electronics

radio, sound, communications and industrial applications of electron tubes • • • design, engineering, manufacture

Electron tubes at the Chicago World's Fair

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Trends in radio design and manufacturing

✦

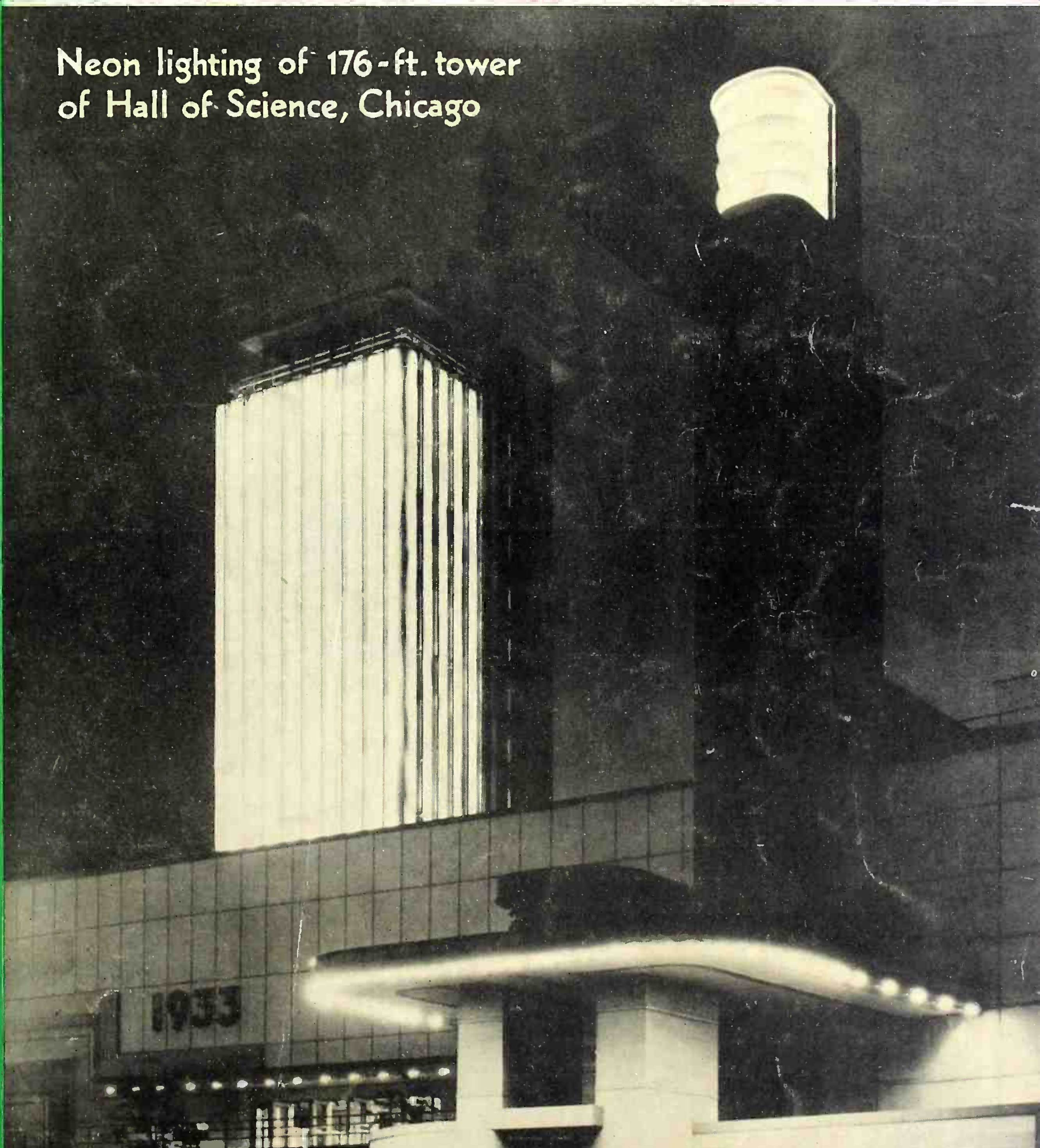
The Ignitron— a new rectifier

✦

Modern reflex circuits

✦

Landing of aircraft in fog by radio



Neon lighting of 176-ft. tower of Hall of Science, Chicago

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O. H. CALDWELL
Editor
KEITH HENNEY
Associate Editor

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radio
sound pictures
telephony
broadcasting
telegraphy
counting
grading
carrier systems
beam transmission
photo cells
facsimile
electric recording
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measurements
receivers
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traffic control
musical instruments
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A Job for the I.R.E.

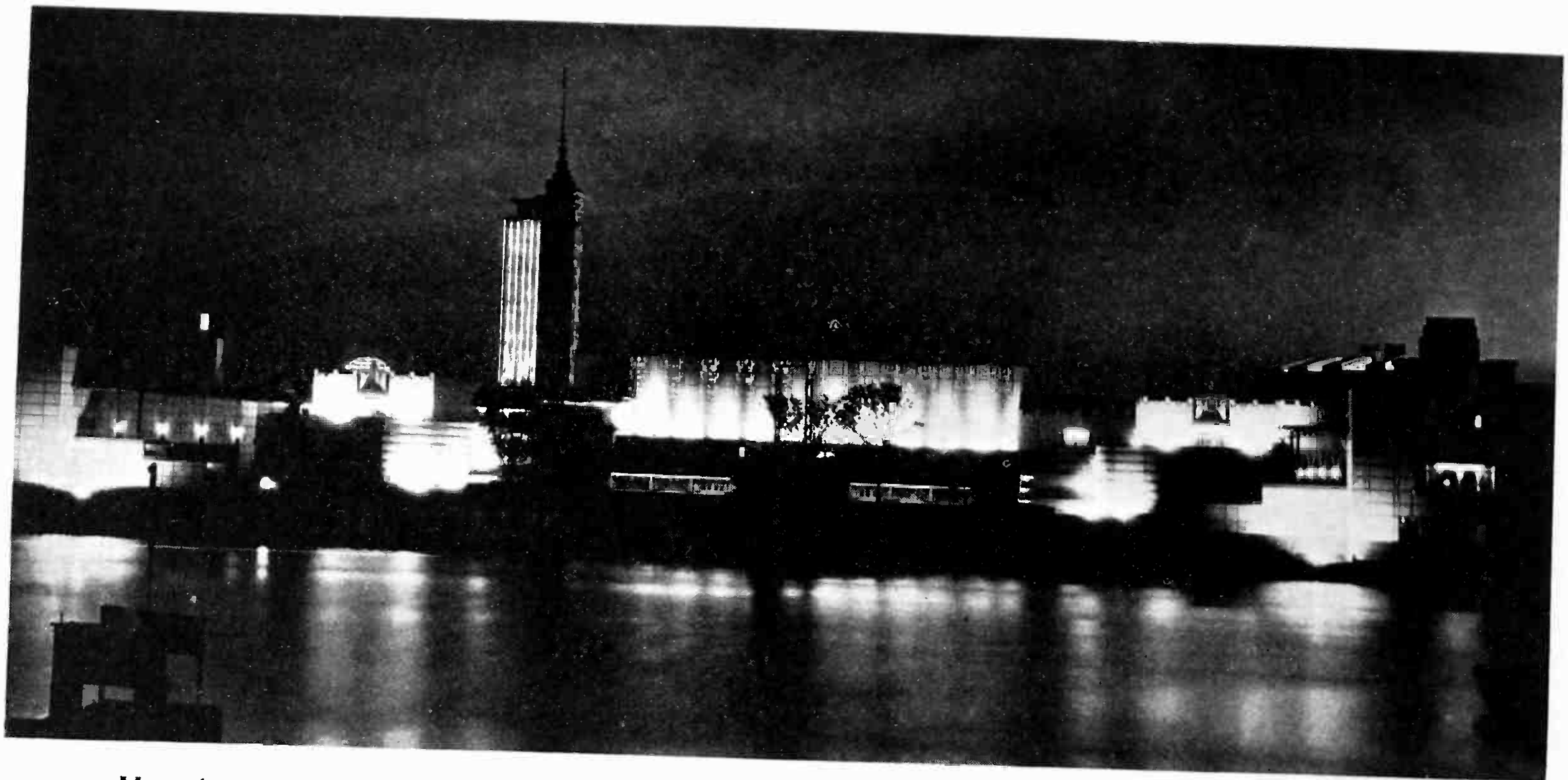
WITH events at Washington moving in the direction of industry control and government partnership in industry, it is likely that the radio manufacturers will shortly be called upon to set up a Code of Fair Competition under the expected new law. For this the instrumentality will undoubtedly be the Radio Manufacturers Association, which now has imposed upon it new responsibilities and opportunities such as never before. With the radio industry's Code of Fair Competition approved by the President, or by his delegated Radio Administrator (or "radio dictator"), the burden of price competition will then be lifted off the radio industry, and manufacturers and engineers can turn once more to their prime job of improving service and quality.

THIS will leave the radio engineers free to develop better technical equipment,—instead of engaging in price-whittling and quality-degradation which has been the sole theme in most engineering offices for twelve months past. It is to be hoped that the Institute of Radio Engineers will seize this opportunity to exert leadership in co-ordinating the work of radio engineers to produce a better complete radio system, all the way from microphone, through transmitting station, to the listener's set and speaker. This task of designing and engineering the whole chain, as well as its individual links, can become a timely theme at the Chicago Convention this month, providing a "new deal" in the technical as well as in the business end of radio.

A list of the I.R.E. papers will be found on page 173.

ELECTRONICS AT THE

"Century of Progress" Exposition opened by electronics, lighted by electronics



More than 75,000 feet of gaseous-tube lighting in various colors—red, gold, blue, green and purple—is employed in the illumination effects of Chicago's "A Century of Progress" Exposition

THE Chicago World's Fair of 1933 is an all-electronic exposition.

It was opened by electronics; it is lighted by electronics; in large measure it is being operated by electronics; and electronic phenomena and apparatus are among the outstanding features of its many exhibits.

And if the feet of the great American public are not so tired from tramping up and down 85 miles of exhibit aisles and corridors as to drive any other consideration than that of aching "dogs" out of its collective mind, that great American public is going to have a much enlarged and improved understanding of the electronic arts when it gets home from "A Century of Progress" exposition in Chicago this coming summer. The g.A.p. can save a lot of shoe leather if it will allow its electronic interest to be satisfied with explanations and demonstrations of basic phenomena, for these are shown in a most illuminating series of educational exhibits in the Hall of Science. But this is highly improbable, for undoubtedly the public will investigate thoroughly all parts of the Fair exhibits and everywhere will see or hear evidences and examples of electronic application.

Photocell control of lighting

The opening of the Fair, with its employment of a quantum of light energy from the star Arcturus caught by a photocell, was a triumphant gesture of electronics. That struck a keynote that continues its tone throughout the period and over the whole area of the Exposition. As on the opening night the big searchlight atop the west Skyride tower, nearly 700 feet in the air, picked out each major group of buildings with its beam and in response, by photo-electric cell control, each spectacular lighting display sprang into brilliance against the dark, so every night of the coming summer will the crowds gasp their "Oh's" and "Ah's" when the electronic lamplighter makes its appointed round. Man has never made a more impressive demonstration than this of the cosmic imperative, "Let there be light."

Fifteen miles of gaseous-tube lighting

And the distinctive new lighting units which characterize the 1933 Chicago Fair's general illumination are electronic—gaseous discharge tubes, 15 miles of them. Building facades will be outlined with them.

Among the most interesting of the new developments is the new cascade of green and blue light on the windowless walls of the Electrical Building, employing nearly a mile and a half of tubes. This waterfall effect is horseshoe-shaped, following the contour of the Electrical Building. Seven banks of green and blue gaseous tubes rise vertically 55 ft. at intervals along the wall. Spray and steam flowing from nozzles at the base of the wall heighten the cascade effect. In this display the tubes are all exposed, unlike the concealed-tube lighting which makes up the rest of the World's Fair architectural illumination.

Neon red, gold, blue, green and purple color combinations of tube units have been worked out, and altogether between 75,000 and 100,000 feet of gaseous discharge lighting is in use on the Exposition grounds.

An outstanding characteristic of the demonstrations

CHICAGO WORLD'S FAIR

Electronic apparatus and electronic phenomena featured among the many displays and exhibits

of electronic phenomena in the Hall of Science is their comprehensibility. Every electronic engineer who has wearied himself in trying to explain his art should tell his questioners to go to the Fair and see these exhibits. A previously uninformed person, after studying these demonstrations for a while and having a fairly good memory, can easily qualify as the neighborhood expert when he gets home. Here is the "Edison effect" explained in its own terms of operation, not by analogy or diagrammatic concept. A vacuum tube, not a little one, but big enough for its parts and operation to be clearly seen, has an emitting filament and two fluorescent plates. As their polarities are changed automatically the plates attract electrons from the filament and glow alternately while meters indicate the flow of current in the particular circuit thus energized.

Two pairs of neon lamps revolving concentrically in different diameters show by their stroboscopic effect in changing patterns the phenomena of full and half wave rectification. An oversize radio tube 12 inches high and 6 inches in diameter in association with indicating instruments shows how plate current is controlled by grid potential. Demonstrations of amplifying processes, of oscillation generation and control, of trigger type tubes—thyratron and grid-glow—of capacitive effects, of continuous wave modulation, of photo-electric effects, of piezo-electric phenomena, of the X-ray spectroscope, of beta and gamma rays and alpha ray tracks, of cosmic rays that people read about in the newspapers and of many other electronic phenomena are carried out in operation and movement that cause the visitor to stop and look, and, shortly, to understand. Probably in no laboratory or

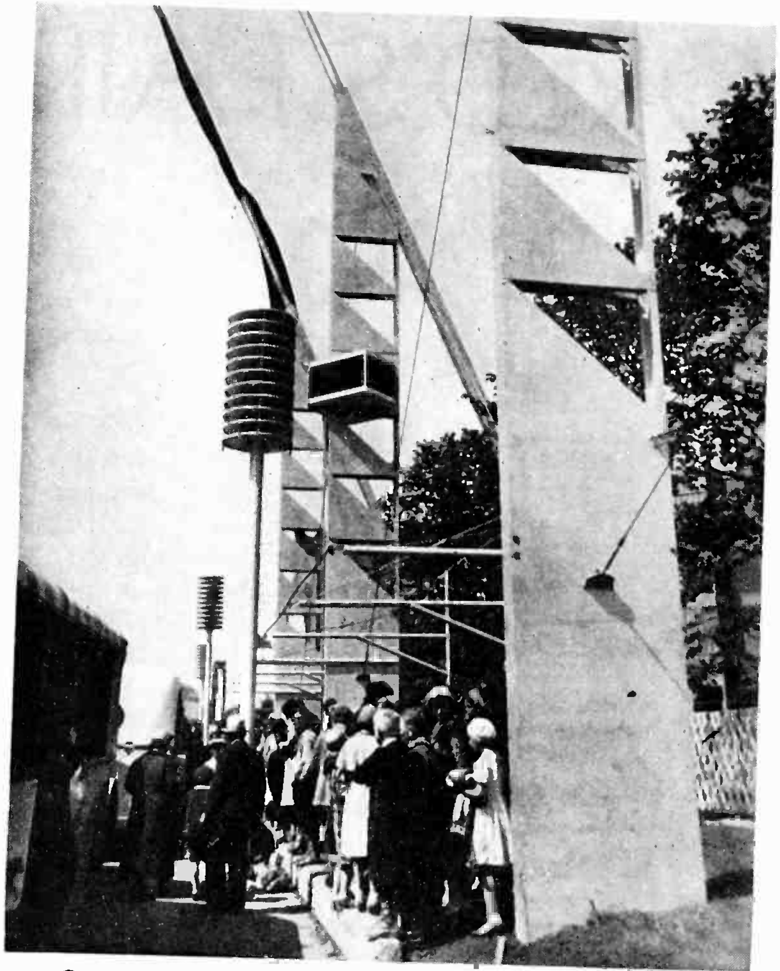
Rectification is made comprehensible by this exhibit of revolving neon tubes whose changing patterns illustrate effect of rectifier tubes

Loudspeakers throughout the grounds. Each of these 45 posts carries two speaker units, with the amplifier in the base

scientific display of any kind has there been presented so comprehensive and so lucid a demonstration of the fundamentals of electronics as is found in this series of exhibits in the Hall of Science.

But these do not by any means include all of electronic displays in the exposition. The Westinghouse, General Electric, Bell telephone, RCA and other groups have opened wide their research laboratories in their large exhibits. G. E. pursues its "House of Magic" theme with a 200 seat auditorium, so named, in which a continuous show of scientific vaudeville is presented. Westinghouse has set up its research demonstrations on a long mezzanine above its main exhibit with the experiments so arranged and equipped that visitors many operate or participate in them. Space does not permit an extended description of the many experiments and demonstrations in these exhibits, which include everything from radio power transmission to the latest developments in sodium vapor lamps. In the applications of electronics to power uses, the visitor can see into a mercury arc rectifier in operation and can watch the glow of a pair of phanotron tubes supplying direct current to a moving stairway.

All these things so far discussed are exhibits, demonstrations set up to explain and to educate. But these do not encompass completely the electronic aspect of the Fair. As previously stated, building illuminations are



On the Avenue of Flags, the speakers are mounted on the flag standards. At the left are the light sources

controlled by photoelectric cells and these versatile imps are found everywhere throughout the Exposition. Doors are opened by the waving of a hand, machinery is started by a shadow. Changing colors of fountains and gaseous tube illuminations, such, for instance, as the beautiful neon-mercury shaft in one of the General Exhibits building courts and the light cascades on the Electrical Building are electronically controlled.

But the populace expects, and it gets, in the Fair an outstanding example of radio and audio amplification.

Scattered about the Fair grounds are 120 loud speakers in 45 locations, some mounted on stands and building structures, but most of them set on poles about 30 feet high. The usual installation consists of two dynamic speakers mounted in a square quarter box with an amplifier in the circular seat at the base of the pole. There are four conductors carried underground in lead covered cable to each amplifier, two for the regular programs, one an order or talk wire and one the control conductor by which the amplifier is turned on and off. The control relays are operated by a pair of dry cells in each amplifier box. Power supply for each amplifier is taken from the nearest point at which 24-hour electric service is available. Normally the loudspeakers are controlled and operated in groups, but all may be handled as a unit or any single one may be operated independently. The system is so flexible that the music of a parade marching down an avenue may be amplified along the way and accompany each band as it comes closer, goes by and passes out of hearing. There are three main control stations, one in the Hall of Science, one in the replica of old Fort Dearborn and the third at the south end of the grounds in the Travel and Transport Building.

At 72 different points on the grounds are located pick-up stations for microphones, connected by 202 audio circuits to four main broadcasting studios. One of these, in the basement of the Administration Building, is a work studio only. The other three are in the "Hollywood" group of concessions and are used, in addition to broadcasting, for demonstrations of talking movie production, of television and for stage presentations. The audience capacities of these studios are 400, 800 and 2,500. All three stages are sound proofed from their respective auditoriums. Contracts have been made with local Chicago stations—WENR, WMAQ, WGN, KYW WLS, WCFL, WWAE and WIBO—and with the National Broadcasting Company and the Columbia Broadcasting System for programs originating in the Fair studios and pick-up points.

Many exhibit novelties

Radio and electronic principles are employed in many control functions in connection with exhibits outside of electrical apparatus. For example, in the display of the International Harvester Company a farm tractor, controlled by radio, is seen crossing a two-acre field, maneuvering, and returning, all under the direction of a radio transmitter and switchboard located at the edge of the field.

Another novelty is the RCA "color organ." In this instrument the production of color-tones corresponding to musical notes has for the first time been automatically synchronized by means of radio tubes. It is only necessary for the operator to start a record—the color organ automatically translates the recorded notes into color values.

Another curiosity is the "fire scanner" which shows the possibilities of the photoelectric cell as an automatic fire scanner. On the floor is a sheet iron pit into which balls of flaming waste paper may be thrown. Observing the pit constantly is a "scanner" consisting of a hose nozzle controlled by an electric eye. It moves right and left and up and down incessantly like a bear pacing its cage. The moment its eye perceives a flame it stops instantly and spurts forth a jet of water which extinguishes the flame. When the fire is out the water is shut off and the electric eye resumes its ceaseless patron.

