NEWNES

TELEVISION MANUAL

By

F. J. CAMM

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A practical and up-to-date handbook on all branches of television, including the latest stereoscopic colour television system. Every aspect of television is fully dealt with and a useful Dictionary of Television Terms defining the meanings of the new nomenclature is included. Constructional details of power units and rectifiers are given, together with installation and operating details.

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F. J. CAMM

Editor of
"Practical Wireless", "Practical Mechanics,"
and *"Practical Engineering"*

WITH 94 ILLUSTRATIONS

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PREFACE

This new edition—the fifth—has been fully revised and includes the latest information on this newest of sciences. It includes the list of terms agreed by the Television Committee of the Radio Manufacturers' Association. All of the information relating to disc receivers has been deleted, for low-definition television has ceased to exist.

In view of the post-war developments likely to ensue in connection with the erection of television transmitters throughout the country, it is necessary for every listener to become acquainted with the elementary principles of television transmission and reception.

This book does not only deal with television proper, but the many secondary applications of television principles, such as talking film television. There can be no doubt that television is now here to stay, and that it is beyond the experimental stage. It is more than probable that within ten years television programmes will occupy the majority of the programme time whilst ordinary sound broadcasts will be confined to news, weather reports, and special announcements.

Practical Wireless each month contains the latest news concerning television developments.

F. J. Camm

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CHAPTER I

TELEVISION PRINCIPLES SIMPLY EXPLAINED

ONE of the most remarkable parts of a human being is the eye, at the back of which is a remarkable little focusing screen known as the retina. This consists of millions of minute cells from each of which a nerve cell connects to a similar minute cell in the brain. These retina cells contain a purple substance, and when light falls upon it a " message " is sent to the brain cell. The eye, therefore, sees things as millions of tiny bits, which the brain " sees " in their correct value of light, shade and colour.

For many years scientists have endeavoured to make a mechanical eye, by means of which a scene in the studio could be scanned and transmitted through the ether as a series of tiny bits which could be built up again in a receiver of the

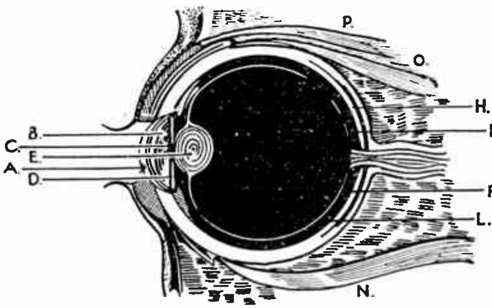


FIG. 1.—A representation of nature's television system — the eye. (P, O, N), muscles of eyeball ; (A), cornea, which closes the front of the anterior chamber (B), which is filled with aqueous humour, and the back wall of which is formed by the curtain of the iris (D). In the middle of the back wall is the opening of the pupil (C), through which is seen the lens (E). Behind the lens is the posterior chamber (L), filled with vitreous humour. Entering the eye from behind is the optic nerve, which is distributed to the retina. The posterior wall of the eye shows from within outwards the image-forming retina, the dark choroid with blood vessels (I), and the firm, protective sclerotic (H).

type which we now know as a television receiver. Fortunately, success has now been achieved, and real television, when everybody may *see* the scene in the studio as well as *listen* to it, cannot now long be delayed.

For more than ten years, television had been the missing link to complete home-radio entertainment, but it was inevitable that very soon television would relegate our present programmes to a position analogous to silent films. The time has now arrived when television can yield real entertainment, and it is certain that in the not-too-distant future we shall have regular sound and vision programmes.

At the present time our radio entertainment depends upon the ear to complete a sort of mental vision of what is happening in the studio, but no sound can convey to us the antics of an acrobat, nor enable us to see a conjuring turn, or the facial contortions of clowns or comedians upon which they rely for their effects.

The electrical simulation of the eye cells and brain cells is not, of course, possible. Even though possible it would not be practicable, nor even desirable, for fortunately we are able to make use of a peculiar optical defect known as the persistence of vision, which means that the eye continues to " see " a thing after it has passed from the range of vision. As is well-known, this is the principle on which the cinematograph works.

An Analogy.—An excellent analogy can be drawn between the telephone and television. When you speak into a telephone your voice causes a small diaphragm to vibrate. This diaphragm is in contact with a bowl-shaped block containing carbon in a finely granulated state, and the vibrations cause a variation in the degree of adhesion between the various granules. This variation causes a sympathetic variation of an electric current which hence varies absolutely in unison with the voice operating the diaphragm. The varying current thus set up passes along the telephone wires and causes vibrations in the earpiece at the receiving end. The same principle, of course, applies to wireless telephony, with the exception that the varying impulses set up by the microphone are despatched *via* the transmitting aerials into the ether instead of along wires as in the case of the telephone just considered.

The First Television Broadcast.—It was in August of 1932 that the B.B.C. first incorporated television transmissions in its programmes. Before that date the only programmes were those transmitted from the Baird Company's

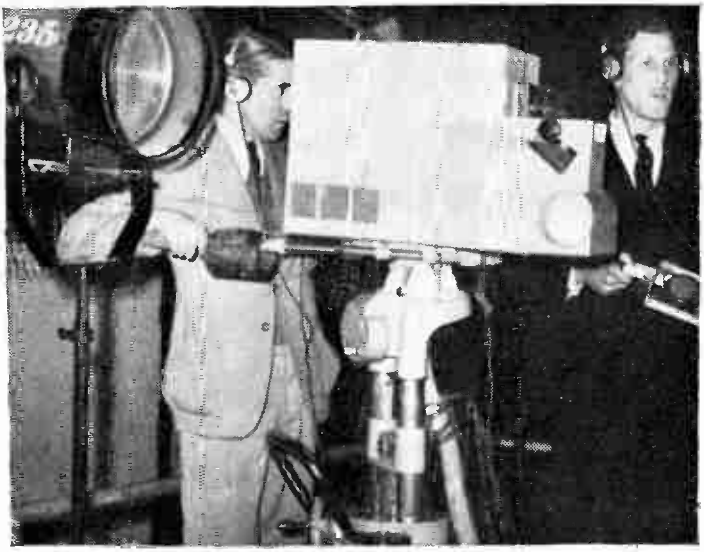


FIG. 2.—The Emitron Camera at work on an Outside Broadcast.

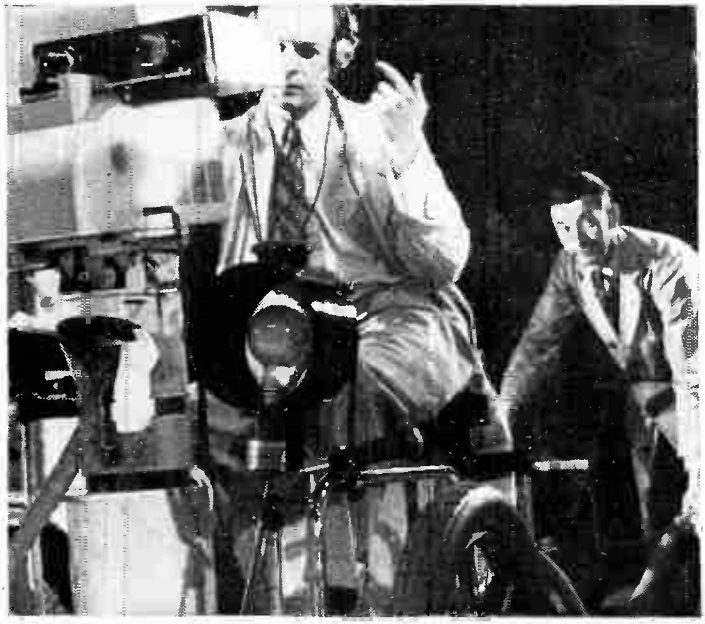


FIG. 2A.—The Television Camera.

transmitting station at Long Acre, London. They passed by land-line to Savoy Hill (2 LO), and thence to Brookman's Park. Later a studio was specially set aside at Portland Place (Broadcasting House) for television programmes on the Baird System. The apparatus there installed was a mirror-drum transmitter suitable for close-up and extended scenes. The times of the pre-war transmissions, which were made on the Marconi-E.M.I. System, were 3 to 4 p.m. every day, and in the evenings from 9 p.m. to 10 p.m. The whole outlook of television has been changed by the high-definition system which has now superseded the old low-definition systems.

Vision signals before the war were broadcast from the Alexandra Palace on 6.67 metres, with accompanying sound on 7.23 metres.

Until the war, two programmes per day, each one of an hour's duration were radiated. Only one system of transmission was employed, the Marconi-E.M.I. on 405 lines interlaced. The interlacing system is explained on later pages. It is claimed that it avoids flicker. The two systems were at first used alternately so that the relative merits could be judged by the public and the B.B.C.

The Television Transmitter.—In the spotlight method, when a scene or person is being televised it is necessary for a spot of light to traverse the scene or person, and therefore the first piece of apparatus to be considered is that which causes the spot of light to move. Previously, the scanning disc was used, and this consisted of a disc of metal with a series of holes equally spaced and punched near the edge of the disc in the form of a spiral.

Television Scanning.—When a photograph is taken with a camera the lens is uncovered to permit the whole of the view to be impressed upon the photographic plate at one instant. The varying degrees of light and shade are recorded by the photographic emulsion, and if movement is to be recorded a cinematograph camera is employed in which this process is carried out a number of times per second, each small section of the final film being exposed to the view instantaneously. Unfortunately, it is not possible to transmit television images by a similar means, as the photographic

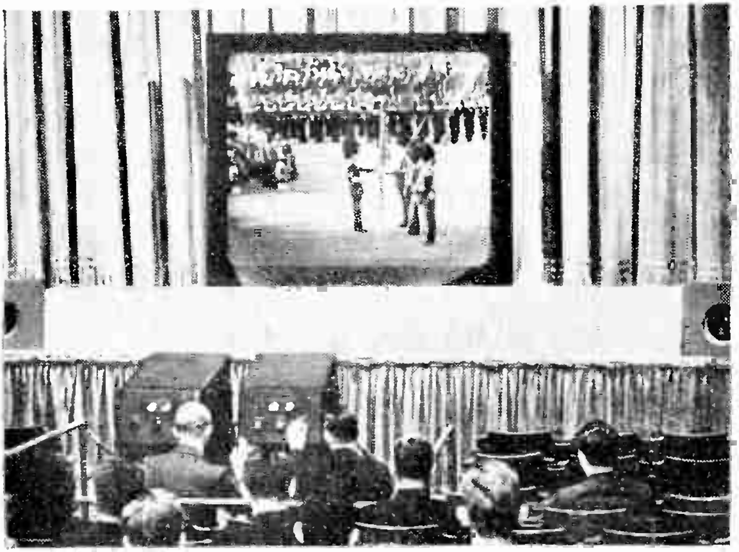


FIG. 3.—Showing how the "Trooping of the Colour" picture was reproduced on a big screen in The Tatler Cinema, using a Baird Projector.

FIG. 3A.—Miss Jasmine Bligh, one of the first two lady television announcers, in the studio. The television cameras are on the left. Miss Elizabeth Cowell was the other television announcer.

plate cannot be reproduced in an electrical sense. In the emulsion which is used to coat the negative a number of small grains of a special sensitive salt are held in suspension, and it is each of these which receives the light rays and is thus affected and caused to reproduce the image. Therefore, to employ a similar device, in an electrical sense it would be necessary to replace the grains of salt by some similar infinitesimal light sensitive device. In the very early days of television experiment this point was fully realised, and instead of splitting up the image after passing through a lens, it was split up before, and this breaking-up was carried out through the medium of what is known as a Nipkow disc.

The Earliest Scheme.—A German inventor, by name Paul Nipkow, conceived the idea of employing a disc of metal carrying a number of holes or lenses arranged in spiral formation, and supported behind this was a lens and other optical apparatus. When the disc is rotated, the spiral of holes or lenses travels across the front of the lens and thus only permits one small portion of the image to be passed through the lens at a given moment. The series of holes is, however, arranged in such a manner that the strips formed by the successive holes build up into a complete light area, and thus the image is divided into a number of small sections. The positioning of the holes is, of course, a very delicate task, as it is necessary that the light track formed by each hole shall accurately align with the next so that no overlap or underlap takes place with consequent ruin of the televised image. This form of apparatus is still in use at the transmitter and is known as a scanning disc. The number of apertures may be varied, and this enables a really well-defined picture to be transmitted. Formerly designers of television receivers had to make their sets capable of immediate change-over from one system of transmission to another. When the B.B.C. decided which system was finally to be used, design was simplified and costs reduced.

Electrical Systems.—As distinct from the mechanical methods above referred to there are a number of electrical schemes which are able to overcome the various defects inherent in a mechanical process and which also enable much greater detail to be obtained. Foremost amongst these is the cathode-ray tube, in which the scanning is performed by a stream of electrons inside a glass tube. This system is fully described later on. It permits of much greater detail, and has no inertia, and furthermore permits of a much larger image with increased brightness. The associated apparatus for controlling the tube is certainly rather complicated, but by utilising the short-wavelengths for transmission it is possible to obtain a picture which is capable of very minute detail and which will enable the television programme to compete with the home-cinema in home entertainment. This is the apparatus now in general use.

The Iconoscope.—A development of the cathode-ray tube has been introduced by Dr. V. K. Zworykin in which a photo-sensitive electrode is incorporated. Thus it is similar to the photographic plate in that it instantaneously converts the received image into electrical impulses without the difficulties attending scanning. The principal advantage of this arrangement is seen on the transmitting side, and the arrangement is shown in a later chapter. The image is focused on to a plate covered with the minute grains or cells as mentioned in a later chapter, but these are also electrically arranged in such a manner that they are insulated from one another. The application of an image (through a lens) focused on to the plate, results in a certain flow of current through the circuit and thus influences the transmitter according to the detail which is received by the plate. At the receiving end, the received impulses are fed to a fluorescent screen of a cathode-ray tube and reproduce the image.

The television system adopted by the B.B.C. makes use of scanning in a horizontal direction (this applied to both of the systems at one time employed). In continental and American systems, horizontal scanning is also employed. In the English systems scanning takes place from the top left hand corner of the area being televised, each spot of light travelling from the left to right of the area in the form of a strip, each succeeding strip building up the picture.

It will be apparent that the Iconoscope is really a development of the cathode-ray tube and is probably one of the greatest achievements in television research for many years. It was invented by Dr. V. K. Zworykin, and has often been referred to as a "cathode-ray tube with a memory." The Iconoscope is used for transmitting purposes in conjunction with a cathode-ray receiver, and after exhaustive tests such an all-electric system has proved considerably more efficient than any arrangement which depends for its functioning upon mechanically-operated devices. The Marconi–E.M.I. system makes use of the Iconoscope principle in the Emiscope.

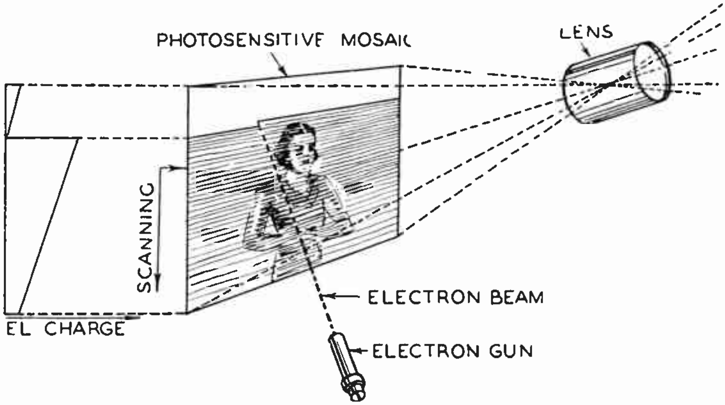


FIG. 4.—Showing how the scenes projected on to the mosaic are scanned.

In order to understand the functioning of the Iconoscope it is first necessary to consider how the cathode-ray tube functions. An electron stream liberated by a cathode and applied to a phosphorescent screen is controlled by what is known as an electron gun and various deflecting plates and coils. By applying varying alternating potentials to the deflecting plates the stream can be made to move backwards and forwards in a horizontal line so as to traverse a complete rectangle. If the beam is modulated by the received television signals, it will produce numerous spots of light of different intensities on the phosphorescent screen. The result of the action referred to is to form a complete picture.

In the case of the Iconoscope the phosphorescent screen is replaced by millions of minute photo-electric cells, each of which consists of a tiny globule of metallic silver covered with cæsium. This mosaic of cells is deposited as a thin layer on a film of mica, and each individual cell is insulated from its neighbour.

A general arrangement and method of functioning of the Iconoscope, or electric eye, is shown in Fig. 4, where the

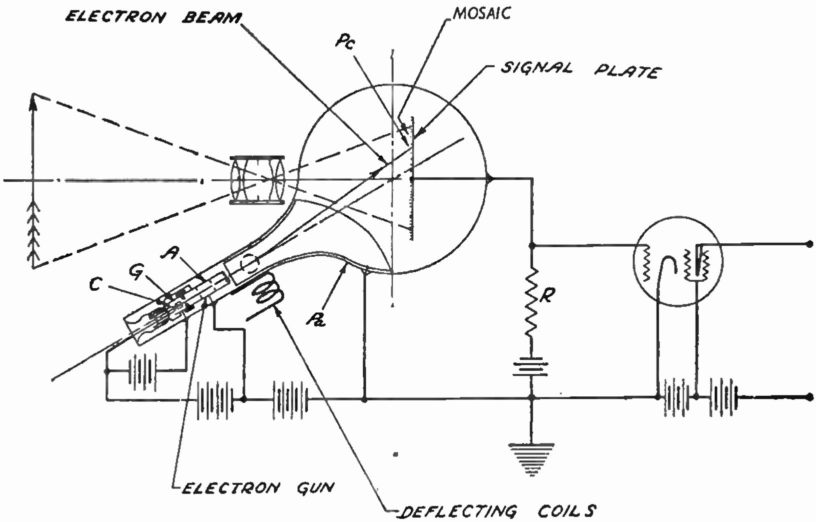


FIG. 4a.—Theoretical circuit of the Iconoscope and part of its associated equipment.

picture which is to be transmitted is focused by means of a lens on to the mosaic bank of photo-electric cells, inside the tube. The varying light intensities applied to this mosaic of cells produces an electrical change, which can be compared with the chemical change taking place on an ordinary photographic plate, when the camera lens is open and focused. When this is done, each individual cell of the mosaic liberates a certain number of electrons proportional to the intensity of the light directed upon it. This results in the cells (which act as minute condensers) becoming charged. The principle of the charging action can be followed in Fig. 5, where one of the tiny cells is represented at C. As light falls upon its sensitised surface some free electrons are liberated with the result that there is a surplus charge of positive electricity on one plate of the condenser and a corresponding negative charge on the other.

The next step is to convert the electrical charges built up on the condensers into corresponding signal currents, which can be used (after suitable amplification) to modulate the carrier wave of the transmitter, so as to radiate the electrical equivalent of the complete picture. At this juncture an important advantage of the Iconoscope comes into play. The electrode assembly in Fig. 4A is set in the path of the electron stream produced by the " gun," which acts as

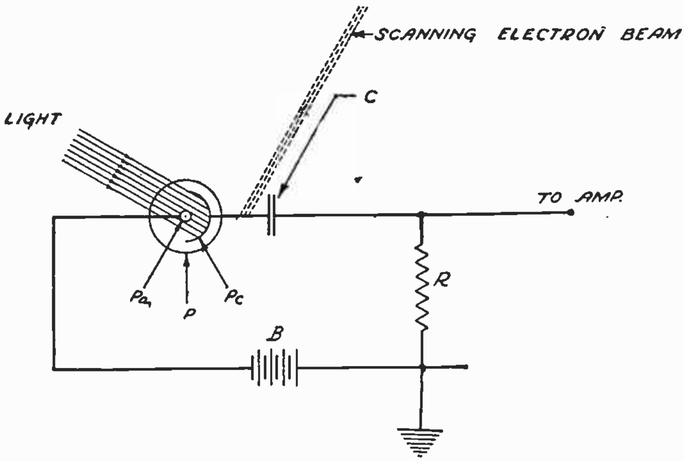


FIG. 5.—Showing the condenser action of each cell.

a scanning beam as it passes to and fro over the cells; the beam discharges each cell in turn, and causes a series of current surges to pass through a resistance R, which is connected in the input circuit of the amplifier. Each pulse of current is the electrical equivalent of the light intensity of a particular portion of the original picture. Consequently, it will be seen that the whole of the original picture is converted into its electrical counterpart by the charging action of the bank of cells. These charges are afterwards scanned in correct sequence by the electron beam, and thereby applied to the amplifier and thence to the transmitting apparatus proper.

At the receiving end the signals are applied to an ordinary type of cathode-ray tube, and the electrical pulses are thereby reconverted into points of light which are of varying intensity.

The result is that the picture seen on the fluorescent screen of the cathode-ray tube is identical with that focused on to the bank of photo-cells of the transmitter.

A particular advantage of the Iconoscope is for the transmission of outdoor scenes. This is because the picture to be transmitted is constantly focused upon the mosaic cells, so that they are constantly building up a charge during the complete length of time between one scanning period and the next. This permits of the formation of a much stronger electrical image than can be obtained by normal methods of scanning, where the spot of light rapidly passes over the picture, and is only applied to the photo-electric cell for a very short time. As a matter of fact the response of the cell to a ray of light which rests on it for one twenty-fifth of a second is 40,000 times stronger than it is to an impulse which lasts barely the one-millionth of a second. It is clear, therefore, that the Iconoscope has this much more energy in hand, for which reason it will operate efficiently in outdoor conditions—and even in dull weather—when television by ordinary methods is not practicable.

CHAPTER II

THE TRANSMITTING SYSTEM

THE television system which was employed by the B.B.C. in the pre-war broadcasts, transmitted 25 complete pictures per second, each of 405 total lines. These lines were interlaced so that the frame and flicker frequency was 50 per second. The transmitter radiated signals with sidebands extending to about 2 megacycles either side of the carrier frequency. Good pictures can be received utilising only a fraction of the radiated band, but naturally the quality of the received picture will depend upon the degree to which the receiver makes use of the transmitter band width. The transmitted wave-form is shown in Fig. 5A. These fundamentals are now dealt with individually.

Line and Frame Frequency.—This is 10,125 lines per second, scanned from left to right when looking at the received picture. The frame frequency is 50 frames per second, scanned from top to bottom of the received picture.

Type of Scanning.—The scanning is interlaced. Two frames, each of 202·5 lines, are interlaced to give a total of 405 lines with a complete picture speed of 25 per second. The line component and the frame component of scanning are regularly recurrent, the interlace being derived from the fractional relationship between line and frame frequencies. An explanation of the method of interlacing is given at the end of this chapter.

Interval Between Lines.—There are intervals between the vision signals of successive lines, which intervals provide time for the transmission of a line synchronising signal, and also provide time for the return of the cathode-ray beam to the beginning of the next line. The minimum interval between the vision signal of successive lines is 15 per cent of the total line period (1/10,125 sec.), the first 10 per cent of this interval between lines being occupied by the line synchronising signal and the remaining 5 per cent by a signal corresponding to " black " in intensity. The remaining

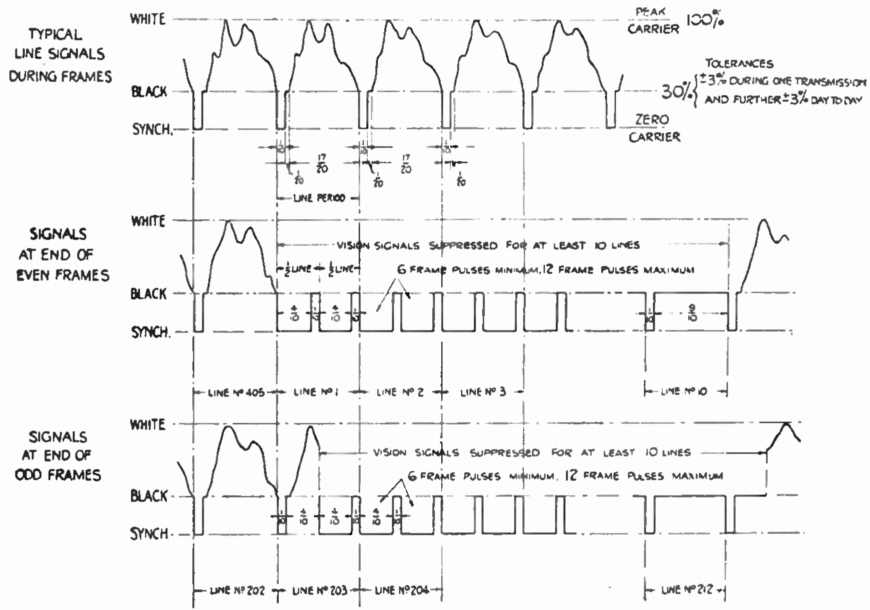


FIG. 5A.—The transmitted wave-form of the television system employed by the B.B.C.

85 per cent of the total line period is available for transmitting vision signals.

Interval Between Frames.—There are intervals between the vision signals of successive frames. The minimum interval between frames is 10 lines, leaving a maximum of 192·5 active lines per frame, or 385 active lines per complete picture.

Picture Ratio.—The picture ratio is 5 : 4, that is to say, the distance scanned during the active 85 per cent of the total line period is 5/4 times the distance scanned during the 192·5 active lines of the frame.

D.C. Modulation.—The picture brightness component (or the D.C. modulation component) is transmitted as an amplitude modulation so that a definite carrier value is associated with a definite brightness. This has been called "D.C. working," and results in there being no fixed value of average carrier, since the average carrier varies with picture brightness. The radio-frequency transmitter output is specified in what follows as a percentage of the peak output. This percentage is in terms of current (or voltage) and not in terms of power.

Vision Modulation.—The vision modulation is applied in such a direction that an increase in carrier represents an increase in picture brightness. Vision signals occupy values between 30 per cent and 100 per cent of peak carrier. The amount by which the transmitted carrier exceeds 30 per cent represents the brightness of the point being scanned.

Synchronising Modulation.—Signals below 30 per cent of peak carrier represent synchronising signals. All synchronising signals are rectangular in shape and extend downwards from 30 per cent peak carrier to effective zero carrier.

Line Synchronising Signals.—The line synchronising signals are of one-tenth of a line duration, and are followed by a minimum of one-twentieth of a line of black (30 per cent peak) signal.

Frame Synchronising Signals.—The frame synchronising signals comprise a train of two pulses per line, each occupying four-tenths of a line and having one-tenth of a line interval of black (30 per cent peak) signal between them.

At the end of even frames, the first frame pulse starts coincident with what would have been a line signal. At the end of odd frames the first frame pulse starts half a line after the preceding line signal. At least, six frame signals are transmitted at the end of each frame, but the number may be increased to any number up to 12 pulses (6 lines). During the remainder of the intervals between frames, normal line synchronising signals are transmitted with black (30 per cent peak) signals during the remaining nine-tenths of the line.

It will be noted that throughout the interval between frames (as during the whole transmission), the carrier falls from 30 per cent to zero regularly at line frequency and in phase with the beginning of the normal line synchronising pulses.

Variations in Transmitted Wave-form.—The 15 per cent interval between vision signals of successive lines, and the 10 lines interval between successive frames are minimum intervals used at the transmitter. During the initial development of the transmitter, certain transmissions may have longer intervals between lines and between frames, which lengthened intervals correspond to the transmission of a black border round the picture.

The 30 per cent carrier is the "black level" below which no vision signals exist and above which no synchronising signals extend. The mean black level of any transmission is 30 per cent ±3 per cent of peak carrier. The black level during any one transmission does not vary by more than 3 per cent of peak carrier from the mean value of that transmission.

The residual carrier during the transmission of a synchronising pulse is less than 5 per cent of the peak carrier.

The line frequency and the frame frequency are locked to the 50-cycle supply mains, and therefore will be subject to the frequency variations of the mains.

Explanation of Method of Interlacing.—The method of interlacing is demonstrated in Fig. 5B, which represents the top and bottom portions on the scanned area with the distance between the lines very much enlarged. The lines show the track of the scanning spot, which moves under the influence of a regular downward motion (frame scan) with quick return and a regular left to right motion (line scan) with very quick return (not shown on drawing). The combination of these motions produce the slightly sloping scanning lines. Starting at A, not necessarily at the beginning of a line, the spot completes the line A B, returns to the left and traverses the line C D, then E F, and so on down the "dotted" lines on the drawing. At the bottom of the frame the spot travels along line G H and then starts at J and travels to K. At this point the return stroke of the frame motion begins and returns the spot to L at the top of the frame. A complete frame scan has now been made since

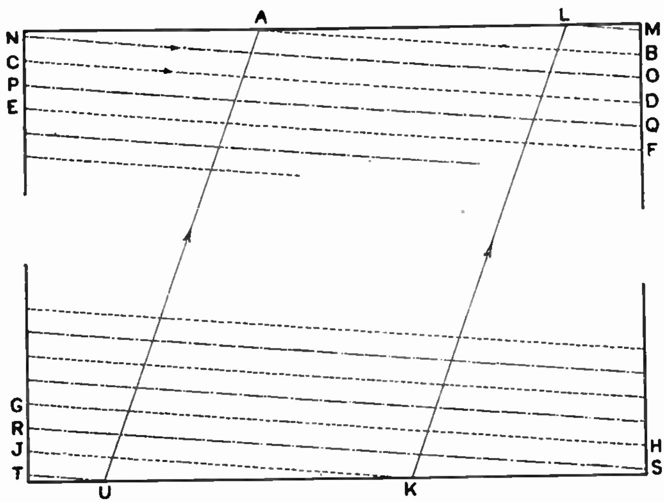


FIG. 5B.—Diagram explaining the system of interlaced scanning.

leaving A, so that 202½ lines have been completed, and the point L is half a line away from A. The downward frame motion now starts again, causing the spot to travel along L M, completing a single line motion J K L M. The spot then returns to the left and traces out line N O, which, due to L being half a line ahead of A, will lie between lines A B and C D. Similarly the next line P Q will lie half-way between C D and E F. The spot now traces down the chain dotted lines to R S and finally traces out T U, at which latter point the frame return causes the spot to rise again to the top. When the spot reaches the top it will have completed 2 frames since leaving A, and, as two frames occupy the time of exactly 405 complete lines, the spot will return exactly to A, after which the cycle begins again.

From the foregoing, it will be seen that the complete picture is scanned in two frames, but as each frame contains an integer number of lines, plus a half, the two frames will interlace. The system does not require the short return times shown for the line and frame scans, nor need the lines begin in the positions shown. Provided the line and frame traversals are regularly recurrent and have the correct frequency ratio (two frames = odd number of lines), an interlaced picture will be obtained.

The result of this interlacing is to provide a picture which is crisper and which possesses much less flicker than a sequentially scanned picture of the same number of lines. Furthermore, by making use of a circuit which will more or less suppress the flyback—as described on page 59, the double lines U-A and K-L in Fig. 5B may be to all intents and purposes obliterated and a picture comparable with a cinema picture obtained. At the critical focal point the individual lines may be seen when the screen is viewed at close quarters, but when it is found necessary to be close to the screen the individual lines may be almost eliminated by a slight out of focus setting without seriously impairing the sharpness of the received picture.

CHAPTER III

ANALYSING THE SIGNAL

In the case of ordinary radio reception, except for knowing that the converted sound signals are radiated on certain definite wavelengths as an amplitude modulation of the carrier wave, the average listener is not concerned with the form of the wave. The depth of modulation of the carrier wave, frequencies involved, and so on, do not enter into questions of design for ordinary broadcast listening, and in consequence, the reader is justified in asking why he is called upon to study such questions in the case of television.

Associated Problems.—Let it be said straight away that the problems associated with combined "watching and listening" are rather more complex and detailed than is the case with aural radio work alone. This arises from a variety of circumstances, among which can be mentioned the necessity for using ultra-short waves with their somewhat limited range as compared with the wavelengths now employed for broadcasting, the extremely wide frequency band which must be accommodated, the inclusion of synchronising signals which have to be filtered out at the receiving end in order to make the tracing device simulate the scanning motion of the transmitting end, and so on. It will be obvious, therefore, that if full efficiency is to be obtained with television receiving equipment, it is not only advisable but very instructive to study the conditions of transmission very closely.

The Importance of Synchronising.—In every system of television the success which attends it depends to a very large degree on the question of synchronism. Briefly, there are two factors which must operate. First of all, the periodicity of a complete picture traversal must be the same at the scanners working at both the transmitting and receiving ends. Furthermore, when strip scanning is used (and this is the accepted method at the moment), the length of time taken to scan a complete strip at the end generating the signal must be identical with that taken by the reconstituting device at the receiving end. Also, correct phase demands that each position along the strip and each portion of a complete traverse must be coincident at transmitter and receiver.

It seems that at the present stage of development the cathode-ray tube is destined to fulfil an important function as the modulated light source and scanning agent with its associated equipment, and although other methods (mechanical or electrical or a combination of the two) may supplant or supplement the cathode-ray tube, most of the television companies are at present pinning their faith on the C.R. tube, and the results shown are certainly outstandingly good.

The synchronising signal in the case of the bulk of the receivers does not function as a driving force, but serves to time or trigger the particular devices which are imparting the regular scanning motion to the tracing spot. First of all, the B.B.C. have agreed on the direction of scan—namely, that the line trace as observed when facing the receiver is in the direction of left to right, while the complete line traces are effected from top to bottom. Each picture, therefore, makes its beginning in the top left-hand corner and finishes in the bottom right-hand corner. Furthermore, each picture is rectangular in shape with the longer side horizontal, the ratio being five to four. The ratio applies to the picture itself, and does not include the synchronising signals or black edging which surrounds the picture. Since the length of the sweep traces for line and frame traversals are under the jurisdiction of the set user, this dimension ratio is one which is easily allowed for in practice.

Modulation Allocation.—Referring back to Fig. 5A (page 21), it will be seen that the total amount of modulation of the complete signal is divided into two sections. For reproducing a picture correctly the signal intensity must vary from complete black to complete white, so that intermediate intensities give the required light gradation or half tones. Now the aerial current amplitude corresponding to white is the peak or maximum condition, but black is represented by a condition which is a certain height above the zero ordinate or zero carrier condition. The mean figure is 30 per cent with a tolerance of ± 3 per cent during a single transmission and a further ± 3 per cent from day to day.

If no picture modulation or synchronising impulses were being transmitted, the wave-form would consist of a steady carrier having an amplitude governed by the mean value of the predetermined " black " limits. Assuming now that no picture is being transmitted, but the synchronising signals are modulating the ultra-short carrier wave, then this steady carrier condition will be interrupted or reduced in a definite periodic manner. The reductions are in one case to supply the high frequency or line impulses which are of relative high periodicity, and in the other to furnish the low frequency to form the frame synchronising signals. They are of definite rectangular shape, and exist for periods which are governed entirely by the scanning devices employed at the transmitting end.

Line Synchronising.—These sharp dips in carrier amplitude in the case of the line trace occur at either the beginning or end of the line. With the present system, since there are 10,125 lines traced per second (405 lines with 25 complete pictures) the length of line allotted to synchronising is 10 per cent, giving a duration period of this rectangular pulse of $\frac{1}{101,250}$ second. Another 5 per cent of the line time is allotted to the black mask, so that the respective time period allotted to transmitting vision signals is 85 per cent for the existing transmission.

Frame Synchronising.—Coming now to the frame or synchronising pulses, these are also rectangular in shape and extend from the mean black carrier condition to effectively zero carrier, being for the purpose of ensuring that the picture reconstituting device builds up the same number of frames as are generated at the transmitting station, namely, 50.

With the Marconi-E.M.I. system, due to their method of interlacing, 25 complete pictures are transmitted in one second in the form of 50 frames, each frame containing half the line traces for a complete picture. With one frame the odd lines are traced, and with its accompanying or succeeding frame the even lines are traced. It is stated that the minimum number of lines masked between successive frames will be 10, so that out of a total of 405 lines there are 385 active lines for tracing the picture or 77/81sts of the total for each complete picture.

When the picture signal itself commences all carrier levels above the " black " limit correspond with definite brightness levels in the transmitted picture. In both cases this picture brightness component is transmitted as an amplitude modulation, and in this way the mean brightness of D.C. light value of the picture is made implicit in the signal. That is to

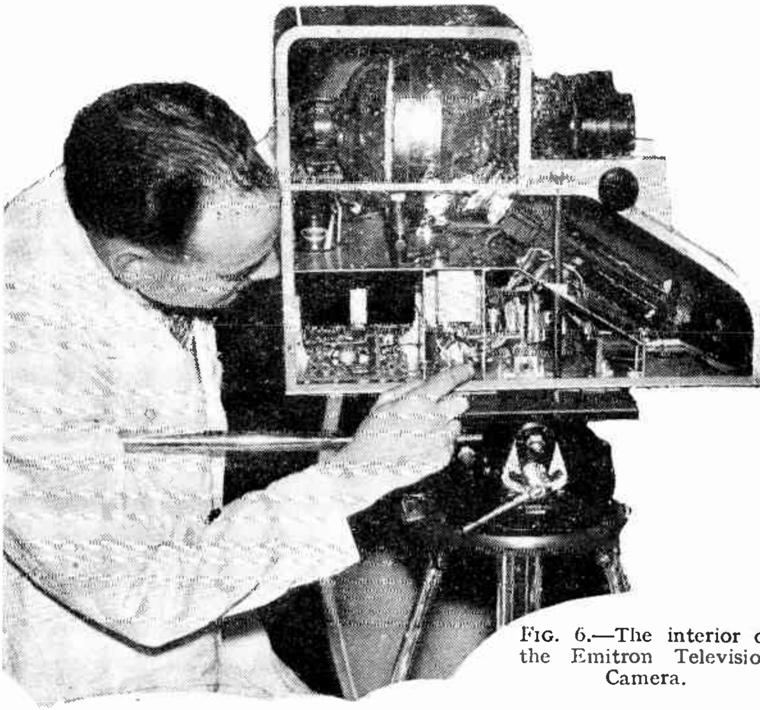


FIG. 6.—The interior of the Emitron Television Camera.

say, there is no fixed value for the average carrier, this varying according to the degree of lighting which is present in the scene being transmitted at the studio end. This is a most important point, and will be amplified in the next chapter.

CHAPTER IV

FREQUENCY BANDS AND D.C. LIGHTING

It is as well to note here that in the case of the Marconi-E.M.I. transmission the maximum frequency involved in the transmission is 4 mc/s. Naturally the quality of the received television picture will depend upon the ability of the set to make use of the side-bands involved. If only 2 mc/s. is accommodated, the picture will suffer, although the E.M.I. assert in their published specification that good pictures can be received utilising only a fraction of the radiated band.

Reverting now to the general question of the radiated signal in its form of amplitude modulation with the synchronising pulses, produced by interlacing square-topped signals periodically in the picture signal of such a polarity that the signal amplitude is reduced almost to zero when they occur, it is necessary to examine the reason for this method. By working in this way, a scheme is provided for separating the pulses quite effectively at the receiver and using them without any form of picture modulation for synchronising purposes.

Functions to be Performed—The receiver itself has to perform several functions, but the most important of its operations are (*a*) the process of demodulation or detection, which serves to convert the carrier envelope into video frequency currents (as distinct from audio frequency currents in the case of the broadcast reception of sound), containing both the television picture and synchronising signals; (*b*) the separation of the synchronising pulses generally by means of amplitude selection and the application of these *two sets* of pulses to the two time base circuits in order to lock them into step with the scanning devices at the transmitter end; (*c*) the application of the picture signals themselves to the reconstituting device biased in such a way that black comes out as black, and white as white in the final observed picture.

Schemes for separating the line and picture repetition pulses from the main signal are many, and one method is to invert the signal and apply it to a rectifying valve working as an anode bend detector, so that only amplified pulse tips arrive in the anode circuit. This is termed amplitude selection, and the resultant signals are in the nature of triggering pulses of sufficient peak amplitude to hold the devices generating the scanning traces in step.

Yet another simple arrangement is shown in Fig. 6A, where a pentode valve receives the audio frequency signal from the set's detector valve, and owing to the double filter circuit arrangement in the valve's output circuit the H.F. or line pulses and the L.F. or picture pulses are forced into the two appropriate channels, where they feed the grids of the controlling valves in the time base circuits.

Pulse Generators.—One point which must be borne in mind is that the separating and injecting schemes depend

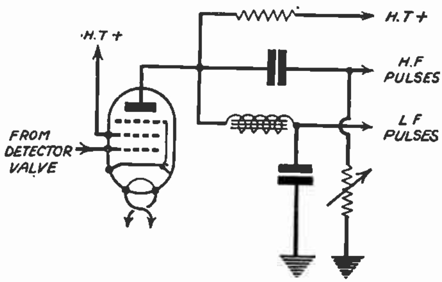


FIG. 6A.—A simple synchronising pulse-selector circuit.

upon the form of scanning generator in use. For example, it is possible to use a " blocking oscillator " in which case the synchronising pulses are applied to a portion of the grid circuit of the oscillator valve. Then if the oscillator normally tends to run slow these impulses serve to shorten the period of each saw-toothed pulse generated by it, and so keep it in step with the incoming signal.

D.C. Lighting.—It is now necessary to deal with a question which has come to be known as D.C. lighting, as this effect is included in the radiated signal. It concerns the relative degree of lighting used in the studio when a subject or scene is transmitted. When at a cinema each member of the audience is able to appreciate how the brilliance portrayed on the screen varies. Bright sunshine, twilight or certain shades of darkness, all have their place for the purpose, and in this way complete entertainment is portrayed.

Coming now to television pictures produced through any standard form of light-modulation device, such as a cathode-ray tube, Kerr cell, gas-filled lamp, etc., the screen can be adjusted to any degree of brilliancy within the limits of the device before any picture signal is tuned in. On applying the television signal the varying modulation will produce the light variations and so build up the picture, but unless the direct component of the light is radiated the "average" brilliance of the screen will remain unaltered, and the natural light changes in the film or real scenes being televised will be missing. For true pictorial effects not only must the variations of light occur while the spot of light is carrying out its traces over the screen, but the mean illumination intensity must be reproduced as well. Prior to the advent of the present form of high-definition television, it was the usual custom to adjust the initial screen brilliance to a value which would serve as the average for the whole transmission. With a straightforward spotlight scanner this was all that was required, for the signal generated depended only upon the variations of light reflected from the small but intense spotlight as it performed its rapid scan.

Radiated Component.—Now that the electron camera, the Iconoscope (Emiscope), the intermediate film process, and the transmission of standard talking films have found their place in the art of television, exterior and interior scenes, with all the arts of studio and stage lighting, have become items which may be radiated as a television signal. The screen brilliance on the receiver must be varied by the radiated signal to take cognisance of this important lighting factor. In addition to the varying or alternating component of the television signal, the direct-current component must be included. How this is done at the transmitting end is not a matter which need concern us here. It is sufficient to mention that the company concerned with the generation of the signals for ultimate radiation on the ultra-short waves has stated quite definitely in the published reports that the direct component of the lighting is included. At the receiving end this fact must be borne in mind when designing the set, for, if not, the chain of amplifying stages will include coupling condensers or other devices which will act as a complete block to the D.C. component.

Receiver Questions.—Cathode-ray tubes are now being developed which do not require a large A.C. voltage swing for full modulation and, in consequence, can be worked direct from the second detector stage of a superheterodyne receiver. Under these circumstances questions of post-detector amplification do not arise, and the problem is in this way greatly simplified.

Modulation Frequency.—One important fact should be remembered when considering the present system from a theoretical and a practical point of view. While there is no definite standard for the percentage of the ultra-short wave carrier frequency which can be used as the limiting modulation frequency, the present practice is one of 5 per cent.

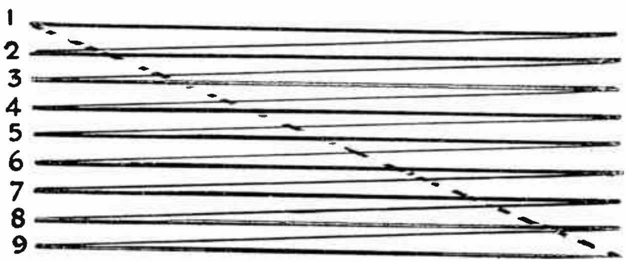


FIG. 6B.—A nine-line scan greatly exaggerated, showing how an orthodox sequential scan is built up.

Using the wavelength of 6·6 metres as recommended by the Television Advisory Committee, that is a frequency of 45·45 mc/s., 5 per cent of this is 2·27 mc/s.

On this calculation 405 lines, 25 pictures per second with a picture ratio of 5 horizontal to 4 vertical (the E.M.I. standard), has a limiting frequency of very nearly 5·1 mc/s. which is right outside the modulation band which can be accommodated on 6·6 metres. The correct wavelength, to give full measure to the benefits conferred by this high line definition would be about 3·0 metres!

In spite of this, results are fully satisfactory.

Scanning Spot Size.—Coming now to the size of the actual spot of fluorescence on the cathode-ray tube screen if overlap is to be avoided between lines, every increase in the number of lines for the picture reproduction means a decrease in spot size. This is not the simple matter it seems if a sharp, truly focused spot is required. With a reasonable sized picture, say 12 in. by 9 in., the spot size is 0·025 in. for the standard which has been chosen by the Committee. On the other hand, it may no doubt be desirable to use smaller cathode-ray tubes on the score of initial costs and possible replacements. Therefore with, say, a picture of 4 in. by 3 in. the size becomes 0·008 in.!

The Orthodox Method.—The building up of an orthodox sequential field of scansion lines is now no doubt familiar to readers, but a glance at Fig. 6B will serve to recall what is

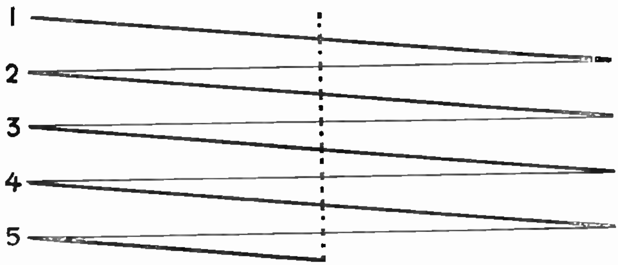


FIG. 6C.—Showing how the first section of an intercalated scan is built up in a similar manner to the orthodox, or sequential, system.

done. The line " 1 " is very slightly inclined in the direction of its trace (shown very exaggerated in this illustration for clarity of explanation). A rapid horizontal flyback occurs at the end of the trace when the process is repeated in sequence so that each line is contiguous to its immediate neighbour. At the end of the scan both L.F. and H.F. time bases trigger together and the flyback is made to the point of origin, for the process to repeat itself 25 times per second.

Coming now to the scheme used to-day, which results in 202½ lines repeated 50 times per second, it should be mentioned that the term " interlaced " is not strictly the correct one to use. The term " intercalated," however, which was used in one of the original patents describing the idea leaves no doubt as to the scheme, and for the sake of clarity, therefore, the expression " intercalated " is desirable in preference to " interlaced."

Intercalating.—In order to produce an intercalated scan of 405 lines worked 202½ lines 50 frames per second, the L.F. time base pulse generator must work at a frequency which is twice the normal 25 pictures per second standard. The lines of successive scansions are then displaced vertically

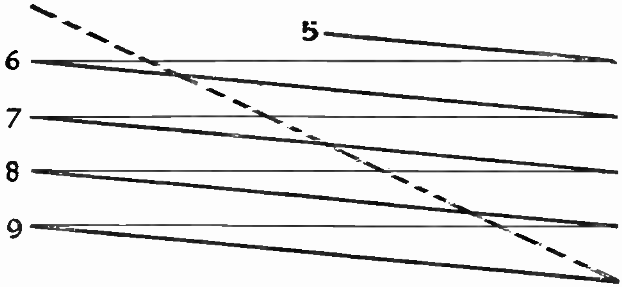


FIG. 7.—The second or intermediate section of an intercalated scan, where, on the completion of the final line trace, both time bases trip together.

from each other by one-half the distance between lines. This will be made clear by a reference to the diagrams. Taking, for the purpose of illustration, a 9-line scan greatly exaggerated, then in Fig. 6c is shown how the first set of lines is built up in a manner similar to the sequential system.

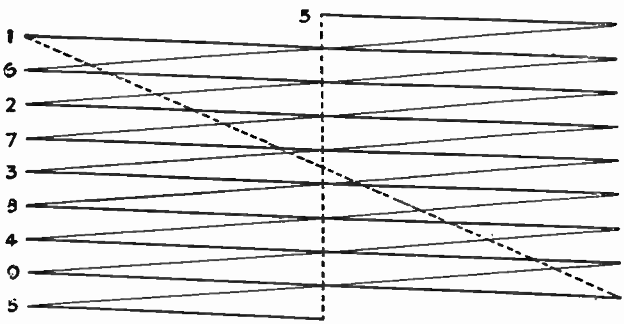


FIG. 7A.—The complete interlaced scan.

