

NEWNES
TELEVISION
AND
SHORT-WAVE
HANDBOOK



NEWNES TELEVISION AND SHORT-WAVE HANDBOOK

WITH 230 ILLUSTRATIONS

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PREFACE

THIS book goes to Press before publication of the findings of the Television Committee appointed by the Postmaster-General to enquire into the possibilities of Television and to report to him regarding suitable systems which, in conjunction with Radio Telephony, would afford entertainment value and form a regular part of daily broadcast fare.

Television has emerged from the experimental stage and is practicable as well as commercially possible. For more than ten years television has been the missing link to complete home radio entertainment, and the time is not far distant when it will relegate our present programmes to a position analagous to silent films in the film industry. It is known that several systems are competing for the privilege of linking up with B.B.C. programmes and it would certainly seem that the cathode-ray system of broadcasting vision and film is the most successful. At the present time radio entertainment depends very much upon the ear to build up a sort of mental picture of what is happening in the studio. We still are not able to have acrobatic turns in the programme, nor can we obtain the full effect of comedy items. Sound alone imposes a great restriction on complete home radio entertainment. I have endeavoured in the first section of this handbook to deal with the elementary principles of television, the construction of simple vision apparatus, the methods of adapting receivers to receive television, and later chapters deal with possible developments.

The second section of the book deals with the short-wave and ultra-short-wave sides of radio telephony. As is well known, television, when it does arrive, is likely to be transmitted on the ultra-short-waves regarding which very little experiment has been carried out by home constructors, but as it is necessary to gain experience in this direction first of all by studying the short-waves, that is to say, transmissions on wavelengths from 20 metres to 100 metres, I have thought it advisable to include chapters dealing as well with that particular field. There is a fascination about the short-waves which, once sampled, greatly add to the pleasure

PREFACE

obtainable from wireless receivers. Additionally, they provide greater scope for experiment than with ordinary broadcast programmes, and it is hoped that this handbook, which is uniform in size and style with my *Everyman's Wireless Book*, *Wireless Constructor's Encyclopædia*, and *Encyclopædia of Popular Mechanics*, will aid the reader to a complete understanding of the subjects of which it treats.

I am indebted to the publishers for permission to use certain material originally published as articles in *Practical Wireless*.

F. J. CAMM

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LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

A.—Anode, or plate.	I.C.—Intermittent current.
A.C.—Alternating current.	I.C.W.—Interrupted continuous waves.
A.E.—Aerial.	I.F.—Intermediate frequency.
A.F.—Audio frequency.	I.P.—In primary (of transformer); start of primary.
A.T.C.—Aerial tuning condenser.	I.S.—In secondary (of transformer); start of secondary.
A.T.I.—Aerial tuning inductance.	kw.—Kilowatt.
A.V.C.—Automatic volume control.	L.F.—Low frequency.
B.A.—British Association.	L.R.—Low resistance.
B.O.T. Unit—Board of Trade unit.	L.S.—Loudspeaker.
C.C.C.—Closed circuit or secondary condenser or S.T.C.	L.T.—Low tension.
C.C.I.—Closed circuit or secondary inductance or S.T.I.	mfd.—microfarad.
cm.—centimetre.	mhy.—microhenry.
C.P.—Candle power.	mm.—millimetre.
C.W.—Continuous waves.	O.P.—Out primary (of transformer); end of primary.
D.C.—Direct current.	O.S.—Out secondary (of transformer); end of secondary.
D.C.C.—Double-cotton covered.	P.—Plate, or anode.
D.E.—Dull emitter.	P.D.—Potential difference, same as D.P.
D.P.—Potential difference.	Pot.—Potentiometer.
D.P.D.T.—Double-pole double-throw.	P.V.—Power valve.
D.P.S.T.—Double-pole single-throw.	Q.A.V.C.—Quiet automatic volume control
D.S.C.—Double silk covered.	Q.P.P.—Quiescent push-pull.
D.X.—Long distance.	R.F.—Radio frequency (same as high frequency).
E.—Earth.	R.M.S. Valve—Root-mean-square valve.
E.M.F.—Electro-motive force.	S.C.C.—Single cotton covered.
F.—Filament.	S.I.C.—Specific inductive capacity.
G.—Grid.	S.P.—Series parallel.
G.B.—Grid battery or grid bias.	S.P.D.T.—Single-pole double-throw.
G.C.—Grid condensers.	S.P.S.T.—Single pole single-throw.
G.L.—Grid leak.	S.S.C.—Single-silk covered.
H.F.—High-frequency (same as radio frequency).	S.W.G.—Standard wire gauge.
H.P.—Horse power.	T.T.—Tonic train.
H.R.—High resistance.	
H.T.—High tension.	

SYMBOLS

QUANTITIES		UNITS	
Amplification Factor	μ	Resistivity (Specific Resistance)	ρ
Capacity	C	Reactance	X
Current	I	Self-inductance	L
Conductance	G	Ampere	A
Dielectric Constant	ϵ	Ampere-hour	A h
Efficiency	η	Coulomb	C
Energy	W	Farad	F
E.M.F. (voltage)	E	Henry	H
Frequency	f	Ohm	Ω
Impedance	Z	Volt	V
Magnetic Flux	S	Watt	W
Magnetic Flux Density	B	Watt-hour	W h
Magnetic Field	H		
Power	P	PREFIXES	
Period Time	T	Mega	M
Phase Angle	ϕ	Micro	μ
Quantity	Q	Milli	m
Resistance	R	Kilo	k

CHAPTER I

TELEVISION SIMPLY EXPLAINED

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

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

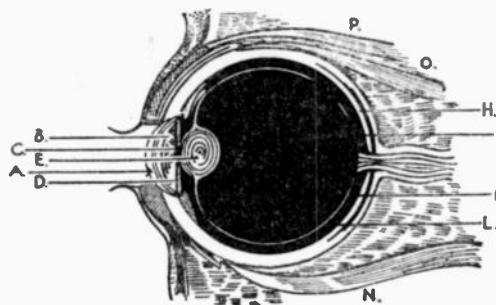


FIG. 1.—A representation of nature's television system — the eye. (P, O, N), muscles of eyeball; (A), cornea, which closes the front of the anterior chamber (B), which is filled with aqueous humour, and the back wall of which is formed by the curtain of the iris (D). In the middle of the back wall is the opening of the pupil (C), through which is seen

the lens (E). Behind the lens is the posterior chamber (L), filled with vitreous humour. Entering the eye from behind is the optic nerve, which is distributed to the retina. The posterior wall of the eye shows from within outwards the image-forming retina, the dark choroid with blood vessels (I), and the firm, protective sclerotic (H).

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

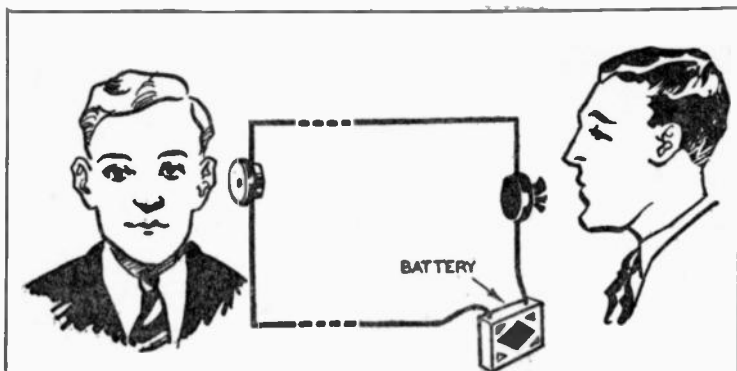


FIG. 2.—A simple diagram explaining the principles of speech transmitted by means of a microphone.

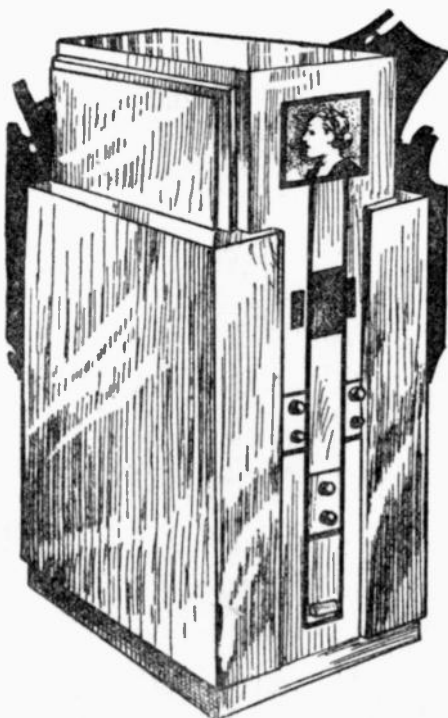


FIG. 3.—A commercial vision and sound receiver.

