TELEVISION CYCLOPEDIA

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LONDON
CHAPMAN & HALL LTD.
11 HENRIETTA STREET, W.C.2
1937

First published
1937

Printed in Great Britain by
Biddles Ltd., City Press, Martyr Road, Guildford.

Bound by G. & J. Kitcat, Ltd., London.
Flexiback Binding Patent. No. 441294.

PREFACE

THE writer confesses to some diffidence in entitling a book of this size a "Cyclopædia." However, as the object of the book is to provide concise knowledge as distinct from mere definitions, the title chosen seems to be the most appropriate.

In the radio and electrical industries there are a large number of people who are keenly interested in television, yet who have not the necessary time at their disposal to be able to study the subject seriously. To these, and to keen radio amateurs, this book will prove useful, containing as it does an outline of the principles involved in the science and practice of television, presented in a manner that renders the information readily available and easily assimilated.

The writer has endeavoured to make the book as complete as possible. On this subject, however, it is difficult to know where to limit the range of information, television being a combination of so many of the arts.

Acknowledgment is very gratefully made to Mr. W. H. Nottage, B.Sc., M.I.E.E., F.Inst.P., etc., who corrected the manuscript with a very critical pen and greatly improved many of the articles. Also to Mr. L. M. Myers, author of the comprehensive "Television Optics," who helped freely with his specialised knowledge, writing some 5,000 words, including the articles on velocity modulation, photon and work function.

A.T.W.

LONDON,
January, 1937.

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Aberration

A defect in lenses that produces inexact focussing (q.v.) of component rays in a beam. In television practice it is of the utmost importance that the focussing of the light source be carried out without aberration, otherwise lack of definition results. Aberration may also occur in the electron-optical system (q.v.) of a cathode ray tube, producing a halo round the light spot on the screen.

Accelerating Lenses

The type of electron lens (see Electron Optical System) which produces an acceleration on the electron beam. An electrostatic lens has this property.

Accelerator

An alternative name for anode in a cathode ray tube. It is so called because it produces an acceleration on the electrons that pass through it.

Achromatic Lens

A combination of two lenses designed to overcome chromatic dispersion (q.v.). Usually the combination consists of a converging lens (q.v.) and a diverging lens (q.v.) of different glass so that the dispersion of one lens corrects that due to the other. An achromatic lens combination is illustrated in Fig. 1, which shows the converging lens *C* and diverging lens *D*, this arrangement being converging as a unit, and known as an achromatic doublet.

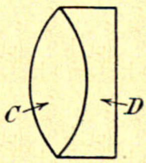

Fig. 1. Achromatic Lens.

Actinic Rays

Rays capable of producing chemical change.

After-Glow (see Phosphorescence)

Amplification of Photo-Electric Cell

The ratio of the anode current to the original cathode current. This amplification takes place in gas-filled photo-electric cells, and is produced by the collisions between electrons and gas molecules. By impact, electrons are liberated from the gas molecules and are drawn towards the positive anode electrode, and these electrons in their turn liberate additional electrons from other gas molecules. Amplification of electron current is thereby produced.

Amplitude

The maximum value of an alternating phenomenon. For example, in Fig. 2 are shown curves representing two high-frequency currents in respect of time and amplitude. It is

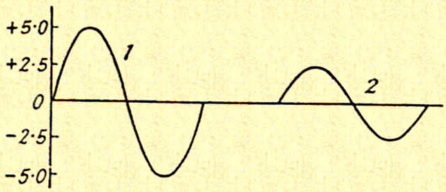

FIG. 2.—Illustrating relative amplitudes.

seen that curve 1 reaches 5 units in strength, whereas the curve 2 only attains a maximum of 2·5 units. The H.F. current represented by curve 1 is, therefore, said to be of double the amplitude of the current represented by curve 2.

Amplitude Filter

In many systems of synchronisation, the synchronising signal is superimposed on the carrier and transmitted with the picture signals. The actual synchronising signal consists of a series of negative impulses, and in order to extract these impulses at the receiver some means must be provided whereby the signals, which are of a higher amplitude, are separated from the synchronising signals of smaller amplitude. Such a device is called an amplitude filter.

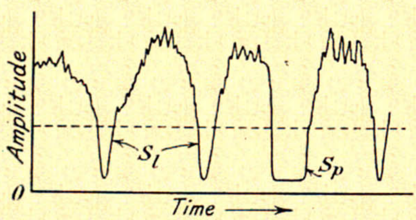

FIG. 3.—Showing the necessity for amplitude filtration.

The general problem can be seen from Fig. 3, which shows a schematic illustration of the carrier wave bearing the vision signals and the synchronising impulses S_l and S_p. An amplitude filter has to operate in such a manner that the impulses below the amplitude, indicated by the broken line, are passed to the synchronising device, but the higher amplitudes of carrier wave are blocked from this path. Furthermore, the filter must be designed so that it will not be affected by fluctuations in mean carrier wave amplitude, such as may occur during fading. The negative synchronising impulses will be of greater amplitude with strong signals than with weak ones, but the amplitude filter must operate on all signals. It is required to pass a short current pulse at each line synchronising signal S_l and a long current pulse at each picture synchronising signal S_p.

There are a large variety of types of amplitude filter. Most of them rely for their successful operation upon the working of a thermionic valve, the operating voltages of which are arranged to be dependent in some way upon the amplitude of the received signal.

One method of carrying out amplitude filtration is to operate a pentode at the point of saturation by applying to the grid a suitable voltage. This positive bias is such that a black signal reduces it to the voltage corresponding to the beginning of the saturation part of the anode current-grid voltage curve. The synchronising signals, however, being negative impulses (q.v.), carry the grid bias more negative than the black signal (i.e., they are of the blacker-than-black type) and this reduces the anode current of the pentode valve and an impulse is thus provided to trip the time base circuits.

Analysing Apparatus or Analyser

The device that dissects or scans the picture to be televised *at the transmitter*. This scanning process is effectively an analysis into a large number of minute elements, hence the term analysing apparatus. Compare with Synthesising Apparatus. Analyser in the present sense should not be confused with the analyser of a Kerr cell (q.v.)

Anastigmatic Lens

A lens system in which astigmatism (q.v.) is corrected.

Angle of Deflection

The angle between the normal paths and the deflected path. In a cathode ray tube the angle of deflection is shown as θ

in Fig. 4. It should be noted that the angle θ is only half the complete deflection between two sides of the normal path. That

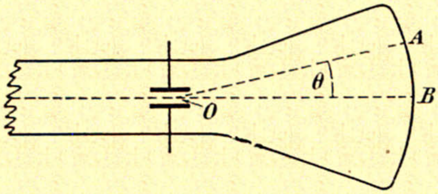

FIG. 4.—The Angle of Deflection is θ.

is to say, if AOB in Fig. 4 represents maximum deflection, then the angle between the extreme deflections on either side of OB will be twice AOB, i.e., twice the angle of deflection θ.

Angle of Divergence

The angle between the required direction and the actual direction. In a cathode ray tube the angle of divergence of the beam of electrons passing between cathode and fluorescent screen has a considerable influence on the efficiency of the working of the tube, and the angle must be kept as low as possible. Angle of divergence is illustrated in Fig. 5, where C is the cathode, CR_0 the direction it is desired the beam shall keep to, and CR_1, CR_2 the outside rays of the complete beam. The angle between CR_0 and *either* of CR_1 or CR_2 is the angle of divergence, this being a measurement of the "spread" of the beam. A shield (q.v.) is inserted round the cathode to reduce the angle of divergence of the ray, and with a well-constructed and properly operated tube the angle of divergence may be kept as low as 2° or less.

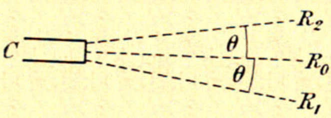

FIG. 5.—Showing the divergence of a Cathode Ray Beam.

Angle of View

The solid angle through which an object can be viewed. In television receivers, the angle of view θ Fig. 6, in respect of

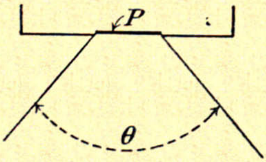

FIG. 6.—The Angle of View is θ.

the reproduced picture P, determines the maximum permissible number of persons that can view the picture; the larger the angle θ, the greater may be the number of viewers.

Angstrom

A unit of the wavelength of light vibration, equal to 10^{-10}m. i.e., one ten thousand-millionth part of a metre. Alternative units are the micron (q.v.) and the millimicron (q.v.).

Anisotropic

A substance is anisotropic when it does not possess identical elasticity in all directions. Most crystals in nature are anisotropic. As a result of this property light will travel at different speeds for different vibration directions within the anisotropic crystal and in this manner the properties of double refraction arise.

Anode Drop

The sudden rise of potential in the neighbourhood of the anode of a simple discharge tube. The electric field is very large and positive close to the surface of the anode, but is very small or even negative at 1 or 2 mm. distance from it. The anode drop occurs between the anode and the positive column and is due to the presence of negatively charged electrons and positive ions.

Aperture Disc (see Scanning Disc)

Aperture Distortion

The distortion in the reproduced picture due to the size of the scanning aperture or cathode ray. The larger the area of the scanning cathode ray, whether at transmitter (such as the Emitron) or at the receiver (as in a cathode ray tube), the greater is the aperture distortion and the lower is the definition. Aperture distortion is evidenced by a loss in definition, the sharp dividing lines between black and white being reproduced as grey owing to the overlapping of the edges of the paths traced by the scanning. In the modern television systems aperture distortion is not very evident.

Arc Lamp

A lamp that depends for its illuminating power upon the maintenance of an electric arc between two electrodes. The arc may be assisted by a filling of mercury vapour, and the electrodes may be composed of carbon. An arc lamp is capable of producing an exceedingly intense light, and is frequently used for illuminating the scene or object to be televised, and a small type is also employed at the receiver as the source of light that is modulated by the light valve, such as a Kerr cell. The brightness (q.v.) of the small arc lamps may be 2,000/3,000 candles/cm.^{2}, and the large ones as much as 200,000 candles cm.^{2}

Arc Screen

A type of television reproducer screen in which an arc is guided over a screen. The arc screen has not yet found practical application.

Argon

An elementary gas used in some types of gas-filled tubes that are employed in time bases (q.v.) for cathode ray tubes, and also in soft cathode ray tubes.

Astigmatism

A defect in a lens that results in distortion of the image due to rays from the object not being in correct parallel vertical and horizontal positions at the image. This fault is corrected in the anastigmatic lens system.

Attenuation

Reduction in amplitude. Transmitted signals are attenuated, for example, in their passage over the earth's surface, with the result that received signal strength is normally less at a point farther from the transmitter than at a point nearer to it.

Audio Frequency

A frequency that lies within the audible range, i.e., between 25 and 16,000 cycles per second.

Background Noise

The background of parasitic noises that is present in a radio receiver, or the parasitic voltages that are produced in a television receiver. If too many thermionic valves are employed, or if the amplifier is badly designed, the background noise or mush level may be higher than the signal, with the result that reception is impossible. The aim of receiver designers is to make the signal/noise ratio as large as possible so that the effect of mush may be negligible.

Balanced Deflection

A type of push-pull deflection, in which the voltages applied to the deflecting plates are equal in amplitude but opposite in phase. One circuit, due to O.S. Puckle, for carrying out balanced deflection is given in Fig. 7. Across the saw-tooth voltage generator V_1 is connected a condenser potentiometer (q.v.) consisting of C_1 C_2, which splits up the available saw-tooth voltage and applies a portion to the control grid of V_4. As the output voltage of a valve is in opposite phase to the

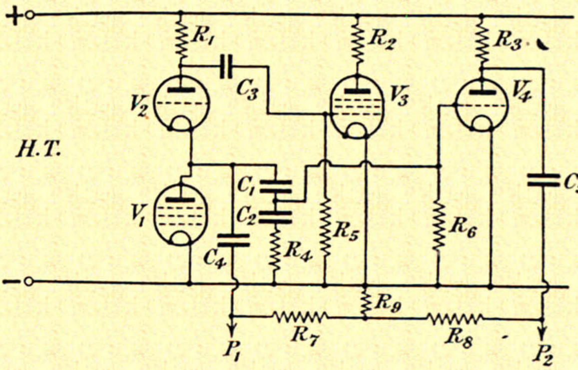

FIG. 7.—Circuit for providing balanced deflection.

input voltage, it follows that the saw-tooth voltage delivered by V_4 to deflecting plate P_2 is opposite in phase to that supplied directly from the anode circuit of the generator V_1 to deflecting plate P_1. The balanced deflection circuit is so designed in respect of C_1 C_2, R_4 and the amplification provided by V_4 that the voltages applied to P_1 P_2 are equal. There are thus obtained deflection voltages of opposite phase and equal amplitude ; i.e., balanced deflection. This arrangement overcomes trapezium distortion (q.v.).

Band Width

Range of frequencies. For example, the band width passed by the high-frequency stages of the usual radio receiver is nine thousand cycles per second (9 kc/s.). Within this 9 kc/s. band is a carrier (q.v.) and two sidebands (q.v.), and the actual range of frequencies dealt with by the low-frequency part of the receiver will be half of this figure, i.e., 4·5 kc/s. The band width of the L.F. amplifier is, therefore, required to be 4·5 kc/s. A television signal may comprise a band width of two million cycles per second and over. If the total band width is two million cycles per second, then each sideband consists of a band width of one million c.p.s. and the television receiver must be capable of responding to this very wide band. Unless the receiver has been designed to pass the entire band width of the received signal, the definition will be diminished. (See also Sideband.)

Barkhausen-Kurz Generator

A very high-frequency thermionic generator in which the actual frequency of oscillatory voltage generated is determined by the operating voltages applied to the valve rather than the value of tuning elements (i.e., inductance and capacity) in the circuit. In a Barkhausen generator the grid is positive and the anode is usually negative with respect to the cathode. In operation the electrons oscillate between the anode and grid inside the valve, instead of passing straight through it from cathode to anode as in more usual practice.

Barrel Distortion

The type of distortion produced by defective optical systems that causes a square image to have rounded (convex) sides, similar to the form of a barrel.

Barrier Layer Cell

A type of photo-electric cell comprising a molecular layer of copper oxide on copper. Light incident on the copper oxide layer liberates electrons which immediately pass to the copper metal. This charges the copper negatively so that a potential difference is introduced between a wire mesh resting on the oxide layer and the copper itself. Owing to the rectifying properties of the copper oxide layer on the copper metal, the potential difference causes a small current to flow in an external circuit as the current cannot flow directly across the copper oxide layer to the mesh. This effect finds wide commercial use in illumination meters. Light is allowed to fall on the cell and the current consequent thereon gives indication of the illumination, the meter being calibrated directly in foot candles or in lux.

Beam Current

The value of current in a cathode ray beam. In practice the beam current in a television receiver tube is somewhere in the region of 150 microamperes, but may be a quarter of a milliampere. The maximum permissible beam current increases rapidly with the anode voltage.

Becquerel Effect

If one of two electrodes immersed in the same electrolyte is strongly illuminated, a small potential difference of about 00·1 to 0·1 volt is set up between the electrodes. These electrodes may be of selenium deposited on platinum sheet. This effect was the first discovered of the now many well-known photo-electric effects. The phenomenon is as yet unexplained.

Beehive Neon Lamp

The type of neon lamp (q.v.) in which one electrode (the cathode) is shaped somewhat in the form of a conventional beehive, as illustrated in Fig. 8. The anode electrode is a flat disc situated at the opening of the beehive.

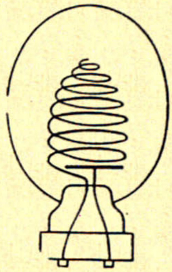

FIG. 8.—Beehive type of Neon Lamp.

Biconvex Lens

A double convex lens (q.v.).

Birefringent Material

The substance employed in a light valve, such as a Kerr cell, across which the voltage is applied for polarising a light beam passing through. In the Kerr cell the initially unirefringent material is usually nitrobenzene, which becomes birefringent on stressing, but it may be other substances. For example, it is found that many substances such as ethylani-salamino-cinnamate are highly sensitive birefringent materials when used in such a state that they are midway between being a solid and a liquid. Solids may also be employed as birefringent material.

Blackening of Bulb

A defect that occurs in glow discharge tubes (q.v.), resulting in the inside of the tube being covered with a black layer. Blackening is caused by the disintegration of an electrode, the particles of which are deposited on the interior of the bulb. To reduce risk of this defect the discharge tube should never be run at a current in excess of the rating of the tube.

"Black-Out" the Screen

The act of preventing the screen from being illuminated.

Brightness

The light intensity of a reproduced picture or of the light source. It is measured in candles per square centimetre.

Braun Tube

An alternative name for cathode ray tube (q.v.) after Dr. Braun, a German scientist, who did a considerable amount of research work in connection with the cathode ray tube.

Burning the Screen

This term refers to the fluorescent screen of a cathode ray tube. If the light spot is focussed on to the screen and is left in one position too long, the heat generated by the electron beam striking the screen is so great that the fluorescent material will be destroyed.

Calcite

A highly, doubly refracting mineral that possesses in a marked degree the property of splitting the light passing through it into two rays which have different refractive properties. This property makes calcite of very great interest in television receivers, and the material is used in the Nicol prism (q.v.) of a Kerr cell (q.v.) arrangement.

Camera Gate

In telecinematographic work the camera gate is the opening immediately in front of the cinematograph film through which the image rays pass to expose the film.

Candle Power

The unit of illuminating power. This is theoretically equal to that of a standard candle, i.e., a spermaceti candle weighing one-sixth of a pound and burning at the rate of 120 grains per hour. Although candle power is referred to throughout this book with reference to the power of illumination, it is not used a great deal in scientific work owing to the variation in illumination that may occur from the standard candle in different states of the atmosphere. Candle power is usually referred to the light given from a standard electric lamp of given light emitting power.

Candle, Standard (see Standard Candle)

Carrier or Carrier Frequency

The frequency of the transmission on which the modulation is impressed. This corresponds to the frequency or carrier wave of the transmission. (See also Sideband.)

Carrier Wave (see Carrier or Carrier Frequency)

Cathode Drop

The sudden fall of potential in the neighbourhood of the cathode of a simple discharge tube. Negative electrons arise at the cathode and positive ions are travelling towards the cathode so that in the minute space between cathode and negative glow the electric field is very intense.

Cathode Ray

The stream of electrons of small thickness compared to its length, emitted in one definite direction by a cathode and attracted by a positive electrode. This definition does not describe the phenomenon in an ordinary thermionic valve, as in this case the passage of electrons from cathode to anode takes place in all directions.

Cathode Ray Spot

The luminous spot produced on the fluorescent screen by the cathode ray beam.

Cathode Ray Tube

A device in which an electron beam is deflected in such a manner that it may be caused to trace any desired path by applying suitable potentials to the deflecting means. The electron beam, or cathode ray, impinges on a screen and in doing so sets up a physical reaction that causes the particular spot struck by the beam to be luminescent.

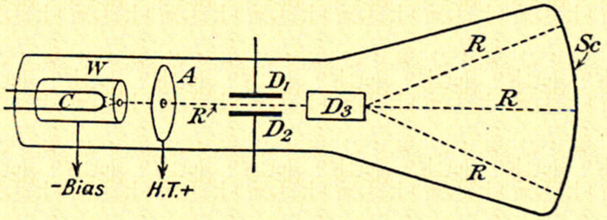

FIG. 9.—Illustration of an elementary Cathode Ray Tube.

A simple cathode ray tube is illustrated diagrammatically in Fig. 9. The cathode *C* emits electrons when heated in the usual way, and these are focussed by the cylinder *W*, termed the Wehnelt cylinder (q.v.), on to an aperture in a disc *A*. This disc *A* has a positive potential applied to it, and is the anode of the tube. The electron stream or cathode ray passes through the aperture in anode *A*, as shown by the broken line, and passes between a set of four deflecting plates (q.v.), as illustrated, or four magnetic deflecting coils (q.v.). These plates are enabled by the application of a voltage to them to deflect the ray in any direction towards the screen *Sc* (see Deflection). One pair of plates D_1 D_2 bends the ray in one direction, say vertically, while the other pair of plates D_3 bends the ray in the other direction, horizontally. There is thus effected on the screen *Sc* called the fluorescent screen (q.v.) because it fluoresces when struck by the cathode ray, a trace of luminosity that is determined by the variation in voltage applied to the deflecting plates.

This voltage, called the deflecting voltage, is provided by a time base circuit (q.v.) especially designed to provide a voltage that moves the ray across the screen to scan a line of the picture and at the same time to move the ray slightly downwards so that by the time it has reached the end of one scanning line and flies back it is in the correct position for commencing the following scanning line. In a series of sequential scans, the whole picture area on the screen is thus covered. This is not the only method of scanning; for example, see "Interlaced Scanning."

In order to provide the light and shade of the picture, the cathode ray beam has to be modulated or varied in intensity, so that the light spot it produces on the fluorescent screen varies correspondingly in luminosity. This variation in light intensity is effected by applying the picture signal voltage to the Wehnelt cylinder, otherwise termed the modulation electrode. By causing the normal negative bias on this cylinder to fluctuate, the intensity of the cathode beam is altered by virtue of the variations in effective concentration of the beam, although the light spot size remains the same owing to the constant size of the aperture in the first anode that determines it. There is thus produced on screen *Sc* a series of lines of light, the position of which at any particular instant is determined by the voltage provided by the time base to the deflecting plates, and the intensity of which is controlled by the received picture signals. A copy of the picture transmitted is thereby built up on the screen.

The cathode ray tube as outlined above is the simplest possible model. In practice, cathode ray tubes have a number of modifications, but in all cases the principle of operation is as given above. Some types employ between the anode and deflecting plates of Fig. 9 a second and third anode. The first, second and third anodes each have a positive potential applied that is higher than the electrode nearer the cathode. This produces a high acceleration of the ray as it passes through the anodes, and at the same time assists the focussing of the stream into a minute ray. In other types of tube, auxiliary electrodes are inserted for various purposes, mostly for concentrating the ray, between the deflecting plates and the screen.

Cathode ray tubes may be used for transmission or reception, and are also commonly employed in testing laboratories for examination of all kinds of phenomena associated with the variations in voltage in a circuit or circuit element. It should be noted that there are no moving parts whatever in a cathode ray tube receiver, the entire control and picture reproduction being obtained by electrical voltages. Mechanical inertia is, therefore, entirely eliminated, and this is the greatest advantage of the cathode ray tube systems.

Cathode ray tubes may be hard (q.v.) or may be gas-filled (q.v.). In receivers at present on the market hard tubes are almost invariably employed. (See particularly Deflection, Electron Optical System and Electrostatic Focussing.)

Cathode Screen

A metallic shield partly surrounding the cathode in some cathode ray tubes in the direction of the anode. This screen may be connected directly to cathode.

Centimetre

There are 2·54 centimetres to one inch.

Characteristic Curves

With reference to a cathode ray tube, the following characteristics are frequently required: anode current—brilliancy (of fluorescent screen), grid volts—anode current, grid volts—brilliancy. (See Grid Base.)

Chromatic Dispersion

A defect in the focussing of lenses due to the component rays of different colour (see Dispersion) coming to a focus at different points. Owing to chromatic dispersion, it is impossible to produce a sharp image of a white source of light by means of a single simple lens. This defect may be overcome by the use of an achromatic lens combination (q.v.).

Chromatism (see Chromatic Dispersion)

Coaxial Cable

The type of cable comprising two metallic conductors, one inside the other. For television work these conductors are separated by some kind of insulating material so arranged that a large proportion of the space between the conductors

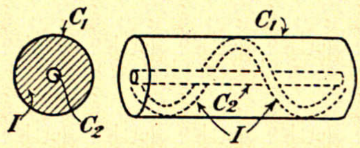

FIG. 10.—One type of Coaxial Cable.

is filled with air. The need for air spacing between the conductors arises from the necessity of keeping the capacity of the cable to the lowest possible value and thus obviating capacitative losses. In Fig. 10 are shown two illustrations of one type of coaxial cable employed in Germany for land-line purposes.

Condenser Lens

A lens that is employed for projecting light over a given area. Usually, a condenser lens, or lens system, is used for providing an even illumination over the entire area, such as the slide in a projection lantern. (See Cylindrical Condenser.)

Convergent Meniscus

A lens with a crescent-shape section, the radius of curvature of the two faces being such that rays of light passing through the lens converge to a point. In Fig. 11 is seen the section of a converging meniscus.

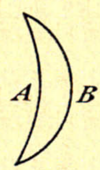

FIG. 11.—Section of Converging Meniscus.

Converging Lens

A lens that causes parallel light rays passing through it to converge. The effect of a converging lens on a light beam is illustrated in Fig. 12, which shows a beam *R* impinging on a converging lens *L*. The lens refracts or bends the component parts of the beam in such a manner that they converge on to a point at *F*. After passing through *F* the rays diverge or spread out. The point *F* is termed the principal focus, or merely the

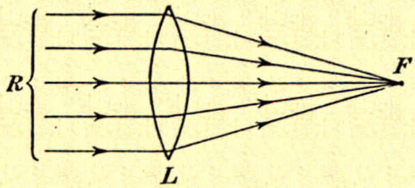

FIG. 12.—The focussing effect of a Converging Lens.

focus, of the lens *L*. Types of converging lens are the double convex, plano-convex and the concavo-convex (q.v.). Compare with Diverging Lens.

Convex Lens

This term is usually intended to mean double convex lens (q.v.).

Co-ordinate Scanning Plates

The pairs of plates used in a cathode ray tube to effect the scanning process by electrostatic deflection (q.v.). In the types of tube most generally used, the co-ordinate scanning plates consist of two pairs of plates situated in mutually perpendicular positions.

Contrast Sensitivity

The capacity of the eye to detect slight differences in screen illumination. This sensitivity is found by experiment to be approximately the same for all colours at high levels of illumination, but for below 0·3 lux illumination it is higher for blue and lower for red than for white light. For the higher illumination the contrast sensitivity of the eye is in the order of 0·05.

Cornea

Transparent layer in the front of the eye (q.v.).

Crater Discharge Tube

A particular design of glow discharge tube in which the glow occurs in a tube round one electrode. Crater discharge tubes have been used in television receivers and are commonly employed in sound recording.

Critical Frequency

When illumination is intermittently presented to the eye, flicker (q.v.) is noticeable unless the frequency of presentation is high enough to overcome the flicker. The minimum frequency of presentation for which flicker is not observed is termed the critical frequency.

Crookes Dark Space

The small space separating a negative glow (q.v.) from the cathode producing it. Compare with Faraday Dark Space.

Cross Current

The current introduced into a deflecting plate from the cathode ray when the deflection of the ray is such that the electrons in the ray strike the plate. This sometimes occurs when a deflecting plate receives a high positive voltage. In Fig. 13 is seen the way in which cross current is produced. The ray R from

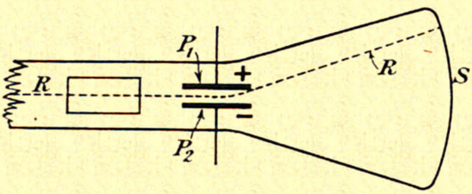

FIG. 13.—Illustrating how a Cross Current is produced in Deflecting Plates.

the cathode and electron focussing elements, in passing through the vertical deflecting plates P_1 P_2 on its way to the screen S, is attracted to P_1 by the highly positive potential applied to this by the time base circuit. Some of the electrons in ray R strike the plate P_1 and so set up an electric current therein, this being termed the cross current. The amount of cross current introduced into P_1 is proportional to the voltage applied to it.

Crossed Cylindrical Lens

A lens system in which two cylindrical lenses (q.v.) are used with their axes at right angles to each other. One cylindrical lens produces an image along the vertical direction, while the other lens provides an image in the horizontal direction. At the same time each lens has no influence on the focussing effect of the other. The image produced by such a system has therefore two dimensions, length and width, as distinct from the unidimensional image produced by the single cylindrical lens. A crossed cylindrical lens is thus suitable for reproducing television pictures, and is, in fact, employed for this purpose in one of the well-known systems. (See Split Focussing.)

Cross-over

In optics and electron optics it is the point where the rays are concentrated and then diverge again. The cross-over must, therefore, be at a focus (q.v.) of the lens system. In a cathode ray tube, it occurs between the cathode and first anode (see Fig. 27.)

Crystalline Lens

A part of the lens system of the eye (q.v.).

Cycle

A complete alternation. In Fig. 2 are seen two separate cycles of voltage or current. It is noticed that in each cycle there is a positive and a negative half cycle as indicated by the signs.

Cylindrical Condenser Lens

An optical condenser lens (q.v.) system consisting of two plano-convex lenses (q.v.) spaced apart along a common axis. In Fig. 14 is seen a cylindrical condenser lens. This type of lens generally employed with the mirror screw is scanner (q.v.).

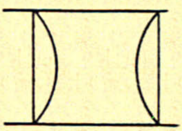

FIG. 14.—A cylindrical Condenser Lens.

Cylindrical Lens

A lens whose surfaces are cylindrical. The particular property of a cylindrical lens that makes it valuable for television purposes is that it is capable of rendering the normal image into a line image. This line image is not a real one, and is not distinguishable by the human eye. Nevertheless all the real image elements are present and the line may be reconstructed into the real image by suitable optical arrangements. In one system of television reception a cylindrical lens and the phenomenon outlined above form the basic idea of its operation.

In Fig. 15 is illustrated a cylindrical lens and the manner in which it produces a line focus of a source of light. The cylindrical lens L receives from light source S a beam of light, bounded by the rays R_1 R_2 on one side and R_3 R_4 on the other side. These rays are focussed as seen, i.e., R_1 R_2 are brought to a point at A, while R_3 R_4 are focussed on to B. All intermediate rays will be similarly focussed on to a point somewhere between

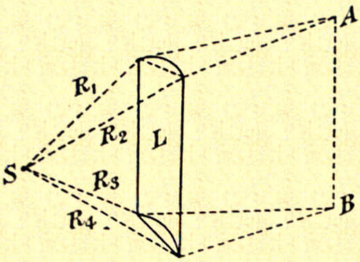

FIG. 15.—Showing the focussing effect of a Cylindrical Lens.

A and B on the same line. Hence the broken line joining A and B represents the image produced by the cylindrical lens. (See also Crossed Cylindrical Lens.)

Dark Current

The current that is passed by a photo-electric cell when this cell is not illuminated. In the barrier layer cell (q.v.) the dark current is a function of temperature and takes the same direction as the current that passes during exposure to light.

d.B.

The symbol of decibel (q.v.).

