic couplers which are of such dimensions as to project frequencies as low as 28 cps. The efficiency of these couplers is estimated to be about 65 per cent at 30 cps. The high frequency units are Western Electric No. 594A loudspeakers driving Western Electric No. 26A multi-cellular acoustic couplers. There are two high frequency loudspeaker units driving each coupler.

Because of the limitations of the sound projection units, the audible spectrum of 28 to 15,000 cps is divided into two parts at about 250 cps. The lower portion is radiated by the low frequency unit and the higher portion by the high frequency unit. The filters for dividing the spectrum are located between the voltage amplifier and the power amplifiers as shown in the block diagram. Separate 250 watt amplifiers feed the low and high frequency units of each igloo. The characteristics of the filters are such that

Circuit diagram of amplifier system. Each of four sound projectors is fed by a separate group of amplifiers





Block diagram of complete system. Stereophonic perspective is provided by two complete and separate sound systems, one for each aspect of the orchestra

they are complementary to the characteristics of the sound projectors with the result that the response over the transition range is flat within one db.

Stereophonic Perspective

This is the first known installation of 360 degree acoustic perspective and stereophonic distribution. Such distribution of sound creates in the mind of the listener a very strong illusion of the orchestra being spread out before him, but hidden by the streams of water. Instead of coming from a point source, the music seems to come from an area and the listener is able to determine the location of the individual instruments in the orchestra. To obtain stereophonic distribution, the sound projectors are diagonally paired as to the aspect of the orchestra radiated, that is, on either side of the lagoon, the right aspect is on the listeners right and the left aspect on his left. But on the ends of the lagoon, the perspective is reversed and the right aspect is on the listeners left an vice versa. However, this effect takes place so gradually as a person walks around the lagoon that it is unnoticeable. Also, the effect is unnoticed by a listener at the end of the lagoon unless he is familiar with the layout of the orchestra.

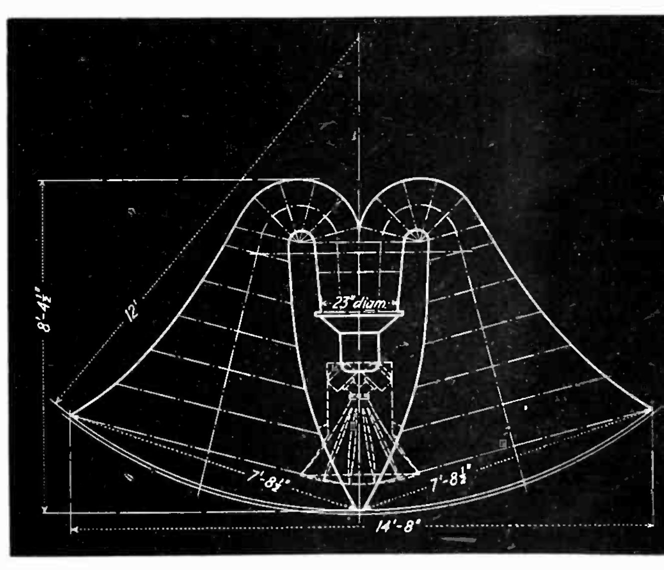
There are several unique features of the Cinaudagraph low frequency electrodynamic speaker, which is the largest of its kind ever made. It is capable of handling 125 watts of audio power under adverse conditions of moisture. The 27 inch paper cone is made by the flotation process and is water repellant to withstand the effects of continual wetting. The cone is of varying thickness being thickest at the center and becomes thinner in several steps towards the edge. The voice coil is six inches in diameter and one-half inch long, with the coil form one and three-sixteenths inches long. The long form is necessitated by the long excursions required to radiate extremely low frequencies at high amplitudes. The magnetic flux density in the magnetic gap is 21,000 lines per sq cm which is about ten times higher than that used in conventional loudspeakers. This high flux density requires the use of special alloys in the magnet and very careful proportioning of the gap to keep the losses at a minimum. The gap is of such length that the voice coil does not leave the uniform portion of the magnetic field in its greatest excursions. The speaker has a good response up to about 7000 cps.

The installation comprises two separate and distinct sound systems, one for the right aspect and one for the left aspect. Each sound chamber has its own group of amplifiers, one voltage amplifier and two 250 watt amplifiers, one each for the high and low portions of the spectrum. The power amplifiers are all capable of covering the complete range of frequencies in the interests of complete flexibility of operation. The amplifiers operate in Class B and have a total harmonic distortion of less than 1.4 per cent at any volume. The odd harmonics are cancelled out in the cathode circuit of the 6SF5 of the voltage amplifier by means of a feedback connection from the plate return of the following tube to the cathode of the 6SF5 with the bias voltage kept constant with a voltage regulator tube, VR150. The cores of the interstage, output and impedance matching transformers (by AmerTran) are of hypernic, a special high permeability steel. The total insertion loss of the output transformer, 500 ohm line and impedance matching transformer is less than one db at 30 cps.

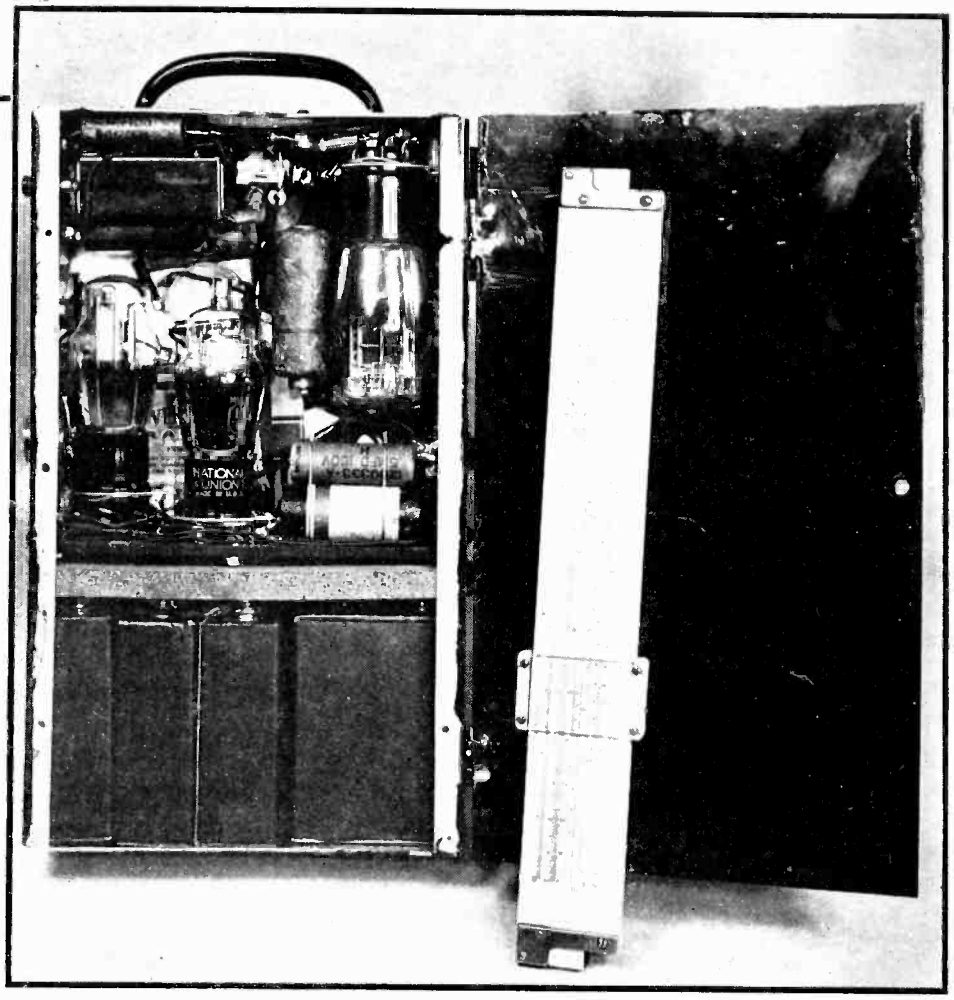
Each channel has its own gain control and power level meters. In addition to the power level meters, each power amplifier has its own peak power level indicator in the form of a small neon lamp which is set to glow when the power level is just under 250 watts. This is provided because the meters have too much lag to indicate instantaneous peaks such as given by percussion instruments. The neon lamps permit the amplifiers to be operated at peak power with the definite knowledge that they are not being overloaded.

The four 500 watt amplifiers and associated power supplies are contained in nine racks, each 24 inches wide and seven feet high. The total weight is approximately seven tons. Included in the equipment are a Hammond organ, a carillon, a duplex turn-table for recorded music, and a radio receiver. The sound system is used for incidental music and special announcements during the day, in addition to its use during the regular Lagoon of Nations display. —C.W.

The sound projection system shown below has a frequency range from 28 to 15,000 cps



A Compact Remote



View of amplifier with cover open. Filament power is supplied by single 3-volt battery with a dropping resistor and the plate voltage is supplied by three small batteries. Four tubes of the 1.5 volt series are used

THE following article is presented in the interests of smaller and more portable remote amplifiers. It is a description of an amplifier designed and constructed here at WHP to meet conditions sometimes found on remote pickups, where space is at an absolute minimum. The ultimate object in view when design was started was to build as small an amplifier as possible, and while some few minor refinements had to be sacrificed in the attempt, certain standards had to be met. The finished product must be portable in the extreme, both as regards weight and size. It must be contained in a single unit, since the presence of a battery box in addition to the amplifier would greatly reduce the ease with which the unit could be transported and set up. Alternating-current operation was immediately ruled out, since experience has shown that there are numerous remote programs occurring in places where the most troublesome job is finding a source of 110 volts ac which may be considered reliable. Also, where a-c operation is used near switchboards etc., as are found in backstage theatre pickups, a good ground is often invaluable in reducing hum pickup. With battery-operated amplifiers, these worries are over. The type and number of microphones to be used next came under consideration. It was decided to use the high impedance type, since this would eliminate the usual input transformer, which adds weight and takes up a large proportion of the available space. The tendency in modern remote amplifiers seems to be more and more toward three and four microphones, but it was decided that sufficient versatiliy could be obtained with two, and the addition of more channels would defeat the original purpose of the unit, i.e., compactness.

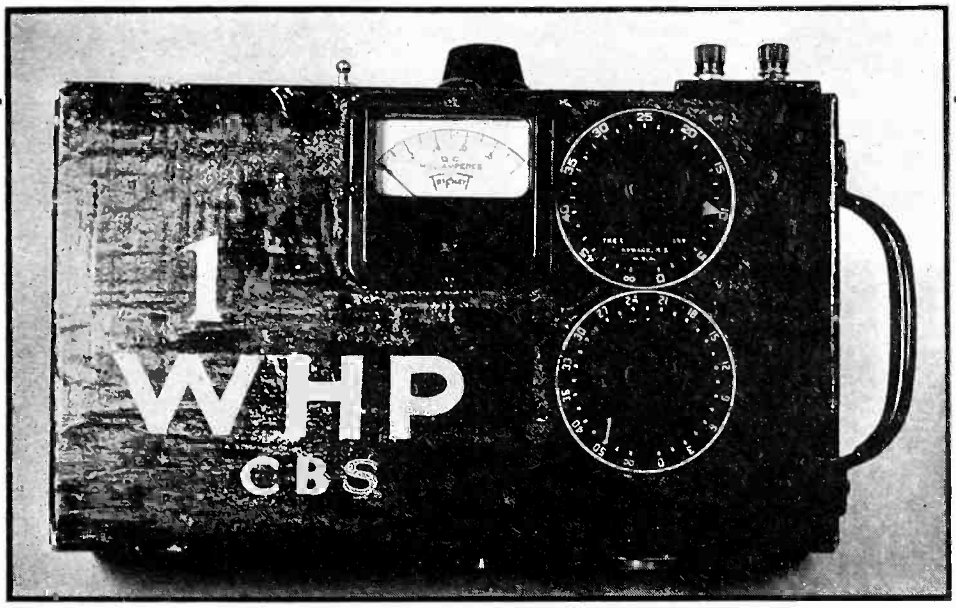
The choice of batteries was determined largely by the types available and the voltage required. Several power output pentodes were found that would operate very nicely at the required output level with a plate potential of only 135 volts. Thus, the batteries used were of the extremely small, portable type. A single 3-volt battery was used for filament supply and a small dropping resistor employed to provide the necessary voltage drop. The four batteries, placed side by side, fit snugly across the chassis as shown in the accompanying photograph. The life of these batteries has not yet been determined. Their initial cost, however, is quite reasonable, and replacement costs in this particular unit will not be appreciable, since the amplifier is used only on occasions when lightness and great portability are demanded.

The choice of tubes for the unit was the next step in design, and resulted in the use of 1J6G mixer, a 1D5G resistance coupled amplifier, and a 1F5G output pentode. The 1J6G is a twin triode, intended originally for use as a Class B power amplifier, but after experimenting with it as a Class A voltage amplifier at extremely low levels, it was found to be satisfactory for that class of service. It is used as a mixer tube directly following the microphone. Mixing is accomplished in the plate circuits of the 1J6G by the use of 500,000 ohm potentiometers as shown in the circuit diagram. Since the voltage amplification of this tube is rather small when used as a Class A amplifier, it was deemed wise to follow this stage with a high-gain pentode stage. The 1D5G was used in this position, and resistance-coupled to a 1F5G pentode-connected in the output stage.

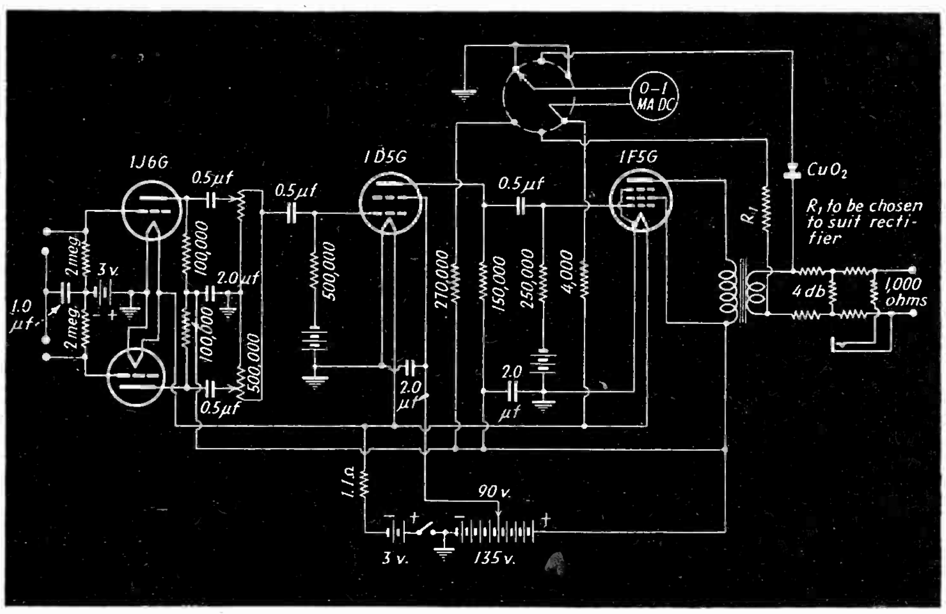
Since the batteries are not of the heavy-duty type, and it was decided that a frequent check on their condition was advisable, the volume indicator was made up from a O-1 milliammeter, using a small copper-oxide rectifier. This permitted the meter to be switched, by means of a three-

AMPLIFIER

By
R. S. DUNCAN
WHP, Harrisburg, Pa.



In the interests of portability, only two high-impedance microphone channels are used and the usual transformers which occupy much of the space are eliminated



By the use of a 0-1 milliameter with a CuO rectifier and a three-way switch (top, above), it is possible to check the output level, the A voltage or the B voltage at any time

position switch, to read either A voltage, B voltage, or output level. This makes possible the checking of batteries even during the program, and has proven to be one of the most convenient features of this particular amplifier. The effect of shunting the copper-oxide rectifier with its associated condenser and resistor across the output has proved to be not seriously detrimental to the frequency characteristic of the unit. It causes a drop in level of approximately 1.7 db at 8000 cycles, and less than this at 70 cycles. The damping characteristics of the needle on this meter are not ideal, but are considerably better than one would expect. The remainder of the circuit is quite conventional and no unusual features are found. The usual terminations are provided for monitoring headset, lines, and microphones.

As to actual size, the entire unit was built in a standard chassis 12 x 7 x 3 inches. A hinged cover on the rear makes the tubes, batteries, and faders easily accessible. The photograph clearly shows the position of the batteries, and the accessibility of parts for maintenance, even though extreme compactness has been maintained.

The performance of the unit is quite satisfactory for the purpose for which it was built. The frequency characteristic is within 2.0 db from 70 to 8000 cycles. Distortion was measured at one frequency only, due to lack of equipment for spot measurements, and the r.m.s. sum at 400 cycles with zero level output (6 mw) was 2.08 per cent. The output is easily plus 8 db maximum, at normal voice level. Since general practice here is to feed zero level through a 4 db pad to a 500 ohm line, plenty of room is provided on the faders for the rather large dynamic range of volume found on some types of pickups.

As was mentioned at the beginning of this article, some things have been sacrificed in order to obtain minimum size and weight. The symmetry of the front panel is poor due to the necessity of placing units where they would fit best, and not where they would look best on the front panel. A master fader has been omitted, but does not, we think, seriously affect the flexibility of operation of the unit. The frequency and distortion characteristics, while not up to the standards usually expected in a studio type amplifier, or even in a remote amplifier that might be used for symphony or similar broadcasts, are quite good. In some tests, this unit was used side by side with a remote amplifier having frequency characteristics as good if not better than most commercial units. The two amplifiers were switched, and the resulting slightly noticeable change in quality was attributed to the different microphones used, and not to any overall characteristics of the amplifier itself. Otherwise, the unit meets all requirements, and seems well adapted to jobs requiring a minimum amount of equipment, and these occasions do occur at the average radio station.

Coaxial Cable Installation

For broadcast engineers who intend installing coaxial lines, or who have trouble with their present installation, Mr. Epperson's practical review of coaxial problems and procedures has much to offer. The first of two parts

By J. B. EPPERSON
Chief Engineer, Scripps-Howard Radio, Inc.

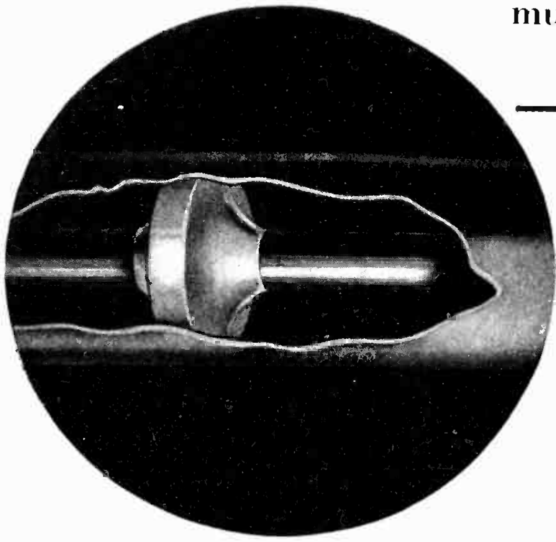


Fig. 1—Section of Isolantite coaxial cable. The shape of the insulator serves to distribute the lines of force uniformly over its surface

CONCENTRIC transmission lines have provided subject matter for much published material concerning their characteristic impedance, loss per unit length, necessity for proper impedance matching, and so on. Little if any material, however, has appeared regarding the failures of concentric lines in practice and regarding the installation procedure for such lines. This paper is being presented with the idea in mind that most failures of concentric lines are caused by faulty installation. It is believed that with proper care in the initial installation of such lines and with proper consideration given to their protection from lightning and static discharges, trouble-free operation may be obtained. Reference to the use of concentric lines in this article is confined to those which serve as a connecting length between a radio transmitter and its antenna system.

