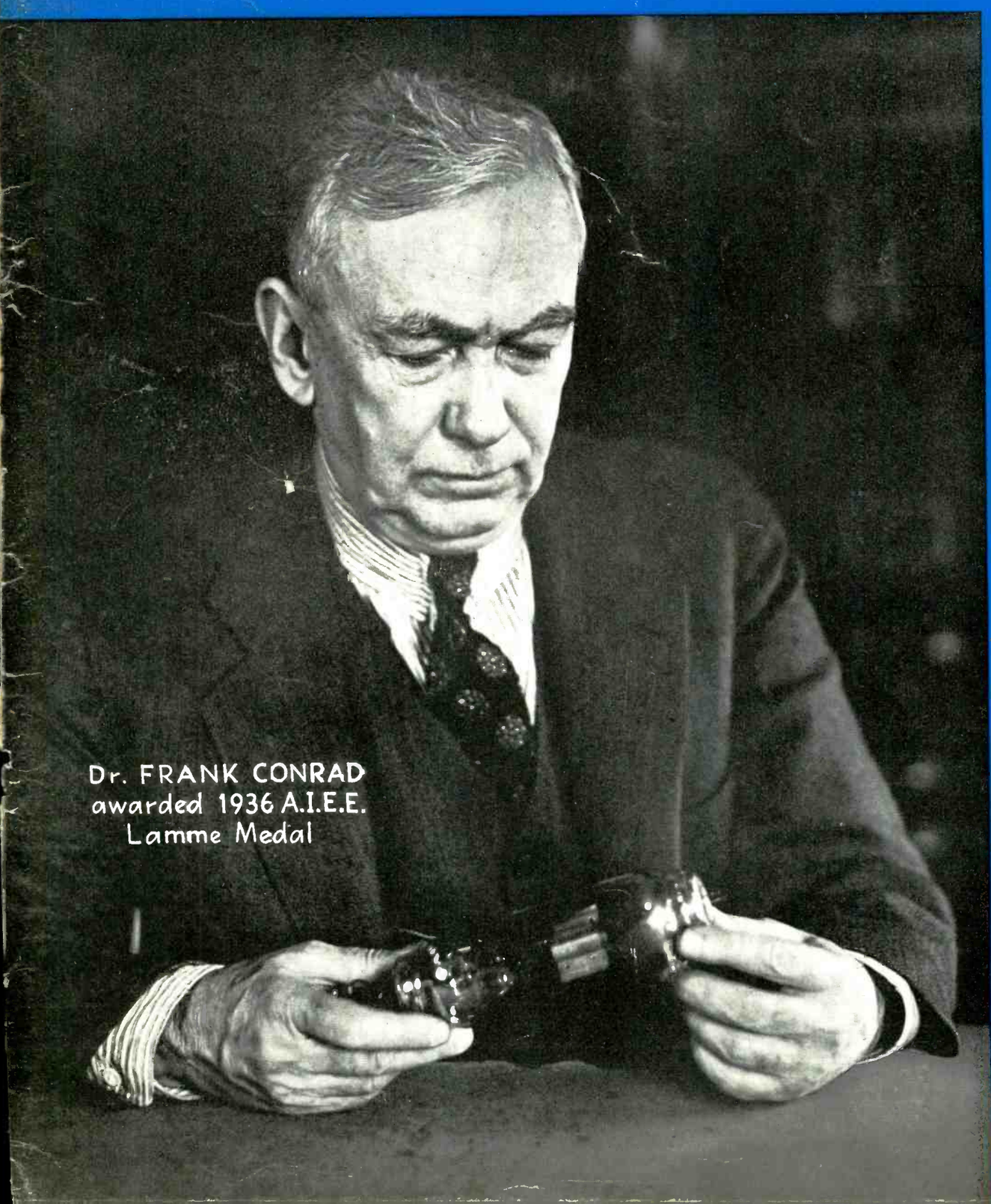
electronics

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



Dr. FRANK CONRAD
awarded 1936 A.I.E.E.
Lamme Medal

MARCH
1937

Price
50 Cents

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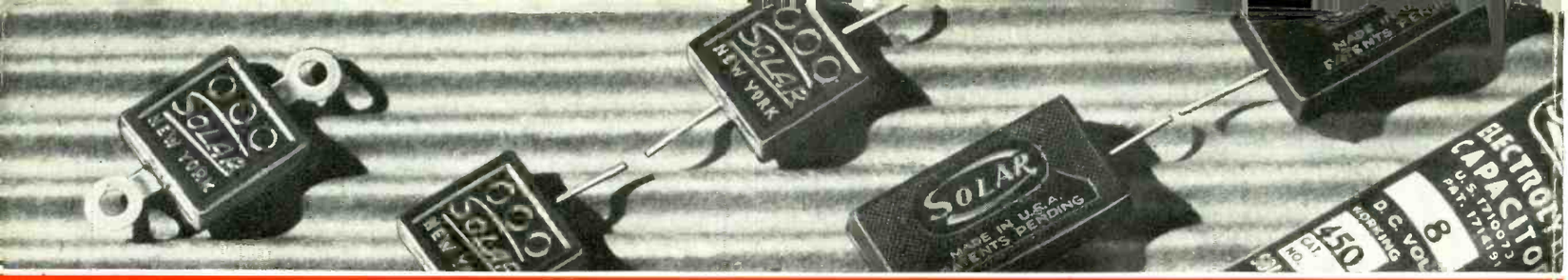

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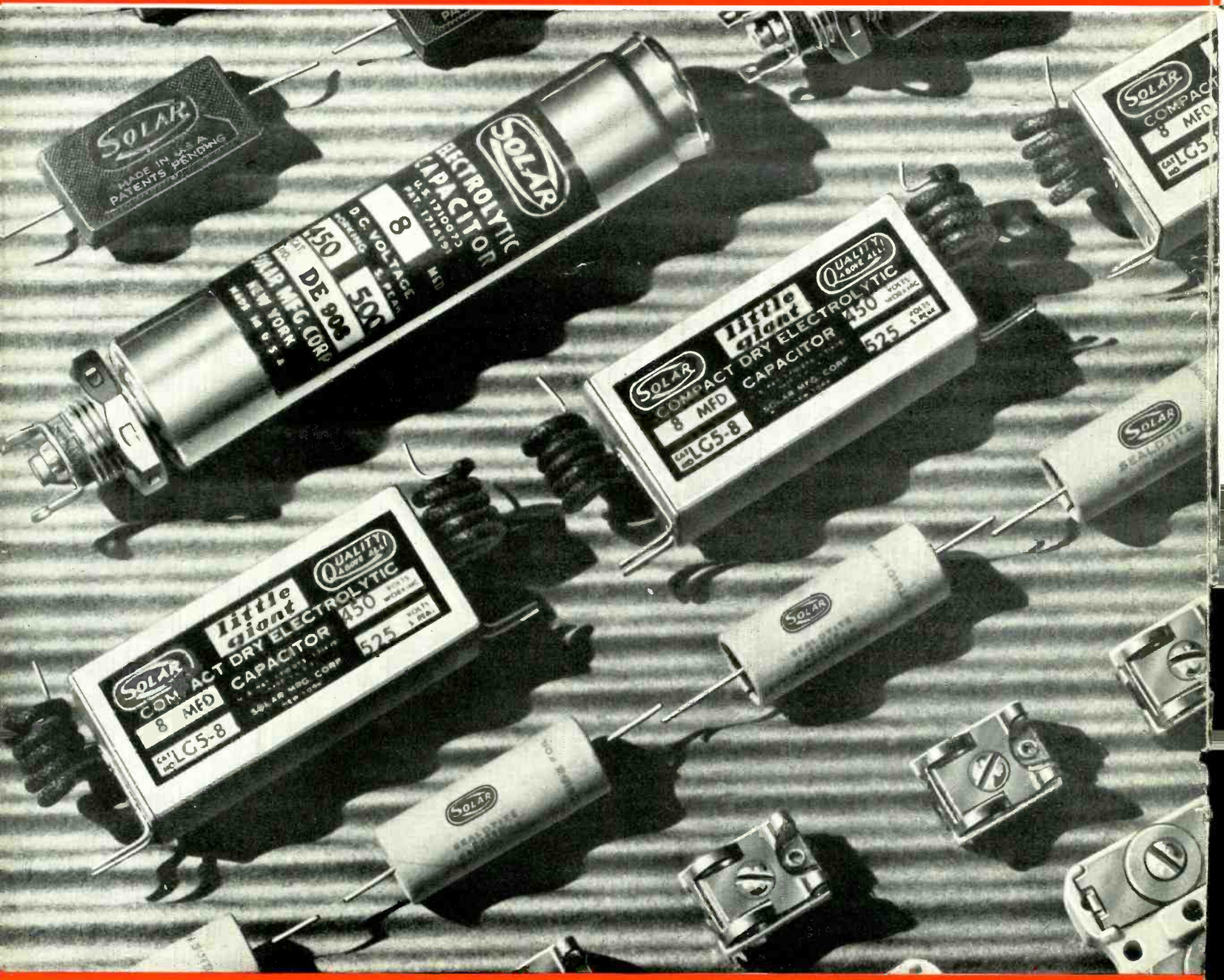

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ELECTRONICS

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

Contents • March 1937

COVER: *Dr. Frank Conrad, Assistant Chief Engineer of the Westinghouse Electric and Manufacturing Company, a pioneer in broadcasting, who has been awarded the Lamme Medal by the American Institute of Electrical Engineers. Dr. Conrad built the equipment with which KDKA started broadcasting in 1920. The Lamme award, however, is for his achievements in the fields of electric metering and protective systems.*

DEPARTMENTS

Volume 10 . . . Number 3

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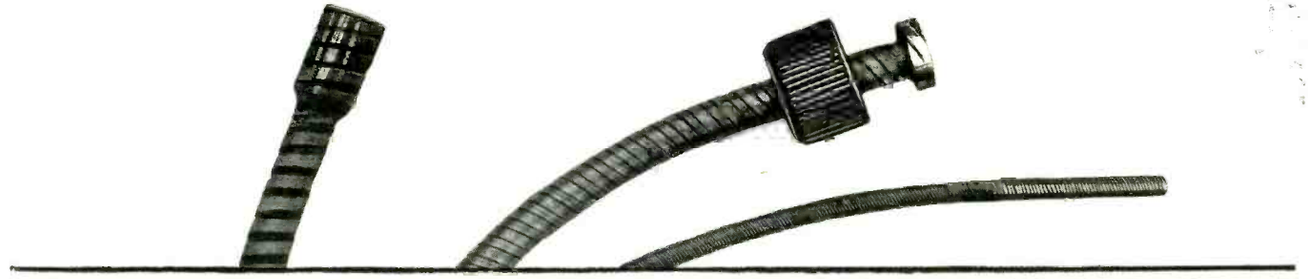

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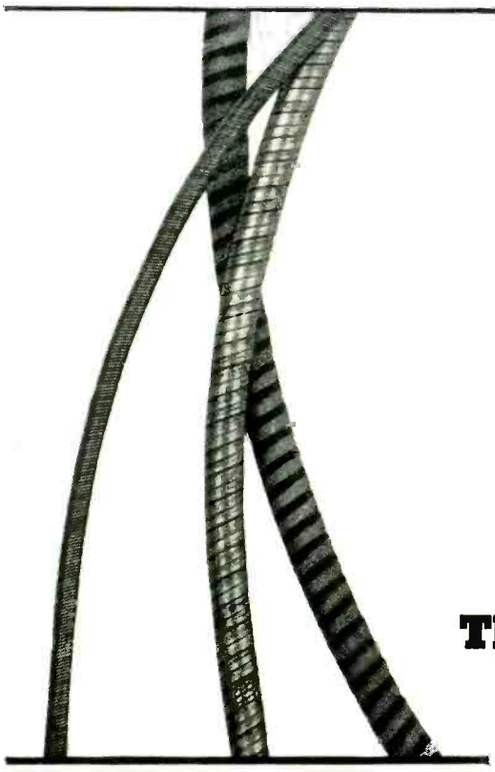

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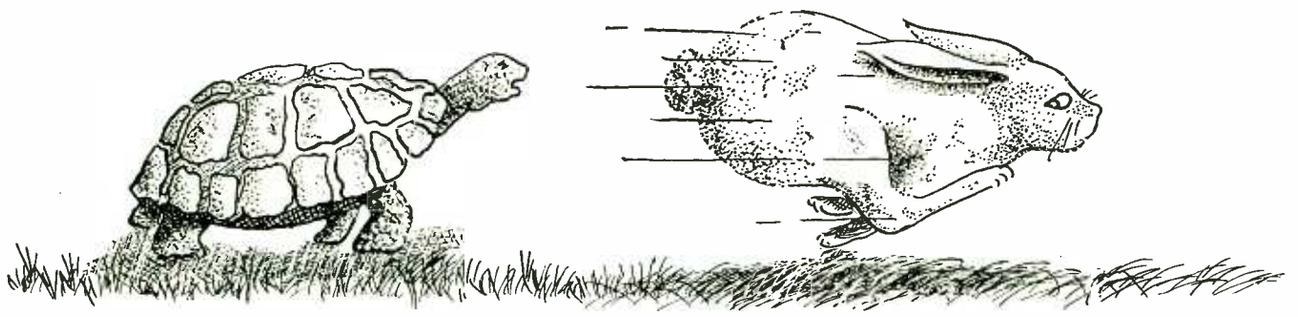

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For complete information on RCA Phototubes, write to Commercial Engineering Section, Harrison, N. J. If your supplier cannot take care of your requirements, write to Sales Department, Camden.

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RCA Radiotrons

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ELECTRONICS

MARCH
1937

KEITH HENNEY
Editor

Crosstalk

▶**TALKING BOOKS** . . . Ten thousand talking books for the blind have been constructed with government funds, according to an announcement by Mr. M. C. Migel, president of the American Foundation for the Blind. These machines are radio-phonographs playing discs, but especially made to bring to the blind the many manuscripts now translated into wax records. The records are available from libraries acting as distributing agencies for the Library of Congress. They are transported by mail free of charge.

▶**QUESTION** . . . Numerous subscribers to *Electronics* have requested that means be provided for keeping up to date their Reference Sheet file without the necessity of tearing the monthly sheets from the magazine. The circulation department of Electronics wishes to know how many subscribers would be willing to pay $1 per year to get unbound copies of Reference Sheets once a year. If a sufficient subscription list for this service can be procured to bring down the cost to the above figure, the service will be instituted. Address, H. C. Henderson or the Editor.

▶**TICKER TALK** . . . The news ticker reports that Dr. Frank B. Jewett, president of the Bell Telephone Laboratories declared at FCC hearings that he was very skeptical about television as a commercial thing.

AT&T completes co-axial cable between New York City and Philadelphia, tests circuit preparatory to actual service. Will it be wide enough for good television? It will use crystal filters to separate many voice channels.

Marconi states in trans-ocean broadcast to Mr. Sarnoff, "We shall soon see each other by television." Local newspapers state that Senatore Marconi was cruising in his yacht Electra. Photographs from abroad, however, show telephone men stringing up wires from the yacht, near shore, to a landed station.

American Institute of Chemical Engineers in session in Baltimore recommend a Federal court of patent appeals and that scientific advisers be provided for patent courts.

Science Service discovers the fact that Drs. Einstein and Bucky had taken out patent No. 2,058,562 on a photoelectric device which automatically controls camera expose by moving in front of the lens a screen of varying transparency. Numerous patents have been granted on automatic schemes to control exposure, but none have come to successful commercialization. The trouble is the lack of energy in the beam of light to operate the control device.

▶**HUNCH** . . . Application of the reversed feedback principle to r-f amplifiers was made in the very early days of radio but it was done on an unscientific basis. Lately there has been much interest in the Black circuits which apply degeneration to audio and carrier frequency amplifiers to reduce noise, decrease distortion and improve stability. What is needed is an excess of voltage gain. Now present day r-f and i-f amplifiers are not operated near full gain. Is it not possible that negative feedback can be applied to radio receivers in these stages where stability, freedom from noise and other advantages accruing from degeneration are not to be sneezed at?

▶**SUPERSONICS** . . . Interest in ultra-high audio frequencies prompts many inquiries for a bibliography on the subject. Readers are referred to a publication by Professor R. W. Wood and Alfred R. Loomis, in *The Philosophy Magazine*, (7) 4, p 417–436, 1927. Here is described work with a frequency of 300,000 cycles and at considerable voltage which was applied to a quartz crystal immersed in oil. Many physical and biological effects are described.

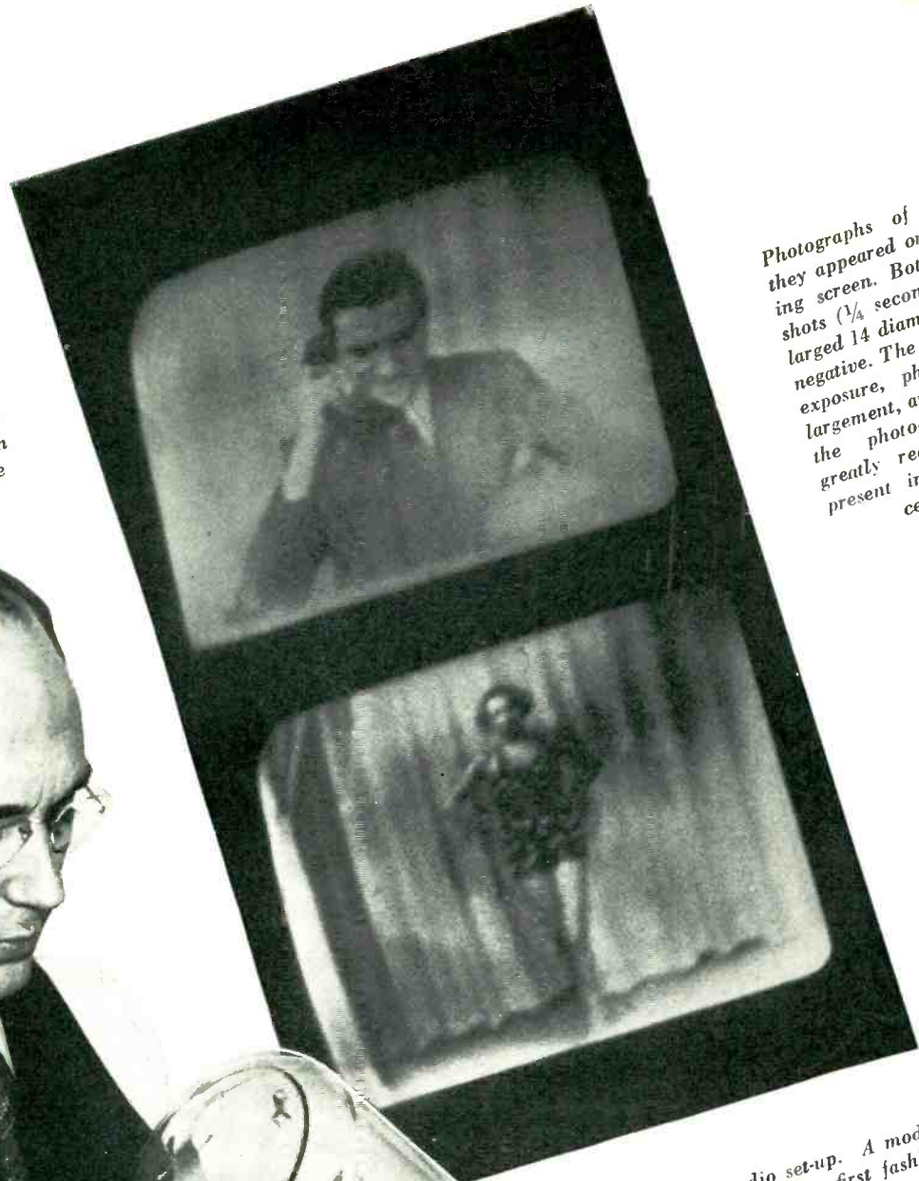
Some work is being done at present in the use of medium high frequency (3,000 cycles or so) currents as an anaesthetic but nothing appears to be available for publication.

▶**USELESS** . . . American Institute of Physics meeting at the Hotel Pennsylvania in New York recently heard philanthropists and physicists alike berated for impractical aims, for "brilliantly useless" projects. Millions of dollars for 200-inch telescopes to look into the sky at night attracted the ire of one industrialist who pointed out that almost nothing was being spent on research on the basic problem of human shelter.

▶**TEN LONG YEARS AGO** . . . About this time there was much squabbling about "bloopers." For the youngsters in the art, these were radiating receivers, mostly single tube regenerators which created havoc in the ether by not only receiving signals but by transmitting them as well.

Now it seems that there is some danger of blooperitis again. Some of the under-twenty dollar radios have the oscillator directly and rather closely coupled to the antenna. One of these put a neat 70 millivolts into an antenna and its wobbling signals could be heard a good mile. Imagine one of these beauties in a congested apartment house.

▶**MR. AYLESWORTH SAYS** . . ."Television cannot be stopped, no more than we can stop progress. The motion picture stands today in regard to television in much the same position as the ice manufacturers who fought automatic refrigeration and the railroads who opposed interstate bus invasion. Both would now be in enviable positions if they had had the foresight to aid and encourage and cooperate with the new developments in their fields."



Photographs of images as they appeared on the receiving screen. Both are Leica shots (1/4 second at f.2.) enlarged 14 diameters from the negative. The effects of slow exposure, photographic enlargement, and the screen of the photo-engraving have greatly reduced the detail present in the original received image

Below, the camera tube used in the Philco demonstration. The cylindrical glass envelope is a new form, easier to construct and to use than the older spherical shape

The studio set-up. A model in "television's first fashion show", before lights and camera. The operator's head-phones receive instructions from the monitoring booth

Philco Shows 441-Line Television

First public showing of new "high-fidelity" system in Philadelphia reveals use of 4.5 Mc. side-bands, made possible by a new method of modulation. Contrast between 345-line and 441-line images demonstrated by adjusting band-width

WHEN the RMA Committee on Television testified before the FCC last June it recommended that the standard television image for the United States consist of 441 lines, be sent 30 times per second, and consume a signal sideband 2.5 Mc. wide. It was agreed that these recommendations looked to the future, since the best demonstrated images at the time consisted of 343 or 345 lines and were sent on a 1.5 Mc. sideband. The change from a 343-line image to a 441-line image was not in itself difficult; in fact the main difference was the frequency of the line-synchronizing generator, which needed only to be changed from about 10,000 cps to 13,000 cps. But to utilize a 441-line pattern to the fullest extent, each line in the image should contain 29 per cent more picture elements than are required for a 343-line picture. This increase in number of lines and picture elements gives a total increase of 65 per cent in the required band-width, that is, from 1.5 Mc. to 2.5 Mc. To effect this increase in band-width was not easy, since it involved circuits already loaded to the limit. In particular the problems of modulating a transmitter over this range and of accepting the side-bands at the receiver seemed to stand in the way.

Now, less than a year later, progress in both directions has been reported by the engineers of the Philco television department, who demonstrated 441-line high definition pictures to nearly 200 members of the newspaper and technical press on February 11, at the Germantown Cricket Club in Philadelphia. According to the announcement of A. F. Murray, Philco's chief television engineer, the highest modulation frequency used in the system was 4.5 Mc., which is nearly twice as great as that recommended by the RMA for a 441-line picture. This enormous increase in band-width means that the pictures demonstrated were capable of furnishing over 680 picture elements per line, whereas only 588 elements are needed to create a horizontal definition equal to the vertical definition of 441 elements. From this point of view, the system lays claim to the term "high-fidelity."

The extremely wide range of modulation at the transmitter is made possible by the use of a new system, developed by Mr. Parker of the Philco engineering staff, which is described as being neither grid nor plate modulation. Details of the new modulator, which is basic to the whole system, are not yet available pending issuance of patents. The transmitting antenna has a measured response without appreciable attenuation over a range of nearly 5 Mc.; the carrier frequency is chosen so that one side-band of the signal coincides with this range and hence is not attenuated.

At the receiver quasi-single-side-band reception is used. The head-end circuits are carefully "de-tuned" so that the i-f band-pass region is centered over the unattenuated side-band. The i-f circuits are of exceptional wide response: the over-all band-width response of the receiver is 4.5 Mc. at 70 per cent of peak response. Such a wide band is passed, of course, only at the expense of very low gains per i-f stage. The entire receiver contains only 26 tubes, however.

The receivers, of which six were used in the demonstration, are fitted with 12-inch cathode-ray tubes, producing pictures about 7.5 by 10 inches in size. The screen material, a compound of zinc sulphide and other fluorescent materials, produces a black-and-white image tinged slightly with blue.

The transmitter operated on 49 Mc. with a peak power output of 4 kilowatts, giving a transmitter range of about 10 miles from an antenna 210 feet above street level. Conventional two-to-one interlaced scanning covering the field 60 times per second was used, in accordance with the proposed RMA standards.

Contrast Between 345- and 441-line Images Shown

The program of the demonstration included a variety of pick-ups from the studio, from the roof of the Philco plant, and from motion picture film. Included in the live talent was Boake Carter, radio commentator, who interviewed Connie Mack, manager of the Philadelphia Athletics, on the prospects of the forthcoming base-ball season. Also was staged a fashion show, put on by Bonwit Teller and carefully designed for the delectation of hard-boiled newspaper men; this feature emphasized the commercial possibilities of the new medium. Of principle technical interest, however, was a test conducted at the beginning of the demonstration for the purpose of contrasting 345-line with 441-line definition in the images. The change-over was accomplished by varying the band-width of the transmitted signal, so that while the basic pattern contained 441-lines in both cases, the detail present in each line could be changed from that of a 345-line image to that of the full 441-line definition. A convincing test of the relative definition in the two cases was made with an ordinary pocket watch, so placed before the camera that its reproduction at the receiver was about life-size. With definition equivalent to 345 lines the second-hand of the watch could not be discerned, but with the 441-line definition it was clearly visible and could be followed readily.

60-megacycle Teletypewriter

Bureau of Air Commerce operates 40-mile, Washington to Baltimore circuit with antennas 800 feet below line-of sight, demonstrating efficiency of the ultra short waves in giving static-free communication

By REX MARTIN

Assistant Director of Air Commerce
Washington, D. C.

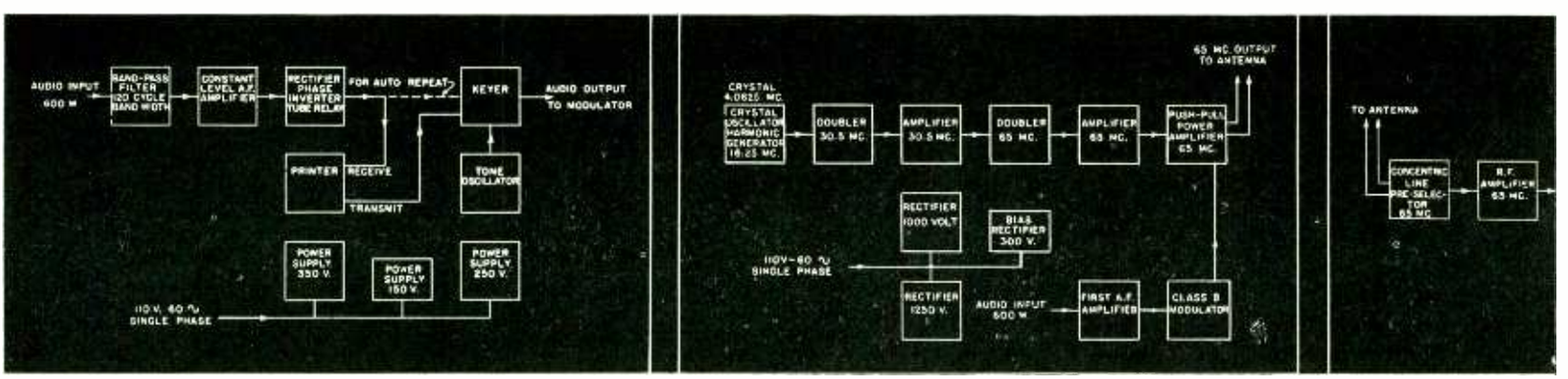
MORE than $50,000,000 have already been spent by the Government to provide an airways system to aid in navigation of aircraft to and from various points throughout the United States. By far the larger proportion of these funds has been expended in providing a communications service to permit gathering and dissemination of weather information. This communications service comprises approximately 23,000 miles and consists about equally of point-to-point radio and land-line teletype circuits. The cost of leasing the teletype circuits alone now amounts to somewhat over $382,000 per year. Two years ago this cost was 30 per cent more. In an effort to reduce costs further, development was started approximately two years ago on the operation of the teletypewriter by means of radio circuits. For over a year and a half a circuit has operated between Washington, D. C., and Baltimore, Maryland, on a 24 hour per day basis, and today the only thing that prevents a service installation between Washington, D. C., and Nashville, Tenn., is the allocation of suitable frequencies by the Federal Communications Commission.

Simply stated, a radio circuit has been substituted for land wires and the record of performance has proved to be more perfect in automatic transmission than it has been possible to obtain through the use of land lines. A large amount of the traffic over the Bureau of Air Commerce system originates at various weather observing stations along the airways, and is handled manually at speeds in the neighborhood of 30 to 35 words per minute. Increasing the speed capability of the system, in itself would be of little value, since manual operation of the teletypewriters limits the useful speed to that given above, and only the automatically transmitted traffic originating at terminals would be benefited. An increase in the number of separate channels, however, would be of advantage, but very expensive.

The ultra-high frequencies (above 30 megacycles) were previously found particularly well-suited for communication over relatively short distances, within line-of-sight, primarily due to their freedom from high noise levels and absence of the reflected sky wave. However, over a year's operation of the Washington-Baltimore radio teletypewriter circuit at these frequencies has indicated that reliable performance may be obtained over distances considerably below line-of-sight, using frequencies as high as 80 megacycles.

The distance between the Washington and Baltimore stations is 40 miles airline, placing the antennas approximately 800 feet below line-of-sight. Horizontally polarized transmitting and receiving antenna arrays are located atop 125-foot steel towers at each point. The frequencies in use at Washington and Baltimore are 61 and 65 megacycles, respectively.

