# ELECTRONICS AND TELEVISION & SHORT-WAVE WORLD

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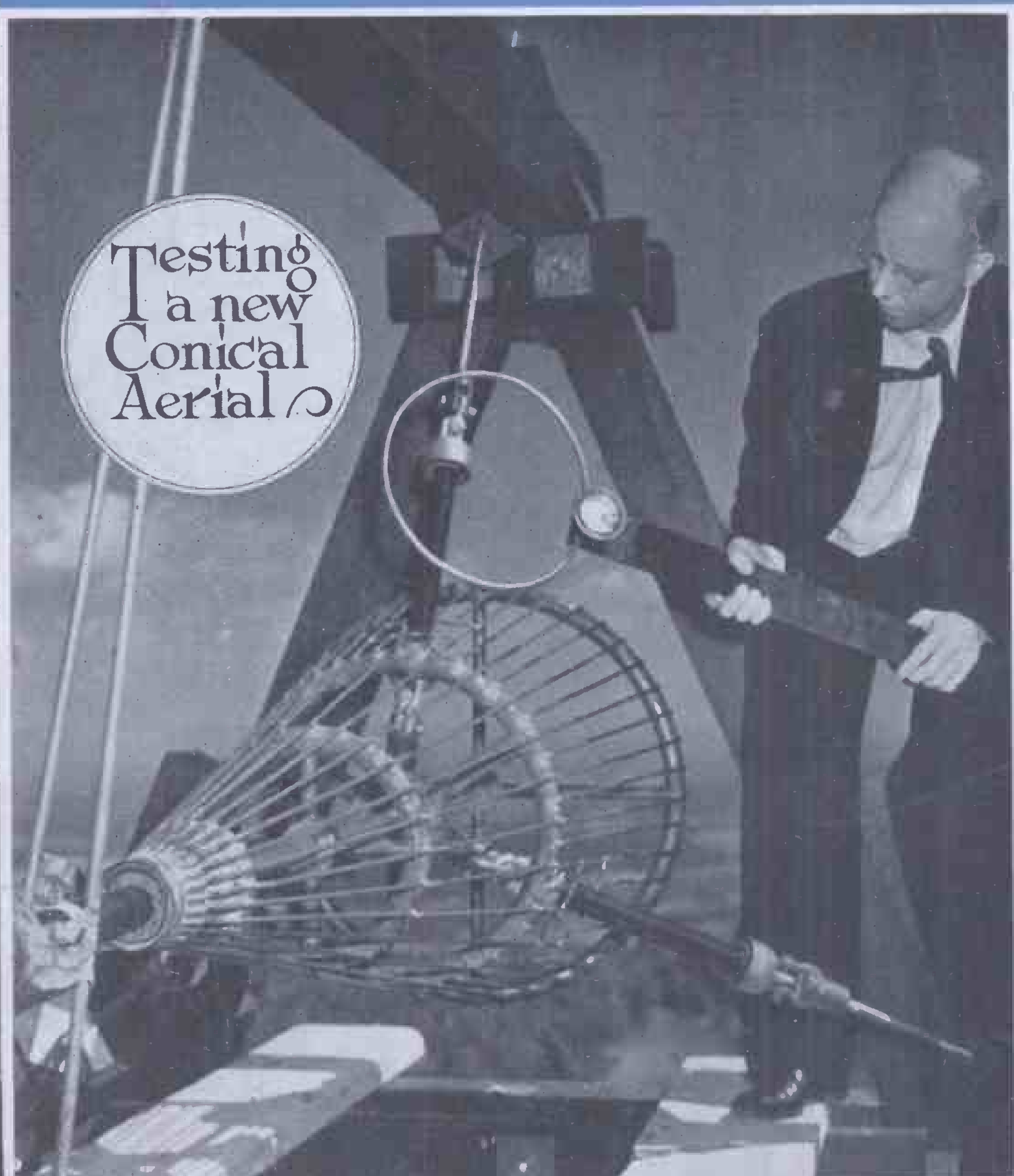
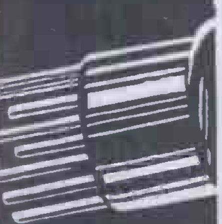
DECEMBER, 1940



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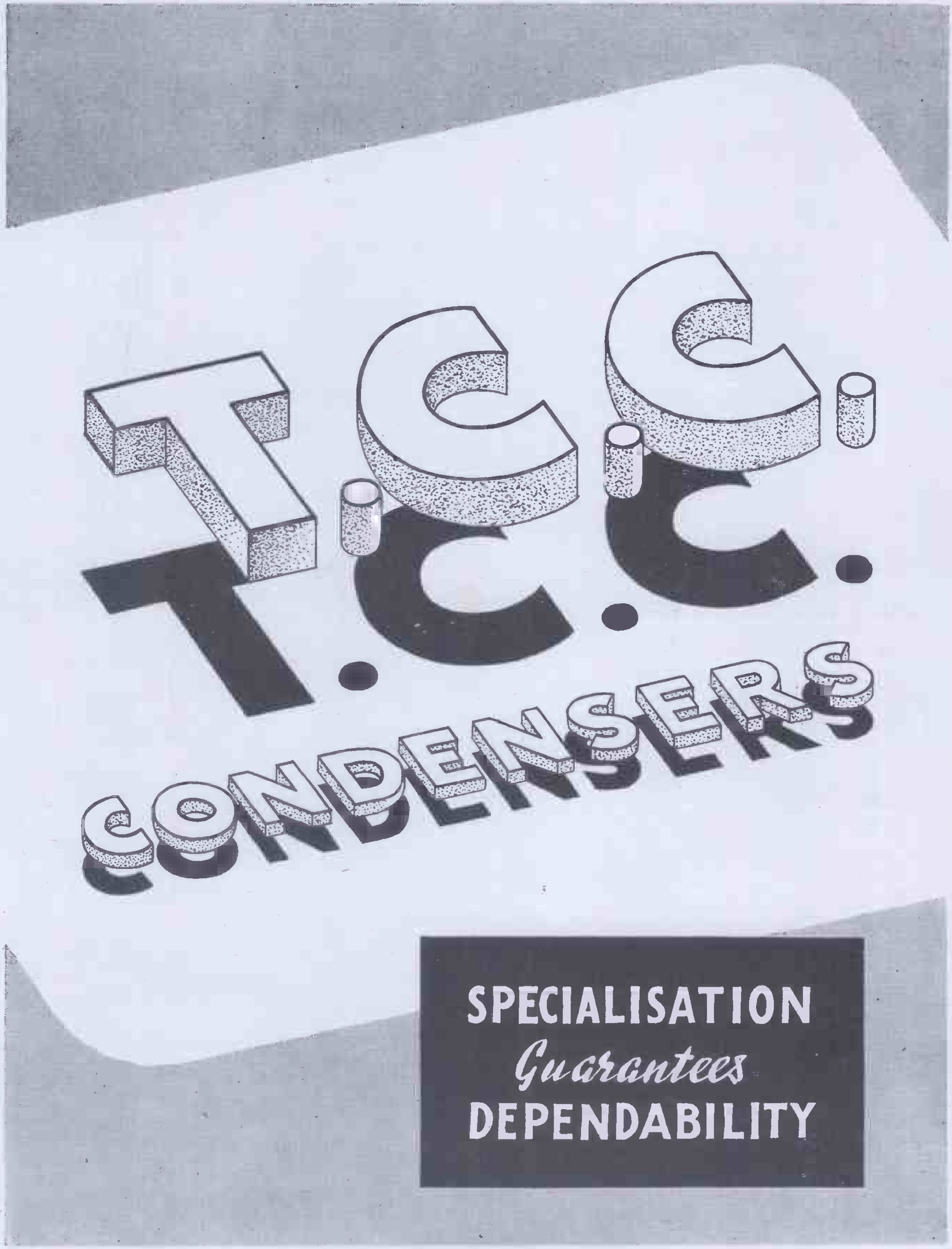
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# ELECTRONICS AND TELEVISION & SHORT-WAVE WORLD

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## CURRENT ELECTRONIC LITERATURE

*Refractories for High-Frequency Induction Furnaces.* (Keeley.) After outlining earlier and unsuccessful types of refractory and methods of furnace lining, the author describes in detail the "Rohn" process of ramming a lining of crushed refractory into the annular space between the coil and a former, and emphasises the importance of exercising care in the tamping-in and fritting operations. Typical analyses of modern refractory materials and their properties are enumerated, the two main classes being acid ganister and basic. Factors tending to reduce the life of the lining are discussed, and the technique of patching is described.
—*Metallurgy*, Sept., 1940.

*Storage Batteries : A Review of their Application.* (McKinnon.) The paper presents a comprehensive review of the applications of lead-acid storage batteries in present-day electrical engineering practice. The following main subjects are considered : batteries in supply undertakings, control of batteries for emergency lighting and power, emergency lighting and power on consumers premises, A.R.P. batteries, batteries for communication, marine applications, mining applications, railway applications, batteries for electrically-propelled road vehicles, batteries for vehicle starting and lighting, battery housing, and miscellaneous considerations. Many of the applications are surveyed in details as regards design, purpose, latest improvements and practice, and actual results obtained in service.
—*Journal of the Institution of Electrical Engineers*, Sept., 1940.

*Lightning and the Transmission Line.* Progress in the design and application of lightning arresters is reviewed. Experimental work and operating experience in the British Isles and in the United States in recent years are outlined and attention is drawn to the most profitable directions to be taken by future research. In particular the importance of gaining a better knowledge of the nature of lightning and the surges it produces is emphasised. A noteworthy step in this direction is the development of the fulchronograph, which is an instrument to measure the magnitude and the wave form of surge currents.
—*Engineering*, Sept. 20, 1940.

*Photo-electric Meter Testing.* The principles of photo-electric meter testing are explained with the aid of a circuit diagram, and the advantages of this method of testing are enumerated. An accuracy of 0.004 per cent. in one revolution of the meter has been claimed for the photo-electric testing equipment, and the accuracy of testing depends mainly on the accuracy of the rotating standard. Photo-electric testing is claimed to have many advantages, besides accuracy, over the hand switch method, the gang method and the stroboscopic method, among which are reduction in running time, elimination of the human element and avoidance of eye strain.—*Engineer*, Sept. 20, 1940.

*Magnetic Crack Detection.* Methods of magnetic crack detection employed by Johnson Fel Electric are outlined and some of their typical machines are described. One method consists of slightly magnetising the part under test by an electro-magnet with the suspected crack at right angles to the flux. The part is then immersed in a fluid carrying fine iron particles, which indicate the cracks. In another method the field is produced by passing heavy alternating current through the suspected part in the form of an impulse.—*Engineer*, Sept. 20, 1940.

**Abstracts by Research Department, Metropolitan Vickers Electrical Company Ltd.**

## PRINCIPAL CONTENTS DECEMBER, 1940



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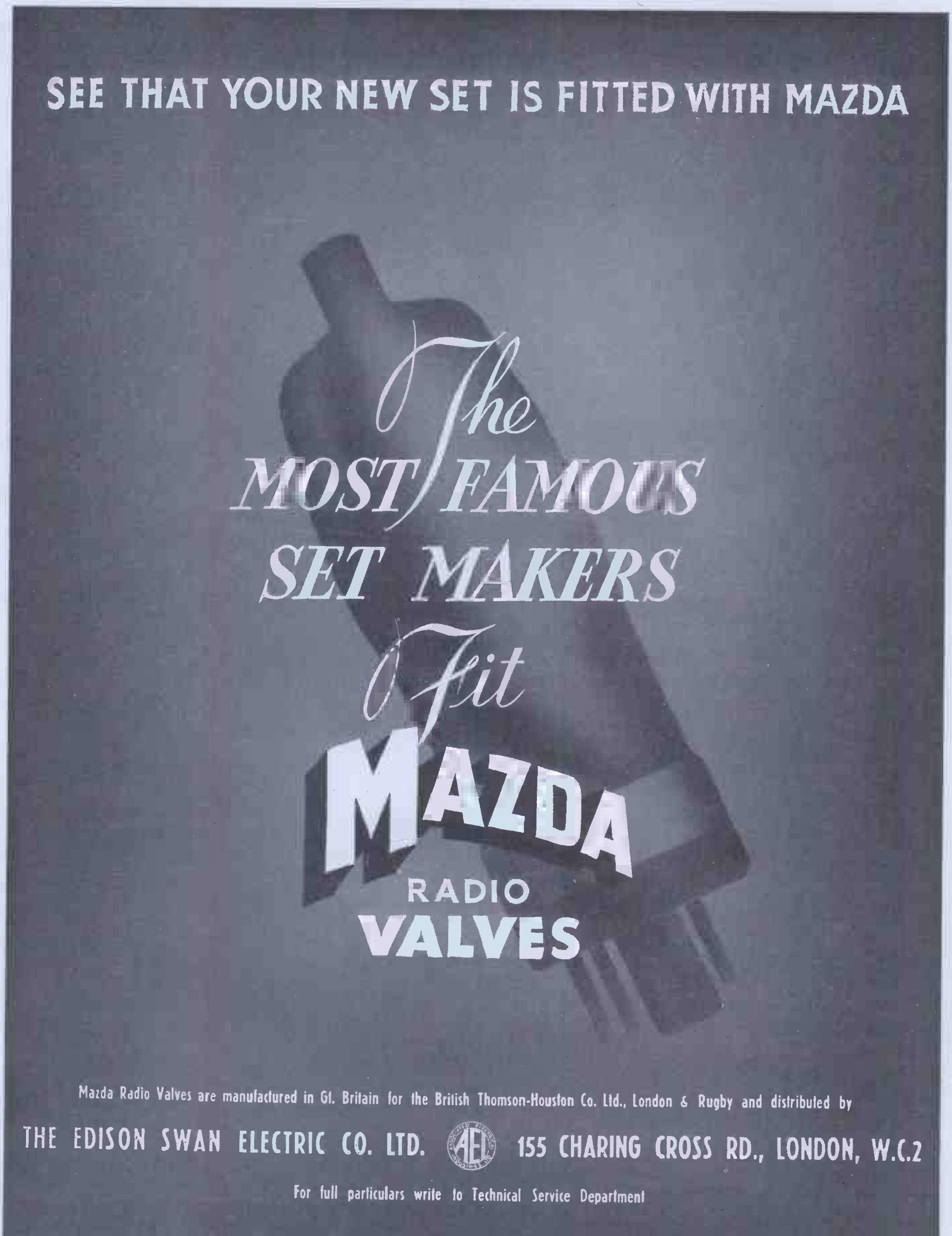
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# *News and Views*

ONE of the concepts which the student of physics has great difficulty in grasping is the complex structure of the atom.

Most students at one time have visualised matter as a conglomeration of atoms resembling ball bearings packed tightly together and the news that matter contained more space than solid came as a revelation which did not clarify their ideas on the subject.

Now that the electron microscope has evolved from the laboratory stage into yet another useful tool for the research worker in physics it is possible that the atom may be persuaded to reveal itself and many vexed questions will be settled by practical proof.

As W. Davis says in the "Science News Letter," lifetimes of labour and millions of dollars have been spent on chemical methods of getting circumstantial evidence of molecular design and the advance of organic and physical chemistry would be enormously speeded up if they could see the molecular structure shaping under their eyes.

Electron microscopes at present available have a range of 10,-90,000 volts giving wavelengths of 50 Angstroms, but if the voltage can be increased to a million or more—a by no means impracticable project —the wavelength can be reduced to a fraction of an Angstrom, which is less than the separation of the atoms in certain compounds. We may confidently assert that it will not be long before this goal is reached and a new era in physical chemistry will be opened, aided by electronics.

The Institution of Electrical Engineers announces that the regular monthly meetings are temporarily suspended, but that, the issue of the *Journal* will be continued as usual. This month's copy contains an interesting survey on the use of ceramics in H.F. work, by W. G. Robinson of Messrs. Bullers, Ltd.

It is pointed out in the paper that many of the discrepancies in previously published data may be explained by the difficulties of measurement and by the variation of some of the quantities to be measured with factors not always sufficiently controlled or specified. Differences between test samples and values obtained in practice are emphasised.

It is now about fourteen months ago since the London television transmissions ceased and it is of interest to note that during this period there have been no major developments either here or abroad, if the Columbia colour system be excepted. So far as the European countries are concerned a state of quiescence is to be expected, but it does seem strange that further advance has not been made in America. In one sense these conditions are gratifying for it means that this country still retains the lead in television development and is the only one with the practical experience of a public service.

As remarked, the one exception is the Columbia colour system, but it is apparent that, ingenious as this is, there are certain inherent disadvantages which, assuming that colour is really desirable, it is problematical whether they can be surmounted. The major trouble appears to be loss of light, both at the transmitter and receiver due to the use of colour filters, the light transmission efficiency being only about 30 per cent.; this in the case of the receiver means a more intense beam current and increased anode voltages. Additionally, there is the necessity of driving the colour filter disc at the receiver in synchronism with that at the transmitter. Up to the present the filter discs have been driven from a common alternating supply and though there is no insuperable difficulty in driving them independently and still maintaining synchronism, as experience with mechanical type receivers has shown, a considerable amount of complication is unavoidable. The further development of this system will be watched with interest.

# Light-operated Relay Circuits

*The circuits described below have been developed in the R.C.A. Laboratories for special applications of photo-electric work, and they will be of particular interest to research engineers who may have an unusual problem to solve in this field.*

THE first diagram (Fig. 1) shows a simple two-stage photo-cell circuit intended for operation direct from A.C. mains, the number of components being a minimum. A high impedance photo-cell is connected to a power output stage through an amplifier buffer valve of the 6J7 type. The cathode. The impedance of the condenser $C_1$ acts as a load impedance for the photo-cell, the condenser being charged to a definite negative potential on one half-cycle and discharging through the cell on the next half. The amount that the condenser is discharged by the photo-cell determines the work- supply cycle with no light on the photo-cell, the cathode of the 6F5 goes negative with respect to the grid, passes current to the grid, and thus during a period of several cycle charges $C_1$ to a value equal to the peak value of the A.C. voltage applied between the grid and cathode. This volt-

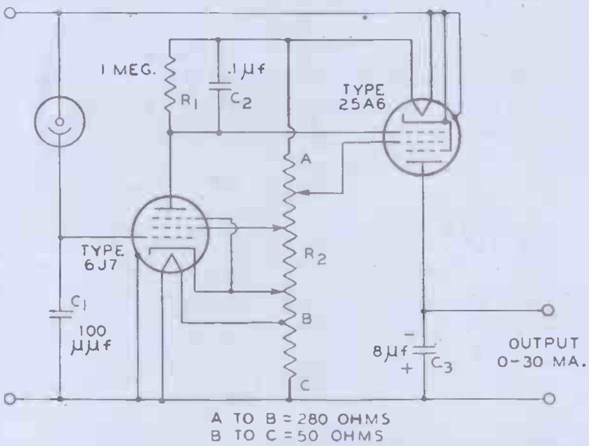



**Fig. 1. A simple two-stage A.C.-operated photo-amplifier relay.**

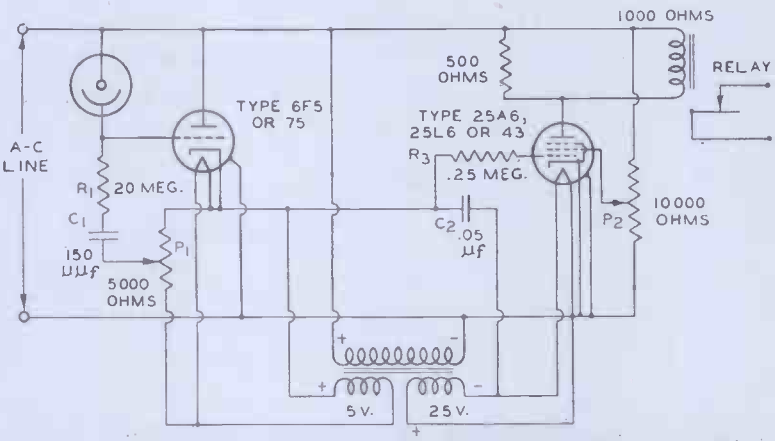



**Fig. 3. A quick-acting non-degenerative A.C.-operated photo-amplifier relay functioning in a positive direction on the received light.**

British equivalents, such as the Mazda SP41 or the Mullard TSP4 will probably give slightly higher gain in this stage.

An alternative, which would be more economical, would be to use an AC/DC valve of the SP2220 type. In the circuit the heater voltage of the buffer stage has been deliberately lowered to reduce the grid emission of the valve and the anode current is also kept as low as possible to reduce grid current. The bias is obtained by the rectifying action of the grid itself which tends to keep the anode potential current constant and independent of large fluctuations in contact between the grid and ing potential on the grid of the buffer. $C_1$ may be adjusted to any desired value depending on the sensitivity range of the relay.

Figs. 2, 3 and 4 show three variations of an A.C. operated photo relay that will respond to a pulse of light having a duration as short as one-sixtieth of a second, or 1/120th of a second if the pulse is properly phased with the power-supply voltage.

The operation of these circuits is essentially as follows:—

On the negative half of the power-age added to the instantaneous a-c voltage applied between the grid and cathode is sufficient to reduce the anode current of the output valve to zero. When light is received by the photo-cell, the cell current has two effects:—first, an instantaneous drop appears across the photo-cell load $R_1$, and second, the photo-cell current into condenser $C_1$ opposes the current fed into $C_1$ from the grid of the amplifier. This action causes the potential across $C_1$ to balance at some negative value between zero and a value equal to the

(*Continued on page* 537)

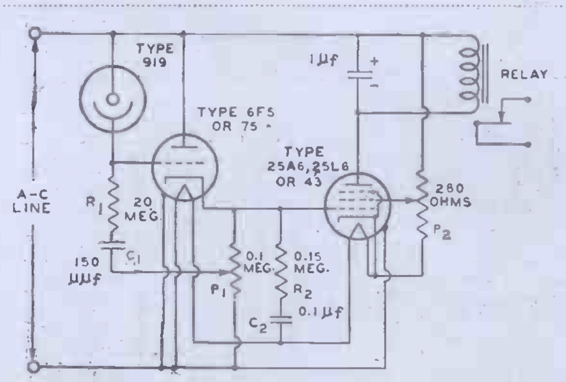



**Fig. 2. A quick-acting A.C.-operated photo-amplifier relay functioning in a positive direction on the received light.**

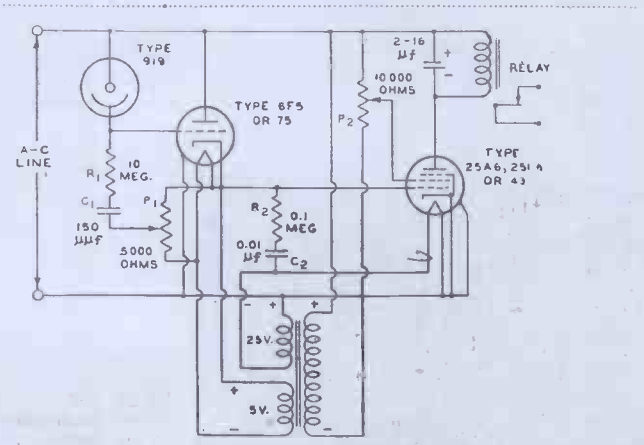
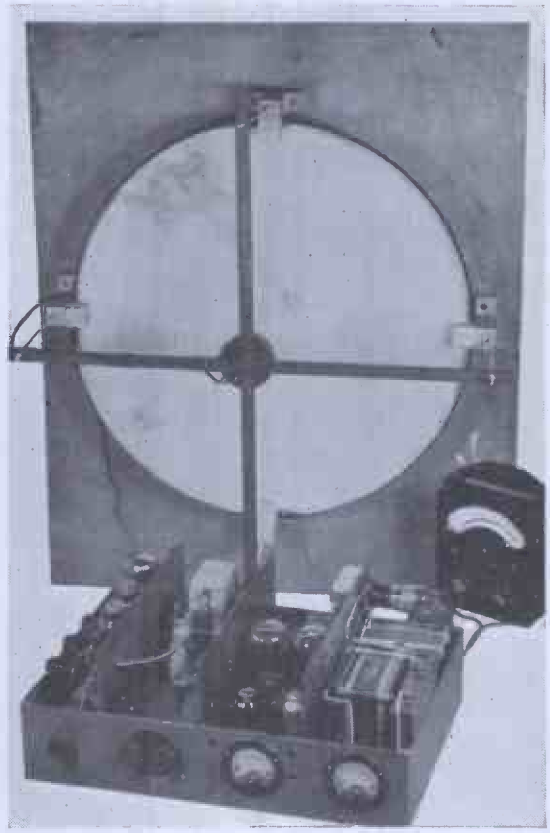



**Fig. 4. A quick-acting slow-releasing A.C.-operated photo-amplifier relay functioning in a positive direction on the received light.**

# Aeroplane "Spotting" by Electro-acoustical Methods

*This article gives the results of a series of experiments carried out for the development of apparatus for the location of aircraft by electro-acoustical methods. Although complete efficiency is not claimed for the system, it is now installed on a large public building in the London area, and its value, at times when visibility is bad, has been definitely established.*



**This photograph shows the complete sound-locating equipment consisting of parabolic reflector, microphone, amplifier and A.C. voltmeter.**

ONE of the most urgent needs at the present time is the development of apparatus that will accurately locate hostile aircraft invisible either by reason of darkness or cloud.