Concentric Line Failures

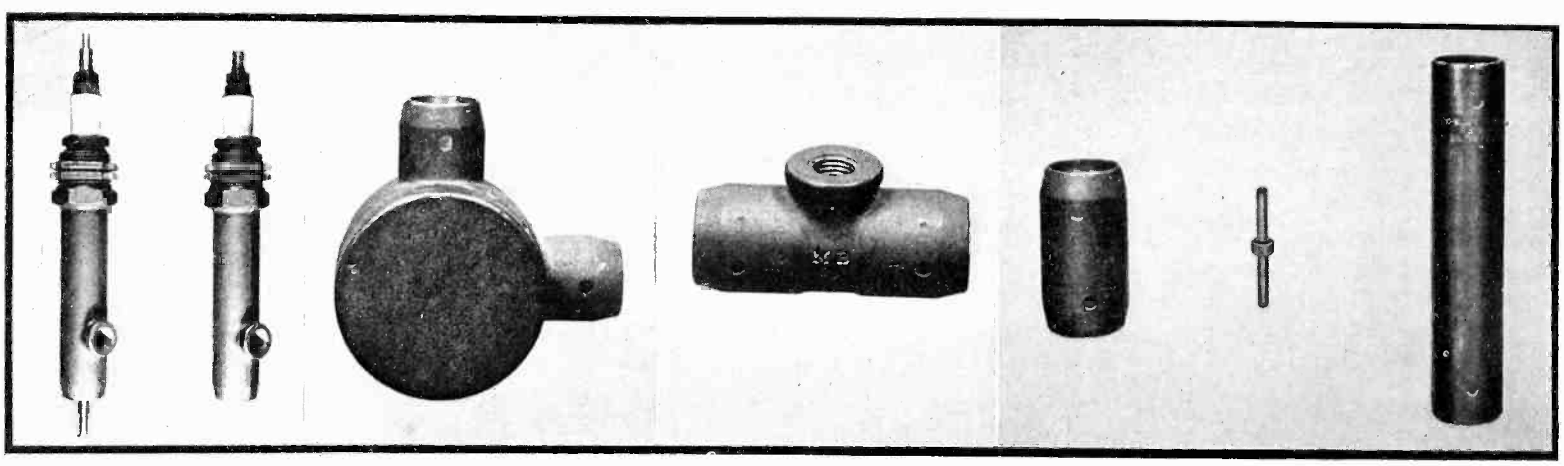
In September 1938 the writer prepared a concentric line questionnaire, copies of which were mailed to 90 broadcast stations believed to be using concentric lines and returns were based on 61 replies.

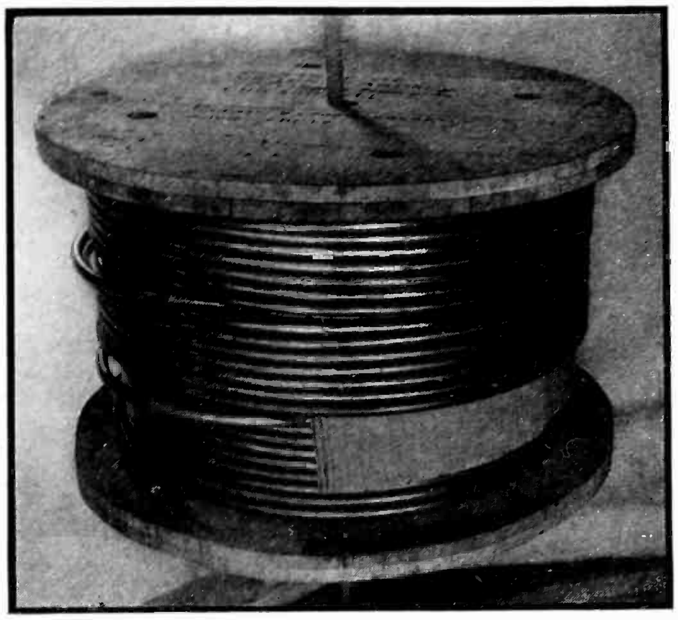
Forty-nine stations had lost no time off the air due to defective lines while 12 stations reported one or more failures. The cause of line failure for the 12 stations was given as follows: Faulty installation, six; faulty installation and/or lightning, five; lightning, one. Four of the five stations checking both faulty installation and lightning as the cause of their difficulties used no power interruption circuits or other means for satisfactorily protecting the line from lightning and static discharges. One of the twelve stations reporting failures employed a shunt fed radiator while the other eleven stations used series feed to their antennas. Six of the failures occured on underground lines, five on surface installations and one occured on a line partly underground and partly on the surface. Nine stations used gas filled lines while three operated their lines at atmospheric pressure.

In June, 1937, the Columbia Broadcasting System made a survey of its member stations to determine to what extent failures on concentric lines had occured. The results of this survey, which were furnished for use in this article by Mr. William B. Lodge, Engineer-in-chief of the Radio Frequency Department of CBS, are as follows: Out of 26 CBS stations of 1000 watts or more power which were using concentric lines, 9 stations had experienced one or more failures. This summary further showed that faulty construction or lightning, or both, caused the difficulties.

From the replies to the questionnaire it was found that $\frac{7}{8}$ inch line

Fig. 2—Typical solder-couplings for use with Isolantite cable. Left to right, gas-tight seals, right-angle coupling, gas fitting, couplings for straight runs (1¾-inch and 4-inch lengths). The center conductor is coupled by the small member shown between the outer couplings





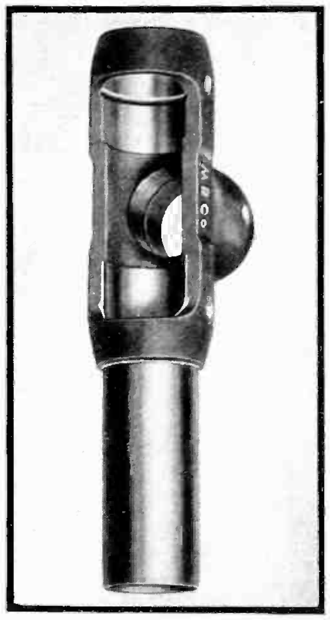
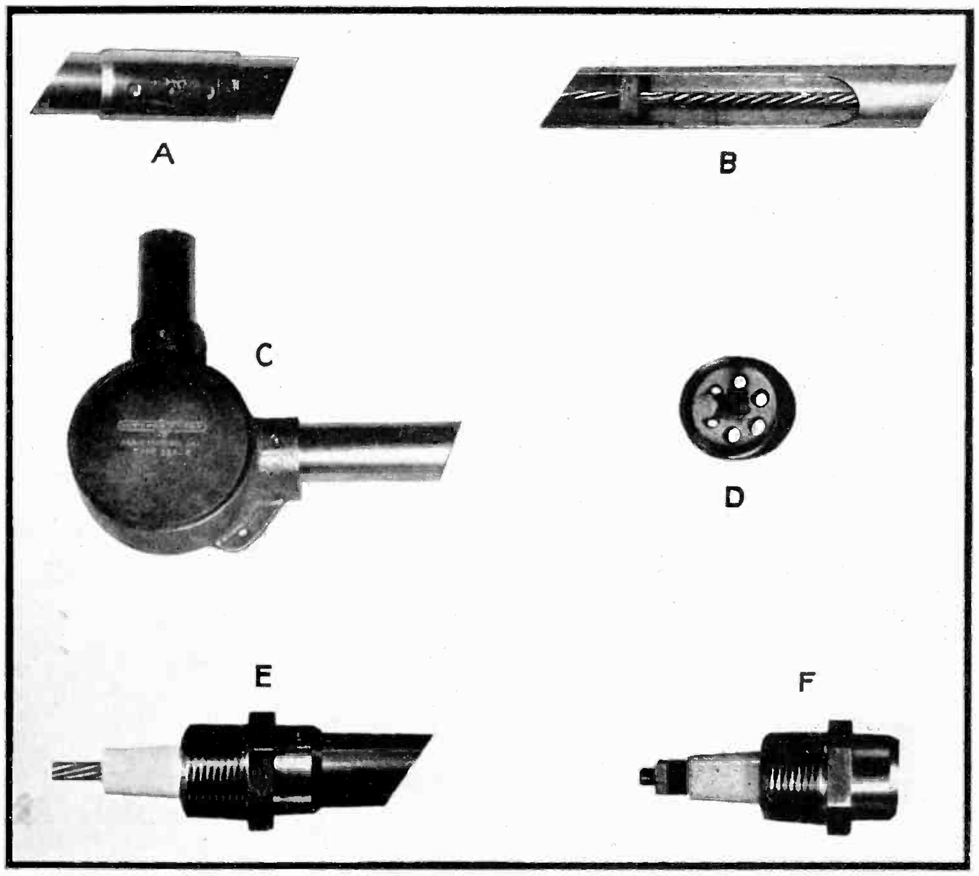


Fig. 3—(Extreme left) Cable five-eighths inch in diameter may be rolled for shipment, although assembly from straight lengths is more usual in larger sizes

Fig. 4—Cutaway view of "Streamline" solder coupling, showing internal groove which carries solder to all parts of the joint

Fig. 5—Cable and fittings offered by Heintz and Kaufman. (A) Solder coupling (B) cutaway view of cable, (C) right-angle fitting, (D) cross-section view, (E and F) gas fittings



is the most popular size for carrier powers of 5 kw and below. Some of the lower powered stations use the $\frac{7}{8}$ inch line because of the additional safety factor provided through its use. Others plan in advance to increase their power and consider it an economical move to install a line of sufficient rating to meet future needs.

Neglecting dielectric losses, the conductor losses for different sized lines having the same characteristic impedance will vary inversely with the line diameters. Also, for a given line, these losses will increase directly as the square root of the frequency. These relations should be borne in mind when deciding the size line to use for a given power output and frequency. At standard broadcast frequencies the losses are so small that they can usually be neglected. On the ultra high frequencies, however, it is often a requirement that the cable losses be reduced to a minimum due to the low power used and to the relatively high losses at these frequencies. Some police stations, for instance, which are in operation on the ultra high frequencies use as little as 15 to 20 watts power. While the smallest line available would probably handle this output, noticeable gains in signal strength will be realized if a larger line is used.

Assembly of Coaxial Lines

Most lines up to $\frac{1}{2}$ inch in diameter are constructed of soft copper and are therefore semi-flexible. Installation of this type line is a very simple procedure since it may be readily bent for changing direction. It is shipped in continuous lengths up to 500 feet and a special solder coupling is used for joining sections when required. Solder couplings are also available for sealing the ends and for admitting gas. Figure 3 shows a section of $\frac{5}{8}$ inch coaxial cable as placed on a reel for shipping.

The larger sizes of lines are usually shipped in 20 foot or 10 foot straight sections and the conductors are of hard copper. With this type line, "Streamline" solder fittings are in universal use for connecting sections of pipe, for connecting right angle junction boxes, for end seal attachments and for gas fitting accessories. For those who are not familiar with these fittings the following information will be of interest:

Streamline Solder Couplings

The Streamline solder coupling was first introduced by the Mueller Brass Co., of Port Huron, Mich. which now licenses several manufacturers for its use. Tests anticipating service conditions were instituted and worked out for a number of years before this fitting was placed on the market. In the tests, two $\frac{3}{4}$ inch sections of copper pipe with wall thickness of .065 inches were connected with a $\frac{3}{4}$ inch solder coupling and pulled in the Olsen

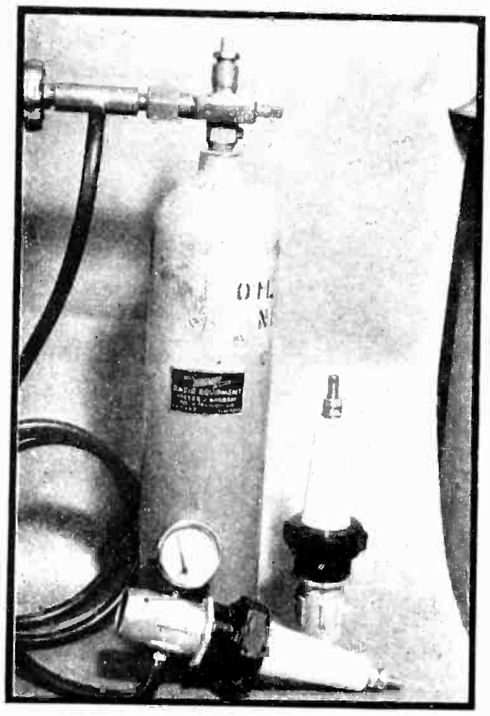


Fig. 6—Equipment for filling cable with dry nitrogen. The fittings are intended for a line 1⅜ inch in diameter

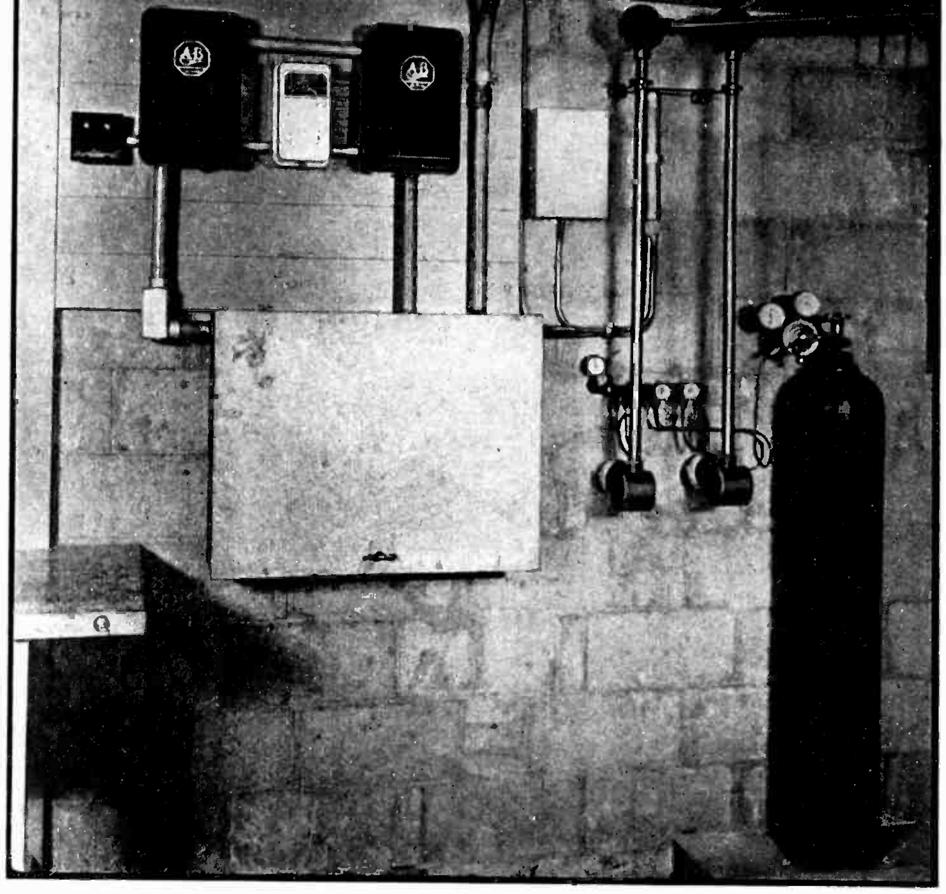


Fig. 7—A neat gas-filling installation, at WKBN. Note that a duplicate cable is maintained as a spare (Communications Products)

testing machine. It was found that a tension of approximately nine thousand pound per square inch was required to fracture the pipe while the joint itself invariably remained intact. In other words the joint was shown to be stronger than the pipe itself. Tests for the effect of heat, pressure and underground use in various soils are continuously under way. The manufacturers report that they have never had a case of failure of the joint where it was installed properly.

Figure 4 shows a sectional view of this solder fitting. It is a radical departure from methods previously used for connecting pipe in that the joint is made by soldering rather than by threading or flaring. The soldering operation is made by feeding wire or stick solder through a feed hole in the fitting after the copper pipe has been assembled in it and sufficient heat applied with a blow torch. The liquefied solder is carried around the entire surface between the pipe and fitting by the phenomenon of capillary attraction, and becomes visible as a bright line at the outer edge between the pipe and fitting, thus affording visual evidence that a leakproof, bonded joint has been completed. The distance to which the pipe may be inserted in the fitting is made positive by a shoulder in the fitting itself against which the pipe rests. This shoulder is approximately the same height as the thickness of the pipe wall thus insuring a continuously smooth internal surface. Those who are not familiar with the installation of streamline fittings erroneously conclude that the solder feed hole must be located at the top of the fitting. However, the solder will flow up, down, or laterally with equal facility, and the operator can just as readily make a perfect joint by applying the solder through the feed hole located at the bottom or side as he can if it is located at the top.

The ⅞ inch and most larger size lines are installed with special fittings which employ streamline soldered joints throughout. Figure 2 shows some of the Isolantite line of solder fittings in which the solder feed holes are plainly visible. Figure 5 shows concentric line and accessories manufactured by Heintz and Kaufman. The fittings shown by Isolantite and Heintz & Kaufman are similar to those manufactured by other companies.

General Installation Instructions

The tools needed for installation are: blow torch, file (10 inch mill half round), hack saw (32 tooth blade), medium No. 1 sandcloth or sandpaper, streamline solder and solder flux or equivalent, solder flux brush. The procedure for making joints in the outer conductor is as follows:

1. Cut pipe square with fine hack saw; remove bur.
2. Using sandcloth or sandpaper, clean outside end of copper pipe equal to depth of fitting. Leave no dark spots. See that all filings are removed from inside of pipe.
3. Using sandcloth or sandpaper, thoroughly clean inside of fitting where pipe is to be inserted until a bright surface is obtained. Clean feed hole.
4. Apply a coat of soldering flux to outside of pipe and to inside of fitting. Be sure that the flux is distributed evenly. Make certain that there is some flux in feed hole also. In extremely cold weather warm fitting slightly with torch to approximate room temperature.
5. Slip pipe into fitting until it will go no further and turn back and forth once or twice to further insure an equal distribution of the flux.
6. Use pure solder consisting of 50 percent lead and 50 percent tin. Do not use a flux core solder.
7. Using a blow torch or gas tip, melt a drop of solder into the solder feed hole. Apply heat around the fitting until drop of solder disappears, indicating that the proper temperature has been reached. Where the feed hole is located at the side or bottom, the proper temperature may be ascertained by touching the heated fitting with the end of the solder wire (preferably at

the feed hole). When solder melts upon contact, the proper temperature has been reached. Feed solder through feed hole only until solder appears around the end of the fitting for the full pipe circumference. Remove the flame a second or two later and as the connection starts to cool, completely fill feed hole with solder and remove surplus with a small piece of cloth. Bonding the surfaces and filling the hole should be done completely in one heating operation. It is advisable to move the fitting on the tubing or tap with hammer when the solder starts in, thus breaking the surface tension and insuring equal distribution.

The procedure for making joints on the inner conductor is similar:

1. Cut tubing square with fine hack saw; remove bur.
2. Clean connector and inside of inner conductor until a bright surface is obtained.
3. Apply a thin film of soldering flux to the connector; insert it half way into one inner conductor section and solder in place with a small flame.
4. Insert protruding half of connector into other section of inner conductor to be joined, heat with a small flame and solder. Wipe off any excess solder before it hardens.

Installation should start at one end of the line and proceed toward the other. This avoids the difficulty of making a junction in the middle of the line. Cut off about six inches from the outer conductor of the first section of line so that the inner conductor protrudes by this amount. This facilitates installation by causing an offset between the joints of the inner and outer conductors. Following the instruction procedure for making joints, the inner conductor connector should be inserted half way into the inner conductor of section 1 and soldered in place. With the outside coupling slipped over the outer conductor of section 1, the inner conductor of section 2 is slipped over the half of the coupling pin protruding from the inner conductor of section 1 and soldered. Make sure that the adjacent inside conductors are firmly butted together and that all excess solder is wiped off. Then butt the outer conductors of section 1 and 2 together within the coupling sleeve and solder. If the procedure for making joints in the outer and inner conductor were followed closely, a gas tight joint should result. The remaining joints in the straight run will be made in a similar manner.