TELEVISION SIMPLY EXPLAINED

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

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

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

An Analogy.—An excellent analogy can be drawn between the telephone and television. When you speak into a telephone your voice causes a small diaphragm to vibrate. This diaphragm is in contact with a bowl-shaped block containing carbon in a finely granulated state, and the vibrations cause a variation in the degree of adhesion between the various granules. This variation causes a sympathetic variation of an electric current which hence varies absolutely in unison with the voice operating the diaphragm. The varying current thus set up passes along the telephone wires and causes vibrations in the earpiece at the receiving end. Fig. 2 shows this scheme in diagrammatic form. The same principle, of course, applies to wireless telephony, with the exception that the varying impulses set up by the microphone are despatched *via* the transmitting aerials into the ether instead of along wires as in the case of the telephone.

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

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transmitting station at Long Acre, London. They passed by land-line to Savoy Hill (2 LO), and thence to Brookman's Park. Now, a studio is specially set aside at Portland Place (Broadcasting House) for television programmes on the Baird System. The apparatus there installed is a mirror-drum transmitter suitable for close-up and extended scenes. The times of the present transmissions which are made on the 30-line system are 11 to 11.45 p.m. on Wednesday evenings, and from 4.30 p.m. to 5.15 p.m. on Saturday afternoons. It is possible that even as this book is going through the Press the whole outlook of television will be changed by the introduction of high-definition programmes in supersession of the present low-definition systems.

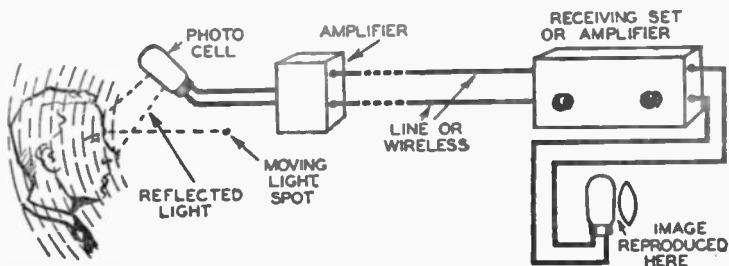


FIG. 4.—The method of televising an image.

Vision signals are at present broadcast from the London National Station on a wavelength of 261.1 metres, whilst the accompanying sound is transmitted from the Midland Regional on a wavelength of 391.1 metres.

The Television Transmitter.—It is obvious that when a scene or person is being televised it is necessary that a spot of light must traverse the scene or person, and therefore the first piece of apparatus to be considered is that which causes the spot of light to move. Previously, the scanning disc (Fig. 5) was used, and this consisted of a disc of metal with a series of holes equally spaced and punched near the edge of the disc in the form of a spiral. Latterly, however, this system has been superseded by the mirror-drum. This consists of a casting in the form of a flywheel on the face of which is a series of mirrors disposed at a slight

TELEVISION SIMPLY EXPLAINED

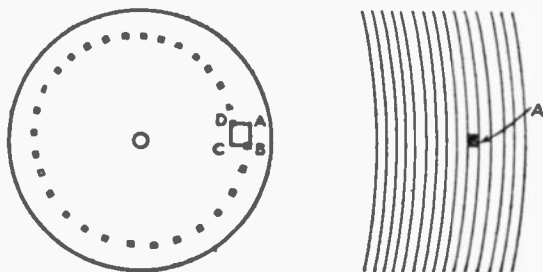
angle to the axis of rotation. The face of the mirror-drum is machined in the form of a spiral with a series of angular steps on which the mirrors are clipped. The mirror-drum is superior to the scanning disc in that it produces brighter images.

The Light Source.—Usually this is a specially designed metal-filament lamp or an arc lamp. It is mounted in a metal container provided with a funnel at the front. At the back of the funnel a reflector is fitted which concentrates the rays and directs them down the funnel. This arrangement causes a rectangular beam of light to emerge, and in the case of a disc machine this is directed on to a flat metal disc running at a constant speed. The disc has a series of small square holes pierced through it near the outside edge and in the form of a clockwise spiral as already explained. The shaded portion in Fig. 5 represents the light area thrown on to the face of the disc. It will be seen that the holes are so punched that the outer edge of one hole lies along the same circumference as the inner edge of the next hole. Thus, when the disc is rotated the rectangle of light enables each hole to pass through it ; hence, a square beam is directed through every hole and if a piece of white cardboard is held on the opposite side of the disc a light area A B C D is built up (Fig. 5). The equipment includes a lens, which focuses the beam on to a screen. When the disc is stationary a square area of light only is shown on the screen, the size of which depends, not only upon the distance between the lens and the screen, but also upon the difference between the distances of the first and last holes from the disc centre, and the distance between each hole around the circumference. An inspection of Fig. 7 will convey an excellent impression of the scheme just described.

The Mirror-Drum.—The mirror-drum transmitter is comprised by an arc light capable of movement in a backward and forward direction ; this movement is provided for by means of suitable channel guides. In front of the arc lamp is a circular metal shield having a square hole cut in it which permits a corresponding beam of light to "escape" and to be focused on to an inclined mirror. The beam is reflected by the mirror on to the mirror-drum described earlier, and which in the 30-line system has 30 mirrors round

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its circumference. By virtue of the arrangement of the mirrors already mentioned, as the drum revolves the light projected on to each mirror is thrown as a spot of light on to any screen interposed in its path. This spot is caused to move vertically from the bottom of the screen to the top. Thus, as each mirror receives the light spot a strip of light is created, this producing a rectangular arc of light as explained later. Notice that the area covered by the light consists of parallel straight lines, whereas with the disc type the lines, although still parallel, are slightly curved. The whole apparatus is capable of movement in much the same



Figs. 5 and 6.—The holes in the disc form a light opening having an area embraced by the letters A, B, C, and D, and (right) the complete area is sub-divided into small light squares in the manner shown.

way as the cine-camera in a film studio, so that it can be brought nearer to the object being televised or moved further away for long shots.

Obviously, then, the area being televised will be broken up in the "eye" of the transmitter into a series of 30-lines. In the high-definition system which, of course, gives rather more than 30 times the definition, the picture is broken up into 180 lines. A parallel can be drawn between the televised image and the half-tone process of reproducing illustrations. In Fig. 17 is an illustration made by the half-tone process through a screen of 55, which means to say that every linear inch of the picture is divided up into 55 dots (3,325 to the square inch). The dots, according to the areas of light and shade, are close together or widely disposed. Fig. 18 shows the same illustrations shown through a screen of 85, where it

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will be noticed that the definition is greatly improved. In Fig. 19, made to a screen of 120, the definition is still further improved, whilst in Fig. 20 (screen 180) even more detail is apparent.

Vertical and Horizontal Scanning.—The television system adopted by the B.B.C. makes use of scanning in a vertical direction (this applies to both disc and mirror-drum transmitters). In continental and American systems, however, horizontal scanning is employed. In the English system scanning takes place from the bottom, right corner of the area being televised, each spot of light travelling from the bottom to the top of the area in the form of a strip, each succeeding strip forming to the left of the previous strip. It will thus be observed that this takes place at every revolution of the disc or mirror-drum.

The Selenium Cell.—Several years ago it was discovered that selenium was sensitive to light ; that is to say, that its resistance varied according to the intensity of light directed upon it. Thus, when the metal is connected up in a circuit and exposed to light, an electric current will flow in the circuit of which it forms a part, but when the selenium is shielded from light rays the current flow will cease. Unfortunately, selenium, which hitherto was thought to provide the solution to the television problem, is far too sluggish in its action, and it was not until 1888 that Hertz discovered the photo-electric effect and constructed special cells which function on this principle. These cells are capable of converting light into electricity. Here again, difficulties presented themselves, for although the cells were sufficiently rapid in action they were unresponsive to the very small amount of light available and it was only possible to transmit shadows effectively. With television, of course, only the light reflected from the scene is available, and as this light is of low intensity the problem remains.

