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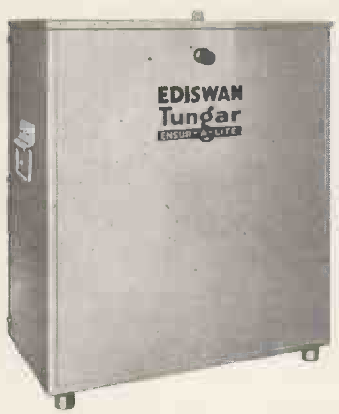
Light—

IN ANY EMERGENCY!

EDISWAN
Tungar
"*Ensur-a-lite*"



Ediswan Tungar "Ensur-a-lite" with protecting shutter in normal position, thus sealing the unit from danger of interference by any unauthorised person.

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The Ediswan Tungar, the heart of the "Ensur-a-lite," is a tried and tested unit; thousands are in normal constant use for other peace-time duties.

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Ediswan Tungar "Ensur-a-lite" with shutter removed—ready for use.

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THE EDISON SWAN ELECTRIC CO. LTD., PONDERS END, MIDDLESEX

B.C.345

675

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Electronics AND TELEVISION AND SHORT-WAVE WORLD

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News and Views

Munitions and Electronics: Last month we were able in a very large works to see for ourselves to what extent electronic methods are coming into general everyday engineering practice. Armed with a magic pass, without which even our guide, an employee of the company, would have been denied admission, we passed through the portals of a great munition works. At the foot of the staircase on the left was a lamp focused on an electronic device on the right, and as porters laden with work or engaged in pushing trolleys approached the doors they cut the ray of light and the doors automatically opened. No lost time fiddling for the door handle and no woodwork damaged by the porters' kicks !

Electrical Forging: In another works which we visited during the same week, we were fascinated in watching electrical forging, by means of which high quality forged work in iron and steel of an extremely difficult character is produced rapidly and cheaply. A steel rod is forged for the blank of a Diesel engine valve for example, or if need be a bulge or knob is raised halfway down a steel rod, in a matter of seconds, the process being simple, clean and economical, the consumption of current being no more than 1 unit for 14 lbs. of metal shaped. The rod is placed in the machine, tight up against the "anvil," current is switched on, and as the temperature and plasticity of the steel increase, the work is automatically pressed up against the anvil, thus causing the end of the rod to be up-set, using the old blacksmithy term. In a few seconds, the work is lifted from the machine, dropped between dies and given by the blow of the hammer its final forged shape preparatory to machining. Many non-ferrous metals can be worked in the same way.

Television Economics: Dr. A. N. Goldsmith has been contributing an interesting series of articles on Television Economics in our American contemporary *Communications*, and in the latest issue he reviews the position of European television manufacture up to August, 1939. By European he is understood to refer to the British market, as no other country on this side of the Atlantic had sufficiently developed television as a commercial proposition. It is noted that in August, 1939, the range of prices for a given size of picture was comparatively narrow and had been slightly reduced from those obtained at the introduction of the service. American receiver prices at the outset were ranging from $190 to $600 or at the rate of $50 per inch of picture.

Dr. Goldsmith also points out the economic desirability of auxiliary broadcasts in the U.S.W. band in order that the advantages of short-wave reception of music may be realised to the full and that the high cost of receivers may be justified by making them available for more hours per day than those occupied by the television programme. We cordially recommend this suggestion to the B.B.C. when the service is resumed—let us hope that the first programme radiated will be an outdoor broadcast of the peace celebrations.

Baird Television: Elsewhere in this issue will be found the bare statement of the appointment of a Receiver to the Baird Company. In a company which relied solely on television the coming of war has naturally had a most disappointing effect.

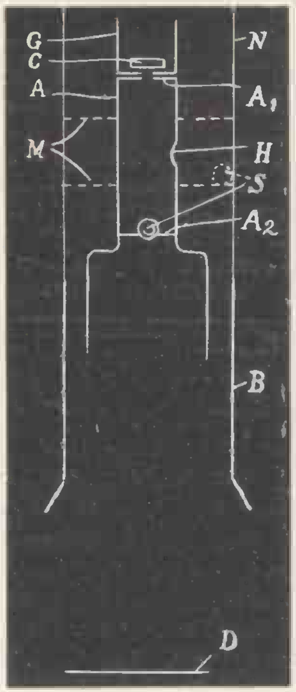
Mr. Baird himself must feel keenly the loss of a great deal that he has worked for, and we hope with him that the Baird Company will recover its former activity when things are brighter.

The name of Baird is always and will be always synonymous with television, and no adversity can deprive him of the knowledge that it was his foresight and ingenuity that gave us the modern marvel of home entertainment.

Research Engineers:—Advertisements are appearing regularly in the technical and daily Press for research engineers for the various Government establishments and all over the country men are engaged in careful, painstaking work on developing new applications of electronics.

The research engineer can be trained to a certain degree, but like the artist, he is born and not made. There are some who have inventive genius, and some who spend infinite pains in pursuing one line of work. One thing characterises their work and that is care and attention to detail. Students of radio and elec-

(*Continued at foot of 3rd col. on next page.*)



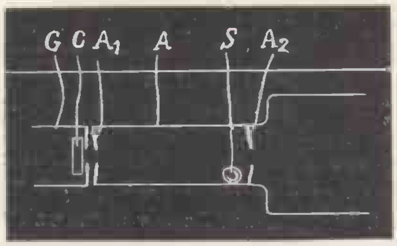


Fig. 1 (left) and Fig. 2 (above). Two schemes for preventing discolouration of screens of cathode-ray tubes.

PREVENTING "BLACK SPOT" IN CATHODE-RAY TUBES

IN the manufacture of cathode-ray tubes, the tube is subjected to an ageing process after sealing off the glass envelope from the pump, the purpose being to render the cathode fully activated and also to harden the tube by removing residual gas in the presence of the "getter" employed. A further beneficial effect is the reduction of negative ion emission in the tube, which would otherwise cause the formation of a black spot; this effect may be enhanced by intensifying the ageing process so that the cathode is bombarded by high speed positive ions by applying a high voltage (of the order of 1,000) to the first anode of the electron gun, or by increase of the cathode temperature.

This process, however, usually produces dark zones upon the screen of the tube, the size of which and their density, depends upon the voltages applied and other conditions. The zones are produced by electrons from the cathode or charged particles in the tube impinging on the screen.

The ageing process may be carried out with an electrode, such as a second anode, earthed, in which case positive ions produced in the space beyond the first anode away from the cathode will be attracted to the earthed second anode and tend to produce a dark zone on the screen. Alternatively, if an electrode such as a second anode be maintained at the same or a higher positive potential than the first anode, electrons and negatively charged ions when attracted to the second anode also tend to produce a dark zone on the screen; neutral particles may also have the same effect, these being produced by positively charged particles, such as are produced in the space between the cathode and first anode, bombarding the cathode.

The electons, which by their impingement on the screen produce a dark zone, may be relatively easily deflected and prevented from reaching the screen by means such as a magnetic field, but intense magnetic fields would be necessary to deflect the positively and negatively charged particles, and moreover magnetic fields would not be effective at all for reflecting the neutral particles.

This undesirable phenomenon can, however, be considerably reduced by providing an obstruction within the tube which will block the path of such particles towards the screen during the ageing process and can be moved out of the path of the electron beam afterwards.

In the arrangement illustrated in Fig. 1 a tetrode gun is shown with its axis vertical, the cathode C being adjacent to a modulating electrode G, beyond which is positioned the anode A having two apertured diaphragms A_1 and A_2, the apertured diaphragm A_1 being closer to the cathode and the apertured diaphragm A_2 being further from the cathode. The usual second anode B is provided which may consist of a conductive coating on the inner surface of the envelope of the tube. The screen of the cathode-ray tube is indicated at D.

Positioned in the aperture of the diaphragm A_2 is a sphere B, which is of such a size as to entirely block this aperture, and ageing of the tube is carried out with the sphere in the position shown. Charged particles of gas and electrons, as well as neutral atoms are thus prevented from reaching the screen.

After the ageing process has been completed the sphere S may be removed by tilting the tube and allowing the sphere to roll through the hole H provided in the anode A. It may then be retained in the position shown dotted by means of two mica discs, shown dotted at M, in the neck N of the tube. In most cases, however, where the sphere is metallic and the size only a fraction of the anode diameter it may safely be left inside the anode.

In the arrangement illustrated in Fig. 2 the anode A of the electron gun is provided with concave or conical shaped apertured diaphragms A_1 and A_2, the concave or conical shape of these diaphragms ensuring that the sphere S will block the aperture in the diaphragm A_2 only when the tube is held so that the axis of the electron gun arrangement is vertical, and the screen is lower than the cathode. The arrangement may thus be normally employed with its axis horizontal or with its axis vertical and the screen above the cathode. When it is desired that the arrangement be normally used with its axis horizontal, it is only strictly necessary to have the apertured diaphragm A_2 of concave or conical form.

Alternatively another apertured diaphragm can be placed between the apertured diaphragms A_1 and A_2 and closer to the apertured diaphragm A_2, the apertured diaphragm A_2 being concave as viewed from the cathode and the other apertured diaphragm being convex as viewed from the cathode.

The obstruction utilised need not necessarily be placed in the apertured diaphragm furthermost from the cathode, but this disposition is preferable.

In an electron gun arrangement such as a triode in which an anode having apertured diaphragms is usually not provided, a diaphragm placed along the axis of the tube can be used. The obstruction may take the form of a flap which is pivoted or hinged to a suitable apertured diaphragm.

This development is reported from the Laboratories of Electric and Musical Industries, Ltd.

"News and Views"

(Continued from preceding page).

tronics cannot take too much trouble over their work in the early stages if they intend to take up research after qualification. Several well-known engineers will point with pride to note-books of work done and classified in the days when they were students, which are still a source of reference to them.

It is very seldom that a brilliant invention comes to the semi-trained amateur. It may appear original, but further investigation shows that it has been the subject of a patent many years previously. The trained engineer will know from his reading and notes in what direction the ground has been previously covered.

Commercial Applications of LIGHT-RAY CONTROL

Pedestrian crossing, with Bollard illumination controls. A contains the light-cell and B the control gear.

THE various uses to which light-control apparatus is now put probably numbers some hundreds and additional applications are constantly being made. In every case the fundamental principle is the same—operation of some electrical or mechanical apparatus is brought about by varying the light intensity to which a special type of light-sensitive cell is exposed. Two types of cell are in general use—the selenium cell of which the resistance varies under the influence of light and the photo-electric cell which is emissive. In many cases of ordinary commercial application, the former is used and we are indebted to the Radiovisor Company, who are a pioneer concern in light control, for the following particulars of applications of this type of cell. For certain special purposes, however, the Radiovisor Company also use the photo-electric cell. Research and development of the selenium cell have resulted in the production of an instrument which can be operated on commercial voltages and remain on closed circuit continuously for an indefinite period.

Lighting Control

One of the most important applications of light control is the automatic turning on and off of street lighting. Lamps are automatically switched on or off at the proper daylight intensity, irrespective of the hour. In the event of premature darkness or a dark fog occurring during the daytime the lamps are automatically lighted, and when normal daylight conditions return they are automatically extinguished. Factors such as latitude and longitude, the clarity of the atmosphere and the proximity or otherwise of tall buildings are taken into consideration in the functioning of the apparatus.

Operation of the Unit.—In darkness the resistance of the cell, or bridge as it is termed, is high in respect of a fixed resistance in series with it (which is an internal part of the unit) and the grid of the thermionic valve controlled by this combination is made sufficiently negative to prevent the passage of anode current. The snap switch relay, which is actuated by the anode current, thus closes by virtue of its permanent polarisation, and completes the lamp or other circuit to be controlled.

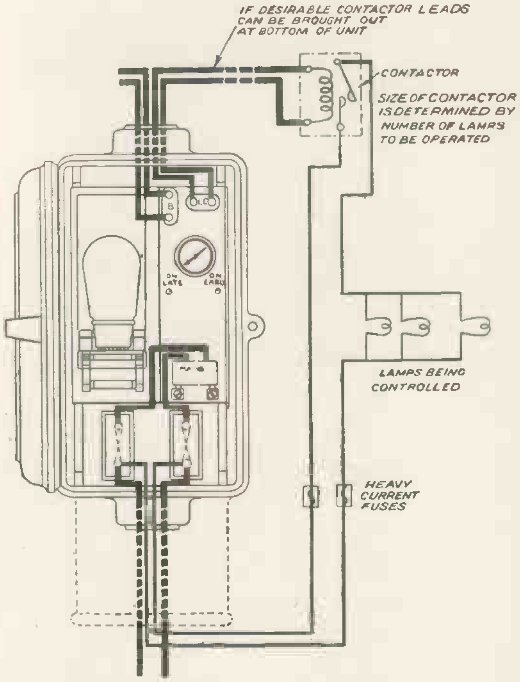
During daylight the resistance of the bridge is lowered so that anode current passes through the coils of the snap switch relay, which opens the circuit to be controlled. The exact degree of illumination at which operation occurs is, of course, finally relative to the potential of the grid of the valve, and to set this there is a potentiometer, which is the only necessary adjustment in the unit.

Light-cell street lighting control at Swiss Cottage, London. The light-cell is in the box indicated by B and the control equipment is in box A.

Factory Applications

Burglar Alarms

An obvious use of light-actuated apparatus is for the protection of valuables against theft. In this case, it is sufficient to explain at this stage that the scheme essentially comprises a ray of invisible infra-red light whose continuity from source to light sensitive cell and alarm relay must remain unbroken if an alarm is not to be given. Immediately such an invisible barrier is broken by the passage of a burglar, electrical means are set in motion to give an audible or visible alarm at any chosen place continuously until re-set, so that the owner or person in charge may take immediate steps to deal with the emergency or call whatever police protection that may be required. The ray is quite invisible in the light or in the dark, so that even if it is known to exist, moral as well as physical protection is given.



Schematic diagram of control gear for group lighting.

Turbidity Indicator

Processes in which liquids of various natures are continuously flowing, in a system of manufacture or purification, are often of such a nature that a constant check on either the clarity or colour is required. Where the liquid is flowing at a considerable rate, a large quantity of detrimental content would be liable to pass through the system in a very short time were not a constant observation maintained.

The Radiovisor Turbidity Indicator is primarily intended to give immediate warning when the liquid flowing through a pipe begins to run turbid or cloudy, and to close a contact from which can be actuated a larger switch, controlling any desired mechanism. The apparatus consists of three parts: a projector, containing a low voltage focusing lamp and adjustable lens, in a metal housing and having a collimator slit; a receiver containing a light-sensitive cell in a metal housing with mask carrying slit; and a control box, which is a self-contained unit containing the valve relay circuit, milliammeter, relay and adjustable control knobs by which, as indicated by the milliammeter readings, the warning can be arranged to be given at the required opacity.

The optical principles employed are such that a very small change of turbidity produces a large change in the amount of light received by the cell. The projector is arranged in the form of a collimator to throw a narrow focused beam of light obliquely upon a glass tube, preferably not less than $2\frac{1}{2}$ in. in diameter, through which the liquid is passing. The tube is arranged to form, as it were, the prism of a spectroscope, and the beam, after its second refraction, emerges and enters a narrow slit in front of the light-sensitive cell.

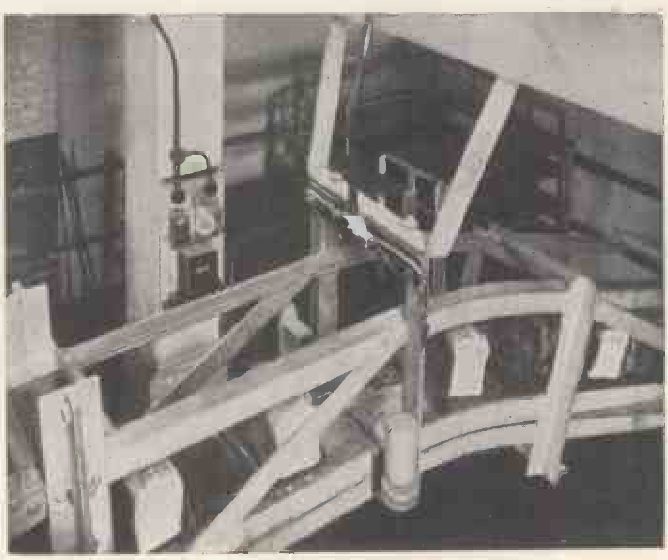
As long as the liquid is clear this focused beam traverses a clean-cut path, and is refracted on entering and leaving the tube so that it enters the receiving slit without loss. When the liquid becomes cloudy due to the presence of solid particles, the light entering the tube is scattered, and there is a very great decrease of that entering the receiving slit. The arrangement is primarily intended for giving warning, but once set to indicate a certain standard of clarity or turbidity, the instrument will always give identical readings for liquids in the same state, assuming, of course, that the conditions of observation are kept the same. This method can also be used to indicate a change of refractive index in the liquid.

Counting Unit

A very useful light-control application is that of counting objects without contact with them by passing them through a beam of light, the cutting off of which causes the counting operation. This method is specially applicable to factory processes, such as articles or cases coming down a conveyor. The equipment is shown below.

In addition to the electro-magnetic counter to be operated, the apparatus

A counting unit for counting objects without contact. The articles on the conveyor interrupt a beam of light projected on the light cell.



Smoke Indicator

comprises two units, the projector and the receiver, consisting of similar cast iron boxes, fitted with small windows, each box being mounted on a bracket that provides universal movement for setting up and alignment.

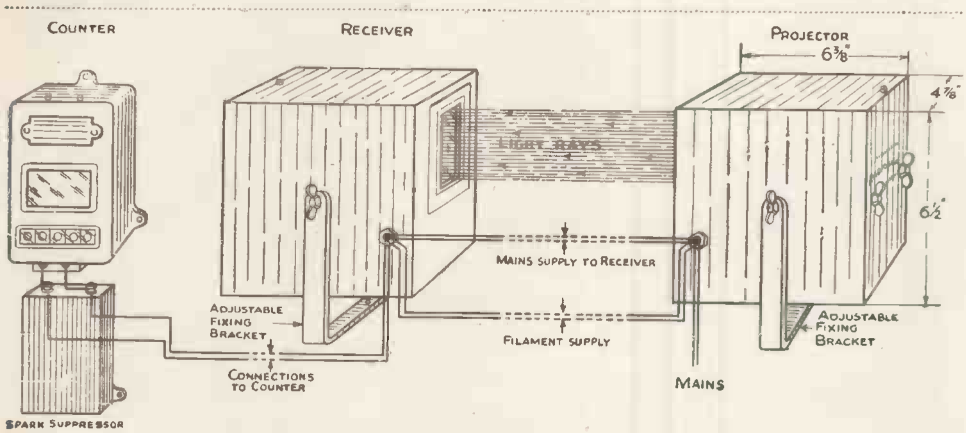


Diagram showing the arrangement of the counting apparatus.

The projector unit contains a low-voltage focusing lamp with lens and focusing arrangement and a transformer which supplies not only this lamp, but also the filament current for the valve contained in the receiver. The latter contains both the bridge and the valve relay circuit, from which ordinary leads go to the electromagnetic counter.

The counting apparatus can be used in any place without special precautions to protect it from the effects of daylight or from the general illumination of the factory or other position. This is achieved by the use of a circuit which automatically adapts itself to slow changes in the general illumination, while remaining responsive to the sudden cutting off of the light which occurs when the article to be counted is moved so as to intercept the beam. The apparatus, therefore, will not count any object moving exceedingly slowly.

The interposition of an object in the beam causes the closing of the relay contacts, and if it remains long in the beam, the circuit will automatically recover of its own accord, the counting operation, however, having been performed.

Smoke Indicator

Smoke control is necessary to power and works engineers on the grounds of both smoke abatement and obtaining efficient combustion. The smoke indicator is an up-to-date and highly satisfactory method of achieving these purposes, as well as of giving valuable information regarding the running of the plant.

The smoke density is made evident before the smoke reaches the top of the stack and prompt operation of the controls is thus greatly facilitated. Two holes are cut opposite each other in a flue or chimney base, and from one a light ray is focused on to the light-sensitive cell in the other. The current emitted by the cell shows (as recorded by the necessary instruments and charts) the measure of the light obstruction by the intervening smoke. When there is no smoke, the cell receives the maximum quantity of light, and when the smoke is very black practically no light reaches the cell. Intermediate degrees of smoke density are registered between these two extremes. Indicators are now installed and in successful operation in most of the important power stations in Great Britain.

The apparatus consists of a projector, receiver and control box, together with external indicator, recorder or alarm.

Connected to the receiver is the control box which may be in any convenient place, though preferably near the receiver. Leads from the control box are taken to the distant local indicators. The standard indicator is a 7-in. dial switchboard mounting instrument, which can be placed on the station instrument panel or wherever convenient. It is fitted with a scale calibrated in Ringelmann smoke units. The optical parts are protected from direct contact with the flue gases by a plate glass window which will require either manual or automatic cleaning. Compressed air has proved most effective for cleaning, particularly where pulverised fuel is burnt, but water jet cleaning is also practicable.

The measuring circuit employs a single standard three-electrode valve, the anode current of which it is that is registered by the indicators. The circuit has two adjustments, viz., "set light" and "set dark," each being made by a separate potentiometer, corresponding to the extreme conditions of smoke density or limits of the indicator scale.

The smoke indicator apparatus has also been adapted to determine the density of exhaust gases from Diesel engines. The projector and receiver units are mounted in line with two specially designed observation window pieces bolted to the exhause pipe about half-way between the engine and silencer.

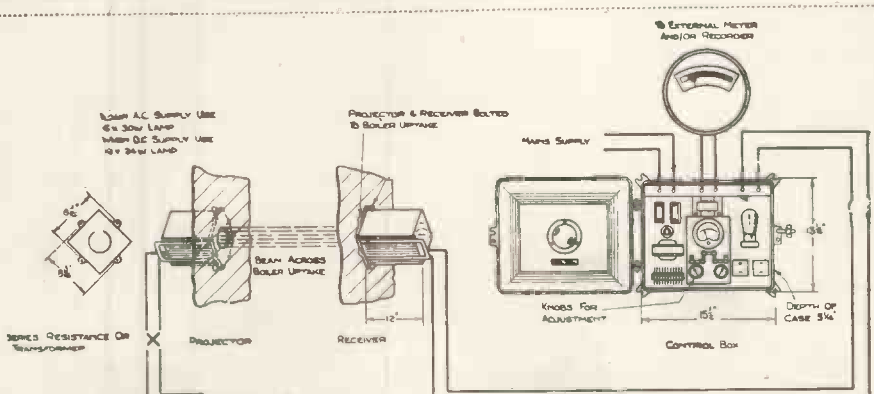
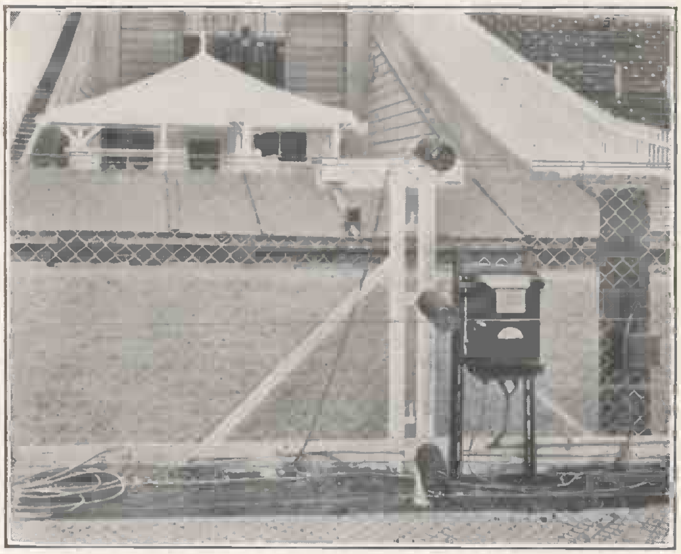


Diagram showing arrangement of smoke indication apparatus for use on smoke stacks.

Race Timing

Oil Burner Control

An apparatus for the safe control of the operation of oil burners has been devised which does not depend for its operation upon the heat rays which are emitted when the combustion of the oil takes plac.e. If, through any cause, the flame in these furnaces is extinguished, it is essential that the burner should be shut down as rapidly as possible in order to avoid the risk of fire or explosion which may occur if unignited oil or vapour is injected into the furnace. The flame control operates by virtue of the light emitted by the flame. The moment the flame goes out, the light-ray cell—operating through a switch—closes the burner and gives an alarm. The apparatus shuts down simultaneously the oil feed, air supply and igniter spark if used; the burner can then only be put back into operation by manual action of the attendant.



Race timing unit installed at Wembley Stadium for greyhound racing.

Height Gauges

The Mersey Tunnel is equipped with light actuated gauges. By arranging light-rays at a predetermined height and in such a position that the vehicles must pass under them, those loaded up to a height which intercepts the rays give immediate warning that they are *overloaded*. Height gauges are installed at a short distance from all entrances to the tunnel.

Visibility apparatus is also installed in the Mersey Tunnel which operates on similar principles to the Smoke Indicator giving a direct reading of Tunnel air smoke density and a chart record in the Control Room so that the operatives can maintain adequate ventilation at all sections of the tunnel.

Control of Doors

Automatic opening and closing of doors on the approach of persons or vehicles is another application. By a special device the action (started by interruption of the ray) can be prolonged for several minutes thus allowing the door to remain open for such length of time as will permit the persons or vehicle to pass through it. Apparatus of this nature has been adapted to turning on water fountains on the approach of a person to drink, and for starting gramophones when the ray is interrupted by the human hand, or other obstacle.

Apparatus for announcing the arrival of cars at petrol pumps and equipment to open garage doors automatically by focusing motor car headlights on cells placed in appropriate positions is yet another application. In the former case, customers' cars cut across an invisible ray and a bell rings in the reception office.

Race Timing

The most accurate method of timing races is by the use of a light-ray system. A stop-watch is started by the raising of the gate or trap, and is stopped by the horse or greyhound intercepting the ray across the track at the winning post.

Lift Control

Several interesting light-ray devices have been designed by which lifts are self-levelled at any desired point, and gates controlled in such a manner as to prevent them closing when persons or goods are entering and to ensure that elevators for goods and merchandise, whilst being loaded up on one floor, cannot be put into motion from another floor.

Paper Control

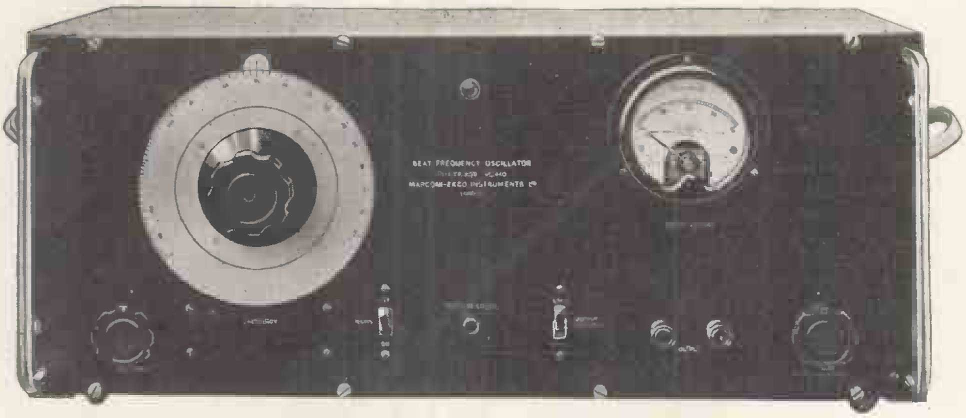
One device fitted to the equipment of a paper-machinery firm automatically (without any slowing up of the paper feed) joins up the new roll of paper to the roll just printed, and a similar apparatus has been devised for printing machinery which detects joins or breakages in the paper, and stops the machine automatically before damage or wastage occurs.

Another, for use in the paper and printing trades, observes certain indicating lines on a paper feed for wrapping or for embossing or overprinting, and the correct wrapping of articles in exact registration with the printed patterns is thus obtained.

A somewhat unusual application is to obviate the dangers of somnambulism. A light-ray is projected across the the bed on to a cell in such a manner that should the sleepwalker or patient get out of bed and start wandering round the room the ray must be interrupted and an alarm given in any part of the house desired. The ray is usually arranged diagonally across the bed from wall to wall, and about 18 in. above the bedclothes, a diagonal direction being chosen in order to allow the person access to bedside table and requisites.

It is apparent that even all the principal applications of the light ray system cannot be comprehensively described in the limits of an article, but the fact that it is used for such widely different purposes as detection of ammonia in air conditioning and refrigerating plants, control of escalators, the detection of noxious gases in chemical manufacturing plants or storage places, shop door warnings, etc., is convincing proof that the light ray system has become an indispensable factor in many fields of commerce and manufacture and that its applications are almost illimitable.

THE PRACTICAL DESIGN OF BEAT-NOTE OSCILLATORS



A Marconi-Ekco mains-operated oscillator of the heterodyne type covering the audio frequency range between 10 and 12,000 cycles per second. The harmonic content is low and the output voltage is sensibly level over the whole frequency range.

BEAT-NOTE oscillators are nowadays almost universally used when a variable audio frequency source is required for measuring purposes.