This photo-electric siren is operated by series of holes to produce the proper frequencies, using a bar of light from a prism

Trends in radio design and manufacturing

ENCOURAGING signs are in the air—despite the long continued efforts of the radio industry to ruin itself on the rocks of squeak boxes made of tin. Not only is automobile radio on the up and up; not only are there signs of a revival of interest in high quality reception; but there is evidence that such reception will soon be possible in spite of the smallness of the sets now merchandised to virtual exclusion of consoles. And looming largely is the heretofore unheard-of vision of Government fostering, demanding, insisting on the radio industry cooperating within itself.

The public has taken to the small set like ducks to water. Encouraged by the manufacturers to discount ten years of advice on what constitutes high tone fidelity, the public has grabbed many products inferior in musical—even speech—reproduction, mechanically and electrically weak, potential liabilities for much service anguish.

But the public would not refuse a small set if good tone quality went with it. Progressive manufacturers are, therefore, ready to try on this long suffering, ever-game-public, the adventure of the external loudspeaker. The future may see radios sold in double units, the tuning mechanism housed in a small beautifully made cabinet, an external loudspeaker with sufficient baffle to provide good bass reception. Such a scheme would not only provide new purchasers with the desirable compact, near-at-hand tuning mechanism, but good quality to boot. Furthermore, it would persuade many owners of aged consoles to part with their antiquated receivers in favor of the better sensitivity and higher tone quality now possible plus automatic volume control, intercarrier noise suppression and all the frills of present day perfection.

The recent demonstration of binaural transmission and reproduction of music over a high quality (15,000 cycle) system capable of handling a wide range of volume (70 db.) without frequency or amplitude distortion proved conclusively the desirability of transmitting a wide band, and that binaural transmission was not an idle dream (*Electronics*, May 1933, page 118).

Hill-and-dale records

Those who long for high-class home entertainment will find further encouragement in the possibility that the long-playing vertically-cut records of Dr. Fredericks (Bell Laboratories) may be available to the public. These records transmit a wide range of volume and are good up to 10,000 or more cycles. Played on the proper instrument with sufficient power and the proper speaker system they will provide entertainment of the highest caliber.

These two possibilities, the transmission of three-channel high band-width sound to various cities over the Bell System and the sale of high-class reproducing machines with hill-and-dale records constitutes a threat to the radio industry to think of something besides cheapness of sets.

Circuit engineers in their search for methods of reducing the space required for a given sensitivity and selectivity and for reducing costs are leaving no stones, old or new, unturned. Lessons in economy learned in the hectic a.c.-d.c. scramble are being utilized in strictly a-c sets.

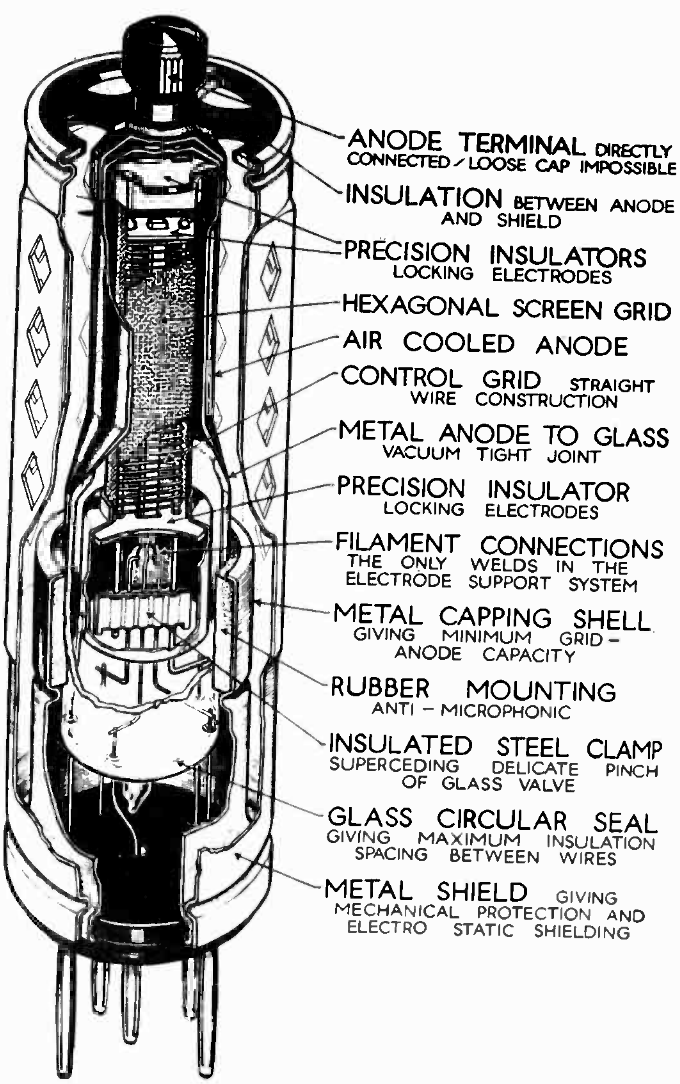
The long dead reflex is being revamped (page 153, this issue). A single tube now acts as second detector, intermediate frequency amplifier, audio-frequency amplifier, a.v.c. tube and possibly inter-carrier noise suppressor. Together with the electron-coupled oscillator, the reflexed tube will permit a seven tube set to be compressed into four tubes. Even the power tube may be worked twice in some sets, once at i.f. The authors of the reflex data in this issue point out that years ago, reflex circuits received considerable attention and extensive application, because of the relatively high price of tubes, the high order of sensitivity required to receive weak or distant broadcasting stations, and the heavy

Mechanical strength forms one of the advantages of the all-metal tubes

drain on batteries by the tubes then available. Any circuit combination which gave greater sensitivity for a given number of tubes was considered meritorious. Consequently, reflex circuit-arrangements were used extensively since they answered many of the design problems encountered at that time.

Later the reflex circuit was dropped, disappearing from use entirely. The reasons for its loss of popularity were primarily the poor stability obtainable with the available triodes, the poor quality of output, and the introduction of cheaper and more efficient tube types which permitted the use of more tubes in the set without greatly increased cost or excessive battery drain. Furthermore, the growing demand for a single-control receiver which would give approximately maximum sensitivity at any dial setting, did much to push the erratic and complicated reflex receiver into temporary discard.

The spontaneous public approval accorded the introduction of the "pocket size" compact receivers has led



Construction of all-metal tubes

radio engineers to an almost frantic search for new circuits and new methods which would give improved performance without an increase in the size or cost of the set. The number of parts and tubes which can be put in the chassis space available in these small receivers is now, and has been, at the saturation point. The use of duplex tubes has been a considerable aid to performance capabilities without an increase in chassis size.. In automobile sets the problem is to get the best performance possible with the smallest drain on the car's battery. Consequently, the next logical step is to make some of the tubes perform additional functions. Reflexing may be the answer to these problems.

With reflex arrangements, higher gains are attainable with a given number of tubes than with a straight circuit. The size and weight of the chassis are not much increased by the use of reflex circuits, while current consumption remains the same.

While fewer tubes are used with a reflex circuit to secure the same overall gain, the cost of circuit elements is slightly higher for a reflex arrangement, since filters must be provided to isolate the reflexed frequencies. The increased cost and complication of the circuit may offset the saving in tube costs for a straight circuit. Consequently, the principal advantages of the reflex-circuit may be its economy of space, and reduced power consumption.

The electron-coupled oscillator is a distinct advance. It improves the set. It is difficult to put in the same category all of the many hybrid tubes brought out at apparently the slightest pretext. Since the new numbering system went into effect a new tube has appeared at least once a week, often differing but slightly from tubes already in production.

Where the tube manufacturer is to get a profit remains a mystery. He has got himself out of the quantity production basis onto a piece work scheme. No sooner does a tube become popular enough to be built at a high speed, and at low cost, than he combines it with some other tube into a small production item complicated to build, expensive to test and to throw away if not up to specification.

In spite of the economical uncertainty, at least two of the larger tube plants are expanding their manufacturing facilities, secretly hoping that most of their competitors will go out of business and thereby permit themselves a profit. Tube manufacturers report more rapid swing toward the use of SVEA metal for plates and support wires.

All metal tubes

First announcement of the Osram Catkin all-metal receiving tubes in England must be taken seriously in this country. This is a combined Osram-Marconi development and at the moment seems to be of considerable importance. It will change the appearance of tubes, will increase their stability and rigidity, lower the shipping cost, etc.

Fundamentally, the tubes resemble large water-cooled tubes. These have exposed anodes, glass being used only for the seal. The catkin tube takes its name from the fact that the transmitters with exposed anodes were called "cooled anode tubes" (cats) and the new tubes being smaller, were give the diminutive title.

According to Osram (General Electric Company, Ltd.) the features of the metal-envelope tubes are as follows:

1. Uniformity of characteristic, due to new methods of support and mounting the electrodes.
2. Absence of electrostatic charges due to the elimination of the insulating envelope. Screen-grid tubes have lower grid to anode capacity. The tube is self-shielded.
3. Greater cooling. In the case of power output tubes a higher rating can be put on the tube. Output tubes are supplied without the outside screen, the anodes being coated with a heat-resisting and insulating enamel.
4. Elimination of losses in the seal. Mica is used instead of glass in the pinch and steel supports insure rigidity.
5. Non-microphonic mounting.
6. Retention of high vacuum. The air cooled anode and the elimination of glass reduces the evolution of gas during use.

COMPONENTS MARKET IN 1932

Component	1932 Average Price	Number Per Set	Total in millions	1932 Market Value
Sockets	$.022	8	20.8	$400,000
Audio transformers	.70	1	2.6	1,820,000
Power transformers	1.47	1	2.6	3,820,000
Power chokes	.60	1	2.6	1,560,000
Loudspeakers	1.65	1.1	2.76	4,550,000
R-F coils	.17	4	10.4	1,770,000
Tuning condensers	.65	1	2.6	1,690,000
By-pass condensers	.09	9	23.2	2,080,000
Filter condensers	.33	2.5	6.5	2.140,000
Fixed resistors	.04	10	26.0	1,040,000
Volume controls	.26	2	5.2	1,350,000
Total				$22,220,000

[*Continued on page 161*]

Reflex circuit considerations

By J. M. STINCHFIELD
and O. H. SCHADE
*RCA Radiotron Company—
E. T. Cunningham, Inc.*

In THE search for ways to increase the effectiveness of a radio receiver without increasing its cost or its space requirements, engineers have naturally thought of reflexing one or more of present-day multi-element tubes. The discussion below deals not only with the fundamental principles of reflex but of the difficulties in using it, its advantages and some general comments on the design of reflexed circuits.

In Fig. 1 is shown a fundamental reflex circuit, employing a pentode and a diode, the former reflexed so that it amplifies both i-f and a-f voltages. The two tubes shown can be replaced by a single tube of the 6B7 type. In operation, the incoming i-f signal is passed through T_1 and amplified as usual. The plate circuit of the i-f amplifier also includes the a-f load (R_4) by-passed by C_4 to make the impedance for i-f relatively low. The diode detector is coupled to the i-f amplifier through T_2. Detection of the signal takes place in the diode, producing an a-f output which is fed through an i-f filter (R_2C_3) back to the control grid. It prevents any i-f component from being fed back to the control grid of the pentode. In passing to the control grid of the pentode, the a-f signal will pass unaffected through the secondary of T_1, of relatively low impedance to a-f. The a-f signal is then amplified by the pentode, producing an a-f voltage across R_4. Although the primary of T_2 is in the plate circuit, it has little effect on the a-f plate current due to its relatively low impedance to a-f. Thus it is possible to develop an a-f voltage across the a-f load (R_4) which can be fed to another stage of a-f amplification or an output tube.

From this elementary discussion of a typical reflex circuit, it will be seen that the operation of the circuit depends upon its ability to separate the reflexed frequency from the other frequency. Naturally, it will be simpler to design circuits for frequencies which differ widely. For this reason, the reflexing of a-f voltages through an i-f amplifier is perhaps the simplest. However, it is possible, although considerably more difficult, to reflex i-f through an r-f amplifier.

In Fig. 2 is shown a typical family of plate characteristic curves for a pentode amplifier. A load line A-O-B, representing an effective a-f load of 83,400 ohms is shown. The static center of the a-f swing is the point O, showing that a bias of —2.75 volts is required. The amplitudes of the a-f swing may be OA and OB.

Since the amplitude of the a-f swing are much larger than the amplitudes of the i-f swing, due to the amplification of the system, the dynamic center of the i-f swing will be moved up and down along the a-f load line. The location of the dynamic center of the swing at any instant will depend upon the instantaneous value of the a-f voltage applied to the grid of the tube.

An i-f load impedance of 313,000 ohms is represented by the load lines, L-A-M and P-B-Q, at the extreme ends of the a-f swing. The i-f load with no a-f signal on the grid of the tube is represented by the line X-O-Y.

If the characteristics of the tube could be made absolutely linear over the entire range of the a-f and i-f swings, the tube would be ideal for reflex amplification. Since the characteristics are not absolutely linear, some distortion is introduced, and the selection of the proper load becomes important for stable operation.

It is apparent from the curves that the a-f voltage is distorted but slightly by the curvature of the characteristics. The dynamic center of the i-f voltage swing, however, is carried back and forth along the a-f load by the a-f grid voltage. Consequently, the i-f plate voltage amplitude is subjected to considerable change with respect to the i-f grid voltage amplitude. Hence the i-f voltage is distorted. An appreciable part of this distortion is eliminated by the tuned i-f circuit, but the percentage of modulation of the i-f signal is also changed.

When an unmodulated i-f signal voltage is applied to the input of the circuit shown in Fig. 1, a d-c voltage is developed across the load resistance (R_1) of the

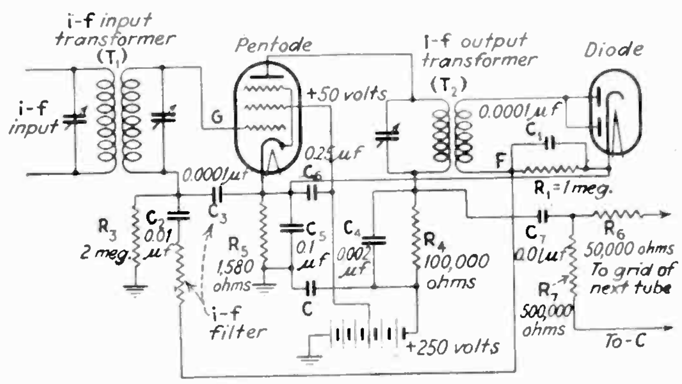


Fig. 1—Typical reflex circuit. In this case the diode and pentode are distinct; they may be combined in a single envelope, such as the 6B7

diode. The point F (Fig. 1) becomes negative with respect to the cathode. An increase, or decrease, in the i-f amplitude due to modulation increases, or decreases, the negative potential at the point F. The changes in potential occur at a-f. The a-f voltage is directly effective at the grid of the reflexed tube through the coupling connection R_2 and C_2. The changes in potential at the grid and at F are identical in sign with respect to the cathode.

It is evident that when the modulation increases the amplitude of the i-f signal, the dynamic center of the i-f swing is shifted by the a-f voltage towards the point B. Similarly, when the carrier is modulated downward (decreased i-f amplitude), the a-f voltage shifts the dynamic center of the i-f swing towards A.

The spacing of the grid voltage lines (Fig. 2) increases towards A and decreases towards B. This causes a decrease in the percentage of modulation of the i-f signal, since the small amplitudes are amplified more than at point O and the large amplitudes are amplified less. This decrease in the percentage modulation has a stabilizing effect of the system, while the gain and output are reduced slightly.

If the output of the diode detector were connected to the grid of the reflexed tube in the opposite phase, there would be an increase in the percentage of modulation. This effect tends to be accumulative and motorboating may result.

Consider the normal stable circuit arrangement with the loads shown in Fig. 1. Suppose a small, modulated i-f signal is applied to the input and its amplitude is gradually increased by means of a gain control operating on the preceding amplifier stages. When the positive a-f voltage swings the grid appreciably beyond the point A, the i-f amplitude no longer receives increased amplification as compared with that at the point O, due to the curvature of the characteristics near the point C. The amplification rapidly decreases beyond the point A, causing a further decrease in i-f amplitude to the detector, which in turn causes a more positive grid voltage on the reflex tube.

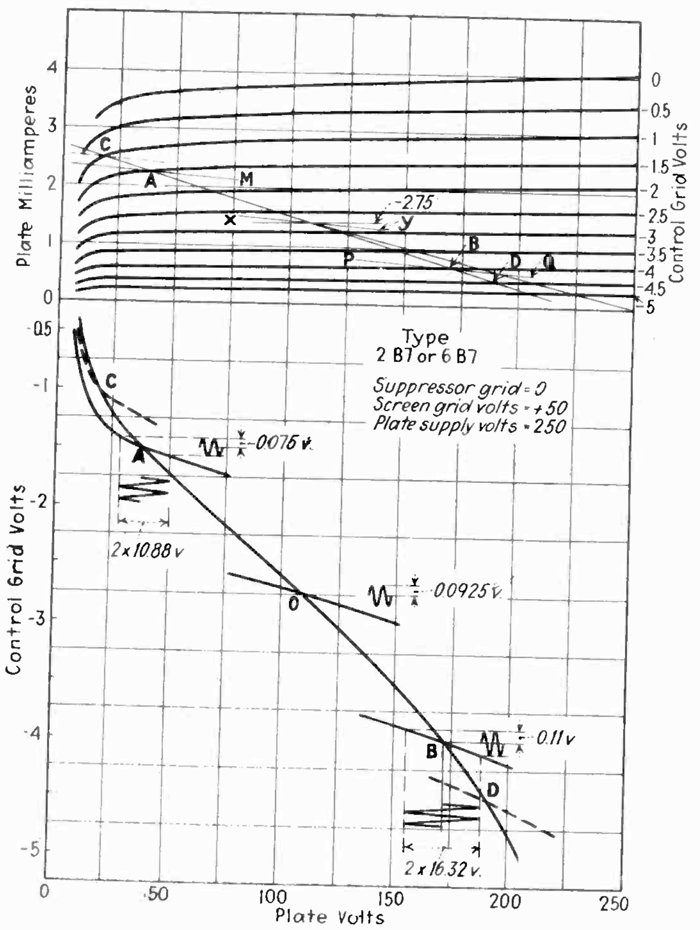


Fig. 2—Plate characteristics of the 6B7 or 2B7 and (below) the dynamic a-f characteristic

Stable operation is obtained, if the change in the i-f amplification over the operating range of the a-f grid voltage values produces a distortion of the modulated i-f which, when rectified by the diode, causes a considerably larger change in the a-f amplitude at the lower end of the grid swing than at the upper end (Fig. 2). Even though the characteristic at the upper end tends to produce an increase in percentage of modulation, the characteristic at the lower end is counteracting this effect.

In general, for stable operation in reflex circuits, the i-f voltage amplification over the operating range must either be constant, or tend to oppose the changing amplitude of the input carrier-voltage.

The limiting conditions for stable operation, therefore, depend upon the a-f and i-f loads, the plate, screen, and grid-bias voltages. It is necessary to use a somewhat lower screen voltage than that normally used in i-f amplifiers in order to obtain high a-f voltage-amplification. The control-grid bias must be selected so that the tube operates near the central part of the plate characteristics to obtain maximum output and stable operation. High output requires high plate voltages, particularly when resistance coupling is employed.

The i-f plate load impedance and the a-f load impedance should not be too high. Low impedances give better stability, but also, low voltage-amplification. While it is possible to secure volume control on the reflexed tube, it is generally more satisfactory to use a volume control operating on preceding tubes.

Analysis of operation of circuit

The 100,000 ohm load resistance (R_4 in Fig. 1) and a bias voltage of —2.75 volts place the static center for the a-f plate voltage swing at a favorable point (O in Fig. 2) on the plate characteristics for a plate supply of 250 volts and screen voltage of 50 volts. The grid resistor (R_7) in parallel with load resistor (R_4) constitute the a-f load (R_p a-f) of 83,400 ohms. This load is represented by the line A-O-B in Fig. 2.

The transformer (T_2) has a primary to secondary voltage ratio (N_E) of 1.7 to 1. The parallel resonance impedance of the primary (Z_{pr}) is 400,000 ohms. The secondary of T_2 is loaded by the diode. The diode impedance (Z_D) to the 175 kc. i-f is approximately one-half of R_1, or 500,000 ohms. The resistance and reactance of the secondary T_2 are negligible in comparison with this diode load. Therefore, the total i-f plate load impedance is the parallel value of Z_{pr} and the reflected diode impedance, or 313,000 ohms.