It is obviously out of the question for these cells to convert an entire scene into a comprehensible current variation simultaneously, for there are far too many varying light values spread over an illuminated area. Therefore, it has been found necessary to analyse or split up the subject being televised into a comparatively large number of areas by means of the apparatus illustrated in Fig. 7. Every one of these small

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areas will have a defined light value when illuminated by the travelling spot of light, and the photo-electric cell is capable of responding to each of these small varying light values in turn instantaneously. This will produce a corresponding current variation which can be reproduced or re-translated into a similar form at the receiving end. The scanning or exploring of the subject is completed continu-

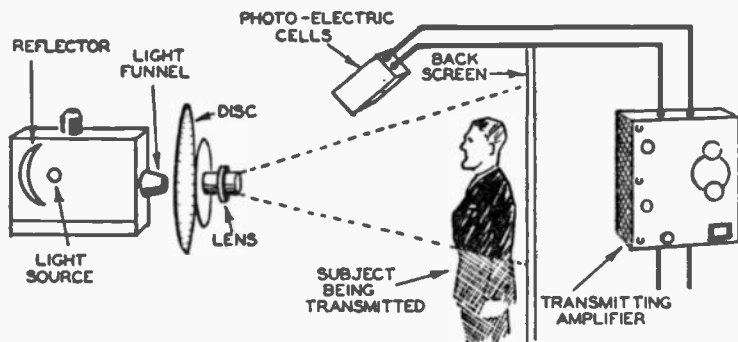


FIG. 7.—This illustration shows the arrangement of the subject and the photo-electric cells.

ously, many times a second—in the case of the B.B.C. transmission, $12\frac{1}{2}$ times per second. With these transmissions a picture is transmitted in the shape of a rectangle bearing the ratio of 7 vertical to 3 horizontal, 30 scanning strips and 750 pictures per minute. Even with this comparatively low definition, excellent pictures may be transmitted. For the rest the defect in the human eye known as persistence of vision, to which I have already referred, is relied upon.

Fig. 16 shows in schematic form the Baird system of television transmission on the ultra-short waves. The apparatus is installed at the Crystal Palace. The author has witnessed reception of films as well as studio scenes transmitted by this system, and assures the reader that it is almost perfect.

CHAPTER II

TELEVISION SCANNING

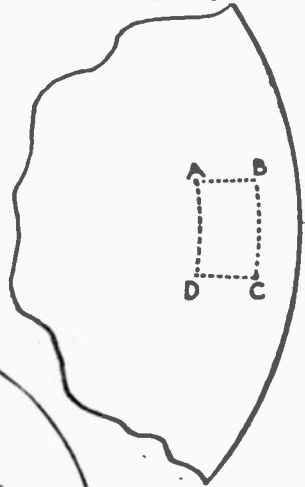
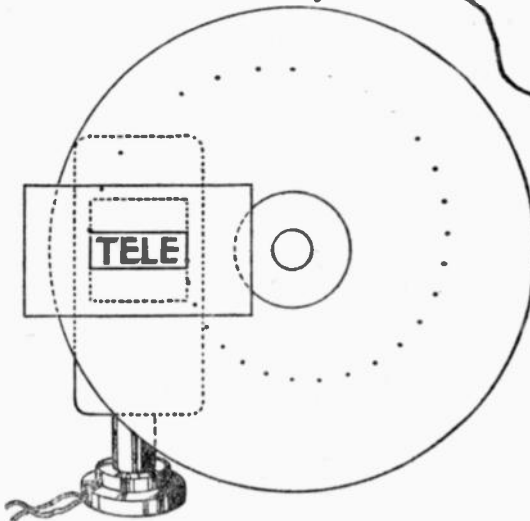
WHEN a photograph is taken with an ordinary camera the lens is uncovered to permit the whole of the view to be impressed upon the photographic plate at one instant. The varying degrees of light and shade are recorded by the photographic emulsion, and if movement is to be recorded a cinematograph camera is employed in which this process is carried out a number of times per second, each small section of the final film being exposed to the view instantaneously. Unfortunately, it is not possible to transmit television images by a similar means, as the photographic plate cannot be reproduced in an electrical sense. In the emulsion which is used to coat the negative a number of small grains of a special sensitive salt are held in suspension, and it is each of these which receives the light rays and is thus affected and caused to reproduce the image. Therefore, to employ a similar device, in an electrical sense it would be necessary to replace the grains of salt by some similar infinitesimal light sensitive device. In the very early days of television experiment this point was fully realised, and instead of splitting up the image after passing through a lens, it was split up before, and this breaking-up was carried out through the medium of what is known as a Nipkow disc.

The Earliest Scheme.—A German inventor, by name Paul Nipkow, conceived the idea of employing a disc of metal carrying a number of holes or lenses arranged in spiral formation, and supported behind this was a lens and other optical apparatus. When the disc is rotated, the spiral of holes or lenses travels across the front of the lens and thus only permits one small portion of the image to be passed through the lens at a given moment. The series of holes is, however, arranged in such a manner that the strips formed by the successive holes build up into a complete light area, and thus the image is divided into a number of small sections. The positioning of the holes is, of course, a very delicate task,

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as it is necessary that the light track formed by each hole shall accurately align with the next so that no overlap or underlap takes place with consequent ruin of the televised image. This form of apparatus is still in use and is known as a scanning disc. The number of apertures has been fixed at 30 and this enables a really well-defined picture to be transmitted and received on the normal broadcast wavelengths. Obviously the detail cannot be very high, but the limitations of the broadcast wave-band render it impracticable to employ higher detail and therefore the scanning disc serves its purpose.

Other Mechanical Schemes.— To rotate the disc it is necessary to employ some form of motor, and therefore this type of scanning may be referred to as "mechanical." There are obviously limita-



FIGS. 8 and 9 (left).—The holes in a simple disc are arranged in a spiral and (above) the rectangle ABCD is the actual picture opening which is seen on the disc.

tions to the efficiency of mechanical methods of scanning an object, and these lie in the vagaries of motor speed, inertia of the disc, etc. To overcome certain troubles connected with the perforated disc a scheme has been developed in America by Jenkins in which the disc

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is of thick glass, and it is ground and cut in such a manner that it forms a prism, the section varying gradually and continuously around the circumference (Fig. 10). By directing a beam of light on to the edge of this disc a deflection of the light will result, and upon rotating the disc the light is compelled to travel or scan. By the simple method of arranging a second disc over the first, so that the overlapping edges revolve at right-angles to each other, the complete television scanning process (that is, vertical and horizontal) is effected (Fig. 11). The defect of the schemes so far referred to is the lack of light which is available at the receiving end, and to overcome this, various methods of projecting the image have

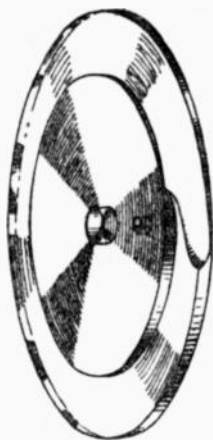


FIG. 10.—A prismatic disc, as used in an American type.

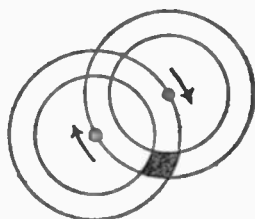


FIG. 11.—How two prismatic discs are arranged to give the necessary scanning effect.

the drum may be fitted with mirrors to reflect the light.

The Mirror - Drum. — This arrangement is known as a mirror-drum, and each small mirror is mounted at a slightly different angle from its neighbour, and the light source is directed on to a special prism assembly which is supplied with the signal variations from the

been experimented with. For instance, by converting the disc into a drum and rotating it across two pulleys, as in Fig. 31, it is possible to employ a very powerful light source inside the drum and thus obtain a pencil of light from the drum which may be focused at a good distance from the apparatus and so give an increased size of image as well as a brighter one. As a variation of this arrangement,

SCREEN.

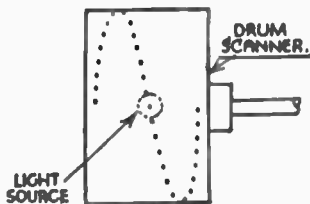


FIG. 12.—This diagram shows how the apertured drum apparatus works.