In comparison with a straightforward oscillator operating at its fundamental frequency, a beat-note oscillator has the following advantages:—

(a) A wide frequency range may be covered rapidly without any attendant switching of inductances and condensers.

(b) Very low frequencies may be produced without the attendant bulk of large inductances and condensers.

(c) An almost constant output is obtained with reasonable ease over the audio frequency range.

On the other hand, in order to avoid the generation of unwanted harmonics, certain precautions must be taken in the design. Some of the more important features affecting performance will therefore be discussed in greater detail below.

Constancy of Output versus Frequency

If two oscillations of different frequencies are applied to the input of a *non-linear* device, then among the components of different frequency components present in the output of this device there will be present one component whose frequency is equal to the frequency difference between the two applied signals. Thus if two signals Vs sin 2πfst and Vn sin 2πfnt are applied to a non-linear device, then in its output will be present a component of frequency (fs − fn) and (fn − fs).

If the non-linear device has a square-law characteristic the frequency difference or beat component will have an amplitude:—

$$V_o \sin 2\pi(f_s - f_n)t \propto V_s V_n.$$

If, on the other hand, the two signals are applied to a linear rectifier, the beat frequency output will be a function of the envelope of the combined input signals. If we call the ratio of the amplitudes of the two signals "r" then

$$r = \frac{V_s}{V_n}$$

and the amplitude of Vo is given approximately by

$$V_o = V_s\left(1 - \frac{r^2}{8}\right)K$$

and the amplitude of the second and third harmonics of the beat note are given approximately by

> ### *By C. Lockhart.*
> *The author of this article is a research engineer engaged in the development of electronic measuring instruments.*
> *The result of his investigations on the requirements of beat-note oscillators is embodied in this discussion which will be followed later by a design including the features described.*

$$V_{20} = V_s\frac{r}{4}\left(1 - \frac{r^2}{4}\right)K$$

$$V_{30} = V_s\frac{r^2}{8}\left(1 - \frac{5}{16}r^2\right)K$$

where K is a constant.

It will be seen from the above expressions that provided the ratio of the two signals is more than two to one ($r < \frac{1}{2}$) the amplitude of the beat note is sensibly independent of the amplitude of the larger of the two signals. The value of r must, however, be made much less than one-half if the harmonic content is to be kept low. For small values of r the percentage second harmonic is equal to $\frac{r}{4}$, and percentage harmonic $\frac{r^2}{8}$. For a value $r = \frac{1}{10}$ we therefore have $2\frac{1}{2}$ per cent. 2nd harmonic and $\frac{1}{8}$ per cent. 3rd harmonic.

If we fix the frequency of the oscillator fs and vary that of fn to alter our beat note frequency, then with a normal type of oscillator the amplitude of the output Vn will vary as we change fn, the amount of change being a function of the value of $\frac{F_s - f_n}{f_n}$.

The choice of method of rectification is thus a function of the value of $\left(\frac{f_s - f_n}{f_n}\right)$.

If $\frac{f_s - f_n}{f_n}$ is small, either a linear or square law detector may be used, while still maintaining a constant output versus frequency. If, however, $\frac{f_s - f_n}{f_n}$ is appreciable, a linear detector with a small value of "r" must be employed, as the output is then independent of variations in Vn and the harmonic content can be made low.

The normal methods of producing the beat frequency using a pentode valve, are shown in Fig. 3, 1a and 1b.

For "square-law" detection, the

Oscillator Frequency Determination

two inputs of frequency fs and fn are applied to the control grid, which is biased back to the bottom bend of the anode current grid volts characteristic. The two signals are kept small in order to keep within the proper portion of the characteristic. A low-pass filter is connected in the output circuit in order to reject all frequencies outside the desired pass-band.

If linear detection is required, the bias is increased and the amplitude of the variable frequency oscillator Vn is considerably increased in order to ensure that the beat frequency output is proportional to the envelope of the signal. With the large value of signal Vn applied, it is possible to obtain the fixed bias by means of rectified grid current with a condenser and grid leak, as shown in Fig. 1b.

A different method of obtaining the beat frequency is by the use of a hexode or heptode valve as a mixer in a similar manner to the frequency changer in a broadcast receiver. This method using a standard triode-heptode is illustrated in Fig. 1c. It has the great advantage of isolating the two oscillators without the necessity for a buffer stage. Further features of the latter circuit are discussed in a later paragraph.

Choice of Oscillator Frequency

When choosing the oscillator frequencies, frequency stability, variation of oscillator output and the generation of spurious frequencies have to be considered.

The frequency stability will be mainly affected by temperature drift and supply voltage drift if good suitably aged components are employed.

We can write the beat frequency

$$fs - fn = fs\left(1 + \frac{fn}{fs}\right).$$

From this it will be seen that if by suitable layouts and circuit arrangements we could ensure that the percentage frequency drift is equal in the two oscillators, then the percentage error in the beat frequency is independent of the oscillator frequencies. The above stipulation is, however, rather difficult to realise in practice, so that the oscillator frequency should be kept as low as possible in order to reduce drift.

The variation of oscillator output Vn wnth tuning being a function of $\frac{fs - fn}{fn}$ will, however, improve as the oscillator frequencies are increased.

The generation of spurious frequencies is the most important factor controlling the choice of the lowest operating frequency, as these spurious frequencies cannot be subsequently filtered out. These spurious frequencies make themselves apparent as "tweets" superimposed on the beat frequency. The mechanism of their generation is identical to the familiar "harmonic responses" in broadcast super heterodyne receivers, and as in the case of broadcast frequency changers they are best studied by means of a chart.*

Such a chart is shown in Fig. 2 and it relates the different frequency components present in the output of the detector to the applied frequencies fs and fn. It will be seen that the ordinates are plotted as a percentage of the fixed frequency fs, while the abscissa is the beat or difference frequency plotted as a percentage of fs. The abscissa has a centre zero and to the right of it fn > fa, while to the left fn < fa.

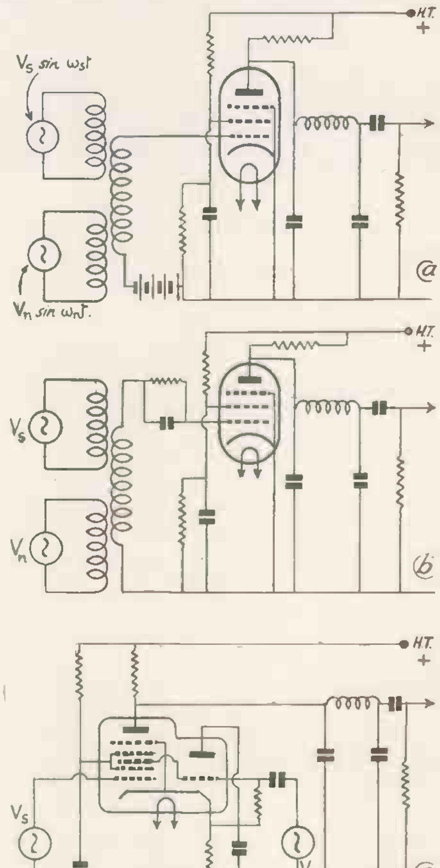


Fig. 1.—Three methods of producing beat frequency. By using a pentode (a & b) and a hexode (c).

On the chart there are three lines at 45° in heavier type, one is a plot of fn as a percentage of fs and the other two are plots of the beat frequency as a percentage of fs. Similarly, lines are drawn to represent the second harmonic 2(fs − fn) and 2(fn − fs) of the beat frequency, and the third harmonic 3(fs − fn) and 3(fn − fs). Other harmonic responses are represented by lines (2fn − fs), (2fs − fn), (3fn − fs), (3fs − fn), (3fn − 2fs), (3fs − 2fn).

* Though these charts have been in common use for broadcast receivers for many years, they were first applied to Beat Note Oscillators by Barber (*Radio Engineering* 1936).

Wherever two lines intersect, a "tweet" may occur, though the intersection, with the beat frequency lines (fs − fn) and (fn − fs) are by far the most serious, as the amplitudes of the other components are appreciably lower.

At the actual point of crossing between lines, a single frequency output is obtained as the same beat frequency is produced by two separate component orders of the rectifier.

On either side of the crossover, however, a second note will be superimposed on the desired beat frequency. This occurs due to the different rate of change in the output frequencies as fn is varied and is best understood by illustrating the effect with an example.

We will take for the purpose of this example the crossing point between (fs − fn) and (3fn − 2fs); we will also make fs = 40,000 cycles per second, a convenient value for computation. Then :—

fs − fn = 40,000-30,000 = 10,000 cycles per second.

3fn − 2fs = 90,000-80,000 = 10,000 cycles per second.

If we now increase fn to 30,100 cycles per second. Then :—

fs − fn = 40,000-30,100 = 9,900 cycles per second.

3fn − 2fs = 90,300-8,000 = 10,300 cycles per second.

We now have in addition to the desired output of 9,900 cycles/sec. a lower amplitude output of 10,300 and in addition, due to further rectification, a still lower output of 400 cycles/sec. may be present.

After having decided the highest beat frequency, it is desired to produce, the fixed oscillator frequency fs is given the lowest frequency possible without producing a crossover in the working range.

For fn > fs the first crossover is (3fn − 3fs) with (3fs − 2fn) and this occurs when

$$\frac{fn - fs}{fs} = 0.2.$$

Similarly $\frac{fs - fn}{fs} = 0.167$ for fs fn

It is thus advantageous to operate with fn greater than fs, as for a given specified maximum beat frequency, this mode of operation allows a lower value for fs.

Unfortunately, with the normal type of variable condenser vane shape this would cramp the lower portion of the frequency scale, which is very undesir-

Types of Oscillator Circuit

able. The experimenter buying standard components is therefore constrained to use $fs > fn$ and

$fs > 6$(maximum beat frequency).

This mode of operation has the further disadvantage of entailing a larger percentage variation in the frequency of fn; actually nearly $\pm 9\frac{1}{2}$ per cent. change is required.

If, for example, it was required to make an 0 – 12,500 cycle beat note oscillator, the fixed frequency would have to be not less than 75,000, say, 80,000 cycles/sec.

Provided that a low pass filter is inserted between the rectifier and the first amplifier stage, oscillator harmonics will have no appreciable effect on the output if the harmonics of one of the oscillators are filtered out.

This is evident from the fact that for a given beat frequency term $(fs-fn)$ the second harmonics of the two oscillators can combine to give a term $(2fs-2fn)$ which is the second harmonic of the beat frequency. Other harmonics will produce a similar effect.

If the harmonics of one oscillator are removed, the combination terms such as $(2fn-fs)$ and $(3fn-fs)$, etc., will be eliminated in the low pass filter. A strong oscillator second harmonic can still, however, produce a small amount of second harmonic of the beat frequency, due to the $(2fs-fn)$ component of the rectifier output. Taking, for example, the same value for $fs=40{,}000$ cycles, as in our previous example; for a beat frequency of 4,000 cycles $fn = 36{,}000$. Due to the presence of harmonics in the output of fn we have applied to the detector frequencies of 72,000 cycles, etc., in addition to 40,000 and 36,000. This will result in the following frequencies being present within the pass band of the low-pass filter:

$fs-fn=40{,}000-36{,}000=4{,}000.$

$2fs-fn=80{,}000-72{,}000=8{,}000.$

Provided the harmonic amplitude of the unfiltered oscillator is not excessive, this effect will not cause any trouble.

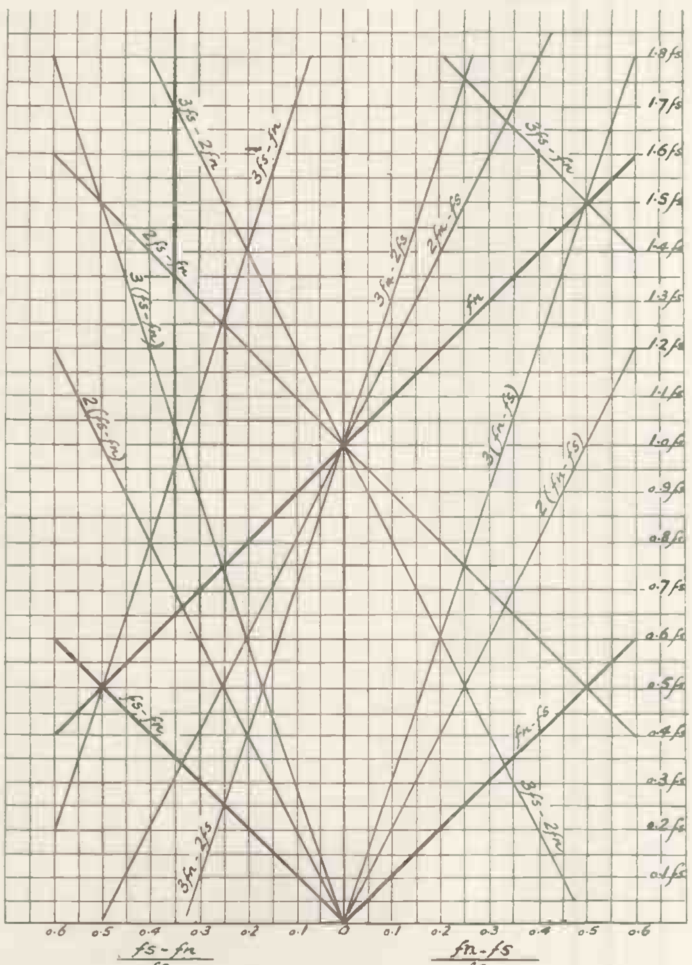


Fig. 2. A chart showing the spurious frequencies present in the output of the detector fed by the two frequencies f_s and f_n.

Oscillator Circuits

In considering the type of oscillator circuit to be used for beat note oscillator work, three points must be considered:—

(a) The effect of the oscillator on the wave form of the output.

(b) The factors affecting the stability of the oscillator frequency with changes of supply voltages.

(c) The tendency of the two oscillators to lock.

In considering the effect of variation of supply voltages on the beat frequency, it is necessary to analyse the effect of such changes on the frequency of the individual oscillators.

Taking first of all valve parameters, here we are concerned with both static and dynamic values. For example, the input capacity of the oscillator valve consists of the static capacity plus a further capacity due to space charge effects, which depends upon the operating conditions. The static capacity may vary with heater voltage (in the case of indirectly heated valves) while the space charge capacity effect will also vary with H.T. supply variations. In order to reduce the effect of these variations on frequency, it is desirable to employ as large a tuning capacity as possible. Also taking the case of a tuned anode oscillator, it is desirable to have a coupling coefficient (between the grid and anode windings) as near unity as possible. This will also ensure that the number of turns in the grid coupling coil is a minimum. A valve with a high mutual conductance will be advantageous as it will allow a lower mutual coupling to be employed, and thus reduce the effect of the grid capacity variations on the tuned anode circuit.

A high μ valve is also required as this, in addition to requiring a lower mutual coupling to be employed between the grid and anode circuits, will have a high anode A.C. resistance, which fact reduces the dependance of the oscillator frequency on the valve parameters.

Low-loss tuning coils should be employed for the same reason.

The frequency of the oscillations generated by an oscillator is affected by the harmonic content in its output, in addition to the valve parameter effects discussed above.

The change in frequency due to the harmonic content is given by:

$$\frac{\Delta f}{fo} = D^2$$

provided harmonics above the third are small.

Δf = the change in frequency

$$fo = \frac{1}{2\pi LC}$$

$$D = \sqrt{\frac{V_2^2 + V_3^2 + V_4^2 +}{V_1^2}}$$

Circuits

where the suffix denotes the order of the harmonic. Thus an oscillator having a 2 per cent. total harmonic content across its resonant circuit condenser would oscillate at a frequency 400 parts in a million below the natural frequency of the resonant circuit.

As the harmonic content will, to a certain extent, depend upon the applied voltages, it is important to choose circuit constants which will keep it low in order to reduce drift.

It will be seen that $\frac{\Delta f}{fo}$ is a function of the harmonic voltages appearing across the oscillator tuning condenser, so here again, a large capacity will reduce drift effects.

Variation in the amount of grid current loading will also cause frequency drift, and the best method of reducing this effect is to provide a grid leak and condenser bias arrangement. The value of the grid leak should be kept high in order to keep the loading small.

There are many types of oscillator circuits designed to reduce the frequency drift produced by supply variations, and it is proposed to discuss three of these below.

The first type to be discussed was introduced by the General Radio Co. of America, and is illustrated in Fig. 3a. The circuit is a straightforward tuned anode oscillator with the exception of the addition of the resistance R. This resistance is primarily intended to reduce the harmonic voltages across the tuned circuit. At the fundamental frequency the impedance of the tuned circuit is large compared to R and most of the voltage is developed across R. At the harmonic frequencies the impedance of the tuned circuit can be made low and then most of the harmonic output voltage is dropped across R. Another effect of R is to increase the effective anode circuit resistance and also reduce the effect of variations in valve anode circuit parameters; this, however, is affected at the expense of a reduction in mutual conductance. Both series and parallel tuned circuit feeds are shown.

Another circuit working on a completely different principle due to Dow is shown on Fig. 3b. Here use is made of the fact that in this circuit an increase in screen volts decreases the frequency, while an increase in anode volts increases the frequency. By a suitable choice of component values it is possible to keep the frequency remarkably constant.

With some valves it may be necessary to obtain the screen voltage by means of a potentiometer.

Another important feature of the circuit is that the output circuit is sensibly isolated from the oscillator section, so that very little pulling of the oscillator frequency is likely to occur, making a buffer stage unnecessary.

The first circuit in Fig. 3b has an unfiltered output suitable for the variable oscillator. A condenser is connected across the output coupling resistance, in order to reduce the harmonic content. The second circuit shows a tuned circuit output which removes the harmonics from the output of the fixed oscillator.

A third very simple and efficient method is shown in Fig. 3c: in this circuit an attempt is made to include most of the features discussed in the previous paragraphs. A pentode valve is used in order to provide a high mutual conductance with a high anode A.C. resistance. Negative feed-back is included in the cathode circuit so as to reduce the variation valve parameters, with supply voltage changes, and in addition this will also reduce the harmonic content. By a suitable choice of R (which may easily be found experimentally), it is possible to reduce frequency drift with supply voltage changes to a very low value.

As in the case of all negative feed-back circuits of this type, both the mutual conductance and the input capa-

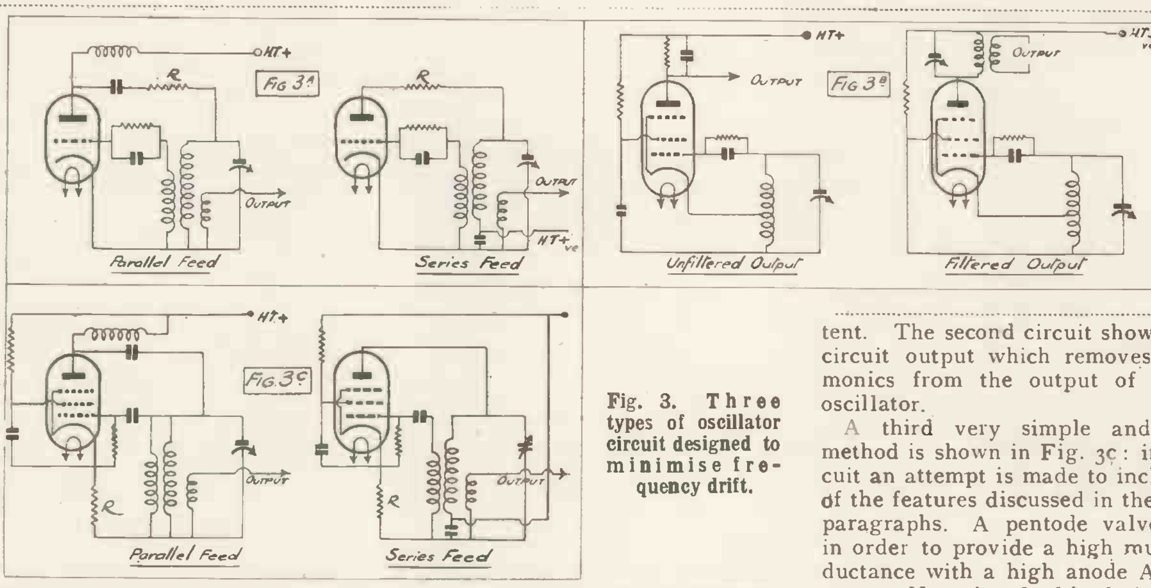


Fig. 3. Three types of oscillator circuit designed to minimise frequency drift.

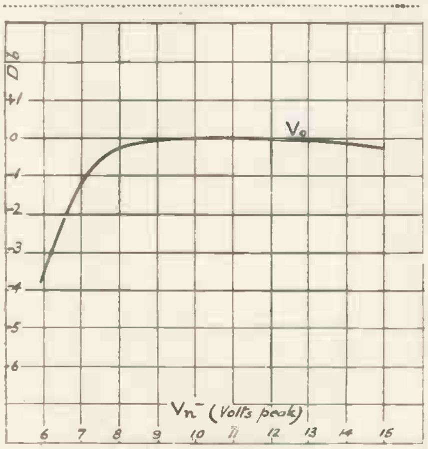


Fig. 4. Variation of beat frequency output V_o with the output voltage V_n of the variable oscillator.

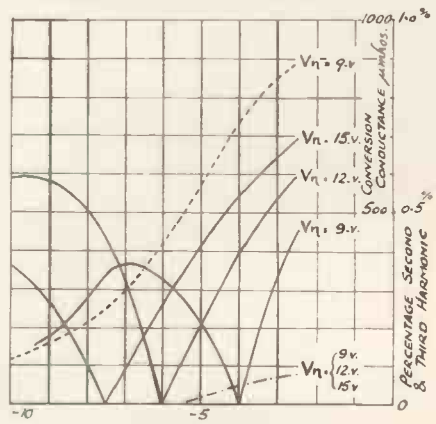


Fig. 5. Variation of 2nd and 3rd harmonic of beat frequency with the amplitude of V_n. The full line is % 2nd harmonic and the chain dotted line 3rd harmonic. Conversion conductance is shown by the dotted line. (V_s 0.2 v. peak).

Low-frequency Oscillators

city are reduced by the ratio $\frac{1}{1+g \times R}$ where g is the value of the mutual conductance without feed-back. In practice, therefore, the coupling will have to be increased, as R is increased.

Temperature Effects

The question of the design of temperature compensated components is outside the scope of this article, and the constructor is advised to purchase temperature compensated inductors and condensers from a reliable manufacturer.

The two oscillators should be mounted on either side of a common metal panel and their compartments well ventilated. All components dissipating an appreciable wattage, or working at an appreciable temperature, such as power supplies and smoothing components and resistors should be kept well away so as to reduce the temperature rise in the oscillator compartments.

"Locking"

When it is desired to generate very low frequencies (below 50 cycles per second), trouble may be experienced due to "locking."

As the beat frequency is reduced, the frequency of the two oscillators becomes very nearly equal, and unless the coupling between the two oscillators is very weak, one oscillator will pull the frequency of the other until the two oscillators become "locked" and oscillate at the same frequency.

This trouble can be reduced to some extent by loose coupling, but can only be eliminated by the use of a buffer stage between one oscillator and the detector, or, alternatively, by the use of Dow oscillators or the circuit illustrated in Fig. 1c. It should be realised, however, that none of the above arrangements will eliminate the trouble unless very efficient decoupling is provided for the oscillators.

A heptode or triode-heptode designed for short-wave frequency changing when used in the circuit, Fig. 1c, will be found particularly efficient in reducing these unwanted couplings without necessitating the use of a separate buffer stage. In fact, if a specially stabilised oscillator circuit is not required, it is possible to use the triode portion for the variable frequency oscillator.

Another feature of Fig. 1c is that provided the voltage Vn is kept above a certain value the amplitude of the beat-frequency output is almost independent of the variation of Vn. This feature is illustrated on Fig. 4.

As the second harmonic of the beat frequency is proportional to (Vs) and the third harmonic to $(Vs)^2$, it is essential to keep Vs small. Fig. 5 illustrates the magnitude of these harmonics for a well-known triode-heptode frequency changer used in a circuit as Fig. 1c.

In this figure the percentage 2nd harmonic a percentage 3rd harmonic of the beat frequency is plotted against grid bias for values of Vn equal to 9, 12 and 15 volts peak. The harmonic outputs which are given for a value of Vs equal to 0.2 volts peak are seen to be negligibly small for this small input. On the same print is also given a curve showing the conversion conductance of the valve.

If we multiply the conversion conductance by the transfer impedance of the low pass filter, we obtain the conversion gain of the stage.

$$\text{Conversion Conductance} = \frac{\text{Beat Frequency Anode Current Amplitude}}{\text{Vs}}$$

Choice of Condenser Values

Fig. 6 is a suggested circuit for a complete beat-note oscillator.

The two oscillators employ the circuit discussed in Fig. 3c. These are coupled to a triode-heptode frequency changer, which, in turn, is coupled through a low-pass filter to a two-stage amplifier with negative feed-back. A tuning indicator is provided for setting up the calibrated dial, using the mains frequency and harmonics as a standard.

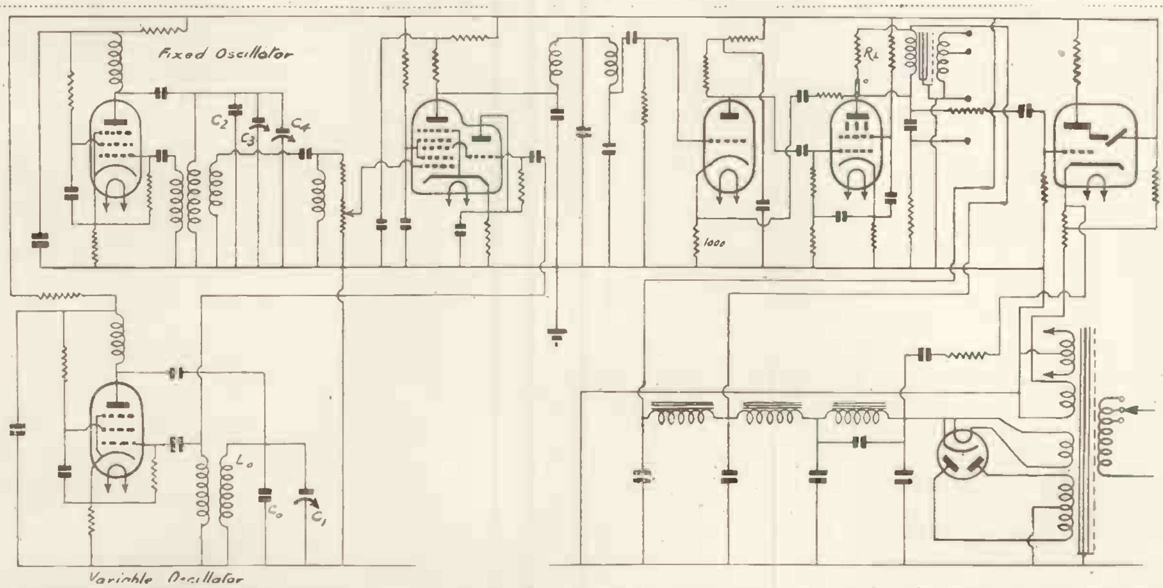


Fig. 6. A suggested circuit for a beat note oscillator embodying the points discussed. A design based on this is being given shortly.

In practice the condenser C1 is set to, say, the 50 or 100 cycle calibration, and C3 at zero; a small vernier condenser C4 is then adjusted to give zero beat with the mains. The condenser C1 then gives the requisite coverage of, say, 0-12,500 cycles. Alternatively, the condenser C1 is set to zero and the condenser C3 to the 50-cycle calibration, and the zero beat obtained as before on the tuning indicator by means of C4.

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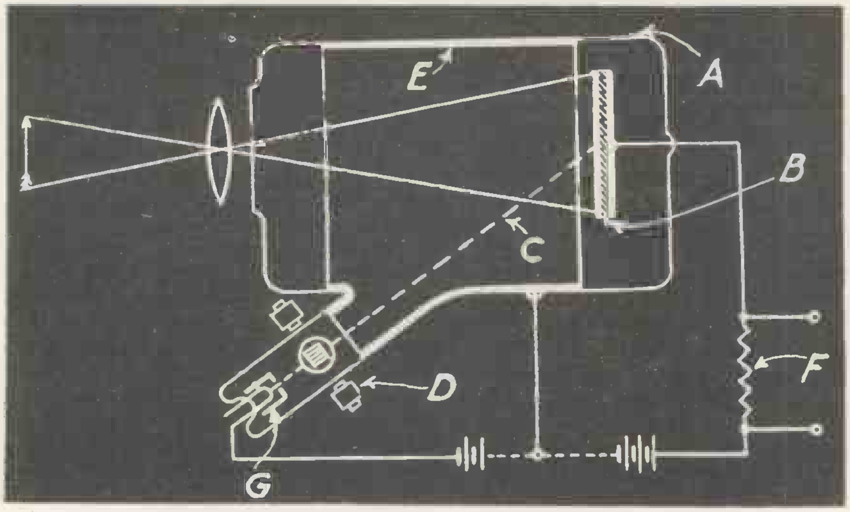


Fig. 1. Schematic diagram of television transmitter employing the new tube.