The points A and B mark the limits of the assumed a-f plate voltage swing on the dynamic a-f characteristic in Fig. 2 (obtained by projecting instantaneous values of grid voltage and plate voltage from the load line A-O-B). The amplitude of the fundamental a-f plate voltage swing is 67 volts. This corresponds to a grid voltage swing of 1.25 volts, giving a voltage amplification of $67/1.25 = 53.5$.

Since the voltage produced across the diode load (R_1), modified by the voltage ratio of the network comprised of R_2, R_3, C_2 and C_3 gives the a-f grid voltage swing, the voltage across R_1 must be equal to

$$1.25 \times \frac{R_2 + R_3}{R_3} = 1.44 \text{ volts}$$ (over the frequency range for which C_2 and C_3 are negligible).

For a diode efficiency of 90 per cent, the amplitude of the i-f modulation on the secondary of T_2 is $1.44/0,9 = 1.6$ volts.

With 20 per cent modulation, the i-f signal voltage on the secondary of T_2 is $1.6/0.20 = 8$ volts. The voltage on the primary of T_2 is the voltage in the secondary times the step-down ratio of the transformer $= 8 \times 1.7 = 13.6$ volts. Since this voltage is 20 per cent modulated, it varies between 16.32 volts and 10.88 volts.

Since the d-c voltage across the diode load (R_1) increases with increasing i-f voltage, the maximum value of a modulated wave causes the highest voltage, while the minimum causes the lowest voltage. The d-c voltage change across R_1 produces the instantaneous a-f grid voltage on the tube. Consequently, when the modulated i-f voltage swing is 16.32 volts the dynamic center is at B, when it is 10.88 volts the dynamic center is at A.

It will be seen by inspection of Fig. 2 that the i-f voltage amplification for a given i-f amplitude depends upon the instantaneous grid voltage. The voltage amplification is low at highly negative values of grid voltage, and it increases gradually as the negative grid voltage decreases towards point A. For negative grid voltages less than that at A, the amplification begins to decrease rapidly, until at C it is considerably lower than at A. The decrease in voltage amplification at C is due to curvature of the plate characteristics for low plate voltages.

The amplification at points A and B is found from the i-f load lines on the dynamic characteristics, and it equals the ratio of the peak-to-peak plate voltage swing to the peak-to-peak grid voltage swing. At A the amplification is $2 \times 10.88/2 \times 0.075 = 145$. At B it is $2 \times 16.32/2 \times 0.11 = 148.2$.

As brought out in the discussion on the theory of operation of a reflex amplifier, stable operation can exist only when the i-f amplification is constant or tends to oppose the changing amplitude of the input carrier-voltage. Under the conditions obtaining at A and B, the modulation of the i-f signal is increased, due to the difference in amplification at these points. Due to the distortion of the a-f amplitude, the a-f grid voltage is not sinusoidal as assumed for the construction of Fig. 2. The point B actually should be more distant from O than point A, and not as shown.

With a slightly larger amplitude of i-f input the stabilizing effect of the unequal a-f amplitudes no longer predominates and the system becomes unstable. Larger i-f amplitudes cause the points A and B to move away from O into regions of increasing instability until the tube draws grid current. As a result of grid current, the point O is shifted to a more negative value, restabilizing the system for an instant. The rapid reoccurrence of this phenomenon is the so-called "motorboating" effect. For smaller a-f plate voltage swings, the voltage amplification in the direction of A becomes greater than that in the direction of B, producing slight demodulation. This condition adjusts itself instantly, so that stable operation is obtained.

Higher percentages of modulation require smaller i-f grid voltages for the same audio output. Therefore, larger audio-output voltages can be obtained without exceeding the i-f grid voltage swings which mark the end of stable operation. The following table shows the results of experiments which illustrate this:

Per cent modulation of i-f signal	Peak a-f output voltages for stable operation
10	45.3
20	64.0
30	79.0
50	105.0
80	116.0

The values for 50 and 80 per cent modulation show that the entire a-f dynamic characteristic is used, and they represent the maximum possible voltage-output obtainable without causing the tube to draw grid current.

The calculation shows that the i-f amplification is 145 and the a-f amplification is 53.5. Due to the step-down ratio of T_2, the overall i-f gain is $145/1.7 = 85.4$. The gain of the entire circuit of Fig. 1 with an i-f signal of 20 per cent modulation is $67/0.0925 = 725$, for 30 per cent the gain is 1,090 and for 100 per cent it is 3,625.

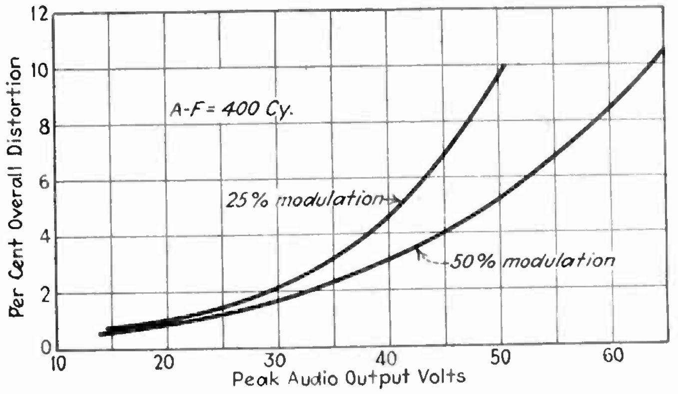


Fig. 3—Distortion from the reflex circuit and tube showing decrease at higher modulation due to weaker necessary i-f signal

Harmonic analysis shows a distortion of 2.7 per cent for the a-f amplifier alone with a peak plate voltage swing of 64 volts. The measured overall distortion is shown versus the peak a-f output in Fig. 3. The measured overall distortion is considerably higher than the calculated value for the a-f amplifier alone since it contains distortion due to the change in percentage modulation of the i-f signal, and also the distortion of the diode detector.

Reflex circuit design

There should be no a-f coupling between the plate circuit of the pentode (Fig. 1) and the diode-detector circuit, if audio-feed-back and audio-rectification are to be avoided. The capacity between the T_2 primary and secondary windings should be low to eliminate a-f coupling. There should be no i-f coupling between the plate circuit of the pentode, or the diode circuit, and the grid circuit of the pentode, since i-f feed-back will cause oscillation or degeneration.

In resistance-coupled circuits, the plate supply voltage should be at least 5 times as high as the screen grid voltage. The audio load should be placed for low distortion and be such that the least negative required peak grid-voltage value does not occur at too low a plate voltage. The reflexed a-f voltage must return to the control grid of the reflex tube in the proper phase. In resistance coupled circuits such as that shown in Fig. 1, the correct phase relation automatically obtains. In transformer coupled circuits, the polarity of the a-f transformer must be correct.

For an i-f signal of given percentage modulation there may be a limiting amplitude beyond which instability results. The i-f and a-f plateload impedances have critical values which determine the limits for stable operation. If the volume is controlled only by varying the a-f voltage fed back to the reflex tube, rectification of the i-f in the plate circuit of the reflex tube will, at low volume levels and high i-f input voltage, introduce some a-f voltages which may be appreciably distorted. For this reason it is generally advisable to control the volume on some other tube in the set.

Self-bias is recommended, since the operation with correct loads will remain satisfactory for a considerable variation in plate-supply voltage.

With present tube types it is possible to design reflex receivers having performance capabilities comparable with those of a straight receiver employing a larger number of tubes. The stability and output quality of the reflex receiver can be made to compare favorably with that of receivers employing straight circuits.

RADIO BROADCAST

Washington situation and International Radio Conference, July 10, add to complications

ONCE again the radio broadcasting situation is in a state of flux. New ideas in the use of the wave channels are being brought to the light of day. A new allocation along new lines of international requirements is not outside of the early possibilities. And even the Federal Radio Commission itself may be abolished or tucked into the Department of Commerce, with a Director of Radio reporting to the Secretary of Commerce, and a commission sitting merely as an appellate body. No less radical is the "new deal" now facing radio, than have been the many other new policies to which Washington is now getting accustomed.

Meanwhile the Supreme Court of the United States has handed down a decision in the WIBO case which has the effect of imposing absolute authority in the Federal radio administrative body (at the present time the Commission), giving it powers to grant, transfer or cancel transmitter licenses at will, thus at last putting the final stamp of complete power on the Commission. Such a ruling sustaining the Radio Commission would have been generally regarded as a stabilizing influence by the station licensees, were it not for the fact that the broadcasters and others are getting to feel little confidence in the actions of the Commission, as based on other than political pressure and expedience, rather than radio principles. At the present time therefore consternation reigns among the broadcasters and other licensees of desirable channels, not knowing when the new political autocratic power may run amuck and lop off heads and transfer licenses, regardless of the service records and radio performance of the parties involved.

To a degree never before observed, political influence seems now to be the force which sways the Commission's actions, as it carries out the behests of political commanders with all the unassailable authority of its newfound autocratic power, based on the Supreme Court's decision.

North American conference still doubtful

For months the United States authorities have waited for an invitation from the Mexican Government to take part in the long-planned North American Radio Conference, at which the wavelength situation on this continent could be worked out between the United States, Canada, Mexico and Cuba. The date now set is July tenth. Mexico is known to be busy building new broadcast transmitters just over the border, with one station rated at 500 kw., the most powerful unit on the continent. Perhaps the plan in the Latin-American mind is to have more of these high-power pounders of the ether ready for operation, before going into a conference at which the plums of the air are to be re-distributed.

Increasingly it also becomes evident that from such an international conference the United States has only to lose, and nothing to gain. If agreement among the American interests could be reached as to some basis for widening the broadcasting band, it might then at least be possible to have "more loaves and fishes" to pass around. But so far the American committees themselves cannot get into concord as to the united American policy to be maintained. The shipping interests have blocked the broadcasters' appeals for a widened broadcast band, the Navy has sided with the shipping point of view, and the Army has backed the Navy, so that a deadlock in the American position now obtains. If the American delegates cannot find out what their own nationals want, the difficulties of the international conference table are further enhanced.

With the existing broadcast channels to be divided among the other three countries expected, the United States is bound to come out with less wavelengths than before. At once this will precipitate a reallocation of United States stations, and then the floodgates will be opened for appeasement of political demands that have been collecting over many months. In such a reallocation, substantial stations and chain outlets are likely to be the chief sufferers, and the listening public will undergo further reduction of its prime broadcasting facilities.

Demands for power increases

Meanwhile there is a vigorous movement among the medium-size and regional stations to effect a horizontal increase of power on shared channels. Nearly all engineers are agreed that if the several stations sharing a channel all increase their powers proportionately, such as double or even tenfold, the relative interference between the stations will be unchanged, and the net result will be higher field strength laid down in all service areas, offsetting static and electrical interference so much more effectively. Thus it is pointed out that all the regional and local stations might share in a general increase of power, and while the heterodynes in unserved areas might become more vociferous, the effect in all listening areas would be to give more satisfactory service to the public. The Commission has been very slow to admit this principle, with its well-known skittishness at any increase of that mysterious thing called "power," which the politicians can kick up a rumpus about. It is probable therefore that nothing will be done about this horizontal power increase at present—at least not until all stations on all channels involved have voluntarily agreed to increase, and also not until after the problematical North American Conference, which may leave as its aftermath more channels to be doubled up.

New chains, new methods of linking up local stations for chain operation, and new short-wave plans are also buzzing around Washington at this time. Each of the new chain proposers claims unlimited political influence with the practical men in the new Administration, and the claim of each is that his own group of favored 100-watt stations will during the first month of operation have their powers increased to the clear-channel dimensions of corresponding NBC and CBS station ratings!

In this direction of short-wave interconnection of regional and local stations one of the most interesting and constructive suggestions is that which has originated

PROBLEMS GATHER

Politics rampant. New chains proposed. Possibilities of short-wave distribution of programs

with Federal Radio Commissioner Harold A. Lafount.

"Many of the 450 stations now affiliated with the chains, and 50 others who broadcast chain programs only a small portion of their time, are having trouble in providing worthwhile sustaining programs," declares Mr. Lafount, adding: "A recent study shows that there are approximately 25,000 hours per week of unsold time now being used for sustaining programs.

"We now have 605 licensed broacasting stations in this country. A study of the published programs of each of the major chains reveals the fact that of that number, from 26 to 132, or an average of 79 stations, broadcast network programs. Dividing a day of a typical week into three parts, the published programs indicate that an average of 58 stations are on the three networks between 6:45 a.m. and noon; 88 stations between noon and 6 p.m.; and 86 stations between 6 p.m. and midnight. The number of hours per week when there are 100 or more stations on the three networks combined are as follows: 2½ hours before noon; 11 hours between noon and 6 p.m.; 6 hours between 6 and 10 p.m.; and 9 hours between 10 and 12 p.m.

"The object of presenting these figures on chain broadcasting is to show that on an average we have over 500 stations broadcasting local programs, whose unsold or sustaining programs I seek to improve, and by so doing to offer a plan to put to immediate beneficial use already existing facilities, thus eliminating waste, and providing educational programs to *all* our people.

"Educational programs could, and I believe in the near future will, be broadcast by the Government itself over a few powerful short-wave stations, and then rebroadcast by existing local broadcast stations. This would not interfere with local educational programs, and would provide all broadcasters with the finest possible sustaining programs. The whole nation would be taught by one teacher instead of hundreds, and would be thinking together on one subject of national importance. I shall not undertake a description of the mechanics of this proposed plan, other than to say it would be very flexible and inexpensive. I do not consider this a step towards Government ownership or operation of radio broadcasting stations. The Government's activities would be confined to the transmission and wholesale distribution of educational material and discussions of subjects of national importance to all the stations in the United States, and not to the maintenance of any particular station."

In discussing the proposal, it was suggested that Army and Navy short-wave stations are now available which could be used to put the plan into immediate operation.

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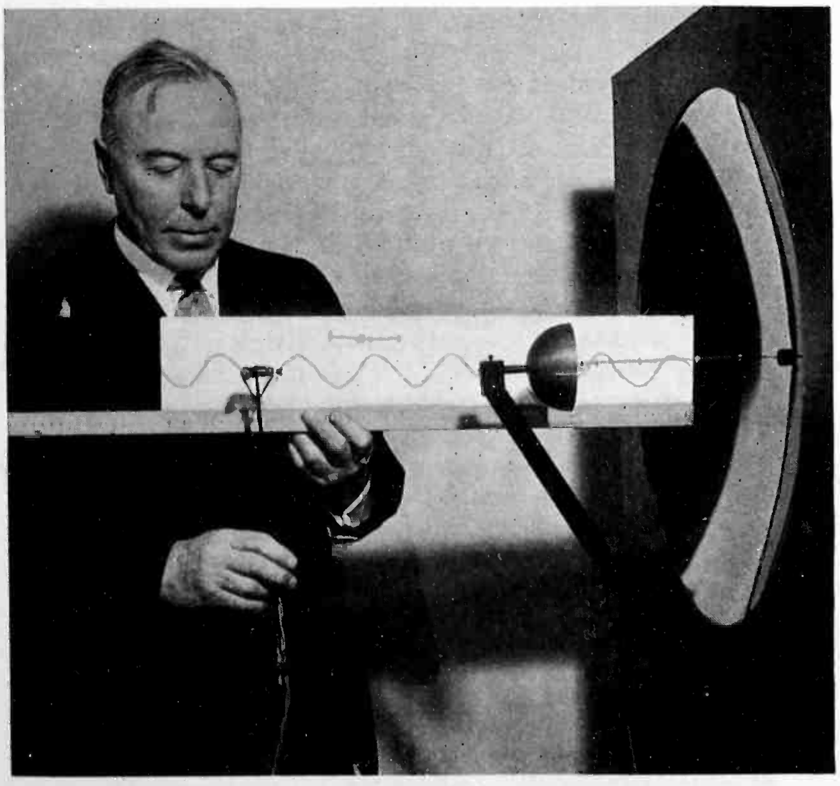
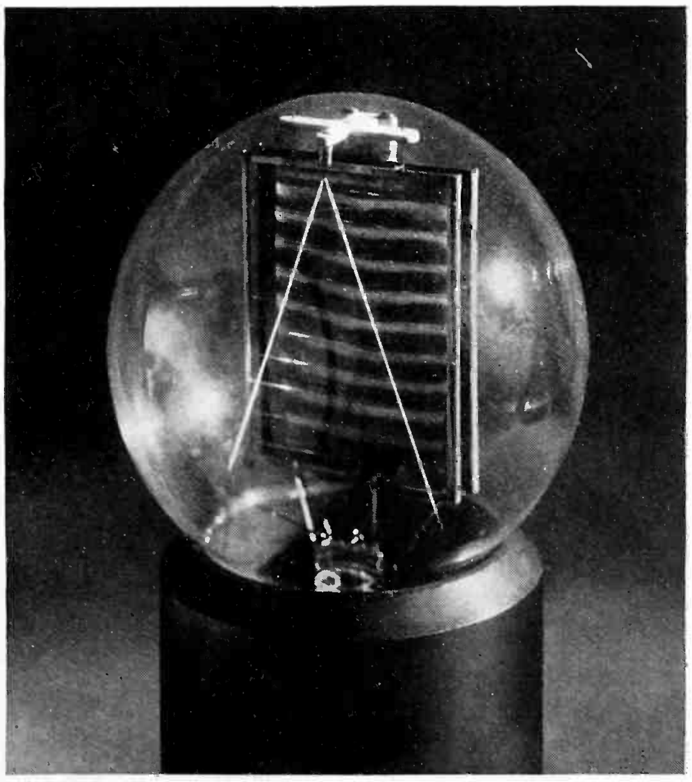
TWO OUT OF HUNDREDS OF ELECTRONIC NOVELTIES AT CHICAGO WORLD'S FAIR



An ultra-shortwave generator producing 9-centimeter waves, is shown having its output measured by Dr. S. M. Kintner, vice-president and chief engineer Westinghouse company. The output of one watt of power can be reflected like light, but penetrates smoke and fog unimpeded.



In this huge model of a three-element tube, exhibited by the Bell Telephone Laboratories, the plate is coated with a fluorescent material which glows proportionally to the number of electrons which come from the filament.

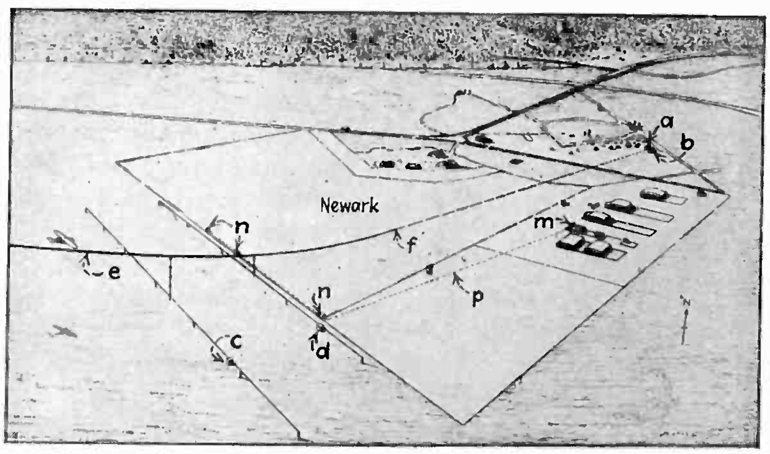
Radio system for landing aircraft during fog

Installation at Newark Airport

By H. DIAMOND
Bureau of Standards

FROM its infancy, aviation has relied upon the radio art to serve as its eyes and ears. The radio range-beacon, for guiding aircraft over invisible radio airways, and the radiotelephone, for carrying on two-way communication between aircraft and ground, are examples of such dependency. However, these aids have hitherto proved insufficient to free scheduled air transportation from interruptions due to low visibility. An aircraft arriving over an airport in dense fog has previously lacked means to permit it to come safely to ground. Radio has again come to the aid of aviation in providing these means.

Tests and demonstrations carried on at the Newark Municipal Airport, Newark, N. J., during March and April, 1933, indicate the complete practicability of the Bureau of Standards system developed to assist aircraft in making safe landings under conditions of zero visibility. The work on this system was conducted by the Research Division, Aeronautics Branch, Department of Commerce, at the Bureau of Standards. The system employs three elements, a runway localizing beacon, marker beacons, and a landing beam, to provide continuous and accurate information on the position of the aircraft in three dimensions as it approaches and reaches the instant of landing.