D.C. Component

That value of current representing the average brightness of the picture being transmitted. This definition should be distinguished from the d.c. component of a radio detector which is a steady direct current dependent upon the amplitude of the incoming carrier wave. The d.c. component in a television signal alters with the average brightness of the picture being transmitted. For example, if the subject being televised is a man speaking, the background does not change and the d.c. component is then constant. If the scene depicted the gradual extinction of the light in, say, a room, such extinction taking half a minute from bright illumination to complete darkness, then the d.c. component would alter at the rate of 1/30th of a cycle per second. This d.c. component is, of course, the lowest frequency in the television signal, and must be reproducible at the receiver for faithful reproduction.

Decelerator

In a cathode ray tube a decelerator is an electrode to which a negative potential is applied. This retards the velocity of the electrons in the beam.

Decelerating Electrode (see Retarding Electrode)

Decibel

A comparative unit of power. The decibel expresses the logarithmic ratio of two powers, and is used very considerably in television and radio work. Let P_1 and P_2 be two powers to be compared. Then the ratio of power between these two in decibels is $10 \log_{10} \frac{P_1}{P_2}$. This may be either negative or positive, thus representing a loss or a gain in power. A power is said to be so many decibels up or down on the power with which it is compared.

Decoupling

Providing an alternative path for undesired voltages. It is essential, for example, to separate the vision signals from the sound signals, and so the sound signal circuits must be decoupled so as to provide a by-pass path for any residual voltages due to the vision signals. Similarly, the picture signal circuits must be decoupled from the ultra-high frequency voltages of carrier-frequency.

Definition

The amount of detail in a picture. This is governed by the number of picture elements per picture and the number of pictures shown per second. (See also Low Definition and High Definition.)

Deflecting Voltage

The voltage applied to the deflecting device of a cathode ray tube to provide the deflection (q.v.) of the ray.

Deflection

The distance the light spot on a fluorescent screen of a cathode ray tube is moved from its rest position. This movement is produced by the application of voltage to the deflecting electrodes. In Fig. 16 is illustrated an arrangement of cathode ray tube that shows how deflection can be measured. At rest position, the ray from the cathode impinges on the screen at A, undeflected to either side. When an alternating voltage, say from a time base circuit (q.v.), is applied to the deflector plates D_1 D_2, the ray is attracted to whichever plate is positive and to an extent that depends upon the positive voltage value. That is to say, if the deflection from A to B is obtained by the application of $+200$ volts to D_1, then a deflection of $\frac{AB}{2}$ takes place when only 100 volts is applied to D_1. As the alternating voltage on the plates D_1 D_2 changes, D_1 becomes negative and D_2 becomes positive, and so the ray is deflected to the other side of the central position at A. The amount of deflection is again proportional to the positive voltage on the deflecting electrode or plate and there is thus provided a movement along the

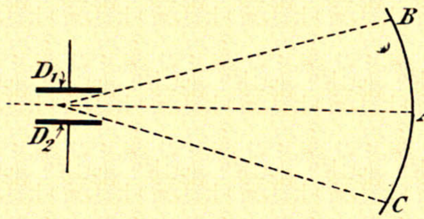

FIG. 16.—Showing process of deflection.

screen between B and C that has the same frequency as the voltage at the plates D_1 D_2 and the instantaneous position of the light spot is dependent upon the corresponding voltage on the positive plate.

Any distance AB or AC (Fig. 16), i.e., the actual amount of deflection, can be found out by multiplying the deflectional sensitivity (q.v.) by the voltage applied to the deflecting means. For example, if the deflectional sensitivity of a tube is 0·3 millimetres per volt, and 200 volts are applied to the deflector electrodes, then the deflection will be $0{\cdot}3 \times 200 = 60{\cdot}0$ millimetres. This is the distance AB or AC, so that if the deflecting voltage is alternating, the total deflection from B to C will be twice this, i.e., 120 millimetres. It should be noted that when an alternating voltage is employed for deflecting purposes, the effective value is the peak voltage and not the R.M.S. voltage. (Peak voltage $= \sqrt{2}$ times the R.M.S. voltage.)

Deflectional Sensitivity

A measure of the facility with which the ray in a cathode ray tube may be deflected. The means whereby the ray is deflected is the voltage at the deflecting plates or the current in the deflecting coils, and the amount of deflection produced is measured at the fluorescent screen. Consequently, the deflectional sensitivity when electrostatic deflection is considered is expressed as the ratio of the deflection of the light spot on the screen in millimetres to the voltage on the deflecting electrodes; or, briefly, in millimetres per volt or mm./v.

Deflectional sensitivity is directly proportional to the length of the deflecting plates themselves, to the voltage difference between the plates, and to the distance between the centre of the plates and the fluorescent screen. Thus for a high value of deflectional sensitivity there is required a tube which has (1) long deflecting plates, (2) a high voltage between the plates, and (3) great length between screen and plates.

Deflectional sensitivity is inversely proportional to the distance between the deflecting plates and to the voltage on the anode preceding the deflecting system in the direction of the cathode. In a hard tube the distance between the deflecting elements is greater than in a soft tube and so the deflectional sensitivity is less.

When magnetic deflection is employed, the actual voltage applied to the deflecting coils is of secondary importance, deflection being produced by the magnetic field provided by the CURRENT in the coil windings, the larger the number of turns, the greater the deflection at a given current flow. In this case, therefore, sensitivity is measured in the amount (length) of movement of the light spot on the fluorescent screen in proportion to the magnitude of current flow in the coils and the number of turns in the coils; i.e., in millimetres per ampere turn, or millimetres per ampere turn at a given diameter of coil. An alternative term is millimetres per gauss of magnetic field.

Deflector Plate Impedance

This is the capacitative impedance of the deflector plates in the cathode ray tube. The impedance is given by the usual expression

$$Z = 1/(C2\pi f)$$

where C is the capacity of the plates and f the frequency of the applied voltage.

Defocus

The process that results in less concentration of the rays. This is the reverse process to focussing. Defocus is a term used in optics and electron optics. In a cathode ray tube, defocussing of the cathode ray may take place owing to the presence of ions (q.v.) in the tube. The presence of a space charge in a hard cathode ray tube produces defocussing if the amount of current in the beam is raised above a certain value depending upon the size and design of tube.

Degas (see Outgas)

De-ionisation

The elimination of ions in a gas, usually for the purpose of stopping a discharge between two electrodes, as in a discharge tube. By de-ionising the gas, the path between the electrodes is rendered non-conductive.

Demodulation

The process of separating the modulation component (q.v.) from the carrier wave (q.v.) employed for the transmission of television or radio signals. This is an alternative name for detection (q.v.).

Detector

That member of the receiver that translates a modulated high-frequency voltage into a unidirectional one. Detection is necessary in order to obtain (1) vision signals that may be utilised by the vision reproducing device and (2) audible radio signals for operating the loudspeaker. Thermionic valves are generally used for detectors, but the particular type of valve actually employed depends upon the design of receiver. A detector valve may be a diode, triode, screen grid valve or pentode. With multi-electrode valves, detection may be either of the grid type or anode detection. See also First Detector, Second Detector and Metal Rectifier. Compare with Rectifier. The general process is outlined under Diode Detection.

Detector Distortion

The defects produced in the reproduced picture by the detector stage. Unless this stage is designed to pass the whole range of frequencies in the sideband, the contrast in the reproduced picture is diminished and a whitish tint permeates it.

Detuning

Altering the tuning of a circuit in such a way that it becomes out of resonance with the voltage applied to it, i.e., it becomes "out of tune."

Diaphragm

In television and optical work a diaphragm is usually understood to be a disc or sheet with a hole through which pass electron rays or light.

Diode Detection

The process of translating a modulated high-frequency voltage into unidirectional voltages by means of a diode. In Fig. 17 is illustrated the manner in which this is carried out. A curve *OA* represents the usual characteristic curve of a diode with respect to anode voltage and anode current. Input signal voltage is applied to the anode to produce fluctuations as shown at V_i. Owing to the operating point *O* being at about zero anode current, the input voltage fluctuations to the left of *OB* do not provide any response in the anode circuit and

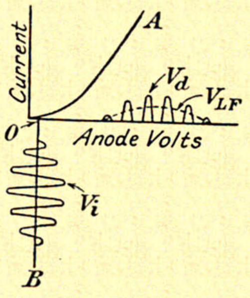

FIG. 17.—Illustrating process of detection.

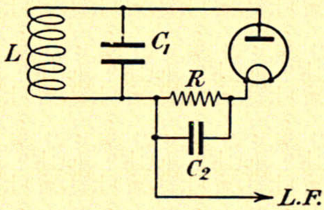

FIG. 18.—Basic Diode Detector Circuit.

are therefore cut off. The positive half waves of V_i, i.e., those to the right of *OB*, cause an increase of anode current as seen by the series of current pulses at V_d. These half waves of current V_d are unidirectional and their average value V_{LF} represents the modulation that constitutes the signal.

In Fig. 18 is shown a diagram of the basic circuit for providing the detection by means of a diode. Signal voltages are tuned by LC_1 and applied to the diode. Unidirectional current impulses (V_{LF} of Fig. 17) flow along *R* and set up voltages of low frequency which are taken off by suitable coupling arrangements and utilised by the low-frequency amplifier. Condenser

C_2 is to bypass the high-frequency carrier component V_d of the signal, so that only L.F. voltages are produced across R.

Dioptre

A measure of the power of a lens, equal to 100 divided by the focal length in centimetres.

Diplex Communication

Two-channel communication on the same circuit. The practical carrying out of diplex communication presents many serious problems, and so far as television is concerned, no such system has as yet been devised. Compare with Duplex Communication.

Direct Scanning

The type of scanning in which light rays from the subject being televised pass directly to the photo-electric cell or other modulating device. One example of direct scanning is the floodlight scanner (q.v.).

Directly Heated Cathode

A cathode that is formed by the heater element itself. In a battery valve, for example, the wire that is heated to provide the required electron emission acts as the cathode and is thus a directly heated cathode as distinct from an indirectly heated one (q.v.).

Discharge Tube Time Base

A circuit including a relaxation oscillator (q.v.) in which the discharging of the condenser takes place over a grid controlled

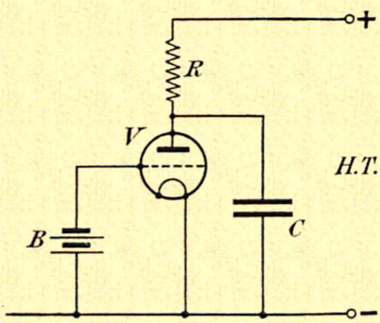

FIG. 19.—Basic Time Base Circuit using a Discharge Tube.

discharge tube. In effect, this circuit arrangement is similar to the neon time base (q.v.), a grid controlled discharge tube being used instead of the neon tube shown in Fig. 57.

A discharge tube time base circuit is given in Fig. 19, the working of this circuit being as follows: condenser *C* is charged through *R* from the high-tension supply until the voltage across its terminals reaches the ignition voltage of the discharge tube *V*. Adjustment of the bias provided by *B* is carried out before the circuit is connected to the H.T. supply, so as to ensure that the tube discharges at the required voltage. This ignition voltage must be such that the time taken by *C* to acquire it is that required by the deflecting plates for a traversal.

Disc Scanner (see Scanning Disc)

Dispersion

The splitting of light into its component parts of coloured rays. When a beam of light is passed through a prism, the emergent light consists of a series of rays of the following colours and in the order named, violet, indigo, green, blue, yellow, orange, red. The complete band of colour is known as the light spectrum (q.v.). (See Light Spectrum.)

Dissector (see Image Dissector)

Diverging Lens

A lens that causes a parallel beam of light passing through it to spread outwards, i.e., to diverge. The manner in which this divergence is produced can be seen from Fig. 20. Individual

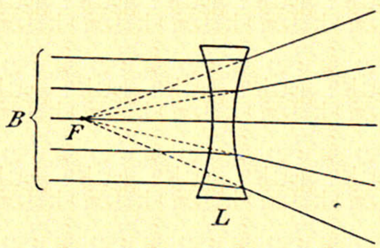

FIG. 20.—Diverging effect of a Lens.

rays of a beam of light *B* reaching the diverging lens *L* are refracted (q.v.) to an extent depending upon their distance from the centre of the lens. The ray in the exact centre of the lens passes through without being bent but as the edge of the lens is approached the rays are bent more and more, thus producing the divergence seen in the emergent beam. To an observer the divergent ray appears to come from a point *F*, which is connected to the individual rays by the broken lines in Fig 20, and this is the principal focus, or focus of the lens. Types of diverging lens are the double concave, plano-concave (q.v.) and the diverging meniscus. Compare with Converging Lens.

Diverging Meniscus

A lens with two curved faces of different radius of curvature which causes the rays passing through it to diverge. In Fig. 21 is seen an illustration of a section of a diverging meniscus.

Fig. 21.—Section of Diverging Meniscus.

Double Acceleration

The process of accelerating the electrons at two points in their path from cathode to fluorescent screen in a cathode ray tube. Several types of tube employ double acceleration, one accelerating electrode usually being inserted between the cathode and modulating electrode, and the other between modulating electrode and deflecting plates.

Double Anode System (see Two Anode System)

Double Concave Lens

A lens with both faces curved inwards, as illustrated in Fig. 20. This type of lens is diverging (q.v.).

Double Convex Lens

A lens with two faces curved outwards, as shown in Fig. 11. This type of lens is converging (q.v.).

Double-Ended Mosaic Screen

A mosaic screen that has two active sides, one on which an optical image of the object is projected and the other which is scanned by the cathode ray. These two sides are situated back to back. Compare with Single-Ended Mosaic Screen.

Double Modulation

Referring to a cathode ray tube, double modulation is effected by applying the modulating voltage to an anode in addition to the shield.

Drift

The alteration in frequency that is produced by various factors. In a time base circuit employed for synchronising, the coupling arrangements between the line-frequency time base and the frame frequency time base must be designed to interlock these respective frequencies, otherwise drift occurs and the efficiency of the synchronising arrangements is jeopardised.

Dry Rectifier (see Metal Rectifier)

Duddell Oscillograph

A type of electro-mechanical device for recording wave forms photographically. Before the development of the cathode ray oscillograph the Duddell device found wide application in low-frequency investigations.

Duplex Communication

The transmission and reception of signals in two directions simultaneously, i.e., two-way communication such as a conversation between two stations. Usually two channels—one for transmission and one for reception—are employed. Compare with Diplex Communication.

Earth Plate

That plate of the deflecting system of a cathode ray tube that is connected to earth. See also Oscillation Plate.

Echelon

A device consisting of a number of parts in stepped formation. The actual shape of the parts may be very varied without departing from the echelon formation. In optical work in connection with television, the echelon formation of a number of refracting or reflecting bodies is used considerably. A simple form of echelon is shown in Fig. 22, which illustrates four plane rectangular glass refracting bodies in contact with each other. Many more than four could be used, and the shape of each piece of glass could, if desired, be, say, triangular. All such formations are echelons. The mirror screw (q.v.) is another example.

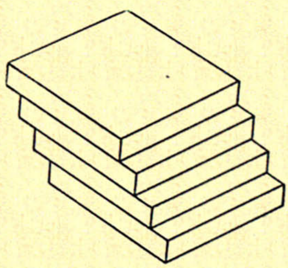

FIG. 22.—One form of Optical Echelon.

Efficiency of Cathode Ray Tube

The proportion of electrons reaching the fluorescent screen to those passing the modulating electrode. If the entire beam passing through the shield reached the fluorescent screen, the efficiency would obviously be unity. In practice the efficiency is less than this owing to the attraction of the electrons by the positive electrodes spaced along the path of the electrons from the shield to the screen. The electrons that are drawn to and reach these electrodes are thus subtracted from the cathode ray beam impinging on the screen, and the efficiency of the cathode ray tube is thereby reduced. From this it follows that the efficiency of the tube may be measured by the ratio of the anode current to fluorescent screen current.

Electrical Neutral Axis of Cathode Ray Tube

By this is understood the path of the cathode ray beam when no deflecting voltage is applied to the deflector plates. The spot on the fluorescent screen should then be roughly at the centre, or origin, of the fluorescent screen.

Electrical Scanning (see Electron Scanning)

Electromagnetic

Pertaining to a magnetic field produced by an electric current. A magnetic field is set up when an electric current flows along a conductor. If the conductor is wound into the form of a coil, the magnetic field produced by it at a given point is very

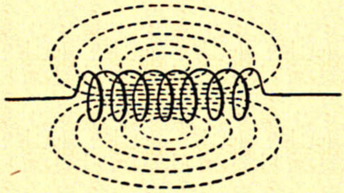

FIG. 23.—Illustrating the formation of an Electromagnetic Field.

greatly increased. If, further, the current flowing round the coil is varied in magnitude, the resultant electromagnetic field is altered correspondingly. The shape of a magnetic field round a coil traversed by current is seen in Fig. 23. If a magnetic substance is placed within the influence of the magnetic field, or lines of force as the individual lines forming the magnetic field are called, it will be influenced by the field and, therefore, by any alteration in the flow of current in the coil producing the field.

Electromagnetic Deflection

The deflection of a cathode ray beam by means of an electromagnetic field. The direction of the deflection is at right angles to the magnetic field, which in practice is provided by pairs of coils situated on the exterior of the neck of the cathode ray tube. So long as the frequency of the deflecting voltage is not very high, electromagnetic deflection is satisfactory. It is, in fact, employed in television receivers for the picture scan. At high frequencies, however, the reactance of the deflecting coils becomes so great that it is impossible to effect a satisfactory scan. For this reason it is usual to employ electrostatic deflection (q.v.) for the line scan.

One advantage of electromagnetic deflection as compared with electrostatic deflection is that it is not so susceptible to variations in the voltage at the accelerating electrode. The sensitivity (see Deflectional Sensitivity) of electromagnetic deflection is expressed by

$$S=Ll\sqrt{(e/2mV)}$$

where L=picture length in direction of scan; l=length of deflecting coil; m=mass of electron; V=potential of accelerator; and e=the charge on the electron.

Electromagnetic Focussing

The method of concentrating the cathode ray beam to a sharp spot by means of an electromagnetic field, which is thereby acting as an electromagnetic lens. The focussing effect is produced by virtue of the force acting on the electrons in the beam as they pass through the electromagnetic field. This force is at right angles to the direction of the field in the same manner as the force on the armature of an electric motor. Electrons that have a direction away from the axis of the cathode ray beam are thus impelled back to the axis of the beam as they pass through the magnetic field. The point at which focussing takes place is arranged to be at the fluorescent screen of the cathode ray tube.

When focussing is effected by a magnetic field, the electrons move in helical paths towards the focus. This must necessarily be the case, since there are two directions of motion to be compounded—one in the direction of the velocity of the electron on entering the magnetic field, and the other at approximately right angles to this due to the deflecting force of the magnetic field.

Electromagnetic focussing does not have such a wide application in television apparatus as electrostatic focussing.

Electron Camera

An electronic device that scans an object and provides the requisite picture voltages to an amplifier connected to the transmitter. In operation an image is thrown upon a photo-electric layer inside the electron camera. This layer emits electrons according to the intensity of light falling on it, and as it is scanned by an electron stream controlled by a magnetic deflecting system (q.v.) the electrons collected in the front of the camera will be proportional to the brightness of the individual points of the picture. See also Iconoscope and Image Dissector.

Electron Gun

The set of electrodes in a cathode ray tube that provides a concentrated beam of high velocity electrons. These electrodes usually consist of cathode, shield and first anode. The electron gun is thus a combination of electrodes.

Electron Lens (see Electron Optical System)

Electron Multiplier

This is a device in which the number of electrons produced at its input electrodes is multiplied to provide at the output electrodes a greatly increased number of electrons. An enormous amplification may be thereby produced.

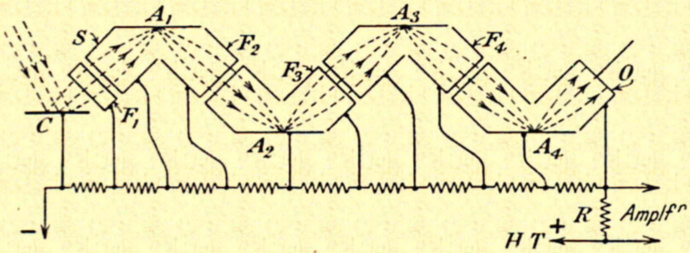

FIG. 24.—One type of Electron Multiplier.

The principle on which electron multipliers work is the utilisation of the secondary emission that results from a high velocity impact of electrons on a metal plate. When an electron, travelling at a high velocity, strikes an electric conductor, electrons are liberated from the latter to an extent dependent upon the velocity of the impinging electron. The electrons so liberated are termed secondary electrons, whereas the impinging electron is the primary electron. The number of secondary electrons liberated by one primary electron may be as many as ten. In the electron multiplier these secondary electrons are directed on to a further conductor to which they are attracted so strongly that they in turn liberate more electrons. This process is carried out a number of times in one valve. The actual amplification provided by one electron multiplier tube may be as much as a million times.

One form of electron multiplier is illustrated in Fig. 24. A photo-electric cathode C emits electrons in response to the light rays incident on it. These electrons are attracted by anode plate A_1, this electrode being maintained at a fairly high positive potential with respect to cathode C. Between C and A is another electrode F_1 in the form of a cylinder, which is maintained at a potential that is positive with respect to the cathode by some hundreds of volts, but is less positive by an almost equal potential with respect to A_1. There is thus set up between F_1 and A_1 an electric field of the type required for focussing the electrons proceeding from the cathode, as described under "Electron Optical System." The electrons from C are thereby attracted by the electric field of A_1 and concentrated by the electric field produced by the difference in potential between cylinder F_1 and the anode A_1. Owing to the high velocity the primary electrons have attained by the time they reach A_1 a large number of secondary electrons are liberated, and these then act as primary electrons with respect to the second anode A_2. A similar process to that already outlined takes place at all the anode plates A_2, A_3 and A_4, and focussing electrodes F_2, F_3, and F_4 the secondary electrons liberated from each anode automatically becoming the primary electrons for the succeeding anode. The output electrode is anode O, at which the multiplied number of electrons are collected and produce a voltage along an output resistance R connected, if desired, to an amplifier.

It will be noticed that in order to attract the electrons from one anode to the next, the positive potential of each anode must be high with respect to the preceding focussing electrode F. This is effected by means of potential dividing resistances joined across the source of high tension supply.

Another type of electron multiplier is illustrated in Fig. 25. Light rays are focussed on to the photo-electric cathode C and thus produce an electron emission. Electrons from C encounter an electrostatic field from the field plates F and a magnetic field from a magnet external to the envelope. This magnetic field is arranged to be at right angles to the electric field, with the result that the electrons emerging from *C* are focussed in the path as indicated by the arrows. The photo-electrons strike the anode A_1, which is coated with a substance to produce a good emission of secondary electrons. Secondaries are thus knocked off A_1 and are forced along a path of similar direction to that between *C* and A_1, finally striking A_2 to effect a further secondary emission. This process is continued

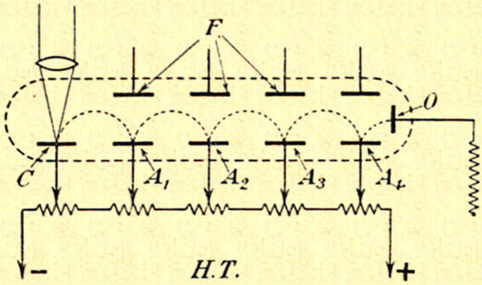

FIG. 25.—An alternative form of Electron Multiplier.

all along the tube as indicated, the output or collecting electrode *O* taking the multiplied electron current and applying it to an external circuit for utilisation or for coupling to an additional amplifier.

In order that the device illustrated in Fig. 25 may operate properly, each anode must be given a potential that is higher than the one preceding it in the direction of the cathode. This is easily arranged by means of the potential divider shown in the diagram. See also Image Dissector.

Electron Optical System

An electrical arrangement that produces on the electron beam a similar effect to that of lenses on a light beam, i.e., convergence and divergence. In television apparatus, convergence or focussing of the electron beam is usually required, one example being given under "Electrostatic Focussing." The example referred to is the electrical equivalent to a convergent lens system. Another method of concentrating the electron beam is by means of magnetic fields; this being outlined under "Electromagnetic Focussing."

In order to explain more clearly the similarity between the electrostatic focussing of an electron beam and the optical concentration of a light beam, Fig. 27 is reproduced in Fig. 26, underneath being illustrated the equivalent optical arrangement. The cathode is the source of the electrons which pass through the aperture in the shield and thence through the first anode. The electric field existing between the shield and the first anode produces a similar effect on the electron beam to that of the double-convex lens L_1 on the light beam emerging from the source. Thereafter the electron beam diverges until it

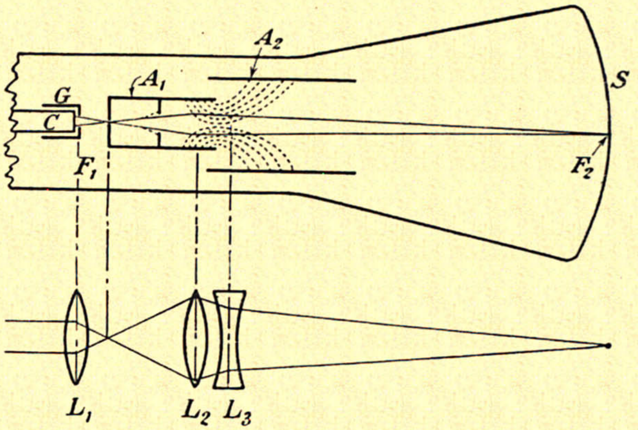

FIG. 26.—Electrostatic focussing system with its optical analogue.

reaches the second lens, this being the electric field between the first and second anodes. This produces a further concentration of the beam in a similar manner to that of the double-convex lens L_2 on the light beam, whilst the divergence effected by the highly positive second anode cylinder A is the equivalent of L_3.

Electron Picture

An arrangement of electrons representing a picture. Such an arrangement need not be on a screen, but may be in space as described under "Image Dissector."

Electronic Emission (see Emission)

Electronic Scanning

Any type of scanning that uses an electron stream as the scanning device. Examples of apparatus using electronic scanning are the cathode ray tube, iconoscope, kinescope, Emitron.

Electronic Scattering

The diffusion of electrons. Electronic scattering sometimes takes place in a cathode ray tube owing to the presence of gas.

This scattering produces an enlargement of the light spot and a corresponding reduction in the definition provided in the picture reproduced on the screen. Electronic scattering is dependent upon the gas pressure and the nature of the gas.

Electro-optical Translating Device
An apparatus for converting electrical currents into light variations. Any type of optical light valve is an example, the most commonly used type being the Kerr cell.

Electro-optically Refractive Field
An electric field that refracts or bends the paths of electrons passing through it. The electro-refractive field of the electron optical system (q.v.) collects the electrons into a ray in the cathode ray tube.

Electrostatic
Pertaining to an electric charge as distinct from an electric current flow. The action of an electric condenser, for example, is electrostatic. Compare with Electromagnetic.

Electrostatic Concentration (see Electrostatic Focussing)

Electrostatic Deflection
Deflection due to the influence of an electric field. When cathode ray tubes are referred to, electrostatic deflection is the alteration in position of the light spot by the electric field existing between the deflecting plates. In Fig. 9 is shown a simple diagrammatic representation of a cathode ray tube employing electrostatic deflection. The deflecting voltages for scanning the fluorescent screen are applied to the plates D_1, etc., and the electric field due to the voltages at the deflecting plates alters the direction of the ray in the sequence and manner determined by the time base circuit.

The sensitivity of electrostatic deflection (see Deflectional Sensitivity) can be shown to be expressed by

$$S=L/2Vd$$

where L=picture length in direction of scan; V=voltage on accelerator; d=distance between the deflecting plates.

Electrostatic Focussing
The method of concentrating the electron beam in a cathode ray tube to a point at the fluorescent screen by means of plates to which high potentials are applied. Alternative

methods are gas focussing (q.v.) and electromagnetic focussing (q.v.).

Electrostatic focussing is usually carried out by two or three anodes spaced along the axis of a cathode ray tube. The principle of operation is similar whether two or three anodes are used, so only the two-anode system is outlined here. In Fig. 27 is shown diagrammatically a cathode ray tube with two anodes for focussing purposes. The operation of the tube is outlined under "cathode ray tube," and will not be given now. The point of interest is the two-anode electrostatic focussing device shown at A_1 and A_2. The second anode A_2 is at a much higher positive potential than the first anode A_1, with the result that an electric field is in existence between these anodes, of the shape indicated by the broken lines. As the beam passes through A_1 it is seen to diverge and become of greater section.

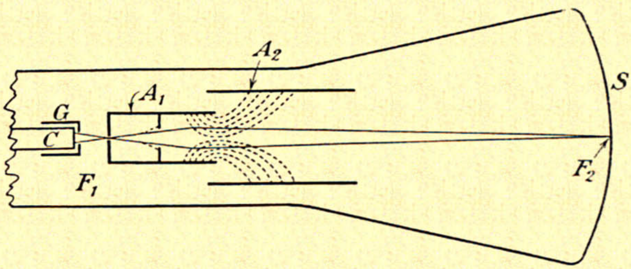

FIG. 27.—Electrostatic focussing by the two-anode system.

On entering the electric field, however, the force acting on the beam is such that the divergence is overcome and concentration or convergence takes place. Now the influence of an electric field on an electron is inversely proportional to the velocity of the electron. One important result of this is that the concentrating effect of the electric field as first encountered by the electron beam is considerable owing to its comparatively low velocity. As the beam passes into the second anode, however, its velocity increases and thus the influence of the electric field becomes much less. The effect of the electric field within the section of the second anode is to cause the beam to diverge, but as, owing to the higher velocity of the electrons, the divergent influence is small, the concentrating or focussing effect produced by the first part of the electric field is not seriously diminished. Thus, there is brought about a focussing of the electron beam, the actual focus (q.v.) being at the fluorescent screen *Sc*.

Another property of a high velocity electron beam is that the repulsive influence of the component electrons on each other is largely overcome, and this again facilitates the formation of the point focus by increasing the permissible degree of concentration of the ray.

Focussing by the electrostatic electron lens is mainly dependent upon the ratio of the voltages on the two electrodes forming the lens, as distinct from the actual difference in voltage. For example, if the voltages on the first and second anodes are, respectively, 1,000 and 2,000 volts, and it is required to increase the first anode voltage to 2,000, the second anode voltage must be raised to 4,000 volts if the same degree of focussing of the cathode beam is to be obtained. The voltage ratio employed on any particular pair of focussing electrodes depends upon the form of the electrodes and their situation along the cathode ray tube. (See Electron Optional System.)

Electrostatic Image

An image formed by minute condenser elements each containing a charge proportional to the light intensity corresponding to its position in the picture. An example of an electrostatic image is that formed on a mosaic screen, as in the Iconoscope (q.v.).

Electrostatic Lens (see Electrostatic Focussing)

Electrostatic Multiplier

An electron multiplier of the type illustrated in Fig. 24.

Element Frequency

The reciprocal of the element period. The element frequency is the product of the picture frequency (q.v.) and the number of elements.