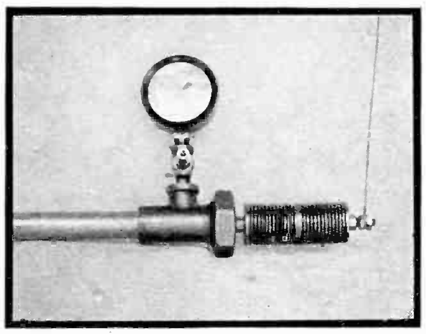


Fig. 8—Expander fitting for allowing changes in length with temperature (Doolittle and Faulkner)

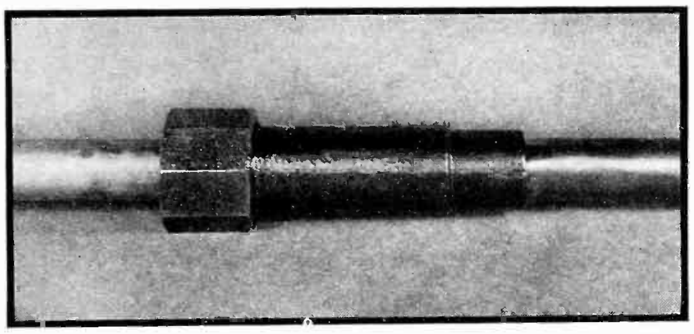


Fig. 9—Another type of expansion joint, of the "self-contained" variety made by E. F. Johnson Co. The take-up nut (left) tightens the joint

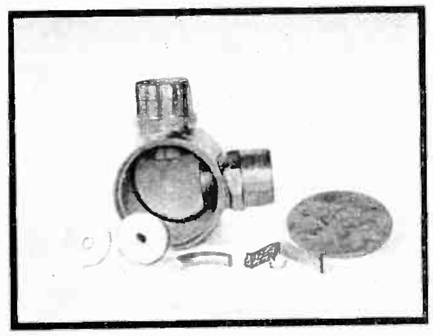


Fig. 10—A right-angle junction for $2\frac{5}{8}$ inch diameter line (Victor J. Andrew)

The manner in which the end seals are installed will vary with the different types of end seals by different manufacturers. For the type shown in Fig. 2, approximately 10 inches of the outside conductor is cut off so that when the end seal is soldered in place to the outer conductor, the inner conductor extends through the end seal and protrudes for making the electrical connection. The inner conductor is then sweated at the top to make a gas tight joint. Since severe heat may crack the insulator of the end seal or destroy the gas seal, a flame should never be permitted to strike it. The insulator should be wrapped with a wet cloth while the joints are being soldered.

Making Bends in the Line

The $\frac{7}{8}$ inch line may be bent to a radius of approximately 15 inches if a length of special soft drawn copper line is obtained and the bend carefully made. Rather than use soft tubing for making the bends, however, it is more practical to obtain the bends from the manufacturer of the line. Bends may be obtained on any degree of turn on a 14 inch radius.

Two methods of making right angle bends are shown in Fig. 2, including a special tee with a screw plug and a right angle junction box with a solder cover. It is recommended that the tee type bend not be used. It is very difficult to get a small iron in to this type bend for making a satisfactory soldered splice of the two branches of the inner conductors. Even when this has been done satisfactorily, the spacing is so close that a small amount of expansion may cause a short circuit between the inner conductor connector and the end of the "tee." The right angle bend was designed to overcome these difficulties. Figure 10 shows a similar type right angle junction box as manufactured by Victor J. Andrew. These two junction boxes are typical of those available from other manufacturers.

To assemble the right angle bend, cut the transmission line so that the inside conductors extend $\frac{3}{4}$ inches beyond the outside conductors with insulators located as near as possible to the ends of the outside conductors. After the outer conductor joints have been completed, the inner conductors are completed with a rigid or flexible right angle connector as desired. If both branches of the line are horizontal, a flexible connector may be used to take care of the differential expansion. If the line is vertical one way, a rigid right angle connector should be used to offer support to the inner conductor.

(To be concluded)

NEW BOOKS

Alternating Current Bridge Methods

By B. HAGUE, *University of Glasgow. Fourth edition. (578 pages, 193 illustrations. Price, $8.50). Pitman Publishing Corp., New York.*

IN PREPARING the fourth edition of Dr. Hague's important treatise on electrical bridge methods, the author states that three objects have been kept in view: (1) to insert the supplementary matter of former editions into its proper place in the text, (2) to give an account of the developments up to the end of 1937, and (3) to expand certain matters which experience had shown to be in need of further explanation. The result has been a much enlarged and more fully illustrated volume than the last edition of six years ago. About 150 pages of new material has been added and the present edition presents a much more logical and systematic treatment than former editions. New material which has been added includes a discussion of the circuit locus diagrams to explain their use in illustrating sensitivity and balance of convergence of bridge networks. A complete classification of bridge networks has been included and additions have been made to the theory of bridge circuits containing mutual inductance in one arm.

As in former editions, this one is concerned with the measurement of inductance, capacitance, effective resistance, and frequency at low and audio frequencies. The author states quite bluntly that "radio frequency bridges fall outside of the declared scope of this book", although much of the material presented is directly applicable to bridge measurements at radio frequencies.

The first chapter deals with the fundamentals of bridge measuring networks and includes a historial outline of the development of bridge methods. A general discussion is given of capacitance, inductance, and effective resistance as a basis for further treatment of these components as brige arm constituents. The second chapter deals with the symbolic theory of alternating currents, particularly with reference to its application in a-c bridge networks. The general theory of such networks is derived as a basis for later treatment in which specific forms of bridge networks are discussed. Much of the chapter can very well stand on its own feet as good general a-c theory totally aside from its application to bridges.

The third chapter discusses bridge apparatus and presents an excellent discussion of the desirable characteristics and design data for component parts and standards for bridgearms. This discussion of the properties of standards of L, C, and R will be valuable to any laboratory worker, whether or not he is mainly concerned with bridge measurements. The classification of networks with respect to the way they are built up is thoroughly treated in chapter four, and the student is shown the various possible electrical relationships between the structure of the various arms. The treatment employed is also advantageous to the engineer for it enables him to select the type of bridge most suitable for a given purpose. Chapter five contains a discussion of the choice of networks and establishes the precautions which should be observed in making bridge measurements.

The book is advanced and the reading is mathematical and not particularly easy, although it is lucid and clear. For the well trained worker in the electrical laboratory who desires a thorough, up-to-date, authoritative treatise on bridge networks and measurements, this volume is heartily recommended. As this reviewer sees it, the only difficulty with the book is the rather high price it bears for the American market.—B.D.

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Electric Circuits and Wave Filters

By A. T. STARR, *Research Engineer. Marconi's Wireless Telegraph Co. Second Edition, Pitman Publishing Corp., New York, 1938. 476 pages, 402 diagrams. Price $6.00.*

THE SECOND EDITION of this well-known British treatment of filter theory has been enlarged by 100 pages, and includes developments which have come to light since the first publication in 1934. The book should serve principally as a reference for research workers, since its compactness of presentation and lack of illustrative problems would make it very difficult reading for the student.

The book begins by laying down the basic mathematical processes underlying filter theory, and while this order is logical it is somewhat disquieting to the reader who desires to wade into the subject at once. For this reason, the mathematics might better be included in an appendix, especially since the mathematical knowledge must largely be presupposed in any event. Following the introductory chapter, alternating current theory is taken up, followed by a description of the electric circuit and its theorems. The discussion of filter theory proper begins in Chapters V and VI which discuss two-terminal and four-terminal impedances respectively. The remainder of the book is concerned with various forms of wave filters, including the low-pass, high-pass and band-pass forms.

The principal fault with the book is the fact that it maintains a "non-numerical" attitude, stating the results in general algebraic form only. While this generality is an advantage to the specialist who thoroughly understands the subject, it tends to be non-communicative to the reader who desires a working knowledge of the magnitudes involved in filter work.—D.G.F.

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Introduction to Contemporary Physics

By KARL K. DARROW, *Research Physicist, Bell Telephone Laboratories. Second Edition. D. Van Nostrand Co., New York, 1939. 659 pages, illustrated. Price $7.00.*

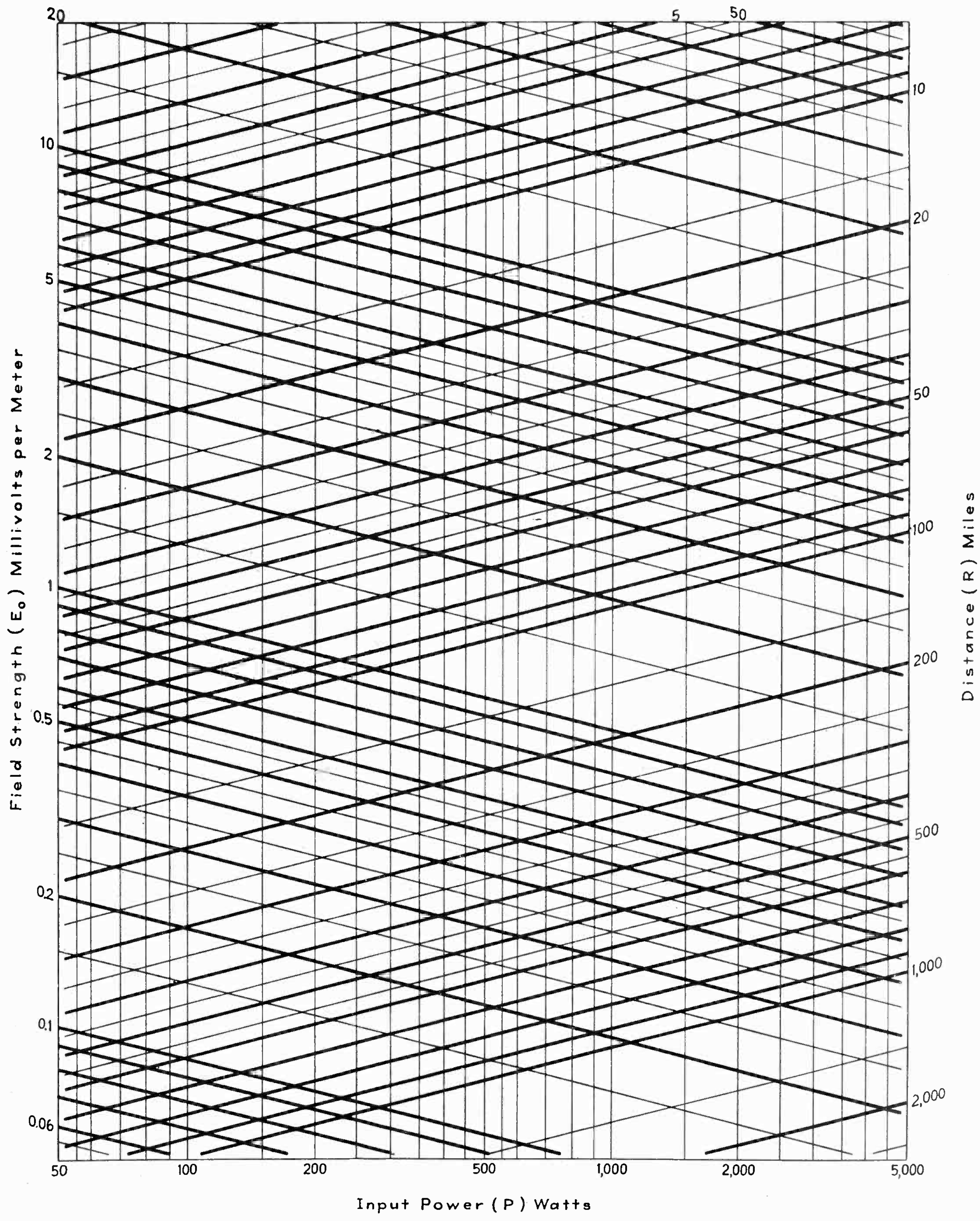
READERS OF THE *Bell System Technical Journal* are familiar with the series of articles on contemporary physics which Dr. Darrow has been writing for many years (the latest in the series is numbered thirty-two). There is perhaps no man writing who has a better command of scientific English, nor a broader grasp of the significance of modern advances in atomic physics. The present book is a second edition of an earlier work which appeared in 1926. Since that time, as the author states, the "body of recorded phenomena" has increased immensely, the theories, in all branches except nuclear physics, seem to be stabilized, and the whole concept of the wave-particle has been interpreted.

It is therefore good time for a thoughtful review of what the physicists believe to be the truth, and Dr. Darrow has accomplished this job in a manner which will disappoint none of his many readers. The book is devoted almost entirely to miscropic physics, and as such is highly recommended to readers of *Electronics* who wish to know the present status of the elementary particles on which the science is based. The presentation comes as near being a work of art as a book on physics can be.

The subjects covered include: The Fundamental Charge, Electrons, Ions and Isotopes, The Elements, Correlation of Waves and Corpuscles, Diffraction of Wave by Crystals, Ionization, Analysis of Spectra, Bohr's Atom, Wave-Mechanics, Magnetism and Electron Spin, Transmutation, Neutrons, and Nuclear Instability. The mathematical treatment is in the main supplementary to word descriptions, and need deter no one from reading the book. No attempt has been made to over-simplify the presentation; its simplicity resides in judicious choice of words and orderly presentation.—D.G.F.

ANTENNA RADIATION CHART

By L. J. GIACOLETTO



ANTENNA RADIATION CHART

By L. J. GIACOLETTO

FOR several years, radio engineers have occupied themselves with the problem of predicting the strength of the electromagnetic field at a given distance from an antenna.

If a perfectly conducting plane earth is considered, the Hertzian expression for the electromagnetic field produced at a distance, R, is:

$$E_o = \frac{K\sqrt{P}}{R} \qquad (1)$$

where K is a factor depending on the antenna design. For a quarter-wavelength vertical antenna, K is 6.14 if E_o is in millivolts/meter (mv/m), P in watts, and R in miles. Equation (1) then becomes:

$$E_o = \frac{6.14\sqrt{P}}{R} \qquad (2)$$

The antenna radiation chart printed on the reverse side is a plot in triangular logarithmic coordinates of the basic relationship given in Equation (2).

Effort has been made to cover the range most used in practice. Range extension can be most easily effected by multiplying by powers of 10. Thus if P is extended by a modulus of 100, and R by a modulus of 10, the E_o scale remains unchanged.

The value of K in Equation (1) is dependent on the antenna height and for antenna heights other than one-quarter wave, correction of the radiation chart can be made. For antenna heights of less than one-quarter wave, K is very closely 5.9, or the value of E_o found on the radiation chart is to be multiplied by 0.96; for one-half wavelength antenna, K is 7.45, or E_o from the chart is to be multiplied by 1.213; for 0.625 wavelength antenna, K is maximum equal to 8.6, or E_o from the chart is to be multiplied by 1.4 and for heights above 0.625 wavelength, K decreases rapidly.

It is true that equations (1) and (2) hold only for a highly idealized case. However, the more exact treatments of the radiation phenomenon introduce only a correction factor to the Hertzian expression of equation (1). These more exact solutions can be written in the form:

$$E = E_o A \qquad (3)$$

where E_o is the field strength as obtained from equation (1) or (2), and A is a correction factor.

In the Austin-Cohen formula, the correction factor is:

$$A_1 = \epsilon^{-\frac{0.0764\,R}{\lambda^{0.5}}} \qquad (4)$$

where ϵ is the natural base (2.72) and λ is the operating wavelength in meters. This correction takes care of the increased attenuation due to currents induced in the earth of a wave propagated along the ground. A more exact form of the correction was given by L. W. Austin in 1926 as:

$$A_2 = \epsilon^{-\frac{0.142\,R}{\lambda^{0.6}}} \qquad (5)$$

A. Sommerfeld has considered the case of propagation of a wave over a plane earth of finite conductivity. The results of this investigation are altogether too complicated for practical application. Van der Pol has derived an empirical approximation of Sommerfeld's equations for which A in equation (3) is:

$$A_3 = \frac{2.0 + 0.3\,\rho}{2.0 + \rho + 0.6\,\rho^2} \qquad (6)$$

where ρ is Sommerfeld's numerical distance given approximately by:

$$\rho_1 = \frac{8.44 \times 10^{-10}\,R}{\sigma\,\lambda^2} = \frac{0.938 \times 10^{-20} f^2 R}{\sigma} \qquad (7)$$

where

- σ is the conductivity of the earth in emu
- λ is the wave length in meters
- f is the frequency in kilocycles
- R is the distance in miles

Equation (7) gives the numerical distance quite accurately at low frequencies where the impedance of the earth is primarily resistive. At the high frequencies the impedance of the earth is largely capacitive and the numerical distance is given more exactly by:

$$\rho_2 = \frac{0.00505\,R}{(\xi + 1)\,\lambda} \qquad (8)$$

where ξ is the dielectric constant of earth[1] assuming air as unity. For ρ between 5 and 10 a more exact expression for the correction factor is:

$$A_4 = \frac{4 + 5\,\rho}{4 - 16\,\rho + 10.4\,\rho^2} \qquad (9)$$

For ρ greater than 10, the correction factor will be given with sufficient accuracy by:

$$A_5 = \frac{1}{2\,\rho} \qquad (10)$$

The Sommerfeld analysis neglects entirely the curvature of the earth, and therefore gives calculated field intensities which are slightly too high.

G. N. Watson has studied the propagation of radio waves over a perfectly conducting spherical earth. In his solution, the factor, A, in equation (3) is:

$$A_6 = 0.4558\,\frac{R^{1/2}}{\lambda^{1/6}}\,\epsilon^{-\frac{0.0605\,R}{\lambda^{1/3}}} \qquad (11)$$

Watson's formula does not hold for regions near the transmitter (say within 500 miles), in this region, Sommerfeld's equations will give good results. C. R. Burrows has derived an empirical formula based on Watson's results which will hold up to 8000 miles. In Burrow's formula the correction factor is: where:

$$A_7 = (1 + 2\,Z)^{1/2}\,\epsilon^{-Z} \qquad (12)$$

where:

$$Z = 0.0564\,\frac{R}{\lambda^{1/3}} \qquad (13)$$

The problem of propagation of radio waves over a spherical earth of finite conductivity has been studied, but as yet only approximate curves are available.

It is seen that the basic radiation formula is the Hertzian expression given in equations (1) and (2) and graphed on the radiation chart. To this basic equation is added a correction factor whose value depends on the degree of approximation desired. The formulas do, however, serve a very useful purpose in engineering work and whenever necessary, the computations can be checked with field intensity surveys.

[1] The dielectric constant of soils in this country varies from 5 to about 30 with a good average being 14. The dielectric constant of water is 80.

TUBES AT WORK

A two-tube measuring circuit for determining amplification factor and mutual conductance, and a tube-indicator bridge with a range from 0.1 ohm to 10^{12} ohms

A Method of Measuring Vacuum Tube Coefficients

By H. S. Polk

In measuring vacuum tube coefficients care must be taken to eliminate the unbalancing effects of interelectrode and stray wiring capacities. These are most troublesome when the dynamic plate resistance is high. The method to be described has been used with good results, possessing the advantages of simplicity and ease of adjustment.

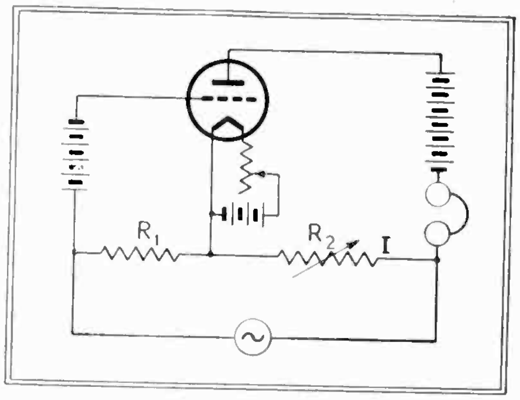


Fig. 1—The conventional measuring circuit

The conventional circuit for measuring the amplification factor is shown in Fig. 1. The oscillator applies to grid and plate circuits voltages IR_1 and IR_2 respectively which are in phase opposition. These are varied in magnitude by adjusting R_2 until a minimum signal in the phones indicate zero ac plate current. Thus

$$\mu E_g = E_p \therefore \mu IR_1 = IR_2$$

Whence $\mu = R_2/R_1$

Ordinarily zero signal cannot be obtained because of the small capacity currents through the grid-to-plate, grid-to-cathode and plate-to-cathode tube capacities as well as through stray wiring capacities. The capacitive reactances at 1,000 cycles are very large, of the order of 10 megohms. Hence when considered in series with the low impedance phones, the phase angles of these unbalancing circuits is almost exactly 90° leading. The current which prevents a perfect balance is therefore practically in quadrature ahead of the oscillator voltage and main ac plate current. It may be cancelled out by an equal and opposite quadrature current without interfering with the main in-phase current which is reduced to zero by adjusting R_2. This is also true of circuits used to measure mutual conductance and plate resistance.