The transmitters are crystal controlled and capable of delivering 100 watts, modulated 100 per cent. The crystal is a low temperature coefficient quartz plate at 4062.5 kc. The fourth harmonic is taken directly from the oscillator and drives a doubler stage. The 32.5 Mc. output of the doubler is then amplified and again doubled in another stage to 65 Mc. This is followed by one intermediate amplifier at the final frequency the output of which is used to excite a push pull power amplifier. A conventional class B modulator is used to modulate the power amplifier. Separate mercury vapor rectifiers are used for the radio and audio frequency stages. Power is supplied to the apparatus at 110 volts 60 cycles single phase.



The receivers are of the crystal controlled superheterodyne type, employing one stage of r-f amplification, with two concentric line preselection circuits and inductive coupling to the transmission line. The crystal controlled beating oscillator utilizes a 10.191 Mc. crystal, the third harmonic of which is doubled. The output of the doubler is then used to beat with the incoming signal in the frequency conversion stage. Two stages of i-f amplification at approximately 4,000 kc. are employed. The i-f amplifier has a band width of about 60 kc. A double diode triode tube is used as a diode second detector, first a-f amplifier and automatic gain control. Resistance-capacity coupling is employed between the first and second audio amplifiers. The output of the receiver is transformer-coupled to a 600 ohm line.

The terminal equipment comprises a two-section a-f filter having a band width of approximately 120 cycles, the output of which is fed into a constant level amplifier or automatic gain control, which is capable of keeping the output level constant within 2.5 db. for variations of input of the order of 40 db. The signal from this amplifier is then rectified in a double diode tube, whose rectified output feeds a d-c phase inverter, producing plus or minus d-c pulses at its output, in accordance with the teletypewriter signals. These pulses trigger two gas discharge triodes, which in turn operate the printer magnet. Standard start-stop teletype printers are used, capable of operating at 60 words per minute. The equipment is designed for essentially unattended operation, and no adjustments of either transmitting or receiving equipment need be made for periods extending over several months.

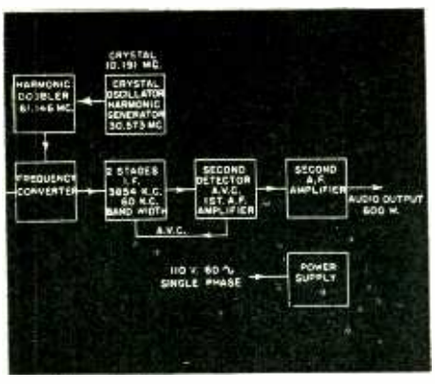
The circuit at present operates on a single channel basis, but provision is made for future addition of several other teletypewriter channels as well as a voice channel for simultaneous communication to aircraft. Further provisions have been made in the test equipment to simulate a three station circuit with one automatic repeater station, by transmitting from Washington to Baltimore, automatically regenerating the signal and repeating it back to Washington.

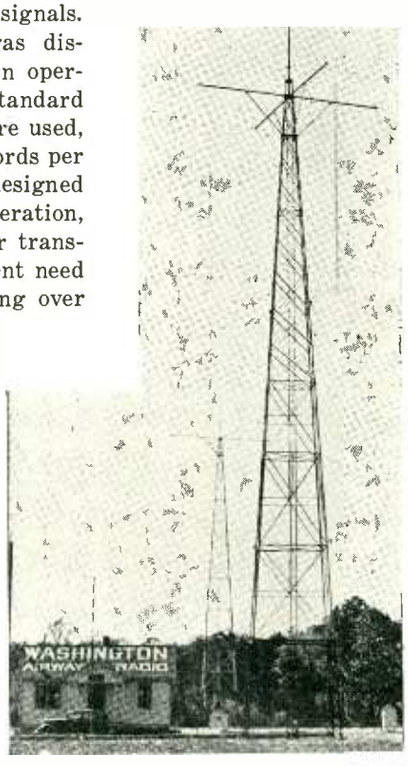
The Washington-Baltimore radio teletypewriter circuit was first demonstrated on October 1st, 1936, to the members of the Radio Technical Committee for Aeronautics, although it has been in continuous operation experimentally for over one year and has proved to be very reliable. So successful has this circuit been that the Bureau of Air Commerce, upon assignment of frequencies, will proceed with the establishment of a multi-channel ultra-high frequency circuit on the Washington-Nashville airway. A voice channel for communication from ground to aircraft, and three 60-word per minute teletypewriter channels are to be provided, any or all of which can be used simultaneously. Each teletypewriter channel will operate in a manner similar to the land line circuits, i.e., traffic can originate at either terminal or any intermediate station on the airway, and all stations will receive copies of the message.

As has been previously mentioned, the Federal Communications Commission is considering the allocation of frequencies which will be involved in the operation of radio printers. This is in the frequency band between 30 and 200 megacycles. There is, of course, a great demand for these frequencies both by industry and by Government. When one considers that radio channels is the one remaining national resource, it becomes apparent that careful consideration should be given to allotments.

Possibilities in u-h-f Operation

In recent months a wider recognition has been achieved of the difficulties encountered from static. It has become generally apparent that radio range operation has been consistently reliable, but that receiving ability is limited under certain static conditions. Operation of the radio teletypewriter circuit between Baltimore and Washington on ultra-high frequencies has been uniformly excellent, and static which would block out an ordinary receiver has had no appreciable effect on transmission on this frequency band. It, therefore, seems possible that a radio receiver can be developed using the ultra-high frequencies which will not be affected by static. Nothing of a definite character is known at the present which would permit me to make the statement that this is true, but sufficient experimental work has been done to indicate that the possibilities for success along this line are very great.





Block diagrams of electrical circuits, at left. Antennas and typewriter, below

A Condenser Tracking Test Set

In any but the simplest receivers, accurate tuning over the band, or bands, is predicated upon the near-exact similarity of capacity of the gang tuning condenser sections

By JOSEPH L. ROEMISCH,

Western Electric Company, Inc., Kearny Plant, Engineering Department, Radio and Instrument Shop

PRACTICALLY every radio receiver manufactured today uses the multiple or "gang" type tuning condenser in which it is necessary that the capacity of some of the sections be as nearly equal to each other throughout the arc of rotation as is possible. The percentage variation in "tracking" that is permissible is generally determined by the application. There are many cases that require extremely close tolerances throughout the range of a 250 μμf condenser. An attempt to purchase condensers from regular suppliers soon made it apparent that tolerances desired were too close for the equipment they had available and that all condensers would have to be carefully checked and readjusted before assembly into receivers. Any equipment that would be suitable for the condenser tracking operation on a production basis would have to meet the following requirements:

1. It must be capable of permitting tracking to within 0.05 μμf and must give an automatic indication, without any action on the part of the operator, if the difference in capacity varied by more than 0.01 μμf.
2. The automatic indication must be both visual and aural and must give an indication of the magnitude of the difference.
3. The equipment should also be capable of determining the capacity of the condenser up to a maximum of 350 μμf and to within an accuracy of .1 μμf without reference to an external standard.
4. It should be a-c operated, capable of continuous 24-hour service without danger of erratic behavior or failure, and must completely protect the operator from any voltages that might cause shock while in normal use.

The test set built consists essentially of two stable, shielded, electron-coupled oscillators of identical electrical constants, each feeding resistance coupled screen grid buffer amplifiers whose output is fed into a co-planar grid mixer tube. The output of this mixer tube is transformer coupled to a type 56 tube used as an audio amplifier, and again transformer coupled to a 2A5 pentode power tube which feeds into a loud speaker. The output of the 2A5 is also fed into a low pass 1000 cycle cut-off filter which is used in conjunction with a type 56 tube and a Weston model 301 microammeter as a visual indicating system. The whole equipment is mounted in a standard 36" steel cabinet designed for mounting on standard size 19" relay rack panels, and provided with a hinged door in the rear.

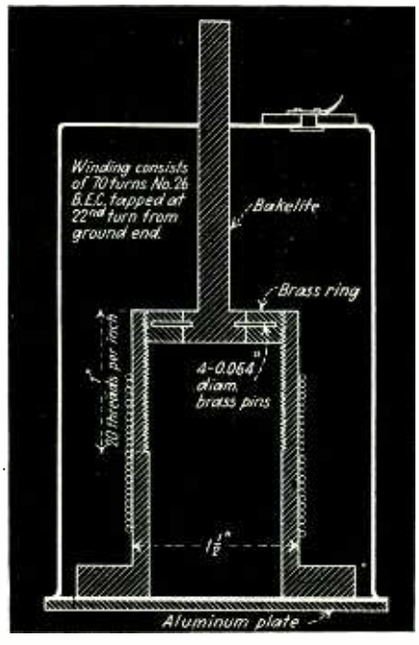


Fig. 1—Details of coil form

The most important and only critical unit in this apparatus is the dual oscillator and mixer unit. Both of the oscillators have been shielded in a very thorough manner. Any attempt to eliminate some of this shielding will result in difficulties when an attempt is made to balance the two inductances L_1 or when the two oscillators are at zero beat, which is the condition under which both of these oscillators are operating when the condensers being tracked are perfectly adjusted. In addition, when the covers of both shields are replaced after balancing coils L_1, the set may be unbalanced unless the two coils are adequately shielded. The location of the two oscillators is important and should be placed as shown so that the leads which go from the "hot" end of L_1 to the stators of C_1 and C_2 be spaced at least 6 inches apart so as to prevent a tendency for the oscillators to interlock near zero beat.

Each oscillator unit is identical. It consists of a bakelite base plate equipped with 4 small General Radio plugs, sometimes referred to as "banana plugs," an aluminum shield which contains L_1 and plugs into an identical mounting base plate as the one above, and a shielded type 57 oscillator tube. Attached to the coil assembly is the grid leak and condenser assembly equipped with flexible lead and grid cap contact clip. The vacant base plate above the coil assembly is provided for use with the balancing condenser unit C_3. This unit may be observed as the identical aluminum shielded objects with knobs shown in Fig. 2 resting on top of each oscillator shield. These units are required only to balance the two coils L_1 and to check them from day to day if the

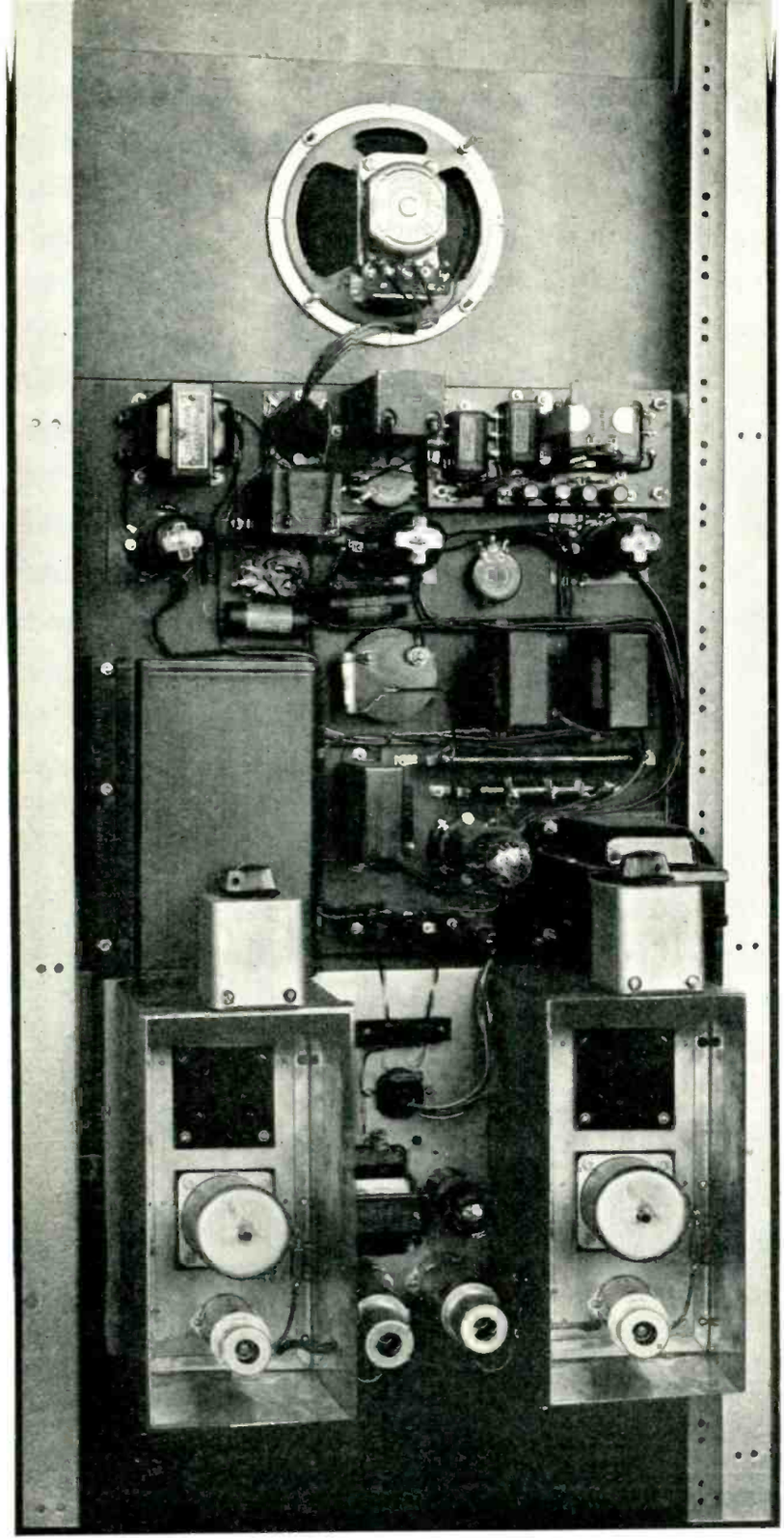


Fig. 2—Details of apparatus. In shielded compartments (covers removed) are the two oscillators

utmost accuracy must be maintained.

Each of the two balancing units consists simply of a 250 μμf mica condenser in parallel with a 50 μμf variable air condenser. Care must be exercised in selecting the mica condensers for these units as any considerable difference in capacity will make them useless. Select two mica condensers exactly equal or within 5 μμf of each other as determined by exact bridge measurements. Ordinary mica condensers of the low voltage, molded bakelite type of reputable make are satisfactory, provided they are carefully matched. A word of caution:—do not choose condensers by their markings as many instances have been found where these markings have been in error by as much as 50% and rarely less than 5%. The type of shield can, contacts or contact bases is not important as long as they are identical to permit interchanging the two units and are made of a good insulating material. Provision must be made to permit adjustment of the 50 μμf condenser while the unit is plugged into its base plate.

A comprehensive idea of the construction of the two oscillator coil units L_1 may be obtained by referring to the half-section view in Fig. 1. This coil is wound on an XL bakelite coil form, $2\frac{1}{4}$" long and has four jack type contacts to fit the contacts of the base plate. The assembly in Fig. 1 is used to vary the inductance of either unit so as to equal the other by changing the distance between the end of the winding and the brass plate. When the plate is made to approach the winding, the inductance of L_1 will decrease. The actual construction of this coil unit may be varied somewhat but it must be remembered that all parts must be made so that the two coils are identical and interchangeable.

Associated with the two oscillator circuits are two sets of variable condensers C_1 and C_2 which are used to compensate for basic differences in condensers to be tracked due to lack of trimmers, etc., to determine the extent of capacity differences, and to determine the value of any capacity up to 350 μμf. Condensers C_1 are Hammarlund type MC20S with one stator plate removed and the rotor bent so as to produce a capacity variation from minimum to maximum of 10 μμf which will then result in decimal sub-multiples that can easily be calculated when a 100 division National type N vernier dial is used to operate this condenser. Normally both condensers C_1 are set to 50 degrees on the dial and are only used to determine the extent of very small capacity variations and their direction.

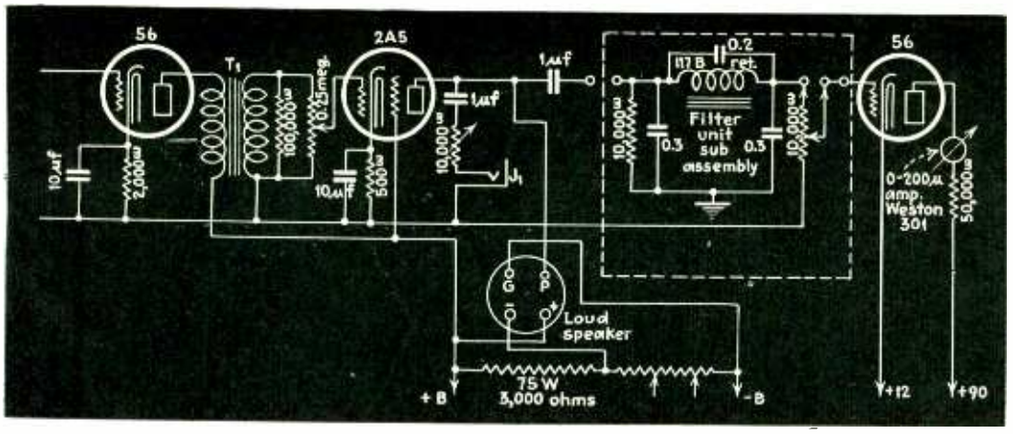


Fig. 3—Audio and visual indicator circuits of the condenser tester

Condensers C_2 are precision condensers, type 149-L, manufactured by the Radio Engineering Laboratories. These condensers are very sturdily built, are well insulated with Isolantite, and maintain their calibration to within any readable limit of the dial over indefinite periods. The change in capacity of this condenser is approximately 320 μμf which represents the useful range for checking unknown capacities. This condenser is driven by a variable ratio National vernier dial, type NW, having 100 main divisions and readable to sub-divisions of one-tenth, thus making it possible to accurately read values to within 0.3 μμf with an accuracy of ± 0.1 μμf. All four of these condensers are enclosed in a partitioned aluminum box. The top of the box is drilled and tapped with a series of holes to permit the fastening of jigs or fixtures to the top. It is absolutely necessary to have total shielding between the two halves of the box to permit the proper functioning of this equipment. Two test leads are also fixed to the top of this box and should be spaced at least 12 inches and should be as thoroughly shielded as possible. Any flexible No. 18 wire over ¼" in diameter with rubber or other high grade of insulation and covered with a tight fitting flexible copper braid will be satisfactory. The braid should be securely bonded to the box. Carelessness in the observance of these precautions will seriously affect the performance due to interlocking of the oscillators. In the event that it is desired to determine the value of capacities greater than 350 μμf, condensers C_2 may be replaced by some other type having a change in capacity equal to the desired value. In selecting a condenser, care should be exercised to choose a type having large rugged bearings, preferably of the cone type, sturdy construction and good insulation.

Buffer Amplifier and Mixer Tube

To assure complete isolation between the two oscillators, it is advisable to place a screen grid tube such as the RCA type 58 as an untuned r-f amplifier between each oscillator and the mixer tube. Nothing about the buffer circuit is critical except that it is well to use parallel feed to the plates through a 3.5 millihenry low distributed capacity choke such as the National type R-100. This choke is designated L_2 in Fig. 4. Very low values of screen and plate voltages are applied to this tube as well as to the oscillator tube to keep the signal applied to the grids of the mixer tube within 15 volts. The purpose of the buffer amplifier is primarily to isolate and not to amplify to any great extent.

The mixer tube consists of an Arcturus Wunderlich co-planar grid tube operating with a few volts bias. The exact value is not important or critical. This tube lends itself peculiarly to a circuit of this type where both signal voltages are essentially equal and because it has a fairly low plate impedance that will satisfactorily work into an ordinary interstage coupling transformer.

Amplifier Cut-Off Filter and Visual Indicator Circuits

Considerable output of the first audio stage (56) has been sacrificed by the resistor voltage divider network across the secondary of the 1st audio transformer, which would tempt one to eliminate this circuit. If suitable precautions are taken, it is possible to operate this equipment with the mixer tube feeding directly into the grid of the 2A5 but the results may not be satisfactory and it is likely that trouble due to r-f blocking of the 2A5 may result. The transformer T_1 aids considerably in preventing any r.f. from getting into the grid of the 56 and 2A5. Ordinary class A amplifier considerations govern the operation of both the 56 and 2A5 amplifier tubes. The output of the power amplifier tube is fed simultaneously to a loud speaker, head phone jack and low pass 1000 cycle cut-off filter with its associated visual indicator. For average work, the visual indicator may be eliminated as well as the filter. To obtain the full benefits of this equipment, however, it is well worth while to include this unit. This filter unit should be readily removable so that another filter having a cut-off point corresponding to a definite percentage capacity variation expressed in terms of frequency may be substituted. This will relieve the operator of all checking operations such as moving the limit dials and calculating the capacity difference, because a certain capacity variation will cause the visual indicator to instantly show this variation to the operator. For accurate production testing of gang condensers, this feature is invaluable. The components of the low pass filter are not critical and any good reactor may be substituted for the Western Electric 117-B retard coil, provided it has an inductance of 0.8 henries.

The power supply is an entirely orthodox multi-section filter having a low ripple content. Any type of apparatus may be used provided it delivers from 250 to 300 volts at 75 ma. continuously without heating.

Adjustment and Operation

There is only one simple adjustment necessary in order to always maintain the absolute accuracy of this equipment and that consists in balancing the inductances L_1 so that they are exactly equal to each other. The balancing operation is very simple and is as follows:

a. Remove the shield covers from

both oscillator compartments and set both limit condensers C_1 at 50 on the dial.

b. Rotate both large dials so that the condensers C_2 are at minimum capacity and adjust either dial so that both oscillators are zero beat as indicated by the loud speaker and visual indicator.

c. Plug the balancing condenser units into their respective base contacts in each oscillator and adjust the balancing unit variable condenser so that the zero beat condition is restored. Then interchange the two balancing units, taking care not to change the setting. If the inductances L_1 are greatly out of balance, the beat frequency may be so great as to be inaudible in which case it will be necessary to adjust either of the condensers C_2 until zero beat is again restored. While adjusting C_2, it must be noted whether the capacity was either increased or decreased so as to restore zero beat. If the capacity had to be increased, then it follows that L_1 associated with that condenser is lower in value than the other inductance. This means then, that L_1 must be increased and is accomplished by turning the adjusting shaft of L_1 in a counter-clockwise direction. If it developed that C_2 had to be decreased, then the inductance of the associated L_1 is too large.

d. After the inductance has been adjusted, repeat steps *b* and *c* until there is absolutely no change in the zero beat condition when the balancing condenser units are interchanged. The equipment is then ready for use.

To measure capacities without reference to a standard variable condenser, it will be necessary to accurately calibrate either, and preferably both, condensers C_2 so as to permit checking one against the other. Both limit condensers C_1 must be accurately calibrated. This calibration should be performed on a capacity bridge having a suitable degree of known accuracy. Before performing the calibration, it will be necessary to remove both inductances L_1. It is also best to set both limit dials of condensers C_1 at exactly 50 divisions before calibrating condensers C_2.

After the condensers have been suitably calibrated and the inductances L_1 have been properly balanced, this equipment may be used to measure capacities in accordance with the following procedure:

a. Set both dials of C_1 at exactly 50 and rotate both dials of C_2 so that the capacity change will be considerably in excess of the estimated value of the unknown capacitor and adjust both of C_2 to zero beat. It is advisable to adjust one of the two dials at a point which corresponds to an even figure on the calibration chart. Note the capacity at this point.

b. Connect the unknown capacitor to the leads of the C_2 that you have chosen to use as the standard and back off the capacity until zero beat again exists. Read the corresponding capacity value from the chart and deduct from the original value noted in paragraph *a*. This difference is then the exact value of the unknown capacitor. It is apparent that the degree of accuracy is limited to the accuracy of the dial reading and the accuracy of the original calibration. These limitations must always be borne in mind. Another precaution is to always remember that the capacitor being checked is being placed across an oscillator circuit and if the dielectric is faulty or has high loss then the oscillator will cease oscillating. For this reason, only air dielectric, mica and good paper dielectric condensers can be tested in this type of equipment.

The use of this equipment in tracking condensers is very simple and consists in merely connecting one section, usually the one without a trimmer to one lead and the adjacent section to the other lead, setting the dials of C_1 at 50 and adjusting both dials of C_2 so that zero beat exists with both of these condensers set near minimum capacity and with the condenser to be tracked also at minimum. The condenser being tracked is then rotated slowly to maximum capacity. If both sections are obsolutely "in track" then the zero beat condition will continue but if any variation greater than 0.005 μμf exists, a beat note will be heard and the visual indicator will show a reading. By adjusting the dial of C_1 used in conjunction with the section being tracked to restore zero beat, the exact difference will be determined. The necessary adjustment may then be made to the condenser, the dial returned to 50 and the operation continued until the section is satisfactorily adjusted throughout its arc of rotation. The operations are then repeated on each section. By proper choice of the cut off point of the low pass filter, it will not be necessary to use the dials of C_1 thereby speeding up the adjustment operation considerably.

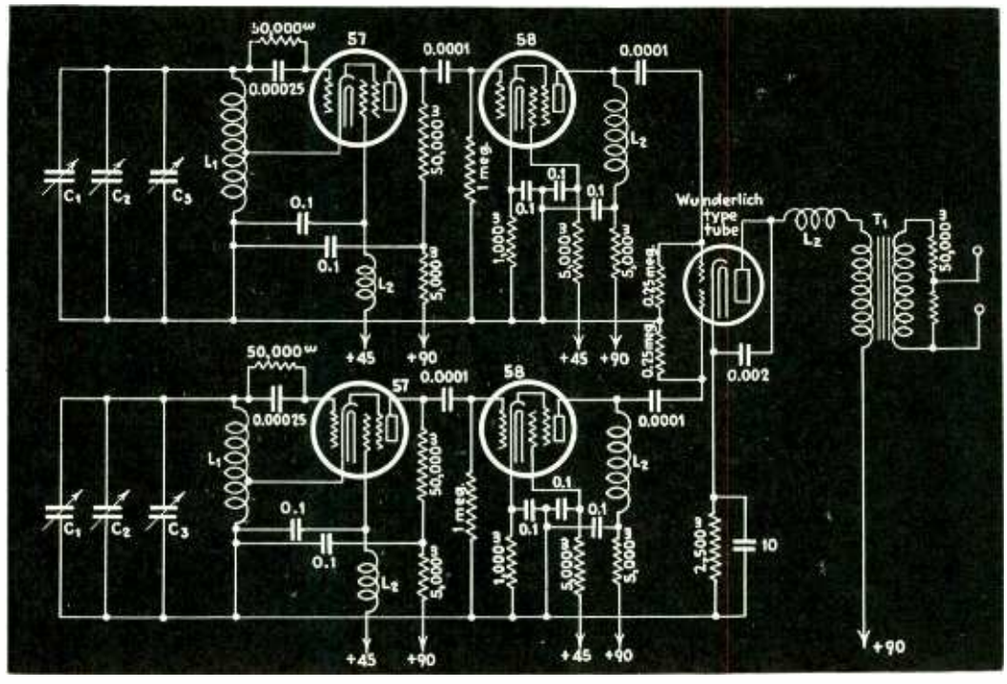


Fig. 4—Schematic of beat frequency oscillators, detector, etc.

Movable Anode Tubes

New members of the vacuum tube family in which the control of the anode current is effected by changing the position of the anode with respect to the other tube elements

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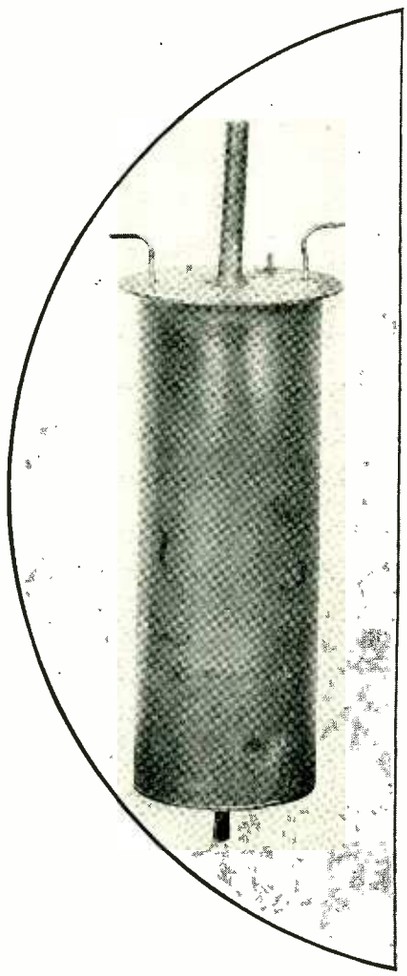


WE ARE so accustomed to thinking of high-vacuum tubes as voltage-operated devices that only rarely is any consideration given to other methods of changing the plate current.

It is well known that, in a high-vacuum tube, space charge limits the current flow between parallel plane electrodes to a value given by the following equation:

$$i = 2.335 \times 10^{-6} \frac{V^{3/2}A}{X^2} \text{ amperes}$$

when V is the potential difference, X is the electrode spacing in centimeters and A is the area of one electrode in square centimeters. Any one of these three terms may be used to vary the maximum value of current flow independently of the others.

Recently, some tubes have been built to study the possibilities afforded by varying the value of A, the anode area. These tubes promise to be very valuable tools for measurement purposes. The tube is so constructed that the anode may be moved with respect to the cathode from outside the tube. The tube is of the all-metal type.[1] The outer shell is seamless steel tubing 4 inches long and about 1.5 inches in diameter. The ends are closed by punching steel headers welded to the shell. One of these headers has a large hole in the center which is covered by a thin flexible iron diaphragm. The anode is a rectangular box open on one edge and carried on a heavy steel rod projecting through the flexible diaphragm.