THE DIAVISC

An entirely new type of image screen has been evolved in the Scophony laboratories which it is claimed possesses important advantages over the use of the usual photo-electric or secondary electron emitting screens.

TELEVISION transmitter tubes of the Iconoscope type employ the so-called external photoelectric effect, that is the ejection of electrons from a photo-electric surface layer when irradiated by light. In such tubes the electric charges produced by the action of an optical image of the object to be transmitted formed on the photoelectric layer are accumulated in a number of small electric condensers arranged over the signal plate or screen, and these charges, stored during the picture period, are released by scanning the screen. Thus the luminous energy of the image is convertd into electrical energy which is stored by the condensers, and is released by the scanning beam.

Volume Effects

With the screen described below, volume instead of surface effects are employed. It is contended that when a surface effect is employed, the redistribution effects of electrons on the surface between neighbouring elemental areas of different intensity reduce the efficiency and partly annul the advantages gained by the storage effect, besides giving rise to so-called spurious signals superimposed on the image signals. With the new type of screen redistribution effects it is claimed are absent or are so small that they can be ignored, and also as the substances employed are all good insulators no appreciable volume redistribution can occur.

Use is made of certain physical effects, discovered in research work on the electric phenomena in luminous phosphors and certain crystals. These effects are closely connected with the conduction of electricity in solids and with electrical phenomena connected with the formation, storage and extinction of the latent photographic image.

It was found that when certain crystals (particularly alkali halide crystals) and phosphors are irradiated with an exciting radiation such as light of a suitable wavelength, or cathode rays, certain sensitive " centres " in these substances are transformed from an initial state of lower energy to an excited state of higher energy. This higher state possesses considerable stability, but the stored-up energy can be released; that is, the " centres " in the excited state can be brought back to the initial state by certain external influences.

This release of the stored-up energy can be effected by influencing the substance with light of a suitable wavelength (usually different from that of the exciting light and in the red or infra-red spectral regions), with other radiations such as cathode rays, with heat or with electric or magnetic fields. This action of releasing the stored-up energy has been termed " quenching " and a radiation effecting this a " quenching radiation."

In the case of certain substances such as many luminous phosphors, the quenching is accompanied by a sudden emission of light, i.e., a considerable part of the stored-up light energy is released again as light during the quenching process. But in general, whether such luminescence occurs or not, the quenching as well as the excitation is usually connected with the liberation and the transportation of electric charges in the interior of the substance.

The theory is that during the excitation, electrons are liberated from certain sensitive " centres " in the substance and are loosely bound in higher semi-stable energy levels from which they are freed again by the quenching process. During their period of freedom the electrons can diffuse through the substance, either irregularly by thermal collision with the ions or, if an electric field is present, in a direct manner towards the positive pole of the field. Even without a quenching process a certain number of the excited " centres " fall back to the initial energy state, this process being mainly caused by thermal collisions with neighbouring atoms, and increasing with rising temperature of the substance.

Crystal Colour Centres

The well-known Farbzentren or " colour centres " in the alkali halide crystals are one form of the sensitive centres which can exist in such crystals and they are of particular importance in connection with the new image screen. Where they do not originally exist in a crystal, they can be artificially producd in it by various methods. For example they can be produced by heating a crystal in the vapour of its own alkali metal or by bombarding the crystal with cathode rays. A crystal containing such colour centres possesses a different absorption range for a luminous exciting radiation than a crystal without such colour centres.

In general, the luminous exciting radiation must be in the ultra-violet spectral range for a crystal without colour centres, but by providing the crystal with colour centres the spectral range of the luminous exciting radiation can be shifted into the visible portion of the spectrum.

If such material is placed in an electric field the poles of which are connected by an external circuit and

— A NEW TYPE OF TRANSMITTING TUBE

the substance is illuminated by a weak exciting radiation, then a small current will flow in the circuit. If a strong quenching radiation is applied momentarily to the substance the current will suddenly increase in value and will then return to a very low value due to the sudden transition from the higher to the lower energy state.

For a given temperature the increase in the current depends upon the intensities of the exciting and quenching radiations. The higher the temperature the smaller will be the sudden increase in the current. Conversely, if the substance is illuminated with a weak quenching radiation, and is then illuminated momentarily with a strong exciting radiation, a sudden increase in the current will again occur due to the transition from the lower to the higher energy state.

Working Principles

A television transmitter employing the new system comprises an image screen of the type described, means for subjecting the image screen to the influence of exciting and quenching radiations, the latter utilising some form of radiations to form an image of the object to be transmitted on the screen, and focusing and deflecting means to form a scanning beam. A signal plate is associated with the image screen and serves as one electrode of an electric field in which the screen is situated. The object is to allow the image radiation to fall on each volume element of the screen, causing the energy contained in each element to assume a level which differs from a fixed datum level by an amount depending on the intensity of the radiation. The scanning radiation will then cause the energy to return to the datum level, the return being accompanied by a flow of current in an external circuit connected to the signal plate, the magnitude of this current depending upon the intensity of the image-forming radiation.

The image-forming radiation may act as the quenching radiation and the scanning radiation serves as the exciting radiation.

Alternatively, the image-forming radiation may act as the exciting radiation and the scanning radiation serve as the quenching radiation. In the former case the fixed datum level of energy is high and corresponds to the excited state of higher energy previously mentioned, whilst in the latter the fixed datum level of energy is low and corresponds to the initial state of lower energy previously mentioned.

In choosing the appropriate radiations the following practical considerations apply. If light is employed both as the image-forming and scanning radiations, then the intensity of the latter must be high relative to that of the former. If an electron image of the object is formed on the image screen, then an electron beam should be employed for scanning. If light is employed as an exciting radiation (either as the image-forming or as the scanning radiation) then the absorption range of the image screen should be in the visible portion of the spectrum.

Fig. 2. Energy variation-time graph of volume element.

In the case of an alkali halide crystal this can be achieved, as mentioned before, by providing the crystal with colour centres. The spectral range of light used as a quenching radiation (either as the image-forming or as the scanning radiation) will depend upon the material of the image screen. In the case of certain alkali halide crystals, such as potassium chloride, normal white light can be used, although usually it is preferable that the light should contain a substantial red component. The addition of the sensitisers to the material, however, will enable light of any desired spectral range to be used.

The methods by which these principles can be applied will be clear by reference to the illustrations.

Fig. 1 shows schematically a television transmitter in which a luminous image is formed on the image screen and a cathode beam is used for the scanning.

This consists of a transmitter tube A with an image screen consisting of an alkali halide crystal mounted on a signal plate B. A luminous image of the object is formed on the surface of the crystal by means of a lens. A beam C of cathode rays proceeding from the cathode is deflected by the pairs of coils D to scan the surface of the crystal. A metal coating E inside the tubes serves as an anode, and also as the negative electrode of an electric field, in which the crystal is situated, the signal plate B serving as the positive electrode of this field.

The output circuit of the device includes an impedance F, across which the picture signals are developed.

The luminous energy of the image serves as an exciting radiation, the crystal having been previously prepared to produce colour centres, either by heating the crystal in the vapour of its own alkali metal, or by bombarding the crystal with cathode rays.

The cathode-ray beam serves as the quenching radiation, and the appropriate quenching action can be regulated by adjusting the potential on the control electrode G to adjust the strength of the beam.

Each element of the luminous image of the object projected on to the crystal will excite a corresponding elemental volume of the crystal to a more or less degree depending upon the intensity of the element. There is thus stored in each corresponding volume element of the crystal a corresponding amount of energy for the whole time existing between two successive scannings of a given elemental area of the crystal. During this time, a small displacement current will flow, due to the movement of electrons within the crystal.

At the instant when such an area is scanned with the beam of quenching radiation most of this energy is freed, this being accompanied by a temporarily freeing of electrons within the volume element of the crystal. These free electrons move within the crystal itself and have a tendency to move towards the signal plate. This increase in electron movement produces a momentary increase in the displacement current in the external circuit, the increase being proportional to the intensity of the exciting and quenching radiations falling on the elemental area of the crystal.

The free electrons nearest to the signal plate will naturally escape from the crystal, but this loss is made

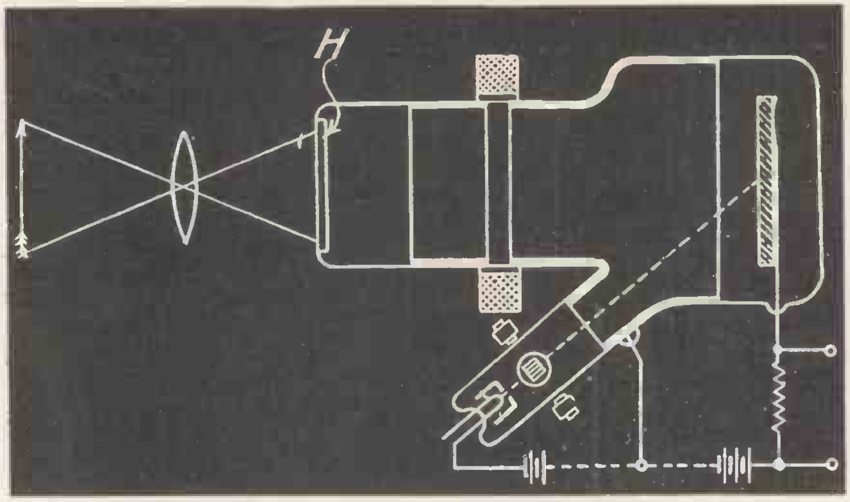


Fig. 3. An alternative method of using the principle employing an electron image.

good by fresh electrons injected by the scanning beam.

Thus there will flow in the impedance F a direct current component, the intensity of which for a given temperature depends upon the average intensity of the whole image projected on the crystal. This direct current component is the sum of all the substantially constant displacement currents flowing through the individual volume elements, as a result of the illumination falling upon them (which may be regarded as being substantially constant during one frame period). Superimposed on this constant current will be the current impulses produced by the scanning beam and therefore a varying voltage will be produced across the impedance, which can be used to modulate the amplitude of a carrier wave, the mean amplitude of which can be determined by the direct current component.

To obtain an efficient transformation of the luminous intensity of the image elements into voltage impulses it is necessary that the magnitude of the current changes should be large relative to the magnitude of the constant displacement current in one elemental volume of the crystal.

To achieve this the intensity of the quenching beam must be intense, and the temperature of the image screen maintained at a moderate value, for, with increasing temperature, the "centres" of the crystal tend to return from the higher energy state to the initial energy state, independently of the quenching radiation, with a resulting loss in the stored energy and an increase in the direct current component.

It must also be arranged that the image radiation is not so strong that all the centres of an elemental volume are excited in the interval between successive scans of the volume, unless it happens that the illumination falling on this volume corresponds to picture white; otherwise, an increase in the illumination will not produce any increase in the stored energy. Furthermore, the scanning radiation must be sufficiently strong to ensure that all excited centres, whatever their number, can be reduced to their initial state, for otherwise the datum level will not be restored.

The variation in the energy contained in a volume element of the material with time is illustrated in the curve of Fig. 2 in which the ordinates represent the energy, and the abscissæ represent time. During the period a—b the volume element is illuminated with the luminous exciting radiation, and the energy rises from a low datum level e to a high level e_1, depending upon the strength of the exciting radiation. The time a—b represents one frame period. The quenching beam 6 causes the energy to return abruptly to the low level e during the time b—c which represents one picture element duration.

The contribution of any element of the screen to the current flowing in the impedance F is determined by the changes in the internal energy of this element; the greater the change of energy at any instant, the more electrons are in the transition state between the two energy levels and are thus temporarily free, and consequently the stronger will be the corresponding current. As this current flows always in the same direction (the free electrons being attracted towards the positive pole of the electric field), the current contributed at any instant by one picture element is determined by the absolute value of the steepness of the curve of Fig. 2 at that instant. The total current is the successive super-position of all these partial elementary currents.

The apparatus of Fig. 1 can be modified so that the luminous energy of the image serves as the quenching radiation, and the cathode-ray beam serves as the exciting radiation. Since there is not a great deal of freedom in choosing the spectral composition of the light which forms the image on the crystal, the latter must be suited to the nature of the light, i.e., it must exhibit an absorption range for a luminous quenching radia-

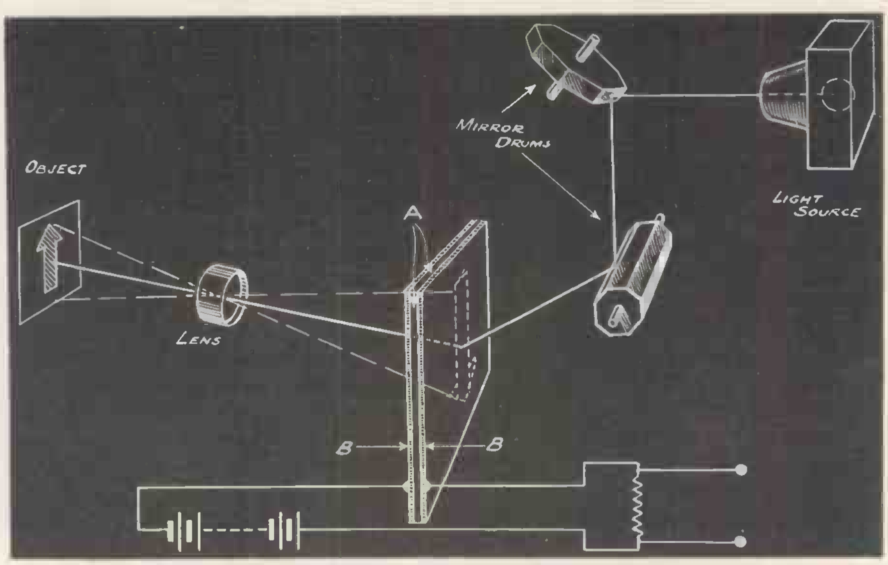


Fig. 4. Scheme for employing light for both image formation and scanning.

tion which corresponds to the spectral range of the light. For normal white light a potassium chloride crystal sensitised with thallium chloride is suitable. The intensity of the beam must be regulated to provide a suitable exciting action; in general, its intensity must be less than when used as a quenching radiation.

An alternative form of apparatus is shown in Fig. 3. An optical image of the object is formed on the semi-transparent photo-electric layer H of the tube by means of a lens. The electrons emitted by the layer are focused on the crystal by means of an electron optical system to form on the surface of the crystal an electron-optical image of the object. The crystal is scanned with the cathode-ray beam and picture signals are developed across the impedance.

The intensity of the electron optical image is such as to excite the volume elements of the crystal, while the higher intensity of the cathode beam permits this beam to serve as the quenching radiation.

How light is employed both for the image-forming and scanning radiations is shown in Fig. 4. The crystal A is provided on each face with a semi-transparent electrode which can be a metal film or an electrically conducting oxide such as zinc oxide. The lens forms an image of the object on one side of the crystal, and the opposite side is scanned with a beam of light, which has the scanning motion imparted by mechanical scanners. The electrodes B are connected in series with source of potential and the impedance across which the picture signals are developed.

The crystal C is provided with colour centres so that the light from the object will exert the necessary exciting action. The scanning light, which is of a very high intensity relative to that of the image-forming light, serves as the quenching radiation.

Alternatively, the image-forming ligth can be used as the quenching radiation, and the scanning light as the exciting radiation.

"Beat-note Oscillators"

(*Continued from page* 685)

The condenser C3 can now be used to provide a reduced frequency coverage of, say, 0-500 cycles.

The condenser C3 may also be used as an incremental pitch condenser.

The condenser C1 should be made as large as is convenient; this will usually mean a maximum of about 0.001 μF. the relationship between C1 and Co is given by:—

$$\frac{\Delta C}{Co} = \frac{2x - x^2}{(1 - x)^2}$$

$$x = \frac{\text{Maximum beat frequency}}{\text{Frequency of fixed oscillator}}$$

ΔC = Available capacity change in condenser C1.

Co = Capacity of condenser Co + minimum of C1 + all stray capacities.

If we take, for example, a variable condenser C1 having a maximum of 0.00105 μF., and fs = 80,000 cycles. If a frequency range of 12,500 cycles is required x = 0.156.

$$Co = 0.001 \frac{(0.844)^2}{0.312 - 0.0243}$$

$$= 0.00246\ \mu F.$$

The value of Lo is given by

$$Lo = \frac{2.54 \times 10^4}{Co\ f^2}\ \mu \text{ henries}$$

where Lo – is in μ henries
Co – is in μ farads
f – is in kilocycles

$$Lo = \frac{2.54 \times 10^4}{0.00246 \times (80)^2}$$

$$= 1,615\ \mu \text{ henries.}$$

The component values of the other oscillator may be calculated in a similar manner. If the inductance of the anode feed choke is not very large, its shunting effect across Lo must be allowed for.

It will be seen from the circuit that the output of the variable oscillator is applied direct to the G3Go grid of the triode-heptode, while the fixed oscillator is applied to the control grid through a harmonic-eliminating filter, and volume control.

From the curve in Fig. 5 we obtain a conversion conductance of 870 μA/V with a bias of -2.5 volts. By designing the low-pass filter to have terminating resistances of 20,000 ohms, we obtain a conversion gain of 8.7.

With an amplifier following, consisting of a triode having a μ of about 35 and a high-slope beam-power amplifier, we can obtain an overall gain of over 1,000. If this gain is reduced to 100 by providing a 10 : 1 reduction in gain with negative feed-back, we have an amplifier with a very low harmonic content and very good frequency response. When the output is fed into a high impedance, the resistance RL should be connected across the primary of the output transformer, in order to limit the distortion.

With RL = 5,000 ohms and a maximum desired power output of the order of 2 watts, the maximum value of Vs required is of the order of 0.16 volts peak.

Provided a small amount of frequency drift is allowable, a grid bias volume control to the trode-heptode may be substituted if desired. Care, however, should be taken to limit the value of Vs to the lowest required value in order to keep harmonics low.

The tuning indicator used as a monitor for setting up the frequency scales has harmonics of the mains frequency applied to it from the mains rectifier, as well as a pure 50 cycle input. It is thus easy to set up the frequency dial at 50 cycles, 100 cycles, etc.

If very great freedom from hum components is desired, the heaters of the valves must be fed from a rectified and smoothed supply, otherwise a normal centre-tapped winding may be employed.

It should also be realised that the suggested circuit is not suitable for supplying extremely low frequencies, as for this kind of work special amplifiers with stabilised supplies are essential.

Book Review

Static and Dynamic Electricity. W. R. Smythe (McGraw-Hill Book Co.) 40s. 537 pp.

This book is the latest addition to the well-known McGraw-Hill International Series in Physics, and is written by the associate Professor of Physics at the California Institute of Technology.

It is not a book for the beginner in electrical theory, and in fact many experienced radio engineers would find it "strong meat." For the advanced student in a post-graduate course it is excellent, and as the author says, it should provide a reference to methods of attack on common research problems for which the handbook formulæ are inadequate.

The basic theory of electrostatics is dealt with in the opening chapters together with the theory of condensers and dielectrics. A chapter on general theorems follows—Gauss', Stokes, and Green's, leading to two-dimensional and three-dimensional potential distributions.

The second part of the book deals with current theory and the magnetic interaction of currents. There is a chapter on transient phenomena in networks, and the book concludes with a discussion on special relativity and the motion of charged particles.

The author's wide reading is shown by the references to books and treaties at the end of each chapter, and a valuable feature is the number of problems included.

A NEW SCANNING OSCILLATOR

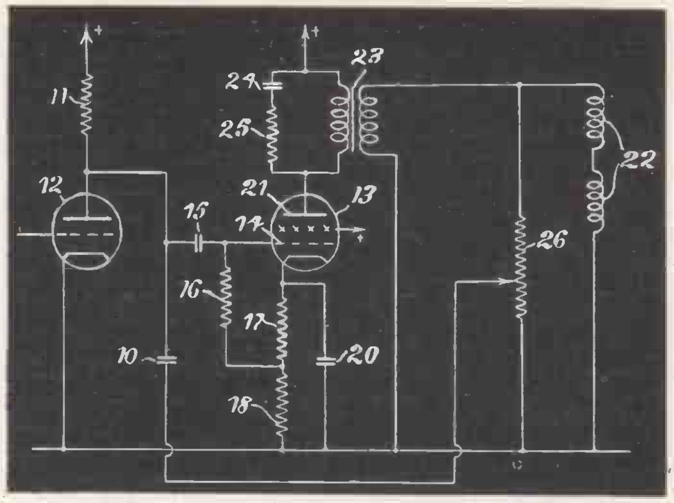


Fig. 1. Circuit diagram of improved scanning oscillator

A COMMON circuit for generating a saw-tooth current wave-form for deflecting the electron beam in a cathode-ray tube comprises a source of saw-tooth potential such as is obtained by charging a condenser through a resistance and discharging through a thermionic device, and an amplifier valve to the control-grid of which the saw-tooth potential is applied.

The required saw-tooth current is developed in the anode circuit of this valve, increasing substantially linearly with time during the long forward stroke of the saw-tooth and rapidly decreasing during the return stroke. On account of this rapid decrease large positive potentials appear at the anode durng the return, and as a result certain difficulties are encountered, arising from the existence of Miller effect in the valve.

In order that the return time be short, it is desirable to utilise the resonant effect that is obtainable with the inductive load that is presented by the scanning coils in a television receiver, by reason of the self-capacity of the windings forming the load circuit.

When such an arrangement is adopted, it is, of course, necessary to provide means for damping out the resonance after one half-cycle of oscillation has been carried out, and these means are conveniently provided by a suitably biased diode valve connected across the load circuit; or with some slight lengthening of the return period a resistance critically damping the load circuit may be employed. It is very necessary, however, that the damping imposed on the resonant load circuit should in no event be substantially more than critical, and it is from this point of view that the difficulty with regard to Miller effect can be appreciated.

Particularly on account of the need for obtaining a large output so as to provide a wide angle of scan, the positive potentials reached by the anode during the return period are of very great magnitude. Consequently, in spite of the existence of only a very small capacity between anode and control-grid an appreciable positive potential is fed back to the control-grid from the anode, and this potential may be so large as to prevent the valve ever approaching the region of cut-off.

During the whole of the return time, therefore, the impedance of the valve may be maintained at a comparatively small value by reason of the effect, and this low impedance is in shunt across the load circuit. Thus, if the load circuit is to exhibit resonance during the return stroke, it is necessary to devise some means counteracting this effect of anode to control-grid capacity, and if possible to arrange that the valve may be rendered entirely non-conducting during the return period of the saw-tooth.

Referring to the circuit diagram, Fig. 1, the conventional arrangement of the charging-condenser 10 and the charging-resistance 11 charging the condenser 10 from a suitable source of high-tension supply, together with the discharging valve 12, which may be a blocking oscillator or may merely be controlled by applied pulses, form a source of saw-tooth potential variation. This variation is applied to the control-grid 14 of the valve 13 by way of the condenser 15, the grid 14 being connected through the leak resistance 16 to a bias point provided by the join of the two resistances 17 and 18, which are connected in series between the cathode 19 of valve 13, and ground and shunted by the capacity 20.

The output current from the anode 21 of valve 13 is fed to the scanning coils 22, 22, by means of the transformer 23, across the primary winding of which there is connected in series the capacity 24 and the resistance 25. The capacity 24 can be chosen to give the correct resonance period to the output circuit of the valve 21 and the resistance 25 can be adjusted so that this resonance is just critically damped. Across the scanning coils is arranged the potentiometer 26, from which a tap is taken to the plate of condenser 10 not connected to resistance 11.

In operation, and supposing that no feed-back is applied to the control-grid of valve 13 by way of the potentiometer 26, a saw-tooth variation of potential as shown in Fig. 2a, tends to be set up on this grid. The corresponding variation in potential at the anode 21 is of the form of that shown in Fig. 2b. In virtue of the capacity existing between anode 21 and control grid 14, even though this capacity may be extremely small, there is transferred, since the excursion of anode potential is so large, an appreciable pulse of potential to this grid from the anode.

The effect of this on the wave-form of potential on the grid 14 is shown in Fig. 2c. Thus it is clear that the valve 13 is maintained conducting during the whole of the return stroke and the damping effect of its anode impedance in this condition is imposed on the anode circuit, thereby lengthening the return time as indicated by the dotted line in Fig. 2b.

If, however, even only a small amount of feed-back via the potentiometer 26 exists to the control-grid 14, this effect can be entirely overcome; for even a comparatively small fraction

(*Continued at foot of page 692*)

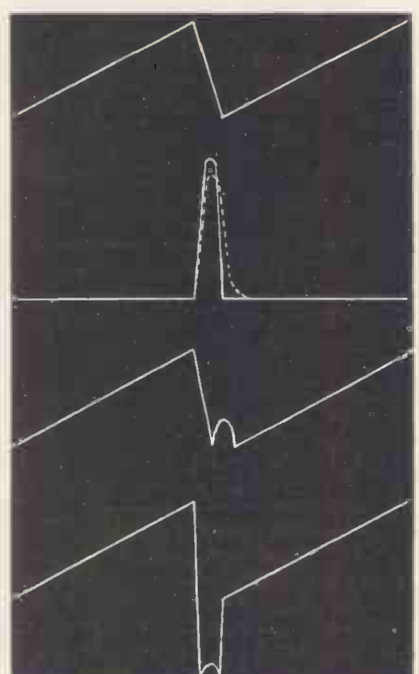


Fig. 2. a, b, c, and d graphs showing waveforms produced.

News Brevities—

Commercial and Technical

A COMMUNICATION service to members of the third Byrd Antarctic Expedition will be inaugurated on Friday night, December 8, by international broadcast station WGEO, formerly W2XAF, operating on 31.48 metres or 9,530 kilocycles, and will continue every two weeks until the expedition returns. The time will be 11 to 11.45 p.m., EST, which will be 4 to 4.45 in the afternoon at Little America.

Persons desiring to send letters or messages which should be confined to 50 words or less, may do so by mailing them to the Byrd Antarctic Mailbag, care of General Electric Company, Schenectady, N.Y.

* * *

We understand that flexible glass insulation braid, referred to on page 652 of the November issue, is being manufactured by Scottish Glass Fibres, Ltd. It is now being extensively used for transformer and motor windings.

* * *

Following the resignation of Mr. A. Scott from the managership of the Ediswan Belfast Office, Mr. C. W. W. Torrance has been appointed in his place.

* * *

A novel instruction course in modern radio is now transmitted over short-wave station WRUL—the World Radio University, Boston, Massachusetts. The radio class meets over the air each Monday night at 7.00 p.m. EST over 6.04 and again at 10.00 p.m., EST, on 11.73 mc. The instructor is Dr. C. Davis Belcher, in Boston. Students are receiving these broadcasts in many parts of the world including Britain, New Zealand, and South Africa.

* * *

Photographing lightning as it strikes the Empire State Building in New York is the unique task assigned to a General Electric engineer in order to provide data for the General Electric high-voltage laboratory at Pittsfield, Mass., where research workers hope to solve the mystery of how exactly lightning behaves. His observations on the storm are recorded and a special timing mechanism is provided which records the exact time when the photographs are taken. This information, it is hoped, will eventually be of value in devising better protective devices for protecting transformers, power lines, circuit breakers and other high-voltage equipment against lightning.

* * *

Lectures to meet the needs of students and others who may wish to qualify themselves for possible future service in radio branches of the Defence Forces will be given at the Royal Institution as follows: Four lectures on the Transmission of Radio Waves Through the Atmosphere by Dr. E. V. Appleton, Wednesday, December 6, Friday, December 8, Wednesday, December 13, and Friday, December 15. Lecture hour, 5.15 p.m. Tickets, for which no charge will be made, may be obtained from the General Secretary, Royal Institution, 21 Albemarle Street, W.1.

* * *

Columbia Broadcasting System has leased the Ritz Theatre, 219 West 48th Street, New York City, as a supplementary playhouse to accommodate many of its outstanding radio programmes and their constantly increasing audiences. It is to be known as CBS Theatre No. 4.

* * *

The General Electric Co., Ltd. (London) has decided that during the war the "G.E.C. Journal" will be published twice a year, instead of quarterly. The next issue will appear in February, 1940, and will contain a Review of Electrical Progress and Development during 1939 in addition to various articles dealing with the scientific and technical activities of the Company.

* * *

Marconi's Wireless Telegraph Co., Ltd., has decided to suspend entirely the publication of "The Marconi Review" during the war.

* * *

It is estimated that over 250,000 people witnessed television during the demonstrations at the New York World's Fair, and at least 27,000 persons took part in the informal interviews before the television camera. Of these, not more than one in 500 had seen television before. Standing with the interviewer about seven feet from the camera, the visitors were able to see their own televised images in a monitor receiver and one of the most widespread misconceptions was that television involved the recording of a picture on a film. A common question by visitors was: "If I leave you my name and address, will you send me the negative of my television picture?" The questions most often heard were: "How far can you send a television programme? When will television programmes be available in my part of the country? How much do the receiver sets cost? Can you have coloured pictures in television? What makes the television picture?"