Consider next Fig. 2 which is designed to measure the amplification constant of tube A. Resistors R_1 and R_2 perform the same function as before. The headphones of Fig. 1 have been replaced by R_3, the signal voltage across which is applied to the grid of tube B through the blocking condenser C_1. This voltage E_b consists of two components,

$$E_b = E_1 \sin \omega t + E_2 \sin(\omega t + \theta).$$
$$\text{where } \theta = 90^\circ$$

E_1 is reduced to zero by proper adjustment of R_2. E_2 is due to the unbalancing capacity currents and is to be eliminated from the output.

Tubes B and C have their plates connected in push-pull to the primary of the output transformer. Hence to eliminate the E_2 component from the output, it is only necessary to apply a voltage $E_2 \sin(\omega t + \theta)$ to the grid of tube C. This is done by adjustment of of potentiometer P_1 and condenser C_2 as this circuit is designed to make $X_{c_2} >> R_5$ and therefore to take a current almost in quadrature ahead of the oscillator voltage. The voltage drop across R_5 may therefore be made equal to E_2 in magnitude and phase and as the corresponding plate current components flow in opposite directions in the two halves of the primary, E_2 will be completely eliminated from the output. The headphones can be connected directly to the secondary or the secondary voltage may first be amplified and then fed to the null indicator. To obtain a balance adjustment is made alternately on R_2 and P_1 the tone becoming successively weaker until completely eliminated. C_2 is made

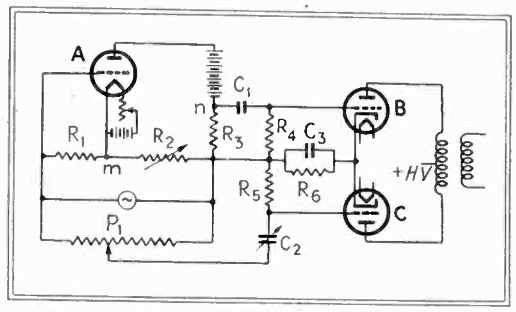


Fig. 2—Improved circuit, used to measure μ of tube A

variable so that the phase of the balancing voltage can be adjusted slightly but for the most part adjustment of P_1 is sufficient.

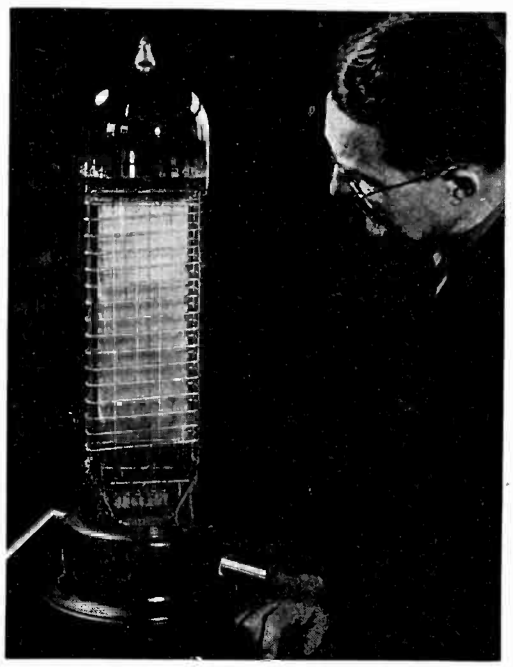
A convenient value for R_1 is 10 ohms which gives $\mu = \frac{R_2}{10}$. The potentiometer P_1 has a resistance of 500 ohms, $R_5 = 1{,}000$ ohms and $C_2 = 0.0001$ μf. max. The current in this circuit will lead the voltage by 89°56′. The input to tube B on the other hand is designed to introduce as small a phase angle as possible. $C_1 = 0.2$ μf. and $R_4 = 1$ megohm, giving a phase angle of 3′ at 1,000 cycles. $R_3 = 500$ ohms. The self-biasing circuit is of the usual type and the values of C_3 and R_6 will depend on the particular tubes used. A twin triode such as the 6F8-G will serve well for this purpose.

The same phase correcting circuit may be used in circuits for measuring mutual conductance and in some circuits for measuring dynamic plate resistance. A slight change in the circuit of Fig. 2 will enable it to measure g_m. A resistor R_7 is connected between m and n. R_2 and P_1 are adjusted and when balance is obtained it may be shown that

$$g_m = \left(1 + \frac{R_7}{r_p}\right)\frac{R_2}{R_1 R_7}.$$

• • •

ELECTRON TUBE EXPOSED



A three electrode vacuum tube of giant dimensions is specially constructed with filaments on the outside and plate on the inside. The plate is coated with fluorescent materials so that the operation of the tube can be determined visually

A Wide Range Wheatstone Bridge

By Jack Avins

The use of the vacuum-tube voltmeter for d-c resistance measurements has been largely limited to megohm bridges, although the same factors which make it more suitable for high-resistance bridges also make it desir-

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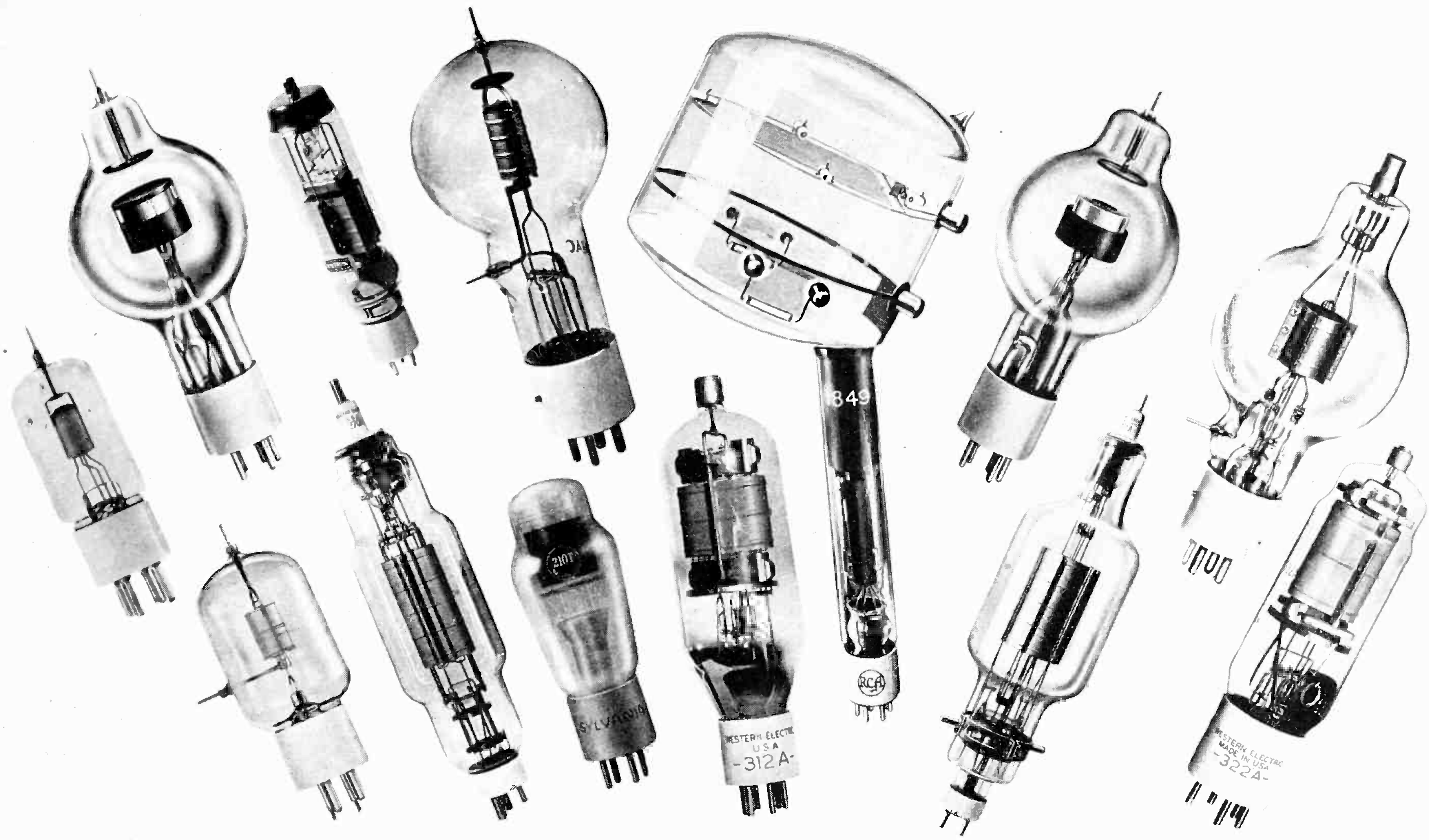

Tubes shown above are representative of the variety of tubes using Isolantite bases as made by the following companies: Eitel-McCullough, Inc.; Heintz & Kaufman; Hygrade Sylvania Corporation; Hytron Corp.; RCA Manufacturing Co., Inc.; Raytheon Manufacturing Co.; Taylor Tubes, Inc.; and Western Electric Company.

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able for general use. The bridge here described takes advantage of the electronic type of indicator and the departure from conventional ratio arm design which it makes possible the measurement of resistance over a range extending from less than 0.1 ohm to a million megohms — a range of 10^{13}. Features of this bridge are the ruggedness of the indicator, ease of operation, relatively few standard resistors required, and suitability for precision measurements as well as production checking to specified tolerance limits.

It is well known that in the conventional Wheatstone bridge, using a galvanometer as the indicator, the greatest sensitivity is secured when the four arms and the galvanometer are approximately equal in resistance. This condition, however, is not applicable where the balance indicator is voltage operated and draws zero current from the bridge network. For the latter

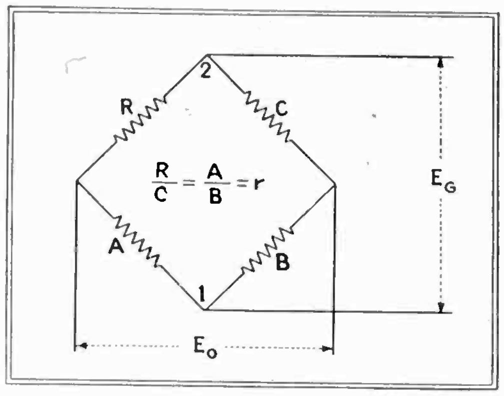

Fig. 1—Basic bridge circuit

condition the resistance of the several arms may vary by more than a million to one and yet the bridge may be operated at optimum sensitivity.

The calculation of the conditions which determine the sensitivity of a voltage-operated bridge is considerably simpler than the corresponding calculation for the case where the indicator draws current. Referring to Fig. 1, A and B represent two of the arms, while R and C represent the two remaining arms. Using the notation of the figure, the potential difference actuating the indicator is equal to

$$E_G = \frac{R}{R + C} E_o - E_o \frac{A}{A + B} \quad (1)$$

The factor denoting the sensitivity S of the bridge can be written as

$$S = \frac{\Delta E_G}{E_o \left(\frac{\Delta R}{R}\right)} \quad (2)$$

since this represents the change in voltage applied to the indicator for a fractional unbalance $\Delta R/R$ per volt applied to the bridge. Evaluating this from the expression (1)

$$\frac{dE_G}{dR} = \frac{C}{(R + C)^2} E_o \quad (3)$$

since E_o, A and B are constant.

But when the bridge is approximately

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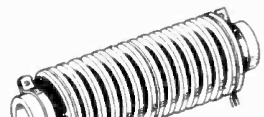

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balanced $R = rC$, so that, substituting in (2)

$$S = \frac{\Delta E_o}{E_o \frac{\Delta R}{R}} = \frac{r}{(1+r)^2} \qquad (4)$$

When $r >> 1$

$$S = \frac{1}{r} \qquad (5)$$

Thus for ratios greater than 10:1, the sensitivity of balance varies inversely as the ratio r. For a ratio of 10:1, the sensitivity is ⅓ that of the optimum value which obtains for unity ratio. For a ratio of 1,000:1, the sensitivity drops to 1/250 of the value for unity ratio.

It will be noted that the sensitivity is entirely independent of the ratio between the upper and lower arms, a factor which is used to advantage in the design of the bridge arms for wide coverage. Obviously the indicator and voltage supply positions are not interchangeable in this type of design.

In accordance with the above principles governing the sensitivity of balance, a standard decade box is used at A and together with one of several fixed resistors B forms the two lower

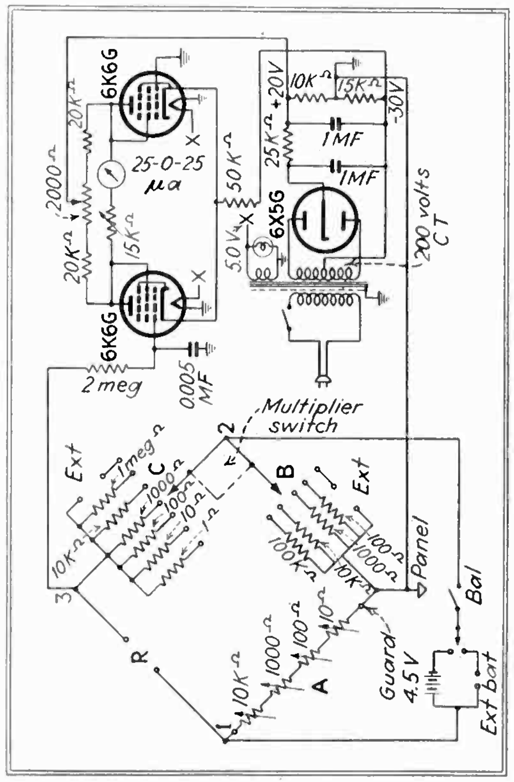
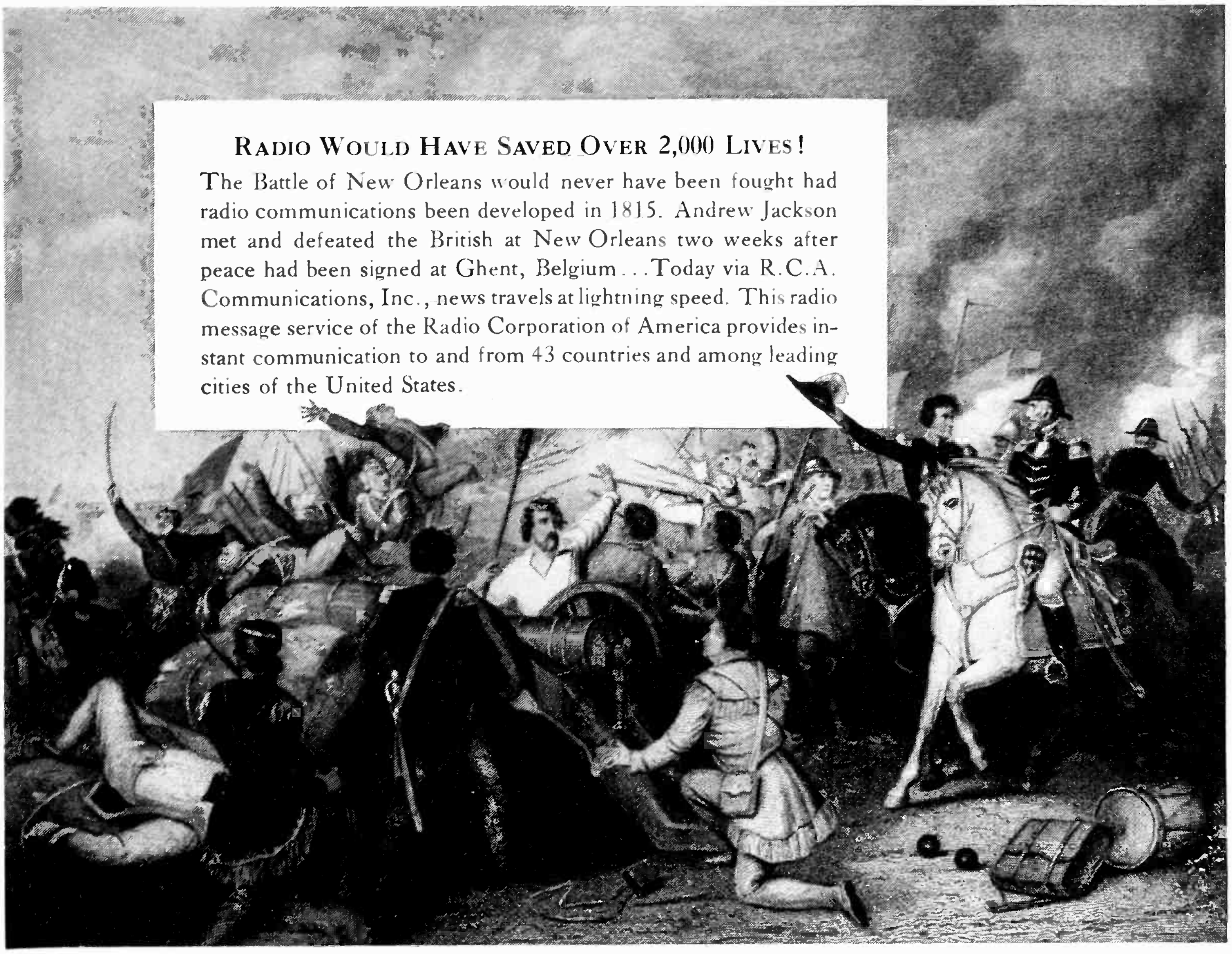


Fig. 2—Complete circuit diagram of bridge

arms of the bridge. The unknown R in conjunction with another one of several fixed resistors forms the two upper arms. To keep the ratio r near unity, B should be comparable in value to A. This immediately fixes the value of C, which must of the same order as R. By making B and C switch-controlled, this switch can be used to provide a multiplying factor in conjunction with the decade box. The values shown in the Table are such that the bridge ratio is kept close to unity over the entire range; over the range from 1 ohm to 10 megohms the ratio never exceeds 10:1. Since



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the greatest accuracy is not required ordinarily for resistances less than 1 ohm and greater than 10 megohms, the larger ratio which obtains at the extreme ends of the range is of no consequence.

Indicator Design

The expression developed for the sensitivity, that is, the voltage developed for a given fractional unbalance in one of the arms, can be used to determine the sensitivity required in the indicator. Thus from (4)

$$\Delta E_G = \frac{r}{(1+r)^2}\,\frac{\Delta R}{R}\,E_o \qquad (6)$$

When the voltage applied to the bridge is equal to 10 volts, the ratio r is equal to 10, and the desired precision of balance is 0.1%—substitution in (6) shows that the unbalance voltage created by an error of 0.1% in any one of the arms is equal to 0.001 volt. If it is assumed that the meter used in the output of the vacuum-tube indicator is capable of detecting a current of 0.2 microampere when the key is depressed, then it follows that the overall transconductance of the indicator must be 200 microamperes per volt.