Element Period

The time required for the scanning light spot, which is equal in area to that of the picture element, to travel its own width in the course of scanning. The width is here measured in the direction of scan.

Elements

The elements of a television picture are the smallest areas into which the picture is divided to give the maximum detail. If there are n lines in the picture and the picture ratio (q.v.) is K, then the number of elements is given by $N = Kn^2$. Clearly the maximum detail the picture is capable of affording is produced when adjacent elements have maximum variation in illumination. That is, one element is dark and the other bright. In a correctly designed mechanical optical system the size of the light spot should be equal to that of the element, the latter being calculated by dividing the total area of the picture by the number of elements. The same applies to the size of the spot on the fluorescent screen in the cathode ray tube television receiver.

Emission, or Electronic Emission
The total emission from a cathode. Compare with Emissivity.

Emissive Material
The substance that actually emits electrons. This is not necessarily the whole cathode or emitter, but may be merely a very thin coating on a non-emissive core.

Emissivity
The property of a cathode to emit electrons. The greater the number of electrons emitted per unit area at a given temperature, the greater is the emissivity. Substances with the greatest emissity for practical purposes are : thorium, cæsium, alkaline earth metals.

Emitron
A type of Iconoscope developed and used by the Marconi-E.M.I. Television Company.

Equilibrium Potential
The potential between given points during a steady state of the operating conditions. For example, the equilibrium potential of an Emitron is the potential taken up by the photo-electric condenser elements of a mosaic screen in the absence of light rays. It is, therefore, the datum line in respect of the charge on the condenser elements, the voltage being varied from the equilibrium potential upwards according to the intensity of the light reaching the photo-electric element. As soon as the cathode ray strikes the element, the condenser is discharged and the voltage again falls to the equilibrium potential.

Equipotential Cathode
A cathode, the entire surface of which is at the same potential. Indirectly heated cathodes (q.v.) are examples of the

equipotential cathode, which is commonly employed in cathode ray tubes.

Exciter Circuit

Referring to a cathode ray tube, the exciter circuit is the voltage supply circuit for the electrodes.

Exciter Lamp

The lamp used in reproduction from a sound film for exciting the photo-electric cell according to the sound intensity recorded

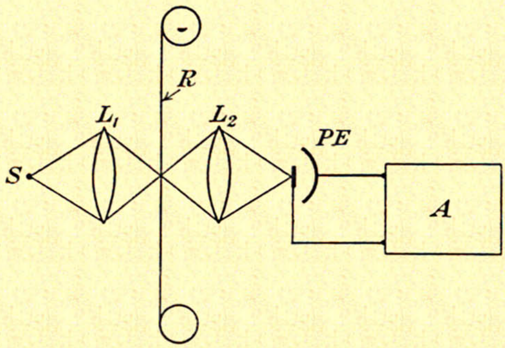

FIG. 28.—Simple arrangement for sound recording.

on the film. In Fig. 28 is seen the actual arrangement in which *S* is the exciter lamp, in front of the lens L_1. Light from *S* passes through L_1 on to the sound record *R*, and a portion of the light beam at *R* is allowed to pass to an extent depending upon the sound intensity represented. The light that passes through *R* is focussed by lens L_2 on to the photo-electric cell *PE*, whose resistance is thereby altered, and this variation in resistance actuates an amplifier *A*.

External Photo-electric Effect

The effect of light on surface atoms in contradistinction to the Internal Photo-electric Effect (q.v.). This is the effect wherein electrons are liberated from the surface layer atoms. Incident light gives up its energy to these surface atoms. Some of the energy is used in overcoming the surface barrier and the rest is interpreted in the velocity of the emitted electrons. (See Work Function.)

Extinction Voltage

The voltage at which the discharge in a gas-filled relay (q.v.) or similar device (e.g. neon lamp (q.v.)) ceases. The gas-filled device then becomes non-conductive until the striking voltage (q.v.) is applied to it.

Extraordinary Ray

That portion of a light beam which, when projected on to certain crystals, e.g., Iceland Spar, is refracted at a different angle to the ordinary rays. Compare with Ordinary Ray. (See Nicol Prism.)

Eye

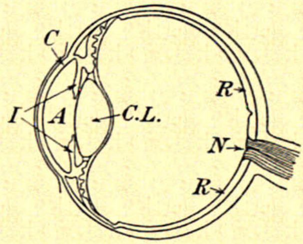

FIG. 29.—The Eye.

An illustration of the human eye is given in Fig. 29. The outer transparent layer or cornea *C* protects the eye, and forms, with the aqueous humour *A* and crystalline lens *CL*, a lens system which focusses the impinging light rays on to the retina *R*. The retina is sensitive to light rays, and stimulates the optic nerve *N* in accordance with the light received and thus the brain receives the impression. A diaphragm or iris *I* limits the amount of light passed through the eye so that the light sensitive retina may not be damaged by too strong a light beam.

Fader

The device that controls the output of one electrical device with respect to the output of another. For example, faders are used by the Marconi-E.M.I. Co. for fading the output of any of six Emitrons. A fader may also be employed for superimposing the output of a number of cameras, hence the effect of "ghost image" (q.v.).

Fading

Variations in signal voltage due to alterations in the media between transmitter and receiver. The actual variations in signal voltage are produced by the combination of two waves at the receiver, one the direct ray, and the other the indirect ray. These two components mix at the receiver aerial, and as their relative phase (q.v.) alters, so also does the resultant strength of signal voltage applied to the receiver amplifier. Fading occurs in both vision and sound radio transmissions but not at short distances from the transmitter owing to the great preponderance of the direct ray, which is sensibly constant in strength.

Faraday Dark Space
The space between the negative glow (q.v.) and the positive glow (q.v.) in a glow discharge tube (q.v.).

Faraday Effect
If a beam of plane polarised light passes through a block of dense flint glass, then the plane of polarisation of the light will be rotated in accordance with the intensity of a magnetic field the lines of force of which are parallel to the direction of the light. The effect is too minute to allow of commercial use.

Farnsworth Camera
A picture scanning device for use at transmitters, designed and produced by Farnsworth Television Inc., the American television company. The Farnsworth camera is portable, being no larger than a standard motion-picture camera. It comprises a lens disc with four lenses for varying the focus, an optical lens system for focussing the picture on to the cathode, multipactor (q.v.), electron focussing and scanning coils, a head amplifier (q.v.) and the necessary batteries. (See also Image Dissector.)

Film Writing Speed (see Writing Speed)

Filter Valve
The thermionic valve employed in an amplitude filter (q.v.).

Fine Mesh Pattern
A defect in reception that results in a mesh pattern being superimposed on the received picture.

Firing Voltage
An alternative term for ignition voltage (q.v.).

First Detector
A valve that detects or rectifies the beats of the combined signal frequency and the local oscillator frequency in a superheterodyne receiver (q.v.). (See Frequency Changer.)

Flashing

Word used to describe the vaporisation of a material by intense heat. Getter material is flashed inside a cathode ray tube or vacuum tube in the process of gettering (q.v.).

Flash-over

Discharge between two electrodes owing to the high potential existing between them. The voltage at which the flash-over takes place is dependent upon the nature of the insulation between the electrodes, and in the case of gas-filled tubes may be low.

Flicker

Flicker is an effect produced by a reproduced television picture due to the presentation of the frames at too slow a rate. It is overcome by arranging that the time interval between successive illumination of any particular portion of the picture should be much less than the time of persistence of vision (q.v.).

Floodlight Scanning

The type of scanning in which the picture or scene to be transmitted is illuminated by an arc or similar floodlight, and is then analysed or dissected by the scanning device. Compare with Spot-light Scanning.

Fluorescent Materials

Several different kinds of substances are employed as fluorescent screen of the cathode ray tube, the most commonly used being calcium tungstate, cadmium tungstate, willemite, zinc phosphate and zinc sulphide.

Fluorescent Screen

A screen coated with a layer of material that fluoresces when bombarded by the cathode ray in a cathode ray tube. There are very many materials that will fluoresce under these conditions, calcium tungstate or barium platinum cyanide being commonly used for this purpose. Sometimes a phosphorescent material such as zinc sulphide is added.

The main requirement for a fluorescent screen is a high sensitivity, i.e., the ability to provide a bright luminosity in response to a small power in the cathode ray. Unfortunately most sensitive screens are damaged if a cathode ray impinging on them is at all powerful, or if the ray remains at a spot for any but a short interval of time. Another difficulty with most fluorescent screen materials is that they do not respond proportionally to the power in the cathode ray. That is to say, if the power in the ray is increased in an attempt to obtain greater luminosity of the picture, the fluorescence provided by the screen does not increase in the same proportion. Beyond a certain luminosity the increase in power brings about a very slight increase in picture brightness.

The material of which the screen is composed determines the colour of the luminescence. For example, a sulphide screen gives a white luminescence ; willemite, green ; cadmium tungstate and calcium tungstate, blue ; zinc sulphide, red.

Fluorescent screens must not be too thick, or the screen material will absorb too great a proportion of the brightness of the light spot, thereby lowering the efficiency of the screen. On the other hand, if the screen is too thin, the grain of the material shows up and produces blurred pictures. In practice, it is found that a satisfactory screen for television reception has an efficiency of from 75 per cent. to 80 per cent.

Fluorescent Screen Carrier

The material on which the fluorescent substance is coated. In a receiver cathode ray tube the fluorescent screen carrier must be transparent so that the light spot variation may be visible.

Fly-back

The return of the light spot in a cathode ray tube. After a line of scan, the light spot must return to its original position at the beginning of the line but slightly spaced from its exact previous position, in order to begin the next scanning line. This arrange-

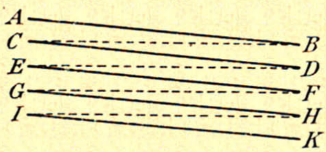

FIG. 30.—The broken line is the Flyback.

ment is shown diagrammatically in Fig. 30, where the full lines *AB*, *CD*, *EF*, etc., represent lines of scan. When the ray reaches the end of the scanning lines *B*, *D*, *F*, etc., it returns to the commencement of the following scanning line *C*, *E*, *G*, etc., and this return is the fly-back.

In Fig. 30 the broken lines *BC*, *DE*, *FG*, etc., are almost horizontal, thus indicating that only a very short time elapses during the fly-back time as compared to the time taken for a scanning line.

Fly-back Time
The period of time occupied by the fly-back. In Fig. 47 the fly-back time is indicated by the distance *BC*. For satisfactory operation of cathode ray tubes as scanning devices, the fly-back time *BC* should be as small a percentage as possible of the total time *AC* taken by the saw-tooth wave *ABC*. In practice, satisfactory results are obtained if the fly-back time is not more than one-tenth the time required for a scanning line.

Flying-Spot Scanning (see Spotlight Scanning).

Focal Length
The distance from the centre of the lens to the principal focus. In Figs. 12 and 20 this is the distance between the centre point of *L* and *F*.

Focus
In a television receiver the knob marked "focus" usually controls, by means of a variable potentiometer, the voltage applied to the focussing electrode in the cathode ray tube.

Foot
An alternative name for the pinch (q.v.) of a valve or cathode ray tube.

Foot-Candle
The intensity of illumination provided by an international candle (q.v.) at a distance of one foot. This is a useful measure of the amount of light as distinct from the intensity.

Frame
That unit of picture formation one or more of which go to make the complete picture. With an intercalated scan the picture will not be completed when the odd, or even, lines only have been scanned. This completes only the one frame. The odd lines form the first frame; the even lines, the second frame; and the two frames, the complete picture. Thus there are two frames each of which occupy 1/50th of a second. The time for the complete picture is thus 1/25th of a second.

Frame Frequency Time Base (see Picture Frequency Time Base)

Fringing

A distortion that sometimes occurs in gas-filled cathode ray tubes, and takes the form of a wavy appearance in the scanning lines over certain areas, though usually not all, of the fluorescent screen. An example of fringing is seen in Fig. 31, which shows the screen *S* and a number of scanning lines. The areas at which fringing occurs are indicated at *F*, and the actual distortion is seen to consist of a wavy scanning line at those areas. Fringing is caused by the fluctuating potential charges on the internal surface of the glass envelope of the cathode ray tube, such fluctuations being produced by the electric fields of the tube electrodes or externally of the tube itself.

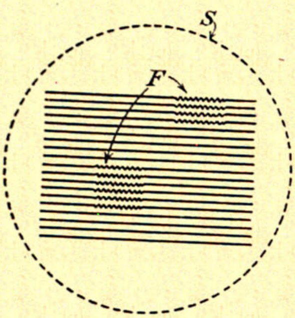

FIG. 31.—Illustrating fringing effect.

Frequency Changer

In television and radio reception this usually refers to the thermionic valve that mixes and rectifies the incoming signal carrier and the local oscillator voltage to bring about the change in frequency outlined under "Superheterodyne Receiver." Special valves are made for this purpose, as the process involves many problems. Examples of frequency changer valves are: hexode, heptode, octode, triode-pentode, triode-hexode. It is not necessary to employ one valve for this purpose, however. In fact, frequency changing can be carried out most satisfactorily when a separate valve is used as the oscillator and another valve as mixer.

Frusto-Cone

A portion of a cone. The part of a cathode ray tube that supports the fluorescent screen is frusto-conical in shape.

Gamma (see Intensity Contrast)

Ganging

The process of aligning one circuit to work in conjunction with another. In a straight receiver the various tuned circuits have to be tuned to a common frequency, but in a superheterodyne receiver the ganging has to be carried out at three frequencies, i.e., the signal frequency, oscillator frequency and the intermediate frequency. Unless these circuits are accurately tuned to their respective frequencies the receiver will not work properly and may even fail to reproduce the signals altogether.

Gap Synchronisation

That system of synchronisation in which the synchronising signal consists of a gap in the carrier wave. The gap may be produced either by suppressing the carrier completely or by merely reducing the amplitude to a level considerably below that of the minimum amplitude of the picture signal carrier. This arrangement is shown diagrammatically in Fig. 32. The amplitude marked *Min* is that of the blackest picture signals. The wave bearing picture signal modulations varies from this

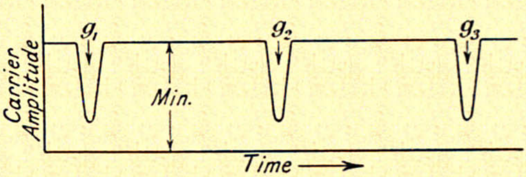

FIG. 32.—Carrier amplitude for gap synchronisation.

minimum value upwards. Usually the minimum value is about a quarter of the maximum amplitude permissible. In the diagram the straight line corresponding to minimum value represents the transmission of a black part of the picture. Breaks in the straight line indicated g_1, g_2 and g_3 are the synchronising gaps, and during reception of the signal the change in voltage brought about by these gaps is made to operate the synchronising mechanism. This is "blacker than black" synchronising.

Gas-filled Relay

A type of gas-filled valve that acts as a relay. In form the gas-filled relay may be a triode or a multi-grid valve with a filling of argon, helium or mercury vapour. In operation the control grid voltage does not control the magnitude of the anode current, but only the voltage at which a discharge takes place between anode and cathode. Once this discharge commences, the grid voltage has no further influence on the operation of the valve. The controllability is the ratio of the negative grid volts applied to the control grid to the increase in anode volts above the normal required to produce a discharge. Gas-filled relays are used in time base circuits, although hard valves seem to be becoming more popular for this purpose owing to their greater reliability in operation.

Gas-filled Triode (see Gas-filled Relay)

Gas Filling

The gas introduced into a cathode ray tube or valve, thus making it "soft." In cathode ray tubes a normal pressure of gas filling is 0·005 millimetres of mercury, and the filling is usually helium or argon.

Gas Focussing

The method of concentrating electron rays in a cathode ray tube by means of gas, usually helium or argon, which is introduced into the tube. Electrons from the cathode come into impact with the gas molecules and, by liberating electrons from them, make the gas molecules positive in sign, i.e., ions. These positive ions together form a space charge which attracts the negative electrons and thus brings about the focussing of the electron beam. Gas focussing is not employed in television cathode ray tubes owing to difficulties that are encountered in connection with the modulation of the ray.

Gate

An opening through which light is passed for purposes of photographic recording, sound recording, etc.

Getter

The material employed for gettering (q.v.). Most metals in finely powdered form absorb gas strongly when heated, especially the alkali metals. Thus barium is most commonly used in vacuum technique. The barium is enclosed in a thin metal (nickel) capsule or in a metallic mesh. This capsule is heated at the appropriate moment by eddy current means and the heat is conveyed from it to the barium, which immediately vaporises. Phosphorus and magnesium are also used. The latter metal is in the form of a strip which is heated by passing current through it. Zirconium and tantalum are used less frequently.

Gettering

The process of vaporising a piece of material the molecules of which seal the residual gas in the glass bulb of a cathode ray tube or thermionic valve to produce a better vacuum. In this way a high vacuum may be maintained during the operation of the valve. Gettering is necessary owing to the impossibility with the means at present available of withdrawing all gas from the electrodes and glass bulb during the pumping process. If gettering were not carried out, the gas remaining after the valve had been pumped out and sealed would spoil the vacuum and render the operation of the valve very erratic. The amount of such gas liberated during operation increases as the electrodes and bulb become heated. During evacuation the electrodes are brought to a high temperature by high frequency induction and the envelope is baked. This causes a large amount of the gases to be given off by these parts. The getter material is then vaporised, or flashed, by raising the temperature still further. The vapour given off by the getter settles on the bulb and imprisons the gas that is subsequently given off by it.

Ghost Image

The type of picture comprising two scenes, one of which (the "ghost") can be seen superimposed on another, the "real" image.

Glow Discharge Tube

A tube containing a cathode and an anode between which an electrical discharge takes place, this discharge producing a luminescence or glow. Glow discharge tubes are of many and varied forms, the most common being those employed for advertising purposes shaped into letters. The glow is provided by the gas filling (q.v.), the most usual being neon and helium, which have a low striking voltage (q.v.). For television purposes, glow discharge tubes have been extensively used in low definition receivers. The most commonly used for this purpose was the flat plate neon lamp (q.v.), but other types that were sometimes employed were the beehive and crater lamps (q.v.). In operation a glow discharge tube is non-luminescent when a voltage below its striking voltage (q.v.) is applied to the electrodes, but once the discharge has commenced it continues until the voltage drops, the area of glow being generally proportional to the voltage across the electrodes.

Grid

In cathode ray tube technique a grid is generally understood to be the modulating electrode (q.v.). Actually it may take any form, and frequently consists of a metal cylinder. In a thermionic radio valve a grid is usually a spiral of wire or a wire-netting.

Grid Base

The permissible grid voltage swing. In reference to a thermionic valve, for example, it is the grid voltage corresponding to the linear change in anode current. In Fig. 33 are shown two grid

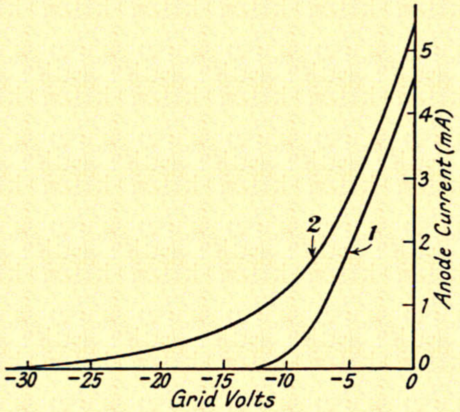

FIG. 33.—Characteristics of two valves with different grid bases.

volts—anode current curves. The valve whose characteristic is curve 1 has a grid base of 12·5 volts, and the other grid base is 30 volts. When a cathode ray tube is being considered, the grid base is reckoned in a similar manner.

Grid Glow Tube

A form of gas discharge tube. The commercially named "Thyratron" is a grid glow tube.

Halation

The reflection of image rays by the back of a screen or film. Such reflection produces a blurring of the image as viewed by an observer, or is reproduced on the film. With cathode ray tubes halation occurs if the fluorescent screen material is too thick.

Halo

The appearance of a ring of light round the cathode ray tube light spot on the fluorescent screen. If this is not due to actual aberrations of the electron-optical system of the tube, then its presence is due to the emission of secondary electrons from the fluorescent screen. These secondary electrons return to the screen and form the halo.

Hard Valve Time Base

A circuit for providing the saw-tooth voltage (q.v.) waveform in which a hard thermionic valve (q.v.) is employed as charging resistance of a condenser. One arrangement, due to Bedford and Puckle, is shown in Fig. 34. The condenser providing the saw-tooth voltage is C_1, and this is charged from the H.T. supply via an H.F. pentode V_1, which is operated on the flat portion of its anode voltage-anode current characteristic and thus maintains a constant charging current. Owing to the

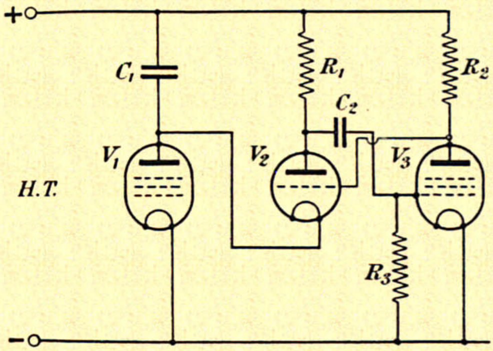

FIG. 34.—Time base circuit using Hard Valve.

high grid bias applied to V_2 by the voltage drop down R_2, this valve (V_2) is blocked during the charging of C_1. After a certain voltage rise takes place on C_1, the point is reached at which the positive potential is such that anode current begins to flow along R_1. This produces a voltage drop in R_1 which is passed to the grid of V_3 via coupling condenser C_2. The voltage from C_2 produces a drop in anode current of V_3 and therewith a diminished voltage along R_2 and consequent reduced negative bias to V_2. This further increases the anode current flow along R_1, and thus the action is progressive and the condenser discharge is rapid.

When the discharge of C_1 is complete, the current flow through R_1 falls and the original conditions are again set up, i.e., excessive bias on V_2 blocks this valve. The time base circuit is thereby reset for the generation of the subsequent saw-tooth waveform, and so the process goes on.

Harmonic

An overtone or multiple frequency. When an oscillatory voltage of any given frequency is generated, there appear voltages of frequencies that are an integral multiple of the fundamental frequency. That is to say, if the fundamental frequency is f, the additional frequencies that appear are equal to $2f$, $3f$, $4f$ and so on, these being known as the second, third and fourth harmonics respectively. In practice it is impossible to generate an oscillatory voltage of one frequency only, as harmonics are always produced. By careful design of apparatus and attention to operating voltages, however, it is practicable to reduce the amplitude of the harmonics to harmless proportions. Conversely, it can be arranged that the oscillatory voltage is rich in harmonics.

Harmonic Distortion

The introduction of undesired harmonics (q.v.) into a television or radio signal.

Head Amplifier

An amplifier fitted adjacent the modulating device which amplifies the modulating voltages for transmission to the main amplifier. In some designs of electron cameras, for example, an amplifier is provided at the camera itself, for amplifying the picture signal voltages provided by the scanning process. Such an amplifier is a head amplifier. Another example of the use of a head amplifier is in connection with a microphone. Frequently a head amplifier is fitted close to a microphone to amplify and transmit the speech, etc., signals over the line to the main amplifier.

Heterodyne

A locally produced oscillation voltage that is injected into a receiver to render the latter operative for the particular purpose desired. The word was coined by the inventor of the heterodyne receiving system, R. A. Fessenden, from the Greek hetero, external, and dyne force. The heterodyne is the local oscillation voltage at the receiver. (See also Superheterodyne Receiver.)

High Definition Pictures

Pictures that are split up into a large number of strips or scanning lines in order to provide a reproduction of good quality, i.e., fine texture. (See also Low Definition.) High definition pictures are understood to be those that are scanned at least with 240 lines, and are shown at the rate of not less than 25 pictures per second.

High Vacuum
A vacuum in which the air pressure is less than one millionth of a millimetre of mercury.

Hollmann Effect
If the frequency applied to the deflector plates of a cathode ray tube is too high (in the order of 10^9 cycles per sec.), then the deflectional sensitivity (q.v.) is impaired. This is because the electron is now travelling slowly compared to the rapidly changing potential on the plates. If the time taken for the electron to traverse the interdeflecting plates space is exactly equal to one-half period of the alternating deflection potential cycle, then, clearly, the deflection sensitivity will be nil. The Hollmann Effect is this decreasing deflection with increasing frequency of deflecting voltage.

Horizontal Scanning
The system of scanning in which the lines of the picture scanned are horizontal. Most systems of modern television employ horizontal scanning.

Horizontal Shift (see Shift Voltage (2))

Horizontal Synchronising
The method of synchronising by means of signals transmitted at the ends of the horizontal scanning lines.

Iceland Spar
An alternative name for calcite (q.v.).

Iconoscope
A device invented by Dr. V. K. Zworykin for translating an image of the picture to be televised into electrical impulses, in which a mosaic photo-electric screen is used in conjunction with a cathode ray. The name is derived from the Greek "icon," meaning image, and "scope," meaning view.

The scene being televised is projected by optical means on to the mosaic screen consisting of a large number (up to some millions may be used) of photo-electric elements electrically insulated from one another, and mounted on, but insulated from, a metal plate in an evacuated chamber. Each element then emits electrons to an extent depending upon the intensity of the light rays reaching it, and thus produces a condenser charge. A ray of electrons, proceeding from a cathode and passing through an electron gun and lens in a similar manner to that in a cathode ray tube, is deflected in the normal scanning sequence by magnetic deflecting means across the mosaic screen, and as the ray strikes the photo-electric elements it discharges them. Each charge corresponds to the total amount of light reaching the mosaic element while the complete picture is being scanned, and during discharge a voltage is set up in a coupling element which is amplified in the usual way to produce the signal voltage transmitted. It should be noted that each photo-electric element acts as a condenser with respect to the signal plate (q.v.) from which it is insulated.

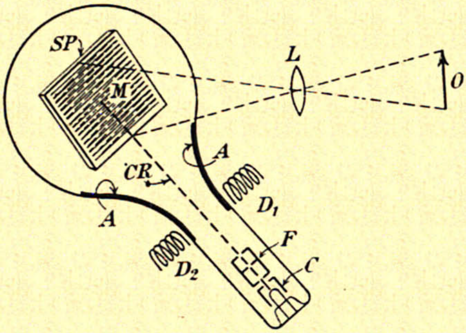

FIG. 35.—The Iconoscope.

In Fig. 35 is given a drawing of an iconoscope as used in a television transmitter. The object or scene to be televised at *O* is passed through an optical lens system represented by *L* and projected on to a mosaic screen *M*, as described above and under "mosaic screen." A cathode ray *CR* is emitted by the cathode *C* and traverses a series of focussing and accelerating electrodes *F*, which concentrate the ray into a point at the surface of the screen *M*. Additional acceleration is provided by an anode electrode *A* on the wall of the tube surrounding the path of the ray. By means of two pairs of deflecting coils, one pair of which D_1 D_2 are shown, the ray *CR* is swept across the screen *M* as in normal cathode ray scanning practice to provide the result outlined above. *SP* is the metal signal plate from which the photo-electric elements are insulated, and which is connected by a resistance to earth. Voltages are thus produced along this resistance by the minute condenser discharges. These represent the picture and may, therefore, be amplified and used to modulate the transmitted carrier in the usual way.

Ignition Potential

In gas-filled discharge tubes or valves this is the potential at which a discharge takes place. In gas-filled valves the ignition potential is largely dependent upon the nature and pressure of the gas-filling. For example, a discharge tube with a filling of neon would have a lower ignition potential than if the filling were argon or mercury vapour.

Illumination

The illumination of a screen is measured by the quantity of light it receives per unit area. As a quantity of light is given in lumens (q.v.), the illumination of a screen is given in lumens per cm.^{2} The unit is termed the phot. Another unit is lumens per metre^2, which is termed the lux. It can be shown that a standard candle placed exactly one metre away from a screen which it is illuminating yields an illumination on the screen of one lux. Thus the lux is also definable as the metre-candle. A third unit of illumination is the foot-candle, and this is the illumination afforded by one candle placed one foot away from the screen.

Image Dissector

An electron camera device invented by P. T. Farnsworth, the American television engineer. The image dissector includes a means for projecting an image of the picture to be transmitted

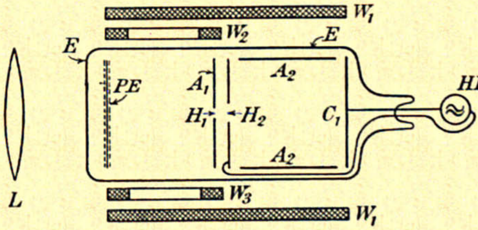

FIG. 36.—The Image Dissector.

on to a photo-electric layer for scanning means, and an electron multiplier for amplifying the resultant vision signal voltages.

In Fig. 36 is illustrated the image dissector, and its method of operation is as follows : light rays from the picture or object O pass through the lens system L and are projected through the glass envelope E on to a photo-electric cathode PE. This cathode consists of a fine gauze structure which is coated with the photo-electric material, such as cæsium on silver oxide. Electrons are thus liberated to an extent dependent upon the brightness of the picture at the different points of the cathode PE, which thus forms an electron image (q.v.) of the object. This electron image is focussed by the magnetic field from the coaxial winding W_1 on to the anode A_1 situated at the opposite end of the first chamber of the image dissector, and is deflected *as a whole* by the combined fields of W_2 and W_3. The windings W_2 and W_3 are joined in series and are provided with saw-tooth current (q.v.) from a time base (q.v.) for deflecting the electron image across the aperture H_1 for line scanning. Another similar set of coils is provided at right angles to W_2 W_3 for deflecting the electrons in the opposite direction at the frame frequency (q.v.). Scanning is thereby produced by magnetically deflecting the entire photo-electric emission from PE in section across the hole H_1 in anode A_1. This method, it will be noted, is different to the usual practice in a cathode ray tube device such as the Iconoscope (q.v.), in which the electron image is scanned by a cathode ray, the image itself being stationary.

Photo-electrons (q.v.) passing through H_1 are greatly accelerated by the electric field due to the high voltage placed on the anode A_1 and are thereby given a high velocity which carries them through the second chamber in the image dissector and on to the plate C_1. Plates C_1 and C_2 are cathodes, and consist of a metallic plate, such as nickel coated with a substance such as cæsium that is a prolific emitter of secondary electrons (q.v.). When the primary electrons (q.v.) from PE pass through H_1 and H_2 to strike C_1 at a high velocity, secondary electrons are emitted. These would be attracted to the cylindrical anode A_2 were it not for the presence of the magnetic field produced by the direct current flow in W_1. As it is, the secondaries liberated from C_1 are impelled towards C_2 by the combined action of the electric field due to the voltage on A_2 and the magnetic field provided by W_1.