Aural methods, of course, are liable to error due to factors over which we have no control, but properly applied it appears that they will render useful service in assisting roof "spotters" to obtain an idea of direction and distance of aircraft more easily and quickly than with the unaided ear.

The following is an account of a number of experiments which were made to assist roof spotters of a large building, and the result has justified the inclusion of the apparatus described as a permanent feature of the warning system.

Various types of directional microphones are available, but the area of pickup is much too wide for accurate sound direction finding. Of the methods tried in order to increase the ratio of desired to undesired sound, the one now to be described provides excellent discrimination and a large magnification. The first experiments carried out made use of a 10 ft. exponential horn with the microphone located at the throat. The angle of coverage appeared to be about 25° which, although it enabled one to ascertain the location of aircraft, it was very cumbersome and heavy.

The final apparatus makes use of a parabolic reflector with a microphone at the focus point followed by a high-gain amplifier, telephones and an A.C. rectifier-type voltmeter. Fig. 1 shows a schematic arrangement of the apparatus. The choice of a parabolic reflector was due to experience of its use in film studios, where it is employed to pick up the voices of the leading actors in a crowd scene.

Before describing the apparatus in detail it will be useful to outline the method of projecting a parabolic curve. It can be described by a point which moves in a plane so that its distance from a given point, which is termed the focus, is the same as its distance from a line termed the directrix.

In order to plot a parabola the following method can be adopted. Pin a sheet of drawing paper to a drawing board and place a pin at any point chosen as the focus A (Fig. 2). With the aid of a "T" square, set it so that the side XY is at right angles to the side of the board S.T. To the pin at A fasten a length of thread and fasten the other end of the thread to the extreme edge of the "T" square at Y, the length of thread being equal to the length of the side XY. By means of a pencil press the thread up against the edge of the "T" square so that it makes contact at B, sliding the "T" square along the edge S.T. and maintaining contact between the pencil and "T" square. Thus one half of the parabola will be drawn, and by inversion the other half can be traced. Thus point A is the

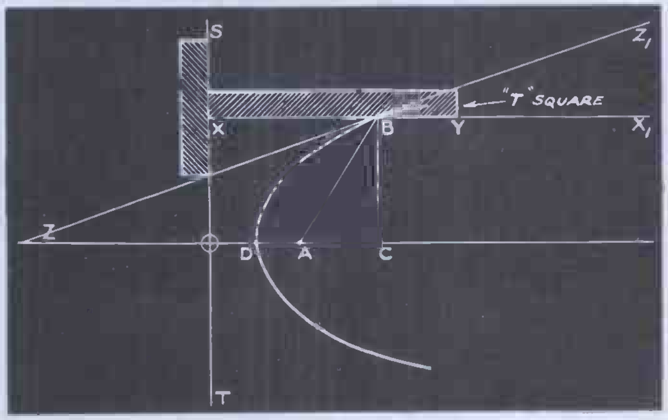



**Fig. 2 (right). Method of plotting parabolic curve.**

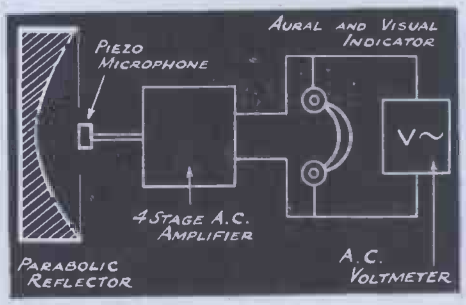



**Fig. 1 (left). Schematic diagram of the sound-locating equipment.**

**Photograph showing means employed for positioning microphone at focal point of reflector.**

focus and the line OX is termed the directrix, from which it can be seen that the length AB = BX = OC.

The point D is known as the vertex of the parabola and let it be assumed that OD = DA = a.

Therefore $(AB)^2 = (AC)^2 + (BC)^2$ – Pythagorus' theorem.
Also $(AC)^2 = (x - a)^2$ and $(BC)^2 = y^2$
Also $BX = OC = (x + a)$
Therefore $(x + a)^2 = (x - a)^2 + y^2$
$y^2 = 4ax$

It will be seen that the lines AB and BX[1] produce equal angles with the tangent ZZ[1]. Thus if, for example, a beam of light radiated from the focus A falls on the internal mirrored surface B, it will always be reflected parallel to the axix OC, because the optical reflection of the angle of incidence ZBA is equal to the angle of reflection Z[1]BX[1].

It is assumed that the focus point A is of zero size and all the radiated light will, therefore, travel in parallel paths similar to a searchlight beam. The reverse of the above operates in a similar manner, that is all light picked up by the parabolic mirror is reflected and concentrated on the point A.

As light obeys these laws, sound radiations will follow the same laws approximately. Therefore, a 24 in. parabolic mirror was used in the initial experiments, the focus point A being 12 in. from the vertex. At this point a microphone was suspended and held rigidly in position. The degree of magnification obtainable is in proportion to the ratios of the areas of the mirror and the microphone, and, therefore, it is desirable to use the smallest microphone possible, provided that it has a good response in the bass register. For the early experiments various types of Reisz and other carbon microphones were used, but the final instrument is fitted with a Rothermel piezo crystal microphone, type D104. It is rugged and has a silent background.

The output from the microphone is taken via a screened cable to a four-stage high-gain A.C. mains operated amplifier. The requirements here are (a) a very low background noise level, (b) high stage gain, (c) means of measuring output signal level. The amplifier follows conventional lines in design, and no special components are necessary; Fig. 3 gives the circuit, but values of the components can vary considerably without affecting the performance of the apparatus, provided that a good low frequency response is maintained. Very adequate smoothing must be provided so that if an A.C. voltmeter is placed across the headphone's terminals no reading should be obtained with zero input. The intervalve transformer may pick up stray hum voltages, and it may be necessary to orientate it for minimum hum level. The output transformer must have a ratio suitable for use with headphones. In the final amplifier Ericsson 120 Ω phones were used so that the transformer ratio was calculated to be

$$\frac{\sqrt{\text{valve optimum load}}}{\text{Headphone resistance}} = \frac{\sqrt{7000}}{120}$$

= 7 to 1 approximately. As the ear is very insensitive to small sound level changes an A.C. Avometer is also connected across the output on a suitable range. This shows the slightest change in output level before it can be appreciated by the ear.

It was found on completing the apparatus that although the microphone was accurately located at the focal point of the mirror, the low-frequency response of the mirror-microphone unit using a carbon microphone was inadequate. A piezo microphone was obtained, and in the final instrument a 36-in. diameter reflector was used. Not only did the magnification increase considerably, but the angle of discrimination decreased also.

The parabolic reflector can be constructed in various ways, but it was found that one made from plaster of Paris was the easiest to make. A rectangular box, 36 in. square with a depth of 10 in. was made from 1 in. deal. A full-scale drawing of a parabolic curve was produced, from which a section of wood 1 in. thick, having the same contour was made. The box was partly filled with plaster of paris, and then slowly rotated on a turntable. The parabolic contour board was carefully lowered into the box and the plaster was moulded into shape as it was rotated. After it had set, it was sandpapered smooth and finally sprayed with a cellulose paint. This gives a very hard and weatherproof surface. The centre of gravity of the box was then found, and it was then mounted on a rigid tripod in a U-shaped arm (Fig. 4) with swinging adjustments so that it could be rotated and elevated at any desirable angle. The microphone is

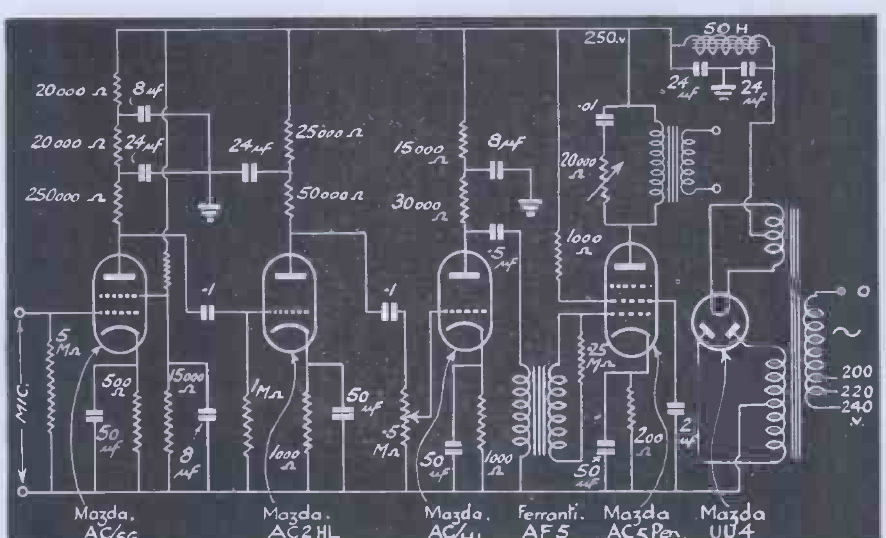



**Fig. 3. Circuit diagram of amplifier employed.**

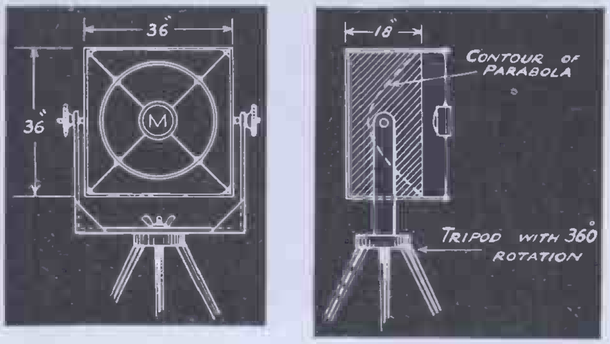
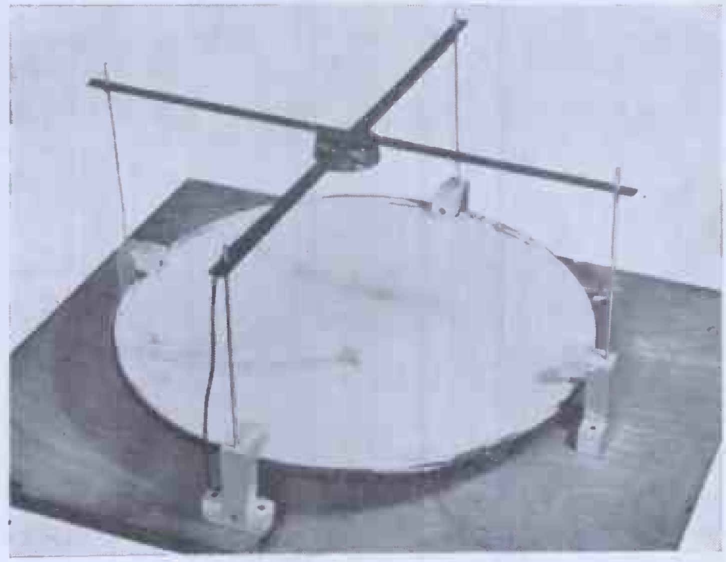



**Fig. 4. Front and side elevations showing reflector mounting.**

attached to two brass rods, which are mounted diagonally across the cabinet; by means of 2BA studding it can be accurately set to the focal point (Fig. 5). The screened lead from the microphone is taken along one of the arms and lead to the amplifier, which can be located in the vicinity.

The microphone unit was placed as high as possible, and clear of any obstacles that would reflect sound waves. A map of London was located below the tripod so that the location of enemy aircraft can be noted, and by means of a pointer attached to the rotating turret the direction of flight can also be ascertained. In addition a protractor was mounted on the side of the cabinet so that the angle of elevation can be read off.

The method of operation is relatively simple, and can be readily mastered by an inexperienced operator. The microphone unit, having been mounted at a suitable location, can be checked by pointing it at a source of sound, for instance, a clock some 10 to 15 feet away, and the unit rotated until the tick can be heard in the 'phones. Then by referring to the A.C. voltmeter, more accurate positioning of the microphone can be made. Speech conversations can be picked up from up to 100 feet away, suitable adjustment of the volume control being made. It is not claimed that great accuracy is obtained with this device, as many variables enter into the final results. Reflection of sound gives rise to erroneous readings, whilst it is difficult to check a mass flight of aircraft due to the large area of incident sound, but for single aircraft its usefulness has been proved. Only a general indication of the method of sound location has been given, as many variations in the design can be made provided the general principles of the reflector are maintained.



**Above. This photograph shows how the reflector is mounted.**

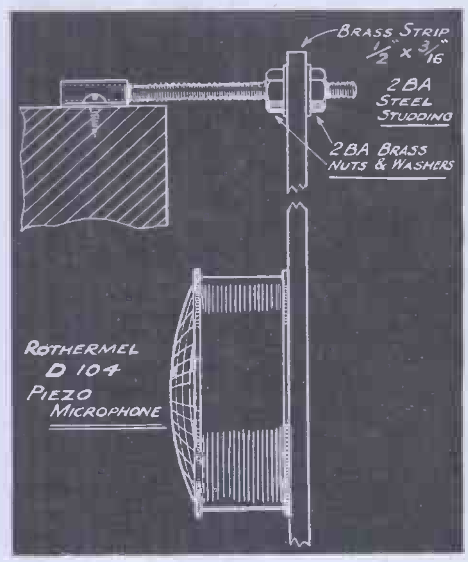



**Fig. 5 (right). Diagram showing method of mounting microphone and adjustments provided.**

## "Light-operated Relay Circuits"

(*Continued from page* 534)

peak of the A.C. voltage between grid and cathode. The potential across $C_2$ is fixed in like manner by a balance between the charging grid current and the discharging buffer-valve current. In Figs. 2 and 3, an instantaneous flash of light occurring on the positive half of the cycle will cause an instantaneous drop across $R_1$, an instantaneous change in the anode current of the buffer stage, and an instantaneous change in grid voltage of the output valve. In Fig. 4, due to the current taken by the buffer stage, there is a rapid loss of potential across $C_2$. This loss is slowly restored through $R_3$ over a period of several cycles. Thus the pulse of output current will have sufficient duration to operate a sluggish mechanical relay, even though the pulse of light be of extremely short duration.

The circuit in Fig. 3 is identical to the circuit shown by Fig. 2 except that the heater voltages are supplied by suitable transformers. The use of a transformer supply for the heaters eliminates the degeneration or loss of gain that is inherent in the circuit shown in Fig. 1, due to the fact that the D.C. potential between the lower side of $C_1$ and the cathode of the buffer valve does not remain constant. In this circuit care should be taken to keep the instantaneous transformer polarities as shown.

These simple photo relays find their application for use in moderately high-speed sorters, counters, register controls, shooting galleries, etc.

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The decision of the Federal Communications Commission (America) to shift the No. 1 television channel from 44-50 Mc. to 50-56 Mc. means that a great many alterations have to be made to transmitter W2XBS and the radiator on top of the Empire State Building, New York. A series of photographs in the current issue of ELECTRONICS (U.S.A.) gives a good idea of the work which confronts the Empire State television engineers.

One of the first jobs was on an ingenious impedance-matching circuit of coaxial elements at the base of the radiator tower. This was opened, cut down to the proper size for the new frequency, and reassembled. The final amplifier of the picture transmitter, which is grid-modulated over a five-Mc. band, had to be carefully adjusted before full output was obtainable without trouble from parasitic oscillations. After reassembly, the long process of adjusting the circuits electrically began, first under low power and then under full output.

# A FAN-TYPE AERIAL FOR ULTRA-SHORT WAVE-LENGTHS

*Details of a new aerial with low centre impedance enabling a comparatively unselective matching network to be employed*

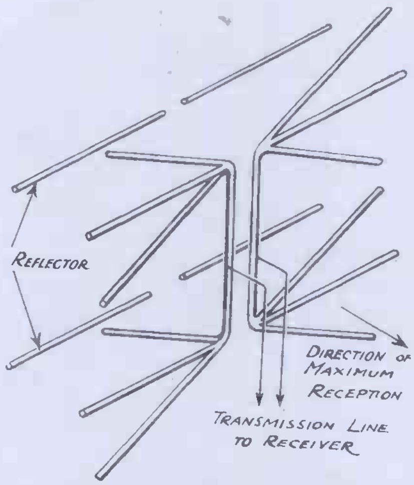



**Fig. 1. Skeleton arrangement of fan-type aerial.**

IT has long been recognised that one of the difficulties encountered in the operation of high-frequency aerials over a wide frequency band is due to their high reactance component which changes rapidly with frequency. Where impedance-matching networks are employed, a similar effect is produced, since the impedance-matching networks also have considerable reactance. Thus, aerial performance is less efficient at any frequency other than the particular "centre" frequency for which the system is designed.

The reactance of an aerial, of course, may be reduced by increasing the size of its conductors, particularly by connecting a number of conductors in parallel so as to form a cage, or by constructing the aerial in the form of a surface of rotation. Such a construction decreases the aerial reactance so that its impedance is more nearly uniform over a wide range of frequencies. The resultant decrease in impedance also produces another beneficial result

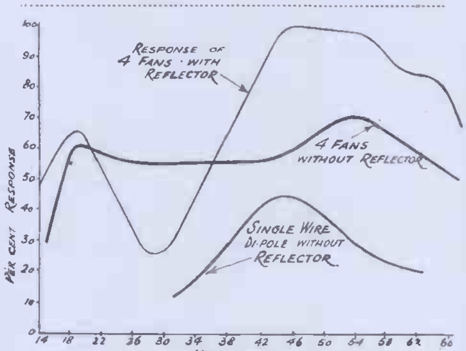



**Fig. 2. Response characteristics with and without reflectors.**

which has particular importance where dipole aerials are concerned.

The value of the impedance measured between the dipole arms, known as the centre impedance, becomes more nearly equal to the characteristic or surge impedance of a conventional transmission line, and the transformation ratio of the matching networks which are used to connect the line to the aerial may, therefore, be greatly decreased, or the matching networks may be eliminated entirely. Inasmuch as the selectivity of a matching network becomes greater as the ratio of transformation increases, it will be appreciated that it is highly desirable to eliminate the network entirely, or at least to use a low transformation ratio.

The systems which have hitherto been used or proposed, however, do not take full advantage of the decreased aerial impedance because, by reason of their three-dimensional construction, they have an appreciable depth with respect to a wavelength in the direction of propagation of the received or transmitted wave front. As a result, the various portions of the aerial structure are impinged upon by the wave front at various time intervals, so producing resultant potentials which are frequently in phase opposition, and cancellation of the received energy takes place.

The aerial which is described in this article, and which has been developed in the laboratories of the Radio Corporation of America, consists basically of a dipole arrangement each arm of which is formed by a number of conductors extending radially from an apex and lying in a plane parallel to the wave front of the signal which is to be received. It inherently possesses the advantage of a low centre impedance, thus permitting a less selective matching network to be used or the matching network to be dispensed with altogether; also it provides maximum response from a direction perpendicular to the plane of the aerial, since the potentials induced in the various wires are in time phase.

A greater response may be obtained by providing a pair of similar "fan-dipole" aerials mounted in spaced relation in common plane. By connecting the two fan-dipole aerials in parallel with a half-wave transmission line, and connecting the transmission line from the receiver to the centre of the half-wave line, quarter-wave matching sections between the receiver transmission line and the two aerials are automatically provided. As the two fan-dipole aerials are effectively in parallel, the impedance presented to the receiver transmission line is one half of the impedance which would be presented by one fan-dipole aerial, thus further decreasing the impedance transformation which must be provided by each matching section.

In view of the fact that the combined effect of the fan-dipole arrangement and the parallel connection makes the transformation ratio which is required to match properly the receiver transmission line to the aerial very low, it is possible to increase the length of the arms of the dipole aerial to approximately a half wavelength, thus even further increasing the response. In-

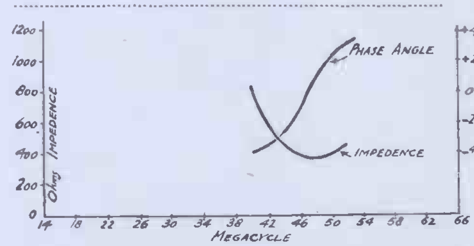



**Fig. 3. Phase angle and impedance curves.**

creasing the length of the dipole arms increases the centre impedance of the dipole. In single-wire systems the impedance between quarter-wave dipole arms is approximately 70 ohms, but the impedance between half-wave arms is approximately 2,000 ohms, so that the length of the arms cannot be increased without sacrificing the desirable flat impedance characteristics. In the present instance the centre impedance between quarter-wave dipole arms is not greatly affected, but the centre impedance between half-wave dipole arms is greatly reduced; thus the system may be made to have an impedance characteristic which is flat over a wider band of frequencies than hitherto.

The use of two fan-dipole aerials spaced vertically a half wavelength apart automatically, of course, increases the directivity of the systems. Thus, the sensitivity to high-angle sky waves and to interference from under the aerial is greatly reduced quite apart from the sensitivity in a horizontal plane being increased. The horizontal directivity may be further increased according to standard practice by the use of parasitic or directly connected reflectors.

(*Continued on page 572*)

# The Manufacture of Quartz Crystals for High-frequency Control

**Fig. 1. A group of natural quartz crystals.**

*This article describes in detail the cutting, grinding and final adjustment of quartz crystals for use for high-frequency control as carried out in the laboratories of The General Electric Company of America. The information is published by kind permission of the Editor of "General Electric Review." An exhaustive article on the technique and applications of quartz crystals appeared in our September issue.*

THE raw material, or "mother quartz," from which piezo-electric crystals are made occurs in nature in many parts of the world, including the United States and Canada. The largest known deposits are in Brazil, and it is from there that most of the quartz is obtained.

It is mainly silicon dioxide ($SiO_2$) but contains an appreciable amount of impurities. Generally, it is clear and colourless, but is occasionally found with a reddish, bluish, smoky or milky tinge. In shape, it is hexagonal and uniaxial. It has a hardness of 7 on the Mohs scale. (That of the diamond is 10). It is optically positive. Its mean index of refraction is 1.55, its double refraction 0.009, and its dispersion 0.013—all of which are low. It is optically active, rotating the plane of polarised light traversing it in the direction of the optical axis.

It occurs in many forms, chief among which is the pyramidal type, but because of having been broken off and rolled around in a river bed for perhaps several centuries, it has had its regular faces worn off until it has become more or less round in form. Since most quartz defects occur near these regular faces, the river quartz from which these faces have been worn away contains a larger percentage of usable material than the prismatic form, but it is more difficult to cut correctly because of its lack of reference faces.

Ordinarily quartz is "mined" by natives who merely pick it up or break it off with hammers from the igneous rock in which it is embedded. It occurs in a great range of sizes—from pieces not much larger than a pea, such as the so-called Herkimer diamonds found in New York States, up to magnificient specimens weighing perhaps several hundred pounds. For ordinary commercial piezo-electric use, pieces between three and eight pounds are the most economical, and contain a reasonable percentage of usable material.