Figure 2 is a complete schematic including both the bridge circuit proper and the vacuum-tube indicator. In the bridge circuit, the multiplier switch selects the proper values for the B and C arms in accordance with the table of Fig. 2. The A arm consists of a standard decade resistance box permitting settings from 10 ohms to 111,100 ohms. While a 1-ohm decade may be substituted for the larger 10,000-ohm decade, the latter is to be preferred since it permits the application of

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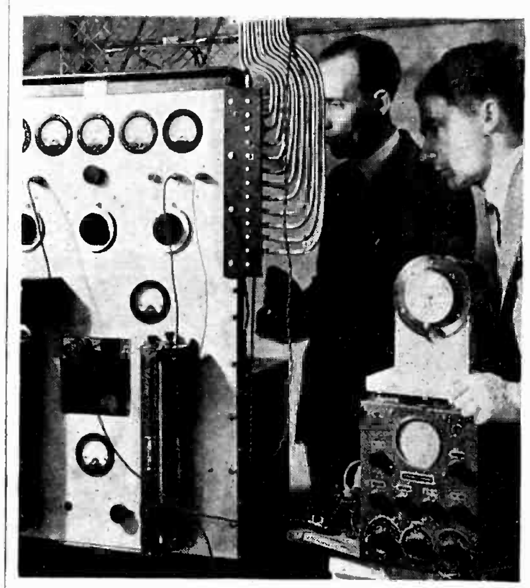

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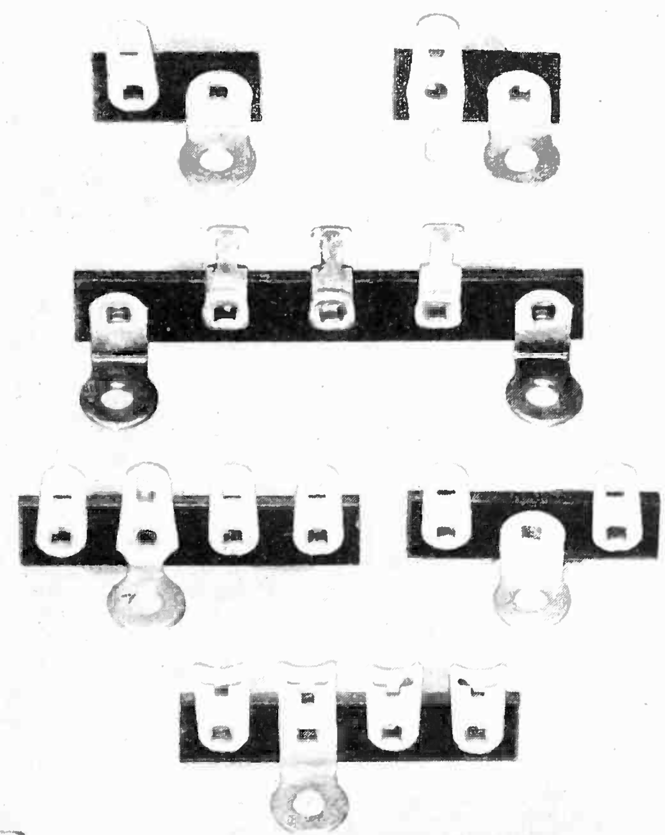

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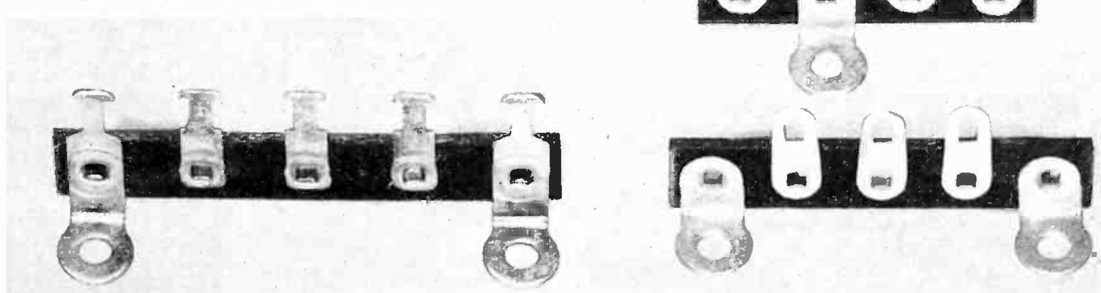

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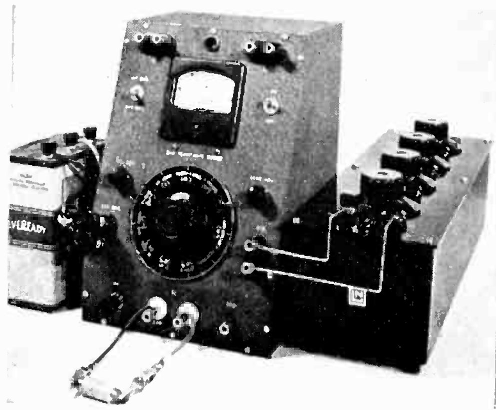
higher voltages when measuring high values of resistance. For convenience all the arms of the bridge are brought out to separate terminals when the multiplier switch is placed in the "External" position. This makes it possible to extend the range of the bridge, or to substitute other standards. The guard terminal which is also made available can be used in the measurement of three-terminal resistances.

To eliminate the necessity for batteries, the indicator is completely a-c operated. Referring to Fig. 2, it will be noted that a balanced circuit is used in which the cathodes of the two 6K6G tubes are connected together and returned through a 50,000 ohm resistor to a negative point on the power supply. The power supply is conventional and provides the plate voltage of plus 20 volts, the cathode-return voltage of minus 40 volts, and the heater voltage of 5.0 volts. These low operating voltages assure long tube life.

Because of the high value of cathode resistance, an unusually high degree of self regulation is secured. However, this is not accompanied by any appreciable loss in sensitivity since a push-pull action takes place which minimizes the degenerative effect normally obtained in a single-sided circuit. As a result of this self-regulating action, the indicator is highly stable and independent of line voltage variations over a wide range.



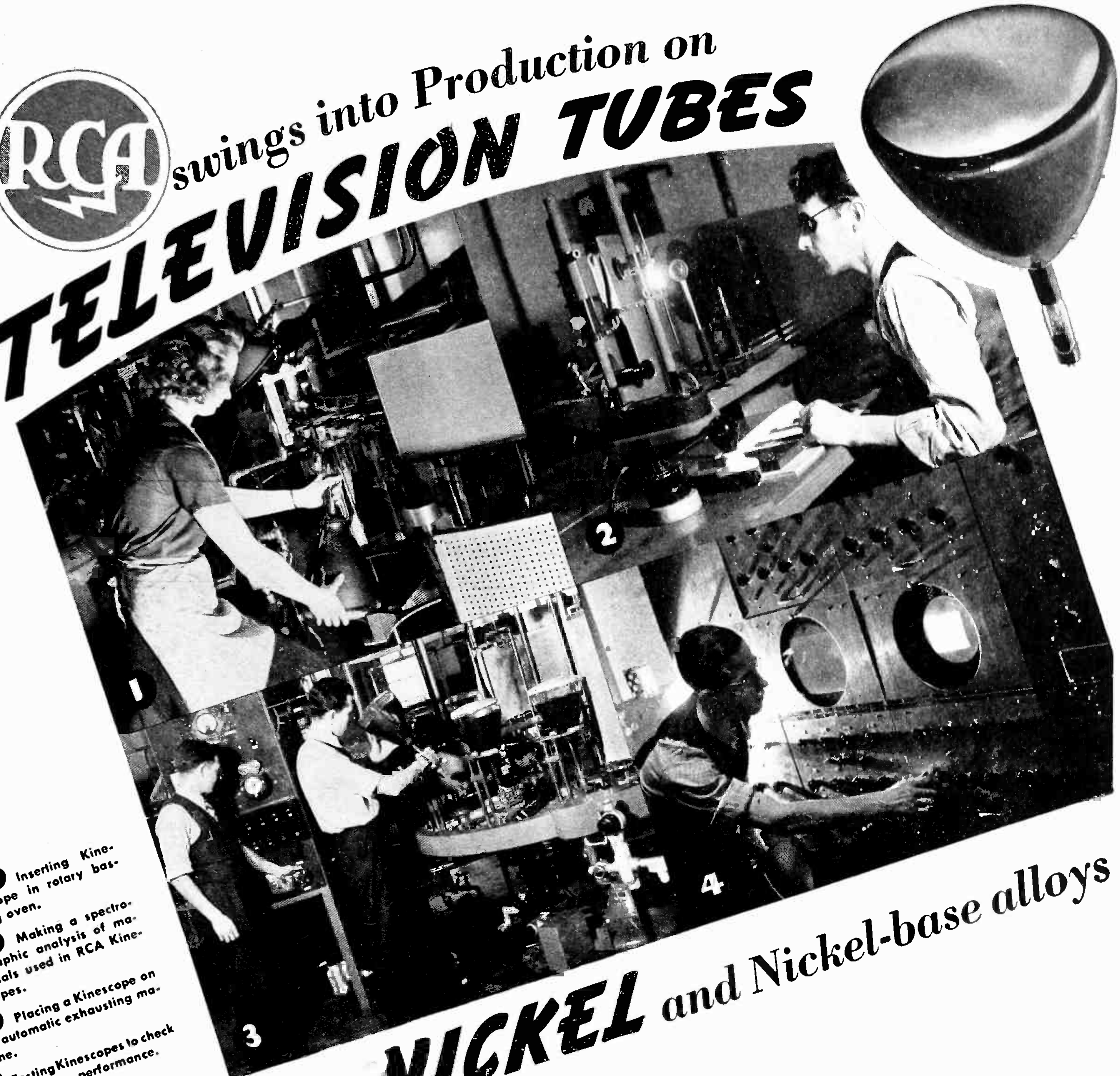
Physical appearance of wide-range unit

Possible error which might arise as the result of grid current is eliminated by reducing the grid current to a very low value and by placing the balance switch in the bridge voltage-supply circuit rather than in the indicator circuit. The choice of tube type, operating conditions, and circuit design all combine to reduce the grid current to less than 0.0001 microampere. At all times it will be noted that the total resistance in the grid circuit when the zero is being checked has the same value as that when the bridge is being balanced. Because of the low value of grid current, this condition is not essential, but it is desirable when very high values of resistance are being measured.

The galvanometer is protected against injury by means of the 2-megohm resistor in the grid circuit and the 50,000-ohm cathode resistor. Both of

RCA swings into Production on

TELEVISION TUBES



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THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

these combine to prevent an excessive increase in cathode current and consequently in the current through the galvanometer. At the same time, the grid resistor and condenser form a filter which prevents an indication as the result of stray alternating voltages.

Leakage Problems

Because of the extended high resistance range of the bridge, care must be taken to prevent stray leakage paths from impairing the accuracy of measurement. Although this may seem somewhat paradoxical at first thought, greatly improved performance can be obtained by using a conductor rather than an insulating panel. Where a metal panel is used, the leakage paths which exist are not between the several junctions of the bridge, but are directly to the guard terminal which is connected to the panel. This is especially important because of the fact that the vacuum-tube indicator and its associated B-leads are in proximity to the panel, and any leaks between these leads and points in the bridge circuit would produce an error.

As far as the insulation of points 1 and 2 from the panel is concerned, the values of shunt leakage resistance must be high in comparison with 100,000 ohms, the latter being the maximum value of resistance used in the *A* and *B* arms. This condition is of course easily satisfied. In this connection the voltage used to supply the bridge must also be carefully insulated from the panel since any leakage to the panel will appear as a shunt resistance across the *A* and *B* arms. Again this leakage must be kept to a value high in comparison with 100,000 ohms.

The point at which the insulation must be of the highest quality is at the high terminal of the unknown resistance *R*. To satisfy this requirement a ceramic insulator which has low surface leakage is used. It will be noted from the photograph that separate insulators are used for the two terminals of *R* so that these two terminals in conjunction with the panel form a three terminal network in which the leakage to the panel does not affect the accuracy; the only affect of leakage between the high terminal of *R* and the panel is to slightly lower the sensitivity of balance where high values of resistance are being measured. As long as the leakage resistance between the low terminal of *R* and the panel is high in comparison with 100,000 ohms the accuracy is not impaired.

Measurement of High Resistances

The measurement of resistances above 100 megohms is preferably made by using a 100-megohm standard in the *C* arm in accordance with the arrangement shown in Fig. 2. An inexpensive and satisfactory standard can be made by placing ten 10-megohm resistors of the metallized type in in series. Although this resistor is not so stable as a wirewound standard, it

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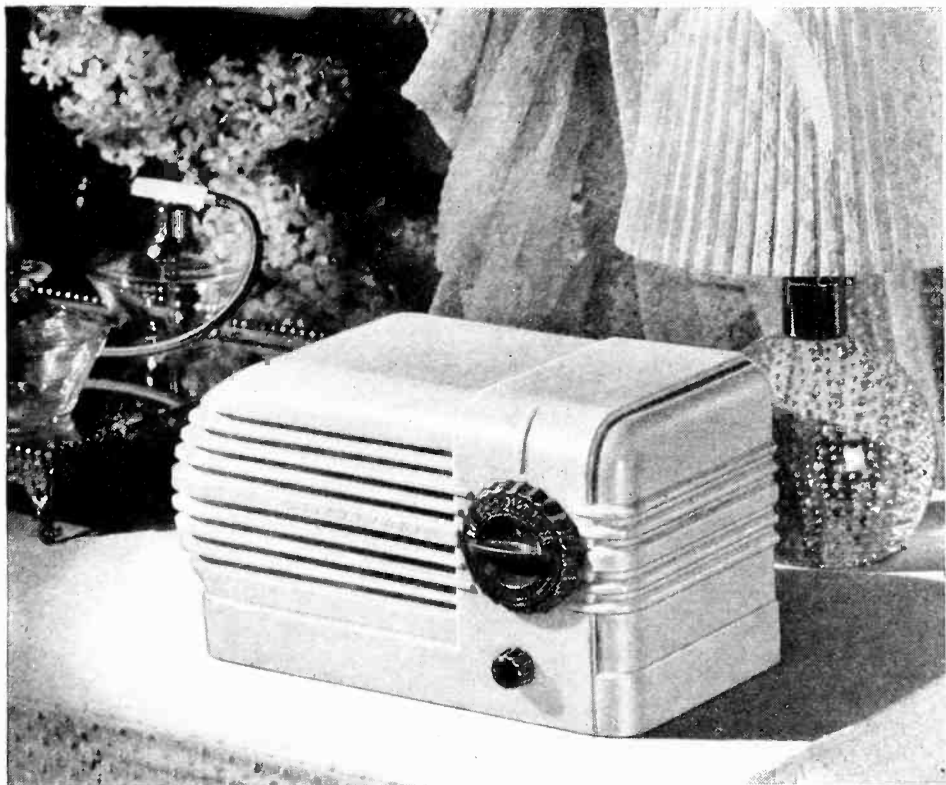
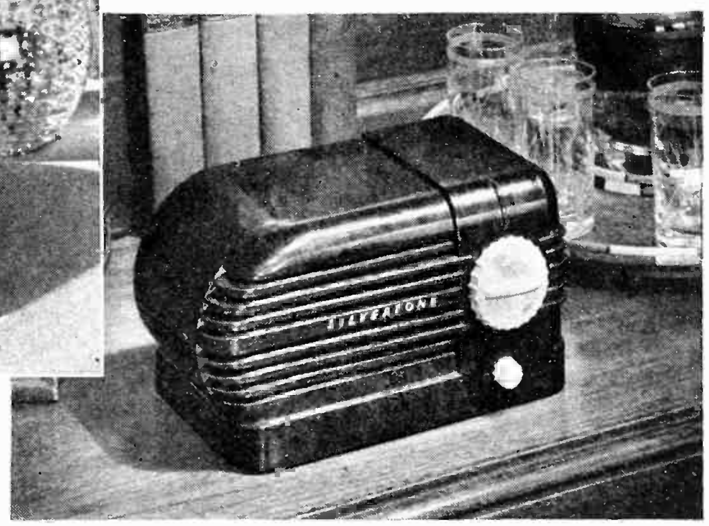


In spite of its intricate design, the entire cabinet of the Crosley Sixer is produced in a single molding operation with Bakelite Molded. Molder: Firestone Tire & Rubber Company.



Above: Easily-cleaned ivory urea Bakelite Molded imparts feminine daintiness to the cabinet of this Sears, Roebuck Silvertone model. Right: This model of the Sears, Roebuck Silvertone has a cabinet of light-weight, heat-resistant brown Bakelite Phenolic molding material. Molders: Modern Plastics Corporation.

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It will be noted that the temperature coefficient of this standard has the same values as its 10-megohm components, while the voltage coefficient is one-tenth that of the 10-megohm components. For precision work these coefficients must be taken into account.

Measurement of Low Resistances

Although the measurement of very low resistances requires the use of a Kelvin bridge, careful attention to design makes it possible to extend the lower limit of resistances which can be measured. To reduce errors due to switch-contact resistance, the minimum value of resistance used in the C arm is kept to 1 ohm; this minimum value is used for the measurement of resistances below 1 ohm. Since the switch contact resistance is less than a milliohm, the error from this source will not exceed 0.1%.

Heavy bus bar should be used to connect the low side of R to the battery junction 1 and the high side of R to the indicator junction 3. Alternatively, the need for these heavy leads can be reduced by wiring the indicator to the high terminal post of R, and by wiring one side of the bridge supply voltage directly at the low terminal post of R. Where this arrangement is followed, the internal lead resistances connecting the R arm with the A and C arms appear as part of the A and C arms rather than as part of the resistance being measured. Since the minimum value of resistance ever used in the A and C arms is 10 ohms, these lead resistances do not cause any error provided reasonably heavy wire is used.

A useful feature of the bridge is its ready adaptability for the production checking of resistors. For this purpose the indicator is provided with a 15,000-ohm rheostat which can be preset so that the maximum allowable error will cause a deflection in either direction from the zero to two fixed indices on the meter scale.

VALUES OF B AND C ARMS

Switch Position	Range-Ohms	B-Ohms	C-Ohms
1	.001–1	100 K	1
2	1–10	100 K	10
3	10–100	100 K	100
4	100–1000	100 K	1000
5	1 K–10 K	100 K	10 K
6	10 K–100 K	10 K	10 K
7	100 K–1000 K	100 K	1 M
8	1 M–10 M	10 K	1 M
9	10 M–100 M	1 K	1 M
10	100 M–1000 M	100	1 M
Ext.	100 M–1000 M	10 K	100 M
Ext.	1000 M–10,000 M	1 K	100 M
Ext.	10,000 M–	100	100 M
Ext.	100,000 M–1 MM	10	100 M

K = 1000 M = 1,000,000

THE ELECTRON ART

Impulse detector in television receivers, negative resistance oscillators, projection kinescopes, mentioned in this month's news

Output Tubes

IN AN ARTICLE "Pentode and Tetrode Output Valves" by J. L. H. Jonker, in the June issue of the *Wireless Engineer*, an attempt has been made by investigating the static and dynamic characteristics of screen grid tubes, to lay down the requirements that the static characteristics of such a tube must fulfil, in order to insure a minimum of distortion in the output under all circumstances.

To meet these requirements, it is necessary to suppress secondary emission and to make the deflection of the electron of the grids as small as possible. The passage of secondary electrons between two electrodes is subjected to close examination, an inquiry being made as to the possibility of preventing this passage of electrons by the use of two methods of suppression: a space charge and a suppressor grid. The optimum effect is obtained by the cooperation of both of these expedients, the more potent of the two being the suppressor grid. By judicially planning the geometrical positions of the electrode, deflection of the electron paths can be reduced to small magnitude.

Television Transmitter

AN ARTICLE by A. Mallein and G. Rabeteau "The Eiffel Tower Television Transmitter" in the April issue of *Electrical Communication* gives a 16-page treatment of the radiating system, video and audio equipment, power and water supply, monitoring equipment and antenna which is used at the present time in the television transmitter atop the Eiffel Tower in Paris.

The standards for picture transmission are sufficiently different from those used in the United States so that the transmitter would be unsuitable for American practice, but the article does provide a good general picture of a modern television transmitter having a nominal peak power of 30 kw. An interesting part of this article deals with the performance characteristics of the transmitter and an outline of the measuring equipment, most of which had to be developed, for determining the performance of the transmitter.

The Absolute Ampere

AN ARTICLE by H. L. Curtis, R. W. Curtis, and C. L. Critchfield, "An Absolute Determination of the Ampere Using Improved Coils," appearing in the *Journal of Research of the National Bureau of Standards* gives the the results of a new determination of the absolute value of current as measured by the current balance method. The article gives complete details of the method of measurement, as well as the results of measurements made at a number of national physical laboratories. The results obtained from this new determination indicate that 1 N.B.S. international ampere is equal to 0.99986 absolute ampere.