Across C_1 C_2 is connected a high-frequency generator HF which applies an oscillatory voltage of frequency 25 to 80 megacycles per second at a peak of about 50 volts. This oscillatory potential causes the secondaries from C_1 to be accelerated to C_2 and, if the potential is of sufficient magnitude, it imparts such a velocity to them that tertiary electrons (q.v.) are emitted from C_2 by the impact of the secondaries with this plate. The tertiary electrons then travel to C_1, and so the process goes on, providing a multiplication of the number of photo-electrons originally arriving at C_1 from PE. A definite proportion of the electrons passing backwards and forwards between the cathodes C_1 and C_2 will eventually strike the anode cylinder A_2 and thus set up a current the magnitude of which is dependent upon the number of primary electrons passing through H_2 from PE ; i.e., upon the brightness of the individual point of the picture being scanned.

The current in A_2 is passed through a resistance and thereby produces a vision signal voltage which is applied to an amplifier in the usual way.

Image Multiplying

When light illuminates a screen, the quantity of light reflected or diffused from the screen is less than that reaching the screen. But when an electron image is formed on a convenient screen, if the work function (q.v.) of the screen is low, then the intensity of electron emission from the screen is greater than the intensity of the incident flow of electrons. This property can be turned to account and an electron image can be formed by employing the secondaries from the previous image. The second electron image is brought about by suitable electrostatic or magnetic focussing. A third electron image may be formed in a similar manner from the second image and so on, each time the intensity of the image is increased, the effect being termed that of image multiplying.

Implosion

The collapse due to pressure from outside. With cathode ray tubes the risk of implosion is considerable unless the glass envelope is made thick, owing to the high pressure of the atmosphere on the large surface of the envelope. In modern commercial cathode ray tubes there is little risk of implosion owing to the strong construction employed. Triplex glass is frequently used as a safety precaution.

Indirect Scanning

The type of scanning in which light rays from the subject being televised do not pass directly to the photo-electric cell or other modulating device. An example of indirect scanning is the spotlight scanner (q.v.).

Indirectly Heated Cathode

A cathode that does not form part of the actual heating circuit, but is heated by conduction from the heater element. A typical indirectly heated cathode (or I.D.H. cathode) is illustrated in Fig. 37. Here the heater wire *H* is connected to a voltage source, which passes a current through it. The heat so generated raises the temperature of the insulator member *I*, over which fits metal sheath *S* carrying the emissive material *C* forming the actual cathode. In practice the heater element may be spiral formed, or wound longitudinally through *I* backwards and forwards, or various other forms. Generally an oxide coating is employed for the cathode. Indirectly heated cathode valves are more satisfactory for most radio and television purposes than directly heated cathode valves.

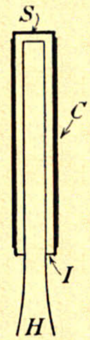

FIG. 37. Indirectly Heated Cathode.

Infra-Red Rays

That part of the light spectrum that appears outside the visible red limit. Although these rays are invisible to the human eye, their presence may be detected by means of special substances that emit electrons when impinged on by infra-red rays. By means of infra-red rays it is possible to scan objects in the dark and to transmit such a picture which, at the receiver, will appear in a similar manner to the more usual picture. One of the simplest ways of providing infra-red rays is to place a thin sheet of ebonite in front of a source of light so that all visible light is prevented from being radiated. Under these conditions the infra-red rays will penetrate the ebonite and may be detected by suitably sensitive material.

Infra-Red Region

That part of the light spectrum (q.v.) adjacent to, but beyond, the red end.

In Phase

Two bodies or electrical phenomena that move in the same sense at all time. Curves showing two electric currents in phase are given in Fig. 60 under "Phase." When currents or voltages are exactly in phase, the resultant sum is the simple arithmetic sum of the individual components, i.e., if ten milliamperes of alternating current is flowing in a circuit in phase with another alternating current of five milliamperes, then the total effective current is fifteen milliamperes.

Insulation Resistance

The effective resistance of an insulator, numerically equal to the voltage applied to it, divided by the leakage current flow. Although an insulator prevents a current flow when used under the conditions for which it is suited, a certain leakage of current is observable as the voltage applied across it is raised. This leakage current divided into the voltage applied gives the numerical value of the insulation resistance. From this it follows that the higher the voltage applied across an insulator, the higher should be its insulation resistance. With cathode ray tubes, for example, the anode may be 10,000 volts positive with respect to the cathode. Consequently the insulation resistance of the electrode supporting system must be very high.

Intensity Contrast

The contrast in detail in a picture, sometimes referred to as the gamma of the picture. In cinematograph practice and intermediate film television systems the intensity contrast produced on the picture screen is greater than that actually in the original picture, as this procedure is found to give greater comfort and interest to the viewer.

Intensity Modulation

The type of modulation employed with a cathode ray tube wherein the light intensity of the fluorescent spot on the screen is made to vary according to the picture signal voltage impressed on the modulation electrode. Usually the grid or shield (q.v.) is employed as modulation electrode, the intensity modulation process then being as shown in Fig. 38. Electrons from the cathode are attracted by the highly positive anode *A* in the centre of which is an aperture through which a portion of the electrons proceed towards the fluorescent screen. Battery *B* applies a negative bias to the shield or modulation electrode *G*, and this produces a concentration of the cathode ray on to the aperture in the anode.

Now if the concentration of the ray is complete, the entire cathode emission will pass through *A* to the picture screen, and no electrons will be lost. Owing to the application of the modulating potentials, i.e., the picture signal voltages at *M* to the modulating electrode, the effective concentration of the cathode emission is actually variable to an extent depending upon the instantaneous voltage on *G*. When this voltage is highly negative, the concentration is very great, but as the negative voltage becomes less, the ray spreads out and a lower proportion of the total emission passes through the aperture in *A*. Since the resultant potential of *G* at any instant is dependent upon the value of the picture signal voltage applied to it, the degree of concentration is similarly dependent and thus the number of electrons reaching the fluorescent screen. As the brightness of the light spot on the screen is proportional

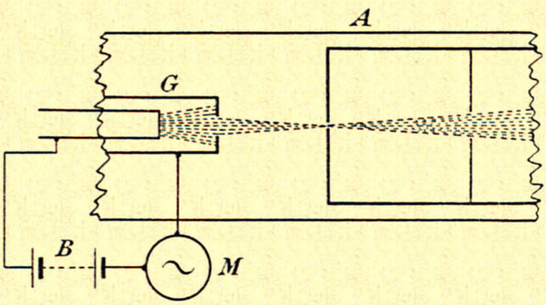

FIG. 38.—Showing effect of the modulating grid in Cathode Ray Tube.

to the number of electrons reaching the latter, the picture intensity is thus dependent on the voltage of *G*, i.e., intensity modulation is carried out.

Interference

Interference in television reception is a more serious problem than that associated with receivers of ordinary broadcast sound signals. This is because a large number of sources of interference have a natural frequency approaching that used for the transmission and reception of television signals. For example, the frequency of the interference set up by diathermy apparatus is in the ultra short wave band and it is received directly by the television receiver. The worst type of apparatus in this respect is the diathermy apparatus employing a quenched spark gap. Various other types of ignition and spark apparatus, however, also set up a similar interference and it is found extremely difficult to eliminate its effect on the receiver. The reason for this difficulty is the wide band filters that are employed for receiving the large band of frequencies necessary for satisfactory vision reproduction. Furthermore, the signal intensity at the receiving aerial is not so great as in the case of many of the medium and long broadcast signals.

The most satisfactory way of overcoming the interference trouble is to use a tuned dipole aerial as high as practicable, and to have a screened transmission line as down-lead. This is the method adopted by most television installation engineers. The interference encountered from the mains is eliminated in the usual manner as for broadcast receivers, i.e., chokes and filters. The screening from the interfering apparatus is, of course, particularly important from the point of view of satisfactory television reception.

Interlaced Scanning

The type of scanning in which the scanning spot does not scan the entire picture progressively from one end to the opposite end but instead scans the picture by repeated partial scans, each partial scan covering lines of the picture lying between the lines scanned previously. One method of carrying out interlaced or intermeshed scanning is shown diagrammatically in Fig. 39. The lines scanned in one frame (q.v.) will be 1, 3, 5, 7, etc., and after the bottom odd numbered scanning line has been finished, the even numbered scanning lines are scanned in the next frame, i.e., scan lines numbered 2, 4, 6, 8, etc. It is thus seen that with interlaced scanning of the type shown, double the number of frames are required for a given picture frequency as compared with sequential scanning.

Fig. 39.—Interlaced scanning in which a frame consists of odd or even lines respectively.

Interlocking

The process of forcing alternating voltages or currents of one frequency to vary in step with those of another frequency. For example, in scanning with the cathode ray tube, it is necessary to interlock the voltage of line frequency with the voltage of frame frequency so that at all times these voltages shall operate the deflecting means in the correct sequence to provide the picture scanning.

Intermediate Film (see Intermediate Record)

Intermediate Frequency

The frequency of the voltage produced in a superheterodyne receiver (q.v.) by mixing the local oscillations and the incoming signal voltage and then rectifying the resultant beat frequency. This intermediate frequency is numerically equal to the local oscillator or heterodyne frequency minus the incoming carrier frequency. For example, if the heterodyne frequency is 1,100 kilocycles per second (1,100 kc/s.) and the incoming carrier is 1,000 kc/s., the intermediate frequency is 100 kc/s. The tuning arrangements of the signal frequency circuit and the oscillator circuit are so devised that the intermediate frequency is constant, while actual tuning is carried out by altering the oscillator frequency.

Intermediate Frequency Amplifier

That portion of a superheterodyne receiver (q.v.) that amplifies the intermediate frequency. As indicated under "Intermediate Frequency," the amplifier is tuned to one frequency only, and this simplifies the construction very considerably. It also enables a very efficient amplifier to be made which, added to the high selectivity obtainable at the lower frequency, makes the superheterodyne receiver by far the most popular for television and radio receivers.

Intermediate Record System

The method of transmitting television signals in which the scene to be televised is first photographed as in normal cinematograph practice and then the photographic record is rapidly developed, fixed and dried and then scanned by the television apparatus. The photograph film is termed the intermediate record. In practice the whole photographic process takes only about thirty seconds, and the television transmission thus lags behind the original scene being televised by this period of time.

The intermediate record may be an endless band, in which case the complete sequence of the various processes necessary for producing the record and providing a blank for the subsequent sequence must be carried out during a traversal by any given point. The complete process is illustrated in Fig. 40, which shows the record carrier going in the direction of the arrows. Considering any strip between *G* and *A* this moves into *A*, where the photographic emulsion is coated on to it. After that, the strip moves along and passes into the chamber *B*, where it goes through a hardening and drying process. The photographic properties of the film are now complete, and it enters the cinematographic camera *C* for exposure in the usual manner. From the camera the film passes into the photographic bath *D*, where it is first developed and then fixed. Now the record is complete and proceeds along to the television scanning

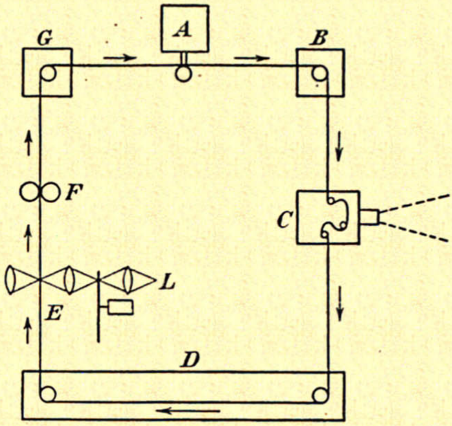

FIG. 40.—The complete process in one system of intermediate record system of television.

apparatus at *E*, where the record produces variations in the light beam from *L* and thus modulates the transmitter. From there the record passes to *F*, which consists of a pair of scrapers for removing the photographic record. The final process takes place in *G*, where the carrier is dried and thus made ready once more for the following sequence.

Intermediate Time Base

An auxiliary time base (q.v.) that generates a voltage of frequency intermediate the line frequency and frame frequency and assists in interlocking (q.v.) the time bases that produce voltages of these frequencies.

Internal Conducting Screen

A metallic internal coating on the glass wall of a cathode ray tube which acts as collector for the return emission that occurs with some fluorescent screens.

Internal Photo-Electric Effect

The effect of light on the interior atoms of a substance. Electrons are released from the parent atom and these electrons, which cannot escape from the material, become free charge carriers, thus altering the resistance of the material. The element selenium exhibits this effect in a marked degree. Owing to considerable time lag in the effect it does not find employment in television.

Internal Resistance
The ratio voltage to current at the electrodes of a thermionic valve or cathode ray tube. By means of the voltages applied to the various electrodes the internal resistance may be altered over a very wide range.

International Candle
The unit of light intensity standardised by several countries (including Great Britain). It is reckoned in reference to the light emitted by special designs of electric lamps.

Inverse Squares, Law of
The law of optics relating to the intensity of illumination of light proceeding from a point source of light. This law is as follows: the intensity of illumination produced by a point source of light varies inversely as the square of the distance from that source. If the distance between a television screen and the source of light that illuminates it is doubled, the light intensity of the reproduced picture is therefore one-quarter.

Ion
A molecule of gas from which one or more electrons have been liberated. Owing to the removal of these electrons, the ion is positive in potential in usual thermionic and cathode ray tube technique.

Ion-Bombardment
Bombardment by a large number of ions. This phenomenon may occur in valves or cathode ray tubes with a gas filling and is brought about by the ions being attracted by the cathode. Ion-bombardment shortens the life of the cathode and steps have to be taken to prevent it.

Ionisation
The production of ions or positive particles of electricity. If a certain particle in its normal state is neither positive nor negative in sign it will become either positive or negative as electrons are extracted or added to it respectively. To produce ions, therefore, electrons have to be taken away from the par-

ticles it is desired to convert. This process is usually carried out in a gas, wherein electrons are emitted at a high velocity and come into impact with the gas molecules. The force of the impact is sufficient to release electrons from the gas molecules, and this leaves them positive in sign, i.e., ions. This process is ionisation.

Ionisation Inertia

That inertia evident in a cathode ray due to the presence of ions in a cathode ray tube. Owing to this inertia the ray does not respond so rapidly to the change in voltage applied to the modulation electrode. This is obviously a defect so far as television transmission or reproduction is concerned, as it places a limit on the modulation frequency, which is quite intolerable. Ionisation inertia occurs in gas-filled cathode ray tubes (q.v.), but not in hard tubes (q.v.).

Iris

A part of the eye (q.v.) that controls the amount of light reaching the retina in accordance with the intensity of the incident light.

Iron Cross Distortion

An alternative name for origin distortion (q.v.).

Isotropic

A substance is isotropic when it possesses equal physical properties, especially elasticity, in all directions. (See also Anisotropic.)

Johnson Noise

The name given to the noises in a radio or television receiver due to thermal agitation (q.v.).

Karolus Cell

A particular type of multi-electrode Kerr cell attributed to Karolus of Germany. Actually, the Karolus cell was designed for use in facsimile telegraphy in 1934, but later was found to be of value in television receivers and was used for this purpose by L. M. Myers as early as 1929.

Kerr Cell

A light valve in which a pair of electrodes act in a similar manner to a condenser, on a singly refracting liquid filling the space between them. When a voltage is applied to the electrodes the liquid is rendered doubly refringent by the stress set up. If the electrode voltage is varied, say by applying vision signals to them, the light intensity of the emergent beam is thereby modulated. The Kerr cell is named after Dr. Kerr, who first observed the effect of the double refraction of light when passing through a simple arrangement of the type outlined above. Kerr's observations were as early as 1886.

In Fig. 41 is given an illustration of an elementary Kerr cell. Light from a source S is projected on to a lens L_1 in front of a nicol prism (q.v.) N_1. Between nicol prisms N_1 and N_2 is a cell containing two electrodes E_1 and E_2, between which is a dielectric such as nitrobenzene. Lens L_2 focusses the emergent light on to the picture surface Sc. Prism N_1 allows only plane polarised light to pass, and N_2 is arranged so that only light

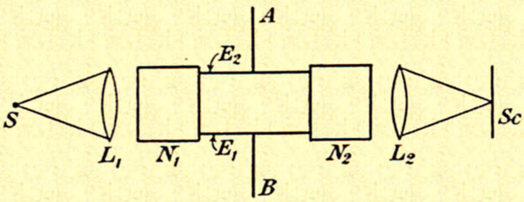

FIG. 41.—Simple Kerr Cell arrangement.

polarised in a plane at right angles to the light passing through N_1 is allowed to get through. Consequently no light can normally pass through the combination.

When a voltage is applied to the Kerr cell between N_1 and N_2 the active liquid (nitrobenzene) is affected so that the plane of polarisation of light passing through it is rotated through an angle and consequently some of the light can now pass through N_2. Since the amount of rotation depends on the voltage at E_1 E_2 the amount of light passing varies with this voltage, and is projected on to the lens system L_2 and the picture screen or an optical projecting device such as a lens disc (q.v.). Leads A and B go to the output of an amplifier, which, in practice, is the television receiver. The voltage actually applied to E_1 E_2 is therefore the picture signal voltage, so that the light from steady source S that reaches L_2 and the picture screen is proportional to the signal voltage. This simple system as outlined above is used in facsimile reception, the screen Sc in this case being the revolving receiver record surface. As Sc revolves, the light variations are recorded on it, and when the whole surface is covered the received picture is complete.

In practice it is found necessary to apply a polarising voltage or bias to the electrodes of a Kerr cell in order that the maximum efficiency, i.e., the percentage light intensity change per given alteration in electrode voltage, may be obtained. Actually some 1,000 volts bias is commonly used. (See Kerr Cell Bias.)

Kerr Cell Bias

The direct voltage applied to the electrodes of a Kerr cell in order to obtain the maximum efficiency of control of light. In Fig. 42 is seen a curve showing the effect of different values

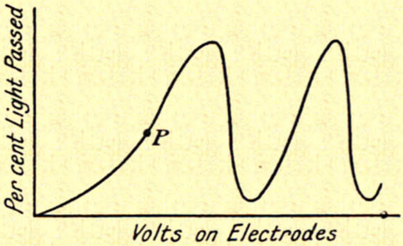

FIG. 42.—Characteristic curve of Kerr Cell.

of bias voltage on the percentage of light projected by the optical system on the output side of the cell. From this curve it is seen that the most suitable point to operate the cell is at *P*, and the bias must be adjusted to this value.

The curve in Fig. 42 follows the equation

$$\frac{I_e}{I_{max.}} = sin^2\frac{\pi}{2}\left(\frac{V}{V_{max.}}\right)^2$$

where I_e=intensity of the emergent light; $I_{max.}$=maximum intensity of light; V is voltage between the electrodes; and $V_{max.}$ is the voltage applied to the electrodes at the peaks of the curve.

Kerr Constant

When certain initially isotropic liquids are electrostatically stressed, they become doubly refracting to a degree in conformity with the intensity of stress. When doubly refracting, polarised light passing through the liquid splits into two components, each of which travel at different speeds. Because of this, retardation (q.v.) is set up between the two light components, and the amount of retardation, or path difference, was first shown by Kerr to be proportional to the distance the light travelled through the liquid, and to the square of the applied electrostatic field. Thus, if ϕ is the retardation expressed as a fraction of the wave-length and if F is the field and l the distance through the liquid which the light travels, we have

$$\phi = BlF^2 = Bl\frac{V^2}{d^2}$$

In the last expression V is the potential difference between two plates between which the light travels, and d is their distance apart. V is here given in electrostatic units. Now B is the constant of the expression and is termed the Kerr constant after the discoverer of the effect. This constant is given for a number of liquids in the following table :

Formula	*Liquid*	*Kerr Constant*
CS_2	Carbon disulphide	$0{\cdot}32 \times 10^{-6}$
$CHCl_3$	Chloroform	$0{\cdot}32 \times 10^{-6}$
C_3H_6O	Acetone	$1{\cdot}6 \times 10^{-6}$
C_5H_5N	Pyridin	$2{\cdot}0 \times 10^{-6}$
$C_5H_7NO_2$	Ethyl cyanoacetate	$3{\cdot}8 \times 10^{-6}$
$C_7H_7NO_2$	Para nitrotoluene	$22{\cdot}0 \times 10^{-6}$
$C_6H_5NO_2$	Nitrobenzene	$30{\cdot}0 \times 10^{-6}$

Kerr Effect

The production of the property of double refraction in a dielectric by the application of a voltage to electrostatic plates bounding it. The Kerr cell (q.v.) is based on this phenomenon.

Keystone Distortion

The type of distortion produced in a cathode ray tube that produces a scanning pattern of non-rectangular shape similar to a keystone. The actual shape of the picture area affected by Keystone distortion can be seen in Fig. 43, where the outline $ABCD$ encloses the picture area and the dotted rectangle $EFGN$ encloses the desired picture area. It is seen that the shape of the distorted picture is similar to that of the keystone. This kind of distortion may arise in transmission systems of the type employing a cathode ray tube with one-ended mosaic screens (q.v.), for in these cases the cathode ray strikes the screen at an

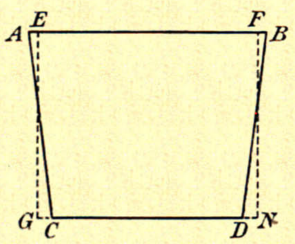

FIG. 43.—Illustrating Keystone distortion.

angle of about 45°, the upper line *AB* of the picture being farthest from the cathode and the lower line *CD* being the nearest. Special precautions must, therefore, be taken with that type of transmitter gear to annul the keystone distortion, otherwise the reproduced picture at the receiver will be correspondingly distorted.

Killer

In reference to phosphorescence of cathode ray tube screens, it is that material that prevents the lag of luminescence after the exciting ray has passed. L. Levy and D. W. West have found a small trace of nickel—about 1 part in 2 millions—to be very effective for this purpose.

L Type Electron Multiplier

The form of electron multiplier illustrated in Fig. 24.

Lag of Fluorescent Screen (see Phosphorescence)

Lamp Screen

A receiver screen composed of a large number of small lamps. The principle of the lamp screen can be seen from Fig. 44. A large panel forming the screen is divided up into a very large number (some thousands) of partitions and in each partition is placed a small electric lamp, shown at *L*. The

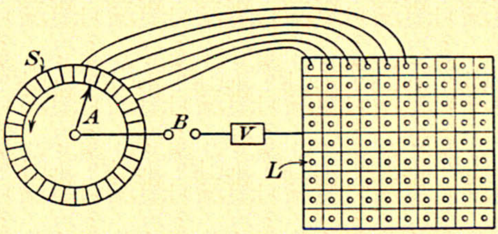

FIG. 44.—Single lamp screen television receiver arrangement.

lamp is in circuit with a commutator strip *S* and a rotating commutator arm *A*. As *A* rotates and makes contact with each strip *S* in turn the circuit of each lamp on the screen is completed momentarily and an electric impulse is given to each lamp. The magnitude of the individual impulses is governed by the light valve shown at *V* and is, of course, dependent upon the light and shade of the picture to be received. It is thus evident that the total light emerging from the lamp screen will represent the picture.

This type of screen has been used for demonstrating to large audiences, and although the definition is limited by the size of the lamp, it has the advantage of reducing the effect of flicker owing to the persistence of light at each lamp, for each lamp is not rendered non-illuminant as soon as the electric supply is cut off from it.

It is possible to further increase the persistence of illumination by connecting a condenser across each lamp. In this case the condenser is charged by the electric impulse transmitted from the commutator, and as the condenser takes some time to discharge, the light emitted by the individual lamps is maintained.

Lateral Image Movement

A movement of the picture image to one side or the other. In the old thirty-line scanning receivers, undesired lateral image movement sometimes occurred owing to defects in the scanning disc.

Leader

In reference to a film, it is the beginning of the film.

Lens Disc

A scanning device in which a helical series of lenses are arranged in a disc which, in operation, is rotated at high speed. The light from the source behind the lens disc is focussed by the lenses on to the picture at the transmitter, and reflected light is picked up by banks of cells in a similar manner to that described under Spot Light Scanning. At the receiver, the source of light is modulated by the signal voltages applied to it and the modulated light is focussed on to the receiver screen.

Lens Drum

A scanning device consisting of a series of lenses mounted on the periphery of a rotatable drum. Lenses for this purpose are generally of the simple convex type (q.v.).

Light Quanta

Light possesses energy by virtue of its wave-length or frequency. The smallest amount of indivisible light energy in a ray of light of frequency μ is given by $h\mu$, where h is a constant termed Planck's constant. This smallest amount of energy is termed the light quanta, and, pursuing the corpuscular theory of light, is often regarded as the kinetic energy of a corpuscle moving with the velocity of light. It will be clear from this that energy in a light beam is not determined by the amount of light but by the wave-length, or frequency of the light.

Light Siren

A device that produces a note similar to that emitted by a siren by means of a light sensitive cell and interrupted light. The light from a source, such as a lamp, is made to impinge on a light sensitive cell, and in the path between light source and cell is arranged some kind of rapidly moving device that interrupts the light falling upon the cell. The electric current in the circuit of the light sensitive cell is dependent upon the amount of light received by the cell, and by interrupting the light beam impinging upon it a series of pulses of current are thereby produced that may be made to actuate an amplifier. These amplified pulses are applied to a sound reproducer, say a

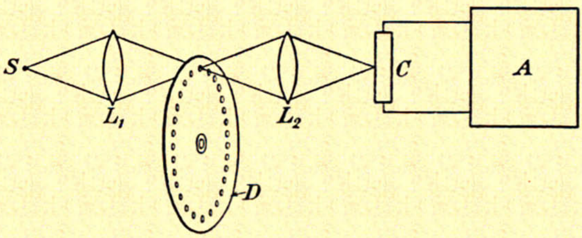

FIG. 45.—The Light Siren.

loudspeaker, to provide an audible signal, or they may be used for synchronising some kind of apparatus.

In Fig. 45 is seen the diagrammatic arrangement of a light siren. Light from source S is focussed by lens L_1 on to a point in the plane of a perforated disc D. In line with the lens L_1 on the other side of D is a second lens L_2 that collects the light passed through the holes and projects it on to light sensitive cell C. To operate the siren, the disc is rotated so that the rays from S to C are interrupted by D to produce the requisite current changes in the input circuit of amplifier A. The frequency of the current changes, and therefore the audible note if reproduced, is $f \times n$, where f is the frequency of rotation of D in revolutions per second, and n is the number of holes in D.

Light Spectrum

The band of colour that is produced by the resolution of a light beam into its component rays. A simple method of doing this is illustrated in Fig. 46. Interposed between a light source *S* and a screen is a prism *P*. As the beam passes through *P*, it is split up, and the different colours of which it is composed

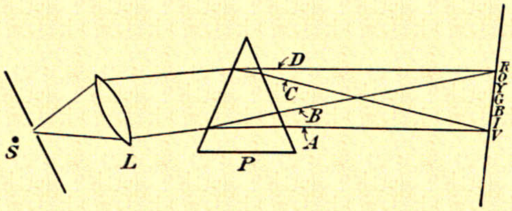

FIG. 46.—Showing how the component colours in a light beam may be seen.

emerge from the opposite side of the prism and may be seen on the screen to be in the order indicated: *R*, red; *O*, orange; *Y*, yellow; *G*, green; *B*, blue; *I*, indigo; *V*, violet. These are known as primary colours.

Light Splashes

Undesired spots that sometimes appear on a reproduced picture, due to a fault in the receiver gear.

Light Spot

The size of the light spot places a limit on the definition obtainable; the larger it is, the lower is the definition. For an eight-inch picture of high definition, the light spot should have a diameter of not more than 0·03 inch.

Light Spot Brightness

In a cathode ray tube the brightness of the light spot on the fluorescent screen is directly proportional to the electron current in the beam and to the accelerating voltage. Another factor, and, of course, a very important one, is the material of which the screen is made, some screen materials being far more sensitive than others. (See Fluorescent Screen.)

Light Valve

Any type of device that effects control or modulation on the light passing through it. (See Kerr Cell and Supersonic L.V.)

Line Corrector

The device employed for correcting any irregularities in the frequency characteristic produced by the length of the cable that connects a modulating device—such as an electron camera—to the modulating apparatus.

Line Frequency

The reciprocal of the line period. It is numerically equal to the number of lines per frame multiplied by the number of frames per second.

Line Frequency Generator (see Line Frequency Time Base)

Line Frequency Time Base

The time base (q.v.) that provides the voltage for deflecting the cathode ray in a cathode ray tube across the fluorescent screen in line sequence. In Fig. 47 is depicted the relation between the line time base voltage and the picture signals with respect to time. A line of scan begins at *A*, and as the voltage provided by the time base increases, the ray moves

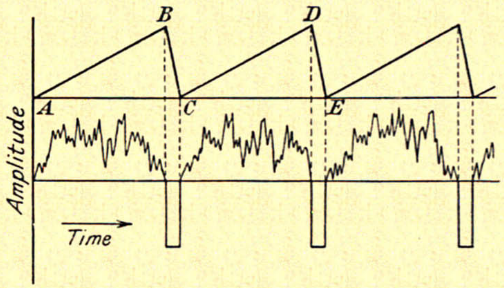

FIG. 47.—The line time base voltage in relation to picture signals.

across the screen to provide a luminosity dependent upon the amplitude of the signal voltage shown underneath the time base curve. At the end of the line *B* a negative synchronising impulse (q.v.) is injected, as shown, during which time the cathode ray flies back to the beginning of the line to start again at *C*. For high definition television the time taken for one of scan, i.e., from *A* to *C*, must be not more than 1/6000th second. It is thus seen that the line frequency time base has to provide a series of saw-tooth waves (q.v.) *ABC*, *CDE*, etc., at line frequency. Compare with Picture Frequency Time Base.

Line Gap

The reduction in steady value of carrier wave corresponding to the synchronising signal in respect of a scanning line. (See Gap Synchronisation.)

Line Image
An image in the form of a line. Such an image is produced by a cylindrical lens, as described under that heading, and may be as narrow as 1/250th of an inch.

Line Lamp
A lamp consisting of a discharge tube with the electrodes separated by a thin length of glass tube, so that when the discharge takes place the illumination is in the form of a line. This type of lamp is frequently used with the mirror screw scanner.

Line Period
The time taken to trace one complete line. This will be equal to the picture period (q.v.) divided by the number of lines.

Lines of Force
Imaginary lines along which the influence of an electric or magnetic force is applied. (See also Electrostatic and Electromagnetic.)

Locking the Time Bases (see Interlocking)

Longitudinal Velocity
Of an electron in a cathode ray beam, longitudinal velocity is the velocity in the direction from the cathode to the fluorescent screen.