**Fig. 3. Quartz crystals in different stages of preparation. Top centre : an uncut mother-quartz crystal. Lower right : a crystal after the first sawing operation. Top left : one of the resulting sections, and beneath it a section after being sawed into bars. Bottom left : bars before and after the final sawing operation, and also four of the resulting radio crystals ready for the various finishing operations.**

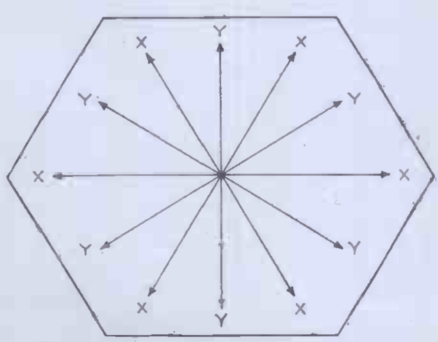



**Fig. 2. The directions of the electrical axes X and the mechanical axes Y in a plane perpendicular to the optic axis of a quartz crystal.**

So many defects occur in quartz, however, that in many pieces only a relatively small percentage of the material is usable. Many of these defects, such as cracks, veils, ghosts, inclusions, etc., are readily apparent, but others are not, and special methods are used for their detection.

As stated, previously, quartz has the power of rotary polarisation with respect to light traversing it in a direction parallel to the optic axis. When this rotation is clockwise, or right-handed, the quartz is designated as dextro, and when counterclockwise, or left-handed, it is termed levo. Although either type can be used to equal advantage, it is unfortunate that most specimens are more or less ambidextrous; that is, they are both right and left-handed because of the presence of both types of rotation. This defect is commonly known as twinning.

The presence of twinning can be detected by means of polarised light or hydrofluoric acid etching. It is undesirable to use portions which show any indications of this defect, although a small amount of twinning may not prevent oscillation of the crystal; it will, however, almost invariably show up in impaired performance at some temperature or in reduced life.

Fig. 1 shows a shipment of these natural quartz crystals as received from Brazil. A reproduction of a group of them appeared as the front cover illustration of the September issue, and it could be seen that the faces appeared to have been sawed and polished with lines running crosswise resembling the marks made by a cutting wheel of some kind. These characteristics are merely evidences of a form of growth, however, even to the extent that some of the faces—particularly at the apexes—are nearly optically flat.

although not ordinarily of equal length, and all the six included angles are 120 degrees.

The angle at which a piezo-electric crystal plate is cut from the mother quartz determines its characteristics as an oscillator, particularly with respect to its temperature-frequency coefficient. For rough work, the crystal can be cut to approximately the correct angles by visual inspection of the faces and growth lines, and setting the piece in the sawing machine accordingly. For the better-quality crystals, however, the x-ray diffraction method of orientation is used.

## *Methods of Manufacture*

Because of the hardness of quartz, special methods of cutting and lapping must be used. The methods are simple, but the maximum of care must be exercised throughout the manufacturing operations to ensure that the proper angles of cut are maintained in order

tions are then cut, at the correct angle, into bars as shown also in Fig 3. The cutting of the bars into blanks at another definite angle is then performed with a blank-cutting saw. All cuts are made using a gang of several saws in parallel, to reduce cutting time.

After the blanks have been cut, they are put through cleaning-up and conditioning operations to prepare them for orientation by X-ray. When in the X-ray equipment, the blanks are held in adjustable fixtures so that they can be oriented by means of X-ray reflection to a position that will result in the production of an accurately oriented face when the crystal, still attached to the fixture, is later placed in a rigid-arm grinder and its face lapped plane. After a number of crystals have been so oriented and one face ground to the correct plane, they are placed on a flat plate, 50 or more at a time, with the corrected faces toward the plate; then the entire lot is ground parallel to the approximately correct thickness on a surface grinder. They are now ready for the precision

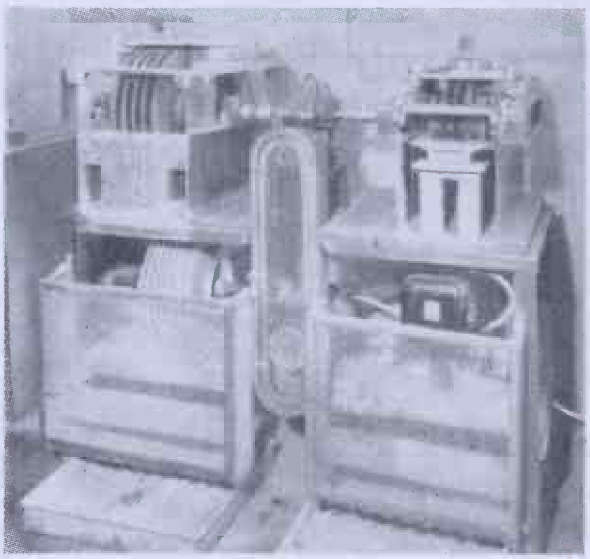
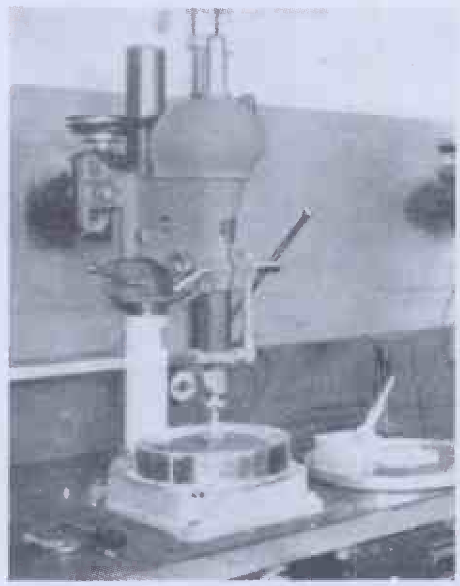


**Fig. 4. (left) The sawing machines for cutting the mother-quartz crystals first into hexagonal sections and then into bars.**

**Fig. 5 (right). After being cut and properly oriented by X-ray examination, the crystals are lapped to high precision by machines of this type.**



The transverse facial lines are known as growth or striation lines and encircle the specimens in planes which are exactly normal to the optical axis. The optical axis, therefore, runs in a direction essentially lengthwise of the crystal. Lying in planes parallel to the growth lines (that is, perpendicular to the optic axis) are the X or electrical axis, and the Y or mechanical.

There are three of each of these axes, occurring alternately, so that 30 degrees each side of an electrical axis is a mechanical axis. The three electrical axes are each parallel to two crystal faces, and each of the three mechanical axes is perpendicular to two faces, as shown in Fig. 2. In this diagram, the direction of the optical axis is perpendicular to the plane of the page. The opposite faces are parallel,

to produce crystals having the required low temperature frequency coefficients. In general the sawing, grinding, and lapping operations are done with relatively soft metal discs and plates continuously charged with abrasive of the proper fineness. Although such discs and plates wear away in time, the brunt of the cutting is taken by the abrasives whose grains are gradually broken down and rounded off until their cutting properties are lost.

The first and second cuts of the native crystal (Fig. 3) are made with the equipment shown in Fig. 4, and the final cut with a smaller machine of the same general type. After being examined for defects, each of these crystals of mother quartz is mounted in a definite manner for the first cut, and hexagonal sections are obtained as in Fig. 3. These sec-

lapping machines (Fig. 5). These equipments, which handle eight blanks at a time, perform a remarkable job of lapping the crystals flat and parallel, as close to the correct thickness as is considered desirable or economical at that stage of manufacture.

Crystals so lapped will normally run as follows :—

(1) Deviation of either face from flatness ± 1 fringe of sodium light.
(2) Variation in thickness not over one micron.

The number of minutes of lapping time necessary to reduce the thickness the required amount has been determined, and is then controlled by time-switch mechanisms. The care taken for this preparation of the blank is justified as it reduces to a minimum the amount of hand work required by the finisher to place the crystal within the desired limits. The finisher is thus enabled to focus his attention and skill mainly on keeping the crystal active piezo-electrically and free from spurious frequencies over the usually wide temperature range necessary.

Each finisher is provided with a miniature radio transmitter, and a set of flat glass lapping plates (Fig. 6). The test oscillator is equipped with three metal blocks, held at − 30 C, + 25 C, and + 50 C (typical figures) respectively, for chilling and heating the crystal during manufacture and test. The crystal is first placed between a pair of metal electrodes which are connected to the oscillator circuit in such a way as to control its frequency in much the same manner as it will be called upon to do in actual service. The first two tests are made on the room-temperature block. The readings of the various meters tell the finisher immediately whether the crystal activity is up to normal.

The crystal frequency is determined by feeding the oscillator output (controlled by the crystal) into a receiver along with a signal of known accurate standard frequency. Their difference or beat note as measured by an audio-frequency meter or audio oscillator indicates just how much the crystal frequency has to be raised. With this information, the experienced finisher knows about how much lapping down is needed to put the crystal on frequency.

Ordinarily the amount to be taken off will be between 0.0005 and 0.0001 in. To the uninitiated it might appear that the removal of so little material would require only one or two minutes. Unfortunately, or fortunately, depending upon how one looks at it, this is not at all the case. Commercial frequency limits are close, for example ± 0.005 per cent. at 8,000 Kc. This represents an allowable variation in physical thickness of only plus or minus *six ten-millionths* of an inch, therefore, only small amounts of quartz must be removed at a time, and a number of cut-and-try tests must be made during the process. If, for instance, after one test the crystal was found to be just outside the low limit, that is, − 0.006 per cent. instead of within − 0.005 per cent., and on the next and supposedly final lapping operation the finisher removed 13 ten-millionths instead of the required six ten-millionths, the crystal would be too thin and, therefore, outside the high-frequency limit, and spoiled. Difficult as this may appear to be, it would be relatively simple if there were not two or three other conditions to be watched.

There must be no "frequency jumps" or excessive changes in activity as the crystal is moved back and forth between the hot and cold plates, while the "tank" or tuning circuit is varied or the electrode pressure is varied. Also, the grid current must be at a maximum and not vary appreciably over the temperature range. These conditions must be observed and maintained even until the last ten-millionth of thickness has been removed. The methods of correction necessary may vary for different crystals, and it is only by long practice and experience that the finisher becomes adept at being able to place the crystal frequency within narrow limits at the same time that it has the best activity, and a smooth frequency-change throughout the temperature range.

**Fig. 6. At this bench the finishing work necessary to adjust the performance of the crystals to meet specified requirements is carried out.**

The crystal must fit a certain holder without too much side play. Although optimum dimensional ratios have been worked out for the length and breadth of the crystal based on the speed of supersonic vibrations through it, the exact values vary with the quartz structure and other conditions, and in any case must be so exceedingly precise that actual cut and try is invariably necessary. Whether to reduce the width or the length, increase the bevel of the edges or round a corner is something that can be told only by a little judicious and careful feeling out by an experienced finisher. The removal of a micron of length or width, etc., may be just enough; three microns may be too much.

While all this corrective work is going on, the frequency may be slowly rising as well so that if the wrong remedy is tried too many times the crystal may be too high in frequency by the time it has been made to operate properly otherwise. Although a crystal cannot be made thicker, methods of lowering the frequency a small amount have been devised and may be applied to some advantage, but it is usually assumed that a crystal made a few millionths too thin is a crystal spoiled.

It might seem from the number of operations involved, and the care necessary throughout, that a prohibitive amount of time would be consumed in the manufacture of a crystal. This is not the case, however, and at the present time the General Electric Company (U.S.A.) is producing over 300 close-limit crystals per week.

Final tests wherever practical are made by means of automatic equipment. This device saves testing time and produces a graphical record of the frequency shift of each crystal with changes in temperature from − 30 C to + 50 C (typical values) without supervision other than to install the crystals and start the run. Six crystals are tested simultaneously, the charts being analysed after each run to see that all conform to the specifications.

## Holders

The crystal mounting must be so designed and built as not only to permit free vibration of the crystal, but also to afford adequate protection against dirt, and in most cases against moisture. The holder consists primarily of the metal electrodes between which the crystal is mounted, the terminals which are used to connect these electrodes to the oscillator tube, and the housing which supports them and provides the protective covering. Holders may be classified according to their various features as follows:—

(1) Fixed-air-gap, adjustable-air-gap, or pressure types.
(2) Hermetically sealed or mechanically sealed types.
(3) Temperature-controlled, temperature-protected, or neither temperature-controlled nor temperature-protected types.

Any combination of these three groupings may be used as required.

For operation below about 1,800 kc, crystals of normal size will not work properly when clamped (owing to their abnormal ratio of thickness to length), hence they are mounted with a slight clearance between the upper crystal face and the upper electrode. Such holders are easier to adjust than those of the pressure type, for by increasing or decreasing the air gap some frequency change can be made. In some cases this adjustment is made during manufacture and cannot be altered. In other types, adjustment can be made as desired by the user.

The reason that a change in the air gap affects the crystal frequency is purely electrical, not acoustical. It simply changes the capacity between the crystal face and the electrode, which capacity being in series with the mechanical capacity of $C_m$ and inductance $L_m$ of the crystal produces a change in the total series capacity, and hence in the frequency. The air-gap capacity, although small, is large in comparison with $C_m$, and, therefore, produces only a fourth-order effect.

As the air gap is changed, however, there will be regularly spaced points at which the crystal activity will definitely diminish. This effect is acoustical, not electrical, and is a function of crystal frequency, and the supersonic vibrations set up in the air in the gap. It can be shown that this effect occurs whenever the magnitude of the gap is any multiple of a half wave-length of sound at the crystal frequency. When this condition exists, compression waves leaving the crystal face encounter compression waves rebounding from the electrode in such phase that a damping action is exerted on the crystal. This condition is not serious at the lower frequencies as the distance between successive damping points is fairly large, and the usual practice is to work the gap below the lowest critical point. For the higher-frequency crystals, however, it becomes more serious and necessitates even smaller gaps unless operation between a pair of points higher up can be used. Best operation, however, generally occurs below the first damping point.

Crystals for operation above 1,800 kc can be pressure mounted or rigidly clamped between electrodes. In such an arrangement, they cannot move about and, therefore, can be operated in any position without change of frequency. To ensure good operation, however, the pressure should be so high that ordinary plane electrodes would have a restraining effect. To solve this problem, recessed electrodes were developed. In these the central area is recessed to a depth that depends on the crystal frequency, leaving slightly raised corners or a circular embossing at the periphery. The crystal is of such size that only its corners are gripped by the electrodes, and the remaining 90 per cent. of the blank is left floating in air and free to vibrate. As mentioned previously, if this gap is of improper depth—that is, too deep or too shallow—it will prevent proper operation of the crystal.

Hermetic sealing is usually accomplished by soldering or electrically welding the metal cover and base together, and by using fernico wire and fused glass lead-ins. Mechanical seals are made by means of cements or flexible gaskets.

In the temperature-controlled units, used in precision equipment, and in some outdoor applications, there is a heater winding controlled by a thermostat of the mercury or bimetallic type (slow or snap-acting) which maintains the crystal temperature within close limits. The temperature-protected types, are similar except that the arrangement employed merely prevents the crystal temperature falling below some fixed value, usually the dew point.

There are three types of thermostats available for crystal-temperature control :—

(1) The mercury or contact-making thermometer type which is probably the most sensitive but somewhat fragile, which may not work properly upside down, and which, owing to its low-current-carrying capacity, generally requires an additional relay to carry the actual heater current. They are widely used, however, in stationary precision equipments, and are extremely temperature sensitive and dependable in such applications.

(2) The slow-acting bimetallic types are more sturdy, operate in any position, can be made nearly as sensitive as the mercury type, and can carry the full heater current. Under severe vibration they may, however, exhibit a tendency to chatter, and the resultant sparking causes radio interference.

(3) The snap-acting bimetallic type has all the advantages of the slow-acting type except sensitivity (as commercially made). It may require a considerable mass of metal of high thermal inertia next to the crystal to smooth out the thermostat cycle.

Electrodes are made as flat as the crystals themselves, and are chromium plated or made of hard, corrosion-resistant metals such as monel or stainless steel.

The insulation used has reasonably low loss and is physically stable, particularly that of the air-gap-type holders, where any shift in the air gap with temperature or vibration would change the crystal frequency. For example, in the case of a 1,000,000-cycle crystal running with a 0.0003-in. air gap, a change of only 0.0001 in. in this gap will change the crystal frequency about 15 cycles—and the tolerance allowed may be only 10 cycles. In the pressure-type holders used for crystals operating above 1,800 kc this condition does not occur, for slight variations in the spring pressure do not cause appreciable frequency change in a well-made crystal.

Another form of electrode known as the metallic-coated type is used in some cases, particularly at the lower frequencies. In these a thin metal coating such as aluminium is evaporated on to the crystal faces and is used in place of the two solid electrodes. The problem then becomes one of making positive and permanent connection to the coating. In some cases the contact is made by gripping the crystal between two " knife edges " at a nodal point. The knife edges support the crystal as well as make contact with the coating.

The utmost care is taken by the operator who places the crystal in the holder. The crystal and holder must be very carefully cleaned before assembling to exclude any dust, grease, or moisture.

## Effect of Light on Neon-tube Striking Voltage

A GAS-FILLED discharge tube, for example, a neon lamp, is often used to discharge a condenser automatically as soon as the potential difference between the plates of the condenser has risen to a certain value.

As the potential difference between the electrodes of the discharge tube is increased from a low value, practically no current passes through the tube until the potential reaches the so-called striking potential at which the discharge takes place and the tube is then capable of conducting comparatively large currents. In this state the potential may be reduced considerably below the striking potential before the tube ceases to conduct.

The striking potential depends amongst other things on the amount of light that falls on the tube. Thus a tube designed to have a striking potential of 90 volts in daylight may not strike until 123 volts are reached in complete darkness. The striking voltage can be stabilised, however, at the daylight figure if a small amount of luminous paint of the radium activated type be applied to the outside of the bulb.

## Book Review

CHAMBERS TECHNICAL DICTIONARY, published by W. R. Chambers, Ltd., 28, Soho Square, London, W.1. 15/- net.

This dictionary is a compilation of definitions of terms that are of importance in pure and applied science, engineering and the more important industries. It reveals the astonishing fact that at a rough computation there are over 42,000 of these. In all, the dictionary covers approximately a hundred subjects which include acoustics, radio, television, cinematography, telephony, chemistry, electrical and mechanical engineering, etc., etc. Definitions of each subject have been prepared by specialists in their own particular sphere, and the book, therefore, is quite authoritative. Correct pronunciation is indicated in those cases where it has been considered desirable, and when words have separate meanings in different sciences and industries a full explanation is given of each.

The editors are C. F. Tweney and L. E. C. Hughes, A.C.G.I., D.I.C., B.Sc., Ph.D., A.M.I.E.E., A.M.I.R.E., M.A.S.A., and they have certainly succeeded in presenting a very complete explanation of the language of science and technology. The book will be found invaluable to all engaged in the technical industries.

## GAS-FILLED TRIODES AND THEIR PRACTICAL USE—IV

# Methods of Control of Gas-filled Triodes

By G. Windred, A.M.I.E.E.

*One of the most important features of the gas-filled triode is its adaptability to a wide variety of applications. This adaptability arises largely from the fact that the flow of anode current may be controlled accurately in a number of ways by relatively simple means. The present article deals with the basic principles of these alternative methods of control.*

IT is possible to use either direct or alternating voltages on the anode and grid circuits of gas-filled triodes. The operating characteristics vary considerably according to the kind of supply used for the respective circuits, and this fact determines to a large extent the type of control required for a given application. In practice, the great majority of circuits employ alternating voltages, at least for the anode, so as to make use of the rectifying properties of the tube. In the interests of completeness it will be advisable to consider also the conditions applying to operation by direct voltages, although this method has only restricted application.

### 1. *D.C. Supply to Anode and Grid*

The circuit arrangement for this method of operation is shown in Fig. 1 at a. The grid potential is seen to be variable by means of a potentiometer, but always negative with respect to the cathode except in the extreme right-hand position of the slider when the grid potential is the same as that of the cathode, so that $v_g = 0$. The D.C. grid supply has a sufficiently high voltage to prevent striking of the anode discharge with the particular value of anode voltage employed. When the grid potential is reduced to a value corresponding to the critical grid voltage, the tube strikes and the resulting anode current is given by

$$I_a = \frac{V_a - V}{R}$$

where V is the arc drop measured from anode to cathode and R is the value of the non-inductive load resistance. Prior to striking, the voltage drop across the tube is equal to the applied anode voltage $V_a$, so that

$$V_a - V = 0$$
$$\text{and } I_a = 0$$

in accordance with the foregoing equations.

The possibilities of the circuit as a means of control are shown in Fig. 1b. It is here assumed that to begin with, no anode current flows, the applied grid potential $v_g$ being considerably more negative than the critical value. If now we assume that $v_g$ is reduced, by moving the potentiometer slider to the right, the critical value of grid voltage is reached eventually, as at the moment $t_2$ in Fig. 1, and at this instant the tube strikes. So long as anode voltage is maintained, subsequent variation of the grid potential, whether above or below the critical value, has no effect upon the flow of anode current owing to the neutralisation of the grid by positive ions flowing to it from the discharge.

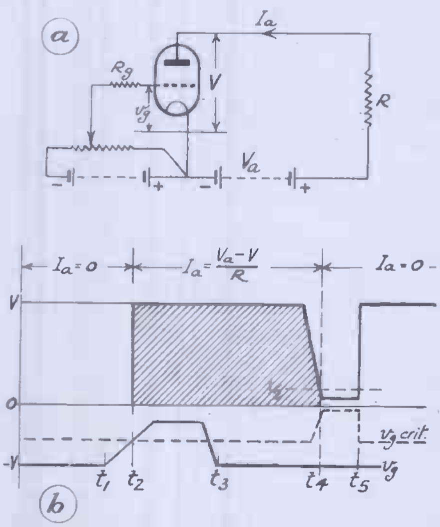



**Fig. 1. Circuit arrangement and operation of gas-filled triode with D.C. supply to anode and grid.**
**Correction : In the b figure, ½ should read $V_g$.**

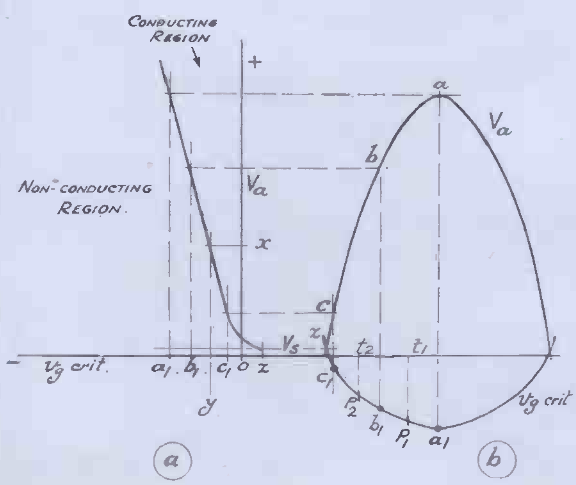



**Fig. 2 (left). Critical grid voltage curve applied to alternating anode voltage.**

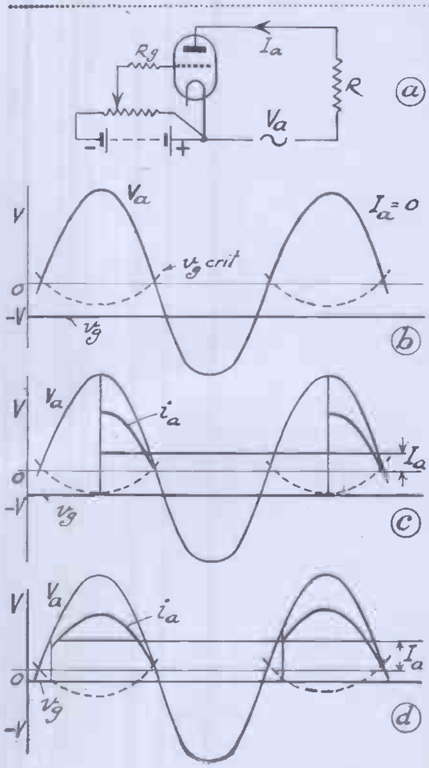



**Fig. 3 (right). Circuit arrangement and operation of gas-filled triode with A.C. supply to anode and D.C. supply to grid.**

# Gas-filled Triodes—*Windred*

The anode current flow stops only if the anode circuit is interrupted, or its voltage reduced below the minimum voltage at which the discharge will persist. This quench voltage varies according to the nature of the gas filling, and usually lies between the approximate limits of 10 and 20 volts. It is represented by $V_q$ in Fig. 1.