* * *

A television programme was recently received in an aeroplane in the substratosphere at a height of 21,600 feet. The plane, a United States Air Lines machine, took off from Newark early in the morning, and as it passed above the clouds over Philadelphia on its way to Washington, Ralph Holmes, an RCA engineer and W. A. R. Brown, NBC expert, switched on a television receiver. Almost at once the NBC test pattern, now familiar to American viewers, appeared on the screen, and the occupants of the plane, breathing oxygen through tubes to guard against the effects of the rarefied atmosphere, saw the transmission of a football match clearly.

Later, when the machine approached North Beach Airport on its return journey, passengers saw on the screen the picture of a plane. It was their own machine, and it stood out in sharp contrast on the receiver as it circled above the cameras of the mobile television transmitter at the airport, slowly descended and alighted gracefully on the runway.

* * *

The Mullard Wireless Service Co., Ltd., announce that while present stocks last there will be no increase in the price of the Mullard Master Test Board, which is a combined valve tester and analyser. Production costs are, of course, rising and an increase in the near future will be unavoidable. New prices have not yet been decided but it is hoped to make a further announcement shortly.

An apparatus for rapidly measuring the surface irregularity of sheets of material has been introduced by Dr. Abbot, of Michigan, U.S.A. The apparatus, named the Profilometer, employs a small stylus which traverses the surface at a speed of 1 in. per second.

The movement of the stylus is amplified in the usual way and indicated on a cathode-ray tube or similar indicating device.

The instrument will respond to a variation of one millionth of an inch in surface level and weighs about 40 lbs.

* * *

The *Wireless and Electrical Trader* recently issued a questionnaire asking for information from retailers stocking television. One hundred and thirteen forms were completed, and replies to the questions gave the following information:

Retail value of television sets in stock.	Lowest £20; highest £716 17s. Total for 113 dealers £14,364 14s.
Retail value of sets they already had out on uncompleted hire purchase.	Total for 113 dealers £10,690.
Number of general complaints about lack of television service.	Many left blanks; others indicated "numerous," "lots," "dozens," "very many," "from all" and so on. A number specially emphasized the fact that the black-out made such a home entertainment as television more desirable than ever.
Estimate of number of sets they would have sold between September 1, 1939, and August 31, 1940, if war had not broken out.	Total indicated by 113 dealers was 3,577, so that 2,000 dealers in the television service area might have sold 63,310 televisors in the current year.

It is estimated that the total number of dealers approximates 2,000 and assuming this figure, the retail side of the industry alone has at this moment a dead stock of £250,000 worth (retail) of television sets, and is losing the sale of a possible 60,000 televisors during the current season.

* * *

A receiver and manager of Baird Television, Ltd., was appointed in the Chancery Division on November 4 on a motion by two plaintiffs in a debenture-holders' action against the company. The ground was "unable to carry on business." Mr. Justice Crossman said he would appoint a receiver and manager, with liberty to act at once, but not beyond January 18 without the leave of the court.

* * *

On November 7, Mr. J. A. Sargrove, F.T.S, N.C.M.E., M.I.B.E. (Chief Engineer of the British Tungsram Radio Works), delivered a lecture to the University of Birmingham Radio Society, on the subject of: "Parasitic oscillations and space-charge coupling as a by-product of the mixer phenomenon, and its practical utilisation for the generation of ultra-short waves."

Mr. Sargrove opened his address with a comprehensive review of the historical development of the superheterodyne which started with the classical work of Levy in 1916-17, pointing out that in this country the superheterodyne was generally neglected as it was inferior in quality to a straight set, though it had better selectivity and sensitivity.

He then described the development of special mixer valves since 1930. Very little experimental work was carried on in this country, but by 1932 both in Germany and America, independently and simultaneously, efforts were directed to the fullest comprehension of the difficulties, with a view to their being mastered, so as to enable use to be made of the superior selectivity of the circuit which became important in consequence of the over-crowded ether.

At this point, Mr. Sargrove described the difficulties that beset experimenters, until eventually the multiplicative mixer was evolved by taking the double grid valve (which at that time was the most successful frequency changer) and perfecting it by the addition of screens in between the two control grids, the second control grid and the anode. "It is interesting to note," said Mr. Sargrove, "that this was tackled in two opposite ways; in Germany the so-called mixer hexode had the locally produced oscillation applied to the second control grid; in America the local oscillation occurred on the first control grid."

At this juncture, Mr. Sargrove examined the mechanism of the multiplicative mixer in some detail, illustrating his points with numerous diagrams. It appeared that the final mixer valves had not been evolved until these were used for short-wave reception, many difficulties being encountered below 50 metres. That was in 1935; to-day, having perfected the triode-heptode valve, we have a practically perfect mixer on all but the very shortest wavelengths, where some field has still to be covered, but Mr. Sargrove assured his audience that the question of "kinetic grid current," which seems to be the last bogey and is due to the transit-time of electrons, is well in hand in the Tungsram laboratories.

The lecture concluded with a graphic description of the use that could be made of the parasitic oscillations first encountered in mixers for the generation of ultra-short wavelengths of 1 metre and less, with the use of ordinary structure valves (such as the Tungsram APP4C) utilising space-charge coupling. Mr. Sargrove also mentioned the possibility of the practical use of these very high frequencies in therapy, as well as bacteriological research.

An Improved D.C. Restoring Circuit

A Correction

We regret that the note with the above title which appeared on page 672 and cover iii of the November issue contained two errors.

(1) In the third line on cover iii it was stated that the signals are fed with the synchronising signals positive to the grid of the amplifier valve V_1. This is obviously incorrect and should read, with the *picture* signals positive.

(2) On the 12th line of the same page the time delay of the network is said to be 10 microseconds. In practice, the time delay would have to be less than this in order that the observing valve may be switched off before the picture signal following the 5 microsecond black interval after the synchronising pulse; the time delay found to be convenient is 3 microseconds.

"A New Scanning Oscillator"

(*Continued from page 690*).

of the anode excursion of potential (as shown in Fig. 2b) if applied in a negative sense, is sufficient to carry the control-grid 14 considerably past cut-off and to render the valve 13 non-conducting. Fig. 2d shows the form of variation of potential on the grid 14 when this is so arranged.

This feed-back is of the positive type, namely, that it tends to assist the formation of the excursion of potential occurring at the anode. It need, however, only be of very small magnitude, and so may be of negligible consequence on the forward stroke, particularly if the current through the scanning coils 22, 22 is a comparatively accurate linear function of time. Such linearity may be assisted by making condenser 20 comparatively small and by utilising the resistances 17 and 18 in the cathode circuit of valve 13 to provide negative feedback. This feed-back will be very much larger than the positve feed-back, but it can be restricted so as not to operate at the higher frequencies at which the positive feed-back is essentially required to operate, by choosing the condenser 20 to be of the right value.

This development is reported from the Designs Department of The Gramophone Co., Ltd.

DESIGN CONSIDERATIONS OF

THE CATHODE-RAY OSCILLOGRAPH

The increasing complexity of all types of electronic devices makes the need for adequate test equipment more than ever essential, both during the actual design to permit observations of performance to be secured, but also in the elucidation of the cause of any faults that might develop.

Undoubtedly one of the most useful pieces of test apparatus for this purpose is the cathode-ray tube oscillograph. This article is a fairly comprehensive survey of typical design considerations of the oscillograph.

IT is not necessary to reiterate the information already adequately given in various publications concerning the types of screen colours and characteristics, but it will be useful to give a brief survey of the types of C.R. tubes available, for the tube chosen will influence the design of the auxiliary apparatus, for if the oscillograph is intended only for limited applications it is probable that a gas focus tube will suffice, whereas there are many cases where the characteristics of this type of tube render it inadequate. Despite this fact such a large field of uses exists for the gas-focused tube, especially in connection with the examination of low frequency phenomena, that it is felt some description of the circuits appertaining to this tube should be given.

The gas-focused tube has fallen out of favour in recent years because of its inherent defects when employed for observation of high frequency phenomena, and since a large and increasing proportion of recent work is concerned with such frequencies, a corresponding development of hard tubes has taken place. Hard tubes prove very suitable for use at quite high frequencies.

Some interesting elaborations of hard tubes have also appeared during the past year or so permitting the examination of two or more distinct phenomena to be made without recourse to the conventional elaborations of electronic amplifier switching.

For example, a tube recently introduced by Cossor arranges for a single electron beam to be split and this split beam can subsequently be influenced by separate sets of deflecting plates.

Image Size

Any experimenter who has worked with C.R. tubes will confirm the desirability of having a reasonably sized image, but here a difficulty is encountered for usually the potentials to be examined will require to be amplified before they can be applied to the deflecting plates of the tube since quite high voltages are necessary to secure adequate deflection.

In passing, the reader is reminded that perhaps the most favourable characteristic possessed by the gas-focused tube is mainly that it is very sensitive to low amplitude potentials. This is attributable to the fact that good light spot focus is readily obtained with low final anode voltages. It is well to note that in the case of a gas-focus tube the Wehnelt is sometimes positive in respect to cathode and acts as the focusing element. It has no appreciable control over the brilliance, which is a function of the filament temperature and the final anode voltage.

It is well known that the deflection sensitivity of a C.R. tube is inversely proportional to the final anode voltage. Consequently it is desirable to operate the tube at as low a final anode voltage as is consistent with good trace focus and brilliance. From the above considerations it is apparent that some care in the choice of a tube is desirable and the following points will assist this choice.

(1) A gas-focused tube is useful up to frequencies of the order of 100 Kcs. The frequency range of a hard tube is limited by the shunt capacity due to the deflecting plates having an effect upon the external circuits, or at extreme frequencies of mutual interference between the deflecting circuits occurring and resulting in an apparent trace deformation giving rise to conflicting results, though actually these effects can be largely mitigated by modification to the external circuits. Strictly speaking, the question of electron transit time must be considered, and results in the deflection sensitivity, as plotted against frequency appearing as the curve Fig. 1. The failure of deflection at certain frequencies is due to phase variations occurring during the time in which the beam is entering and leaving the deflecting field.

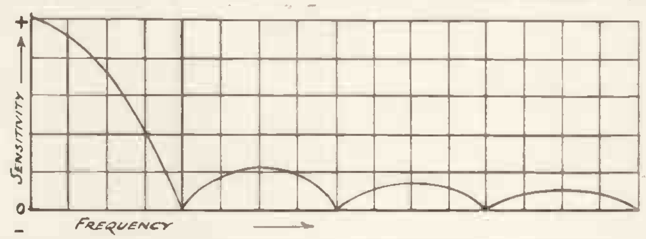


Fig. 1.—Approximate effect of transit time on deflection sensitivity.

(2) *Image Dimensions.* As was earlier remarked it is desirable to have an image which adequately imparts the required information, consequently a tube having a screen diameter of at least 3 in. should be chosen. It can be added that this does not necessarily imply that the deflection sensitivity will be low, for a cursory examination of C.R. tube data will reveal that the deflection sensitivity is not proportional to screen diameter. It is largely determined by tube design.

Setting up a C.R. Tube

In order to maintain a high forward velocity of the electron beam towards the screen it is necessary to ensure that the deflecting plates are at approximately the same potential

Oscillograph Sweep Circuits

with respect to cathode as is the final anode. Failing this, trapezium distortion and defocusing will occur at the edges of the trace.

Such conditions are simply secured by connecting each deflecting plate through a high resistance to the final anode. With this done it is apparent that as the final anode is at maximum

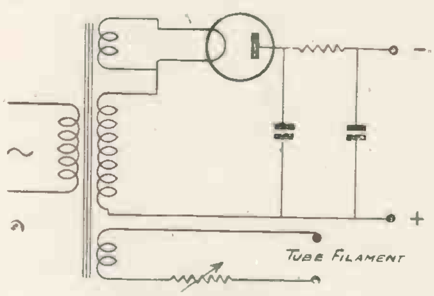


Fig. 2a.—Rectifier unit.

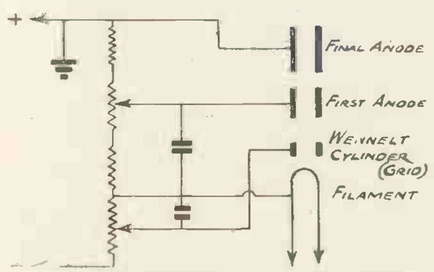


Fig. 2b.—Potentiometer for use with hard tubes.

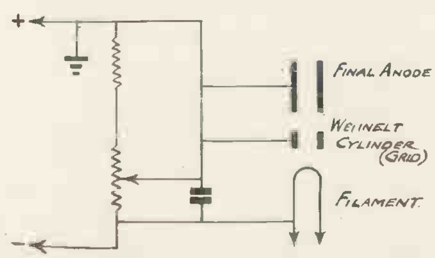


Fig. 2c.—Potentiometer for use with soft tubes, which usually require positive Wehnelt.

positive potential, and as the circuits to be investigated are usually at earth potential, in the interests of safety and economy and also to permit a ready examination of the D.C. component of any phenomenon, positive earthing of the tube exciter potential is desirable. Accordingly the circuit of Fig. 2 is recommended for furnishing the exciter potential.

Sweep Circuits

A number of useful tests can be made simply by employing the alternating mains potential as a sweep circuit. It will be apparent that two traces will be produced, and to avoid this it is usual to apply the return potential to the Wehnelt so that the beam is cut off during this half cycle. Also as the potential varies sinusoidally with time, the trace, unless the sweep is of such magnitude that only a small portion of the sinusoidal wave is utilised, i.e., the straight portion, will be non-linear.

Various circuits exist which will provide a sweep which is linear in respect to time. Probably the simplest of these is that employing a gas relay. A typical example of this arrangement is depicted by Fig. 3.

To secure a linear sweep with this simple circuit it is necessary to use a potential of such magnitude that only a portion of the condenser charging curve (which is an exponential function: Instantaneous voltage is equal to the product of $1-\epsilon^{\frac{-t}{CR}}$ and the applied H.T. voltage) is utilised. From this it is obvious that the supply voltage required must be greatly in excess of the actual voltage at which ignition occurs. It is apparent from the fundamental equation $V = Q/C$, where Q is equal to the product of current and time, that a linear sweep is obtained when the condenser charging current is maintained substantially constant.

The circuit given by Fig. 4, which employs a pentode valve in the charge circuit, has the advantage of practically fulfilling these conditions with relatively low supply voltages. Actually, it is seen that the only additional potential needed over and above that required for the actual sweep is that necessary to maintain the constant current valve at correct operating potentials. With some types of valve this waste potential need not exceed some 60 volts or so.

Time bases employing gas relays cannot in general be persuaded to operate satisfactorily at frequencies exceeding 20 Kc. and it becomes necessary to employ more elaborate gear at higher frequencies. There are, however, a large number of time base circuits which are capable of providing saw-tooth deflection potentials up to quite high frequencies. It is proposed initially to deal with the simplest of these.

Fig. 5 depicts an arrangement which functions well. It has, however, in common with many similar forms of saw tooth generators, the disadvantage that it will operate only over a limited frequency range. Moreover for reasons which need not be discussed here, there is a limit set by the inability of the circuit to provide a rapid flyback.

There are many variations of this type of single-valve oscillator, but all have defects of some nature. Accordingly, it is recommended that where a high-frequency scan is required the well-known circuit arrangement of Fig. 6 be employed. This circuit is due to Puckle. Its mode of operation has been adequately treated in several previous publications and accordingly only the following brief description is provided. Referring to Fig. 6, the pentode valve V1 is employed as a constant current charging device and is subsequently referred to only in connection with its effect upon the operating speed. The virtue of the circuit lies in the fact that the flyback time is a very small percentage of the complete saw tooth cycle, as will be apparent from the description of the part played by the valves V2 and V3.

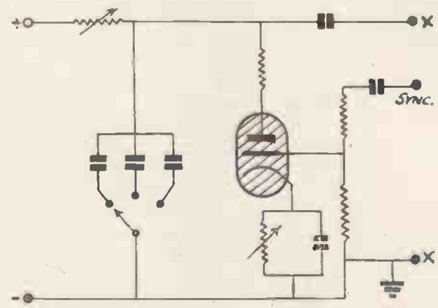


Fig. 3.—Simple form of gas-relay time base.

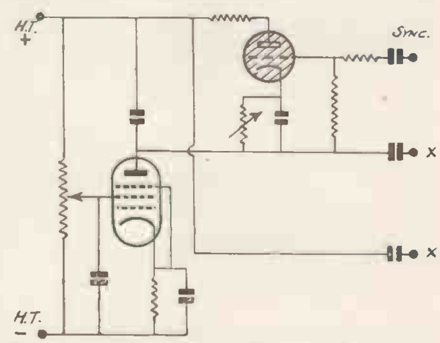
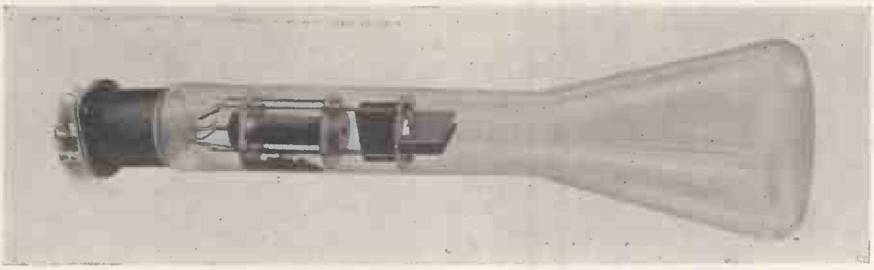


Fig. 4.—Gas-relay time base using pentode charging.

Commencing with condenser C1 discharged, it is easily seen that as there is no potential difference across



The 4096-AB cathode ray tube, as manufactured by Standard Telephones and Cables Limited, is a high vacuum tube with a 3 in. diameter screen. It employs electrostatic deflection and focusing. The gun is of the two-anode type and its simple construction ensures great accuracy in alignment without complicated manufacturing methods.

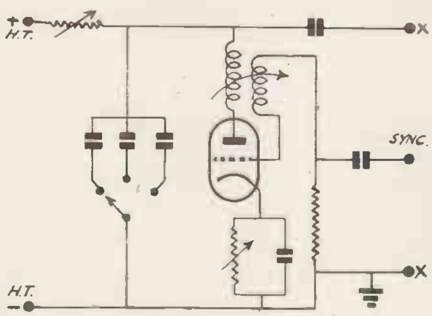
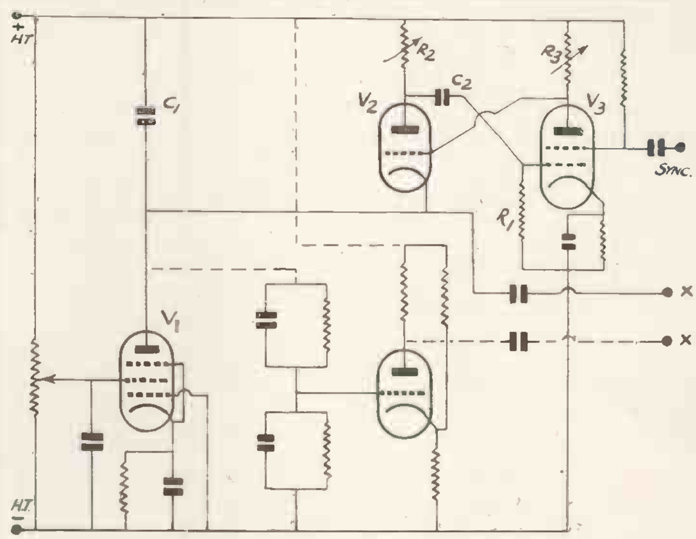


Fig. 5 (left). Simple form of hard valve time base.

Fig. 6 (right). This figure gives the circuit diagram of a hard valve time base, efficient up to quite high frequencies. Balanced deflection is provided.



its terminals the cathode of V2 is at the same positive potential as the H.T. positive line, thus no current can flow in this valve. When C1 is charged to a potential such that the cathode of V2 approaches the potential of its grid, current commences to flow through the valve. This causes a negative impulse to appear at its anode which is passed to the grid of V3 through the coupling comprised by C2 and R1; in turn this causes a positive impulse to appear at the anode of V3 which it is seen is fed back to the grid of V2, thus further increasing its current. This cumulative effect is practically instantaneous and causes a very rapid discharge of the condenser C1.

Sync. pulses can be applied either direct to the screen of the valve V3 or through an additional amplifying stage, it being only necessary to ensure that the sync. pulses are of such phase and amplitude as appreciably to decrease the current through V3.

The frequency of operation is controlled by varying the G2 or the G1 potential of the charging valve V1. The resistances R2 and R3 are made variable. It will be seen that R3 will determine the average grid potential of V2 and therefore will provide a convenient means of varying the amplitude of the saw tooth oscillations. The resistance R2 is usually assigned a low value and will control the retrace speed.

In a later section of this article suitable amplifier circuits will be described which are applicable to the time bases dealt with earlier. However, in the case of the Puckle circuit the necessary connections may not be quite clear and accordingly the amplifier details are included in Fig. 6, the required connections being shown dotted. This arrangement provides a push pull deflection, the need for which will be outlined in the amplifier section.

In the concluding part of this article low-frequency time bases and amplifier circuits will be described.

A New Osram Valve

A new valve of the screened pentode type, with indirectly heated cathode, has been added to the Osram range. It has been given the nomenclature Z62. A high slope R.F. pentode, it is designed primarily for use in the amplifying stages of a television or ultra short-wave receiver, but it may be used wherever a comparatively high stage gain is desired, being applicable also to audio frequency amplifiers.

Due to the internal construction involving short lead wires and electrodes of small dimensions, a considerable gain is obtainable at frequencies as high as 60 mcs., so that the valve is particularly suitable for use in short wave applications, giving complete stability with high overall gain. A very wide frequency response can be obtained by suitable choice of anode resistance.

It is not normally suitable for use as H.F. amplifier in broadcast receivers, but can be used as a sensitive detector. The price is 12s. 6d.

CHARACTERISTICS OF OSRAM Z62.

Heater Voltage	6.3 volts.
Heater Current	0.45 amps. approx.
Anode Voltage	300 max.
Screen Voltage	150 max.
Grid Voltage	—2.0 approx.
Anode Current average	10.0 mA.
Screen Current average	2.3 mA.
Bias Resistance (ohms).	160
Mutual Conductance (at Ea 300, Es 150, Eg —2)	7.5 mA./volt.
Impedance	0.75 megohm.
Input resistance at 40 mc/sec.	4,000 ohms. approx.
INTERELECTRODE CAPACITIES :	
Grid to Anode	0.02 micro-mfd. approx.
Anode to other Electrodes	8.0 ,, ,, (6.75 mmfd. with unshielded valve)
Grid to other Electrodes	10.8

ELECTRONICS AND TELEVISIO
COMPREHENSIVE GUIDE TO THE

MC/s.	Metres.	Call.	Station Name.
31.60	9.494	W1XKA	Boston, Mass.
31.60	9.494	W2XDV	New York City.
31.60	9.494	W3XKA	Philadelphia.
26.55	11.3	W2XGU	New York City.
26.55	11.3	W2XQO	New York City.
26.05	11.51	W9XH	South Bend, Ind.
25.95	11.56	W6XKG	Los Angeles, Cal.
21.64	13.86	GRZ	Daventry, England.
21.63	13.8	W3XAL	Bound Brook, N.J.
21.57	13.91	W2XE	New York City.
21.565	13.92	DJJ	Berlin.
21.55	13.92	GST	Daventry, England.
21.54	13.93	W8SK	Pittsburgh, Pa.
21.53	13.93	GSJ	Daventry, England.
21.52	13.94	2RO16	Rome, Italy.
21.50	13.95	WGEA	Schenectady, N.Y.
21.48	13.96	PH13	Huizen, Holland.
21.47	13.97	GSH	Daventry, England.
21.46	13.98	W1XAL	Boston, Mass.
21.45	13.99	DJS	Berlin.
19.02	15.77	HS6PJ	Bangkok, Siam.
18.48	16.23	HBH	Geneva, Switzerland.
17.85	16.8	TPB3	Paris, France.
17.845	16.81	DJH	Berlin.
17.84	16.82	HVJ	Vatican City.
17.84	16.82	—	Moydrum, Athlone, Eire.
17.83	16.83	W2XE	New York City.
17.82	16.84	2RO8	Rome, Italy.
17.81	16.84	GSV	Daventry, England.
17.80	16.85	OIH	Lahti, Finland.
17.80	16.85	XGOX	Chungking, China.
17.79	16.86	GSG	Daventry, England.
17.785	16.86	JZL	Tokio, Japan.
17.78	16.87	W3XL	Bound Brook, N.J.
17.77	16.88	PH12	Huizen, Holland.
17.76	16.89	DJE	Berlin.
17.755	16.9	ZBW5	Hongkong.
17.75	16.90	LKW	Oslo, Norway.
17.31	17.33	W2XGB	Hicksville, N.Y.
17.280	17.36	FXE8	Djibouti, French Somaliland.
15.55	19.29	CO9XX	Tuinicu, Oriente, Cuba.
15.51	19.34	XOZ	Chengtu, China.
13.37	19.52	HAS3	Budapest, Hungary.
15.36	19.53	DZG	Zeeson, Germany.
15.36	19.53	—	Berne, Switzerland.
15.34	19.56	DJR	Berlin.
15.34	19.56	W2XAD	Schenectady, N.Y.
15.33	19.56	W6XBE	San Francisco, California.
15.32	19.58	OZH	Skamlebak, Denmark.
13.30	19.6	GSP	Daventry, England.
15.3	19.61	YDB	Soerabaja, Java.
15.3	19.61	XEBM	Mazatlan, Mex.
15.3	19.61	2RO6	Rome, Italy.
15.29	19.62	VUD	Delhi, India.
15.29	19.62	LRU	Buenos Aires.
15.28	19.63	DJQ	Berlin.
15.27	19.65	HI3X	Ciudad, Trujillo.
15.27	19.65	W3XAU	Phila., Pa.
15.27	19.65	W2XE	New York City.
15.26	19.66	GSI	Daventry, England.
15.25	19.67	W1XAL	Boston, Mass.
15.245	19.68	TPA2	Paris, France.
15.24	19.68	2RO	Rome, Italy.
15.24	19.68	CR7BD	Lourenco, Marques, Mozambique.
15.23	19.7	OLR5A	Prague, Bohemia.
15.23	19.7	HS6PJ	Bangkok, Siam.
15.22	19.71	PCJ2	Huizen, Holland.
15.21	19.72	W8XK	Pittsburgh, Pa.
15.2	19.74	DJB	Berlin.
15.195	19.74	TAQ	Ankara, Turkey.
15.19	19.75	OIE	Lahti, Finland.
15.18	19.76	GSO	Daventry, England.
15.18	19.76	RW96	Moscow, U.S.S.R.
15.17	19.77	TGWA	Guatemala City, Guat.
15.166	19.78	LKV	Oslo, Norway.
15.16	19.79	JZK	Tokio, Japan.
15.16	19.79	XEWW	Mexico City.

MC/s.	Metres.	Call.	Station Name.
15.155	19.79	SM5SX	Stockholm, Sweden.
15.15	19.8	YDC	Bandoeng, Java.
15.140	19.82	GSF	Daventry, England.
15.135	19.82	JLU3	Tokio, Japan.
15.13	19.83	TPB6	Paris, France.
15.13	19.83	W1XAR	Boston, Mass.
15.120	19.84	SP19	Warsaw, Poland.
15.120	19.84	HVJ	Vatican City.
15.120	19.84	CSW4	Lisbon, Portugal.
15.11	19.85	DJL	Berlin.
15.1	19.87	CB.1510	Valparaiso, Chile.
15.1	19.87	2RO12	Rome, Italy.
15.08	19.95	RKI	Moscow, U.S.S.R.
14.96	20.05	RZZ	Moscow, U.S.S.R.
14.93	20.09	PSE	Rio de Janeiro, Brazil.
14.92	20.11	KQH	Kahuku, Hawaii.
14.78	20.28	IQA	Rome, Italy.
14.60	20.55	JVH	Nazaki, Japan.
14.535	20.64	HBJ	Geneva, Switzerland.
14.44	20.78	—	Radio Malaga, Spain.
14.42	20.80	HCIJB	Quito, Ecuador.
14.166	21.15	PIIJ	Dordrecht, Holland.
13.997	21.43	EA9AH	Tetuan, Spanish Morocco.
13.635	22	SPW	Warsaw, Poland.
12.862	23.32	W9XDH	Elgin, Ill.
12.486	24.03	HIIN	Trujillo City, Dominica Rep.
12.460	24.08	HC2JB	Quito, Ecuador.
12.310	24.37	VOFB	St. Johns, Newfoundland.
12.235	24.52	TFJ	Reykjavik, Iceland.
12.230	24.53	COCE.	Havana, Cuba.
12.2	24.59	—	Trujillo, Peru.
12	25	RNE	Moscow, U.S.S.R.
11.970	25.06	CB.1180	Santiago, Chile.
11.97	25.07	HI2X	Ciudad, Trujillo, D.R.
11.94	25.13	TI2XD	San Jose, Costa Rica.
11.94	25.13	XMHA	Shanghai, China.
11.91	25.19	CD.1190	Valdivia, Chile.
11.9	25.21	XGOY	Chungking, China.
11.895	25.23	2RO13	Rome, Italy.
11.885	25.24	TPA3	Paris, France.
11.87	25.26	W8XK	Pittsburgh, Pa.
11.87	25.26	VUM2	Madras, India.
11.865	25.28	—	Berne, Switzerland.
11.86	25.3	GSE	Daventry, England.
11.85	25.31	DJP	Berlin.
11.85	25.32	OAK2A	Trujillo, Peru.
11.84	25.35	KZRM	Manila, P.I.
11.84	25.35	CSW	Lisbon, Portugual.
11.84	25.35	OLR4A	Prague, Bohemia.
11.83	25.36	W9XAA	Chicago, Illinois.
11.83	25.36	W2XE	New York City.
11.81	25.4	2RO4	Rome, Italy.
11.805	25.41	OZG	Skamlebak, Denmark.
11.801	25.42	DJZ	Berlin.
11.80	25.42	COGF	Matanzas, Cuba.
11.80	25.42	JZJ	Tokio, Japan.
11.795	25.42	DJO	Berlin.
11.79	25.45	W1XAL	Boston, Mass.
11.78	25.47	HP5G	Panama City.
11.78	25.47	OFE	Lahti, Finland.
11.77	25.49	DJD	Berlin.
11.76	25.51	TGWA	Guatemala City, Guat.
11.76	25.51	XETA.	Monterey, Mexico.
11.76	25.51	OLR4B	Prague, Bohemia.
11.75	25.53	GSD	Daventry, England.
11.74	25.55	HVJ	Vatican City.
11.74	25.55	CR6RC	Loanda, Angola.
11.735	25.57	COCX	Havana, Cuba.
11.735	25.57	LKQ	Oslo, Norway.
11.73	25.57	PHI	Huizen, Holland.
11.73	25.58	W1XAR	Boston, Mass.
11.725	25.58	JVW3	Tokio, Japan.
11.720	25.6	CJRX	Winnipeg, Canada.
11.72	25.60	ZP14	Villarica, Paraquay.
11.71	25.62	—	Saigon, French Indo-China.
11.705	25.63	SBP	Motala, Sweden.
11.7	25.64	HP5A	Panama City.