Low Definition Pictures
Pictures that are coarse, i.e., that are produced by scanning with a small number of scanning lines. When the picture is dissected line by line, its definition or clearness is a function of the number of lines into which it is cut up. In the extreme limit, where the picture is cut into halves, the reproduction would be unrecognisable as the reproducer responds to the *average* intensity of the line. At the other extreme, when the picture is analysed into a very large number of strips, say 1,000, the eye is unable to observe the difference from the original picture. Between these two limits the definition or quality of reproduction improves as the number of strips into which the picture is cut, i.e., as the number of scanning lines is increased. The early television transmissions by the B.B.C. were of low definition and employed a 30-line scan. High definition is provided with 180 lines of scan, although 240 lines are to be

preferred. Cinematograph reproduction definition is the equivalent of 500 lines. The number of complete picture scans per second governs the definition also, and the minimum number for *high* definition is 25 per second.

Lumen

The measure of light quantity. This is the amount of light emitted by a standard candle throughout unit solid angle. As there are 4π solid angles subtended at the centre of a sphere by its surface, there will be 4π lumens, in all, radiated by unit candle.

Luminous Screen (see Fluorescent Screen)

Lux

A unit of illumination. One lux is equal to a light intensity of one candle power (q.v.) at a distance of one metre, i.e., one metre-candle power.

Magnetic Concentration

The method of concentrating cathode rays by means of a magnetic field. With a cathode ray tube the magnetic field is produced by an electromagnet situated outside the envelope. (See Electromagnetic Focussing.)

Magnetic Deflection

The deflection effected by an electromagnetic field. With cathode ray tubes, electromagnetic deflection may be used, in which case the coil windings are situated in four perpendicular directions round the tube. The deflecting voltages from the time base circuit are applied to these coils and so influence the cathode ray beam that it moves across the screen for scanning purposes as required. One pair of coils deflects the ray in the horizontal direction, while the other pair deflects it in the vertical direction, and the ray is thus moved over the fluorescent screen to cause the light spot thereon to move in the desired manner, as outlined under "Scanning."

Magnetic deflection is at present used in about 80 per cent. of television transmitters and in a fair percentage of receivers. This is because by doing so possibilities of spot distortion on the fluorescent screen are greatly minimised. In both the Farnsworth electron camera transmitter and the Zworykin iconoscope magnetic deflection is employed exclusively.

Magnetic Lens

An arrangement of magnetic field that produces a concentrating effect on a cathode ray, in a similar manner to that whereby an optical lens concentrates light rays. (See Electromagnetic Focussing.)

Magnetic Multiplier

An electron multiplier of the type illustrated in Fig. 25.

Mc/s.

An abbreviation for megacycles per second.

Matching

In order that amplification of the television signal may take place under efficient conditions, the impedance of various coupling circuits must be carefully matched. In particular, the impedance of the photo-cell, which is very high, has to be matched by the coupling resistance to the first stage in the photo-cell amplifier.

Meniscus

A crescent-shaped lens. (See Convergent Meniscus and Diverging Meniscus.)

Metal Rectifier

A rectifying device consisting of layers of metal and usually metallic oxides. The most commonly used metal rectifier is the Westinghouse rectifier in which a plate of copper carries a layer of cuprous oxide which is in contact with a lead plate.

Micron

A unit of length, being equal to 10^{-3} millimetres, or one-thousandth of a millimetre. The symbol for this is μ.

Microphony

The setting up of an electrical disturbance in the output circuit of a thermionic valve by the mechanical vibration of the electrodes. If the electrodes vibrate, the slight alterations in the distance between them is sufficient to produce changes in the operating constants of the valve, with the result that in the output circuit there appear spurious voltages. If the output circuit is coupled to a loudspeaker, a note is set up, usually low pitched, which cannot be eliminated by any electrical measures that are taken. Microphony is not a common fault in modern valves owing to the special construction of the electrode supporting systems and the valveholders.

Micro-Waves

Radio waves shorter than one meter.

Miller Effect

The name given to the action of a thermionic valve that causes the effective input impedance (grid-cathode impedance) to vary. It can be shown that this impedance can be represented by a capacity and a resistance in parallel across the grid and cathode electrodes. Under certain conditions, such as when the load impedance is capacitative, the resistance becomes negative, and when this negative resistance equals the damping resistance of the input circuit, oscillations are produced.

Millimicron

A unit of length, being one-millionth of a millimetre or 10^{-6} millimetres. The symbol is $m\mu$ or $\mu\mu$.

Mirror Arc

A device employed in cinematograph projection apparatus, consisting of an arc placed at the focus of a parabolic reflector.

Mirror Drum

A device in the form of a drum with a series of mirrors on the periphery, used for some methods of scanning in low definition television. In use the mirror drum is rotated at a high speed, and light incident on it is reflected on to the picture to be televised or the receiver screen, as the case may be. For transmission, the light reflected by the view being televised is picked up by banks of cells, as described under "Spotlight Scanning." Scanning in a series of sequential strips is effected by means of the arrangement of the reflectors on the drum, the setting of each reflector surface being at a slight angle to the reflector immediately preceding it so that light incident on it will be reflected to an adjoining strip of the picture.

In Fig. 48 is shown the simplest form of mirror drum scanning device as employed at the receiver. The received picture signals, after amplification and detection in the receiver, are applied to a light valve *V* that provides a light of intensity dependent upon the signal voltages. This fluctuating light source is focussed by a lens system *L* on to the mirrors *M* fitted to the periphery of the drum *D* rotated by an electric motor (not shown). If the drum *D* were stationary, the varying light at *V* would merely be shown at a fixed point *P* as a fluctuating light. If each mirror were at the same angle relatively to each other and the drum were rotated in the direction of its arrow, the fluctuating light would be reflected on a single line on the screen *P* by a series of light rays in the direction of the arrow relevant to *P*. That is to say, for every

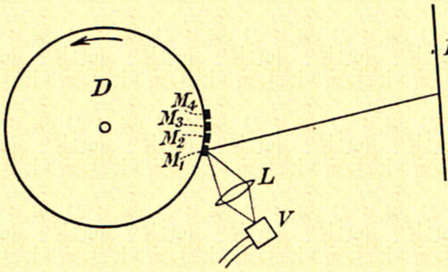

FIG. 48.—Mirror Drum scanning device.

mirror *M* there would be a line of fluctuating light on *P*, but each line would coincide with the preceding ones. If, however, the mirrors on *D* are each inclined at a small angle with respect to each other, the lines of reflected light will fall on different parts of *P*. Further, if this angle between each mirror is adjusted in such a way that the line of fluctuating light on *P* is next to that traced by the preceding mirror, then as the drum is rotated, the mirrors reflect the light over sequential strips in the manner required for scanning (q.v.). Fig. 49 shows a number of scanning lines on the received picture screen, from the mirrors numbered M_1, M_2, etc., as in Fig. 48.

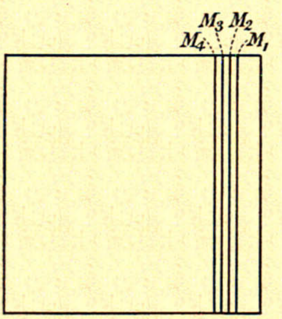

FIG. 49.—The line trace on the picture screen using Mirror Drum scanning.

The following are the main points of advantage of the mirror drum method of scanning as compared with the scanning disc: (1) The mirrors can be made capable of adjustment so that should any of the scanning lines overlap or leave a gap in the picture, the fault can be remedied. (2) Light from each mirror passes over a scanning path (q.v.) that is similar, and all the scanning lines are parallel. (3) As the aperture through which the light beam is projected is the same for all mirrors, there is no variation in size of light spot used for scanning the different parts of the picture. On the other hand, a mirror drum is much heavier than the scanning disc, and this produces a number of difficulties owing to the high speed it has to be made to revolve.

Mirror Screw

A scanning device consisting of a number of mirror surfaces arranged in helical formation about a driving shaft. In operation the shaft is rotated at the picture frequency (q.v.) and as each mirror passes in line with the light source, light is reflected. The light reflected from each mirror constitutes a scanning line of the received picture.

In actual form the mirror screw consists of a series of laminations fitted on to the driving shaft. The light source employed is modulated (q.v.) by the picture signals, and the

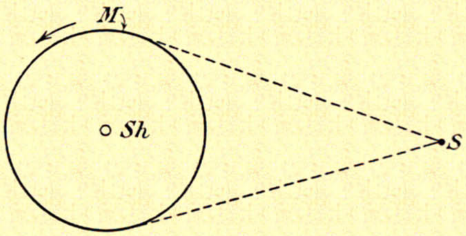

FIG. 50.—Arrangement for using Mirror Screw scanning device.

modulated light is projected on to the surface of the mirrors as they rotate. In Fig. 50 is given a diagram setting out the arrangement employed in operation. As driving shaft *Sh* is rotated by an electric motor, the laminations forming the screw are revolved and the mirrors on the periphery at *M* reflect the modulated light emitted by the source *S*, so for each revolution of the shaft the entire picture area has been scanned. An observer, therefore, sees in the plane of the mirror screw an image of the picture.

Obviously, the definition provided by the mirror screw will be governed by the thickness of each lamination, for this measurement determines the thickness of the scanning line. The actual number of laminations is equal to the number of scanning lines in the reproduced picture, and the size of the picture is the same as the overall plane area of the mirror screw.

One serious limitation of the mirror screw scanner is its cumbersomeness. Owing to the screw being viewed directly, the size of picture is limited to the size of the screw itself, and since for high definition a minimum of 240 mirrors have to be rotated, 25 times per second, it is found impracticable to employ the mirror screw for this purpose.

Modulate-out

Term used to describe the process of preventing the formation of the luminous spot on a fluorescent screen of a cathode ray tube. A high negative bias on the grid may be used to modulate-out.

Modulating Electrode

In a cathode ray tube this is the shield (q.v.) that modulates the cathode ray.

Modulating Cathode Ray

A cathode ray employed in a transmitter tube such as the Iconoscope. It is so called because as it sweeps over the photoelectric layer it discharges the condensers that provide the modulating potentials for the transmitter.

Modulation

When the light intensity produced by a cathode ray on the fluorescent screen is varied in accordance with impressed

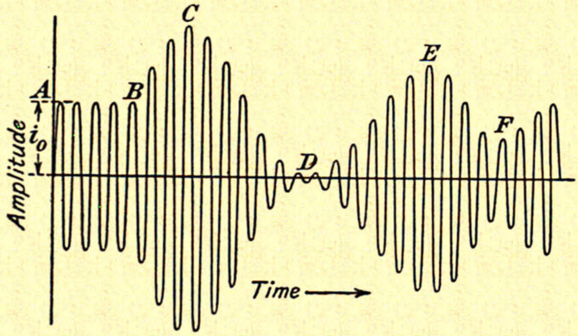

FIG. 51.—Carrier-wave modulated in amplitude.

signals, it is said to be modulated. The extent, or degree, of this modulation is proportional to the variation from the steady or unmodulated brightness of the spot. Modulation is usually expressed in percentage, i.e., 100 per cent. modulation of the ray would mean that the light spot was completely extinguished, whereas zero modulation would indicate that the steady value of luminosity is undiminished. The process of cathode ray modulation is outlined under "Intensity Modulation."

Applied to a carrier wave, modulation means the amount by which the carrier wave is varied. Confining the discussion to amplitude modulation (there are other and more complicated methods of modulating the carrier wave than by amplitude), the degree of modulation is an expression indicating the alteration in carrier wave amplitude to its unmodulated amplitude. Modulation can be explained best by reference to Fig. 51. The unmodulated carrier wave is seen from *A* to *B*, where the amplitude is constant and indicated by i_o. From *B* to *C* the amplitude rises to double the steady value i_o and then drops to zero amplitude at *D*. Now the actual degree of modulation can be found from the expression

$$m = \frac{i_x - i_o}{i_o}$$

where i_x is the maximum amplitude and i_o the steady unmodulated amplitude. In the particular case now being considered, we have

$$m = \frac{2 - 1}{1} = 1$$

which, of course, is 100 per cent., i.e., the maximum degree of modulation possible. It is seen from *D* that the zero amplitude is reached and obviously the carrier cannot be less than this. Although the *maximum* amplitude is considered in the equation above, the resultant minimum has the same difference in amplitude to the i_o value. That is to say, in periods of 100 per cent., i.e., complete, modulation when the maximum amplitude is the value i_o above the steady value i_o, then the minimum value is i_o less than i_o, i.e., zero. Similarly, at 50 per cent. modulation, the maximum value is $\frac{1}{2}i_o$ greater than i_o, and the minimum value $\frac{1}{2}i_o$ less than i_o, as seen at *E* and *F*.

It is important that the process of modulation be thoroughly understood, because it is frequently referred to in this book. (See also Velocity Modulation.)

Modulation Component

That part of a transmitted or received signal that contains the modulation or signal. After modulation (q.v.) of a carrier wave at the transmitter there is obtained a combined carrier and modulation wave, both carrier and modulation components retaining their individual characteristics. This combined wave is transmitted, and at the receiver the wave is passed through a demodulation process (q.v.) to separate the signal voltage, i.e., the modulation component, from the carrier.

Molecule

The smallest possible unit of a chemical substance. The molecule, according to current theory, is constituted by a number of electrons and a positive nucleus. Some of these electrons are "free" in the sense that they can be knocked off the molecule and attracted by a positive electrode. Compare with Ion.

Monitor

A device that provides a check signal. At a television transmitter a monitor stage is necessary in order to ensure that the transmitted picture is satisfactory. In a monitor stage a certain proportion of the signal voltage is shunted away from the main circuit and made to operate a receiver, at which the reproduced check picture is observed.

Mosaic Electrode

A system of elements insulated from each other constituting an electrode, usually the screen, of a cathode ray tube. (See Iconoscope.)

Motor

In electrical work a motor is a device that converts electric energy into mechanical energy. For example, the device that rotates a scanning disc, etc., derives its motive force for rotating the disc from the electric energy supplied to it and hence it is a motor.

Moving Aperture

A means of scanning, using a rotating disc having a series of holes. (See Scanning Disc.)

Multipactor

A type of electron multiplier developed by the American inventor, P. T. Farnsworth. (See Image Dissector.)

Multiple Spiral Mirror Screw

A mirror screw (q.v.) in which two spirals of mirrors are employed. In operation, when the screw is rotated, a shutter device is worked in such a way that the observer sees only half of the complete screw at any instant.

Multiplex Transmission

The transmission of several signals on one carrier wave. Although many systems of multiplex transmission of radio signals have been put forward from time to time, no proposals have yet been formulated for the multiplex transmission of television signals of high definition. This is because the very wide band of frequencies that have to be transmitted in a television signal render it impracticable to impress several signals on a single carrier wave by the known methods.

Multiple Spot Scanning

A method of scanning in which, at the receiver, several light spots are focussed on a common screen. If *n* light spots are required for scanning, *n* sources of light are modulated (q.v.) by the vision signal voltages which are received over the usual vision channel. These modulated light sources have applied to them signal voltages which are at a predetermined phase difference with respect to each other, with the result that the modulated light beams, when utilised at different parts of the scanning device, may be superimposed.

An obvious advantage of multiple spot scanning is that a much greater illumination of the screen takes place, for if *n* light spots are used, the resultant brightness of the picture screen will be *n* times as great as if a single spot were employed.

Multiplying Lens Drum

This is a lens drum, sometimes used for film scanning, which is distinguished from the simple lens drum (q.v.) by the fact

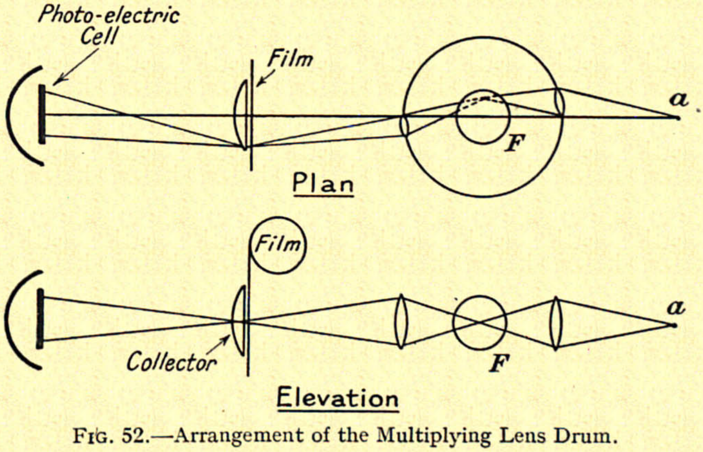

FIG. 52.—Arrangement of the Multiplying Lens Drum.

that light passes through two remotely disposed lenses in the drum. As seen in Fig. 52, an initial scan will be effected in the centre of the drum when light passes through one lens only. When the light has passed through the second and opposite lens in the drum, a second image is formed which is broader, or longer, than the first. This increase in length of the image is effective in increasing the efficiency of the system. A field lens is placed at the centre of drum.

Multi-turn Spiral

A spiral that consists of more than one turn. Fig. 53 shows a scanning disc with two spiral turns. If the apertures ended at *B*, the disc would be the usual single-turn spiral scanner.

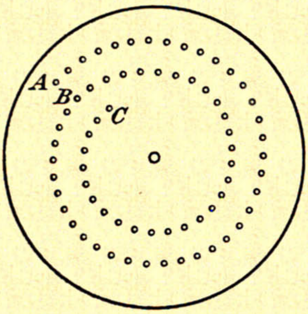

FIG. 53.—A Multi-spiral Scanning Disc.

Multivibrator

A device invented by Abraham and Bloch for the generation of non-sinusoidal oscillations with the aid of two electrically interlocked valves. Fig. 54 shows the multivibrator circuit and Fig. 55 indicates the resultant waveform.

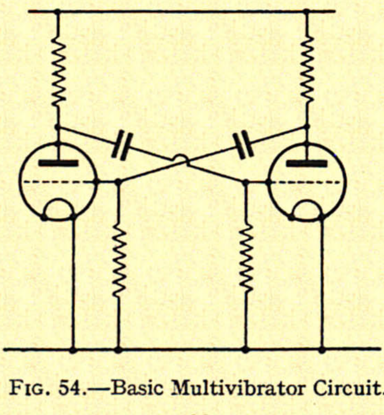

FIG. 54.—Basic Multivibrator Circuit.

The action of the multivibrator is as follows: When the first valve has maximum anode current, induced by zero or positive grid potential, the anode potential will be a minimum, and the coupled grid of the second valve will thus receive minimum bias. This means that the anode current of the second valve will be a minimum, or even cut off altogether. In turn, as the anode potential of the second valve is then maximum, the grid of the first valve is held positive owing to the condenser coupling. When this condition is reached, the grid coupling condenser will begin to discharge until anode current begins to flow in the second valve. When this grid becomes sufficiently positive the electrical state of affairs is reversed, there will be maximum current now in the second valve and minimum in the first valve. This swing over from one condition to the other

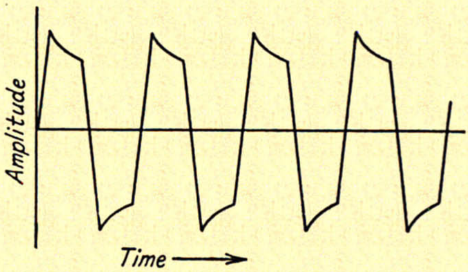

Fig. 55.—Waveform of Multivibrator.

takes place very rapidly and the speed is controlled by the value of the coupling condensers and the grid leak resistances. Application of this circuit has been made to provide a time base for the line and picture scanning of the television picture. (See Time Base.)

Negative Glow

A luminescence round a cathode or negative electrode in a glow discharge tube (q.v.). Negative glow occurs in glow discharge tubes (q.v.). (See Crookes Dark Space.)

Negative Image

An image in which the bright portions of the picture are reproduced as dark parts and the dark portions as bright. This is a fault that occurs when the picture voltage applied to the reproducing device is not in the correct phase.

Negative Impulse

An impulse that results in a diminution of voltage or current. This is shown diagrammatically in Fig. 56, where a current of

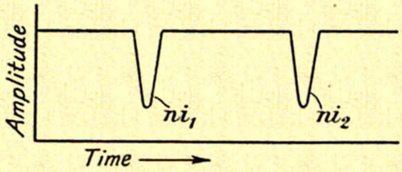

FIG. 56.—Negative impulses are shown at ni_1 and ni_2.

steady amplitude i_0 has two negative impulses ni_1 and ni_2 impressed on it, these impulses producing a reduction in current while they last.

Negative Resistance

That phenomenon that produces the opposite effect to an ordinary resistance in a circuit. If the resistance of a circuit is 10 ohms and there is added 10 ohms of negative resistance, the resultant resistance is zero. An increase in potential difference in a negative resistance effects a *decrease* in current flow.

Neon Lamp

A glow discharge tube (q.v.) in which a gas filling of neon is employed. Neon lamps were widely used in receivers for the low definition transmissions, the most common type being the flat-plate neon lamp. During reception of the television signals, the scanning disc was rotated in front of the cathode plate, the glow on which was varied according to the intensity of the signal voltage. As each individual aperture in the scanning disc moved across the cathode, the instantaneous luminescence was passed through to form one line of the complete picture. It should be noted that the anode, consisting of a small piece of metal, is insulated from the cathode so as to avoid the discharge taking place directly between them. In these circumstances the cathode glows evenly all over its surface at any given voltage. (See Beehive Neon Lamp.)

Neon Time Base

A time base (q.v.) in which a neon lamp (q.v.) acts as discharge path for a condenser. This type of time base, although widely used in the past, has not found employment in modern television receivers owing to its irregularity in operation. The fundamental circuit is given in Fig. 57. When the H.T. voltage is switched into circuit, the condenser *C* begins to acquire a charge at a rate depending on its capacity and the value of resistance *R*. When the voltage at the terminals of the condenser reaches the ignition potential (q.v.) of the neon lamp *N*, a discharge occurs in the latter and the voltage on the condenser drops

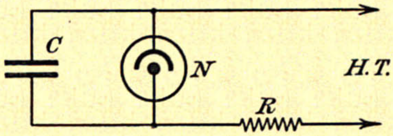

FIG. 57.—Circuit of the Neon Tube Time Base.

back. In practice the value of *C* and *R*, and also the ignition voltage of the neon lamp, are arranged to suit the particular type of cathode ray tube to which the time base is applied, and the purpose for which it is being used.

Nicol Prism

A device consisting of two pieces of doubly refracting mineral, such as calcite, with faces at an angle (usually about 22°) to one of the plane surfaces joined together by a transparent cement. This device is illustrated in Fig. 58, which shows one piece of calcite bounded by *POR* and the other by *RSP*, the faces being cemented along *PR*.

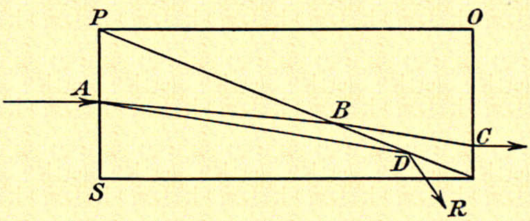

FIG. 58.—Showing how a light ray is split up by a Nicol Prism.

The particular property of a Nicol prism is that it splits an incident light beam into an ordinary ray (q.v.) and an extraordinary ray (q.v.). An incident light beam strikes the face *PS* of the prism at *A*, and one part of the beam goes through the prism as seen along *ABC*, emerging in a direction parallel to the direction of incidence. This is the extraordinary ray. The other portion goes along the path *AD* and passes out from the prism before reaching the surface *OR*. This is the ordinary ray.

The Nicol prism is used in television receivers, usually with a Kerr cell (q.v.), of which it forms an indispensable auxiliary.

Nipkow Disc
An alternative name for an apertured scanning disc. This name is used after Nipkow, who invented it as early as 1884.

Nitrobenzene
This is a liquid which, owing to its high Kerr constant, finds use in the Kerr cell. It is also known as Oil of Mirbane and is prepared by allowing a nitrating acid, composed of sulphuric and nitric acids, to run slowly, with continuous stirring, into benzene contained in large cast-iron cylinders. By suitable means the temperature is maintained first at 25° C, and towards the end of the reaction is allowed to rise to 70°–80° C. Nitrobenzene then separates out in an upper layer above the denser acid and is removed, washed with water and finally distilled in steam.

Noctovision
The science and practice of the operation of means enabling the vision of scenes in the dark. This is generally carried out by means of invisible rays, such as the infra-red rays, which record the scene or picture on a screen or other device that is sensitive to them.

Non-Sequential Scanning
Scanning by lines that are not immediately adjacent to each other. Interlaced scanning (q.v.) is an example.

Oil of Mirbane (see Nitrobenzene)

Opposite Phase
The state of two bodies or electric phenomena when their motion is in the opposite sense. For example, two alternating currents are in opposite phase when the positive peak of one current occurs at the same instant of time as the negative peak of the other. These conditions are represented by the curves in Fig. 59 in respect of currents *a* and *b*. It should be noted that if currents *a* and *b* are of equal amplitude, the resultant current flow in a common circuit is zero, for one current annuls the effect of the other. On the other hand, it is not necessary for both currents to be of the same amplitude to be in opposite phase, for the phase relation is the same regardless of the

individual amplitudes. When currents are in opposite phase, they differ by 180° in respect of their individual cycles, and are, therefore, out of phase by 180°.

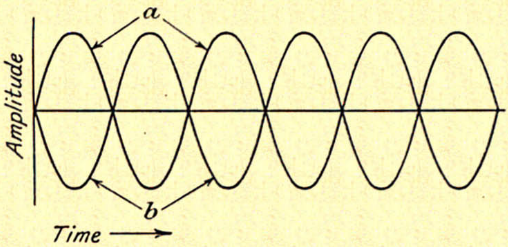

FIG. 59.—Illustrating two voltages of opposite phase.

Optical Centre of Lens

That point in the lens through which rays of light pass without being deviated. In some lenses the optical centre lies inside the lens, but in others it lies outside. It should be noted that *all* rays pass through the optical centre without having their direction altered, even if they are displaced laterally.

Optical Distance

The direct line from an observer's eye to the horizon. For radio and television transmissions on wave-lengths shorter than 8 metres, the direct range is approximately limited to the optical distance. In Fig. 60 is seen an explanatory diagram in which E represents the earth's surface, A the point of transmission at

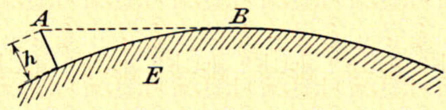

FIG. 60.—The optical distance is $\overline{AB}$.

height h. Then the direct transmission will strike the earth's surface at a point B, owing to its curvature. Distance AB is the optical distance. It is obvious from this diagram that the higher is the point of transmission, the longer will be the optical distance, and, therefore, the greater will be the range of a television short-wave transmission. The optical distance in miles is approximately equal to 1·2 times the square root of the height of the observer's eye in feet. Referring to Fig. 60, this is

$$\overline{AB}\text{ (in miles)} = 1{\cdot}2\sqrt{h}\text{ (feet)}.$$

Optical-Mechanical Scanning System
A method of scanning in which an optical device is combined with a mechanical construction. Examples of optical mechanical scanning are the mirror screw, mirror drum, lens disc, etc.

Ordinary Ray
That portion of a beam of light which, when projected on to double refracting crystals, e.g., Iceland Spar, passes through it in accordance with the ordinary laws of optics. (See Nicol Prism.)

Origin Distortion
The distortion produced in a gas-filled cathode ray tube that results in the appearance of a pair of bright crossed lines in the centre of the fluorescence screen. It is produced by the space charge close to the negative deflecting plate and is due to the ions reducing the deflectional sensitivity at zero field. Origin distortion may be overcome by employment of a special design of deflector plate system in which one pair of plates is split along its length.

Oscillating Field Multiplier
An electron multiplier (q.v.) wherein the potential on the multiplying electrodes is oscillatory in nature. The Farnsworth multiplier is a good example.

Oscillation Plate
That plate of the deflecting system of a cathode ray tube to which the fluctuating potential is applied for deflecting the ray. Compare with Earth Plate.

Oscillight
The name given by P. T. Farnsworth to his cathode ray tube for use at a television receiver. Magnetic concentration of the beam is employed, the focussing coil being situated near the electron gun. Deflection of the ray is also carried out by means of magnetic fields, these being produced by two coils at right angles to each other, the line deflecting coil being at right angles to the gun axis.

Oscillogram
A record obtained from an oscillograph. An oscillogram may be obtained by photographing the waveform produced on the fluorescent screen of a cathode ray tube.

Oscillograph

An instrument for recording or indicating the curvilinear form of a varying quantity. In an oscillograph the light spot is of *constant* intensity and is varied in position on the fluorescent screen according to the voltages provided by the apparatus being tested.

Out of Phase

Bodies or electrical alternating phenomena that do not move in the same sense. For example, if the peaks and minimum values of two alternating currents do not occur at the same instant of time, they are out of phase, and one is leading and the other lagging. (See also Phase, Opposite Phase, In Phase.)

Outgas

To remove the gas from anything. For the satisfactory operation of a hard cathode ray tube or thermionic valve, for example, it is necessary to extract the gas that remains in the metallic electrode system and glass envelope after the vacuum has been produced by pumping. This outgassing process is carried out by heating the electrodes by high-frequency induction, and baking the envelope whilst still pumping. In this way the gases that are forced to the surface by heat are pumped out and there will be less tendency for gas to be produced during the operation of the valve.

Overall Amplification

The amplification provided by a complete receiver or specified part of a receiver. When a receiver is being considered, it is the ratio of the signal voltage at the output terminals to the signal input voltage. In Fig. 61 is seen a schematic representa-

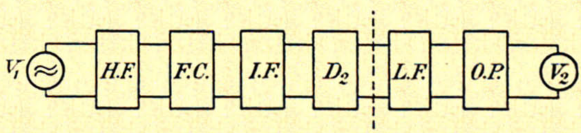

FIG. 61.—Points of measurement to obtain the Overall Amplification.

tion of a superheterodyne receiver, showing at V_1 the voltage applied to the receiver from the aerial and at V_2 the signal voltage in the anode circuit of the output stage. It will be noticed that V_1 has passed through the high-frequency amplifier *HF*, frequency changer *FC*, intermediate-frequency amplifier *IF*, second detector *D*2, low-frequency amplifier *LF*, and output stage *OP*. If the overall gain of the low-frequency stages were required, the input voltage to the *LF* stage would have to be measured as indicated at the dotted line in front of *LF*, Fig. 61, and then divided into V_2.

Panchromatic
Responsive to all the colours of the spectrum.

Paraphase Push-Pull
A push-pull (q.v.) circuit in which opposition in phase at its two input terminals is obtained by means of a resistance-capacity coupled amplifier, so designed that the amplitudes are equal. The type of push-pull described under "Balanced Deflection" is paraphase.

Paraxial Ray
The light ray passing through a lens near its axis.

Period
Time taken for a complete cycle.

Periodicity
The number of periods per second, i.e., the frequency.