If the anode voltage is reduced more or less gradually, while the grid voltage is maintained more negative than the critical value, the quenching point is eventually reached at the moment $t_4$, and the flow of anode current ceases. It will be noticed that the critical grid voltage changes during variation of $V_a$ in order to preserve a constant relationship between the two. If now the anode voltage is increased again, as at $t_5$, the discharge does not restrike, provided that $v_g$ is at all times greater than $v_g$ *crit.*, and the conditions are now the same as they were previously, with $I_a = 0$. It is seen that any number of these discontinuations of anode current may be carried out provided that $v_g$ is greater than $v_g$ *crit.* and that $V_a$ is brought to zero or less than $V_q$. The time interval between $t_4$ and $t_5$ must be greater than the deionisation time of the tube; otherwise the discharge will restrike.

The necessary reduction of anode voltage may be effected without actual reduction at the source. If, for example, an uncharged condenser is connected between the anode and cathode, so as to shunt the discharge path, it will act virtually as a short-circuit at the moment of connection and thus cause the discharge to fail. At the same moment, the voltage across the condenser, i.e., across the discharge path, commences to rise and the condenser current commences to fall until, after the lapse of an interval depending upon the size of the condenser, the voltage across it becomes equal to the applied voltage and the current becomes zero.

Whether or not the discharge through the tube restrikes in the meantime depends upon the result of a race, as it were, between the deionisation process in the tube immediately following extinction, and the rate of rise of voltage across the condenser. The conditions required to prevent restriking are sufficiently large capacitance and a high negative grid voltage. The large condenser retards the rate of voltage recovery across the discharge path and the high negative grid voltage ensures rapid neutralisation of the ions in the discharge path, as well as prevention of anode current flow when the voltage reaches its normal value.

There are several modifications of this method of operation. In one case the condenser is connected across the tube through the anode of a second gas-filled triode; both tubes being arranged for independent grid control. In this case the necessity for manual switching of the condenser is eliminated.

## 2. *D.C. Supply to Anode. A.C. Supply to Grid*

This case has only slight interest from the practical viewpoint. If an alternating voltage be imagined substituted for the direct grid voltage $v_g$ in Fig. 1b it will be seen that there is a continuous flow of anode current, regardless of any alterations in magnitude or phase of the alternating grid voltage. The only exception to this condition arises in the case where at the moment of switching on the anode voltage the negative loop of grid voltage is taking place and its instantaneous value exceeds $v_g$ *crit.* Conduction will then be delayed by the interval required for the instantaneous grid voltage to become equal to the critical value. In ordinary circumstances this would be a purely chance occurrence, but with a means of determining precise moments in the grid voltage wave at which anode voltage shall be applied it would be possible to ensure delayed commencement of anode current flow by an interval depending upon the frequency of $v_g$.

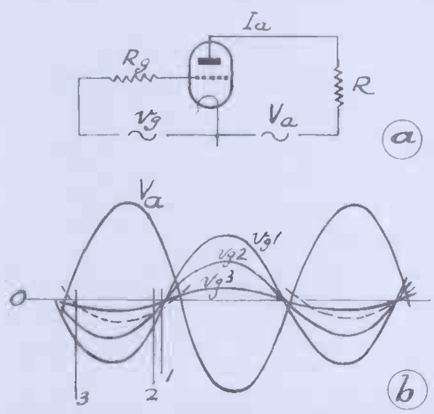



**Fig. 4. Circuit arrangement and operation of gas-filled triode with A.C. supply to anode and grid.**

## 3. *A.C. Supply to Anode, D.C. Supply to Grid*

The use of an alternating anode voltage introduces many important possibilities, since the anode voltage passes through zero automatically at the end of each half-cycle. It follows that if conduction occurs during any part of a positive half-cycle the flow of anode current will cease at the zero of anode voltage, or more strictly when the instantaneous value of voltage across the tube reaches the quench value. After the lapse of the deionisation time, during the negative half-cycle of anode voltage when no anode current can flow, the conditions in the tube are the same as before conduction took place. The point at which conduction starts in the next positive half-cycle, or whether it starts at all, depends upon what has happened to the grid potential in the meantime.

The conditions are best understood by plotting the relationship between critical grid voltage and anode voltage during a positive half-cycle. This is shown in Fig. 2, where a is the usual grid control characteristic. For a given value of positive anode voltage, such as x in the diagram, the applied grid voltage must be more negative than y in order to prevent conduction, and so on for all values of $V_a$ throughout the curve. The lower end of the curve has some rather special features. In the first place, the linear relationship between $V_a$ and $v_g$ *crit.* is departed from; lower values of grid voltage being sufficient to prevent conduction. The curve does not normally pass through the origin, and the condition $v_g$ *crit.* $= 0$ corresponds to a definite positive value of $V_a$. In order to allow conduction for lower values of anode voltage it is necessary for the grid to be made positive, and the limiting case is represented by the minimum striking voltage $V_s$ of the tube with a positive grid voltage z.

It must be pointed out that this part of the characteristic curve varies considerably among different types of tube, and there may be appreciable differ-

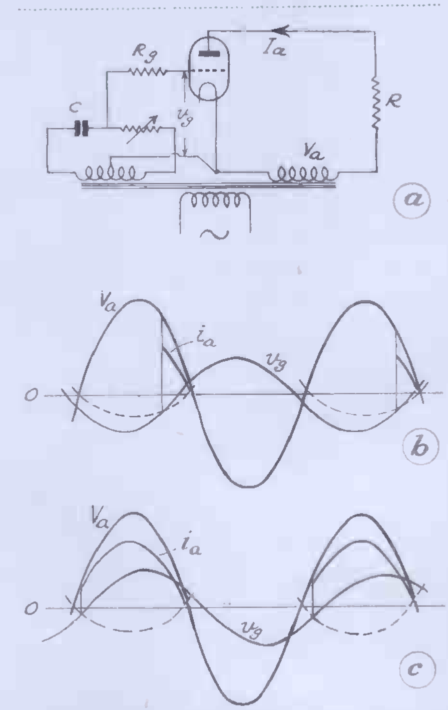



**Fig. 5. Circuit arrangement and operation of gas-filled triode with phase-shift control.**

# Gas-filled Triodes—*Windred*

ences even among tubes of the same type. The curves issued by manufacturers seldom give any information concerning this region.

In Fig. 2b, values of critical grid voltage have been plotted beneath a positive half-cycle of alternating anode voltage $V_a$. The crest value of $V_a$, corresponding to point a, requires a grid voltage $-a_1$ to prevent conduction. Likewise with intermediate values of $V_a$ such as b and c the critical grid voltage has the intermediate values $b_1$ and $c_1$ respectively At the instant when $V_a = V_s$ the critical grid voltage has the small positive value corresponding to point z.

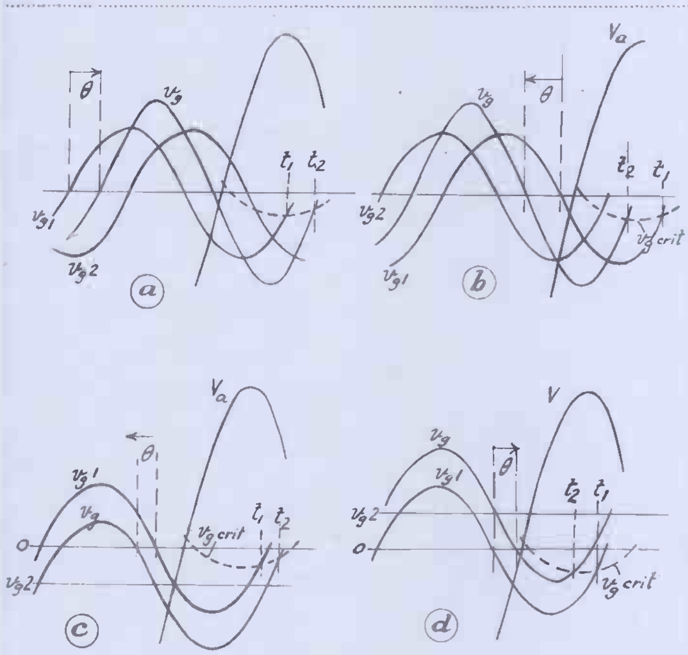


Fig. 6. **Change of striking point by means of supplementary grid voltage.**

The complete curve for $v_g$ *crit.* represents the striking value of grid voltage at every instant during the half-cycle. Conduction will occur at the instant when the applied grid potential is less negative than the particular value of $v_g$ *crit.* corresponding to the curve at that instant. If, for example, this condition occurs at point $P_1$, then conduction commences at the instant $t_1$, whereas if it occurs at point $P_2$ the conduction starts earlier, at $t_2$, and lasts longer in each half-cycle, since the anode current is automatically quenched at or near the stage when $V_a$ passes through zero.

These relationships are modified if the anode voltage wave departs from sine shape. The presence of harmonics, or distortion caused by transient conditions due to switching may change the wave shape considerably, and estimates of striking time based on the assumption of a sine wave would necessarily be inaccurate in such cases. When the wave shape of $V_a$ is known, the correct values of striking time may be estimated on the basis of a critical grid voltage curve showing the true relationship between $V_a$ and $v_g$ *crit.* at every instant.

With the aid of Fig. 2b we may now consider the simple case of direct voltage grid control when $V_a$ is alternating. The circuit is shown in Fig. 3a, and differs from Fig. 1a only in the use of an A.C. supply for the anode circuit. The nature of the control obtained can be followed from the diagrams in Fig. 3 at b, c and d. In the case of b the grid voltage is high enough to prevent conduction at any point, and no current flows in the anode circuit. If $v_g$ is gradually reduced, the condition shown at c is reached. The grid voltage coincides with the critical value at the maximum point, corresponding to the crest value of $V_a$. Anode current commences to flow at this point, and continues until the end of each positive half-cycle.

When the anode circuit is non-inductive there is no distortion of the anode current wave, which will accordingly follow the sine law, if $V_a$ is a sine wave, from the point of striking. The mean value of the unidirectional anode current $I_a$, as indicated by a moving coil ammeter is in this case the minimum obtainable with this form of control, since the line representing $v_g$ cannot intercept the critical grid voltage curve any later in the cycle.

It will be seen that if $v_g$ is kept steady, and $V_a$ does not vary in shape or magnitude, the point of striking will be at the same instant in each positive half-cycle, and $I_a$ will have a steady value. If now $v_g$ is further reduced, as shown in diagram d the instant of striking is advanced, so that anode current flows longer in each positive half-cycle and the value of $I_a$ shows a corresponding increase. Maximum anode current flows when $v_g = O$, in which case the tube strikes early in the cycle.

The precise striking point depends upon the tube characteristic. In the case of a tube having the characteristic shown in Fig. 2 the grid would require to be made slightly positive to secure earliest possible striking, corresponding to the instantaneous anode voltage $V_s$. It is seen that with this form of control the average anode current can be regulated between the limits of $I_a$ *max.* and $\frac{1}{2}I_a$ *max.*, where $I_a$ *max.* is the greatest value of anode current, corresponding to conduction over practically the whole of the half-cycle. The smoothness of regulation is determined by the smoothness with which the grid voltage may be changed. Any jumps in the value of $v_g$ will cause corresponding jumps in $I_a$.

It is important to notice that any roughness in the applied anode or grid voltages will change the conditions from those depicted in Fig. 3. If, for example, the grid voltage is taken from a generator without special smoothing arrangements, the superimposed ripple will give rise to changes in the striking point. If the ripple is of constant magnitude and the generator is in step with the alternating anode voltage the anode current meter reading will be steady, but in general where accurate control by this method is desired it is best to use a battery supply for $v_g$. It is equally necessary that $V_a$ should have a steady value.

A further point which must be mentioned is the effect of inductance in the anode circuit. This causes a more gradual rise of current after the striking point and retards the peak anode current in relation to the anode voltage. During the conduction period, inductive energy is stored in the anode circuit, and is dissipated when the anode voltage passes through zero at the end of the cycle. The resulting changes in the circuit conditions are best neglected when dealing with fundamental processes, and it is preferable to limit the considerations to the case of a non-inductive anode circuit, where instantaneous values of anode voltage and current bear a constant relationship to each other.

## 4. *A.C. Supply to Anode and Grid*

The method of control represented by the simplified diagram in Fig. 4a makes use of A.C. supplies both for the anode and grid circuits. There are

## Gas-filled Triodes—*Windred*

several ways of arranging the circuit in practice. Either or both supplies may be taken from the mains, through potentiometers for example, or the respective circuits may be fed from suitable windings on a transformer. In this case, the heater would normally be fed from a third secondary winding, which would be connected to the anode and grid circuits as shown.

If it be assumed that the grid voltage may be varied in magnitude and its phase fixed in some predetermined relation to that of the anode voltage, the conditions of operation are as shown at b in Fig. 4. Diagram b represents the conditions when the phase of $v_g$ differs by nearly 180 degrees from that of $V_a$. If the grid voltage has a high value, as represented by the curve $v_{g1}$, conduction commences at a point 1 late in the cycle, and a small anode current flows. If $v_g$ is reduced, its slope through zero becomes less, and the point of conduction is moved forward to position 2, corresponding to a higher anode current. Further reduction of grid voltage, as indicated by $v_{g3}$ increases $I_a$ still more, until in the limiting case when $v_g = O$ the anode current is a maximum. If $v_g$ is increased again while its phase position remains fixed, the point of striking is correspondingly retarded and the anode current reduced.

It is thus possible to control $I_a$ with a degree of smoothness determined by the smoothness with which the magnitude of $v_g$ may be varied. For the particular phase position shown, the anode current cannot be altogether interrupted, regardless of how high $v_g$ is made. The smaller the difference in phase between $V_a$ and $v_g$, the smaller is the range of current control and the larger the minimum value of current.

More complete control is given by the arrangement shown in Fig. 5. From the connection diagram it will be seen that the grid is supplied with alternating voltage from an auxiliary circuit consisting of a resistance and condenser connected across a centre-tapped secondary winding on the supply transformer. If desired, an inductance may be used in place of the condenser; the object in either case is to use a component with which the voltage drop will be approximately at right-angles to that of the resistance. This condition ensures a change of phase in the applied grid voltage relative to the phase of the corresponding transformer winding, and therefore in general also with respect to the anode voltage supply, regardless of whether this is as shown in the diagram or taken direct from the supply mains. Furthermore, the phase of $v_g$ may be varied between wide limits by adjusting the values of one or both of the respective components forming the bridge circuit. A considerable range of adjustment may be obtained by varying only the resistance, and this arrangement is often more convenient than varying capacitance or inductance. On the other hand, the latter quantities admit of variation without mechanical friction, such as by varying the distance between condenser plates or their effective area, or varying the position of a magnetic core or armature relative to an inductive winding. By using a selenium resistance, the response could be made dependent upon variations in light intensity.

The operation of this method of control is shown at b and c in Fig. 5. In the first of these diagrams, $v_g$ is nearly 180 degrees out of phase with $V_a$, and conduction is accordingly late in the cycle, so that only a small anode current flows. As the phase of $v_g$ is progressively brought nearer that of $V_a$ the point of striking becomes earlier so that the anode current increases, as shown at c. The extreme limits of current regulation by this method are seen to be

1. When the phase difference between $v_g$ and $V_a$ is 180 degrees, $I_a = O$.
2. When the phase difference is zero, $I_a = I_a$ *max.*, corresponding to full conduction.

All intermediate values of current are possible if the phase regulation is sufficiently smooth.

It is important to observe that the amplitude of $v_g$ must exceed that of the critical grid voltage curve. It may also be pointed out that the greater the amplitude of $v_g$, the more clearly defined is the striking point, since the relative slopes of the curves representing $v_g$ *crit.* and $v_g$ are then more widely different. When there is only slight difference of slope, any variation in the critical grid voltage curve due, for example, to temperature variations in the tube will cause a shift of striking point without any variaton of $V_a$ or of the phase or magnitude of $v_g$ having taken place.

### 5. *The Mixing of Grid Voltages*

It is possible to use two or more grid voltages simultaneously for controlling the anode current in a gas-filled triode. Such an arrangement introduces the possibility of making the control dependent upon more than one factor, and is a very useful feature in some cases.

With reference to the connection diagram in Fig. 5a, we may consider the effect of introducing a second alternating grid voltage from a source connected in series with the grid lead from the phase-shift bridge. This source may take the form of a suitable transformer secondary in which the required supplementary grid voltage may be induced.

If the supplementary voltage, which we will call $v_{g2}$, is in phase with the voltage $v_{g1}$ from the phase-shift bridge, the total grid voltage $v_g$ at any instant will be $v_{g1} + v_{g2}$. A certain degree of variation of striking point, and hence of anode current, will be obtainable by varying the magnitude of $v_{g2}$, since this will simply vary the magnitude of the resultant grid voltage. Similar considerations apply when the supplementary voltage is 180 degrees out of phase with $v_{g1}$. In this case $v_g = v_{g1} - v_{g2}$, at any instant, so that with equal amplitudes of the component grid voltages $v_g = O$ and maximum anode current flows.

Different conditions occur when $v_{g2}$ differs in phase from $v_{g1}$, as shown in diagram a of Fig. 6. In this case, the phase displacement is 90 degrees behind $v_{g1}$, and the phase shift of the resultant grid voltage is by an amount $\Theta$ in the same direction. If $v_{g2}$ is 90 degrees in advance of $v_{g1}$, as shown at b, the direction of phase shift is reversed, although it is of the same amount if the values of $v_{g1}$ and $v_{g2}$ are the same. It will be seen that if the respective voltages are arranged with suitable phase relationship to the anode voltage it is possible to obtain control of anode current by varying the phase or relative magnitude of the component grid voltages.

### *Phase-shift Control*

Phase-shift control may be obtained also if $v_{g2}$ is a direct voltage. In Fig. 6c, for example, a negative direct voltage $v_{g2}$ is superimposed on $v_{g1}$. The resultant grid voltage $v_g$ is seen to be a displaced sine wave, and the change is accompanied by a change of striking point from $t_1$ to $t_2$ when the voltages are disposed as shown with respect to the anode voltage. This change corresponds to a reduction of anode current, since $t_2$ is later than $t_1$. If $v_{g2}$ is positive, as shown at d in Fig. 6, the phase-shift is in the opposite direction, and the new striking point $t_2$ is earlier, so that more anode current flows. It follows that phase-shift control of anode current may be obtained by varying the polarity and magnitude of a direct voltage superimposed upon a constant alternating voltage. It will be evident that control by any of these methods will be considerably affected by the presence of ripples or other transient conditions in the respective sources of voltage, and careful attention to this matter is necessary in arranging such circuits.

# News Brevities—

## Commercial and Technical

THE Columbia colour television system was demonstrated to a group of commissioners and members of the staff of the Federal Communications Commission on September 27, and the new development was discussed in detail with the inventor, Dr. Peter G. Goldmark.

Dr. Goldmark also presented a new experimental "magnified" screen development which, for comparative purposes, enlarged the colour picture images by approximately 80 per cent. without loss of detail.

The opinion was expressed that the new development had confirmed the commission's judgment in postponing the establishment of fixed standards six months ago.

Following the demonstration, the group discussed with Columbia officials the possibility of early colour television for the public, the possibility of colour pictures of two-foot size for home reception and the effect of colour upon television programmes and on public interest. Particular interest was expressed in the feasibility of converting ordinary black-and white receivers into colour receivers. Dr. Goldmark pointed out that such conversion would be easy and inexpensive on sets built to anticipate such conversion, but would be more expensive, and therefore might not be practical on sets which have already been sold without provision for colour.

Technical details of the new system were published in our November issue.

* * *

Application has been made by the General Electric Company (U.S.A.) to the Federal Communications Commission for permission to extend the power of its FM station, W2XOY, from the present power of 2,500 watts to 50,000 watts. Operating on 43.9 megacycles, W2XOY is located on the Helderberg Mts., 1,200 feet above the valley floor. It overlooks Albany, Schenectady, and Troy and will serve an area of 16,030 square miles populated by 1,560,000 potential listeners.

Transmissions from the G-E frequency modulation station which is housed in the same building as the G-E television station, W2XB have been made for some months.

W2XOY's 50-kilowatt transmitter will comprise a 250-watt and 3-kw transmitter as the exciter for the 50-kw. amplifier. Both the 3-kw and 50-kw units employ new valves developed particularly for frequency modulation and television transmitters.

A specially designed 3-bay turnstile aerial will be used for the new station.

* * *

An American newspaper, the *Philadelphia Inquirer,* claims that by employing a photo-electric system of register control on a rotogravure colour press, approximately $15,000 a year are saved, this resulting from a reduction in waste of from 7 to 3 per cent.

A brief description of the register control is given in the October, 1940, issue of *Electronics* (America). The press operates at a web speed of approximately 1,000 feet per minute. Each colour unit in the press is fitted with two photo-electric scanning heads, one of which scans the margin of the web of paper as it moves through the press. On this paper are register or index marks equally spaced and printed simultaneously with the first colour impression. The second photo-electric scanning head is so arranged that it scans a disc attached to the printing cylinder. When the marks on the paper and the disc on the printing cylinder are accurately in register, the two scanning heads produce synchronous impulses.

If the paper gets ahead of, or falls behind the disc on the printing cylinder, the two sets of impulses are not synchronised, a net control voltage is produced, and relayed through thyratrons to a pilot motor which advances or retards the position of the paper with respect to the printing cylinder until synchronism is again achieved. Thus, it is possible to maintain automatically four-colour impressions within the narrow tolerances necessary to avoid fringes of colour in reproduction.

The Executive Committee of the British Kinematograph Society has decided experimentally to resume general meetings of the Society on Saturday afternoons.

The first meeting was held on November 16 at the Gaumont-British Theatre, Film House, Wardour Street, W.1, when the programme included a Presidential Address by A. G. D. West, M.A., B.Sc.; talks by news-reel cameramen who shot the historic films of Narvick and Dunkirk, and more recently of the warfare around our coasts; a demonstration of the R.A.F. camera-gun, and films of actual aerial combats taken with it.

Particulars of future meetings can be obtained from the Organising Secretary (R. Howard Cricks), British Kinematograph Society, Dean House, 2 Dean Street, London, W.1.

* * *

The Crossley Corporation (America) are making plans to build a television transmitter in Cincinnati. The constructional permit has already been granted by The Federal Communications Commission. The new station will operate on television channel No. 1 (50,000 to 56,000 Kc.) with 1 Kw of power for vision and sound.