(a) Runway localizing beacon, (b) landing beam, (c) approach marker beacon, (d) boundary marker beacon, (e) spatial landing path followed by landing aircraft, (f) point of contact with the ground, (m) location of monitoring equipment and ground two-way communication set-up, (n) remote control stations for two-way equipment.

Fig. 1—Installation of radio landing system at Newark Municipal Airport

The runway localizing beacon gives indications of the directional position of the aircraft with respect to the airport and permits keeping the aircraft directed to and over the desired landing runway. A 200-watt set of the visual beacon type, operating on 278 kc. feeds two small, multi-turn loop transmitting antennas, modulated with 65 and $86\frac{2}{3}$ cycle notes, respectively. The intersections of two figure-of-eight space patterns produce four equi-signal zones of courses. Along each course, the signals received from the two loop antennas are equal, while on each side of the course the signal received from the nearer antenna is the stronger. Means on the airplane for comparing the relative magnitudes of the received signals guide the pilot.

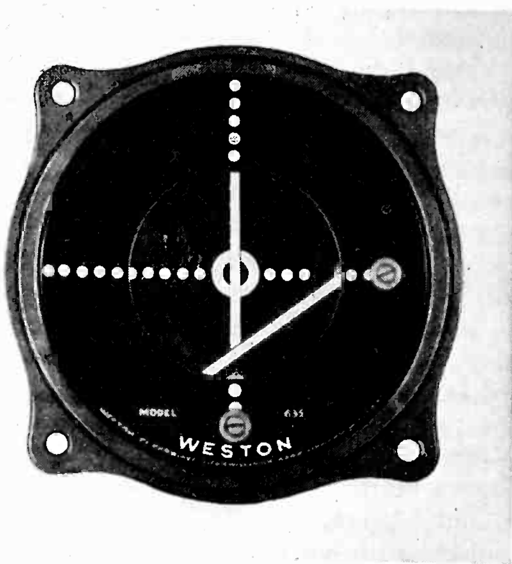


Fig. 2—Combined instrument used for securing lateral and vertical position of the landing aircraft

The orientation of the beacon courses is governed by the wind conditions at a given airport. To take care of all wind conditions the runway beacon may be located underground at the center of the field and one of the four courses may be rotated to coincide with the prevailing wind direction. A study, however, of meteorological data for a number of airports has shown that the wind during low visibility generally comes from one major direction. At the Newark Airport this is usually from the northeasterly quadrant. The runway beacon, accordingly, is located at the northeast end of the field and one of the courses is oriented along the northeast-southwest runway. With the aid of a goniometer to swing the course anywhere between the two hangar lines, service can be given for winds from this quadrant.

On the aircraft, the same receiving set used for radio range-beacon signals and weather broadcasts is employed for the runway beacon signals. This set is augmented by a reed converter to convert the beacon signals to pointer-type course indications, and also by an automatic volume control (a.v.c.) unit to relieve the pilot of adjusting the sensitivity of the receiver as the distance between the airplane and the ground station changes. The reed converter employs two vibrating reeds tuned to the modulation of the runway beacon (65 and $86\frac{2}{3}$ cycles) and driven by electromagnets actuated by the output signals from the receiving sets, so that the amplitudes of vibration of the two reeds indicate the relative amounts of the two signals. The motion of each reed induces a voltage in a pick-up coil, the magnitude of which is proportional to the amplitude of reed vibration. The two generated voltages are rectified and applied differentially to the movement operating the vertical pointer of a combined instrument (see Fig. 2).

A vertical index line across the face of this instrument represents the landing field runway, while the vertical pointer shows the relative position of the aircraft with respect to the runway. When the two rectified voltages are equal, the vertical pointer is at zero-center and coincides with the vertical index line, indicating that the airplane is on the runway course. A reversing switch makes the deflection of the pointer and the direction of deviation of the aircraft coincide whether the aircraft is flying *away from* or *toward* the beacon.

Distance indicator and marker beacons

Longitudinal position of the aircraft as it approaches the airport is given by the combination of a distance indicator on the aircraft with the aural signals received from two marker beacons.

The distance indicator consists simply of a d.c. milliammeter connected in the plate supply to the r.f. tubes of the beacon receiver. Since the a.v.c. increases the negative bias on the grids of these tubes with increasing input voltages the plate current is approximately inversely proportional to the field intensity of the runway beacon.

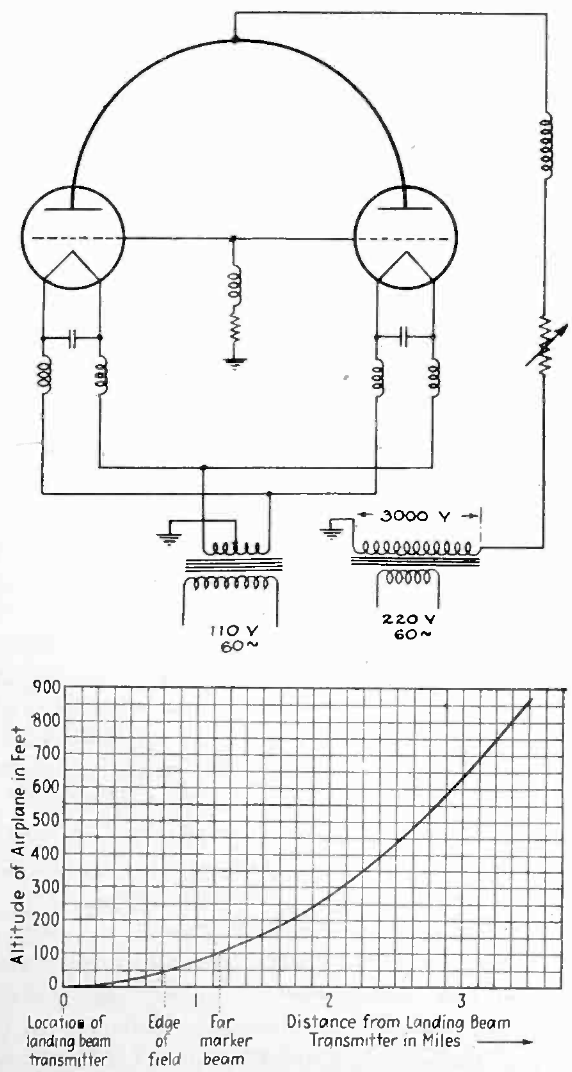


Fig. 3—Circuit of ultra-high frequency landing beam transmitter and landing path at the Newark Airport. No variations in this path have been noted during two months of intensive tests

The instrument may therefore be calibrated approximately in miles from the beacon (say, 0 to 5 miles).

Absolute indication of the longitudinal position of the aircraft when near the airport is given by aural signals from two 5-watt (3,105 kc.) marker beacon transmitters in the set normally used for communication purposes.

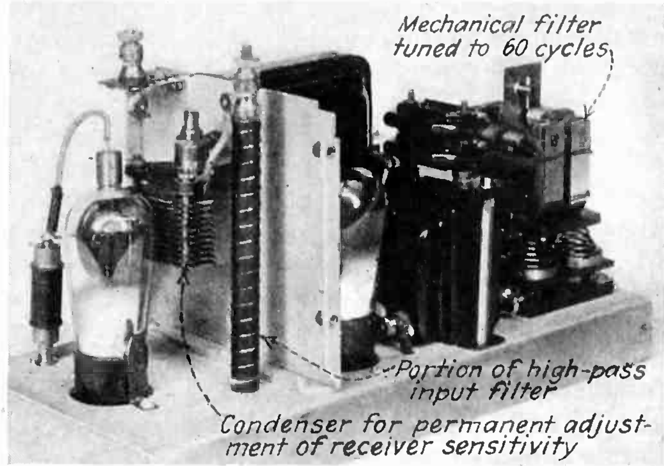


Fig. 4—Exposed view of landing beam receiving set

One signal (1,250 cycles) is heard when within 2,000 feet of the southwest end of the airport. The second signal (250 cycles) is received when over the field boundary. These transmitters are modulated by a ½-watt a.f. oscillator and use a power pack for 60-cycle operation. The marker beacon antennas, 2 to 6 feet high, are stretched transversely across the line of flight of the aircraft, and are of sufficient length to provide signals for all orientations of the runway beacon course. Terminating resistors (600 ohms) at each end prevent the production of standing waves along the antennas. The radiated space pattern from this antenna is sharply directive upwards, forming virtually a wall of signals through which the aircraft passes. The distance along the line of flight of the aircraft over which the signal is heard is controlled by the amount of power fed to the antenna and the sensitivity of the receiving set.

The high-frequency landing beam

Vertical guidance of the aircraft is given by a horizontally-polarized ultra-high-frequency landing beam (90,800 kc.), produced by two 500-watt three-element tubes operating in push-pull. The landing beam transmitter feeds a directive array which gives the necessary directivity of beam in the vertical plane, while spreading it out in the horizontal plane to afford service in the 40-degree sector between the hangar lines. The array comprises six half-wave horizontal antennas, arranged in pairs end to end, the pairs being displaced vertically by one-half wave length. The transmission line feeds all of these antennas in phase. A parasitic reflector consisting of six half-wave horizontal antennas identically arranged is placed one-quarter wave length behind the radiating antennas. There is no electrical connection between the radiating and reflecting antennas.

On the aircraft, a simple ultra-high-frequency untuned receiver without external volume control is used, fed by a transmission line from a horizontal half-wave antenna located in the wing slightly ahead of the leading edge. Permanent adjustment of its sensitivity is made by means of a condenser (Fig. 4). A high-pass filter is inserted in the detector input, while a mechanical filter tuned to the transmitter modulation (60 cycles) is in the audio output. The rectified output operates the horizontal pointer of the combined instrument in Fig. 2. The sensitivity is so adjusted that the line of constant received signal below the inclined axis of the beam, corresponding to half-scale deflection of the horizontal pointer, marks out a landing path which is suitable for the aircraft and airport considered. The horizontal index line across the face of the instrument represents the half-scale deflection and corresponds to the proper landing path shown in Fig. 1. The horizontal pointer represents the position of the aircraft relative to this path.

The point of intersection of the two pointers (Fig. 2) represents the position of the aircraft relative to the desired landing runway and to the proper landing path. Deviation from the two courses may be corrected simultaneously. By keeping the pointers crossed over the small circle on the instrument face, a suitable spatial landing path is followed down to the point of landing.

In addition to the ground equipment there is installed at the Newark Airport, in the National Guard Administration Building, a monitoring panel and a two-way communication system (3,105 kc.) so that the operator may keep in constant communication with the pilot of a landing aircraft. Assurance can be given him that the equipment is functioning properly (as seen from the monitoring panel), and that the airport is clear for a landing. Under conditions of practically zero visibility, it has proved desirable to station a man at the southwest end of the field to assist in determining that the airport is clear. Remote control junction boxes are accordingly located here to provide direct two-way communication with the landing aircraft as well as communication with the control room.

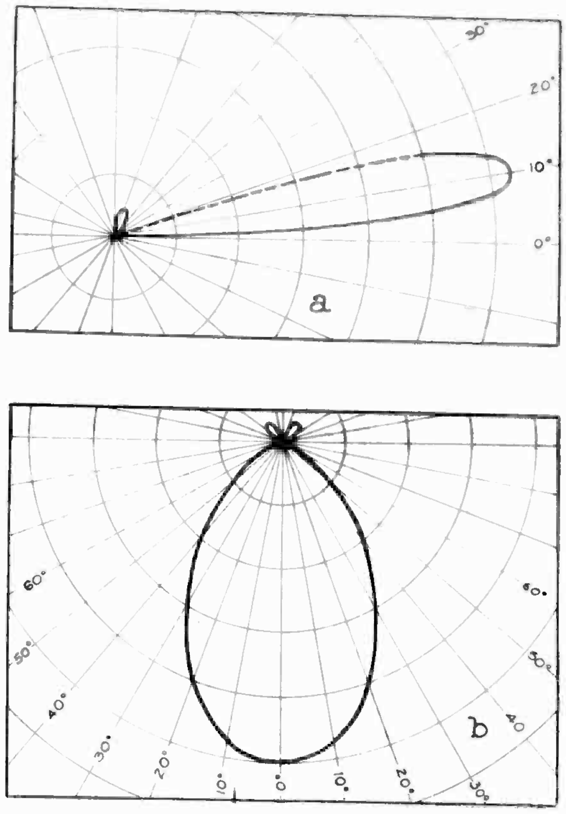


Fig. 6—Shape of landing beam (a) vertical directive pattern, (b) horizontal directive pattern

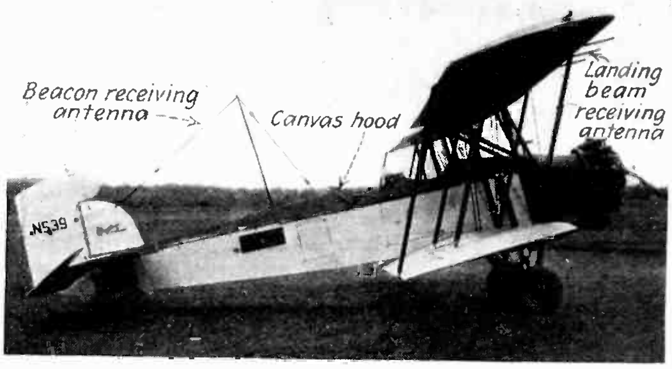


Fig. 5—Airplane used in hooded landings

The marker beacons and the communication transmitter operate on 3,105 kc. to permit use of the standard aircraft receiver and at the same time to stand by for messages from the control room. For this combined service, the receiver is equipped with a.v.c. to insure proper adjustment of sensitivity at all times. In future experiments at Newark, when a number of air transport operators are equipped to use the landing system, it is expected to change the frequency of the marker beacons to 10,000 kc. A 2-tube receiving set will then be needed on the aircraft to pick up the marker-beacon signals.

A typical flight in fog

The use of the system by a pilot attempting a landing during fog may best be outlined by an account of an actual blind flight from College Park, Md., to the Newark Airport, during which radio was the sole means used for navigation. The writer was a passenger on this flight. The ceiling was so low, upon starting from College Park, that it was found impossible to fly below it. Pilot Kinney maintained an altitude of 3,000 feet throughout the flight. No sight of the ground or sky was had except for an instant over Baltimore. Guidance from College Park to Hadley Field, New Brunswick, N. J., was obtained through the use of the aural type radio range-beacons. After passing through the "zero-signal" zone of the Hadley station, the beacon set was tuned to the Newark Airport runway beacon (278 kc.). The vertical pointer of the combined instrument showed approximately "on-course," the projection of the southwest-northeast runway at Newark being approximately over the Hadley station. The distance indicator showed the distance from Newark to be greater than 5 miles. A switch was thrown, turning on the landing beam receiving set. This completed the manipulations of radio equipment required on the part of the pilot to make use of the landing system.

Flying at 3,000 feet the horizontal pointer of the combined instrument began to deflect, gradually reaching the horizontal "on-course" position. This corresponded to a distance of 8 miles from the landing beam transmitter, as determined from the normal landing path previously calibrated. After communicating with the airport station to determine that the field was clear the pilot maneuvered the airplane to keep the two pointers intersecting over the small circle in the center of the combined instrument dial. This gradually brought the aircraft along the runway direction and down the landing path. The distance indicator showed continuous approach to the airport boundary, and the barometric altimeter (while not sufficiently accurate for landing) showed continuous approach of the aircraft to ground. When within about 2,000 feet from the southwest edge of the airport, the high-pitched marker beacon signal began to be heard becoming most intense at 1,700 feet from the edge and receding beyond that point. At this stage of the landing the ground became visible for the first time, the aircraft being somewhat over 100 feet above ground. The pilot proceeded to land visually. Had the ground not become visible, the pilot would have continued at the same engine speed until the low-pitched field marker beacon signal was heard. He would then throttle down the engine and pull back the control stick so as to be in correct position for a three-point landing when contacting the ground.

Performance tests of the system

The demonstrations at Newark were preceded by an extensive series of tests at College Park, Md., where the practicability of the system was studied through the medium of flights and landings in an airplane equipped with a canvas hood over the pilot's cockpit (rear cockpit of airplane). Over a hundred hooded landings were made during these tests. A check pilot was used in the front cockpit to take care of faulty landings or other emergencies. The remarkable accuracy of the system was well established by these hooded landings. The landing runway at College Park is only 2,000 feet long and 100 feet wide with the approach unobstructed for a lateral distance of only 300 feet. Off the runway, the landing field is quite rough. In consequence, the runway beacon course had to be made sufficiently sharp to give appreciable off-course indications on the aircraft for deviations of the order of 20 feet (at the approach end of the field).

To utilize the course sharpness available it was found necessary to adopt a directional receiving antenna on the airplane which compensated automatically for a tendency to "weave" or "hunt" about the course and thus facilitated holding accurately to the course. The desired compensation was secured through the addition of an inclined wire running from the top of the vertical pole antenna back to the rudder fin.

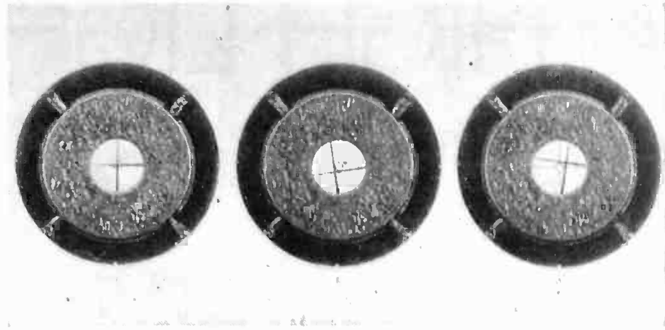


Fig. 7—Three typical course indications on combined instrument

Tests over an extended period showed the system to be inherently stable under all weather conditions. It was then decided to make an installation at Newark to determine the operation of the system under the conditions obtaining at a commrcial airport. During the two months of tests, besides making a large number of hooded landings, it was possible to fly at all times when the scheduled air mail and passenger airplanes were grounded by fog. The operation of the system was demonstrated in the air to many engineers and officials as well as to nearly one hundred air transport pilots. It is interesting to note that not even a minor adjustment of the transmitting equipment nor of the receiving equipment on the two test airplanes was required during the entire period of the tests.

Publication Approved by the Acting Director of the Bureau of Standards of the U. S. Department of Commerce.

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Trends in radio design and manufacturing

[*Continued from page 152*]

7. Compactness and durability. The tubes may be made much smaller than with glass envelope; and more capable of withstanding shocks in shipping and handling.

There is a strong possibility that the rapid increase in tube types may cease as a result of another English tube development which appears to simplify appreciably tube construction. Negotiations are now under way to exploit a new type of tube, already tried successfully in England, through American tube manufacturers or through a separate and new tube company set up for the purpose. More complete details of this development will be found in an early issue of *Electronics*.

Exploitation of the ultra high frequencies

Much work has been done on the development of new tubes for use on the very short wavelengths (1 meter and below). This work will be described in *Electronics* very soon. The tubes will be much smaller than conventional types, and if useful at broadcast frequencies may permit still further reduction in the size of sets.

Even with present equipment much exploitation of the 5-meter region and below is taking place. Several police radio systems have been set up on an experimental basis in the 3 to 5-meter region. These systems give complete two-way communication between headquarters and the cruisers or between two or more cars. With low power small cities can be efficiently covered. Similar equipment in a forest conservation plane has communicated successfully with the home station at distances up to 100 miles.

Sales of auto radio sets continue to set the pace for all radio. Reports indicate that dealers cannot get enough of the sets made by the well known companies. Certainly the public is auto-radio minded and if given good sets at low prices with power sources free from trouble will purchase equipment in large quantities.

Owing to the high prices asked for farm radios, and to the high plate voltage upkeep cost, this large market remains practically untapped. It seems that the engineering behind present day inexpensive auto sets could be applied to the farm radio. The rural dweller would not object to toting his storage battery to town to be charged or to charging it from his automobile generator if it provided him with a complete source of radio power—especially if that radio cost no more than a good auto set.