MC/s.	Metres.	Call.
11.766	25.7	IQY
11.402	26.31	HBO
11.04	27.17	CSW5
11.00	27.27	PLP
10.95	27.40	—
10.67	28.12	CEC
10.66	28.14	JVN
10.53	28.48	JIB
10.40	28.85	YSP
10.36	28.96	EAJ43
10.35	28.95	LSX
10.33	29.04	ORK
10.26	29.24	PMN
10.1	29.7	—
10.05	29.85	TIEMT
10.05	29.16	DZC
10.04	29.87	DZB
9.995	30.02	COBC
9.92	30.24	JDY
9.892	30.33	CPI
9.955	30.45	EAQ
9.83	30.52	IRF
9.815	30.57	COCM
9.785	30.66	HH3W
9.753	30.75	ZRO
9.735	30.82	CSW7
9.73	30.83	CB.970
9.705	30.92	—
9.7	30.93	HNF
9.69	30.96	LRAI
9.69	30.96	ZHP
9.69	30.96	GRX
9.685	30.96	TGWA
9.675	31.01	DJX
9.67	31.03	W3XAL
9.665	31.04	2RO9
9.66	31.06	LRX
9.66	31.06	HVJ
9.65	31.09	W2XE
9.65	31.09	CS2WA
9.65	31.09	IABA
9.645	31.10	JLT2
9.64	31.12	CXA8
9.635	31.13	2RO3
9.62	31.19	CXA6
9.618	31.20	HJ1ABE
9.61	31.22	LLG
9.606	31.23	ZRL
9.6	31.25	RAN
9.6	31.25	CB.960
9.6	31.25	GRY
9.595	31.27	HBL
9.59	31.28	HP5J
9.59	31.28	VUD2
9.59	31.28	PCJ
9.59	31.28	VK6ME
9.59	31.28	VK2ME
9.59	31.28	W3XAU
9.58	31.32	GSC
9.58	31.32	VLR
9.57	31.35	KZRM
9.57	31.35	W1XK
9.566	31.37	OAX4T
9.56	31.38	XGAP
9.56	31.38	DJA
9.55	31.41	HVJ
9.55	31.41	TPB11
9.55	31.41	W2XAD
9.55	31.41	OLR3A
9.55	31.41	XEFT
9.55	31.41	YDB
9.55	31.41	VUB2
9.54	31.45	DJN
9.538	31.46	VPD2
9.53	31.46	—
9.53	31.48	WGEAF

N AND SHORT-WAVE WORLD

WORLD'S SHORT-WAVE STATIONS

Station Name.
Rome, Italy.
Geneva, Switzerland.
Lisbon, Port.
Bandoeng, Java.
Tananarive, Madagascar.
Santiago, Chile.
Nazaki, Japan.
Taihoku, Taiwan.
San Salvador.
Teneriffe.
Buenos Aires.
Ruysselede, Belgium.
Bandoeng, Java.
Deutche Freiheits Sender.
San Jose, Costa Rica.
Zeeson, Germany.
Zeeson, Germany.
Havana, Cuba.
Dairen, Manchukuo.
Sucre, Bolivia.
Madrid, Spain.
Rome, Italy.
Havana, Cuba.
Port-au-Prince, Haiti.
Durban, S. Africa.
Lisbon, Portugual.
Valparaiso, Chile.
Fort-de-France, Martinique.
Baghdad, Iraq.
Buenos Aires.
Singapore, Malaya.
Daventry, England.
Guatemala City.
Berlin.
Bound Brook, N.J.
Rome, Italy.
Buenos Aires.
Vatican City.
New York City.
Lisbon, Portugual.
Addis Ababa, Ethiopia.
Tokio, Japan.
Colonia, Uruguay.
Rome, Italy.
Montevidale, Uruguay.
Cartagena, Col.
Oslo, Norway.
KLipheuval, S. Africa.
Moscow, U.S.S.R.
Santiago, Chile.
Daventry, England.
Geneva, Switzerland.
Panama City.
Delhi, India.
Huizen, Holland.
Perth, W. Australia.
Sydney, Australia.
Philadelphia, Pa.
Daventry, England.
Melbourne, Australia.
Manila, P.I.
Boston, Mass.
Lima, Peru.
Peking, China.
Berlin.
Vatican City.
Paris, France.
Schenectady, N.Y.
Prague, Bohemia.
Vera Cruz, Mexico.
Soerabaja, Java.
Bombay, India.
Berlin.
Suva, Fiji.
Schwarzenburg; Switzerland.
Schenectady, N.Y.

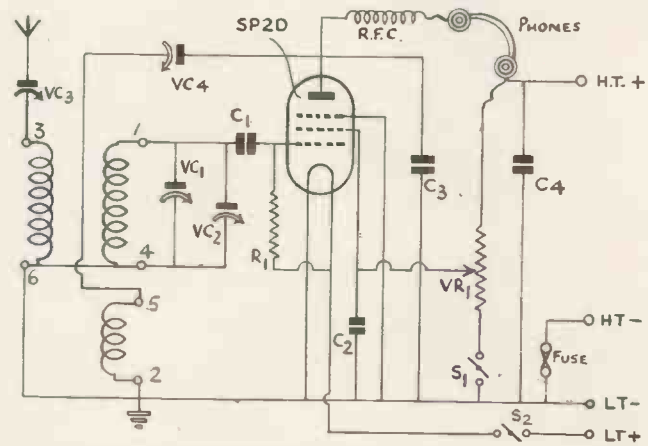
MC/s.	Metres.	Call.	Station Name.
9.53	31.48	BUC2	Calcutta, India.
9.526	31.49	ZBW3	Hongkong, China.
9.525	31.49	LPC	Jeloy, Norway.
9.523	31.5	ZRG	Roberts Heights, S. Africa.
9.52	31.51	OZF	Skamleboaek, Denmark.
9.52	31.51	RV96	Moscow, U.S.S.R.
9.51	31.55	GSB	Daventry, England.
9.51	31.55	HS8PJ	Bangkok, Siam.
9.51	31.55	—	Hanoi, French Indo-China.
9.503	31.57	XEWW	Mexico City.
9.501	31.58	PRFS	Rio de Janeiro, Brazil.
9.5	31.58	VK3ME	Melbourne, Australia.
9.5	31.58	OFD	Lahti, Finland.
9.497	31.59	KZ1B	Manila, Philippine Islands.
9.488	31.6	EAR	Madrid, Spain.
9.465	31.70	TAP	Ankara, Turkey.
9.445	31.77	HCODA	Guayaquil, Ecuador.
9.437	31.8	COCH	Havana, Cuba.
9.390	31.95	OAX5C	Ica, Peru.
9.370	32.02	XOY	Chengtu, China.
9.355	32.05	HCIETC	Quito, Ecuador.
9.35	32.08	COCD	Havana, Cuba.
9.345	32.11	HBL	Geneva, Switzerland.
9.340	32.12	OAX4J	Lima, Peru.
9.295	32.28	HI2G	Ciudad, Trujillo, D.R.
9.280	32.33	LYR	Kaunas, Lithuania.
9.2	32.61	ZMEF	Sunday Island.
9.2	32.61	COBX	Havana, Cuba.
9.188	32.65	HC2AB	Ecuador.
9.17	32.72	HC1G	Quito, Ecuador.
9.125	32.88	HAT4	Budapest, Hungary.
9.124	32.88	HC2CW	Guayaquil, Ecuador.
9.100	32.61	COCA	Havana, Cuba.
9.091	33.00	PJCI	Curacao, D.W. Indies.
9.03	33.32	COBZ	Havana, Cuba.
8.965	33.44	COKG	Santiago, Cuba.
8.841	33.5	HCJB	Quito, Ecuador.
8.830	33.98	COCQ	Havana, Cuba.
8.7	34.46	HKV	Bogota, Colombia.
8.665	34.64	COJK	Camaguey, Cuba.
8.665	34.64	W2XGB	Hicksville, N.Y.
8.652	34.67	HJ4DAU	Medellin, Colombia.
8.580	34.92	YNPR	Managua, Nicaragua.
8.572	35.02	—	Bucharest, Roumania.
7.894	37.99	YSD	San Salvador.
7.870	38.1	HCIRB	Quito, Ecuador.
7.854	38.2	HC2JSB	Guayaquil, Ecuador.
7.797	38.48	HBP	Geneva, Switzerland.
7.614	39.39	CRAA	Lobito, Angola.
7.520	39.89	KKH	Kahuku, Hawaii.
7.49	40,05	EAJ43	Teneriffe, Canary Islands.
7.45	40.27	TI2RS	San Jose, Costa Rica.
7.44	40.32	FG8AH	Point-a-Pitre, Guadeloupe.
7.41	40.46	HCJB4	Quito, Ecuador.
7.31	41.01	GIG	Port Moresby, Papua.
7.28	41.21	TPB12	Paris, France.
7.26	41.32	CSW8	Lisbon, Portugual.
7.22	41.55	HKE	Bogata, Col., S.A.
7.22	41.55	YDX	Medan, Sumatra.
7.177	41.75	CR6AA	Lobita, Angola.
7.128	42.09	YN3DG	Leon, Nicaragua.
7.1	42.25	FO8AA	Papeete, Tahiti.
7.088	42.3	PI1J	Dordrecht, Holland.
6.97	43.05	XPSA	Kweiyang, China.
6.96	43.10	Z2ZB	Wellington, N.Z.
6.88	43.60	XOJD	Hankow, China.
6.79	44.16	PZH	Paramirabo, Surinam.
6.775	44.26	HIH	San Pedro de Macoris, Dom. Rep.
6.73	44.58	HI3C	La Romana, Dominica Rep.
6.72	44.64	PMH	Bandoeng, Java
6.69	44.82	TIEP	San Jose, Costa Rica.
6.675	44.94	HBQ	Geneva, Switzerland.
6.625	45.28	PRADO	Riobamba, Equador.

MC/s.	Metres.	Call.	Station Name.
6.565	45.70	HI5P	Puerto, Plata.
6.55	45.8	XBC	Vera Cruz, Mexico.
6.49	46.2	TGWB	Guatemala City, Guat.
6.47	46.36	YNLAT	Granada, Nic.
6.384	46.99	ZIZ	Basseterre, W.I.
6.335	47.33	OAXIA	Ica, Peru.
6.324	47.4	COCW	Havana, Cuba.
6.295	47.63	OAX4G	Lima, Peru.
6.28	47.77	HIIG	Trujillo City, D.R.
6.235	48.12	HRD.	La Ceiba, Honduras.
6.19	48.47	JLK	Tokio, Japan.
6.19	48.47	HVJ	Vatican City.
6.17	48.62	W2XE	New York City.
6.153	48.75	HI5N	Moca City, D.R.
6.15	48.78	VPB	Colombo, Ceylon.
6.15	48.78	CJRO	Winnepeg, Canada.
6.148	48.8	ZTD	Durban, S. Africa.
6.147	48.8	ZEB	Bulawayo, Rhodesia.
6.14	48.83	—	Leopoldville, Belgian Congo.
6.137	48.87	CR7AA	Laurenco Marques, E. Africa.
6.13	48.94	VP3BG	Georgetown, British Guiana.
6.13	48.94	CHNX	Halifax, N.S., Canada.
6.125	48.98	CXA4	Montevideo, Uruguay.
6.122	49	HP5H	Panama City.
6.122	49	FK8AA	Noumea, New Caledonia.
6.12	49.01	W2XE	New York City.
6.117	49.03	XEUZ	Mexico City.
6.115	49.05	OLR2C	Prague, Bohemia.
6.097	49.2	ZRK	Klipheuvel, S. Africa.
6.097	49.2	ZRJ	Johannesburg.
6.095	49.22	JHZ	Tokio, Japan.
6.09	49.26	CRCX	Toronto, Canada.
6.083	49.31	VQ7LO	Nairobi, Kenya, Africa.
6.08	49.34	CRY9	Macao.
6.077	49.35	OAX4Z	Lima, Peru.
6.075	49.35	VP3MR	Georgetown, British Guiana.
6.07	49.42	CFRX	Toronto, Canada.
6.07	49.42	VE9CS	Vancouver, B.C.
6.065	49.46	SBO	Motala, Sweden.
6.06	49.5	YDD	Bandoeng, Java.
6.06	49.5	W3XAU	Philadelphia, Pa.
6.057	49.53	ZHJ	Penang, Fed. Malay States.
6.05	49.59	GSA	Daventry, England.
6.045	49.6	XETW	Tampico, Mexico.
6.04	49.65	W4XB	Miami Beach, Florida.
6.04	49.65	WIXAL	Boston, Mass.
6.033	49.75	HP5B	Panama City, Pan.
6.03	49.75	CFVP	Calgary, Alta, Canada.
6.03	49.75	RW.96	Moscow, U.S.S.R.
6.03	49.75	OLR2B	Prague, Bohemia.
6.023	49.82	XEUW	Vera Cruz, Mexico.
6.02	49.83	DJC	Berlin, Germany.
6.01	49.92	OLR2A	Prague, Bohemia.
6.01	49.92	VK9M1	S.S. Kanimbla.
6.01	49.92	CJCX	Sydney, Nova Scotia.
6.007	49.94	XYZ	Rangoon, Burma.
6.007	49.94	ZRH	Roberts Heights, South Africa.
6.005	49.96	CFCX	Montreal, Canada.
6.005	49.96	VE9DN	Drummondville, Quebec Canada.
5.990	50.08	ZEA	Salisbury, Rhodesia, Sth. Africa.

We wish to acknowledge our indebtedness to H. R. Adams, Esq. G2NO, for his painstaking work in compiling this list of short-wave stations by actual listening. We believe it to be the most comprehensive yet published. As readers of this journal are aware, Mr. Adams is the Manager of Messrs. Webbs Radio Limited.

Design Data of Six Short-wave Receivers for Long-distance Reception

Present conditions have created a special demand for short-wave receivers capable of bringing in transmissions from all parts of the world. We are, therefore, providing design data of six types employing one to eight valves, which have been described in detail in previous issues. The information given here will, however, suffice for their construction and meet the large number of requests that we have received for details of short-wave receivers.



One-valve Battery-operated

This receiver is, of course, intended for headphone operation, and by using a set of five Eddystone plug-in coils, the receiver will pick up quite a large number of stations without difficulty, including some American broadcasters on 16 and 19 metres. By inter-changing the coils, the total coverage of the receiver is 9 to 170 metres. The power supply is derived from a 60-volt H.T. battery and a low capacity accumulator. As previously mentioned the coils used are Eddystone, type 959, and although five are needed to cover all wavelengths from 9 to 170 metres, they can be purchased singly if required. The two most important are the 6Lb and the 6Y which tune from 12 to 47 metres, so covering most of the commercial channels. Provision is made on the chassis for the addition of another valve, should signals be required at loud-speaker strength. Details of how the second valve and its associated components should be wired are given opposite. (Full constructional data in the August 1938 issue).

COMPONENTS

CHASSIS
1 Wooden chassis 6 × 6 × ins.

COILS.
1 Set 6-pin coils to cover 9-170 metres type 959 (Eddystone).

COIL HOLDER.
1 Type 6-pin socket type 964 (Eddystone).

CONDENSERS, FIXED.
1—.0001 mfd. type 690W (C1) (Dubilier).
1—.001 type 690W (C2) (Dubilier).
1—.001 mfd. type 690W (C3) (Dubilier).
1—.01 mfd. type 691 (C4) (Dubilier).

CONDENSERS, VARIABLE.
1 Tank condenser type 1042 (VC1) (Eddystone).
1 Bandspread type 1043 with dial (VC2) (Eddystone).
1—.0003-mfd. trimmer type 2150 (VC3) (Jackson Bros.).
1—.0003-mfd. trimmer type 2150 (VC4) (Jackson Bros.).

CHOKE, R.F.
1—Type S.W. 68 (Bulgin).

HOLDER, VALVE.
1—Type 7-pin chassis less terminals (Clix).

HEADPHONES.
1—Pair super sensitive (Ericsson).

RESISTANCE, FIXED.
1—5-megohm ½-watt type (R1) (Erie).

RESISTANCE, VARIABLE.
1—100,000-ohm potentiometer (VR1) (Erie).

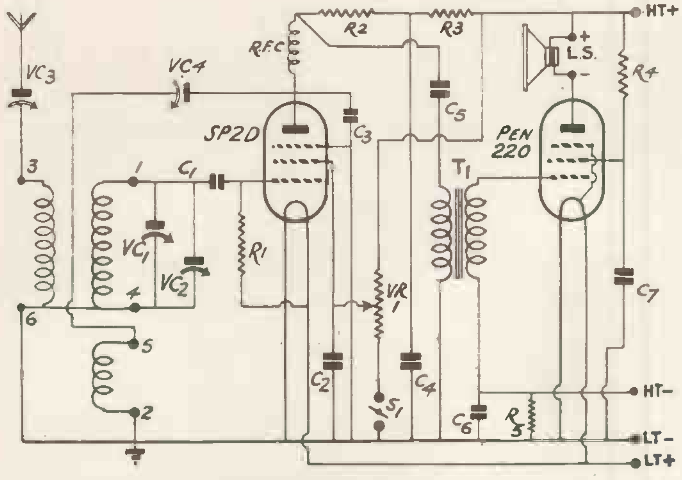
SWITCH.
1—Double-pole single-throw type S88 (Bulgin).

SUNDRIES.
1—Coil Quickwire (Bulgin).
1—Top cap anode connector (Bulgin).
1—Jack type J2 (Bulgin).
1—Plug type P2 (Bulgin).
1—Single fuse holder with fuse (Bulgin).

VALVE.
1—Type SP2D met. (Tungsram).

Two-valve Battery-operated

As previously explained, this is a two-valve version of the simple receiver already described, and by comparing the circuit diagrams, it will be seen that the first part of the receiver is almost unchanged. The loudspeaker is connected to the same two terminals which were originally used for headphones. In the two-valve arrangement, however, one side of the loudspeaker is connected directly to the anode of the pentode, while the other side of the speaker goes to maximum H.T. voltage. If the original design is followed the additional valve can be included without disturbing the remainder of the set. This second valve is a low-frequency amplifier of the Mazda PEN220 type, which gives very high amplification without unduly increasing the H.T. current, thus providing reliable loudspeaker reception on the short waves. With a two-valve circuit, as shown, a 120-volt battery is required, which must provide a current flow of 10 mA. The total consumption of the receiver should not be more than 7 mA., but a larger battery will have a much longer life than an actual 7 mA. battery. With this power supply available an aerial of only 25 ft. total top length, is required. (Constructional details were given in the September, 1938, issue).



Circuit diagram of the two-valve battery-operated receiver.

The same chassis is used as for the one-valve receiver.

COMPONENTS

CHASSIS
1—Wooden chassis 6 × 6 × 3 ins.

COILS.
1—Set 6-pin coils to cover 9-170 metres, type 959 (Eddystone).

COIL HOLDER.
1—Type 6-pin socket type 964 (Eddystone).

CONDENSERS, FIXED.
1—.0001 mfd. type 690W (C1) (Dubilier).
1—.001 mfd. type 690W (C2) (Dubilier).
1—.001 mfd. type 690W (C3) (Dubilier).
1—.01 mfd. type 691 (C4) (Dubilier).
1—.01 mfd. type 690W (C5) (Dubilier).
1—2 mfd. type B.B. (C6) (Dubilier).
1—.01 mfd. type 691 (C7) (Dubilier).

CONDENSERS, VARIABLE.
1—Tank condenser type 1042 (VC1) (Eddystone).
1—Bandspread type 1043 with dial (VC2) (Eddystone).
1—.0003 mfd. trimmer type 2150 (VC3) (Jackson Bros.).
1—.0003 mfd. trimmer type 2150 (VC4) (Jackson Bros.).

CHOKE, R.F.
1—Type S.W.68 (Bulgin).

HOLDERS, VALVE.
1—Type 7-pin chassis less terminals (Clix).
1—5-pin chassis less terminals (Clix).

HEADPHONES.
1—Pair 4,000-ohm (Ericsson).

LOUDSPEAKER.
1—Type Baby (W.B.).

RESISTANCES, FIXED.
1—.5 megohm ½-watt type (R1) (Erie).
1—75,000 ohm type ½-watt (R2) (Erie).
1—25,000 ohm type ½-watt (R3) (Erie).
1—5,000 ohm type 1-watt (R4) (Erie).
1—500 ohm type 1-watt (R5) (Erie).

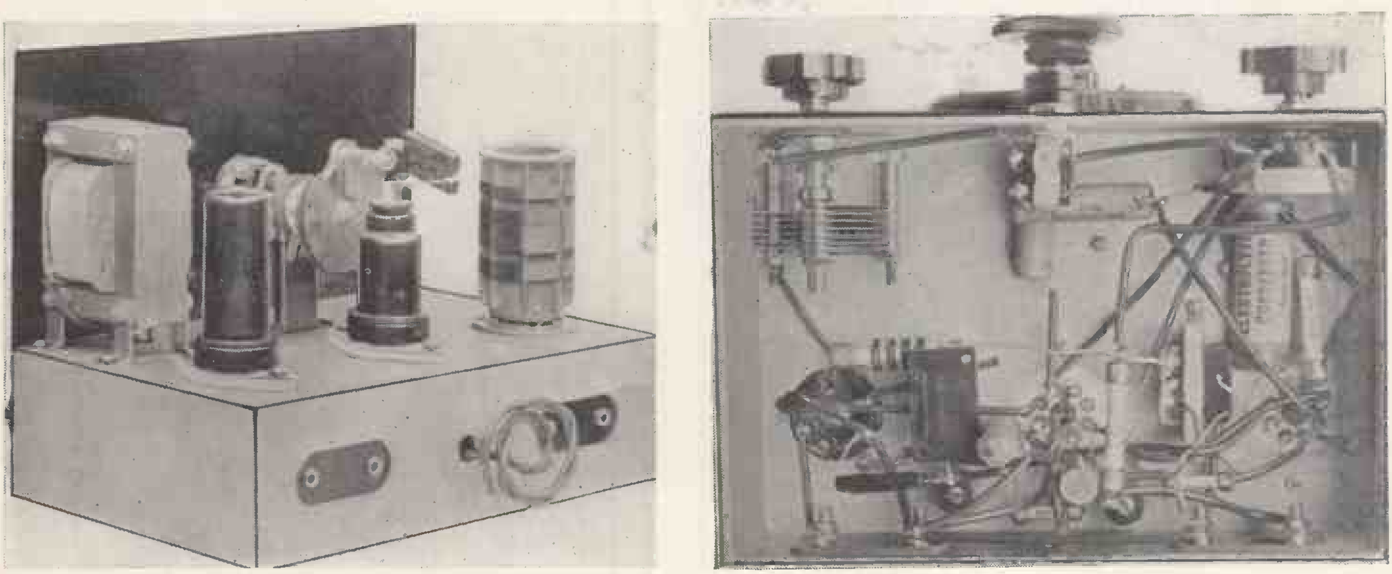
RESISTANCE, VARIABLE.
1—100,000-ohm potentiometer (VR1) (Erie).

SWITCH.
1—Double-pole single-throw type S88 (Bulgin).

SUNDRIES.
1—Coil quickwire (Bulgin).
1—Top cap anode connector (Bulgin).
1—Jack type J2 (Bulgin).
1—Plug type P2 (Bulgin).
1—Single fuse holder with fuse (Bulgin).

TRANSFORMER.
1—1-3.5 type AF4 (Ferranti).

VALVES.
1—Type SP2D met. (Tungsram).
1—PEN220 (Mazda).



Back and inside views of the two-valve mains-operated receiver.

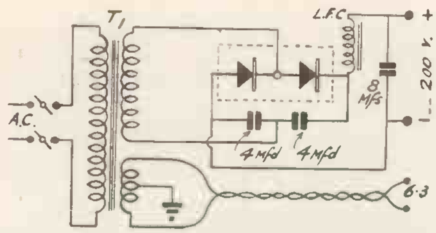
Two-valve Mains-operated

This receiver was designed for those listeners who require a sensitive two-valve receiver operating from the mains supply.

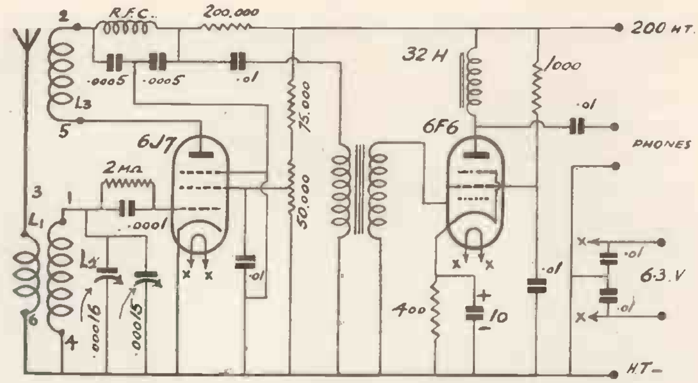
By the use of plug-in coils, a continuous coverage from 9 to 2,000 metres without a break is possible, although the receiver is particularly suitable for use below 200 metres. Advantage has been taken of the modern steep slope mains valves now available, and as a result, world-wide coverage is easily obtainable.

The power pack is built in its own chassis, to eliminate hum, and connected to the receiver by means of cables. In this unit a Westinghouse metal receiver is used, which provides 200 volts at 30 mA., with an A.C. input of 140 volts at 120 mA.

The receiver is intended for headphone reception, and full details regarding construction, wiring and layout will be found in the April, 1939, issue of this journal.



A metal rectifier is used in the power unit. This is the circuit.



Circuit diagram of the two-valve mains-operated receiver.

COMPONENTS

CHASSIS AND PANEL.
2—Chassis type 1117 (Eddystone).
1—Panel type 1118 (Eddystone).

COILS.
1—Set 6-pin 9-170 metres type 959 (Eddystone).

CONDENSERS, FIXED.
1—.0001 mfd. type 690W (Dubilier).
2—.0005 mfd. type 690W (Dubilier).
6—.01 mfd. type 691W (Dubilier).
1—10 mfd. 50-volt type 3016 (Dubilier).
2—4 mfd. type LEG 400 volt (Dubilier).
1—8 mfd. type 402 (Dubilier).

CONDENSERS, VARIABLE.
1—.00016 mfd. type TRO160 (Premier).
1—.000015 mfd. type TRO15 (Premier).

CHOKES, L.F.
2—Type 40 m/A. 30H. (Premier).

CHOKE, R.F.
1—Type CHM (Raymart).

DIAL.
1—Type indigraph (Peto-Scott).

HEADPHONES.
1—Pair type Supersensitive (Ericsson).

HOLDERS, VALVE AND COIL.
1—Type 964 (Eddystone).
2—Type ceramic octal (Clix).

JACK.
1—Open circuit type with plug (Bulgin).