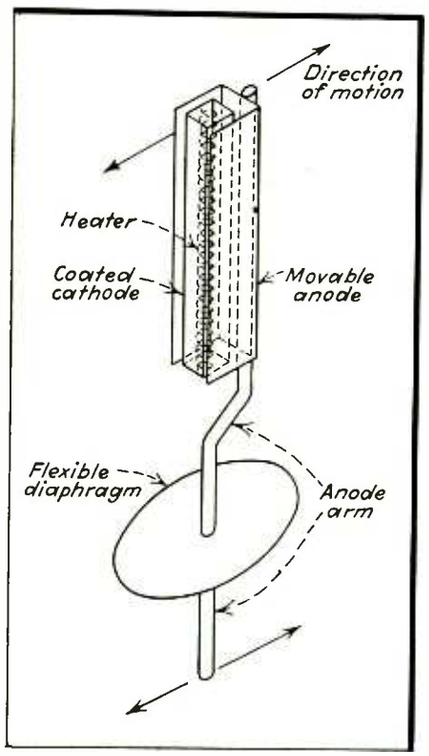
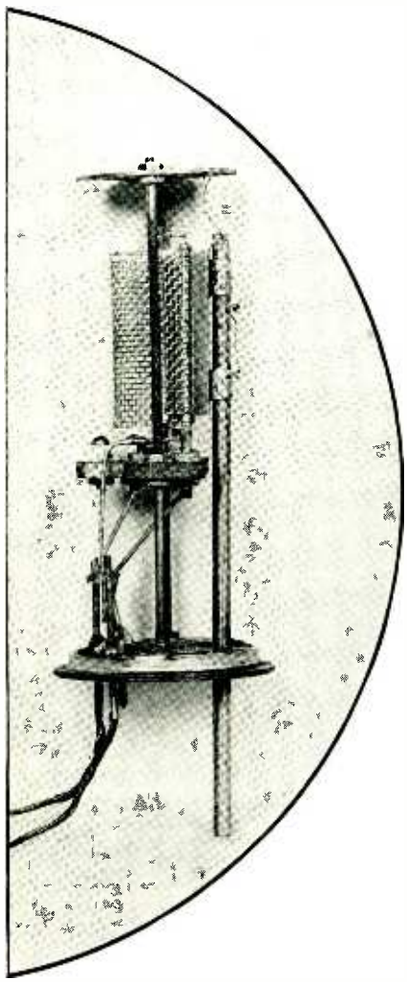


Fig. 1—Construction of tube in which anode current is controlled by mechanical motion

The anode may be moved with respect to the cathode by moving the external rod. The cathode is an indirectly heated rectangular box mounted so that the anode may be moved over it edgewise or completely withdrawn. The relative position of the cathode, anode and diaphragm is illustrated in Fig. 1. The electrical leads to the inside of the tube are made by sealing glass to the lead wires and to small fernico eyelets welded to the header around the flexible diaphragm. Moving the external arm in the direction of the arrows will make more or less anode area available for collecting the electron emission. Since the anode area is directly proportional to the displacement of the anode arm and the plate current varies linearly with electrode area, the relation between plate current and displacement should also be linear if all other variables are held constant. This relation for one of the developmental tubes is shown in Fig. 2.

Over the straight position of the



Experimental metal-envelope, movable-anode tube

curve a motion of one mil (.001 in.) at a distance of 1.0 inch from the end of the tube will produce a change in plate current of about 7.0 milliamperes. The curvature at the bottom of the characteristic (Fig. 2) is due to stray currents from the cathode to the anode and may be reduced by internal shielding.

The tube operates with a maximum of 100 volts d.c. on the anode and will permit a maximum displacement of the anode arm of 0.05 inch at a distance of 1.0 inch from the end of the tube. The filament rating is 4.0 amperes and 2.5 volts. The torque required to move the anode varies somewhat from tube to tube but the average is 0.2 inch-ounces. The power supply may be alternating current as well as direct although in this case the current sensitivity will be reduced in the ratio of 1.0 to π.

This device suggests many potential possibilities. Tubes can be built which will have deflection characteristics other than linear. This can be accomplished by an appropriate choice of electrode shapes. The only limitation on power capacity and sensitivity is permissible size. It is apparent that the sensitivity and total current change can be increased at will by using longer cathodes and anodes and by using higher voltages.

This tube may be used in many applications which require the transformation of a small mechanical motion into a proportional electrical signal voltage. For example, it might be used as a seismograph, extensometer, microphone, thickness recorder or regulator, pressure indicator, phonograph reproducer, thermo-regulator, and in many other ways.

Some simple tests were made with the tube having the characteristics shown in Fig. 2 where the movable anode tube was used to supply power to the d-c winding of a saturable reactor. A total motion of about .05 inch was sufficient to change the a-c power through the reactor from nearly zero to the full rating of about 1.0 kva.

Applications which involve the use of this type of tube as an electric micrometer gauge use the tube as one arm of a resistance bridge. Since the tube resistance changes with voltage, it is advisable to use another vacuum tube having similar characteristics in the opposite arm of the bridge. This precaution makes the device much less sensitive to line voltage variation. For precise work it will be found necessary to provide a fairly constant source of voltage for the bridge. These factors are determined, of course, by the accuracy required. With a well designed bridge of this type it is possible to measure 0.01 mil (0.00001 inch) without the use of high sensitivity milliammeters.

These suggested applications illustrate the wide variety of uses to which this newest member of the vacuum tube family may be put. To date these tubes have only been built in developmental form. Therefore, no standardized type is as yet available or on the market.

1 "All Metal Vacuum Tubes", O. W. Pike and G. F. Metcalf. *Electronics*, Vol. 7, No. 10, October, 1934.

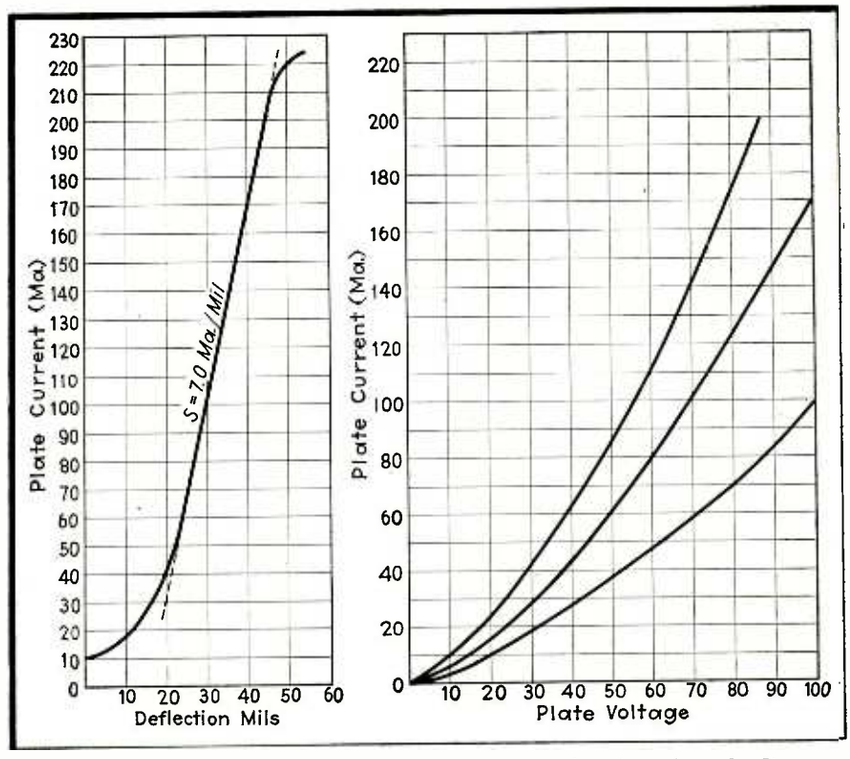


Fig. 2—Characteristics of movable-anode tube as a function of anode displacement; Ip-Ep data for several anode positions

The Strobotron—II

Practical use of this new cold-cathode tube, described in the February issue, depends on a knowledge of the grid voltages and currents required to start the gas-discharge. Herewith are the starting characteristics

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THE strobotron, developed principally by Germeshausen,[1] has been applied by Germeshausen and Edgerton[2] in a number of circuits, the best-known of which is the "Strobotac"—a small stroboscope manufactured by the General Radio Company for use as a tachometer. Here the tube is used as an instantaneous light source. In combination with a simple pool-type mercury arc, the strobotron may be used as a controlled arc rectifier capable of handling hundreds of amperes. An example of such an application for the accurate control of a standard small power resistance welder has been described by Gray and Nottingham.[3] Since there are many other possible uses of the strobotron, it seems worth while to present a fairly comprehensive discussion of its starting characteristics.

The strobotron is a gas-filled (neon) tube with a caesium-coated cold cathode. The two grids serve as auxiliary electrodes for starting purposes and for electrostatic shields. Throughout the discussion below, all potentials will be referred to the cathode as zero unless otherwise specified. The discharge is initiated by starting a glow between two elements. For example, if the plate is 300 volts positive, and the inner grid (g_1) is zero, a discharge from cathode to plate may be created by raising the outer grid (g_2) potential to about +100 volts. This starts a glow between grids with the inner one as a "momentary cathode," following which, a discharge develops from cathode to anode if the glow between grids is sufficiently intense. With the same plate potential (300 volts positive) a discharge may also result if the outer grid (g_2) is made about 110 volts negative, in which case a glow first starts between the two grids with the outer one as the "momentary cathode." In either of the above cases the current carried by the glow discharge between the grids must exceed a certain magnitude in order to form a true plasma and give rise to a complete breakdown from the cathode to the anode.

These characteristics of the strobotron are summarized by Table I and Fig. 2. The information presented in Table I can best be understood by the graphical representation of Fig. 2. In this figure the outer-grid (g_2) potential referred to the cathode as zero is plotted as the abscissa, and the inner-grid potential as the ordinate. The six solid lines of this figure may be placed independent of anode potential, while the location of the dashed line depends upon anode voltage. The area inside the figure represents the range of outer- and inner-grid potentials for which the strobotron will remain nonconducting. The boundary line defines critical values of potential for which a discharge will develop.

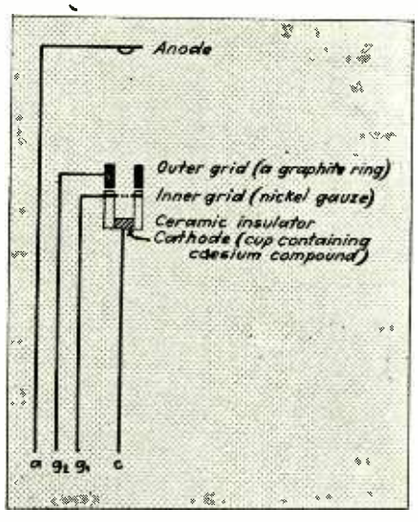


Fig. 1—Diagram showing relation of strobotron elements

In order to clarify the connection between Table I and Fig. 2, let us consider in detail the conditions represented along each line of the figure. Along the line *a-b*, which is drawn at an angle of 45 degrees with the horizontal, the outer grid (g_2) is everywhere positive a constant amount with respect to the inner grid (g_1). A point located just to the left of line *a-b* corresponds to a potential less than that required to initiate a glow discharge between these grids. If we attempt to set the actual potentials of the grids to correspond to a point on the right of line *a-b*, then a glow discharge will start and the current carried by this discharge will become very large unless limited by resistances in the associated circuit. In case the resistance in this circuit is so high that the grid current has too small a value (a milliampere or or less, depending on the anode-to-cathode voltage as shown by Fig. 5), a complete breakdown may not take place. This point will be expanded in discussing Fig. 6.

At the intersection of lines *a-b* and *b-c* of Fig. 2 the process of initiating the discharge changes from that of a glow between grids to a

glow between the cathode and the outer grid (g_2). The critical potential for this process is $v_{2c} \cong 175$ volts.

TABLE I

Approximate Initial Glow Potentials

Positive Electrode	Negative Electrode	Critical Potential Diff. Desig.	Volts	Expected Variations in Volts	
g_2	g_1	v_{21}	96	+15	-5
g_1	g_2	v_{12}	100	+50	-30
Anode	g_2	v_{a2}	500	+50	-100
Cathode	g_1	v_{c1}	130	+15	-10
g_2	Cathode	v_{2c}	175	+25	-15
g_1	Cathode	v_{1c}	130	+10	-10
Cathode	g_2	v_{c2}	200	+40	-60
Anode	g_1	v_{a1}	600	+50	-40

If the circuit is properly arranged it is possible to instigate a complete breakdown with the minimum of control-grid current (approximately 2×10^{-9} amp) by crossing the line *b-c* near the point *c*. Further details are given below.

The line *c-d* is the boundary determined by the critical potential $v_{1c} \cong 130$ volts with the initial glow forming between the inner grid (g_1) and the cathode. The diagonal *d-e* again represents the locus of points of constant difference in grid potential $v_{12} \cong 110$ volts, and for this the outer grid is the "momentary cathode."

The construction involved in the location of the dashed line *e-f* is more complicated. This corresponds to a breakdown between the outer grid (g_2) as "momentary cathode" and the anode. For a particular value of anode potential we locate the line by subtracting the critical glow potential $V_{a2} \cong 500$ volts from the anode potential (V_a). In symbols we have

$$V_a - V_{a2} = V_2$$

Thus if V_a is 325 volts and V_{a2} is 500 volts, we have $V_2 = -175$ volts. Since V_{a2} is a constant of the tube, we see that V_2 or the location of the dashed line *e-f* will shift linearly with the anode voltage.

An analogous equation, namely, $V_a - V_{a1} = V_1$, may have to be used to locate the lower boundary of the region of nonconduction when an anode voltage V_a greater than the critical voltage difference ($V_{a1} - V_{c1}$) is used with strobotrons which happen to have critical potentials such that $V_{a2} + V_{21} > V_{a1}$.

Figure 3 represents an experimental determination of the "characteristic loop" for a particular strobotron, showing how corners are rounded off and that the observed diagonal lines are not strictly 45-degree lines, but deviate very slightly. These minor differences from the idealized diagram of Fig. 2 are unimportant.

In the following paragraphs on grid-current characteristics it will

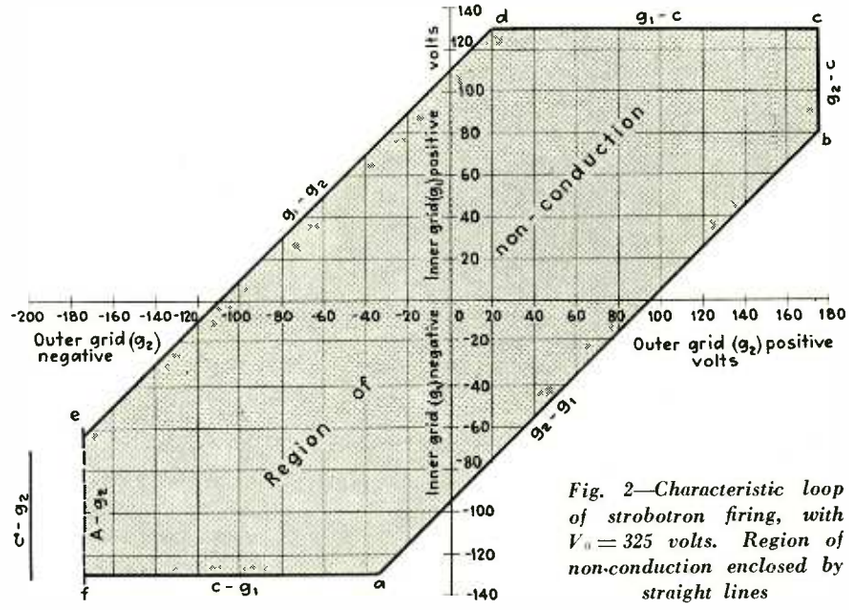


Fig. 2—Characteristic loop of strobotron firing, with $V_a = 325$ volts. Region of non-conduction enclosed by straight lines

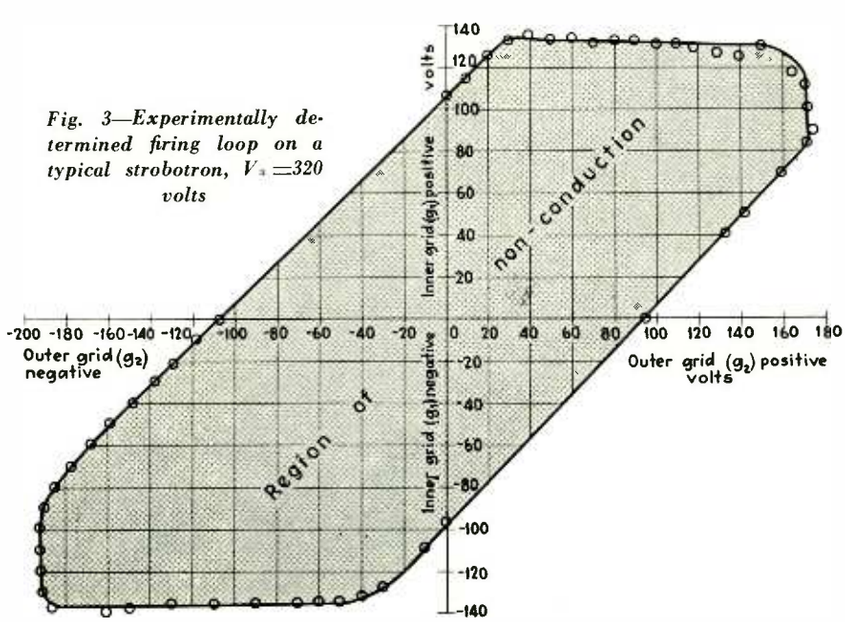


Fig. 3—Experimentally determined firing loop on a typical strobotron, $V_a = 320$ volts

be shown that as the potential difference between two elements of the tube is increased, the current flow is very small (about 10^{-7} amperes or less) until the critical potential difference is reached. A complete characteristic shows that oscillations begin at this point and the average potential drop between elements *decreases*. The potentials recorded in Table I and Fig. 2 show the critical values in volts which must be exceeded in order to initiate the discharge. It is important to realize that these values do not represent the actual potential across the two elements which is observed after the glow has been started and its intensity increased enough to cause a complete breakdown in the tube. In

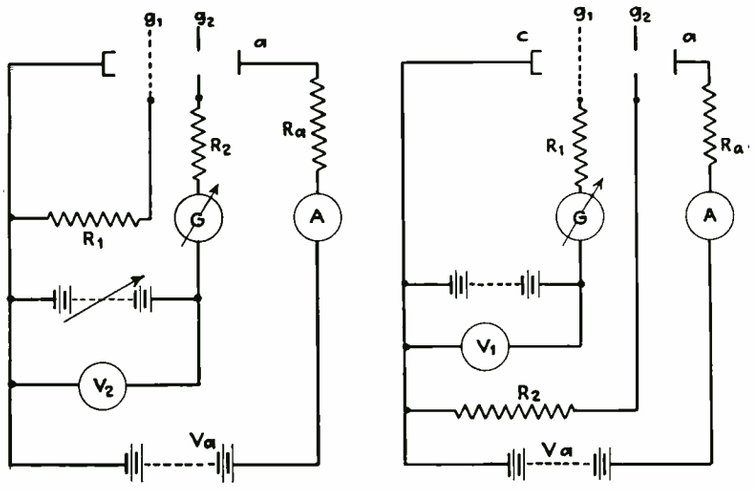


Fig. 4—Circuits for determining grid current, (left) in outer grid and (right) in inner grid

terms of the discussion to follow, the critical potentials of Table I correspond to the point *B* of Fig. 6.

Grid-Current Characteristics

The grid-current characteristic of a strobotron is difficult to determine with accuracy, since the current is not a strictly reproducible function of the voltage. This must be expected, since cold-emission effects are undoubtedly dependent on the surface conditions on the electrodes, and these change as a result of the ion bombardment taking place each time the tube is "fired." These changes alter the critical voltage by only one or two volts in most cases. The problem of observing the grid-current characteristic just before the tube is fired is difficult, since over certain ranges of current the glow discharge is inherently not stable and oscillations result which cannot be eliminated no matter how high the resistance in the external circuit. Because of these complications the important end results are presented in Table II and no attempt has been made to prepare detailed curves showing the grid current as a function of the voltage over the entire range. Two of the circuits used for studying the grid currents at the moment of "firing" are shown in Fig. 4. The circuit illustrated at the left was used to determine the grid current and potential required to cause a complete breakdown in the tube when the outer grid (g_2) was made positive or negative. The grid current thus obtained was found to be a function of the anode potential and is shown in Fig. 5. The true grid voltages were found by measuring the meter voltage V_2 and subtracting from that the IR drop through resistance R_2.

Table II should be very useful in connection with the design of circuits using strobotrons, since it is essential to consider the grid current which must be supplied in order to accomplish a complete breakdown between the cathode and the anode. Fortunately it is not necessary to deliver the current for more than a few microseconds, and the use of a condenser which may be charged by a small current often makes perfectly satisfactory operation possible.

One of the important features of the double-grid strobotron is that it can be used so advantageously in circuits for which the simultaneous action of two different potentials is required for operation. This property was utilized by Gray and Nottingham[3] in the welder control by putting a 60-cycle peaked wave on the inner grid and a contact control on the outer grid. For all such applications the boundary shown in Fig. 2 must be crossed somewhere on the 45-degree lines, i.e., either *a-b* or *d-e*. The grid-current data presented in Table II show that smaller currents are required for crossing *a-b* than for crossing *d-e*, and furthermore we have found that boundary line *a-b* is definitely more reproducible than the *d-e* boundary.

TABLE II

Minimum* Glow Current in Amperes For Strobotron Breakdown

Boundry Crossing	Anode Voltage 125	300	400	Current in
a-b	10^{-3}	1.5×10^{-5}	10^{-5}	g_1 or g_2
*b-c***	10^{-3}	5×10^{-9}	2×10^{-9}	g_2
c-d	5×10^{-3}	6×10^{-6}	4×10^{-6}	g_1
d-e	7×10^{-3}	3×10^{-4}	1.2×10^{-4}	g_1 or g
e-f	5×10^{-7}	6×10^{-8}	5×10^{-8}	g_2
f-a	5×10^{-4}	1.5×10^{-4}	3×10^{-9}	g_1

* In all cases the condenser method of "firing" permits operation with a control current less than 10^{-7} ampere.

** These data for trigger method of operation with 20,000 ohms or less in the inner-grid (g_1) circuit.

This is brought out by the column of "expected variations" in Table I.

Before discussing the other details of Table II, it will be necessary to consider certain facts brought out by the determination of the current flowing between adjacent elements as a function of the voltage between them. For example, the inner grid (g_1) and the cathode were connected together while the outer grid (g_2) and the anode were connected and made positive with respect to the other two elements. The current observed to flow is shown in Fig. 6.

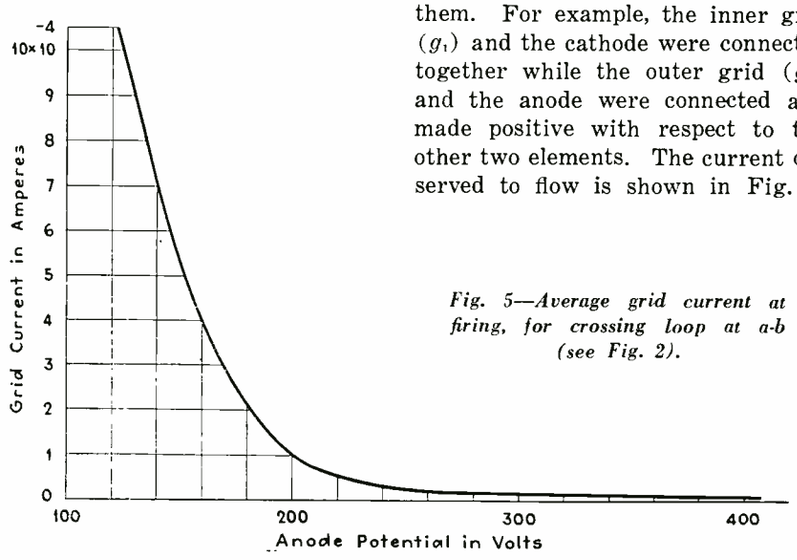


Fig. 5—Average grid current at firing, for crossing loop at a-b (see Fig. 2).

Starting at very low voltages, the currents are small (less than a microampere) and increase very gradually over the range *AB*. At *B* oscillations set in, resulting in a definite decrease in the average value of the potential drop over the tube, while the average value of the current increases. A plot of the average curve would lead one to think that the characteristic curve should have been stabilized by the resistance *R* used in the circuit, but the fact that different "average" curves were obtained for different resistances showed at once that oscillations were present and these were observed with a cathode-ray tube. As the current was increased, the oscillation ceased and a more or less regular curve was obtained. Curves of this kind were determined for each pair of elements. Since these current-vs-voltage curves were taken under conditions which clearly did not represent typical operating conditions, it was considered worth while to compare the observed currents and voltages at the time of "firing" with those of the two element characteristics. For example, with 150 volts on the anode and with the inner grid (g_1) at zero, the grid current in the g_2 circuit at the instant of complete discharge was observed to be 4.5×10^{-4} amperes, and the corresponding voltage was 78 volts. This point is shown by a circle next to the curve of Fig. 6.

In order to initiate a discharge between any two elements the point of maximum voltage, point *B* of Fig. 6, must first be exceeded. It is for this reason that the critical potentials presented in Table I correspond to this point and not to the actual grid potential impressed on the grid at the instant of "firing." If a line is drawn through the point *B* with a slope of $-1/R$, where *R* is the resistance in the grid circuit, the intersection of this line with the current-voltage curve will give the current and voltage immediately after the glow discharge to this grid is initiated, as shown by point C of Fig. 6. In case this current is less than that required to cause a complete discharge between the cathode and anode, the tube does not become fully conducting.

Let us redirect our attention to Table II, and notice in particular that with the help of a small condenser (.0005 to .01 μfd.) connected between grid and cathode, or between grids, depending on the type of circuit used, the large instantaneous current required to complete the discharge can be furnished by the condenser, since in this case the "load-line" can be made so nearly vertical through the point "B" that its intersection with the grid-current characteristic curve is well beyond the minimum current required to "fire" the strobotron. The maximum current required from the control circuit corresponds to that at point B, since the condenser is charged up by the control current between consecutive operations of the strobotron.

Another way of operating a strobotron with an exceedingly small current results from crossing the boundary *b-c* near the point *c*. The currents demanded in the outer-grid circuit for this operation never exceed 10^{-8} ampere and in many cases are nearer 10^{-9} ampere. The breakdown here occurs as a two-stage process. When the potential of the inner grid is maintained only three or four volts less than the critical potential $V_{1c} \cong 130$ volts, and the resistance in this circuit is less than 20,000 ohms, it is easy to see that very little current will be required in the outer-grid circuit to initiate the glow by crossing the critical potential V_{2c}. This crossing triggers off the glow between the inner grid and the cathode which in turn brings about the complete breakdown cathode to anode. Either the condenser method or the "trigger action" method of firing should be used whenever it is necessary to control a strobotron with a photoelectric cell or any other high-resistance low-current source.

In designing circuits for strobotron use, it is important to visualize the characteristic loop shown in Figs. 2 and 3, and to remember that starting by crossing the line *a-b* can be accomplished with the least grid current when double grid control is needed. The use of a small condenser to furnish the instantaneous grid current is strongly recommended when the control current is very small. If only single grid control is needed, then the "trigger" method should be used for small currents in the control circuit. Since the initial currents used in the strobotron are the result of field emission, assisted in some cases by the minute room-temperature thermionic or photoelectric emission (assuming that the tube is not in the dark), the starting characteristics are not as reproducible as one would like for operation on a narrow voltage margin. It is therefore necessary to provide for a considerably greater range of operating potentials than is required for the conventional hot-cathode type of grid-controlled gas-discharge tube. The advantage gained in having no "stand-by" power, an instantaneous peak current capacity of a hundred amperes or more, no heating period, and negligible temperature effect, often more than compensates for the wider operating range for which provision must be made.

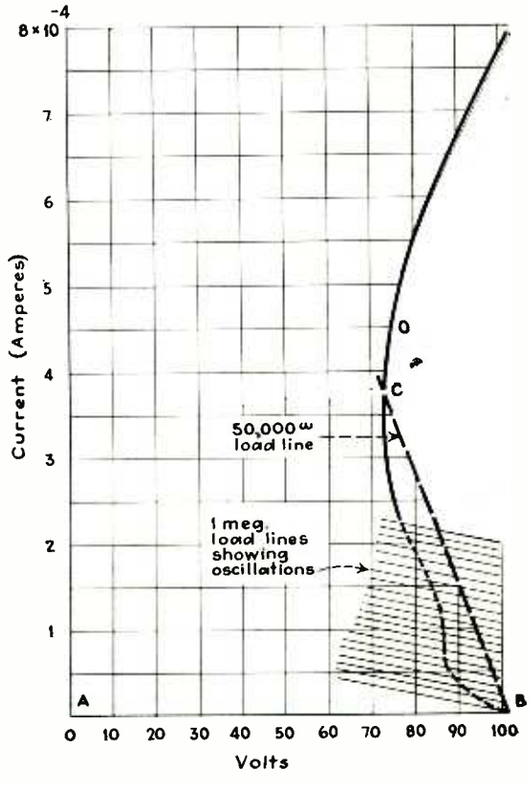


Fig. 6—Current flow between grids as a function of potential difference

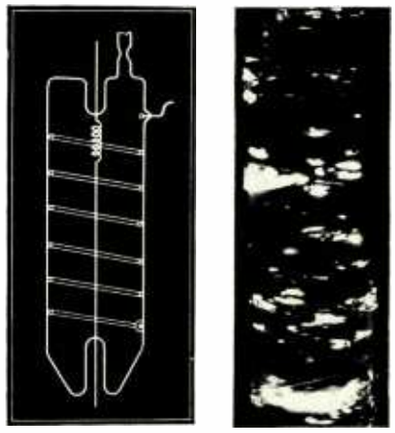
1. Germeshausen, K. J. and Edgerton, H. E., *Electrical Engineering* Vol. 55, p. 790, (1936)
2. Germeshausen, K. J. and Edgerton, H. E., *Electronics*, Vol. 10, No. 2, p. 12, February 1937.
3. Gray, T. S. and Nottingham, W. B., Review of Scientific Instruments, (1937).