TELEVISION AND SHORT-WAVE HANDBOOK

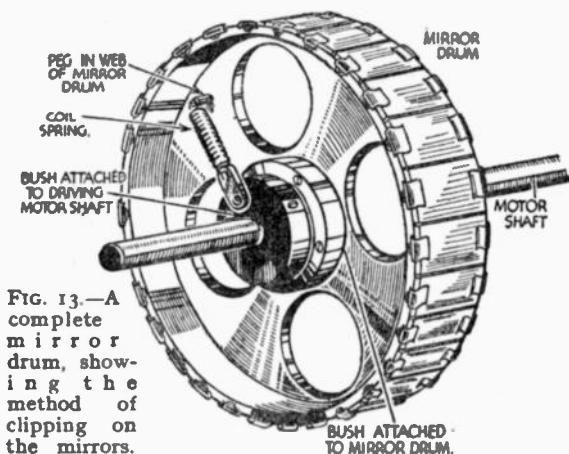
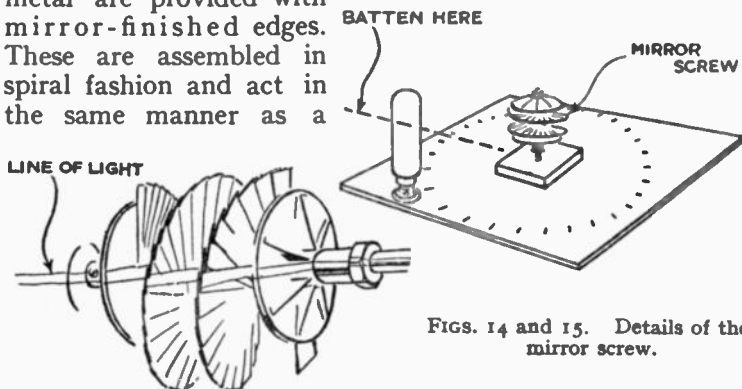


FIG. 13.—A complete mirror drum, showing the method of clipping on the mirrors.

amplifier. (Fig. 13). The prisms control the light passed on to the mirror-drum and thus the image is built up from the controlled light reflected from drum on to a suitable screen. With this

type of apparatus a very powerful electric lamp is employed as the light source, and it is possible to obtain an image about 9 inches by 5 inches of such a brilliancy that it may be viewed in a normal room illuminated by natural or artificial light.

The Mirror-Screw.—A variation of the mirror-drum is to be found in the mirror-screw, in which a number of plates of metal are provided with mirror-finished edges. These are assembled in spiral fashion and act in the same manner as a



FIGS. 14 and 15. Details of the mirror screw.

mirror-drum, in reflecting a controlled light-source on to a suitable screen. This arrangement is much more compact than a drum, but the light source has to be provided in the

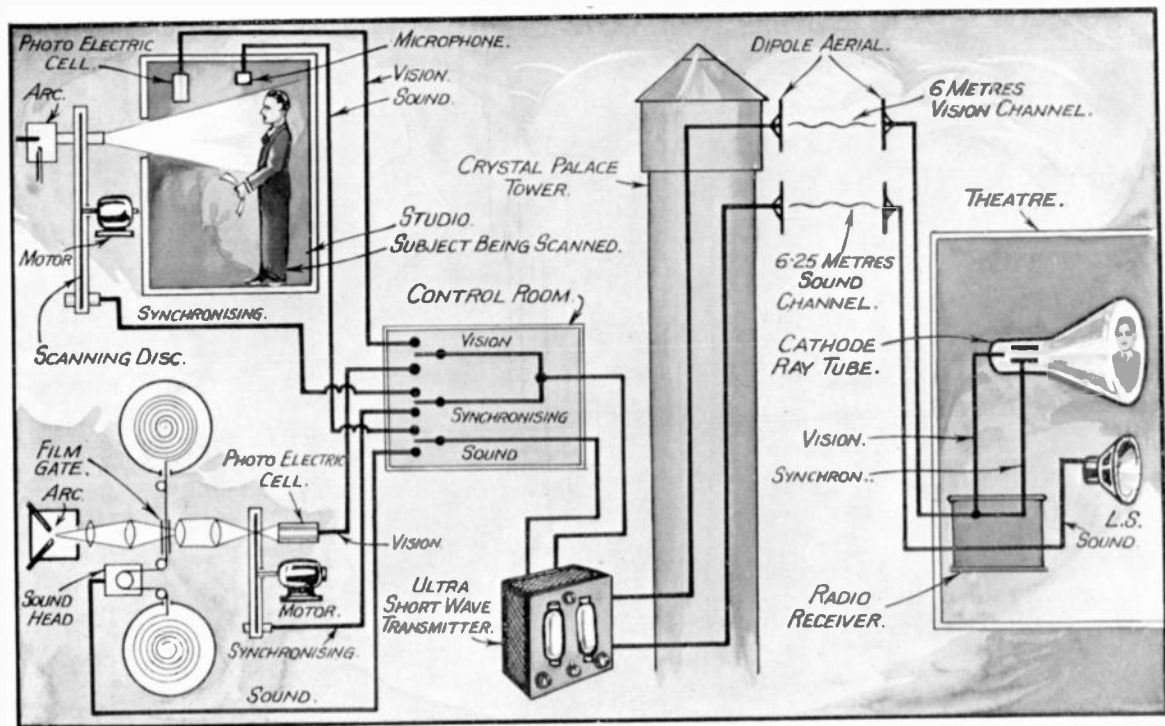


FIG. 16.—This diagram shows the complete transmitting and receiving arrangements of the new Baird system.



FIG. 17.—A block made through a 55 screen shows how imperfect is the detail obtained.



FIG. 18.—A considerable improvement in detail is seen in the photograph when made through an 85 screen.



FIG. 19.—Still further improvement is obtained when made through a 120 screen.



FIG. 20.—Perfect detail is obtained in the photograph when made through a 180 screen.



FIG. 21.—A complete transmitting equipment using an apertured drum.

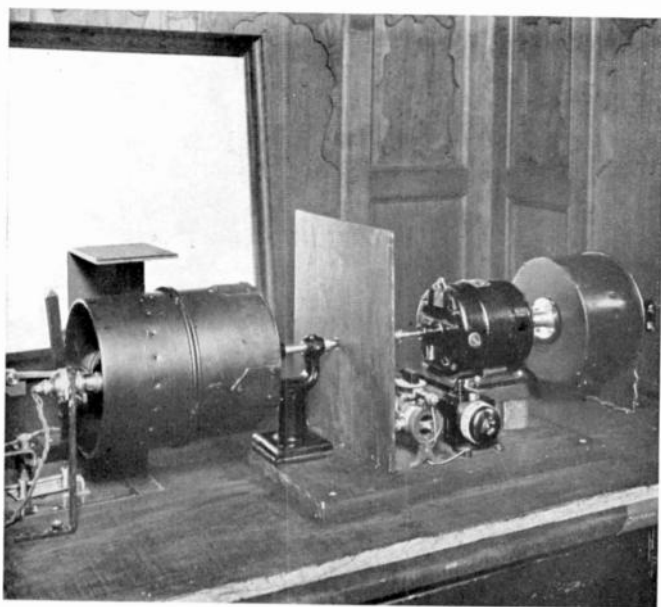


FIG. 22.—An apertured drum device operated from a single shaft.

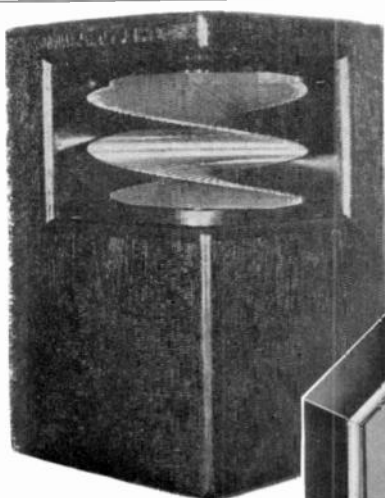


FIG. 23.—Showing how a mirror screw is built up like a spiral staircase.

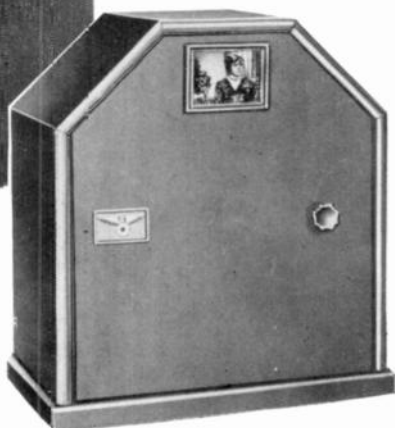


FIG. 24.—Showing how an image will look when correctly phased and framed.



FIG. 25.—An actual subject being televised.



FIG. 26.—How the subject appears on the television screen.

TELEVISION SCANNING

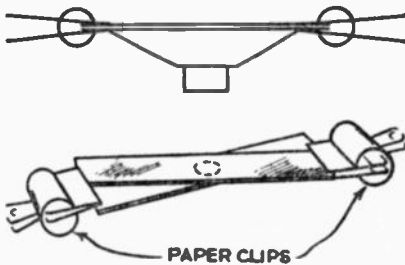


FIG. 27.—The method of fitting the mirror strip into position.