When line 5 is half-way across its total scanning distance, however, the L.F. time base "trips" and assuming an instantaneous return, the scanning spot on the screen will move vertically upwards as shown by the dotted line. The second or intermediate scan is now carried out as in Fig. 7 where, on completion of the final line trace, both time bases "trip" together and the double sequence of events starts all over again. The combined effect of this intercalated scan really amounts to the insertion of one series of lines between the other as shown in Fig. 7A, and owing to the first "trip" taking place after half a scanning line was completed, then theoretically the two sets of lines should just fit one between the other.

An extremely accurate control of the scanning frequencies is necessary, otherwise there is a dithering or shimmering action between the two sets of scansion lines, and this may become a far more distressing effect to watch than any suggestion of a straight flicker.

CHAPTER V

THE SCOPHONY SYSTEM

UNLIKE the majority of the apparatus which is available, this system makes use of a mechanical arrangement by means of which the picture is projected on to a screen. The accompanying illustrations show the large screen model and a view of the interior. The light source is a standard 100-amp. arc for large screens and a mercury lamp for the domestic model, the light from these being directed through a condenser and lens assembly on to a quartz crystal D. The crystal is situated at the foot of a container which is filled with a liquid and it is found that when a radio-frequency supply is fed to the crystal, waves are set up in the liquid. The frequency of the waves is dependent upon the liquid, and in the Scophony apparatus has been chosen to give a wave-form suitable for the present broadcast service.

Scanning.—Situated between the light source and the crystal is a bar which, when no R.F. is applied to the quartz, blocks out the light which would otherwise be directed on to a further lens situated just in front of the motor E. As soon as the R.F. is applied, however, the refraction of light caused by the waves through the liquid cause the light to "spread

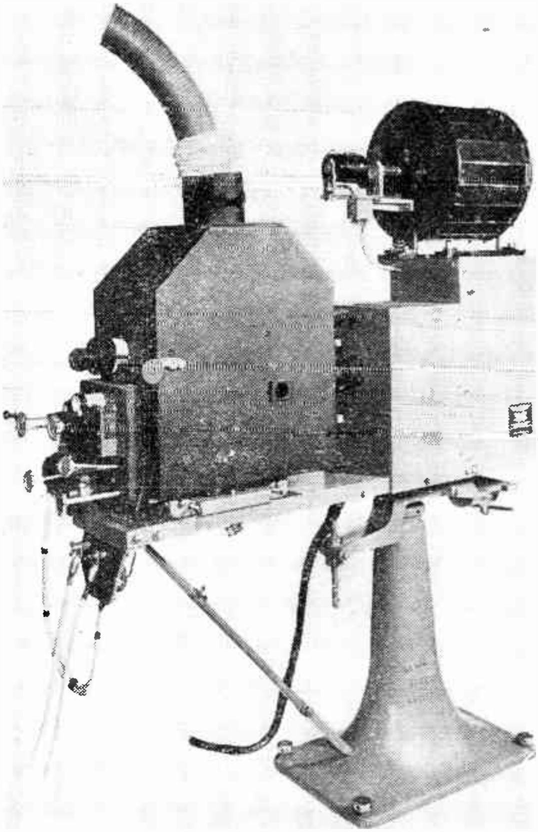


Fig. 8.—The Scophony television projector, for use in public halls. This model is for pictures 6 ft. by 5 ft.

over " and thus reach the second lens. It is obvious, therefore, that if a modulated R.F. is applied to the quartz the amount of light passed on will vary in intensity and time in accordance with the modulations of the R.F. The television signal is therefore applied to this quartz control and thus gives rise to a variation in the light in accordance with the television signal. Mounted on the spindle of the motor E is a stainless steel polygon scanning element which is kept exactly in step with the oscillations through the liquid and it therefore follows these faithfully. The motor E is synchronously controlled by the line frequency broadcast by the B.B.C., and the light which impinges on the multi-surfaced scanner is directed upwards through a lens on to the scanning drum B which is also controlled by á special synchronous motor A. This drum provides the picture repetition frequency.

The relationship between the speed of the two motors A and E and the number of mirrors on the drum B and surfaces on the scanner at E ensure perfect interlacing and synchronism with the transmission. The mirrors on the drum B direct the picture forwards on to the rear of the screen which is of ground glass or oiled silk or any similar material. All the usual controls, focusing, brilliance and so on are provided and the apparatus is almost fool-proof. The large cinema model may be operated by any ordinary cinema engineer and does not require to be handled by a television expert. In the home receiver, the maximum voltage which is available at any one point is only 350 volts so that it is no more risky to handle than a standard A.C. mains set. The screen (24 in. by 22 in.) in the provisional domestic models is made to draw out when required for use, and to push back into the cabinet when only radio is being received.

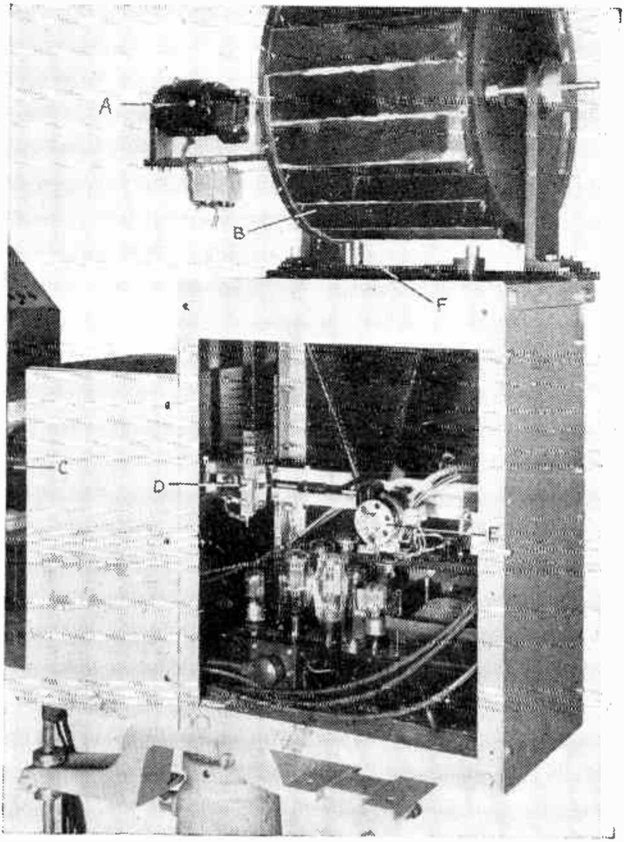


FIG. 9.—Interior view of the Scophony public hall projector, which gives pictures approximating cinema standards of brightness up to 6 ft. in size. The illustration shows the amplifier which drives the light control, and above the amplifier is seen the high-speed synchronous motor.

CHAPTER VI

THE CATHODE-RAY TUBE

Sweep Voltages.—The methods used to make the light spot on the screen traverse a rectangular area in the form of distinct lines of light by means of time-bases are by now quite plain, but there are still other factors which merit close attention. First of all, depending upon the type of tube employed, so the sweep voltages applied to the two pairs of deflector plates must be of sufficient magnitude to make the area covered fill the space available to the limits set by the slight curvature at the screen's circular extremities.

In this way the size of picture watched will be brought to the full economical limits set by the screen's diameter. Remembering previous remarks, this factor is controlled by the value of the anode voltage used in the gas-filled relays,

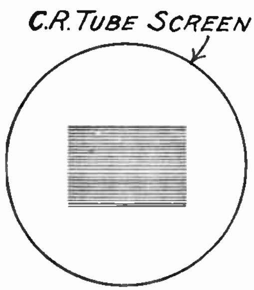


FIG. 10.—A picture area made too small by insufficient sweep voltages on each pair of deflector plates.

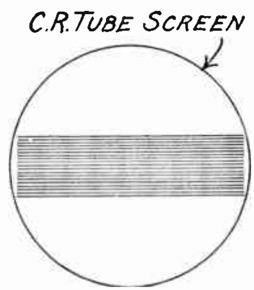
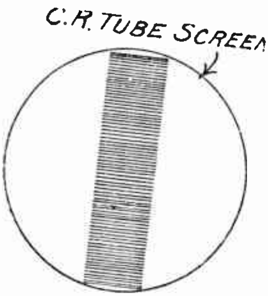


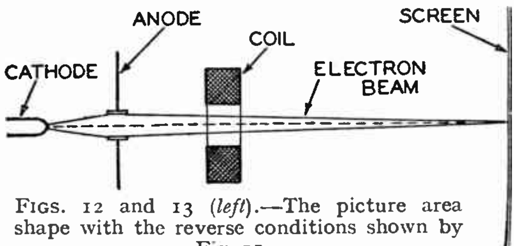
FIG. 11.—Using too large a voltage sweep on the vertical deflector plates, and too little on the horizontal deflector plates.

together with the grid-control ratio and applied negative bias. For example, if both the vertical and horizontal sweeps are insufficient, the picture area would be as in Fig. 10, and would not do justice to the tube's capabilities.

Another Feature.—In addition, one must see that *both* these sweep voltages receive attention, otherwise the results obtained may resemble those shown in Figs. 11 and 12. In the former the horizontal sweep is too great (derived from the vertical plates), and the vertical sweep too small (derived from horizontal plates) while the latter figure shows the conditions reversed. In any case, these conditions are completely under the control of the user, and a potentiometer bias on the gas-filled relays is capable of giving the limits desired. These same controls will set the picture to the right ratio, which is of the order of 6 horizontal to 5 vertical, that is, of a similar standard to ordinary talking films.

When such a course is felt desirable, the user of this apparatus is at liberty to " magnify " any particular section of the picture by increasing the sweep voltages, and so en-





FIGS. 12 and 13 (*left*).—The picture area shape with the reverse conditions shown by Fig. 11.
(*Above*)—Method of bringing the electron beam under the influence of a magnetic field.

larging the total area that the extremities are lost in the limits of the screen size, but the centre section of the picture is magnified to fill the space available. Mechanical receiving apparatus, of course, does not possess a feature of this nature, and this is sometimes cited as an advantage of cathode-ray tube working.

While on the subject of deflector plates, it is well to mention here that they are very frequently referred to as the " X " and " Y " plates. The reason for this should be quite apparent, and arises from the relation to ordinary graphical expression which we use so often to show effects which would otherwise be difficult to explain in words only. With every graph there are the X and Y ordinates (horizontal and vertical respectively) at right angles to one another, and this is the condition featured by the plates in the neck of the cathode-ray tube.

Hard or Soft Tubes.—Although gas-filled cathode-ray tubes have certain advantages arising from the ionisation conditions associated with their action, the general tendency at the moment for high-definition television reception is to use " hard " tubes, that is, those from which any form of gas has been pumped so that they work in an evacuated state. This means that the anode with the hole in its centre—so frequently referred to as the " gun," because its purpose is to accelerate the electrons (bullets) and propel them at very high velocity towards the fluorescent screen or " target " —have to be furnished with higher operating voltages than would be the case with gas-filled or soft tubes.

This does not present any prime difficulty, however, for there is infinitesimal power expended in this part of the circuit owing to the extremely small "gun" currents which flow. It is for this reason that batteries of small capacity, but high voltages, can be used if desired at this part of the apparatus, and many manufacturers, anticipating this requirement, have produced high-tension batteries solely for this particular purpose. Their compact form and special design make them ideal for this purpose, and readers not desiring to make up a power unit for the " gun " volts can use these with every confidence.

" Origin " Distortion.—Very frequently, when the unmodulated light field scan of a cathode-ray tube is examined it will be noticed that there are two bright arms, like rectangular axes, positioned within the scan. The effect is very often referred to as "origin" distortion or the "white cross" effect. It arises in the case of hard tubes from a slight lack of proportionality in the deflector plate action, especially when these are worked at low voltages. With soft tubes it is caused from a secondary ionisation action owing to the presence of positive ions within the field of the deflector plates.

To overcome this it is possible to make the electrode system asymmetrical inside the tube, and thus deflect the axial centre of the scan either off or near the edge of the screen. Picture-centring devices are then able to bring the image back to its appropriate position on the tube. In some tubes certain electrode refinements, such as an electrostatic shield, are introduced to overcome the slight defect.

Focusing.—In any optical lens system used for photography, light experiments and so on, means are provided for mechanically positioning the lenses so that the emergent light beam can be focused into a sharp spot or area on any object or screen with which it is used. With cathode-ray tube working, a similar focusing effect of the spot on the screen has to be produced, otherwise the resultant fluffy-edged or misfocused spot will bring about an imperfect television picture. This process of beam concentration is often referred to as fasciculation, and in practice it can be carried into effect in a number of ways. With soft tubes a small trace of inert gas is capable of giving the electrical "focus" effect required in conjunction with an adjustment of filament current.

Then, again, there is the simple expedient of bringing the electron beam under the influence of a magnetic field as shown in Fig. 13. The coil surrounds the beam and has a steady direct current passed through it capable of being varied at will. The strength of the resultant field produced, together with the mechanical dimensions of the electrode system and accelerating potentials used, enable a balance to be struck where the spot appears in sharp focus on the screen. Remember that the size of this spot is very small under practical conditions, and unless this is so, there will be overlap between the scanning lines, and a blurred image will result.

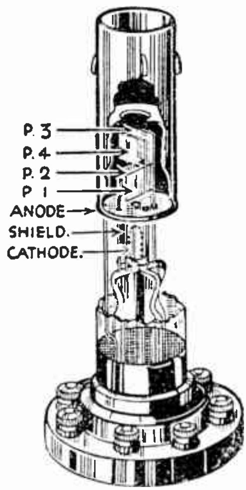


FIG. 14.—The electrode system of a cathode-ray tube in which the Wehnelt cylinder is indicated as a shield.

Using the Shield.—A more common electrostatic method now in use employs the Wehnelt cylinder, or shield. When the potential of this cylindrical electrode, seen very clearly in Fig. 14, is varied in relation to the cathode, the field of force between these two electrodes is modified. In practice this is given a negative bias, sometimes approaching a figure up to as much as one-tenth of the operating anode voltage—and the electrons leaving the cathode surface and tending to move in a divergent direction come under the influence of the repelling negative field (remember the electrons are minute negative particles of electricity) and are forced back into the centre of the beam.

In this way the forward electron movement is confined to a narrow cross-section, and the concentrated beam not only passes through the small orifice of the gun, or accelerating anode, but reaches the screen and evidences itself as a bright, sharp-edged spot. The only real drawback to this arrangement is that, as in the action of the grid of an ordinary thermionic valve, the application of the negative potential places a limit on the number of electrons which actually "escape" from the filament (or cathode). In consequence, this shield bias has to be very carefully adjusted, and must not exceed a certain rated figure for each particular tube.

Modulation.—So far our prime attention has been directed towards imparting a regular movement to the screen spot, and seeing that this is correctly focused, as well as eschewing minor defects (such as origin distortion) in building up the observed field. To build up the picture in terms of light and shade with these lines, the incoming television signals, amplified by the radio receiver to a sufficient strength, must be made to modulate the beam, as this is the only source of light.

The light intensity of the observed spot at any position of its motion, when only under the influence of the accelerating potentials and time base circuit voltages, is constant, being due to the actual number of electrons which reach the screen while the whole beam undergoes its constant velocity motion. A form of modulation has to be devised which is quite independent of these earlier constant and varying potentials. If this is not done then an incorrect image will result. For example, suppose it is desired to vary the actual number of electrons which reach the screen. This will cause the spot to alter in brightness throughout its travel, and due to the rapidity of movement coupled with the phenomena of visual persistence which every normal eye possesses, a picture can be traced out which "shows" on the screen a replica in light of the actual scene radiated from the transmitting station.

If this signal voltage variation was applied, say, to the shield or cylinder, then not only would the number of electrons vary but the spot of light would alter in focus due to the variations in the static negative field between cathode and shield.

CHAPTER VII

MODULATING THE C.R. TUBE

WHILE it is known generally that each of the various television systems which have been developed, not only in this country but in various parts of the world, have special or distinctive features that are claimed to give a measure of superiority over their immediate rivals, these features in many cases amount to improvements in particular sections. Consequent upon this there are many factors which are common, and in the provision of any public service of television it is essential that the type employed shall include features which enable it to be received on sets of differing design.

This is the case with the high-definition television service now in use. Here, the signal which is propagated from the ultra-short-wave radio transmitter is generated, as a result of the equipment producing voltage variations that are a direct function of the brightness (or dullness), of successive picture areas explored in an ordered and consecutive manner. These areas are scanned at a rate which is quite independent of the nature of the subject being televised. At the receiving end, therefore, it is essential for the light intensity of the picture-reproducing device to be modulated in an identical manner, this being known as "intensity modulation."

Velocity Modulation.—When it comes to using the beam of cathode rays in a C.R. tube for the purpose of showing television pictures, the intensity of the beam must be modulated, but in so doing the fasciculation or focusing of the spot on the fluorescent screen must not change, while the mean velocity of the electrons themselves, strictly speaking, must not alter.

As a variant to this, reference must be made to the television system sponsored and developed by the Cossor Co. from the original work carried out by Thun. This is known as velocity modulation. In other chapters descriptions are given of the action of the time base circuits in causing the spot of light to move across the screen at a constant velocity, and in this way trace a line of fluorescent light of constant intensity. If the spot is made to move exceptionally fast the degree of line fluorescence observed on the screen will be relatively small, but if, on the other hand, the speed is reduced, the intrinsic brilliance of the traced line will correspondingly increase.

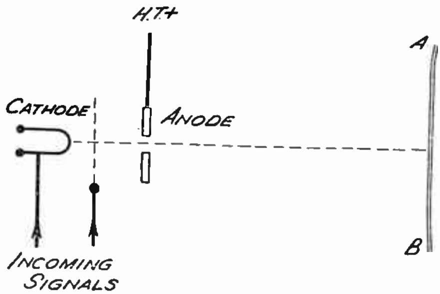


FIG. 15.—Inserting an additional mesh electrode between cathode and anode for modulation purposes.

This is termed velocity modulation, and the various light and shade details in the televised scenes are reproduced at the receiving end by adapting the velocity of the electron trace across the screen to high and low values, and thus give dark and bright sections of the picture. The scheme is a very ingenious one, but since intensity modulation is the method proposed by the Television Committee as a result of adopting the E.M.I. system, attention will be directed here to a consideration of the different schemes of intensity modulation which have been proposed from time to time with varying degrees of success.

The First Schemes.—It is actually necessary to alter the number of electrons which reach the screen in the constant sized beam and so adjust the light intensity. The first proposal for effecting this was by means of the interposition of an additional electrode at some point between the cathode and orificed anode, the electrode, of course, being actually in the path of the beam. This is shown in Fig. 15 where A B represents the tube screen, and the orificed anode is indicated with its positive potential applied for the purpose of effecting acceleration to the electrons emitted from the cathode.

Placed between the anode and the cathode is the modulating electrode, the incoming signals being applied between this electrode and the cathode in order to produce the required variations. This electrode first of all took the form of

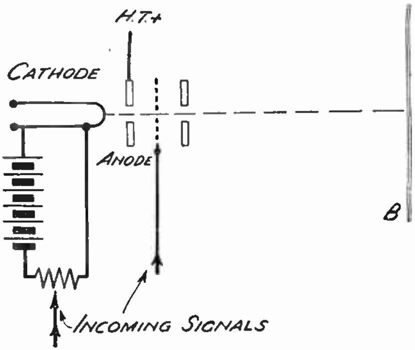


FIG. 16.—Another suggestion for intensity modulation which included a potentiometer control.

a fine mesh grid, and was then modified to a circle or loop of wire. Other alternatives were the proposals to place the grid mesh relatively close to the fluorescent screen after the ray had been influenced by both the accelerating electrode, and also the deflector plates, and the inclusion of two grids instead of one.

As far back as 1924 an idea was patented which in some respects is rather similar to present-day practice, inasmuch as it introduced a form of potentiometer control. The scheme is shown in Fig. 16, the control grid being positioned after the orificed anode, while between this grid and the screen was fixed in the beam path a second anode. This was also orificed, but not connected to any potential or part of the circuit, being included with the object of assisting in the focusing of the beam. The incoming signals were applied between the grid mesh and the moving arm of a potentiometer, which effectively altered the mean potential of the grid.

Drawbacks.—At first sight schemes of this character would seem to be quite satisfactory. Their object is to affect only the electron density of the cathode beam, and not to alter the electronic acceleration to a degree which will

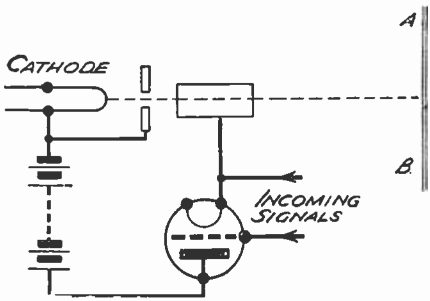


FIG. 17.—Including an amplifying valve in an anode modulation circuit.

manifest itself in the picture built up on the screen. This did not materialise in practice, however, and it was found that the beam focus was changed quite materially by alterations in the potential of this modulation grid by the applied incoming signals. The same remarks applied when the control grid was placed remote from the cathode, for then the modulation potentials have to be amplified very considerably to be in any way effective.

Yet another idea propounded was to modulate the anode, and this is shown in Fig. 17. Actually, the television signals were applied between the grid and the filament (cathode) of a three-electrode thermionic valve, the cathode of which was connected to a hollow cylinder in the beam path. Not only was the scanning velocity altered quite materially, but "mis-focusing" of the screen spot occurred, this resulting in a very material blurring of the fine detail and structure in the reproduced picture. Effects of this character are shown quite clearly in Fig. 18, where the resultant television picture that is illustrated is not only harsh, due to a measure of over-modulation (often referred to as " soot and white-

FIG. 18.—An imperfect image resulting partly from misfocusing and over-modulation.

wash " in modern television parlance and being synonymous with the overloading effects in a loudspeaker), but the measure of misfocusing has removed the detail from the face and hair and given a relatively coarse appearance.

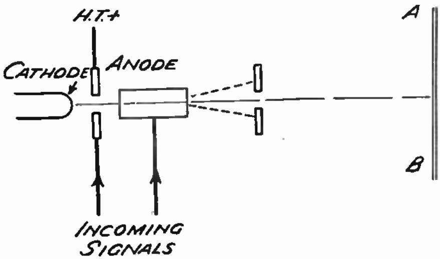


FIG. 19.—Interposing an apertured mask to cut off the electron beam in accordance with incoming signal intensity.

Cylinder Modulation.—A more workable scheme was first suggested some 12 years ago, and consisted in including a hollow cylinder in the beam path, but on the screen side of the orificed anode, as shown in Fig. 19. Between this and the screen A B was interposed a mask having a small aperture in the direct electron path, and the potentials were adjusted during the quiescent condition, so that the beam was focused on the screen. The effect of the incoming signals was such that the rays were made to diverge somewhat (shown by the dotted lines), and in this way a number of the electrons were cut off and prevented from passing through the mask aperture. This variation in the diameter of the bundle of rays impinging on the mask in the neighbourhood of the aperture was sufficient to give the modulation desired by adjusting the intensity of the ray passing through the hole.

Modern Practice.—With modern cathode-ray tubes used for television purposes, however, the Wehnelt cylinder

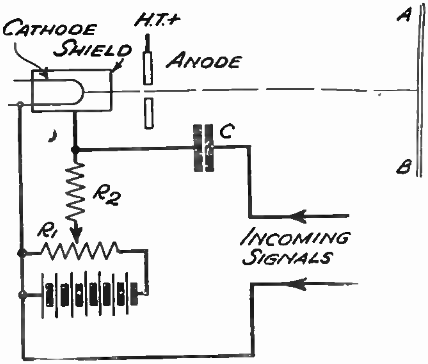


FIG. 20.—Simplified circuit of intensity modulation on the C.-R. tube shield.

actually surrounds the cathode (or filament), and this is supplied with a negative biasing potential to assist in the necessary process of fasciculation or beam concentration to a sharply focused spot on the screen. In addition the incoming television signals vary the potential difference of this cylinder with respect to the cathode, this serving to alter the intensity of the beam reaching the screen in conformity to the scanning potentials originally generated.

In Fig. 20 is shown the simplified scheme of connections for work of this nature. The initial negative bias is applied to the cylinder from the moving arm of the potentiometer

R_1. The modulating signal voltages are passed from the radio receiver to the cathode and cylinder *via* the fixed condenser C. In addition, however, a stopper resistance R_2 is included between the potentiometer arm and the cylinder for the purpose of preventing these modulation signals taking the relatively low impedance path provided by the potentiometer winding itself.

Results obtained by this method of intensity modulation are, in practice, very satisfactory, but as a general rule the nature of the electrode assembly is modified somewhat to

FIG. 21.—Showing the result of over-correction, and slight over-modulation.

prevent any of the picture defects (such as defocusing) detailed earlier from materialising. To give the reader an impression of the results which have been obtained under conditions simulating those of an actual service, reference can be made to Fig. 21. This is a radio-received picture obtained some time ago. A measure of over-correction and slight over-modulation is evident by the " shadows " thrown off from the face contour, but even so it proves very conclusively that a correct intensity modulated picture is replete with very minute detail.

This is emphasised even more when the difficulties associated with photographing pictures directly from the cathode-ray tube fluorescent screen in early apparatus are appreciated. First of all, there is the relatively small amount of light available coupled with the short time exposure required in order not to take cognisance of the normal artist movement consequent upon performing her actions before the television scanner. Then, again, under actual " looking-in " conditions there is the accompanying sound and the eye's visual persistence, which together impart a more natural effect to the pictures watched as compared to the signal picture photographed and reproduced as evidence of television's capabilities. It must be conceded, however, that the results are more than promising and, subsequent to this picture being taken, very material improvements have been effected.

CHAPTER VIII

RECEPTION ON C.R. TUBES

CONSIDERABLE time has been so far spent in detailing quite fully the various operating details and working of the auxiliary equipment used in conjunction with cathode-ray tubes, for it is felt that in this way the reader, when he comes to use this device for the reception of high-definition television pictures, will not regard his equipment as something complicated and dangerous, but rather look upon it as an intelligent means to a definite end, namely, better home entertainment. Furthermore, the home constructor will be in a far superior position to the person who buys a complete set (he always is, of course, but it is as well to bear in mind that the same conditions will operate with television transmissions as for standard radio conditions), for he can see exactly the function of each part, and can manipulate his controls with the full knowledge of the results which accrue from each of these variables.

Electrode Systems.—In dealing with the building up of a picture on the fluorescent screen by intensity modulation, mention was made of the steps which have to be taken to avoid any question of de-focusing, so as to keep the picture sharp and clear. This means that the complete electrode system must maintain the spot in its true electrical focus irrespective of the modulation voltages applied to the shield or cylinder. In consequence of this the electrode systems of modern "hard" cathode-ray tubes used for television purposes are something more than a mere cathode, shield, and accelerating anode (gun).

Just as in a very accurate lens-focusing system one, two, or more lenses are positioned at proper distances apart to give a sharp image, so in the cathode-ray tubes one, two, and sometimes three successive anodes or accelerators (no doubt we shall have standardised names for these various parts in the not too distant future, at least we hope so in order to avoid confusion) mounted at suitable points along the cylindrical section of the tube, and fed with positive potentials (increasing in magnitude as these electrodes approach nearer to the fluorescent screen) correlated one to the other.

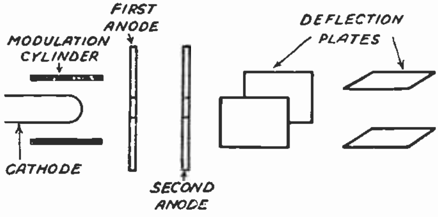


FIG. 22.—Adding a second accelerator anode to cathode-ray tubes for television reception.

Second Accelerator.—Complete details of these arrangements have not yet been made public in many cases, but as a case in point mention can be made of the Ediswan cathode-ray tube, type B.H. This has two accelerator plates as shown in Fig. 22, and according to the makers' rating these are supplied with positive potentials of 250–800 volts for the first electrode and 800–2,000 volts for the second electrode, that is the one farthest from the cathode. The shield, under these conditions, has applied to it a negative bias of 50–150 volts and becomes entirely the electrode concerned with varying the spot brightness as a result of the incoming signal voltages.

These two accelerating electrodes, in conjunction with the potential relation to the negative cylinder, accomplish electrostatically the focusing of the electron beam. In practice a fixed relationship exists between the positive voltages applied to these two electrodes, that is to say, an increase in second accelerator voltage requires a *proportional* increase in first accelerator voltage. The anode voltages and negative bias for the cylinder are nearly always furnished from a potentiometer arrangement of tappings connected across the main D.C. supply to the tube. This is called the power pack exciter unit, and many different schemes are used for this purpose. That shown in Fig. 23 however, will suffice for descriptive purposes, and is arranged to work in conjunction with the dual accelerator electrodes previously mentioned.

Supplies to the Electrodes.—There are many features which should be noted in connection with this power pack and exciter unit. First of all, the positive side of the H.T. supply is earthed, and, due to the high potentials required for television C.R. tubes, proper precautionary measures must be adopted to ensure that the insulation is adequate in every component position. The rectifying valve can be an MU.2 or one of a similar rating, and as will be seen it acts as a half-wave rectifier. Across this 2,000-volt H.T. feed is the series combination of fixed and variable resistances to furnish the correct electrode voltages.

In this case the second accelerating anode is connected to the extreme positive H.T. voltage through a resistance, while the corresponding first anode is linked to a potentiometer. By adjusting the movable arm of this component it is possible to determine the correct potential with reference to the first anode to give a correct spot focus. The feed to the cathode or filament is derived from a 2-volt accumulator, a coarse and fine resistance being included together with an ammeter to obtain a correct filament current. This cathode is joined to its appropriate point on the main H.T. feed. In this way resistance R_2 is negative with respect to the cathode, and it

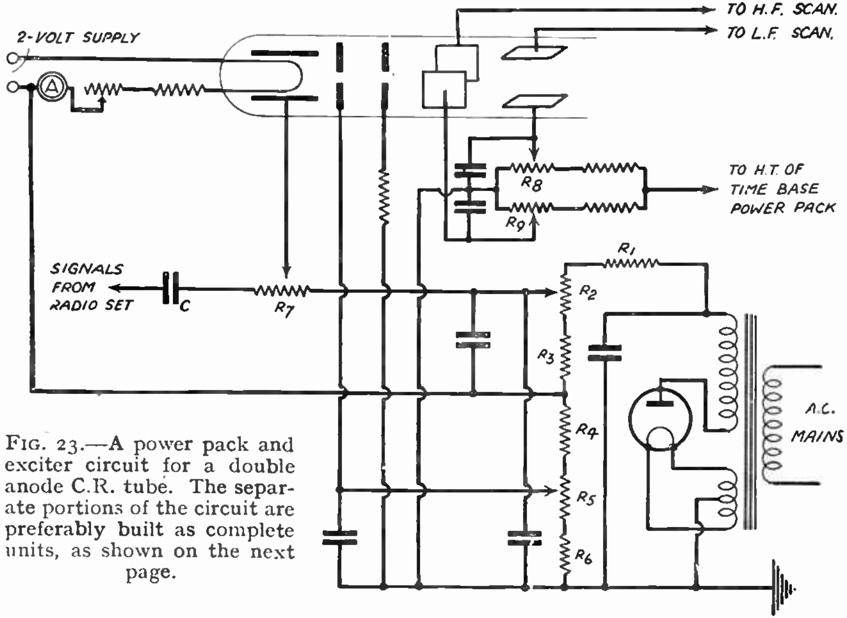


FIG. 23.—A power pack and exciter circuit for a double anode C.R. tube. The separate portions of the circuit are preferably built as complete units, as shown on the next page.

is from this potentiometer that the negative cylinder or shield potential is derived, being joined to the arm of R_2 through an input potentiometer R_7. Under working conditions the incoming television signal from the output circuit of the radio receiver is applied to R_7, through the medium of the fixed condenser C, which of course serves to isolate the cathode-ray tube proper from the radio set.

"Shift" Voltages.—Instead of one of each pair of the electrostatic deflector plates being joined direct to earth they return by way of a double potentiometer R_8 and R_9. This furnishes the "shift" voltage to which reference is made in an earlier chapter (batteries can be used if desired), and serves to adjust the position of the electron beam on the fluorescent screen in order to obtain a centralised scan. In this arrangement, therefore, as far as the exciter unit is concerned the potentiometer R_2 is adjusted to furnish the intensity of the beam and in some measure a degree of focus. R_5 is the prime focusing control, while the extent of the intensity

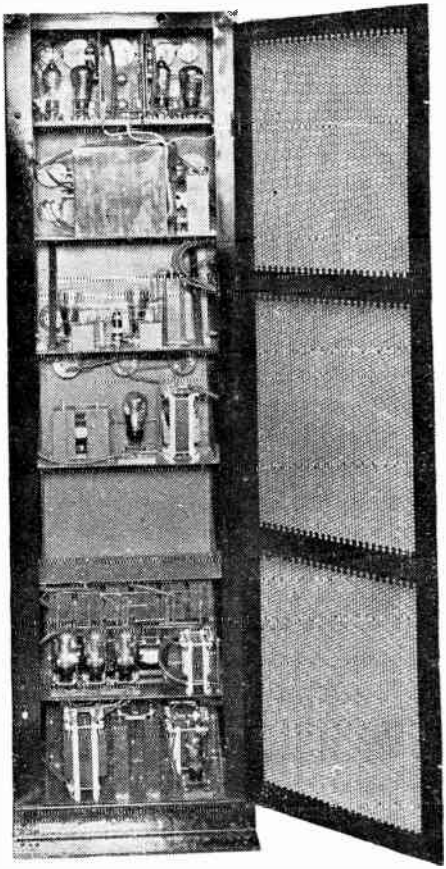
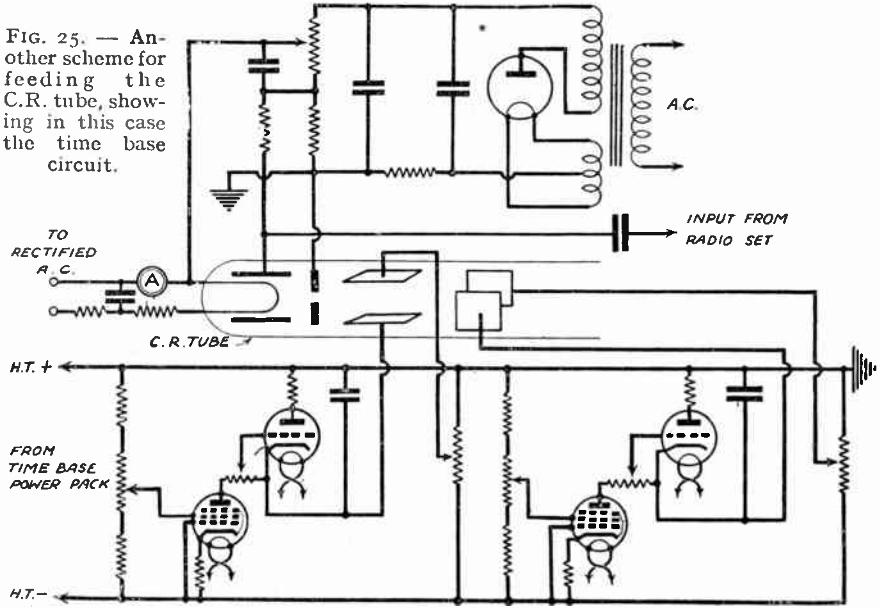


FIG. 24.—Sectionalising the various auxiliary units used in connection with a cathode-ray tube monitoring panel.

FIG. 25. — Another scheme for feeding the C.R. tube, showing in this case the time base circuit.



modulation which produces the final picture for a given radio signal input is governed by the amount of adjustment given to R_7 by the user of the tube. The anodes of the separate gas-filled relays of the time bases connect to the deflector plates in the manner shown in previous chapters, and in this way the beam is made to trace out the scanning lines either vertically for low-definition television, or horizontally for high-definition signals.

For ordinary reception purposes the complete equipment is not unduly bulky, and can be sectionalised into separate units if preferred. An interesting example of this practice as applied to a cathode-ray tube monitor panel, such as would be used to check transmissions, is furnished by a reference to Fig. 24. This tall unit has compartments allotted to separate functions. That at the top is the double time base unit, and gives a fair impression of the size of equipment of this character. Below this is the back of the cathode-ray tube—the tube projects out from the front panel of the assembly, being shielded by a metal cylindrical cover—together with the requisite focusing and brilliancy controls.

Another Arrangement.—The next two sections house the "B" or power amplifier and its power pack unit, while in the base are two compartments taking the mains eliminators for the time bases and the tube exciter unit. The whole scheme represents present practice for most monitoring or checking purposes, and by using an assembly of unit fashion it is more convenient for servicing or making alterations to parts of the circuit as required.

Yet another scheme for the complete time base and exciter unit is given in Fig. 25. Only one accelerator anode is shown in this case for simplicity, while the power pack and filament feeds for the time base have been omitted for clarity. The rectifying valve to furnish the gun volts is a SU2130 and, as before, half-wave rectification is employed. The cathode or filament of the tube is shown fed from a rectified L.T. source with a large electrolytic condenser to give proper smoothing. Shift voltages for the deflector plates are derived from potentiometers across the time base H.T. feed, the scanning potentials being fed from the cathode end of the fixed condensers joined in parallel across the pair of gas-filled relays.

Suppressing the Flyback.—Input signals from the radio receiver pass *via* the fixed condenser C, the appropriate negative bias to the shield (with reference to the cathode) being derived, as before, from a potentiometer device across the exciter power pack. It is as well to point out here that one of the precautions taken to obtain a television picture free from untoward blemishes is in connection with the elimination of the visual return stroke of the low-frequency time base. In many cases this will trail very noticeably across the fluorescent screen and tend to mar the picture.

One scheme adopted for suppressing this effect is to make the sharp rise of current in the low-frequency gas-filled relay, as the parallel condenser is discharged, produce an inductive voltage " kick " in the secondary of a transformer through the primary of which this current is caused to pass. By applying this kick voltage with suitable polarity to the modulation cylinder of the cathode-ray tube, a momentary static field is produced which will completely cut off the electron beam and so render the return stroke invisible.

In order to ensure that the active life of the cathode-ray tube shall be the maximum possible, it is necessary to treat it with the care it merits. One factor which has extended the life of this component when compared to its earlier prototypes is the inclusion of the negatively biased shield, which ensures that the bulk of the electrons emitted from the cathode reach the front fluorescent screen. The earlier gas-filled tubes brought about a rather intense cathode bombardment as a result of ionisation, and this caused a gradual destruction of the filament.

Preventing a " Burn."—While the application of a large positive potential to the gun or accelerating electrodes results in a bright picture, to prevent undue disintegration within the tube this should be kept as low as is convenient for the provision of pictures bright enough for normal observation. In addition, when using high accelerator voltages do not at any time allow the spot to remain at full brilliance and stationary on any one portion of the screen. This will " burn " the chemical surface and so bring about unnecessary damage owing to loss of fluorescence. It is for this reason that makers frequently recommend that adjustments to beam focus, intensity, etc., should be carried out when the spot is expanded into a single scanning line, or even made to cover its complete scanning area.

Again, it is a precautionary measure to switch on the filament supply first and allow this to become incandescent before the high tension is applied. When "shutting down" the reverse process will hold; that is, break the H.T. supply first and then the filament feed, as this will avoid any undue strain arising from the absence or decrease in the electrons available from the cathode when that electrode is allowed to cool.

Contrary to general belief, the modulation voltages required for the successful production of pictures on the C.R. tube screen is quite small. In many cases a change of negative shield bias of only 15 volts will give ample brilliancy. Quite moderate receiver outputs can be used, and in some cases the tube can be worked direct from the detector stage.

CHAPTER IX

RADIO RECEPTION AND TELEVISION

ALTHOUGH primarily our intention is to deal with questions made important as a result of the standard high-definition television service, it must not be overlooked that the cathode-ray tube is a very versatile piece of apparatus and adapts itself to the reception of different systems with ease.

Whereas with the high-definition signals the scanning is horizontal, with a picture ratio which has been settled upon as 5 horizontal to 4 vertical, with the original B.B.C. transmissions scanning was vertical with a 7 to 3 ratio. Then, of course, line dissection and pictures per second were different. These separate items are easily accommodated, however, by altering the values of the discharge condenser in parallel with the gas-filled relay in both the L.F. and H.F. time bases, while the picture ratio is met by adjusting the "sweep" voltages by means of the bias potentiometer on the grid of the gas-filled relays. Scanning directions are altered by interchanging the time base connections to the deflector plates.

The Cathode Ray Tube.—This case of adaptation is always cited as one of the principal advantages of the cathode-ray tube for television picture presentation. It is generally conceded, however, that the low-definition images, as seen on the tube's fluorescent screen, are not up to the standard of a good Kerr cell mirror-drum combination. As a rule, however, they are much easier to synchronise, and a steady image, even if not "clean cut," is regarded by many as superior to a bright sharp picture which floats or hunts about a mean position. When it comes to high-definition images, however, at the present stage of development the cathode-ray tube undoubtedly gives infinitely better results than mechanical methods.

Whether this condition will continue to hold is, of course, still a debatable point, and the onus is now on the mechanical system protagonists to improve or modify their designs to meet the more stringent conditions imposed by the television pictures which have 180- or 240-line definition, and a picture repetition frequency twice that of the original B.B.C. service. At first sight it appears that the mirror-screw scanner stands the best chance of achieving this with an intensely bright strip light source capable of adequate modulation.

Low-Definition Pictures.—Reverting now to the radio receivers suitable for linking to a cathode-ray tube when it is desired to look in at low-definition pictures, it may be stated straight away that, provided the set employed is a good quality one, with even a moderate output power, then the results obtained will be quite satisfactory. It is a common practice to resistance-capacity feed the output valve to the cathode-ray tube, and although there may be several detailed schemes in this connection, the skeleton arrangement shown in Fig. 26 gives a general idea of how this is done.

The signal input from the set is fed *via* a 0·1 mfd. high-working-voltage condenser (1,000 to 1,500 volt) to one end of a potentiometer R_1 whose function is to control the depth of modulation applied to the tube shield. The other end of the potentiometer connects to the negative shield bias, while the moving arm connects direct to the shield. The television signal also includes the synchronising signal as well as the picture modulation and, in the case of the low-definition operation, Fig. 26 indicates how the synchronising pulses of

375 per second (which were originally used) are fed to the grid of one of the gas-filled relays V_1 of the dual time base to ensure a correct triggering action.

Time-Base Locking.—A potentiometer is connected across the signal input and the moving arm is joined through a resistance and 0·1 mfd. coupling condenser to V_1. This valve, therefore, receives a regularly-timed impulse (its value is controlled by R_2) from the television scanner, and the anode is joined to the " sweep " plate of one pair of the deflector plates. Now there is a definite ratio between the line dissection pulse of 375 and the picture repetition pulse of 12·5, so the two separate time bases are " locked " together ensuring that one frequency is exactly 30 times the other. If this is not done there is a tendency for the picture lines built up on the fluorescent screen to wander across the screen and so upset the viewing conditions.

The simplest method for this is to introduce some of V_1's 375 pulse signal into the grid of V_2 which controls the picture repetition tuning. A ·01 mfd. fixed condenser and one megohm resistance, therefore, links the anode of V_1 with the grid of V_2. Of course, the gas-filled relay discharge frequencies are really independently controlled by the constants of their circuits, but their separate actions must be steady for proper working, and the triggering effect imparted to both grids of V_1 and V_2 ensures that this steadiness, once set to the required values, is maintained.

Ultra-short Waves.—Coming now to the radiation and reception of the high-definition television picture signals, the problem is not quite so easy of solution. First of all, the extremely wide frequency range demanded by these pictures rules out the use of medium- or long-wave broadcasting stations. The only available channels for accommodating these rigid requirements are those provided by ultra-short waves, that is, wavelengths below the figure of 10 metres. To many amateurs this introduces an entirely new radio technique, while even those who have worked with what are commonly termed short-waves will find that conditions differ when a migration is made to this lower region of the wavelength scale.

These waves of such short length (relatively speaking) and extremely high frequency (wavelength and frequency are

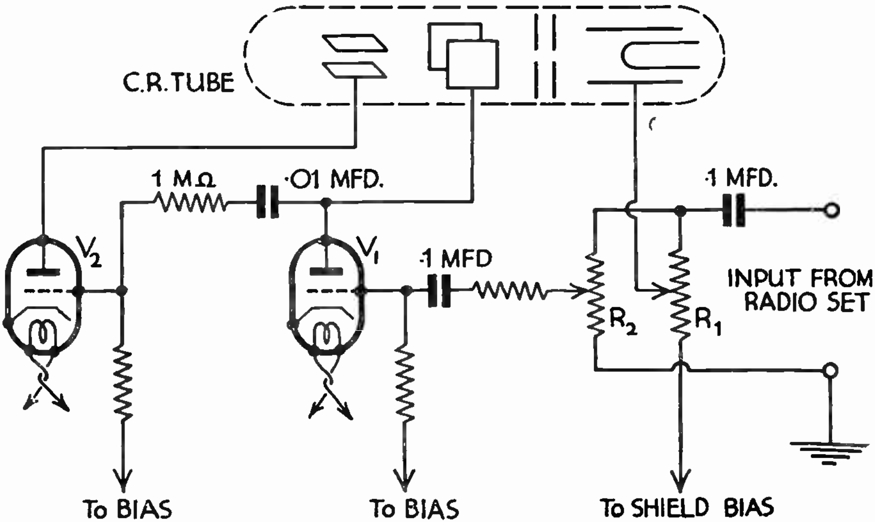


FIG. 26.—One arrangement for linking the signals from the radio receiver to the C.R. tube.

linked by the standard formula of wavelength multiplied by frequency equals 300 millions) establish communication from point to point by means of the direct ray. That portion of the electro-magnetic disturbance which goes in a vertical or inclined direction, that is, above the line which is tangential to the earth's surface, is not reflected back by the Heaviside layer as is the case with other wavelengths.

Quasi-Optical Properties.—It is for this reason that they are said to possess quasi-optical properties resembling uniform directed beams from a light source which sheds its rays in all directions. From this reasoning it is easy to see that the higher the location of the transmitting aerial with reference to the surrounding country, the greater will be the range over which these signals will extend.

The necessary aerials or radiating structures are not bulky or costly, and one example radiates the waves in all directions with equal intensity. On the other hand, these ultra-short-wave radiations can, when desired, be confined to a concentrated beam somewhat like that from a searchlight. An aerial structure for this purpose can take several forms, but usually a network similar to the radiating network is placed one-quarter of a wavelength behind it. This then acts as a tuned reflector and quite effectively neutralises any signal radiation to the rear of the beam. This scheme is in operation at the Alexandra Palace, where the di-pole aerial equipment is mounted on a special mast on one of the towers.

Other Advantages.—Since the carrier wave itself has an extremely high frequency (a 6-metre wave corresponds to 50 million cycles) it can be modulated quite readily with a very wide band of frequencies. As television progress is made and pictures with greater line definition become possible, the wavelengths which will be employed will become progressively lower, but at the present time from 5 to 7 metres form a very convenient medium for the work. Although, as has just been pointed out, in these ultra-high-frequency bands no ground waves exist owing to the high absorption while "sky waves" are lost, the direct ray which is used is free from fading, and this is an outstanding advantage. Furthermore, this advantage is supported by the fact that there are practically no atmospheric disturbances to mar or mutilate the picture in the form of light striations.

Of course, every advantage is accompanied by a corresponding disadvantage, and with ultra-short waves it has been found more difficult to build valves which will furnish very high powers, owing to the limitations imposed by the high-frequency effects in the valve construction. This is being overcome, however.

Field Strength.—Then, again, these waves are liable to be easily reflected from high buildings or objects in the path of transmission. This causes complicated interference patterns and standing waves, the latter being conspicuous as shadows when hilly districts are present. Tests have shown that a receiver will pass from a region of high signal strength on a hill-crest to one of almost negligible pick-up in a valley, and then emerge into strong signals again when out of the "shadow" cast by the hill from the transmitting aerial site.

Under any condition of environment a cathode-ray-tube receiver will portray a good television picture where the field strength is above 1,000 microvolts, while for those locations giving measurements of between 250 and 1,000 microvolts, a good picture is possible provided the receiving aerial is not within 50 yards of an arterial or main road. From 100 to 250 microvolts, results worth looking at will only be secured in quiet locations.

These latter considerations arise partly from the fact that "man-made" electrical disturbances, particularly those derived from the ignition systems of motor cars or aeroplanes as well as those induced from transmission lines, telephone lines, high-frequency or X-ray machines, and so on, cause trouble. In view of the very intensive campaign of attack against electrical interference of any man-made form which is now being conducted, it is reasonable to expect that the troubles from this direction will soon disappear. In any case, proper precautionary measures applied in the radio receiver itself can do much to neutralise the observable effects.

On the question of the radio receiver itself, there are three forms open to choice on these ultra-short waves—straight, superhet, and super-regenerative. Naturally there are protagonists of each class, and each has its own advantages and disadvantages.