Persistence of Vision
A property of the eye that enables the effect produced by a ray of light to continue to influence the optic nerve system after the ray has disappeared. It is, in reality, due to sluggishness in the optical system brought about by the inertia of the retina. When a series of pictures, each showing characters in slightly different positions to others, is viewed by the eye and moved in rapid succession, the optical system of the eye is unable to follow the changes, with the result that the pictures appear to show movements as in normal life. It is found that if these changes are greater than sixteen per second, the eye cannot distinguish them owing to this persistence of vision. A certain amount of flicker will be evident, however, and for this reason both television and cinematograph pictures are shown at a rate of about twenty-four per second. Persistence of vision is of even greater significance in television than in cinematography, however, owing to the fact that in the former the picture is dissected line by line. If there were no persistence of vision, therefore, the eye would follow the scanning spot over the picture line by line and the illusion of viewing a picture would not be present.

Phase

The angular relation of relatively moving bodies or electric currents or voltages at any particular instant. If the electric alternating currents reach their peaks and minimum values at the same instant of time, they are "in phase," whereas if the respective instants of peak and minimum values are different, they are "out of phase." In the upper part of Fig. 62 are seen curves representing two currents of the same frequency in phase with each other. The lower curves in Fig. 62 represent two

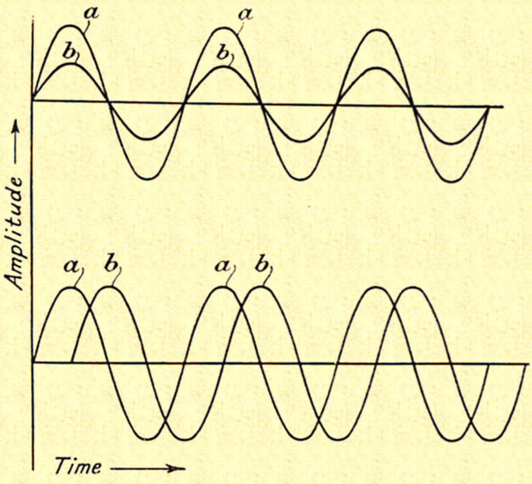

FIG. 62.—Illustrating Relative Phase.

currents that are out of phase by 90°, i.e., one-quarter of a complete cycle. In this case *b* is leading *a* by 90° and the currents are 90° out of phase. If the phase difference were 180°, then the currents would be of opposite phase (q.v.).

Phosphorescence

The persistence of luminosity after the exciting means has passed. Television picture screens can be made to have a certain persistence in luminosity, and they are then referred to as phosphorescent screens.

L. Levy and D. W. West, in the Journal of the Institution of Electrical Engineers, 1936, vol. 79, p. 11, give the following periods of phosphorescence of materials employed for fluorescent screens :

Material.	*Duration of directly excited phosphorescence.*
Calcium tungstate	8 microseconds
Cadmium tungstate	8 microseconds
Willemite	2–8 microseconds
Zinc Phosphate	About 0·25 second
Zinc Sulphide with nickel "killer"	Too small to be measured (fraction of 1 microsecond)

Phot

A unit of illumination, being equal to one lumen per square centimetre.

Photo-Current

The total electric current provided by a photo-electric surface in response to the impinging light rays.

Photo-Electric Cell

A device that provides a varying electric current in response to variations in light that reaches it. The photo-electric cell is used very considerably in television transmitters and also in facsimile telegraphy (q.v.) and various commercial apparatuses. In construction the photo-electric cell consists of a glass bulb, which may or may not be evacuated, inside which are mounted two electrodes, a cathode and an anode. The cathode consists of a layer of a substance such as potassium or cæsium that emits electrons when a ray of light impinges on it. Electrons thus set free are attracted to the anode that is held at a positive potential by means of an external battery. In circuit with the anode is an amplifier which magnifies the voltage changes produced by the varying electron current provided by the light intensity fluctuations. If these amplified fluctuations are applied to the radio transmitter, they are sent out as a picture signal.

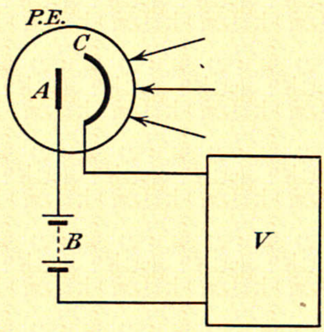

FIG. 63.—Basic circuit for using Photo-electric Cell.

It is seen from the outline given above that the photo-electric cell is the medium whereby the light intensity fluctuations are translated into electrical current or voltage fluctuations for actuating a power circuit. In form the cell may be very small, about the size of an ordinary thermionic valve, or it may have a diameter of up to sixteen inches, depending upon the use to which it is to be put. The principle of operation is the same in all cases, however, and is illustrated in Fig. 63. Light rays indicated by the arrows strike the cathode *C* of photo-electric cell *PE*. Electrons thus liberated are drawn to *A* by the electric field due to the positive potential applied to it by the battery *B*. As the light intensity of the rays reaching *C* varies, so will the number of electrons liberated, and consequently the amount of current flow round *A*, *B*, *V* and back to *C*. *V* is a valve amplifier. Current or voltage variations are thereby produced that correspond to the intensity of the light rays reaching *C*.

Various materials are photo-electric, i.e., that are suitable to act as cathode in a photo-electric cell, but the most commonly used substance is cæsium. Other possible cathode materials are cuprous iodide, alkali metal, uranium.

Photo-Electric Effect

The phenomenon in which a light ray releases electrons from a substance. The operation of the photo-electric cell (q.v.) is based upon the photo-electric effect.

Photo-Electric Screen

A type of screen used in some forms of cathode ray tube, consisting of a compact arrangement of minute photo-electric cells, each insulated from each other. In one form the photo-electric screen consists of a large number of deposits of photo-electric material on a mica sheet, which is situated at the large end of a cathode ray tube. Photo-electric screens are often employed in cathode ray transmitting tubes, an image of the picture to be transmitted being projected on to the screen, the photo-electric elements of which emit electrons according to the intensity of the light impinging on them. (See also Iconoscope, Image Dissector.)

Photo-Electric Sensitivity

The facility with which a layer emits electrons in response to light rays that impinge on it. If one photo-electric layer of a given area emits twice as many electrons as another layer when the same intensity of light reaches it, then the first layer must be twice as sensitive as the second. Photo-electric sensitivity is measured in micro-amperes of electric current emitted by the cell per lumen (q.v.) of light reaching the sensitive layer.

Photo-Electric Threshold

From the expression

$$h\mu = \tfrac{1}{2}mv^2 + e\phi$$

given in the description of the work function, it will be apparent that if the energy of the photon (q.v.) does not exceed that required just to liberate the electron from the surface, then there will be no emission. As the energy of the photon is determined by the wavelength of the light, then we define the threshold wavelength or the photo-electric threshold as that wavelength at which the emission begins. If the wavelength is shorter than this critical value, there will be photo-electric emission; if longer, then there will be no emission. It will be appreciated that the determination of the photo-electric threshold is a means of direct computation of the work function because for the threshold wavelength we have

$$h\mu = e\phi$$

In the above expression μ is, of course, the frequency; that is, the reciprocal of the wavelength.

Photo-Electrons

The electrons emitted from a photo-electric substance in response to impinging light rays.

Photolytic Cell

A type of photo-electric cell in which two plates are in contact with a liquid dielectric or electrolyte, one of the plates being covered with a photo-electric material.

Photometry

The science of measuring light.

Photon

In most recent times it has been shown that the properties of light waves resemble very closely those of material particles. Energy liberated by light is not continuous in that it seems to expend itself in discrete quantities, termed quanta, which, in themselves, do not appear to be divisible. The energy in a light beam is proportional to the frequency of the light and is given by

$$h\mu$$

where μ is the frequency and h is a constant, known as Planck's constant (q.v.). As this energy is purely kinetic in virtue of the speed of the light, then on division by the square of this speed we have a quantity possessing the dimensions of mass, for

$$\text{kinetic energy} = \tfrac{1}{2}mv^2$$

so that

$$\text{mass} = 2(\text{kinetic energy})/v^2$$

and is thus proportional to $h\mu/v^2$.

As the light is thus corpuscular in nature it may be regarded as comprising corpuscles possessing a mass of $h\mu/v^2$. This imaginary corpuscle is often referred to as the photon.

In the following table the masses of some light quanta are given. In the first column is given the wavelength of the light, and in the second column, the frequency. Multiplication of the frequency by Planck's constant yields the energy of the photon in the third column and division by the square of the light velocity gives the apparent mass. In the final column the ratio of the quanta mass to that of the electron is given. (The mass of the electron is $9{\cdot}0 \times 10^{-28}$gm.)

Wavelength in Angstroms	*Frequency*	*Energy in ergs hμ*	*Mass of Photon*	*Mass of Photon / Mass of Electron*
10^4	3×10^{14}	$1{\cdot}96 \times 10^{-12}$	$2{\cdot}2 \times 10^{-33}$	$2{\cdot}4 \times 10^{-6}$
1	3×10^{18}	$1{\cdot}96 \times 10^{-8}$	$2{\cdot}2 \times 10^{-29}$	$2{\cdot}4 \times 10^{-2}$
10^{-3}	3×10^{21}	$1{\cdot}96 \times 10^{-5}$	$2{\cdot}2 \times 10^{-26}$	$24{\cdot}2$
$24{\cdot}2 \times 10^{-3}$	$1{\cdot}24 \times 10^{20}$	$8{\cdot}1 \times 10^{-7}$	$9{\cdot}0 \times 10^{-28}$	1

In the X-ray region, for wavelength h of $24{\cdot}2 \times 10^{-3}$ Angstroms, the mass of the photon is equal to that of the electron.

Pick-up

The device employed at the transmitter for receiving the light rays constituting the picture. For example, the Emitron camera and image dissector (q.v.) are pick-ups.

Picture Element

The elemental area into which a picture is separated for purposes of scanning. The smaller the elements into which a picture can be dissected, the greater is the definition or amount of detail provided. The number of picture elements in a picture is roughly proportional to the square of the line frequency.

Picture Frequency

The reciprocal of the picture period, i.e., the number of times in one second a complete picture is scanned. It is found that if 16 pictures per second are shown, the eye cannot respond to the rapid light changes and gives the impression that one picture is being shown. In this case the picture frequency is 16. To avoid flicker (q.v.) 25 pictures per second are employed in television transmissions.

Picture Frequency Time Base

The time base that provides the voltage for the deflecting plates of a cathode ray tube for deflecting the ray, at picture frequency, in the direction at right-angles to that due to the line frequency time base (q.v.). As the ray moves horizontally across the fluorescent screen line by line, the voltage provided by the picture frequency time base causes the ray to move vertically from top to bottom, so that each line of scan is adjacent to the preceding, or, in the case of interlaced scanning (q.v.), in the correct sequence. The picture time base is thus complementary to the line frequency time base, and it is essential for the satisfactory operation of the cathode ray tube

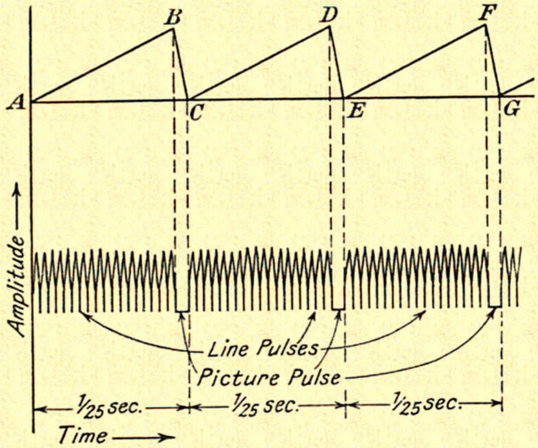

Fig. 64.—Illustrating the relation between the picture frequency synchronising signal and the picture signals.

that these two time bases should operate in correct relation to each other.

In Fig. 64 is shown diagrammatically the general relation between the picture frequency voltage provided by the time base and the picture signals. A series of line scans begin at *A* and end at *B*. As these scans proceed, the voltage provided by the picture frequency time base gradually increases and the position of the ray is thus moved down the picture screen from top, corresponding to *A*, to the bottom at *B*. From *B* to *C* the ray flies back to its starting point at the left-hand corner of the picture, and during this time the picture frequency synchronising impulse is injected, as shown. Thus time *ABC* represents one complete picture scan, which, for high definition, must not take longer than 1/25th second. During this time, 240 line synchronising impulses have been injected into the signals, as indicated in Fig. 64.

Picture Gap
The break in carrier transmission corresponding to the synchronising signal in respect of the picture frequency. The picture gap is usually of longer duration than the line gap. (See Gap Synchronisation.)

Picture Gate
The opening in a projector through which light, modulated by the picture film, passes on to the screen.

Picture Period
The time occupied by the scanning of one complete picture. This is at most 1/25th of a second for high definition.

Picture Ratio
The ratio of the width of the picture to its height. This ratio has an important influence on the definition provided by the scanning. (See Definition.)

Pinch
That part of a cathode ray tube or valve next to the base on which the electrodes are mounted.

Pincushion Distortion
The distortion produced by optical systems that results in the sides of a square image being curved like those of a pincushion.

Pitch Control
The control for the purpose of ensuring that only one raster (q.v.) appears on the picture screen.

Planck's Constant
The constant which appears in the expression for the amount of energy in a single light quanta (q.v.), or photon (q.v.), has the dimensions of action, and is termed Planck's constant. It has a value of

$$h = 6{\cdot}55 \times 10^{-27} \text{ erg sec.}$$

Plano-Concave Lens

A lens with one surface plane and the other curved inwards as illustrated in Fig. 65. This type of lens is diverging (q.v.).

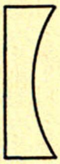

Fig. 65.—Section of Plano-Concave Lens.

Fig. 66.—Section of Plano-Convex Lens.

Plano-Convex Lens

A lens with one surface plane and the other curved outwards, as shown in Fig. 66. This type of lens is converging (q.v.).

Plastic Distortion

A type of distortion that may occur in a cathode ray tube reproducer due to a weak reception of the synchronising signal.

Polarimeter

An optical device that measures the amount of rotation of plane polarised light effected by certain "active" materials such as sugar. Hence the alternative term "Saccharimeter."

Polyhedral

Several sided. Rotating mirror drums are polyhedral reflectors.

Positive Column

The column of luminescence produced by an anode or positive electrode in a discharge tube. This is similar to the Positive Glow, but a column usually implies a more extended surface of glow.

Potential Divider

A device from which a number of different voltages from a single-voltage source can be obtained. The most commonly used type of potential divider consists of a number of resistances in series, the various voltages being tapped off the resistances. It is usual to supply the different electrodes of a cathode ray tube with their respective voltages by means of a potential divider, and one simple method of doing this is illustrated in Figs. 24 and 25 in respect of electron multipliers. The full direct voltage provided by the power unit is supplied to the terminals marked H.T.+ and H.T.—. In series between these terminals is a series of resistances, and the voltage drop along each is proportional to the value of its resistance. To the output electrode *O* is applied the full H.T. voltage, after which a drop occurs in each resistance, the reduced voltage available along the respective resistances after each voltage drop being applied to an electrode nearer the cathode. This voltage may be made adjustable by a tapping along the resistance which, therefore, by itself constitutes a variable potentiometer.

Primary Colours

The colours into which the light spectrum (q.v.) can be divided by the eye.

Primary Electrons

The electrons that are emitted by a body in the first instance. This term distinguishes from secondary electrons (q.v.) that are emitted from a body as a result of the impact on it of the primary electrons.

Priming Grid (same as Suppressor Grid)

Prism

A piece of glass with two plane faces that are not parallel and, usually, rectangular in shape. The prism possesses the property that light may be totally reflected by it and the reflected ray passes out of the prism at an angle of 90° with respect to the incident ray. This is illustrated in Fig. 67, which shows the incident ray at *A* passing through the side of the prism to meet the surface at *B*. From this point it is reflected and goes in the direction indicated by the arrow at *C*. It should be noted that reflection from *B* does not take place due to the nature of the surface, for the prism is completely transparent, but is due to the angle at which the incident ray meets the surface at *B*.

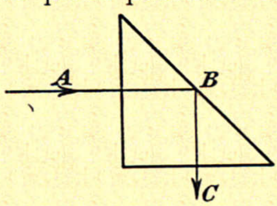

FIG. 67.—Showing the effect of Prism on a beam of light.

Projector-Lens

The lens used in some optical systems, such as mirror drum scanners, for casting an image of the light source on to an object, such as a rotating reflector.

Push-Pull

The system of amplification in which the voltage to be amplified is applied to two valves in opposite phase and equal in amplitude. As the anode current of one valve increases, that of the other valve decreases. In Fig. 68 is seen the circuit of a push-pull amplifier. Voltages from amplifier *A* are applied to the primary winding of the push-pull input transformer T_1, the secondary winding being centre-tapped and connected to the grids of the push-pull valves V_1 and V_2. Now when signals pass through the amplifier the voltage at one end of the secondary of T_1 will be opposite in phase to that at the other end. That is to say, when the grid of V_1 is, say, 10 volts positive, the grid of V_2 is 10 volts negative with respect to the centre tapping and the common cathode connection. It should be noticed also that whereas in the example just given there are 20 volts available at the ends of the secondary of T_1, only 10 volts are applied to each valve. The input voltage is thus halved and,

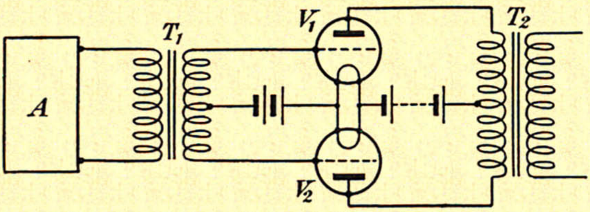

FIG. 68.—Push-pull circuit for radio reception.

consequently, so also is the effective amplification provided by the stage.

In the output circuit of V_1 and V_2 the voltages produced by the fluctuating currents are added in the primary winding of the push-pull output transformer T_2. The steady currents due to the application of the operating voltages to the valves, however, flow in opposite directions, and thus the magnetic fields produced thereby is cancelled out. This is a great advantage for many purposes in radio and television and accounts for the common use of a push-pull amplifier. There are other advantages of a push-pull connection, such as an increased capability of the stage to handle a large power, better quality in reproduced voltage, and greater efficiency of operation of the valves.

The term push-pull is applied not only to amplifier valves but also to any type of connection wherein the voltage is applied to the load in opposite phase and equal in amplitude. For example, if diodes (q.v.) were joined across the secondary of T_1 instead of triodes, as shown in Fig. 68, this would still be a push-pull connection, although there would be no amplification. Deflector plates are often connected in push-pull, one method of doing this being shown in Fig. 69. Each pair of deflector plates is connected to a transformer secondary winding with centre point earthed, the ends of each winding being

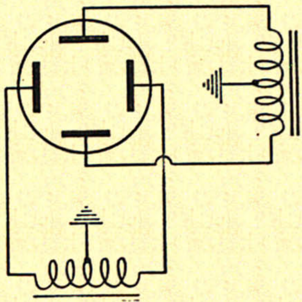

FIG. 69.—Push-pull arrangement for deflecting plates.

joined to the plates as shown so that at any instant the voltages at the individual plates of any pair are in opposite phase. Balanced deflection (q.v.) is another example of the practical application of push-pull in television.

Push-Pull Sound Track
A system of sound recording in which the positive and negative half waves are recorded on separate tracks. During reproduction the records are passed in front of two photo-electric cells (one for each track) which feed a push-pull amplifier. The push-pull sound track system greatly reduces the background noise level in reproduction.

Quadratic Distortion
The distortion produced by the shape of the characteristic of a detector of television or radio signals that usually follows a square or quadratic law over at least a portion of its length.

Quasi-Optical Waves
Radio waves that obey optical laws of propagation in many respects. These are on wavelengths below 8 metres.

Raster
A term derived from the German. It indicates the general formation of the scan. Thus a line raster may be used to denote the formation of the television scan in contradistinction to

point raster indicating the formation of the reproduction of photographs in the newspaper. The raster, when specifically referred to, may be taken to denote the unmodulated light spot scan of a television picture.

Reciprocating Mirror
A mirror that is moved backwards and forwards. Reciprocating mirrors have been used in mirror drum scanning systems.

Record Carrier
The material on which light sensitive substance is coated, the record or picture being made photographically on to the light sensitive substance.

Rectifier
The component in a circuit that provides unidirectional voltage pulses from alternating voltage. This is similar to the definition of "Detector," except that the latter is referred to in connection with high-frequency voltages. The term rectifier is used almost exclusively in connection with low-frequency alternating voltage, i.e., mains supply voltage. Such a rectifier may be a thermionic two-electrode valve expecially designed to handle considerable power, or a copper-oxide rectifier.

Re-entrant End
The end of a cathode ray tube that is doubled back inside the main envelope for the purpose of supporting electrodes.

Reflecting Echelon
An optical mirror in the form of an echelon. The property of the reflecting echelon that is used in television work is its ability to split up an incident light beam into a series of separate rays. This is effected by virtue of the difference in length of the path of each component ray produced by the stepped reflectors. In Fig. 70 is drawn the section of a reflecting echelon, showing at *a*, *b*, *c* and *d* four reflecting surfaces. The splitting up of the light beam is illustrated in Fig. 71, which shows the incident light beam at *B*, falling on the four stepped reflectors *a*, *b*, *c* and *d*. The path of the beam to mirror *b* is greater than

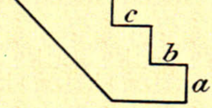

FIG. 70.—Section of a reflecting Echelon.

to *a*, and similarly it is greater to *c* and *d*, as indicated. This causes the reflected light rays to be projected along different

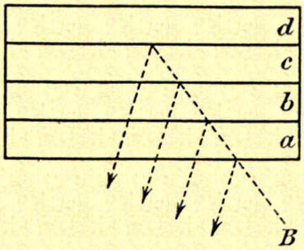

FIG. 71.—The effect of a reflecting Echelon on a beam of light.

paths, as shown by the arrows, and a series of separate rays are produced. These rays can be used independently.

Reflection, Laws of

There are two fundamental laws of reflection that are of interest from the point of view of television. They are as follows:

1. That the incident ray and the reflected ray are in the same plane, which includes the normal (or perpendicular) to the reflecting surface.
2. That the angle of incidence equals the angle of reflection.

These laws may be explained by reference to Fig. 72. Here, the plane reflecting surface is *ABC*, the incident ray is *DB*, and the reflected ray is *BE*. According to law 1, rays *DB*

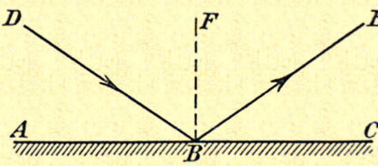

FIG. 72—Illustration for describing the Laws of Reflection.

and *BE*, together with the perpendicular *BF*, all lie in one plane. Law 2 states that the angles *DBA* (the angle of incidence) and *EBC* (the angle of reflection) are equal.

Refracting Echelon

An optical arrangement in the form of an echelon (q.v.) for refracting light. One such arrangement is illustrated in section in Fig. 73, which shows a series of pieces of glass *a, b, c, d,* one on top of the other, each piece being of different width to the others but of the same thickness. The degree of refraction provided by each component in the echelon to a ray of light passing through it is proportional to the actual length of glass traversed. A beam of light falling on an echelon of this type will, therefore, be split up owing to the varying amount of refraction produced in the different pieces of glass. The result of this is seen in Fig. 74. A beam of light *B* falling on the echelon is split up in the manner indicated by the broken lines passing through the echelon. There emerges from the other side of the echelon four individual components of the incident light beam *B*.

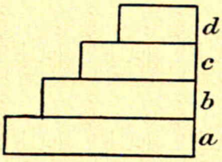

FIG. 73.—Simple Refracting Echelon.

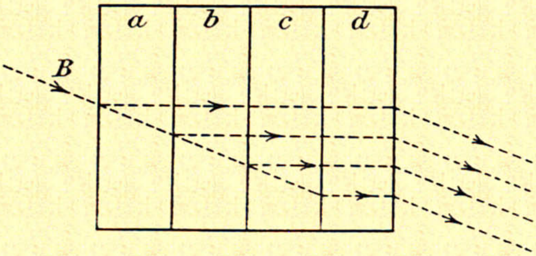

FIG. 74.—Showing how a light beam is split up by a Refracting Echelon.

The principle outlined above is employed in one well-known system of television reception. Other types of echelon configuration are possible, but the method of operation is similar in all cases. Compare with Reflecting Echelon.

Refraction

The bending of rays when they pass from one medium to another of different refractive index. Refraction of light rays is effected by water or glass or other transparent substances. In the case of a cathode ray passing through an electric or magnetic field refraction takes place owing to the attraction and repulsion that occurs in the space through which the ray passes.

Relaxation Oscillation

An oscillating current whose value increases comparatively slowly in one direction and then falls rapidly to the initial value. This type of oscillation is produced by charging and discharging a condenser. A good example of relaxation oscillations is provided by many of the circuits used to produce the time base (q.v.) of a cathode ray tube.

Resistance-Capacity Amplifier

The type of amplifier in which the coupling between successive valves consists of resistances and condensers. This type of coupling is used a great deal in television amplifiers owing to the adaptability of the design for amplification of the large band of frequencies that are employed. The fundamental circuit of a resistance-capacity amplifier is given in Fig. 75. Input voltage is applied to the grid and cathode of V_1, and

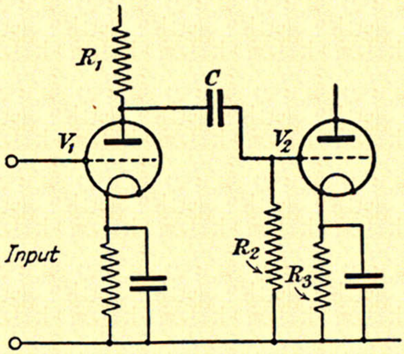

FIG. 75.—Resistance-capacity coupled amplifier circuit.

amplified voltages are produced across R_1 owing to the corresponding fluctuations in anode current. These voltages across R_1 are applied via coupling condenser C to the grid of V_2. A grid leak resistance R_2 is employed to prevent the valve V_2 being blocked by an excessive grid negative charge that might otherwise accumulate on the grid condenser C. Grid bias for V_2 is obtained from the voltage drop down R_3.

Retardation

When referring to the phenomena of polarised light, by retardation is meant the path difference between the two components of plane polarised light passing through a doubly refracting medium. This path difference is usually expressed a fraction of the wavelength. Thus when $\phi=\frac{1}{2}$, we mean that one component has advanced one-half wavelength on the other, or, alternatively, one component has suffered one-half wavelength retardation.

Retentivity of Fluorescence

The quality of a fluorescent material that causes the illumination to remain visible after the light spot has passed over it. In a cathode ray tube the retentivity of fluorescence must not be too great, otherwise the picture will be blurred, owing to the luminescence due to one frame of scanning being mixed with that of the subsequent frame. On the other hand, the retentivity of luminescence should not be too low, for this will provide insufficient brightness in the reproduced picture. (See also Phosphorescence.)

Retina

The screen at the back of the eye on to which an image of a picture is focussed by the pupil which acts as a lens. From the retina the vision impression is passed to the brain by the nerves. (See Eye.)

Return Deflection (see Fly-back)

Return Trace

An alternative name for fly-back.

Rim Ray

The light ray passing through a lens near its edge or rim. Compare with Paraxial Ray.

Ripple Distortion

The distortion produced in the reproduced picture on the fluorescent screen of a cathode ray tube by the mains ripple in the electric supply. This distortion is due to the picture having wavy sides instead of straight sides, the scanning lines being thereby displaced with respect to each other. Ripple distortion can be overcome by providing a very efficient smoothing system in the mains supply to the time base circuits, or by special circuits which have as their object the compensation of the ripple voltage in the circuits connected to the deflecting plates.

Roentgen Effect

If a beam of plane polarised light passes through a thin metallic film, then the plane of polarisation will be rotated in accordance with the intensity of magnetisation of the film. This is the Roentgen Effect. In a particular case the film may be of soft iron and of a few molecules thick so that the light will be not greatly absorbed. The specific rotation, that is the rotation per unit thickness per unit field strength, is extremely high.

Saturation

In the study of thermionics saturation indicates the state wherein maximum current is flowing between cathode and anode for given conditions of operation. The conditions which control the saturation are (1) the anode potential and (2) the distance between the cathode and the anode. For a given potential difference E and distance between the electrodes d, whatever the emission from the hot cathode, the current reaching the anode is given by the expression

$$I = K \ (E^{3/2}/d^2)$$

when the cathode and anode are two parallel electrodes and K is a constant. Although far more current could be supplied by the hot cathode, this current cannot be drawn to the anode owing to space charge (q.v.).

Saw-tooth Waveform

A waveform of the type illustrated in Fig. 64, *A* to *C*, similar in shape to the teeth of a conventional saw. The voltage and current required for scanning with a cathode ray tube have to have a saw-tooth waveform, as described under Time Base, Line Frequency Time Base and Picture Frequency Time Base.

Scanning

The process of dissecting a picture to be transmitted, or reconstructing a picture to be reproduced. Various methods of scanning are employed, and many more have been proposed or actually used in the past. These are outlined under Scanning Disc, Scanning Systems, Mirror Drum, Mirror Screw, Interlaced Scanning. The basic principle of scanning is given under Scanning Disc.

Scanning Disc

A rotating disc provided with a helical series of apertures, used for scanning. This device was employed in the earliest experiments in connection with scanning, and was actually patented by Nipkow, in Germany, in 1884. The process of scanning can be seen from Fig. 76. On a shaft *S* is fitted a thin metal plate or disc *D* into which a series of holes *A* has been made. An electric motor is coupled to the shaft *S* and when this motor is supplied with power it rotates at a predetermined speed and carries *D* with it. As the disc moves round, the apertures *A* sweep across an area *P* which represents the size of a picture to be scanned. Owing to a slight difference in the distance of each aperture from the centre of disc, each one sweeps over a slightly different part of the picture area. The exact position of each aperture is such that closely adjacent areas of *P* are scanned by successive apertures, so that by the time the last aperture sweeps over the picture, the entire picture area has been scanned.

If this complete scanning process is carried out slowly, the eye can distinguish the apertures moving over the area *P*, which may be, for example, a neon lamp to which the picture signals are applied. The brightness of the light at the lamp is proportional to the voltage representing the signal at any instant, so that as the scanning aperture moves across the neon

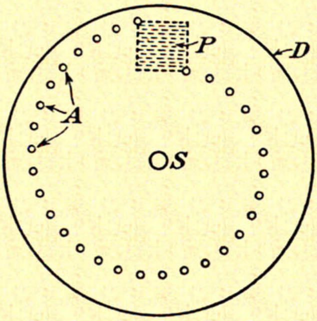

FIG. 76.—Process of scanning with Scanning Disc.

lamp, the light passing through forms the required intensity for the part of the picture corresponding to the position of the scanning aperture. If the aperture moves slowly, therefore, a series of moving light sources appears to the eye. As the speed of the apertured disc increases, lines of light develop and finally, as the correct speed of rotation is reached and the persistence of vision (q.v.) becomes effective, the series of lines merge into one complete picture, the light intensity at each point being that corresponding to the required picture at that point as produced by the vision signal voltages on the neon lamp.