Dictionary at back of book). The light is directed on to the central mirror, and the screen is placed in such a position that the reflections from the outer stationary circle of mirrors cast their reflection on it and so build up the image.

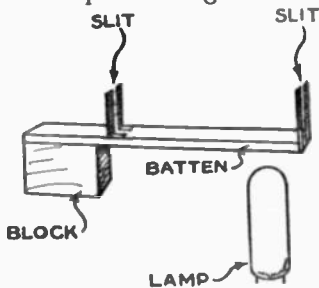


FIG. 29.—Arrange two slits on the board as shown, so that a spot is seen reflected on the mirror edge.

much greater detail to be obtained. Foremost amongst these is the cathode-ray tube, in which the scanning is performed by a stream of electrons inside a glass tube.

form of a very narrow strip and thus it may not be capable of quite such brilliancy as the mirror-drum.

The Mihaly Device.

—In Germany a research worker (Mihaly) has developed a scheme in which a motor rotates a single mirror inside a ring of mirrors (see

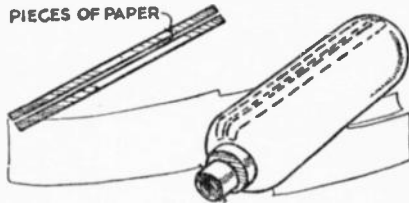


FIG. 28.—Showing how two pieces of paper can be glued to the lamp to produce a narrow beam of light.

Electrical Systems.

—As distinct from the mechanical methods above referred to there are a number of electrical schemes which are able to overcome the various defects inherent in a mechanical process and which also enable

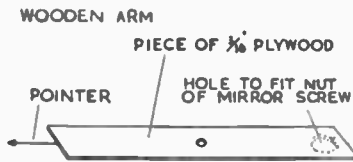
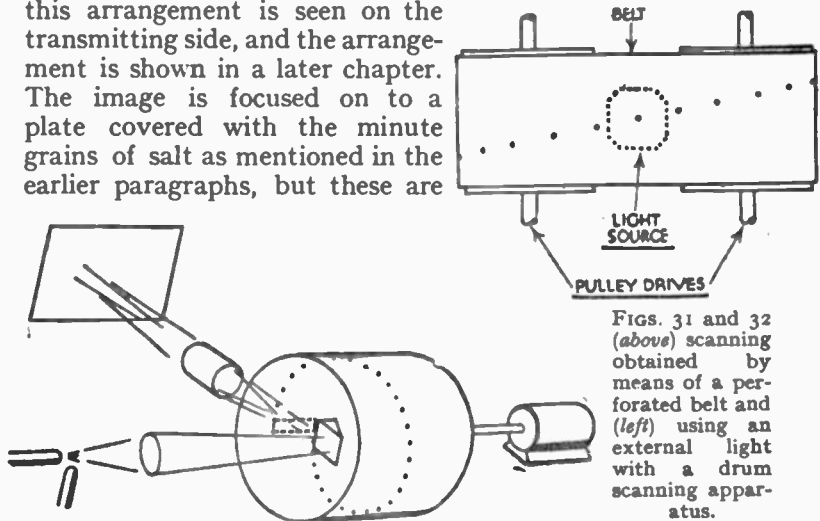


FIG. 30.—The wooden arm which is fixed to the mirror base.

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This system is fully described later on. It permits of much greater detail, and has no inertia, and furthermore permits of a much larger image with increased brightness. The associated apparatus for controlling the tube is certainly rather complicated, but by utilising the short-wavelengths for transmission it is possible to obtain a picture which is capable of very minute detail and which will enable the television programme to compete with the home-cinema in home entertainment.

The Iconoscope.—A development of the cathode-ray tube has been introduced by Dr. V. K. Zworykin in which a photo-sensitive electrode is incorporated. Thus it is similar to the photographic plate in that it instantaneously converts the received image into electrical impulses without the difficulties attending scanning. The principal advantage of this arrangement is seen on the transmitting side, and the arrangement is shown in a later chapter. The image is focused on to a plate covered with the minute grains of salt as mentioned in the earlier paragraphs, but these are



FIGS. 31 and 32
(above) scanning obtained by means of a perforated belt and
(left) using an external light with a drum scanning apparatus.

also electrically arranged in such a manner that they are insulated one from another. The application of an image (through a lens) focused on to the plate, results in a certain flow of current through the circuit and thus influences the transmitter according to the detail which is received by the plate. At the receiving end, the received impulses are fed to a fluorescent screen of a cathode-ray tube and reproduce the image.

CHAPTER III

THE CATHODE-RAY OSCILLOGRAPH

NOTWITHSTANDING the many ingenious mechanical systems of scanning, the perfection of the cathode-ray oscillograph bids fair to be the ultimate system employed. In point of fact the most successful systems so far demonstrated make use of this simple piece of apparatus. A knowledge of the methods of controlling the scanning spot in the cathode-ray tube, which is far from being generally understood, is therefore necessary.

The main essentials of the electrode system in the tube itself should first be examined. An ordinary filament (the cathode) is heated by an electric current, as a result of which a stream of electrons is emitted from the filament surface, just as is the case with an ordinary valve. The Wehnelt cylinder, named after its inventor, and sometimes known simply as the control cylinder or the "gun," completely surrounds the filament. This has a negative charge applied to it, the effect of which is to direct and concentrate the stream of emitted electrons towards the anode—the circular disc mounted just in front, as shown in Fig. 33. Incoming television signals, applied to the control cylinder, vary the potential accordingly,

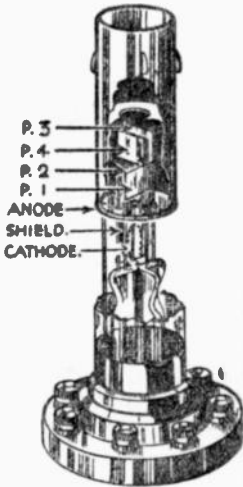


FIG. 33.—The internal construction of the tube.

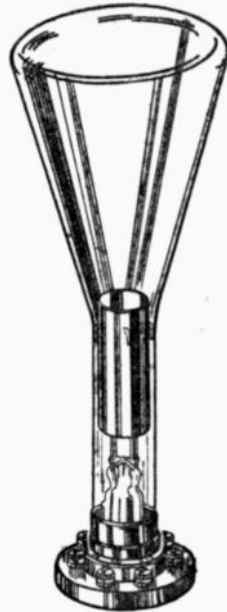


FIG. 34.—A cathode-ray oscillograph tube.

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and succeed in altering the intensity of the electron beam.

The Visible Electron Spot.—A high positive voltage of between a few hundred volts and two or three thousand volts is applied to this anode, the amount varying according to the type of tube employed, and the purpose for which it is required. The electrons are thus forced at tremendous speed towards the plate, at the centre of which there is a small hole. A large proportion of electrons pass through this hole and reach the front screen, where their high velocity renders them visible as a spot on the fluorescent material coating the screen. Two pairs of plates, called deflector plates, at right-angles to each other are placed alongside the path of the electron stream between the anode and the screen, and, no voltage being applied to either pair, the electron path is normal to the screen. An electrical charge given to either, or both, pairs of these deflector plates causes the electron path to be deflected and so to strike the screen at another point, the amount of deflection being proportional to the potential charge or charges given to the plates.

Controlled Movement of the Spot.—Thus is provided a method whereby the visible spot on the screen may be moved to describe any definite path within the space limits of the apparatus, provided that the plate potentials can be varied to suit the conditions imposed by the scanning spot movement at the transmitting end. With all scanning processes there is a primary and a secondary movement, the primary movement depending on the number of strips dividing the picture, and the number of picture repetitions per second, and the secondary movement simply on the number of picture repetitions per second. For example, with the B.B.C. television service the primary movement takes place 375 times per second ($12\frac{1}{2}$ pictures per second multiplied by the 30 scanning strips), and the secondary movement, $12\frac{1}{2}$ times per second. With higher-definition images now being investigated the frequencies are greatly increased, being, for instance, 4,500 and 25 respectively for 180-line pictures.

The "Saw-Tooth" Motion.—With regard to the primary movement, the spot has an upward movement at

THE CATHODE-RAY OSCILLOGRAPH

constant velocity from the top of which a quick return is made. The process is then repeated along a path next to the one just followed. The same effect occurs with most high-definition processes, except that scanning is horizontal instead of vertical. The movement in both cases is termed "saw-tooth" motion for obvious reasons (see Fig. 35).