Reflexed Amplifiers

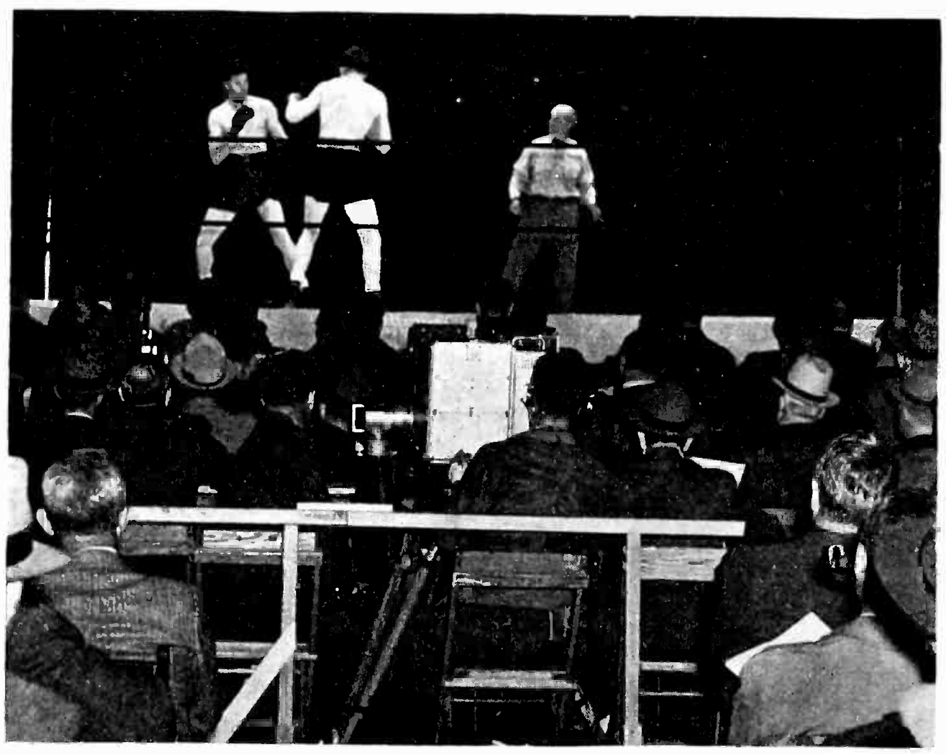
THE SUBJECT of reflexed amplifiers is opened by S. J. Watson, in an article "Reflexed Amplifiers," in the Australian *A.W.A. Technical Review* for January, 1939. Such amplifiers are employed for simultaneously amplifying the intermediate and audio frequencies in superheterodyne receivers, especially where the cost of production and size of the receiver are to be kept low. The requirements of a reflexed amplifier are high gain, low distortion, and small minimum volume.

Measurements of mutual conductance indicate that a maximum gain is obtained for a special value of resistive audio anode load, but in general values of anode load smaller than this special value are required in order to maintain the distortion within tolerable limits. The conclusion is reached that the least distortion and the least "minimum volume defect" are obtained by using the lowest feasible grid bias and adjusting the screen voltage so that the tube operates at the peak of the mutual conductance curve.

In operating a fixed bias reflexed amplifier, conditions of screen and grid voltages should be selected so that the tube operates over the region of the maximum of a mutual conductance curve. For any specified conductance curve the peak is shown to give maximum gain and minimum overall distortion.

The figure of merit or overall gain depends upon the values of each of the anode loads in the plate circuit of the tube, but at an optimum value of resistive load it reaches a maximum independently of the transformer load. This optimum value of resistive load

TELEVISING NOVA-BAER FIGHT



First television program of prize fight occurred June 1 when the Nova-Baer fight was staged at the Yankee Stadium. This photograph, taken during the semi-final bout between Max Marek and Wally Sears shows the television camera at the ringside

FORMICA

FOR SPECIAL PURPOSES!

IN THIS single element radio safety core produced by Arthur O. Austin of Barberton, Ohio, a special canvas base Formica tube 3½"x5"x 20" is used as the safety core. To each end of the Formica tube is attached a metal collar, one attached to the base of the insulator and the other to the bolt seen at the top. The porcelain tube is placed between the castings with seals at each end and the whole is filled with oil. The Formica has to take a compressive strain of upwards of 40 tons. There is a grade of Formica for every purpose for which materials of the type can be used. Consult our engineers about your insulating problems.

THE FORMICA INSULATION CO.
4638 Spring Grove Ave., Cincinnati, O.

FORMICA

● Formica is made in a large number of grades and variants to adapt it to a large number of insulating purposes. Mechanical strength, resistance to moisture absorption, resistance to chemical action, punchability and machinability are some of the qualities emphasized in these various grades. Put your insulating problems up to our engineers.

may be found by means of a simple geometrical relationship.

Low distortion and low minimum volume are associated with operating conditions which employ low screen voltages, low resistive anode loads and high values of mutual conductance. Except in special cases, therefore, a compromise must be made between gain and distortion in the design of a reflexed stage.

The reflexed tube, owing to the minimum volume effect, must be followed by a power output valve, and not by an audio driver or preamplifier feeding the power stage.

Radio Slide Rule

A BRIEF DESCRIPTION of a slide rule designed specifically for the radio engineer, and manufactured by the Keuffel & Esser Co. is given in the June issue of the *Bell Laboratories' Record*. In addition to the ordinary scale usually provided, the radio slide rule carries the usual L scale with an added db designation which is used for the conversion of ratios of power, voltage, and current in reference to the D scale. The LC constants for a given frequency, the values of inductance and capacitance to resonate a reactive circuit, and the transformation of vectors from rectangular to polar form or vice versa, may be determined. Scales are also provided to simplify the calculation of propagation of radio waves.

The Impulse Detector in Television

AN INTERESTING and straightforward treatment of the television amplifier problem is contained in an article entitled, "Point Detectors-Applications to Television" by R. Barthelemy in the October 1938 issue of *L'Onde Electrique*.

One of the fundamental problems arising in television is to separate the two types of periodic signals in which only the ratio of maximum amplitudes alone is determined, viz; the amplitudes may be variable.

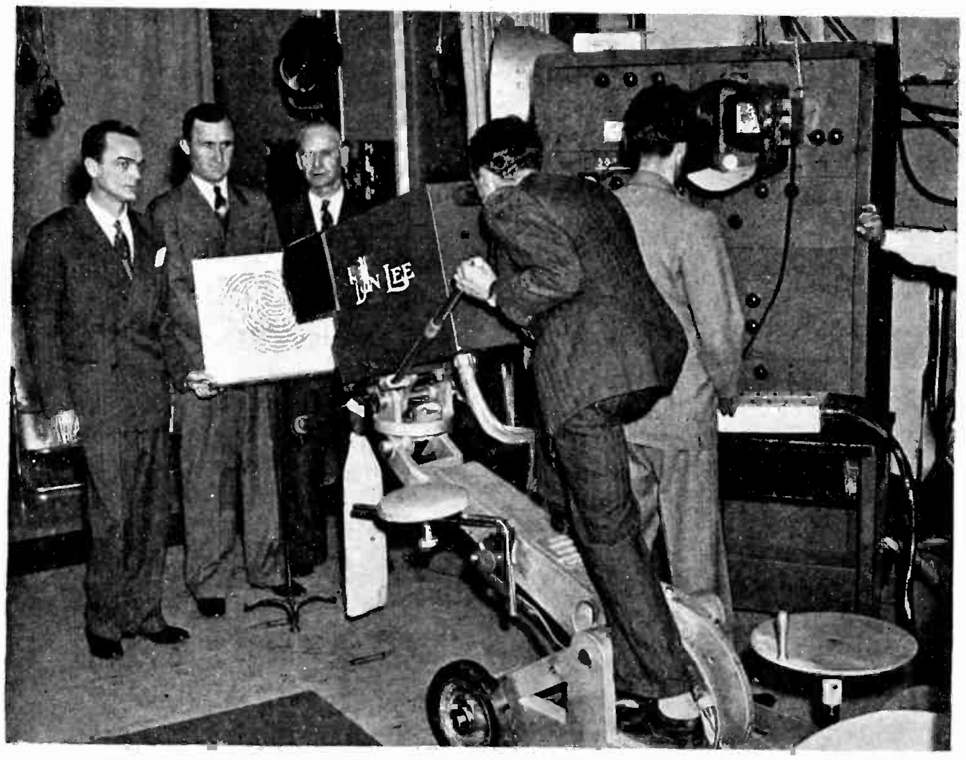
In the case of fixed amplitudes, the solution is simple in that one signal is eliminated by a diode or a suitably polarized tube. If the amplitudes vary then it is necessary to regulate the polarization as a function of these variations. The purpose of the article is therefore designed to show how this regulation may be obtained automatically.

Due to the oscillatory current introduced in the detector circuit, a current i flows to the anode and condenser C acquires a charge Q according to the relation:

$$Q = CRi.$$

The oscillatory voltage μ is effective in driving current i through the tube only to the extent that its amplitude is superior to the polarizing voltage Q/C i.e. the portion of voltage μ which is of higher amplitude than Q/C serves to furnish the current i in the detector.

CRIMINAL IDENTIFICATION BY TELEVISION



A set of fingerprints, transmitted by television from W6XAO in Los Angeles, was received by police in Long Beach who made a correct identification and telephoned their result back to W6XAO. Police officials who witnessed the demonstration expressed the opinion that television might become a valuable means of identifying criminals

A state of equilibrium is attained after a time and a definite interdependence is found to exist between polarizing voltage Q/C and the maximum amplitude of μ.

The quantity of charge lost by the condenser due to discharge through the resistance R is compensated for by the current i flowing through the circuit. The equation which determines the relationship is:

$$\int_{t_1}^{t_2} idt = \int^{T} Q/CR\, dt \qquad (1)$$

where the limits t_1 and t_2 are determined from the wave-shape of the oscillatory voltage μ.

Consider the case of a wave-shape such that the time-constant CR is always large in comparison to the period T of the voltage μ. Thus by

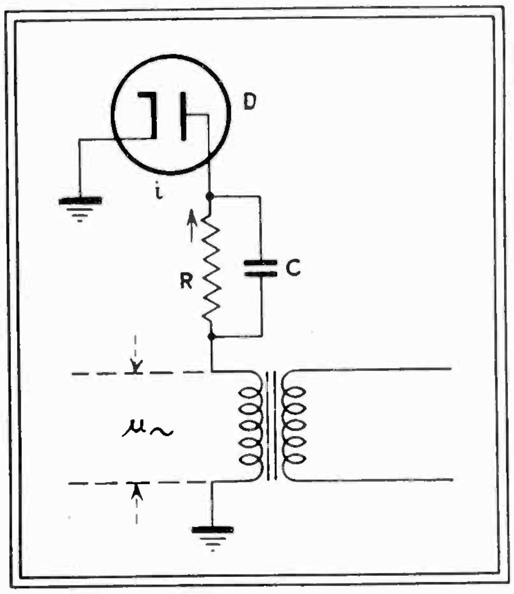


Fig. 1—Schematic wiring diagram of impulse detector

giving CR a value equal to $20T$ the variation of Q/C does not exceed 5 per cent in the course of a period T and may be considered constant. The current due to the condenser C which flows in R may likewise be considered constant, hence:

$$\int_{t_1}^{t_2} idt = Q/CR\ T$$

To simplify matters suppose the detector characteristic to be linear, i.e. in a sense it presents a constant internal resistance ρ. The circuit impedance for the most part being negligible for the impulse-moments under consideration. The current i is given by:

$$i = \frac{\mu - Q/C}{\rho} \text{ during the interval } t_2 - t_1.$$

The relation (1) can now be rewritten as:

$$\int_{t_1}^{t_2} \frac{\mu - Q/C\ dt}{\rho} = Q/CR\ T$$

The instants t_1 and t_2 are determined by:

$$\mu_a = Q/C$$

μ being expressed as a function of t. For a rectangular wave-shaped figure or signal of amplitude U as used in television, it is shown that if we desire to eliminate all the signal which is under 90 per cent of the amplitude U, the ratio $\delta = R/\rho$ becomes $\delta = 90$. It is therefore desirable to operate with a diode having a low internal resistance in order that R may be kept from being many megohms in value.

It should be kept in mind that the value of R thus determined is the suitable minimum value and that although higher values of R will give more assured separation it will simultaneously result in a reduction in useful signal amplitude.

In order to meet the actual transmission conditions which do not possess the idealized properties which were previously imposed for simplicity, it is necessary to make use of a double diode circuit such as shown in Fig. 2.

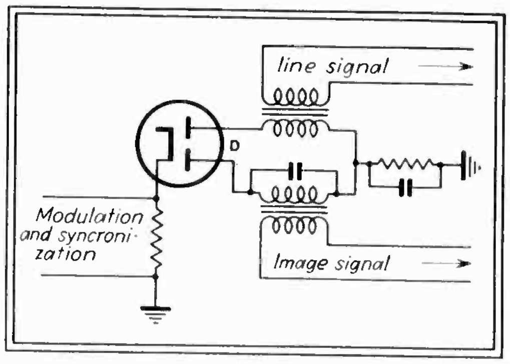


Fig 2—Double diode impulse detector circuit

It can be seen that the R-C combination develops a voltage which may be utilized for automatic amplification control.

The author illustrates the case for a sinusoidal voltage wherein he shows that for an equivalent amount of protection i.e. for equivalent ratios of Q/C to U the values of δ in the sinusoidal and the preceding rectangular wave case compare as 13 to 23 respectively. The difference is attributable to the increased time interval in the sinusoidal-wave case. In conclusion the author considers the amplitude control obtainable from a triode by utilizing the lower bend in its characteristic, and points out to what extent the resultant operation may be compared with similar actions in the previously studied diode detector circuit.

Cathode Ray Tube in Mass Production

TWO EXAMPLES are discussed of cases in which the cathode ray oscilloscope make it possible to adapt an otherwise rather complicated measurement to the tempo of mass production in an article entitled "Application of Cathode Ray Tube in Mass Production," by H. van Suchtelen in the March issue of the *Philips Technical Review*. The first application refers to the determination of the resonant curve of radio receiving sets and the second refers to the detection of defects in the winding of motors or dynamo armatures.

Projection Kinescopes

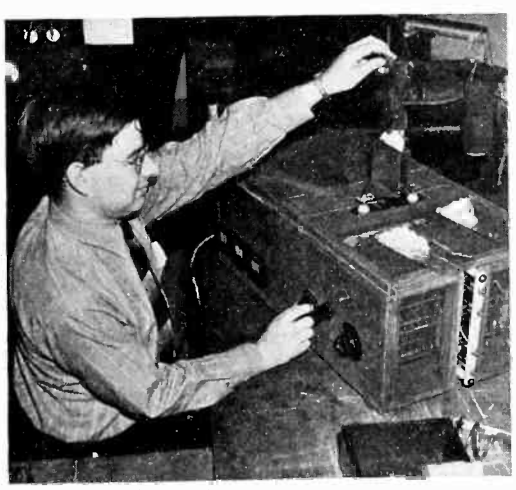
PROJECTION KINESCOPES have been the subject of considerable investigation and speculation. Distinguished groups of workers have concentrated on direct magnification of the primary received image. A few have attacked this elusive problem by seeking to apply a signal modulated secondary image device. An interesting proposal along this second approach has recently appeared by Manfred Von Ardenne in *Telegraphen-Fernsprech-Funk-und Fernseh Technik*, 1938 supplement pp. 518–524.

The author, bases his tube design on the experiments of Ch. Schramm[1] with electron optic effects in zinc blende crystals. In the suggested tube a video-modulated beam strikes a crystal screen composed of native zinc sulphide. The electric field produced about this crystal causes the screen's optical polarizing angle to rotate to a degree dependent on the field strength. A polarized beam which a projection lamp throws on the crystal is thus subjected to further polarization as it passes thru the crystal and produces an enlarged image on a motion picture screen after the beam has passed thru a polarizing filter and a projection lens. The scanned portions of the crystal remain charged until they are blanked out by an auxiliary discharge beam which is in synchronism with the television image beam and is timed to precede it by a short distance.

The storage effect obtainable with the proposed system obviously would permit reductions in line and picture frequency requirements, and would improve flicker.

[1] Ch. Schramm, "On the Electron Optical Effect in Zinc Blende." *Annalen der Physik* (5) 25, page 309, 1936.

ELECTRON TUBE CORN POPPER



Charles Millikan, graduate engineer at the California Institute of Technology, pops corn in a cellulose bag by using short radio waves. The device operates on the same principle as that employed in diathermy machines, but is rather uneconomical when used solely for corn popping

ORTHICON

(Continued from page 14)

Thereafter the beam travels into the tube proper, shown in Fig. 10. A coil surrounding the tube produces a uniform magnetic field whose lines of force are parallel to the axis of the tube. The low-velocity electrons in the beam, when left to their own devices, travel along these lines of force. Deflection is accomplished by superimposing on the magnetic field an electrostatic field between two large deflecting plates. The actions of these deflecting plates is shown in Fig. 8. The deflecting plates impart a transverse motion to the electrons, in the direction of the positive plate. This transverse motion, through the axial magnetic field, causes the electron to describe a path which projected on the end-view resembles a half circle, returning the electron to its original distance from the positive plate. The half-circle motions are repeated and the result, as projected, is a cycloidal motion which displaces the beam to the right as shown. During this motion, the beam is proceeding forward. Consequently when it emerges from the deflecting plates, the beam has been moved sidewise by the width of the cycloidal motion. However, on emerging from the plate, the beam no longer executes the cycloidal motion but takes a path depending on its components of velocity at the instant of leaving the field between the plates. If the electron happens, at this point, to be at the bottommost point of one of cycloids, the path after emerging is a straight line parallel to the axis of the tube.

The cycloidal motion is a means of deflecting a beam without introducing any angular deviation between the beginning and end of the electron motion. While the cycloidal motion is a possible mode of operation it is difficult to control. The cycloidal motion may be modified, as shown by the line (B) in Fig. 8, to a motion which moves directly across the tube. This modification of the cycloidal motion is obtained by using deflection plates with appreciable fringing field at their edges. The electron is thus introduced into the electric field gradually, and the cycloidal motion gives way to a straight-line motion across the tube. By means of curving the edges of the deflecting plates, the necessary fringing field is established, and the smooth deflection motion obtained.

A similar type of deflection could conceivably be used for both directions of scanning (vertical as well as horizontal), but it is more convenient to restrict this type of deflection to the high-speed horizontal motion. The low-speed vertical motion may then be introduced by the use of a transverse magnetic field imposed, as shown by Fig. 9, by a pair of magnetic coils whose axis is at right angles to the tube axis. This type of deflection tends to set up helical motions in the beam, but the diameter of the helices is so small that they do not affect the geometry of the scanning pattern or the sharpness of focus.

A diagram of the complete tube is shown in Fig. 10. The internal coating of the tube is grounded, and the cathode of the electron gun is operated at about —25 volts with respect to ground. The two-sided mosaic target at the other end of the tube assumes cathode potential automatically. The horizontal deflecting plates cause the beam to move along each line of the image, while the vertical deflecting coils cause the vertical frame-scanning motion. The electrons travel to the mosaic, and arrive there with substantially no velocity. As one observer put it, the electron "nuzzles" the globules of the target. If photoelectrons have been lost at that point, due to the influence of the optical image, the beam electron is collected by the mosaic, otherwise it turns around and travels back to a collector electrode near the cathode.

The authors of the paper illustrated the results obtainable with it in several lantern slides. One of these, of the toy duck which serves as a studio subject, is reproduced on the cover of this issue. Others showed absence of uneven shading in the background, and freedom from streaking.

The Orthicon is still in the experimental stage, and no plans for its commercial production have as yet been formulated. However, there is no doubt that some time in the future it will be available for use in regularly-scheduled television transmissions.—D. G. F.