CHAPTER X

RECEPTION FAULTS

RECALLING for a moment the picture building-up process involved, the scanning takes the form of a series of almost horizontal lines traced, say, from left to right and appearing in turn one below the other in sequence until an area in terms of light fluorescence is built up as shown in Fig. 27. Only a few lines are shown here, but in practice with such a high definition the lines will not be visible at a distance of a few feet from the screen, the eye appearing to see a plain, uniformly-lit surface within the picture-area limits.

With a signal modulation of the constant-velocity variable-density type applied to the control cylinder of the tube, the rapidly-moving spot of light of constant small area has its intensity varied during every moment of its trace to conform to the strength of the received signal, which in turn is generated by the light and shade of the scene being scanned at the transmitting end. Under perfect conditions of reception, therefore, the television picture watched will be really a reproduction in miniature of the indoor or outdoor scene, or the talking film which forms the subject matter, coming within the range of the scanning equipment at the transmitting end, whether this is mechanical or electrical in character. A television picture produced under such conditions as these, but having only 180-line definition, is shown in Fig. 28. Although seen as a mirror reflection from the end of the tube, it will furnish a good standard with which comparisons can be made.

A Focused Spot.—Before attempting to build up the scanning lines, or " raster " as it is now called, the first essential is a properly-focused spot small enough in size to prevent any line overlap. This size is, of course, a direct function of the maximum picture depth (assuming horizontal scanning) which can be accommodated on the circular C.R.-tube fluorescent screen. It is quite usual practice to specify tubes in terms of the diameter of the fluorescent screen, the units being either centimetres or inches. Thus, in a 12-in. tube one can very easily accommodate a rectangular picture 8 in. by 6 in. This will mean that the maximum spot size is a circle one-fortieth of an inch in diameter for a 240-line picture, and each individual line will then touch its

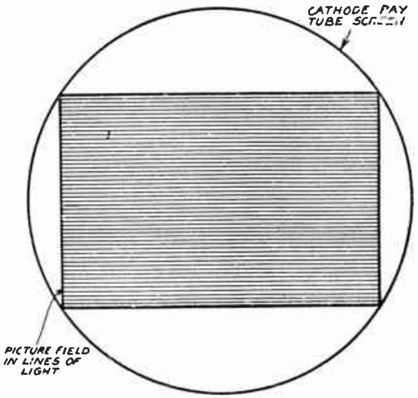


FIG. 27.—Utilising the full available screen space for building up the lines of light.

two neighbours. With smaller or larger tubes the spot sizes will, of course, be less or greater than this quantity.

Now to obtain a very small uniform spot of this nature is not the easy matter it at first appears. It is no good having a spot with a bright centre and a fringe of jagged light surrounding it. The spot must be sharply in focus, otherwise the image will have a fluffy appearance with no clearly-defined detail. This is shown very clearly in Fig. 18, although, in addition, the poor picture has also been contributed to by a large measure of over-modulation on the control cylinder, a point which will be referred to later.

Means Adopted.—In general the focusing of the beam of electrons into a sharp, clean-edged spot is effected by either electro-magnetic or electrostatic methods, although, in addition, results are often obtained by a combination of the two schemes. Focusing by magnetic means consists primarily of surrounding the neck of the C.R. tube with a large solenoidal coil whose position relative to the main electrode system can be altered, while the current through the coil must also be under the control of the user. The arrangement in its simplest form is shown in Fig. 13, and by carefully positioning the coil and making the magnetic field strength of the right magnitude the spot can be brought to the correct dimensions as a " pin point " of concentrated light, whose movement is then effected by the particular deflector system in use with the equipment.

With electrostatic focusing the scheme employed is really an electrical replica of an optical focusing system. In addition to the main accelerating anode, or gun, a further one or two anodes perforated with a small hole are placed certain distances away in the tube neck. By a suitable proportional adjustment of the positive potentials applied to these electrodes the electron beam is focused on the fluorescent screen, it being essential in this and other methods of focusing to maintain that focus irrespective of the spot position on the built-up field of lines of light.

Using both Methods.—In many cases an improvement in focus is brought about by combining electro-magnetic with electrostatic focusing, and with the present state of cathode-ray tube development it requires a measure of acquired

FIG. 28.—A properly-produced 180-line television picture, shown as a masked reflection in a mirror from the end of a cathode-ray tube.

skill to secure the desired size of focused spot. Any time spent in this connection, however, is well repaid, for the resultant picture seen by the observer exhibits a much cleaner and sharper appearance. That is why particular stress has been given here to this focusing question (technically known as fasciculation) so that the reproducing device has a chance to "start fair" before other faults are diagnosed.

Assuming now that the tracing spot is correct, attention must be turned to the line-scanned area which it builds upon the screen through the medium of pulsing electro-magnetic fields applied from external coils, or pulsing electrostatic fields derived from the two pairs of metal deflector plates set mutually at right angles inside the tube neck. Neglecting for the moment whether the H.F. and L.F. frequencies are correct, the first thing to watch is the sweep voltages. Different types of tubes require varying voltage limits for the condenser-charging action in the time base equipment in order to make the spot of light trace right across the screen and reach the full allowable picture depth. The voltage available is a function of the gas-filled relay, being dependent on the applied anode and grid voltages together with the factor known as the grid-control ratio.

Using a potentiometer in either or both of the grid and anode circuits, it is possible to widen the picture area and increase its depth, since the time base is a dual unit. The effects which one must guard against are illustrated simply in Figs. 10, 11, and 12. In Fig. 10 there is insufficient sweep voltage with both the horizontal and vertical deflecting plates, while with Fig. 11 the horizontal sweep is excessive and the vertical too small. Coming to Fig. 12, however, the effects of Fig. 11 are reversed. The two sweep voltage controls are entirely under the jurisdiction of the user, so that the rectangular-shaped picture of the true ratio conforming to the transmitted standards is readily obtained and can then be left set for the whole transmission.

Hum.—While on the question of time base it is as well to point out another very annoying fault which can be observed unless proper precautions are taken. The high-tension voltages required for feeding the time base, and also for supplying the anodes of the cathode-ray tube itself, are derived from A.C. mains rectifier units. The presence of mains transformers is liable to cause leakage fields unless careful shielding or statically-wound components are in use. Any 50-cycle mains disturbance which finds its way into the time base generator equipment will cause the normal vertical edges of the rectangular light field to become wavy. With the full number of lines in use and working at 25 pictures per second, two complete sine waves will be noticed at each edge, somewhat as shown in an exaggerated form in Fig. 29.

Obviously, this will distort the picture very badly, and steps must be taken to remove the A.C. mains hum if pictorially good results are the aim of the user of the cathode-ray equipment. For radiated high-definition television signals using the medium of ultra-short waves a certain number of the total 405 picture lines are masked off at the bottom of the " raster " (this is, of course, carried out at the transmitting end) in order to provide the short time duration of the low-frequency or picture-repetition synchronising pulse. Therefore, the received picture under these conditions, and assuming an induced time base hum, will not show two complete sine waves, since part of the second one at the bottom of the scan is not seen owing to the " black " syn-

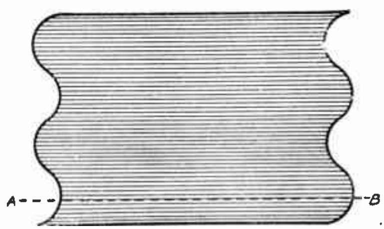


FIG. 29.—A wavy edge in the scanning field is brought about by " hum " in the time base.

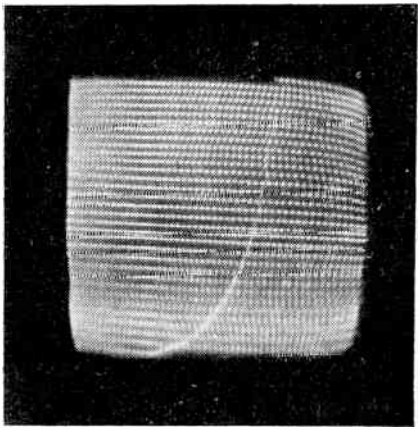
chronising signal. Thus, the cut off would probably be at the line A B in Fig. 29, but in spite of this the effect illustrated is most annoying, and must be removed at its source without delay. It is as well to point out here that with an interlaced form of scanning this hum effect may be even more damaging. This is easily appreciated when it is remembered that every other line is traced for the first picture while the second picture trace fills the interstices between the original lines. If the hum is very bad the effect can become almost intolerable, and in some quarters this is regarded as an objection to interlacing when compared to the linear sequentially-scanned picture.

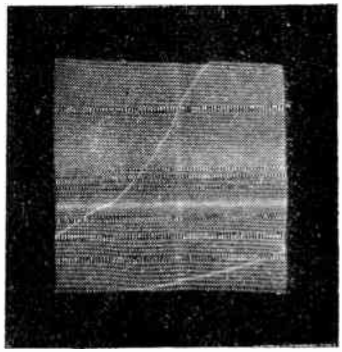
Since the cathode-ray tube is a wholly electrical device, and the user is controlling the operation of a stream of electrons which move with enormous speeds within the glass envelope (evacuated of all trace of gas for most television purposes and hence known as hard tubes), it is only natural that the performance of this device is one susceptible to many outside and inside influences. The very nature of the scheme adopted for reproducing the received television picture makes this so, and in a previous chapter several of the faults which may arise and the methods which can be employed to eradicate them were described at length. In the notes which follow it is proposed to give the reader details of other defects.

Double Modulation.—The question of non-linearity of scan has been mentioned and will be remembered as a defect located in the dual time base. It arises from a reduction in the uniform velocity of the H.F. and L.F. scanning traces and can only be cured by a more careful design of the equipment involved and the use, in the case of H.F. pentode time bases, of valves whose characteristics exhibit constant anode currents over a wide voltage variation.

Another point which should be noted in this connection, and one which is overlooked invariably, is that this change of scanning velocity brought about by non-linearity has a modulation effect. For a given beam cross-section the intensity of the spot trace (apart from its intensity modulation) is a function of the speed with which it moves over the fluorescent screen. Slow movement gives a bright trace and fast movement a dim trace (the terms " fast " and " slow " are, of course, purely relative one to the other), so that, although intensity modulation demands a constant trace velocity, there will be a secondary modulation at the ends of the line trace due to this reducing trace velocity, and this causes a brightness variation which tends to destroy partially the true television picture formation. This, of course, is apart from the more noticeable picture trace distortion, and is yet another reason for avoiding non-linearity in the time base trace.

Parasitic Oscillations.—If by faulty design parasitic oscillations are present in the equipment, the built-up line scan will give the appearance of being modulated. When the spot is focused sharply this may appear as wavy lines, and in Fig. 30 is shown an actual low-definition light field scan exhibiting this defect. One way to cure the trouble is by employing earthed metal shields round the cathode-ray tube electrode system. The result of this is very clearly demonstrated in Fig. 31, where a photograph has been made of the same scan but with the disturbing oscillation removed.





FIGS. 30 and 31.—(*left*) Showing the effect of parasitic oscillations (*Above*)—A view of the scan on the left with the oscillations removed.

Incidentally, this same photograph portrays very prominently yet another possible defect, giving the appearance of two bright axes at right angles. The peculiarity has been termed very frequently the white cross effect, but it should be noted that this result is only noticed as a rule when there is some form of gas-filling present, and, as was mentioned earlier, for television picture reproduction nearly all the tubes used are classed in the hard (exhausted) category. It arises from ionisation effects, producing a conducting current between each pair of deflecting plates. To eliminate the effect the electrode system can be made asymmetrical inside the tube itself, when the axes are then transferred to the edge of, or even beyond, the observed scanning field.

The Flyback.—Also in Fig. 31, the return stroke or flyback of the spot to its initial position after the L.F. time base has triggered is very conspicuous. This will naturally mar the picture, but under service conditions it is arranged that the flyback is submerged in the rectangular shaped L.F. synchronising pulse, which is located in the black region of the signal, and is therefore not visible. One way of eliminating the flyback, however, is to arrange for the sharp rise of the current in the gas-filled relay as it ionises to give an inductive voltage "kick" in the secondary of a transformer, through the primary of which the current is caused to pass. By suitably arranging the polarity this voltage kick can be applied to the cathode-ray tube's modulating cylinder, and the effect is to black out the beam and so render the return stroke quite invisible.

Hum Bands.—In the previous chapter reference was made to the deleterious effects of 50-cycle A.C. mains hum in the time base generating circuits. If a similar hum is induced on the light-modulation cylinder of the tube through bad

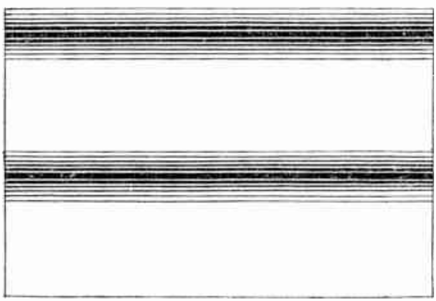


FIG. 32.—50-cycle hum bands in a scanning trace repeated 25 times per second.

screening or inadequate power-pack smoothing in the gun-volt supply, there will be an alternate darkening and lightening of the scanned field, in the form of zones or bands. This is shown in Fig. 32, for a horizontally-scanned picture, and if the hum is severe this will completely spoil the picture, just as in an ordinary radio receiver mains hum will drown the programme sound heard from the loud-speaker.

With a 25-picture-per-second repetition the 50-cycle hum will exhibit two light and two dark bars which, under properly synchronised conditions, will remain quite steady. Any lack of synchronism will be exhibited by the bars moving up or down according to whether the picture speed is greater or less than the required figure. From an examination of the cause mentioned previously the cure is obvious, namely, much better smoothing and/or more careful attention to the screening or earthed shields, which will prevent such an induction on the modulation electrode.

A Neutralising Field.—Since the very nature of the electron stream makes it highly susceptible to both electric and magnetic influences, it is possible that the reconstituted picture may appear slightly out of centre. Careful lay-out and the elimination of stray fields will do much to overcome this trouble, but even then the picture may be deflected or turned as a whole. This can be corrected and normality restored by using either a permanent magnet or a coil

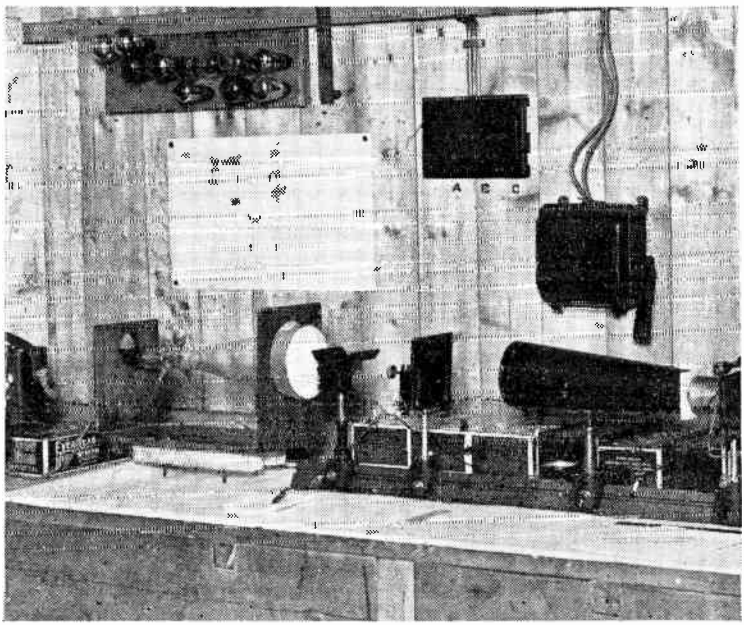


FIG. 33.—Photometric equipment involved in C.R. tube luminosity tests.

carrying direct current suitably placed with reference to the tube. The resultant magnetic field will then neutralise the stray one, and in practice it is found better to use a relatively powerful field located at reasonable distance from the tube in lieu of a weak field in close proximity.

Picture brightness is another important factor, and within the limits set by the tube's rating is under the control of the user. Originally it was thought that television pictures reproduced on a cathode-ray tube screen would not be bright enough for comfortable observation at home. This has now been disproved by practical demonstration, while in the laboratory luminosity tests have been undertaken to obtain proper quantitative data. The photometric equipment involved is quite simple in character, and in Fig. 33 is illustrated material laid out for this purpose. When using an actual receiver do not have the screen brighter than is necessary, otherwise there may be a tendency to overrun it with a consequent decrease in useful life.

Modulation.—Coming now to modulation, it is essential that the tube should give a constant spot size over the range of cylinder voltage required to give the full depth of modulation. Even assuming that the radio receivers and amplifiers are capable of accepting and passing through each stage television signals without mutilating them, the observed picture will lack detail if the spot is misfocused or fluffy. Again, contrast will be lacking if instead of the spot darkening with decrease of signal intensity it expands. These factors necessitate a very careful voltage adjustment over the several electrodes, so that within the working range of signal voltage only electron beam intensity is altered.

Pictures can have an excess or deficiency of high frequency. In the case of the former multiple images will appear giving a throw off at the trailing edges of the vertical lines in the picture. Frequency cut-off will show itself as an absence of detail, just as in the case of an ordinary low-definition transmission.

Overloading.—Just as it is possible to overload an ordinary thermionic valve, so the cathode-ray tube can be overmodulated. Harsh, dark pictures will then be seen somewhat as indicated in Fig. 18. The remedy is, of course, to reduce the signal input through the appropriate volume control.

It is only by experience that the proper balance between all the variable quantities can be obtained, but if attention is paid to the various points which have been outlined the experimenter will be rewarded with results which will surprise him for their quality.

CHAPTER XI

C.R. TUBE FOCUSING

In every type of television receiver of the home constructed or commercial type, there are several controls made available for the user and although under normal viewing conditions none of the knobs need be touched, the importance of each control should be appreciated. One whose function is so often misunderstood is the focusing control, for unless left set in its correct position it can mar completely what may otherwise be a perfectly satisfactory picture. Since there are two types of cathode-ray tube available, two distinct methods of focusing are employed, but although the "means" are different, the " end " is the same, that is a sharp clear picture on the screen of the tube.

A Lens Combination.—Anyone who has handled a camera or any form of optical system whether simple or complex, realises that one or more lenses in the equipment must take up relative positions with reference to the plane in which the image is being viewed, in order to secure a sharply defined optical replica of whatever is under observation—a scene, person or object. A coarse and fine mechanical adjustment of the lens' positions ensures this happening, otherwise the image is fluffy and imperfect ; detail is lost and narrow lines become widened so that the combined effect is to destroy the identity of the subject under observation. Exactly the same sort of thing can happen with a cathode-ray tube picture reproducer, except that now we are dealing with a stream of swiftly moving electrons instead of light rays.

Taking the case of the electrostatically operated cathode-ray tube first, it must be remembered that the early tubes relied on the presence of gas inside the glass bulb in order to give the focusing action. This inert gas was ionised by the impact of the electrons moving at high velocity as a result of the combined action of the anode and cathode. This ionised gas then formed a kind of guiding path for the electrons, and by adjusting the cathode current it was possible to secure quite a good focused spot on the screen. The introduction of a negatively charged cylinder partially surrounding the cathode as shown in Fig. 34 was the next step forward. The electric field produced by the cylinder had a constricting effect on the electron stream, and concentrated them so that a larger number passed through the accelerating anode hole.

Maintaining Modulation and Focus.—For television purposes, however, no trace of gas should be present inside the

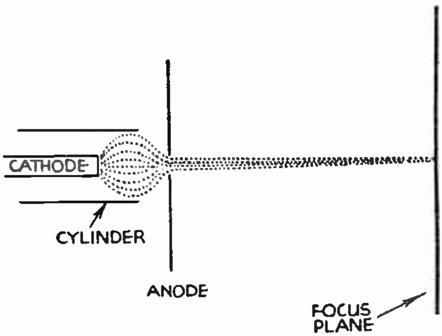


FIG. 34.—Showing the constricting effect produced on the electron stream by the negatively charged cylinder.

tube. Normally, with a gas-filled tube of the simple type the voltages applied to the anode and cylinder are interlinked with one another. As the incoming television signals are applied to the cylinder electrode, however, it is easy to see that the depth of modulation of the signal not only altered the intensity of the beam which is correct, but also altered focus. Hard tubes are now employed, therefore, the cylinder or modulator as it is called is given the sole function of intensity modulating the electron stream, and the task of maintaining correct spot focus, that is a spot of constant size but of varying brightness irrespective of its position on the screen, is undertaken by a combination of anodes. These anodes, generally up to three in number, are fixed in predetermined positions inside the tube electrode assembly and are frequently termed electron lenses owing to their similarity of action to ordinary optical lenses. A typical commercial assembly of this type is illustrated in Fig. 35 which shows a Cossor high vacuum tube for television receivers.

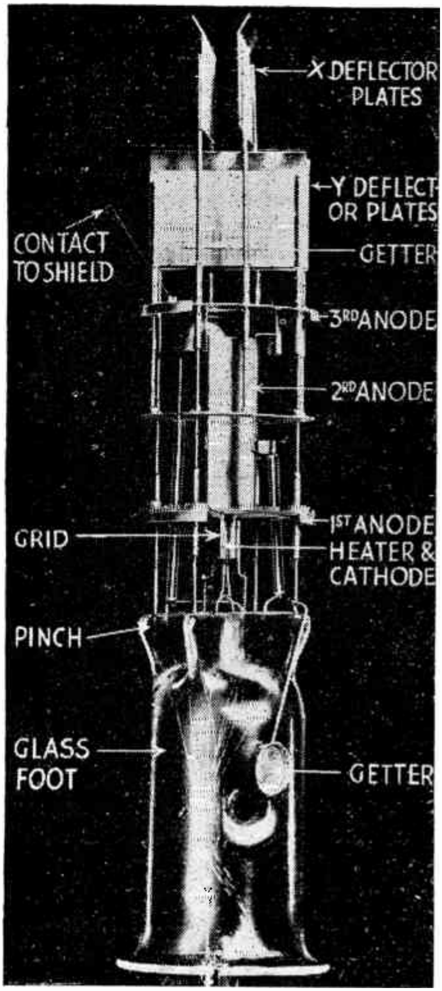


Fig. 35.—A typical electrode assembly for a commercial electrostatically-operated C.R. tube for television.

An Analogy.—To better understand the action of these anodes reference can be made to Fig. 36. A beam of light from the point X is passed through a pair of lenses and whereas on entry into the lenses the beam was diverging, on exit it is converging, becoming a fine point of light in the plane A B at some definite setting of the distance between the lenses with reference to X. This action is, of course, a very familiar one and electron engineers have "borrowed" the principle for application to cathode-ray tubes. The glass lenses are replaced by discs having a centre perforation or cylinders with holes at each end.

Since it would be unpractical to move the positions of these anodes, as they are called, inside the tube neck, they are fixed in place and the positive voltages applied to them are graded. This produces a series of electrostatic fields which guide the electrons in the beam over a definite path. To take a practical case the first anode may have applied to it a positive voltage covering the range of 150 to 400 volts; the second anode a fixed potential of 1,200 volts; while the third anode is given the highest voltage of 6,000. By arranging a potentiometer to alter the first anode volts between the makers' specified limits, the spot seen on the screen is focused to a sharp clear outline of very small dimensions—a condition very essential for high-definition television working where such a large number of lines must just fill the available picture height.

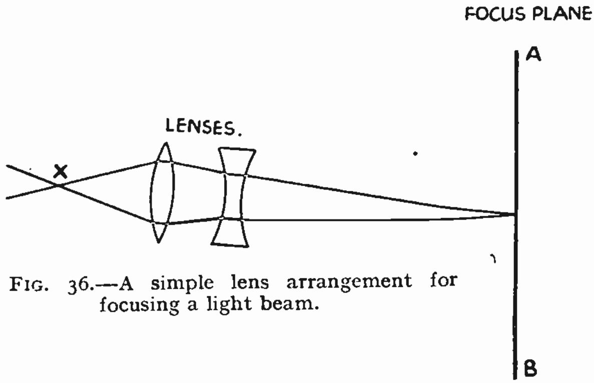
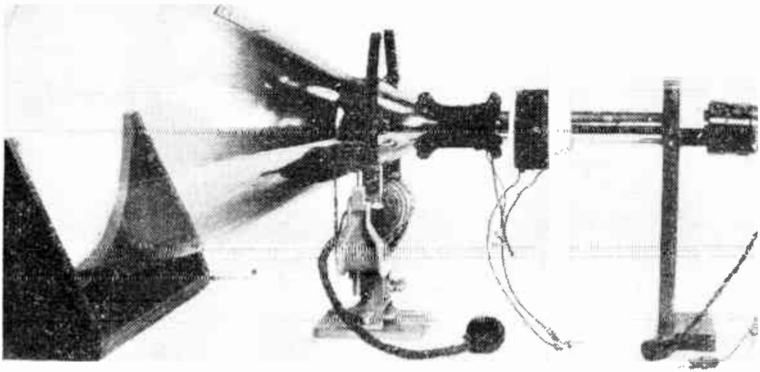


FIG. 36.—A simple lens arrangement for focusing a light beam.

For example, with a picture 8 in. high and 400-line definition, the spot diameter must not exceed a fiftieth of an inch if overlap is to be avoided. With a multiple anode arrangement of this nature the cylinder or modulator electrode is left quite free to control the intensity of the beam of electrons which pass to the anodes. This it can now do without in any way upsetting focus and produce a full range of brilliance from light to dark with a relatively small range of signal volts—something between 15 to 30 volts according to type. A simple rotation of the focus control knob incorporated in the television receiver will ensure that the picture is adjusted to suit individual tastes.

Magnetic Focusing.—With those cathode-ray tubes which are operated electro-magnetically only a cathode, modulator and single anode constitute the whole electrode assembly. The scheme adopted for focusing, therefore, must be one which performs its function external to the neck of the tube. For this fasciculating action the rather complicated multiple anode assembly is replaced by a solenoidal coil of wire slipped

FIG. 37.—Showing the solenoid focusing coil and deflecting arrangement on a cathode-ray tube.



over the neck of the tube between the anode position and the line scan coils. This mode of assembly is seen very readily in Fig. 37 which indicates the focusing and scanning arrangement used by the Baird Company in one of their receivers. When a direct current is passed through the coil it produces the familiar type of magnetic field. The electron beam which diverges as soon as it leaves the tube's orificed anode comes under the action of this field. The effect is to rotate the beam so that the electrons follow a spiral path towards the screen. This spiral traverse is brought about by the axial velocity of each electron (a negatively charged particle of electricity) combining with the lines of force of the magnetic field.

A somewhat similar corkscrew or twisting action to the electron beam is brought about in the image dissector tube used in the original Baird electron camera at the Alexandra Palace. The degree of twist is a function of the strength of the magnetic field which of course for a given coil dimension is dependent on the magnitude of the current fed round the coil turns. In effect the coil becomes a very efficient type of lens system and avoids the necessity of using carefully graded anode voltages.

An Advantage.—Another important advantage of magnetic focusing is that the tube can be " set up " very readily on site. The coil is mounted over the tube neck so that it can have an angular movement within certain predetermined limits. If it is found that the spot is not circular but changes from a narrow horizontal ellipse to a narrow vertical one when the focus and current is altered, the angle of the coil can be manipulated to give the desired minute circular spot of light. This is done by a trunnion coil support or shaped wedges. Another factor associated with this form of tube, apart from the cheaper electrode assembly and lower manufacturing costs, is that defocusing of the spot does not occur when the brightness of the spot is altered for any particular reason in the television receiver. The merits and demerits of the two types of tubes with their respective focusing arrangements is a matter which cannot be discussed in this article. As far as the set user is concerned the control in both cases consists of the movement of a single knob attached to a potentiometer type resistance. From the points which have been enumerated, however, the reader will understand more clearly what is happening during the operation and the importance of handling this control intelligently must never be lost sight of.

CHAPTER XII

SINGLE CONTROL OPERATION

MANY amateurs meeting for the first time a commercial televison receiver are intrigued by the fact that the vision receiver is not provided with a tuning control. In most cases the television receiver is arranged so that when switched over to the television band a small trimmer knob only is operated and this tunes both the sound and the vision programmes. To obtain the correct adjustment the operator adjusts this trimmer until the sound is correctly tuned, and automatically the picture is then obtained at its best, except, of course, for adjustments of brilliancy and focusing. There are several reasons for this method of arranging for tuning,

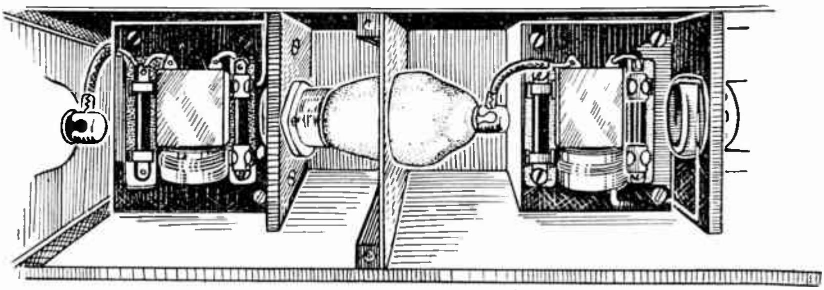


FIG. 38.—One method of building the I.F. stages of a vision receiver to reduce losses.

apart from a simplifying of the controls, of which there are already a large number in a combined television and radio receiver. Firstly, the vision programme occupies a band of about 5 mc/s. Those amateurs who are used to handling a modern highly-selective receiver will know that as the set is put " off tune " the side band cutting which takes place results in the speech being distorted and this is very noticeable. In the case of a very flatly-tuned receiver (such as a simple crystal set for instance), one may put the set many degrees off the correct tuning point and no ill-effects of any kind are noticed. Thus, in the television receiver, it would be possible to put the receiver many kilocycles off tune so far as the vision section is concerned and on the majority of scenes broadcast no ill-effects would be noticed. On titles and certain scenes, however, the distortion would show up in various ways, according to the degree of mis-tuning. Therefore, if the vision receiver is in some way locked to the tuning of the sound receiver, it will be possible to adjust the vision to the exact resonant point, simply by tuning until the sound is clear, and this accounts for the usual method of arranging the combined sound and vision receiver.

Circuit Arrangements.—There are, however, several methods of carrying out this single tuning scheme, but the majority of them depend upon careful and accurate

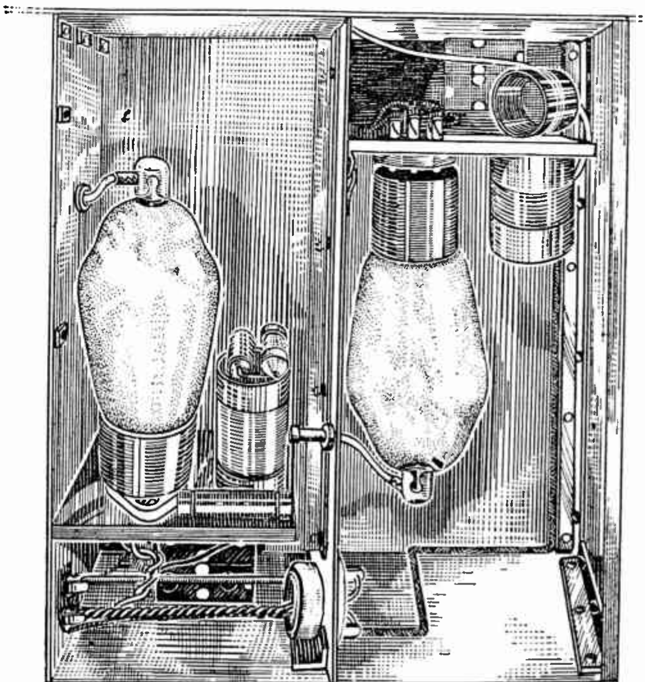


FIG. 39.—An alternative constructional scheme which prevents some of the wiring difficulties met with in the scheme shown in Fig. 38.

alignment of circuits with suitable oscillators and other instruments found in the factory but not in the hands of the average experimenter. No doubt the simplest scheme for the home-constructor is to build the vision section of the receiver as a complete unit, paying all the care and attention to detail necessary to produce a first-class picture. For this purpose inter-valve couplings must be very carefully arranged, and losses in the leads from the anodes must be avoided by keeping these as short as possible. In most cases this means that adjacent valves must be inverted so that the anode of one stage is in one direction and that of the other in the opposite direction. Each stage must also be adequately screened, but it will generally be found that screening of the anode by means of the popular screened cap connectors is inadvisable in view of the high capacity to earth which may be introduced.

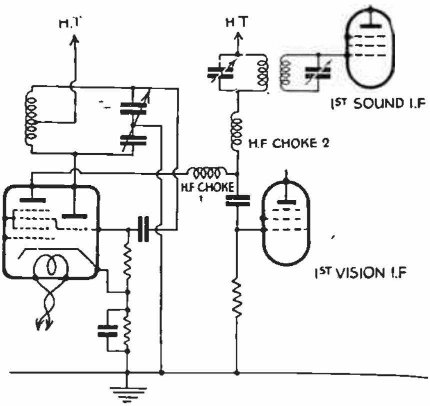


FIG. 40.—Skeleton circuit arrangement of the input for combined sound and vision receivers.

Tuning.—A superhet will obviously be employed, and the frequency-changer which is found to provide best results on the ultra-short wavelenths is the combined triode-hexode or similar multi-valve. The output from this stage should be arranged to provide two intermediate frequency beats and fed to a stage containing two I.F. circuits, one adjusted for the vision and one for the sound wavelength. A typical arrangement is shown in Fig. 40, where the anode circuit is tuned by a split condenser which gives rise to the two required intermediate frequencies. For the sound section the ordinary type of I.F. transformer may be employed, but for the vision there are a few alternative schemes, one of the most popular, which is favoured by many manufacturers as well as by many constructors, is the single-sideband arrangement in which ordinary chokes are provided. This avoids certain constructional difficulties and does not require trimming in each stage.

CHAPTER XIII

CUTTING OUT STATIC INTERFERENCE

THE main cause of electrical static on a television programme, embracing both sound and vision, may be attributed to the ignition systems of motor vehicles. Through the loudspeaker it is heard as a burring or staccato noise of regular beat, but increasing and then dying down in intensity as the offending vehicle passes along the highway, close to and then away from the aerial system. On the screen it manifests itself as a mild snowstorm, sometimes causing drift in the synchronisation or even complete temporary wipe-out of the picture.

Another and fortunately less common form of interference is that due to electro-medical apparatus. Whereas the ignition static is rarely radiated more than 200 yards, that due to medical apparatus, such as diathermy machines, X-ray, violet-ray and similar appliances, creates complete wipe-out many miles from its source. It has been heard as much as 2,000 miles away!

Ignition Static.—Electrical and natural atmospheric statics heard on medium and long wavelengths rarely affect the 6 to 7 metre band which is now used for television purposes in this country. On the other hand, it so happens that ignition static is at its greatest intensity between about 7 and 12 metres, due to the inherent inductance and capacity of magnetos and spark coils providing their natural resonances over those frequencies.

From the very outset it should be made clear that for both the cases cited, complete freedom from interference is a matter for legislation, by compelling all car owners, hospitals and makers of home violet-ray outfits to silence, in a radio sense, the offending apparatus. Whereas such legislation will prove inevitable in course of time, it is desirable to be familiar with such devices as are available at present to reduce the static to bearable proportions. In other words, steps taken at the receiving end can only be considered palliatives, and not complete cures.

Most forms of di-pole, doublet and double-doublet aerials are suitable for television reception and when

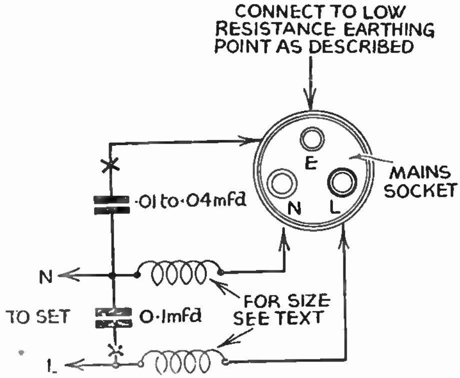


FIG. 40A.—Connecting an H.F. filter to a 3-pin mains point.

erected directionally, that is, in optical relationship to the transmitter, will provide a large signal pick-up with a relatively low static accompaniment. Under these conditions the aerial is not made noise-proof but provides a high signal-to-noise ratio. Matters can be further improved by erecting the aerial as high as possible above surrounding objects and additionally, keeping it as far from highways as space and circumstances will permit. A long lead-in often necessitated is no detriment, as by proper impedance matching, its losses can be reduced to a negligible amount.

Aerial Screening.—With a vertical television aerial, it is possible to screen it by means of a similar vertical wire half a wavelength away, or by a parabolic reflector consisting of a number of such wires spaced over half a circle of half a wavelength radius. The latter aerial, while somewhat cumbersome, is immune to static radiations except in a line corresponding to that of the transmitter (at the open end of the array).

To render all forms of television aerials most effective, particularly under the conditions outlined, the receiving equipment must be *completely* screened. Minute signal pick-up without the aerial must not be tolerated, a condition which can be satisfied by increasing the sensitivity to maximum without the aerial to see if reception can be achieved, and adding screens where found necessary.

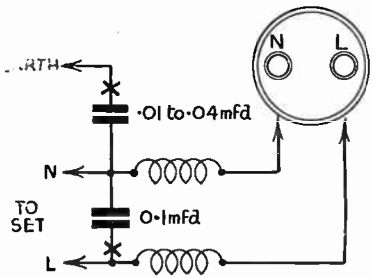


FIG. 41.—How to connect the filter to a 2-wire mains system. It is necessary to ascertain correct polarity by testing with a lamp between each pole and earth. The one which lights the lamp is "L" (live).

Although in the usual way a good earthing connection is not essential with a di-pole aerial system, yet it sometimes happens that another point of earthing will alleviate an obstinate case which does not otherwise yield to treatment. A direct earth connection by means of a very heavy insulated wire or copper strip, ½ in. by 20 S.W.G. to a buried zinc plate or a copper tube about 3 to 4 in. in diameter will provide a low D.C. resistance path. Use preferably heavy bolted and soldered joints, finally taped or painted over (as if the installation is for an electrical sub-station).

Mains Filters.—A mains filter must be looked upon as a necessity and should be introduced at the local power-point used for the receiver. Those designed for normal broadcast reception are useless unless augmented with small H.F.

chokes possessing high impedance at 6 to 7 metres, and capable of carrying the current passed by the equipment. Coils of about 10 turns or less, close wound, of No. 20 S.W.G. D.C.C. or D.S.C. wire wound on 1½ in. diam. formers will provide a reliable starting-off point, provided they are used in conjunction with non-inductive 1,500-volt D.C. test condensers, in accordance with B.S.S. No. 613.

The object of this mains filter is to act as an efficient by-pass to mains-conducted interferences at low wavelengths. Due to the possibility that interferences may be existent at wavelengths above or below the television range, the chokes are made of larger inductance than 6 to 7 metres, to prevent shock-excitation effects. By adding suitable capacity condensers, high frequency interferences flowing along the mains wiring will be localised and returned to earth. A value of ·1 mfd. across the A.C. mains leads and a value of between ·01 and ·04 mfd. between neutral and earth should prove the most effective (see Figs. 40a and 41).

Fuses.—Fuses in series with the condensers are not essential, but if desired, can be introduced at the points marked X on Figs. 40 and 41. The type which is ¾ in. long, capacity 2 amps. each, is the most suitable. A small wood box can be used for mounting the filter parts, and as previously explained, the complete filter may be used in conjunction with a normal existing one so as to provide complete mains filtration at all wavelengths.

CHAPTER XIV

PROJECTING TELEVISION PICTURES

WITHIN recent years the protagonists of cathode-ray tube picture reproduction have furnished their answer to the larger type television pictures reconstituted through the medium of mechanical scanning methods. In many quarters it had been widely stated that only with the aid of mechanical scanning schemes coupled with brilliant light modulation would it be possible to show large size television pictures capable of being received in comfort in a large room or a small hall. The projection-type cathode-ray tube had been dismissed as incapable of undertaking such a task, but recent developments have given the answer to the critics.

More Recent Demonstrations.—For some time these projection C.R. tubes have been working in different companies' laboratories, but little information has been forthcoming because the problems associated with large television picture reconstitution by electronic methods have been both diverse and intricate. That very material progress has been made, however, was substantiated when at the opening of the television exhibition at the Science Museum, South Kensington, the Baird Company installed a complete television receiver incorporating a projection tube and a remote screen. Perfectly satisfactory pictures had been shown on this set in the laboratories, but at the exhibition in question it was displayed in a section where actual reception of the B.B.C. pictures was not allowed. The brilliant and large scanning field, however, seen by those members of the public operating the apparatus left no doubt as to its technical efficiency.

Following on this came the R.C.A. demonstration in America, where actual pictures over 10 ft. wide reproduced by a projection C.R. tube were shown to radio engineers at an annual convention. Next we had two or three companies showing a home type set capable of giving pictures up to 3 ft. wide using a similar device. The harnessing of the electron beam in a cathode-ray tube of special design for the production of large pictures is certainly one of television's major developments, and although certain factors at the moment make it a high-priced product greatly in excess of normal cathode-ray tube television receivers, there is no doubt that in the future the scheme will become a practical commercial proposition.

Development.—It is opportune, therefore, to examine some of the problems involved, and see how the modern projection C.R. tube differs from its earlier prototype. The first cathode-ray tubes used for picture reconstitution on the fluorescent screen at the large end of the conical shaped glass envelope gave images which were not very brilliant. Very careful investigation into the chemical combination of the powders used for the screen, coupled with accurate design of the electrode assembly, and the application of final anode voltages in the neighbourhood of 4,000 to 6,000 volts soon overcame this difficulty. Many of the pictures seen on the sets shown at Radiolympia in 1939 were outstandingly brilliant, so bright in fact that they could be watched comfortably and without eyestrain either in daylight or with ordinary room lighting. This has removed the objection of room activity restriction which followed the earlier necessity for complete darkness when watching the B.B.C. television transmissions.

The tubes themselves were then reduced in size, and the brilliance of the picture reproduced on the screen still further increased without, however, losing the quality or detail of

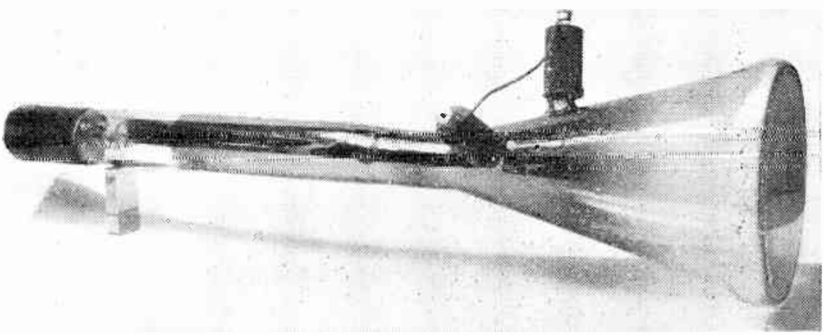


FIG. 42.—An example of the Baird projection tube.

the resultant image. In other words, by paying very careful attention to the primary scanning field size it has been found possible to reduce the effect of defocusing in the picture highlights to an almost negligible quantity. The actual tube itself differs from the ordinary cathode-ray tube. For example, the Baird projection tube which was shown at the Science Museum is a bulb made from Hysil glass, having a uniform thickness of the order of 5 mm. The screen end is seen to be carefully ground and polished optically flat on the outside, the diameter at this end of the tube being about 5 in., while the total length is nearly 20 in. An excellent example of the form taken by the tube is shown in Fig. 42. A conical section connects to a long neck terminating in a cap and socket. The high voltage anode terminals are brought out on long insulators to minimise brush discharge and voltage breakdown.

Details.—For the purpose of focusing the brilliant picture on the tube screen a solenoidal coil surrounds the cylindrical glass neck. Through this is passed a direct current and by varying this current the resultant uniform magnetic field produced causes the electrons in the beam passing from the orificed anode to follow helical paths, yet be in exact focus at the plane of the fluorescent screen.

Owing to the relatively high anode voltages employed in tubes of this character every precaution has to be taken to ensure that the tube screen is free from all suggestion of fatigue and burning. A very fine grain powder is employed, for if this was not the case the picture, when enlarged to the required size on a remote screen, would be coarse and lacking in the fine detail and definition so essential for sustained entertainment appeal as distinct from novel technical achievement. Modulation of the electron beam is undertaken in the standard manner, that is by altering the intensity of the minute but brilliant spot as it travels across the screen at uniform velocity in a series of adjacent lines. In order to modulate the tube fully from black to the highlights it is in some cases found necessary to have an increased signal output from the receiver, but in the latest tubes the output from a standard set is found sufficient for the purpose. Due to the higher anode voltages necessary—10,000 to 15,000 volts—special design is required in building the power units feeding the supplies to the tube itself, but suitable safety precautions eliminate any possibility of danger when working with these rather high potentials. It seems certain, however, that subsequent research will find methods for reducing the magnitude of these anode voltages without impairing the picture brilliance. At the moment the rather more elaborate associated apparatus is responsible for the increased cost of the equipment when compared with the ordinary type cathode-ray receivers.

Synchronising the picture presents no difficulty since there is no question of the momentum of moving mechanical parts to consider. Rock-steady pictures free from any objectionable hunting in either the line or frame scan direction are observed, and either sequential or interlaced scanning is undertaken without any measure of difficulty.

Projection.—The actual size of the picture built up on the projection tube screen varies according to conditions, but may be anything between 2 to 4 in. wide, the depth being settled automatically by the ratio of width to height in the radiated picture which is being received. The actual composition of the screen powder used by different manufacturers to permit of the intense bombardment of the electron stream for long periods is naturally a secret, but at the R.C.A. demonstration in America it was stated to be primarily zinc orthosilicate of fine crystalline structure. The resultant picture reproduced by this powder has a yellowish-green hue, but the Baird tube shown at the Science Museum has a close approximation to the more popular black and white colouring.

In order to maintain the high quality of the brilliant picture reproduced in miniature on the flat tube face and ensure freedom from any optical distortion, a high quality lens is essential. This has an aperture of the order f/1·5 and is placed relatively close to the tube. Various types of screens can be used and their fundamental construction will depend primarily on whether the observed picture is to be front or back projected. The scheme in simple form is shown in the accompanying pictorial diagram, Fig. 43, According to the type of lens employed and the distance of the equipment from the screen, so the resultant picture size can be varied. Pictures have been shown on a crystal beaded screen of a somewhat similar character to that used for home ciné-projection, this being in the case of front projection. For back projection the screen is semi-transparent and has to be designed to give the largest diffusion angle, coupled with an adequately brilliant and clear picture. Loss of light has to be guarded against, otherwise the picture size will not magnify to the desired dimensions. For normal home use a 2 ft. picture width is adequate with C.R. tube projection, but three or four times this magnification is essential when using equipment of this nature in a hall.

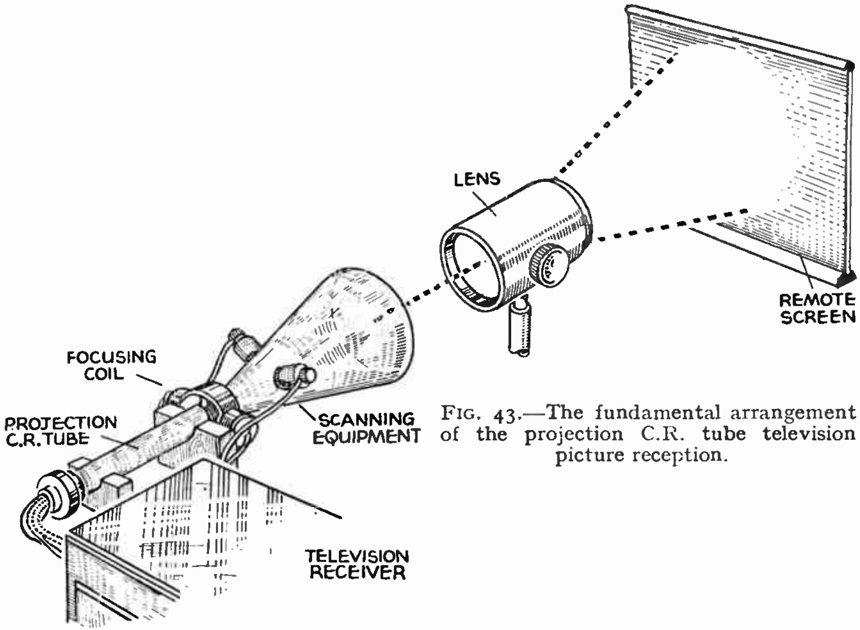


FIG. 43.—The fundamental arrangement of the projection C.R. tube television picture reception.

Important Points.—Without the slightest doubt all the fundamental problems of this type of television picture reconstitution have been solved. These are many and various and among the most important can be mentioned adequate picture brilliance to meet all conditions of viewing without defocusing occurring in the highlights. Maintenance of picture detail and a full range of contrast between black and full white through all the intermediate half tones is also essential. It was sometimes observed that with the earlier types of C.R. tubes, if the picture was run too bright then contrast was reduced and a general overall flatness of the results was apparent. This has to be avoided with projected pictures, which of necessity must have a brilliance at least comparable with a good quality home ciné.