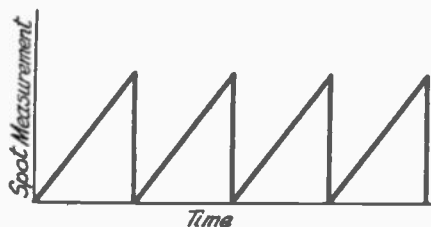


FIG. 35.—This graph illustrates the saw-tooth motion of the television scanning spot.

It is necessary to devise a means whereby this can be brought about by the electron spot.

In the first place each pair of deflector plates is connected to a separate frequency generator. If a suitable voltage variation can be applied to one pair of plates, the

required primary scanning motion can be brought about, provided that the cycle of operations is uniformly repetitive. The use of a thyratron or gas-filled discharge tube is a simple and effective means to accomplish this. These tubes are suggestive in appearance of an ordinary valve, but the electrode construction and gas-filling cause them to behave differently. The grid voltage can be fixed at a certain pre-arranged figure, above which no anode current will flow. The moment the grid voltage falls below this value, the full anode current immediately flows or, in other words, the anode current is "triggered."

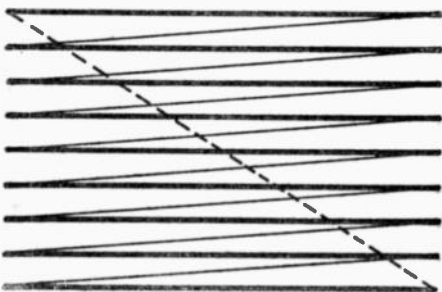


FIG. 36.—The heavy and light lines show how the scanning field is built up by the time bases.

Deflection of Electrons.—What is commonly known as a time-base circuit is therefore arranged, this essentially being merely a saturated diode valve. This is connected with the biased gas-filled discharge tube and a fixed condenser in such a way that a uniformly increasing potential is applied to a pair of the deflector plates in the cathode-ray

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tube. The electron stream is deflected in a proportionally uniform manner so that the electron spot now describes a line on the fluorescent screen, either vertical or horizontal according to which pair of deflector plates is charged. The thyatron is arranged to trigger when the electron stream has been diverted the required scanning distance, and at this instant the voltage suddenly drops, corresponding to the vertical drop in the "saw-tooth" graph, Fig. 35.

Superimposed Effect.—Simultaneously with this primary scanning operation, another action is imposed on the second pair of deflector plates, at right-angles to the first operation. Either a $12\frac{1}{2}$ - or a 25-frequency time-base circuit is brought into operation, its action being to pull the spot down or pull the spot across (horizontal or vertical scanning), so that each line traversed is not over the same path, but contiguous to it. At the end of the last scanning line the second thyatron is triggered and a "fly-back" stroke is made to the starting-point once more. If the whole of this scanning operation is imagined to be stretched out it will appear as in Fig. 36.

Simple in theory, the time bases call for skilled and careful arrangement. To allow one unit to perform the dual function they are, as a rule, built up in "double" form, as explained in the Dictionary at the end of this book. The two thyatrons, flanked by the saturated diodes, are in the centre. The frequency of the scanning and the length of the strokes are determined by the controls on the panel.

Quite small high-tension batteries are sufficient for the operation of a cathode-ray receiver, little power being consumed.

CHAPTER IV

TELEVISION OPTICS

ACCORDING to present-day methods of working, nearly every television receiver has lenses or mirrors, or both, included as part of the actual equipment. For example, in the case of the simple disc set one or more lenses is necessary to magnify the image built up by the disc and neon lamp owing to the economic limitations imposed on disc diameter resulting in a small actual image. With mirror-drum equipment lenses and mirrors are used for focusing

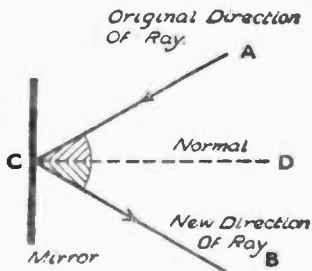


FIG. 37.—When light is reflected the angle of incidence equals the angle of reflection.

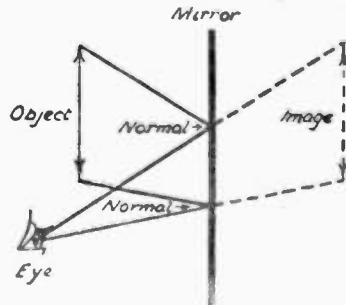


FIG. 38.—Showing why the reflected image appears to be behind the mirror.

the modulated beam of light on to the rotating drum (which itself has mirrors mounted round its outside edge), and also for changing the direction of the light beam.

In the case of actual mirrors the problems involved in making a correct choice are easy of solution. Only good-quality optically-tested glass should be used, otherwise secondary reflections will give rise to misfocused light spots. Furthermore, they should be of uniform thickness, while the mirrors mounted on the rotating drum itself need to have their backs cleaned so that only the thin reflecting surface is left.

An Optical Law.—When it comes to the question of adjusting any mirror position so that it reflects a beam of

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light and changes its direction, the only law to remember is that the angle of incidence is equal to the angle of reflection. This is made clear by a reference to Fig. 37, where the beam A strikes the mirror surface at CD and is reflected or diverted to the new path CB. The line CD is normal (i.e. at right-angles) to the mirror at the point C and in consequence the angle ACD (angle of incidence) is equal to angle BCD (angle of reflection).

If a mirror is brought into play to observe an object from a certain direction when the object itself (which in television is nearly always the received image) is obscured from direct

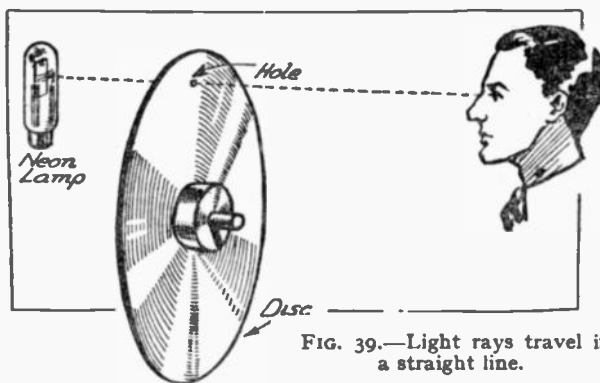


FIG. 39.—Light rays travel in a straight line.

vision, then what is really seen is a virtual image of the object. Fig. 38 shows how this is brought about. Since the eye sees things only in a straight line (Fig. 38), it in effect transposes the image to an imaginary position behind the mirror, so that the imaginary object image is as far behind the mirror surface as the real object is in front.

Another phenomena which must be remembered in television optics is that known as refraction (see Fig. 40). This is the term applied to the "bending" of the light rays when they pass from one transparent medium to another—say, air to glass. This is explained by saying that the light beam (really a form of radiant energy which travels from point to point in the form of ethereal vibrations of minute wavelength) travels at different speeds through differing media.

It is this fact which imparts to lenses their special

TELEVISION OPTICS

qualities, one of the most important of which is focusing. With television, lens use is confined principally to single convex and double convex types. Both are really discs of glass whose convex surfaces are ground to a curvature corresponding to the surface of a sphere, this surface curvature governing what is termed the focal length of the lens. A reference to Figs. 41 and 42 will indicate how the focusing effect operates. A parallel beam of light has a double convex lens interposed in its path. Refraction of the individual light rays constituting the whole beam occurs at entry into and exit from the lens surface (shown by the extreme beam rays being bent), and the resultant rays focus to a point a definite distance from the centre plane of the lens. Of course, the reverse effect can take place whereby the rays from a point source of light are transformed into a parallel beam.

Faults in Lenses.—Speaking of lenses generally, there are several faults which must be guarded against if the best results are required. First of all, there is the fault known as spherical aberration, whereby the rays from the outside

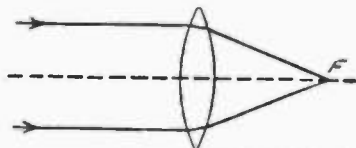


FIG. 41.—The focusing effect of a double convex lens on a parallel beam of light.