THE INDUSTRY IN REVIEW

News

✦ Donald M. Simmons, chief engineer of the General Cables Corp. was awarded the honorary degree of Doctor of Engineering by Princeton University . . . WTIC, Hartford, Conn. is getting two new vertical radiators. Directional array will prevent interference with KRLD of Dallas, Tex. Blaw-Knox is doing the job . . . Willard H. Cobb has been appointed general manager of the Mechanical Goods and General Products division of the United States Rubber Co . . . NBC has doubled the time of television broadcasts. At least eight of the ten program hours weekly will be presented by live talent . . . The first television queen was selected at the New York World's Fair . . . The Universal Microphone Co., Inglewood, Calif. has been granted a license by Western Electric, ERPI and AT&T to cover all microphones manufactured by that company, past, present and future . . . RCA is popularizing electronics with the introduction of a group of electronic toys. One kit contains condensers, inductance coils, resistors, a radio tube, a microphone, etc. and a booklet which explains the different parts and gives instructions for using them. A sound effects kit has apparatus to produce 22 different sound effects . . . The New York Herald-Tribune is cooperating with RCA to publish a facsimile newspaper at the World's Fair . . . Western Union has several automatic facsimile telegraph transmitters in operation at the San Francisco Fair . . . The first sound installation on an ocean going vessel to utilize hill-and-dale transcriptions was made by Western Electric on the new passenger liner SS Panama . . . A group of 500 deaf persons had its first experience with wireless communication at a television demonstration at the Frisco Fair.

Literature

Crystal Calibrator. Inexpensive device for indicating 100 and 1000 kc points described in Bulletin E-7 by Bliley Electric Co. Erie, Pa.

Selenium Rectifiers. A discussion of the characteristics and uses in a bulletin by International Telephone Development Co., Inc., 67 Broad St., New York.

Condensers. For radio and automotive use described in catalog sheet by H. R. S. Products Co., 703 N. Cicero Ave., Chicago.

Dynamotors. Bulletin 14-25 gives specifications of a variety of sizes. Janette Mfg. Co., 556 West Monroe St., Chicago.

Test Set. For line and cable fault location in signal and communication circuits. Catalog E-53-44(1) Leeds and Northrup Co., 4907 Stenton Ave., Philadelphia.

Coaxial Transmission Line. Bulletin 101-B on ¾ inch line and Bulletin 101-C describes larger sizes. Isolantite, Inc., 233 Broadway, New York.

Electrical Connecting Devices. Specifications and list prices given in set of bulletins by Howard B. Jones, 2300 Wabansia Ave., Chicago.

High Fidelity Radio. Discussion of receiver in Bulletin 103 by Pacent Engineering Corp., 79 Madison Ave., New York.

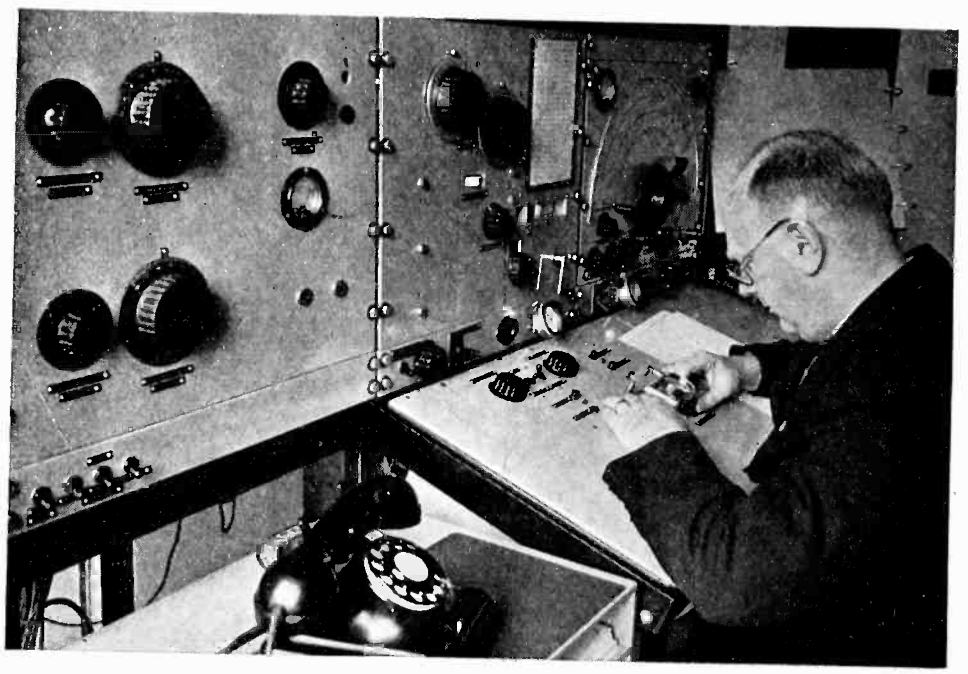
Variacs. Description and specifications in Bulletin 242-C by General Radio Co., Cambridge, Mass.

Pilot Lamps. Discussion of operation in series heater operated receivers in Bulletin 39-3. Also diagrams of tube bases. Tung-Sol Lamp Works, 95 Eighth Ave., Newark, N. J.

Electrical Specialties. Large variety described and also discussion of electrical equipment in new catalog of Ideal Commutator Dresser Co., Sycamore, Ill.

Circuit Breaker. In Catalog 6-c, insulation and bushing tester in Catalog 11-a, potential indicator in Catalog 11-b, and control relays in Catalog 12. Roller-Smith Co., 1766 West Market St., Bethlehem, Pa.

CONTROL BOARD OF INTERNATIONAL UNION OF RADIO FUSION



The apparatus shown here monitors the short and long waves and is used to indicate the source of short wave interference at the International Union of Radio Fusion

Steatite. Bulletin 39 gives more complete information than before. American Lava Corp.,, Chattanooga, Tenn.

Circuit Breakers. A discussion of two solutions of the problems involved in circuit breaking in power stations. Publication GEA-3143, General Electric Co., Schenectady, N. Y.

Insulation. A large variety of electrical insulation materials described in Catalog 11, Insulation Manufacturers Corp., 565 West Washington Blvd., Chicago.

Power Cable. Description, applications, physical and electrical properties of rubber insulated cable in Publication C-42, Anaconda Wire & Cable Co., 25 Broadway, New York.

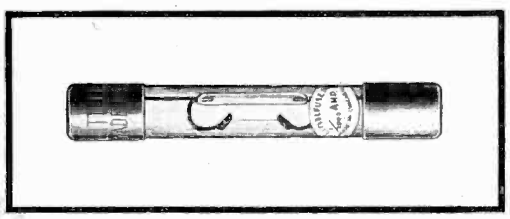
Television. General description including the manufacture of cathode-ray tubes. Inco, Spring edition, 1939. Also Hardness Conversion Table for nickel alloy steels (revised). International Nickel Co., 67 Wall St., New York.

Characteristic Sheet. For radio tubes. Ken-Rad Tube and Lamp Corp., Owensboro, Ky.

New Products

Television Fuses

A SERIES of vacuum enclosed "Video" Littelfuses has been announced by Littelfuse, Inc., 4238 Lincoln Ave., Chicago. There are six sizes available between 1/1000 and 1/16 ampere. These



fuses protect high voltage equipment against damage and protect operators against lethal shocks. Because they operate in vacuum, the fuses will break as high as 20,000 volts.

Loudspeakers

THE WORLD'S LARGEST electrodynamic speaker, 27 inches in diameter, is announced by Cinaudagraph Corp., Stamford, Conn. This speaker has a linear response from 30 to 10,000 cps at a level of 85 watts. The voice coil is six inches in diameter and works in a gap whose flux density is 21,000 lines per sq in. The total weight of the speaker is 455 lbs. The list price is $500.

A DUAL LOUDSPEAKER with a low frequency unit and a high frequency unit in a single housing is announced by University Laboratories, 195 Chrystie St., New York. The frequency response is substantially flat from 60 to 10,000 cps without the use of filter networks. The power capacity is 25 watts continuously. A smaller unit is also available.

A LINE OF PERMANENT magnet and electro-dynamic speakers is announced by Lansing Mfg. Co., 6900 McKinley Ave., Los Angeles, Calif. These speakers are available in sizes from five inches to fifteen inches and are furnished complete with transformers.

Walnut Cabinet Amplifiers

AMPLIFIERS ARE NOW being placed in attractive matched burl walnut cabinets by Thordarson Electric Mfg. Co., 500 West Huron St., Chicago. These

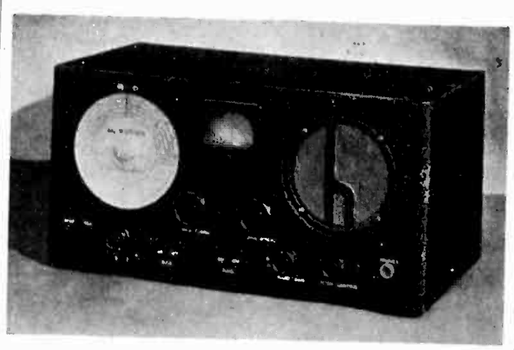
cabinets feature a sloping front panel with "Edge Glow" illumination which makes for ease of operation and minimizes the need for remote control. These units are rated at 20, 30 and 45 watts.

Relay

A NEW GENERAL PURPOSE transmitter relay has been announced by Advance Electric Co., 1260 W. Second St. Los Angeles, Calif. This relay has been designed primarily as a substitute for larger and more expensive relays. The entire relay is above ground and may be mounted on any type of panel by means of the metal mounting bracket.

Communications Receiver

A REVISED MODEL of the Sky Buddy receiver is announced by Hallicrafters, Inc., 2611 Indiana Ave., Chicago. The



new receiver, model S-19-R, has six tubes including the 6K8G. Continuous coverage from 545 kc to 44 Mc is pro-

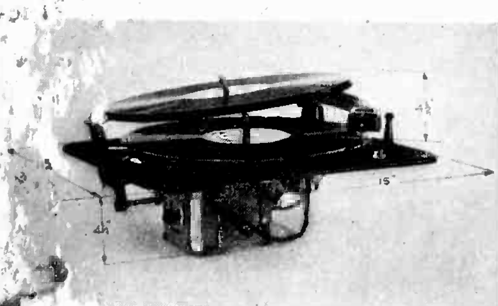
...by four bands. Easy tuning is ...d by an electrical band spread ...n. Other features are a self-con...ned dynamic speaker, a head-phone ... which cuts out the speaker when ...phones are plugged in, send-receive ...ch, beat frequency oscillator with ...h control and on-off switch, a-v-c ...ff switch, and audio gain control.

...urrent Flow Test Set

...RRENT FLOW TEST Set No. 695 for ...ys has been announced by Shall... Mfg. Co., Collingdale, Pa. The ...se of this instrument is to pro... a convenient and rapid means for ...ing the flow of current through ...ys and other apparatus. The cur... through the relay may be regu...d and measured so that the operate ... non-operate currents may be deter...ned.

Record Changer

A NEW RECORD CHANGER, model RC-... announced by Garrard Sales ..., 296 Broadway, New York. A non-slip spindle eliminates the possibility of



...slippage regardless of warpage. It is considerably smaller than the ...vious model and is mounted so that ... unit floats free of the cabinet. It ...ailable with either a crystal pickup ... high impedance magnetic pickup.

...-way Radio Telephone

...NEW TWO-WAY RADIO telephone has ... announced by Western Electric ... 195 Broadway, New York for use ...ice and fire departments for ... communication. The output has ...ncreased to fifteen watts, three ... as much as in previous models, ... little increase in demand on the ... storage battery. A relay circuit ... off the output of the receiver in ...bsence of any signal. Therefore, ... no sound comes through the ... receiver or loudspeaker ex...ing periods of transmission.

...levision Transmitter ...uipment

TYPE 203 Synchronizing-Signal ...r for studio control in tele... transmitting stations has been ...nced by Allen B. DuMont Labs., ... Main Ave. Passaic, N. J. It has ... designed to operate as the master generator for all synchronizing, e[illegible]ing, scanning and blanking [illegible]s which are a necessary part of the com[illegible]posite video signal fed to the transmitter. The equipment locks into synchronism at any phase with the power supply frequency within 30 seconds after it is turned on so that there is no necessity to keep the equipment operating 24 hours per day. The construction is such that it is capable of supplying control signals for many possible future changes in television standards. This company is also in a position to supply complete television transmitters.

Mirrors

FRONT SURFACE mirrors for use in the lids of television cabinets are available from Evaporated Metal Films Corp., Ithaca, N. Y. and Semon Bache & Co., Greenwich & Morton Streets, New York.

Television Receivers

TWO TELEVISION receivers are announced by Pilot Radio Corp., 37–06 Thirty-sixth St., Long Island City, N. Y. Model 4095 has a nine-inch picture tube and an eight tube all-wave audio receiver and model 4125 has a twelve inch picture tube and a twelve tube all-wave audio receiver. Both receivers have a video i f of 12.75 Mc

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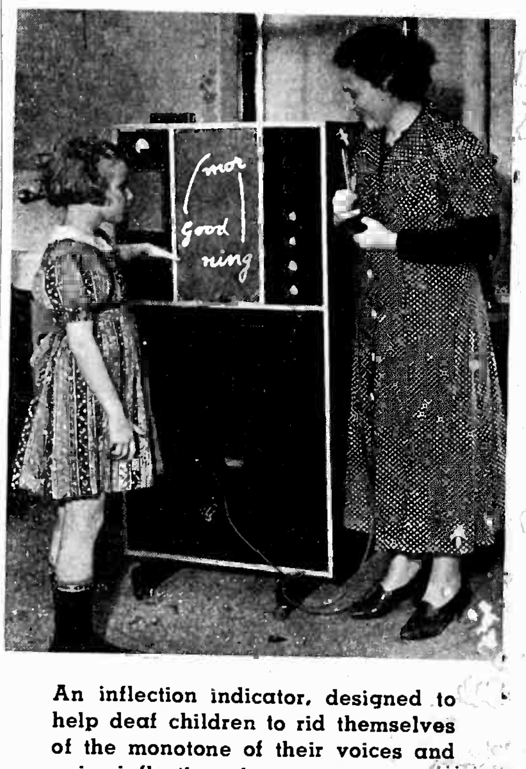
INFLECTION INDICATOR FOR THE DEAF



An inflection indicator, designed to help deaf children to rid themselves of the monotone of their voices and gain inflection, is now in use [illegible] the Central Institute for the Deaf [illegible] St. Louis. An electronic frequency meter records the inflection of a person's voice on a column of seven lights and simultaneously transmits vibrations which the person can feel.

and an audio i f of 8.25 Mc. Both have a 200 microvolt sensitivity and a band width of four Mc. Magnetic deflection is used in both receivers.

Decimal Equivalent Chart

A DECALCOMANIA measuring 8 by 1¾ inches which contains all the usual decimal equivalants from 1/64 to 63/64 inches is offered free by The Frederick Post Co., Box 803, Chicago. It is sized to fit the T-square so as to eliminate squinting at the distant figures of a wall chart.

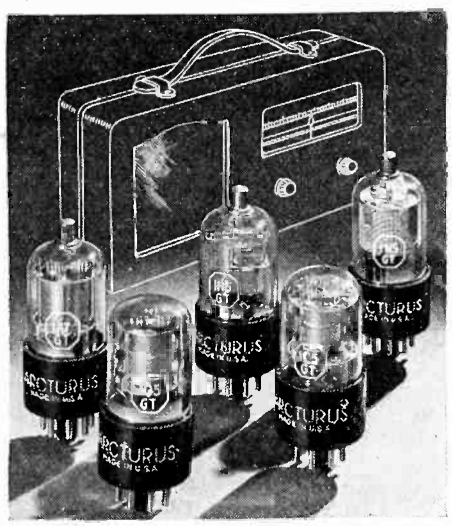
Volt-ohmmeter

A VACUUM TUBE volt-ohmmeter, Model 660, was recently announced by Radio City Products Co., 88 Park Pl., New York. It will measure as low as 0.1 volts and as high as 6000 volts. The resistance range is from 0.1 ohms to 1000 megohms. There are twelve ranges on this instrument.

New Tubes

AMONG THE NEW tubes announced by Hygrade Sylvania Corp., 500 Fifth Ave., New York are type 117Z6G, a full wave rectifier designed to operate with the heater directly across the a 117 volt power line, type 1232, which is similar to type 1231, except that additional shielding has been provided, and types 5AP1/1805-P1 and 5AP4/1805P4, television picture tubes with green and white screens respectively which are electrostatically deflected.

SIX 1.4-VOLT tubes have been introduced by Arcturus Radio Tube Co., Newark, N. J. They are: 1A5G and



GT, power output pentode; 1A7G and GT, pentagrid converter; 1C5G and GT, power output pentode; 1H5G and GT, diode-triode; 1N5G and GT, r-f pentode; and 1Q5G and GT, beam power output tube. Also announced by Arcturus is a line of eight new dial lights.

A LOW COST type 866 mercury rectifier tube having a filament shield has been announced by Hytronic Laboratories, 76 Lafayette St., Salem, Mass. A pair of tubes will deliver up to 500 ma at d-c voltages up to 2385.

A COMPLETE LINE of television picture tubes, both electrostatically and electromagnetically deflected, has been announced by Cath-Ray Electronics Corp., 115 Edison Pl., Newark, N. J.

A SEVEN-INCH and a five-inch cathode ray tube are announced by Northern Manufacturing Co., 36 Spring St., Newark, N. J.

SEVERAL NEW TUBES are announced by RCA Manufacturing Co., Harrison, N. J. Types 2050 and 2051 are hot-cathode gas tetrodes, type 1624 is a transmitting beam power amplifier,

types 924 and 927 are gas phototubes with caesium-surfaced cathodes, type 925 is a vacuum phototube with a caesium-surfaced cathode, type 926 is a vacuum phototube with a rubidium-surfaced cathode, and type 5AP4/1805-P4 is a 5-inch electrostatic deflection kinescope with white phosphor.

Rotary Converters

A NEW LINE of rotary converters, the Pincor "K" Series, is announced by Pioneer Gen-E-Motor Corp., 466 West Superior St., Chicago. The following units are available: Type AK, 100 to 200 watts; Type BK, 300 to 500 watts and Type CK, 750 to 1000 watts as well as units of greater capacity. They are available with filters for radio operation. Pioneer also announce new lines of motor generator sets and centrifugal pumps.

Contour Shaping Machines

DO-ALL CONTOUR SHAPING machines are available from Continental Machines. Inc., Minneapolis, Minn. Contour sawing, filing and polishing are all done on one machine which also replaces such operations as nibbling or torch cutting. Large savings are possible in cutting tool steel, special shapes, making jigs and fixtures, templates, automatic true circles, cutting non-ferrous metals and plastics, and making experimental parts and models. There are several sizes available.

Television Antennas

A NEW DIPOLE television antenna has been announced by Consolidated Wire & Associated Corps., 520 S. Peoria St., Chicago. There are two telescopic brass rods which allow for adjustment to the exact frequency to be received. A low loss transmission line is used, 75 feet of which is provided with the unit.

A TELEVISION antenna with universal joint mounting which permits adjustments in all directions is announced by Technical Appliance Corp., 17 E. 16th St., New York. It is constructed of heavy dural rods held together with a center insulator. Extension rods screw into the center rods for attaining the correct length of the di-pole. A reflector is available for this antenna.

Coil Form

AN IMPROVED COIL form tubing is offered by Spaulding Fibre Co., 484 Broome St., New York. It is mechanically and electrically strong, tough and rugged, impervious to changing atmospheric conditions, immune to electrolysis, and easily punched, machined and threaded. Moisture tests show less than 1.5 per cent absorption on a 1/16 inch wall in 24 hours immersion.

Rheotrol

THE RHEOTROL, a stepless 0 to 100 per cent manual control for electrically operated furnaces, ovens, etc. has been announced by Wheelco Instruments Co., 1929–1933 So. Halsted St., Chicago. It consists of rotating cams operating switches to make and break the current. For example; if it is set

• • •

ELECTRONIC DEVICE PACES RUNNERS

A group of track men testing out an electronic device invented by George Dadakis of the Massachusetts Institute of Technology. The track is divided into four points, at each of which a post is erected. As the runner passes the post, a bell rings. It is expected that by this method, the runner may time himself better on each lap f … 30 per cent control, the power is on for 18 seconds and off for 42 seconds. Also announced by this company is a … dulating gas valve.

Aircraft Antenna System

A TRAILING WIRE aircraft antenna system, type AVA-41, has been announced by the Aviation Section, RCA Manufacturing Co., Camden, N. J. When installed in the recommended manner above the ship, this antenna permits short distance communication when it is reeled in. The pull exerted by the drag unit is substantially the same at all speeds so that there is little difficulty in reeling in the wire at high speeds.