Raw materials and components prices

Manufacturers are hesitant to lay in big supplies of raw materials and components on the theory that prices of commodities will rise. On the other hand they are hesitant not to take advantage of present prices. And so the average maker of parts is in a dilemma. Prices indicated on page 152, obtained from prominent radio set manufacturers indicate the average prices paid during 1932. Whether these prices will decrease or rise is an open question. At the moment the trend is upward.

Laundry conveyor operated by photocell

"We used to control the belt conveyor in our wrapping department by pushbuttons. But one of the two men employed there had to spend about half his time pressing the buttons, because the connection was such that the belt could move forward by only one compartment-length at a time while the button was held down," explains S. H. Cashman, president of the Cashman Laundry, Inc., 144th and Girard Streets, New York City. "By any other pushbutton system the operator would have had to pay too much attention to controlling the belt."

"However, the arrangement was such that if the sorting girls missed several compartments in succession, the wrapper had to push the button, wait for the belt to move one compartment and stop, then push again, and wait, and repeat the performance until a full compartment reached him.

"A photo-cell now removes this difficulty. A beam of light cuts across the belt, just at its surface, and strikes the cell on the other side. As long as nothing interrupts this beam the conveyor continues in motion. But if anything is in a compartment—even a single handkerchief—the current is interrupted and the belt stops.

"We estimate that by relieving the wrappers of the necessity of paying any attention to the conveyor, we have speeded up their production thirty per cent," declares Mr. Cashman.

The cell control was made complementary to the pushbutton control, but did not supersede it. Thus, when a fiber sleeve obscures the light, the belt may be controlled by the button.

As long as nothing interrupts the light beam the conveyor continues in motion. In other words, the belt moves as long as the compartments passing the cell are empty. But if there is anything in a compartment a relay drops, and the belt stops.

By means of clips properly spaced on the belt, actuating a small contactor, the cell is short-circuited while the aluminum uprights interrupt the beam, so that their cutting across the light does not stop the belt.

The cost of this photocell installation was $125. The management estimates that without it, the two wrappers could not keep up with the orders when the plant is operating at capacity. Thus, the salary of another workman, at least for part time, is saved—amounting to considerably more than $125 in a year.

✦

Color matching in automobile plant

The control of the color of paint for automobiles becomes a matter of considerable importance in some large plants, as different parts are finished in different places, even other factories, and later brought together for assembly. The colors must then match exactly.

A color-matching outfit that would eliminate the variables of light source and eye fatigue of the inspectors was considered advisable in the Chrysler plant at Detroit so an instrument to obtain these features was developed by W. A. Lindberg, color specialist, and E. L. Bailey, electrical engineer.

The equipment consists of a concentrated-filament 100-watt tungsten lamp with suitable reflector and condensing lens, arranged to shine on two paint panels, one the standard, the other the sample. The panels are set at 30 deg. to the light beam and 60 deg. to each other, so that the light beam is reflected off the panels at 30 deg.

Two photoelectric cells are placed facing the normal beam of light from the panels, thus avoiding the effect of reflected light from the glossy surface and receiving the stimulus for the photocells due to the color only. The photocells are connected through a potentiometer to a Weston zero-center microammeter. The circuit is so arranged that when the color of the panels is exactly alike the meter needle is in the center of the scale, and the potentiometer is also at the mid-point.

"There is another way the instrument can be used to check a color as follows," explains Mr. Bailey. "Place the standard panel in the instrument together with a neutral gray panel which is made of all colors combined. Then turn the potentiometer until a center scale reading is obtained. Now, with the same instrument setting, place the sample panel in the instrument and if the needle swings to center scale the panels match. Thus we match a sample against its standard and check the standard and sample against a neutral gray.

"The instrument seems to function consistently and without any delicate adjustments. The light source variations are almost completely balanced out by the differential connection of the cells to the micro-ammeter.

"The photronic cell of Weston company was selected for this work as it operates the meter direct without an amplifier, and also because the color response is of the same general shape as the color response of the eye. The outfit is portable and easy to operate, and, we believe, its use is a step in the right direction toward the satisfactory control of paint color specification and color in production."

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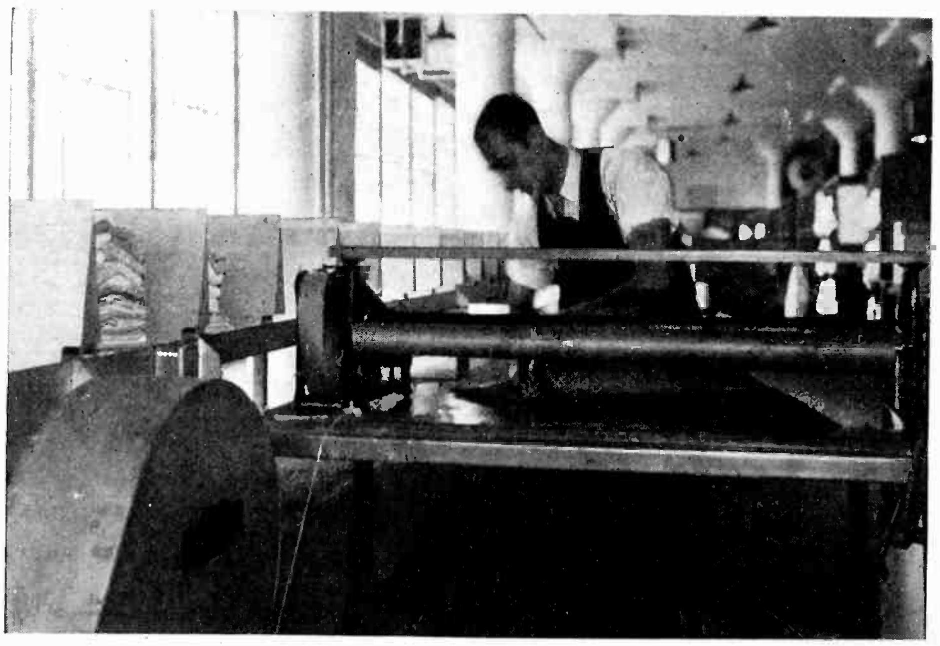


At the left is seen the conveyor belt with its compartments. A light-beam and photo-cell advance the conveyor, if nearest compartment is empty.

Infra-red fog-eye picks up ships below horizon

While in Bermuda following the cruise of the steamer Queen of Bermuda, last month, Commander Paul H. Macneil carried on six days and nights of intensive tests with the British fleet stationed there, using the "fog-eye" to detect distant ships. This instrument employs a thermo-couple which is extremely sensitive to faint infra-red rays, and through an amplifier gives an audible as well as visual signal of the presence of any object either warmer or colder than the surrounding ocean.

While results of a number of the tests undertaken for naval purposes cannot be disclosed, Commander Macneil describes two sets of experiments which show the great sensitivity of the thermocouple in its reflector mounting.

DEVICES IN INDUSTRY + +

"Detecting ship below horizon. Thirty-six readings were taken on one ship at increasing distances from one mile to 12 miles—or 6 miles beyond the horizon, the instrument being operated by three different persons during this test. The fog-eye was then mounted only 16 feet above the water: had it been higher, a much greater distance would have been possible.

This result appears definitely to prove *refraction of the infra-red rays,* opening up remarkable possibilities.

At night a small unlighted naval pinnace, whose funnel temperature was hardly higher than that of a man, attempted to approach the ship under cover of darkness and from an unannounced direction, but was easily detected at 2½ miles.

A naval plane was also detected at 4½ miles and its course readily followed.

In a letter to *Electronics,* Commander Macneil says:

"You will, no doubt, be as astonished as I was when you hear that after a sailor had accidentally dropped the amplifier on the steel deck, not even an adjustment had to be made.

"Though this instrument is only an experimental one, it was subjected to conditions that a properly designed and installed one could hardly be expected to experience, and not only was it completely successful, but has come back even more sensitive and effective than it was before the tests."

✦

Electric signs controlled by traffic lights

THE INTERESTING SUGGESTION that merchants' advertising signs be controlled by traffic lights through the medium of photo-electric cells, has been made by George Comtois of the Ray Hawley Associates, 330 West 42nd St., New York City.

Ordinary advertising signs greatly interfere with automobile drivers observing traffic signals, but by this new method the merchants' signs along the street might aid and assist the direction of traffic.

For example a big sign reading "STOP at Loft's" would be switched on when the red traffic signal is burning. As soon as the green traffic light appeared, the merchant's sign would change to "GO to Loft's."

Police authorities have usually refused to allow their traffic-control circuits to be tapped for the control of private circuits, but by focussing a photo-cell on the traffic light, the nearby signs can be synchronized with the traffic system. Mr. Comtois has notarized his proposal before a patent attorney.

Photocell insures perfect jig-saws

By Nicholas Heyman

EVEN THE PHOTOCELL contributed its share to making possible the hundreds of thousands of cardboard jig-saw puzzles which the public has been buying.

These puzzles have been presented to the public in two forms, either flat and unbroken, or broken up into pieces. In the latter case the operation of breaking, as performed by the more progressive manufacturers, is by means of a special machine into which the puzzles are fed by the operator. From this machine they pass into the box, which is then sealed and packed for shipment. Manufacturers, without exception, have found that some boxes pass through with one or more pieces missing.

Nothing is more annoying than sitting hours trying to piece one of these puzzles together and then finding that it is incomplete. The result is loss of sales and extra cost due to replacements and adjustment of complaints. The solution to this trouble was found by one manufacturer in the application of the photocell.

When the puzzles are die-cut by means of a rule die consisting of a plywood base board in which are set the knives previously bent to the shapes of the final cut design, it is necessary to cut all pieces apart as far as possible and yet not so much so that they fall apart in handling. In other words, they must be held by small "ties" or "nics," which at least keep the pieces together until the puzzle enters the breaker. It is between this die-cutting operation and the breaking operation that one or more pieces can be lost.

Feeding the puzzles to the breaker at the rate of forty per minute does not permit the operator to inspect for missing pieces. Furthermore, when one stops to realize that these puzzles contain anywhere from 150 to 300 or more pieces, the difficulty of inspection is apparent.

The device shown in the sketch below inspected perfectly and insured for the manufacturer 100 per cent complete puzzles in every box.

The operation was as follows: A puzzle was fed under the hood, and when in position the light source was turned on. If all pieces were intact the puzzle passed on to the breaker conveyor belt. Should, however, a piece be missing, light would pass through the glass plate and the reflector cone to the photocell. This cell would in turn actuate the solenoid arranged to deflect the shelf so that the defective puzzle was diverted from passing on to the breaker. One can readily see how simple and effective this device is. For the manufacturer it served a twofold purpose. It not only insured a perfect product, but in addition impressed on his customers the important fact that "the electric eye" was on the job.

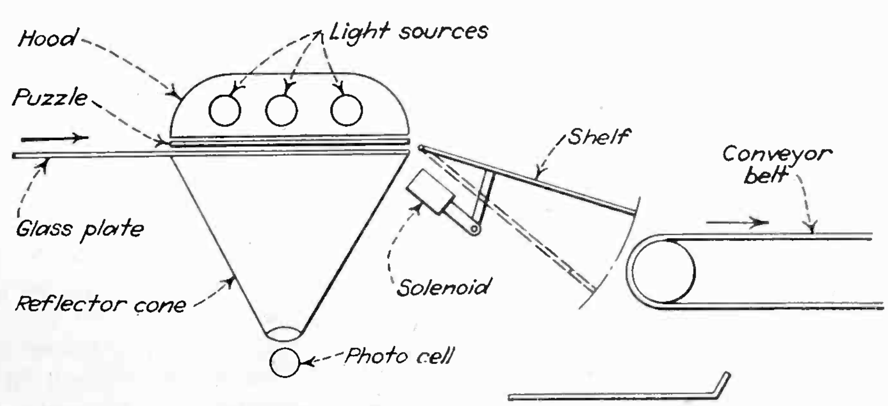
✦

Short-waves bake crustless bread

HIGH-FREQUENCY APPARATUS of the type used to produce artificial "radio fevers" in hospitals, is now being employed to bake bread internally, that is "from the inside out" in such a way that the bread is thoroughly baked without forming a crust.

Such crustless bread is greatly desired by hotels and restaurants, which usually have to waste about one-third of ordinary bread in trimming off the crusts when serving sandwiches.

A Brooklyn bakery is now turning out experimental quantities of this new radio-baked bread which is devoid of crusts. Under the effect of the high-frequency field, currents are generated in the moist dough itself, which are sufficient to bake the bread internally, so that baking proceeds from the center outward, and no crust is formed. Thus the new radio-baked bread can be used for sandwiches without waste, and being used more efficiently, can command a higher price than ordinary bread which is one-third wasted.



As the puzzles pass under the hood, any incomplete puzzle will allow photocell to shift the shelf, discharging imperfect puzzles below conveyor

The Ignitron—a new controlled rectifier

By D. D. KNOWLES

Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa.

THE Ignitron* is the latest arrival in the rapidly growing family of industrial electronic tubes. It is a tube in which conductivity is established by igniting the arc in much the same manner that an explosion is ignited in the cylinder of an automobile engine. The advantages of such a device cannot be adequately appreciated without first reviewing the properties of other tubes that are now used.

The most familiar type of controlled tube is the ordinary high vacuum amplifier, such as used in radio receivers. Tubes of this type have been developed to carry currents up to several hundred milliamperes[1] and with characteristics and life that make them very valuable in industry. Although the comparatively small capacity of these tubes does not bring them into the class of power apparatus, they serve a very useful purpose nevertheless in sensitive circuits, linear amplifiers and as accessories to high power tubes.

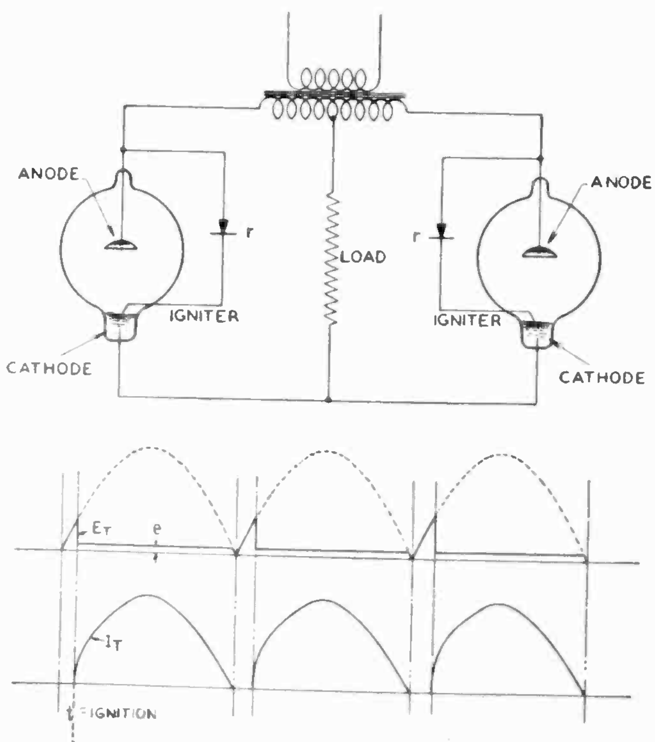


Fig. 1—Full wave single phase rectifier using the new tubes

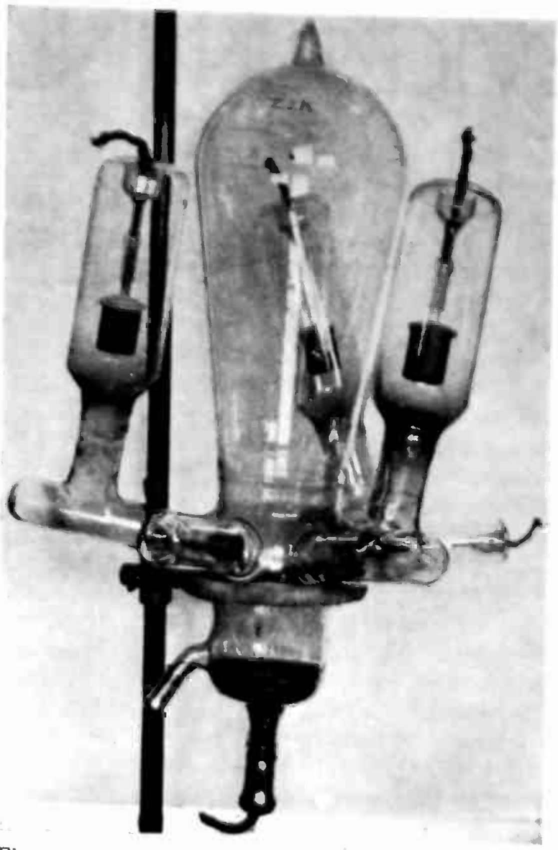


Fig. 2—A three-phase mercury pool rectifier of conventional type

Within the last few years many types and sizes of grid-controlled gas and vapor tubes have been introduced under the trade names Grid-Glow Tube[2], Thyratron[3], Trianode, Kathetron[4], etc. These tubes utilize a gas or vapor which ionizes under impact by electrons, and the resulting ions reduce the space charge limitations inherent in high vacuum tubes. As a result, tubes of this type have been made to carry several hundreds of amperes and are, therefore, power devices.

Their field of usefulness is very great, and there is little doubt that the next few years will see more and more of them used for the control and conversion of electric power. They do, however, have certain specific limitations that can best be illustrated by describing a typical tube. This tube will contain an oxide coated cathode which is the electron emitter, an anode which collects the electrons and a grid which controls the discharge. To provide the necessary gas or vapor for ionization a small globule of mercury which will vaporize and give an atmosphere of mercury vapor at the desired pressure is introduced into the tube.

The cathode limitations

A time delay in starting is essential in order that the cathode shall reach operating temperature before current is drawn. This delay may be only two or three seconds for small tubes or as much as an hour for very large tubes. The disadvantage of such a delay is obvious. Indirectly, this feature introduces a less obvious but nevertheless serious difficulty in those applications where it is not permissible to have power interruptions; for example, in inverters or rectifiers feeding industrial or domestic power systems. In such instances spare tubes must be kept in readiness in case of tube failure, and to avoid delays the cathodes must be kept energized.

Another serious limitation results from the fact that the cathode has a fairly definite capacity to emit electrons and that any current in excess of that value will damage the cathode to an extent depending on the amount of overload and the time that the overload exists. This property makes it impossible to design an efficient tube that will have a satisfactory overload rating.

Therefore the cathode introduces three principal limitations: 1. Power losses; 2. Time delay in starting; 3. Low overload capacity.

As previously mentioned, mercury vapor is used to provide ions for space charge reduction. There are several reasons why mercury is used instead of other gases or vapors.

1. It is a heavy material so that a positive ion formed in the discharge will remain there for a relatively long time and thus counteract the space charge effect of many electrons. This results in a marked decrease in the number of ions striking the cathode per second and a consequent increase in tube life.

2. The ionization and resonance potentials of mercury are low so that the tube drop is also small. This is obviously desirable from an efficiency standpoint, and furthermore it prolongs the cathode life by limiting the energy of the ions striking the cathode.

3. Being volatile at tube temperatures it furnishes an inexhaustible supply of vapor which will not clean up in the discharge. It introduces, however, a temperature effect which is often objectionable. As the tube temperature is changed, due to variations in ambient temperature, cooling, or tube load, the vapor pressure is altered and the grid control characteristic changes.

Tubes with other gases, such as argon, neon and helium are free from temperature effect[5], but other factors enter that limit their use to small tubes.

In a grid controlled gas or vapor tube the grid is called upon to prevent or hold back a discharge, which in the absence of a grid, would start at a very low potential. Not only would it start at a very low potential, but it would start in an extremely short time, say one to 25 microseconds. Due to the properties of an arc, the discharge, once it has started, cannot be extinguished except by removing the potential at least for a short time. We thus have a kind of switch which will close instantly unless held open, and once closed can only be opened by removing the potential. In the case of a.c. this occurs at the end of each half cycle.

In many respects this characteristic is very desirable, and in others, it is a severe handicap. For example, in a parallel type of inverter for changing d.c. into a.c., the potential is removed from the conducting tube for only a short time. During this time it is imperative that the tube extinguish and the grid regain control and retain it until time for it to start again. If for any reason during the insulating period the grid relinquishes its grip even for a microsecond or so, the tube starts and in general will throw the inverter out of service.

We see, therefore, a definite need for a tube which will remain non-conducting until *made* to start instead of one that is non-conducting only so long as it is *prevented* from starting.

Further requirements for an ideal tube of this type would include: 1. Instant starting—no delay when put into service; 2. High overload capacity; 3. Long life; 4. Efficiency.