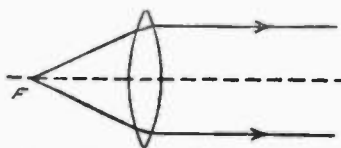


FIG. 42.—A parallel beam from a point source of light using a lens.

of the lens focus nearer to it than those from the centre. A blurred image, will result but it is possible to counteract this by using two lenses of differing focal lengths in conjunction with each other. Then, of course, there is the familiar effect called astigmatism, wherein the focus across one axis is not the same as that across an axis at right-

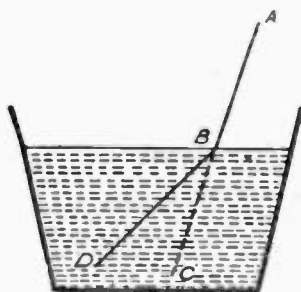
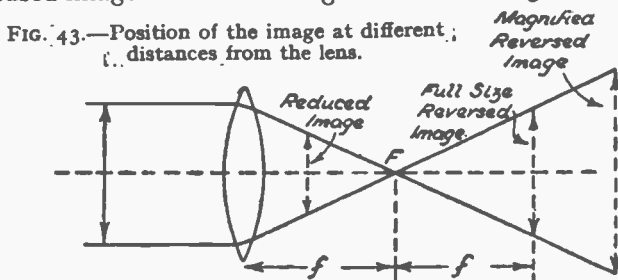


FIG. 40.—A simple example of refraction. Obviously, the true position of the stick in the water is A B C, but it appears to be A B D.

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angles. This, naturally, will produce a distorted image and should be watched for when purchasing a lens.

If the main requirement which has to be considered in the case of the television receiving equipment is maximum light-collecting ability, then choose a lens of the largest diameter, which can be accommodated conveniently in the apparatus, this lens at the same time having a short focus, and being mounted as near the image as possible. A very simple way to measure the focus with reasonable accuracy is to hold the lens vertically in front of a wall or a sheet of paper, so that the image of, say, a window, is sharply focused on the wall or paper. The distance between this focused image and the lens edge is the focal length of the lens.



A Condenser Lens.—Cases arise where it is found necessary to focus a beam of light that calls for the use of a condenser lens. This lens gives partial concentration of the beam through the medium of its central portion and a second lens is then used to bring about the accurate focusing that may be required.

Another point to note is that if we have an illuminated object such as a bright television image, and a lens is placed between this and a screen on which the image is to be observed, then if the screen is placed between the lens and its own focal point, the object will be seen as an image reduced in size but positioned the right way up. Beyond the focal point of the lens the object will be seen on the screen as an inverted image, while the image size is governed by the distance from the lens (as shown in Fig. 43). If less than twice the focal length from the lens, the image on the screen will be smaller than the actual object, but beyond this the image becomes magnified.

CHAPTER V
THE ICONOSCOPE

THE Iconoscope is really a development of the cathode-ray tube and is probably one of the greatest achievements in television research for many years. It was invented by Dr. V. K. Zworykin, and has often been referred to as a "cathode-ray tube" with a memory. The Iconoscope is used for transmitting purposes in conjunction with a cathode-ray receiver, and it is feasible to suppose that such an all-electric system should prove considerably more efficient than any arrangement which depends for its functioning upon mechanically-operated devices. As yet, however, the Iconoscope has not been fully exploited, although it has been used with success in numerous experiments carried out in America.

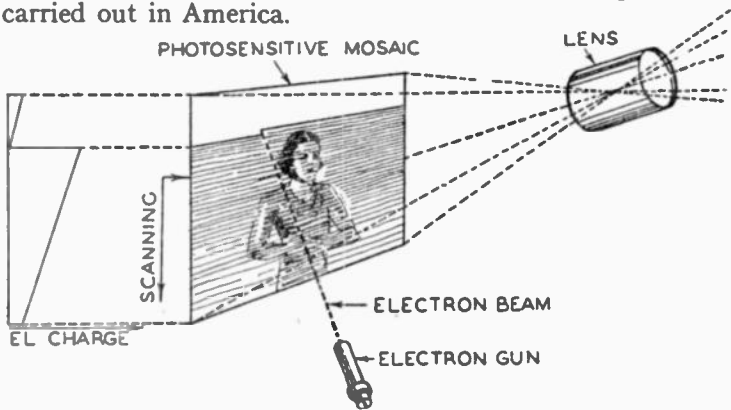


FIG. 44.—Showing how the scenes projected on to the mosaic are scanned.

In order to understand the functioning of the Iconoscope it is first necessary to consider how the cathode-ray tube functions. An electron stream liberated by a cathode and applied to a phosphorescent screen is controlled by what is known as an electron gun and various deflecting plates and coils. By applying varying alternating potentials to the deflecting plates the stream can be made to move backwards

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and forwards in a horizontal line so as to traverse a complete rectangle. If the beam is modulated by the received television signals, it will produce numerous spots of light of different intensities on the phosphorescent screen. The result of the action referred to is to form a complete picture.

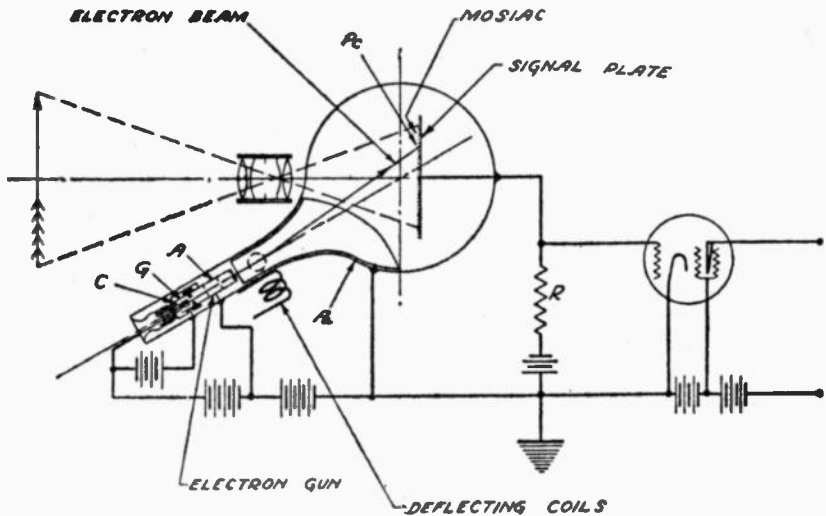


FIG. 45.—Theoretical circuit of the Iconoscope and part of its associated equipment.

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

A general arrangement and method of functioning of the Iconoscope, or electric eye, is shown in Fig. 44, where the picture which is to be transmitted is focused by means of a lens on to the mosaic bank of photo-electric cells, inside the tube. The varying light intensities applied to this mosaic of cells produces an electrical change, which can be compared with the chemical change taking place on an ordinary photographic plate, when the camera lens is open and focused. When this is done, each individual cell of the

THE ICONOSCOPE

mosaic liberates a certain number of electrons proportional to the intensity of the light directed upon it. This results in the cells (which act as minute condensers) becoming charged. The principle of the charging action can be followed in Fig. 46, where one of the tiny cells is represented at C. As light falls upon its sensitised surface some free electrons are liberated with the result that there is a surplus charge of positive electricity on one plate of the condenser and a corresponding negative charge on the other.

The next step is to convert the electrical charges built up on the condenser into corresponding signal currents, which can be used (after suitable amplification) to modulate the

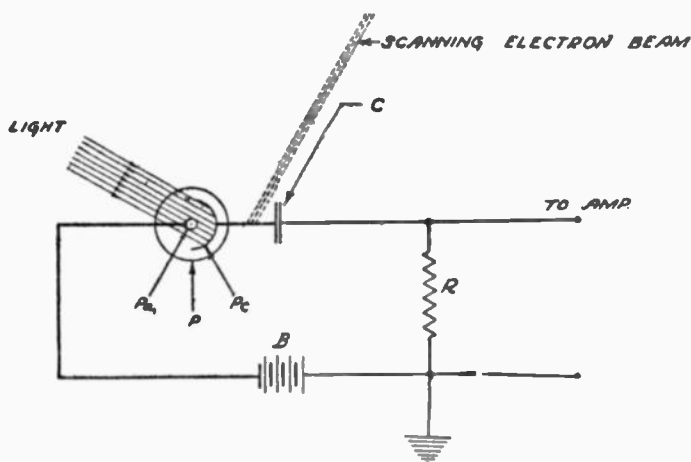


FIG. 46.—Showing the condenser action of each cell.

carrier wave of the transmitter, so as to radiate the electrical equivalent of the complete picture. At this juncture an important advantage of the Iconoscope comes into play. The electrode assembly in Fig. 45 is set in the path of the electron stream produced by the "gun," which acts as a scanning beam as it passes to and fro over the cells; the beam discharges each cell in turn, and causes a series of current surges to pass through a resistance R , which is connected in the input circuit of the amplifier. Each pulse of current is the electrical equivalent of the light intensity of a particular portion of the original picture. Consequently, it

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will be seen that the whole of the original picture is converted into its electrical counterpart by the charging action of the bank of cells. These charges are afterwards scanned in correct sequence by the electron beam, and thereby applied to the amplifier and thence to the transmitting apparatus proper.