# DESIGN FOR AN AUDIO-FREQUENCY GENERATOR

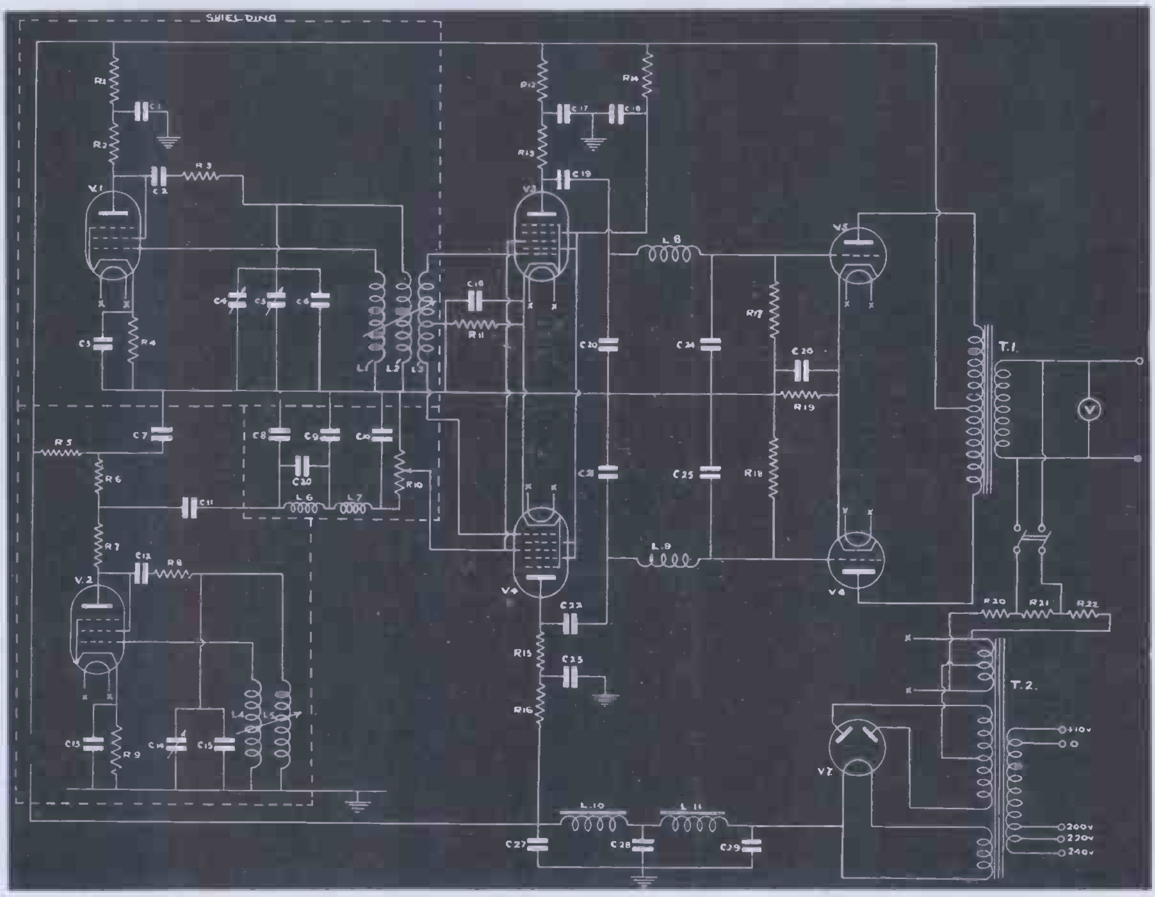
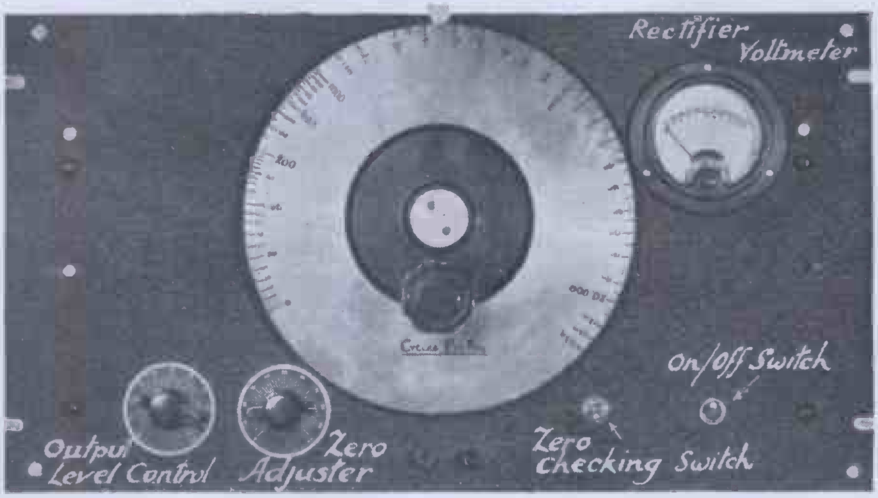


Fig. 1. The complete circuit diagram of the audio-frequency generator.

ONE of the most useful pieces of apparatus that the experimenter and professional engineer can possess is an audio-frequency generator or beat-frequency oscillator designed to cover the whole of the audio-frequency spectrum. If the apparatus is to function satisfactorily several important problems and requirements must be solved before a final design can be made. It is proposed in this issue to devote some space to the consideration of these problems and in the next issue the complete design for an A.C. mains-operated A.F. generator will be provided.

An audio-frequency generator is one in which two radio-frequency voltages of slightly different frequency are caused to heterodyne each

**Front panel of the complete instrument showing the large hand-calibrated dial.**




**As will be seen from this photograph, the oscillator is built on substantial lines to ensure mechanical rigidity.**

## This equipment, designed by J. C. G. Gilbert, A.M.I.R.E., A.M.I.W.T., F.R.S.A., covers the audio-frequency range from 10 to 23,000 cycles per second. The construction is simple and efficiency is guaranteed.

other, the resultant difference being the required audio frequency. By suitable design a variable condenser having a capacity of 0.001 $\mu$F maximum will enable a frequency range of 0 to 25,000 c.p.s. to be reached. This is done by having one fixed oscillator and one variable one, the 0.001 $\mu$F condenser being used as the capacity for the variable tuned oscillator.

Of the difficulties that arise, that of "pulling" between the two R.F. oscillators is of major importance. This tendency becomes very pronounced when the two R.F. frequencies are approximately equal, for then the oscillators tend to lock in synchronism. This difficulty can be overcome by placing buffer valves between the two oscillators and the demodulator stage, and completely screening each oscillator from each other. Again, the R.F. voltages that appear on the grid of the demodulator valve are $F_1$, $F_2$, $F_1+F_2$, $F_1-F_2$, and the fundamentals and harmonics appear in the anode circuit. Hence very good low-pass filters must be employed so that the only voltage to appear on the grid of the A.F. output stage is that of $F_1-F_2$, i.e., the A.F. output. The omission of this low-pass filter will cause the A.F. amplifier to be overloaded with unnecessary signals, and the subse-

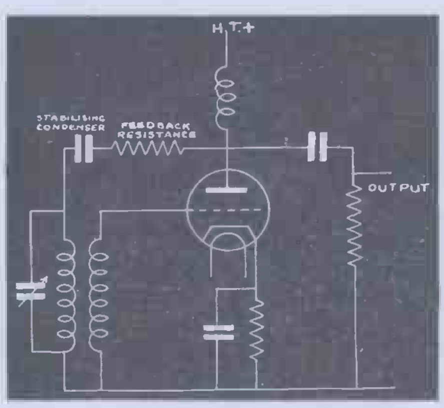
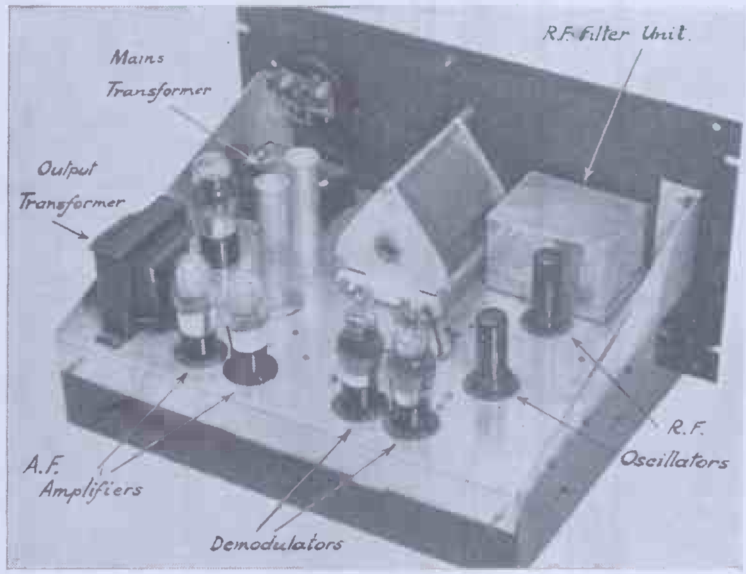



**Fig. 2. The basic circuit arrangement of the two R.F. oscillators showing the negative resistance feed-back.**

quent heterodyning will cause unwanted beat notes.

The amplitude of the A.F. output should remain constant over the complete frequency range. This can be accomplished by making the output voltage from the fixed oscillator small compared with the variable frequency oscillator. Provided that the de-



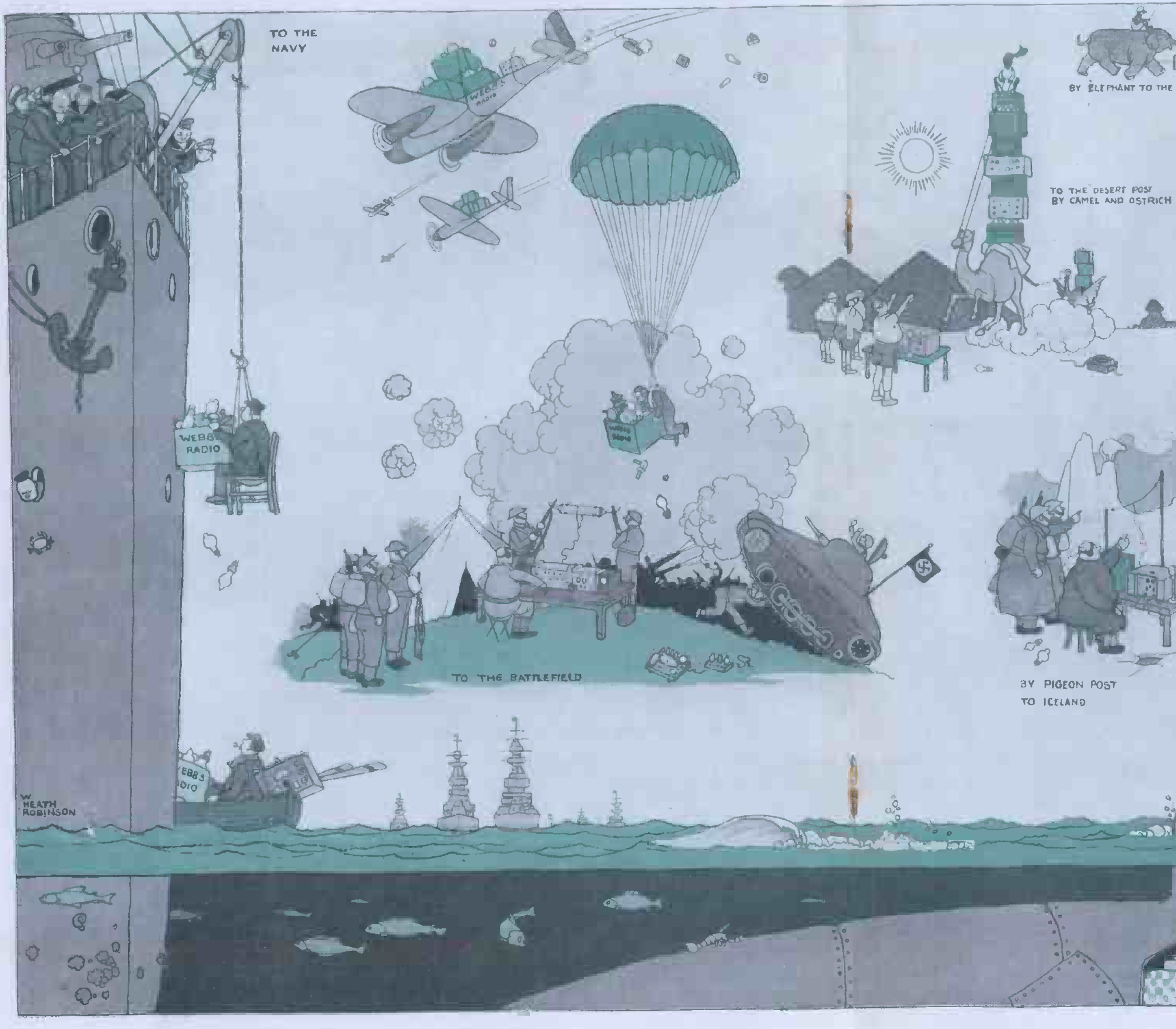

**Rear view of instrument showing the positioning of the valves. On the right are the two triode oscillators, the centre pair the push-pull demodulator, whilst on the left are the two push-pull amplifiers.**

modulator system is linear over its operational range, the A.F. amplitude will be independent of frequency changes, and the waveform will be sinusoidal.

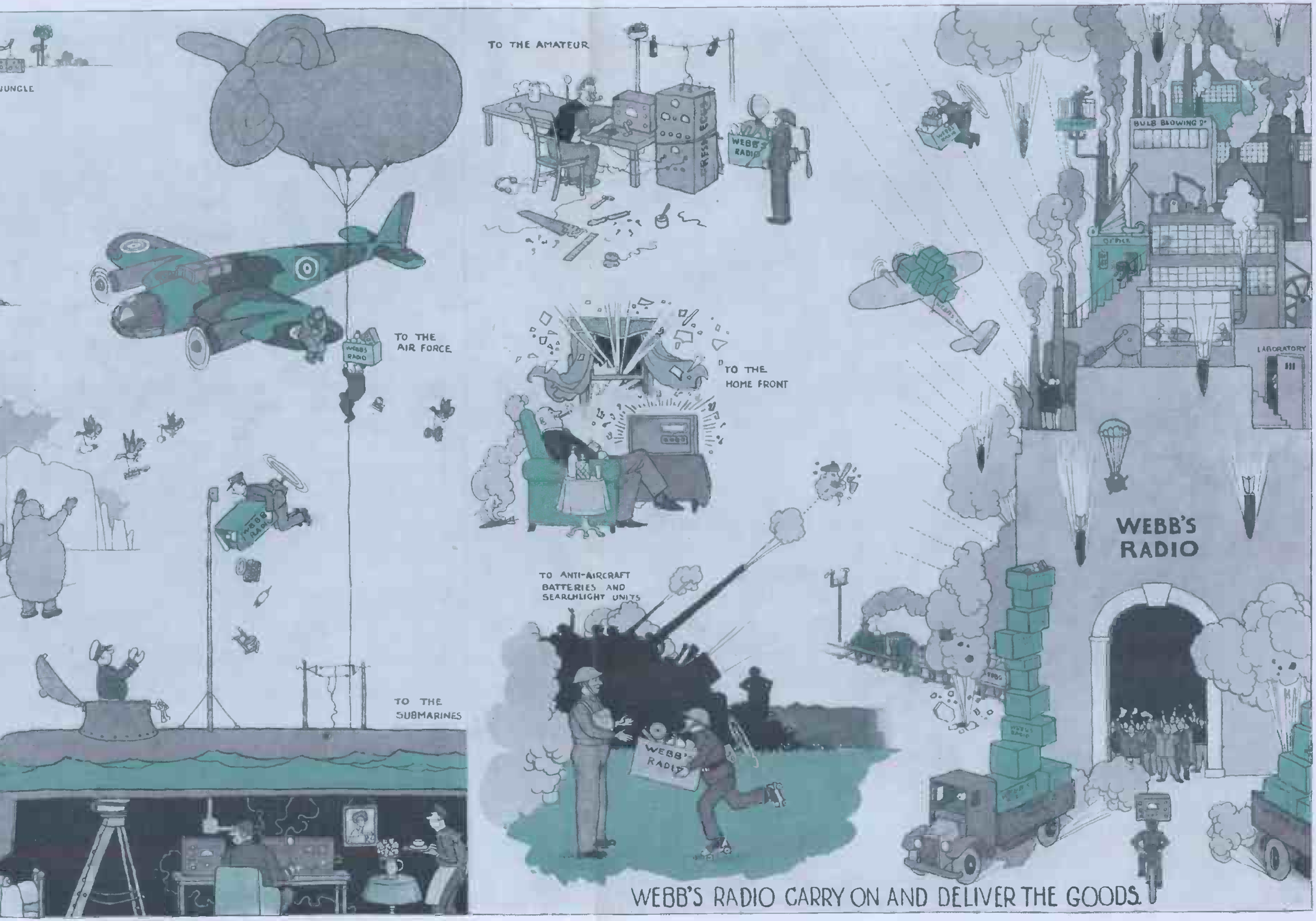
In order to minimise frequency drift, due to one oscillator slightly changing its frequency and causing a considerable change in the audio-frequency valve, it is necessary to build both oscillators as symmetrically as possible, prevent temperature changes over a long-time period, and minimise fluctuations in the main H.T. voltage supply. By the provision of a very small variable capacity in parallel with the main tuning condenser, the adjustment of zero beat is facilitated. Means of checking the calibration should be readily available and in the completed instrument a rectifier voltmeter is used to accomplish this calibration in conjunction with a cathode-ray tube and sinusoidal time base.

Many different circuit arrangements have been used for A.F. generators, but one of the most ingenious and stable is that designed by H. W. Anderson, who is Chief Engineer of the American station KFAC, and the oscillator to be described is based on his original work and that of Professor F. E. Terman of Stanford University, U.S.A. The stability of radio-frequency oscillators is dependent on the temperature co-efficients of the tuning coils, and associated components, whilst the mechanical rigidly of the variable tuning condenser dictates the short period stability. When an oscillator is operated between 100 to 200 kc. the type of stabilised circuit shown in Fig. 2 has great frequency stability. The advantage of this circuit is that the anode feed-back resistance maintains the effective anode resistance constant in spite of anode voltage changes, whilst the fixed condenser keeps the frequency stability practically constant regardless of the ageing of the oscillator valve.

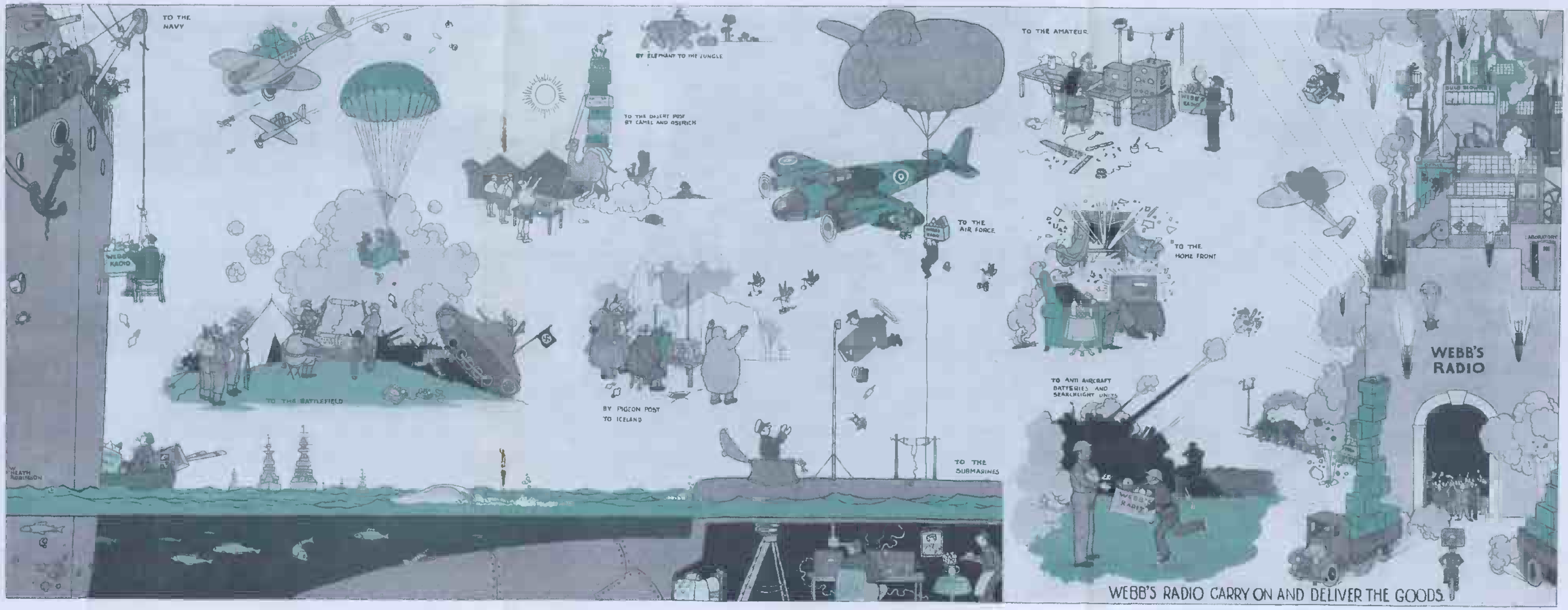
If the General Radio type 539X 900 $\mu\mu$F condenser is used in conjunction with a fixed condenser of .002$\mu$F and a tuned circuit resonant around 130 kc., the audio-frequency output will cover a range from 0 to 23.000 c.p.s. This particular condenser has been specially designed for audio-frequency generators, having a spread out scale on a practically logarithmic basis. Besides being very rigidly built its




*Advertisement of WEBB'S RADIO, 14 SOHO STREET, LONDON, W.1. (Gerrard 2089).*



JUNGLE
TO THE AMATEUR
WEBB'S RADIO
BULB BLOWING Dt
OFFICE
TO THE AIR FORCE
TO THE HOME FRONT
LABORATORY
WEBB'S RADIO
TO ANTI-AIRCRAFT BATTERIES AND SEARCHLIGHT UNITS
TO THE SUBMARINES
WEBB'S RADIO
WEBB'S RADIO CARRY ON AND DELIVER THE GOODS.


TO THE NAVY
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BY ELEPHANT TO THE JUNGLE
TO THE DESERT POST BY CAMEL AND OSTRICH
BY PIGEON POST TO ICELAND
TO THE AIR FORCE
TO THE SUBMARINES
TO THE AMATEUR
TO THE HOME FRONT
TO ANTI AIRCRAFT BATTERIES AND SEARCHLIGHT UNITS
WEBB'S RADIO
WEBB'S RADIO CARRY ON AND DELIVER THE GOODS.
W. HEATH ROBINSON

# AUDIO-FREQUENCY GENERATOR—GILBERT

losses are extremely low, being in the order of $R\omega C^2 = 0.03 \times 10^{-12}$.

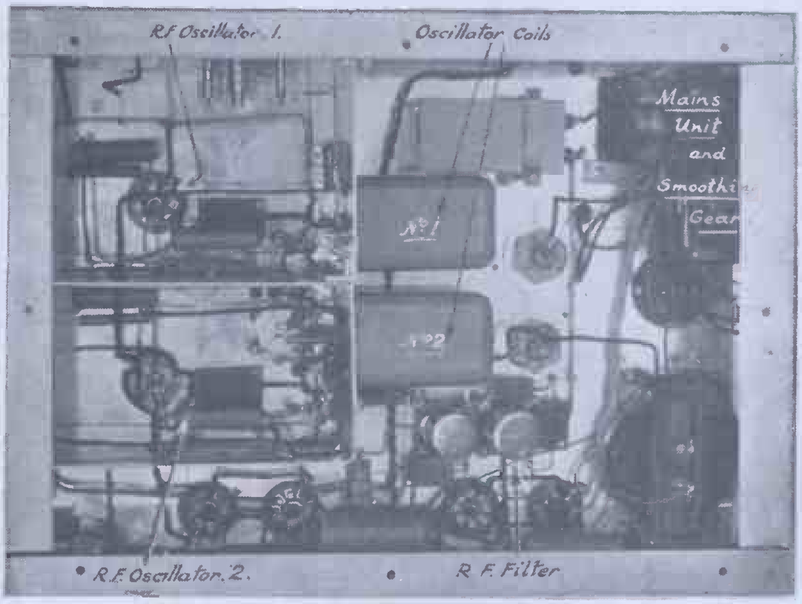
In the final design, the fixed oscillator frequency operates at 130 kc. whilst the variable oscillator is adjustable from 107 to 130 kc. In order to cover this range a silvered mica condenser of .002 $\mu$F is necessary and this must be of a type that is free from temperature and capacity changes. The design necessitates the use of high "Q" coils and the use of Litzendraht wire is imperative in order that the $\frac{\omega L}{R}$ ratio is kept high. It is particularly necessary with the resistance stabilised oscillator that the grid-to-anode coupling should be as close as possible and the coils are therefore pile wound. As the whole of each R.F. stage and coil are screened it is desirable that as large a coil can as possible is utilised in order to obtain the necessary heat radiation and maintain a constant temperature within the coil cans. In order to secure similar temperature changes the coil cans are mounted as near as practicable to each other, and as far from any heat liberating component as the layout facilitates.

Mechanical rigidly of the chassis, wiring and suitable location of the components is necessary in order to preserve frequency stability. The original chassis was constructed from 16 s.w.g. aluminium sheet, but as this metal is now unobtainable, tinned sheet iron can be successfully used. The individual screens for the separate oscillators, together with the base cover, are constructed from the same material.

Triode oscillators of a low impedance type are used, and 6F6 valves having the screened grid and anode strapped together produce excellent results. The values of the feedback resistance and blocking condenser are chosen so that the valve just oscillates, and provided that the valves conform to the maker's characteristics, the value of the resistance is approximately 5 to 8 times that of the anode impedance. The value can be calculated from the formula $R = Ra(u-1) - Ro$

where R = feedback resistance
Ra = anode load resistance
u = amplification factor
Ro = valve's A.C. impedance

The output from the variable oscillator is fed via a split secondary R.F. transformer to the control grids of two 6L7 demodulator valves. The signals on these grids are 180° out of phase with each other, whilst the signal from the fixed oscillator after passing through a low-pass filter and attenuator designed to have its maximum attenuation at 260 kcs., i.e., the second harmonic of the oscillator, is fed in phase to grids No. 3. Thus electron coupling within the demodulator valve is achieved, which greatly reduces the possibility of the two oscillators locking in synchronism.