Another factor is the life of the tube which must be sufficient to avoid the necessity of frequent replacement and the consequent high running costs. Proper attention to details in manufacture, that is a satisfactory electrode system; ample strength in the glass envelope and freedom from flaws so that the vacuum is maintained; proper screen powder of fine grain and one which will not burn when the tube is used correctly. All these points and many others are engaging the attention of television research engineers throughout the world, for the importance of ample picture size coupled with adequate brilliance and detail has never been lost sight of by the protagonists of electronic methods of picture reconstitution.

CHAPTER XV

ELECTRON-MULTIPLIERS

THERE is no doubt that the recent rapid developments in the science of television in research laboratories all over the world has brought about improvements in allied subjects. Outstanding among these is photo-electricity, for any system of television has a fundamental bearing on the electrical effects produced by light whether visible, ultra-violet, or infra-red. The earliest successful television system, namely the spot-light scanner, relied on the capability of photo-electric cells to impart to amplifier circuits voltage changes which corresponded in magnitude to the light charges acting on the cathode surfaces of the cells. In the modern forms of electron cameras the photo-emissive properties of metal surfaces or mosaics are harnessed, so that in conjunction with some form of scanning operation television signals are generated which simulate electrically the light and shade analysis of the scene to be televised.

The main obstacle met by early television pioneers was centred round the wholly inadequate sensitivity of these photo-electric devices, and in addition to improving this, schemes have been developed whereby the initial electronic cathode emission can be augmented so that the resultant output signal was of sufficient magnitude to be handled with normal thermionic valve amplifiers having a reduced number of stages. The advantage of this should be at once apparent to those who have handled high-gain valve equipment which had to deal with minute signals covering such an enormous frequency range as is demanded by high-definition television. No matter how careful the design, instability and microphony, coupled with the well-known Schott effect, rendered the operation of these amplifiers a difficult task, while the signal-to-interference ratio was not of the required order for efficient service.

Multipliers.—This modern form of increasing the main electron stream has been brought about by what are termed multipliers, and up to the present the fundamental conceptions of the different types have been due to Zworykin, Farnsworth and Weiss, but in every case they depend on secondary emission. This is a process associated with the fact that when an electron is made to strike a prepared metal surface with a high enough velocity, the impact is capable of causing secondary electrons to be removed from the surface.

Dependent on the initial electron velocity and the character and composition of the metal surface, so the number of secondary electrons released for each primary electron impact will vary, but measurement has shown that up to 10 secondary electrons can be set free for each initial electron. Another particularly important factor associated with this phenomenon is that since it is similar in principle to the normal primary photo-electric emission, no time-lag is present, and even when handling signal modulations of three or four megacycles, as in the case of high-definition television, the factor of multiplication associated with the device is maintained quite readily.

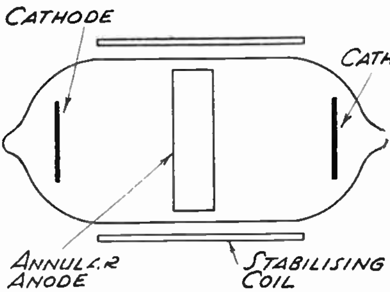


FIG. 44.—The form of multiplier due to Farnsworth, which operates in a reciprocal fashion.

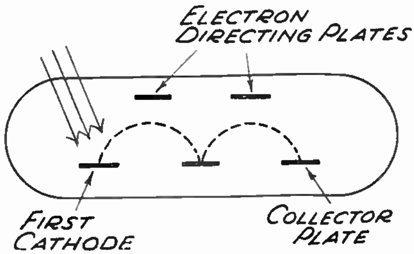


FIG. 45.—One form of Zworykin multiplier.

Electron Path.—As a rough discrimination between the types of multipliers proposed, they are referred to frequently as reciprocal and successive. The first named is the result of Farnsworth, who first of all had two opposing metal surfaces along which an external source maintained a potential gradient. The zigzag path, followed by the initially introduced electrons, produced a progressive multiplication, but a subsequent development of this same inventor operated in a slightly different way. This can be seen in Fig. 44, where two circular cathodes are positioned at opposite ends of an evacuated glass container. An alternating potential difference is established electrically between the cathodes, and this, in conjunction with a ring anode placed midway between the cathodes, swings the electrons to and fro at a periodicity depending upon the potential of the anode with reference to the cathodes. An axial magnetic field produced from an external solenoid coil, through which is passed a direct current, stabilises the working of the multiplier, and prevents the electrons being collected too quickly by the anode. At a certain frequency of the alternating potential difference between the cathodes, a value is reached when the time of flight of the electron from end to end is exactly equal to a half period, and under this condition the electrons collected by the anode are a maximum giving a resultant multiplication of considerable magnitude.

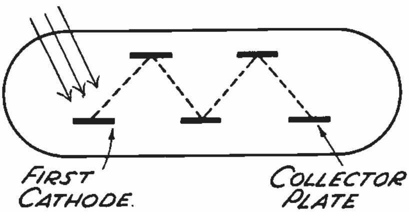


FIG. 46.—Showing the zigzag path, followed by the electrons in moving from each secondary emitting surface.

The first multipliers of the successive type were suggested by Jarvis and Blair over 10 years ago, but later this was improved very materially by Zworykin. In this case the multiplier has a chain of separate and distinct secondary emitting surfaces. The primary electrons are directed to fall on the first surface, and from this the secondaries are led to the next surface, and so on down the chain. Figs. 45 and 46 show simply two ways in which this sequence of events takes place. In one case the metal surfaces lie on one side of an exhausted tube, and by a combination of electro-magnetic and electrostatic fields the electrons follow the path shown by the dotted lines. The modification of Fig. 46 makes the path a zigzag one in the electron route to successive surfaces. Amplification of primary photo currents up to a hundred thousand are claimed for multipliers of this type, although under strict service conditions there is a critical adjustment of the applied voltages, with a possibility of variations in the measure of overall gain.

Secondary Amplifying Stages.—The Weiss principle of secondary emission amplification has been further developed by Baird Television, Ltd., and definite figures are now available concerning the performance of the two sizes

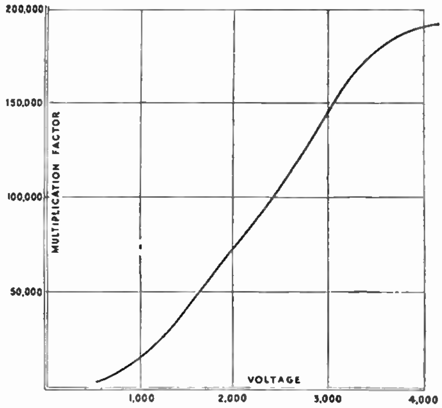


FIG. 47.—Multiplication plotted against total voltage for the smaller type Baird cell.

available. Of the successive type, there is a chain of secondary amplifying stages, and the current is made to pass in sequence down the chain to be amplified at each stage. Instead of metal plates, however, the stages are really electron permeable grids, the surfaces of which have been specially prepared to give a high secondary factor. The primary electrons incident upon the first grid liberate secondaries at low velocity which are attracted through the meshes of the grid by the positive potential on the next grid. Sufficient striking velocity is acquired to liberate further secondaries which are in turn attracted onward down the chain. The amplification factor per stage is variable up to four, depending on the voltage applied to succeeding grids.

A reference to Fig. 48 will make the action quite plain, the arrows denoting the direction of the electrons, while the secondary emission multiplication per grid is assumed to be

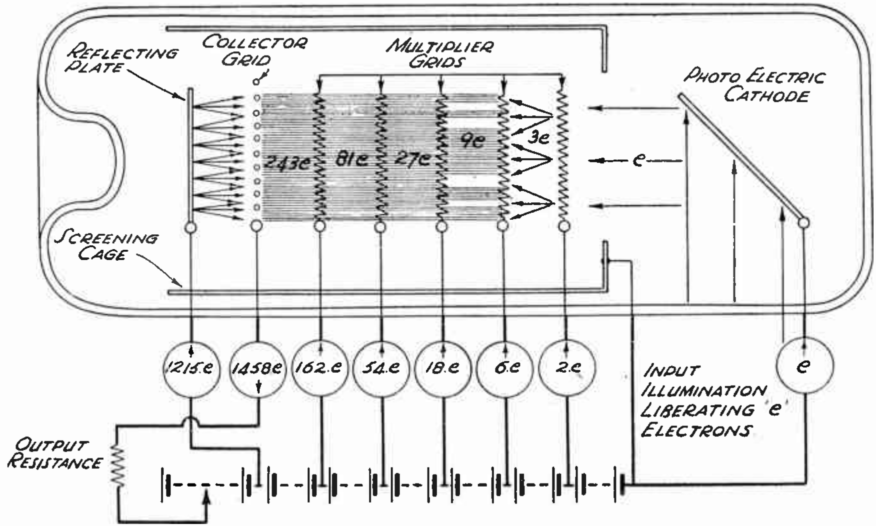


FIG. 48.—A simple schematic diagram to show the Weiss principle of secondary multiplication.

three. At the end of the multiplier there is arranged a secondary emitting plate upon which the electrons from the last multiplying grid impinge. A secondary factor of 8 can be obtained by a solid surface, and hence a large multiplication takes place in the last stage, but in the diagram a factor of 6 has been taken. The electrons liberated from the plate are collected by an unsensitised open mesh grid, and from here pass into the output circuit of the multiplier.

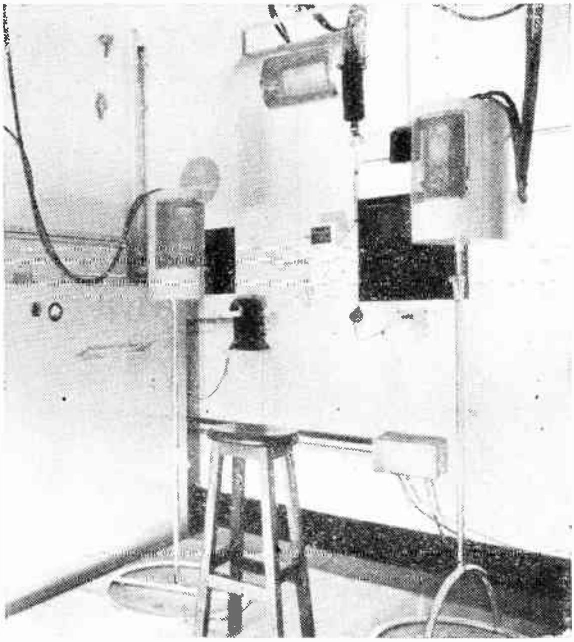
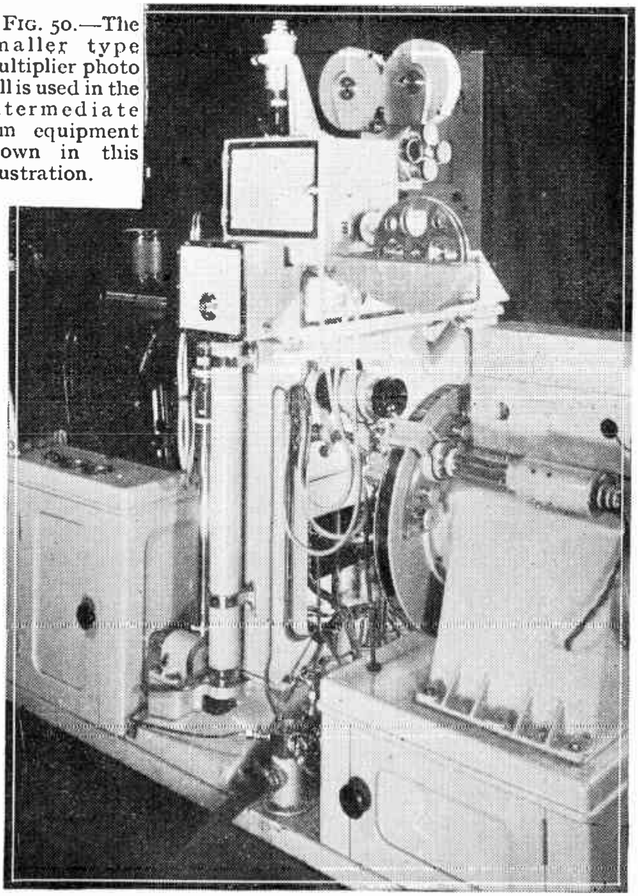


FIG. 49.—The larger type cells shown in use with spotlight television.

Output Stage.—These grids are arranged as parallel circular discs inside a cylindrical screening tube, which has an aperture in the end nearest the first grid so that the primary photo-electrons leaving the cathode enter the multiplier under saturation conditions and impinge on the first multiplying grid.

In the commercial form of an earlier Baird experimental model the cathode connection is taken out at the top while the grid connections are at the base. The primary photo-electric cathode is normally a special caesium silver oxide having a sensitivity of about 30 micro-amperes per

FIG. 50.—The smaller type multiplier photo cell is used in the intermediate film equipment shown in this illustration.



lumen and a maximum spectral sensitivity at 6,500 A.U., but the response is quite good down to 8,000 A.U., and the cells may therefore be used for infra-red detection and amplification of infra-red signals.

Naturally the overall amplification obtained with multiplier photo-electric cells of this type is dependent upon two factors—the voltages supplied to each stage and the number of stages employed. As an indication of the results obtained in practice, however, reference can be made to Fig. 47, which shows the total applied voltage plotted against amplification factor for the small type Baird cell having a cathode area of 15 sq. cms. and a nine-stage multiplier. This particular form of cell finds its greatest application with concentrated light beams, and is employed in the intermediate film scanner shown in Fig. 50. The light variations passing through the scanner apertures are focused on to the cathode of the cell which is incorporated in the metal case seen on the right of the photograph. For diffused light operation the multiplier cell is altered in construction to give an active cathode area of 250 sq. cms., and three of these are shown in Fig. 49.

CHAPTER XVI

TELEVISION RECEIVER DESIGN

THERE is a considerable difference in the design of the modern broadcast receiver and the modern television receiver. In the latter we have both the sound and the vision wireless section, to which are added the time base units for both vertical and horizontal scanning movements. Thus there must be three separate supplies of voltage (both H.T. and L.T.), as it is essential to avoid interference between any one of these sections and another. Slight interference which might be present in a sound receiver, and which would be masked by the received music, would, in a picture receiver betray its presence by either distortion of the picture, or as an accompaniment of lines, spots, or flashes. This means that the vision receiver must be designed on very efficient lines, and considerable care has to be paid to the screening and avoidance of losses. Interference in the time base will also give rise to various forms of distortion, and therefore it is preferable, when designing the television receiver to arrange for completely separate mains sections.

These may each be built on a separate chassis, or all made up together on one chassis, the latter arrangement being preferable as it enables the high-voltage A.C. leads to be kept in the lower part of a cabinet, and only D.C. leads and the low-voltage heater A.C. leads have to be run from one section to another.

Combined or Separate Receivers?—As it is necessary to tune both sound and vision, a further problem concerns the design of the wireless section, as distinct from the time base and its associated circuits. One method now being favoured by many manufacturers is to adopt a single frequency-changing stage, to which the sound and vision signals are fed by using a flatly-tuned input circuit. Separate I.F. circuits can then be used to " tap off " the resultant two beats which are produced by the two signals in the single mixer stage, and each circuit may feed I.F. stages in the usual way, all tuning then being carried out by the oscillator trimmer. Obviously, for this to produce good results the I.F. tuners must be correctly designed, but it enables the vision signal to be accurately tuned, as the ear decides the exact tuning point. By turning the volume control down until the signal is barely audible the exact point is easily located, and the picture is then correctly tuned. A standard superhet arrangement is adopted in this case for the sound receiver, but in the vision receiver there are several alternatives. For high-quality pictures a band width of at least 2 mc/s. should be aimed at, and this may be obtained by flatly-tuned I.F. transformers or choke-coupling. The former may be obtained by winding the transformer with resistance wire, or shunting a transformer with an ordinary resistor of suitable value. In the second case, in order to obtain a satisfactory band width and good amplification in each stage, the design of the choke must be carefully considered.

Components.—In view of the very high voltages which are present in a television receiver, certain standard broadcast components are not suitable for use. For inter-connection between the various chassis, multi-cables may be employed, but in certain cases the insulation between adjacent leads may prove inadequate unless special cables are employed, and in view of the number of leads, multi-contact plugs and sockets will have to be employed. Messrs. Bulgin are producing a special plug and socket for such cases, in which 12 contacts are provided and these are available for circuits carrying up to 7,000 volts. Messrs. Belling-Lee also manufacture multi-contact plugs having 5 or 10 contacts and these are provided with an extended bakelite boss which must first be inserted in the correct position before any of the pins or sockets make contact, and this prevents damage due to a wrong connection.

The insulation in the mains transformer may also have to receive a considerable amount of attention, but this will depend upon the circuit employed with the cathode-ray tube. In the circuits at present being developed it is possible to earth either the anode or the cathode, and less smoothing is required if the cathode is earthed. Expense can also be saved in certain cases by using components connected in series, thus avoiding the high wattage rating of a single component, which would be dearer than the two smaller components. Messrs. Haynes Radio have designed mains transformers specially for television receivers, in which high-insulation is provided, and both Dubilier and T.C.C. can supply condensers designed to operate up to 8,000 volts or so. In the Dubilier components oil is employed for increasing the insulation, whilst in the T.C.C. components petroleum jelly is employed for a similar purpose.

Special Valves.—The Mazda Company have produced special H.F. valves for use in the intermediate-frequency stages of the vision receiver, whilst special double-diodes are also being produced for the second detector, as it is the output from this which feeds the tube. For the high voltage for the tube special rectifiers are also employed, these being of the half-wave type, with the anode brought out to the top of the valve to avoid the cathode being destroyed by the powerful field which would be created. As connection has to be made to the top cap and the associated condensers may hold their charge at a dangerous potential for several days (due to the high insulation) special insulated cap top connections are desirable, and these also are produced by the Bulgin Company.

CHAPTER XVII

SOLVING THE MAINS PROBLEM

In the last chapter we discussed in broad detail the problem of the design of the modern television receiver, and we can now pass to the individual sections and find the best method of attacking the various problems and so designing an efficient receiver. It is logical to start with the mains supply voltages, as these apply to every section of the complete receiver and all of the valves must receive H.T. and L.T. voltages. In addition the cathode-ray tube has its own H.T. and L.T. to obtain, and thus we find to commence with that we must obtain about 24 or 25 amps. at 4 volts for the various valve heaters, plus 4,000 or more volts at a few milliamps. for the cathode-ray tube H.T., plus the heater supply for the latter. To these outputs must be added the supplies for the valve rectifiers. It is obviously impossible to arrange for all of these windings on one transformer, not only on account of the physical consideration, but in order to maintain the necessary high degree of insulation between certain windings, and in order to prevent interaction. The vision and sound receivers each require H.T., as also does the time base, and thus we can use three separate transformers and rectifiers, obtaining each supply individually. Small mains transformers would suffice in this case, and standard types of rectifiers could be employed. To maintain a high degree of efficiency in the time base, however, we require a high voltage source so that there is some margin with which to play.

Separate Rectifiers.—We may, therefore, tap off part of the H.T. supply for the C.R. tube to supply the time base, and in addition make use of some of the surplus from the wireless section, provided that interaction is avoided. This would enable the complete mains section to utilise only two rectifiers, and the save in expense is not offset by any additional components or condensers of high-voltage test. There is a further advantage in this method of construction, in that it becomes easier to arrange that no H.T. shall be applied to the time base until the heater supplies have been switched on, and a single switch may be employed for on-off switching. If the separate transformer and rectifier arrangement is adopted, we shall require a transformer for the "wireless" (sound and vision) section, giving 4 volts at about 18 or 20 amps. (according to the design of the combined sound and vision receivers), with a 500-volt H.T. output and an associated rectifier. In this respect the arrangement will be perfectly standard radio practice, and the usual H.T. chokes and filter condensers will be fitted.

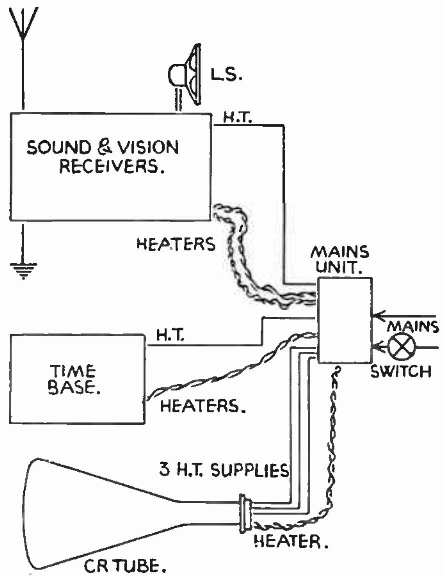


FIG. 51.—A diagrammatic representation of the arrangement for feeding the various sections of the television equipment.

The combined receivers would be built on a single chassis with the mains section arranged at one end in the usual manner, but would have to be carefully screened to avoid the external field from the mains transformers affecting the C.R. tube, as it would be assumed that the receiver would be so placed that the controls were easily handled, and thus would be in close proximity to the C.R. tube which must also be in a similar position to enable the picture to be viewed comfortably.

The Time Base.—In the time base, the H.T. output will depend upon the circuit employed, that is, whether a gas-discharge tube is employed, or the hard-valve type of circuit. In the former case we would require about 1,500 volts at about 50 mA. plus the heater supply which would be 4 volts at 6 or 7 amps. A high-voltage rectifying valve could be employed for the H.T. supply, or two smaller valves in a voltage-doubler circuit, or alternatively the latest pattern Westinghouse metal rectifiers could be employed. The modern C.R. tube has a low-voltage heater, with a rather large current consumption, and it would be preferable to design the heater winding round the tube it is eventually decided to employ. Details of the standard tubes now obtainable are given on page 272, together with some gas-discharge valves. For the low-voltage C.R. tubes, such as the Cossor, which take only ·6 volts, special series resistors may be

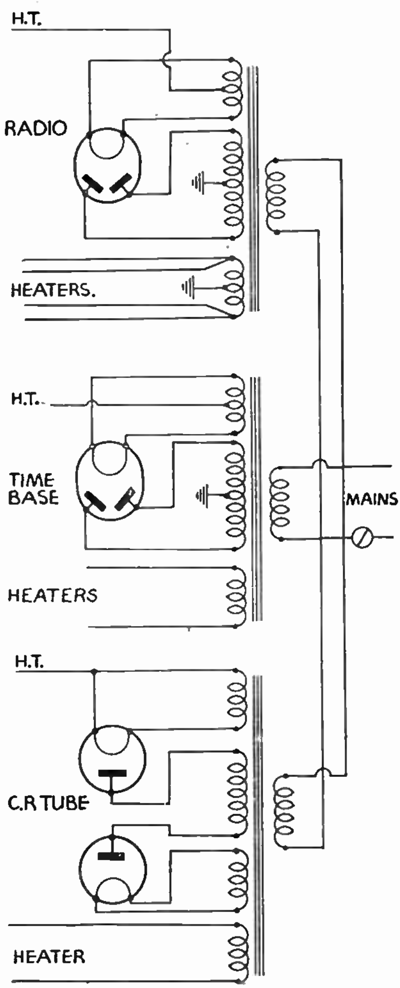


FIG. 52.—How each mains transformer is wired up to carry out the arrangement mentioned in this article.

obtained from Messrs. Bulgin, for inclusion in a 2-volt heater supply. For the H.T., half-wave rectification may be employed, again utilising either the valve or metal rectifier. An economical method of obtaining this part of the supply is to employ two of the special half-wave rectifying valves in a voltage-doubler circuit, and this will enable more elaborate smoothing to be incorporated, and the condensers employed may practically all be of only half the test voltage working characteristics which would otherwise be required. To avoid risks of breakdown due to insulation, and to avoid interaction, a good scheme is to have the transformer for this part of the outfit made as a completely separate unit. We may then use one mains transformer for the supply of all the voltages to the vision and sound sections, and another transformer for the time base supply, thus reducing the mains equipment to a fairly economical value, and greatly simplifying the construction. As mentioned last week, to avoid the running of mains supply leads all round the back of the cabinet, the mains section is preferably built as a single unit, in which case there will be simply the three transformers, and associated rectifiers, with the various smoothing chokes. The speaker field may be included in the smoothing supply as an additional point of economy, and the sections may be separated on the chassis, to facilitate testing and to avoid interaction. The radio section should occupy one side of the chassis, and the time base and C.R. tube sections may be grouped on the other side. Multi-contact plugs and sockets will enable the supplies to be conveyed to the radio and time base chassis, but to carry the very high heater current, double leads will have to be fitted, and even so these will have to be of the heaviest flex. The type known as 76/30 should be employed, and in the radio chassis, the double leads should be separated to feed individual valves to avoid heating of the flex, and the avoidance of voltage loss through it. The primaries of the mains transformers may then all be joined to a common switch, with due provision for insulation and the avoidance of heat.

Separate Sound Section.—One scheme which may appeal to some listeners is the building of the sound section as a completely individual unit, so that it may be used when no television programmes are being transmitted. In such a case, of course, the standard radio scheme may be incorporated, and a separate mains on/off switch fitted to this section. This will add one more control to the complete outfit, and may result in some difficulty when no sound is heard accompanying a picture, and with the multiplicity of controls there is a possibility of it being overlooked that the appropriate switch has not been operated, and some delay would accordingly be experienced whilst a non-existent fault is being looked for.

CHAPTER XVIII

MAKING A C.R. TUBE POWER UNIT

THE various receivers at present on the market, and the two types of transmission, have been fully discussed, and the technicalities explained. We now introduce a power pack giving an output of 3,000 volts at 2 mA.—sufficient to work any but the largest of cathode-ray tubes.

Layout of Components.—The power unit follows the same lines as that for an ordinary A.C. mains set and contains rectifier, transformer and smoothing circuits, the only difference being the higher voltages. The necessary voltage dropping resistances and decoupling condensers are shown in the diagrams, Figs. 53 and 54, but have not been included in the unit. These are for feeding the various anodes and shield of the cathode-ray tube, and have not been included because the values of the resistance network vary considerably for each individual type and make of tube. They can, of course, be easily added to the chassis of the unit. Those shown in the diagram are for the Cossor type 3272 tube.

Fig. 56 shows that the power pack is extremely simple and consists of two of the new Westinghouse " J " type units connected in the well-known voltage doubler circuit with reservoir condensers of 0·5 mfd. capacity. These rectifiers have a maximum current rating of 2 mA. which is sufficient to not only feed the tube, but also to allow for the current passed by the various potentiometers. These rectifiers have been chosen for two very good reasons—they require an input of only 1,400 volts, whereas the corresponding valve would require 3,000 volts half-wave or 3,000–0–3,000 volts (6,000 volts in all) full-wave. This of course means that the circuit is safer, and also that the mains transformer is much cheaper and smaller as the insulation between the windings need not be so great.

Mounting the Rectifiers.—The " J " type units consist of very small rectifying discs connected in series and enclosed in an insulating tube, the connections being made at each end. The rectifiers are mounted about 1 in. off the metal chassis by means of two ebonite blocks. A " Terry " spring clip is fixed to each block by means of a bolt screwed into a

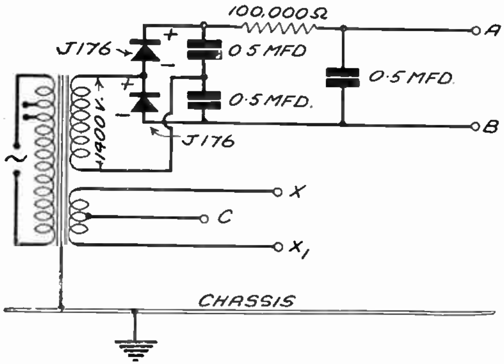


FIG. 53.—Theoretical circuit of the mains unit.

hole tapped in the centre of the block. Care must be taken to see that this bolt does not go right through the block and touch the chassis, as this would stress the insulation of the rectifiers unduly, especially at the high potential end. The manufacturers of the rectifiers state that the material used for the insulating tubes will withstand a stress of 3,000 volts so that the use of an ebonite block, with the tubes entirely insulated from the chassis, is an extra factor of safety. The blocks are fixed to the chassis by the two nuts and bolts shown.

Another method of fixing is to drill a $\frac{7}{16}$ in. hole through the centre of each block, and then to cut each block in half. The rectifier is then laid in the semi-circle formed in the bottom half of the ebonite, and the other half of the block placed on top. The whole is then bolted to the chassis thus holding the rectifier firmly in position. Fig. 55 clearly illustrates both methods of fixing.

Wiring Connections.—Having fixed the rectifiers, transformer and condensers in position, the wiring becomes a matter of a few minutes work. Use 18 or 20-gauge tinned copper wire, covered with a good thick insulating sleeving. Where wires pass through the chassis, make sure that there is ample clearance between the sleeving and the chassis, and cover the sleeving with a short length of larger diameter

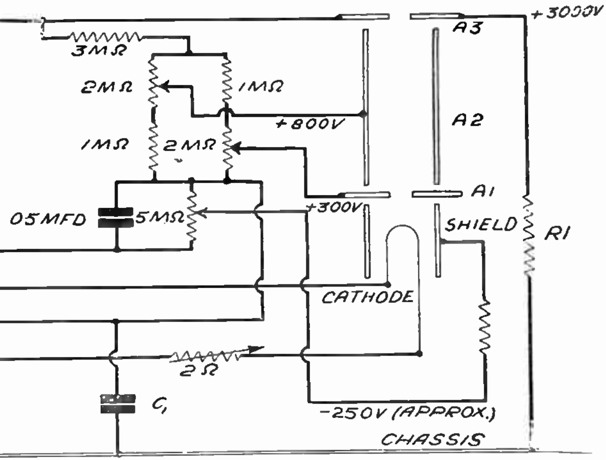


FIG. 54.—The full C.R. tube circuit.

sleeving at the point where it passes through the chassis. Note, that because the cathode of the television tube is at high potential, a separate H.T. negative line has to be employed, and it is not possible to connect this to the metal chassis. A separate earthing terminal is provided for earthing the chassis which is entirely insulated from both H.T. positive and negative.

Instead of the more usual smoothing choke, a resistance has been used for smoothing purposes, as a choke is not a practical proposition in circuits such as this, and a resistance is certainly very much cheaper. The value is 100,000 ohms, and that of the smoothing condenser 0·5 mfd. Note that this condenser is of the 4,000 volts D.C. working type, while the reservoir condensers are rated at 2,500 volts D.C. working. The volts dropped in the resistance are 200 when the full current of 2 mA. is taken so that, in such a case, the maximum voltage available would be 2,800—sufficient to work the tube efficiently.

In Fig. 54 is shown the voltage network for a Cossor tube. It can easily be calculated from the values given for the various resistances making up the potentiometers, that the current passed by these is 0·46 mA. The current taken by the tube is about another 0·5 mA. so that the total current required is under 1 mA., at which figure the voltage output from the pack will be about 3,500 volts.

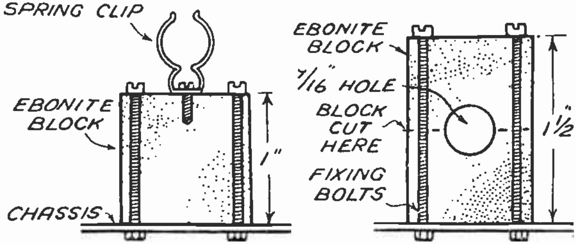


FIG. 55.—Constructional details of the supports for the metal rectifiers.

Resistance Network.—The resistance network is arranged to provide the full available voltage to the third anode, about 800 volts to the second and 300 volts to the first, while the 500,000 ohms potentiometer at the bottom of the network is used to deliver a negative voltage to the shield, varying between 180 and 450 volts approximately. The third anode of the tube should be at or near earth potential. It is preferable, however, not to connect it direct to earth as this would involve a certain ripple on the cathode voltage relative to earth. Although this percentage ripple would be very small, the total voltage is very high, and hence an appreciable 50-cycle hum would be introduced which would appear on the screen, and spoil the picture. To avoid this, the third anode is connected to earth through the high resistance R.1, whilst the cathode of the tube is earthed in the A.C. sense through the high-voltage condenser C.1. Note that the deflector plates and their associated circuits are not shown in the diagram.

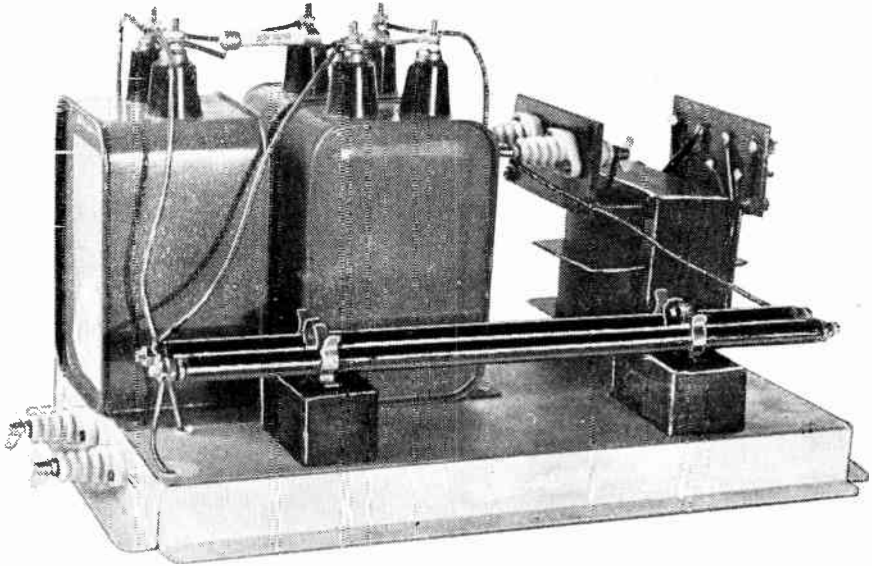


FIG. 56.—A view of the completed mains unit.

In conclusion, we would stress that, although the unit has been made as simple as possible, great care must be taken with insulation. The variable potentiometers for voltage control must have their spindles well insulated from the chassis. In fact, it is preferable to use an ebonite panel,

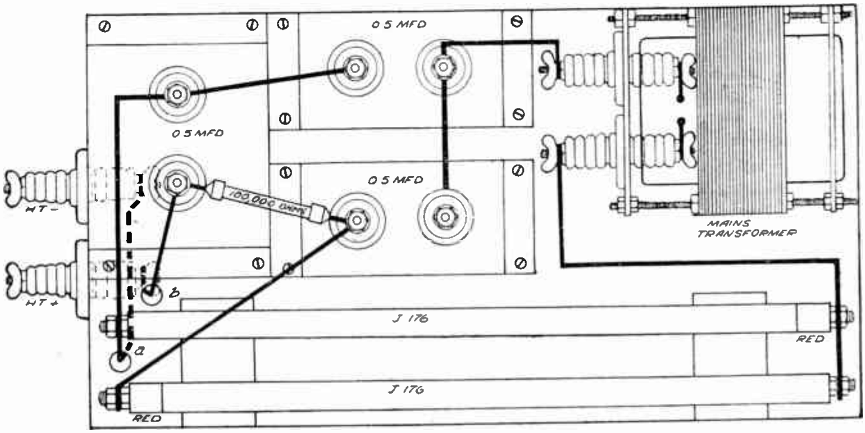


FIG. 57.—Wiring diagram of the television mains unit.

and the hole in the knobs through which the grub fixing screws pass should be filled with wax when the knobs have been securely fixed to the spindles. On no account make any alterations to the wiring, or touch any of the components or chassis, while the unit is switched on.

COMPONENTS REQUIRED

Two Westinghouse type " J.176 " Metal Rectifiers.

One Mains Transformer, primary tapped 200, 220, 240 volts, Secondary 1,400 volts and 2 volts 2 amps.—London Transformer Products.

Two Oil-immersed Paper Dielectric Condensers, capacity 0·5 mfd. 2,500 volts D.C. Working type—Dubilier.

One Oil-immersed Paper Dielectric Condenser, capacity 0·5 mfd. 4,000 volts D.C. Working type—Dubilier.

One 100,000 ohms 1-watt metallised Resistance—Dubilier.

Two Porcelain Insulated Terminals—Belling-Lee type.

One Aluminium Chassis, 13 in. by 10 in. by 2 in.

Nuts and Bolts, Wire and Sleeving.

CHAPTER XIX

METAL RECTIFIERS FOR TELEVISION APPARATUS

For the benefit of experimenters we give below some of the many applications of metal rectifiers to Television circuits, together with the marked advantages which the metal rectifier shows in each case over the corresponding valve rectifier. This information has been compiled and submitted by the makers of the rectifiers, The Westinghouse Brake and Signal Company, Ltd.

H.T. Supply to Vision Receivers.—The current consumption of the present design of vision receiver varies from about 200 volts at 40 mA., to 230 volts at 50 mA., and for these outputs we should recommend the use of rectifiers style H.T.12 and H.T.9 in the voltage-doubler circuit.

D.C. Output.	*Rectifier.*	*Voltage Doubling Condensers.*	*A.C. Input (approx.).*
200 volts, 30 to 40 mA.	H.T.12	4+4	140 volts, 120 mA.
230 volts, 50 mA.	H.T.9	4+4	180 volts, 170 mA.

The great advantage of this arrangement is that the use of the voltage-doubler circuit limits the output current of the rectifier, and accidental short circuits, which are particularly liable during experimental work, can do no damage to the rectifier or transformer.

H.T. Supply to Sound Receivers.—H.T. consumption for the sound receiver is normally of the order of 250 volts at 50 mA., and for this output the Westinghouse Company suggests the use of the H.T.9 rectifier used in the voltage-doubler circuit with two 4-mfd. condensers. The A.C. input for the above-mentioned output would be approximately 200 volts at 170 mA. This rectifier is, however, quite suitable for a maximum output of 300 volts at 60 mA., in which case the input must be increased to 200 mA. at 240 volts.

The advantages of these voltage-doubler circuits also apply here, and either of these rectifiers would be suitable for the average hard-valve time base.

H.T. Supply to Time Base Generator.—The requirements of thyratron time base circuits vary from about 900 volts at 14 mA. to 1,000 volts at 18 mA. For the latter output two H.T.9 rectifiers connected in series, and used in the voltage-doubler circuit, will be found excellent. The voltage-doubling condensers should each be 2 mfd. 750 volts working, and the A.C. input 460 volts.

The advantages of the voltage-doubler circuit are even more marked at this voltage, as the transformer can be wound for a very much lower voltage than if valve rectification were used, and this results in a smaller and cheaper

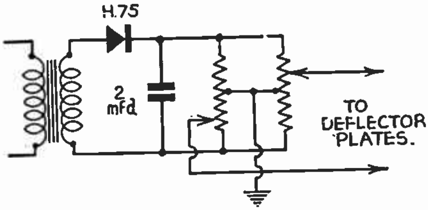


FIG. 58.—A half-wave circuit utilising the type H.75 rectifier.

transformer. The elimination of the high-voltage secondary winding also has an important bearing on the question of safety from shock, and this is particularly important in home-constructed apparatus. A further advantage is great stability of output, since vibration and sudden draughts will not affect the D.C. voltage, and this results in freedom from drift, and reliable operation of the time base.

Supply to Picture Shift Circuit.—An output of about 250 volts at 4 mA. is usually required for this purpose, and a very suitable rectifier is the H.75, which may be used in the half-wave circuit shown in Fig. 58. For this output, an input voltage of approximately 230 volts 8 mA. R.M.S. will be required. The rectifier is, of course, quite small, and need take up very little space, since it can be supported by reasonably heavy wiring, or, if this is not possible, a small clip is quite sufficient. The rectifier is capable of a maximum output of 10 mA.

H.T. Supply to Cathode-Ray Tube.—Tube requirements vary from 3,000 volts at 0·75 mA. to 4,000 volts at 0·75 mA. " J " type rectifiers are most suitable for these outputs as shown below :—

D.C. Output.	*Rectifier.*	*Voltage Doubling Condensers.*	*A.C. Input (approx.).*
3,000 volts 0·75 mA.	2 units J.176.	0·5+0·5 (2,000 volts)	1,200–1,300 volts.
4,000-volts 0·75 mA.	4 units J.125.	0·5+0·5 (3,000 volts)	1,600–1,700 volts.

The advantages of cheaper transformer construction and greater safety from break-down and shock are even more marked when dealing with the high voltages required for

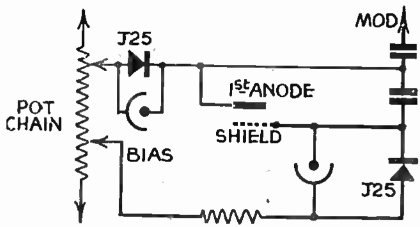


FIG. 59.—A patented circuit now employed in certain commercial receivers, built round the type J.25 rectifier.

the tube anode supply. The automatic protection against damage by short circuits, mentioned below, also applies in this case, and, in addition, full wave rectification is obtained.

The " J " type rectifier units are capable of a maximum output of 2 mA.

Double Modulation and Restoration of D.C. Components—The circuit shown in Fig. 59 is being widely used by manufacturers at the moment, and presents a particular application where the use of metal rectifiers shows a marked saving in space and increase of safety.

As the present tendency is to earth the tube anode, the use of diode rectifiers in the positions shown is dangerous and necessitates highly insulated heater windings. It will be seen that the above circuit provides double modulation and restores the D.C. component of the picture signal which is normally lost when V.F. amplification is used. This circuit forms the subject matter of Letters Patent applied for by a leading manufacturer, and this fact must be borne in mind.

CHAPTER XX

THE TIME BASE GENERATOR

THE electrical time base having the dual function of providing the H.F. and L.F. current variations necessary to produce the fluorescent spot movement in a cathode-ray tube, is an extremely important piece of apparatus. Any failure to generate the correct saw-tooth action, previously

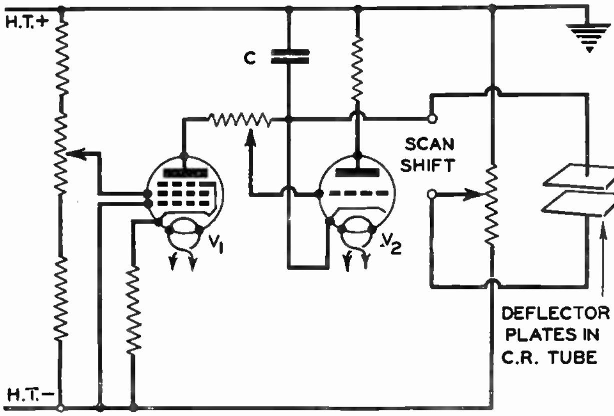


FIG. 60.—A typical time base circuit using a pentode valve and a gas-filled relay.

described, will result in an imperfectly constructed picture, so that a fair knowledge of its characteristics is essential if the best results are to be obtained by the user.

Two Important Points.—First of all, it should be quite linear in action, that is to say, the velocity of trace must be uniform with time. If this is not so, the picture will exhibit a crowding effect at the end traces in both the horizontal and vertical directions, and a reconstitution of the televised scene in its true dimensional ratio becomes impossible. Again, the flyback or return stroke at the end of each line and picture trace, must be sufficiently rapid to remove any diagonal bright white lines across the picture. In developing time bases to conform to the rigid standard of television, many schemes have been tried, and although perfection has not been reached the arrangement shown in Fig. 60 is representative of a good quality time base scheme for use in conjunction with electrostatic deflection.

A simple form of time base using a neon gas tube in conjunction with a diode valve has been illustrated before to

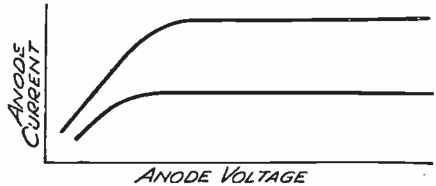


FIG. 61.—Showing how with a screened pentode valve the anode current is constant after a certain minimum anode voltage is reached.

indicate the principles of action, but this arrangement suffers from many drawbacks. The voltage range between the values for ionisation to start and stop in the neon lamp is limited, while in addition, the diode valve functioning in a saturated condition is unreliable. It is preferable, therefore, to replace the neon lamp with a gas-filled relay, and the diode valve with a pentode valve whose operating voltage conditions are such that the anode current remains constant over a relatively wide range of anode voltage variations. This fact can be verified by referring to Fig. 61 which shows the static characteristic for a pentode valve under these conditions of working.

Action.—Referring back to Fig. 60, therefore, the action involved in producing the saw-tooth pulses follows somewhat on these lines. First of all, the bias conditions for the indirectly heated pentode valve are set by potentiometer adjustments as shown, the main H.T. supply voltage value depending primarily on the total voltage required in order to make the beam of electrons in the cathode-ray tube make a full sweep across (or down) the available screen area on which the television picture is reconstituted.

The steady current from the valve, V_1, passes into the condenser, C, and so charges it up uniformly. Due to this steady feed, the voltage across the plates of C rises uniformly with time which, as we saw earlier, was necessary to secure linearity of action in the time base itself. Neglecting for the moment the gas-filled relay, V_2, which is in parallel with the condenser, C, the steadily rising voltage will be imparted to the pair of electrostatic deflecting plates marked "shift" and "scan" respectively in Fig. 60. The changing electrostatic field of force concentrated between the plates, and between which the beam of electrons is made to pass on its journey to the fluorescent screen of the tube, will cause the beam to move horizontally or vertically, depending upon whether the plates themselves are mounted in a vertical or horizontal plane. On the completion of the spot trace across the screen it is necessary to restore the electrical conditions to those which operated at the beginning, and it is here that the gas-filled relay, V_2, comes into action.

The Gas-Filled Relay.—Whereas in an ordinary valve the glass envelope is exhausted, with these relays a filling of mercury or helium vapour is given at a certain pressure during the course of manufacture. Furthermore, the current passed through the device is not a flow of electrons in the same sense as a receiving valve but is an actual arc discharge between the positively charged anode and the heated cathode. This discharge is brought about by the process of ionisation and for given conditions of electrode separating distances, gas pressure, etc., there is a very definite minimum voltage, which must be reached before the arc or visible ionising discharge can take place inside the valve.

Then again, the grid performs a function which differs from ordinary valve technique. Variations of anode current are not brought about through the medium of this electrode but it alters the anode voltage value at which ionisation occurs in the relay. This measure of control is expressed as the "grid control ratio" which in terms of figures in the case of a relay having a ratio of 25 and a negative grid voltage of 8 means that it would require $25 \times 8 = 200$ anode volts in excess of normal to cause an arc discharge.

Limiting Resistance.—The grid exercises no further control when ionisation is present and the discharge is stopped by interrupting the anode circuit or reducing considerably the voltage. Since the internal impedance drops to a very low value under ionising conditions a limiting resistance is included in the anode circuit as shown in Fig. 60 to ensure that the anode current does not exceed the maker's rating.

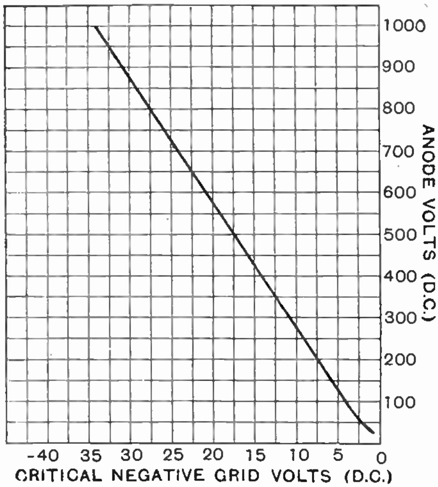


FIG. 62.—The characteristic curve of a gas-filled relay.

Different relays have different characteristics but in Fig. 62 is reproduced the average characteristic curve for an Osram gas-filled (mercury vapour) relay type G.T.1, and it is seen that to increase the sweep voltage both the anode and critical negative grid volts need to be increased accordingly.

Having appreciated the relay's inherent action it is easy to see now how the time base functions in its saw-tooth manner. The steadily rising voltage across the condenser C (and hence between anode and cathode of the relay) makes the fluorescent spot move at constant velocity in its direction of trace until the limiting voltage set by the negative grid bias and grid control ratio is reached. Ionisation occurs at once, the voltage drops and the condenser is discharged rapidly. This brings about a collapse in the electrostatic field between the pair of deflector plates, and the fluorescent spot flies back to its original datum line. The initial conditions being thus restored the process begins all over again, and this spot motion (resembling somewhat that of a cam action) is repeated a number of times per second.