Slepian and Ludwig[6] have described a new method for initiating the cathode of an arc which consists in immersing certain materials, such as a carborundum crystal, in a mercury pool and then passing current from the crystal to the mercury. At a definite value of voltage and current, a tiny spark appears at the junction and immediately grows into the cathode spot of an arc. If an anode properly spaced is held at a positive potential with respect to the arc, the latter will transfer very quickly to the anode and the relay or switching action is complete. This whole mechanism may occur in only a few microseconds. Figure 1 shows a simple diagram of such a tube and circuit for full wave single phase rectification. The two waves shown illustrate the voltage E_T across the tubes and the current I_T through the tubes, assuming a resistance load and neglecting the current taken by the igniter itself. The igniter current is approximately proportional to E_T.

A new tube—the Ignitron

The operation of such a circuit is very simple—starting at the beginning of the voltage cycle, the current and voltage increase along the wave E_T until at the instant the spark occurs. The cathode spot forms immediately and the anode which is positive picks up the arc. The rectified current I_T flows for the balance of the cycle accompanied by a constant voltage drop e of about 10 volts. At the end of the cycle, the arc goes out and on the inverse cycle, the small rectifiers r prevent reverse current and consequent heating in the igniters.

What are the advantages of such a rectifier? As compared to the hot cathode type previously described, it requires no delay when placed in service; it has a high overload capacity and longer life.

The features of long life and overload capacity can, of course, be obtained with the conventional mercury pool rectifier but only with greater complication or tendency to arc back. To be more specific, each pool cathode in the conventional rectifier requires a starter of some kind to form the arc and a keep-alive transformer and reactor to maintain the arc at all times. To insure stability, at least 5 amperes are necessary in the keep-alive circuit. This consumes energy which is wasted, and what is even more serious, in a single anode tube, produces ionization during

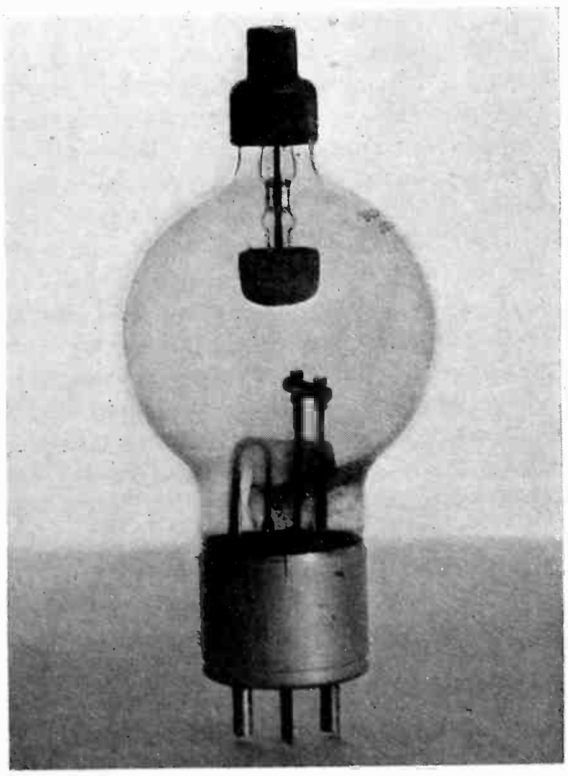


Fig. 3—The Ignitron, a new controlled rectifier

the inverse cycle, thus increasing the tendency to arc back. To prevent arc backs, the anodes are placed out in anode arms and since each pool requires expensive keep-alive equipment, they are usually combined into one to serve from two to twelve anodes.

Figure 2 shows a three phase mercury pool rectifier of the conventional type, and Fig 3 one of the new Ignitrons.

Since the Ignitron starts at the beginning of each conducting half cycle, we require no starter, and since there is no arc during the inverse cycle, there are no anode arms. Three such tubes will replace such a conventional rectifier with less auxiliary equipment, lower replacement cost and with better performance.

There are many applications, such as motor speed control, theater light dimming, voltage regulation, etc., in which the output of the rectifier must be varied. This can be accomplished with Ignitrons by shifting the phase of the control voltage.

Figure 4 shows such a circuit feeding the armature *A* of a d.c. motor for variable speed control. A single Ignitron is shown for simplicity, though in general, full wave rectification would be used.

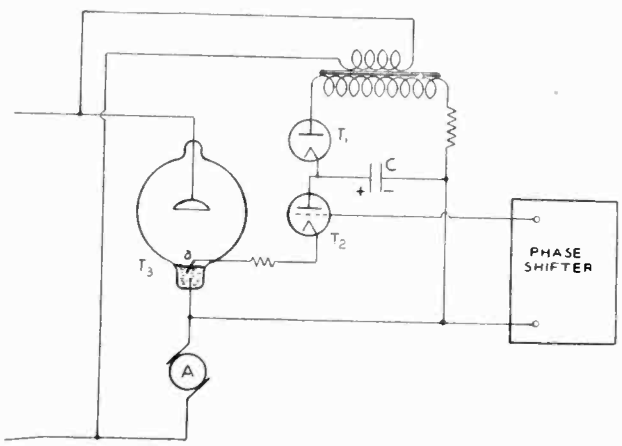


Fig. 4—Use of Ignitron for variable speed control

In connection with this circuit, it should be explained that at the present stage of development the instantaneous current required by the igniter to start the arc reliably is from 5 to 30 amperes. This does not represent much power, however, in view of the fact that it need last but a few microseconds. In other words, the requirements are very mluch the same as for gas engine ignition.

In Fig. 4 the condenser C is charged with the polarity shown during the half cycle of inverse potential on the Ignitron. The rectifier T_1 prevents this charge from reversing on the next half cycle during which the grid-glow tube T_2 is biased to break down and discharge the condenser through the igniter electrode (a). The point on the cycle at which this occurs may be varied by adjusting the phase of the grid voltage on the grid-glow tube. The average rectified output of the Ignitron is thus varied in the well-known manner from a small value corresponding to breakdown at the end of the half cycle to a maximum value corresponding to breakdown at the beginning.

When Ignitrons are developed as they inevitably will be, to operate with control currents of an ampere or less the phase control circuit of Fig. 4 can be considerably simplfied by the omission of the auxiliary tubes T_1 and T_2 as well as the condenser. The output of the phase shifter would be applied directly to the igniter electrode with a small copper oxide rectifier, for example, to prevent back current through the igniter on the inverse cycle.

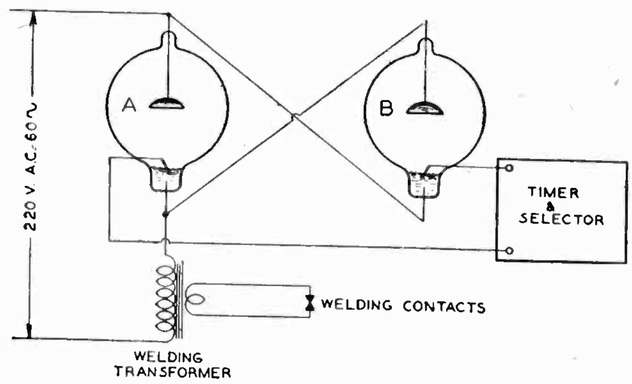


Fig. 5—High speed, high current spot welder controlled by the new tube

It is frequently very difficult or impossible to make mechanical contactors and circuit breakers for very large capacities and with the desired speed. An example of such a requirement is in high speed spot welding, where an a-c current of several thousand amperes may be required for as short a time as one-half cycle. Here again is an opportunity for the Ignitron. It may be started in a time which is short compared to a half cycle and by its very nature extinguishes completely at the end of each half cycle. The fact that the mercury pool has an average current rating instead of a crest current rating makes it possible to handle such high currents with ease.

Figure 5 shows a simplified wiring diagram of a welder, the details of timing etc. being omitted for clarity. Two Ignitrons are used (A and B) one for each half cycle of the a-c power and are connected in series with the primary of the welding transformer. The number of half cycles are pre-selected by the timing mechanism and the Ignitrons do the rest.

The examples given serve only to illustrate the field of usefulness that tubes constructed on the ignition principle promise to fill. Considerable remains to be done on the development of the igniter electrode itself before the ideal tube characteristic is approached. This problem is not a simple one as shown by the following requirements.

1. It must be a highly refractory material to avoid being damaged by contact with the arc.

2. It must not decompose or otherwise give out gas during operation.

3. It must not be wetted by mercury as this would short circuit the electrode.

4. It should have a resistivity of 0.04 ohms per cubic inch or more.

5. It should be mechanically strong.

The author does not wish to leave the impression that the Ignitron will completely replace grid control tubes. Both have their respective advantages, the decision usually resting on the importance of time delays, efficiency, life, sensitivity and overload capacity.

In closing, the author wishes to thank Messrs. Stoddard, Smede, Bangratz and Berkey for the use of data, photographs, etc., and Dr. Slepian and Dr. Ulrey for helpful suggestions.

*Pronounced like the word "ignite."

[1]A New Industrial Amplifier Tube, L. Sutherlin, *El. Journal,* March 1932, p. 139.

[2]The Theory of the Grid-Glow Tube, D. D. Knowles, Part I. *El. Journal,* Feb. 1930, p. 116; Part II, *El. Journal,* April 1930, p. 232.

Grid-Controlled Glow and Arc Discharge Tubes, Knowles and Sashoff, *Electronics,* July 1930, p. 183.

[3]Hot Cathode Thyratrons, A. W. Hull, Part I., *G. E. Review,* April 1929, p. 213; Part II., *G. E. Review,* July 1929, p. 390.

[4]The Kathetron, Palmer H. Craig, *Electronics,* March 1933, p. 70.

[5]The KU-610 Grid-Glow Tube., R. K. Gessford, *El. Journal,* July 1932, p. 351.

[6]Presented at the Winter Convention of the A.I.E.E., New York, N. Y., January 23-27, 1933.

Suppression of transmitter harmonics

By CARL G. DIETSCH
National Broadcasting Company

IN CONSIDERING the proportionate band width of the radio frequency spectrum within which interference is liable to occur due to the radiation of harmonics by transmitting stations it is apparent that this band includes all but a very small fraction of 1 per cent of all the channels at present available. With the assignment of more stations to operate within the spectrum and the general use of higher power the problem of harmonic suppression has become rapidly more important. Design requirements of a modern transmitting station, therefore, point not only toward adequate frequency stability and a minimum of adjacent channel interference, but also toward the suppression to the highest degree of radiation of all spurious frequencies, particularly of a harmonic or parasitic nature.

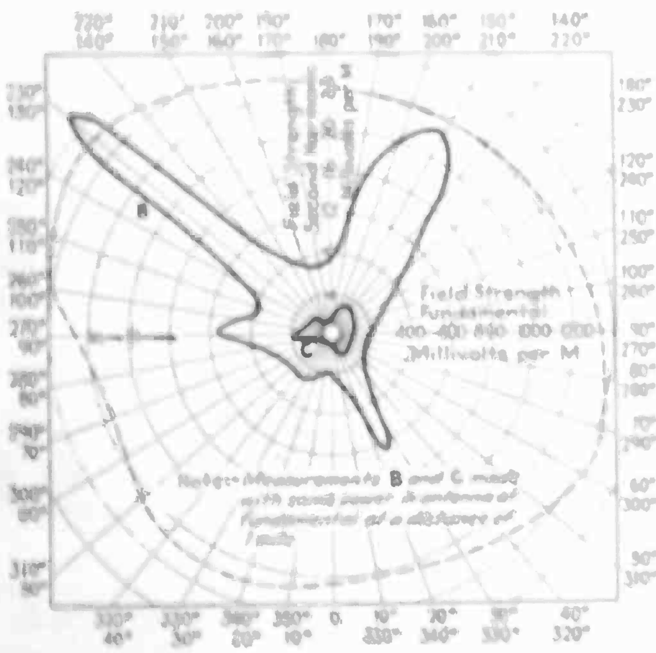


Fig. 1—Radio field intensity survey. The dotted curve gives fundamental frequency field strength; B and C are second harmonic intensity before and after reduction

This has presented a difficult problem in so far as vacuum tube transmitters are concerned since it is the inherent characteristics of a vacuum tube while functioning at a reasonably high efficiency in an amplifier circuit to become a very effective generator of harmonics. Vacuum-tube transmitters are the frequent source of such interference. The extent to which the interference becomes objectionable depends not only upon the amount of power a given vacuum tube generates at harmonic frequencies within an amplifier circuit but also how effectively it is radiated from the station.

Since the only method of determining how effectively a station radiates power is by means of a field intensity survey, it is evident that if it is desired to suppress harmonic radiation to an absolute minimum, such field measurements are indispensable. While circular surveys of field intensity at various angles between the horizon and the zenith is a difficult procedure, a survey made in the plane of the earth's surface is valuable since low angle radiation is apparently very effective even at the higher frequencies.[1] Some of the results of work performed along these lines by the Radio Engineering Department of the National Broadcasting Company under Mr. Raymond Guy are illustrated in the polar curves of Fig. 1. These curves show the results of a survey taken near a high-powered broadcasting station.

In specifying allowable harmonic radiation from a broadcasting station, the IRE Committee on Broadcasting[2] has recommended that the maximum radio field intensity of a harmonic component measured at a distance of one mile from a station should not exceed 0.05 per cent of the field intensity of the fundamental. A field strength of 500 μv. m at a distance of one mile is recommended as a maximum allowable intensity from a high-powered transmitting station. If in the case of a 50-kw. station a circular field pattern and equal attenuation is assumed for both a harmonic and the fundamental in the immediate vicinity of the station, a field strength of 500 μv. at one mile would correspond to approximately seven milliwatts of radiated power at a harmonic frequency.[3] The effect of directivity (illustrated in curve *B*), may cause a field intensity of a number of times the value of 500 μv. to be projected in a given direction with a very small fraction of one watt of harmonic power in the transmission line and antenna circuits. Such a concentration of radiated power may form very objectionable interference. Considering the factors involved therefore, it is evident that harmonic suppression must be attacked from a number of angles. These may be briefly outlined as follows:

1. Design of the transmitter circuits to reduce the harmonic content of the power delivered to the antenna circuits to a minimum.
2. Thorough and effective shielding of the entire transmitter or building.
3. Effectively grounding all harmonic drain circuits and elimination of long conductors near the transmitter coupled to it inductively or capacitatively.
4. Reduction of directivity of harmonic radiation to a minimum.
5. Installation of shielded band or low pass filters at the input end of the transmission line, to the antenna.

Some commonly used triode amplifier circuits are shown in Figs. 2 and 3. The push-pull amplifier is superior to the single-ended circuit as it is capable of producing a sum plate current of the two tubes which is symmetrical in waveshape and therefore containing no even harmonics.[4] Individual plate currents, of course, contain even harmonics which are drained to ground

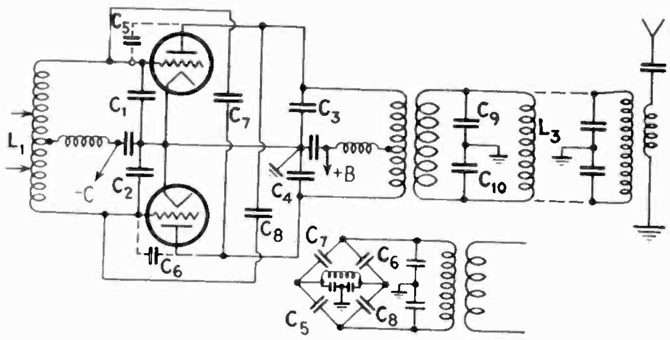


Fig. 2—Push-pull amplifier with high kva. tank circuit in transmission line

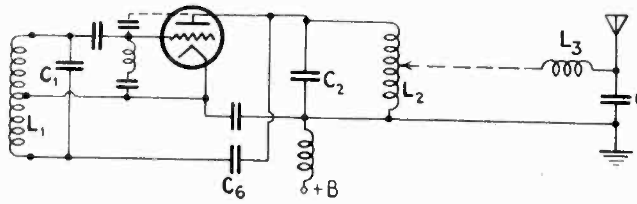


Fig. 3—Line termination effecting reduced harmonic radiation

through C_3 and C_4 resulting in identical instantaneous even harmonic potentials being set up on each side of L_2 but no actual even harmonic current through it. Under these conditions, an electrostatically shielded inductive coupling permits transfer of only fundamental and odd harmonic frequencies to the coupled circuit. For a condition of symmetrical plate current it is evident that the tube characteristics must match closely, $C_1 = C_2$ and $C_3 = C_4$. The neutralizing bridge must be balanced not only for the fundamental frequency but for even harmonics. This requires that the internal capacities of the tubes should match. As will be shown later, a high ratio of circulating kva. in the tank circuit to the kw. delivered from the amplifier reduces the output of harmonics from a single-ended amplifier to a very low value. This is also true in the push-pull circuit.

The circuit shown in Fig. 3 will give a very small amount of harmonic output by proper design of the circuit constants. The curves in Fig. 5 show the filtering effect of a high kva. tank circuit in suppressing harmonic components of current generated in the tube. These curves show actual harmonic transferred to a given load circuit Z_L with a constant output at the fundamental and various kva/kw. ratios of L_2 and C_2. Fig. 4 shows improvement in tank circuits so as to increase the normal filtering action of an ordinary tank circuit. A high kva/kw. radio applied to these circuits is capable of reducing harmonic output to an extremely small amount. There are some limitations in the amount of filtering which can be secured by a high kva. tank circuit, however, since the I^2R losses in the circuit increase in proportion to the circulating kva. and the cost of apparatus for increasing kva. in a circuit without increasing losses is considerable. In broadcasting transmitters there is the limitation of too low a decrement in a circuit attenuating too greatly the high frequencies of a modulated envelope. In Fig. 4 the series of trap L_3C_3 is tuned to a particular harmonic to be eliminated. The use of antiresonant circuits (parallel traps) in the plate lead of an amplifier while reducing to some extent a single harmonic has a tendency to allow considerable voltage to build up at others. Most satisfactory results are usually secured by designing a minimum impedance path for harmonics to ground as compared with a given high impedance at the fundamental.

The effectiveness of the shielding of a transmitter may be determined by operating the transmitter with full power output into a shielded phantom antenna. Measurement of the harmonic field strengths produced from the transmitter itself is direct evidence of how well it is shielded. Such radiation can be usually traced to a long conductor near the transmitter coupled to it through a common ground return or capacitively. Ground conductors serving to drain harmonic frequency power to ground therefore should be as direct as possible and should not be extended so as to have a free end which might attain a high potential at resonant frequencies. This is particularly true of the harmonic drains near the antenna itself. These should have a separate ground to prevent coupling of harmonic frequencies into the antenna.

A sensitive wavemeter is very useful in determining the relative harmonic field intensities near the various circuits of a transmitter. When tuned to the frequencies of various harmonics, and coupled to various circuits of the transmitter or placed at positions along nearby open conductors, this instrument will indicate proportionate amounts of the harmonic components of the current flow. By effectively grounding a long open conductor either directly or through large capacity condensers at a number of distributed points harmonic radiation can usually be eliminated.