**Underside of chassis. Note the symmetrical layout of the two R.F. oscillators and the very rigid 14 s.w.g. wiring to prevent frequency drift.**

In order to prevent either $F_1$, $F_2$ or $F_1 + F_2$ frequencies appearing at the grids of the push-pull output stage, a further R.F. filter is included between each 6L7 valve and the output valve. This filter is designed to cut off around 50 kcs., and is terminated by the grid resistors of the two push-pull output triodes, type 6C5.

As the audio-frequency generator is designed to cover an extremely wide audio-frequency range, the choice of the push-pull output transformer presents several problems. It must necessarily cover the A.F. generator range with the minimum of frequency attenuation and phase shift. Finally, a special transformer was designed by Mr. N. Partridge, and on measurement it was found to be 1 DB down at 20 and 20.000 c.p.s. Even at less than 1 c.p.s. the transformer operates satisfactorily, although the overall waveform does not remain sinusoidal. With an output power of 6 milliwatts into a 500Ω load resistance the total harmonic content at 800 c.p.s. upon measurement was 0.3 per cent.

By using medium impedance output valves the total heat dissipation is kept down to a low limit, thus assisting in the reduction of frequency instability. The power supply is quite conventional, adequate smoothing being provided in order to prevent any mains hum being induced in the output transformer. The smoothing chokes are of the constant-inductance type, and by using a push-pull circuit, fluctuations in the H.T. line voltage is largely overcome.

In order that the apparatus can be checked before use, a small A.C. voltage is taken from the mains transformer and fed into the secondary of the output transformer. As a great majority of A.C. mains are frequency controlled, and the audio-frequency generator is set to 50 c.p.s., a beat frequency should be produced, but as it will be of the order of a few cycles per second, a rectifier-type voltmeter is coupled in parallel with the output transformer secondary. When the checking switch is closed

(*Continued in 3rd column of page 558*)

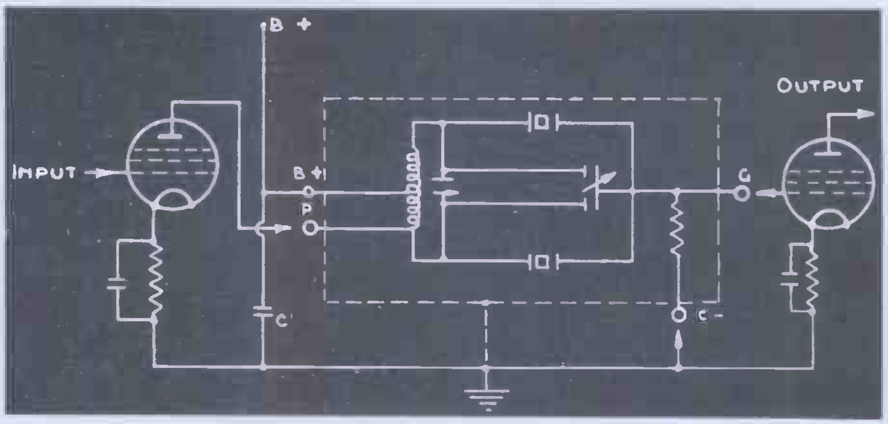



Fig. 1. Telegraphy filter circuit.

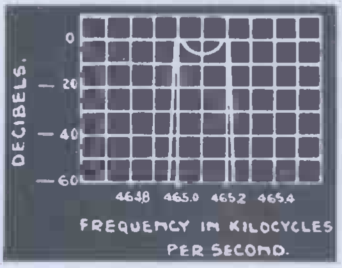



Fig. 2. Telegraphy filter response curve.

# New Double-crystal Band-pass Filters

By W. A. FLINT

## A New System Employing Pairs of Matched Crystals

A NEW double crystal unit which provides a new technique in radio reception has recently been put on the market by Simmonds Accessories, Ltd., Great West Road, Brentford.

The standard filter consists of a pair of matched crystals ground to the correct frequency and band-width, connected to one or more coils, the whole assembly being housed in a standard I.F. transformer can.

The double crystal unit is provided with a built-in balancing condenser, by means of which the filters can be adjusted to give the maximum performance, or the cut-off slope adjusted to eliminate any particular source of interference (other than static) external to the pass band. It is thus possible to vary the selectivity at will, and the filter may be completely cut out of circuit when desired at the expense of selectivity.

Two types of filter are available. The first is a single unit for use in telegraphy circuits with a band-width of 300 c/s and a mean operating frequency of 465 kCs. It consists of the usual inductance and tuning condensers together with two quartz crystals and is connected in circuit as shown in Fig. 1, the dotted line enclosing the filter.

### Response Characteristics

The response of this filter is given in Fig. 2, being level over the band to within less than plus or minus 3 db.

Band widths of from 100 cycles to 500 cycles can be provided if required, and the filter would appear to be admirably suited for the separation of C.W. and other telegraphic signals in communication receivers.

A similar type of filter is available for communication telephony or selective broadcast reception, the band-width being from 500 c/s to 5 kCs. The standard band-width is 3 kCs, and this response should be suitable for reception under conditions of from extreme selectivity up to normal.

### Connection to Receiver

The connection of this filter to a receiver is shown in Fig. 3 (the dotted lines again enclosing the filter unit) and the response curve in Fig. 4. It will be noted that there are two peaks separated by approximately 3 kCs with a symmetrical dip of about 6 dB between them. This curve shape is intended to allow for the effects of other I.F. couplings in the receiver.

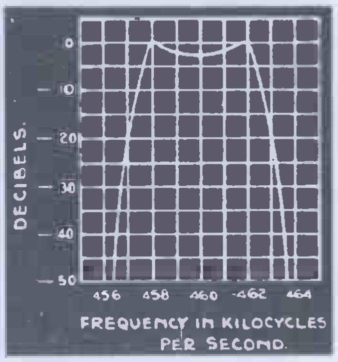



Fig. 4. Telephony filter response curve.

The miniature differential condenser contained in both filter units is the "Rejection" control, and its adjustment considerably modifies the nature of the response curve.

The general nature of the curve is shown in Fig. 5. The peaks are the resonant frequency of the crystals and define the approximate limits of the band-pass. Outside these peaks, the response falls off rapidly, and the position of the two rejection points may be varied simultaneously over a frequency range of about one-fifth to twice the frequency separation of the crystals. As these points are moved inwards, the sides of the band-pass become much

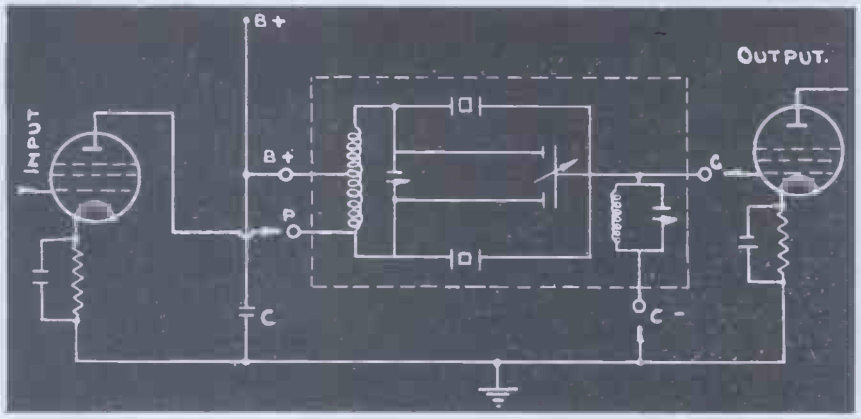



Fig. 3. Telephony filter circuit.

steeper and the trough is filled in to obtain a response as shown by Fig. 6. It will be noted that the response outside the rejection points has now been increased.

In order to obtain good "rejection" points, it is essential that the screening of the I.F. amplifier be good and that there is no leakage capacity between the input and output high potential leads of the filter and other wiring carrying H.F. or I.F. currents. By observing these precautions, it should be possible to obtain an attenuation of some 60 db. at the rejection points and, by adjusting them to the frequency of the interfering signal, practically complete suppression of the interference should be obtained.

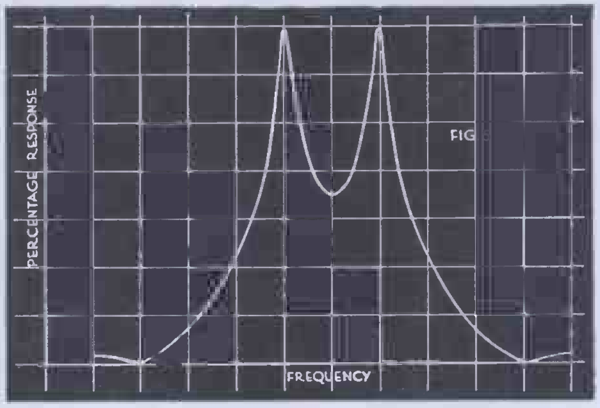



**Fig. 5. General response curve showing crystal peaks and pass band. Note response falls off rapidly outside peaks.**

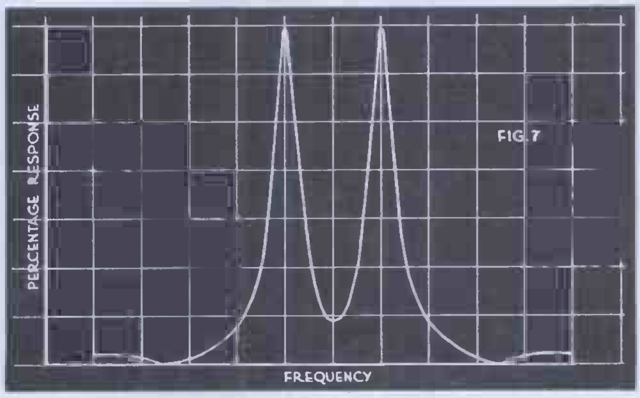



**Fig. 7. Note the deep trough due to damping of filter by low impedance diode detector.**

The filter should be fitted between the frequency changer and I.F. valve, or between the I.F. valves if there are two I.F. stages in the receiver. In the case of communication-type receivers, the crystal gate should be removed and replaced by the double filter unit, unless the gate immediately precedes the detector valve, in which case it should be removed and replaced by a conventional I.F. transformer, and the filter unit fitted in an earlier stage.

H.F. pentodes with an impedance of the order of 0.5 megohm and a capacitance of about 12 mmf. and a very high input impedance and a capacitance of some 7 mmf. are suitable. Higher impedances will not produce any adverse effect, but lower impedance will cause the stage gain to decrease and the trough in the curve to be more pronounced. In particular, the filter must not be connected to a diode or other low impedance detector or a response curve of the nature of that shown in Fig. 7 will be obtained.

When fitting the filter unit care must be taken to keep the grid and anode leads as short as ever possible and far away from other leads in the receiver which carry H.F. or I.F. currents, otherwise high attenuation outside the band-pass will not be attained. It is generally desirable, in order to ensure correct operation of the filter, to incorporate a condenser C of the order of about .01 mfd. as shown in Figs. 1 and 3.

## *Alignment*

The operating frequency of the crystal filter is fixed by the resonant frequency of the crystals and can be altered only by changing them, so that, when substituting a unit for a normal I.F. transformer, it is necessary to align the remainder of the amplifier to the unit.

It is necessary to use an unmodulated signal for alignment as the crystal can discriminate between the carrier and side bands of a modulated signal, and it is not possible, therefore, to use an audio output meter to measure the change in signal strength. By far the best method is to connect a microammeter in series with the diode load resistance, the A.V.C. circuits being disconnected during alignment.

Unfortunately, few constructors will possess a sensitive microammeter, so they will have to resort to measuring the change in anode current of an A.V.C. controlled valve or by using a signal strength meter such as the "magic eye." In such cases the A.V.C. circuits must not be disconnected.

When a signal generator is available for ganging purposes, it should be connected to the grid of the frequency-changer valve in the normal manner and should be tuned to the approximate frequency of the filter. It is first necessary to find the resonant frequencies of the crystal unit. To do this, the I.F. circuits should first be detuned, and the crystal peaks then be located by swinging the generator from a few kilocycles above to a few kilocycles below the filter pass-band and noting their frequencies as read on the generator. The generator is then set to a point two or three kc outside the pass-band and the rejection control (top of the can) controlling the miniature differential condenser adjusted for lowest output. The generator is then set to a point midway between the crystal peaks and all the I.F. tuned circuits in the receiver are aligned for maximum response in the normal manner.

The filter should now be correctly aligned, and it will be found that the trough which was present between the crystal peaks has either completely disappeared, or else is much less pronounced.

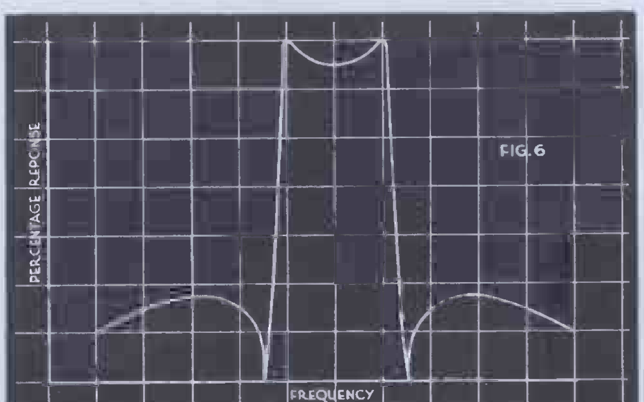



**Fig. 6. Effect of adjusting rejection control. Note how trough is filled in, while response outside peaks increases.**

It may be found that one of the crystal peaks is much lower than the other and this is usually due to the tuned circuits having been aligned nearer to the frequency of the other crystal. A slight retuning to shift their frequency nearer the lower peak is all that is necessary.

It is important to remember that it is not possible to align the filter by setting the signal generator to the stated mean frequency of the filter by its own dial reading. Most signal generators have an error of ±5 per cent., representing over 2 kc. at a frequency of 465 kcs. so that the tuned circuits could easily be aligned to a frequency outside the filter pass-band and thus give an entirely wrong type of response curve. It is absolutely necessary to first find the crystal peaks and then carry out the alignment at a frequency which is definitely their mean.

### Ganging on a Broadcast Signal

It is quite possible to use a broadcast signal for carrying out the alignment of the filter unit providing the signal is really steady and a little care is taken over the procedure. In such a case, it is imperative to use a meter as it will not be possible to readily locate the crystal peaks by ear. The instructions for ganging with a generator are followed, with the exception, of course, that the signal is fed to the aerial circuit and not to the grid of the frequency-changer valve.

If an oscilloscope is available, it should be connected direct to the detector output and A.V.C. should be rendered inoperative by short-circuiting one of the A.V.C. filter condensers. The instructions outlined above are carried out, but in this case the adjustment of the various trimmers and their precise effect is clearly shown and they are adjusted for the desired shape of resonance curve and maximum height of the trace.

Prices of the various units are as follows:—

Pairs of matched crystals ground to a specified frequency and mounted in a special holder with balancing condenser ... ... ... ... 40/-

These can be supplied for frequencies between 440 and 480 kcs., while crystals for 110/140 kcs. or 1,600 kcs. can be supplied to special order.

Complete telegraphy filter unit for incorporation in existing receiver, and comprising inductance, tuning condenser, two crystals and balancing condenser ... ... ... 60/-

These are suitable for band-widths of 300/500 cycles.

Complete telephony filter, comprising two inductances and tuning condensers, double crystal unit and balancing condenser ... ... 67/6

These are suitable for band-widths up to 3 kcs.

In both cases, the mean operating frequency is approximately 465 kc., but other frequencies can be supplied to order.

# THE SHORT-WAVE RADIO WORLD

*A Review of the Most Important Features of the World's Short-wave Developments*

A SUGGESTION for minimising the flow of grid current through batteries when used for bias is put forward by P. F. Crabill in October *QST*. The battery, which is normally used to bias the oscillator grid when there is no excitation, is by-passed by a small neon lamp which serves as a grid leak to provide bias during excitation. The proportion of grid current flowing through the battery is thus reduced to a few microamps.

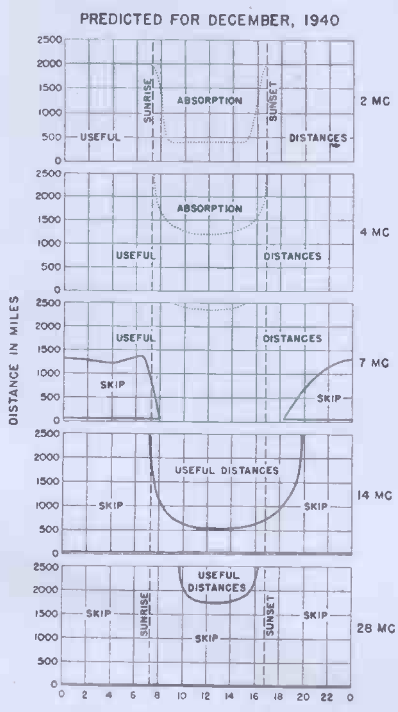
In the case of the 809 used the voltage drop across the 3 watt neon lamp was approximately correct with the grid current flowing, a 45-v. battery being used in series with a 10 meg. leak to provide the standing bias.

It is pointed out that the lower end of the r.f. choke should not be by-passed to earth in case the neon lamp tends to oscillate. It is important that the neon lamp does not light on the battery voltage used, and for high bias two or more lamps can be used in series. When the grid current exceeds 30mA., lamps will require to be connected in parallel.

### Communication Distances for December

The chart reproduced below has been prepared by the National Bureau of Standards, Washingten, U.S.A. and gives predictions of maximum and minimum useful distances in the amateur frequency bands.

It is pointed out that as winter approaches, the day skip distances will decrease and the night skip distances increase in transmission via the regular layers. Absorption and static will also tend to decrease during the day and the day transmission at 28 mC. will be affected. Skip distances are increasing from year to year with waning sunspot cycle and this trend will continue for several years. This will probably be the last winter for several years for regular long-distance transmission on 28 Mc.




**Useful distances for radio wave propagation via the regular layers of the ionosphere, predicted for December, 1940. The 56-Mc. band will be useful only for local transmission (optical and quasi-optical paths).**

### Centimetre Waves for Aircraft Landing

The Massachusetts Institute of Technology has been carrying out research over a period of years to improve methods of landing aircraft in fog and have now developed equipment operating on 700 Mc. (42 cm.).

A straight line landing path is made for the aeroplane to follow by sending up two overlapping beams one above and one below the path, and two more to the right and left of the path. Each is distinguished by a different modulation so that they give an easily recognisable signal in the receiver.

The region in the intersection of the four beams where they are all the same intensity provides an "on-course" indication at the receiver. As one of the beams has to lie below the glide path, which is 3° to 10° above the horizon (usually the former), it is necessary to produce very sharp beams. It is desirable to use ultra-short wave-lengths in order to obtain these with reasonable aerial size.

With the 42 cm. wavelength, it was found possible to use horn aerials only 10 ft. high, 2½ ft. wide and 25 ft. long to obtain sharp enough beams. The ground equipment consists of two "standpipe" oscillators using concentric-line tuning elements with Western Electric 316-A valves and associated power supply and modulation equipment. The set-up in the aeroplane was a sensitive, stable superheterodyne receiver using an acorn valve oscillator and a diode as a mixer valve.

## A RECORD OF PATENTS AND PROGRESS

# RECENT DEVELOPMENTS

**PATENTEES**

*The British Thermostat Co., Ltd., :: Kolster-Brandes Ltd., and C. N. Smyth :: Marconi's Wireless Telegraph Co., Ltd., (Drawing) :: Fides Gesellschaft :: H. E. Kallman :: Kolster-Brandes Ltd., W. A. Beatty and P. K. Chatterjea :: Standard Telephones and Cables Ltd.*

### Photo-electric Control

(Patent No. 524,303.)

AN arrangement is known for locking the door, say, of a safe or a strong-room, in such a way that it can only be opened by applying a beam of light to a photo-electric cell. The object of the present invention is to ensure that the door will only respond to light of a particular kind, so as to afford an additional safeguard.

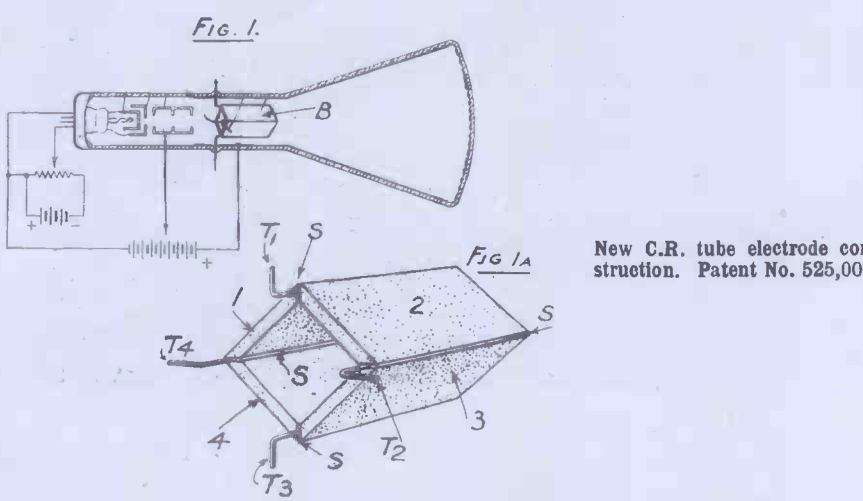
The light source, to be used as a "key," may, for instance, emit rays of a particular wavelength, such as infra-red or ultra-violet. In addition the rays can be "chopped" or interrupted at a definite frequency by a rotating toothed wheel or perforated disc. The "lock" which receives the rays, is fitted with a light-filter which only allows light of the right frequency to pass, whilst, in addition, an electric filter circuit cuts out current of any frequency except that corresponding to the rate at which the light-source is interrupted.—*The British Thermostat Co., Ltd.*

### Light Control for Television Receivers

(Patent No. 524,672.)

If a television programme is being viewed in a darkened room, and the light is switched on, some readjustment of the brightness and contrast value of the reproduced pictures is desirable. This could, of course, be effected manually by turning the appropriate controls on the set, but the invention makes provision for doing so automatically, as the room-illumination alters.

For this purpose a photo-electric cell is included in the potentiometer circuit supplying a biasing-voltage to the screening-grid of one of the vision amplifiers. The photo-electric cell is exposed to the same local lighting as the fluorescent screen of the cathode-ray tube, and, as this alters, the P.E. cell automatically readjusts the gain of the amplifier valve accordingly.—*Kolster-Brandes, Ltd.*, and *C. N. Smyth.*



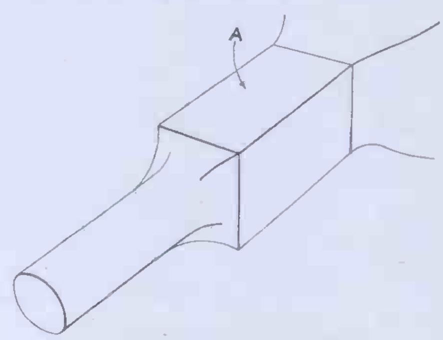

**New C.R. tube electrode construction. Patent No. 525,000.**

### Scanning Electrodes

(Patent No. 525,000.)

The scanning or deflection plates of a cathode-ray tube are usually arranged in two opposed pairs, set one pair behind the other along the path of the electron stream. The fact that they occupy different positions has certain disadvantages. For instance it increases the overall length of the C.R. tube, and also tends to increase the width of the stream more than is necessary. In addition, the deflection-sensitivity of the pair in the horizontal plane differs slightly from that in the vertical plane, since the two pairs of plates are at unequal distances from the "target," *i.e.*, the fluorescent screen.

According to the invention, the two pairs of plates are combined into a box-like structure B, as shown enlarged in Fig. 1A, so that they all exert their influence at the same part of the stream. Each side 1, 2, 3, 4 of the open-ended box is made of a porous ceramic material impregnated, say, with powdered graphite, so that it is semi-conducting. A conducting strip S is inserted along each corner of the square, and is connected to the terminals T1-T4 to which the deflecting or scanning voltages are applied.—*Marconi's Wireless Telegraph Co., Ltd. (Drawing).*




**Square-necked cathode-ray tube. Patent No. 525,181.**

### Cathode-ray Tubes

(Patent No. 525,181.)