The above outline is the principle of scanning and is applicable to the cathode ray tube, with obvious modifications in the actual method of producing the scanning effect. Read also the notes under "Low Definition" and "Persistence of Vision."

The construction and operation of a scanning disc presents many problems. For example, unless the apertures are in good spiral alignment the picture will not be scanned properly; if the distance between the holes along the radius of the disc is too great, black lines appear in the picture, whereas if the holes are too close together along the radius, the margin areas of each aperture are scanned twice and give an unclear picture. When efforts are made to rotate the disc rapidly to provide high definition, difficulties are encountered due to the centrifugal force on the disc.

Scanning Path

The actual path traced by the scanning spot on the screen or picture televised. When an apertured scanning disc is employed, the scanning path is slightly curved, as shown in an exaggerated form in Fig. 77. The curvature of the path becomes greater as the hole in the disc that produces the scan is nearer the centre of the disc. This curvature in the scanning path is a

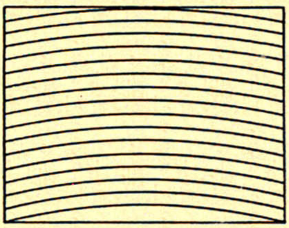

FIG. 77.—Showing the scanning path when using Scanning Disc.

defect and produces a certain amount of distortion in the picture reproduced.

In a cathode ray tube the scanning path is straight but sloping, and the defect mentioned above is not present. As seen in Fig. 30, the scanning paths are all parallel to each other, separated by the distance the light spot travels vertically during the fly-back time (q.v.). Compare with Fig. 49.

Scanning Systems

Various methods have been tried out for scanning a screen besides the sequential horizontal or vertical line scan given under "Scanning Disc." Interlaced scanning (q.v.) is one example. The following methods are either in use or are possible ways of scanning that have particular advantages and have been tried out with varying degrees of success.

1. Scanning with greater detail in one area than in others. In many pictures the centre of interest is not distributed over

the entire picture surface, but lies in a comparatively small area. If this small area were scanned in greater detail than the remainder of the picture a considerable reduction would be effected in the frequency band occupied by the picture transmission as compared to that necessary if the entire picture were scanned to give a high definition. At the same time, the area of picture outside the centre of interest, although of lower definition, would contribute to the overall value of the picture. In systems of this nature it is necessary to interchange the picture areas of fine and coarse scanning so that as the area corresponding to the centre of interest moves, the finely scanned area may be altered with it.

2. Transmitting simultaneously several areas of one picture. In this method the picture is divided into a small number of parts, say, three to six, and each part is treated just like a separate picture, i.e., it is scanned separately, transmitted over a separate channel if necessary, and at the receiver has a separate path to the receiver screen. This makes the receiver much more complex than in the more normal single-area picture. When the Derby was televised some years ago, this method was used and the picture was divided into three picture areas.

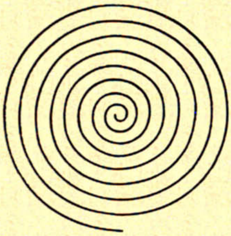

Fig. 78.—Scanning path when using a Spiral Scan.

3. Spiral Scan. In this method the picture area is scanned by means of a helical trace of the light-spot, as shown in Fig. 78, instead of in a series of lines. Great difficulties are encountered in this system, which has not been adopted as the normal practice.

4. Scanning different pictures which are combined at the receiver. This method is useful for the type of picture that represents different scenes; for example, if a person is supposed to be dreaming of the sea, one picture scanned would be the person and the other would be a sea view. These two objects are scanned separately at the transmitter and impressed on two different transmitted carrier waves. The two scenes are separately reproduced at the receiver and shown in appropriate portions of the receiver screen. (See also Fader.)

Scansion

The process of scanning. This is an American term.

Screen

Any surface on to which the picture is projected for purposes of viewing by an observer. In cathode ray tubes the screen is made of fluorescent material (see Fluorescent Screen), but in mechanical scanning systems the screen may take one of a large variety of forms, as outlined under the different systems.

Screen Charge

The charge on a fluorescent screen of a cathode ray tube due to the electrons striking it. This charge is negative in sign. Secondary electrons (q.v.) are emitted by the screen due to the high velocity of the primary electrons (q.v.), and these produce a steady condition known as the charge on the screen. Usually, the potential of the screen is slightly less than that of the anode.

Screen Grid

A grid used in cathode ray tubes for various screening purposes and in screen grid and other radio valves for shielding the control grid from capacitative effects with respect to the anode.

Screen Grid Valve

A thermionic valve having a screen grid. The term is usually used in reference to a tetrode (q.v.).

Screen Sensitivity

Capability of the fluorescent screen to fluoresce in response to the impingement of the cathode ray. The brighter the spot of light provided by the screen for a given power in the ray, the greater is the screen sensitivity.

Second Anode

In a cathode ray tube the anodes are numbered in respect of their distance from the cathode.

Second Detector

The valve in a superheterodyne receiver (q.v.) that detects or rectifies the voltage provided by the intermediate frequency amplifier. It is the equivalent of the detector in a straight receiver (q.v.). The vision reproducing circuit in a television receiver is fed from the second detector or the following amplifier. Compare with Frequency Changer.

Secondary Electrons

The electrons that are liberated from a conductor by the impact of other electrons from outside, termed the primary electrons. The number of secondary electrons liberated by a primary electron depends upon the velocity of the primary electron at the instant of impact, the material of which the conductor on which the impact takes place is composed, and the nature of the gas inside the envelope. Under usual conditions of secondary emission, the maximum number of secondaries liberated by a primary electron is about ten.

Secondary emission sometimes takes place from the first anode of a cathode ray tube if the voltage applied to the second anode is excessively high. This secondary emission proceeds towards the fluorescent screen, but is not effectively focussed by the electron lens and distortion is thereby produced owing to the diffusion of the light spot edges.

Selenium Cell

A light sensitive cell in which the active element is selenium. The selenium is usually mounted on a metal plate, and when light rays reach the selenium the electrical resistance between it and the plate is reduced to an extent depending upon the amount and intensity of the light impinging on it. As the selenium and metal plate are connected in an electric circuit, the current in the latter varies with the resistance of the selenium, thus providing a strength of current depending upon the light reaching the cell. Selenium cells are not used in television work due to their inertia in operation. Owing to the extremely high frequencies that are employed in television installations (up to millions per second) an inertialess light cell is a necessity, and this requirement rules out the selenium cell. It was, nevertheless, employed in some of the early experiments in television.

Sense

The direction of movement or operation. For example, a mirror drum revolving clockwise is said to be revolving in opposite sense to that of another drum moving in the anti-clockwise direction. In a similar way an alternating or high-frequency current has sense, depending upon which side of the datum or zero line is being considered. Referring to Fig. 2, page 10, for instance, the part of the cycle *above* the zero line is positive, while that portion below the zero line is negative.

Separate Heterodyne

The local oscillator of a superheterodyne receiver (q.v.) when a separate valve is employed for this purpose. It is more economical to make one valve of special type (see "Frequency Changer") carry out the work of mixer and local oscillator, but when cost is not of prime importance a separate heterodyne is employed owing to the general improvement in working that thereby results.

Sequential Scanning

The method of scanning in which each line of scan is adjacent the preceding one. Compare with Non-sequential Scanning. An example of sequential scanning is given under "Scanning Disc."

Shadow Effect

A fault that becomes apparent in the reproduced picture due to insufficient amplification of the lower frequencies. Objects in the picture appear to throw shadows. This is also referred to as "throw-off" effect.

Shield

A cylindrical electrode surrounding the cathode of a cathode ray tube. The object of the employment of a shield, modulation electrode or grid, as it is alternatively called, is to concentrate the electrons emitted by the cathode on to the anode aperture

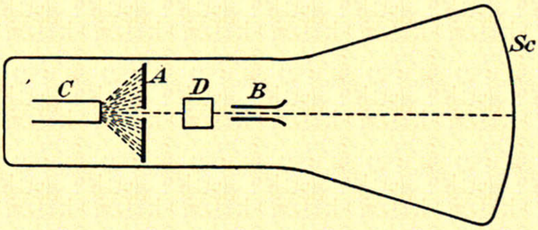

FIG. 79.—Beam formation without a Shield.

so as to prevent the loss of a large percentage of the electrons. In Fig. 79 is seen an illustration of a simple cathode ray tube without a shield. The electrons leave the cathode *C* in various directions towards the anode *A*, which is at a positive potential. Some of the electrons go straight from the cathode to the fluorescent screen *SC*, but most of them are lost on the anode *A*.

The effect of using a shield is seen in Fig. 80. Owing to the negative potential that is applied to this cylinder *Sh*, the electrons are repelled by it and are thus prevented from dispersing as they do when the cylinder is not present. The net result is that the electrons are concentrated into a beam that passes through the aperture in the anode *A*, as seen in Fig. 80, and the electron loss avoided. (See Intensity Modulation.)

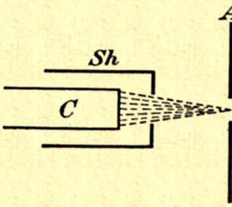

FIG. 80.—Beam formation when using a Shield.

Shift Potentiometers

The potentiometers (q.v.) employed for the purpose of shifting the position of the entire picture in a cathode ray tube. One potentiometer, known as the X-shift, permits movement of the picture in the horizontal direction, and the other potentiometer, the Y-shift, enables the picture to be moved vertically. Shift potentiometers are connected between the H.T. supply

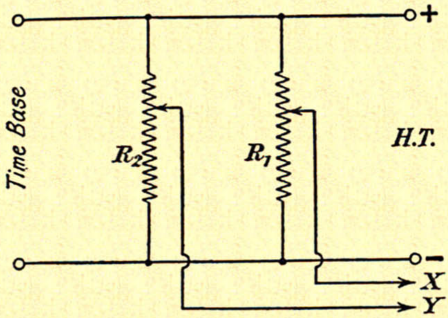

FIG. 81.—Showing the arrangement of X-shift and Y-shift Potentiometers.

and the time base, as shown diagrammatically in Fig. 81, where R_1 is the X-shift potentiometer, and R_2 is the Y-shift potentiometer.

Shift Voltage

There are two types of shift voltage :

1. That variable voltage applied to the deflector plates of a cathode ray tube to adapt the deflectional sensitivity to the voltage of the anode at any particular instant.

2. The bias voltage applied to the deflector plates to correct for the eccentricity of the image with respect to the fluorescent screen. Such bias voltage is independent of the voltages used

for scanning purposes, and adjusts the picture on the screen either vertically (vertical shift) or horizontally (horizontal shift). (See Shift Potentiometers.)

Shot Effect

The disturbance in a thermionic valve due to the slight unevenness of the electron emission from the cathode. Small variations are thus produced in the anode current and a disturbing voltage is produced in the output circuit. Shot effect is most harmful when it occurs in the early stages of an amplifier, owing to its amplification in the subsequent stages.

Shutter Disc

A disc that is used in conjunction with another device for scanning purposes. For instance, a rotating shutter disc may be employed in combination with a scanning disc of the multiturn spiral type (q.v.) to provide the correct sequence of operation of the different spirals.

Sideband

A television or radio transmission consists of a carrier wave on which are impressed the frequencies constituting the signal. These signals modulate the carrier wave amplitude, as outlined under "Modulation," and are carried on both sides of the carrier wave, as seen in Fig. 51.

A television signal may consist of frequencies varying from a few cycles per second to two million cycles per second. Each sideband of the transmitted signal must therefore consist of frequencies up to two million cycles per second. The arrangement of carrier frequency and sidebands is illustrated in Fig. 82, where the carrier frequency C is seen in the middle of a rectangle and the two equal sidebands SB are on either side of it. In the case of the television signal now being considered the sidebands would each cover a range of two million cycles. A broadcast radio signal covers a frequency range of only nine thousand cycles per second (i.e., 9 kc/s.), each sideband having a width of 4·5 kc/s. It is seen from this that the sideband width governs

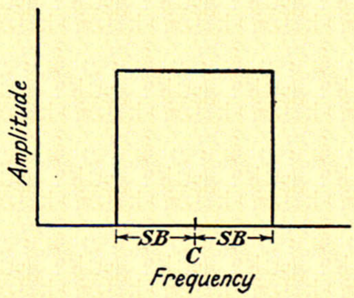

FIG. 82.—Simple illustration of the frequency relation of a carrier and two sidebands.

the total frequency band taken up and therefore the number of signalling channels that are available over a given frequency spectrum.

Sideband Cutting

The undesired reduction in amplitude of the sidebands comprising a signal due to defects in the circuit elements. If sideband cutting is severe, serious distortion is produced in the reproduced television picture or radio sound signal. In Fig. 83 is seen the effect of sideband cutting. The carrier frequency is seen at C, the sidebands extending to S_1 on one side and to S_2 on the other. If all the sideband frequencies are amplified equally, the resultant amplification curve is S_1PQS_2, and no distortion will occur. If the amplifier at the transmitter or receiver is too selective, the higher sideband frequencies, i.e., those farthest from C, will be diminished in amplitude, as shown by the curve. These high frequencies are, therefore, not reproduced satisfactorily and distortion takes place.

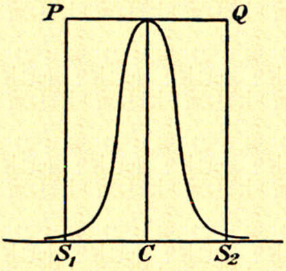

FIG. 83.—Illustrating the effect of Sideband Cutting.

Silent Track

A method of sound recording in which several tracks are employed, one or more being used depending upon the amplitude of the sound being recorded. Automatic change-over is effected between the tracks.

Sine Wave

A waveform that follows a sine law with respect to time. The waveforms shown in Fig. 62 are sine waves.

Single-Ended Mosaic Screen

A mosaic screen in which all the operations are effected on one side only. When such a mosaic screen is used, the cathode ray sweeps over the same side as that on to which the image of the picture is projected. Compare with Double-Ended Mosaic Screen. (See also Iconoscope.)

Siren (see Light Siren)

Skew Rays
Light rays that impinge on a lens at an angle with respect to its axis.

Skip Distance
In certain cases wherein wireless signals are received by reflection of the wireless waves from an ionised layer some distance above the surface of the earth there are positions on the earth's surface whereat the signals are not received. The distances between the transmitter and the various points whereat reception is possible are termed the skip distances.

Sound Gate
The small opening through which passes light from the exciter lamp (q.v.) to the sound track (q.v.) to record the sound signals.

Sound Head
That part of a sound film reproducing apparatus that comprises the electrical device for translating the variation in the sound track (q.v.) on the film into corresponding signal voltages.

Sound Track
The portion of a sound film that actually represents the sound. Sound tracks may have the width varying according to the intensity of the sound, or they may be of constant width but varying area. These two systems are described under "Variable Width" and "Variable Area" sound recording respectively. In Fig. 84 is shown an illustration of a film *F* bearing a vision track T_1 and a sound track T_2 of constant width.

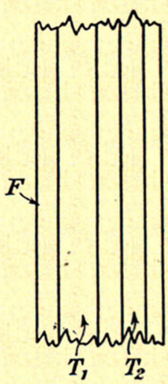

FIG. 84.—A Film bearing vision and sound tracks.

Space Charge
When a hot cathode provides copious electron emission the liberated electrons form a dense electron cloud in the neighbourhood of the cathode. This electron cloud is termed the space charge. If a collecting potential is applied to a conveniently disposed anode, then lines of force will begin at the anode and end on those electrons of the space charge which face the anode. As the lines of force end here, electrons in the space charge

cloud remote from the anode will not be influenced thereby. This means that only a certain proportion of the space charge cloud will be able to travel to the anode. That proportion, when flowing to the anode, is termed the saturation current, and its amount depends on the anode voltage, the distance between anode and cathode and also upon the geometric display of the electrodes.

It will be appreciated from the above explanation of space charge that the raising of the cathode temperature will increase the space charge indefinitely until the cathode burns out. This means that for a given condition of potential across the electrodes and distance between the electrodes a certain current will flow to the anode. This is the saturation current, and it cannot be increased by further increase of the cathode temperature.

Alternatively for a given temperature of the cathode increase of anode potential will bring about increase in current until all current is drawn off the cathode. Further increase in anode potential will not result in further increase in the anode current.

Space Charge Control Cylinder (see Shield)

Sparking Voltage

In reference to a photo-electric cell the sparking voltage is that voltage at which a discharge occurs owing to excessive ionisation of the gas filling. Such a discharge is very harmful to the cell.

Spectrum (see Frequency Spectrum or Light Spectrum)

Spherical Aberration

A defect in a lens that prevents the production of a sharp focus point owing to the light rays that pass through different parts of the lens coming to a focus at different points. The effect of spherical aberration is to produce a diffused image round the principal focus of the lens. This defect may be overcome by proper design of optical system, usually by employing more than one lens.

Spherical Lens

A lens with spherical surfaces. An example is the convex lens.

Spherical Mirror Screw

A type of mirror screw in which each mirror is concave.

Spiro-Helical

A helix in the form of a spiral. Mirror drums sometimes have the reflecting mirrors mounted on a conical drum in the form of a spiral, thus providing a spiro-helical track of reflectors.

Split Deflector Plate

A type of deflector plate that is employed to provide special effects. For example, a split deflector plate is used to overcome the defect known as origin distortion (q.v.).

Split Focussing

The method of optically focussing a light beam in which a crossed cylindrical lens (q.v.) is employed, the component lenses being separated.

Split Picture

A fault that may occur in a receiver whereby the picture is divided. The bottom part of the picture may appear at the top of the viewing screen and the top half at the bottom ; or the right-hand side of the picture may appear at the left of the screen, and the left-hand side at the right.

Spot Area Modulation

The system of modulation in a cathode ray tube in which the area of the luminous spot at the fluorescent screen is varied according to the signal voltage applied to the modulating electrode. In spot area modulation a signal voltage corresponding to a dark part of the picture will reduce the area of the light spot or even eliminate it altogether, whereas in a bright part of the picture the area of the spot will be greatly increased.

Spot Brightness

The intensity of light in an illuminating spot, such as that which scans a cathode ray screen. Focussing of the cathode ray determines to a large extent the spot brightness, which is also influenced considerably by the substance used for the fluorescence screen.

Spot Shift

The alteration in position of the luminous spot on the fluorescent screen of a cathode ray tube that is produced by the influence of the picture signal voltages on the modulating electrode. For satisfactory operation of the tube the position of the light spot on the screen must be quite independent of the voltage on the modulation electrode. Spot shift is, therefore, a form of distortion. The actual amount of such distortion is dependent upon the amplitude of the signal voltage.

Spot-Light Scanning

A scanning method due to Eketrom employing a spot of very intense light that is projected on to the object to be televised by the scanning device, and the reflected light from each individual point of the object is picked up by banks of photoelectric cells.

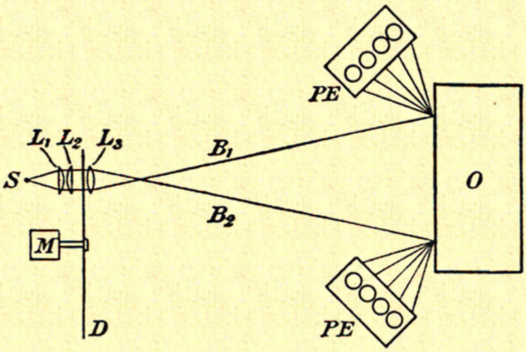

FIG. 85.—A Spot-light scanning arrangement.

In Fig. 85 is shown an illustration of how this system works. A light source is situated at S in front of a condensing lens combination L_1 L_2. The light source may be a powerful arc. The light rays emerging from the condenser lens are all parallel, as shown in Fig. 85. The lenses L_1 L_2 have a large diameter so that the parallel beam reaching the scanning disc D is of sufficient area to cover the complete height and width through which the apertures pass in order to provide the necessary scanning. As each aperture passes in front of L_2, therefore, a small beam of parallel light is allowed to pass through the scanning disc D and on to the spherical lens L_3. This small beam of light is focussed by L_3 on to the surface of the object O being scanned.

As the scanning disc rotates a series of lines of light are traced out on the surface of O by virtue of (*a*) the rotation of D by the electric motor M, and (*b*) the sequential series of apertures in D which are arranged to be adjacent but not overlapping (see Scanning Disc). The two extreme horizontal beams that are used in scanning the object O in Fig. 85 are seen at B_1 and B_2. When one helical series of scanning holes is provided on *D* there will, therefore, be one complete picture scan for each complete rotation of *D*. A certain proportion of the light striking the object *O* will be reflected on to the banks of photo-electric cells *PE* situated close to the object but not, of course, in the line of the incident light from the scanning disc. The proportion of this reflected light will depend upon the brightness of the picture elements swept over by the scanning beam. The total photo-electric current, therefore, varies with the brightness of the picture elements being scanned.

The construction of the photo-electric cells for this system of scanning must be such that they have wide apertures so as to allow as great a proportion as possible of the reflected light to actuate their cathodes. Although it is preferable that the object scanned be a plain surface, this is not necessary and it is found in practice that the object may move over a fair distance without definition becoming too blurred for satisfactory reproduction. On the other hand the brightness of the pictures reproduced from a transmission of the type shown in Fig. 85, is determined to a large extent by the distance between *O* and *PE*. This follows from the fact that the greater the distance between *O* and *PE* the weaker must be the reflected light rays reaching the photo-electric cells. At the same time, as the distance between *O* and L_3 becomes greater, the picture becomes correspondingly larger owing to the constant angle between the extreme scanning rays B_1 and B_2.

In a reproduced picture from a spot-light scanning transmitter the picture is that which would be observed at the point L_3, but the light and shade is that appearing at the cells *PE*, since in this case the photo-electric cells at positions *PE* are the actual pick-ups.

Spot-lighting is satisfactory for interior scanning, but is not practicable for outdoor scenes owing to the impossibility of arranging the photo-electric cells in suitable positions. Compare with Floodlight Scanning.

Spot Size Distortion

The distortion produced in a cathode ray tube due to the size of the light spot on the fluorescent screen being influenced by the signal potentials applied to the modulating electrode. When the picture is produced by the usual intensity modulation process (q.v.) it is necessary for satisfactory reproduction of the picture that the area of the light spot shall be independent of the voltage applied to the modulation electrode. The spot size should, in fact, be constant at all points of the screen. Spot size distortion tends to occur to a greater extent as the modulating potentials increase.

Squigger Time Base

A particular circuit for providing the saw-tooth oscillation required for deflecting the beam in a cathode ray tube. This circuit employs an oscillating screen grid valve for effecting the periodic discharge of the time base condenser (see Time Base). The screen grid valve is back-coupled between control grid and anode in such a manner that oscillations are produced when control grid current flows. During the oscillatory state, however, the control grid rapidly acquires a negative voltage until the valve is blocked, and this discharges the time base condenser connected to it. On the cessation of the oscillations, the condenser starts being recharged, and this applies a positive voltage to the grid that increases slowly until the oscillations start again and the condenser is discharged as before.

The synchronising impulses are applied between screen grid and cathode to trip the time base condenser discharge at the proper instant for synchronisation. The saw-tooth wave is usually amplified before being applied to the deflector plates.

Stage

Some radio and television manufacturers refer to a tuned circuit as a stage and term a band pass filter two stages. However, a stage is more generally understood to be the complete circuit associated with the valve or valves concerned. For example, an H.F. amplifier stage comprises the input circuit, valve, output circuit and associated resistances, condensers, etc. Similarly, a detector stage comprises the complete set of valve and circuit elements that take part in the process of detection. Sometimes there is more than one valve in the stage. For instance, a push-pull stage consists of two valves and their associated components.

Staggered Scanning (see Interlaced Scanning)

Standard Candle

The type of candle taken as the standard for purposes of providing a unit of intensity of illumination. This standard candle weighs one-sixth of a pound and is made of spermaceti. (See also Candle Power.) Standards which are more uniform and reproducible are now used in place of the standard candle.

Static Field Multiplier
An electron multiplier (q.v.) wherein the potential on the multiplying electrodes is constant.

Stepped Reflector (see Reflecting Echelon)

Stepped Refractor (see Refracting Echelon)

Stereoscopic Reproduction
The method of reproducing pictures in which relief is produced as in the original scene. There has not been a great deal of work done on stereoscopic reproduction of television signals so far.

Stixograph
A single line image, such as that produced by a cylindrical lens (q.v.). This name was coined by Mr. G. W. Walton, the originator of the Scophony system.

Straight Receiver
A receiver in which straightforward amplification and detection takes place, as distinct from special arrangements such as the superheterodyne receiver and the super-regenerative receiver.

Straight Scan
Scanning method in which the picture is scanned in successive parallel strips, as distinct from the intercalated scan.

Streaking
A defect in cathode ray tube receivers that is due to an unsatisfactory modulation arrangement.

Striking Voltage
The voltage at which the electrical discharge takes place between two electrodes in a discharge tube. Gas pressure determines to a great extent the striking voltage, although the proportionality is not a direct one. For example, if certain gases are added to a neon tube (q.v.) the striking voltage is reduced as the amount of such gases is increased up to a point, and then the striking voltage increases.

Strip Pulse
The voltage impulse transmitted between the scanning of adjacent strips of the transmitted picture for purposes of synchronising. This is the line synchronising signal (q.v.).

Stripped Molecule

A molecule of an element from which electrons have been released by collision with other electrons.

Stroboscopic Effect

The optical phenomenon that enables the eye to distinguish a single scanning line during blinking. The line being scanned at the instant an observer's eye blinks stands out distinctly from adjacent lines. Horizontal scanning helps to overcome this effect, as compared with vertical scanning.

Sub-carrier Wave

An auxiliary carrier wave that is superimposed on a main carrier wave. A sub-carrier is generally employed for providing an additional or separate signal for a special purpose. For example, the sub-carrier may be modulated by a synchronising signal. At the receiver the sub-carrier is separated from the main carrier and then detected in the usual way to provide the synchronising signal.

Superheterodyne Receiver

A receiver in which a local oscillator voltage or heterodyne is mixed with the received signal voltages to produce a beat frequency which, after rectification is above the audible spectrum, i.e., it is super audible. This rectified beat frequency contains the modulation or signal characteristics of the incoming signal carrier wave, and may thus be amplified in the usual amplifiers and detected to provide the audible frequency voltages. A superheterodyne receiver must, therefore, have two detectors, one for the mixed incoming and heterodyne frequencies, and one for the rectified beat frequencies. (See Fig. 61.)

Superheterodyne receivers are commonly employed in television and radio receivers owing to the high degree of selectivity that is obtainable. This is due to the high efficiency of the intermediate amplifier circuits which need to be designed to receive one frequency only, i.e., the frequency of the rectified beats. Owing to the much lower frequency at which the main amplification takes place, the receiver is much more stable in operation, i.e., there is less tendency to self-oscillation. This feature of the superheterodyne is probably its greatest advantage from the point of view of the reception of television programmes transmitted on ultra-short waves, because the effective amplification of a receiver that does not employ the superheterodyne principle is so small that satisfactory reception is difficult. The shorter the wavelength of reception, the more difficult it becomes to construct a stable amplifier. Further difficulties arise due to the losses in the stray capacities in the valves and circuit elements as the wavelength of reception is lowered, and here again the superheterodyne receiver solves the problem. A full discussion of this type of receiver, with practical notes and examples of commercial receivers, is given in "The Superheterodyne Receiver" by the present writer. See "Vision Receiver" for an outline of a complete receiver.

Supersonic Light Valve

This is a device for controlling an emergent light beam by means of a mechanical oscillator that vibrates at a supersonic frequency. The supersonic light valve was invented by John Henry Jeffree in 1934, and forms an important element in the Scophony system of television reception.

The principle on which this light valve works is that if a supersonic mechanical wave passes through a material in which a beam of light is passing, a series of retardations and accelerations of the light beam are set up. Such retardations and accelerations of the light beam correspond to the waves produced in the body by the mechanical oscillator. Owing to the nature of the mechanical oscillations the compression and retardations in the body through which the waves travel are regularly spaced. The net result of this is that a light beam passing through such a device will be separated into two parts: one will be defracted by the mechanical waves, and the other will pass through the medium unaffected. It is possible to separate these two portions of the light beam and to use either one. That is to say, either the defracted waves from the light valve may be employed or the waves that pass directly through. If to the mechanical oscillator, such as a piezo electric crystal, there are applied high-frequency electrical oscillations, this oscillator will be influenced correspondingly, and there will be set up in the body of the cell a series of compressional waves the intensity of which corresponds to the amplitude of the applied high-frequency oscillations.

In the supersonic light valve the mechanical oscillator is not necessarily a quartz crystal, but may be a vibrating tuning fork or a diaphragm actuated electromagnetically. However, the quartz crystal is found to be satisfactory and is generally employed in a light valve of the type being outlined. The defraction body may be water or paraffin oil.

One method of employing the supersonic light valve is shown in Fig. 86. Here S is the source of light which is made into a parallel beam by the spherical lens L_1. The parallel beam of light thereafter passes through the glass walls of the light valve and the defracting medium W, through a converging lens L_2 to a diverging lens L_3. A diaphragm D, situated at the focus of L_3, cuts off the unwanted part of the light waves reaching it. In the example shown the aperture is in the centre, so that the defracted waves are suppressed whilst the light beam passing straight through the light valve is allowed to impinge on the rotating mirror drum M (q.v.). From the mirror drum the light waves pass through a lens and are thereby focussed on the

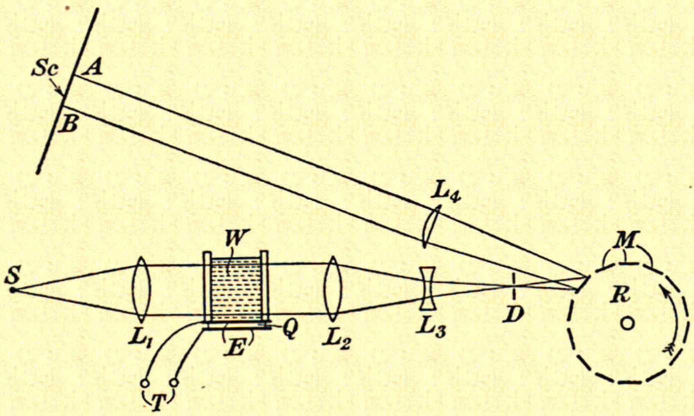

FIG. 86.—One arrangement for using the Supersonic Light Valve.

picture receiving screen SC. The quartz crystal is seen to be situated at the bottom of the light valve and is indicated by Q. The crystal is coated on its upper and lower surfaces with a metal deposit that forms the two electrodes. Aluminium foil serves this purpose, or the crystal may be gilded.