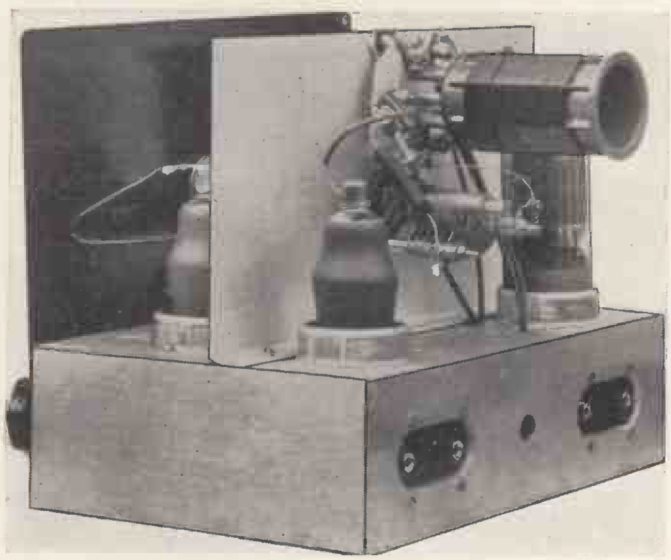
RESISTANCES, FIXED.
1—2 megohm ½ watt (Bulgin).
1—200,000 ohm 1 watt (Bulgin).
1—75,000 ohm 1 watt (Bulgin).
1—400 ohm 1 watt (Bulgin).
1—1,000 ohm 1 watt (Bulgin).

RESISTANCES, VARIABLE.
1—50,000 ohm type potentiometer (Reliance).

RECTIFIER.
1—Metal type H.T.15 (Westinghouse).

TRANSFORMERS.
1—Inter-valve type LF58 (Bulgin).
1—HT type 140 volt 120 m/A. (Premier).

VALVES.
1—6J7 (Webbs Radio).
1—6F6 (Webbs Radio).



Rear view of three-valve mains receiver.

Three-valve Mains-operated

The straightforward design and construction of this receiver makes it particularly suitable for use on the broadcast bands, such as 13 and 19 metres, and readers who require high quality short-wave reception will find it distinctly above the general run of two or three valve receivers.

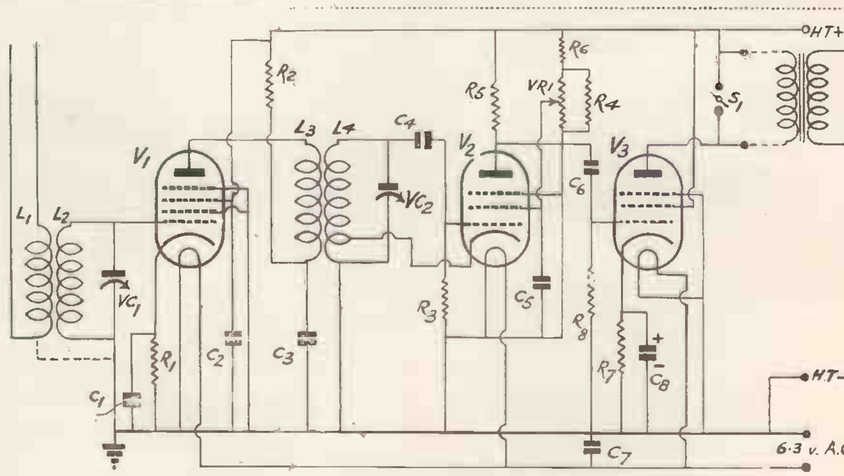
The valves employed are of the "E" type recently introduced by the Mullard Company, and as these are considerably smaller than normal in physical dimensions, not only is the resultant compactness of the receiver very attractive, but the method of connection is greatly improved.

The receiver is primarily designed for use with headphones, although loudspeaker reception is also possible owing to the high output of the valves. (Full constructional details were given in the December, 1938, issue).

COMPONENTS

CHASSIS.
1—Type aluminium No. 1118 8½ × 5¾ × 2⅞ Eddystone).

CONDENSERS, FIXED.
1—.01 mfd. type tubular (C1) (Premier).
1—.01 mfd. type tubular (C2) (Premier).



The circuit diagram.

1—.001 mfd. type tubular (C3) (Premier).
1—.0001 mfd. type mica (C4) (Premier).
1—.006 mfd. type tubular (C5) (Premier).
1—.006 mfd. type mica (C6) (Premier).
1—.005 mfd. type tubular (C7) (Premier).
1—25 mfd. 25 volt electrolytic (C8) (Premier).

CONDENSERS, VARIABLE.
1—Type VC15X (VC1) (Raymart).
1—Type VC15X (VC2) (Raymart).

COIL FORMS.
1—CF6 (Raymart).
1—CF4 (Raymart).

DIAL.
1—Type Indigraph (Peto-Scott).

HOLDERS, VALVE.
3—Type VH24 (Bulgin).

HOLDERS, COIL.
1—Type SW21 (Bulgin).
1—Type SW51 (Bulgin).

HEADPHONES.
1—Pair supersensitive (Ericsson).

PLUGS, SOCKETS, ETC.
2—Top cap anode connectors type T41 (Bulgin).
4—Parallel sockets (Clix).
4—Plugs, type 3 (Clix).

RESISTANCES, FIXED.
1—300 ohm type 1 watt (R1) (Erie).
1—500 ohm type WE10 (R2) (Bulgin).
1—250,000 ohm type HW28 (R3) (Bulgin).
1—40,000 ohm type HW22 (R4) (Bulgin).
1—100,000 ohm type HW25 (R5) (Bulgin).
1—100,000 ohm type HW25 (R6) (Bulgin).
1—150 ohm type 1 watt (R7) (Erie).
1—1 megohm type HW23 (R8) (Bulgin).

RESISTANCE, VARIABLE.
1—50,000 ohm potentiometer (VR1) (Reliance).

SWITCH.
1—Type S80T (Bulgin).

VALVES.
1—Type EF8 (V1) (Mullard).
1—Type EF6 (V2) (Mullard).
1—Type EL3 (V3) (Mullard).

A complete kit of components can be obtained from Messrs. Peto-Scott, Limited, Webbs Radio, Limited, and Premier Supply Stores.

DIAL.
1—Type 1070 (Eddystone).
1—Type 1097 (Eddystone).

EXTENSION OUTFITS.
2—Type 1068 (Eddystone).

HEADPHONES.
1—Pair type A (S. G. Brown).

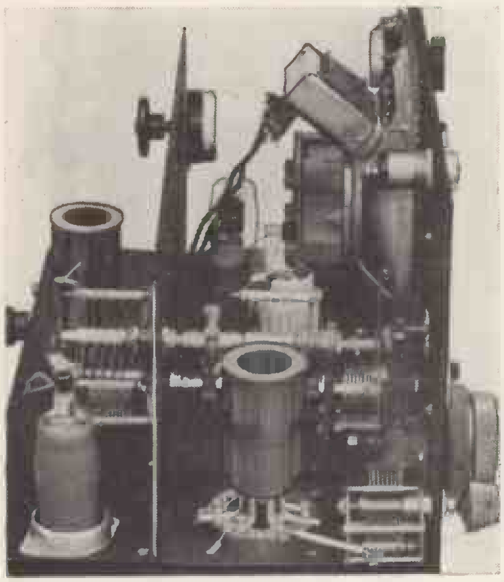
HOLDERS, COIL.
1—Type 969 (Eddystone).
1—Type SW21 (Bulgin).

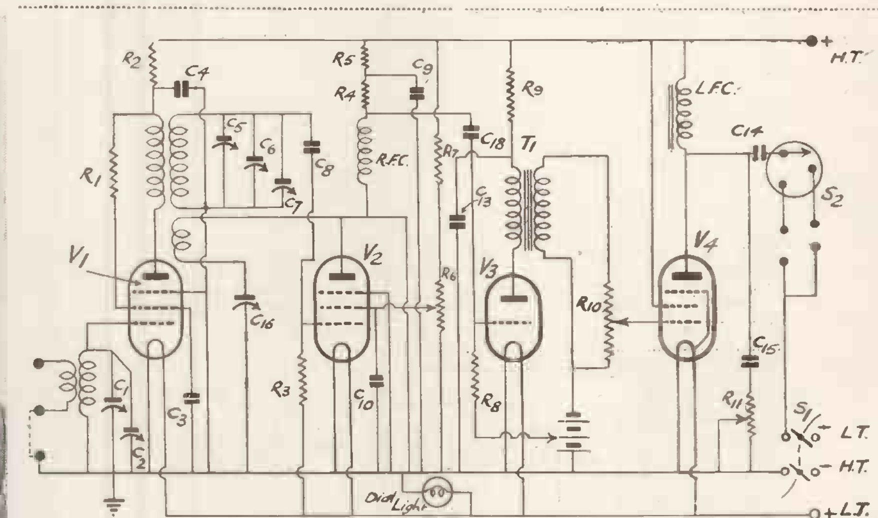
HOLDERS, VALVE.
4—Octal type VH56 (Bulgin).

JACK.
1—Type J1 (Bulgin).

PLUG.
1—Type P15 (Bulgin).

RESISTANCES, FIXED AND VARIABLE.
1—200,000 ohm type ½ watt (R1) (Dubilier).
1—1,000 ohm ½ watt (R2) (Bulgin).
1—3 megohm type ½ watt (R3) (Bulgin).
1—75,000 ohm type ½ watt (R4) (Bulgin).
1—25,000 ohm type ½ watt (R5) (Bulgin).





This theoretical circuit has the components marked with reference numbers so that the values are easily obtained from the printed list.

Four-valve Battery-operated

This set is eminently suitable for listeners who require a sensitive and trouble-free receiver, but who are, for some reason, without the added facility of a mains supply.

The valves incorporated are extremely economical in use and make it possible to build an excellent four-valve receiver with a total anode current well within the capabilities of a medium type battery. The loudspeaker has been built in, as will be seen from the illustration, but provision has been made for headphones to be switched into circuit should they be required. The normal coverage is 15 to 200 metres, and it is not considered suitable for medium wave-band reception except by Colonial listeners. (Constructional data was given in July, 1939).

COMPONENTS

CHASSIS, PANEL, CABINET.
1—Aluminium panel 17 × 9⅛ finished black (Peto-Scott).
1—Aluminium chassis to specification finished black (Peto-Scott).
1—Screen to Specification (Peto-Scott).
1—Steel cabinet finished black type 1034 (Eddystone).

COILS.
1—Set type 959 (Eddystone).

COIL FORMS.
3—Type CF4 (Raymart).
2—Type CT4 (Raymart).

CHOKE, R.F.
1—Type CHN (Raymart).

CHOKE, L.F.
1—Type LF40 (Bulgin).

CONDENSERS, FIXED AND VARIABLE.
1—160 mmfd. type 1131 (C1) (Eddystone).
1—18 mfd. type 1094 (C2) (Eddystone).
1—.01 mfd. type 4601/s (C3) (Dubilier).
1—.01 mfd. type 4601/s (C4) (Dubilier).
1—160 mmfd. type 1131 (C5) (Eddystone).
1—18 mfd. type 1094 (C6) (Eddystone).
1—3.30 mmfd. type SW95 (C7) (Bulgin).
1—.0001 mfd. type mica (C8) (Raymart).
1—1.0 mfd. type 4609 s (C9) (Dubilier).
1—.01 mfd. type 4601/s (C10) (Dubilier).
1—.001 mfd. type 690 W (C11) (Dubilier).
1—.01 mfd. type 691 W (C12) (Dubilier).
1—1.0 mfd. type 4609/s (C13) (Dubilier).
1—1.0 mfd. type 4609/s (C14) (Dubilier).
1—.01 mfd. type 4601/s (C15) (Dubilier).
1—.0002 mfd. type 957 (C16) (Eddystone).
1—50,000 variable potentiometer type B (R6) (Dubilier).
1—25,000 ohm type 1 watt (R7) (Dubilier).
1—.25 megohm type ½ watt (R8) (Bulgin).
1—5,000 ohm type 1 watt (R9) (Dubilier).
1—500,000 ohm variable potentiometer type B (R10) (Dubilier).
1—10,000 ohm variable potentiometer type B (R11) (Dubilier).

SWITCHES.
1—S88 (S1) (Bulgin).
1—S92 (S2) (Bulgin).

SUNDRIES.
3—Knobs type 1086 (Eddystone).
2—Type 1009 couplers (Eddystone).
1—Dial light type D9 (Bulgin).
1—4-way battery cable type BC2 (Bulgin).
1—A-E socket type X383 (Clix).
3—Valve screens type VS (Raymart).
2—Anode connectors (Bulgin).
Loudspeaker Gauze (Peto-Scott).

TRANSFORMER.
1—Type LF33 (T1) (Bulgin).

ACCESSORIES.

ACCUMULATOR.
1—S150 (Ever Ready).

BATTERY, H.T.
1—Super power (Siemens).

BATTERY G.B.
1—9 volt Winner (Ever Ready).

VALVES.
1—VP23 met. (V1) (Mazda).
1—SP22 met. (V2) (Mazda).
1—HL23 met. (V3) (Mazda).
1—PEN25 clear (V4) (Mazda).

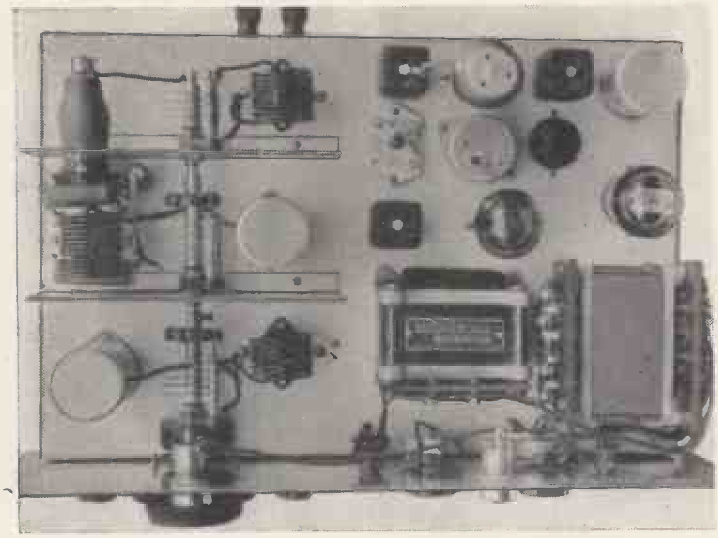
Eight-valve Mains-operated

A multi-valve receiver designed to provide maximum signal strength, selectivity and minimum noise on all wavelengths between 4.5 and 190 metres. Plug-in coils provide for this coverage which is divided into the following ranges:—

Range 1: 4.5—8 metres
Range 2: 9.5—17 metres
Range 3: 16—28 metres
Range 4: 28—70 metres
Range 5: 70—130 metres
Range 6: 125—190 metres

Full winding data and tables for the coils are given in the May, 1939, issue.

The receiver is fitted with R.F., I.F., and A.F. gain controls, stand-by switch, B.F.O. switch and three band setters, refinements usually to be found only in commercial sets of very high quality.



This plan view shows how the components are laid out, particularly in the R.F. and detector-oscillator stages.

COMPONENTS

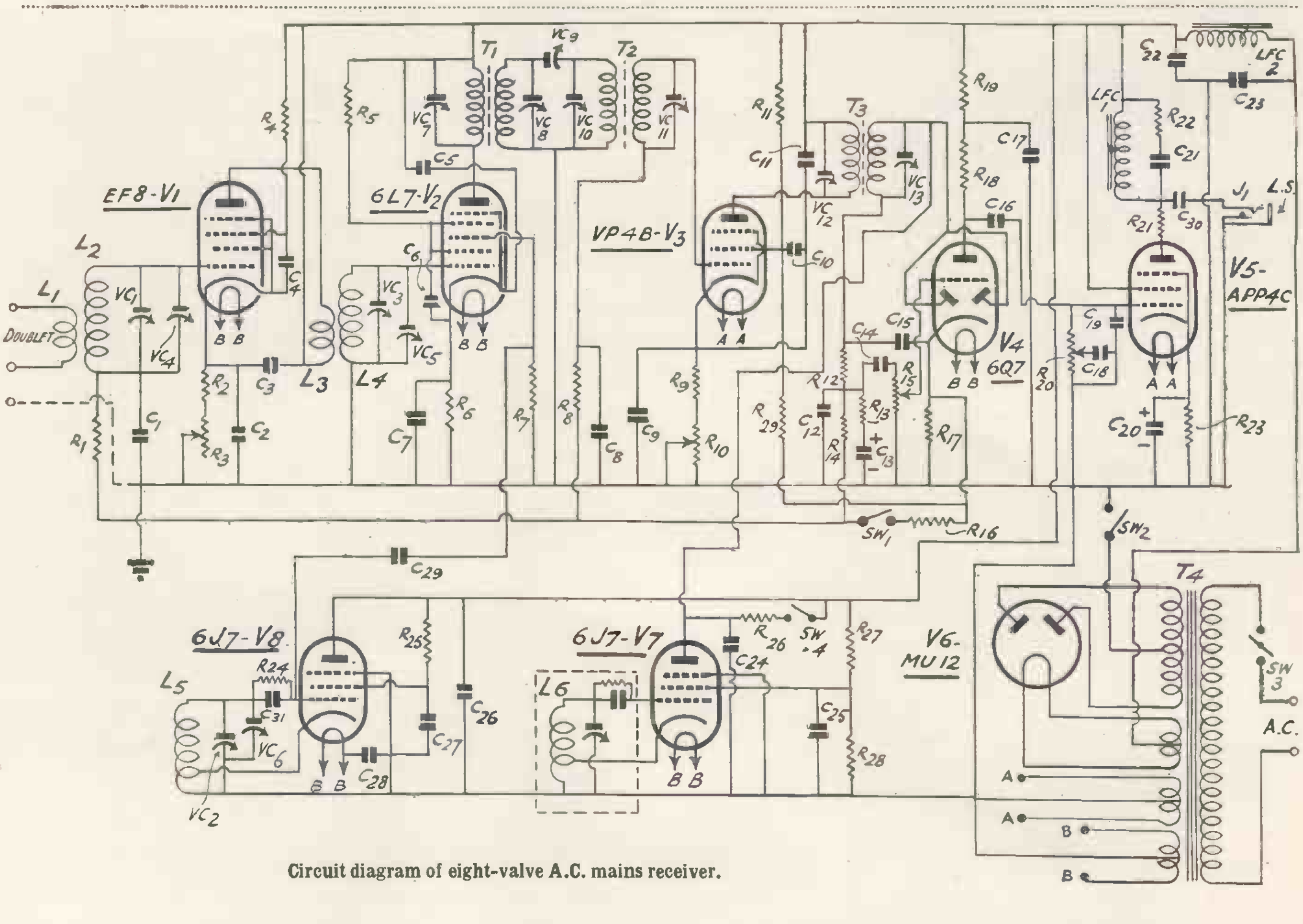
BEAT-FREQUENCY OSCILLATOR UNIT.
1—Type 1119 (L6) (Eddystone).

CHASSIS, PANEL AND CABINET.
1—Steel chassis finished grey type T8 (Peto-Scott).
1—Steel panel finished grey type T8 (Peto-Scott).
1—Special cabinet with hinged lid type T8 finished grey (Peto-Scott).

COIL FORMS.
3—4-pin type CT4 (Raymart).
3—4-pin type CF4 (Raymart).

CONDENSERS, FIXED.
1—.1 mfd. type 4603/2 (C1) (Dubilier).
1—.1 mfd. type 4603/s (C2) (Dubilier).
1—.1 mfd. type 4603/s (C3) (Dubilier).
1—.1 mfd. type 4603/s (C4) (Dubilier).
1—.1 mfd. type 4603/s (C5) (Dubilier).
1—.1 mfd. type 4603/s (C6) (Dubilier).
1—.1 mfd. type 4603/s (C7) (Dubilier).
1—.1 mfd. type 4603/s (C8) (Dubilier).
1—.1 mfd. type 4603/s (C9) (Dubilier).
1—.1 mfd. type 4603/s (C11) (Dubilier).
1—.0001 mfd. type 4601/s (C12) (Dubilier).
1—25 mfd. type 25 v. working 3016 (C13) (Dubilier).
1—.03 mfd. type 4601/s (C14) (Dubilier).
1—.0001 mfd. type 4601/s (C15) (Dubilier).
1—.01 mfd. type 4601/s (C16) (Dubilier).
1—1.0 mfd. type 4609/s (C17) (Dubilier).
1—.01 mfd. type 4601/s (C18) (Dubilier).
1—.0001 mfd. type 4601/s (C19) (Dubilier).
1—25 mfd. type 25 v. working 3016 (C20) (Dubilier).
1—.002 mfd. type 4601/s (C21) (Dubilier).

(*Continued on page* 704)



Circuit diagram of eight-valve A.C. mains receiver.

A RECORD OF PATENTS AND PROGRESS

RECENT DEVELOPMENTS

PATENTEES

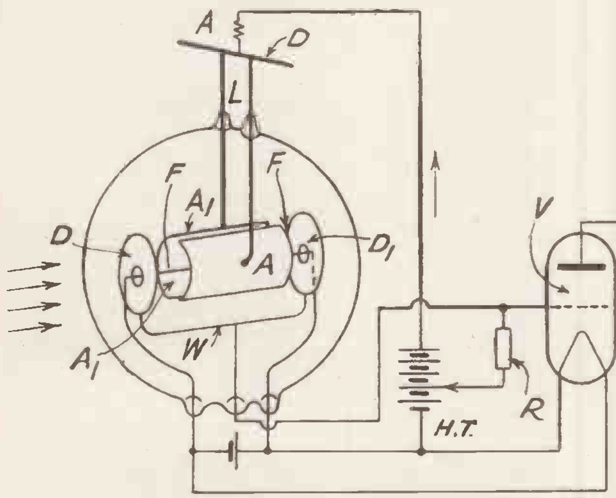
Telefunken Ges. fur drahtlose Telegraphie m.b.h. :: Radio-Akt. D. S. Loewe :: Askania-Werke Akt. :: V. H. Gilbert and Radiovisor Parent Ltd

A Magnetron Circuit

(Patent No. 501,048.)

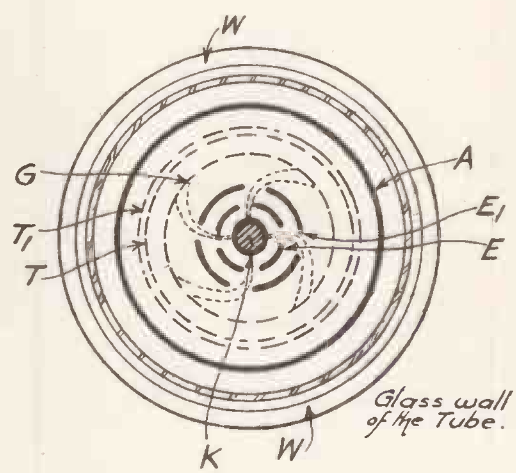
A strong magnetic field is applied from an external winding, in a direction parallel with that of the filament F, as shown by the arrows. This forces the electrons passing between the filament and the two "split" anodes A, A1 to take a spiral, instead of a straight path, and so regulates their time of flight. In general, for maximum output, the wavelength produced by a magnetron valve of this type is inversely proportional to the strength of the field.

The circuit is designed for the reception of ultra-short waves. The incoming signals are picked up by a dipole aerial D which is coupled to the two split anodes A, A1 by a pair of Lecher wires L. Two stabilising discs D, D1 are arranged one at each end of the anodes, and are joined together by a wire W, the mid-point of which is connected through an impedance R to a tapping on the H.T. battery. The rectified signals voltages appear across the "load" R, and are fed to the grid of an amplifier V.—*Telefunken Ges. für drahtlose Telegraphie m.b.h.*



Left : Magnetron circuit for reception of ultra-short waves.

Right : Combined magnetron type valve and electron multiplier.



Short-wave Receivers

(Patent No. 504,836.)

Ultra-short-wave signals are received on two short rods, or dipoles, which are mounted partly inside and partly outside an exhausted glass tube. The inside ends of the two dipoles are joined together by a fine resistance wire or "barretter," which is kept heated to a sensitive "threshold" temperature by means of an auxiliary battery.

The energy of the received signals is sufficient to vary the threshold temperature of the barretter wire, and the heat so produced is projected by a curved reflector on to a cathode which is coated with a substance particularly responsive to infra-red rays. The electrons liberated in this way from the heat-sensitive cathode are collected on a ring-shaped anode, and fed to the grid of an amplifying valve.—*Telefunken für drahtlose Telegraphie m.b.h.*

Electron Multiplier

(Patent No. 505,557.)

A valve of the magnetron type, in which an external magnetic field is used to impart a spiral motion to the electron stream, is combined, according to the invention, with an electron-multiplier in which amplification is secured by projecting electrons against targets coated with highly-emissive materials. The purpose in view is to produce an effective discharge stream which consists of having approximately the same velocity, and to exclude electrons travelling at higher or lower speeds. This is stated to increase the amplification factor.

As shown in cross-section, electrons emitted from a central cathode K are forced by the magnetic field from an external winding W to follow a curved path, so that only those with a given velocity can pass through slots made in two concentric electrodes E and E1, which block the passage of electrons emitted from the filament at other velocities. The outer electrode E1 then serves as an effective cathode, so far as the remaining electrodes are concerned. These include a control grid G, and two "target" electrodes T, T1 which amplify the stream by secondary emission, before it finally reaches the collecting anode A.—*Radio-Akt D. S. Loewe.*

Frictionless Remote Control

(Patent No. 505,872.)

It is possible to keep the movement of a distant magnetic needle in step with the movement of some other element, such as the needle of the master-compass on a ship, by causing the latter to transmit currents of varying value from a circular winding or potentiometer over which the compass needle moves as the course of the ship is changed. In such a case it is obviously desirable to keep the friction between the compass and the contact potentiometer as low as possible.

According to the invention, the compass needle and the ring-potentiometer are both enclosed in an air-tight chamber filled with gas at low pressure. Electrodes associated with the compass needle move close to, but not in contact with the glass ring, and pick up varying currents in the form of the glow discharge which takes place between them and the potentiometer windings. In this way rubbing friction is completely eliminated.—*Askania-Werke Akt.*

Gas-filled Discharge Tubes

(Patent No. 505,951.)

In gas-filled valves of the grid-controlled type, where the cathode is first heated to a temperature at which it readily emits electrons, it has been found that the cathode deteriorates rapidly owing to the tendency of the oxide coatings to break away as a result of severe bombardment by free ions.

To prevent this the cathode is formed by winding a tapered ribbon of oxide-coated nickel or nickel-cobalt into a conical-shaped core, with a crater-like depression. The core is surrounded by a heating element embedded in refractory material, and the lower end of the tube contains a small pool of mercury or other readily-vaporisable material.

With this construction it is stated that the loss of oxide from the crater of the cathode is comparatively small, and takes place very gradually, thus giving the discharge tube a longer life than usual.—*Westinghouse Electric and Manufacturing Co.*

Photo-electric Testing

(Patent No. 509,061.)

The presence of impurities in water, particularly ammonia or other matter which may be injurious to health, is detected by a photo-electric cell. The apparatus is particularly suitable for use in air-conditioning plant where there may be danger of leakage of ammonia from the cooling apparatus.

The water to be tested is passed into a chamber containing a heating coil. If ammonia is present, it will produce a cloudiness—owing to the calcium carbonate which is invariably present in ordinary tap water.

This, in turn, obstructs the light passing from a lamp, through the liquid, on to a photo-electric cell, to such an extent as to sound a warning bell. Or it may operate a relay, to shut off the pumps automatically.—*V. H. Gilbert and Radiovisor Parent, Ltd.*

Summary of other Electronic Patents

(Patent No. 504,396.)

Purifying liquids and gases by subjecting them to electric discharges.—*Lodge-Cottrell, Ltd.*

(Patent No. 504,443.)

Coil-less "resonator" unit for ultra-short waves.—*Telefunken Geo fur drahtlose Telegraphie m.v.h.*

(Patent No. 504,526.)

Electron-multiplier and image-dissector, with magnetic focusing and deflection of the electron stream.—*Farnsworth Television, Inc.*

(Patent No. 508,650.)

Photo-electric control for a telegraph keyboard transmitter.—*Creed and Co., Ltd.*

(Patent No. 508,778.)

Cooling the target electrodes and preventing the formation of excessive space-charges in an electron multiplier.—*N. V. Philips Gloeilampenfabrieken.*

(Patent No. 508,845.)

Generating very high frequencies by periodically deflecting and intercepting the electron beam passing through a tube of the electron multiplier type.—*W. S. Percival.*

(Patent No. 511,681.)

Electron-multiplier tube in which the photo-electric cathode is set at an angle of 45 degrees to the axis of the target electrodes.—*Radio-Akt. D. S. Loewe.*

(Patent No. 512,245.)

Filament mounting for an electron discharge tube designed to prevent microphonic noise and valve "hiss."—*Marconi's Wireless Telegraph Co., Ltd.*

8-valve Mains-operated Short-wave Receiver (*Continued from page 702*)

1—8 plus 8 mfd. type 500 v. working 0288 (C22 & C23) (Dubilier).
1—.1 mfd. type 4603/s (C24) (Dubilier).
1—1 mfd. type 4603/s (C25) (Dubilier).
1—.1 mfd. type 4603/s (C26) (Dubilier).
1—.1 mfd. type 4603/s (C27) (Dubilier).
1—.1 mfd. type 4603/s (C28) (Dubilier).
1—.1 mfd. type 690W (C29) (Dubilier).
1—.1 mfd. type 4609/s (C30) (Dubilier).
1—.0001 mfd. type 4601/s (C31) (Dubilier).