Time Period.—The exact frequency of this action depends on the capacity of the condenser C, ionisation voltage, etc.,

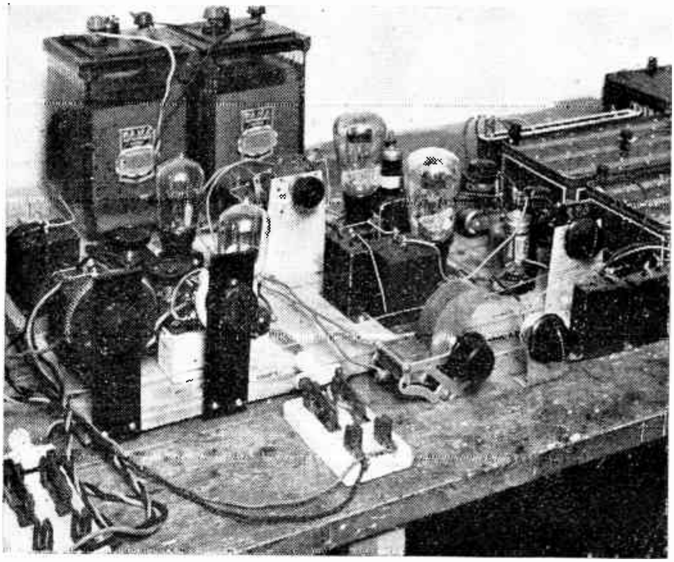


FIG. 63.—A temporary layout for a double time base in order to become familiar with its main functions.

the greater the capacity of C, the greater being the time period of the arrangement. Hence for the L.F. time base, C will be large, and for the H.F. time base, C will be small, this of course being in a comparative sense. By varying the negative voltage applied to the grid—shown as a potentiometer control in Fig. 60—the width of the scan can be adjusted to requirements within the H.T. voltage limits.

In addition, in the same diagram, it will be noticed that whereas the cathode of the gas-filled relay passes direct to one deflector plate called " scan " the second deflector plate called " shift " is taken to the moving arm of a potentiometer linked across the full H.T. supply (this supply, by the way, is furnished from a power pack unit which also produces the "gun" volts for the cathode-ray tube). This is to enable the position of the scan on the tube screen to be adjusted at will. For example, it may happen that the spot trace is too far to one side but by adjusting the "shift" control it can be set centrally where required.

A Dual Arrangement.—Two time bases exactly similar except for the condenser C values, furnish the H.F. and L.F. time pulses, being fed from the same high-tension supply, the positive side of which is earthed. The "popping" action of the L.F. gas-filled relay can be seen as a bluish-violet flashing glow, but the H.F. relay is so fast that it gives the appearance of a continuous glow.

Dual time bases built up in this way are quite tricky to handle at first, and readers who intend to interest themselves in this work of receiving high-definition television images using cathode-ray tubes would be well advised to lay out their first dual time base as a "hook-up" on a large base-board. This is shown in Fig. 63, the various parts being readily recognisable, while battery supplies are employed for simplicity. Once the nack of shifting the scan, shortening and lengthening the trace, increasing and decreasing the number of scanning lines, etc., is mastered, then steps can be taken to incorporate the equipment in a properly designed box or rack. Under normal circumstances, once the main controls have been set for any one particular standard of transmission they can be left alone, but, as was mentioned before, this is an "acquired handling" which will come with experience.

CHAPTER XXI

OPERATING A TELEVISION RECEIVER

BEFORE the various designs of high-definition television receivers appeared on the market it was thought in many quarters that their operation would be difficult. No doubt this was based on early experiences with radio sets where the knobs were multitudinous. Each valve was provided with a filament rheostat, the tuned circuits had separate condensers to operate, variable aerial coupling and reaction control, and an adjustable grid leak presented considerable difficulties to the operator whose knowledge of radio was scanty. Knowing that a television receiver was in effect two sets in one—a sound set and a vision set—the idea got abroad that to tune in a picture was certain to be a complexity that only the expert could solve.

A few months experience with manufacturers' sets has shown very clearly that these preconceived notions were quite erroneous. It is admitted that with the television demonstrations given by radio some time ago, the experimental sets used gave the appearance of being difficult to operate. As many as 15 knobs were used on the sloping panel beneath the picture screen of the cathode-ray tube. In use, however, only one or two of these controls had to be handled, the knobs attached to the time base generator which governed the scan on the screen being pre-set on installation.

Common Features.—Nowadays, however, a considerable proportion of these controls are hidden from view, being incorporated only for the convenience of the engineer making the initial installation. After that the time base generator knobs have only rarely to be adjusted by the owner of the set. Naturally, each particular make of set has its own particular features but there are many points common to all types, for at the moment the majority of receivers now available, use a cathode-ray tube as the picture reconstituting device. As an example, the reader is referred to Fig. 64

which shows a pictorial diagram of one commercial receiving set with the various controls, etc., carefully labelled.

The Effect of Tuning.—Taking the operation of tuning first of all, with some sets both the sound and vision tuning condensers are ganged together. It is claimed that in this way the set user has only to tune in his sound correctly—an operation with which he should be quite familiar owing to his previous radio set experience—and it will be found that the vision chassis is then tuned correctly to give full effect to the picture. In practice, however, this is not always found to be the case and some makers therefore provide a trimmer tuning control, while others make the tuning of the sound set a pre-set operation which is undertaken by the engineer on installation. After all, there is only one station radiating signals and as the frequency of the sound wave is crystal-controlled it is quite satisfactory to pre-tune the set on installation, so that the owner is relieved of any further responsibility in this connection. The vision tuning is still left as a variable quantity, however, for it is found in practice that a careful adjustment of this knob provides an excellent picture detail control. This arises from the wide frequency band encompassed by the video signal, and practice has proved quite conclusively that the vision tuning is a valuable asset for it enables the user to adjust his picture detail to individual taste.

Tone Values.—Another important operation is associated with the knob marked "contrast". An adjustment of this knob has the effect of altering the relative tone values of the built-up picture. That is to say, the correct relationship between the light and shadow can be found according to individual requirements. Turning the knob varies the degree of picture detail or gain passed to the modulating electrode of the cathode-ray tube without in any way affecting the strength of the synchronising signals. Too much contrast results in a soot and whitewash effect (something akin to an overloaded loud-speaker), while insufficient contrast makes the resultant picture look dull and flat. The advisability of incorporating an adjustment of this nature is therefore apparent quite readily, being a feature common to nearly every make of set.

Closely associated with this control is the one termed "brightness" whereby the *mean* brightness level of the observed picture can be governed at will. Picture brightness is really a multiple function of several items in the cathode-ray tube itself, for there are several ways in which the degree of luminescence, under the stimulus of the electron beam at

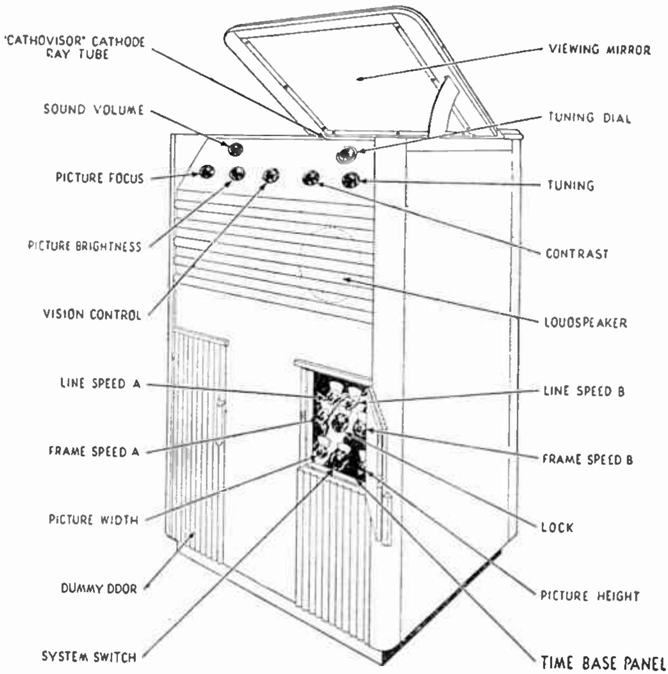


FIG. 64.—A pictorial representation of the controls on a typical Baird television receiver. For the new standard definition of Knob Markings see p. 219

the point of impact on the screen, can be adjusted. A very bright picture may tend to become somewhat trying to the eyes and the mean level can be set at the beginning of the programme in conjunction with the contrast, or at times it may be felt desirable for certain types of scenes to raise or lower the level to suit the nature of the transmission. For example, it is very often found that when news-reels are being radiated the picture brightness can be increased to give better effect to the whole result.

Of course, it must not be overlooked that every vision signal transmitted from Alexandra Palace incorporates the D.C. lighting component, and this must not be confused with the screen brilliance control to which reference has just been made. The D.C. lighting, as has already been explained, concerns the relative degree of overall lighting used for interior or exterior scenes. In addition to the varying or alternating component of the picture, which is the amplitude modulation, the mean brightness of the scene is made implicit in the signal. That is to say, the viewer can differentiate between the portrayal of brilliant sunshine, a partially lit room, twilight and so on. There is no fixed level for the average carrier as this is made to vary automatically at the transmitting end according to the scene lighting present at the studio end.

Strength and Focus.—Yet another important control is often termed the vision control. This resembles to some extent the volume control of the sound receiver, and the particular setting at any situation depends primarily on the distance separating the receiver from the transmitting station and the height of the aerial above any form of possible shielding. Its operation increases or decreases the total signal, that is both synchronising and video modulation, and as a general rule is set in that position which gives a picture sufficiently pronounced and holding well in place.

Then we have the focus adjustment which must be turned one way or the other until the lines on the picture are sharp, in just the same way as you manipulate the lens on a home cinema or camera. In the case of electrostatically controlled cathode-ray tubes with two or three anodes, it is the relative positive voltages between these electrodes which the focus control adjusts. This corresponds to moving the positions of lenses in any standard form of optical system. With an electro-magnetically operated tube, this control either increases or decreases the measure of direct current passing through a solenoidal coil surrounding the narrow glass neck. This change in the magnetic field alters the degree of constriction imparted to the beam of electrons passing through the centre of the coil inside the neck.

These constitute the main controls for operation with the usual type of home television receiver, and when it is desired to look in, these controls can be set initially and need not be handled day in and day out, except for very occasional slight movement. The usual procedure on first using a set is to switch on, and after waiting approximately a minute for the valves to warm up the picture brightness is adjusted to an average level and the focus set. Contrast is then advanced to its maximum and the vision control adjusted very carefully until the picture is found to be sufficiently pronounced. Contrast and picture brightness can then be operated together to give the right balance of tone values for personal taste. The best compromise between these two will ensure that the picture is of a pleasing nature.

The Final Effects.—As a general rule all the time base generator controls will have been set on installation, but if the picture, by chance, does not remain quite steady, the line and frame speeds can be set at about their mid position and the "lock" turned very carefully until the picture is steady within the mask frame limits of the screen. The picture height and picture width—quite self-explanatory to the reader—may then be set if required so that the proportions of the picture are correct, that is, 6 to 5.

From the foregoing it will be appreciated quite readily that operating a television

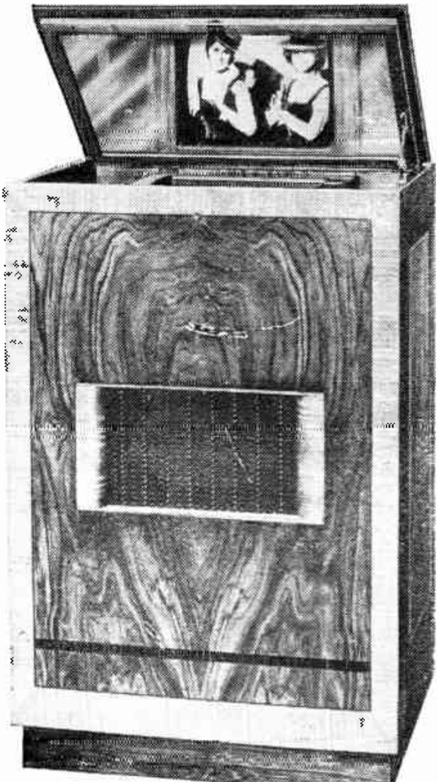


Fig. 65.—A television receiver with very simplified vision controls.

set is a process easily assimilated by the normally intelligent person. In some of the sets featured at the last Radio Exhibition further simplification was aimed at by providing only two controls—contrast and brilliancy. This is illustrated in Fig. 65. No doubt further research will bring about other "economies" in operational controls but it can be said with every degree of sincerity that modern television receivers are quite simple to use after the set has been handled on a few occasions to learn the true function of each knob provided.

CHAPTER XXII

COMPONENTS FOR TELEVISION APPARATUS

In this chapter, we will discuss the various accessories which are now available for experimental purposes. The modern television receiver may be divided up into four separate sections—the Mains unit, the Time Base Generator and the two Radio units, one for Sound and the other for Vision. Into each of these sections components and valves such as are normally used for broadcast apparatus may be incorporated, but there are many special parts and valves which must be utilised. The radio section for sound may be dismissed as this follows normal ultra-short-wave practice, whilst the time base generator will also employ only standard components and valves except where a special gas-discharge tube is employed. This may be considered, however, as a valve and presents nothing out of the ordinary in its connection or mounting. The first consideration among the unusual or special parts required for the complete apparatus is the connection between the various chassis. The mains unit may be built to develop all of the voltages required in every section and thus multi-cables will have to be employed for inter-connection. Apart from the fact that some interaction may be experienced if all of these cables are run in a single "bunch" there will also be difficulty in providing adequate insulation. The supplies for the cathode-ray tube will therefore, be kept separate, and for the various leads high-quality flex or rubber-covered V.I.R. cables should be used.

Connectors.—Multi-contact connections will be needed on each chassis and for these either the Bulgin or the Belling-Lee components designed for the purpose may be used. Large diameter insulated sleeving may be slipped over certain leads to provide increased insulation, or rubber tubing such as is used in player pianos may be employed. Care will have to be taken to keep the various leads separated according to the voltage differences existing between them. When mounting the sockets on the chassis adequate spacing must be allowed between the sockets and the chassis if this is of the metal pattern, although with a metal-surfaced wooden chassis this difficulty will not arise.

Mains Unit.—On the mains unit special transformers will have to be employed for the tube supply voltages and there are several of these now obtainable from B.T.H., Sound Sales, Haynes' Radio, Heayberd, and other firms. Although ordinary valve-holders may be used for the rectifiers, if the H.T. is obtained from valves for the tube, special top-cap connectors of the insulated cowl type should be employed to avoid the risk of shocks. Special metal rectifiers are, as has already been explained, now available for this purpose and are preferred by some experimenters. There are several advantages in the use of this type of rectifier for the very high voltage low current supply which is required, and details will be found on another page.

Special Valves.—For the vision radio chassis, certain special valves are now on the market, amongst these being special diodes for the second detector stage. Special I.F. transformers to provide the requisite band-width, or special chokes where choke-coupling is employed are also now available from such firms as B.T.S., Eddystone, Bulgin, etc. Very elaborate screening is needed in this particular section of the receiver, and it is almost impossible to avoid the use of metal for the construction of the screens and chassis. Remember that aluminium is the best material for these, not only on account of the ease of working the soft metal, but on account of its low H.F. resistance. Standard resistors and condensers may be employed in the normal circuit wiring, but a special output transformer may be required, according to the type of circuit which is adopted.

Fixed Condensers.—A special point which should receive attention is in the selection of the fixed condensers. On the radio units the highest insulation from an H.F. point of view is needed and where possible mica dielectric should be adopted. For the high-voltage circuits, the special oil or petroleum-jelly condenser should be used and the peak voltages must be carefully calculated in order to avoid damage to these. The problem of insulation is probably one of the most important items met with in the general constructional design and thus no risks should be taken in the wiring, or in the mounting of the individual parts. Thick wire should be employed for connection, and insulated sleeving should be used over every lead, with additional sleeving of larger diameter (or the rubber tubing previously mentioned) where leads pass through holes in a metal chassis.

In certain cases it may even be found necessary to drill a very large hole—say ½ in.—in the chassis so that the lead passing through it may be given sufficient spacing to avoid arcing to earth.

Ventilation.—Owing to the large number of valves employed in the complete equipment a considerable amount of heat may be expected, and thus each chassis should be well spaced from its neighbour and adequate air circulation should be provided. The mains unit should be kept clear, for instance, of the underside of a radio unit so that no damage can arise to insulation on leads or components.

Many experimenters may prefer to obtain ready-assembled units for certain parts of a television receiver, and in this connection it should be remembered that one company can supply complete units of the various parts of a modern television receiver so that much experimental work is avoided. These units may be used together to form a complete receiver, or the separate parts be incorporated with home-made units for the purpose. The following is a list of the separate units.

Line Time Base—A hard-valve time base of generous construction for magnetic scanning. Designed for a line frequency of 10,125 sweeps per second.

Frame Time Base—Of similar construction and circuit arrangement to the line time base, but arranged for the frame frequency of 50 sweeps per second.

Television Receiver.—A special superhet circuit with which D.C. restoration of the video signal following the pentode output stage is effected by a diode included on a synchronising impulse separate unit obtainable separately.

Synchronising Impulse Separator Unit—for use with the above receiver.

H.T. Units—Model TV.52 is designed to supply H.T. and heater current for the two time bases above-mentioned, and also for the synchronising impulse separator unit.

Model T.V.2/52 is designed to provide G.T. current for the television receiver in addition to H.T. and heater current for the two time bases and synchronising impulse separator.

Model T.V.16—is designed to provide 5,000 volts at 2 mA to give the final anode voltage on the C.R. tube and a voltage up to 1,000 for the first anode adjustable focus.

CHAPTER XXIII

RECEIVING THE U.S.W. SIGNALS

Gaining Experience.—Since it is known that the sound which accompanies the television service is radiated on 41·5 mc/s., the reader can accustom himself to work in this region, and thus be in a better position to understand the working of these frequencies, when he comes to build the vision apparatus.

The importance attached to the work, however, at least merits a slight measure of overlap, although it must be made clear straight away that a set which is capable of receiving sound signals on the ultra shorts, and reproducing them with clarity in the 'phones or loud-speaker, is in no way suitable for handling the vision signals. Adapters or converters can make the home broadcast set into one which will tune in these ultra-short-wave signals, but for vision's frequency sideband that same set acts as an excellent barrier, and would produce a useless output for passing on to the picture-reproducing apparatus.

A Satisfactory Unit.—Nevertheless, some interesting work can be undertaken with apparatus of this nature, and quite a wide range of circuits is open to individual choice.

As a case in point, reference can be made to Fig. 66, which shows a very satisfactory scheme for a converter to use in conjunction with an efficient radio set. It is as well to mention here that some confusion exists as to the functioning of either adapters or converters. The first named is a unit which has a plug for inserting into the detector valve-holder stage, the valve normally used in this stage being employed in the unit. The tuning system of the original set is thus ignored (and the H.F. stages, if any are included in the receiver), and the signals from the ultra-short or short-wave

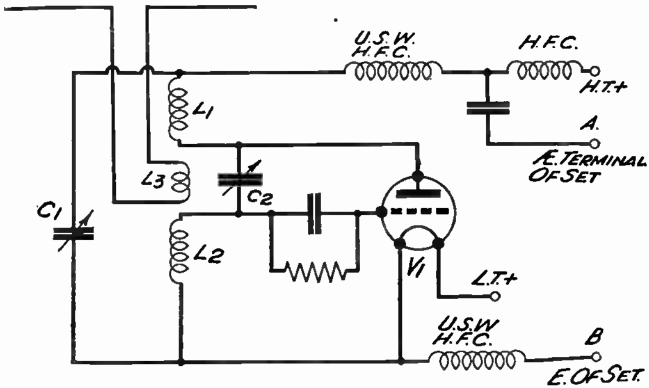


FIG. 66.—The circuit for a suitable ultra-short-wave converter.

adapter unit are amplified by the low-frequency side of the set.

With a converter, however, a frequency change takes place, for the unit converts the set to work on a super-heterodyne principle. One of the requirements for using a converter is that the set should contain one or more efficient high-frequency stages. The unit then works as a combined oscillator and first detector, while the H.F. stages become the intermediate-frequency stages with the set's own detector working as a second detector.

Acting as a Converter.—The theoretical circuit featured in Fig. 66 functions in this manner. The coils L_1 and L_2 are separate, being wound on a $\frac{3}{8}$-in. outside diameter paxolin former. The number of turns required for each will vary according to the wavelength it is desired to receive but as a guide it may be stated that seven turns of No. 18 gauge wire having a spacing between turns equal to the wire diameter is suitable for a wave of 8 metres. This can be altered to five turns for 6 metres, and four turns for 5 metres. Both coils can be identical, although in some cases it may be found desirable to reduce slightly the turns of the anode coil L_1 for efficient and stable oscillation. The degree of magnetic coupling between the coils can best be determined on site, and in consequence either L_1 or L_2 should be capable of sliding gently along the former to locate the optimum position, after which it can be fixed in place.

These coils are tuned across their extremities with a high-grade short-wave condenser C_1 of ·0002 mfd. maximum capacity. Condenser C_2 (·00005 mfd. capacity) is in effect a reaction condenser controlling the measure of energy feed-back to maintain the condition of sustained oscillation which, as pointed out before, is essential for the converter's action as a combined detector and oscillator. Two ultra-short-wave H.F. chokes are inserted in the positive and negative H.T. leads respectively, suitable types for this purpose being the Eddystone 947, while in the positive high-tension feed is also included a standard broadcast form of high-frequency choke of the fieldless type, to prevent feedback from the converted I.F. stages of the set itself.

A Di-pole System.—The H.T. negative connects to the set's earth terminal, while the aerial terminal of the set connects to the junction of the two H.F. chokes *via* a fixed (or sem-variable) condenser of about ·00005 mfd. capacity. Either a separate H.T. and L.T. source can be used, or, if preferred, a tapping can be made to the set's own battery supplies. Furthermore, if the set happens to include a pre-set condenser in the aerial lead, this should be screwed to its maximum value or better still, short circuited.

When receiving the ultra-short waves, it is much better to use an actual aerial designed for this purpose. This is shown in Fig. 73 and consists of a straight length of wire mounted (for the best results) vertically in the highest possible position on the roof of the house in which reception is being undertaken. It is really a di-pole, being of total length just half the wavelength of the transmission it is desired to receive. Thick stiff copper wire is quite satisfactory, and at the centre is a definite break giving a gap of 2 to $2\frac{1}{4}$ in. To these wire extremities is joined the aerial feeder, a length of twisted flex, kept well insulated from the house wall, and led into the unit to be joined to the ends of the coil L_3. This is a two-turn coil wound close to L_2 on the earth end of the same former used for L_1 and L_2. The exact degree of coupling between L_3 and L_2 can be determined experimentally for efficient working.

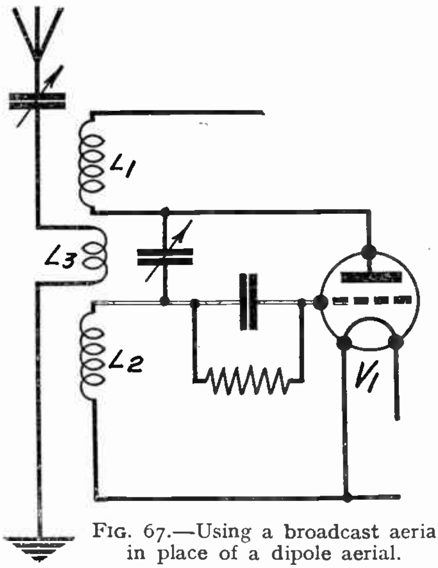


FIG. 67.—Using a broadcast aerial in place of a dipole aerial.

Operation.—If it is inconvenient to use an ultra-short-wave di-pole of this character, then the ordinary broadcast receiver aerial can be employed. This is as shown in Fig. 67, where coils L_1, L_2, L_3 are as before and a ·00005 mfd. maximum capacity variable condenser is inserted in the aerial feed to L_3. A valve which oscillates readily should be used in the unit, such as the L210, 210LF, or PM1LF, and in laying out the components be sure that all leads are kept as short as possible. Where it can be arranged, mount the coils directly by the side of the tuning condenser, and certainly restrict the grid leads to a short path.

With the valve oscillating freely, tune the unit carefully and slowly, having the broadcast set tuned to a long wavelength if possible. The scheme is simple and effective, and will certainly give a measure of practice in searching and handling ultra-short-wave components in readiness for future application. If desired, the unit can be disconnected from the broadcast set and a pair of 'phones joined across points A and B (Fig. 66), the converter then being used as a single valve set.

Another Auxiliary Unit.—Yet another form of auxiliary unit suggested on the Continent is shown in Fig. 68. The tuning system L_1 C_1 follows standard practice, the coil turns of L_1 depending on the coil diameter and the wavelength it is desired to tune. Reaction (when desired) is effected by including a small differential condenser C_2 in the position shown. In the anode circuit of V_1 is an ultra-short-wave H.F. choke and a load resistance of about 20,000 ohms. The " coupling circuit " consists of a fixed condenser of ·01 mfd. capacity, and a fixed resistance of 100,000 ohms value. The terminals A B can then be joined to the tuning circuit of the ordinary set's detector stage by means of a vario-coupled coil, or to the H.F. amplifier, or to R.C. coupled L.F. stages.

Experimental Details.—In addition to experimental ultra-short-wave radiations, which have been conducted in this country, a large number of tests have been made in America with special reference to their application to television signals. Although the vision and sound signals are sent out from two separate transmitters working on different wavelengths, experiment has shown that one single communication channel can be used, this consisting of the vision carrier and its own modulation signal, together with an accompanying sound carrier and signal modulation. The radio receiver used for this work then had a solitary band-pass tuning system for receiving and accommodating the complete channel (that is, both carriers and their own sidebands). Then a heterodyne oscillator beat with the two carriers to produce two intermediate frequencies, separated by a predetermined frequency which was the frequency separation of the sound and vision carriers. From here the separated signals passed through distinct sections of the radio set, the output in one case feeding the loud-speaker, and in the second the picture-reproducing device.

Aerials.—The aerial system used for receiving an ultra-short-wave system of this nature varies according to the nature of the district and the degree of "screening" experienced from the transmitting aerial. In many locations the aerial could be fixed inside the house (its exact interior position was a matter of experiment on site), and consisted of a vertical rod almost half a wavelength long (di-pole). The feeder lines from this could be twisted flex, as previously mentioned, or two wires spaced about 2 in. apart throughout

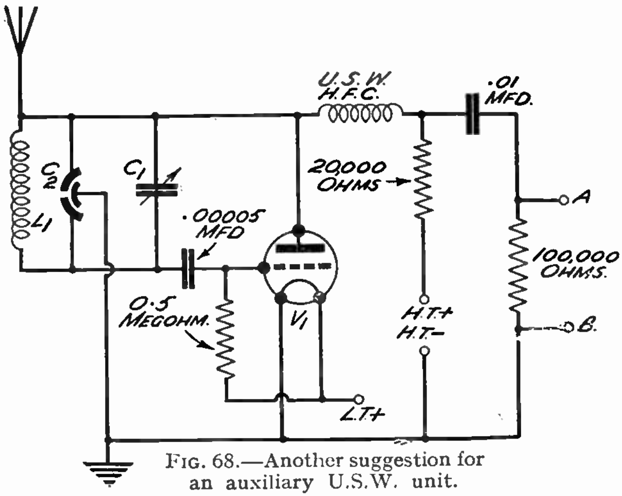


FIG. 68.—Another suggestion for an auxiliary U.S.W. unit.

their whole length. Short spreaders maintained this separation, being placed at convenient intervals. Another type of receiving array is the Zepp aerial, which consists of two rigid and parallel feeders separated by approximately two inches. One of these terminates at the end of a vertical di-pole, while the other is left free. Any tendency for the feeder to radiate is neutralised by the double wire. In some cases the dual feeder consists of two concentric metal tubes, the inner one joining to the base of the di-pole, while the outer is an effective neutraliser.

Ample Scope.—On the question of receiving ultra-short-wave transmissions, it would appear that the suitability of different types of aerial arrays will provide a very fruitful source of experiment to the interested home constructor.

Directive aerial arrays can be built, and the improvement in signal strength and increase in range of reception derived from this have proved of marked advantage. In some cases the assembly of spreaders, aerials, and reflectors becomes a trifle cumbersome and requires a large flat roof or open space for erection, but reasonably compact modifications of these, although, of course, not so effective as their properly designed counterparts, will repay amply the time and work spent in building and erection.

CHAPTER XXIV

A "SOUND" ONE-VALVE SET

VERY few components are required to construct the Ultra-High-Frequency Receiver seen in Fig. 69, and, in fact, it can be made from odd components to be found in almost any enthusiast's workshop. R, the grid leak, should be about ¼ megohm, the grid condenser should be ·0003 mfd. and must be a mica type. C2 should also be of the mica variety with a capacity of ·005 mfd. The radio frequency choke (R.F.C.) may be home constructed in the following manner. Obtain a paxolin or ebonite former about 2½ in. in length and wind on 30 turns of fine cotton covered wire about No. 36 gauge. The wire can be terminated at each end of the former with a blob of sealing wax and the ends bound round a short length of 16-gauge tinned-copper wire ready for wiring direct into the circuit.

A reliable manufactured radio-frequency choke may be used if desired, but care should be taken to make sure that it is designed to work on these very short wavelengths.

The tuning condenser, VC, should have a capacity of about ·0001 mfd. and should preferably be of good manufacture having easy movement and a pigtail connection to the moving vanes. A slow-motion dial is essential if the best results are to be obtained.

The other essentials for the complete receiver are a wooden baseboard and a metal panel about 6 in. by 6 in., a push-pull or " click action " switch for cutting the L.T. supply, a 2-volt power valve (with full emission !) a 4-pin ceramic valve-holder, a 2-volt accumulator and a 90- or 100-volt H.T. battery. A pair of headphones completes the requirements.

Building the Set.—In constructing the receiver the grid leak and condenser, R and C_1, should be wired direct on to the valveholder and all leads must be kept as short as possible. It is recommended that wiring should be carried out with 14-gauge tinned-copper wire. The lead from the grid leak and condenser to the tuning condenser must also be as short as possible. All the earth connections should be taken direct to L.T., and the earth connections to the tuning condenser should be connected to the moving vanes terminal. This terminal should also be connected to the metal panel at some point. All forms of " fancy wiring " should be avoided and leads should be soldered and taken direct to their various points. The coils L_1 and L_2 may be constructed of 12-gauge tinned-copper wire and should be about 1 in. in diameter and closely spaced. A convenient former for winding these coils is a 1 in. test tube. L_2 requires about 6 turns for reception of the television sound programmes and about 4 turns for reception of amateur transmissions on 5 metres. The coil should be mounted direct on the tuning condenser and owing to the stiff wire used it should be perfectly rigid in this position.

Care should be taken before sliding the coils off the former to see that enough length has been left at each end for connection to the tuning condenser.

L_1 should be 3 turns for the television sound and 2 turns for 5-metre reception. This coil should be coupled fairly close to L_2 and may be mounted on some small pillar insulators fixed to the baseboard or any convenient form of mounting which appeals to the constructor.

The connection shown in the circuit diagram from the centre of L_2 to the radio frequency choke may be attached to the coil by means of a small clip and a short flexible lead.

The above details for coils are only approximate and some experimenting may be necessary for exact sizes as conditions alter in individual receivers but the sizes given are a good guide to commence with.

The Aerial.—A doublet type aerial is recommended for best results with this particular receiver and details are given in Fig. 70. The two top lengths of 4 ft. 6 in. should preferably be made of 12-gauge tinned-copper wire and the gap between the two top pieces in the centre, should be 6 in.

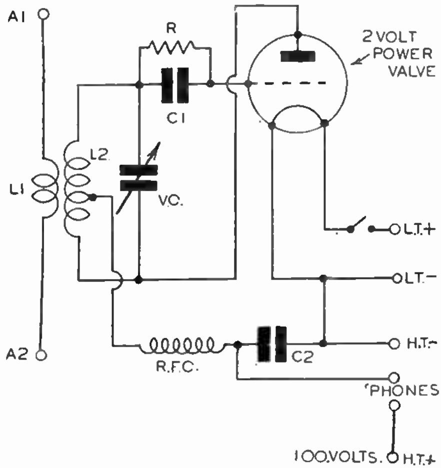


Fig. 69.—Theoretical circuit of the "Sound" 1-valver.

For the twisted flex down lead good quality flex should be used to avoid trouble from moisture. The two ends of the

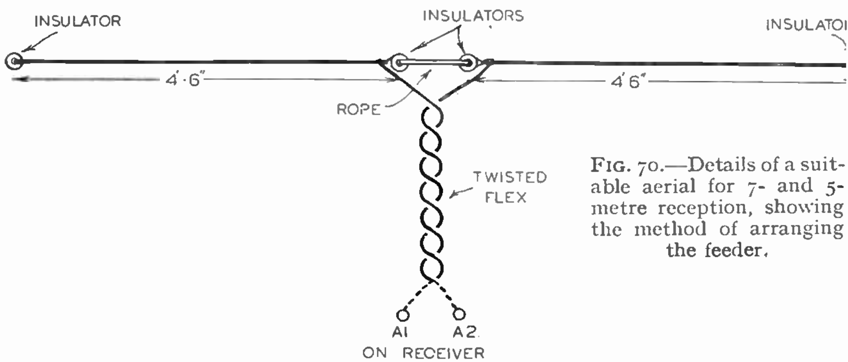


Fig. 70.—Details of a suitable aerial for 7- and 5-metre reception, showing the method of arranging the feeder.

doublet are connected to terminals A_1 and A_2 on the receiver, these being the ends of L_1.

Where room permits, some experiments may prove worth while for the best direction of the aerial in relation to the signals desired. The flex down lead may be any length, but naturally it should be kept as short as circumstances will permit. The whole aerial should be fixed high and in a clear place away from trees and buildings, if possible.

Where it is not convenient to fit this type of aerial a single wire may be used and coupled through a midget variable condenser direct to L_2. In this case L_1 will not be required.

No difficulty should be experienced in "getting things going" if care has been exercised in the construction of the receiver but a few general remarks may help to give the constructor an idea as to what should happen when the set is switched on.

As the receiver is a "super-regenerative" a fairly loud hiss should be heard in the 'phones and this will continue until a carrier or modulated signal is tuned-in. When tuning a signal the hiss will disappear except in the case of weak signals when some hiss may still be audible. The television sound should be received quite well in most cases up to 30 miles radius of Alexandra Palace and using this circuit signals from A.P. have been received some 50 miles south of the transmitter. On 5 metres amateur transmitters should be heard on telephony, and the best time to listen for them is on Sunday mornings.

Ample volume for normal use should be obtained from this set, but if more volume is desired a stage of choke coupled amplification with a variable audio output control can quite easily be added to the existing arrangement.

CHAPTER XXV

AERIALS FOR TELEVISION

The aerial is the first link in the chain of the television receiver, and so it is essential to make it as efficient as possible in order to obtain the maximum input signal, as this may mean a saving of one or two valves in the receiver itself. The first thing to remember about the aerial, in fact, about any aerial, is that it must be erected as high, and as far away from surrounding objects, and sources of interference, as possible. The ultra-short waves, such as are used for television, are affected to a much greater extent by surrounding objects than the lower frequencies used for sound broadcasting, since they travel in straight lines, and are not usually reflected by the ionised layers in the upper atmosphere. Metal objects, in particular the metal framework of buildings, screen the aerial or reflect the waves back so that they cancel out or reduce the signal at the aerial. Interference is also much more objectionable as it appears as white spots on the screen, giving a snowstorm effect which completely spoils the picture, while it may only appear as a faint crackle in the speaker. Cars cause a large amount of interference on the ultra-short waves, so that it is advisable to mount the aerial as far from any main road as possible.

All television aerials must be mounted vertically, as the transmitting aerial is vertical, the transmitted waveform being vertically polarised, but at long distances when the signal has been reflected, or when the receiver is to be operated in the shadow of a hill, the wavefront may have become tilted, and so it may be advantageous to tilt the aerial, so that it may still be parallel to the wavefront. In the first case, the tilt may be in any direction, depending on the number and angle of the reflections, but in the second case, the top of the aerial will have to be tilted away from Alexandra Palace.

Three Main Types.—Not including complicated arrays, there are three main types of aerials in use for television reception, and all consist of a vertical wire or tube, which is half-wave at the vision frequency. The vision wavelength is 6·66 metres, so that a half-wavelength is 3·33 metres in air, but the velocity of the wave is slower in copper than in air, therefore from the well-known formula that: Velocity is equal to Frequency times Wavelength, it is obvious that if the frequency is constant at 45 mc/s per second the wavelength must be less in copper than in air. The distributed capacity also causes a decrease in velocity, so that the wavelength is usually taken as being approximately 95 per cent of that in air, that is about 11 ft. $\frac{1}{2}$ in.

As most of the figures in connection with ultra-short-wave aerials vary according to the materials of which they are constructed, and their location, it is advisable to make up an experimental adjustable di-pole, for use in determining the exact lengths to use, but it must be remembered that the thinner the wire, the more it slows the wave down, but at the same time, the L/C ratio decreases, and so the selectivity goes up. Thus in order to have sufficient band-width for good definition, and to give adequate input on sound, the same aerial is invariably used for both vision and sound ; it is advisable to use tube for the aerial, or at least a fairly

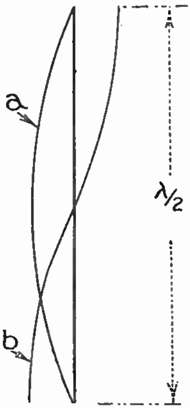


FIG. 71.—Showing the distribution of (*a*) current and (*b*) voltage in a half-wave aerial.

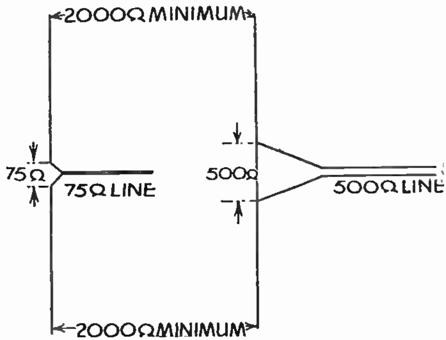


FIG. 72.—Showing the connections for (*a*) low-impedance and (*b*) high-impedance feeders to a centre fed aerial.

heavy gauge of wire. Amateurs who possess a camera tripod, can use two of the legs, lengthened if necessary, as the two sections of a split di-pole, thus facilitating adjustments.

The impedance of a continuous half wavelength of wire is about 75 ohms at the centre and rises to upwards of 2,000 ohms at the ends, depending on the gauge of wire used. If this wire is split in the middle, the impedance between the inner ends is therefore approximately 75 ohms.

Balanced Feeders.—Fig. 71 shows the distribution of current and voltage in a half wavelength aerial, and it at once becomes obvious that it may be either current fed by connecting to its centre, or voltage fed by connecting to either end. The simplest method of connecting the aerial to the set, is to split it, and connect a length of 75 ohms balanced feeder (such as the Belling-Lee), to the inner ends (Fig. 72). If it is desired to use a higher impedance line, say 500 or 600 ohms, the aerial is not split, but the feeders are tapped on to it at points equal distances either side of the centre, so that

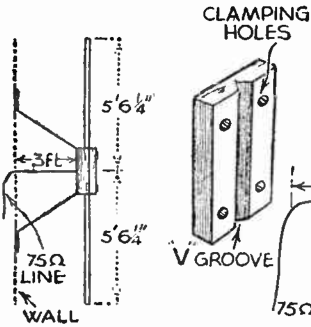


Fig. 73.—Shows the construction of a practical split di-pole using tube, and details of the clamping block.

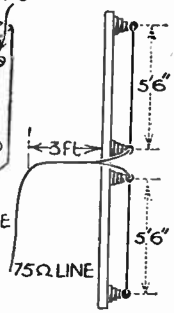


Fig. 74.—The construction of a practical split di-pole using wire.

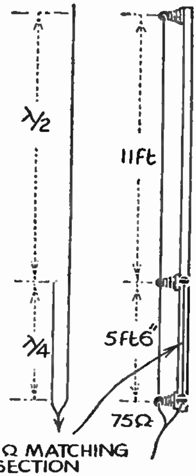


Fig. 75.—The method of end-feeding a half-wave aerial, and (*right*) a practical arrangement of the aerial.

it is terminated in its correct impedance. For those who want to make up a high impedance line, or a matching transformer, the formula is $Z = 276 \log \frac{D}{d}$ where Z is the required impedance, D is the spacing, and d is the diameter of the wire. Figs. 73 and 74 show two practical methods of constructing split di-poles, by using tube or wire. The first type consists of two quarter wavelengths of copper or brass tube, $\frac{3}{8}$ in. to $\frac{5}{8}$ in. diameter mounted end to end in a wooden clamp suitably weatherproofed. Wood is quite satisfactory as an insulator here, as the centre of the aerial is an anti-node as far as voltage is concerned (Fig. 71). In fact, when the continuous type of aerial is used, Fig. 72, it is quite satisfactory to use a metal clamp in the middle, and not have any insulation at all.

The aerial shown in Fig. 74 consists of two quarter wavelengths of wire mounted on stand-off insulators on a piece of wood about 12 ft. long. This aerial has the advantage that it is cheaper to construct and can be mounted by its end if necessary, but it must be remembered that the feeder should not hang down directly behind it, but should be taken about 3 ft. perpendicularly away from it before being allowed to drop, as otherwise it unbalances the aerial. The best quality stand-off insulators should be used at the ends, as these are anti-nodes for voltage (Fig. 71), and the wire should be as heavy a gauge as possible in order to keep the band-width up.

Matching Transformer.—As with transmitting aerials, it is possible to end-feed the aerial, using a quarter wavelength matching transformer as the impedance of the end is over 2,000 ohms; thus making the aerial three quarters of a wavelength long. (Fig. 75.) Owing to the large variations possible in the impedance of the end, it is necessary to take an approximate value for it, and make final adjustments on test. The formula for the impedance of the transformer is: $Z_T = \sqrt{Z_A Z_L}$ where Z_T is the transformer impedance, Z_A is the end impedance of the aerial, and Z_L is the impedance of the feeder. Assuming Z_A is 2,000 ohms, and Z_L is 75 ohms, then Z_T is approximately 387 ohms. In the formula $Z = 276 \log D/d$, Z is 387 ohms, and using 16 gauge wire $d = {\cdot}064$ in. D, the spacing, becomes approximately 1·63 in.

The easiest method of constructing an aerial of this type is to make it of wire, and mount it on a pole, the remarks made about insulators, and the gauge of wire, in connection with Fig. 74, apply equally here.

Using a Reflector.—The signal picked up by any of these aerials, can be easily doubled by the use of a reflector. This simply consists of a continuous half-wavelength of wire or tube, placed one quarter of a wavelength behind the aerial, that is to say, on the side away from Alexandra Palace, so that the reflector, the aerial, and the Palace are in line. This may sound a difficult adjustment, but the reflector may be as much as 15 degrees out of line either way, without any

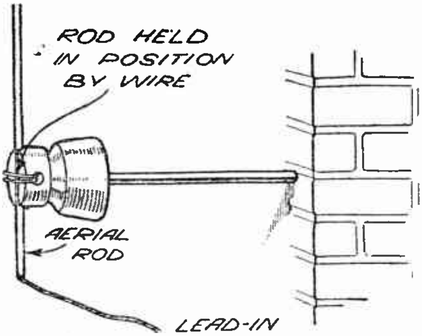


Fig. 76.—The Aerial rod, or leading-in wire may be held away from the wall by means of an insulator of this type.

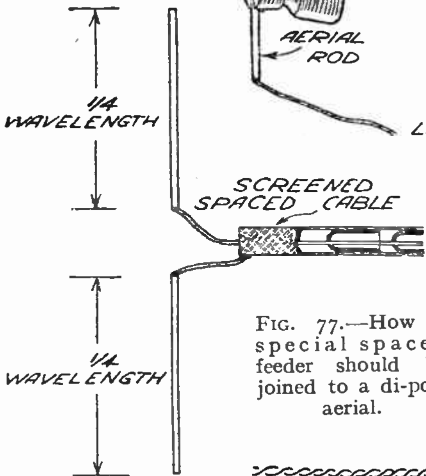
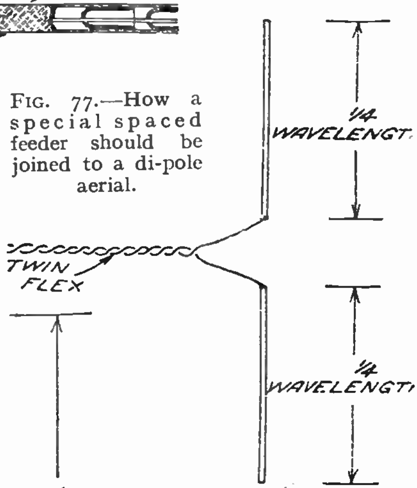
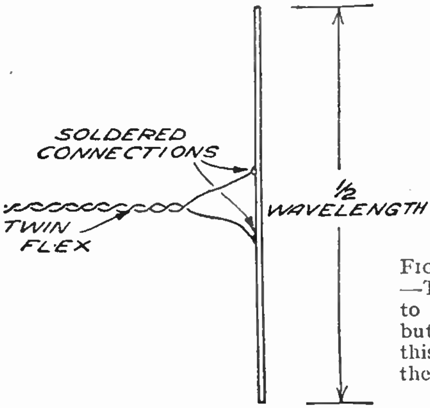


Fig. 77.—How a special spaced feeder should be joined to a di-pole aerial.





Figs. 78 (*above*) and 79 (*left*)—The feeder should be joined to the centre of the di-pole, but it is not essential to cut this. The distance separating the two feeder ends is critical.

noticeable difference, and in many cases it should be possible to move the reflector round to locate the position of maximum signal strength.

Aerial Construction.—For the aerial either wire or rod may be used, but it should be made a point that the largest possible area of metal should be used, and therefore heavy copper rod or tube is desirable. Above a certain thickness it will be found that there is little improvement in signal strength except when going below 5 metres, and even then the additional surface will introduce other factors which will offset the advantages gained. Half-inch copper tubing, or 12 S.W.G. copper wire may be considered the most satisfactory the latter affording the simplest constructional details and being cheaper. The standard type of stand-off insulator will accommodate this gauge of wire, and to hold it rigid clear of walls, etc., a wooden extension must be fitted. Again each constructor will have to try for himself the best arrangement, and where a short chimney stack is within easy reach the aerial may be held to this. The wire must be stretched tightly so that there is no sway or whip in the wind and a support top and bottom will be adequate. With the copper tube, more supports will be needed to avoid collapse of the tube in a gale, unless very heavy gauge tubing is obtained. The expense of this is not justified.

Feeder Arrangements.—The feeder should be connected by soldering, and the joint should be painted to prevent corrosion. Ordinary lighting flex (14/36) may be used, or similar gauge of wire obtained as a single lead and twisted throughout its length by the use of the standard Cross-feeder or similar components. With the latter arrangement it is important to try and arrange the run of the feeder so that the whole arrangement does not twist upon itself. That is, it should run from aerial to receiver exactly as drawn in Fig. 78, and it will be found that this can be done by stretching the wire from the aerial as the separators are placed into position, and anchoring the lower one to a window frame by means of rope and ordinary egg insulators.

In Fig. 79 the twin flex is shown connected to the centre of the single aerial, and the distance separating the ends should not be less than 6 in., nor greater than one foot. Furthermore, each half must be identical in length to get the best from this arrangement. In Fig. 78 the intervening space has been removed, but it should be noted that the two separate halves should be equal to one half of the wavelength, the intervening space being ignored. This is not of great importance above 6 metres, but below this wavelength it may prove very critical. In Fig. 77 the special spaced screened lead is employed, where the inner wire is held rigid in the centre of a screened cable. This is sold by Messrs. Ward & Goldstone under the trade name of "Metocel," and in this particular arrangement, the screening is joined to the lower half of the aerial and the lead to the upper half. In each of these arrangements it is essential that the feeder be taken away at right-angles to the aerial and it should not run in the same plane within a considerable distance if it is to function properly.

Other arrangements may suggest themselves to the experimenter, based upon these fundamental schemes, and it will be found that the results on the lower wavelengths may be considerably improved by the use of these special aerial arrays.