Electronic Self-Portraits

By creating fluorescent images of themselves in a radial electron microscope, electrons emitted from wire filaments reveal the progress of activation in thoriated tungsten and other effects of interest. Photographs taken by Messrs. Johnson and Shockley at M.I.T.

THE production of electron pictures, by recording the images produced by electron beams impinging on fluorescent materials, has become a highly valuable tool in many fields of scientific research. One of the latest applications of this technique has been made by Dr. R. P. Johnson and Mr. W. Shockley, who reported in the Physical Review[1] the use of a new and simple electron microscope to examine the emission of electrons from filaments. The results, while of more scientific than engineering significance, are remarkable examples of how much can be learned about electron behavior by direct observation.

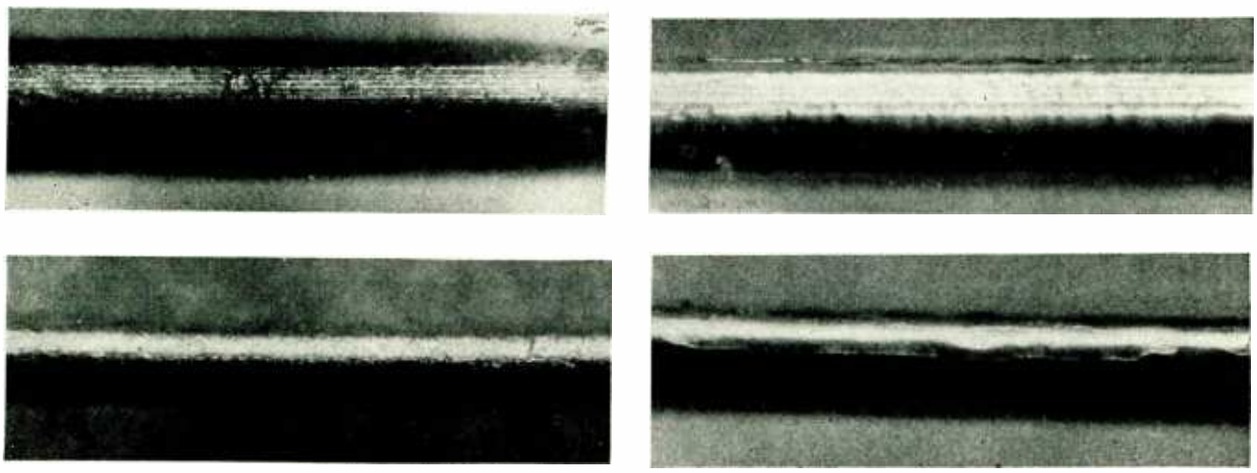
The electron microscope tube used in obtaining the pictures is shown in the figure. It consists of an evacuated cylinder coated on the inside surface with fluorescent willemite. This surface acts as the anode of the tube and is maintained at a positive potential of several thousand volts, applied to a wire helix



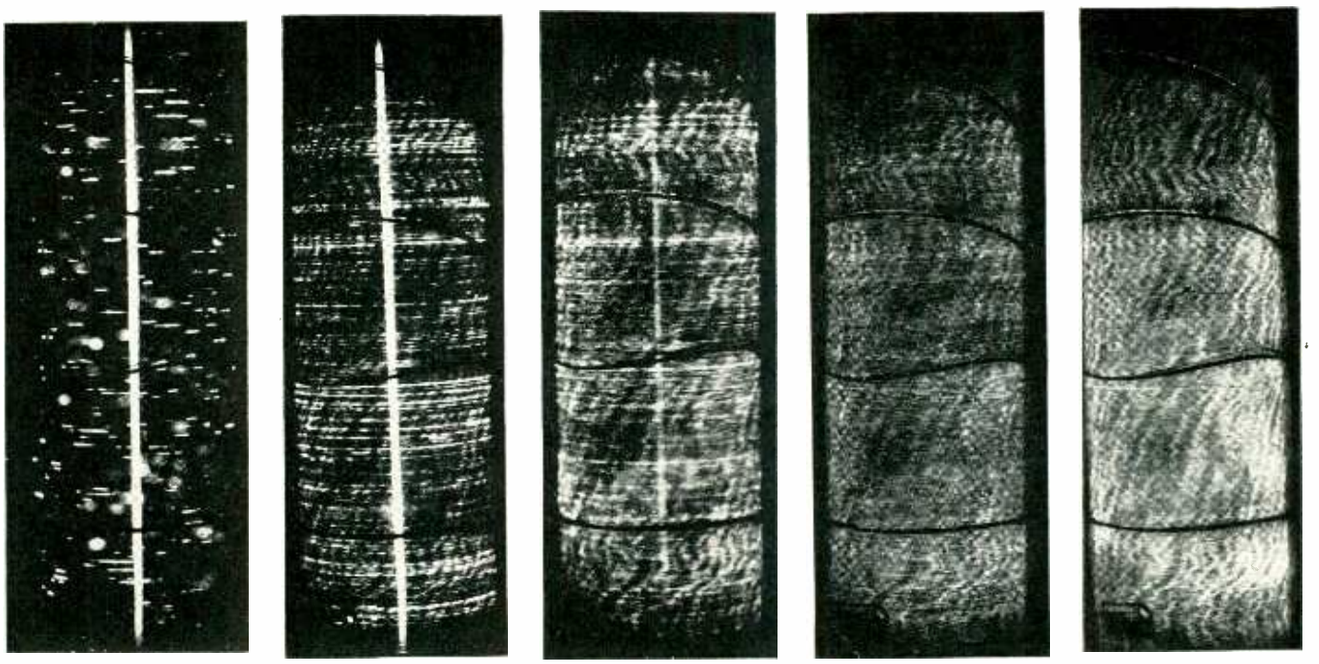
Left, diagram of typical microscope tube used in obtaining the electron pictures. Right, emission pattern obtained from raw tungsten wire at room temperature

coiled inside the tube and resting against the coating. The filament under examination is suspended under spring tension along the axis of the tube. It forms the cathode of the tube; electrons emitted from it are attracted radially toward the anode coating, where they produce fluorescence whose brilliance depends on the number of electrons hitting per second and their velocity. The "pattern" formed on the fluorescent surface is a magnified image of the electron emission at the surface of the filament. With a 5-mil wire in a two-inch tube the magnification is about 400 times, with a resolution of about 1° horizontally and 0.2 mm. vertically.

If a raw tungsten wire is placed in the tube and operated at room temperature, the pattern shows electron emission in blotches, which Messrs. Johnson and Shockley attribute to field emission from rough spots on the filament surface. When the wire is heated to a dull red the splotches of fluorescence disappear, and as the temperature is increased, the thermionic type of emission comes into play. The emission pattern in this case is marked with



Microphotographs of the surfaces of tungsten wires used in the test, for comparison with the magnified images produced electronically. Above, left, raw wire from spool showing die-marks (compare with electron images on opposite page). Right, same wire after operating for one hour at 2800°. Below, left, wire smoothed by electrolysis. Right, electrolyzed wire after one hour operation at 2800° K., showing large crystal boundary

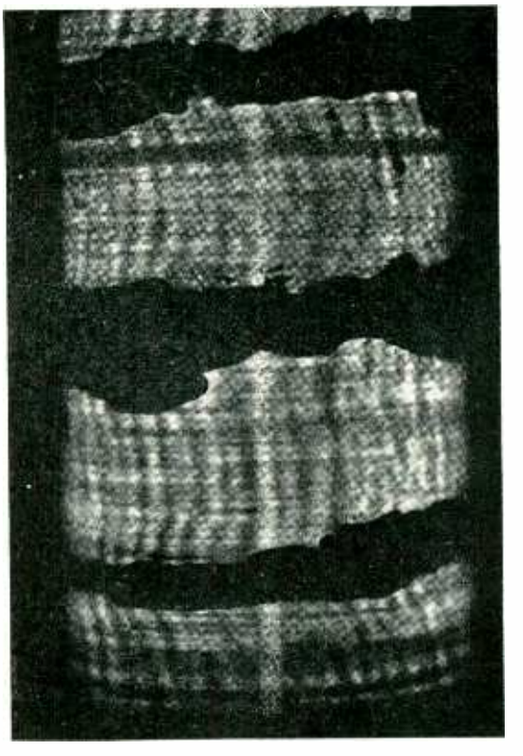


Activation of thoriated tungsten (all pictures made at 1200° K. with decreasing exposure times). Left to right, after ten second flash at 2800° K.; after four minutes activation at 1850° K.; after 20 minutes; after 30 minutes; and after 70 minutes, showing complete activation

light and dark stripes, more or less regularly spaced and continuous along the length of the tube. Apparently these stripes are reproductions of die-marks made in drawing the wire; smoothing the wire by electrolysis or abrasion will produce a pattern comparatively free from groove-marks. As the temperature of the filament is increased, the pattern becomes more brilliant but does not change in form.

The unusual behavior of thoriated tungsten as an electron-emitting substance is well illustrated in the series of five photographs shown above. The thoriated wire is first "flashed" at a temperature of 2800° K. which removes the thorium from the surface. The temperature is then reduced to 1200° K. The emission pattern shows bright spots under this condition. The temperature is then raised to the "forming" or activation temperature of 1850° K. where it remains for more than an hour. At intervals during this activation period, the temperature of the filament is reduced to 1200° K. and the emission pattern examined. The progress of the activation, that is the formation of the active thorium layer on the surface of the filament, can be followed by examining the photographs. Each original bright spot seems to act as a source of thorium, which migrates over the surface until it covers it almost completely. When the activation is complete, the emission pattern is very similar to that of pure tungsten, including the groove stripes previously mentioned. However, the thoriated filament will produce as bright a pattern at 1200° K. as will pure tungsten at 2000° K.

[1] An Electron Microscope for Filaments: Emission and Absorption by Tungsten Single Crystals, R. P. Johnson and W. Shockley, *Phys. Rev.* 49, 436 (March, 15, 1936). This work was performed at the Eastman Research Laboratories of the Massachusetts Institute of Technology. The Editors are indebted to Dr Johnson, now with the G. E. Research Laboratory at Schenectady, for supplying the photographs.



Emission pattern from drawn tungsten wire, showing the stripes produced by die-marks in the wire, photographed at approximately 2000°K. The wire helix has been replaced by a strip of platinum paint in this tube

A D-C Amplifier

R_2 5,000 ohms
R_3 10,000 ohms
R_4 30,000 ohms
R_5-R_8 100,000 ohms
R_9, R_{10} 40,000 ohms
R_{11} 15,000 ohms fixed plus 20,000 ohms variable
R_{12}, R_{13} Two gang variable resistor, 1,000 ohms and 5,000 ohms
R_{14} Resistor equal to resistance of recorder
R_{15} 10,000 ohms, 50 watts
P_1-P_5 200,000 ohm potentiometers
S_1, S_2, S_6 SPST jack switches
S_3 12 position rotary switch
S_4 3PDT jack switch
S_5 12 PDT rotary switch
S_7 DPDT toggle switch
T_1 Transformer with plate voltages of 450-0-450 volts and filament voltages suitable for tubes used in the amplifier.
Ch 20 henry choke coil
C_1 8 μfd. filter condenser

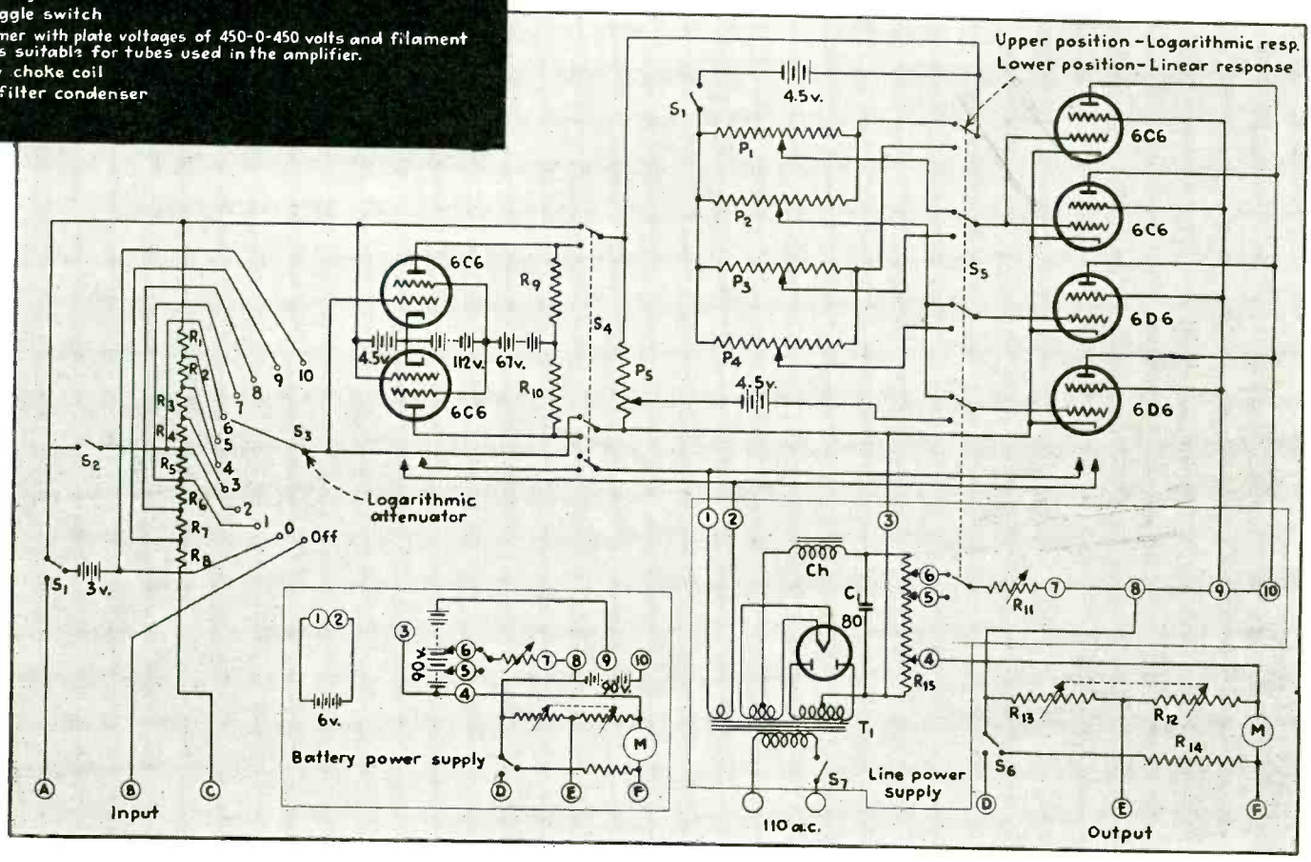


Fig. 1—Schematic wiring diagram of the amplifier showing alternative forms of power supply

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IN THE older branches of the electrical industry the widespread use of graphic recorders is axiomatic. Similarly, as electronics comes of age, there in an increasingly apparent tendency to employ graphic recording instruments, not only where permanent records are desired, but also in the measurement and observation of continuous phenomena encountered in development and test work.

However, the application of recording instruments to electronic applications differs in one marked respect, namely, the more frequent occasion for recording of other-than-linear quantities. This is particularly true in the fields of audio, video, and radio propogation where the quantitative criterion is very often a logarithmic function. In such cases, direct recordings on a logarithmic scale are obviously desirable.

Although logarithmic-response instruments of the panel type have been devised (for instance, those used in portable sound-level measuring equipments), there is to date, no standard graphic-recording instrument with this type of response. It is, therefore, necessary to use the ordinary linear-response recorders, and provide some intermediate means of driving these logarithmically. This can be done in two ways, ie., by designing the particular equipment to have an inherent logarithmic response, or by using an external amplifier having a linear input-logarithmic output characteristic. Where equipment for permanent installation is concerned, the first alternative is usually preferable. However, for general laboratory applications an external logarithmic amplifier is ordinarily more advantageous in that it can be combined with existing measuring equipment of practically any type, without necessity of redesigning or recalibrating such equipment.

The amplifier described was designed for applications of this kind. The original need arose in connection with the problem of making logarithmic recordings of broadcast station field intensities. However, considerable flexibility was purposely incorporated in order that the same

for Logarithmic Recording

equipment might be used for any similar application wherever a linear-logarithmic response is required. The method followed, and the results obtained, may, therefore, be of some general interest.

General Characteristics

The type of recorder most widely used requires 5 milliamperes for full-scale deflection. Output of this order is, therefore, the first requisite of equipment for this purpose. Since most electronic measuring devices are not designed for this load, a certain amount of power amplification is required. The present amplifier has been designed to provide an output of 5 ma. (across any load up to 5000 ohms) with an input of 3 volts. Since the impedance of the input attenuator is approximately 450,000 ohms, the load which it places on the source is less than ten microamperes. To provide wide flexibility of input, a switch is arranged to cut out one stage of the amplifier. In addition, any intermediate range is available by using the input attenuator which is calibrated in logarithmic steps.

The second requirement of an amplifier of this type is a useful response throughout a range appropriate to the phenomena to be encountered. Since the difficulty of obtaining stability and accuracy increases rapidly as this range is increased, the choice must represent, to some degree, a compromise. Thus, although a range of 70 or 80 db might find occasional use, a more practical amplifier results if a less extended range is chosen. The amplifier described was designed with the idea of obtaining a useful response approaching 50 db. This provides for most all likely requirements, and, as will be noted later, is a convenient choice as regards scale.

In addition to these primary requirements, equipment for general laboratory and field use must have a certain amount of overall flexibility. Several features have been included with this in mind. For instance, a six-pole switch has been provided so that the amplifier may be instantly changed from logarithmic to linear amplification. Again, provision has been made for either battery or a-c operation. Finally, a simple means of calibrating the equipment has been built-in.

The most difficult problem in building a direct-current amplifier is that of maintaining stability. This follows from the fact that, unlike a-c amplifiers, the output is markedly dependent on supply voltages. If no compensating arrangement is used, changes in plate current cause corresponding changes in output and near zero on the scale these may amount to very large percentage errors. In a logarithmic amplifier this is still more pronounced because of the very high gain at the bottom of the scale. In developing the present amplifier, various means of compensating for first-stage drift were tried, but it was found that no simple method would suffice. As a result it was necessary to use a balanced-type amplifier. The arrangement is quite simple (see Fig. 1). Since it is essentially a bridge circuit, ordinary changes in battery voltage will not affect the output. The use of pentode tubes makes feasible a gain of about 30 db without resorting to an impractically high plate voltage. The values of resistances R_9 and R_{10} are not critical, but these must be well-matched. Similarly the two 6D6's used should be selected for identical characteristics. These tubes have good uniformity and it has been found that two of practically identical characteristics can be found easily.

Exponential Second Stage

At zero input the voltage across R_9 R_{10} is zero. When input voltage is applied the instantaneous plate current of one tube increases, causing a negative voltage to appear across the resistors. This voltage is applied to the grids of four tubes in parallel in the second stage. The reason for this arrangement will be evident from a study of Fig. 2. Curve *a* is the plate characteristic of a single 6D6, biased slightly negative. This tube, which is of the remote cut-off type, has a characteristic usually referred to as exponential. However, as can be seen, it closely approaches this over only a comparatively small range (about 20 db). Nevertheless, it is roughly exponential over a much wider range—and hence occurs the idea of obtaining a logarithmic curve by adding correction. As can be seen the departures from exponentiality occur at the top and bottom of the curve—at which points the curvature is not sufficiently great. Correction at the top is obtained by placing two 6D6 tubes in parallel, and biasing them so that they cut off curve *b* rapidly, thus increasing the curvature near the axis. Correction at the other end is obtained by adding another 6D6 with its grid fed from a potentiometer. This is adjusted so that only a small part of the first-stage output voltage operates on this tube. The resulting characteristic (curve *c*) drops off slowly, thus providing the curvature desired. The screen grids and plates of all four tubes are connected together. Curve *d* is the total current—and is

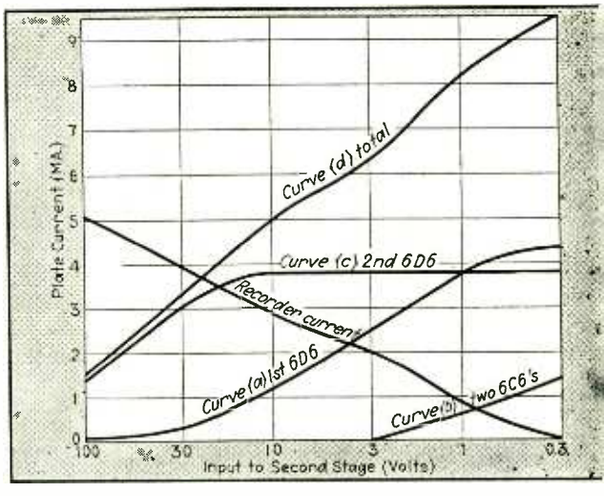


Fig. 2—Electrical characteristics of the tube combinations and recorder current

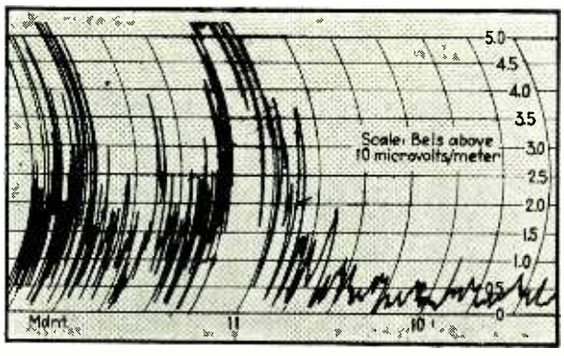


Fig. 3 — Field strength record made automatically with the field intensity meter and amplifier shown on page 27

a logarithmic curve of good correspondence. The abscissa of Fig. 2 is, of course, the voltage input to the second stage.

The current of curve *d* is used to drive the recorder—which is placed directly in the circuit. However, as the total variation is to be limited to 5 ma., and the recorder is to read zero at the position corresponding to zero on Fig. 2, it is necessary to provide a balancing current, and also to shunt the recorder terminals. The first is accomplished by tapping an additional positive voltage off of the bleeder, and feeding this back in reverse direction. By adjusting resistor R_{11} the recorder can be made to read zero at zero input. The arment used also makes it possible to compensate for changes in line voltage in relatively simple manner. This is accomplished by adjusting the value of the feedback voltage. Since this voltage is obtained from the same bleeder as the plate voltage, a point will be found such that changes in the two voltages, caused by changes in line voltage, will just balance each other. This balance, of course, will be perfect for only one point on the output scale. However, by choosing this point toward the lower end of the scale, a balance is obtained such that a 10% variation in line voltage will cause a variation of only 0.1 ma.—or 1 db—at the worst point. This is an error that is well within the overall error of the equipment.

As will be seen from Fig. 2, the total change in plate current for a 50 db. change in input, that is, from 0.3 volts to 100 volts—causes a variation in total plate current of 8 ma. The recorder is placed in series with this circuit, and is shunted with a variable resistor R_{12} R_{13} which reduces this variation in recorder current to 5 ma. Then, if 50 division recording paper as shown in Fig. 3 is used, each scale division represents one decibel. The recording is then direct reading, convenient, and of quite good accuracy. To facilitate operation a 5 ma. meter, *M*, is placed in series with the output terminals, and a switch S_6 arranged so that the recorder may be cut out of the circuit, a resistance R_{14} equal to the resistance of the recorder, being substituted. This allows the setup to be adjusted or the calibration checked without causing meaningless marks on the record. Since several types of recorders are in general use, three output terminals have been provided, and the shunt resistor R_{12} R_{13} is of the ganged two-section type with the center point brought out to terminal *E*. Where a high resistance recorder is used the connections are made to terminals *D* and *F*, and terminal *E*. left open. For a low resistance recorder terminals *E* and *D* are shorted.

The above description covers the circuit for operation as a logarithmic amplifier. If the unit is to be used for general laboratory applications, there will also be occasions when it will be desired to use it in connection with making linear recordings. Such operation has been provided for and the changes are made by means of a single switch S_5. Operation of this switch connects the tubes of the second stage to a different group of potentiometers and places the two 6D6's in parallel. These potentiometers P_1 and P_2 are adjusted so that the tubes work over only the linear part of the characteristic. The shunt resistance across the recorder must, of course, be reduced. For this operation an input of three volts to the second stage causes full deflection on the recorder. The switch S_5 also changes the feedback voltage tap, thus allowing compensation to be independently obtained for linear as well as the logarithmic amplifier connection.

Logarithmic Step-attenuator

With the above operation in mind the function of the input attenuator can be considered. This consists of eight resistors R_1-R_8, with taps brought out to a twelve position switch S_3. Positions 0 to 5 of this switch constitute a logarithmic step-attenuator, each step causing a 10 db. attenuation. This is a convenient arrangement since it, as well as the output meter, will be direct reading and the readings are directly additive. Thus, if the attenuator is set, for instance, at the position marked 3 and the output meter reads 4 ma., the input voltage is immediately read as 70 db. above the reference level (10 microvolts when both stages are utilized).

The remaining steps, 6 to 10 constitute a linear potentiometer, each step being one quarter of the total. This part of the attenuator is placed in operation by closing switch S_2, which shorts resistors R_1 to R_4. It is useful in calibrating the linear operation of the amplifier and requires no added resistors, since taps are merely brought out from sections of the resistors composing the logarithmic attenuator.

A word about the value of resistors R_1 to R_8 is desirable. Since an overall accuracy of 2 db. is sufficient for this type of work, and since errors of the order of $\pm$ 1 db. occur due to other factors, it was thought that resistors chosen such that the error on any step would not be more than $\pm \frac{1}{2}$ db would be satisfactory. This allows use of a minimum number of standard-size resistors—the values of which are indicated in Fig. 1. These may be of the semi-precision wire-wound type, specified for 5% accuracy. If several of each value of these are available to choose from and a means of measurement available, it is usually possible to find values within 2% or so. However, the 5% accuracy values are sufficiently good providing the errors are not all additive.

When the input attenuator is used the input connections are made to terminals *A* and *C*. This places an

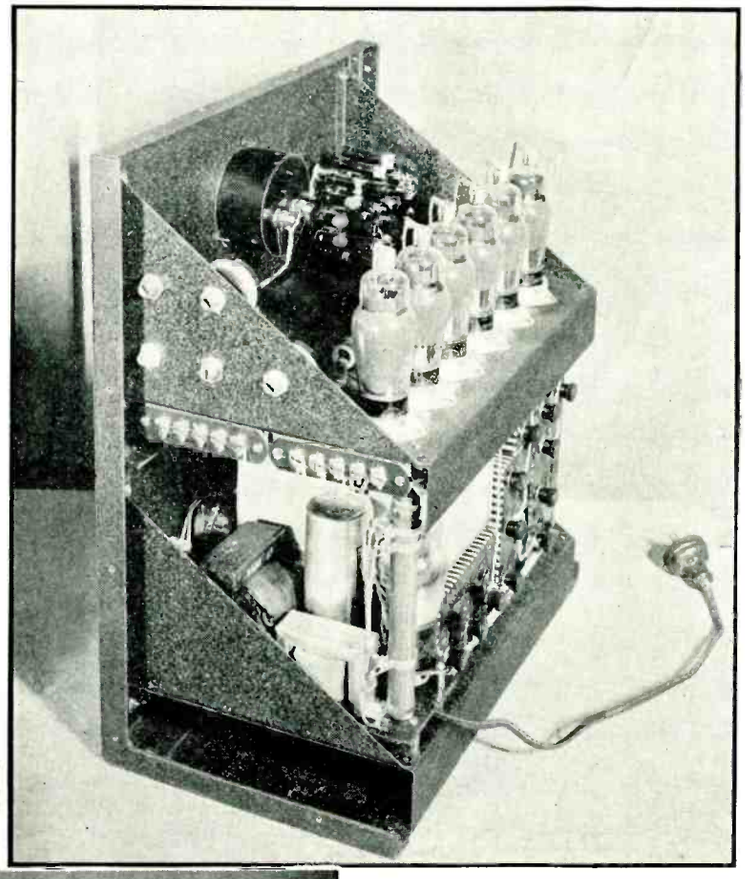
impedance of 450,000 ohms across the source. If it is desired to eliminate this load, switch S_3 may be set at the "off" position, and the input connections made to terminals *A* and *B*. This, of course, makes it impossible to use the attenuator.

In order to have available a means of quickly checking the calibration of the amplifier a three volt battery is arranged so that throwing switch S_1 will connect it in the circuit. When this is done, taps 0 to 5 afford a means of direct calibration which is quick and convenient. Thus with switch S_3 set on tap 5 the output meter should read zero, on tap 4 it should read 1 ma. and so on up to tap 0, at which it should read full scale. The same calibrating procedure can be followed for the linear calibration by closing switch S_2 and throwing switch S_4 to the one-stage position. This allows taps 6 to 10 to be used to calibrate the amplifier for linear operation.

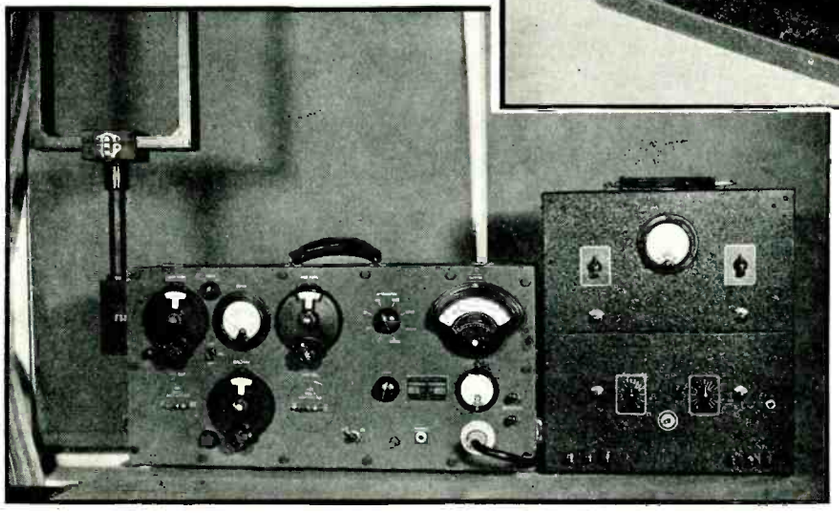
It will be noted that the plate voltage for the first stage is supplied by batteries while that for the second stage is obtained from a power unit. Because the total first stage current is only a few milliamperes, it was decided to use batteries exclusively for this stage.