The neck of a cathode-ray tube is made with a part A which may be square, or of rectangular section having a ratio of length to breadth equal to that of the picture actually shown on the fluorescent screen. This provides flattened outer surfaces on which the magnetic deflection coils can conveniently be mounted with their magnetic pole-pieces abutting against the glass wall of the tube.—

# *Presenting*- the EDDYSTONE 358 COMMUNICATION RECEIVER

Attention is drawn to a new "EDDYSTONE" Production—the 358 Communication Receiver—a first-class engineering job embodying all essential features of a dependable Communication Receiver. Based on proved design the 358 gives a high performance and its reliability is calculated to meet the exacting requirements of Service operation. It is eminently suitable for every general communication purpose and is the product of engineers with wide practical experience of communication work. The 358 is the progressive development of previous well-known "EDDYSTONE" Receivers—it is designed to do a particular job of work—and to do it consistently well. When absolute reliability and outstanding performance are demanded, the "EDDYSTONE" 358 will be found most fitting to the need—a fact given emphatic point by the orders already placed by Government Departments.

## SPECIFICATION

Tuning range of 31,000 Kc/s to 1,250 Kc/s by the use of interchangeable range units (additional coil units will shortly be available to extend the range to 100 Kc/s).

Power supply—A.C. mains (200-250 volts) for which a power unit giving 6 volts 1.4 amperes and 175/180 volts 65 mA. is provided. (Later it is hoped to offer the 358 to work from a 6 volt accumulator input.)

Chassis of unit construction permitting ease of service. Housed in welded steel cabinet, ripple grey finish.

**Dimensions :** 20½" by 12" by 13½" deep. **Weight :** 50½ lbs.

**Selectivity : I.F. total bandwidth :** Two kilocycles at 2.5 db. down. Ten kilocycles at 40 db. down.

**Sensitivity :** Better than 3 microvolts : 30 per cent. modulation for 50 milliwatts output on all ranges.

**Audio Output :** 1.5 watts.

**Image Ratio.**

| | | | |
|---|---|---|---|
| At 30 | megacycles | 20/1 | |
| At 12 | ,, | 100/1 | |
| At 19 | ,, | 210/1 | (Range 'B') |
| At 4.5 | ,, | 400/1 | |
| At 3 | ,, | 500/1 | |
| At 2 | ,, | 1,500/1 | (Range 'D') |
| At 1.6 | ,, | 8,000/1 | |
| At 1.2 | ,, | 10,000/1 | |

**Frequency Ranges of Coil Units are :—**

| | | | | |
|---|---|---|---|---|
| Range A. | 22,000 | — | 31,000 | kilocycles. |
| Range B. | 9,000 | — | 22,000 | ,, |
| Range C. | 4,500 | — | 9,000 | ,, |
| Range D. | 2.100 | — | 4,500 | ,, |
| Range E. | 1,250 | — | 2,100 | ,, |

Output Circuit incorporates twin jacks for 120 ohm or 2,000 ohm Headphones. (Other impedances can be fitted to order.) To simplify maintenance a meter and test switch is fitted by which the emission of each valve can be checked while in position.

**ENQUIRIES ARE INVITED FROM GOVERNMENT DEPARTMENTS AND ALL UNDERTAKINGS OR PERSONS ENGAGED ON WORK OF NATIONAL IMPORTANCE**

# STRATTON & Co., Ltd.

**BROMSGROVE STREET - - - BIRMINGHAM 5**

*Telephone : Mid 3771* *Telegrams : Stratnoid, Birmingham*

*Kolster-Brandes, Ltd.*, and *C. N. Smyth.*

### Photo-electric Cells

(Patent No. 525,344.)

A photo-electric cell of the type that reacts to light by electronic emission is limited, as regards efficiency, by the fact that the alkali-metal with which the sensitised cathode is coated only responds effectively to a comparatively-narrow band of wavelengths. Any light energy lying outside this narrow band of frequencies is therefore lost so far as its effect on the cell is concerned.

In order to overcome this limitation, certain parts of the cell are coated with a fluorescent material which is made to glow by those light-frequencies that do not directly excite the coated cathode. The fluorescent material is chosen so that the glow produced by it is of the proper wavelength to stimulate the sensitive cathode and cause it to emit electrons.

The total output from the cell is thereby increased, since part of the incident light-ray, which would otherwise be lost, is now brought into action by its effect on the fluorescent screen.—*Fides Gesellschaft.*

### Minimising Interference

(Patent No. 525,628.)

The sound and picture signals of a television programme are sent out on the same carrier wave, the sound signals being conveyed by frequency modulation, and the picture signals by amplitude modulation. This reduces the unpleasant "crackling" effect of motor-car interference, since a frequency-modulated wave is less susceptible to such disturbances than an amplitude-modulated wave. The effect of motor-car ignition on the picture as seen on the viewing-screen is, in any case, less disagreeable than its audible effect on the ear.

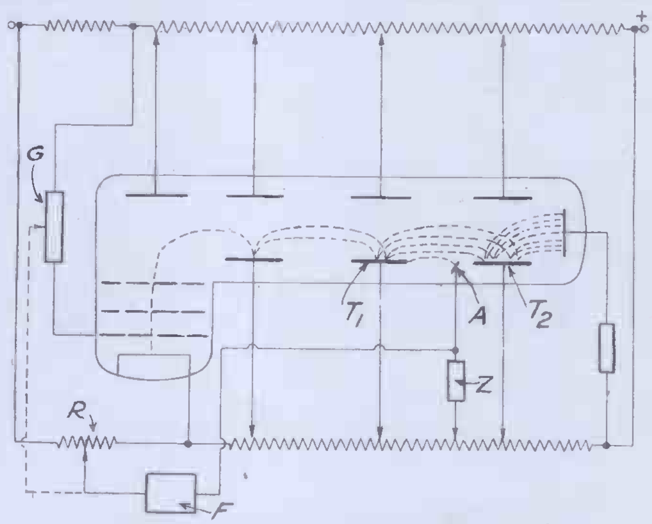
After the carrier has passed through the frequency-modulator stage, it is subjected to the action of a "limiter" valve, which cuts out any "accidental" amplitude-variations. The carrier is then fed to the amplitude-modulating stage to receive the picture signals. The line and frame scanning impulses are transmitted by interrupting the picture current at the proper intervals. Sound and picture signals can be radiated in this way on a narrower frequency-band than is usually required.—*H. E. Kallman.*

### Electron Multipliers

(Patent No. 525,758.)

The application of reaction to an electron-multiplier is subject to the fact that the phase-difference which exists between any particular "target" or secondary-emission electrode and the anode immediately following it depends upon the time taken by the electrons to pass between the two electrodes, and therefore, upon the frequency that is being amplified. For this reason it is possible for the same circuit arrangement to produce a negative feed-back at one time, and a positive feed-back at another, according to the working frequency.

As shown in the drawing, an auxiliary anode A (which has been carbonised or otherwise so treated that it does not emit any secondary electrons) is inserted at a part of the tube between two target electrodes T1 and T2 where it can collect a fraction of the main electron discharge stream. The resulting voltage developed in an external impedance Z is then fed back to a preceding electrode, which, similarly, is not a liberator of secondary electrons. The feed-back voltage is returned through an impedance F (which may be frequency-selective) to the cathode resistance R, or it may be tapped back to an impedance G in the circuit of the control grid, as indicated by the dotted-line connections.—*Kolster-Brandes, Ltd.; W. A. Beatty* and *P. K. Chatterjea.*




**Prevention of phase difference in electron multiplier. Patent No. 525,758.**

**More Electronic Patents on 3rd page of cover.**

### The Design of an Audio-frequency Generator

(*Continued from page 551*)

and the two frequencies approach one another the meter swings in sympathy with the $F_1 - F_2$ signal. By adjustment of the zero frequency correction condenser, the oscillation of the meter movement is brought to zero, and at this point the A.F. output frequency is equal to the mains frequency. The rectifier voltmeter is permanently coupled in parallel with the output, and by adjustment of the potentiometer across the fixed oscillator, the output voltage can be kept constant over the whole of the audio-frequency range.

Before concluding these introductory notes, it will be of interest to recapitulate the outstanding features of this generator.

Frequency range 20-23.000 c.p.s. sinusoidal output.

Output level, .006 watts into 500Ω.

Harmonic content, less than 0.3% at .006 watt.

Overall frequency characteristic
−1 Db at 20 c.p.s.
−2 Db at 20.000 c.p.s.
−2.9 Db at 23.000 c.p.s.

Noise level −55 Db below .006 watt at zero frequency.

In the next issue of this journal the complete construction and details of the A.F. generator will be given, together with the methods adopted for accurate calibration by means of a C.R. tube and Lissajou figures.

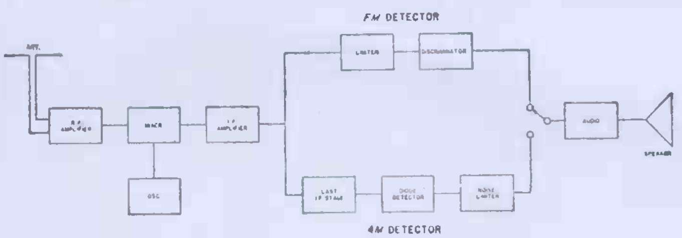
*Here are details of a remarkable new Hallicrafter receiver—the S27U which is designed for reception of both amplitude and frequency modulated signals. It is a precision instrument and as the test report proves has wonderful capabilities.*

# The New Hallicrafter Ultra-high Frequency Receiver-S27U

THE Hallicrafter S27, the latest introduction of Hallicrafters' gives, at last, a receiver with an extremely high performance on the high-frequency bands between 27 megacycles and 140 mcs. The mechanical construction and electrical design are sound to a degree and even weak signals can be tuned in with amazing ease and held in a stable condition for any length of time.

Both amplitude and frequency modulation are catered for. One stage of high-frequency amplification, an RCA Acorn type 956, assures a reasonable degree of H.F. input over the entire bands for both types of reception.

Appreciation of the basic differences between amplitude and frequency modulation will assist in a brief review of the instrument. A block diagram of the S27 Receiver is shown below and this incorporates the amplitude and frequency modulation systems.




**Schematic block diagram of the S27 showing the units employed.**

Amplitude modulation in the past has been the accepted, and usual method, of impressing an audio signal (speech or music) on the transmitted signal. With this method, the signals vary in *amplitude,* the variations taking place at a frequency or rate determined by the frequency of the sound.

In direct contrast, a frequency-modulated signal consists of a carrier which remains constant in amplitude, while the frequency of the signal is varied, the rate or speed of the variation being determined by the frequency of the audio signal. In addition, the stronger the audio signal the greater is the change in frequency of the radio signal. Thus the "band width" (through which the carrier of the F.M. signal is swung) is determined by the amplitude, but not by the frequency of the modulating signal.

In general, a frequency modulation receiver has practically all the same components as an amplitude modulation instrument with the exception of the detector system. First we have the radio-frequency amplifier which increases the useful sensitivity and image ratio of the receiver in both cases. In the F.M. receiver, a stronger signal will be delivered to the limiter-valve ensuring greater freedom from static interference and greater response to very wide frequency swings occasioned by periods of over-modulation of the transmitter.

The mixer serves the same function in both A.M. and F.M. reception, its purpose being to convert the ultra-high frequency signals to the intermediate frequency—in this case 5.25 megacycles. Any inherent difference would be in favour of F.M. as this system allows greater freedom from valve hiss introduced by the mixer when operating at very low signal value.

The heterodyne oscillator again performs identical functions. The slight drift which is bound to take place in the initial heating period, has the effect of detuning the receiver, causing severe audio distortion and reduction in intelligibility with amplitude modulated receivers. With frequency-modulated reception the band pass is much wider allowing more oscillator drift before serious distortion occurs. The distortion will only occur on the highest percentages of modulation.

The S27 I.F. amplifier is designed with very high Q iron core coils to allow sufficient station discrimination on the 10-metre band, but at the same time being broadly expanded for proper reception of F.M. signals by means of the selectivity switch. The output of the I.F. amplifier feeds into both the A.M. and F.M. detectors. The sharply tuned I.F. stage precedes the A.M. diode detector to provide the necessary selectivity in both the sharp and broad operating positions and to provide the means of compensating for variations in stage gain. The Dickert noise limiter which can be switched in at will is particularly effective and reduces impulse noises to a negligible amount.

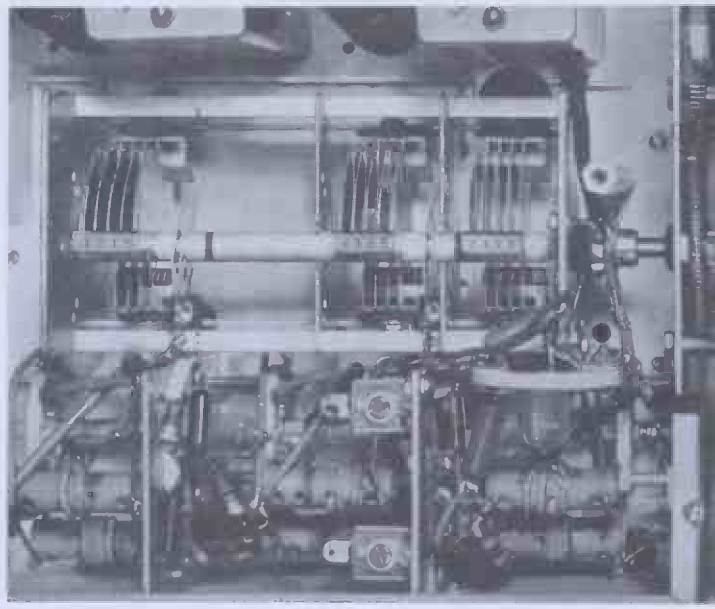
The frequency-modulator detector system includes the limiter which serves as an amplifier when the signal is weak, but prevents the amplitude from rising beyond the fixed limit as the signal increases, with the result that amplitude modulation is removed from the signal, reducing noise pulses which have no

wide-band frequency modulation component. It also compensates for inequalities of the I.F. transmission characteristic caused by a sharp or double-humped selectivity curve. The limiter circuit characteristic also aids the receiver in reducing interference on the same channel. For example if the interfering signal is minus 6db. below the desired one, it will not be heard providing the limiter valve is saturated by the desired signal.

The F.M. detector differs from the A.M. detector in that its linearity characteristic and consequent freedom from distortion depends upon the proper design and alignment of the resonant circuit rather than upon valve characteristics.

Also included in the F.M. detector circuit is the de-emphasised circuit designed to reduce the higher audio frequencies in the same proportion in which they are increased in the transmitter. By this means the transmission of high audio fidelity without attendant noise amplification is possible. The same audio amplifier is used for both A.M. and F.M. reception.

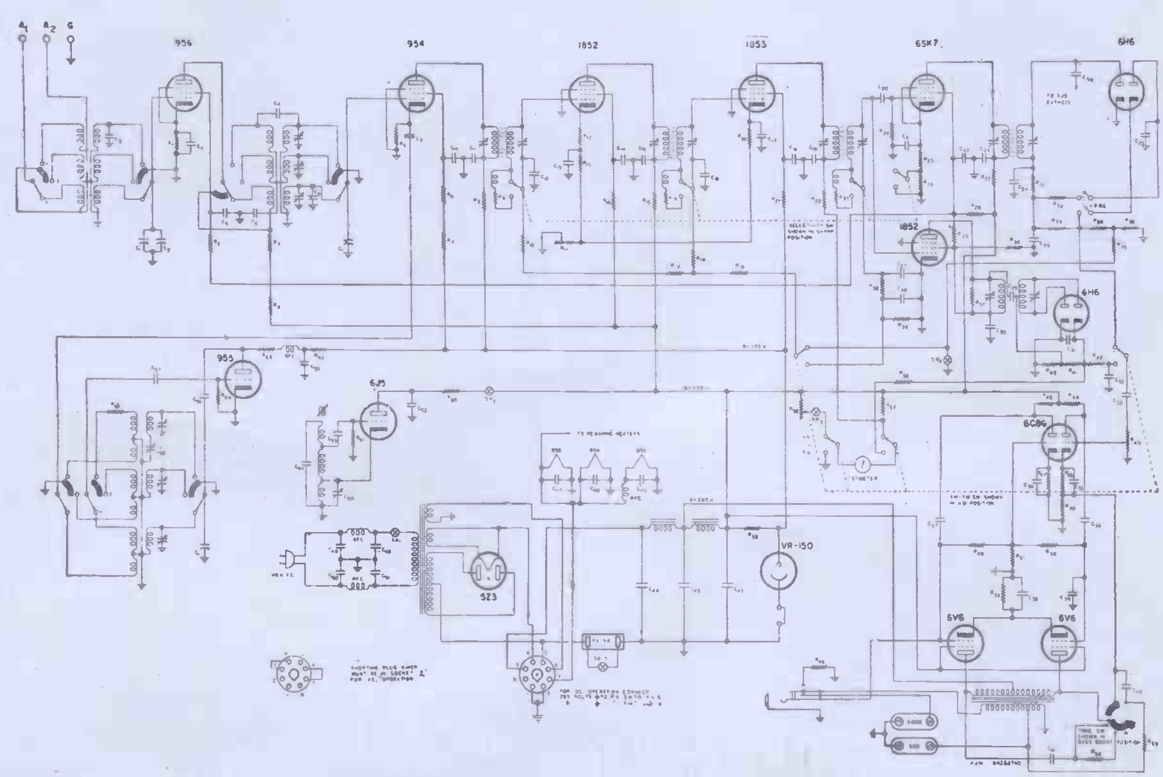
The output stage is interesting and unusual. A push-pull resistance-coupled unit feeds into a push-pull pair of 6V6 Beam Power pentodes using degeneration; a bass boost circuit is provided to emphasise low note response when desired. The receiver is designed to operate into an output load of 5,000 ohms or 500-ohm impedance.



This photograph shows the R.F. tuner unit.

Details in the construction of this receiver have been very carefully watched by the manufacturers and the general design of the instrument is extremely solid.

A photograph shows the R.F. Tuner Unit. This unit is rather difficult to photograph and the picture does not do justice to the ertremely neat and compact layout. The main tuning condenser together with turret switched coils and three acorn valves are mounted as one unit of very rigid design. It is interesting to note the quite large amount of inductance included in the R.F. and oscillator sections even on the 140-megacycle range. The drive mechanism is entirely free from back




The complete circuit diagram of the Hallicrafter S27.

lash and the accuracy of calibration extremely high.

The receiver which was used for this review was delivered in the original packing case, with the seals unbroken and it was found that even the acorn valves had been shipped *in situ* from the United States. No R.F. trimming was necessary, but a slight readjustment of the I.F. trimmers was found to increase considerably the sensitivity. We would suggest that the manufacturers seal the I.F. condensers providing a method can be found which will not cause distortion of the vanes in varying temperatures.

The examination of the rear apron of the receiver brought to light the inclusion of an A.C. outlet socket designed apparently for convenient operation of relay energising and inclusion of an 8-pin octal socket for easy conversion from mains operation to battery or vibra-pack. By open circuiting this socket and utilising an octal plug, a 6-volt accumulator was used to heat the filaments and a vibrator unit of the Mallory Type VP554 was driven from the same LT. This proved highly satisfactory on the lower frequencies, but it was not possible to use this vibrator above 40 megacycles without modification and considerable time was spent in smoothing the output from the vibrator before all interference disappeared. It was found that as interference was cleared with one set of chokes, etc., from one frequency on the dial, another frequency was entirely obliterated. We have yet to find a vibrator unit suitable for use with ultra high frequency receivers and suggest that the development of such units is worth the attention of manufacturers.

Operating direct from 230-volt A.C. mains (the input of the receiver is adjustable at the A.C. transformer primary from voltages from 210 to 250) the receiver was found to be extremely quiet, and the signal-to-noise ratio on A.M. highly satisfactory.

As a means of comparison on the initial test, a well-known American super regenerative receiver was coupled by change-over switch to an aerial. While only two stations were audible on the 50- to 80-megacycle band with the other receiver, 34 signals were received on the S27. It is not possible to disclose or discuss the wide variation of signals received on the entire bands from 27 to 142 megacycles covered by the S27, but it is extremely instructive to operate for a few hours such a sensitive receiver as the S27 on these bands, particularly if one has not recently had the opportunity to investigate the enormous use now being made of U.H.F.

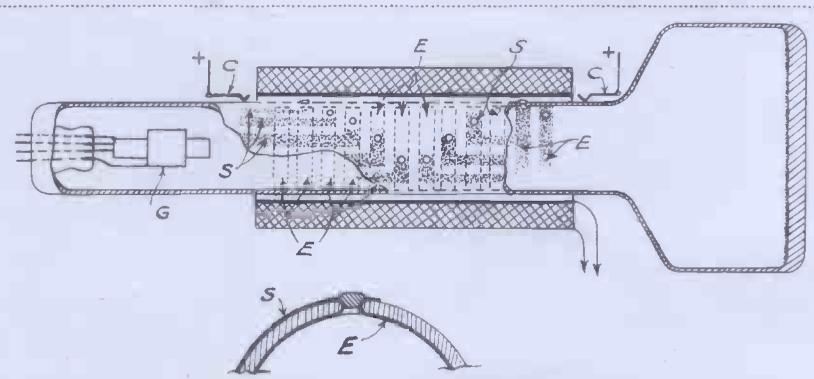
The receiver is undoubtedly far and away ahead of any other ultra-high frequency instrument which we have had the opportunity of testing and the manufacturers deserve the highest praise for the production of such a rigid and sensitive instrument.

The S27U is available from Webb's Radio, 14 Soho Street.

# A Novel Lead-in Seal for C.R. Tubes

THE need for a large number of lead-in conductors in many cathode-ray tubes seriously complicates the manufacture; for example, in some tubes the number of focusing and accelerating electrodes is limited by the number of wires that can be sealed into the stem. It is difficult to seal wires into the side wall of a tube, and the presence of even the ends of the wires on the interior of the envelope distorts the focusing field of the ring-shaped electrodes.

The following description explains how any desired number of leads may be easily sealed into the side wall of a tube.




Details of lead-in seal for C.R. tubes.

The illustration shows a cathode-ray tube closed at the rear end with a known form of re-entrant stem carrying an electron gun G. A beam of electrons emitted from the inner end of the gun is directed toward the screen, the electrons being accelerated and focused to a sharply pointed beam by coaxial ring-shaped electrodes E.

The focusing electrodes E may conveniently be rings of metal deposited as thin films upon the inner wall of the envelope. Direct current positive potentials may be applied to the ring electrodes to cause the beam of electrons emanating from the end of the electron gun to sharply focus upon the screen.

The usual types of lead-in conductor for each ring electrode is either a separate wire sealed through the cylindrical side wall of the envelope and soldered or otherwise joined at its inner end to the film electrode, or a wire extending to the electrode from the press at the end of the envelope. The wire in either arrangement electrically disturbs the smooth continuity of the inner surface of the cylindrical electrode and distorts the electrostatic field with a resulting defocusing of the beam.

Lead-in conductors for the electrodes, however, made according to the following description, leave the fields of the inner surfaces of the ring electrodes cylindrical in shape and the fields undisturbed. The lead-in conductors are made by perforating the envelope opposite each focusing electrode. The holes may conveniently be made by heating a tungsten wire white hot and pushing the end of the wire through the glass. The surface of the glass in the holes and on the inside and outside of the envelope is then coated with a thin layer of metal so that a continuous film of metal not only forms the electrode, but also extends along and is hermetically sealed to the walls of the hole and continues to the outside where it forms an outside contact.

Any metal which will form an adherent conductive film on the glass and also form a hermetical seal to the glass may be used. Good results have been obtained with an adherent conductive metal coating produced with a platinising solution. The entire inner surface of the envelope, between the ends of the focusing region, may be coated with the metal film and the separate sections of the film, electrically separated by removing the film in a series of annular rings.

Alternatively, of course, the separate ring-shaped deposits may be applied by masking.

A narrow strip S of the metal film on the exterior of the envelope is extended some distance from the hole on the out-

(*Continued on page 569*)

# Preventing "Dark" Current in Electron Multipliers

ONE of the most common faults in connection with photo-electric devices is the presence of "dark" current, i.e., residual current, due chiefly to the emission of thermionic electrons even when the photo-cathode is not illuminated. This problem is especially troublesome in the case of multi-stage electron multipliers with photo-sensitive cathodes because the emission of even a small number of electrons here will result in a greatly multiplied undesired current in the output.