The push-pull amplifier when coupled to a long transmission line has often become a source of undesirable even harmonic radiation because of sufficient electrostatic capacity existing between the coupled circuits to permit a transfer of even harmonic energy from the amplifier output circuit to the line. Unless this electrostatic capacity is reduced to an extremely low value, i.e., by installation of a well-grounded electrostatic screen, between the two coils, even harmonics usually find a path along the transmission line with a ground return to the generating source. An unshielded transmission line serves in this case as an effective directive radiator[5] in the form of a large loop. Its effective height

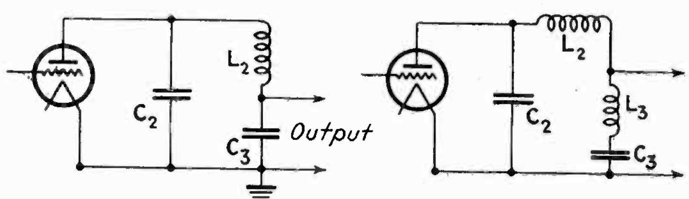


Fig. 4—Improved tank circuits for suppressing harmonic radiation

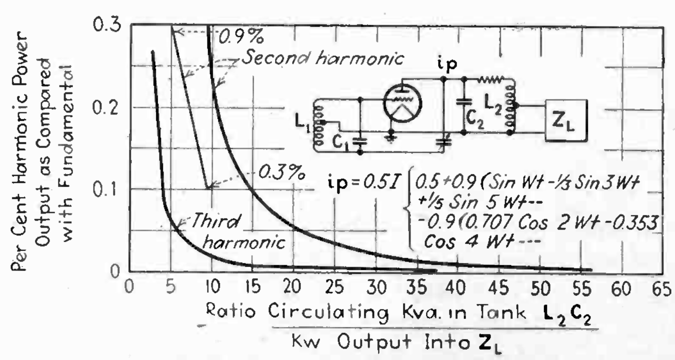


Fig. 5—Effectiveness of high kva.-kw. ratio in reducing harmonic output with constant power output at fundamental

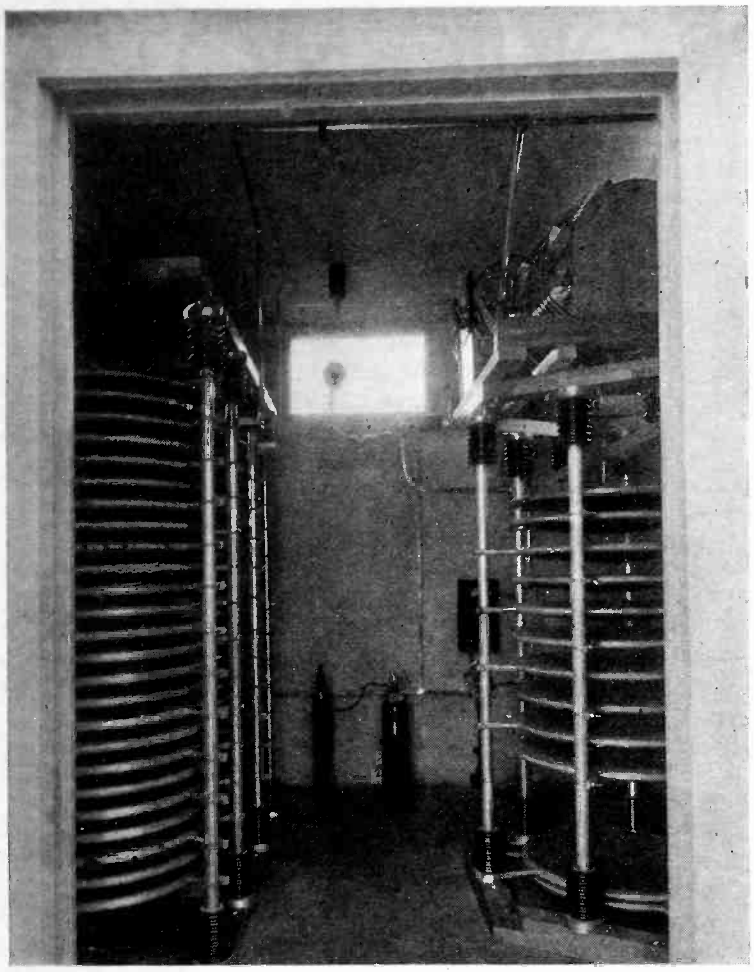


Fig. 6—Harmonic suppressing equipment in field installation of high powered broadcasting station

will be dependent upon the height of the transmission line above ground. Parallel flow of even harmonic currents along the line, therefore, makes it a much more effective radiator in some directions than the push-pull flow of harmonic currents in the line.

A circuit which has been found to be very effective in reducing both the parallel as well as the push-pull flow of harmonic currents in a transmission line is shown in Fig. 2 in the form of a high kva. floating tank circuit $L_3C_9C_{10}$ tuned to the fundamental component of current flowing in the line. This tank circuit, while offering an impedance to the fundamental approaching an infinitely high value, offers a relatively low impedance path to ground for the parallel flow of even harmonics equivalent to

$$Z_{ne} = \frac{-1}{4\pi f_{ne} C_9} = \frac{-1}{4\pi f_{ne} C_{10}}$$

where: resistance of circuit is negligible

Z_{ne} = impedance to n^{th} even harmonic
f_{ne} = frequency of n^{th} even harmonic

and for the push-pull flow of odd harmonics between transmission-line conductors

$$Z_{no} = \frac{-2\pi f_{no} L_3}{(2\pi f_{no})^2 L_3 C - 1}$$

where: resistance of circuit is negligible

Z_{no} = Impedance to n^{th} odd harmonic
f_{no} = Frequency of n^{th} odd harmonic

$$C = \frac{C_9}{2} = \frac{C_{10}}{2} \text{ where } C_9 = C_{10}$$

It is evident that as C_9 and C_{10} are increased in capacity the effectiveness of the circuit in reducing harmonics is increased. Since the transmission line termination impedance is usually made to match the line impedance[6] for the fundamental frequency it usually happens that the line impedance is matched for this frequency only and as a result harmonic components of current and voltage in the line appear as standing waves along the line. In such a case the above tank circuit is most effective for eliminating a particular harmonic if it is placed at a point along the line of maximum voltage. This circuit alone was effective in one case in reducing second harmonic radiation from a station to one-fifth of its former value.

Antiresonant circuits installed in a transmission line at current antinodes have been found very effective in reducing to a great extent a single harmonic to which they were tuned. Extreme care should be taken in shielding these antiresonant circuits to secure best results. A combination of antiresonant circuits and a low pass filter is shown in Fig. 7. This combination has been used successfully in severe cases of harmonic radiation from a very long transmission line and antenna system. The filter in design matches the surge impedance of the line and has a cut-off frequency between the fundamental and second harmonic. Antiresonant circuits have been found useful to sharpen the cut-off so as to attenuate sufficiently the second harmonic frequency. Considerable experience in filter design and adjustment is required to secure optimum results from such an arrangement.

The methods of line termination shown in Figs. 2 and 3 are effective in reducing the possibility of harmonics reaching the antenna circuit. The termination shown in Fig. 3 may be improved by use of a multi-section low pass filter.[7]

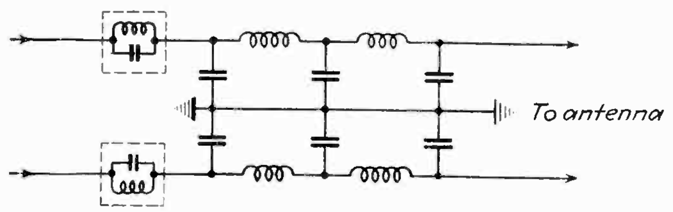


Fig. 7—Low pass filter combined with antiresonant circuits in transmission line

While it has not been within the scope of this article to discuss in length all of the methods used by the Engineering Department of the National Broadcasting Company in effecting reductions of harmonic radiation from various of its 27 stations, the above methods and results are mentioned because of their merits. Considerable work has been done along these lines to bring old types of transmitters up to present standards of the National Broadcasting Company.

[1] *Proceedings IRE* Oct. 1931 "Development of Antennas"

[2] *Proceedings IRE* Jan. 1930.

[3] At very high frequencies ground waves are attenuated rapidly. In estimating relative amounts of radiated power required at two different frequencies to produce equal field strengths at a certain distance the actual attenuation of both frequencies must be known. Refer to Bureau of Standard-Journal of Research, April 1932, page 432.
Modern transmitters made by leading manufacturers have a radiation of harmonic power of the order of not over 14×10^{-6}% of the fundamental power.

[4] Malti, "Electric Circuit Analysis," page 172.

[5] *Proceedings IRE June, 1923.* F. W. Dunmore.

[6] In the case of a parallel wire transmission line this is equal to Z = 276 $\log_{10}$ 2D/d where D = distance between centers of conductors and d = diameter of conductors.

[7] *Proceedings IRE June 1931.* "Suppression of Radio Frequency Harmonics in Transmitters." Labus & Roder.

+ + ELECTRONIC NOTES

Simultaneous traces with cathode-ray oscillograph

By C. Bradner Brown

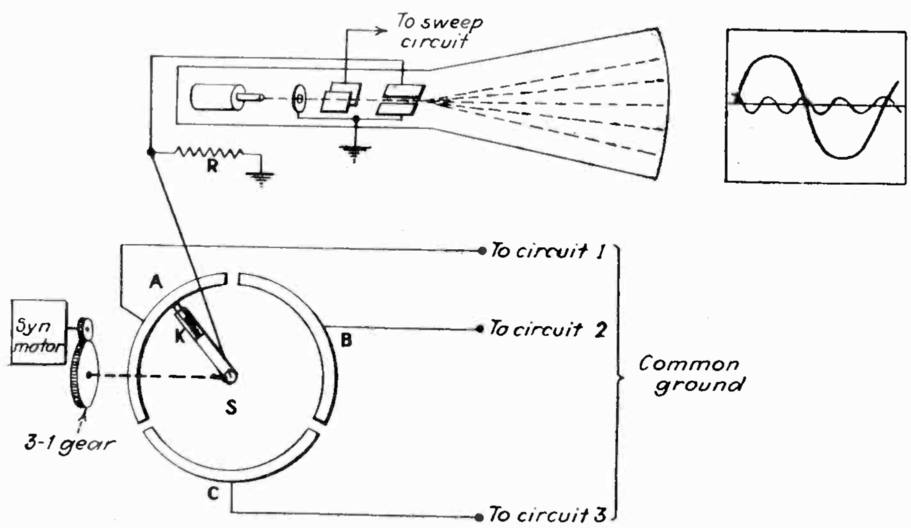
One of the main disadvantages of the cathode-ray oscillograph is its inability to produce simultaneous traces. This lack of flexibility forces the research worker to turn to either the mechanical oscillograph or to photography to obtain wave forms or traces in their proper respective positions on the same record. The mechanical models overcome the simultaneous tracing problem by mounting three separate tracing units in such a position that all three operate on the same screen. The use of separate tracing elements is highly satisfactory, but the production of a cathode-ray tube having three electron streams is out of the question, not only from an economic standpoint, but also from a portability standpoint. The main advantages of the cathode-ray oscillograph lie in its complete portability and simplicity in action together with the exact reproduction obtained. A cathode-ray tube having a multiplicity of tracing elements would greatly limit its scope of usefulness on account of the increase in bulk.

The system devised by the author for the study of simultaneous traces does not in any way interfere with the operation of the cathode-ray tube and is simply an auxiliary piece of equipment. It consists mainly in a mechanical switch for changing the cathode-ray deflection plates from one potential source to another in rapid succession. The system was so designed that it would complete a cycle of operations in a time short enough to make use of the phenomena of visual persistence to obtain a complete set of traces. The circuit is shown in schematic form in the figure. The rotary switch S having three contact segments and a wiping arm driven by a synchronous motor operates at 600 r.p.m., causing it to repeat the cycle of operations 10 times a second. The eye will therefore retain any impression received during one revolution of the switch, the action of which is as follows:

During the first third of a revolution, the arm K is connecting segment A to the deflecting plates, which causes the electron beam to trace the voltage form of circuit 1. A thirtieth of a second later, the arm K has moved around and connected segment B to the deflecting plates, causing a new wave form to be traced on the screen. During the last third of the revolution, C is connected to the tube, and since all three traces have been made in less than a tenth of a second, the eye receives the impression of three separate traces on the fluorescent screen.

In the experimental model, an Allen B. Dumont, model 34 cathode-ray tube was connected to a conventional sweep circuit for the production of a linear time axis. The amplitude deflecting plate was connected to the rotating arm, one side being a common ground. The resistance R prevents any charge from collecting on the deflecting plates during the brief time when the rotating arm is between segments and not connected to anything. The rotating arm K was driven through a 3-1 gear at 600 rpm by a Bodine model NSY-12 1/150 hp. synchronous motor operating at 1,800 rpm. This assured an evenly-timed reproduction of the three traces and eliminated the problem of speed control of the switch mechanism. The switch itself was constructed of bakelite and the segments A, B and C were inset in such a manner that the wiping contact ran smoothly over the joins.

The advantages of the system were at once apparent. The new arrangement allowed the use of a standard frequency wave form for comparison purposes. Not only could the frequency of the unknown wave be rapidly determined, but any deviation from a sine form could be easily distinguished and checked. If the third segment were kept at ground potential, an axis line was traced which allowed the comparison of amplitudes, positive and negative, thus showing any distortion with reference to the axis. It proved particularly valuable in the study of phase shift in electrical equipment, as both the original and shifted wave could be compared and the shift measured quite accurately.

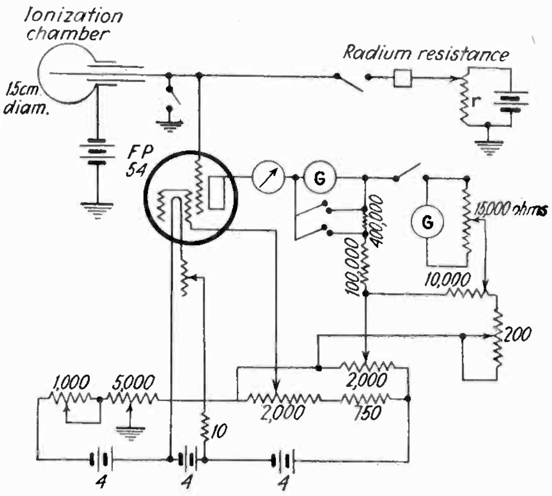


Device for tracing more than a single wave shape on a cathode-ray tube

✦

Measuring the intensity of 700 Kv. X-rays

A large portion of the March number of the *American Journal of Roentgenology* is devoted to the discussion of the relative effects produced by 200 kv. X-rays, 700 kv. X-rays and gamma-rays, as studied at the Biophysical Laboratory of the Memorial Hospital, New York City. In view of the ionization chambers which had to be used a very sensitive instrument was required for measuring the conductivity produced by the rays. A vacuum tube instrument proved to be satisfactory for the task. It consists of two parts, a lead box containing the vacuum tube FP-54, the high resistor (a radium preparation and air gap and the grounding key of lead. The ionization chamber traversed by the X-rays is attached to the bottom of this box by means of its highly insulated stem. Batteries, rheostats and meters are placed outside the roentgen room and connected by wires under lead covers.



Use of the FP-54 for measuring ionization currents

Another practical vacuum tube circuit for measuring the electro-motive force of high resistance sources is described in *Res. Scient. Instr.* 4:131-137, 1933.

FROM THE LABORATORY ++

Comparison of photocells

The following table giving the comparison of merit of the three types of light responsive cells is taken from a paper by A. J. McMaster, delivered before the Radio Engineers Club of Chicago.

The *photo-emissive cell* is in most general commercial use for the following reasons:

1. High red sensitivity.
2. Stability.
3. High impedance resulting in large voltage signal when used with electronic amplifier tubes.
4. Linearity of response.
5. Good dynamic response.

Its principal limitations are:

1. It generally requires amplification in relay equipment.
2. It requires an operating potential of 50 volts or more.
3. Operating current should be limited to not more than 50 microamperes—generally less.

The advantages of the *photo-conductive cell* are:

1. Some types can be made very sensitive to infrared light.
2. Some types have large current output (with low sensitivity).
3. Some types have high sensitivity with low current.
4. Can be operated at low voltage.
5. It has good response in all parts of the visible spectrum.
6. It has a considerable temperature coefficient.

Its disadvantages are:

1. Some types are unstable.
2. It has a rather high dark current.
3. Its time lag is great and dynamic response is poor.
4. It is critical with respect to operating voltage.

The advantages of the *photo-voltaic cell* are:

1. It operates without external source of voltage and is particularly suitable for portable use or installations where 110 volt power is not available.
2. Can be used with relays without amplification if sufficient change in light intensity is available.
3. Two or more cells can be conveniently used in parallel or series.
4. Relatively large output currents can be obtained with sufficient light intensity.
5. Some types are stable over long periods.
6. Color response is similar to that of human eye.

The limitations of this type are:

1. Its output cannot be conveniently amplified by vacuum tube methods.
2. Its dynamic output is very poor.
3. Since the output cannot be efficiently amplified when used with relays, the relays required are of low torque (resulting in low contact pressure and relatively slow speed of operation) and are expensive.
4. For relay operation relatively large changes in illumination are necessary.
5. It has a considerable temperature coefficient.
6. Ambient temperature range is somewhat limited.
7. It has appreciable lag of response in quantitative measurements.

✦

Measuring one billion ohms

By Dr. Irving J. Saxl*

Formerly the use of a few hundred volts was necessary in the measurement of resistances amounting to a billion ohms. This was practically the limit to which resistance measurements could be brought, using Ohm's law and the most sensitive type of galvanometers. In addition, due to the small damping of these suspension galvanometers, these measurements needed an appreciable amount of time.

Now, with an amplifier using the General Electric tube FP-54, it is possible to measure resistances of a billion ohms, with only about one volt impressed.

This new four-electrode tube which makes possible the measurements of currents down to 10^{-17} amperes has already been described in *Electronics*. This makes possible the exact study of highest resistances, to improve the insulating properties of various materials, exact astronomical determination of the light of distant stars, the measurement of cosmic rays, of radium and X-ray emanations.

The new amplifier is compact, portable and easy to use. The control grid is insulated from the rest of the tube elements, by fused quartz inside of the tube. The external control grid circuit must be equally well insulated and care must be taken in the selection of the high ohmic resistors.

The tube is designed to be operated at low voltages and to have very small control-grid current. This is of the order of 10^{-15} amperes. The control-grid resistance is about 10^{16} ohms.

In combination with a commercial type of galvanometer, this supersensitive amplifier makes possible the exact measurement of currents as small as 10^{-15} amperes. When used with a suitable sensitive galvanometer this range may be extended to 10^{-17} amperes.

So sensitive is the device that a person moving about the room would produce readings greater than those of the input circuit, were the amplifier not properly shielded. It is enclosed therefore completely in a metal box, only the two shafts of the two controls coming out on its metal panel.

The circuit is a modification of the Wheatstone bridge, with the plate resistance of the tube serving as one of the legs. A 12-volt storage battery is required to operate the tube.

*Consulting Physicist.

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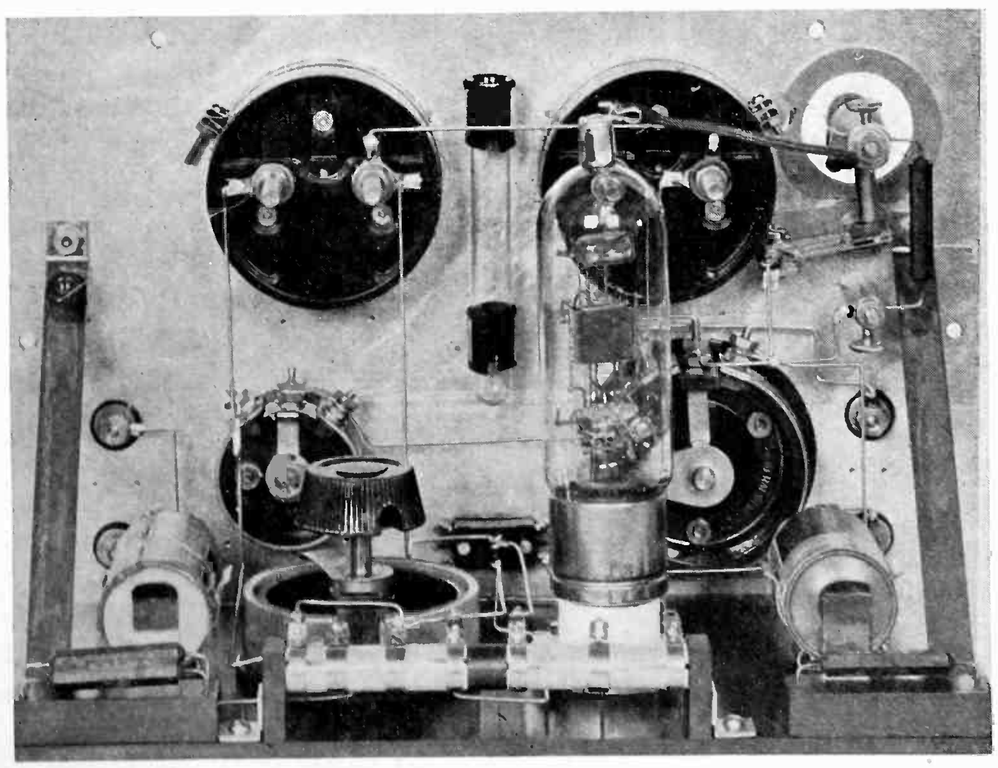
A BILLION-OHM BRIDGE



Rear view of an amplifier for measuring resistances up to a 1,000,000,000 ohms with only about one volt impressed

electronics

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New York City

O. H. CALDWELL, *Editor*

Volume VI —JUNE, 1933— Number 6

Radio cabinet styles and the Chicago exposition

IN cities and towns and villages all over the country, the family "bus" is being made ready for a summer excursion to the World's Fair at Chicago. Millions of people are going to inspect the wonder-palaces of science and electronics on the shores of the lake.