CONDENSERS, VARIABLE.
1—40 mmfd. type VC40X (VC1) (Raymart).
1—40 mmfd. type VC40X (VC2) (Raymart)
1—40 mmfd. type VC40X (VC3) (Raymart).
1—18 mmfd. type 1094 (VC4) (Eddystone).
1—18 mmfd. type 1094 (VC5) (Eddystone).
1—18 mmfd. type 1094 (VC6) (Eddystone).
2—Trimmer condensers (in I.F. transformers) (VC7 and 8).
1—40 mmfd. type UTC (VC9) (Peto-Scott).
4—Trimmer condensers (in I.F. transformers) (VC10 to 13).

CHOKES.
1—Type WWC1 (LFC1) (Sound Sales).
1—LF218 (LFC2) (Bulgin).

DIAL LAMPS.
1—Type D9 Green (Bulgin).
1—Type D9 Red (Bulgin).

HOLDERS, VALVE.
1—8-pin side contact type VH24 (Bulgin).
4—8-pin ceramic octal type chassis less terminals (Clix).
2—8-pin chassis ceramic type less terminals (Clix).
1—4-pin chassis ceramic type less terminals (Clix).
9—4-pin type VH43 (for coil bases) (Bulgin).
3—4-pin type 1073 (for coil bases) (Eddystone).

HEADPHONES.
1—Pair type 'A" (S. G. Brown).

KNOBS.
4—Type 1089 (Eddystone).
3—Type K106 (Bulgin).

JACK.
1—Insulated open circuit (Premier).

RESISTANCES, FIXED AND VARIABLE.
1—500,000 ohm type ½ watt (R1) (Bulgin).
1—200 ohm type 1 watt (R2) (Bulgin).
1—100,000 ohm variable type B (R3) (Dubilier).
1—500 ohm type 1 watt (R4) (Bulgin)
1—15,000 ohm type 1 watt (R5) (Bulgin).
1—500 ohm type 1 watt (R6) (Bulgin).
1—50,000 ohm type 1 watt (R7) (Bulgin).
1—500,000 ohm type ½ watt (R8) (Bulgin).
1—200 ohm type 1 watt (R9) (Bulgin).
1—5,000 ohm type B variabe (R10) (Dubilier).
1—300 ohm type 1 watt (R11) (Bulgin).
1—20,000 ohm type ½ watt (R12) (Bulgin).
1—250,000 ohm type ½ watt (R13) (Bulgin).
1—1 megohm type 1 watt (R14) (Bulgin).
1—250,000 ohm variable type B (R15) (Dubilier).
1—100 ohm type ½ watt (R16) (Bulgin).
1—500 ohm type 1 watt (R17) (Bulgin).
1—50,000 ohm type 1 watt (R18) (Bulgin).
1—100,000 ohm type 1 watt (R19) (Bulgin).
1—500,000 ohm variable type B (R20) (Dubilier).
1—100 ohm type 4 watt (R21) (Premier).
1—10,000 ohm type ½ watt (R22) (Bulgin).
1—400 ohm type 3 watt (R23) (Dubilier).
1—50,000 ohm type ½ watt (R24) (Bulgin).
1—50,000 ohm type 1 watt (R26) (Bulgin).
1—50,000 ohm type 1 watt (R25) (Bulgin).
1—50,000 ohm type 1 watt (R27) (Bulgin).
1—50,000 ohm type 1 watt (R28) (Bulgin).

SWITCHES.
4 Toggle type S80T (Bulgin).

SUNDRIES.
3 Coil cans type VS (Raymart).
1 Anode connector type 1224 (Belling-Lee).
3 Anode connectors type 1173 (Belling-Lee).
2 Terminals type B marked "Aerial" (Belling-Lee).
5 Adjustable couplers type 1009 (Eddystone).
3 Extension outfits type 1008 (Eddystone).
1 Plug type P15 (Bulgin).
1 Slow-motion drive for quarter spindle.
1 Mains plug type 29 (Clix).
3 Slow-motion heads (Peto-Scott).
4 Lengths quickwire (Bulgin).
1 Coil screened wire (Bulgin).
½ lb. 16 gauge enamelled covered wire (Peto-Scott).

TRANSFORMERS, I.F.
3 Type fixed coupling (Alladin—Webb's Radio).

TRANSFORMERS, MAINS.
1 Special type to give:
250-0-250 at 80 m/A.
2-0-2 volts at 3 A.
2-0-2 volts at 2.5 A.
3.15-0-3.15 volts at 2.5 A. (Premier).

VALVES.
1—EF8 (VI) (Mullard).
1—GL7 (V2) (Premier).
1—VP4B (V3) (Tungsram).
1—6Q7 (V4) (Premier).
1—APP4C (V5) (Tungsram).
1—MU12 (V6) (Osram).
1—6J7 (V7) (Premier).
1—6J7 (V8) (Premier).

THE SHORT-WAVE RADIO WORLD

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

Cathode Modulation

CATHODE modulation, as its name implies, has the audio signal applied to the cathode circuit of a class C stage, as shown in the figure. Since the cathode circuit is common to both anode and grid circuits, this is a combination of grid and anode modulation.

The audio power required is 100 per cent. greater than that for grid modulation, but less than that required for anode modulation. An anode-modulated class C amplifier requires audio power equal to 50 per cent. of the class C D.C. input power, but the audio power required for cathode modulation is between 5 and 15 per cent. of the D.C. input, depending on the mu of the valve and the degree of impedance mismatch between the modulator and the cathode impedance.

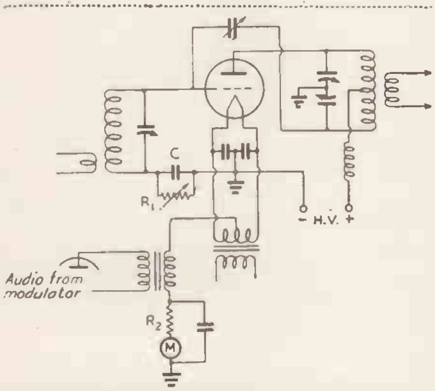


Fig. 1.—The fundamental cathode-modulation circuit. Audio from the modulator unit is introduced in the cathode (centre-tap) circuit of the valve or valves being modulated. The grid-leak resistance R_1 is adjusted for proper modulation characteristics, and R_2 serves to give some original bias to the valve. Condenser C must be large enough to by-pass the modulation frequencies.

The impedance of the cathode circuit is approximately 300-2,000 ohms, depending on the characteristics of the valve, and an average value of 500 ohms will be found satisfactory in most cases.

The principle of cathode modulation is as follows:

The instantaneous negative peak voltage impressed on the cathode increases the anode voltage and at the same time decreases the bias, both of which factors cause an increase in R.F. output. Similarly, an instantaneous positive voltage will cause a decrease in R.F. output due to a decrease in anode voltage and an increase of bias. Thus the grid and anode modulation is in phase and capable of 100 per cent. modulation.

Low-μ triodes should be used in the cathode-modulated class C amplifier, since they are somewhat more suitable for grid modulation. Pentodes or tetrodes are not suitable because of their extremely high amplification factor, although triodes with a μ of 20 to 30 may be used with a slight sacrifice of carrier power. Bias may be obtained by means of a grid resistor, although a source of fixed bias voltage is preferable and will give better grid voltage regulation. The bias should be several times cut-off and, if obtained by a grid-leak resistor, the resistance should be several times greater than that used for C.W. or anode-modulated amplifiers. The grid-leak resistance should be by-passed for audio frequencies by a ½ to 1-μfd. paper condenser. If too much grid modulation is obtained, part of the grid resistance should be left without by-pass to limit the degree of grid modulation. (Jones and Edmonds, QST, November.)

Linear Decibel Meter

By utilising the logarithmic compression characteristics of a cuprous oxide rectifier whose resistance varies logarithmically with terminal voltages of from 0 to about +0.5 volts, a linear decibel meter for about 35 db. can be obtained. By connecting several cuprous-oxide devices, as shown in Fig. 2 in a series-parallel arrangement, the linear decibel scale may be considerably extended. If brief, the voltage relations of the resistances and copper oxide devices are such that when the linear decibel relation of one rectifier is exceeded, that of the next comes into play, and so on, so that the total range may be considerably extended over that of the single rectifier unit.

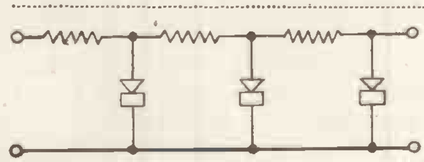


Fig. 2.—Series-parallel arrangement for extending the logarithmic range of the rectifiers.

Based on this principle, a decibel meter capable of measuring linearly more than 70 db. by adding selenium or cuprous oxide rectifiers in series parallel as shown in Fig. 3 has been found practicable. (*Electrotechnical Journal*—Japan.)

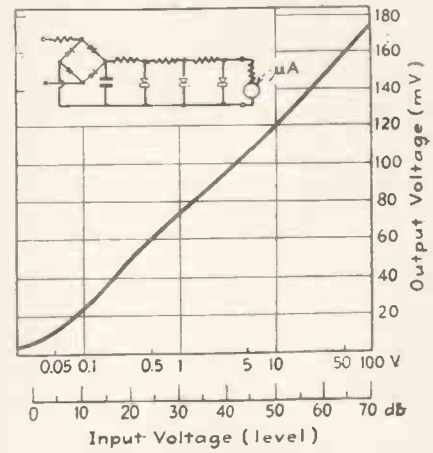


Fig. 3.—Logarithmic characteristics of completed meter with meter connections shown in upper left.

A Single Control Tank Circuit

T. M. Ferrill, in QST, describes a new tank circuit employing a constant L/C ratio obtained by ganging the tuning condenser and the inductance. The shaft of a split-stator condenser is mechanically coupled to the rotor of a form of variometer in which the turns on the rotor are considerably less than those on the stator.

An inductance range of 4 : 1 is obtained, so that with a condenser having an equivalent effective max.-min. capacity ratio, and 4 : 1 frequency range can be obtained.

In the circuit shown by the author, the variable tank coil has 21 turns of 14 gauge on the outer coil and 9 turns of 10 gauge on the inner (U.S. wire gauge). The diameter of the outer coil is 4 in. and the inner 3½ in., both coils being 2½ in. long. The coil is ganged to a National TMA-200D condenser, 200 mmfd. max. per section. This covers the 1.75, 3.5 and 7 metre bands.

Iron Wire for Aerials

Galvanised iron wire has several advantages over copper wire apart

New American Valves

from its cheapness. It is lighter, and is less prone to stretch and break. The zinc coating acts as a conductor for H.F. on the skin of the wire, the resistance of zinc being only three times that of copper. This increase in resistance causes negligible loss as the wire loss in most aerials is only 1-2 per cent. of the aerial power. Owing to the reduced weight, it is possible to use a gauge or two thicker of iron wire. The lasting properties of the iron are determined by the climatic conditions, but a life of several years is assured.

Class C Grid Excitation

The D.C. grid bias for class C may be anywhere from slightly above to six or more times the cut-off value. Cut-off bias is the value generally considered as the D.C. plate supply voltage divided by the μ or amplification constant of the tube. Normally the D.C. grid bias is run at about 2 to 3 times the cut-off. For plate modulation where the plate supply varies from zero to twice the D.C. value, at least twice cut-off bias must be applied to the grid to ensure class C operation. The latter is necessary for distortionless operation. Low-μ or medium-μ valves normally run at $2\frac{1}{4}$ to $2\frac{1}{2}$ times cut-off bias for plate modulation and from $1\frac{1}{2}$ to 3 times cut-off for C.W. transmission. High-μ valves in plate modulation need from $2\frac{1}{2}$ to 5 times cut-off bias for linearity or distortionless output.

New American Valves
R.C.A. 828

The 828 is a beam power valve designed particularly for class-AB_1 modulator and A.F. power amplifier service, but is also useful as an R.F. power amplifier, frequency multiplier, oscillator and grid- or anode-modulated amplifier. Two 828's in class AB_1 service are capable of delivering 300 watts of audio power with only one per cent. distortion. Maximum anode dissipation of the 828 for this service is 80 watts. Because of its high power sensitivity, the 828 can be operated in R.F. services to give full power output with very little driving power and, consequently, with a minimum number of driver stages.

Rating and typical operating conditions are as follows:

Filament voltage (A.C. or D.C.)	10
Filament current	3.25 amps.
Transconductance, for anode current of 43 m/A.	4,500 ohms
Interelectrode capacities:	
Grid-anode (with external shield)	0.05 $\mu\mu$fd.
Input	13.5 $\mu\mu$fd.
Output	14.5 $\mu\mu$fd.

Push-pull Class-AB Modulator

Typical Operation

D.C. anode voltage	1,700	2,000
D.C. suppressor voltage	60	60
D.C. screen voltage	750	750
D.C. grid voltage	— 120	— 120
Peak a.f. grid-to-grid voltage	240	240
Zero-sig. D.C. anode current	50 m/A.	50 m/A.
Max. sig. D.C. anode current	248 m/A.	270 m/A.
D.C. suppressor current	9 m/A.	9 m/A.
Zero-sig. screen current	4 m/A.	2 m/A.
Max.-sig. screen current	43 m/A.	60 m/A.
Anode to anode load resistance	16,200	18,500 ohms
Max. sig. power output	300	385 watts

Plate-Modulated Class-C Telephony

Typical Operation

D.C. anode voltage	1,000	1,250
D.C. suppressor voltage	75	75
D.C. screen voltage	400	400
Screen resistor	26,000	30,000 ohms
D.C. grid voltage	— 140	— 140
Grid leak resistor	14,000	11,700 ohms
Peak r.f. grid voltage	230	250
D.C. anode current	135 m/A.	160 m/A.
D.C. suppressor current	13 m/A.	15 m/A.
D.C. screen current	23 m/A.	28 m/A.
D.C. grid current approx.	10 m/A.	12 m/A.
Driving power approx.	2.1	2.7 watts
Power output approx.	100	150 watts

Class-C Telegraphy

Typical Operation

D.C. anode voltage	1,250	1,500
D.C. suppressor voltage	75	75
D.C. screen voltage	400	400
D.C. grid voltage:		
From a fixed supply	— 95	— 100 volts
From a grid resistor	7,900	8,300 ohms
From a cathode resistor of	415	430 ohms
Peak r.f. grid voltage	195	205
D.C. anode current	160 m/A.	180 m/A.
D.C. suppressor current	22 m/A.	14 m/A.
D.C. screen current	35 m/A.	28 m/A.
D.C. grid current approx.	12 m/A.	12 m/A.
Driving power approx.	2.1	2.2 watts
Power output approx.	150	200 watts

R.C.A. 811 *and* 812

Both these transmitting triodes have 6.3 volt filaments, and are similar except for the amplification factor. The 811 has a high mu for zero bias class B audio operation, and the 812 a lower mu for R.F. work.

Typical ratings and operating conditions according to the new R.C.A. classification are as follows:

811 Tentative Characteristics and Ratings

Filament voltage (A.C. or D.C.)	6.3 volts
Filament current	4 amperes
Amplification factor	160
Direct interelectrode capacitances:	
Grid-anode	5.5 $\mu\mu$fd.
Grid-filament	5.5 $\mu\mu$fd.
Plate-filament	0.6 $\mu\mu$fd.
Bulb	ST-19
Cap	Medium Metal
Base	Medium 4-Pin "Micanol," Bayonet

Maximum CCS and ICAS Ratings with Typical Operating Conditions

CCS = Continuous Commercial Service

ICAS = Intermittent Commercial and Amateur Service

As A.F. Power Amplifier and Modulator—Class B

	(CCS)	(ICAS)
D.C. anode voltage	1,250 max.	1,500 max. volts
Max.-signal D.C. anode current	125 max.	125 max. milliamperes
Max.-signal anode input	125 max.	150 max. watts
Anode dissipation	40 max.	50 max. watts
Typical operation:		
Unless otherwise specified, values are for 2 tubes		
D.C. anode voltage	1,250	1,500 volts

New Rating for R.C.A. Valves

A new system of dual rating of valves has been introduced by the R.C.A. to take account of the difference in operating conditions between amateur transmitters and commercial working.

It is estimated that the average amateur does not operate more than 300 hours per annum, and this would give a valve life of 3-5 years when operated under normal rating. Accordingly it is permissible for him to obtain more power output over a shorter period than a commercial station where reliability in service is of prime importance.

Instead of a maximum rating for the valve, there will in future be two ratings, designated CCS (Continuous Commercial Service) and ICAS (Intermittent Commercial and Amateur Service). The CCS ratings are essentially the same as the former maximum ratings. The ICAS ratings, however, are considerably higher, permit the use of much greater power input, and provide a relatively large increase in useful power output. For example, the A.F. power output of two 809's in class B is 100 watts at the old maximum anode-voltage rating of 750 volts. At the new ICAS rating of 1,000 volts, the power output is 145 watts—an increase of 45 per cent. In anode-modulated telephony service, the R.F. output of the 809 is 38 watts with the CCS ratings and 55 watts with the new ICAS ratings —also an increase of about 45 per cent. Complete operating data, including both CCS and ICAS ratings, have been prepared for R.C.A. types 802, 804, 806, 807, 809, 810, and 814, as well as for the new 811, 812 and 828, and can be obtained on request.

D.C. Grid voltage	0	— 9	volts
Peak A.F. grid-to-grid voltage	140	160	volts
Max.-signal D.C. grid current	38	38	milliamperes
Zero-sig. D.C. anode current	48	20	milliamperes
Max.-sig. D.C. anode current	200	200	milliamperes
Load resistance (per tube)	3,750	4,500	ohms
Effective load resistance (anode-to-anode)	15,000	18,000	ohms
Max.-sig. driving power (approx.)	3.8	4.2	watts
Max.-sig. power output (approx.)	175	225	watts

812 Tentative Characteristics and Ratings

Filament voltage (A.C. or D.C.)	6.3 volts
Filament current	4 amperes
Amplification factor	29
Direct interelectrode capacitances :	
Grid-anode	5.3 μμfd.
Grid-filament	5.3 μμfd.
Plate-filament	0.8 μμfd.
Bulb	ST-19
Cap	Medium Metal
Base	Medium 4-Pin "Micanol," Bayonet

Maximum Ratings and Typical Operating Conditions

As Anode-Modulated R.F. Power Amplifier—Class C Telephony
Carrier conditions per tube for use with a max. modulation factor of 1.0

	(CCS)	(ICAS)	
D.C. anode voltage			
D.C. anode voltage	1,000 max.	1,250 max.	volts
D.C. grid voltage	— 200 max.	— 200 max.	volts
D.C. anode current	105 max.	125 max.	milliamperes
D.C. grid current	25 max.	25 max.	milliamperes
Anode input	105 max.	155 max.	watts
Anode dissipation	27 max.	40 max.	watts
Typical operation :			
D.C. anode voltage	1,000	1,250	volts
D.C. grid voltage :	— 100	— 125	volts
From a grid resistor of	4,000	5,000	ohms
Peak R.F. grid voltage	180	245	volts
D.C. anode current	105	125	milliamperes
D.C. grid current (approx.)	25	25	milliamperes
Driving power (approx.)	4.5	6	watts
Power output (approx.)	82	120	watts

A R.F. Power Amplifier and Oscillator—Class C Telegraphy
Key-down conditions per tube without modulation

	(CCS)	(ICAS)	
D.C. anode voltage	1,250 max.	1,500 max.	volts
D.C. grid voltage	— 200 max.	— 200 max.	volts
D.C. anode current	125 max.	150 max.	milliamperes
D.C. grid current	35 max.	35 max.	milliamperes
Anode input	155 max.	225 max.	watts
Anode dissipation	40 max.	55 max.	watts
Typical operation :			
D.C. anode voltage	1,250	1,500	volts
D.C. grid voltage :			
From a fixed supply of	— 725	— 175	volts
From a grid resistor of	5,000	7,000	ohms
From a cathode registor of	835	1,000	ohms
Peak R.F. grid voltage	215	285	volts
D.C. anode current	125	150	milliamperes
D.C. grid current (approx.)	25	25	milliamperes
Driving power (approx.)	5	6.5	watts
Power output (approx.)	116	170	watts

Improved Image Electron Multiplier of Grid Type

THE now well-known grid type of image electron multiplier is illustrated diagrammatically in Fig. 1.

The multiplier consists essentially of a transparent photo-electrically sensitive cathode 2, a series of secondary emitting grids 5, 6, 7 maintained at successively increasing positive potentials, and a fluorescent screen 8. The whole system is mounted in an evacuated envelope 3. In operation an image of a scene is cast by a lens system 1 on the cathode 2. Photo-electrons released at different points in numbers depending on the light intensity at these points are accelerated towards the first grid 5 on which a fraction at least impinges. Secondary electrons released at that grid are accelerated towards the next grid and so on. Electrons from the last grid impinge on the fluorescent screen 8 thereby giving rise to an emission of light whose distribution over the screen corresponds with that on the photo-cathode 2.

The device operates so that nearly every electron impinging on a secondary emitting electrode releases several secondary electrons.

The envelope 3 is conveniently made of glass so that lead in wires to the various electrodes can be sealed through the (usually) tubular portion of the envelope without the provision of further insulation and so that the two end portions form windows through one of which light enters to excite the photo-cathode, the fluorescent screen being viewed through the other.

Now the glass is liable to charge up so that distortion of the electric accelerating fields is set up. This may be prevented by providing on the inside of the tubular portion a resistive wall coating which contacts with a conducting ring in the plane of each secondary emitting grid and is connected thereto. Thus along the walls a current flows between each adjacent pair of electrodes which sets up a potential gradient which is the same as that along the axis in the space between the electrodes. Owing to the difficulty of obtaining uniform resistive coatings various points on the wall around any given cross-section may still not be at one potential. To reduce the errors from this cause, additional conducting rings are provided on the resistive coating at intermediate positions between the planes of the electrodes.

As would be expected with the simple arrangement just described electrons released from a point tend to form a divergent beam so that the final image on the fluorescent screen will be blurred. Numerous methods of focusing electrons have been proposed. But a difficulty arises from the fact that some of the primary

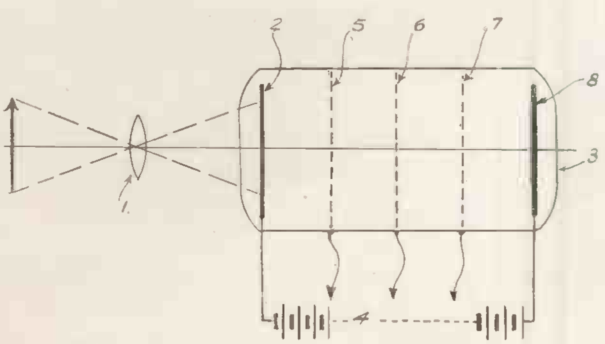
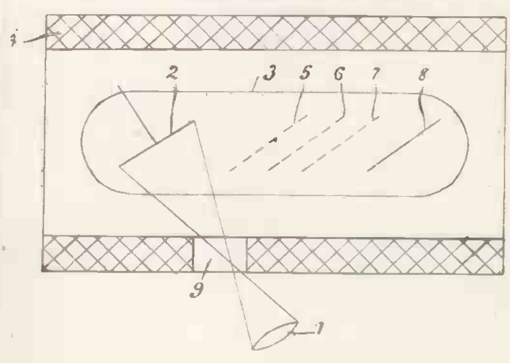


Fig. 1 (left). Diagram of typical grid type electron multiplier.

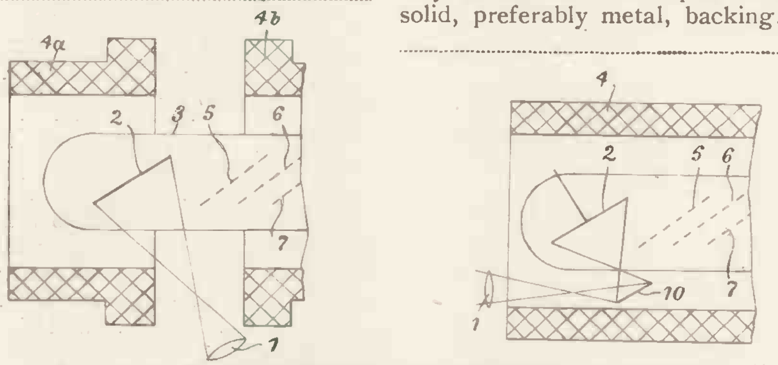
Fig. 2 (right) Modifications of the grid-type electron multiplier.



electrons arriving at the plane of a secondary emitting grid pass straight through the interstices and start from that plane with much higher speeds than the secondary electrons released there by those primaries which do not pass through, but impinge on the grid. Hence simple methods of focusing fail since two diverging beams of electrons having widely different speeds are not readily brought to foci at the same point, even although they emanate from one point.

This difficulty may be overcome by the use of a so-called " strong " magnetic field arranged longitudinally; that is to say, the lines of magnetic force are normal to the planes of the electrodes in Fig. 1. With such an arrangement the electrons describe helices about axes parallel to the lines of magnetic force. If the field be sufficiently strong, the radii of the helices will be so small that the spreading of the electrons will be negligible. Such a " brute force " method rather prevents electrons diverging than focuses them in the usual sense of the term.

The use of strong magnetic fields as above described give rise to further possibilities. Since the magnetic field practically constrains the electrons to move along the magnetic lines of force, one or more of the electrodes may be inclined to the axis of the tube as indicated in Fig. 2. In addition to the elements of Fig. 1, there is shown a coil 4 which provides the necessary strong longitudinal magnetic field. In this case the photo-cathode 2 is no longer transparent and the light falls on the emissive side of the cathode through an aperture 9 in the coil. To reduce distortion of the magnetic field caused by the aperture, the coil may be wound in separate portions, 4a and 4b, as shown in Fig. 3, with extra turns at the adjacent ends of the two portions. A gap or aperture may be dispensed with if the arrangement of Fig. 4 be adopted where 10 is a mirror which reflects light on to the photo-cathode.



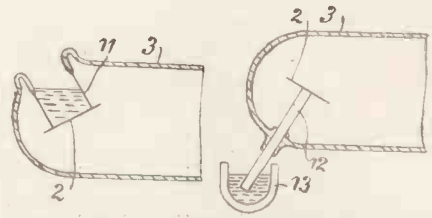
Figs. 3 & 4. **Further modifications of the grid type electron multiplier.**

The fluorescent screen may be observed from the side bombarded by electrons so that the fluorescent layer may be thicker and deposited on a solid, preferably metal, backing. In this way a brighter image is obtained on the screen.

Another advantage of a solid photo-cathode is that it can be made much more sensitive to light and especially to infra-red rays than can the transparent type of Fig. 1. It is further desirable to be able to cool the photo-cathode so as to prevent " cold-emission " which gives rise to an unwanted background even in the absence of light. Fig. 5 shows how this can be achieved in practice. The photo-cathode is mounted on a re-entrant part 11 of the envelope 3 containing, for example, liquid air or carbon dioxide snow. Fig. 6 shows an alternative where the photo-cathode is mounted on one end of a rod having good thermal conductivity. The other end dips into a vessel 13 containing the cooling medium.

The foregoing has referred to the use of a grid multiplier used as an image transformer or intensifier. If the device were to be used with a television transmitting system, for example, the fluorescent screen would be replaced by a mosaic screen which is scanned. Alternatively, the final image instead of being formed on a fluorescent screen would be scanned over an image dissector.

(These developments are reported from Electric & Musical Industries, Ltd.)



Figs. 5 & 6. **Methods of preventing cold emission.**

Books for the Radio Engineer

THE well-known technical publishers, McGraw-Hill Book Company, have recently issued an up-to-date list of books of Electrical and Radio Engineering which covers all the requirements of modern research workers and students.

For laboratory practice there is a volume on Electrical Measurements by Professor Laws, which deals with the measurement of the fundamental units in electricity and magnetism. In radio work there are two companion volumes: High Frequency Measurements by Hund, and Measurements in Radio Engineering by Terman.

Professor Terman's book on Radio Engineering has already been reviewed in these columns and is considered by the majority of radio engineers to be the classic on the subject. A more concise edition has also been published by the same author.

The Theory and Applications of Vacuum Tubes, by Reich, treats of the whole theory of electronics and the application of radio valves to circuits. Electronics as a subject is also dealt with by Donald Fink, the editor of the American paper, in a book: " Electronics in Industry."

Television, mainly from the American viewpoint, is dealt with in the following:—

" Electron Optics in Television," by Maloff and Epstein.

" Television—Its Methods and Uses," by Felix, and in the Radio Handbook, by Moyer and Wostrel, which covers Talking Pictures in addition.

The Radio Engineering Handbook, compiled by a staff of 28 specialists under the editorship of Keith Henney, is the most important reference book for the radio engineer. New chapters have been added on aerials, U.H.F. apparatus and car radio receivers, to name only a few. At 30s. it will be a book for every worker in radio research.

The majority of the books mentioned above can be obtained on deferred payment terms by arrangement with the Phoenix Book Co., of Chandos Street, Strand, who will be pleased to send particulars.

Electric Discharges at Low Gas Pressures*

PART II

By D. Gabor, Dr.-Ing.
British Thomson-Houston Co., Research Laboratory.