Silver Brazing Alloys

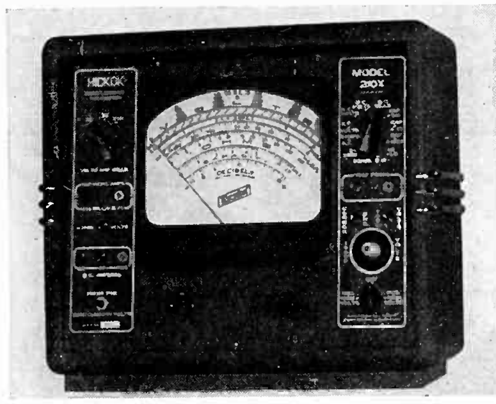
LOW TEMPERATURE silver brazing alloys are available from Handy & Harman, 82 Fulton St., New York. These alloys flow freely at 1175 degrees F and have the following advantages: Joints are made which are ductile and have high tensile strength, electrical conductivity is as high or higher than copper, the joints cannot oxidize and little finishing work is required.

Sound System

A NEW SOUND system is announced by Electrical Research Products, Inc., 195 Broadway, New York. The new system has been designed to anticipate future advances in recording such as the high volume motion picture prints scheduled to appear shortly. Acoustic compensators enable the system to be tailored to fit it to the particular auditorium in which it is installed. Flutter in the associated projector has been greatly reduced by the development of a new scanner fluid.

Voltmeter

A NEW ZERO current voltmeter, model 210X, has been announced by Hickok Electrical Instrument Co., Dupont Ave., Cleveland, Ohio. This instrument



has ranges for measuring up to 10,000 volts. It will also measure currents up to 25 amperes, resistances up to 50 megohms, capacitances to 200 microfarads. A decibel range is included.

Cu O Rectifiers

(*Continued from page 18*)

halves of the carrier cycle. R_c is an average resistance taken over a half-cycle in the conducting direction and R_n is the same in the non-conducting direction. This representation demands that the carrier act simply as a reversing switch, commutating instantaneously at its own frequency. Mathematically a reversing switch of this type can be represented by a a square-top wave whose amplitude alternates between +1 and —1. This can be expressed by a Fourier series expansion of the form,

$$f(t) = \frac{4}{\pi}\left(\cos \omega_2 t - \frac{1}{3}\cos 3\omega_2 t + \frac{1}{5}\cos 5\omega_2 t - \ldots\right) \quad (1)$$

wherein ω_2 is equal to 2π times the frequency of the carrier. With this representation, the output current I_o will be proportional to the product of I_1 times $f(t)$; the factor of proportionality being determined by the losses encountered in the resistors of the modulator network. If we represent this factor by e^{-P} we have the equation,

$$I_o = I_1 e^{-P} f(t). \quad (2)$$

Because the circuit configuration is identical to that of a lattice structure, we can express P as being the propagation constant of a lattice network. This is expressed by

$$P = -\log_e \frac{\sqrt{\frac{R_n}{R_c}} - 1}{\sqrt{\frac{R_n}{R_c}} + 1} \quad (3)$$

It can be shown that for maximum transfer of power,

$$Z_1 = Z_o = R = \sqrt{R_n R_c}. \quad (4)$$

If, now we let the impressed voltage have a frequency f_1, and if we assume for the moment that the resulting current I_1 is of this frequency alone, then expansion of Equation (2) will show that I_o is made up of frequencies $(a_o f_2 \pm f_1)$, where a_o may take on the odd integral values 1, 3, 5, 7, . . . However, it is a property of non-linear circuits that if a voltage of a certain frequency is impressed across the input terminals of such a network, the resulting current, in this case I_1, will be composed of a summation of components whose frequencies are either multiples of the impressed frequency or sums and differences between the impressed and other frequencies in the circuit. For this reason, I_1 cannot be considered as composed of a single component of frequency f_1. Due to the bidirectional property of the lattice structure, we can express these new current components, I_1', by

$$I_1' = I_0\, e^{-P} f(t). \qquad (5)$$

Expansion of equation (5), assuming that I_0 is composed of the frequencies found from Equation (2) shows that I'_1 will be composed of frequencies $(a_e f_2 \pm f_1)$, where a_e may take on the even integral values 0, 2, 4, 6, . . . The true input current I_1 is the sum of a large number of currents of different frequencies and its value can only be arrived at by a series of successive approximations.

In actual practice the carrier voltage (E_{f2}) is adjusted to be about 0.5 volts rms across each disc in the conducting direction. Caruthers[4] has shown that components other than the major sum and difference frequencies $(f_1 \pm f_2)$ decrease much more rapidly than $(f_1 \pm f_2)$ as the amplitude of the signal is reduced. For ordinary speech frequencies satisfactory terminating resistors range in value between 500 and 1,000 ohms, while the internal impedance of the carrier generator should be as low as possible, especially at signal frequencies. For frequencies of three or four megacycles, terminating resistors of 50 ohms or less must be used because of the increased importance of the shunt capacitances. The loss of energy between a single sideband and the input signal ranges between three and six db depending on the frequencies and the terminating impedances.

The bridge modulator serves well as the mixing unit in a beat frequency oscillator. Here, for example, two frequencies of about 150,000 cps are combined to produce a beat frequency varying between 20 and 50,000 cycles. It is desired here that the output be exceedingly free from harmonic distortion and have a constant amplitude throughout the frequency range. If the variable oscillator is connected as E_{f2}, then the beat frequency will be independent of any variations in the amplitude of E_{f2}, if E_{f2} is large in comparison to the amplitude of the signal from the other oscillator. The output can be made quite free from harmonic distortion by reducing the terminal impedances to a few hundred ohms and by reducing the amplitude of E_{f1} to a small value. However, because of the low output under such conditions, considerable amplification is necessary following the mixer. This brings on additional complications in compact a-c operated equipment due to hum and distortion introduced by the amplifier. We have found another region of operation for the mixer which also meets the distortion and amplitude requirements mentioned above and in addition gives a higher difference tone output. The circuit is shown in Fig. 13. The novel features are the high terminating impedance and the fact that the magnitudes of the two radio frequency voltages must be adjusted to reasonably specific values. This can be done empirically by employing a wave analyzer to determine at what voltages the harmonic distortion becomes a minimum. These voltages depend somewhat on the units employed, the terminating impedance and the frequency of the oscillators. When properly adjusted, harmonic distortions as low as 0.05 per cent can be obtained with a difference tone am-

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DRAFTSMAN experienced radio, apply by letter only. State age, experience and salary expected. Detrola Corporation, Detroit, Michigan.

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FORMER CUSTOM RADIO ENGINEER, now employed in well known manufacturer's electronics division, available for employment by radio components, transmitter, or receiver manufacturer. Prefer location either in New York or New England. Highly inventive, versatile, with experience over wide range. Age 28, single. Salary subject to discussion. Photo and details upon request. PW-206, Electronics, 330 W. 42nd St., New York, N. Y.

RADIO ENGINEER former chief engineer experienced in construction, maintenance and operation of broadcast and communication transmitters and sound film projection. Copy code on typewriter and use bug. Telegraph second, Telephone first class licenses. Desire connection in broadcast or communications field. Age 25, married, have late model car. PW-211, Electronics, 520 N. Michigan Ave., Chicago, Ill.

RADIO OPERATOR First class Radiotelephone Graduate Mass. Radio School. Ambitious: Familiar with broadcast procedure and equipment. Desirous of further experience, salary secondary. Age 28, single. Available immediately, any location. PW-212, Electronics, 330 W. 42nd St., New York, N. Y.

POSITIONS WANTED

CERTIFIED RADIO TECHNICIAN with experience in television design and construction, public address systems, receivers and transmitters. 6½ years instructor in New York State high schools in physics, mathematics, and drafting. B.S. degree. Age 30. Married. Laboratory research and testing experience in wood finishing products. Ceramic and textile work. Desires position in research or development of photo cells, amplifiers, instruments or parts. PW-210, Electronics, 330 W. 42nd St., New York, N. Y.

FOR SALE

USED RCA 100-W BROADCAST TRANSMITTER, Complete with set of tubes, some spares, 1420 kc crystal. Frame is built of aluminum, all doors have interlocks. Direct current filament supply, from 12 volt 25 amp generator, also 180 volt generator bias supply. Transmitter uses an 849 as class "B" linear RF amplifier. Suitable for rebuilding for 100/250 watts. In good operating condition; just retired from service. Original cost $8,-500.00, will sell, complete with motor generator, for best offer, FOB Ironwood, Mich. Radio Station WJMS, Ironwood, Michigan.

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ANYTHING within reason that is wanted in the field served by Electronics can be quickly located through bringing it to the attention of thousands of men whose interest is assured because this is the business paper they read.

plitude of 0.1 volt. Another significant feature of this circuit is that both oscillators and the output have a common ground and only one simple intermediate frequency transformer is required. The circuit constants for one of the experimental models built in this laboratory are shown on the schematic, along with the approximate values of the oscillator voltages. The output of this mixer has remained constant and free from distortion for a period exceeding a year under conditions of several hours use daily.

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Electron Tube Applications

Musical Instruments. An electrical musical instrument of the electric organ type. L. Hammond, Chicago, Ill. No. 2,161,706.

Temperature Control System. A phototube application, C. L. Shivers, Minneapolis-Honeywell Co., 2,155,984.

Watch Rate Recorder. Device for recording the rate of a time-piece including a drum on which a stylus marks a frequency determined by the rate of the watch to be tested. C. H. Fetter and J. G. Matthews. ERPI. No. 2,155,646.

Welding Equipment. Circuit utilizing tubes of the ignitron type and other control tubes. J. W. Dawson, W. E. & M. Co., 2,162,530.

Combustion Control. Electric discharge tube for controlling the energy to produce and maintain a spark in a gap for igniting fuel. T. Draper, W. E. & M. Co. No. 2,162,501.

Grid Glow Tube Circuit. Circuit in which the plates are parallel and the grids are differentially connected to light sensitive tubes. D. D. Knowles, W. E. & M. Co., No. 2,162,508

Gas Analysis. In a process for analyzing gas in which a sample of gas is burned with air in contact with a heated catalyst wire mounted in a Wheatstone bridge circuit and the temperature rise of the catalytic wire resulting from the combustion is measured by a galvanometer, a full-wave rectifier supplies alternating voltages to the bridge. Benjamin Miller, Power Patents Co., No. 2,152,439.

Measuring Apparatus. Method of measuring direct currents of minute magnitude which comprises opposing the E. M. F.'s producing such currents to a standard E. M. F. of known magnitude, deriving an alternating current from the resultant. H. F. Parker and J. G. Aceves, Brown Instrument Co. No. 2,150,006.

Gas Detection Apparatus. Apparatus for detecting the presence of dangerous gases by a light reflecting strip impregnated with a solution effective on reaction with such gases to substantially reduce the light reflecting property of the strip. C. W. Johnson, South Weymouth, Mass. No. 2,153,568.

Constant Voltage System. Application of saturable reactor, electron tubes, etc., H. E. Young, Chicago, Ill. No. 2,154,020.

Color Measuring. Application of photo-electric tubes to measuring color and the manufacture of a color analyzer. Alfred L. Holven and T. R. Gillett, Crockett, Calif. No. 2,152,645.

Engine Indicator. System for indicating synchronism of a pair of internal combustion engines, utilizing vacuum tubes corresponding to each of two magnetos. C. I. McNeil, Eclipse Aviation Corp. No. 2,153,264.

Inverter. Device for changing a direct current voltage of varying magnitude and reversible polarity into an alternating current voltage of proportional amplitude and reversible phase. George Agins, the Arma Engineering Co., No. 2,148,718.

Deoscillator. A temperature controlling and regulating system. Frank Moore, The Foxboro Co., No. 2,148,491.

Measuring System. A saturable reactance measurement bridge. C. J. Kettler, G. E. Co. No. 2,149,092.

Door Control System. Tube controlled door operating system involving devices for compensating for humidity and temperature variations. H. C. Miller, Willow Grove, Pa. No. 2,149,177.

Sorting Device. Photo-sensitive apparatus for classifying articles in accordance with their color. J. W. Dawson and E. H. Vedder, W. E. & M. Co. No. 2,162,529.

Motor Drive. Variable speed electric motor drive. W. Leukert, W. E. & M. Co. No. 2,162,509.

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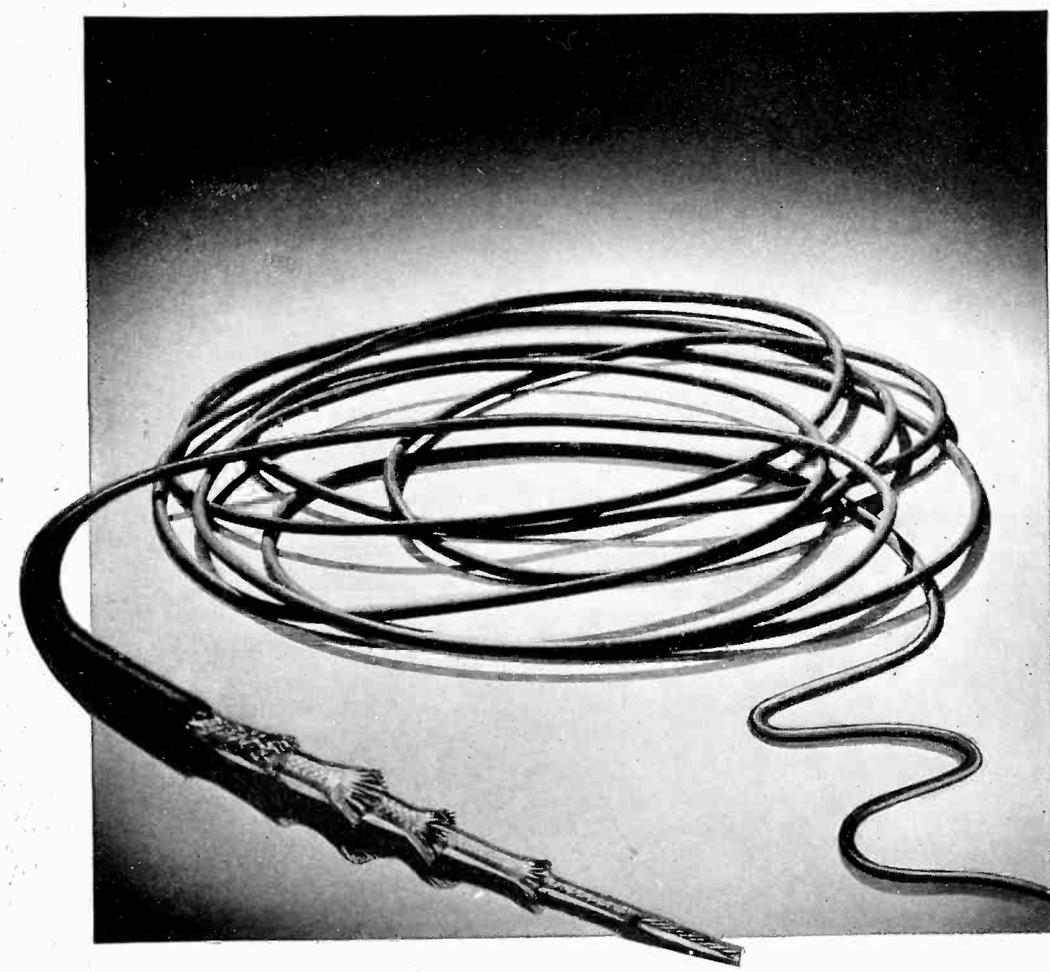

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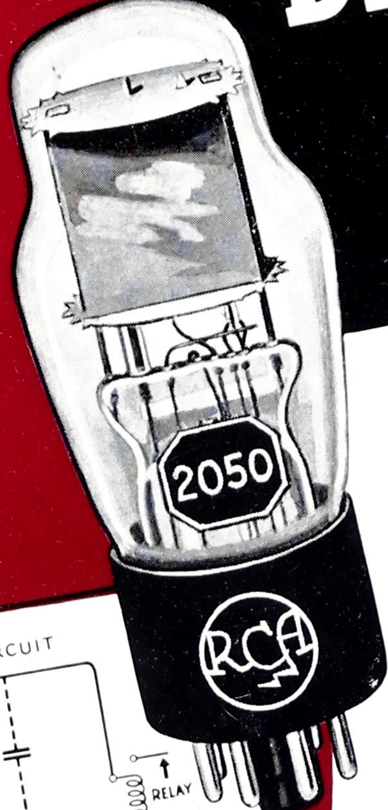

One Tube DOES THE WORK OF TWO

. . . With the New RCA HOT-CATHODE GAS TETRODES

Having extreme sensitivity and outstanding stability over a wide range of anode voltage, the new RCA-2050 and RCA-2051 gas-filled tetrode tubes of the indirectly heated, hot-cathode type, pave the way for important savings in grid-controlled rectifier and relay applications. They are particularly adapted for use in control devices actuated either by phototubes or radio signals.

Grid current is extremely low, permitting high grid resistance to be used in the grid circuit. The resulting high sensitivity permits the tube to be operated directly by a vacuum-type phototube, as shown in Diagram No. 1, thus eliminating one or more tubes previously required in conventional circuits (Diagram No. 2).

The control characteristic is very steep, having a control ratio of approximately 325. Only low values of grid-bias voltage are required. A very small grid-anode capacitance makes the tubes insensitive to line voltage surges and minimizes the undesirable effect of capacitance current flowing through the grid resistance.

Now ready for delivery, the tubes are detailed in an engineering folder available from RCA Commercial Engineering Section, Harrison, N.J.

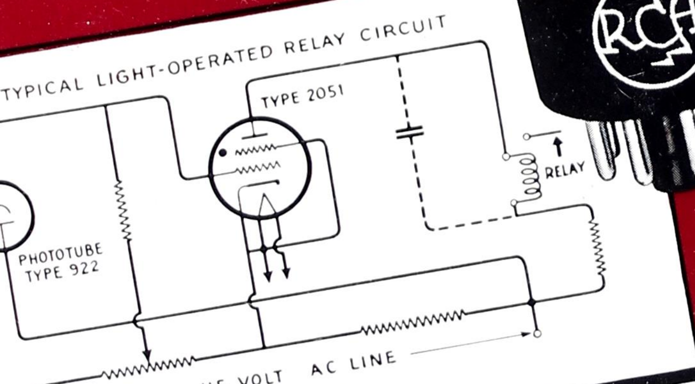

FIG. 1

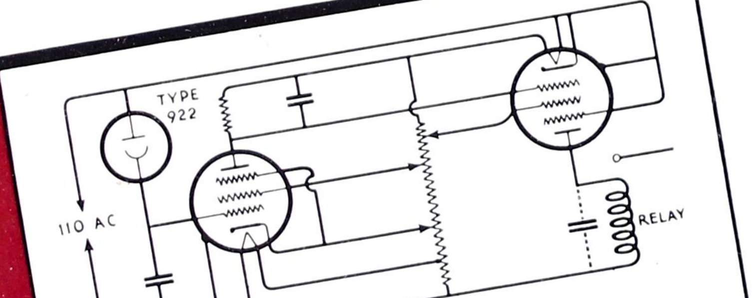

FIG. 2

RCA-2050—Used to control up to 650 volts peak and will handle a peak current of 500 ma. and an average current of 100 ma.

RCA-2051—Used to control up to 350 volts peak and will handle a peak current of 375 ma. and an average current of 75 ma.

The above illustration of RCA-2050 is approximately actual size. Each tube has small, ST-12 bulb, uses standard octal base and is of extremely rugged construction.

CHARACTERISTICS

	Type 2050	Type 2051
HEATER VOLTAGE	6.3	6.3 Volts
HEATER CURRENT	0.6	0.6 Amperes
PEAK ANODE VOLTAGE (Max.)	650	350 Volts
PEAK ANODE CURRENT (Max.)	500	375 Ma.
AVERAGE ANODE CURRENT (Max.)	100	75 Ma.
GRID RESISTOR (Max.)	10	10 Megohms

Visit RCA Television Exhibits at Golden Gate International Exposition and New York World's Fair.

RCA

Radio Tubes

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