CHAPTER XXVI

TELEVISION APPLICATIONS

THE ability to convert a picture or an image into electrical impulses renders a number of novel inventions practicable, and, in fact, certain experiments which have been made in the past have shown that there are some very useful inventions ready to be used. At present, the image is transmitted as varying degrees of light and shade, and therefore with a cathode-ray tube a fair range of colours are available. A darkened room is advisable in order to see the picture with its full brilliancy. With the mirror-drum or mirror-screw

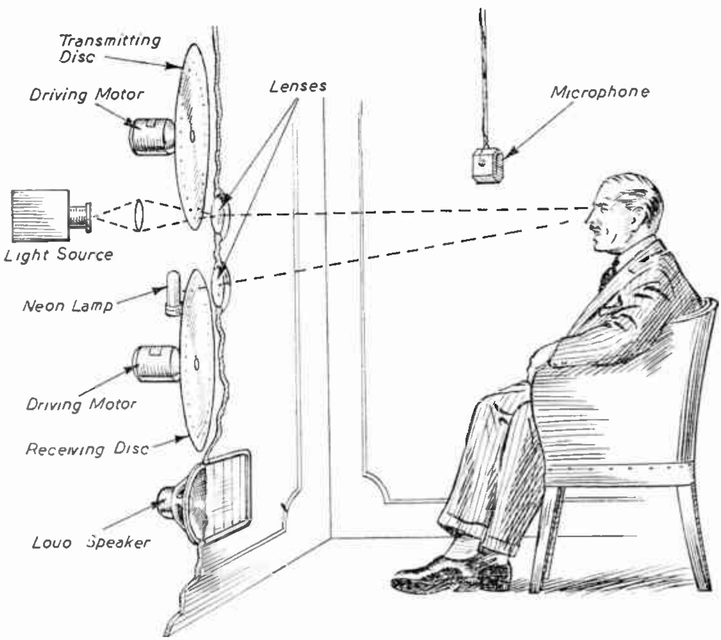


FIG. 80. — Showing the equipment arrangement in the New York experiment described.

a white light was used at the source and thus the picture took on an almost black-and-white effect, a slight discolouring being apparent, due to the passage of the light through the necessary modulating source. With the cathode-

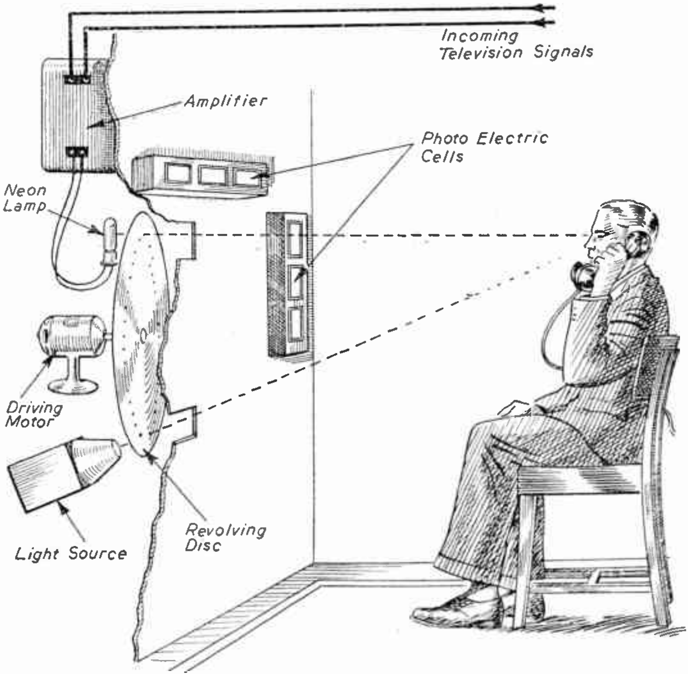


FIG. 81.—A schematic impression of the Berlin demonstration of two-way vision and telephony.

ray tubes the colour of the screen is normally green, although there are now many other colours used, notably sepia and blue. With all of these schemes, we have animation in the artist or person being broadcast, and this is accompanied by sound from the loud-speaker, which gives an illustration of life. This is spoilt, however, by the fact that the image is small and in monochrome. Obviously, it will be necessary in the future to transmit a picture with all the colours of nature if it is to be at all real, and although the cinema film is not perfected to-day in which colours are reproduced correctly, experiments which have been made by Mr. Baird have shown that it is possible to transmit images in colour by present television systems.

How it is Done.— Colours are made up from the three primary colours : red, blue and green, and therefore it seems logical to suppose that if we split up our image into its

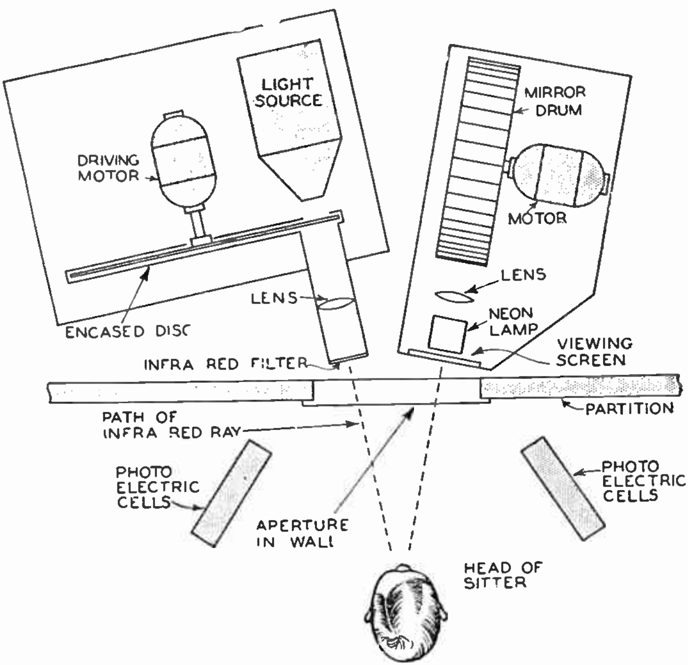


FIG. 82.—Showing how the principles of noctovision were employed in the Paris demonstration of viso-telephony.

separate colours and transmit these, amalgamating them at the receiver end, we should be able to see our picture in colour. The splitting up is carried out by using three light filters, and the scanning disc is provided with three sets of spiral holes. Behind these are arranged three colour filters, the necessary colours being thus filtered as the object is scanned. Three banks of photo-electric cells, each sensitive to one particular colour, are used, and thus the complete scanning almost amounts to three separate scans, one in each colour. These are transmitted in the normal fashion, and at the receiver end a similarly punched disc is employed and behind this are placed the colour lights. These are essentially of the type which will respond to the signal fluctuations and thus a neon lamp is used for the red light source; a mercury and helium lamp for the blue and green source. To split these lamps into their necessary colour tones in conjunction with the scanning holes and the transmitted image, a special form of commutator was employed, and thus it was a fairly simple matter to ensure that as the blue light was illuminated the necessary scanning holes passed across the lamp and thus the complete image built up to form a picture in colour. Unfortunately, there are difficulties, not the least of which is the loss of light which necessarily arises owing to the three sets of holes. Furthermore, the light sources are not brilliant enough to give full strength to the brighter parts of the image, but sufficient has been said to show that the possibilities of television in colour are not beyond reason, and no doubt the time will come when a monochrome image will be a thing of the past.

Noctovision.—Another development of television is to be found in the utilisation of the infra-red rays for the illumination of the subject being televised or transmitted. At present the object is illuminated by a bright light source placed behind the transmitting disc. At an experiment some years ago this light source was replaced by a special light and filter through which only infra-red rays passed. As is well known these rays are invisible, and they are already frequently employed in burglar alarms, etc. If, therefore, the object to be transmitted is placed in a darkened room, and is scanned by means of infra-red rays, the light variations would still be recorded by the photo-electric cells and the image could be transmitted, even although in complete darkness. Sir Oliver Lodge attended a demonstration of this system, and consented to being televised. He sat in a completely darkened room, and although so far as he was aware nothing at all had happened, he was clearly seen in Glasgow by some newspaper representatives and appeared as though he was in a fully illuminated room!

This opens up possibilities of seeing by night and a use for television in times of war is thus produced. The infra-red rays are very far-reaching, and photographs which have been taken in recent months have recorded objects at a distance where normally no eye or camera could pierce. The television apparatus may thus be used for long-sight by a suitable use of the infra-red rays. It is not too much to expect that in time of war an aeroplane could be fitted with the transmitter, using infra-red rays to pierce the clouds and mists, and be sent by wireless control above enemy country and thus enable the activities clearly to be seen without hindrance.

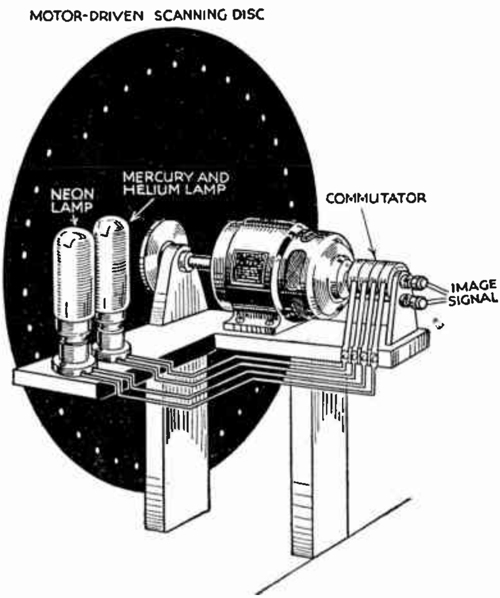


FIG. 83.—Using a commutator to enable switching from one lamp to the other to take place.

Telephones and Television. — A further development, and one which has been carried out in the experimental stage, is that of the combination of television and the telephone. Thus, a television transmitter and receiver is built into a telephone box, and when the subscriber places his coins in the box he is able to see the person at the other end, and two-way conversations are made much more interesting. This experiment has been carried out both in America and in France, and the arrangement of the necessary equipment is shown in Fig. 80 where it is seen that a transmitting disc is arranged on one side of the caller, and a mirror-drum receiver on the other side. Banks of photo-electric cells are arranged in the box, and the action of calling a subscriber switches on the necessary power and starts the

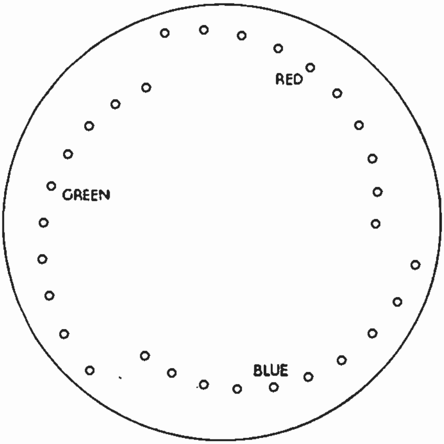


FIG. 84.—A triple spiral scanning disc with red, green and blue filter apertures.

transmitting disc. At the other end a similar action takes place, and the telephone box is provided with a screen near the mouthpiece above which the distant person is seen. To avoid spoiling the image by the telephone equipment, a loud-speaker is fitted in the box and a microphone is employed instead of a mouthpiece, and thus the caller sits and talks as though the distant person were present. The accompanying illustrations show some of the equipment which was employed for the experimental transmissions.

Talking-Film Television.—One advantage of adapting television in such a way that human subjects are replaced by those of talking films is that a greater amount of light is available for activating the solitary photo-electric cell required. In spite of much that is said to the contrary, there is really no further practical simplification of problems that arise. Once the light and shade have been converted to electrical equivalents, the latter have to pass through identical amplifiers and other transmitting equipment before entering (at whatever distance away it may be) identical receivers, there to be re-translated into terms of light and shade for the image that finally presents itself.

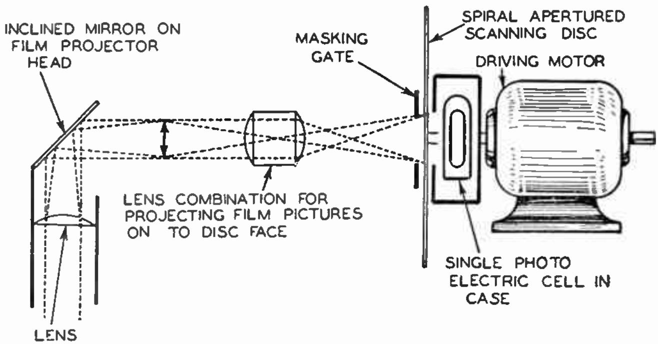


FIG. 85.—Showing how the individual film pictures are projected through the apertured disc for scanning.

The Cinematograph Analogy.—The reader is no doubt aware that in the case of the normal film projector used in cinemas, an individual picture is projected on the screen for a fraction of a second, the light then being cut off by a shutter while the film is whipped forward by sprockets a distance exactly equal to the height of each successive picture, and the shutter again opening, as soon as this movement is complete, to allow of the projection on the screen of the next individual picture, and so on. This intermittent forward movement of the film is carried out 24 times a second, thus giving the illusion of movement.

Continuous Motion for Film Television.—For television purposes, however, the motion of the film forward must be absolutely smooth and continuous, quite apart from any gearing arrangement required for the standard low-definition image-rate of 12½ per second. In the case of the projector first successfully used for purposes of television the film was fed through at a constant and uniform speed, while an arrangement of lenses and mirrors caused two appropriate adjacent pictures to merge together at any one time, and no matter how slowly the film was run there was not the slightest trace of flicker.

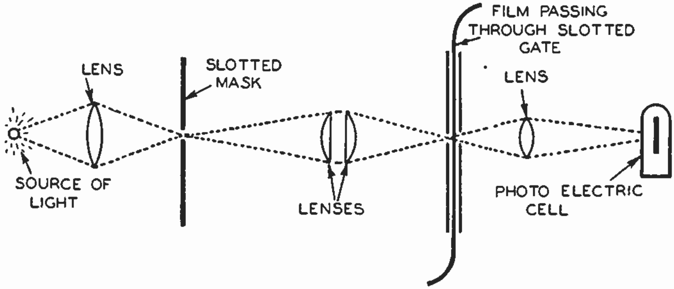


FIG. 86.—The arrangement adopted for reproducing the sound on the film as an electrical signal.

Flickerless film pictures were accordingly projected and focused on to a rotating scanning disc with its series of equi-angularly spaced apertures arranged in the form of a spiral. The projected picture on the disc face was not much larger than the original picture on the film.

Television Transmission.—A single photo-electric cell, shielded by a metal case except for an appropriate aperture, was mounted in line, with the disc intervening, the only light falling on the cell's active electrodes therefore having to pass through the disc apertures. These apertures in turn only passed through them the amount of light falling on the particular part of the picture being scanned. Varying light and shade were accordingly translated into varying voltage, the resultant signal being amplified and transferred to the receiving end in the normal manner.

An aperture gate ensured that only one aperture was scanning the picture at any particular moment, and also masked off the synchronising signal at the top of each light strip, the momentary breaks in the scanning between any two strips producing synchronizing signals. To take full advantage of films with sound-tracks incorporated, an auxiliary sound-head arrangement was added to the equipment, whereby a means was provided for the sound-track to pass between an independent source of light and its appropriate single small photo-electric cell in the normal way.

With only 30-line scanning the nature of the film subjects which could be transmitted was very restricted, consisting mainly of head-and-shoulder photographs. A subsequent improvement provided 48 scanning lines and 25 pictures per second, necessitating an increased sideband for radio transmission, but present transmissions have, as explained before, gone beyond that, and are likely even to extend.

Following on this, Von Ardenne actually used a cathode-ray tube as part of his television transmitter. In this the electron beam spot was focused optically on film pictures projected on the tube's fluorescent screen, the varying light passing through this combination being allowed to impinge on a single photo-electric cell encased in a box. The intensity of the light on the cell controlled the horizontal scanning velocity of the electron spot in accordance with the principles of variable velocity scanning as distinct from variable intensity exploration. The fluorescent screen carried in consequence an image of the diapositive scanned, and this served as a monitor to judge exactly what was being scanned.

Transmitting Ordinary Films.—When it is wished to transmit an ordinary modern talking film complete, instead of head-and-shoulders, or simple black-and-white subjects, it is necessary to increase greatly the number of scanning strips into which the image is divided. The Baird Company are now employing the latest high-definition methods for this purpose. The film passes through a gate at a steady speed of 25 pictures per second, the intermittent shutter movement of the ordinary film projector being, of course, absent. An arc light source and an optical system of lenses projects in turn each individual film picture on the top section of an encased scanning disc rotating at a speed of 6,000–7,500 revolutions per minute. Near its periphery is a circle (not a spiral) of minute holes angularly spaced. The disc rotates at 100 or more revolutions per second, and the film traversing at the rate of 25 pictures per second, it follows that each separate picture is scanned by numerous

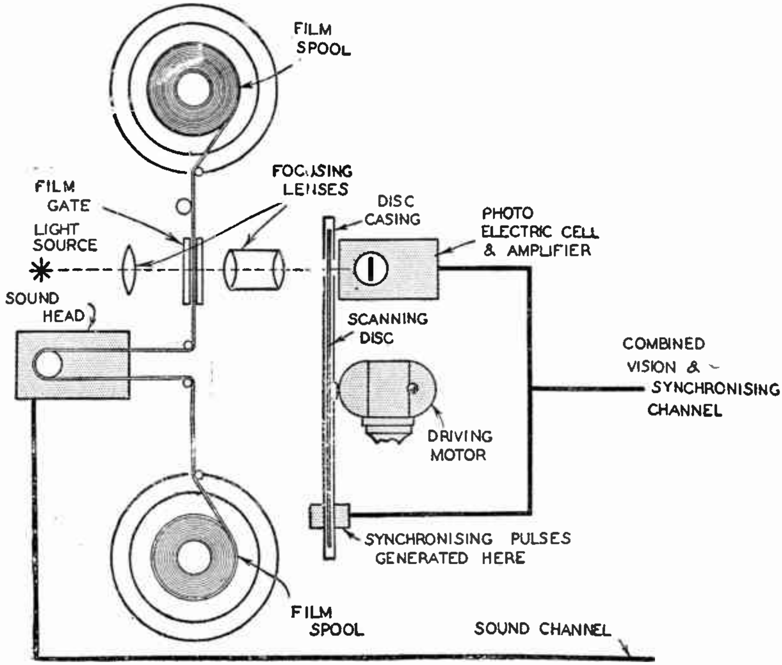


FIG. 87.—Pictorial diagram showing how talking films are televised by the high definition process.

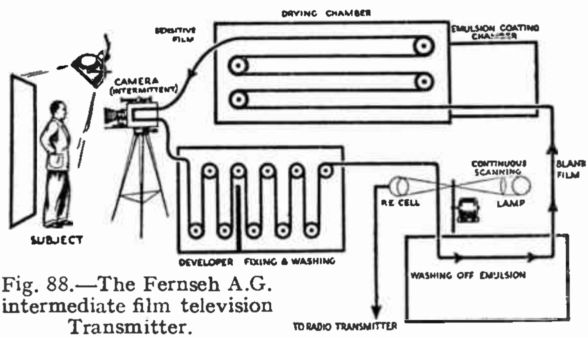


Fig. 88.—The Fernseh A.G. intermediate film television Transmitter.

horizontal lines. A single small projection lamp and cell work in conjunction with the normal means of providing voltage variation, for the purpose of generating the requisite synchronising pulses, which are superimposed upon the pic-

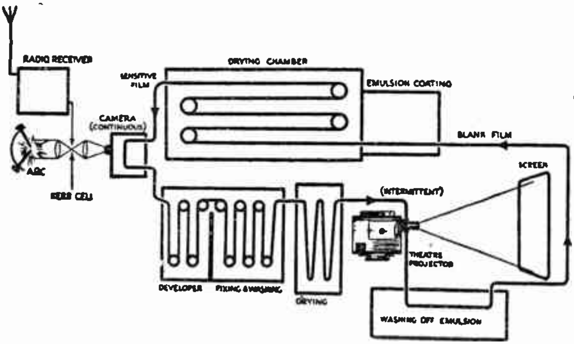


FIG. 89.—Indicating how the received television signals are recorded and finally projected on to a large screen.

ture signal and combine to modulate the carrier wave generated by the ultra-short-wave radio transmitter. At the same time the film passes through a standard film projector sound-head. At the receiving end, as far as the television signals are concerned, images are obtained by using a cathode-ray tube.

CHAPTER XXVII

COLOUR TELEVISION AND STEREOSCOPIC RELIEF

To obtain the complete illusion of reality in the transmission of images to a distance the received image should have both colour and also depth—that is, stereoscopic relief. In 1926, when television was demonstrated for the first time, the little pictures shown by Mr. Baird were small and imperfect, and it might be thought that at that early date no effort would have been made to complicate matters by attempts to add colour or stereoscopic relief. Such experiments were, however, actually made by Mr. Baird as far back as 1928, when he showed television in colour to the British Association. A little later he followed this by an experimental demonstration of monochrome television in stereoscopic relief.

OPERATING PRINCIPLES.—It might be interesting to review briefly the principles employed in these first demonstrations,

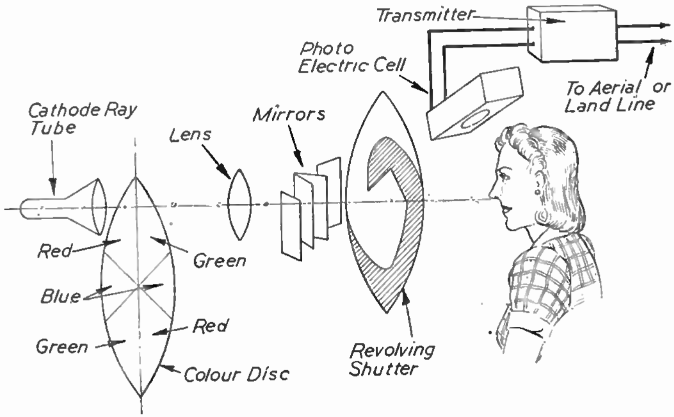


FIG. 90.—Schematic diagram of a colour television transmitter.

as they form the basis of present-day results. The monochrome television image was transmitted by scanning the image in a succession of lines. At the receiver a screen was scanned by a light spot, which varied its brilliance, depending upon the light and shadow of the picture. In the colour process three such pictures were transmitted, one red, one blue, and one green, the three blending to give an image in colour. Stereoscopy was obtained by transmitting two images corresponding to a stereoscopic pair, and viewing them at the receiving station through a stereoscope.

Little was done to develop either colour or stereoscopy for many years. In 1936, however, Baird showed a 12 ft. colour picture to a cinema audience at the Dominion Theatre, London, the picture being transmitted from the Crystal Palace by wireless. This was followed in 1939 by a demonstration of colour, using a cathode-ray tube in conjunction with a revolving disc—the method used to-day. Nothing whatever was done with stereoscopy until recently, when Mr. Baird set out to produce a high-definition stereoscopic image in colour.

The first experiment was applied to his 600-line two-colour apparatus. The red image was made to view the scene from a slightly different angle from the blue, so that the red and blue images constituted a stereoscopic pair, the receiving screen being viewed through glasses fitted with red and blue filters as in anaglyph process. This, while simple, had the disadvantage that it was necessary to wear glasses and that, as the colour phenomenon was used to effect the change-over from the right to the left eye, neither the colours nor the stereoscopy could ever be properly rendered.

FRAME FREQUENCY.—So far the object in mind had been to produce a system capable of being transmitted through the existing channels available to the B.B.C., but in an endeavour to produce as perfect a result as possible, it was decided to produce an entirely experimental apparatus regardless of existing practical limitations. In the apparatus demonstrated the frame frequency has been increased from 50 sec. to 150 sec., the scanning altered to a field of 100 lines interlaced five times to give a 500-line picture, successive 100-line frames being coloured green, red, and blue. At the transmitter a cathode-ray tube is used in conjunction with photo-electric cells, the moving light spot being projected upon the scene transmitted. In front of the projecting lens a mirror device consisting of four mirrors at right-angles splits the emerging light beam into two paths separated by a space equal to the separation of the human eye. By means of a revolving shutter the scene is scanned by each beam alternately, so that images corresponding to the right and left eye are transmitted in rapid sequence. Before passing through the shutter disc the light passes through a rotating disc with blue, red, and green filters. Thus, superimposed red, blue, and green pictures blending to give a picture with full natural colours are transmitted for left and right eye alternately.

PAIRS OF IMAGES.—At the receiver the coloured stereoscopic pairs of images are reproduced in sequence and

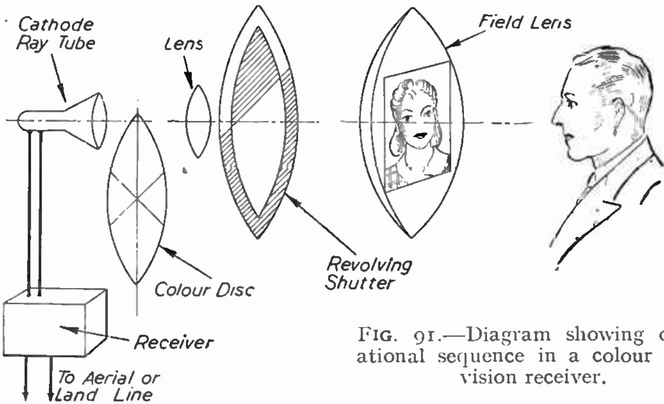


FIG. 91.—Diagram showing operational sequence in a colour television receiver.

projected upon a field lens, alternate halves of the projecting lens being exposed by means of a rotating shutter, the image of the shutter being projected upon the eye of the viewer so that his left and right eyes are presented alternately with the left and right images, the combined effect being a stereoscopic image in full natural colours.

Stereoscopic television is an entirely British achievement, it has been shown nowhere but in England, and this is the first time that stereoscopic television in colour has been achieved.

DICTIONARY OF TELEVISION TERMS

A

Abaxial.—Non-coincident with the axis. In reference to optical systems, the term is sometimes used to denote the marginal rays of light which pass obliquely through a lens.

Abronheim System.—See *Telekino System.*

Accelerator.—See *Anode.*

Actinic.—Term applied to light rays which cause chemical or electro-chemical action. Usually, the actinic rays of the spectrum are those which constitute ultra-violet, blue-violet, and blue light. From the Greek, *aktis*, a ray.

Active Material.—Name often given to the fluorescent substances which are employed in the manufacture of cathode-ray tube screens.

The chief active materials are referred to in this Dictionary under their various names.

See *Zinc Silicate, Calcium Tungstate, Zinc Phosphate*, etc.

Adiactinic.—Name given to materials which prevent the passage of actinic rays of light, as, for example, a sheet of red glass, or celluloid.

After-glow.—Term used to describe the emission of light from a fluorescent material after the exciting cause has passed away.

Fluorescent material which has any very appreciable after-glow is useless for television purposes, for a cathode-ray fluorescent screen made of such material would emit light after the scanning spot had moved on and would thus result in a greater or less degree of image blurring and confusion. Material, however, which possesses a very slight after-glow is often decidedly advantageous, as it enhances the effect of " persistence of vision " and thus assists in the building up of a clear image on the cathode-ray tube screen.

Alexanderson System.—A system devised by Dr. E. F. W. Alexanderson, of America, whereby televised images were projected upon a large size theatre screen. An arc-lamp was employed as the light source of the receiver, this being modulated by a Kerr cell device.

The Alexanderson system, which was first publicly demonstrated at Schenectady in 1930, is stated to have given a picture the brightness of which was approximately one-half that of the usual cinema-screen image.

Alkali Metals.—Name given to the group of alkali-producing metals—*Lithium, Sodium, Potassium, Rubidium and Cæsium*—

which, owing to their more or less pronounced photo-electric properties, provide the active material for many types of photo-electric cells used in television.

Alum Trough.—Name given to a glass cell or bottle containing a strong solution of common alum which is placed in the path of a beam of light in order to absorb the infra-red and heat rays therefrom. Alum is a very good absorber of heat rays. Hence alum troughs are often employed when experimenting with powerful beams of light which possess high heating capabilities.

Angstrom Unit.—A standard of measurement of light wave-lengths and of other exceedingly minute distances. One Angstrom unit equals one ten-millionth of a millimetre or $\frac{1}{10,000}$ micron.

Abbreviation: A.U.

Anode, Accelerator.—An electrode normally positive with respect to the cathode whose primary function is the acceleration of the electrons forming the beam.

See *Cathode.*

Anomalous Dispersion.—Term used in connection with optical matters. When light rays of short wave-length and those of longer wave-length (as, for instance, violet and red rays) pass from one transparent medium to another transparent medium of a different density, the rays of shorter wave-length (the violet rays) are refracted to a greater extent than those of a longer wave-length. In the case of some mediums, however, this " law " is not followed.

Aperture.—That part of the vision-frequency generator which determines the ratio of the area of an element to that of the scene.

Apertured Disc.—The simplest type of scanning disc. It comprises a flat metal disc in which a series of holes, usually square, are punched in spiral or circular formation.

Apertured Drum.—A simple device for projecting a televised image on a screen. It comprises a hollow metal drum, having a series of holes punched in spiral formation around it. By placing a light source at the centre of the drum and by revolving the drum at a constant speed, a televised image can be thrown upon a nearby screen.

See *Lens Drum.*

Arc Modulation.—A television system in which the transmitted signal currents are caused to modulate, or vary in intensity, a special type of arc light. By focusing the arc lamp through an optical system of lenses on to a revolving mirror-drum a brilliant televised image can be obtained on a whitened cinematograph screen.

Argon.—Chemical symbol: A. Atomic weight: 40. A colourless, odourless, inert gas discovered in 1894 by the late Sir William Ramsay in the earth's atmosphere in which it is present to the extent of 0·93 per cent. It is commercially produced for various electrical uses by the careful selective evaporation of liquid air.

Some types of photo-electric cells of the gas-filled variety contain argon under low pressure.

From the Greek, *argos*, inert.

Asynchronous.—Non-synchronised; not in synchronism with.

A.U.—A conventional abbreviation of *Angstrom unit*, which see.

Axis.—In reference to the various optical systems used in television working, the axis of a lens is the imaginary straight line which passes through its centre and through the centre of its radius of curvature. This is known as the "principle axis" of the lens. Any other imaginary straight line passing through the centre of the lens is known as a "secondary axis".

Ayrton and Perry's Apparatus.—An early form of television apparatus, first described about 1880. The transmitter consisted of a mosaic of selenium cells, each cell connected by means of a wire to a correspondingly placed magnetic needle on the receiving apparatus which, by electro-magnetic influence, opened and closed a light shutter, thus reproducing to some extent the degree of light which fell upon the selenium cell counterpart of the transmitter.

B

Bakewell's Apparatus.—An early picture-transmitting instrument devised by F. C. Bakewell about 1850.

The picture was traced in outline in a resinous ink on a rotating cylinder covered with tinfoil along which a travelling metal stylus passed. At the receiving end of the line a similar cylinder rotated at the same speed. At each passage of the transmitting stylus over an ink line a current was transmitted to the receiving end and by electro-chemical action it created a mark on the chemically treated paper covering the receiving cylinder.

Barium Platinocyanide.—Chemical formula: $BaPt(CN)_4$. A yellow crystalline salt containing platinum which, on account of its strongly fluorescent properties, is sometimes employed as an ingredient in the fluorescent screen material of cathode-ray tubes.

Beam Current.—The electron current of the beam arriving at the screen.

Beam Current Characteristics.—The relation between the beam current and the potentials applied to the electrodes.

Becquerel Cells.—See *Liquid Cells.*

Beehive Lamp.—Name sometimes applied to the ordinary commercial form of neon lamp in which a spiral or "beehive" of wire encloses a flat metal disc, these forming the electrodes of the lamp. For simple experiments in television, "beehive" neon lamps are quite suitable after the resistance mounted in the base has been removed.

Belin and Holweck's System.—One of the earlier systems of television devised in France by MM. Belin and Holweck. In this system two vibrating mirrors set at right-angles to each other caused a reflection of the image to be televised to fall upon a light-sensitive cell. The fluctuating current from this cell was transmitted to the receiving apparatus by landline, where, by an electro-magnetic device, it was made to control the intensity of the light-spot in a cathode-ray tube, thus setting up a very crude reproduction of the original image.

Belt Drum.—See *Belt Scanner.*

Belt Scanner.—Name given to a flexible belt having a series of holes punched at equal intervals diagonally across it. The ends of the belt are fastened together and it is caused to move rapidly over two or three pulleys. A light source is situated between the pulleys and the televised image is projected or observed in the normal way.

Synonym : *Belt Drum.*

See *Film Scanner.*

Beryllium.—Chemical symbol : Be. Atomic weight : 9. Melting point : 960°C. A silvery-white metal, closely related in properties to magnesium. It is sometimes called "Glucinum."

Beryllium has been used in connection with television for the coating of the cathode of certain types of neon lamps which have to deal with high-power currents. It is found that the beryllium coating considerably lengthens the life of such lamps.

In the Bell Telephone Company's system of television water-cooled neon lamps are employed. These contain beryllium-coated cathodes.

Bidwell's Cell.—An early type of selenium cell devised in 1880 by the famous electrical experimenter, Shelford Bidwell. It consisted of a square of thin slate containing notches cut on the edges, over which two platinum wires were wound, the spaces between the wires subsequently being filled up with active selenium. Several variations of Bidwell's cell are known.

Bidwell's Theory.—A theory of selenium's light-sensitivity originally due to Shelford Bidwell, an enthusiastic pioneer on the subject. Bidwell's theory ascribes the light-sensitivity of selenium to the presence of selenides in the material. The theory, however, is extremely improbable.

Black Selenium.—Name sometimes given to the "metallic" form of selenium which is light-sensitive.

Blind Spot.—The small area of the retina of the human eye at which the optic nerve trunk is joined up. This spot is entirely devoid of light-sensitive cells, and is quite insensitive to light.

Blocking-oscillator.—A type of oscillator in which oscillations are generated by the charging of a capacitor through an impedance followed by the discharging of the capacitor through another impedance, and used in conjunction with an electronic device to produce a scanning-field.

Bloom.—An iridescent film which appears at times on the surfaces of lenses. It is usually harmless.

See *Iridescence.*

Blue Light Cells.—Photo-electric cells which are specially sensitive to blue light. They are employed for special purposes. Usually their light-sensitive material comprises a layer of colloidal potassium which is extremely sensitive to blue rays and but little sensitive to other colours.

Braun Tube.—The older name for a cathode-ray tube—after the name of its inventor, Professor Ferdinand Braun, of the University of Strasbourg, who, in 1897, described the construction and operation of the tube, and in 1902 showed how it could be used as an oscillograph, or wave-form delineating device.

Brightness Characteristics.—The relation between the brightness of the screen and the potentials applied to the electrodes.

Bull's-Eye Condenser.—A popular name for a plano-convex lens suitably mounted on a stand and used for the purpose of focusing a strong beam of light upon an object. Condensers of this type are used in many television laboratories.

C

Cadmium.—Chemical symbol: Cd. Atomic weight, 112 Melting point, 320°C. A bluish-white metal, resembling zinc in appearance and properties.

Cadmium is photo-electric and when specially prepared is used as the light-sensitive surface of certain types of photo-cells. Such photo-electric cells are specially sensitive to ultra-violet rays.

Cadmium Cell.—See *U-type Cell.*

Cadmium Tungstate.—Chemical formula: $CdWO_4$. A cadmium salt of tungstic acid. It is sometimes employed in the preparation of cathode-ray fluorescent screens, particularly for screens intended for photographic use.

Cæsium.—Chemical symbol: Cs. A member of the alkali group of metals. Atomic weight, 132. Melting point, 28·5°C. Specific gravity, 1·903.

A rare silvery-white metal, similar in properties to sodium, potassium and rubidium.

Metallic cæsium (and also its hydride CsH) have extremely good photo-electric properties, and they form the active material of certain types of light-sensitive cells used in television working.

Calcite.—See *Iceland Spar*.

Calcium Tungstate.—Chemical formula: $CaWO_4$. A calcium salt of tungstic acid. Used in the preparation of fluorescent screens for cathode-ray and other tubes. Under cathode-ray excitation it fluoresces with a bluish colour.

Canada Balsam.—A greenish-yellow resinous fluid obtained from certain North American fir-trees. It hardens into a clear, transparent solid, which, dissolved in certain solvents such as benzene or chloroform, is extensively used for cementing together the various components of lenses and other optical devices employed in television working. Its precise composition is unknown.

Canal Rays.—In the earlier forms of electric vacuum tubes it was observed by Goldstein that if, in place of a solid cathode or negative electrode, which emitted a stream of cathode rays, a perforated cathode was provided in the tube, a stream of rays was emitted from each perforation in the cathode, these rays proceeding in a direction *opposite* to that of the cathode rays.

Such rays, which were termed "Canal rays," are streams of positively charged particles. They produce characteristic luminous and electrical effects, but, up to the time of writing, they have not been applied by inventors to schemes of television working.

Candle-power.—The unit of light for photometric work. It is the light given out by a spermaceti candle burning 120 grains per hour, the height of the flame being 45 mm., the flame being well shielded from draughts.

The following table indicates the candle-power of some well-known sources of illumination:—

Bright sunlight	50,000–60,000 c.p.
Arc lamp	250– 6,000 ,,
Electric filament lamp (household type) .	10– 120 ,,
Limelight	100– 600 ,,
Magnesium ribbon	100– 200 ,,

Incandescent Gas-mantle	40–	60 c.p.
Gas flame (Batswing burner) . . .	8–	16 ,,
Oil lamp (flat-wick type)	6–	10 ,,
Light of Full Moon	1/500th approx. (varies)	

Carley's Instrument.—A crude form of television apparatus invented in 1880. Its transmitter consisted of a mosaic of small selenium cells, each cell being connected by a wire to a miniature electric bulb mounted in a corresponding mosaic of bulbs on the receiver. An outline image projected upon the transmitter was crudely reproduced upon the receiving mosaic, the electric bulbs varying in illumination intensity according to the amount of selenium cell resistance included in their circuits, this latter, of

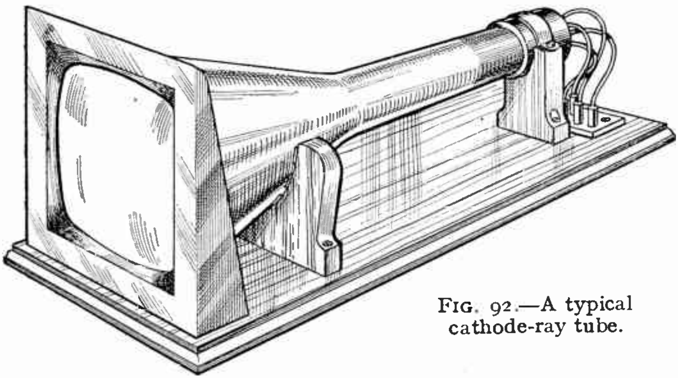


FIG. 92.—A typical cathode-ray tube.

course, being controlled by the light falling upon the " active surface " of the transmitter.

The instrument, like the others of its period, was hopelessly impracticable.

Case Cell.—See *Thalofide Cell.*

Caselli's Apparatus.—See *Pantelegraph.*

Cathode.—The primary source from which the electrons constituting the beam are emitted.

See *Anode.*

Cathode Rays.—Name given to a stream of electrons which are emitted from the cathode, or negative electrode, of an electric discharge tube exhausted to a high degree of vacuum. They were first discovered by Sir William Crookes.

In 1899 Sir J. J. Thomson showed that the cathode rays were quite independent of the nature of the cathode used for their generation, and that they were, in fact, nothing more nor less than a stream of negative electrons travelling with a high velocity. It is upon this electron stream in a cathode-ray tube of special design that many of the modern cathode-ray systems of television are based.

Cathode-ray Tube.—A tube which consists essentially of a negative filament or cathode which is treated with an electron-emitting substance. Near the cathode is an anode, or " gun," as it is sometimes termed, consisting of a circular plate perforated with a central aperture. This is maintained at a high positive potential. As a result, the electrons which are emitted from the heated filament or cathode are violently attracted to the anode. Some of them pass right through the hole in the centre of the anode and thereafter travel in the form of a beam outwards from the anode (being on their way controlled as regards direction by passage between two pairs of " deflector plates ") until they reach the flattened end of the tube, where, by impinging upon a screen of specially prepared fluorescent material; they manifest their presence visibly by causing the fluorescent material to glow strongly.

The cathode-ray tube is being used increasingly in some television systems. Previously it was employed for the examination of the wave-forms of alternating currents. Hence its other name, the " Cathode-ray Oscillograph."

Cell Amplification.—A term used in connection with photo-electric cells of the gas-filled type to denote the ratio of the current which leaves the cathode of the cell under the influence of light to the current present at the positively charged anode.

For an explanation of this difference in current intensity, see *Gas-filled Cell*.

Chance Glass.—Popular name sometimes given to small sheets of intense blue glass which are opaque to ordinary light but which pass ultra-violet rays quite freely. This glass, which is manufactured by Messrs. Chance Brothers, is often used as a light-filter in ultra-violet ray experiments.

Chemical Rays.—Name sometimes applied to ultra-violet rays on acccount of their photo-chemical action.

Chemi-Luminescence.—A term referring to the generation of light by chemical action.

Chopper Wheel.—A perforated or slotted wheel which, by revolving between a source of light and a light-sensitive cell, breaks up the continuous light beam into " pulses," which, impinging on the light-sensitive cell, give rise to a pulsating or fluctuating current.

Synonym : *Light Chopper.*

Choroid.—Anatomical term denoting the second layer or coat of the eyeball. It is composed for the most part of a network of veins and capillaries.

See *Sclerotic.*

Ciliary Muscles.—Small, hair-like muscles which, acting upon the crystalline lens of the eye, vary the formation of the latter as regards curvature and depth, and thus enable an image to be focused clearly upon the retina at the back of the eye.

From the Latin, *cilium*, an eyelash—in reference to the extreme fineness of the muscles concerned.

Close Scanning.—Synonymous with " Fine Scanning," which see.

Coarse Scanning.—The coarse scanning of an image occurs when the light-spot is of relatively large diameter, and when it covers the image in a comparatively small number of lines or sweeps.

See *Fine Scanning.*

Code Picture System.—A crude method of transmitting pictures by wire or wireless, the picture to be transmitted being split up beforehand into a large number of small patches or areas, the degree of blackness of each patch being indicated by a previously arranged code letter, which is telegraphed in the usual manner. After reception, the various transmitted letters corresponding to the different patches in the picture are decoded and subsequently pieced together, and assembled into a rough reproduction of the original picture.

The method is an ingenious one, but it is entirely without practical possibilities, despite the fact that coded pictures of this nature have been transmitted across the Atlantic.

Colloidal.—Literally, " glue-like." The name given to materials such as glue, starch, albumin, etc., and to certain mineral substances which, when " dissolved " in water or some other solvent, do not pass through a porous membrane.

It can be shown that such " colloids " are not really dissolved in the water but that they are, in fact, " suspended " or floating in the water in the form of extremely fine particles, which do not settle. Such " suspensions " are often termed " colloidal solutions."

Many colloidal solutions of metals and their compounds have very interesting properties, including that of light-sensitivity whereby they alter in electrical properties on exposure to light rays.

From the Greek, *kolla*, glue.

Colloidal Cells.—Name usually applied to certain types of light-sensitive cells which contain "colloidal solutions" of various compositions.

Colour Television.—Systems of television in which the picture or image is obtained in an approximation to its natural colours. In one Baird experimental system of colour television, a triple scanning disc is used. This disc contains three spiral series of holes, the series of holes being provided with red, blue and green colour filters respectively. By means of this arrangement the picture is triply scanned.

In the colour television receiver the image is assembled three times by means of a similar triple-scanning disc. Thus it is viewed in rapid succession in red, blue and green lights. By this means the three colours blend themselves together into an approximation to the natural colours of the image.

Two sources of illumination are employed in the Baird colour television receiver, one being a neon lamp for the provision of red and orange light, the other being a helium-mercury lamp which generates blue and green rays. Matters are so arranged that only the neon lamp is illuminated when the red holes of the scanning disc are rotating before the observer, whilst the helium mercury lamp provides the illumination when the blue and green holes of the disc are passing in front of the observer. (See also Chapter XXVII).

Complementary Colours.—Name given to any colours which, when mixed together, form white.

Well-known complementary colours are red and green, yellow and indigo, orange and blue, greenish-yellow and violet.

Owing, however, to practical difficulties in securing perfectly pure colours, most complementary colours when combined together produce a grey rather than a pure white.

Condenser (*Optical*).—A lens device which collects rays of light from a light-source and condenses them on to a limited surface area. An ordinary burning lens is an example of an optical condenser.

Simple condensers contain only one lens; compound condensers are made up of a number of lenses.

In television optical condensers are employed notably for illuminating the film in systems of film television. They are also used for concentrating light rays on light-sensitive cells.

Continuous Film Systems.—Name applied to system of film television transmission in which the object or scene to be televised is photographed on a cinema film. The film is automatically led to a developing tank and from thence to the television transmitter, where it is scanned in the wet condition.

By such methods a scene can be televised within about half a minute of its being photographically recorded on the cinema film.

Contrast.—Term signifying the relationship between the degrees of light and shade in a picture or image, televised or otherwise.

Contrast Sensitivity.—Expression referring to the ability of the human eye to distinguish differences of light and shade.

It is found that the contrast sensitivity of the eye decreases with low intensities of illumination and, also, when the field of vision is severely restricted—two factors which militate against clear television reception on very small screens and with poor illumination intensities.

Convergent Rays.—Light rays which converge or close in as they travel to an object. Rays of light which are focused from an object on to a television transmitter or a camera screen are convergent.

Copper Pyrites.—A natural ore of copper, containing copper, iron and sulphur. Approximate chemical formula: $CuFeS_2$ or $Cu_2SFe_2S_3$.

Copper pyrites, well-known as a radio crystal-detector, is sometimes photo-electric or light-sensitive.

Cornea.—The clear, transparent, horny window or membrane which bulges outwards in front of the eye, and through which light is transmitted to the pupil.

From the Latin, *corneus*, horny.

Covering Power.—An optical term used to describe the area over which a lens will produce a well-defined image.

Crater Lamp.—A type of neon tube or lamp which gives a small point of light of high intensity, and which can, therefore, be utilised for the projection of received television images.

Some types of high-power neon crater lamps are water-cooled in order to maintain the electrodes at a reasonable temperature.

Crookesite.—One of the naturally occurring ores of selenium. It consists of copper selenide, containing also approximately 17 per cent of thallium, and occasionally a little silver.

It derives its name from the famous scientist, Sir William Crookes.

Cryo-Luminescence.—A term denoting the light which is emitted from certain chemical solutions during their crystallisation.

From the Greek, *kryos*, frost—in reference to the formation of crystals.

Crystalline Selenium.—A name applied to grey and red selenium on account of their fine crystalline nature.

Curvilinear Distortion.—The distortion produced by a simple lens on the marginal lines of its field.

If a number of straight lines are ruled vertically and horizontally on paper and examined under an ordinary reading-glass, a good example of curvilinear distortion will be seen, the lines at the margins of the field of view appearing to bend.

Curvilinear distortion occasionally appears in some of the simple types of lenses used for magnifying the images formed by a television receiver.

D

Dark Resistance.—A term which is commonly used to denote the resistance of a selenium cell when in an un-illuminated condition. The " dark resistance " of a selenium cell is much greater than its " light resistance."

D'Arlincourt's Apparatus.—A picture-transmitting instrument working on principles similar to those underlying the operation of Bakewell's apparatus (which see). In D'Arlincourt's instrument, first operated about 1876, a synchronising mechanism maintained the transmitting and receiving cylinders at an identical rotation speed. The instrument was somewhat extensively employed by the French army of the period.

Definition.—A term denoting the degree of sharpness with which images are projected by a lens, or other optical system, or are reproduced electrically in a television receiver.

Referring to television systems, the terms " High-definition " and " Low-definition " are explained under those headings.

Deflector Plates.—Name given to two pairs of metal plates which, in a cathode-ray tube, are fixed at right angles to each other in the path of the cathode-ray beam. Their function is to deviate the beam of rays from its path in accordance with varying voltages applied to them, thus causing a movement of the spot of light on the fluorescent screen at the end of the tube.

See *X plates*, *Y plates.*

Diaphote.—An early form of television apparatus, due, about 1880, to Dr. Hicks, of Bethlehem, Penn., U.S.A.

Diaphragm.—A metal partition of variable circular aperture, which is placed between the components of a lens in order to regulate the amount of light passing through the lens, and also to vary the " depth of focus " of the latter. Diaphragms are also known as " stops."

Directly-heated Cathode.—A cathode heated by a current which passes through the whole or part of it. This type of cathode is commonly known as a *filament.*

Direct Transmission.—Term applying to television transmission whereby the image, view or scene to be televised is focused directly on to the scanning device employed by the instrument, as opposed to "indirect" transmitting systems in which the transmission takes place from a photographic image in one form or another.

Dot-Frequency.—Half the number of elements transmitted per second.

Driving Potential.—Term sometimes used to designate the positive potential which is applied to the anode of a photo-electric cell of the "Emission" type in order to operate the cell by attracting the stream of negative "photo-electrons" emitted from the cathode, or light-sensitive negative electrode, under the influence of light.

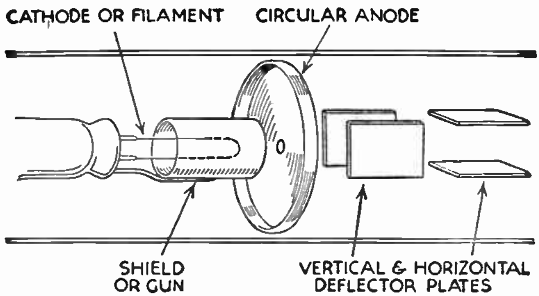


FIG. 93. — The arrangement of the electrode assembly for a standard cathode-ray tube.

Duration of Vision.—The length of time during which a light stimulus must be given to the retina of the eye in order to set up the sensation of vision. This time-length has not been accurately determined. It is, however, an exceedingly minute fraction of a second, as may be judged from the fact that an electric spark discharged from a Leyden jar condenser has a duration of only 0.000000866 of a second, yet it is plainly visible to the eye.