Sheaths

WE can now proceed to other parts of a low-pressure discharge. Adjoining the cathode end of the positive column, there is a darker region, of a length of 1—2 tube diameters (see Fig. 15). This is the Faraday dark space. It is also a plasma, but its mechanism is somewhat different from that of the positive column. The gradient in the dark space is very small and may also become negative. Between the cathode end of the dark space and the cathode there is an intensely luminous region, the cathodic glow. It looks usually as if it started immediately at the cathode surface, but it is really separated from it by a very thin dark sheath, which is the seat of the cathode drop. Electrons starting from the cathode are accelerated in this region, and shooting through the gas produce the cathodic glow.

Let us now examine closely the cathode drop region; a first idea of the processes may be obtained from Fig. 16. The plasma approaches the cathode to a very small distance, which we will determine later. Slow electrons starting from the cathode move through this region towards

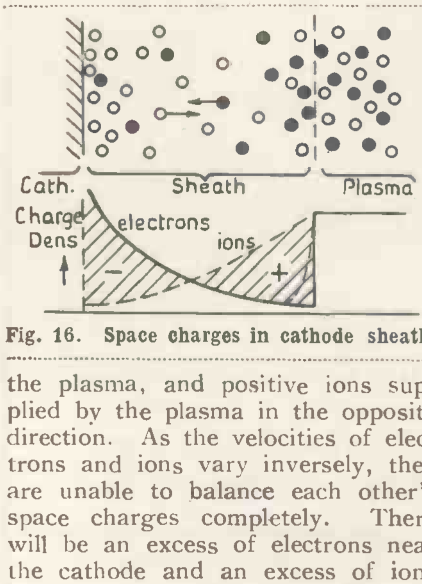


Fig. 16. Space charges in cathode sheath.

the plasma, and positive ions supplied by the plasma in the opposite direction. As the velocities of electrons and ions vary inversely, they are unable to balance each other's space charges completely. There will be an excess of electrons near the cathode and an excess of ions near the plasma edge. Here a sudden jump occurs in the electron density, due to the great number of slow electrons in the plasma that cannot penetrate into the sheath. In reality they can penetrate to a small depth, but have to return, and the distribution is as shown by the dotted

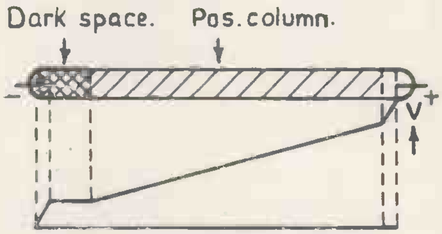


Fig. 15. Regions of discharge tube.

line. In the plasma, space charges are again completely balanced.

Let us now try to understand these phenomena quantitatively, following the lines of the fundamental investigation of Langmuir in 1929. We will first substitute a solid anode for the plasma and eliminate both electrons and ions (see Fig. 17). We should have a linear distribution of voltage between cathode and anode. Now let us introduce the electrons. A current starts flowing that will increase until the cathode is entirely shielded from the anode by the electron cloud before it, and the field strength at the cathode becomes zero. This sets a limit to the increase of the current: if it were further increased it would cut itself off. The space charge limited current is—

$$J_v = 2.3 \times 10^{-6} V^{3/2} . d^{-2} \text{ amp./cm}^2.$$

We will now introduce the ions, and assume that the plasma is able to yield an unlimited supply of slow ions. We can easily see that even in this case the current cannot grow to infinity. The ions will hamper each other near the plasma edge in just the same way as the electrons near the cathode. At both ends the field strength becomes zero, or very nearly so. Between these two ends the potential distribution will be exactly symmetrical. It turns out that the current is only 86 per cent. higher than without ions. This ideal case is established when the ion current and the electron current are in the ratio of the inverse square roots of their masses. This ratio $\sqrt{m/M}$ is, for example, 1 : 608 in the case of mercury. Only one ion will therefore be transported to the cathode for 608 electrons leaving it. This is a very simple result of fundamental importance for the understanding of the working of hot cathodes in gas discharges.

Starting from this result, we can now construct the whole cathode sheath. Its depth "d" is, of course, *a priori* undetermined. We can, however, foretell the voltage drop very easily. We have seen that only a very small number of ions are required, and must expect, therefore, that the voltage drop will establish itself just a little above the ionising potential. This conclusion is verified by experience. For any given current we can now calculate the thickness of the cathode sheath, and we find that it is in all practical cases much smaller than the mean free path. This is an *a posteriori* justification of the assumption we have tacitly made, that we are allowed to treat the cathode sheath as a vacuum, with only electrons and ions in it.

We can now draw some further conclusions. Up to the present we

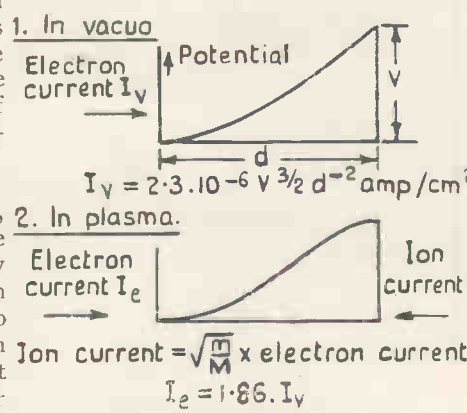


Fig. 17. Space charged limitation of current.

have assumed that the cathode is able to emit a larger current than we are actually drawing from it. What happens now if we underheat the cathode? In this case the condition that the field at the cathode must be

*Lecture delivered before the Rugby Engineering Society.

Cold and Hot Cathode Characteristics

zero will hold no longer. The field can assume any value (see upper curve of Fig. 18). In order to establish such a field distribution, more than the optimum number

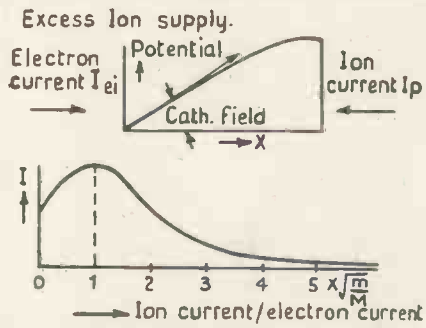


Fig. 18. Effect of ion supply on current.

$\sqrt{m/M}$ of ions per electron must be supplied to the cathode. The normal cathode glow is easily capable of doing this, with only a very small rise in voltage above the minimum. In carrying out similar experiments, Langmuir and Found made an interesting discovery. They found that if more ions are supplied to an underheated cathode, it will also supply more electrons, under the influence of the field at its surface. This is called "field emission" to distinguish it from the "zero field emission" which obtains in vacuo. It turns out that practically all the cathodes in our gas discharge lamps are working with field emission; the zero field emission supplies only a few per cent. of the current. This would have been a great triumph for the theory, if practice had not anticipated it. Years before the discovery made by Langmuir and Found, bold experiments put oxide-coated cathodes into gas discharge lamps, and did not even stop to wonder why their cathodes worked so much better than they should have done according to contemporary theory.

The second graph in Fig. 18 summarises our results regarding ion supply. It shows the electron current that can flow through a fixed gap at varying ion supplies. A normal cathode drop at a highly emitting cathode will work at the optimum point, and an underheated cathode somewhere to the right of this point. Unless, however, the cathode is considerably underheated, this has little influence on the characteristic. Suddenly a point will be reached when the plasma cannot supply more ions without a steep rise in characteristic. We approach then the conditions obtaining at cold cathodes.

Fig. 19 shows the characteristics

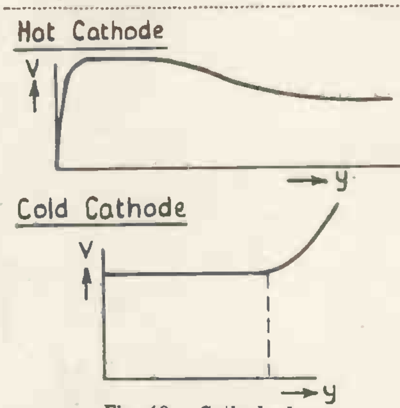


Fig. 19. Cathode drop.

of a hot cathode and a cold cathode. The scales are not comparable. The characteristic of a hot cathode starts with a small positive part, followed by a range in which the cathode drop is almost constant, and very nearly equal to the ionising potential of the

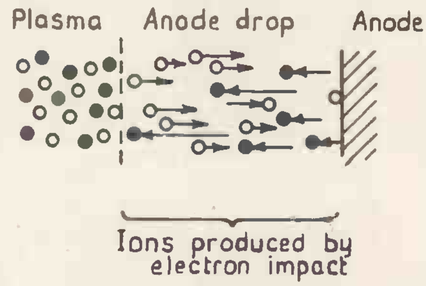


Fig. 20. The anode drop.

gas. At higher currents a decrease occurs, but only to a well-defined new level. We can easily explain this as it is the same effect that caused the drop in the characteristic of the positive column. With increasing current density the proportion of metastables and of other excited atoms in the cathode region becomes so high that the cathode drop establishes itself either near the ionisation potential of the metastables, or near the potential necessary for producing metastables, whichever is higher.

In the case of a cold cathode nothing happens below a certain critical voltage. Then suddenly a glow appears, which spreads with increasing current over the cathode, until it covers its whole surface. In

(*Continued on page 720*)

HOME INSTRUCTIONAL COURSE

THE PURPOSE OF THIS SERIES

With the object of filling the gap which has been temporarily caused in the education of the radio student, we are providing a series of articles on various theoretical aspects of radio engineering.

The present position has led to the suspension of evening classes in many of the Technical Institutes and added to the difficulties in attending those that are available. Some thousands of students of radio will miss the opportunity of increasing their knowledge of the theoretical side of the subject. Practice is not always enough to keep abreast of the subject, and the radio engineer or serviceman must understand fully the theory underlying the practice in order to cope with the frequent "out of the ordinary" jobs that come his way.

The articles are not intended to compete with or in any way displace the "correspondence course" in which the subject is dealt with fully from beginning to end, but are aimed to give concise information on certain fundamental theories which will be of direct use to the student in his work.

Each article will be complete in itself and in order to give mental exercise, examples will be given at the end. While we cannot enter into correspondence with readers on the subject matter of the articles, it will be found that the examples given are answered in the succeeding article and numerous explanatory foot-notes should make the discussion as clear as possible.

Suggestions are invited from students for special aspects of the subject to be dealt with in later articles.

REACTANCE AND IMPEDANCE

IN the last article, in connection with power and power factor, we considered the properties of the choke coil and found that in a pure inductance the current lagged by 90 deg. phase angle behind the applied voltage.

Once more, in order to make the statement quite clear, it must be understood that the term "90 deg. lag" only refers to the position of the zero or maximum values of the current wave in relation to the corresponding points on the voltage wave, and it does not mean that the current arrives in the coil after the voltage has been applied!

When an A.C. voltage is applied to a condenser, the opposite effect is obtained and the current leads by 90 deg. on the voltage wave. The reason for this is as follows:—

Capacity Current.

The definition of current is the rate of flow of electricity through a conductor; that is, the rate at which the electrons pass a given point in a second. When a condenser is connected to an A.C. voltage, it will be "charged," i.e., a quantity of electrons will flow into it until the dielectric is stressed to a given degree after which no further electrons will flow. When the condenser is fully charged, its potential is equal and opposite to that of the potential applied. (Compare this with the "back e.m.f." of an inductance.)

The quantity of electrons flowing into the condenser will be proportional to the potential applied, and in the case of an A.C. wave will vary throughout the cycle in conformity with the variation of the applied voltage wave. We can therefore draw the diagram of Fig. 1 to show the applied voltage wave and a corresponding wave of "quantity" of electricity.

Now, as said above, the current (in amperes or milliamperes) is the rate of flow, which is the same as the quantity per second.

The rate of flow, in the curves shown in Fig. 1, is a maximum when the applied voltage is passing through the zero points on each part of the cycle because the quantity is increasing at the greatest rate. At the peak of the wave the rate of increase is slowest and the "quantity per second" is a minimum. To interpret these variations in terms of current, we draw a third curve marked "current," such that it is a maximum when the quantity curve is a minimum and passes through zero when the quantity curve reaches its peak. It will be seen that this current wave is in advance of the voltage wave in point of time, i.e., it "leads" on the voltage.

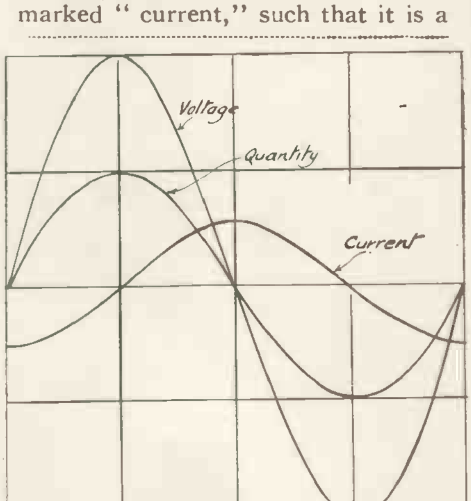


Fig. 1. Showing how the current flowing through a condenser differs in phase by 90° from the applied voltage.

The current taken by a condenser therefore is 90 deg. out of phase with the applied voltage and leads.

Power Lost.

If the curve of Fig. 1 is compared with the inductance curve in the last article (Figs. 4 and 5) it will be seen that the power curve will be the same in both cases. An ideal condenser therefore absorbs no power from the mains over a given period of time.

In practice, a condenser will absorb a certain amount of power due to the losses which occur in the dielectric itself and the leakage which occurs through the dielectric.

These losses can be considered as due to a high resistance connected in parallel with the condenser through which a fraction of the total current is always flowing. The curve of current through the condenser will not, therefore, be exactly as in Fig. 1, but will be as Fig. 2, in which the total current curve is made up of two currents—the charging current and the loss current. This makes a difference in the phase angle and reduces it to a figure below 90 deg. For the sake of comparison, the corresponding curves of an inductance are reproduced in Fig. 3.

Reactance.

If a steady voltage is applied to the condenser, the quantity of electricity which flows is given by the product of the capacity (in farads) and the applied voltage. In symbols, Q = CV, where C is the capacity. For an alternating voltage which has the formula $V = V_{max} \sin\omega t$ the quantity $Q = CV_{max} \sin\omega t$. and the current flowing is given by $CV\omega$.

In the case of an inductance the current is given by $V/L\omega$, which corresponds in form to the familiar $I = V/R$ of Ohm's Law, but in the

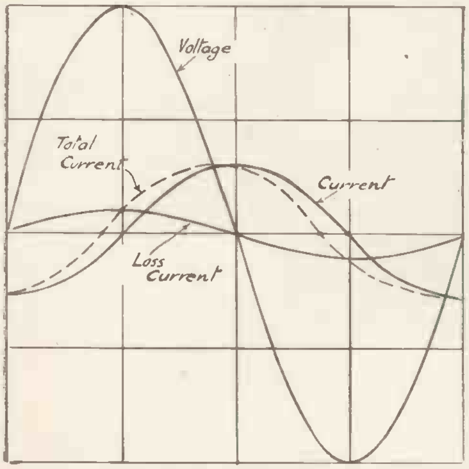


Fig. 2. Where there is loss in the condenser, the current is not at 90°, but at an angle less than 90°.

case of a condenser it is important to note that the current is $VC\omega$ and *not* $V/C\omega$.

To re-write this equation in line with the other two given above, we could put $I = V \div 1/C\omega$, which works out to the same as before. The expression $1/Cw$ then corresponds to the "R" of the resistance formula and the "$L\omega$" of the inductance formula, and is termed the *reactance* of the condenser. It is expressed in ohms as is the reactance of a choke coil.

Condenser Reactance

It is instructive to calculate the reactance of an ordinary condenser at 50 cycles and thence the current which would flow if it were connected to the A.C. mains. Suppose we take a 2-mfd. paper condenser, and assume that it has no leakage or losses. The reactance is $1/C\omega$ when C is in farads. For microfarads we can re-write the fraction as $10^6/C\omega$. ω is 314 at 50 cycles so that $C\omega$ becomes 628 and the reactance is approximately 1,500 ohms.

If the condenser were connected to 240 v. A.C. the current flowing would be 160 mA approximately. At 500 cycles, the reactance falls to 150 ohms and at 5,000 cycles to 15 ohms

If a resistance is connected in parallel with the condenser the total current taken by the combination will be given by adding the two current curves, one in phase with the voltage (the resistance current) and the other out of phase by 90 deg. (the condenser current). The power lost is that lost in the resistance, as the power actually lost in the condenser is usually negligible. These remarks must be taken carefully when applied to electrolytic condensers which always have a leakage current and in which the power loss is slightly higher than in a paper dielectric condenser.

Impedance.

If a condenser or inductance is connected in series with a resistance, the combination offers an effective resistance to the passage of current which is the combined opposition of the *reactance* (of the coil or condenser) and the *resistance*.

This combined effect is called the *impedance* of the circuit, and is usually denoted by the letter "Z." It is expressed in ohms, but it cannot be obtained by adding the values of the resistance and reactance for this reason:

The total current through the circuit can be obtained by dividing the applied voltage by the impedance in ohms, or in a formula: $I = V/Z$. In the same way, the current through the resistance is V/R and through the condenser V/X, where X is the reactance. The total voltage is not, however, the sum of the voltage drops across the condenser and the resistance, since they are not in the same phase relationship. Fig. 4 will

(*Continued on page 719*)

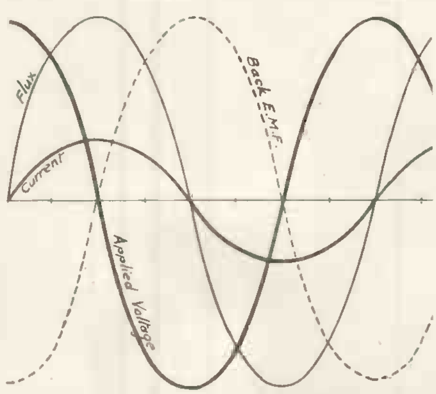


Fig. 3. The curves of voltage and current through an inductance for comparison with those of a condenser (Fig. 1 & 2.)

A BRITISH COMMUNICATIONS RECEIVER

THE PETO-SCOTT 'TROPHY 6'

The communication receiver described below has a continuous waveband coverage of 6.5 to 545 metres and represents a typical reasonably priced receiver which will bring in all the world's news on medium and short waves.

THE short-wave experimenter has for some time been enjoying musical and news programmes from all over the world with the aid of one or other of the American communications receivers which have been available in this country. The demand for these receivers is now very large because of the desire for news from all parts of the world, and we congratulate Messrs. Peto Scott on the production of a first-class British-made equivalent to the less expensive American type.

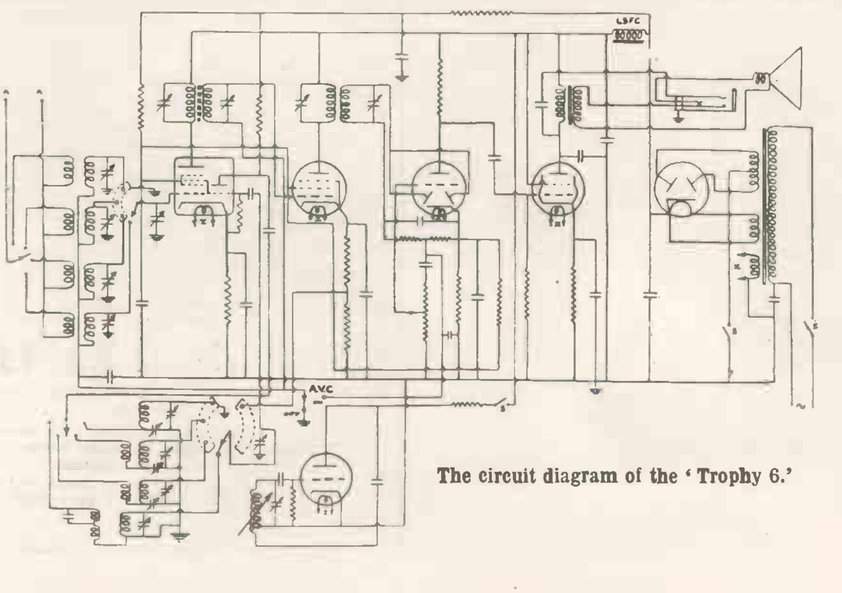
The television viewer, temporarily deprived of his entertainment, would do well to turn his attention to the short wave bands and the possibilities of interest that they hold, and this receiver has been specially designed to exploit these to the full.

Description

The Trophy Junior Communication Receiver employs six valves (inclusive of rectifier) and covers the wave-bands from 6.5 to 545 metres with a four-way selector switch. The frequency scale is directly calibrated and there is in addition a separate band-spread dial. A.V.C. is included, controlled by an on-off switch, and there is a separate beat-frequency oscillator. The loudspeaker is built-in and there is provision for headphones.

A doublet aerial can be used if desired and a send-receive switch is incorporated.

The set is contained in a black crystalline finish cabinet and measures 18 in. by 10 in. by 9 in. deep. The photograph gives a view of the exterior.



The circuit diagram of the 'Trophy 6.'

Circuit

Wave-band selection is by means of the switch shown on the left of the circuit diagram, the oscillator frequency being similarly controlled. The frequency changer is a 6TH8 octal base valve. Following this is a 6K7 I.F. amplifier, supplying a 6Q7 diode detector and amplifier, Controllable A.V.C. is applied from this stage to the input through the switch marked "A.V.C."

The output valve is a 6V6 beam tetrode, which will deliver two watts of audio power. The rectifier is the 5Z4.

A separate beat-frequency oscillator is provided, using a 6C5 triode, the switch "S" serving to disconnect this when not in use.

The present price of the 'Trophy 6' is £10 19s. 6d., and intending purchasers are warned that it may not be possible to keep to this figure for an indefinite period as the cost of

(*Continued on page* 718).

Experimental Apparatus

Readers who find difficulty in getting apparatus for experimental work should communicate with H. E. Sanders & Co., of 4 Grays Inn Road, W.C.1, who are closely in touch with the market for all classes of scientific apparatus, both new and second-hand.

IMPORTANT

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(Continued from page 716.)

raw materials and labour is rising, and early ordering is desirable.

For those who do not wish to incur such expenditure at once, the manufacturers offer deferred payment terms of £2 15s. deposit and £2 5s. 9d. per month.

Test Results.

In a communications receiver too great importance cannot be attached to mechanical rigidity, and in the "Trophy" this point has received special attention. The chassis is cleanly laid out and no components are unduly exposed. The valves dissipating the greatest heat are to the rear of the receiver, away from components liable to temperature effects.

While receiving morse with the beat note oscillator in circuit the receiver was lifted from the table and jarred down with no alteration in the beat note, which demonstrates the rigidity of the construction in a very effective way.

The tuning arrangements are very satisfactory. The main tuning condenser has a large diameter disc dial calibrated accurately in frequency.

The degree of band spread was checked by tuning to W8XK on 15.21 mC. with the dial reading at 50 and then tuning Rome at 15.23 mC. This came in with a dial setting of 58°—approximately 2 kC. for 8° change. Both dials are entirely free from backlash or undue friction.

Sensitivity.

In view of the simplicity of the circuit, the sensitivity of the receiver is remarkable. All the European S.W. stations came in at full loudspeaker strength on a moderate aerial. On the amateur bands results will naturally vary according to conditions, but there is ample gain and the receiver feels "lively" enough to bring in a crop of stations under good reception conditions.

On the broadcast band the results were equally good—in fact, surprisingly good considering the absence of an H.F. stage. All the European stations of any note were easily obtained at full loudspeaker strength, and there is a complete absence of self-generated whistles in spite of the local transmitter.

On some distant stations the need for a tone control was felt at times, to minimise the background hiss—perhaps a pre-set control could be fitted to later models to make the performance 100 per cent. perfect to the critical listener.

This, however, is a minor criticism and the only one which can be made on a thoroughly satisfactory engineering job.

"Reactance and Impedance"

(*Continued from page 715*)

show how this is possible. I is the current flowing through a resistance and condenser in series. The voltage drop across the resistance is shown by the curve V_r, which is in phase with the current, while the voltage drop across the condenser is given by V_c, 90 deg. out of phase with the current. The total voltage is obtained by addition of the instantaneous values of these two waves,

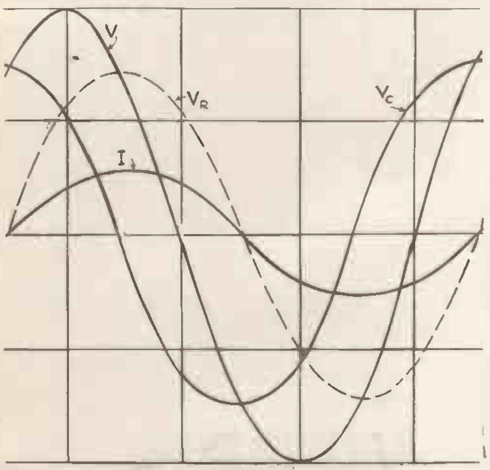

Fig. 4. The curves of current and voltage for a condenser and resistance in parallel. The total voltage is less than the arithmetical sum of the individual voltages.

and it is seen that this is not the same as adding their peak or r.m.s. values arithmetically.

This can be checked experimentally if an electrostatic voltmeter is available.* A 2 mfd. condenser is connected in series with a resistance of 2,000 ohms across 250 v. A.C. mains.

If a voltmeter is connected across the resistance it will read approximately 200 volts, but when connected across the condenser it will read not 50 v. but 150 volts. These values may not be obtained exactly owing to the tolerances on the component values, but there will always be a sufficient margin to demonstrate that the total applied voltage is not equal to the sum of the two individual voltages.

It is obvious that we cannot trouble to draw curves of voltages every time we wish to calculate the impedance of a condenser-resistance combination, or a choke in series with a resistance. Instead we use a formula derived from the phase relationship of the two voltages, which is $Z=\sqrt{(R^2+X^2)}$ where R is the resistance and X the reactance in the circuit.

If the reactance is due to a choke (inductance), X is equal to ωL. If a condenser is in circuit, the reactance is $1/\omega C$, as explained above.

The formulae can then be written out in full as follows:—

For a choke: $Z=\sqrt{(R^2+\omega^2L^2)}$

For a condenser: $Z=\sqrt{(R^2+1/\omega^2C^2)}$

The formulae for parallel connections of condensers and resistances will be given later. In the meantime, we can work out a complete example, showing the impedance, currents and voltages in a circuit consisting of a choke and resistance in series.

The coil has an inductance of 10 henries. Its reactance at 50 cycles is therefore 314×10 or 3,140 ohms.

Assume the resistance is 3,000 ohms, of comparable value, and that there is negligible resistance in the winding of the choke coil.

The impedance of the combined components is $3{,}000^2+3{,}140^2$ which

(*Concluded on next page*)

* An ordinary moving-iron voltmeter usually takes sufficient current to upset the conditions of the circuit. It may work, however, if a reasonable current is taken by the resistance and condenser.

"Reactance and Impedance"

(*Continued from preceding page.*)

works out to 4,340 ohms. If the applied voltage is 100, the current flowing will be 23 mA approx. The voltage drop across the choke will therefore be 3140 × .023 or 72 volts, while that across the resistance is 69 volts. The only power lost will be that in the resistance, which is 69 × .023 or 1.58 watts. The apparent total power, obtained by multiplying the current by the applied voltage is .023 × 100 or 2.3 watts. The power factor of the circuit is therefore 1.58/2.3 or 0.69.

This calculation has given all the information about the circuit, and apart from the "square root" formula is very simple.

The same procedure can be applied to finding the impedance of a condenser of 4 mfd. in series with 1,000 ohms on 50 cycle mains. Try it, and find the current when the applied voltage is 240.

Answer to last month's example.

The working of the example is given in the concluding paragraph above. The impedance of a 50 henry coil at 50 cycles is 15,700 ohms. The voltage drop due to the impedance is 785 v. and that due to the resistance 5 only.

Condenser and choke in series.

If a condenser and choke are connected in series the effective reactance is obtained by subtracting the reactance of the condenser from that of the choke. The reason for this will be shown in a later article, but in the meantime we can note the modified formula, which is:

$$X_t = (\omega L - 1/\omega C)$$

where X_t is the total reactance.

When resistance is included in the circuit, the impedance becomes:

$$Z = \sqrt{(R^2 + (\omega L - 1/\omega C)^2)}.$$

From this it will be noted that if the condenser reactance is equal to the coil reactance the expression $(\omega L - 1/\omega C)$ becomes zero and the only resistance in the circuit is that of the pure resistance R. This special condition is that of *resonance* and forms the basis of tuned circuit theory.

"Electric Discharges at Low Pressure"

(*Continued from page 712*)

this interval the cathode drop remains strictly constant. This is called the normal cathode drop; it depends only on the cathode material and on the gas and is always in the order of 100 to 500 volts. After the glow has covered the whole cathode, the characteristic becomes positive. At even higher potentials a cathode spot is formed and the voltage collapses to a much lower value.

We can now summarise our results and complete them as follows:—

General Law. Every electron leaving the cathode must make possible the emission of another electron.

Hot Cathodes. Every electron must send back $\sqrt{m/M}$ ions to cathode.

Cold Cathodes. Every electron must make so many ions of such velocity that they release by bombardment one more electron. The uncertainty contained in this

(*Continued opposite.*)