The second stage however draws considerably more current and a-c operation is desirable when used in the laboratory. A simple rectifier circuit suffices since a relatively high hum-level has no effect. All of the connections involving this power supply are made through binding posts — terminals 1 to 10 on Fig. 1. For field use the power supply is simply disconnected at these points and removed entirely. Batteries are substituted as indicated in the inset of Fig. 1. It will be noted that the arrangement in this case is quite different. This is done in order to obtain drift compensation without the undesirable course of using a bleeder. This is accomplished by connecting the meter and recorder terminals in the negative side of the plate supply and by taking the feedback voltage from a tap on the battery which furnishes the screen grid voltage. With this arrangement (since pentodes are used) small changes in plate voltage have no affect on plate current and if the tap is correctly adjusted changes in the feedback voltage (since they will be balanced by changes in screen voltage) will not affect the current in the output circuit. Thus, the only voltage change which can cause drift is that in the section of the screen grid battery above the feedback tap — and, since the current drawn from this part of the battery is very small, the corresponding drift will be small and will be partly balanced out by the change in C battery voltage.

(Continued on page 35)



Interior view of the amplifier



An experimental set-up for taking field strength measurements

A New Color-Separator

A double-tube circuit distinguishes between two basic colors by comparing the percentage of each in the test sample, giving positive indications regardless of color impurities

By W. RICHTER

A. O. Smith Corporation
Milwaukee, Wisc.

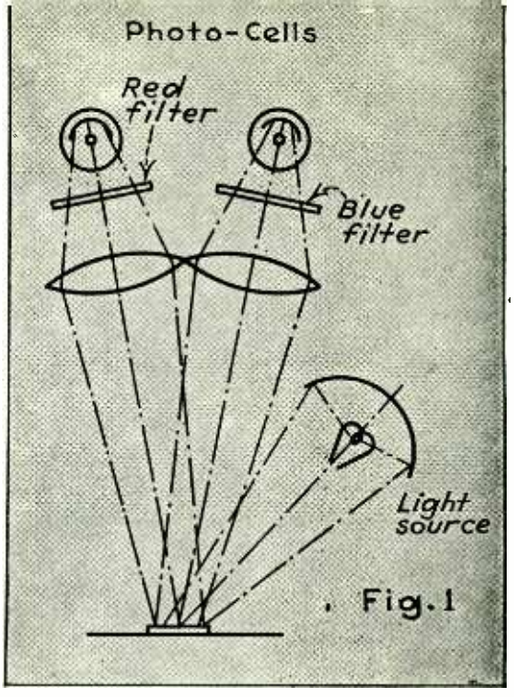


Fig. 1

MOST photoelectric circuits operate on the total amount of light received by the phototube. If the problem is to separate a certain shade of one color from a certain shade of another color, this can usually be solved by the application of a single color filter to the tube. The problem becomes immediately more complicated if, for instance, articles ranging from the lightest to the darkest red are to be separated from articles ranging from the lightest to the darkest blue. The reason for the fact that one cell with a filter fails to function is that the colors usually encountered are never pure colors. Thus by the application of a red filter it should be possible to make a red piece of paper look lighter than a blue one, so that the photo cell would respond to all shades of red with a current larger than for the blue shades. However, it is found that light blue paper will also reflect a good deal of red light, as a matter of fact, more than a very dark red paper.

A circuit had therefore to be devised which would not be affected by the intensity of the total amount of light reflected from the article, but by the ratio of the individual color components of it. Thus while the light reflected from a light blue paper may contain more red light than the light reflected from a dark red paper, yet the ratio between the blue and red components is certainly larger in the case of the blue paper than in the case of the red paper.

This problem was solved very satisfactorily by an arrangement, the principle of which may be stated very simply: Two photo tubes are receiving light from the object simultaneously, one through a red the other through a blue filter. (If separation is desired between two other colors, corresponding filters must be used of course.) By means of a neutral optical wedge or a diaphragm the amount of total light reaching the two tubes is adjusted so that they pass equal currents, if a white or grey piece of paper is made to reflect light on them. (It is assumed that white contains all colors in about equal amounts.) Such an arrangement will of course be practically independent of light fluctuations, because both cells receive light from the same spot. If either the intensity of the light drops or the white is replaced by a grey paper, which absorbs an equal amount of all colors, the light received by the two cells will decrease in both of them the same amount, and the two currents decrease, but remain equal. An instrument showing the difference between the two will therefore remain at its zero setting. Now let the cells look at any shade of red or orange paper; no matter how dark or how light the shade, the light coming from it will contain more red than blue light. The cell with the red filter will therefore receive more light than the one with the blue and the meter mentioned above will go to the one side. The reverse is of course true when looking at any blue paper.

In trying to put the above stated principle into practice several factors must be taken into account. The first thought would be simply to have two cells looking at the same object. The two cells and their lens systems can obviously not occupy the same space; therefore the two cells will look at the object under a slightly different angle, as shown in Fig. 1. Assume for a moment the article to be a light red, which would make the cell with the red filter to pass more current. Now it may easily happen that the surface of the body may have a sheen or lustre or other particles with peculiar reflecting properties such as to make the whole article appear much brighter when looking from the direction of the blue filtered cell. Under these circumstances it may easily happen that the blue cell would receive more light from the red article, than the red cell which of course would cause a wrong indication. It is therefore at once obvious, that it is of the utmost importance that both cells receive the same picture.

This was accomplished by the arrangement shown in Fig. 2, which shows the optical system of the apparatus. The body *B* is illuminated by a strong source of light *A*; in the experimental set up an automobile spot light was used and *B* was brought in its focal point, which resulted in an intense illumination. The light reflected from *B* is collected by a large condenser lens *C*. After passing through *C* it falls on a specially prepared mirror *D*. This mirror, about 6 by 6 inches is of the ordinary variety, obtainable in any store. However, the back was removed and the silvering removed in 1/16″ wide strips, so that the mirror consists of alternate strips of clear glass and original surface, both of them being about 1/16″ wide. Consequently about half of the light coming from *C* passes through it, while the rest is reflected. These two parts pass now thru the lenses *E* and *F*, the purpose of which is simply to reduce the size of the lu-

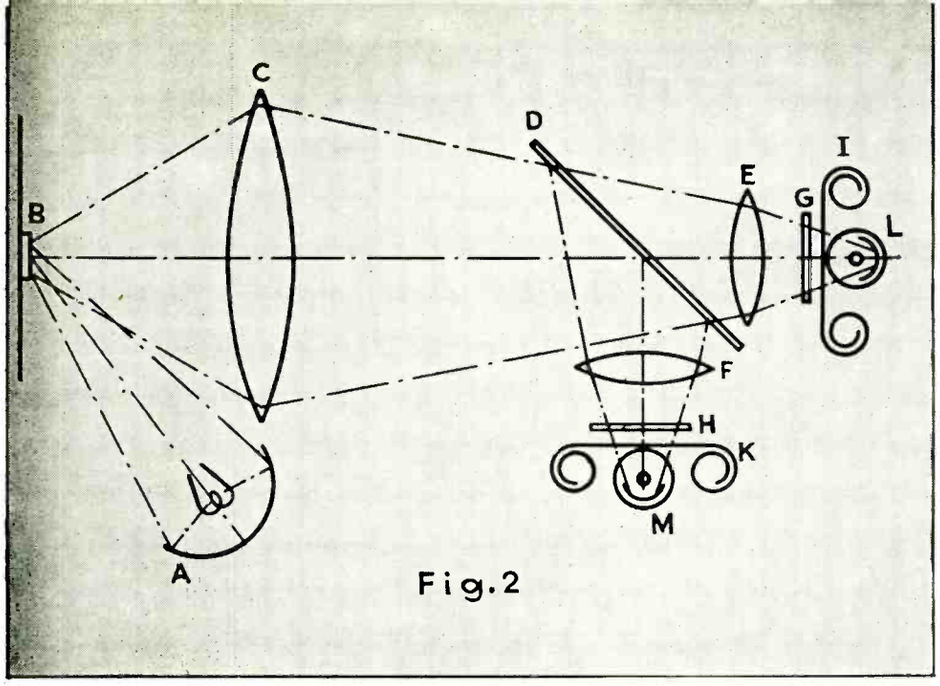
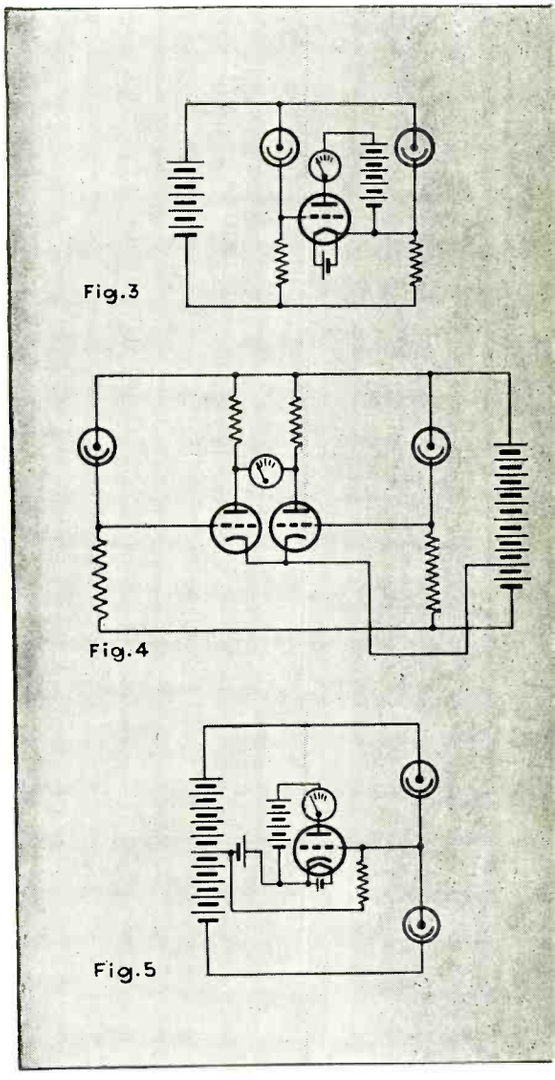


Fig. 2

Fig. 1—Phototubes view sample from different angles, producing errors. Fig. 2. Arrangement whereby both tubes view sample from same angle.

Fig. 3—Method of measuring relative phototube response in bridge circuit. Fig. 4. Same in balanced form. Fig. 5. Circuit actually used measures voltage distribution between tubes



minous spot produced by *B* so that it will be completely on the cells. It then passes thru the two filters *G* and *H*, furthermore thru the optical wedges *I* and *K* and finally produces a picture of *B* on the photo cells *L* and *M*. This picture is made to be somewhat out of focus in order to minimize possible differences in sensitivity over the surface of the cells.

Since the sensitivity of the cells to various colors is very different, usually being larger for the red than for the blue, the cell with the red filter will pass more current for given incident light. Therefore the amount of light reaching this cell must be cut down. Since it is of great importance that both cells receive the light exactly from the same portions of *B*, an optical wedge, which cuts down the intensity of every ray of light individually instead of a diaphragm, which cuts out a portion of the rays entirely, is preferable.

The two wedges were prepared in a most inexpensive manner. A length of about three feet of 35 mm positive film for motion pictures, as obtainable from Eastman Kodak Co. in 100 foot lengths at about 1.5 cents per foot, was mounted on a flat board and exposed by the light from a small bulb held about 6 inches above one of the ends. This causes the end under the bulb to become rather dark, while at the far end not only the intensity of the light is much less but also the angle of incidence smaller, so that the strip remains practically clear on this end. The strip was then fastened to two small wooden rolls provided with knobs, and thus can be moved across the window thru which the light reaches the cell. Excellent stepless control was obtained in this manner.

Two more points might be of interest in connection with the photo electric and optical system. The common caesium coated photo cell has practically all its sensitivity in the red and infra-red part of the spectrum. The gelatine filters obtainable all pass infra-red light very freely, so that as far as the cell is concerned the filters do not produce the desired action. For this reason it is more desirable to use potassium cells which have their peak sensitivity in the visible part of the spectrum. The use of copper sulphate filters for both cells was found to give better results.

There are several ways in which the electrical circuit can be designed to give an indication of the difference of current in the two cells. Thus the cells can be arranged in a Wheatstone bridge, as shown in Figure 3. This would probably be an undesirable circuit, due to the insulation difficulties of the high resistance load resistors needed. However the currents of the two cells could be at first amplified, the two amplifying tubes being arranged in a bridge circuit, as shown in Figure 4. The circuit actually used is shown in Figure 5. This circuit is well known for its high sensitivity due to the flat characteristics of the photo cells. It was run entirely from batteries, but otherwise is with a few minor differences equal to the one described by D. G. Fink in the June 1934 issue of Electronics on pages 190 and 191. A 37 type tube was used with reduced filament voltage and very low plate voltages and the whole tube was boiled in paraffin to eliminate surface leakage. The apparatus was found to give excellent color separation regardless of the intensity of light and the shade of the sample.

Portable Reverberation Meter

Reverberation time measures the acoustic value of a room. This factor may be calculated knowing the dimensions of the room, etc. But it is often desirable, or necessary, to measure the decay period. This calls for an "electrical ear" and a timing device

By HALE J. SABINE
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Chicago, Ill.

IT IS a well known fact in acoustical engineering that the quality of hearing conditions in auditoriums is governed to a large extent by reverberation, the audible continuation of sound throughout the room after its source has been stopped. Faulty acoustical conditions are most frequently due to an excessively slow rate of decrease of this reverberant sound, with a consequent overlapping and confusion of spoken words and musical notes which renders satisfactory hearing difficult or impossible. It has long been known that reverberant sound intensity decays along an approximately logarithmic curve, or, in other words, at a constant rate in decibels per second. This fact has been made the basis of the definition of reverberation time, namely, the time required for sound energy to die out over a range of 60 db. The reverberation time as thus defined has given long and useful service as a yardstick for the acoustical properties of rooms.

Reverberation time in most cases may be easily calculated from the dimensions of a room and knowledge of the sound absorbing efficiencies of the interior surfaces. Often, however, these calculations may be extremely uncertain, and it becomes desirable to measure the reverberation time directly in the room itself. Under normal room conditions, reasonably accurate measurements may be made with simply a calibrated organ pipe and a stop watch. This method, however, does not reveal variations from the theoretical logarithmic decay, which under certain conditions may become quite pronounced.

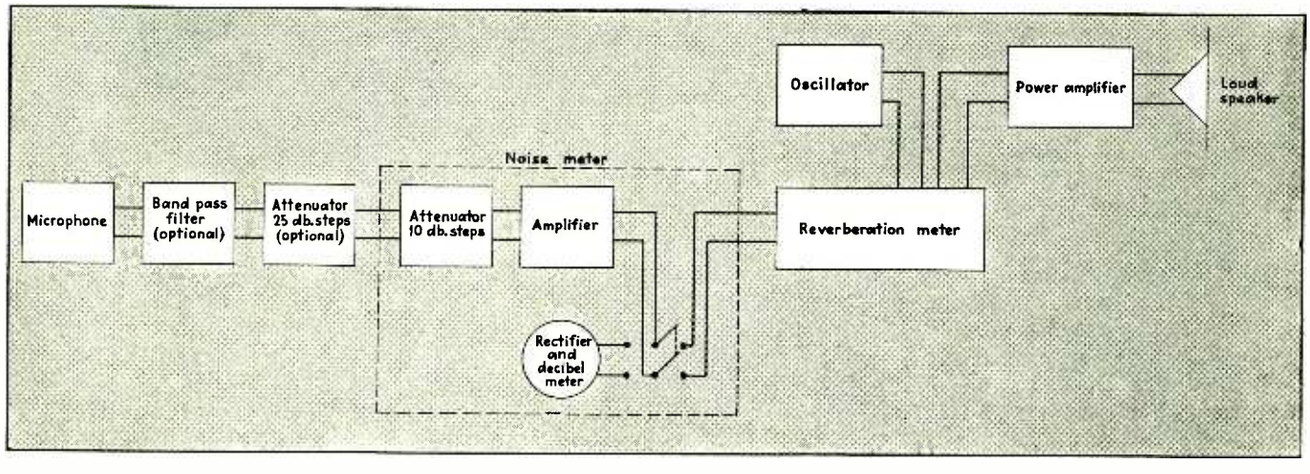
This paper describes a portable, electrically operated reverberation meter designed to measure directly the rate of decay of reverberant sound in decibels per second. The complete apparatus includes the reverberation meter proper and a General Radio noise meter (which together constitute the actual measuring equipment) and a sound source. The latter may conveniently be a portable instrument such as described by Anderson[1]. It was found in this case that the noise meter, which was already available, could be readily utilized as part of the required equipment, and the reverberation meter was designed as an adjunct to the noise meter.

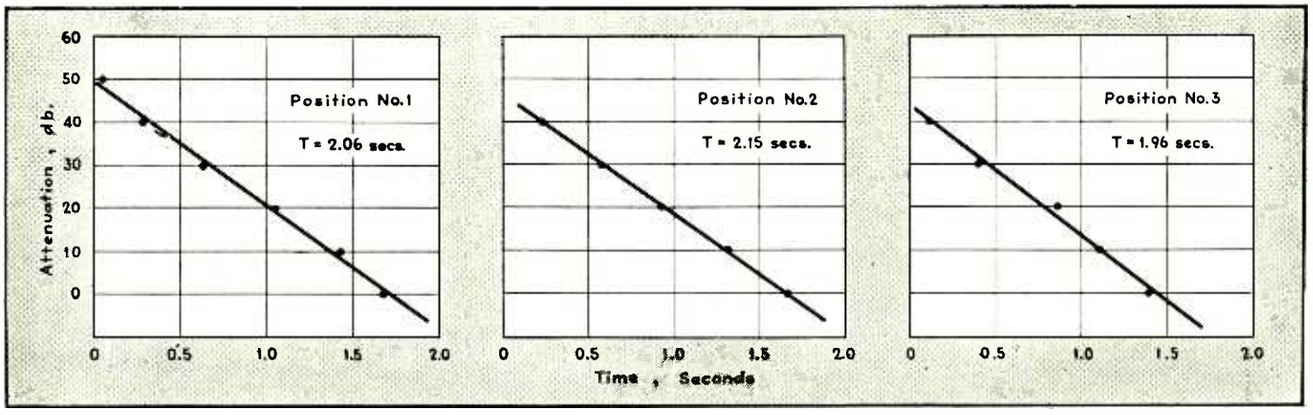
The reverberation meter and noise meter together constitute in effect an electric ear having a threshold which can be varied by 10 db steps, and a timing device which measures the time required for reverberant sound to die out from its initial value at the instant of cut-off to the particular threshold chosen. By plotting the time intervals as abcissae against the corresponding values of threshold settings in db as ordinates, a series of points is located which, when joined by a straight line of best fit, give directly the slope of the decay curve. The reverberation time as defined is, therefore, the time interval along the horizontal axis corresponding to a range of 60 db. along the vertical axis. Absolute values of either time or intensity are not involved, since it is only the slope of the decay curve which is being measured.

The schematic and wiring diagrams indicate the operation of the apparatus. The essential components contained in the noise meter are shown separately inside the dotted lines. The microphone in this case

[1] *Electronics*, April, 1936.

Schematic of complete apparatus for measuring reverberation time





Typical data secured by the equipment placed in several locations

is a duplicate of the pickup device built into the noise meter, but is brought outside for convenience. The band pass filter may be inserted to pass the frequency of the test tone while suppressing interfering noise of other frequencies. The 2½ db step attenuator may also be inserted if it is desired to take smaller steps along the curve. The 10 db step attenuator in the noise meter is utilized as the variable threshold control. Output terminals were added to the noise meter, and a switch was provided for transferring the output of the amplifier from the decibel meter movement to these terminals. Since the amplifier is heavily overloaded while the sound source is operating, it was necessary to take the meter movement out of the circuit to prevent damage to it.

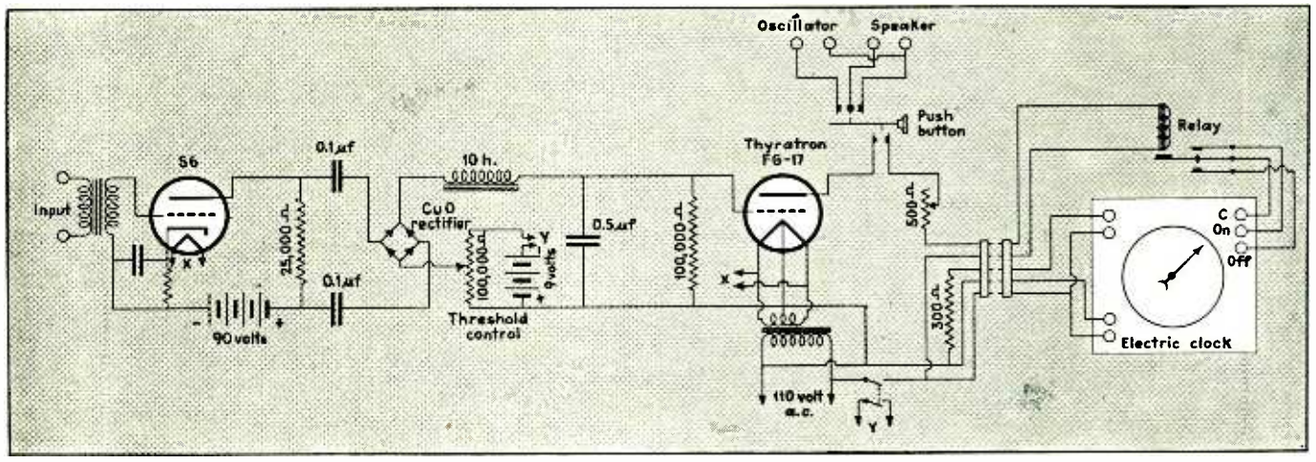
The reverberation meter proper consists of a stage of amplification of conventional type followed by a small copper oxide rectifier and a low-pass filter section. These two elements convert the a-c output of the amplifier tube to a steady positive d-c voltage on the grid of the thyratron. A variable negative bias furnished by the C battery and potentiometer is superimposed on the positive voltage so that their resultant algebraic sum is the effective voltage controlling the plate current of the thyratron. This plate current will flow only when the positive voltage due to the sound input is high enough to bring the total grid voltage more positive than the discharge potential of the tube, in this case approximately —2 volts. The variable negative bias serves as a threshold control supplementary to the 10 db step attenuator, since the more negative this bias, the more positive must be the sound input voltage to cause the tube to discharge. By this means it is possible to set the threshold of the entire system just above the noise level existing in the room under test.

The plate current of the thyratron operates a relay which in turn controls the starting and stopping mechanism of the clock. This is a Leeds & Northrup synchronous timer having a very rapid and positive clutch mechanism operated by a pair of opposing magnets. The clock movement is operated by a standard synchronous clock motor and is geared to complete one revolution in 10 seconds. The dial is graduated in tenths of a second, and may be easily estimated to hundredths. The push button in the plate circuit of the thyratron is arranged so as to turn on the sound source and break the plate circuit simultaneously when pressed, and when released to cut off the source and close the plate circuit, thus allowing the clock to start the instant the source is stopped.

The plate of the thyratron is supplied with 110 volts a.c. from the power line. With this arrangement, the plate current will automatically be turned on and off as the grid voltage is varied back and forth through the critical value. Under field conditions the decay of sound energy actually takes place with rather wide fluctuations about an

(Continued on page 35)

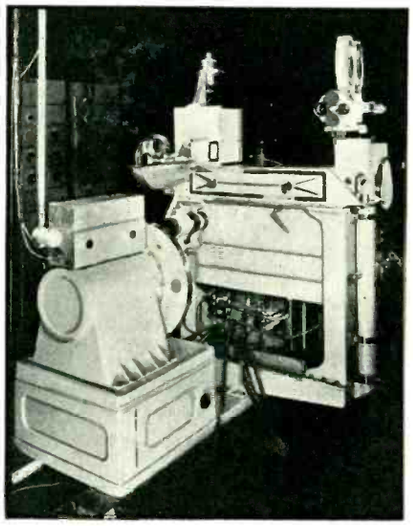
Wiring diagram of reverberation meter for measuring auditoriums



Television — European Style

New intermediate-film pickup cameras and a projector for theatre use appear in England and Germany

This truck, the second of its kind constructed in Germany, is fitted to develop the film taken by the camera on its roof, and scans the film immediately for transmission. The whole process of development and scanning consumes thirty seconds



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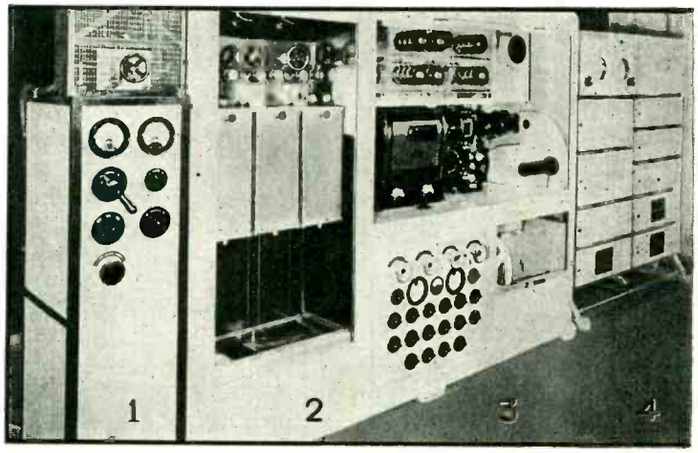
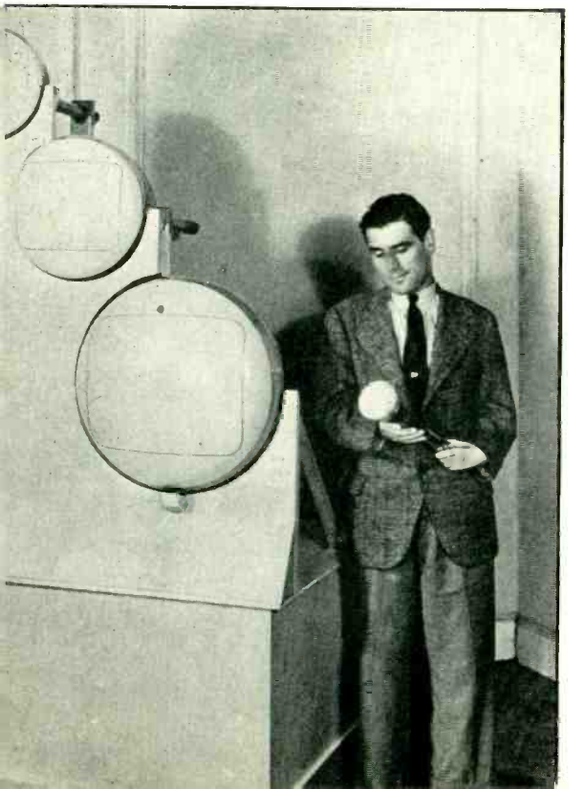
An English version of the intermediate-film pickup camera. The film camera at the upper right feeds exposed film through the hollow standard to the developing tank. After reversing the film is projected on the rotary scanning disc and photocell (left foreground)

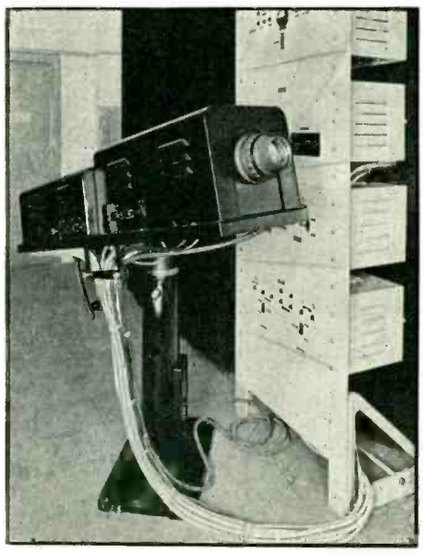


Apparatus installed in the television truck. The units are: (1) power supply controls; (2) developing, washing and fixing tanks; (3) the rotary scanner which scans the film immediately before it is completely dry; (4) the photocell amplifier and u-h-f relay transmitter which sends the signal to the main transmitter



▶

This television receiver is built by Fernseh A.G. of Berlin for use in theatres. The cathode-ray tube behind the lens operates with 18,000 volts on the accelerating anode, producing an image bright enough to be projected on a screen 3 by 4 feet in size



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New members of the cathode-ray tube family. Large-size tubes (12-, 15- and 22-inch screens) constructed in England for television reception. The fluorescent screens produce a practically pure black-white image

Multiple-Circuit Pads

A chart for determining the resistance values in networks designed to match several like impedances to one other impedance of different value, for example, matching several 500-ohm telephone lines to a 2000-ohm amplifier output

By FREDERICK WHEELER
Engineer, Station WKY

FREQUENTLY the communications engineer is confronted with the problem of feeding two or more telephone lines from one amplifier, or the inverse case of feeding two or more amplifiers from one telephone line. In such cases the circuits may be matched by a network, or pad, of resistance elements. While such a pad introduces a loss, the loss is usually not more than 25 decibels, and in many cases is much less than this amount. The simplicity of the network and its freedom from frequency error recommend it in preference to transformer coupling.