And when those families come back to their scattered homes, they will bring back with them new ideas of architectural design and artistic pattern. Other millions scan the photographs of the Chicago Exposition buildings in the rotogravures and magazines. The whole country is being made exposition-conscious.

The Chicago World's Fair may therefor be expected to have a tremendous influence on the tastes of people throughout America, even in the small towns and rural districts. The modernistic outlines of the Exposition will definitely affect the acceptibility of new designs for clocks, automobiles, furniture, plumbing, and above all radios. The new trends in radio design will find a waiting market which will be impatient with old-fashioned and Victorian effects of yesteryear.

Inventions by Government employees

GOVERNMENT employees may privately exploit for their personal profit the commercial results of patents gained by them unless specifically a part of their official duties undertaken directly under instructions of their superiors.

This is the general effect of the decision April 10 in the Supreme Court of the United States telling the government that it may not claim ownership or title to the patents of two Bureau of Standards' investigators, F. W. Dunmore and P. D. Lowell.

The lower courts in this case had decided that this work of the Bureau of Standards had been undertaken by the inventors voluntarily, outside their official assignments, but had been allowed to continue with the knowledge of superiors after the patent conception had occurred. There was no question raised as to the fact that the work was done in official time using government facilities. But, the court says, this does not give the government more than a shop right to use an invention in its own interest.

The court finds that no right of administrative authority exists to deprive the individual employee of the rewards of commercial exploitation of his invention. It declares that the Congress has been silent on this point and that until Congress acts, employees may not be so deprived.

The automobile-radio installation problem

AUTOMOBILE radio continues to be the most active field on which the interest of manufacturers is concentrated. Automobile radio is going ahead this season beyond even the fondest dreams of its enthusiasts.

But now that a good business is underway, pains must be taken not to shatter the auto-radio price level in the way that home radios have been "all shot."

Manufacturers cannot expect dealers to get their installation expense out of the ordinary merchandising discount. The job of installation in the case of auto-radios is too complicated, too variable, to expect the retail contact with the public to absorb it in any ordinary list price.

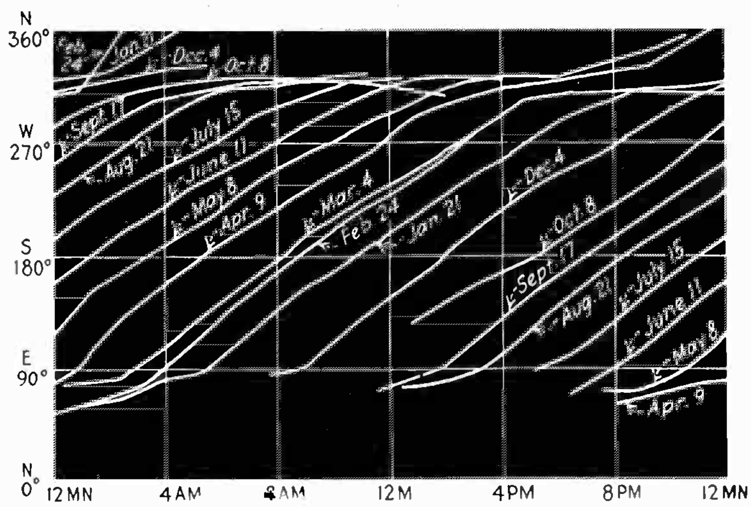
Some of the larger installers think that $5 apiece will cover the average run of installation jobs coming in to-day. But the little retailer, on whom a large aggregate volume depends, cannot operate at any such level. Into 80 per cent of the cars, antennas must be inserted, and then there are the problems of spark-suppression, mechanical movements in the pick-up field causing clicks, brake-static, and other insidious difficulties.

Automobile radio installation is still a radio man's job, and there seems no present way except to make each installation an individual case.

Hearing radio from the stars

DISCOVERY by Karl G. Jansky, of the Bell Telephone Laboratories, Holmdel, N. J., of a "radio hiss" from the depths of the universe, provides one more tie-up between the electromagnetic spectrum and astronomy. There can be no doubt of the sidereal origin of Mr. Jansky's static. For more than a year he has observed the changing of its position as it swings around the horizon daily, yet each day advancing four minutes, which corresponds to the changing position of the starry firmament, as the sun appears to move in front of the stars. More interesting yet, Mr. Jansky locates his static hiss as coming from a definite point in the heavens lying on the 18-hour Right Ascension meridian, which already is notable for two cosmic distinctions,—(1) the destination toward which the sun and solar system are speeding at 720 miles per minute, and (2) the gravitational center of our own Milky Way Galaxy of a hundred billion suns.

PROOF OF SIDERIAL ORIGIN OF RADIO HISS



A year's careful observations by Karl G. Jansky at Holmdel, N. J., have revealed the progressive sidereal shift of the radio hiss on 14.6 meters, following a definite point in the sky of stars

Of course, there is no definite evidence as to how far off is the interstellar broadcasting station whose output we are receiving. Certainly it must be prodigious, to lay down even such signal strength as pours in on our earthly receivers. But with billions of stars radiating energy at average rates of a sextillion kilowatts apiece, on other electromagnetic wavelengths, (light, infra red, ultraviolet), there would seem to be power aplenty for the observed radio phenomena.

▼ ▼ ▼

TECHNICAL PROGRAM, I. R. E. CONVENTION

June 26-28, 1933—Hotel Stevens, Chicago

Monday, 10 a.m.—Some Aspects of Radio Law, by J. Warren Wright, Navy Department; Patent Relations of the Engineer to His Employer, by Leonard Garver, Jr., Larbach & Garver; The Radio Patrol System of the City of New York, by F. W. Cunningham, Bell Telephone Laboratories and T. W. Rochester, New York Police Department; The Iconoscope—A New Version of the Electric Eye, by V. K. Zworykin, RCA Victor Company.

Monday, 2 p.m.—Vacuum Tubes for Use at Extremely High Frequencies, by B. J. Thompson and G. M. Rose, Jr., RCA Radiotron Company, Inc.; Vacuum Tube Characteristics in the Positive Grid Region by an Oscillographic Method, by H. N. Kozanowski and I. E. Mouromtseff, Westinghouse Electric & Manufacturing Company; Application of Graphite as an Anode Material to High Vacuum Transmitting Tubes, by E. E. Spitzer, General Electric Company; Determination of Dielectric Properties at Very High Frequencies, by J. G. Chaffee, Bell Telephone Laboratories.

Tuesday, 10 a.m.—Symposium on Cost vs. Quality in Broadcast Receiver Design: Tubes, by W. M. Perkins, National Union Radio Corporation; Coils, by F. M. Jacob, Meissner Manufacturing Company; Speakers, by H. S. Knowles, Jensen Radio Manufacturing Company; Condensers, by R. O. Lewis, P. R. Mallory Company; Resistors, by D. S. W. Kelly, Allen-Bradley Company; Transformers, by W. J. Leidy, Chicago Transformer Corporation; Circuits, by H. D. Mysing, Grigsby-Grunow Company.

Tuesday, 1:30 p.m.—Studies of the Ionosphere and their Application to Radio Transmission, by S. S. Kirby, L. V. Berkner and D. M. Stuart, Bureau of Standards; Electrical Disturbances of Extraterrestrial Origin, by K. G. Jansky, Bell Telephone Laboratories; Attenuation of Overland Radio Transmission in the Frequency Range 1.5 to 3.5 Megacycles, by C. N. Anderson, American Tel. & Tel. Company; Note on a Multi-Frequency Automatic Recorder of Kennelly-Heaviside Layer Height, by T. R. Gilliland, Bureau of Standards; Determination of the Direction of Arrival of Short Radio Waves, by H. T. Friis, C. B. Feldman and W. M. Sharpless, Bell Telephone Laboratories; Informal Technical Conference on "Criteria for the Introduction of New Tubes" led by J. C. Warner, RCA Radiotron Company.

Wednesday, 9:30 a.m.—A Study of Reflex Circuits and Associated Tube Properties in Modern Receivers, by David Grimes and W. S. Barden, RCA License Laboratory; A New Cone Loudspeaker for High Fidelity Sound Reproduction, by H. F. Olsen, RCA Victor Company; A Life Test Power Supply Utilizing Thyratron Rectifiers, by H. W. Lord, General Electric Company; Radio Cabinet Design and Consumer Acceptance, by H. L. Van Doren, Van Doren & Rideout.

+ NEW PRODUCTS

THE MANUFACTURERS OFFER

Glove-fitting tube shield

Having specialized in the design and production of parts for radio tubes, Goat Radio Tube Parts, Inc., 314 Dear St., Brooklyn, are now marketing a new design of tube shield. This differs from the conventional cylindrical type of shield in that it conforms to the shape of the dome type of bulb, which is why it has been christened the "glove-fitting" tube shield.

The shield is made in two halves, and these so formed that a clamping ring may be slid up on it from the lower end and snapped into the groove provided therefore, thus holding the two halves together, snugly hugging the bulb.

This tube shield is declared to cost less than the cylindrical type, partly in itself, and partly because it is so easily grounded by means of a simple clip fastened to the chassis. Furthermore, it is suggested that, in these days of smaller sets, the space saved as compared with the straight cylindrical type of shield might under certain circumstances be utilized for other parts of the apparatus and permit a reduction in the overall dimensions of the set.—*Electronics, June, 1933.*

✦

Condenser microphone kit

Bruno Laboratories, New York City, has developed a kit of parts of a condenser microphone which can be assembled into a professional instrument. The parts are made with micrometer accuracy. A microphone of this type can be used for broadcasting, public address, or any purpose where good reproduction is required. Being a condenser microphone, there is no hiss or other extraneous noise. Overtones and coloring are well reproduced and the spoken voice is life-like, declares an announcement. The parts can be assembled into a microphone with only the use of a screw-driver. The kit is packed complete with instructions and also the hook-up for an efficient two-stage amplifier. Price, $5.—*Electronics, June, 1933.*

✦

Test oscillator

A test oscillator having the frequency stability of a signal generator, has just been announced by the Clough-Brengle Company of 1134 West Austin Ave., Chicago, Ill.

This Model OA employs three tubes, the r.f. oscillator stage, a separate modulator stage, and a rectifier tube, for this instrument operates from any light socket, a.c. or d.c., eliminating battery cost and weight.

The "Electron-coupled" oscillator circuit gives freedom from frequency variation due to voltage change or input circuit conditions. Complete coverage of all intermediate, broadcast and short wave bands is provided, including the new 456 and 477.5 kc. intermediate frequencies used in the latest Majestic, Stewart-Warner, Atwater-Kent and other sets.

Output frequencies are adjusted to zero-beat against a crystal oscillator, and are sealed while the zero-beat is maintained. Price $29.70.—*Electronics, June, 1933.*

✦

Dry electrolytic condensers

The Aerovox Corporation, 70 Washington St., Brooklyn, N. Y., has announced a new series of Aerovox Hi-Farad electrolytic condensers especially designed to meet the requirements for compact units for use in modern midget radio receivers and other small apparatus assemblies.

These condensers possess exactly the same general characteristics as other types of Aerovox electrolytic condensers in larger size cans, and are made in a wide variety of capacities and voltage ratings for use in all standard filters and bypass circuits.

Single section units in 1 in. diameter cans include types EM, GM, MM and SM; the two latter being especially suitable for bypass condensers.

Types GG and EE condensers present a radical departure from previous types of electrolytic condensers in 1⅜ in. diameter cans, in that they are made with two or three terminals in the cover, permitting various combinations of capacities and voltage ratings in this size can. Type EE condensers are made for universal mounting with a mounting ring, and type GG condensers for inverted (grounded) mounting. —*Electronics, June, 1933.*

Peak voltmeter

The Sensitive Research Instrument Corporation of 4545 Bronx Boulevard, New York City, announces a new three-range peak voltmeter, reading 0-1-10-100 volts, the lowest reading obtainable being 0.2 volt. It is a direct reading instrument eliminating any calculations whatever and is independent of frequency. It is so designed that it has an infinite input impedance and is not dependent on a sine wave for its peak measurements. It is recommended for all peak voltage measurements, including peak of vibrator B-eliminators, mercury-vapor tube rectifiers, and portions of such circuits as well as thyratron oscillator wave-form peak voltages, irrespective of distortion. It is also obtainable in higher volt combinations. It can also be used to measure small-time transients regardless of frequency or combinations of frequencies, including peak values of pulsating direct-current voltages or currents. It is impossible to overload the instrument sufficiently to cause damage.—*Electronics, June, 1933.*

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Flexible shaft for remote control

A new flexible shaft specifically designed to meet the requirements of remote control of radio receivers has just been introduced by the S. S. White Dental Manufacturing Company, Industrial Division, 152 W. 42d St., New York City.

The feature of this shaft which makes it particularly suitable for radio remote control is its reduced torsional deflection when the shaft is turned in either direction.

The ordinary type of flexible shaft designed for speedometer drives has a torsional deflection when turned in the winding direction of from 0.88 to 0.118 degrees per ounce inch per foot, and in the unwinding direction from 2.14 to 2.95 degrees per ounce inch per foot. The total deflection, in going from the winding to the unwinding direction would be 3.02 to 4.13 degrees per ounce inch per foot.

Compared with these figures the new No. 150L53 shaft has only 0.35 degrees per ounce inch per foot in either direction of rotation, or a total of 0.70 degrees per ounce inch per foot.

For use with this shaft a special small diameter metallic casing has also been developed in standard Parkerized finish. —*Electronics, June, 1933.*

Molded-carbon volume control

The Stackpole Carbon Company, St. Marys, Pa., announces its Type 100 molded-carbon variable resistor, a major advance in the design of volume controls and tone controls in radio receivers and manual gain controls in audio amplifiers. It consists of four major parts: 1, the insulated shaft molded permanently into the bakelite hub which carries the spring contact arm; 2, the bakelite frame or base upon which the unit is assembled; 3, the newly developed resistance element and 4, the shield cover with its associated power switch.

The resistance element is made in the form of a molded carbon ring of the same material employed in Stackpole fixed carbon resistors. After the manufacturing process, which makes possible any total resistance from a few hundred ohms up to a couple of megohms, any resistance taper to suit the particular application of the control, and any desired "hop-off" at either or both ends, the resistance element is fired in a continuous furnace at high temperature. This firing process imparts a hard, glass-like surface to the resistance unit, impervious to temperature, moisture, current or hard usage and forming a perfect surface for the nickel-chrome sliding contact. Thus there is no rough, granular structure to the surface to create noises, nor electro-chemical disintegration to cause irregular control action.—*Electronics, June, 1933.*

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Hot-wire time delay

The TD-7 hot-wire time delay, designed for applications where a short time delay is desirable and where rapid but not immediate recycling is required, is announced by Struthers Dunn, Inc., Philadelphia, Pa. The unit consists of a hot wire member, a bow member and two adjustable, fixed contacts, all mounted on a base of insulating material. It is designed for delays from one to five seconds, and the time of cooling is proportional to the time of heating up.—*Electronics, June, 1933.*

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Insulating materials

Arrangements have been made whereby Isolantite Inc., 75 Varick St., New York City, may fabricate parts from Mycalex made by the General Electric Company and market such fabricated parts in the United States.

The technical excellence of Mycalex and the fine qualities of Isolantite, have won for these products a wide acceptance in the communications and electrical fields. The selection of one or the other for a given insulating project, has been dictated largely by engineering requirements. Consequently, Isolantite and Mycalex are not competitive from a commercial standpoint. Those who have considered fully the determining factors in the choice of insulators for communication service have found that Isolantite and Mycalex supplement each other, to very great advantage.

To those having suitable tooling equipment for working Mycalex, and whose experience with this type of material qualifies them to undertake local fabrication, Isolantite Inc., is prepared to furnish Mycalex in standard size bar and sheet stock.—*Electronics, June, 1933.*

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Stroboscope

The International type 180 stroboscope makes available to the world of industry a piece of apparatus which has long been sought by practically all manufacturing industries. No matter what type of machinery is to be examined, whether it be an automobile engine, gears, transmissions, valves, electric fans, motors, printing presses running at high speed, airplane propellers, sewing machines, or any other form of rotating or reciprocating machinery, the Type 180 Stroboscope will make the machine appear to run in slow motion while actually the device is running at full speed. This accomplishment permits the manufacturer and user of any of these machines to observe why certain parts break down, or make excessive noise. A further description is given in Bulletin No. 28, issued by the International Broadcasting Equipment Company, 4508 Ravenswood Ave., Chicago, Ill.—*Electronics, June, 1933.*

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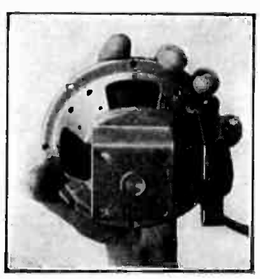
Dwarf dynamic speaker

Measuring only 5 in. in diameter the new Super-dwarf dynamic speaker made by Victory Speakers, Inc., 7131 East 13th St., Oakland, Calif., is built to meet the requirements of manufacturers of a.c.-d.c. receivers.



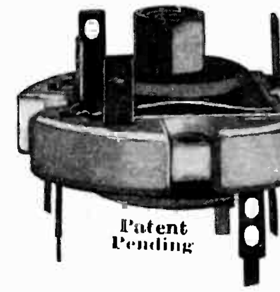
This new speaker is said to have splendid tone fidelity, surprising volume and audio response. Field excitation requirements are from 2 to 4 watts, with output transformer to match specified power tubes.

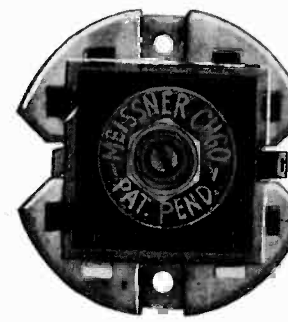
The company also manufactures a complete line of speakers, automobile-type speakers, and amplifiers.—*Electronics, June, 1933.*

Trimming condensers

The Meissner Manufacturing Company, 2815 West 19th St., Chicago, Ill., is now making a unique, very small, new double tuned trimming condenser particularly adapted to small intermediate-frequency units, although capacities up to 850 mmfd. are available.

The illustrations, actual size, show the





two condensers, mounted on either side of the isolantite base. One side is tuned by a spintite, the other by a screw driver. Any combination of capacities can be had by varying the number of plates. The units are also available in the single tuned style. A folder describing the complete Meissner line of trimming and padding condensers may be had on request to the manufacturer.—*Electronics, June, 1933.*

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Manufacturers' bulletins and catalogs

Sound-studio equipment—The Wireless Shop (A. J. Edgcomb), 150 Glendale Boulevard, Los Angeles, Calif., has issued a new binder for its catalogs on speech-input equipment, transmitting condensers, fader controls, power-level indicators, rheostats, relay racks, and other apparatus for broadcast stations, sound-picture studios and laboratories.

Loudspeakers—Jensen electro-dynamic speakers are shown, with complete specifications, electrical resistances, size, prices, etc., in a circular issued by the Jensen Radio Manufacturing Company, 6601 Laramie St., Chicago, Ill.

Photoelectric meter—An illustrated description, with characteristics, of the A.P.C. photo-electric meter for measuring density of liquids, concentrations, turbidity, etc., is contained in Bulletin 103, Eimer & Amend, 18th St. and Third Ave., New York City.

Variable condensers—A new line of small variable condensers for modern compact radio receivers, is described with complete technical details and operating characteristics, in a bulletin issued by the DeJur-Amsco Corporation, 95 Morton St., New York City, manufacturer also of dials, varitors, rheostats, and potentiometers.

Colloidal graphite in resistors—The use of colloidal graphite in the manufacture of electrical resistances, particularly the application of Aquadag for this purpose, is described in a recent bulletin, No. 11.4, published by the Acheson Oildag Company, manufacturers of colloidal graphite products, Port Huron, Mich. Methods of producing resistors, tone-controls and grid-leaks are outlined.