E

Échelon Device.—Name given to the prism or mirror-reflecting device employed in the Scophony system of television, the prism, or mirrors, being "stepped," or cut in ladder-like, or *échelon* formation.

From the French, *échelle*, a step or ladder.

See *Scophony*.

Electrical Scanning.—Name given to any process of scanning, as, for example, the cathode-ray system, in which the exploration of the image to be televised is effected by means of an electrical beam, of one kind or another.

Owing to the absence of moving parts, electrical scanning systems show much promise in the furtherance of practical television.

See *Mechanical Scanning*.

Electric Eye.—A popular term for a light-sensitive cell.

Electric Vision.—A name synonymous with television. It was employed by the earliest experimenters on the subject.

Electrode Currents.—The magnetic sensitivity is usually expressed in terms of millimetres (on the screen) per ampere (through the deflecting coil). The sum of the currents flowing into or out of any electrode. This term includes, for example, anode current and deflector plate current.

Electro-Luminescence.—A scientific term applied to all cases of fluorescence and phosphorescence which are caused by cathode rays, X-rays, and by radio-active compounds.

Electrolytic Selenium Cells.—Name given to certain types of selenium cells, which, instead of varying their resistance under the influence of light, actually generate minute currents under the light action.

Electron-lens.—A system of electric or magnetic fields having an action upon a beam of electrons analogous to that of an optical lens upon a beam of light.

Emission.—In television terminology, as in radio nomenclature, this term usually refers to the emitting of a stream of electrons from the surface of a body, either under the influence of heat, as in a radio valve or cathode-ray tube, or by means of light action, as in a photo-electric cell.

In a cathode-ray tube, or radio valve, the electron emission is controlled primarily by the temperature to which the cathode or filament is raised and, in a photo-electric cell, by the intensity of the light acting upon it.

Emission Cell.—A type of photo-electric cell in which a light-sensitive cathode emits electrons under the influence of light. The free electrons are captured by a positively charged anode, suitably placed, after which the minute current thus created is amplified by normal methods.

Eosin.—A light-sensitive dye, which, in the form of its sodium salt, yields a minute electrical current when exposed to light in a suitable cell.

Exploring.—See *Scanning*.

Extinguishing Voltage.—Term used in connection with neon lamps and tubes to signify the voltage applied across the electrodes which just serves to cause an already glowing neon lamp or tube to be extinguished. Usually the extinguishing voltage of a neon lamp is about 30 volts below its striking or firing voltage. See *Striking Voltage.*

F

Faraday Cell.—See *Faraday Effect.*

Faraday Effect.—Name applied to the rotational effect of a powerful electro-magnetic field upon a beam of polarised light passing within the influence of the field. The effect was first noticed by the great Michael Faraday. Electro-optical cells constructed upon this principle are sometimes employed in television light-modulating experiments, and are known as "Faraday cells."

Farnsworth System.—A television system originated by P. T. Farnsworth, of San Francisco, America. This system employs cathode-ray scanning, a special type of cathode-ray tube being used in which the hot cathode is replaced by a mirror coated with light-sensitive material. The image to be televised is focused upon this mirror, whereupon a stream of electrons is emitted from the mirror. By suitable means, these electrons are led to another portion of the tube where they meet a small cylinder or rod which acts as a collector, and which leads them away to an amplifier, from whence the currents are transmitted in the usual manner.

The cathode-ray tube used for reception by the Farnsworth system is merely a modification of the usual type of tube, and reception is effected in much the same manner as is normally the case with cathode-ray television systems.

Fasciculation.—The term applied to the manner in which the electron emitted from the cathode of the cathode-ray tube bunch together.

Field of Vision.—The vertical and horizontal range of vision. Normally, in human beings, the field of vision extends to about 150° horizontally and to approximately 120° vertically.

Synonym: *Field of View.*

Film Scanner.—A type of belt scanner consisting of an endless band of film in which the diagonal series of holes are photographically printed on a black background. It operates in the same manner as the belt scanner.

See *Belt Scanner.*

Fine Scanning.—Fine scanning takes place when the exploring light-spot is of very small diameter and when it covers the image in a relatively large number of lines or sweeps.

See *Coarse Scanning.*

Flare Spot.—A bright patch of light appearing in an image which has been projected by a lens system. Usually, the flare spot occurs near the centre of the image and is generally due to the presence of internal reflections within the lens.

Flowers of Selenium.—The bright red form of selenium which is deposited by selenium vapour. It is not light-sensitive.

Fluorescence.—The emission of light from certain substances under the influence of light or electrical excitation. As soon as the exciting cause departs, the fluorescence ceases. Calcium tungstate, barium platinocyanide, quinine sulphate and certain aniline dyes, such as fluorescein and eosine, are well-known fluorescent substances.

" Fly-Back."—Term referring to the extremely rapid return to its zero point of the light spot on the fluorescent screen of a cathode-ray tube following the cessation of the activating voltage on the deflector plates of the tube.

Focusing.—The concentration of the electron beam in order to produce a sharply defined small luminous spot on the screen.

Methods of focusing are classified as follows :

(*a*) *Gas Focusing*, in which the beam is constricted by its ionising action on traces of gas present in the tube.

(*b*) *Magnetic Focusing*, in which the electron beam is constricted by means of a magnetic field, parallel to the axis of the tube.

(*c*) *Electrostatic Focusing*, in which the beam is caused to converge by the action of electrostatic fields between two or more electrodes through which it passes.

Focusing Electrodes.—Anodes or accelerators or other electrodes to which a potential is applied in order to produce the focusing action on the beam.

Frame.—This term applies to each of the individual pictures of a cinema film, and, also, to the area of the picture as seen on the television screen.

Frame-Frequency.—The number of scannings of the frame by the scanning-beam per second. In interlaced scanning the frame-frequency is an integral multiple of the picture-frequency.

Framing.—The process by which that portion of the exploring device upon which the phased image is formed is brought into an allocated relationship with a fixed screen.

Framing Mask.—Name given to a sheet of metal or other material having a rectangular aperture cut in the middle of it. It is placed in front of the revolving disc in a television receiver in order to give a picture of the required size and, also, to eliminate any unwanted light from the neon lamp.

Framing the Image.—The process of correctly positioning the image within the bounds of the television screen. This is usually effected by manipulating a small knob.

Free Electrons.—The outer electrons of atoms. They are shot off copiously from the surface of certain materials when the latter are subjected to heat or light action. Hence, they are the electrons which enable the cathode-ray tube, the valve, the photo-electric cell and other electronic devices to function.

Fringing Effects.—Name sometimes given to wave-like effects which are at times seen on the screens of high-power cathode-ray tubes and which appear to be due to the presence of wandering electrons and to other obscure causes. In some of the latest cathode-ray tubes an extra electrode is placed on the interior wall of the tube between the deflector plates and the screen in an endeavour to "bind" the unwanted electrons by electrostatic attraction.

Fringing effects on the screen of a cathode-ray tube have given rise to the expression "Waving in the Breeze," which frequently accurately denotes the character of these effects. The effect is also sometimes termed "Ionic Oscillation."

Fritts' Cell.—A form of selenium cell devised by Fritts in 1883. It comprised two small glass plates coated on their inner sides with gold leaf and having an extremely thin layer of selenium between them, the selenium layer being activated by light passing through the semi-transparent gold leaf.

Fritts' cell was a very permanent one, but it was only of low sensitivity.

Fultograph.—A picture-transmitting and receiving instrument, the invention of Captain Otto Fulton. The Fultograph system was employed by the B.B.C. for the first time on the evening of 30th October, 1928. In the Fultograph receiver, the transmitted picture is traced out by an electrical stylus moving over iodised paper.

G

Gas-discharge Time Base.—A time base circuit in which a gas-discharge tube or triode provides a method of setting up a periodic voltage across a pair of deflector plates in a cathode-ray tube.

See *Time Base, Gas-discharge Triode.*

Gas-Discharge Triode.—Name applied to a special type of neon tube which is fitted with a grid between its two electrodes.

Gas-filled Cell.—A type of photo-electric cell which is constructionally similar to the vacuum type of photo-electric cell but in which a small quantity of an inert gas, such as nitrogen, is admitted before the cell is finally sealed up.

In cells of this type, the free electrons which are emitted from the sensitive cathode under the influence of light collide with the molecules of gas existing within the cell, the result being that further electrons are detached from the gas particles. These electrons collide with other molecules of gas, giving rise to a further quantity of electrons, and so the process continues. Hence, in a gas-filled photo-electric cell the electrons which arrive at the positively charged anode are much greater in number than those which were originally emitted from the cathode by the action of light. Consequently, with a given light source, the current produced by a gas-filled photo-electric cell is considerably greater than that produced by a photo-electric cell of the vacuum type. Gas-filled cells, however, are more difficult to operate than are vacuum cells.

See *Vacuum Cell*.

Gas Focusing.—Term referring to the technique of focusing the beam of cathode rays in a cathode-ray tube by means of admitting a minute quantity of an inert gas into the tube after it has been evacuated in the normal manner.

The rapidly moving electrons constituting the cathode-ray stream collide with the gaseous particles within the tube, stripping them of some of their electrons. The particles of gas after this treatment are said to be "ionised." Ionised gas molecules or particles, being devoid of one or more negative electrons, are always positively charged, and, being relatively heavy, they tend to concentrate themselves within the cathode-ray beam where, by attracting negative electrons to themselves (owing to their positively charged condition), they have the effect of keeping the cathode-ray stream of electrons together in a more concentrated form and of thus producing a clearer and better defined light-spot on the fluorescent screen at the end of the tube.

Within limits, the greater the quantity of inert gas admitted into the tube, the greater the ionising action of the cathode rays upon the gas and the greater the concentrating action of the ionised gas molecules upon the stream of rays within the tube.

Glucinum.—An old and now obsolete name for the metal, *beryllium*, which see.

Graham Bell's Cell.—A selenium cell devised in 1880 by Graham Bell, the famous inventor of the telephone. It comprised a brass plate upon which a series of raised conical projections were formed. A second brass plate containing corresponding holes was brought into position so that the metal cones on the first plate nearly plugged the holes in the second plate. The remaining interstices were filled with active selenium.

Later on, Graham Bell devised another cell of this nature, but of a more complicated cylindrical pattern.

Grey Selenium.—One of the many forms of selenium. It is obtained as a grey-looking mass by heating strongly red or vitreous selenium. When heated carefully it becomes light-sensitive.

Grid.—An electrode which does not primarily serve for the acceleration of the beam, but is for the purpose of otherwise controlling the flow of electrons.

Gun.—A term which is often used to denote the circular anode, or positively charged plate, of a cathode-ray tube. This anode possesses a central hole or perforation through which the cathode rays pass on their way to the screen at the end of the tube.

H

Hallwachs' Effect.—Name given to the discovery made by the German scientist, Hallwachs, in 1888, that areas of certain metals, when illuminated by ultra-violet light, quickly loose a negative electric charge which has been given to them previously. Hallwachs found this effect to be most pronounced with the metals—Sodium, Potassium, and Rhubidium.

Hallwachs' discovery was merely an extension of the Hertz Effect and it led eventually to the construction of the photo-electric cell.

See *Hertz Effect.*

Hard Image.—Name applied to an image on a television screen or elsewhere which bears excessive contrasts between its areas of light and shade.

Hard Tube.—Name applied to a cathode-ray tube which is devoid of any gas filling.

Helium.—Chemical symbol: He. Atomic weight: 4. A colourless, odourless inert gas discovered in the earth's atmosphere in 1894 by the late Sir William Ramsay, one volume of helium being present in approximately 1,000,000 volumes of air. Helium is also found in greater quantities in certain natural gases and in some minerals.

Helium gas is used in certain electric discharge lamps in place of neon, helium lamps of this type glowing with a blue light. Such lamps have been utilised for television receiving purposes.

From the Greek, *helios*, the sun—in reference to the presence of helium gas in the sun.

Helium-Mercury Lamp.—A special type of electrical glow tube containing helium gas and mercury vapour at low pressure. It glows with a light rich in blue and green rays and is favoured by a number of television experimenters.

In conjunction with a neon lamp, the helium-mercury lamp has been used by the Baird Company as the illuminant in its experimental colour-television receivers.

Hertz Effect.—An electrical effect, discovered by Heinrich Hertz, in 1888, which forms the underlying principle of photo-electric cell operation. Hertz found that when ultra-violet light fell upon a spark gap in an electrical circuit, the spark was enabled to pass more easily than was normally the case.

The Hertz Effect is sometimes known as the "Photo-electric Effect."

See *Hallwachs' Effect*.

High-definition.—A system of television in which the number of scanning lines into which the complete picture is divided is 100 or more.

Horizontal Scanning.—Term denoting methods of scanning in which the scanning spot explores the picture or image to be televised in a series of horizontal lines or "sweeps." Horizontal scanning, which has certain advantages over vertical scanning, is employed mainly in American television practice.

See *Vertical Scanning*, *Interlaced Scanning*, and *Progressive Scanning*.

Hunting.—A term which in television parlance refers to the up-and-down or side-to-side movement of the televised image on the screen.

Hydrogen.—Chemical symbol: H. Atomic weight: 1. A colourless, odourless and inflammable gas which, among other properties, has the distinction of being the lightest thing known.

Slight traces of hydrogen gas are sometimes admitted into the neon lamps used in television working in order to modify the glow produced by the lamps.

I

Iceland Spar.—A naturally occurring transparent form of calcium carbonate or chalk, first introduced into this country from Iceland some two hundred years ago. Chemical formula: $CaCO_3$.

Iceland Spar possesses the property of polarising light rays. Owing to its optical properties it is used for the making of Nicol prisms which are employed in some systems of television working in conjunction with the Kerr cell.

Synonym: *Calcite*.

Iconoscope.—A special form of cathode-ray tube used in some systems of television transmission. It is the invention of Dr. V. Zworykin, of America. In place of the usual cathode-ray fluorescent screen, the iconoscope has a metal plate coated with a light-sensitive material. The image to be televised is focused upon this plate which is scanned by a rapidly moving cathode-ray beam. Each grain of the light-sensitive material on the metal plate acts as a miniature light-sensitive cell and when acted upon by the cathode-ray beam it gives up its charge of current which thereupon flows through an external circuit where it is amplified and transmitted in the usual manner.

From the Greek, *eikon*, an image, *skopein*, to see.

Image-Drift.—A term referring to the drifting movement of the received image on a television screen which sometimes occurs in consequence of slight lack of synchronisation.

Image Intensification.—See *Intensifying Circuit.*

Incident Ray.—Name applied to any ray of light which falls upon an object or medium.

Incident rays are usually reflected or refracted, either wholly or partially ; they are seldom completely absorbed by the object.

See *Emergent Ray.*

Indirect Transmission.—See *Direct Transmission.*

Infra-Red.—Name given to the rays of relatively long wave-length which lie beyond the red end of the spectrum and to which the human eye is practically insensitive. Consequently, a person seated in a room which is illuminated by infra-red rays only will have the sensation of complete darkness.

See *Noctovision.*

Intensifying Circuit.—Name given to a valve circuit which has been applied in some cathode-ray television circuits in order to increase or to intensify the contrasts of light and shade in the received picture and thus to render the image clearer and brighter. As yet, the system of picture or image intensification is purely an experimental one.

Intensity Modulation.—The usual method of modulating the output current of a television transmitter by means of variations in the intensity of the light reaching the photo-electric cell of the transmitter.

See *Velocity Modulation.*

Intercalation.—Synonymous term for *interlacing*, as related to television scanning.

Interrupter Disc.—A disc having holes or slots punched in it so that when the disc is revolved in the path of a light beam, the latter is broken up, or " interrupted," into " pulses " of light and darkness. Also known as a " Chopper Wheel," which see.

Invisible Rays.—Expression commonly used to denote the infra-red rays of light, but, nevertheless, equally applicable to other invisible forms of radiation, as, for instance, ultra-violet rays, X-rays, etc.

Indirectly-heated Cathode.—A cathode heated by an electrically separate element known as the *Heater.*

Interlaced Scanning.—A system of exploration of the scene or image in which complete scanning is accomplished in two or more operations, the strips of scanning-field successively traversed in the course of one operation not being contiguous. During subsequent operations the lines previously omitted are scanned according to some set rule or order.

Ion.—An atom which has been stripped of one or more of its electrons.

See *Ionisation.*

Ionic Oscillation.—See *Fringing Effects.*

Ionisation.—In television terminology, this expression refers to the production of "ions" within an electric discharge tube such as, for instance, a neon tube.

The neon tube contains a small proportion of neon gas. An electrical discharge passed through the tube strips away some of the outer electrons from each atom of neon gas. Owing to the loss of negatively charged electrons, each atom of neon gas shows a positive charge and it is called an "ion," the electron-stripping process to which it has been subjected being termed "ionisation."

Ions are electrically conductive. Hence, when they are present in comparatively small numbers within a gas discharge tube, they allow the current to pass and they give off a characteristic glow. The glow of electrically excited neon ions is, as is well-known, a pinkish-orange shade.

Iridescence.—The display of colours produced by extremely thin films, such as oil on water, finely deposited metals on glass, oxide films on metals, and so on. It is due to the splitting up of white light by the iridescent film.

Iridescence is frequently seen in vacuous tubes which contain a metallic deposit within them. It also occurs at times on the surfaces of lenses, being then known as "bloom." Usually, this condition is quite harmless and does not interfere with the functioning of the lenses.

Iris.—The coloured portion of the front of the eye which, by contracting and expanding, controls the amount of light passing through the pupil of the eye to the retina.

Isochronism.—The operating-condition which obtains when the reconstruction of the image and the scanning of the object occur at the same rate (see *Synchronism*).

J

Jenkins' Disc.—See *Jenkins' System.*

Jenkins' System.—An American system of television first demonstrated by Mr. C. Francis Jenkins in 1925. The scanning device employed in this system was a " prismatic disc," i.e., a glass disc the edge of which was ground into a prismatic section of varying thickness. Two of these discs were used, and light passing through the varying prismatic edges was bent from side to side. By means of this contrivance, the rays of light from the image are passed on to the photo-electric cell, or to the viewing screen in the receiving instrument.

K

Karolus Cell.—A name sometimes applied to the Kerr cell, which see.

Karolus System.—A television system devised by Dr. Karolus of the Telefunken Company, mainly in connection with the televising of cinema films. In the Karolus system the usual Nipkow scanning disc is replaced by a special type of disc having small slots made at equal distances around its circumference. A cinema film passes behind the slotted disc. The film is scanned with the aid of a powerful beam of light which passes through the slots in the disc, thence through the film and afterwards is focused on to a special type of potassium photo-electric cell.

In the Karolus receiver, use is made of the ordinary Kerr cell method of reception employed in conjunction with a mirror-drum.

Kathode.—See *Cathode.*

Kerr Cell.—A contrivance which consists essentially of a number of small plates arranged after the manner of an electrical condenser and immersed in a cell containing pure nitro-benzene. An electrical potential placed across the plates twists slightly the vibrational plane (or the " plane of polarisation," as it is termed), of a beam of polarised light passing through the cell.

The Kerr cell is employed in conjunction with two Nicol prisms. Thus arranged, it provides a very sensitive light valve, instantaneous in effect, it being able to control the amount of light passing through the prisms in strict accordance with the current pulsations applied to the plates of the cell. Kerr cells are being increasingly employed in television apparatus for light-modulation purposes.

Kerr Effect.—The rotation of the plane of polarised light under electro-magnetic influence. The effect was first noticed in 1877 by Professor Kerr, who directed a beam of polarised light on to the highly polished end of a powerful electro-magnet.

Kerr's Apparatus.—An early form of instrument for " seeing by electricity," due to Professor Kerr. The transmitter comprised a mosaic of selenium cells, the cells being connected to a corresponding mosaic of electro-magnets on the receiver. The electro-magnets had silvered ends and they were observed through an analysing prism, being themselves illuminated by a strong beam of polarised light. Currents transmitted from the selenium cells operated the electro-magnets and caused the plane of polarisation of the light to be rotated, thus making visible a crude reproduction of the image at the transmitting end when the bank of silvered magnet ends was viewed through an analysing prism.

Key.—Term referring to the character of a picture or image. A picture is said to be in " high key " when it has few gradations of tone and is lightly toned through. A " low key " image is one where the gradations of tone are all on the dark side.

Kinescope.—A special form of cathode-ray tube adapted for television reception. It is the invention of Dr. V. Zworykin, of America. It contains an indirectly heated cathode and two " guns " or anodes, the second of which is maintained at a potential of a few thousand volts and which serves to accelerate the speed of the electron stream, thereby giving an extremely sharp and well-defined light-spot on the fluorescent screen.

From the Greek, *kinema*, motion.

Korn's System.—The first practical system of photo-telegraphy devised by A. Korn, in 1904.

A narrow beam of intense light passed through a revolving glass cylinder on which was mounted a film negative. It was then reflected by a mirror on to a prism and thence on to the active surface of a selenium cell. In this way a fluctuating output current was obtained, the variations of light intensity impinging on the cell being created by the light differences in the negative on the revolving cylinder.

At the receiving end of the apparatus, the incoming pulsating currents were applied to a vacuum tube which glowed brightly or dimly in accordance with the fluctuations of the current. These variations in brightness were, by an optical arrangement, focused upon a sheet of photographic paper which was mounted on a glass cylinder which revolved in synchrony with the transmitting cylinder. In this manner a replica of the transmitted image was slowly built up.

L

Lag.—See *Time-lag.*

" Lag of the Retina."—See *Persistence of Vision.*

Lamp Screen.—A type of television reception screen comprising a large number of small filament lamps arranged in mosaic formation on a large frame. By means of a special mechanism these lamps are lighted in rapid succession by the incoming currents from the television transmitting station, thus giving a coarse but at the same time brilliant reproduction of the original image.

Langmuir Arc.—A type of arc lamp devised by Dr. Irving Langmuir, of America, in which the light comes, not from the crater of the carbon, as is usual in most forms of arc lamps, but from the arc itself. Langmuir arc lamps of this type are being increasingly employed for television projection experiments both in transmission and in reception.

Lateral Inversion.—The state of a picture being sideways inverted, the left side of the original appearing on the right side of the reproduction and *vice versa*.

Lateral inversion appearing on television receiving screens is usually due to some mal-arrangement of the mirrors in the optical system.

Lavender Rays.—Name sometimes applied to the rays which lie at the commencement of the ultra-violet part of the spectrum or at the extreme visible end of the violet ray band of the spectrum which is adjacent to it. They are so called on account of their colour. Like the ultra-violet rays, the lavender rays are extremely active. Unlike the ultra-violet rays, the lavender rays will pass through glass fairly freely.

Certain types of photo-electric cells, as, for instance, the potassium cell, are very responsive to lavender ray stimulation.

Lens Disc.—A type of scanning disc in which the holes punched therein are provided with lenses, thus allowing a more intense illumination to be obtained.

See *Apertured Disc.*

Lens Drum.—A device for projecting a televised image on a screen. It consists of a hollow metal drum having a number of holes perforated in spiral formation around it, each hole being provided with a small lens. A modulated light source is placed at the centre of the drum. The drum is revolved at constant speed, whereupon a televised image is thrown upon a neighbouring screen.

The lens drum is a development of the apertured drum.

See *Apertured Drum.*

Liesagang's Cell.—A very simple type of selenium cell devised in 1890. It consisted of a small sheet of glass which was heavily silvered on one side. Across the silvered side was scratched a thin line, the channel thus made being filled up with active selenium.

Light.—The fundamental " stuff " of television science. The form of energy emitted from all luminous bodies.

The older "Corpuscular" theories of light, due to Newton and others, supposed light to consist of a stream of minute particles or corpuscles which were shot off from the surface of the luminous body. An opaque object placed in the stream of particles stopped many of them, thus throwing a shadow.

The present "Undulatory" theory of light, originated by Young at the beginning of the nineteenth century, states that light is an undulatory or wave-like motion in the ether, this motion being created by the extremely rapid vibrations of the particles of the luminous body.

Whilst the undulatory theory of light still holds the day, the older corpuscular theories still find many adherents in various places.

Light Chopper.—See *Chopper Wheel.*

Light-Currents.—Term sometimes applied to the fluctuating currents from the photo-electric cells of a television transmitter which are the electrical equivalents of the light and shade of the televised picture.

Light Elements.—See *Picture Elements.*

Light-Microphone.—A popular but altogether incorrect term which is sometimes used to designate a photo-electric cell.

Light Pencil.—See *Pencil of Light.*

Light-Quanta.—See *Quantum Theory.*

Light-Resistance.—Term usually referring to the resistance of a selenium cell when illuminated by light rays. The "light-resistance" of such a cell is much lower than its "dark-resistance."

Light-sensitive Cell.—A general term applying to any electrical device which, on illumination, undergoes a modification in its electrical properties. All photo-cells are included under this general definition.

Line-frequency (Strip-frequency deprecated.)—The number of scanning-lines traversed per second.

Liquid Cells.—Name often given to light-sensitive cells comprising two metal plates immersed in a special liquid.

There are several types of liquid cells, one well-known variety comprising two copper plates immersed in a weak solution of copper sulphate. After the plates have been "formed" by standing in contact with the solution for some days, a small current will be found to flow in an external circuit connecting the two plates when one of the plates is illumined, the opposite plate being allowed to remain in shadow. On switching off the light, the current-flow will cease.

Cells of this type were originally discovered by the scientist, M. Henri Becquerel. Hence they are sometimes referred to as

"Becquerel cells." They are purely experimental devices and, so far, have no practical uses.

See *Becquerel Effect, Photo-electrolytic Cell.*

Lithium.—Chemical symbol: Li. Atomic weight: 7. A very light silvery metal, which, like sodium and potassium, to which it is related, is so soft that it can be cut easily with a knife.

Lithium metal has photo-electric properties, and it is employed in the construction of the cathodes of certain photo-electric cells. Lithium photo-cells show an especial sensitiveness to violet rays.

From the Greek, *lithos*, a stone—in reference to the earthy sources of the element.

Low-Definition.—A system of television in which the number of scanning lines into which the complete picture is divided is less than 100.

Lumen.—A unit of light energy.

One lumen is the amount of light energy falling upon one square-foot of the inner surface of a hollow sphere having at its centre a light source of one candle-power.

From this, it can be shown that one candle-power equals 4π, or $4 \times \frac{22}{7}$ lumens.

Luminescence.—A general term which is used to denote all effects in which light is produced without heat.

Under the general heading of luminescence come the well-known terms: "fluorescence" (which see) and "phosphorescence."

Lux.—A metric standard of illumination intensity.

One "lux" (also known as a "metre-candle") is the intensity of illumination at the surface of an object set up by a standard candle placed at a distance of one metre (39·37 inches) from it.

From the Latin *lux*, light.

M

Mu.—The Greek letter μ. It is used to denote the *micron*, which is a thousandth of a millimetre.

Macula.—Known, also, as the *Macula lutea*, or "yellow spot," on account of its colour. A slightly raised spot at the central portion of the retina of the human eye which consists almost entirely of cones and which permits of the perception of very fine detail.

From the Latin, *macula*, a spot.

See *Rods and Cones.*

Magnesium Carbonate.—Chemical formula: $MgCO_5$. A light powder having an extreme whiteness. Magnesium carbonate is the whitest substance known. It is, therefore, used as a standard of whiteness in optical experiments and in trials of reflecting power.

Magnesium Platinocyanide.—Chemical formula: $MgPt(CN)_4$. A bright scarlet salt containing platinum. It possesses fluorescent properties and is sometimes used as an ingredient in the fluorescent screen material of cathode-ray tubes.

Magnetic Focusing.—Term referring to a method of focusing the beam of rays in a cathode-ray tube by placing an electromagnetic coil in their path.

Magnetic Toothed-wheel Synchroniser.—See *Toothed-wheel Synchroniser.*

Magnifier.—Term sometimes used to designate the simple magnifying lens with which some television receivers are provided for the purpose of enlarging the received image.

Mechanical Scanning.—A generic term used to denote any process of scanning which is effected by means of mechanical parts. Thus, scanning discs, mirror-drums, mirror-screws, vibrating mirrors, etc., all constitute appliances for mechanical scanning.

See *Electrical Scanning.*

Mercadier's Cell.—An early form of selenium cell (1881), consisting of two strips of brass foil having a layer of insulating parchment between them and rolled into a spiral, one surface of which was coated with fused selenium.

Mercury.—Chemical symbol: Hg (Hydrargyrum). Atomic weight: 200. Boiling point: 357°C. The well-known silvery metal, liquid at ordinary temperatures, and known through the ages as "quicksilver."

Mercury gives off a vapour at ordinary temperatures and when subjected to a high electric potential at low pressures this vapour glows with an intense greenish-blue light, the "mercury-vapour lamp" being well-known. Mercury vapour has been used in place of neon gas as the illuminant in some colour television systems.

Mercury-Helium Lamp.—See *Helium-Mercury Lamp.*

Mercury-Vapour Lamp.—A lamp comprising a tube of fused quartz in which a little mercury has been confined. On passing an electric current the mercury is vapourised and it glows with a characteristic greenish light. It is used as a powerful illuminant in some television transmitting systems and for many other scientific purposes.

Metallic Selenium.—The light-sensitive form of selenium.

It may be prepared by heating any of the other varieties of selenium above 200°C. It is a greyish-black material having a metallic sheen and appearance.

Metalloid.—A term used with increasing frequency to denote an element which is half a metal and half a non-metal.

The light-sensitive element, selenium, is often erroneously described as being a metal. At the most, however, it is merely a metalloid, in which only non-metallic features preponderate.

Tellurium and antimony are typical " metalloids."

Metre-Candle.—See *Lux*.

Mica.—The well-known transparent material of laminated structure and of high insulating powers. Among many electrical uses, it is employed in the construction of some types of selenium cells.

Mica is the name given to a group of minerals. They all contain silicon combined with varying amounts of magnesium, sodium, potassium, lithium, aluminium and iron.

Microlux.—One-millionth of a lux. A unit employed in the measurement of extremely minute illumination intensities.

See *Lux*.

Micron.—A term signifying a thousandth of a millimetre. It is used in expressing the wave-length of light.

Middleton's Instrument.—An early form of television apparatus, first experimentally demonstrated by its inventor before the Cambridge Philosophical Society on 8th March, 1880. The transmitter consisted of a bank or mosaic of small thermo-electric couples which were connected up to a similar mosaic of couples on the receiving instrument. A crude illuminated image was projected upon the transmitting mosaic and the minute thermo-electric currents thus set up generated heat in the receiving couples, the radiant heat thus created being manifested by means of reflection from a special form of mirror.

Millilux.—One-thousandth of a lux. A unit used in the measurement of small illumination intensities principally in Television research.

See *Lux*.

Millimicron.—The thousandth part of a micron. A term used for expressing small wave-lengths of light.

Minchin's Cell.—An electrolytic type of selenium cell first constructed in 1895 by the Irish physicist, Professor Minchin. It consisted of a short length of aluminium wire, flattened and selenium-coated at one end and enclosed in an open-ended glass tube, which latter was immersed in œnanthol (an organic liquid), in close proximity to a platinum electrode.

This cell, like Sabine's cell (which see), produced its own current when properly adjusted and illuminated.

Mirror-Drum.—A scanning device employed in some television systems. Essentially, it consists of a drum-shaped wheel having fixed upon its periphery or outer edge a number of mirrors, each mirror being tilted at a slightly different angle from that of the preceding mirror. A beam of light is suitably focused upon the edge of the mirror-drum, which is rapidly rotated, thus causing a light spot to be flashed in successive lines over the image or object to be televised.

In a similar way, also, the mirror-drum is made to assemble the televised picture at the receiving end.

The main advantage of the mirror-drum is that it allows a more intense spot of light to be focused upon the object.

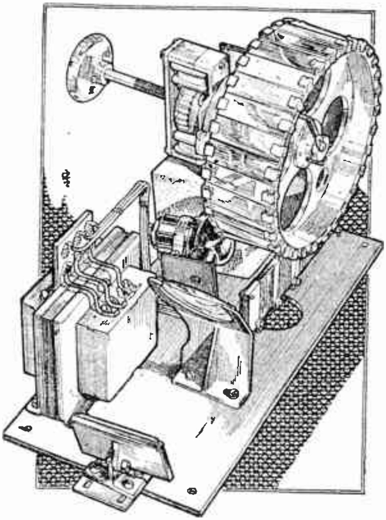


FIG. 94.—A typical mirror drum receiver (now obsolete).

Mirror Effect.—A form of "reversed image" which sometimes occurs on the screen of a television receiver, the televised image appearing with the left and right sides of the original transposed, thus giving rise to a "mirror effect." Mirror-drum receivers which are incorrectly adjusted are prone to give rise to this type of reversed image.

Mirror-Screw.—A television scanning device comprising a number of mirrors arranged on a frame in the form of a screw spiral. Unlike the mirror-drum (which see) the mirrors are not separately tilted in relation to one another, the directing of the light spot on the screen or on the object to be televised being effected by the suitable and exact positioning of the mirrors on the spiral.

The mirror-screw does not reflect the light as does the mirror-drum. It has, however, the advantage of greater compactness (now obsolete).

Mirror-Wheel.—See *Mirror-Drum.*

Mixed-layer Cell.—A photo-electric cell containing a layer of light-sensitive material throughout which has been forcibly diffused traces of a "foreign" metal, such as silver, the foreign metal particles functioning by assisting the replacement of electrons which have been emitted by the light-sensitive particles.

Mixed-layer cells of this nature are still in the experimental stage, but will, no doubt, in time, become more generally used for television purposes. See *Selenium.*

Modulator.—A grid or other device to which a varying potential is applied in order to produce a modulating action on the intensity of the beam.

Moore Lamp.—A special type of neon lamp which was devised for the Jenkins' television system by Dr. D. MacFarlan Moore. It comprises a neon tube, the two electrodes of which are set concentrically and are separated by a glass cylinder, an arrangement which enables the glow discharge of the lamp to be concentrated about the centre of the positive electrode. In this manner, a much brighter source of light is obtained.

Moser's Theory.—A theory of the light-sensitivity of selenium first put forward by Moser in 1881. This theory suggested that the effect was brought about by heat which rendered more complete and effective the contact between the selenium element of the cell and its electrodes. The theory is now untenable.

Moving-tape Transmitter.—A modification of a film television transmission devised by television engineers for the purpose of transmitting printed characters. The messages are printed in a tape by means of a special typewriter, after which they are televised in a manner roughly similar to that in which a film television transmitter operates.

The Moving-tape Transmitter is not applicable to the television of pictures.

Multiple Scanning.—Expression referring to television systems in which two scanning devices, as, for example, two mirror-drums, reflect the televised picture on to a screen, the object of these methods being to increase the intensity of the illumination on the screen.

Systems of multiple scanning are also applicable to methods of television transmission.

Multi-spiral Disc.—A type of scanning disc perforated with more than one spiral series of apertures. Discs of this type have been produced by several inventors. Some of them, as for example, the Sanabria disc, give rise to a scanning principle in which the image is scanned in non-adjacent rows. Multi-spiral discs are, however, still in the experimental stage and their practical value has yet to be proved.

N

Natural Colour Television.—See *Colour Television.*

Naumannite.—A rare mineral containing selenium, chiefly in the form of selenide of silver. Named after its discoverer, Dr. C. F. Naumann, a German mineralogist.

Negative Image.—An image resembling that shown by a photographic negative, i.e. one in which the light parts of the original picture are dark and the dark portions of the original are light. It is the opposite to a positive image.

Some television receivers will give rise to negative images on their screens when a fault or maladjustment is present in the electrical circuit of the receiver.

See *Positive Image.*

Neon.—Chemical symbol: Ne. Atomic weight: 20. A colourless, odourless, inert gas discovered in 1894 by the late Sir William Ramsay.

Neon is present in extremely small proportions in ordinary air, one volume of neon being present in nearly 90,000 volumes of air. For electrical purposes, neon is manufactured by selectively distilling large quantities of liquid air.

From the Greek, *neos*, the new one.

Neon-Mercury Lamp.—A type of gas discharge lamp containing neon gas and mercury vapour under low pressure. Lamps of this nature give a high-efficiency glow discharge, particularly when the lamp is so made that the glow is confined to a small area.

Neon Time Base.—Name given to a time base circuit in which a neon lamp provides the means of providing a periodic voltage across one pair of deflector plates in a cathode-ray tube.

See *Time Base.*

Newton's Disc.—A disc of cardboard or other material around which are painted in equal sectors the colours of the spectrum—Violet, Indigo, Blue, Green, Yellow, Orange and Red. When the disc is rapidly rotated, the various colours blend together forming (under ideal conditions) a white appearance. In practice, however, owing to the difficulty of matching the colours accurately, the resulting appearance of the whirling disc is greyish-white rather than pure white.

Newton's disc serves to illustrate the fact that white light is a composite of all the coloured rays of the spectrum.

Newton's Rings.—Name applied to rings of colour which appear when two ordinary flat surfaces of glass are pressed together. The name is used in remembrance of Sir Isaac Newton, who conducted many experiments with the phenomenon.

Newton's rings are due to the light-interference effects of a thin layer of air existing between the two surfaces of glass which are not *perfectly* flat. If the glass surfaces were absolutely flat, the Newton's rings would disappear.

The production and disappearance of Newton's rings forms a very delicate optical test for perfect flatness. Such a test is used in the making of "optical flats" for the construction of mirrors and colour-filters of extreme accuracy for television and other scientific purposes.

Nickel.—Chemical symbol: Ni. Atomic weight: 59. A silvery-white metal, which, although hard, is malleable and ductile. It is slightly magnetic.

In television and radio construction, nickel is used extensively for the making of the "metalwork" of cathode-ray tubes, neon lamps, valves and other similar devices.

Nicol Prism.—An optical device used in some television systems in conjunction with the Kerr cell, or light-valve. It consists of two specially prepared crystals of Iceland Spar cemented together in such a way that a ray of light passing through the prism is split up into two parts. One of these, the "ordinary" ray, is turned aside and led out of the prism. The remaining ray—the "extraordinary" ray—which is polarised, is utilised for the purpose required.

The device derives its name from its inventor, an ingenious optician named Nicol.

Nipkow Disc.—Name sometimes given to the scanning disc employed in many television systems. It was originally the invention of the Polish scientist, Paul Nipkow, in 1884. Nipkow employed it in the crude shadowgraph transmitters with which he experimented at the end of the last century.

See *Scanning Disc.*

Nitro-benzene.—Chemical formula: $C_6H_5 \cdot NO_3$. A pale-yellow liquid prepared by treating benzene with a mixture of nitric and sulphuric acids. It possesses a powerful almond-like odour.

In television technique, nitro-benzene finds a use in the construction of Kerr cells.

Noctovision.—Name applied by the Baird Company to a system of television by means of infra-red rays. The individual to be televised is placed before the transmitter in a darkened room. His features are then flooded with infra-red light to which his eyes are practically insensitive so that, at the most, all that he perceives is a very faint dull-red glow. The subject of the television is scanned in the usual manner by revolving disc or mirror-drum, the infra-red rays being picked up by photo-electric cells of a special pattern which are highly sensitive to infra-red rays. In this manner, an individual seated in apparent darkness may be televised and his image will appear on the receiving screen just as though the televised subject were subjected to normal white light illumination.

Other very interesting applications of the principle of Noctovision are possible.

Noctovisor.—Term employed by the Baird Company to denote its infra-red ray television transmitter.

See *Noctovision.*

O

Objective.—A frequently used term which denotes the image-forming or projecting lens of an optical instrument, as, for instance, the projecting lens of a television or film-television apparatus.

Optical Axis.—See *Axis.*

Optical Flat.—Name given to a piece of glass one or both surfaces of which are perfectly and uniformly flat. Skilled optical working is required to make an optical flat. " Flats " are used in the construction of mirror reflecting surfaces of extreme accuracy and, also, in the making of the highest grade colour-filters.

See *Newton's Rings.*

Origin Distortion.—A type of image distortion which is set up on the fluorescent screens of some low-voltage cathode-ray tubes under certain conditions.

Below a certain critical potential of the deflector plates (about 10 to 12 volts) the path of the electron or cathode-ray beam is not uniformly deflected by the voltage changes on the deflector plates. The consequence is that the beam apparently drags or slows down, thereby giving rise to an area or line of brighter glow on the fluorescent screen, and thus setting up a distortion of the image.

Origin distortion is sometimes termed " Threshold Effect."

Oscillatory Scanning.—Name given to scanning methods by means of which the light spot oscillates or travels forwards and backwards over the image to be televised. After each complete oscillation the light spot shifts laterally thus enabling a new area of the picture to be scanned. Oscillatory scanning possesses many practical disadvantages.

Oscillogram.—Name given to the wave-like pattern, representing the graphical form of an alternating current, which is traced out by the light spot on the fluorescent screen of a cathode-ray oscillograph tube.

Oscillograph.—See *Cathode-ray Tube.*

Out of Frame.—The state of a televised image when, as seen on the screen of the receiver, it is divided horizontally or vertically, the two portions of the image appearing in opposite positions. The image is correctly " framed " by the manipulation of a small control which influences the synchronising gear of the receiver.

Oxygen.—Chemical symbol: O. Atomic weight: 16. The well-known colourless, odourless, life-giving gas which constitutes about 23 parts by weight of the earth's atmosphere.

Small traces of pure oxygen are sometimes introduced into certain types of photo-electric cells in order to modify their response to light action. Cæsium-oxygen cells, for instance, are specially sensitive to red light.

P

Pantelegraph.—Name given to an early picture-transmitting apparatus demonstrated in this country by the Abbé Caselli, an Italian, in 1856. Between 1865 and 1869 Caselli's apparatus was in actual operation between Paris and Amiens.

Caselli's Pantelegraph was a modification of the chemical telegraph recorder, a metal stylus at the receiving end tracing out a pattern or a drawing on paper sensitised by potassium cyanide.

Parabolic Reflector.—Name given to a light reflector, usually of highly polished metal, which, being shaped to a parabolic curve (a parabola is the section of a cone cut parallel to one of its sloping sides) causes a beam of parallel rays to be reflected from an illuminating source placed in the focus of the reflector.

Parabolic reflectors are frequently used for obtaining strong beams of parallel light rays in optical experiments connected with illuminating and light-projecting matters.

Parallel Rays.—Light rays which travel parallel to one another, as, for instance, the light rays reflected from a parabolic reflector.

Light rays coming from a very distant object, such as the sun, are always parallel from a practical standpoint, although, in strictest truth, they are very slightly divergent.

Pencil of Light.—Name given to a narrow beam of light rays which diverges from or converges to a given point or area. The " flying spot " of a disc television transmitter is, for example, created by a pencil of light.

Pentane Lamp.—A type of standard lamp which, in this country, has been adopted by the Board of Trade as a standard light source.

In the pentane lamp coal gas is passed over the surface of pentane (a constituent of petrol) and is then burned at a special burner of the Argand type, precautions being taken to keep the gas pressure and the height of the flame constant. A pentane lamp usually emits a light of one standard candle-power, although lamps of this type can be obtained which will develop a light of 10 c.p.

Persistence of Vision.—When light rays impinge upon the retina of the eye the impression which they make does not cease immediately the light rays stop. On the contrary, it persists for an appreciable time afterwards, this effect being known as "persistence of vision," or "visual persistence."

It is upon this "lag of the retina," as persistence of vision is sometimes called, that we are able to build up a reproduction of motion on the television or cinema screen, in both instances a series of successive pictures (each differing slightly from the preceding one) being formed or thrown on a screen so rapidly that the eye is not able to get rid of the impression made by the one picture or image before the next one arrives.

Persistence of vision lasts for approximately one-twelfth of a second. Hence, if a series of varying images are projected upon a screen at a minimum rate of twelve per second, the effect of motion will be obtained.

Phase-distortion.—That type of distortion produced by inequality of transmission-velocities of the individual frequency-constituents of the electrical output from a vision-frequency generator.

Phasing.—That process by which the forming of the image is brought point for point into the same space-time relationship as the exploring of the object.

Phase Shift.—A condition in television reception in which, owing to stray circuit capacities in the receiver, the fluctuations in voltage do not keep in step with those originally transmitted, particularly at high and at low frequencies. This results in some of the details of the televised picture being received at a later instant of time than the remainder of the picture, thereby setting up a displacement or distortion of the televised image.

Phonic Drum.—An early synchronising device employed by television workers. It was the invention of M. la Cour.

The phonic drum comprises a hollow drum made of wood or of some non-magnetic material, such as aluminium or copper, on the outer edge of which are fixed at regular distances apart a series of iron strips. By being caused to rotate in close proximity to the poles of an electro-magnet which is fed with alternating or fluctuating current, the phonic drum of M. la Cour can be employed as a simple type of synchronous motor.

Phonovision.—A word coined by the Baird Company to designate a process by which a televised picture or image may be stored up in the form of a gramophone record and subsequently " released " as often as desired.

In the phonovision system the electrical impulses from the transmitting photo-cells are led to a recording pick-up which traverses a wax blank on an ordinary gramophone recording machine. In this way the varying electrical pulses are stored up in the form of variations of the groove.

When it is desired to reproduce the image or picture thus " bottled-up " the record is played over with a pick-up, the output current from which, after being amplified, is led to a neon lamp in front of which revolves a scanning disc. An observer looking through the disc will see a reproduction of the original image.

If desired both light impulses and music or speech may be stored up in the same record, a double track record being made.

Phonovision, at the present day, is merely a scientific curiosity, but it has many interesting possibilities.

Photocell.—An abbreviation of " Photo-electric " cell, which see.

Photo-conducting Cell.—An electrical cell whose electrical resistance varies according to the intensity of the illumination which impinges upon its sensitive surface.

Selenium cells, which do not actually generate current, but merely change in electrical resistance under light influence, are typical examples of photo-conducting cells.

Photo-Conductivity.—Term used to describe the electrical conducting powers of a body under the influence of light.

Photo-electric Cell.—A light-sensitive device which, by emitting a stream of electrons under the influence of light rays and in proportion to the amount of light falling upon it, enables light to be turned into electricity.

Photo-electric cells are of two kinds, viz.: the *Emission* type and the *Photronic* or *Self-generating* type.

See *Emission Cell*, *Photronic Cell*.

Photo-Electric Effect.—See *Hertz Effect*.

Photo-Electrics.—Term applied to denote certain substances which, by a mechanism of electron emission, create minute electric currents when light falls upon them. Many metals, as well as other more complex materials, fall under this category.

It is upon the properties of such materials that the now many types of photo-electric cells are based.

Photo-electrolytic Cell.—A light-sensitive cell whose action depends upon the production of the " Becquerel Effect," i.e. the setting up of a current when two metal plates, one of which is strongly illuminated, are suspended in certain chemical solutions.

" Liquid cells " are well-known examples of photo-electrolytic cells.

See *Liquid Cells, Becquerel Effect.*

Photo-Electrons.—Name sometimes applied to the stream of electrons which are liberated from certain bodies under the influence of light.

Photo-electric cells operate in virtue of the presence within them of a stream of photo-electrons whenever they are illuminated by light rays.

Photo-Emission.—The emission of electrons from bodies under the influence of light.

Photo-Luminescence.—A scientific term which denotes the emission of light from a substance under the action of light. The term is a general one, including all cases of *fluorescence* and *phosphorescence*, which see.

Photo-Sensitive.—Term signifying " sensitive to light." Photo-electric cells, selenium cells, certain chemical solutions, photographic plates, films, papers, etc., are all photo-sensitive articles, although in different instances the photo-sensitivity is manifested in varying ways.

Photo-Telegraphy.—Name applied to various systems whereby a photograph or image is transmitted and received by wireless or by means of a landline communicating channel. Photo-telegraphy is, in some respects, " slow-motion television," for by means of it the picture is transmitted slowly, piece by piece, and reassembled at the receiving end at a similar rate, whereas in systems of true television the breaking up and re-assembly of the picture is accomplished with extreme rapidity.

Photo-Voltaic Cell.—Name given to a type of light-sensitive cell in which a potential difference is set up across the rectifying junction of a metal and certain semi-conductors when the contact is strongly illuminated.

Photronic Cell.—A type of photo-electric cell in which the sensitive surface, under the influence of light, generates sufficient current to flow through an external circuit connected up to the cell. This general type of photo-electric cell is also known as the *Self-generating* cell.

Photronic cells are more sensitive than the Emission types of photo-electric cells, and they are a more recent development than the latter.

See *Emission Cell.*

Picture Elements.—Name given to the minute areas into which a picture, portrait, or scene which is to be televised is split up by one means or another. The picture elements are all of the same size, but they differ in brightness. Each picture element is projected in its turn upon the light-sensitive cell, thus giving rise to a current pulsation corresponding in intensity to the degree of brightness of the picture element. That portion of the scene which determines or is determined by the instantaneous value of the signal current.

Picture-frequency.—The number of complete images transmitted per second.