Chart suitable for six circuits

The chart printed on the reverse side of this page presents curves for calculating the various constants in such multiple pads for from three to six circuits. The curves are calculated for matching one circuit of reflected impedance Z_2 to several circuits of reflected impedance Z_1. The ratio $K = Z_2/Z_1$, the total number of circuits N (including both input and output circuits), and the impedance Z_1 are the factors determining the values of the resistances used in the pad. In terms of K and N, the factors C and E are found from the chart. The resistances R_1 (shown in the diagram) are then $R_1 = Z_1C$ and the resistance $R_2 = Z_1(K - E)$. For example let Z_2 be 2000 ohms and Z_1 be 500 ohms. Then $K = 2000/500 = 4$. Four impedances Z_1 are to be matched with one impedance Z_2. The number N is then 5. The chart gives corresponding values of C and E to be $C=0.525$ and $E = 0.380$. The resistances R_1 are then $R_1 = 500(0.525) = 262.5$ ohms and $R_2 = 500(4 - 0.380) = 1{,}810$ ohms.

For cases where K is greater than 12 and the number of circuits N is greater than 6, the following formulas may be used:

$$C = \frac{K(N-3)(N-1)+1}{K(N-1)^2-1}$$

$$E = (C+1)/(N-1)$$

The losses between circuits in decibels are given in Fig. 1. For values of K larger than 12 and N larger than 6, the formulas are:

$$Db = 10 \log_{10} \frac{(2K-E)^2}{K(1-C)^2}$$

when Z_1 and Z_2 are not equal, and:

$$Db = 20 \log_{10} \frac{1+C}{1-C}$$

when the loss is between circuits of the same impedance, i.e. between circuits of impedance Z_1 and Z_1.

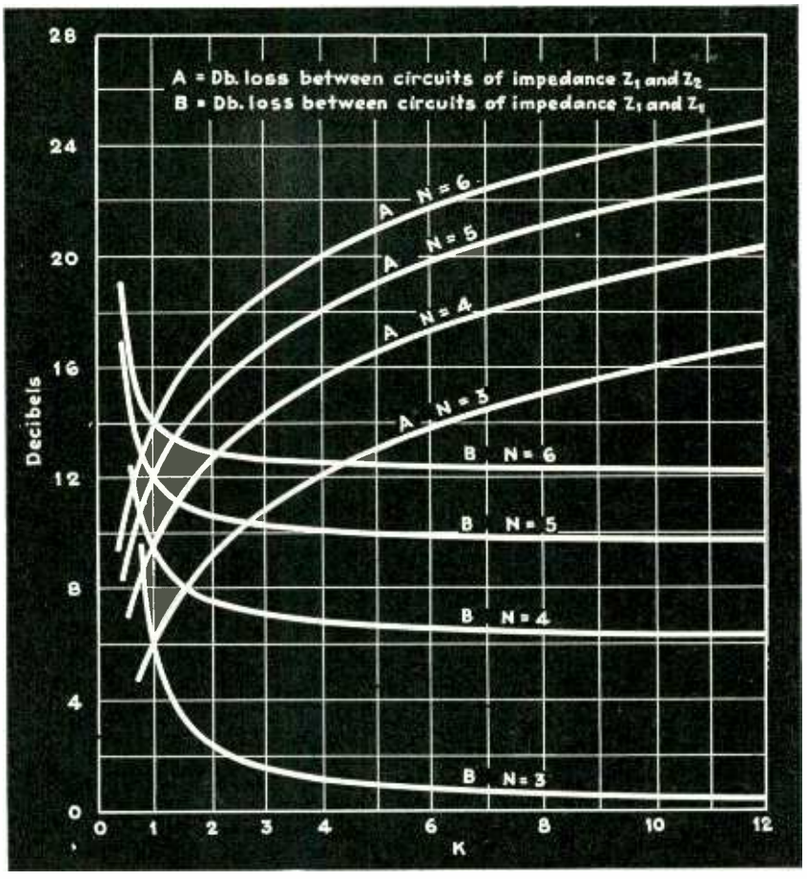
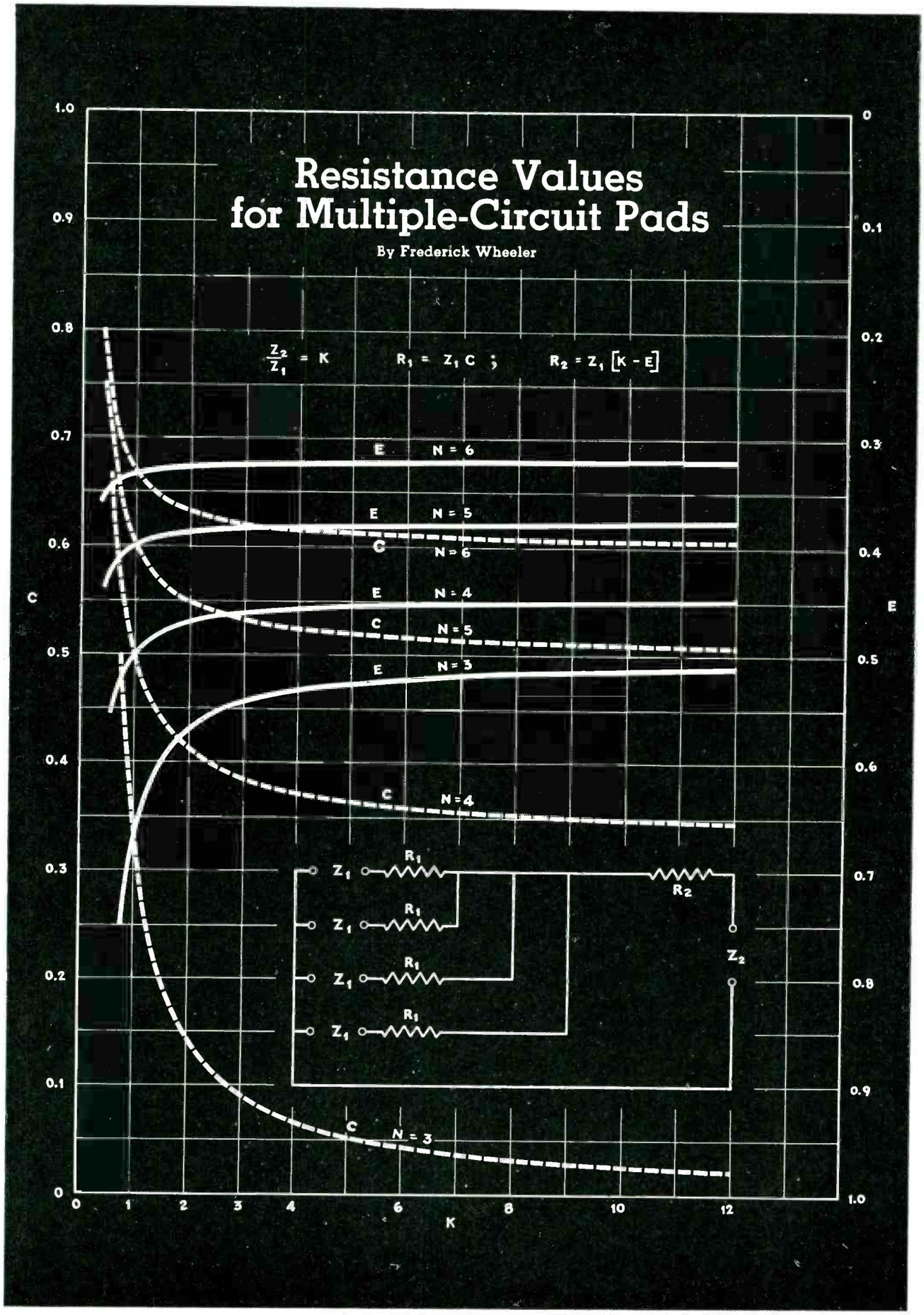


Fig. 1. Decibels loss between impedances in the multiple circuit pads described by Mr. Wheeler



ELECTRONICS REFERENCE SHEET

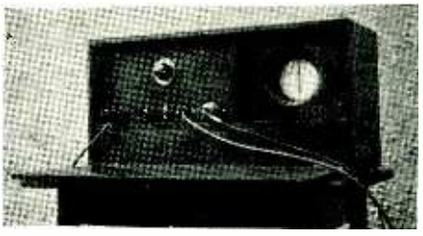
Reverberation Meter

(Continued from page 31)

average straight line, due to the interference pattern in the room, so that the sound intensity may pass through a given value several times before finally decreasing below that value. Due to the automatic on-and-off action of the thyratron, the clock integrates the total time during which the sound intensity has a value above the threshold, thus tending to average out the fluctuations in the decay curve.

Field Measurements

The procedure used in making measurements in the field is as follows. The loud speaker is first set up at a position corresponding to that of the sound source in the normal use of the room. The 10 db step attenuator of the noise meter is set to its lowest value of attenuation, that is, the lowest threshold obtainable, and the potentiometer (marked "threshold control") which varies the fixed bias on the thyratron is adjusted so that the voltage on the grid produced by the small amount of noise in the room is barely insufficient to cause the thyratron to discharge. This setting must be left unchanged during any one series of 10 db steps along the decay curve. The sound source is turned on for a few seconds by pressing the push button, and on releasing it, the clock registers the time of sound decay to the threshold. The attenu-



Reverberation meter on location

ator is then set 10 db higher, and a shorter time is obtained to this higher threshold. By setting the attenuator to successive steps until the threshold is brought higher than the initial sound level itself, in which case the clock does not operate at all, a series of points along the decay curve is obtained. A single series of points will normally deviate widely from a straight line, due to the fluctuations of the sound decay mentioned above. By taking a number of readings, changing the position of the microphone between each series, these deviations will be largely eliminated, and the average values obtained will fall approximately along a straight line. Closer approximation may be obtained by increasing the number of microphone positions or by using a warbled instead of a steady frequency.

The accompanying curves show the results of measurements taken in a large church which had been acoustically treated. Each curve represents each of three widely separated positions of the microphone, and each point is the average of three secondary positions. The curves are fitted to the points by a statistical method. The figures along the vertical axis are the settings of the attenuator, and the horizontal axis shows the actual readings of the clock in seconds. The reverberation times shown are obtained by extending each curve to a 60 db range and taking the corresponding time interval. The average of the three values shown is 2.06 seconds.

The equipment as described is admittedly not intended for laboratory precision. It is believed, however, that portability, simplicity of design, and ease of operation have been achieved, together with quite sufficient accuracy and reliability of results to meet the requirements of field conditions.

Logarithmic Recorder

(Continued from page 27)

In Fig. 1 the tubes indicated are 6C6's and 6D6's. For all-around use these are the best choice since they are suitable for either a-c or battery operation. If a-c only is contemplated, 57's and 58's will be equally as good (and are in fact shown in Fig. 2). Metal tubes—6K7's and 6J7's—would probably also be satisfactory. For battery operation alone the low-current series of metal-glass equivalents should be satisfactory, and would offer a saving in filament power. Finally, if a very small-size amplifier were desired it might be interesting to try 955's and 956's.

The wide range of applications for which this amplifier is suited is sufficiently evident as to require no cataloging. One feature, however, deserves some additional emphasis—namely the adaptability to particular situations. In this respect the linear-logarithmic, one-stage, two-stage, and a-c or battery change-overs are obvious advantages. Not so obvious, but equally important are the possibilities of the adjustable response characteristics by means of the potentiometers P_1 to P_5. This is of great advantage in that it allows the response of the amplifier to be adjusted so as to compensate for any deficiency in the response of the measuring equipment with which it is used. A good example of this occurs when the amplifier is used with a standard field intensity meter. A measuring instrument of this type almost invariably uses a diode detector. Such a device is linear over most of its range, but at the very lower end it becomes almost parabolic. In making logarithmic recordings this would ordinarily be a serious defect, since errors in this range are greatly increased when logarithmic amplification is used. However, when the amplifier shown here is used, the characteristic can easily be adjusted so that this curvature at low-scale readings is very well compensated and output readings of good accuracy obtained over a wide range. Thus, where the output of the field intensity meter itself has good accuracy over only about 20 db, the combined response of the field intensity meter and amplifier when used together is very good over 40 db, and useful to nearly 50 db.

TUBES AT WORK

PHOTOTUBES for bridge-control, street-lighting control, and game-preserve control are among the applications reported this month. Also included are low-frequency carrier control, ignitron welding, and the uses of concentric lines

Phototubes Control Swing Bridge

By JOHN H. JUPE

FOR THE FIRST TIME in the history of British engineering, phototubes have been used in connection with a major undertaking in the new road bridge which was recently opened at Kincardine-on-Forth, Scotland.

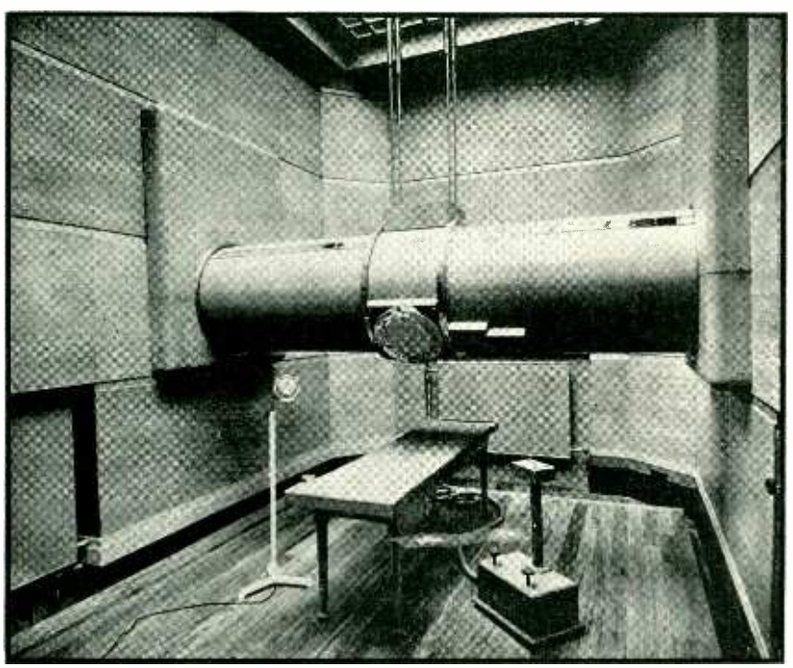
This bridge was built to carry road traffic over the Forth but at the same time had to be partially movable so that shipping could pass freely. The problem was solved by making the central span a double cantilever rotating on a pivot. On the operator's desk in the control cabin is a hand wheel which controls pilot motors. They in turn move the main rheostats in connection with the two fifty-horsepower, d-c motors which move the span through a rack and pinion turning gear. Among other things, the control desk has indicator lamps, a dial to show the position of the span and buttons for "inching" the bridge. When the bridge is closed two bolts and four wedges are "shot" and it was to arrange for this that photo cells were used.

Below the level of the road and on one of the fixed abutments there is a projector cabinet containing three lamps and a similar cabinet containing three caesium cells on one end of the moving span. The operation of the cell control is as follows. The span is closing and approaching the end of its travel, cell No. 1 receives light from the outer lamp of the set, causing a bell to ring in the control cabin, and lighting one of three indicator lamps on the control desk. Moving on, the same cell passes the other two lamps in turn and gives two more signals.

Immediately afterwards, cell No 2, which is higher than the others, glides into the beam of a lamp placed higher than the other two. This causes the center indicator lamp to light on the control desk and shows that the bridge is correctly aligned for the bolts and wedges to be "shot." Should the span overshoot a little, cell No. 3 is brought opposite the last lamp and an indicator informs the operator. The photo cells also cause the driving motors to be de-energized but "inching" buttons are brought into circuit. These are required as the span may not come to rest in quite the correct position owing to wind pressure, etc. They are at all times kept out of operation until the cells indicate that their use is required.

The moving span of this bridge weighs 1,600 tons and is the largest mechanism at present controlled by photo cells in the British Isles.

WORLD'S LARGEST X-RAY TUBE



Said to be the world's largest, this ten-ton thirty-foot tube of St. Bartholomew's Hospital, London, is built within walls of barium-concrete for protection against stray rays. The patient under treatment converses by means of the microphone with the doctors who observe him through a mirror system

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Police Plan Radio Telegraph Net

AT A RECENT CONVENTION of the Associated Police Communications Officers held at Davenport, Iowa, a national intercity radio telegraph system was proposed as a further aid in police radio crime prevention. The project calls for 400 stations, formed about a nucleus of the seven cities now having stations in operation and forty-four more intending to join the system. In addition stations in the interzone regions between cities, to be supported by each state, are suggested. The radio telegraph net is expected to supplement the individual radio telephone stations now operating within each city, and may use the same personnel, which must be trained to operate by telegraph code as well as by voice. No announcement was made of plans for obtaining the necessary operating frequencies, but it is expected that these will not be too numerous.

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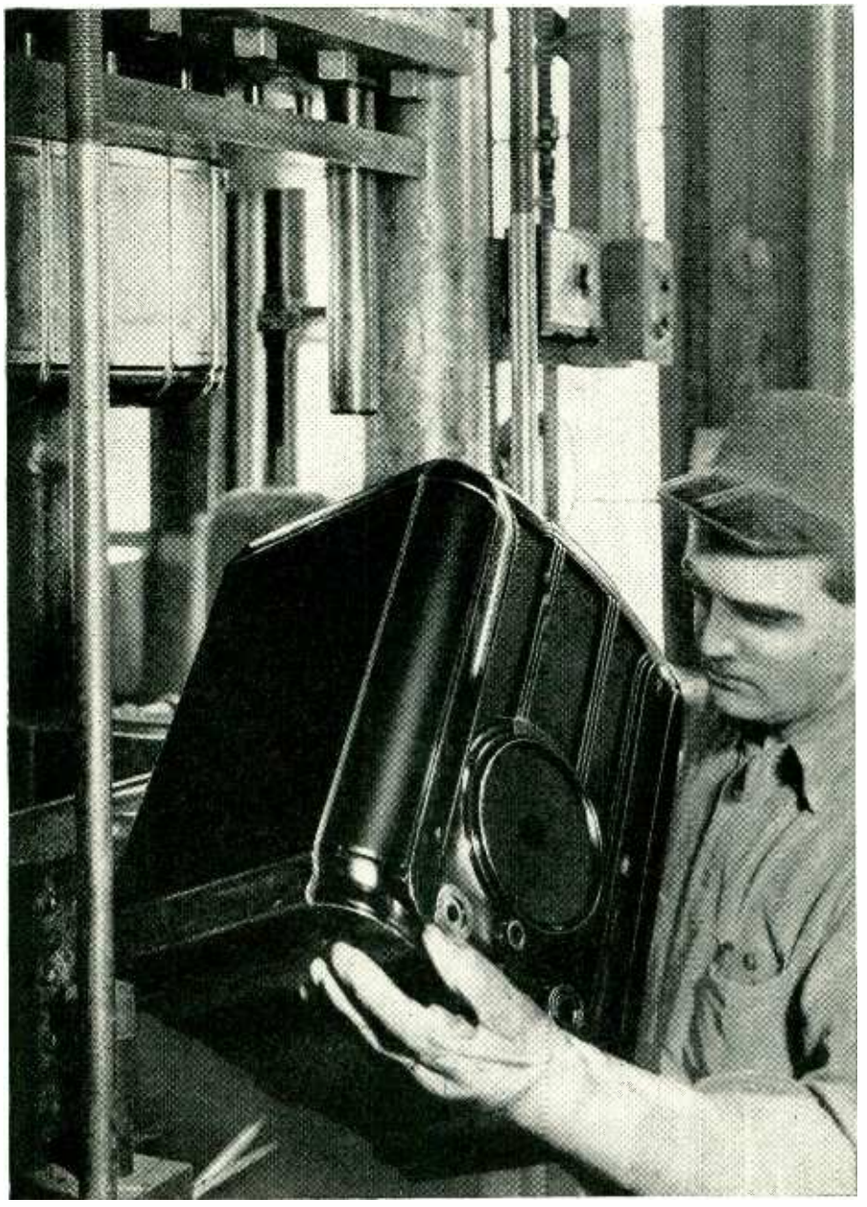
Los Angeles Collects Data on Phototube Control of Street Lighting

ACCORDING TO A RECENT announcement in *Electrical World*, the city of Los Angeles has been experimenting with photoelectric control of its street lighting system. In particular the ornamental street lights in the Hollywood area, which are controlled by carrier current, were fitted with a conventional photoelectric control device, set to operate at the lowest light intensity consistent with stable operation. When the daylight fades the controller trips, operating a buzzer and an indicating

A Dual Achievement *aided by* Bakelite Molded



New large-size Pilot Radio with cabinet of duo-tone brown Bakelite Molded.

THE selection of Bakelite Molded to form the new Pilot Radio cabinet has proved highly advantageous in two important respects. The material not only contributes faithful reproduction of the designer's distinctive style conceptions, but also, furnishes practical ease and economy in producing one of the largest cabinets ever molded.

Although measuring 18¼" x 13½" x 10⅜", and requiring a difficult duo-tone color, the Pilot cabinet is completely formed and finished in one press operation. Each cabinet leaves the mold with lustrous surfaces and self-contained color that preclude further polishing or finish coating. Through-holes are formed and metal inserts accurately positioned in the same operation.

Available in black and handsome mottled colors, and in numerous types to meet special molding tasks, Bakelite Molded offers attractive opportunities for economical production of original designs and new style treatments. Radio designers are invited to write for informative booklet 13M, "Bakelite Molded", which gives data on the various types and functions of Bakelite Molded.

(Left) 18¼" x 13½" x 10⅜" Bakelite Molded cabinet molded for Pilot Radio Corporation by Associated Attleboro Mfrs., Inc.

BAKELITE CORPORATION, 247 PARK AVENUE, NEW YORK, N.Y.
BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

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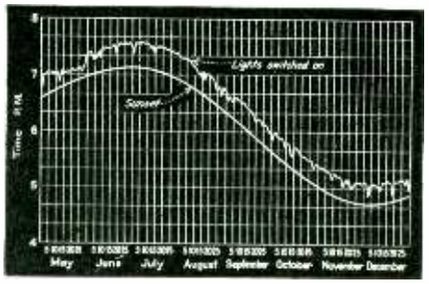
THE MATERIAL OF A THOUSAND USES

lamp. The buzzer gives warning to the station operator to start the carrier current generator, which is subsequently connected to the power line, actuating the carrier current relays in the field and switching on the lights. The operator then opens the switch on the photo-electric control circuit, which is subsequently closed some time the next day.

It is found that the annual hours of operation of the lighting system are



not greatly increased or decreased by the use of the photo-electric control, although departures from the rigid schedule formerly used are made to accommodate changes in light intensity. The accompanying diagram illustrates the variations in time, in relation to sunset, introduced by the photo-electric control. It was found that the operating life of the tubes in the controllers is at least two years.

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PHOTOTUBE GUARDS GAME IN GERMAN PRESERVE

A photo-relay in this gate, actuated by escaping deer or other game, turns on a blinding light and a horn which scares the animals back into the preserve, but allows auto traffic free access to the park

Applications of Concentric Transmission Lines

By VICTOR J. ANDREW, PH. D.

CONCENTRIC TRANSMISSION lines have recently come into widespread use for carrying radio frequency energy over any considerable distances, both in transmission and in reception. The greatest advantage obtained with such line is simplicity and economy of installation, and in many cases the possibility of running a line where an open wire circuit would be impossible. In other instances the practically perfect shielding of such a line is of paramount importance.

Transmitting Installations

Most of the large broadcast stations are using antennas in open fields, with the transmitter building located from 100 to 500 feet from the base of the antenna. A small tuning house is located at the base of the antenna, and a transmission line brings power from the transmitter. When a concentric line is used, it may be supported on short posts but more frequently it is buried underground. When buried, it is out of the way and is safe from damage.

[*Continued on page* 43]

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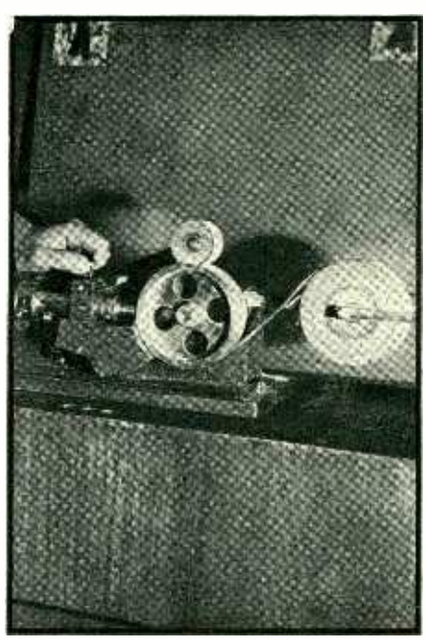
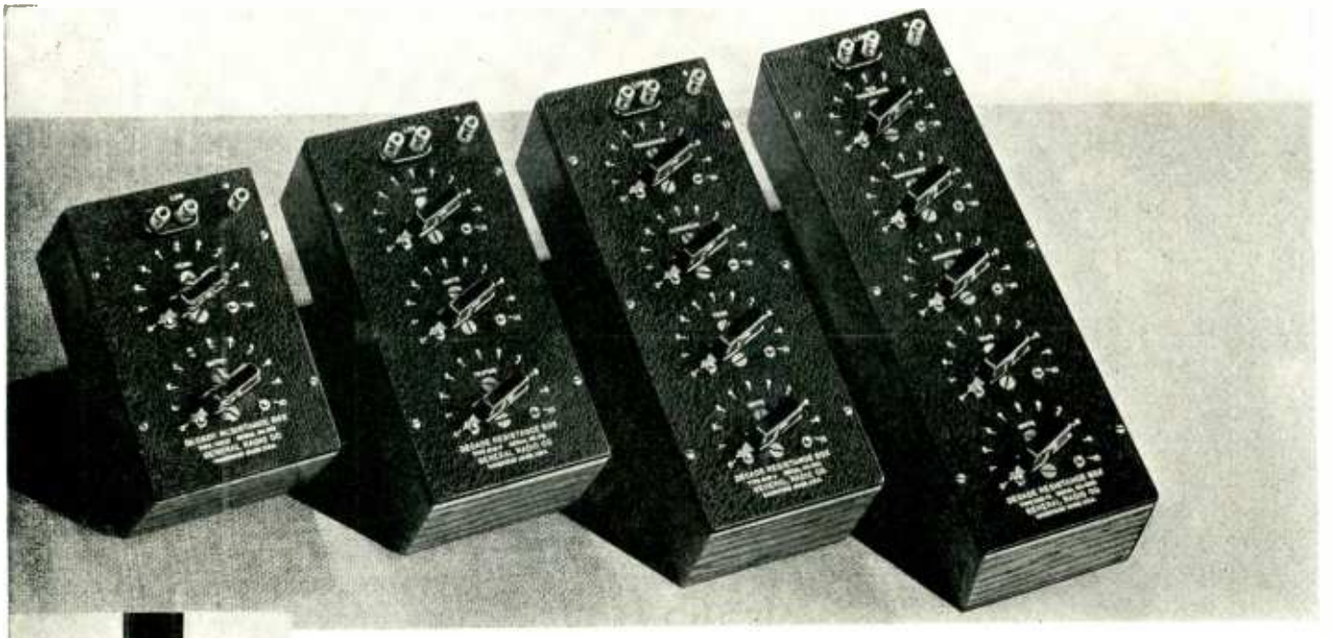
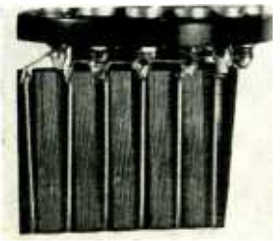
RUSSIAN "TALKING PAPER"



Paper reproduction of film sound-tracks are now printed by lithographic and typographic means, as many as 10,000 copies being made from one original. Above is a phototube pickup for use with the paper copy, invented by the Soviet Engineer, B. P. Skvorsov



Bifilar Manganin winding of 0.1 ohm decade



Aryton-Perry windings of the 1-, 10-, and 100-ohm decades. The 1,000- and 10,000-ohm decades are unifilar windings on mica cards.

Quadruple-leaf, phosphor-bronze switches. Contact surfaces of leaves are ground flat to act as four independent brushes. Contact resistance only 0.002 ohm.

Contact studs ⅜ inch in diameter, ground flat. Cam-type positive detent mechanism. Entire unit shielded behind panel.

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- LOW INDUCTANCE AND CAPACITANCE WINDINGS
- NO APPRECIABLE FREQUENCY ERROR BELOW 50 KC
- LOW AND CONSTANT CONTACT RESISTANCE
- PROTECTED WINDINGS AND SWITCHES
- POSITIVE DETENT MECHANISMS
- SHIELDED CABINETS—NO BODY CAPACITY EFFECTS
- NINE SIZES BETWEEN 0.1 TO 111 OHMS AND 1 TO 111,110 OHMS

Prices on the Type 602 Decade-Resistance Boxes range between $25.00 and $70.00. These boxes are too necessary for you to afford to be without. Why not modernize the resistance measurements section of your laboratory?

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GENERAL RADIO COMPANY

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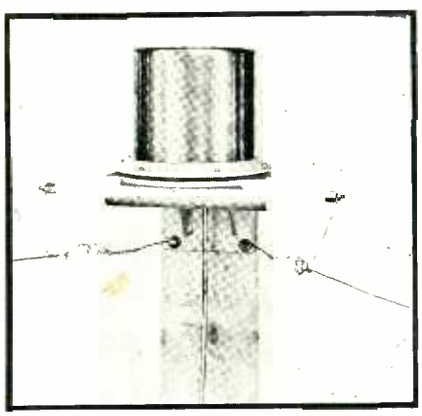
The one danger in a buried line is that water will leak into it. To guard against this, all joints in the line are carefully sealed. As a further precaution, the line is usually filled with dry nitrogen gas at a pressure of two or three pounds. Any leak which occurs in the line will then show on a pressure gauge attached to the line. While gas filling is considered a desirable precaution where dependability is of prime importance, hundreds of unsealed installations have given no trouble.

Because of the ductility of copper, no allowance is necessary for expansion and contraction.

The power flowing through a properly terminated line is the product of the surge impedance times the square of the current. Since the surge impedance is accurately known in a concentric line, this is a very convenient measure of power.