The drawing shows one particular construction of multiplier, and shows also arrangements which are included to enable the photo-cathode to be prepared by a method, developed in the laboratories of the Radio Corporation of America, which greatly reduces this "dark" current. The evacuated envelope T contains photo-cathode 1, staggered multiplying electrodes 2-6, and anode 7. It also has a side bulb B containing the means for activating the cathode.

The cathode base material may be any suitable conductor, e.g., A1, Ba, Ca, Be or Cr, and the emissive surface layer may be any salt or halide of an alkali metal.

It is essential in the process to be described that the surface of the cathode base be as clean as possible, and for this reason the cathode is mounted in place and is re-surfaced after evacuation of the envelope. This is done by evaporating or distilling on to the surface a small quantity of the base material mounted in a coiled filament 11 (capable of being heated) surrounded by a shield 12 in the bulb extension B. The selected salt or halide of an alkali metal is mounted in a second coiled filament 13, and is deposited on the clean surface of the photo-cathode when the filament 13 is heated.

After the cathode has been thus sensitised, the surface may be bombarded with electrons from a third filament 14, for about a minute, the length of time depending on the intensity of the bombardment. This enhances the ability of the surface to emit photo-electrons without increasing the "dark" current. On completion of the above processes the connecting aperture B is sealed off and the bulb extension B is removed. The dark current from a cathode prepared by this method, using caesium chloride as the sensitising material, was found to be only about 0.001 of that of a standard caesium activated surface. Other materials which may be successfully used for the sensitising are CsBr, KCl, NaCl and LiCl.

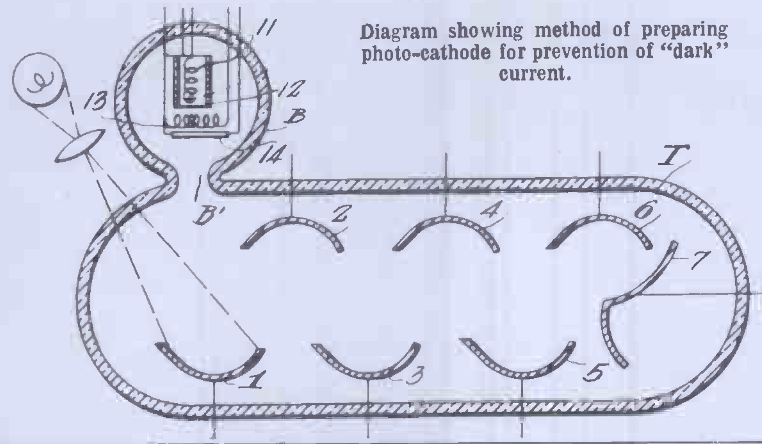



Diagram showing method of preparing photo-cathode for prevention of "dark" current.

# The Link Between Radio Activity and Electronics

*By Ronald L. Mansi, M.R.C.S., L.R.C.P., D.M.R.E. (Camb).*

IT is an interesting fact that the knowledge of X-rays and radio-activity developed side by side, although it was some time before their intimate relationship became evident.

The discovery of radio-activity somewhat upset all the pre-conceived and well-established laws of the conservation of energy and the immutability of the elements because here was one element gradually changing into another and in the process giving out enormous amounts of energy which could not be explained by any known chemical reaction and in fact was an example of actual atomic disintegration.

This emission of this energy cannot be controlled or influenced by any known chemical or physical means such as subjecting the radio active substance to powerful chemical reagents or extreme temperatures or pressures. For this reason, it does not matter whether the element is used alone or in chemical combination, such as the sulphate or the bromide since the radio-activity is not altered in any way.

Unfortunately this energy cannot be put to any practical use for the performance of work, apart from its biological action, as the energy is given out extremely slowly over a very long period of time. For example, it has been estimated that a gram of radium takes about 1,600 years for only half of it to disappear. It has also been shown that one gram of radium in equilibrium with its products emits heat at the rate of some 135 calories per hour, and this energy is emitted quite spontaneously without the help of any outside agency. If all the energy it is capable of giving out during this long period of its life could be condensed into a shorter period and controlled, its utility can be well imagined.

Some very slight idea of the constant changes going on inside radio-active substance is indicated by the constant luminous glow produced. This is always present but, of course, is only visible in the dark. It does not depend on a previous exposure to light like ordinary phosphorescent materials.

Radium is the best known and most used source of radio-activity. It can be obtained in a pure state and in quantities that can be put to practical use. The statement that it can be obtained in quantities that can be put to practical use may seem strange when it is realised that some of the radio-active elements are so rare that their presence can only be recognised by their radio-activity. Its high cost is due to the enormous amount of raw material that has to be treated and the extremely complicated and tedious chemical processes the raw material has to undergo before a minute quantity of pure radium is obtained. It is generally used in the form of one of its salts, for example the sulphate or bromide.

Although, apart from its use in medicine, its field of practical usefulness is limited, the study of radium and its associated radio-active bodies has added greatly to our knowledge of the atom.

Radio activity has been defined as that property of a body to emit three types of rays which have been given the names Alpha, Beta and Gamma rays.

## *Alpha Rays*

The alpha rays have been shown to be actual positively charged helium atoms and are therefore not strictly rays. Their speed is the same for one particular radio-active body from which they originate, the average velocity for all radio-active bodies being about one-tenth that of light. They are capable of affecting a photographic plate and of exciting strong fluorescence in certain chemicals.

This property is made use of in the spinthariscope devised by Crookes in which their presence can be demonstrated. A speck of radium is placed near a small screen of zinc sulphide and in the dark, through a lens, each alpha particle, as it strikes the screen, produces a bright point of light which almost instantly fades. Each scintillation corresponds to the impact of a single alpha particle and in this way the number of alpha particles emitted per second from a radio-active substance can be counted.

They may also be counted by an electrical method devised by Geiger and Rutherford in the well-known Geiger "counter." The effect of a single alpha particle entering a chamber, containing an electrostatic field is so magnified by ionic collision that a measurable effect can be obtained on recording instruments. Later instruments for this purpose employ valve amplification.

The ionising effect of alpha particles is very powerful, but their power of penetration is small being easily stopped by a thick sheet of note paper and their range in free air is only a few centimetres.

They are only slightly deflected by powerful magnetic and electrostatic fields, but the polarity of these fields has demonstrated the positive nature of the charge of the alpha particles.

The alpha particles have actually been collected in a tube and after gaining two electrons each have proved to be ordinary helium atoms, thus demonstrating the gradual transformation of one element into another.

## *Beta Rays*

The beta rays have been shown to be of exactly the same nature as the cathode-rays of the television tube or the X-ray tube except that much higher speeds are involved, some of them approaching to within 0.98 of the speed of light. They exhibit the same properties as cathode-rays and are subject to the same influences and, in short, they are electrons moving at high speed.

Here again the term "rays" is a misnomer since they are actually particles of matter, but the term was applied before their exact nature was fully understood and it has persisted.

## *Gamma Rays*

Since, within the structure of a radio-active substance, we have electrons (the beta rays) moving at high speed, as the necessary factors of the axiom stated at the beginning of this article are present, we should expect to find rays analagous to X-rays also being emitted from the radio-active substance. This actually is the case and the name, gamma rays, has been given to them. They follow the same laws and are subject to the same influences as X-rays.

One way in which this similarity can be well demonstrated is as follows: A photographic film is placed inside a light-tight envelope and a piece of metal in the shape of a cross or similar object is placed on top of it. If a fragment of radium salt is placed a short distance away, after a suitable interval, development of the film will reveal an image of the cross on the film. The gamma rays have penetrated the light-tight envelope except where they have been stopped by the metal. In fact it was this phenomenon accidentally observed by Becquerel in 1896 which stimulated him in his researches on radio-activity except that on this occasion he was using uranium salts.

In practice radium is not used for producing radiographs because of the difficulty of obtaining a sufficient quantity of radiation from a point source to produce sharp images.

There is one essential difference between the wavelength of the radiations produced by gamma rays and X-rays. The wavelengths of the shorter gamma rays is far shorter than that of any man-made X-rays and consequently the rays are more penetrating.

It is because of this that radium has found such large application in the treatment of certain diseases. However, with the extreme high-voltage X-ray tubes that have recently been developed, X-rays have been produced of the same wavelength as the longer gamma rays, but not of the shorter rays. We thus find that nature can produce rays from a tiny speck of material more efficiently than man with large complicated apparatus. There is a difference in the quantity of radiation produced, of course, but that is only due to the lack of the necessary amount of radium; indeed it is not always desirable as it is the quality or power of penetration that is mostly the desirable feature in therapy.

In practice the radium is used in amounts of a few milligrams of the salt put up in platinum tubes or needles with walls up to one millimetre thick. These are placed close to or buried within the lesion it is desired to treat.

The object of the platinum is to screen off the longer wavelengths of the gamma rays and all the alpha particles since they are of no practical use. In addition, most of the beta particles are cut off for they are of little therapeutic value.

Continual changes are always going on in radio-active substances resulting in the product of many other bodies and the gradual transformation into other elements. Thus, uranium gives rise to radium which in turn gives rise to an isotopic form of the common metal lead which is non-radio-active.

These processes may require a period of thousands and even millions of years, but in the case of the more fleeting transformation products, periods of days, minutes, seconds or even fractions of a second only may be involved.

It is not proposed to discuss these transformation products in detail but one, namely, radium emanation called "radon" will serve as a good example. Curiously enough this product is a gas and is continuously being given off from radium. It behaves in every way, both physically and chemically, like a heavy inert gas similar to neon, argon, etc., except that it exhibits radio-active properties similar to the parent substance radium.

The radio-activity of a sample of radon decreases to half its strength in about 3.8 days as compared to the 1,600 years of the parent substance radium. It can be readily separated from the radium and collected in tubes (known as "seeds") and since it has a useful radio-active life of some few days it finds considerable application in the field of radium therapy and is used in a manner similar to radium.

Since the supply, for all practical purposes is inexhaustible, it is used where the amount of radium available is limited, although the actual amount of pure radon obtained from a small quantity of radium is also very small so that there is a limit to the number of radon "seeds" that can be produced in a given time. For example, one gram of radium will only yield about 0.1 cubic centimetre of radon per day after it has been purified enough for practical purposes.

The intensity of the radiation from radio-active bodies can be detected and measured by their ionising effect as in the case of X-rays, but precautions are taken to separate the different radiations according to that which it is desired to study.

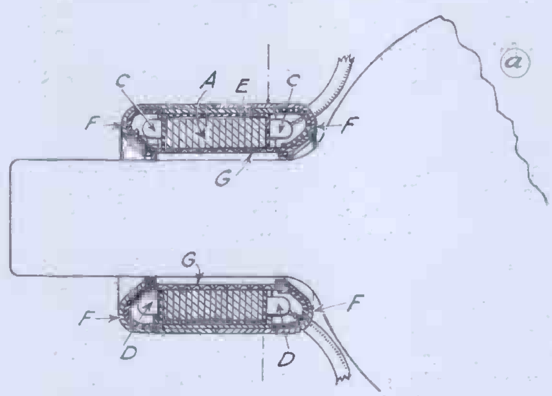
# Screened C.R. Tube Deflecting Yoke

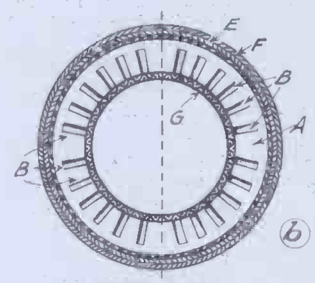
PICTURE transmitter or pick-up tubes such as Iconoscopes are very susceptible to stray electro-magnetic or electrostatic fields. For this reason, if electro-magnetic deflection is employed, the deflecting yoke must be carefully shielded or there will be disturbances in the transmitted picture caused by the stray field.

In a development reported by the Laboratories of the Radio Corporation of America, the deflecting coils have lar end members, shown as F, which fit over the ends of the deflecting yoke, and by means of a cylindrical shielding screen G.

Each of the shielding end members F is of brass or some other material having good electrical conductivity and is so shaped as to be a sliding fit on the brass sleeve E.

Also, the end shielding members are so shaped as to cover the ends of the deflecting coil windings.



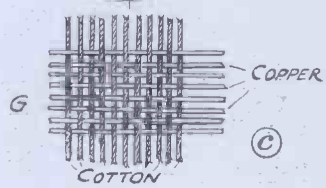




**Fig. 1. Cross-section of C.R. tube deflecting coil showing yoke.**

**Fig. 2. Construction of yoke.**

**Fig. 3. Details of shielding.**

distributed windings positioned in slots in an iron core, these coils being almost totally surrounded by shielding which is formed by annular shaped end shields of brass or other conductor and a cylindrical screen located inside the deflecting yoke and adjacent to the cathode-ray tube.

In Fig. 1 the deflecting yoke is shown applied to a picture pick-up tube such as an Iconoscope. The deflecting yoke comprises an iron core A having a number of radial slots B, as illustrated in Fig. 2.

In the slots there is located a pair of oppositely disposed horizontal deflecting coils and at right angles to these coils there is located a pair of vertical deflecting coils. The ends of these deflecting coils are shown at C and D in Fig. 1. Shielded output leads for the horizontal and vertical deflecting coils are provided, as shown.

The laminations making up the iron core A are held together by means of a cylinder E of brass which has its ends spun over as indicated to clamp the laminations firmly between the spun ends. Suitable insulating material, such as sheets of fibre, is placed between the core and the cylinder before the cylinder ends are spun over.

As already stated, the deflecting windings are electrostatically shielded from the cathode-ray tube by means of annu-

The shielding screen G is made, as shown by Fig. 3, by weaving conducting threads or wires with threads of insulating material, the wires running longitudinally of the cathode-ray tube axis. The warp of the screen is cotton thread, while the woof is double-cotton-covered copper wire. The right-hand end of the screen G is soldered or otherwise electrically connected to the shielding member.

The other end of the screen is not connected to anything whereby the presence of closed electrical paths in the screen is avoided. In order to prevent the left-hand end of the screen from coming into contact with the shielding member there is provided an annular insulating member of fibre, paper or similar material. Another annular insulating member is provided to prevent short-circuiting of the other deflecting coil ends.

It will be seen that the shielding members and the screen forms a toroidal shielding structure which completely surrounds the deflecting coil windings.

When the deflecting yoke is in use in a circuit, the above described shielding as well as the iron core A is earthed, the ground connection usually being made through the shield covering of the deflecting coil leads, this covering being earthed and also connected to the shield member F.



## "Local Lead-in Seal for C.R. Tubes"

(*Continued from page* 564)

side of the envelope to form an exposed area of film to which external contact may be made. Each metal-lined hole is then closed with a bead of glass, which will hermetically seal to the metal film. To do this the envelope is heated nearly to the softening point, but not to its deformation temperature, and the end of a piece of glass rod (preferably of the composition of the envelope) heated until it is soft enough to form a workable globule on the end of the rod, is pushed down over and puddled into the hole in the hot envelope to fill and seal the hole.

As the envelope is below its deformation temperature the shape of the hole in the envelope is not changed during the puddling of the glass bead in the metal-lined hole. After the holes have been closed the tube may be exhausted and sealed off in the usual manner. Electrical connection is made to each of the focusing electrodes with spring contactors C bearing on the exterior metal film at each hole.

Since the lead-in conductor does not extend inwardly beyond the inner surface of the envelope the electrostatic field produced by the electrodes is concentric with the axis of the envelope and the electron beam, and there is no distortion in the field or in the beam, and as the outer diameter of the envelope is not increased, a close fitting deflection coil may be slipped over the envelope.

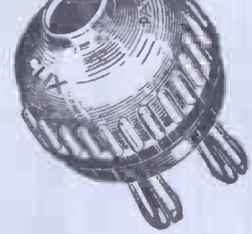
By this method it is easy to produce tubes having a plurality of coaxial annular electrodes very closely spaced and in which the fields of the electrodes are undistorted, yet with ample spacing between lead-in conductors which may be staggered around the circumference of the envelope. The lead-in conductors are of minimum length, which is the thickness of the envelope wall, and are, therefore, of great utility in very high frequency apparatus.

This development was reported from the Laboratories of the Radio Corporation of America.









# Amphenol Valve Holders

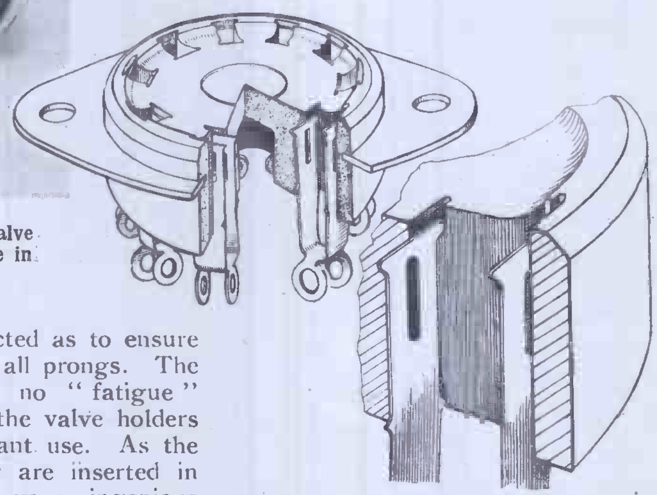
A NEW type of valve holder, the Amphenol, has recently been placed on the market by Celestion, Limited, Kingston-upon-Thames, and a study of the sketch will show that it posseses several novel features which ensure a very high percentage of efficiency both mechanically and electrically.

Of particular interest is the way in which the mounting plate is moulded into the holder. As will readily be appreciated, this ensures the maximum amount of strength, rigidity and, as the body cannot rattle loose, the important advantage of high mechanical stability under any conditions.

The contacts are pressed from specially treated phosphor bronze and are so constructed as to ensure uniform contact on all prongs. The makers claim that no "fatigue" occurs, even after the valve holders have been in constant use. As the sketch shows, they are inserted in the holder in a very ingenious manner.

A group of Amphenol valve holders. They are made in all standard types.

Another interesting feature is that the special properties of the moulding powder used for the body of the holder is of a special type which affords exceptionally fine insulation. The improved electrical qualities of Celestion-Amphenol valve holders makes them ideal for high-frequency work. They are made in both British and American types, and the accompanying photograph shows some of the standard types available.



The cut away sketch shows the construction of the Amphenol valve holder.

### "Fan-type Aerial"

(*Continued from page* 538)

Fig. 1 illustrates the aerial as just described with dipole arms approximately a half wavelength long. The response characteristic is illustrated in Fig. 2 which shows the characteristics with and without reflectors as denoted in the diagram, the response being plotted in per cent. of maximum response with reflectors in the direction of maximum directivity. The bottom curve illustrates the response to be expected from a single-wire dipole comprising two quarter-wave arms. The curves of Fig. 3 illustrate the phase angle and impedance in the operating band, measured at the junction of the transmission lines.

It is not necessary that the vertical spacing between the two fan-dipole aerials should be made equal only to a half wavelength. Greater or less vertical separation may be used where somewhat different operating characteristics are required. Thus, if the vertical separation is a full wavelength and the length of each fan conductor is one half wavelength, as before, at a particular operating frequency it is possible to select values of impedance for the transmission lines which provide two-band operation. It can be shown that an accurate impedance match is obtained not only at the selected operating frequency, but also at one half of the selected frequency. In this case, however, the aerial is preferably operated without tuned reflectors, since reflectors which are a half wavelength long at a given frequency are a quarter wavelength at half the frequency, and no longer function as reflectors. Untuned sheet reflectors are preferred for this two-band modification.

In the lower of the two frequency bands, the operation will be as described above, and the receiver transmission line is effectively coupled to a pair of quarter-wave dipole aerials through quarter-wave matching sections having low impedance ratios, and consequently wide-band frequency characteristics. In the higher of the two bands, however, the receiver transmission line is effectively coupled to a pair of half-wave dipole aerials by half-wave lines having unity input and output-impedance ratios. The centre impedance of a single-wire dipole aerial with half-wave arms is of the order of 2,000 ohms, while the impedance of a transmission line is generally much lower. The centre impedance of the fan-dipole aerial with half-wave arms, however, is approximately 800 ohms. The parallel connection of the two fan-dipole aerials reduces the effective impedance at the midpoint of the connecting transmission line to about 400 ohms, which is a value that may reasonably be matched directly by a receiver transmission line. The impedance match at both of the two frequencies is obtained by adjusting the impedance $Z_0$ of the full-wave line which connects the vertically spaced aerials to a value which is determined by the equation

$$Z^2_0 = 2Z_1Z_2$$

where $Z_1$ is the centre aerial impedance of one fan-dipole aerial at the lowest operating frequency (= 70 ohms) and $Z_2$ is the characteristic impedance of the received transmission line (= 400 ohms). For these approximate values it is seen that $Z_0$ = 236 ohms.

**HOME INSTRUCTION COURSE**

**Owing to the demands upon our space in this issue we regret that we have been obliged to omit the instruction course.**

### Speaker and Transformer Service

As readers will be aware, at the present time there is considerable difficulty in getting repairs to speakers and transformers carried out. We learn, however, that Sinclair Speakers are still in a position to execute this class of work and all inquiries will receive prompt attention. They should be addressed to Sinclair Speakers, Pulteney Terrace, Copenhagen Street, London, N.1. Telephone: Terminus 4355.

# OPPORTUNITIES SECTION

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## Double-acting Relay

A new design of double-acting relay has been put into production by Londex, Ltd., Anerley Works, 207 Anerley Road, London, S.E.20.

This new relay solves the most intricate switching problems in a simple manner and can be used, among other ways, as an interlocking relay or a latch-in or out relay in connection with the remote control of lift gear, motor starters, or employed with thermostats, emergency lighting, etc. The coils of the relay are continuously rated and take only 2 VA. They can be used for impulse operation or continuous excitation.

The magnetic cores are of high quality magnetic material, laminated and fitted with shaded poles. The relay is therefore equally suitable for A.C. or D.C. and is silent in operation. The relay has two definite positions and to alter the position, the opposite coil has to be energised. Each relay is flash tested at 2,000 volts.

## "More Electronic Patent Summaries"

(Patent No. 519,631.)

Superhet control circuit for preventing or correcting "frequency drift" in a television receiver.—*Kolster-Brandes, Ltd.*, and *W. A. Beatty*.

(Patent No. 520,106.)

Television transmitter tube using a mosaic-cell electrode with a "virtual" instead of a conductive back-plate.—*Marconi's Wireless Telegraph Co., Ltd.*

(Patent No. 520,349.)

Apparatus for testing the accuracy of an interlaced system of scanning used in receiving television.—*Scophony, Ltd.*, and *A. F. Thomson*.

(Patent No. 520,412.)

Method of mounting and masking the cathode-ray tube of a television receiver.—*Kolster-Brandes, Ltd.*, and *C. N. Smyth*.

(Patent No. 520,549.)

Wide-band amplifier, suitable for television, in which negative feed-back is used to apply a variable gain control.—*Standard Telephones and Cables, Ltd.*

## INDEX TO ADVERTISERS



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**WARD,** 46, Farringdon St., London, E.C.4. Tel. Holborn 9703.

**LOUDSPEAKER** repairs, British, American, any make, 24-hour service; moderate prices.—Sinclair Speakers, Pulteney Terrace, Copenhagen Street, N.1.

### LOUDSPEAKERS

**3,000 SPEAKERS** P.M. and energised 4" to 14", including several Epoch 18". Sinclair Speakers, Pulteney Terrace, Copenhagen Street, N.1.

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### MORSE EQUIPMENT

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### TUITION

**YOUNG MEN** wanted to train as radio officers in Merchant Navy and R.A.F. Students also prepared for peace-time wireless appointments in radio and television. Boarders accepted; low fees. College in ideal peaceful surroundings. Prospectus free.—Wireless College, Colwyn Bay.

### PATENT AND TRADE MARK AGENTS

**GEE & CO.,** (H. T. P. Gee, Mem. R.S.G.B., etc.). 51-52, Chancery Lane, London, W.C.2. Holborn 4547-8. Handbook free.

### MORSE TRAINING

**MORSE CODE COURSES.** "Book of Facts" Free.—Candler System Co. (Room 55 B), 121 Kingsway, London, W.C.2.

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