Picture Intensification.—See *Intensifying Circuit.*

Plate Neon Lamp.—Name applied to a neon lamp or tube in which the glow appears at the surface of a rectangular metal plate. Neon lamps of this type (of which there are many different varieties) are largely used in television receiving systems.

Point Neon Lamp.—A type of neon lamp in which the glow is concentrated upon a very small surface. In some lamps of this description the glow can be concentrated into an area having a diameter of very little more than a millimetre. Lamps of this type provided a light source of high efficiency for certain television uses.

Polarisation.—Applied to light rays the term denotes the cutting off of all the rays in a beam of light except those which vibrate in one plane. Light consisting of these one-plane vibrations is said to be " polarised," and, in such a condition, it possesses peculiar properties of its own. Light rays are usually polarised by passing them through certain crystals, such as Iceland Spar, which effect the process automatically.

Positive Image.—The image as it is normally seen on a television screen. A photograph or any other type of illustration is a positive image, the lights and shades of it being a true or approximate reproduction of those of the original. A positive image is, as its name implies, the opposite to a negative image.

See *Negative Image.*

Potassium.—Chemical symbol: K (from the Latin, *Kalium*). A member of the alkali group of metals. Atomic weight: 39. Melting point: 65·5°C. Specific gravity: 0·859.

Metallic Potassium, and also potassium hydride, KH, are highly photo-electric and are used in the construction of certain types of light-sensitive cells for television working.

Potassium Iodide.—Chemical formula: KI. A white crystalline substance which liberates free iodine under the influence of an electric current. This electro-chemical action is made use of in several systems of photo-telegraphy, or picture transmission, a moving metal stylus traversing a sheet of potassium iodide-treated paper, which has been wrapped round a revolving cylinder and liberating free iodine in the pores of the paper in accordance with fluctuating currents derived from the transmitting end of the apparatus, in this manner building up a replica of the original picture in brown iodine.

Presser's Cell.—A selenium cell comprising a circular slab of steatite (soapstone) covered with platinum and ruled with concentric groves something after the fashion of a gramophone record. The surface thus created was covered with a thin layer of selenium.

Primary Current.—A term used in connection with gas-filled photo-electric cells to signify the actual minute current set up by the impact of light upon the sensitive cathode of the gas-filled cell.

Prism.—A triangular-shaped piece of glass or other transparent material used in practical optical work for bending rays of light through a right-angle, and also, in the spectroscope, for splitting up rays of light into their component colours.

Progressive Scanning.—A system of exploration of the scene or image in which contiguous strips of the scanning field are traversed in order.

Pupil.—The circular aperture in the centre of the iris of the eye which has the appearance of a dark spot and through which light passes on its way to the retina.

See *Iris*.

Q

Quantum Theory.—A theory of radiation and energy originally put forward by Planck in 1901. According to the quantum theory, no form of radiation is continuous, but, like matter, it consists of small, indivisible units, or "quanta."

Light radiation is not emitted from a body in a continual stream of rays, but is made up of "bundles," or units of energy (known as "light-quanta"), which are released from the luminous body at regular intervals in much the same way as a stream of bullets is released from a machine-gun.

The quantum theory, despite the fact that it affords a reasonable explanation of many phenomena connected with light and other electro-magnetic radiation, is by no means universally accepted by physicists. It is, however, a theory which should be grasped by all students of light energy and its effects.

Quartz.—Chemical formula : SiO_2. Silicon dioxide. A common form of silica, also known as *Rock Crystal*. It freely transmits ultra-violet rays. Selected specimens of quartz are, therefore, sometimes ground into lenses to be used for purposes in which the free transmission of ultra-violet light is essential.

Ordinary glass lenses absorb a considerable proportion of the shorter ultra-violet rays. Hence any future system of television transmitting entirely by the invisible ultra-violet rays will have to make use of lenses ground from clear quartz or rock crystal.

Quartz Lamp.—Another name for a mercury-vapour lamp, which see.

Quinine Sulphate.—A well-known compound which, in addition to being strongly fluorescent when dissolved in suitable solvents, is also light-sensitive. Dissolved in water containing a trace of sulphuric acid, quinine sulphate will generate a minute current under the influence of light when contained in a special cell made for the purpose.

R

Radio-Photography.—A name sometimes applied to systems of photo-telegraphy which employ a wireless communicating channel.

Raster.—The rectangular picture area built up by the scanning spot on the end of the cathode-ray tube.

Recurrent Vision.—Name given to the phenomenon of an image recurring one or more times to the eye after the actual light rays from the object have been cut off.

Recurrent vision was first noted by Young, in 1801, who observed that after an object had been intensely illuminated by an electric spark, the image recurred to the eye several times after the spark had passed, the image becoming fainter with each successive recurrence.

Red Selenium.—A form of selenium having the appearance of a brick-red powder. It is a high insulator, and only becomes light-sensitive after careful and prolonged heating.

Reflection.—The recoil of light rays from the surface on which they impinge.

Reflection is said to be *regular* when, as in the case of a mirror, the light rays are reflected back in an orderly and unbroken manner. Reflection is said to be *irregular* when, as in the case of light reflected from a whitewashed wall or a sheet of white paper, the reflected rays do not travel back in an orderly manner, but are broken up and scattered by the reflecting surface.

Reflection is a very important factor in television science for the reason that most of the light dealt with in the televising of an image is of the reflected variety.

Although glass mirrors form the most usual type of reflectors, the most perfect reflectors are made from the highly-polished surfaces of various alloys of copper, zinc and silver, these forming what are known as *speculum metals*.

There are two well-known " Laws of Reflection " :—

(1) The incident light ray (i.e. the original ray), the reflected ray, and the imaginary perpendicular line drawn from the surface of the reflector are all in one and the same plane.

(2) The angle of incidence of the light ray (i.e. the angle which the original or entering ray makes with the reflecting surface) and the angle of the reflected ray are equal.

These laws operate universally in all cases of reflection. They ought, therefore, to be fully understood by all amateurs who are concerned with the optical side of television working.

Reflection Factor.—The extent to which a surface reflects light. In daylight, white paper has a reflection factor of approximately 80 per cent, whilst grey, yellow, blue and red papers have reflection factors of about 65, 60, 40 and 20 per cent respectively.

Since the light dealt with in normal television transmission is of the reflected variety, a study of the reflection factors of various materials and colours under different kinds of illumination is of the utmost importance to television transmitting efficiency.

Refrangible.—Term meaning " refractable," i.e. that which may be bent or turned aside.

Light rays are capable of refraction and are, therefore, sometimes said to be *refrangible*, the rays at the violet end of the spectrum, which are capable of greater bending, being more refrangible than those at the red end of the spectrum.

Regular Reflection.—See *Reflection*.

Resolving Power.—The ability of the eye or of a lens to determine detail.

The resolving power of the eye is lessened by intermittent lighting and also by feeble illumination—two facts which have to be taken into consideration in the design of an efficient television reception screen.

Retina.—The membrane at the back of the eye, upon which the objects viewed are focused by the lens of the eye. The retina is made up of a very fine mosaic of exceedingly minute cells—the rods and cones—which are filled with a purple dye which is bleached under the influence of light. This bleaching action is communicated to the brain along the optic nerve, there giving rise to the sensation of light.

From the Latin, *rete*, a network.

See *Rods and Cones, Visual Purple.*

Reversed Image.—A reversed image on the screen of a television receiver may manifest itself in two varieties. It may take the form of a negative image, similar to that seen in a photographic negative, in which the white parts of the original picture appear black and *vice versa*, or the image may be laterally reversed, i.e., one in which the right side of the original appears on the left side of the television screen and the left side of the original on the right side of the screen, this type of reversed image giving rise to the term " mirror effect."

Reversed images in television reception are nearly always associated with faulty adjustments, either electrical or mechanical, of the apparatus, and they are remedied without much difficulty.

Rhodamine.—A light-sensitive dye which, in a specially constructed cell, yields up a minute current when illuminated by strong light.

Righi's Cell.—A form of selenium cell, dating from 1888 or thereabouts. It consisted of a series of thin selenium discs held between wire gauze.

Ring Cell.—A type of photo-electric cell in which the cathode consists of a layer of the light-sensitive material deposited on the cell walls the anode consisting of a gauze-covered metal ring fixed above the cathode layer.

Rods and Cones.—Anatomical expression used to denote the exceedingly minute cells which comprise the active surface of the retina of the eye. Spaced over the retina of the eye there are approximately five million of these cells, each of which is filled with a light-sensitive pigment (" visual purple ").

The " rods," or rod-like cells, are sensitive to low intensity illuminations, the " cones," or cone-shaped cells, being sensitive to average and to high-intensity illuminations. The rods and cones are not situated equally in all areas of the retina, there being a superabundance of cones towards the centre of the retina. Hence the retina is more sensitive to average and high illumination intensities at its centre than it is at its margins.

See *Retina, Visual Purple.*

Rosing's Apparatus.—An early form of television apparatus, first devised by Boris Rosing, a Russian, in 1907. Rosing employed in his transmitter an arrangement of revolving mirrors, which threw an image of the object to be televised on to the surface of a selenium cell. The pulsating current from the selenium cell was transmitted along a wire to the receiving instrument in which it charged up a series of condenser plates, which exerted a deflecting action upon a beam of cathode rays in a cathode-ray tube. Rosing's television receiver constitutes a very early use of the cathode rays as a means of practical television.

Rubidium.—Chemical symbol: Rb. A member of the alkali group of metals. Atomic weight: 85. Melting point: 39°C. Specific gravity: 1·525.

A silvery-white metal similar in properties to sodium and potassium, but much rarer than the two latter.

Metallic rubidium and, also, rubidium hydride, RbH, are extremely photo-electric, and they enter into the construction of some light-sensitive cells.

Ruhmer's Cell.—A cylindrical type of selenium cell first constructed by Ruhmer in 1902. It comprised an inner cylinder, or column of steatite, which was wound with wire and subsequently coated with fused selenium. Several patterns of this cell have been produced.

S

Sabine's Cell.—A fluid type of selenium cell consisting of a metallic plate, varnished on the one side and selenium coated on the other, which was placed opposite to a similar plate in a weak acid or salt solution.

Under the influence of strong light, this cell, unlike other selenium cells, was found to generate its own current. Cells of this type are sometimes known as " electrolytic selenium cells."

Sale's Theory.—An early theory of selenium's light-sensitivity, first propounded by Sale, in 1873. The theory ascribes the light-sensitivity of selenium as being due to electro-magnetic waves in the ether, which penetrate the selenium atoms and so increase the conductivity of the entire mass of selenium. This theory is open to several disadvantages.

Sanabria System.—A method of television transmission and reception devised by Ulysses A. Sanabria of Chicago. The Sanabria transmitter operates upon well-known television principles of scanning. The receiver, in virtue of a special type of neon lamp, is enabled to throw an image of considerable size upon a screen.

Scanning (Exploring). (*a*) In a transmitter. The process of analysing the scene or object into picture-elements or elemental areas; (*b*) In a receiver. The process of building up the image from picture-elements or elemental areas.

Scanning Disc.—Name given to a metal disc accurately perforated with a series of holes or apertures in spiral or circular formation, the apertures being sometimes filled up with lenses.

The disc is caused to revolve at a high speed in front of the object to be televised, the result being that a narrow beam or spot of light is made to "scan," or to traverse rapidly in a series of "sweeps" or "lines," each portion of the picture.

See *Nipkow Disc, Apertured Disc, Lens Disc.*

Scanning Lines.—Term referring to the vertical or horizontal lines in which a scanning spot sweeps over an image. Other factors being equal, the greater the number of "lines" the more detail there will be in the received image.

Scanning - line (Picture - strip).—A sequence of picture-elements extending throughout one dimension of the picture and represented by successive signal values.

Scanning Field.—The area explored by the scanning-apparatus at the sending or receiving ends.

Scanning Spot.—The small light spot which, by one method or another, is made to sweep continuously over every portion of the picture or image to be televised, thus enabling the picture to be split up into a large number of small areas, or "picture elements."

Other factors being equal, the smaller the scanning spot, the finer in detail will be the televised image, for a small scanning spot will enable the light and shade (in other words, the detail) of the picture to be picked up and transmitted with precision, a task which becomes more and more impossible with increase in size of the scanning spot.

Synonyms: *Tracing Spot. Exploring Spot.*

Scansion.—The operation of scanning.

Sclerotic.—The outer coat of the eye which completely surrounds it, and which, at the front of the eye, has a white opalescent appearance, thus giving rise to the "white of the eye."

From the Greek, *skleros*, hard.

See *Choroid.*

Scophony.—A television system invented by Mr. G. W. Walton. The image to be transmitted is projected on to a specially constructed "stepped" or *échelon*, prism or reflector, which so displaces the image laterally that the picture is spread out into a continuous line. This line is then scanned by means of some vibrating light spot, the picture elements thus created being passed through the photo-electric cell and transmitted in the usual manner.

At the receiving end of the Scophony apparatus a line of light is created and modulated in exact accordance with the incoming current impulses derived from the transmitter. By means of another stepped prism or mirror-reflector this line of light is built up into a reproduction of the transmitted picture.

Screen.—In connection with cathode-ray tube working this term refers to the flattened end of the cathode-ray tube which is coated with a fluorescent material, and which provides a screen which glows brightly under the impact of the rays, and upon which the picture is formed.

Screen Characteristics.—The relation between the brightness of the screen beam current, and beam velocity expressed in volts at the final anode or accelerator.

Selective Absorption.—When white light falls upon the surface of an opaque object, the object absorbs from the white light all its constituent colours except the one which it reflects. The coloured object, therefore, selectively absorbs certain colours from the white light, reflecting the remainder.

A green object, for instance, selectively absorbs all the colours of white light except green, which it reflects.

The same applies to the selective absorption of light rays by transparent colour filters.

Some photo-electric cells selectively absorb light rays of one wave-length or colour.

Selenide.—Name given to compounds of metals with selenium, as, for example, lead selenide, PbSe.

The presence of selenides in selenium has the effect of very considerably reducing the light-sensitivity of the latter. Hence care should be taken to expose heated selenium as little as possible to metallic surfaces when making selenium cells.

Selenium.—Chemical Symbol: Se. Atomic weight: 79. Melting point: 217°C. Specific gravity: 4·28–4·80 (varies).

A non-metallic element, closely allied to sulphur in many of its properties. Selenium exists in a number of different forms, some of which are light-sensitive, and are used in the construction of selenium cells.

The light-sensitivity of selenium was first noticed by a Mr. May, a telegraph operator in the employ of the Telegraph Construction Company, in 1873, when experimenting with high resistances composed of selenium at the Cable Station on Valentia Island, off the south-west coast of the Irish Free State.

The name selenium (from the Greek, *selene*, the moon) was given to the element by its discoverer, J. B. Berzelius, the great Swedish chemist, in 1817, owing to its resemblance in some respects to the metal tellurium (Latin, *tellus*, the earth), which had been discovered some years previously.

Senlecq's Apparatus.—See *Telectroscope.*

Sensitivity (Electric).—The displacement of the spot on the screen produced by the application of unit potential difference between the deflector plates.

The electric sensitivity is usually expressed in terms of millimetres (on the screen) per volt (between plates).

Sensitivity (Magnetic).—The displacement of the spot on the screen produced by the application of unit magnetic field, perpendicular to the axis of the beam, and acting on unit length of the beam.

Shield.—Name given to a small metal cylinder which, in some cathode-ray tubes, encloses the filament or cathode and extends nearly as far as the anode. The shield is given a negative electrical bias, thus enabling it to repel any of the electrons emitted from the filament which may happen to come near it. It acts in much the same manner as the grid of a valve, its function being to concentrate the electron stream from the filament or cathode into a narrow beam, which will pass almost uninterruptedly through the central aperture of the " gun," or positively charged anode.

The shield of a cathode-ray tube is sometimes known as a Wehnelt cylinder, after its inventor, also any electrical or magnetic screen placed inside or outside the tube.

Siemens' Cell.—The first of all selenium cells to be constructed.

The invention of W. Siemens, in 1876—three years after the discovery of the light sensitive nature of selenium—it comprised two platinum wires, spirally wound and secured to a mica sheet. The wire surface was then coated with selenium, the active " face " of the cell subsequently being " formed " by heating the entire cell to a temperature of 200°C. for four or five hours.

Siemens' Theory.—A theory of the light-sensitivity of selenium first put forward by Siemens in 1875. On this theory there are two forms of selenium, *a-selenium* and *β-selenium*—existing side by side in equilibrium within a mass of the material. *a*-selenium is a poorly conducting variety, whilst β-selenium is a good conductor. Under the influence of light a physical change takes place within the selenium, whereby a quantity of the poorly conducting *a*-selenium is converted into the better-conducting β-selenium, thus increasing the conductivity of the mass of selenium. On the cessation of the illumination the β-selenium thus generated automatically changes back again into *a*-selenium.

Soapstone.—See *Steatite*.

Sodium.—Chemical symbol: Na (from the Latin, *Natrium*). A member of the alkali group of metals. Atomic weight: 23. Melting point: 97°C. Specific gravity: 0·972.

Sodium is a silvery-white metallic element, so soft in character that it can be cut through with a knife. Sodium decomposes water violently with the evolution of hydrogen gas. The metal is highly oxidisable, rapidly becoming coated with a white film of oxide when exposed to the air.

Metallic sodium and, still more, its hydride (NaH) are photo-electric, and are employed in the construction of light-sensitive cells. Some gaseous discharge tubes also contain sodium, these tubes glowing with a yellowish-white light.

Sparking Voltage.—A term used in connection with photo-cell technique to denote the anode voltage of a gas-filled photo-electric cell, which so greatly ionises the gas contained within the cell that a continuous discharge passes through the cell. The applied voltage should never reach this critical point, for the electrical discharge through the cell quickly destroys its efficiency.

Synonym : *Sparkling Potential.*

Spectrum.—Name given to the multi-coloured band of light which can be thrown on to a screen after passing a beam of white light through a prism, or light-splitting device.

The colours of the spectrum are seven in number. In order they are: violet, indigo, blue, green, yellow, orange and red. beyond the violet and the red ends of the spectrum are, respectively, the ultra-violet and the infra-red rays, both of which are invisible to the human eye. It is from combinations of the various coloured rays of the spectrum that all kinds of visible light are made up. The exact constitution of the light used is very often a matter of greatest importance in television technique.

From the Latin, *specere,* to see.

Spermaceti.—Chemical formula: $C_{16}H_{33}O.CO.C_{15}H_{31}$. A white waxy substance, which is obtained, mixed with oil, from the head of the Sperm whale. Among many of uses it is employed for the making of the British Standard Spermaceti candle, whose flame gives an illumination of one candle-power.

See *Candle-Power.*

Spherical Aberration.—A defect inherent in some lenses of poorer quality whereby all the rays of light transmitted by the lens are not focused accurately in the one plane, the light rays passing through the margins of the lens coming to a different focus from those passing through the centre of the lens. The fault is due to the spherical or semi-spherical surface of the lens. It is a defect which is corrected in all good quality lenses.

Spherical Cell.—A type of photo-electric cell in which the electrodes are contained in a spherical bulb.

Spider Disc.—Name applied to television scanning discs in which the outer rim is secured to the centre area or boss by means of metal strips or spokes.

Spiral Scanning.—A scanning system, of American origin, in which the travelling light spot, commencing at the centre of the picture to be televised, describes an expanding spiral outwards to the borders of the picture and, having arrived there, traces a contracting spiral until it reaches the centre of the image again. This succession of expanding and contracting spirals is performed with great rapidity by means of an ingenious arrangement of an eccentrically mounted mirror.

Spiroidal Scanning.—The American name for the system of spiral scanning recently devised in the United States.

See *Spiral Scanning*.

Split-Picture.—Term referring to the state of affairs in a television receiver when, owing to faulty synchronisation adjustment, the received picture is split down the middle and displaced to both sides.

Sputtering.—Term used to designate a phenomenon which sometimes occurs in neon and other gas-discharge tubes. The positively charged ions of gas (which are formed as a result of the electric bombardment of the particles of neon gas within the tube) travelling at high speed, bombard the surface of the negative electrode, or cathode, of the tube, sometimes causing an atom of the cathode metal to disintegrate and to fly off. Such a disintegrated atom will stick to the glass wall of the tube, and it will embed with it also an atom of the neon gas. As a result of this metallic "sputtering" the neon gas content of the tube becomes lower and lower, the vacuum of the tube increasing in proportion, until, eventually, the vacuum becomes so high that the electric discharge refuses to pass through the tube.

In modern neon and other discharge tubes the effects and possibilities of sputtering are minimised and eliminated to as great a degree as possible.

Staggered.—In television terminology this expression refers to the arrangement of the holes on a scanning disc. The holes are set in the disc at equal intervals, and they are "staggered" by being placed on successive concentric circles so that they form a portion of a spiral.

Stationary Mirror-Drum.—A television scanning device due to Denes von Mihaly, the well-known Hungarian television experimenter. It consists of a circular frame around the inside of which are arranged a series of mirrors. A beam of light is reflected round these stationary mirrors from a revolving mirror set in the centre of the drum.

Steatite.—Another name for soapstone. A form of talc having a peculiar soapy feel. It consists chiefly of magnesium silicate, and, on account of its high insulating nature, it has been extensively used in the construction of certain types of selenium cells.

Stereoscopic Television.—Television in which the received image stands out in stereoscopic relief. As attempted by the Baird Company, a form of stereoscopic television has been achieved by the use of a dual scanning system and of two entirely distinct transmitters, the two images thus transmitted being viewed at the receiving end through a stereoscope apparatus.

From the Greek, *stereos*, solid, *skopein*, to see.

Stixograph.—The name given by its originator to an elongated, or ribbon-like development of image being televised. In this special apparatus the stixograph is caused to move over the scanning aperture of the machine by means of an extremely light moving optical part, thus presenting the image in successive stages.

Cinematograph films can be taken by an application of the stixograph method, the images being spread out into a continuous ribbon on a film of narrow width which moves through the gate of the projector at a comparatively slow speed.

Stops.—See *Diaphragm.*

Striking Voltage.—Term used in connection with neon lamps and tubes to denote the initial voltage which must be applied across the electrodes in order to start the electrical glow-discharge within the tube. Once this has been commenced, the applied voltage can be reduced considerably with stopping the glow.

Synonym : *Firing Voltage.*

See *Extinguishing Voltage.*

Stroboscope.—A device by means of which the periodic motion of a mechanism may be rendered apparently stationary.

A stroboscopic disc is a disc of metal, card, or other material, specially marked, and which, when rotated under intermittent illumination (as for instance, that of an A.C. incandescent lamp) appears stationary when its rate of revolution attains a certain pre-calculated degree. On account of this effect, stroboscopic discs of varying patterns and forms of construction are used extensively for speed measurement purposes.

From the Greek, *strobos*, a turning, *skopein*, to see.

Sulphide.—A material formed by the chemical combination of sulphur with a metal or with some other element.

Traces of metallic sulphides are sometimes purposely introduced into the active material of photo-electric cells in order to modify the properties of the latter.

See *Sulphur.*

Sulphur.—Chemical symbol, S. Atomic weight, 32. The well-known yellow, non-metallic element which exists in a variety of different forms.

In order to obtain photo-electric cells of special light-response, the active surface of such cells is sometimes treated with sulphur vapour which combines with the light-sensitive metal, forming a *sulphide.*

Potassium-sulphur photo-electric cells show a special sensitivity to violet light.

Synchronising Band.—The black band running across the top of the picture in images received by means of the Baird television system. This represents the regularly recurring absence of transmitted light owing to those periodic instants of time being occupied by the transmission of the synchronising impulses which maintain the transmitting and receiving motors in step with each other.

Synchronising Valve.—Name given to the valve which in some television circuits deals with the synchronising currents.

Synchronism.—A term signifying the exact coincidence of events in time.

The operating-condition which obtains when all the elements of the image are reproduced in the same spacial relationship as the elements in the scene.

The obtaining of perfect synchronism between the moving parts of a transmitter and receiver is of fundamental importance for the success of practical television.

From the Greek, *syn,* together, *chronos,* time; also *isos,* equal.

Szczepanik's Apparatus.—An early form of television apparatus invented by Jan Van Szczepanik. The object to be televised was reflected by means of a combination of vibrating mirrors on to the surface of a selenium cell, the current pulsations from which, after transmission by wire, operated a magnetic system in the receiver which controlled a moving light spot. Szczepanik's transmitter and receiver were little more than a shadowgraph apparatus.

T

Target.—Used in connection with television technique, this term denotes the fluorescent screen of a cathode-ray tube. It is subjected to a bombardment of electrons, each impact of an electron producing a flash of fluorescent light on the screen.

Telautograph.—A form of writing telegraph similar to the Telewriter (which see). It was the invention of Elisha Gray, and was exhibited at the Chicago Fair in 1893.

Tele-cine Transmitter.—A device for transmitting cinematograph films by means of television. It comprises an ordinary

Thallium.—Chemical symbol: Tl. Atomic weight: 204. A heavy, lead-like metal, first discovered by Sir William Crookes in 1861. Some thallium compounds, notably thallium oxi-sulphide, are light-sensitive.

From the Greek, *thallos*, a green twig—in reference to the characteristic spectrum line of thallium and its compounds.

Thalofide Cell.—A light-sensitive cell containing thallium oxi-sulphide. It was first constructed in 1920 by T. W. Case. Thalofide cells, like selenium cells, are of the " photo-conducting " type, i.e., they decrease in electrical resistance under the influence of light. Thalofide cells are specially sensitive to infra-red rays.

Thermionic Photo-Electric Cell.—A type of photo-cell, due originally to Dr. V. Zworykin, of America, which combines a photo-electric cell and an amplifying valve. It thus delivers an amplified current under the influence of light.

Threshold Effect.—See *Origin Distortion.*

Time Base.—Name given to the fluctuating voltage applied across one pair of deflector plates of a cathode-ray tube in order to vary the lateral position of the light spot on the fluorescent screen of the tube. So-called because the side to side variations in the position of the light spot which occur at every succeeding instant appear as if the voltage on each pair of deflector plates had been charted against a time basis.

A " Time Base Circuit " is an electrical circuit, the purpose of which is to vary the voltage impressed upon a pair of deflector plates and thus to set up the motion of the light spot across the fluorescent screen of the cathode-ray tube. Time base circuits are of several types. The time base generator effects this.

Time-Lag.—This term, usually, in television terminology, applied to light-sensitive cells, signifies the lapse of time between the impact of the light ray on the cell and the setting up of the electrical effect which results. Also, to the time intervening between the cessation of the light action and that of the electrical effect.

Selenium cells have an appreciable time-lag. Photo-electric cells, on the other hand, are devoid of time-lag, being instantaneous in action. Hence they are used exclusively for practical television purposes.

Abbreviation : *Lag.*

Toothed-wheel Synchroniser.—A method of synchronising a television transmitter and receiver which has been evolved by the Baird Company. It comprises a small steel wheel provided with teeth set at equal intervals on its circumference. At opposite sides of the wheel are set two electro-magnets, their poles nearly touching the teeth on the wheel. The synchronising

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Telectroscope.—A form of picture-transmitting apparatus devised in 1879 by M. Senlecq, of Ardres. The picture to be transmitted was projected on to a glass screen in a camera-like instrument, and subsequently traced over by a moving selenium point, the variations of light and shade in the projected image varying the resistance of the selenium stylus and thus causing corresponding variations in the transmitted current which, at the receiving end reproduced a semblance of the lights and shades of the original image by electro-magnetic devices.

Senlecq's " Telectroscope " gave rise to many similar inventions. At a later date, also, Senlecq developed a much more complicated picture-transmitting instrument based on the use of batteries of selenium cells.

Telehor.—Name given in 1923 to a television transmitter by its inventor, Denes von Mihaly, an Hungarian. Mihaly's " Telehor " consisted essentially of two small mirrors suspended by means of two very fine wires, and which were caused to vibrate within a powerful electro-magnetic field. The image was scanned by means of these mirrors, and the light impulses were eventually passed on to a selenium cell.

The " Telehor " was a very complex instrument, impracticable outside the laboratory, and was finally abandoned by its inventor.

Telekino System.—A system of colour television from coloured cinema films developed experimentally some time ago in America by Abronheim, in which, by means of a colour-filter disc geared to the scanning disc, the various colours of the image to be transmitted are sorted out and made to impinge upon a bank of photo-electric cells, each of these cells possessing a selective response to one colour only. At the receiving end the picture is projected or viewed through a similar colour-filter disc, an approximation to the original colours being the result.

Telelogoscopy.—A term applied to the television transmission of printed characters on a moving tape or band.

Television.—It is not strictly correct to define television as the art of seeing at a distance. A telescope enables us to see at a distance, but such an instrument does not fall into the category of television apparatus.

Television is best defined as the electrical transmission and reproduction at a distance of light rays constituting views, scenes or objects, fixed or moving, the electrical transmission being effected either by wire or wireless.

Television Eye.—A popular name sometimes applied to the light-sensitive cell of a television transmitter.

Television Resonator.—A crude television device, the invention of the late Dr. E. E. Fournier d'Albe, in which the image to be televised was broken up (according to its lights and shades) into areas of different musical frequencies. This was effected by a band of perforated paper which was wound in front of the picture. The intermittent light thus produced was concentrated upon a selenium cell, the output current from which was then transmitted to the receiving apparatus.

At the receiving end the incoming signals were turned into sound by means of a loud speaker. The loud-speaker note was "analysed" by means of a composite "television resonator," which consisted of a specially designed rectangular box having a reed of silvered mica at one end. The reed, vibrating in virtue of the resonance of the box, reflected a light spot on to a screen, the position of the light spot varying in accordance with its degree of vibration, which, in its turn, was dependent ultimately upon the amount of light and shade "picked up" from the picture at the transmitting end. In this way a crude reproduction, in coarse patches of light and shade, of the original picture was obtained at the receiving end of the apparatus.

Television Telephone.—An experimental system inaugurated in America by means of which two telephone users may both see and hear each other. The telephone cabinets are illuminated by arc lights, the television controls being situated at the rear of the cabinet and under the supervision of a special operator.

The television telephone working on the above lines is the only one of its kind in the world and is, therefore, the pioneer of a system which may, in due course, become well-nigh universal.

Telewriter.—Name applied to a form of writing telegraph by means of which outline pictures, sketches and handwriting could be transmitted over two landlines. A pencil at the transmitting end was carried by two arms, the movements of these arms operating variable resistances which varied the currents transmitted over the lines. At the receiving end two magnetised bars pulled against light springs. To the bars were attached light arms carrying between them a pencil which traced out the movements of the pencil at the transmitting end. The Telewriter attracted considerable attention about the year 1880.

Telorama.—A word suggested some years ago by Dr. D. McFarlan Moore, the distinguished American scientist and electrician, in place of the now universal term, "television." The expression, however, is now rarely encountered.

Tetrachlorfluorescein.—A light-sensitive dye which, in solution, generates a minute current under the influence of light. Liquid "light cells" containing this material have been made.

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Tracing Spot.—See *Scanning Spot.*

Translucent.—Name applied to describe a body which allows some light rays to pass through it but which reflects and absorbs others. Tissue-paper, "frosted" glass, etc., are translucent materials.

Tribo-Luminescence.—Term signifying the emission of light which is sometimes effected when certain solid bodies, such as sugar crystals, quartz, etc., are rubbed together in the dark.

From the Greek, *tribein*, to rub.

Trichromatic.—Three-colour. Trichromatic television is now an accomplished feat.

See *Colour Television.*

Triple Scanning.—A system by which the image to be televised is scanned three times by means of a disc containing three sets of scanning holes, the series of holes being covered with red, green and blue colour-filters respectively. Such a triple scanning disc is employed in conjunction with the Baird experimental system of colour television.

See *Colour Television.*

Tuning-Fork Interrupter.—A synchronising device employed by Denes von Mihaly in his earlier television transmitters. A magnetised tuning-fork placed within the influence of a strong electro-magnet was used to produce pulsating synchronising currents of constant frequency.

U

Ultra-Red Rays.—Another name for Infra-red Rays, which see.

Ultra-Violet Rays.—Name given to the invisible rays of the spectrum which lie beyond the violet rays. They are extremely active chemically, and are present in sunlight and in many artificial forms of light, such as the arc light, the light of the mercury vapour lamp, that of burning magnesium ribbon, etc. A considerable proportion of ultra-violet rays are stopped by ordinary glass. Hence photo-cells which are made to be specially sensitive to ultra-violet rays are constructed from quartz, or from special types of glass which are reasonably transparent to the rays.

U-type Cell.—A type of photo-electric cell which is specially sensitive to ultra-violet rays. Cells of this type have a cathode, the sensitive surface of which is composed of cadmium. Owing, also, to the fact that ordinary glass is more or less opaque to ultra-violet light, U-type photo-cells are equipped with a window of special glass, which is transparent to rays of ultra-violet light.

Uviol.—Name given to a certain type of glass which, being reasonably transparent to ultra-violet rays, is frequently employed in the construction of photo-electric cells.

V

Vacuum.—A space from which all matter has been removed.

There is, of course, no such thing as a perfect vacuum. Nevertheless, the degree of vacuum obtained by modern methods in some of the electrical tubes used in connection with television working is extremely high, the residual gaseous pressure in many such tubes being reduced to approximately one hundred-millionth of the normal atmospheric pressure.

Electrical tubes in which the degree of vacuum is very high are termed " hard " tubes ; those whose vacuum is of a lower order are called " soft " tubes.

In many instances the vacuum of an electric tube or bulb is deliberately lowered by the introduction of a small quantity of an inert gas such as neon or nitrogen. These constitute the " gas-filled " tubes and lamps.

The most perfect degree of vacuum so far obtained was one in which it was estimated that no less than 99·999,999,990 per cent of the air existing within an electric tube had been removed.

From the Latin, *vacuus*, empty.

Vacuum Cell.—Name given to a type of photo-electric cell in which the electrodes are surrounded by a high vacuum, the electron stream emitted from the cathode under the influence of light being entirely dependent upon the strength of the light. Cells of this type are extremely constant in action and reliable in operation.

See *Gas-filled Cell.*

Valve Time Base.—A time base circuit which employs radio valves as a means of providing a periodic voltage across a pair of deflector plates in a cathode-ray tube.

See *Time Base.*

Variable-speed Scanning.—See *Velocity Modulation.*

Velocity Modulation.—A method of modulating the output current of a television transmitter by means of which the scanning spot moves quickly over the dark portions of the picture to be televised and slowly over the bright parts of the picture.

Velocity modulation, or variable-speed scanning, is only applicable to cathode-ray systems of television.

See *Intensity Modulation.*

Velocity of Light.—Light rays do not travel from point to point instantaneously. Their rate of travel, however, is so enormous that for any distance on the earth's surface, normal observation is unable to detect any appreciable time-interval between the transmission of a light ray and its reception.

It has been shown, however, by several different methods that light travels through space with a speed of approximately 186,830 miles per second.

Vertical Scanning.—Term referring to scanning methods in which the light spot, beginning at the bottom right-hand corner of the picture or image to be televised, covers it rapidly in a series of vertical traces or "sweeps," each successive sweep of the scanning spot being to the left of the previous one.

Vertical scanning is employed by the Baird Company in its B.B.C. transmissions.

See *Horizontal Scanning.*

Viewing Lens.—As provided on most television receivers, this takes the form of a simple double-convex lens which is placed in front of the scanner and which suitably magnifies the received image or picture.

Vision-frequency.—The frequency of any single frequency-component of the electric wave produced by a scanning device.

Vision-frequency Generator.—The apparatus at the output of which appear electric currents corresponding to successive scene-elements.

Visual Acuity.—In poor illuminations, the visual acuity decreases owing to the iris of the eye expanding in order to admit more light and thus, in consequence of its larger aperture, making it more difficult for objects to be finely focused on the retina.

In television reception under low intensities of illumination the factor of visual acuity is often an important one.

Visual Persistence.—*Persistence of Vision.*

Visual Purple.—Name given to the extremely light-sensitive purple dyestuff which fills the cells—the "rods and cones"—of the retina at the back of the eye.

Visual purple is of unknown composition. It is, however, bleached by light action and this bleaching action causes impulses to be sent along the optic nerves to the brain there giving rise to the sensation of light.

See *Retina, Rods and Cones.*

Vitreous Humour.—The clear, jelly-like medium which fills the eyeball and through which vision is transmitted to the retina.

Vitreous Selenium.—A glassy-like dark-brown form of selenium which is a high insulator. On being heated to 205°C for some time it becomes light-sensitive.

von Ardenne Tube.—A special type of cathode-ray tube invented by Baron Manfred von Ardenne, which, owing to a specially devised position of the various electrodes, gives a sharper spot image and which, also—in the very latest tubes—enables a picture in whitish light to be obtained. This is due to the use of a composite fluorescent material.

W

"Waving in the Breeze."—See *Fringing Effects.*

Wehnelt Cylinder.—A name occasionally applied, after its inventor, to the shield of a cathode-ray tube.

See *Shield.*

Weiller Drum or Weiller Wheel.—Names sometimes applied to the television mirror-drum in honour of its inventor.

Willemite.—A natural mineral consisting for the greater part of zinc silicate, which is a very effective fluorescent material for cathode ray working.

The mineral was named by its discoverer after Wilhelm I (Willem), King of the Netherlands.

See *Zinc Silicate.*

Wobbulation.—Variation of the oscillator frequency over a band of frequencies. A slang term, the use of which should be discouraged. It means *wobble.*

Writing Telegraph.—See *Telewriter, Telautograph.*

X

X Plates.—Name applied to the pair of deflecting plates in a cathode-ray tube, the application of a voltage across which, owing to its deflection of the cathode-ray stream, causes the line of light set up by the Y plates to be extended at right angles, thus producing a pattern or configuration upon the fluorescent screen of the tube.

See *Y Plates.*

Y

Yellow Spot.—See *Macula.*

Y Plates.—Name given to the pair of deflecting plates in a cathode-ray tube, the application of a potential across which, owing to the resulting deflection of the cathode-ray beam, causes the light spot on the fluorescent screen of the tube to be spread out into a line.

See *X Plates.*

Z

Zinc Phosphate.—A combination of zinc and phosphoric acid. It has been used as an "active material" for the preparation of cathode-ray fluorescent screens owing to its strong fluorescence under the influence of the rays. Unfortunately, however, its properties in this direction are marred by the persistent "after-glow" which it produces.

Zinc Silicate.—Chemical formula: Zn_2SiO_4 (or $2ZnO{\cdot}SiO)_2$. A combination of zinc oxide with silica. It occurs naturally in the form of the mineral, Willemite.

Zinc silicate is a creamy-white powder and is one of the best fluorescent materials known for the making of the fluorescent screens of cathode-ray tubes. Under the influence of the rays, it glows with a green hue, although this colouration is greatly affected by the presence of impurities in the material.

Zinc Sulphide.—Chemical formula: ZnS. A white powder which, when suitably prepared, is strongly fluorescent under the influence of cathode rays.

Zinc sulphide fluorescent screens glow with a bluish light. Formerly, screens of this material were characterised by a certain amount of objectionable "after-glow." By employing specially treated zinc sulphide in the making of the screens, however, this disadvantage has now been practically eliminated.

Zone Television.—A method of television due, originally, to the Gramophone Company, Ltd. In the H.M.V. method, the picture to be televised is divided up into five separate portions or "zones," each of which is separately scanned and televised through separate channels, the picture "zones" being assembled together into the complete televised picture by the receiving apparatus.

The name also applies to a system developed by the Baird Company in which a large image or picture is split up into several areas or zones, each of which is separately transmitted and received.

Zorgite.—A scarce ore of Selenium containing also lead, copper and cobalt. Named after the town of Zorge in Saxony.

Zworykin Cell.—See *Thermionic Photo-electric Cell.*

Zworykin System.—A television system due to Dr. V. Zworykin, of the Westinghouse Company of America. It makes use of his two specially designed cathode-ray tubes—the "Iconoscope" and the "Kinescope," which see.

STANDARDISED TELEVISION TERMS AND RECEIVER CONTROL MARKINGS

The Technical Section of the R.M.A. Television Development Sub-Committee has given consideration to the desirability of television equipment manufacturers and television engineers using a common form of nomenclature.

It has been decided to recommend that, with a view to securing uniformity of practice and general understanding, manufacturers of television equipment should, as far as possible:

(*a*) Make use of the technical terms recommended in Sub-Sections 108 and 109 of the B.S.I. "Glossary of Terms Used in Electrical Engineering" (No. 205, 1936) in their literature and in any instruction classes which they may operate.

(*b*) Apply markings to the various controls on television receiving sets as indicated below.

The following are now the correct definitions for standard terms: —

Television.—The art of instantaneously producing at a distance a visible image of an actual or recorded scene by means of an electrical system of communication.

High-definition Television.—A system of television in which the number of scanning lines into which the complete picture is divided is 100 or more.

Low-definition Television.—A system of television in which the number of scanning lines into which the complete picture is divided is less than 100.

Scanning (Exploring).—(*a*) In a transmitter. The process of analysing the scene or object into picture-elements or elemental areas; (*b*) In a receiver. The process of building up the image from picture-elements or elemental areas.

Progressive Scanning.—A system of exploration of the scene or image in which contiguous strips of the scanning-field are traversed in order.

Interlaced Scanning.—A system of exploration of the scene or image in which complete scanning is accomplished in two or more operations, the strips of scanning-field successively traversed in the course of one operation not being contiguous. During subsequent operations the lines previously omitted are scanned according to some set rule or order.

Picture-element (Elemental Area).—That portion of the scene which determines or is determined by the instantaneous value of the signal current.

Scanning-line (Picture-strip). A sequence of picture-elements extending throughout one dimension of the picture and represented by successive signal values.

Line-frequency (Strip-frequency deprecated).—The number of scanning-lines traversed per second.

Picture-frequency.—The number of complete images transmitted per second.

Frame-frequency.—The number of scannings of the frame by the scanning-beam per second. In interlaced scanning the frame-frequency is an integral multiple of the picture-frequency.

Synchronism.—The operating condition which obtains when all the elements of the image are reproduced in the same special relationship as the elements in the scene.

Phasing.—That process by which the forming of the image is brought point for point into the same space-time relationship as the exploring of the object.

Framing.—The process by which that portion of the exploring device upon which the phased image is formed is brought into an allocated relationship with a fixed screen.

Isochronism.—The operating-condition which obtains when the reconstruction of the image and the scanning of the object occur at the same rate.

Scanning-field.—The area explored by the scanning-apparatus at the sending or receiving ends.

Blocking-oscillator.—A type of oscillator in which oscillations are generated by the charging of a capacitor through an impedance followed by the discharging of the capacitor through another impedance, and used in conjunction with an electronic device to produce a scanning-field.

Phase-distortion.—That type of distortion produced by inequality of transmission-velocities of the individual frequency-constituents of the electrical output from a vision-frequency generator.

Vision-frequency.—The frequency of any single frequency-component of the electric wave produced by a scanning-device.

Vision Frequency Generator.—The apparatus at the output of which appear electric currents corresponding to successive scene-elements.

Photo-electric Cell (*abb.* Photocell).—A device in which electron-emission is produced by the incidence of light on an electrode, and containing one or more electrodes for the utilisation of these electrons.

Dot-frequency.—Half the number of elements transmitted per second.

Aperture.—That part of the vision-frequency generator which determines the ratio of the area of an element to that of the scene.

Time-base (Time-scale).—The trace of the spot of light on the screen of a cathode-ray tube, which spot of light moves with a pre-determined velocity for the purpose of imparting a time-scale.

Kerr-cell.—A device wherein the optical properties of a medium are modified by an electric field in such a way that when a beam of polarised light is passed through the cell, after optical resolution, the intensity of the emergent light can be controlled by the field.

Faraday-cell.—A device wherein a magnetic field causes a rotation of the plane of polarisation of a beam of plane-polarised light.

Electron-lens.—A system of electric or magnetic fields having an action upon a beam of electrons analogous to that of an optical lens upon a beam of light.

Time-base Generator.—A device for producing a potential varying in a definite and periodic manner and used to impress on the beam of a cathode-ray tube a time-scale deflection (usually linear with respect to time).

Cathode-ray Tube.—A vessel containing an electrode system arranged to emit electrons and to project them in the form of a well-defined and controllable beam. In general, the beam is incident upon a luminescent screen.

Cathode.—The primary source from which the electrons constituting the beam are emitted.

Directly-heated Cathode.—A cathode heated by a current which passes through the whole or part of it. This type of cathode is commonly known as a *filament*.

Indirectly-heated Cathode.—A cathode heated by an electrically separate element known as the *heater*.

Anode, Accelerator.—An electrode normally positive with respect to the cathode whose primary function is the acceleration of the electrons forming the beam.

Grid.—An electrode which does not primarily serve for the acceleration of the beam, but is for the purpose of otherwise controlling the flow of electrons.

Modulator.—A grid or other device to which a varying potential is applied in order to produce a modulating action on the intensity of the beam.

Focusing.—The concentration of the electron beam in order to produce a sharply-defined small luminous spot on the screen.

Methods of focusing are classified as follows:

(*a*) *Gas Focusing*, in which the beam is constricted by its ionising action on traces of gas present in the tube.

(*b*) *Magnetic Focusing*, in which the electron is constricted by means of a magnetic field, parallel to the axis of the tube.

(*c*) *Electrostatic Focusing*, in which the beam is caused to converge by the action of electrostatic fields between two or more electrodes through which it passes.

Focusing Electrodes.—Anodes or accelerators or other electrodes to which a potential is applied in order to produce the focusing action on the beam.

Deflector Plates.—Those electrodes, the primary function of which is to change the position of incidence of the beam on the screen. (The deflector plates are distinguished by the letters X1 and X2, Y1 and Y2.)

Screen (Fluorescent Screen deprecated).—A specially prepared surface which becomes luminescent under the stimulus of the electron beam at the point of impact.

Afterglow (Persistence deprecated).—The persistence of screen luminosity after the stimulus has been reduced or removed.

Colour.—The predominating colour of the luminous radiation from the screen under the electron impact.

Screen Luminous-efficiency.—A measure of the ability of the screen to convert the beam energy into luminous radiation.

Screen Characteristics.—The relation between the brightness of the screen beam current, and beam velocity expressed in volts at the final anode or accelerator.

Beam Current.—The electron current of the beam arriving at the screen.

Beam Current Characteristics.—The relation between the beam current and the potentials applied to the electrodes.

Brightness Characteristics.—The relation between the brightness of the screen and the potentials applied to the electrodes.

Sensitivity (Electric).—The displacement of the spot on the screen produced by the application of unit potential difference between the deflector plates.

The electric sensitivity is usually expressed in terms of millimetres (on the screen) per volt (between plates).

Sensitivity (Magnetic).—The displacement of the spot on the screen produced by the application of unit magnetic field, perpendicular to the axis of the beam, and acting on unit length of the beam.

Electrode Currents.—The magnetic sensitivity is usually expressed in terms of millimetres (on the screen) per ampere (through the deflecting coil).

The sum of the currents flowing into or out of any electrode. This term includes, for example, anode current and deflector plate current.

Shield.—Any electric or magnetic screen placed internally or externally to the tube.

The references for receiver controls are as follows:—

Contrast Control.—The control which normally affects the sensitivity of the receiver, when it is a major control situated on the front should be marked "Contrast." When it is located on a position other than the front of the receiver it should be marked "Sensitivity."

Brightness Control.—The control which affects the general level of illumination of the observed picture should be marked " Brightness."

Focus.—The control which affects the sharpness of the observed picture should be marked " Focus." (*Note.—It should be remembered that the words " focusing " and " focused " should properly be spelt with one " s."*).

Tuning Control.—The control which primarily affects the sound tuning is a minor control and should be marked " Tuning." When alternative television transmissions are available it is umed the tuning would not be continuous throughout the range of the desired frequencies.

Line-hold and Frame-hold.—The controls which normally alter the line and frame generated frequencies until synchronism is obtained should be termed " Line-hold " and " Frame-hold."

Picture Height.—The control which normally adjusts the height of the picture to fill the mask depth should be marked " Picture Height."

Picture Width.—The control which normally adjusts the width of the picture to fill the mask breadth should be marked " Picture Width."

Inverter.—The control which up to the present has been more generally known as " black spotter " and is for the purpose o reducing interference of the ignition type should be marked " Inverter."

Line Shift.—The control which normally positions the picture so that it is centred within the vertical edges of the mask should be marked " Line Shift."

Frame Shift.—The control which normally positions the picture so that it is centred within the horizontal edges of the mask should be marked " Frame Shift."

Line Linearity.—The control which corrects the output wave form to bring about uniform velocity of scan in the horizontal direction should be marked " Line Linearity."

Frame Linearity.—The control which corrects the output wave form to bring about uniform velocity of scan in the vertical direction should be marked " Frame Linearity."

Synchronising Separator.—The control which sets the synchronising separator network to its optimum working condition should be marked " Synchronising Separator," and prefixed, when required, as " Line and/or Frame."

Astigmatism.—The control which adjusts the electron optical system to the condition in which the minimum aberration due to astigmatism is produced should be marked " Astigmatism."

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