The vision signals are applied to the terminals T connected to the electrodes of the quartz crystal and set up in the latter mechanical vibrations corresponding in amplitude to the applied oscillations, i.e., to the modulations representing the vision signal. Compressional waves are thereby set up in W, the actual velocity of these waves, at right angles to the axis of the quartz crystal, of course, being dependent on the nature of the medium W.

The actual image shown upon the screen SC is of the light valve W. This image moves across the screen in the direction from *B* to *A*. At the same time, however, the wave group images within it move at the same velocity in the direction from *A* to *B*. The resultant velocity is, therefore, zero, and the images remain stationary on *SC*. At any given instant the compressional wave amplitude at any point along the medium *W* represents the illumination intensity at the corresponding point on the screen *SC*. By adjustment of the optical system, this intensity at *SC* is made to correspond to the particular elemental area of the picture at the transmitter. In this way it is possible to reproduce a large number of elementary points simultaneously, the light valve *W* being thereby equivalent to a similar number of light valves each reproducing one image. By this means the optical efficiency of the reproducing apparatus is very considerably increased.

The definition provided by the arrangement shown in Fig. 86 is dependent upon the definition of the images produced by the wave groups. To increase the average illumination of the screen *SC*, therefore, for a given degree of definition, it is necessary to lengthen the column of diffracting medium *W*.

For recording sound on a film the arrangement of the light valve shown in Fig. 86 is employed, but in this case the mirror drum or similar scanning device is not necessary. The moving film takes the place of *M*, and the film velocity in one direction is made to equal the velocity of the wave groups passing through *W* in the opposite direction. Elementary images thereby remain stationary on the film. The sound to be recorded modulates a high-frequency carrier, which is applied to the quartz crystal, as already outlined.

Suppression of Ray

The elimination of the electron ray in a cathode ray tube by applying a high negative bias to the modulation electrode or Wehnelt cylinder. If the negative voltage applied to this electrode is sufficiently high, all the electrons emitted b they cathode are repelled back on to it, with the result that none pass through the aperture in the anode. Complete suppression is thus effected.

Suppressor Grid

The grid in a pentode valve situated next to the anode. It is so-called because it suppresses secondary emission from the anode and thereby the undesirable kink in the characteristic of the screen grid valve.

Surface Image

An image extending over an area as distinct from a line image (q.v.).

Sweep Voltage. The time base.

Synchronising

The process of arranging the scanning apparatus at the transmitter and the receiver to be worked at the same velocity and phase. Unless this is carried out in an exact manner, the reproduced picture at the receiver cannot be satisfactory. The requirement is that the scanning spot must move, at both transmitter and receiver, at the same instant and velocity across the picture area, and that it shall start at the top line and each subsequent line at the same sequence. That is to say, the

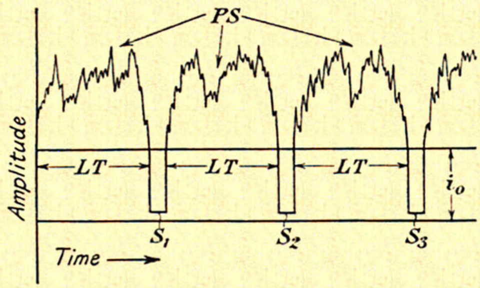

FIG. 87.—Illustrating process of injecting synchronising signal into transmitted waves.

first line and *n*th line (where *n* is any whole number) of the transmitted picture shall be reproduced at the receiver also as the first line and *n*th line. The essential feature is that the sequence *within each picture frame* is the same.

A very large number of synchronising methods have been proposed and used at various stages in the development of television. One method at present in use is described below as an example.

From the outline given above it is seen that two synchronising signals are required, one to ensure that each line shall start at the correct relative time and another to synchronise the picture frames. The line synchronising signal is produced at the end of each line transmitted, and is made to modulate the transmitter carrier to a much deeper degree than the pictures. This arrangement is represented in Fig. 87, which shows at i_o the value of carrier wave amplitude below which the picture signals PS are not allowed to modulate. The time taken to transmit a line is LT, and at the end of this time a negative impulse (q.v.) is impressed on the carrier as seen at S_1, which is the synchronising impulse. At the receiver the synchronising negative impulses are separated from the picture signals by means of an amplitude filter (q.v.) and made to control the frequency of the line and frame scanning devices so that true synchronisation is obtained.

The form of synchronising outlined above is that used in systems employed in Great Britain and also in Germany. In France, however, the system in use employs a positive impulse for synchronising, the waveform of the combined picture and synchronising signals being as illustrated in Fig. 88. Here, i_0 represents the maximum value of the

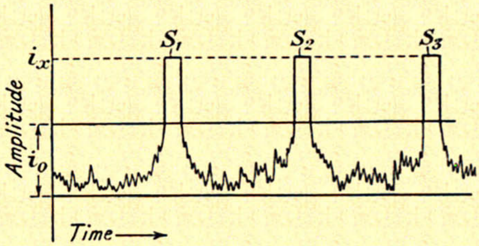

FIG. 88.—Transmitted waveform using positive impulses for synchronising purposes.

modulation due to the picture signal. Synchronising impulses are as seen at S in the form of an increase in amplitude to the maximum i_x.

Synthesise

To reproduce the picture at the receiver by combining in correct sequence and speed the small units into which it has been dissected by the scanning device at the transmitter to reproduce a picture. The process of synthesis is, in fact, the scanning operation *at the receiver* which provides the received picture. Compare with Analyse.

T-Type Electron Multiplier

The form of electron multiplier with the individual sections at right-angles, as seen in Fig. 89. Here, C is the photo-electric cathode, A_1 the first anode (secondary electron emitter), A_2

the second anode. Further anodes are arranged in similar formation. (See Electron Multiplier.)

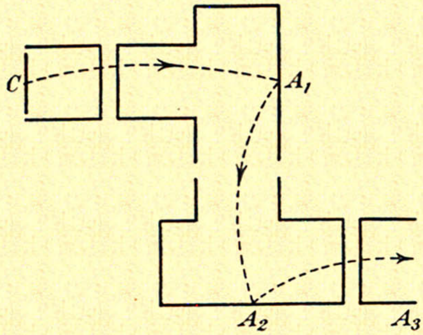

Fig. 89.—T-Type Electron Multiplier.

Telecine Scanning
The scanning of a cinematograph film for transmission by radio or wires.

Telepantoscope
This is a type of electron camera that has been developed in Italy. It employs a cathode ray beam which is deflected along one axis only by a pair of deflecting plates. A mirror drum is used for providing the complementary scanning for outside scenes. When a cinematograph film is being transmitted, the motion of the film itself is utilised for the complementary scan. Within the telepantoscope camera is included a synchronising disc and a pre-amplifier.

Televisor
Registered name for Baird television receivers.

Tertiary Electrons
Electrons produced by impact between secondary electrons and any obstacle, such as a gas molecule or an anode.

Tetrode
Valve with four electrodes. A screen grid valve (q.v.) is a tetrode.

Thermal Agitation
Irregularities in a current flow due to inherent properties in the circuit elements. The passage of electrons round a radio circuit

does not take place in a perfectly smooth manner. Slight irregularities are set up in the coupling elements, resistances, etc., which produce a voltage variation. This is amplified in the valves and causes a disturbance in the output of the amplifier. The first stages of an amplifier are the most critical from the point of view of thermal agitation, for any irregularities in the flow of electrons there will be amplified in all the following stages. (Compare with Shot Effect.)

Third Anode
The anode in a cathode ray tube situated farther from the cathode, next to the second anode.

Throw-off Effect (see Shadow Effect)

Thyratron
A type of gas-filled valve that is trigged into discharge by grid voltage. See Gas-filled Relay.

Time Axis (see Time Base)

Time Base
Electrical means for providing the scanning of the television picture in the cathode ray tube. Assuming the picture to have a horizontal line scan, the horizontal scan provides the line scan and the much slower vertical scan provides the picture, or frame, scan. In both scans the spot has to travel at a predetermined speed in the forwards, or positive, direction, then the spot must return at much higher speed in the fly-back so that it cannot be seen on the screen. The return speed should be at least ten times that of the forward speed. (See also Picture Frequency Time Base, Line Frequency Time Base.)

Time Base Sweep
The length of movement of the light spot across the screen of a cathode ray tube.

Time Constant
Time required for a condenser to discharge to 37 per cent. of its voltage at the peak of its charge. The time constant is proportional to the capacity and the resistance in the discharge circuit, i.e., to CR. For a given time constant, therefore, as the capacity is lowered the resistance must be correspondingly increased.

Translation of Light

The process in which light variations are converted into corresponding fluctuations of electric current. Translation of light is usually carried out by a photo-electric cell (q.v.), the fundamental circuit connections being as shown in Fig. 63. (See also Photo-Electric Sensitivity.)

Trapezoid

A four-sided figure with two sides parallel to each other.

Trapezoid Distortion

The distortion produced in a cathode ray tube that results in the reproduced picture area being in the shape of a trapezoid instead of a rectangle. A typical shape of picture with trapezoid distortion is seen in Fig. 90, which shows the correct picture

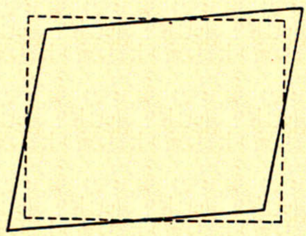

FIG. 90.—Illustrating formation of Trapezoid Distortion.

shape as a broken line. Trapezoid distortion is due principally to interaction effects between the voltages on the two sets of deflecting plates.

Traversal

The process of scanning a picture frame. A traversal does not imply the scanning of a complete picture. For example, in interlaced scanning (q.v.) during a traversal only half the picture is scanned, two traversals being required to complete the picture scanning.

Trigger Current

An electric current that initiates some effect such as the discharge which gives rise to the saw-tooth current (q.v.).

Triode

Valve with three electrodes, consisting of cathode, grid and anode. The grid is interposed between cathode and anode so as to control the electron current flow to the latter and is, therefore, called the control electrode.

Trip Frequency
The frequency of the voltage generated by the tripping generator.

Tripping Generator
The generator of the time base circuit. It is so called because the voltage it provides is used for tripping the cathode ray in the required directions.

Tripping Signal
An alternative name for Synchronising Signal.

Two-Anode System
The method of concentrating or focussing an electron beam by means of two anodes arranged along the axis of a cathode ray tube. This method is described under "Electrostatic Focussing."

Ultra-Short Waves
Wavelengths below 10 metres, corresponding to frequencies higher than 30,000,000 cycles or 30 megacycles per second. Ultra-short waves are employed for the transmission and reception of television signals owing to the very large range of frequencies available in that band. For example, from 10 to 2 metres there is a frequency range of 120 megacycles per second (120 mc/s). Now as the modern television transmitter requires a frequency band of at least 2 mc/s, it follows that on the wavelength band of 10 to 2 metres, $\frac{120}{2}=60$ stations can work without causing mutual interference. It would be quite impracticable to employ the long-wave broadcast band (say 1,000 metres) owing to the impossibility of transmitting a carrier of 300 kc/s. modulated by frequencies up to even 1,000 kc/s. A broadcast station requires only a band of 9 kc/s. for transmission. It is thus seen that one television station takes up as much of the available frequencies as over 200 broadcast stations. Consequently it would be impossible to carry on a television service on the medium wavelengths, and so the ultra-short waves are employed. On these lower wavelengths much more "frequency space" is available.

Ultra-Violet Cell
A photo-electric cell (q.v.) that is responsive to ultra-violet light.

Ultra-Violet Region
That part of the light spectrum (q.v.) adjacent to, but beyond, the violet end.

Umbrella
Word used to describe the curved portion at the end of a cathode ray tube or similar device, shown at *U* in Fig. 91.

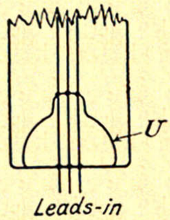

FIG. 91.—Umbrella of a Cathode Ray Tube.

Variable Density Sound Track
The type of sound track (q.v.) in which the sound modulation takes the form of a variable opacity on the film, the width of the track being constant throughout its length. When light passes from the exciter lamp through the aperture and sound film on to the photo-electric cell for reproduction, the amount of light reaching the cell, and thereby the loudness of the sound reproduced, is proportional to the transparency in the sound track. Compare with Variable Width Sound Track.

Variable-Mu Valve
A thermionic valve in which the mutual conductance and thereby the amplification is variable over a wide range. This feature is rendered possible by the special construction of the control grid. A normal control grid consists of a uniform helix of wire surrounding the cathode, but a variable-mu valve control grid has the centre turns more widely spaced than the end turns. The result of this is that as the negative bias applied to the control grid is increased, the amplification is reduced first by the effect of the bias at the ends and then gradually more and more towards the centre. This brings about a large permissible range of grid bias over which control of amplification may be obtained. A straight screen grid valve, for example, may usually not have a higher bias than −2 volts applied to it, whereas a variable-mu valve will respond in effective amplification provided, to grid bias up to about −35 volts. The variable-mu characteristic is essential for the satisfactory operation of automatic-volume control systems. (See Grid Base.)

Variable Width Sound Track
A type of sound track (q.v.) in which the sound modulation is represented by a varying width of transparency along the length

of the track. This type of sound record is illustrated in Fig. 92, the loudness of the sound being proportional to the width of the transparent centre of the track. At *A*, for example, very little sound would be reproduced, whereas at *B* very loud reproduction would take place.

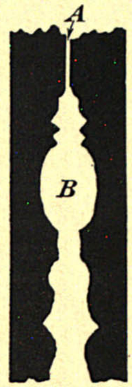

FIG. 92.—Showing sound track using the variable width process.

Velocity Modulation

A method of modulating the illumination of a cathode ray tube fluorescent screen by varying the speed of the light spot. It is well known that the apparent brightness of a moving point of light on a screen varies as the speed of the moving point. Such a method of forming the television picture on the screen was put in the form of a practical proposal by Thun, in Germany, and other contemporaries, and experimental work on these lines has been described by Bedford and Puckle. Briefly, the manner of operation rests in the control of the scanning speed at the transmitter end and a consequent synchronous motion of the scanning spot at the receiver end.

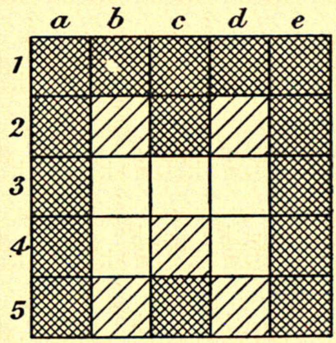

FIG. 93.—Representation of picture to be transmitted.

In Fig. 93 let the 25 squares represent the optical density of the picture to be transmitted. These are enumerated with the aid of the horizontal letters and the vertical numbers. Thus the square 2*c* is black and the square 2*d* is half-tone, whereas the square 3*b* is white. Considering for a moment the intensity-time graph of intensity modulation for the sake of comparison, there is in Fig. 94 such a curve giving the complete scan. In Fig. 95 is given the corresponding curve for the velocity modulation method. In the latter case the ordinate represents the horizontal lettered elements and the abscissæ represent the vertical numbered rows. As the first horizontal row is completely back the spot travels over in very short time. Then it returns as indicated by the return of the graph to the base line. For the

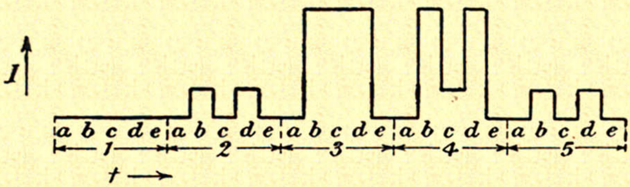

FIG. 94.—Intensity-time curve of a complete scan of the picture shown in Fig. 92.

second horizontal row, the spot traces the 2*a* square rapidly and the 2*b* square at slower speed owing to the half-tone of this square. Square 2*c* is traversed rapidly and square 2*d* at half-tone speed. In the third horizontal line the squares 3*b*, 3*c* and 3*d* are traversed very slowly as they are white.

In actual practice it is necessary to devise a means of effecting this scan with varying speed, and one method of carrying this

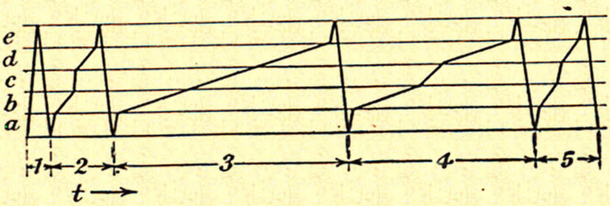

FIG. 95.—Velocity-time curve for the complete scan of the picture shown in Fig. 92.

out is as follows. A normal scan is traced out on the fluorescent screen of a cathode ray tube, and this is projected on to the film, the image on which it is desired to transmit. Behind the film is situated the photo-cell to receive light in accordance with the point-to-point density of the film. Electrical arrangements are made in the circuit such that increased photo-electric current will serve to decrease the anode current of the first value to which the photo-cell is coupled. By this means an increase of light in the contour of the picture will serve to decrease the anode current and thus to slow down the discharge of a condenser. The anode, and therefore the condenser terminal, is connected to the line deflector-plate system in the cathode ray tube, so that decrease in charging time of the condenser will result in decreased speed of the light spot. Conversely, if the picture contour is dark, the anode current will rise; the condenser charging will be speeded up and the velocity of the line scan on the fluorescent screen will also be accelerated. When the condenser has reached a predetermined charge it will be discharged by the thyratron connected in parallel with it. This will complete the line scan and bring about the necessary fly-back.

At the receiver end, the speed of the scanning spot is controlled in much the same manner, by means of a condenser shunted by a thyratron, in the anode circuit of the output valve.

Velocity of Traversal
The velocity at which the scanning spot moves across a picture.

Vertical Scanning
The method of scanning a picture surface in vertical lines. Although vertical scanning was employed in some types of low definition television apparatus, it is not used much in present-day installations.

Vertical Shift (see Shift Voltage (2))

Video
Referring to the vision signal; for example, a video amplifier is a vision amplifier as distinct from the sound amplifier.

Vision Receiver
The problems associated with the reception and reproduction of the vision signals are primarily those pertaining to the design of coupling elements between the valves that will pass a wide band of frequencies (up to 4 megacycles in width) and at the same time of obtaining a useful amplification per stage. It is well known that a band filter or other circuit capable of passing a wide-frequency spectrum must have a low effective impedance. Since the stage amplification is determined by the value of the impedance in the output circuit of the amplifier, it follows that for the satisfactory reproduction of the wide band of frequencies in the television signal, the amplification per stage must be very low. Added to this, of course, is the difficulty

that the carrier frequency, for reasons given under Sideband, must be in the ultra high-frequency spectrum. Here, again, the stage gain is limited, quite apart from the considerations outlined above, by the inter-electrode capacities and by the fact that the impedance of the valve in shunt to the input and output circuits becomes very low when dealing with ultra high frequencies.

Most vision receivers employ the superheterodyne principle owing to the advantages that are obtained by the employment of the intermediate-frequency amplifier as outlined in "Superheterodyne Receiver." At least one company marketing vision receivers, however, uses a straight receiver for this purpose, but as yet no details are available regarding the design employed. The general considerations involved in the design of a vision receiver combined with sound receiver are best explained by reference to the circuit diagram given in Fig. 96 of the 1936 model of the combined sound and vision receiver of the Fernseh A.G. This receiver is described in the television supplement to *Funk-Technische Monatshefte* for December, 1936, and the diagram for Fig. 96 is taken from that journal.

The aerial is connected through a simple tuned circuit to the grid and cathode of V_1, this circuit being damped by a shunt resistance. For obtaining a band pass effect extending over a wide range of frequencies, it is found satisfactory to employ a simple tuned circuit damped by a shunt resistance and as shown in Fig. 96. Both the input and the output circuits of V_1 have shunt resistances for this purpose. The second valve is the mixing valve, the local oscillations being generated by the triode V_3 and applied to the third or mixing grid of V_2. The oscillator frequency of V_3 is arranged to provide a frequency which, when superimposed on the incoming vision and sound carrier waves, produces in the output of the mixing valve V_2 two separate intermediate frequencies. The sound intermediate frequency is 1·2 megacycles and this carries the sound modulation frequencies of $\pm$ 15 kc/s. to 20 kc/s.

The vision intermediate frequency is 3 megacycles, and in this particular receiver is designed to reproduce the modulation frequencies up to 1 kc. The respective intermediate frequencies are separated in the output circuit of V_2 by the two circuits shown connected in series. Connected to the anode of V_2 is the inductance and shunt resistance arrangement which, combined with the valve capacities, forms a flat resonant

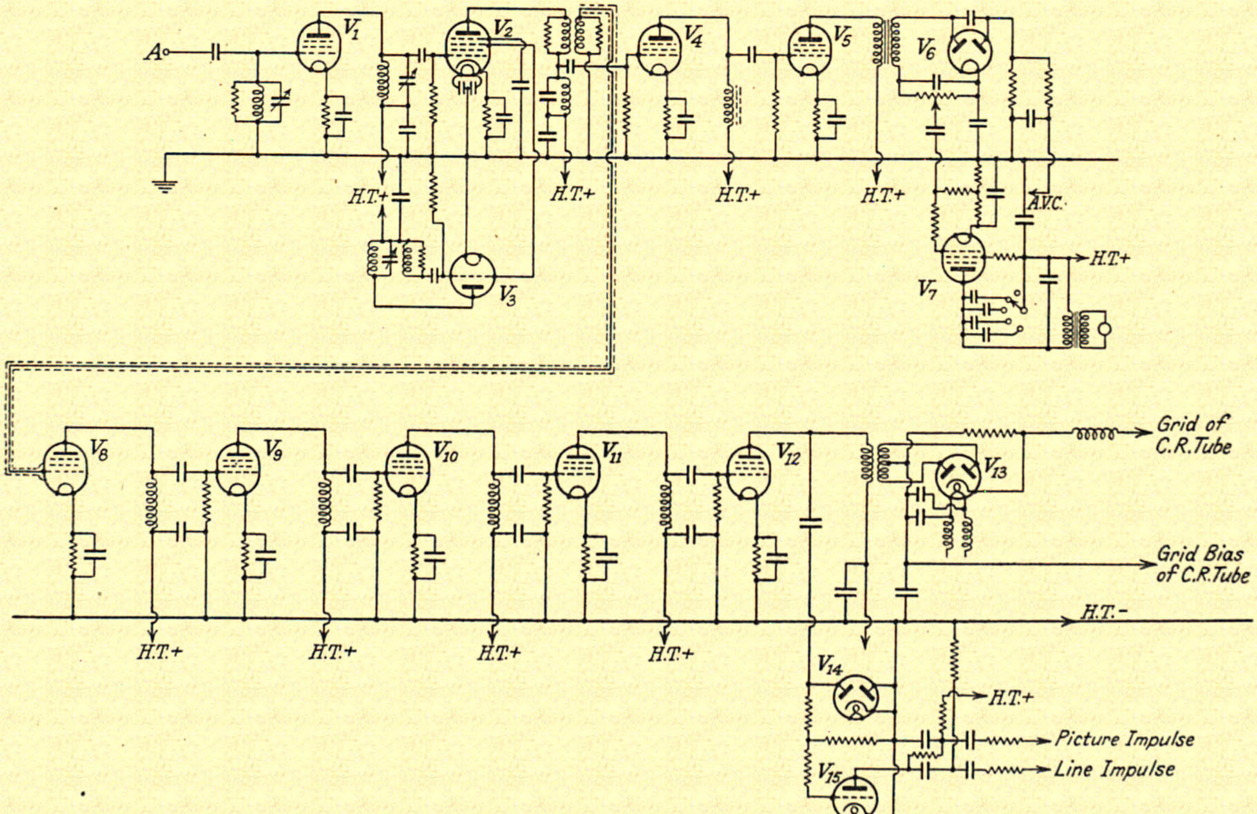

FIG. 96.—Circuit arrangement of the Fernseh A.G. 1936 combined Television and Sound Receiver.

circuit suitable for passing the complete range of vision signal frequencies. These are coupled to a similar circuit and applied to the first intermediate-frequency amplifier of the vision receiver V_8. The sound signal voltages are selected by the comparatively sharply tuned circuit seen to be connected below the vision filter. This circuit, consisting of an inductance and capacity in parallel, applies the sound signals to the control grid of V_4. These voltages are subsequently amplified by the second I.F. amplifier V_5 and applied as in normal radio reception to the double diode V_6. This valve rectifies the sound signals and at the same time provides the voltage for automatic volume control of the sound receiver. It should be noted that as the sound receiver passes sideband frequencies up to at least 15 kc/s. the quality of the sound reproduction will be considerably better than that provided by the usual sound receiver for employment on the broadcast bands, which normally passes up to 4·5 kc/s. only.

The vision intermediate-frequency amplifier consists of five stages associated with valves marked V_8 to V_{12}. These valves are coupled by a choke-capacitance-resistance combination which forms a suitable wide band filter. Owing to the difficulties already enumerated in a receiver of this nature, the stage gain is only about six. The anode of the final I.F. amplifier valve V_{12} is coupled by a transformer to the double-diode valve V_{13}, which acts as the second detector for the vision signals. In the operation of a double-diode as a push-pull detector as shown here, it is of the utmost importance to ensure, firstly, that the inter-winding capacity is the smallest possible, and, secondly, that such stray capacities as do exist are symmetrical with respect to the two diode anodes. Unless this is so, it is impossible to effect a satisfactory rectification. In this particular design it is claimed that the transformer is especially suitable for the purpose under review. The diode load resistance of V_{13} is connected through a high-frequency choke to the modulating grid of the cathode ray tube. The normal shunt capacity to the diode load resistance, as given in Fig. 96, is comprised in this case by the effective capacities of (*a*) the diodes themselves, (*b*) the connection between the diode load resistance and the grid of the cathode ray tube, and (*c*) of the cathode ray tube grid. The damping of the double-diode on the secondary of the transformer supplying it, is sufficient to provide the requisite damping for giving the band pass effect necessary.

The amplitude filter is fed from the anode of V_{12}. The filter is seen to consist of valves V_{14} and V_{15}. In the output of V_{15} the synchronising impulses are separated by suitable filters consisting of resistance and capacity combinations. There are thus provided at the terminals indicated the requisite synchronising impulses for tripping the respective line and picture frequency time base circuits.

Vision Track
The portion of a vision film that contains the actual picture. See "Sound Track" for illustration.

Vitreous Humour
The transparent gelatinous substance in the centre of the eye (q.v.).

Voltage Sensitivity
An alternative term for deflectional sensitivity (q.v.) when electrostatic deflection is employed with a cathode ray tube.

Wall Electrode
A metal coating applied to the interior of the envelope of a cathode ray tube which is arranged to take part in the operation of the tube. The metal deposit forming the wall electrode may be made by "flashing" (q.v.) a piece of metal. Wall electrodes are employed for various purposes, such as the second or third anode, in which case a positive potential is applied to it, or as a screen or shield electrode. If too high a positive potential is applied to the wall electrode, arcing is likely to take place.

Wattless
The state in an electrical circuit in which no electrical power is (*a*) available or (*b*) consumed. The ideal cathode ray tube has a deflection system that is wattless. In practice, however, owing to certain imperfections, there is a small expenditure of power in the deflection of the ray, i.e., deflection is not wattless.

Wave Trace
The form traced out on the fluorescent screen of a cathode ray tube by the electron beam.

Wehnelt Cylinder
An alternative name for the shield (q.v.) of a cathode ray tube. It is named after Wehnelt who discovered its use.

Weiller Wheel

An alternative name for mirror drum (q.v.).

Willemite

A mineral substance used as fluorescent screen in a cathode ray tube that appears pale green when bombarded by an electron stream. It may be used as a fluorescent screen of a cathode ray tube, and is composed principally of zinc silicate.

Work Function

This represents the amount of work, generally measured in volts, that is required to be performed on an electron to remove it from a surface atom. In the first place the work may be executed by the heating of a metal and boiling off the electrons in a manner similar to fractional distillation. This work is termed the thermionic work function and appears in the expression giving the thermionic emission in terms of the various physical conditions of emission. In the second case the work may be performed on the electron by incident light when the photons (q.v.) give up their energy to the electrons. On liberation of the electron from the mother surface, the equation of work performed by the photons would be

$$h\mu = \tfrac{1}{2}mv^2 + e\phi$$

where h is Planck's Constant (q.v.), μ is the frequency, m is the mass of the electron, v its velocity on leaving the surface, e the charge on an electron, and ϕ the voltage through which it is moved. The term on the left indicates the energy given up by the photon and the first term on the right gives the energy of the electron after leaving the surface. This will, of course, be represented by the product of the electron mass and the electron velocity, thus giving the kinetic energy. The final term indicates the work done on liberating the electron from the mother surface. It is expressed in terms of the potential energy required for the liberation. The term ϕ may be regarded as the voltage barrier which the electron has to overcome before leaving the surface. This term is called the photo-electric work function. Clearly the lower the value of this photo-electric work function, the less is the energy required to liberate the electrons. It will be seen in the table below that the film of cæsium on oxidised silver possesses a very low work function and is thus most sensitive photo-electrically.

Table of Work Functions

Material	*Threshold wave-length in Å*	*Work function*
Aluminium	3,460	3·0
Barium	5,000	2·8
Cæsium	7,500	1·0
Cæsium on silver oxide	8,000	0·75
Magnesium	3,300	2·9
Platinum	2,700	6·3

The value of the thermionic and photo-electric work functions are practically the same. The meaning of the threshold wave-length is explained under Photo-electric Threshold.

Writing Speed

The velocity of the recording device on the record. For example, in recording by means of a cathode ray tube on to a moving photographic film, the writing speed is the velocity of the recording light spot in the direction of the line scanning. If the writing speed is too great, the exposure of the film will be insufficient to blacken the film, and the record will, therefore, not be of use. The maximum writing speed is the highest velocity of the recording device (cathode ray beam in the example given above) that is practicable to produce a satisfactory record or blackening of the film.

X Axis

In reference to a cathode ray tube, the X axis lies horizontally on the fluorescent screen, as depicted in Fig. 97.

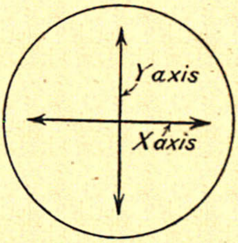

Fig. 97.—The X and Y axes of a Cathode Ray Tube Screen.

X Plates

By convention, the two pairs of deflecting plates (q.v.) of a cathode ray tube are called the X plates and the Y plates, the X plates deflecting the beam horizontally, and the Y plates vertically.

X-Shift Potentiometer (see Shift Potentiometers)

Y Axis

The Y axis of a cathode ray tube is the vertical axis of the fluorescent screen, as illustrated in Fig. 97.

Y Plates (see X Plates)

Y-Shift Potentiometer (see Shift Potentiometer)

THE END

FLEXIBACK BINDING
Patent No. 441294