Many small broadcast stations use radiators on the roofs of buildings. Heretofore, the transmitter has usually been located near the roof, and the antenna has been connected directly to it. With the recent improvement in design of ground systems used on roofs, it has become apparent that no radio frequency fields from leadins should be permitted below the roof level. Two wire transmission lines going out of windows and up the outside of buildings are difficult to install, unsightly, and inefficient due to poor dielectrics in

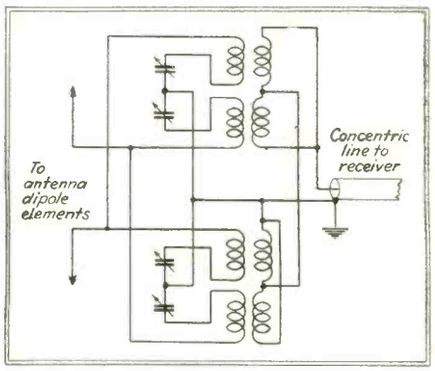


Transmission line termination connecting to antenna in an elevated situation

their field. Concentric line has proven particularly convenient for this type of installations. In one 1000 watt broadcast station, a line is carried 27 stories up an elevator shaft.

A directional broadcast antenna system resembles two or more of the antennas just described, with the additional requirement that the amplitude ratio and phase of the current in the two antennas must be adjusted to prescribed values. To obtain the proper phase relation, correct allowance must be made for the difference in length of the lines. This is easily done, since the measurement of velocity of propagation is quite simple.

[*Continued on page* 44]



Concentric line tuning system

Another unusual antenna system is a single radiator serving more than one transmitter. One such installation was described in October 1935 *Electronics*. Because of the great heights now demanded for antennas this double use of a radiator should find many applications. For instance, a quarter wave broadcast station radiator would make a fine radiator for a low frequency police transmitter, or a support for an ultra high frequency radiator. The service of the broadcast station would be in no way impaired.

There are occasional instances where

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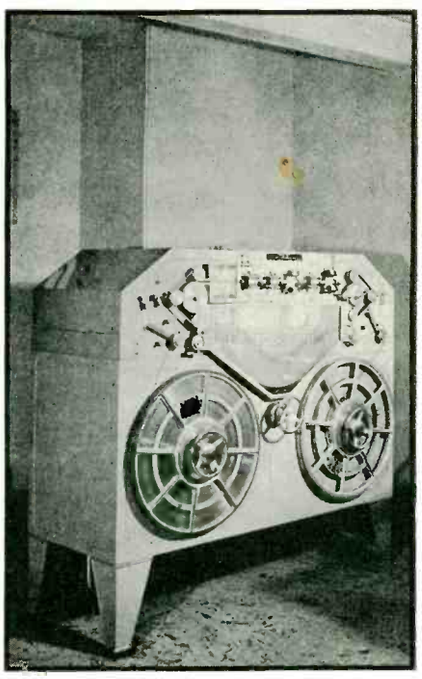
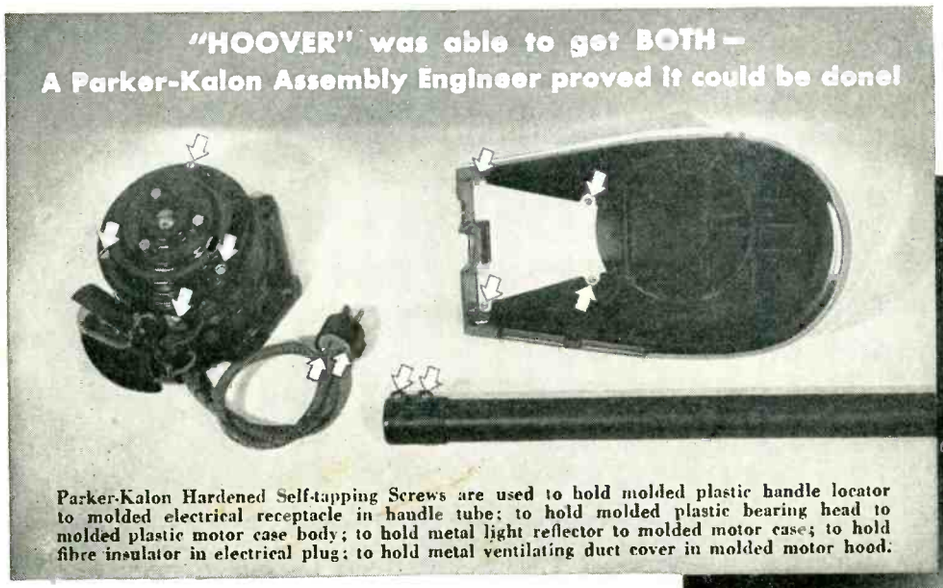
MAGNETIC RECORDINGS FOR SHORTWAVES



A large percentage of the programs sent over the British shortwave system are magnetic recordings made from previous broadcasts. Above is one of the Blattnerfone units used by the BBC

"What we want more than fastening economy is the BEST POSSIBLE ASSEMBLY JOB"



Parker-Kalon Hardened Self-tapping Screws are used to hold molded plastic handle locator to molded electrical receptacle in handle tube; to hold molded plastic bearing head to molded plastic motor case body; to hold metal light reflector to molded motor case; to hold fibre insulator in electrical plug; to hold metal ventilating duct cover in molded motor hood.

INSISTENCE on *quality* is clearly evident in the new "HOOVER". One look at this modern cleaner and you know that the engineers in The Hoover Company meant what they told a Parker-Kalon Assembly Engineer . . . "we want the best possible assembly job; fastening economy comes second here". The five important assemblies shown are being made with Parker-Kalon Hardened Self-tapping Screws only because it was possible to prove conclusively that they would make *stronger* fastenings, as well as reduce time, work and costs.

Famous for the economies they effect in making fastenings to metal and plastics, Parker-Kalon Hardened Self-tapping Screws are often overlooked when the prime consideration is security. Yet it is a fact . . . proved by scores of concerns like HOOVER and by unbiased laboratories . . . that *these unique Screws hold more securely than machine screws, bolts and nuts, and similar ordinary fasteners.* They do a better job . . . in addition to saving time, labor and money by simplifying fastening jobs.

Use this specialized knowledge to determine what you can gain

Right now your assembly work probably holds worthwhile opportunities for using Self-tapping Screws to make better, stronger fastenings at lower cost. It will pay you to hunt them out. And it is easy to do . . . if you use the specialized knowledge of Parker-Kalon Assembly Engineers.

Your invitation will bring one of these Engineers to go over your fastening jobs with you. He will offer no "cure-all". A background of practical assembly work fits him to render intelligent aid. And his specialized knowledge enables him to recognize the many different types of assemblies which Hardened Self-tapping Screws WILL make better and cheaper. Because in 7 out of 10 cases he has helped production and design men to obtain desirable benefits, there is an excellent chance that he can help you, too.

PARKER-KALON CORPORATION
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PARKER-KALON *Modern* FASTENING DEVICES

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it is desirable to locate a radiator several thousand feet from the transmitter. One broadcast station is now planning a 4200 foot concentric transmission line to a vertical radiator.

In ultra high frequency work concentric lines have still greater advantage over balanced lines. The latter are difficult to balance at these frequencies, and even when balanced the separation is a large enough portion of a wavelength to permit appreciable radiation. The half wave vertical radiator usually used at these frequencies can be coupled to a concentric line by various means discussed in August 19353 *Electronics*.

On police cars the ultra high frequency antenna is mounted vertically at the rear of the car. By using concentric line the transmitter may be located in any convenient part of the car. With a line as short as is used in a car, it is not necessary to match impedance at the antenna end. When not matched, the line transmits reactive as well as resistive components of the load impedance, as well as transforming these components to new values. Antenna tuning is then necessary in the transmitter. The standing waves on the line increase loss somewhat above that for a properly terminated line, but this factor is negligible on a short line.

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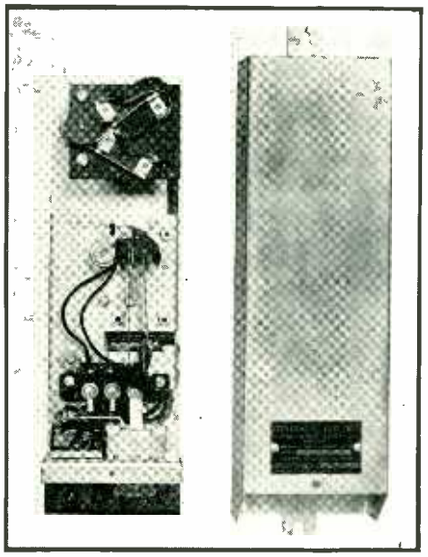
Low Frequency Carrier Controls Water-Heater Load

THE PEAK DEMAND of the Idaho Power Company's system has been reduced by several hundred kilowatts, by the use of carrier-current control which automatically turns on and off the



A carrier-current relay similar to those used in water-heat control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water-heat appliances of the customers. Frequencies of 480 and 720 cycles per second are sent out over the power distribution line by the central station operator. This current energizes relays in the customer's heater, throwing it on or off depending upon the type of carrier impulse received. In this manner the central station operator is capable of releasing a large part of the load on the system at his own discretion according to the demands of other services. Since one customer in every five heats water electrically, this automatic control feature is of considerable importance in reducing the overall peak load of the system.

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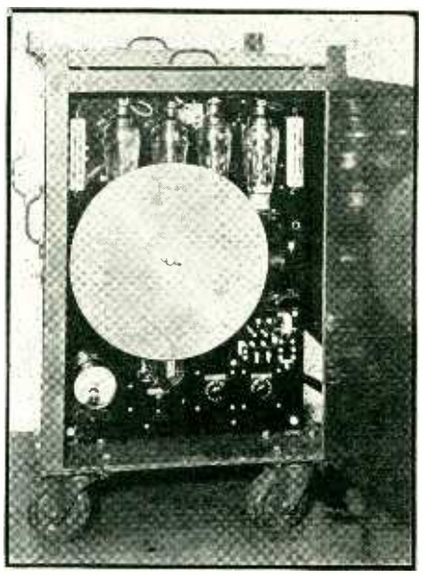
Rotating Disc Used in the Ignitron Welding Timer

THE USE OF A ROTATING disc, containing pins plugged in around its circumference for the inductive control of ignitron welding tubes has been announced in a recent development of the Westinghouse Company, in Pittsburgh. The disc is driven synchronously at a rate of one rotation per second and contains 120 holes, each corresponding



Rotating-disc ignitron welding timer

to one-half cycle of welding current. Steel pins are plugged into the holes according to the particular timing desired. These pins pass through a magnetic circuit as the disc revolves and supplies the control voltage necessary for the ignitron tube. Ignitrons are used since no voltage higher than line voltage is required and the need of contactors and transformers is eliminated.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2. Economical—Large or small quantities produced without expensive tools.
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● Why adapt your equipment to a coil when the coil should be designed for the equipment? Special forms by ISOLANTITE cost little more and will accomplish the ultimate in performance.
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THE ELECTRON ART

EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

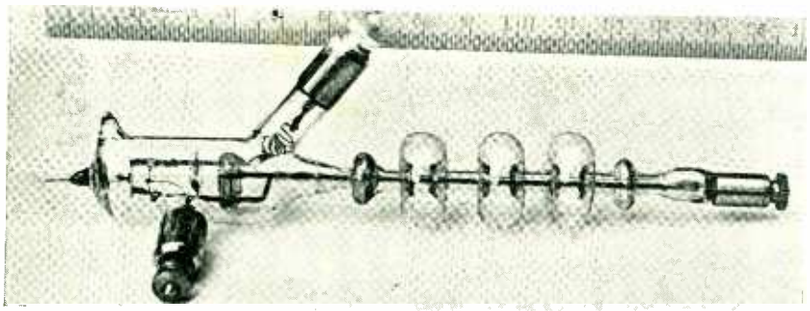
Ultra High Frequency Diode With Movable Anode

A DIODE VACUUM TUBE voltmeter for wavelengths as short as 20 cm. has been developed for the purpose of overcoming the frequency limitations of conventional diodes, and is described by Manfred von Ardenne, pp 117–121, in the October 1936 issue of *Hochfrequenz. u. Elektroacoustik.*

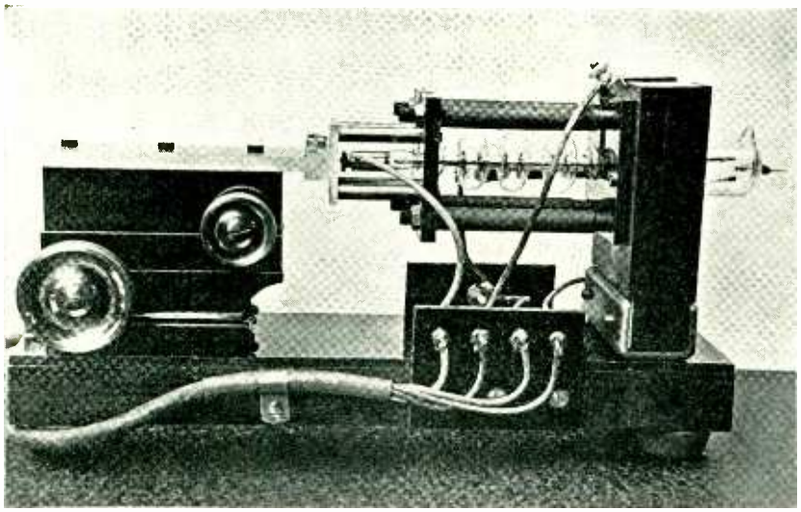
The errors generally introduced at ultra high frequencies due both to the finite electron transit time in the diode circuit and to the reactive voltages developed across the connections to the tube elements have been minimized in this new low capacity diode. The transit time error is reduced by making the distance between electrodes as short as 5×10^{-3} millimeters. This is accomplished by means of a micrometer movement and glass spring mechanism, shown in the photos, which controls the distance of the movable cathode from the anode. The plate to cathode capacitance is only 0.4 $\mu\mu$f. and the plate lead is 10 millimeters long. The leads to the tube have a total self-inductance of 9×10^{-9} henry, which minimizes the possibility of losses from the reactive voltage drops appearing across the leads. With this construction even at 1500 megacycles (20 cm.) measurements made with the device are reliable and practically free from error.

The cathode consists of a tautly drawn tungsten wire which draws about 2.2 amperes heater current. A tiny center tapped filament voltage divider is placed in the envelope, and the connections from it and from the filament are brought out to three connecting caps. The anode lead extends right through the glass envelope at the side opposite to the glass spring. The triple-bellow structure also shown in the photo constitutes the flexible mechanism, i.e. the glass spring, to which the pressure is applied from the micrometer for moving the cathode in one or the other direction within the envelope.

In practice pressure is applied to the glass spring by turning the micrometer mechanism until the cathode touches the plate. At this point there occurs a sudden reduction in cathode temperature due to heat conduction away from the cathode. Injury to the cathode is prevented by a filament series resistor. The microscopic drive is then backed up until the two electrodes are again parted. The reluctance of the metals to separation after contact, limited the shortest distance between electrodes to magnitudes above 2×10^{-3} millimeters. Three resistors controlled the voltage ranges of the laboratory model between the limits of ½ to 7, to 35 and to 140 peak volts, for frequencies up to 1500 megacycles.



The diode for the high frequency vacuum tube voltmeter. Pressure on the bellows at the right changes the spacing between the filament and anode



The high frequency rectifier in its mounting and ready to be connected to its amplifier and measuring circuit

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I.R.E. Index

WITH THE PUBLICATION, early in January, of its cumulative index of articles appearing in its proceedings, the Institute of Radio Engineers has made available a handy and much needed reference index on radio engineering subjects. This index includes all of the articles published in the proceedings during the past twenty-five years, arranged chronologically, by subject matter, and by authors. Copies of this index are available from the Institute of Radio Engineers, 330 West 42nd Street, New York City, at $1 per copy.

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Diathermy Interference Study

IN AN EFFORT to determine the extent and effect of interference produced by high frequency diathermy equipment, the Federal Communications Commission has issued permission to the General Electric Company to operate high frequency generators in the vicinity of 13 megacycles. No call letters have been assigned for this experimental work.

RADIO D-F FOR SURVEYING

This German radio direction-finder, similar to that used for "homing" purposes in aircraft, makes use of a loop antenna and vertical dipole for land surveying. It was constructed for the German Army by the Telefunken Company of Berlin

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Power Supply System for Electric Clocks

A NEW TYPE of source of accurate frequency power for operating a number of clocks has been developed by the General Electric Company and is described by M. S. Mead, Jr., and J. H. Reed under the title "A New Power Supply System for Electric Clocks" in the December 1936 issue of the *General Electric Review*. This source of power does not have extremely high frequency precision, but the results obtained for over a year show a deviation of about one second.

Essentially the power supply system consists of a tuning fork controlled oscillator, a buffer amplifier, and an inverter using two thyratrons. A tuning fork control unit was used because the mass and elasticity which determine the natural frequency of the fork are constant quantities. They are somewhat affected by variations in frequency, but this variation can be overcome by operating the fork at sensibly constant amplitude. The affects of barometric pressure on the variation of the frequency are not sufficient to cause an error greater than about 3/10 of a second per day under the conditions in which the unit is operated. The tuning fork is made of maginvar which has a very low

temperature coefficient of frequency. It is contained in a temperature controlled compartment at 60 ± 0.1° C. The vibration of the tines of the fork control the frequency of the current flowing in the pick-up coil which is then fed to the grid of the vacuum tube oscillator. A rheostat in the pick-up coil circuit permits the frequency to be adjusted over a small range. The output of the oscillator is fed to a buffer amplifier which in turn controls the thyratron inverter.

The thyratron inverter includes a pair of FG-67 tubes in a self-excited circuit, the frequency of which is controlled by the oscillator. The output of the inverter is fed to forty clocks throughout the plant, but the unit is capable of operating as many as 125 clocks.

A feature of this power supply system is that the frequency generating unit is comparatively small in size, contains no moving mechanical parts, operates from 115 volts d.c., and except for tube replacement requires practically no maintenance attention.

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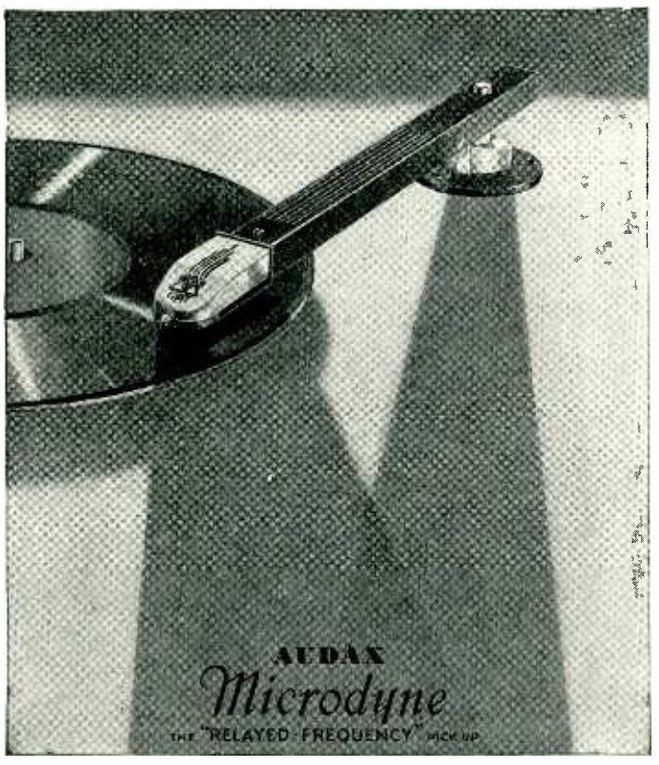
Symposium on Metals

Several of the papers presented at the recent symposium on metals at the Massachusetts Institute of Technology dealt with subjects of interest to electronics engineers.

In a paper on *The Uses and Limitations of X-Ray Diffraction Methods*, Prof. John T. Norton of M.I.T. outlined some of the fields in which useful results can be obtained by x-ray diffraction methods. These include identification of metallic phases, determination of the composition of homogeneous phases and the range of composition in non-homogeneous phases. Crystal orientation can be accurately measured and heterogeneous stress systems producing lattice distortion can be studied.

Dr. A. W. Hull of the Research Laboratory, General Electric Co. spoke on *Properties of Glass Sealing Alloys*, pointing out that the two requirements of a glass sealing alloy are a low coefficient of thermal expansion in order to match the expansion of practical glasses, and non-linear expansion having a transition from low to high expansion in the region of 400°C.

The first condition is satisfied by tungsten, molybdenum, platinum, and certain iron-nickel and iron-chromium alloys, but only iron-nickel and iron-nickel-cobalt alloys fulfill the second condition. In the iron-nickel alloys the transition occurs at too low a temperature to match any commercial glass, but it has been found possible to make special glasses whose expansion is very close to that of 42% nickel-iron alloy. These glasses are suitable for certain purposes. The transition temperature is raised by the addition of cobalt and reaches a maximum for 18% cobalt, 28% nickel and 54% iron.



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***Real high fidelity* RECORDING *has now been made possible as a result of the* NEW *Professional* CUTTING HEAD . . . *pioneered, as the sound industry would expect, by* AUDAX**

A.S.A. Standards on Acoustics

SEVERAL YEARS AGO the Institute of Radio Engineers took the first step in attempting to standardize acoustical terminology by issuing a report containing about forty terms relating to acoustics and electrico-acoustic instruments. This was followed by a report of approximately 150 terms published by the Acoustical Society of America. Extension of this work was then taken up by the American Standards Association under the administrative leadership of the Acoustical Society. The A.S.A. Committee, representing approximately thirty engineering and scientific societies as well as governmental agencies has just published its report on *Acoustical Terminology*, American Tentative Standards Z24.1—1936. Copies are available at twenty-five cents each from the American Standards Association, 29 West 39th Street, New York City. Other standards completed by A.S.A. Committee on Acoustics, which are also available at twenty-five cents, are *Standards on Noise Measurements*, Z24.2–1936 and *Standards for Noise Level Meters*, Z24.3—1936.

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EXHIBITS TUBE DEVICES TO A.A.A.S.

Frank Shepard (third from left) of RCA Radiotron shows his electronic speed indicator to Chief of Police McMenamin, Director of Public Safety Cuthbert of Atlantic City, and Dr. Otis Caldwell, General Secretary of the American Association for the Advancement of Science, at the recent convention of that society held at Atlantic City

Design of Apparatus for Outgassing Electrodes

[C. W. OATLEY AND J. B. SMITH, Wheatstone Laboratory, Kings College, London.] The essential parts of apparatus required are an r-f generator and a solenoidal heating coil surrounding the piece of metal or a pancake coil close to a disk of metal to be treated. It is convenient to have a number of coils of different shapes and sizes, and an r-f transformer of variable ratio between heating coil and generator for matching impedances. The heat generated per second in the metal depends on the field strength and the frequency. Tests made at constant frequency and current with a coil 2½ in. long, wound on a form 3 in. in diameter, with a varying number of turns, n, show that when heating hollow cylinders the efficiency is a maximum for R/n^2 a minimum, where R is the resistance of the coil. It may be shown that the maximum is independent of the number of turns when the coil with least resistance is used. The field E is a maximum when the frequency f satisfies the relation $f = 2.77\ R_1/L_1$, where R_1 is the ohmic resistance and L_1 the self-induction of the transformer represented by the coil and the metal cylinder. For solid metals the efficiency is independent of the frequency. In practice a frequency of 100 kc. is a suitable value. The efficiency of the heating coil increases in this case with decreasing thickness and increasing resistance. *Phil. Mag.* 22 (No. 147) (453-462. 1936).

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Tube noise (fluctuation noise) Between 150 kc. and 15 Mc.

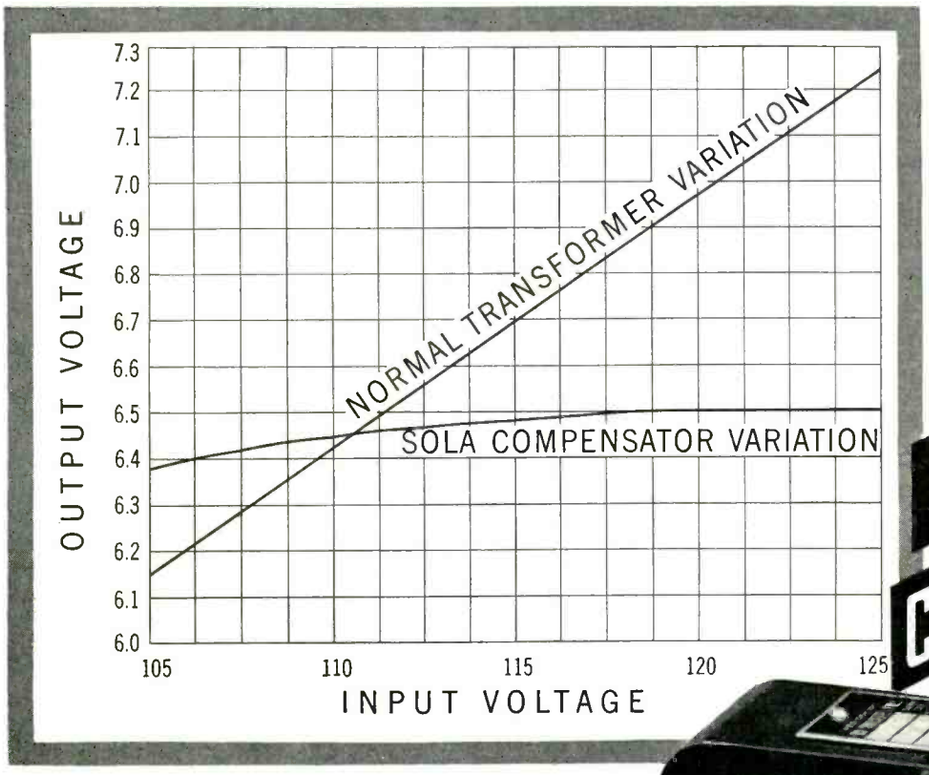
(H. ROTHE AND G. PLATO, TELEFUNKEN LABORATORY) The shot effect is the main cause of tube noise persisting over a wide range of frequencies. The theoretical formula for the shot effect does not apply to radio tubes owing to the existence of space charges which tend to even out the inevitable irregularities in emissions so that only a fraction, *F*, of the normal effect (the square root of twice the product of electronic charge *e* times saturation current *i* times band width *w*) is to be expected. In the case where an ohmic resistance is inserted in the plate circuit the voltage which would have to be applied to the grid in order to produce the noisy portion of the saturation current *i*, measured in milliamperes, is given by

$$v = F\sqrt{2\,e\,i\,w}\,/\,K,$$

when K is the mutual conductance, in practice equal to $ai^{\frac{1}{3}}$, with a between about 0.6 and 1.8. Hence

$$v = 0.56\,\frac{F}{a}\,i^{1/6}\sqrt{w(\text{kc.})}\ \text{in microvolts.}$$

CONSTANT VOLTAGE



with the

SOLA VOLTAGE COMPENSATOR

A transformer designed to supply regulated power to devices requiring a constant voltage. Variations in line voltage are instantaneously corrected and a constant low voltage level maintained. This transformer is specially suited to low voltage applications such as photo-electric cells, X-Ray lamp filaments, exciter lamps, precision and recording instruments, and many others.

Compensators are built to individual specifications, and quotations will be furnished on request. Specify expected line variation, regulation required and a description of the load to be supplied.

Patent No. 1893251

STANDARD CAPACITIES FOR LAMPS OF:

	21 CP	32 CP	50 CP
INPUT	95 to 125 V—60 Cyc. AC	95 to 125 V—60 Cyc. AC	95 to 125 V—60 Cyc. AC
OUTPUT	6½ volts	6½ volts	6½ volts
WEIGHT	5 lbs. 9 oz.	7 lbs. 5 oz.	11 lbs. 8 oz.
HEIGHT	3⅞ inches	3⅞ inches	3⅞ inches
WIDTH	3⅛ inches	3⅝ inches	4⅝ inches
LENGTH	4½ inches	4½ inches	4½ inches

SOLA ELECTRIC COMPANY 2525 CLYBOURN AVE. CHICAGO, ILLINOIS

Changes in the plate current have, therefore, only a small influence, and for practical purposes i may be taken as 1 milliamp. The reduction factor F is determined by the electron emission from the cathode, the constant a by the dimensions and positions of the electrodes. A tube with a small a (that is, a small mutual conductance) produces less noise than a tube with a large mutual conductance carrying the same current.

The formula deduced was tested by measuring with a calibrated radio receiver the noise produced by various triodes and pentodes, taking 50 tubes of each kind, with a tuned circuit shunted by a resistance in the plate lead. The sensitivity of the receiver was adjusted by varying the grid bias. A d-c instrument was inserted in the plate circuit of the diode; the voltage was measured at the output tube. The band used was 4 kc. wide, the load 20,000 ohms. For currents above 1 milliampere the intensity of the tube noise was found to be constant, for weaker currents it increased with the logarithm of the current, which does not then give a K proportional to i^2. As is to be expected the noise increases in general with decreasing filament current, that is, with decreasing space charge. It is independent of the frequency between 150 and 1500 kc. For currents of 1 milliampere, the order of magnitude may be found from the following table.

	F	a	$0.56\,F/a$	R (ohms
Triode directly heated	0.38	0.6	0.35	7200
Triode indirectly heated	0.5	1.3	0.21	2600
Triode indirectly heated	0.57	1.4	0.23	3100
Pentode	0.6	1.5	9.23	3100
R.f. pentode ...	0.75	1.75	0.24	3400

In the r-f tubes of a receiver the noise is therefore of the order of one microvolt. The last column contains the value of the resistance in which thermal agitation produces the same fluctuation noise as the emission does in radio tubes. The values of R are of the same order as those given for tubes by Pearson between 10 kc. and 12 kc. and a load of 50,000 ohms. (*Telef. rohre* No. 7:94–108. 1936).

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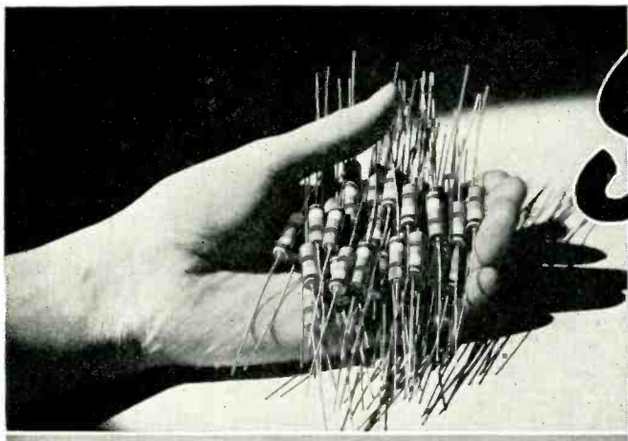
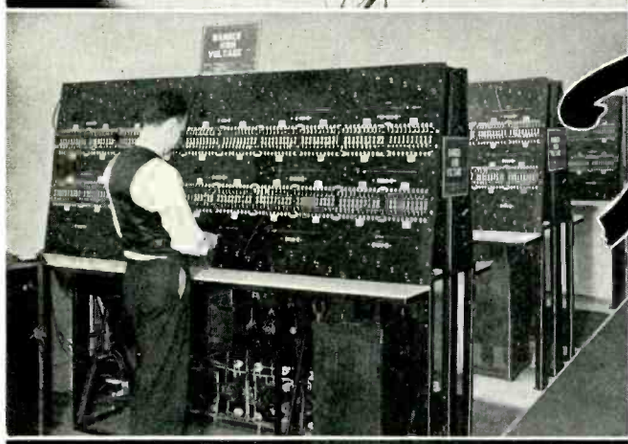
Booklet on Radio Reception

Engineering Bulletin No. 19, prepared by the committees of the RMA, NELA, and EEI, and entitled, *Good Radio Reception* has been recently released from the headquarters of the Radio Manufacturers Association, 1317 F. St., Washington, D. C. The material presented was prepared as a step in the education of the public as to the fundamental conditions necessary for satisfactory reception in the home.



See them

Erie Insulated Resistors are protected by a pre-formed, uniform ceramic wall that will withstand 3,000 volts A. C. Because ceramic case is white, color code paint retains its true hue on application; is easy to read, cannot flake off.



Test them

Erie Insulated Resistors give uniformly superior results in all standard tests for load, temperature, voltage, humidity and noise. We will be glad to send you a generous supply of samples to test in your own laboratories.

Use them

Erie Insulated Resistors are made in 1/4 and 1/2 watt sizes in all resistance values from a few ohms to several megohms. You can depend on them to maintain their actual ratings under all ordinary operating conditions.

TWICE ACTUAL SIZE

ERIE *Insulated* **RESISTORS**

CARBON RESISTORS AND SUPPRESSORS

ERIE RESISTOR CORPORATION

AUTOMATIC INJECTION MOLDING

TORONTO — ERIE, PENNSYLVANIA — LONDON

Selectivity of Radio Receivers

[PIERRE DAVID, National Radioelectric Laboratory, Paris.] Selectivity may properly be defined as the degree to which the radio receiver is capable of differentiating between the desired signal and signals of other carrier frequencies. Prolonged operation of a receiver gives the best idea of its selectivity; short time tests in the laboratory should imitate the conditions met with in practice. In general the receiver is tuned to the frequency of a certain signal and its response to this frequency and to a series of neighboring frequencies is studied, measuring in each case the ratio of output to input, preferably in decibels. The choice of the steps (f—f_1) differs in the various countries; in France the steps are 1, 3, 5, 10 and 20 kc. off resonance, in Germany they are one-fourth of the frequency separation between desired and undesired signals; in other countries f—f_1 is increased by 10 kc. until 100 kc. frequency separation or 80 db. attenuation is obtained. The modulating frequency is practically the same in all countries, 400 cycles per second except in Japan which uses 1,000 cycles per sec. The degree of modulation is 30% (40% in Japan and 50% in Poland). The selectivity is measured at three different wavelengths, or in France at four different wave-lengths of the ordinary broadcast band.

The methods of measuring selectivity are by no means uniform. The tests made with the aid of a single r-f generator may be made in two ways: (a) by keeping the input A constant, (equal to six microvolts, for instance) and measuring the output voltage B. This leaves out of account the fact that detection and audio amplifier stages, which present the least linear relationships in receivers, are thus operated at widely differing levels. (b) The output B is kept constant, equal to four milliwatts, for instance, or equal to the value used when determining the selectivity, and A is varied. Since the purpose is to study interfering signals, the output may be reduced to the level at which jumbling becomes noticeable, which is the case when the output is, normal output of 50 milliwatts (one watt in Russia). A higher output is often chosen for greater convenience so that the results may cease to remain comparable. The curves obtained obey relations of the form $f\text{-}f_1 = AK^b$, where K is the ratio of interference to signal, and A and b are constants.

The tests with a single generator imitate but poorly the actual conditions in which a mixture of signls arrives at the receiver. A method using the two frequencies f and f_1 side by side is preferable but requires two r-f generators which can be started, stopped, modulated and tuned independently. It will then be found that the presence of two frequencies may produce a beat, or that the first stages are

caused to operate in a region which is no longer linear, or in more serious cases the unwanted signal is so strong that it loads the first stages, the desired output decreasing with increasing strength of the interfering frequency.

After having started the modulated signal frequency generator and adjusted it so as to get a normal output B, three different tests may therefore be made with the aid of the second generator, in order to establish the selectivity of the receiver. In test (c) the modulation is suppressed and the amplitude of the interfering signal brought to a value (4 milliwatts) at which whistling exceeds the limit of tolerance. In test (d), after having again suppressed the modulation of f, the interference f_1 is modulated and the amplitude of f_1 noted at which it impresses its frequency upon the desired carrier (180 microvolts) with an objectionable strength (4 milliwatts). Finally in test (e), the modulated signal and the carrier of the jumbling frequency are applied to the receiver, and the amplitude of f_1 is noted at which it weakens the signal in a certain ratio, about 3 to 12 db.

Tests (a) to (e) carried out at the Laboratoire National Radioelectrique on the same receiver show that the different methods are far from giving the same results. Method (a) is likely to yield results which are too favorable, method (c) gives curves which are too steep and too narrow. Method (b) and (d) seem to be in fair agreement when all the stages work without distortion. It is clear, however, that selectivity curves obtained by different methods, may differ by as much as 20 db. for the same frequency separation $f—f_1$. Adoption of uniform tests is therefore an urgent need.—(*Onde el.* 15 (No. 177): 533-563. 1936).

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Interference from Motor Cars

A STATEMENT has been circulated to the effect that the BBC has established a department which is devoted to research in car radio. This is incorrect. The BBC is not concerned with car radio; but it is interested in interference with broadcasting caused by the ignition systems of many motor cars. Experiments are being carried out to see whether arrangements cannot be made to stop this nuisance, and it has been found that it is possible to put suppressors on almost any motor car so as to remove the causes of interference. This particular type of interference has not affected sound broadcasting to any great extent, but it may prove a menace to the television service if allowed to go unchecked.

Note on the Performance of Electro Dynamic Loudspeakers

(N. MEZEY) The power radiated by a loudspeaker is equal to the product, radiation resistance times the square of the velocity of the circular membrane or disk. When plotted as a function of the ratio, diameter to wavelength, the radiation resistance increases until the ratio 1/3 is reached; above this ratio the resistance is practically independent of the frequency. In order to have a constant radiation resistance from the highest to the lowest frequency, the wave-length of the lowest frequency to be used should not be longer than three times the diameter. In the case of a diameter of 3 metres this means a frequency of about 30 cycles. For the diameters used in radio receivers, 20 to 30 cm., the radiation resistance increases necessarily from about 200 c.g.s. at 50 cycles to nearly 30,000 at 1,000 cycles per sec., keeping this value at higher frequencies. In order to render the output independent of the frequency as far as the loudspeaker is concerned it is then necessary to adjust the diaphragm velocity so that at low frequencies it is inversely proportional to the frequency and tends to a constant value at 1000 cycles. This condition may be fulfilled, at least partially, when the lowest resonance frequency of the loudspeaker as determined by the elastic surround and the mass is smaller than the lowest frequency to be radiated. If a force having a frequency higher than the resonance frequency acts upon an elastic system the amplitude produced decreases as $1/f^2$, the velocity as $1/f$.

The author shows the results obtained in a circuit consisting of output tube, transformer and loudspeaker when this condition is not satisfied. With some loudspeakers the resonance frequency lies at 100 cycles per sec. Neglecting resonance in the secondary of the transformer, the stray field and the capacity of the secondary, maximum current in the transformer is obtained when

$$pL_2 \div \sqrt{\frac{(R_2^2+X_m^2)\quad (R+R_1+pL_1)^2}{(R+R_1)^2 + (k^2-1)^2\, p^2 L_1^2}}$$

when p is 6.28 times the frequency, R the internal resistance of the tube, k the coefficient of coupling and X_m the mechanical reactance of the loudspeaker. The distortion at the resonance frequency is quite pronounced. In the example considered the mechanical reactance is given by $20p$–7.02 x $10^6/p$, approximately. (Onde el. 15 No. 176:487–497. 1036).

MANUFACTURING REVIEW

News

✦ Mr. L. W. Olander, for several years employed as transmitter engineer with the RCA Manufacturing Company, and previously with the Bell Telephone Laboratories, has accepted the position as chief engineer with the E. F. Johnson Company, Waseca, Minn., manufacturers of transmitting components. Mr. Olander's past experience in responsible charge of transmitter design will be utilized in the development of new Johnson transmitting equipment.

✦ On the basis of successful experience in the manufacture of high strength magnetic alloys on a limited scale; the Taylor-Wharton Iron & Steel Company, High Bridge, N. J., has begun large scale production operation in a new plant division utilized exclusively for this purpose.

✦ The Continental Electric Company announces the removal of their headquarters from St. Charles into larger quarters across the city line into Geneva, Ill.

✦ The appointment of William L. Hoppes to the post of station relations manager for World Broadcasting System has been announced by P. L. Deutsch, WBS president. During the past three and one-half years, Mr. Hoppes' work as manager of the broadcasting department, Electrical Research Products, Inc. has gained him wide recognition among broadcast personnel. His knowledge of radio station problems, together with his close association with WBS in the operation of World's program service, offer much to station men throughout the country.

New Products

Oscillograph

THE NEW RCA 913 cathode ray tube forms the foundation unit for the model 151 cathode ray oscillograph recently announced by the RCA Manufacturing Company, Camden, N. J. Full scale deflection is obtained at 1.75 ohms r.m.s. Vertical and horizontal amplifiers have a small frequency response between 30 and 10,000 cycles. Net price complete with all tubes, $47.50.

A companion unit to the above is the electronic sweep test oscillator, model 150 having a sweep of from 4 to 40 kc., fundamental frequency ranges of from 90 to 32,000 kc. and 400 cycle internal or external modulation. Net price $64.50 complete with all tubes.

I. F. Transformers

THE J. W. MILLER COMPANY, 5917 South Main Street, Los Angeles, Calif. has begun delivery on a new series of intermediate frequency transformers the middle of February. The transformers are tuned by air dielectric condensers in which approximately 70 per cent. of the total capacity is fixed and the remainder is variable by means of semi-circular plates adjusted by means of an insulated screw driver. Available in both standard and selectivity types with either air core or iron core. List prices range from $5 to $6.50.

Hearing Aid

THE SONOTONE CORPORATION, New York, announces its newest development a "hearing lamp" as an aid for the deaf. An extension cord from the lamp, in which the hearing unit has been incorporated, terminates in an ear piece of either air conduction or bone conduction type.

Punch

A SELF-ALIGNING PUNCH for making large holes in chassis for radio tube sockets, filter condensers, etc., has been brought out by the Insuline Corporation of America, 25 Park Place, New York.

Service Men Signal Generator

A DIRECT READING signal generator operating from the 115-volt, 50 to 60-cycle line and known as model 120 has been announced by the Triumph Manufacturing Company, 4017 West Lake Street, Chicago, Ill. Maximum output is 200 millivolts, frequency range from 100 kc. to 27 mc. through the use of harmonics and 30 per cent. modulation of a 400 cycle audio tone supplied through a separate tube in a compressor injector circuit characterize this unit. The model 120 signal generator employs a 6C6 r.f. oscillator, a 76 suppressor injector audio modulator and a 76 rectifier tube. Available from the factory at $23.95.

Recording Machines

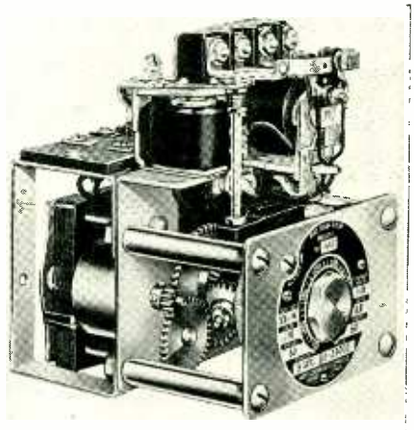
FOUR NEW TYPES of instantaneous recording machines have been introduced by the Recording Equipment Manufacturing Company, 6611 Spencer Boulevard, Hollywood, Calif. The two smaller models consist of an amplifier, loud speaker, crystal microphone, cutting and reproducing head, turntable, and motor, to which may be added a radio receiver. The two larger models are designed for professional use and are supplied with the 7-watt or 12½-watt amplifiers.

Oscilloscope

THE MODEL 60 oscilloscope, a compact, self-contained instrument enclosed in welded steel case, and using the 913 cathode ray tube has been recently brought out by the Burton-Rogers Company, 755 Boylston Street, Boston, Mass. The unit operates from the 110-volt line, 50 to 60 cycles, and consumes 30 watts. The vertical sensitivity is 200 volts per inch for d.c. or 75 volts per inch for r.m.s. values of a.c. A built-in amplifier for the vertical plates increases the sensitivity to 1 volt per inch r.m.s. The horizontal sensitivity is the same as the vertical except that no amplifier is provided. Price $29.95.

Time Delay Relays

A MOTOR-DRIVEN time delay relay using differential gearing, and designed for 110 and 220 volts a.c. operation, has



been made available by the Ward Leonard Electric Company, Mount Vernon, N. Y. Standard units are available with a time delay of from 35 seconds to 53 minutes. Information in Bulletin 362.

Selector Switches

TO MEET THE DEMAND for a wide variety of multiple contact switches such as are used in modern radio receivers, Centralab, 900 East Keefe Avenue, Milwaukee, Wis., has recently made selector switches available in knocked-down form. Standardized parts for the Centralab switch kit are contained in a 25-drawer steel cabinet. The assortment of parts included is sufficient to assemble well over 150,000 different switch combinations, it is reported. Bulletin describing the switch parts is also available.

High Frequency Condensers

A NEW SERIES of ultra high frequency variable condensers, including single and double unit models is being manufactured by the Hammarlund Manufacturing Company, New York City. Single unit models are available in sizes from 15 micromicrofarads to 140 micromicrofarads. The double unit condensers are available from 30 to 140 mmf.

Electrostatic R. F. Voltmeter

ELECTROSTATIC VOLTMETERS for frequencies up to 1500 kc. which are independent of temperature, frequency and wave form errors is available from Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City. The instruments are fitted with a self-contained over-voltage protection device and meters having a range of 3500 volts or less can be used directly either on a.c. or d.c.

Transmitting Triode

THE RCA MANUFACTURING COMPANY, Harrison, N. J., has made available through their transmitting tube distributors a new air-cooled transmitting triode designated as the RCA-806. The 806 is a three-element transmitting tube for use as a radio frequency amplifier, oscillator, and class B audio frequency amplifier. High insulation and low interelectrode capacities are assured by bringing the plate connection through a separate seal at the top of the bulb and the grid connection through a seal at the lower part of the bulb near the filament base. The 806 may be operated at maximum rating of frequencies as high as 30 megacycles. The maximum plate dissipation is 150 watts for class C telegraph and class B services. At 100 megacycles the rated plate voltage and plate input is 50 per cent. of the maximum value obtainable at frequencies of 30 megacycles or lower.

Output Attenuators

AN OUTPUT LEVEL control for power amplifiers dissipating 25 watts continuously, having a minimum insertion loss of 1.3 db. and available in impedances of 8, 15, 50, 200, 250 and 500 ohms, is now being made by the Clarostat Manufacturing Company, 285 North Sixth Street, Brooklyn, N. Y. The attenuation of the CIA output attenuator is linear up to 45 db. in fifteen steps of 3 db. each with an end position of infinite attenuation. The impedance from the load end is approximately three times the line value.

Pickups

TWO NEW PICKUPS models AA-74 and AA-76 have been announced by the Audak Company, 500 Fifth Avenue, New York. Frequency response above 300 cycles is substantially flat; below 300 cycles the response increases gradually to plus 10 db. at 70 cycles in order to compensate for the attenuation in recording at the low end. List prices are $55 and $75 respectively.

Steel Cabinets

A LINE OF black crystalline finish steel cabinets, supplied in knocked-down form for easy assembly by amateurs, experimenters and service men, has been brought out by the Insuline Corporation of America, 25 Park Place, New York City. Seven sizes are available. Cadmium plated steel chassis to fit inside the cabinet are also available.

Battery Charging Rectifier

WITH THE ANNOUNCEMENT of a mercury vapor battery charging bulb, type 2-RA-6 the Continental Electric Company, Geneva, Ill. enters the field of commercial rectifiers. Filament consumption of the 2-RA-6 is 13 amp. at 2 volts. The output of the rectifier is rated at 6 amp. and the peak input voltage is 300 volts. The use of mercury vapor results in a low voltage drop across the tube. The tube is listed at $6.

Relays

A SERIES of small a.c. and d.c. relays is announced by the Guardian Electric Manufacturing Company, 1625 West Walnut Street, Chicago, Ill. and are described in a technical bulletin issued by this company. The series 110 relays are suitable for a.c. operation and consume approximately 2 watts. The series 115 relays consume 3 watts and operate at 110 volts.

Voltage Regulator

A SERIES OF VOLTAGE regulators having no moving parts, with a high degree of accuracy, and unaffected by wave form distortion, have been announced by the Roller-Smith Company, 233 Broadway, New York. Units rated at 2½, 5, and 7½ kva. are available. The output voltage is independent of the load applied to the unit for load voltages between 107 and 123 volts.

Literature

✦ New Tube Developments. The new issue of the Radiotron receiving tube manual, Technical Series RC-13, has just made its appearance. Besides bringing within two covers the essential technical information on all RCA radio receiving tubes, the new edition contains a considerable amount of general technical data on tube principles, installation of tubes in receivers, methods of measuring tube characteristics and parameters, tube applications, typical receiving circuits, and a reading list for further study. A new feature of this edition is a 5-page chart giving the gains of various triode and pentode single stage amplifiers for suitable values of coupling resistors and condensers. The circuit constants for this chart are so chosen as to result in a resistance coupled amplifier having good frequency characteristics. The manual is obtainable from the Commercial Engineering Department, RCA Radiotron Division, RCA Manufacturing Company, Harrison, N. J. at twenty-five cents per copy.

The third edition of Sylvania's Technical Manual, giving characteristics and important technical information on their receiving tubes, typical receiver circuits, and interchangeable tube chart, bias resistor charts, and general technical information has recently been published by the Hygrade Sylvania Corporation, Emporium, Pa. Copies of this 182-page pocket manual of technical information may be obtained for fifteen cents.

A 16-page bulletin of technical and descriptive data on the G-E light sensitive cell is obtainable from the General Electric Company, Schenectady, N. Y., by asking for Bulletin GEA-2467. The essential element in the General Electric light sensitive cell consists of a layer of selenium deposited on the surface of a steel plate. Over this layer of selenium, two transparent layers of material are deposited and these make up the negative terminal of the cell. The technical information presented in this bulletin contains charts showing the output current as a function of external resistance, temperature, and illumination. Data is also given on the fatigue of this cell for different conditions of operation, the frequency response curve, and the internal resistance of the cell.

Information bulletin No. 8, bearing the date of January 1937 describes Westinghouse phototubes. The bulletin contains a list of twelve types of vacuum and gaseous phototubes manufactured by the Westinghouse Lamp Division, Westinghouse Electric & Manufacturing Company, Bloomfield, N. J. The sensitivity of the tubes varies from 0.75 to 125 microamperes per lumen.

Technical bulletins have recently been

received from the Raytheon Engineering Service describing the 6V6G power amplifier and the 0Z4G full wave gas-filled rectifier. With plate and screen voltages of 250 volts, the power amplifier has an amplification factor of 215, a plate resistance of 52,000 ohms and a mutual conductance of 4,100 micromhos. The tube is provided with a 7-prong medium octal shell base. The maximum rating of the gas-filled rectifier is 75 milliamperes at 300 volts, and the tube has a normal voltage drop of 24 volts. The 0Z4G was developed primarily for use in vibrator type B supply units for automobile receivers. Further information from Raytheon Production Corporation, Newton, Mass.

Technical bulletins from the Hygrade Sylvania Corporation, Emporium, Pa. are available describing the 6A5G power amplifier and the 6Y7G class B amplifier. These have output ratings of 3.75 and 8.0 watts respectively.

✦ **Hammarlund Catalog.** The Hammarlund "37" catalog is a 16-page booklet listing the sizes and important characteristics of variable and adjustable condensers, chokes, transformers, coil forms, and similar components. A technical description of the new "Super-Pro" receiver is also given. Copies of the catalog are available from the Hammarlund Manufacturing Company, 424 West 33rd Street, New York City.

✦ **Gammatrons.** Characteristics on the complete line of gammatron tubes manufactured by Heintz & Kaufman, South San Francisco, Calif., are available in a loose-leaf folder of engineering data sheets published by H. & K.

✦ **Compressed Gas Condensers.** Mechanical and electrical specifications for the type 174 compressed gas condenser are given in a loose-leaf technical bulletin published by Heintz & Kaufman, South San Francisco, Calif. The type 174 condensers are available in capacities of 250, 500, 1000, and 1500 μf. The three smaller sizes are continuously variable, the largest size being variable between 1200 and 1500 μf. Through the use of compressed nitrogen rather than air dielectrics at normal atmospheric pressure, the physical size and cost of these condensers has been made quite low. In all of the units the limiting voltage is approximately 42,000 volts r.m.s., at which point sparking takes place between the high voltage terminals and the case. All of the models are rated to have a maximum current of 100 amp. at 1000 kc. or 50 amp. at 20 mc. Breakdown at higher voltage may be obtained through the use of a special type of oil immersed lead-out insulator, permitting breakdown voltages of as much as 80,000 volts to be obtained in certain cases.

✦ **Midget Cathode Ray Oscillograph.** The model 105 cathode ray oscillograph which has been recently announced by the Clough-Brengle Company, of 2815 West 19th Street, Chicago, makes use of the new 913 cathode ray tube with one-inch screen. Except for physical size and screen area, this instrument is identical to their larger oscillograph, model CRA. Built in linear sweeps, high sensitivity amplifier for both horizontal and vertical input and beam centering controls on the front panels are features of this instrument.

✦ **Inter-office Phones.** Bulletins on microphones, private inter-communication systems, and factory or office intercommunication systems are available from the Miles Reproducer Company, 112 West 14th Street, New York City.

✦ **Thermal Overload Switch.** A new thermal overload switch for fractional horsepower motors, operating on line currents and arranged for mounting on the conduit or terminal box of the motor has been placed on the market by the General Electric Company, Schenectady, N. Y.

✦ **Meters.** A folder listing Hoyt meters for radio amateurs and service men is available from the Burton-Rogers Company, 755 Boylston Street, Boston, Mass.

✦ **Plate Transformers.** The Hilet Engineering Company, West Orange, N. J. has available for distribution a folder describing plate transformers of 2½ kva. rating, having secondary voltages from 1300 to 3400 volts.

✦ **Recording.** Published by the Radiotone Recording Equipment Company, 6103 Melrose Avenue, Hollywood, Calif., a booklet entitled "The Mechanics of Instantaneous Acetate Recording" gives an interesting exposition of the method of preparing acetate records.

✦ **Raidio Test Manual.** Complimentary copies of manual A covering tube and radio tester design is announced by the Supreme Instrument Company of Greenwood, Miss. The 60-page manual illustrates and describes the technical design of meters and circuits employed in the present line of Supreme instruments.

✦ **Monel Metal.** The advantages of monel strip as well as technical physical properties concerning the alloy are given in a folder issued by the Somers Brass Company, 350 Madison Avenue, New York City.

✦ **Radio Encyclopedia.** A radio service encyclopedia of more than 200 pages containing a wealth of information for the service man is available at $2.50 per copy from Mallory distributors. For further details of the encyclopedia see the book review section of *Electronics*

Adjudicated Patents

2,022,514, W. A. MacDonald, Wave signaling system, filed May 18, 1936, D. C., N. D. Ill., E. Div., Doc. 15202, *Hazeltine Corp.* v. *Zenith Radio Corp.*

7,763,380, C. E. Trube, Electric coupling system, filed May 18, 1936, D. C., N. D. Ill., E. Div., Doc. 15203, *Hazeltine Corp.* v. *Zenith Radio Corp.*

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1,573,374, P. A. Chamberlain, Radio condenser; 1,707,617, 1,795,214, E. W. Kellogg, Sound reproducing apparatus; 1,728,879, Rice & Kellogg, Amplifying system; 1,894,197, same, Sound reproducing apparatus, filed May 29, 1936, D. C., N. D. Ill., E. Div., Doc. 15221, *R. C. A. et al.* v. *Ultramar Mfg. Corp. et al.*

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Groot et al. Decree for plaintiffs June 26, 1936. Same, D. C., N. D. Ill., E. Div., Doc. 15091, *R. C. A. et al.* v. *B. Olshansky et al.* Doc. 15093, *R. C. A. et al.* v. *Banner Tire Co. et al.* Doc. 15221, *R. C. A. et al.* v. *Ultramar Mfg. Corp. et al.* Consent decree, finding patents valid and infringed, injunction granted Apr. 13, 1936, in each of above cases.

1,614,136, M. C. Latour, Thermionic amplifier apparatus, filed May 19, 1936, D. C., N. D. Ill., E. Div., Doc. 15206, *Latour Corp.* v. *Zenith Radio Corp.*

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(D. C. N. Y.) De Forest patent, No. 1,507,016 and No. 1,507,017, *Held* infringed. *RCA* v. *Andrea*, 15 F. Supp. 685.

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1,329,283, 1,398,665, H. D. Arnold; 1,448,550, same; 1,520,994, same; 1,349,252, same; 1,432,863, K. S. Johnson; 1,442,439, R. C. Mathes, D. C., S. D. N. Y., Doc. E 50/175, *Western Electric Co., Inc., et al.* v. *General Talking Pictures Corp.* Dismissed as to 1,398,665, 1,432,863, 1,442,439 without prejudice Jan. 26, 1934. Dismissed as to 1,349,252 and 1,520,994. Decree for plaintiff (notice Oct. 28, 1936).

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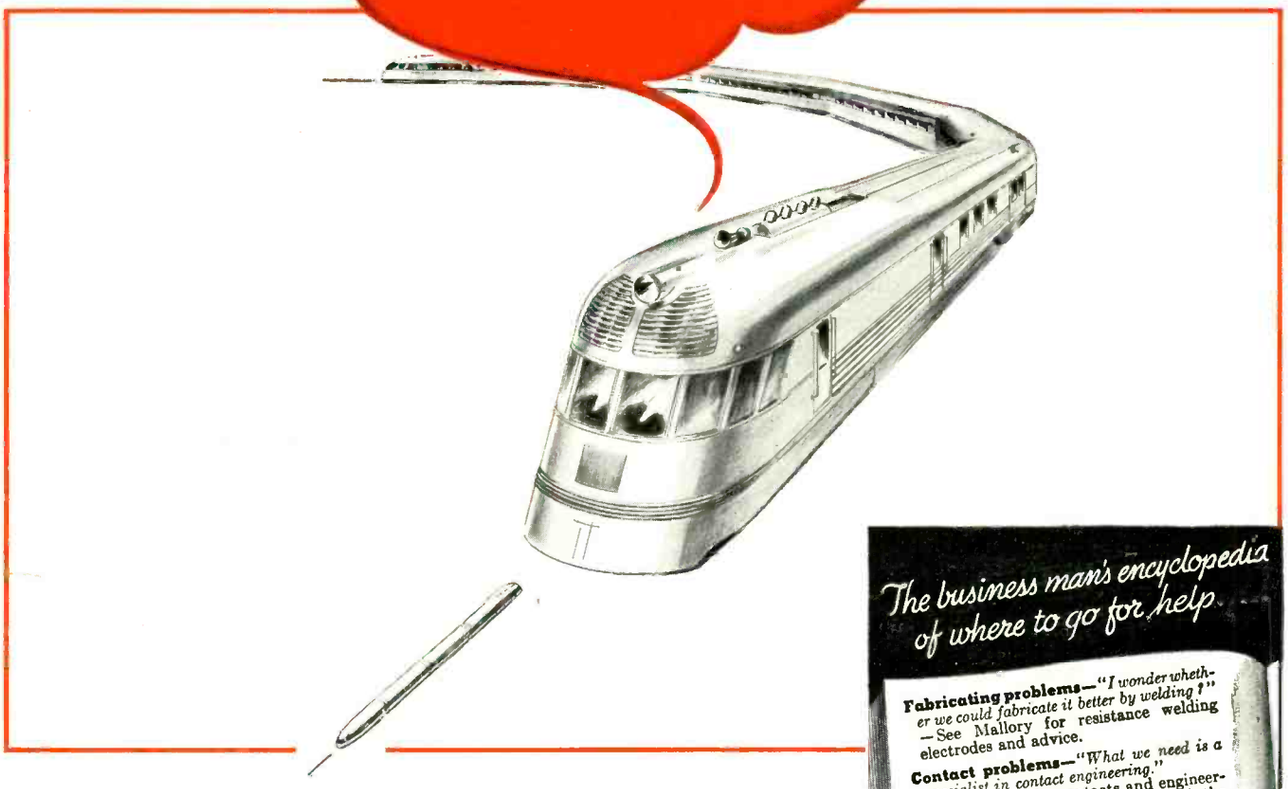

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