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

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

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

CHAPTER VI

LIGHT MODULATION FOR TELEVISION

IN the cathode-ray television receiver an electron stream is directed upon a special screen situated at the end of the cathode-ray tube, and this stream is deflected and moved about by the application of the received impulses to special plates arranged in the path of the electron stream. In all other systems of television reception at present in existence, a distinction is provided in the fact that a source of light is employed, and in some way or another the brilliancy of this light source is modified by the received signal. It will thus be seen that the efficiency of the apparatus depends not only upon the initial brilliancy of the light source, but also upon the variations applied to it.

Neon Lamps.—In its simplest form a lamp containing neon gas is employed and this glows with a peculiar yellowish-red glow, and is familiar to most readers, as it is employed in shop-window signs, etc. This particular tube has the property of responding instantly to any applied current, and does not, like an ordinary electric lamp, take some time to decrease in brilliancy if the applied voltage is modified. The neon lamp

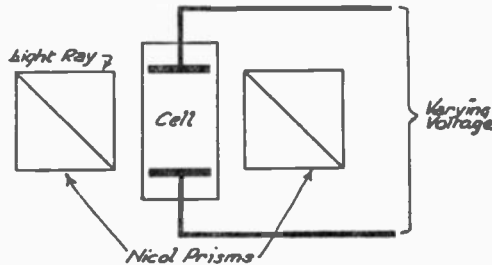


FIG. 47.—A schematic representation of a Kerr-cell combination.

is connected so that a direct current flows through it to provide an initial brilliancy, and then the current variations corresponding to the received signal are applied to it. It will thus flicker, and when viewed through the holes in a scanning disc, the picture will be built up. The total light which is seen by the eye is obviously reduced by the holes in the disc, and as the initial brilliancy is not of a particularly high order, the picture from a disc visor

TELEVISION AND SHORT-WAVE HANDBOOK

has to be viewed in very subdued light or in complete darkness. Various types of light source have been experimented with to overcome this difficulty, and some novel schemes have been tried out. A crater-point neon, for instance, is employed with a mirror-drum or mirror-screw, and this gives a slightly brighter picture.

The Nicol Prism.—For projection purposes we must obviously start with a very bright light source, so that sufficient illumination is available for projection purposes. As no gas-filled lamps have been found suitable to carry the signal fluctuations without time lag, a scheme has been

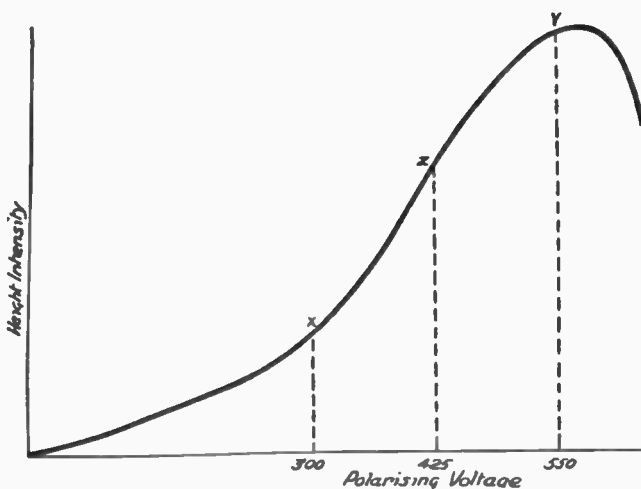
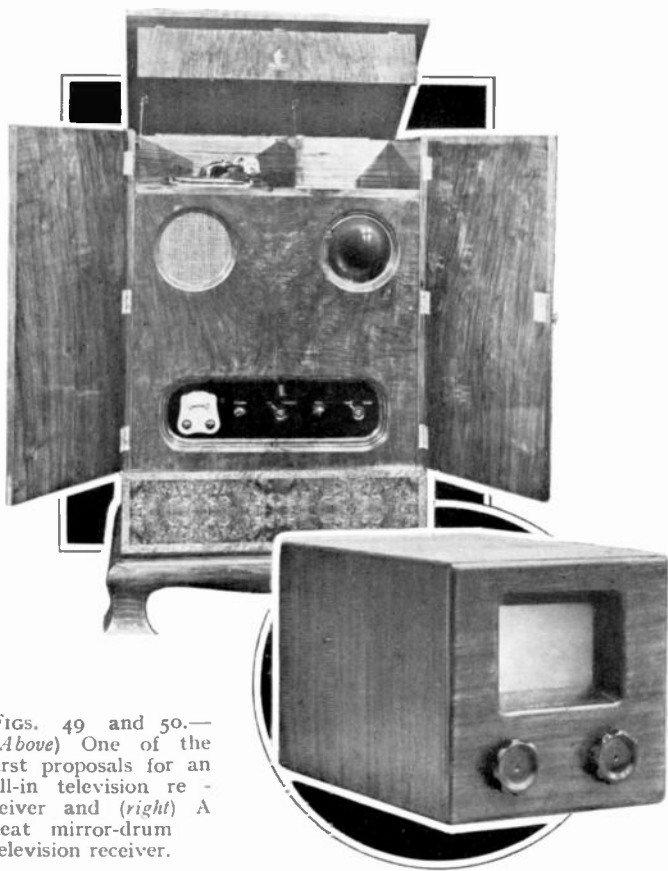


FIG. 48.—The light intensity polarising volts curve for a grid cell combination.

devised in which a normal electric lamp provides the illumination, and this light is passed through a special light-trap, the latter being provided with the signal variations, and thus controlling the light. The working is very ingenious and depends for its effect upon what is known as the Kerr-cell effect. It consists, essentially, of two plates arranged alternately and interposed with separators at the edges, immersed in a liquid known as nitro-benzine. This will pass current, and is employed in conjunction with Nicol prisms. This consists of a piece of Iceland Spar (see Fig. 57)



Figs. 49 and 50.—
 (Above) One of the first proposals for an all-in television receiver and (right) A neat mirror-drum television receiver.

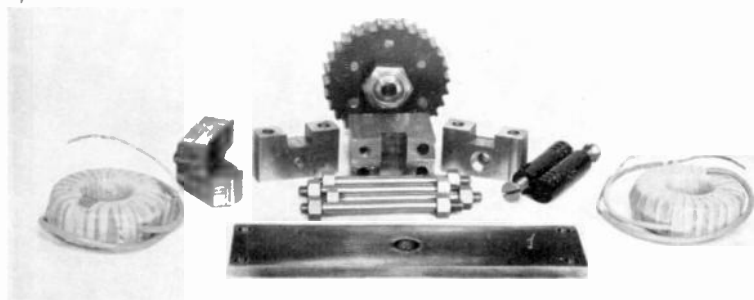


FIG. 51.—Details of the various parts used in making synchronising gear.



FIGS. 52 to 54 (from left to right).—An experimental mirror-drum receiver for home use; a high-quality receiver of novel design; and another novel instrument which incorporates two radio receivers and a cathode-ray tube.



FIG. 55 (below).—Showing a television electric motor and the accompanying toothed-wheel synchronising gear. The synchronising coils and toothed wheel are shown removed from the motor.



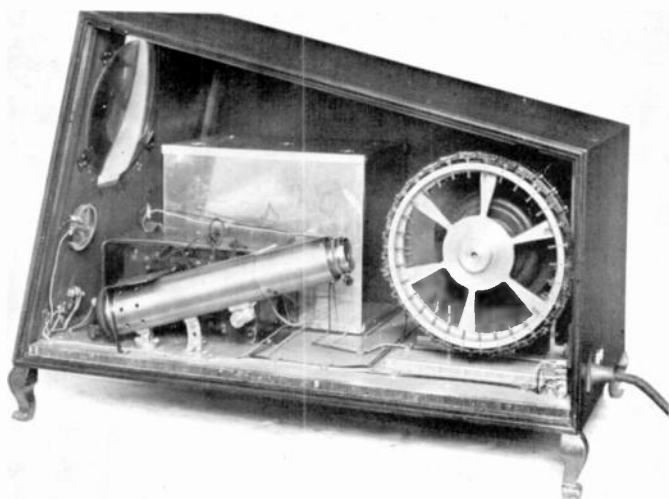


FIG. 56.—An experimental model television projector receiver, using a hot-cathode neon lamp.

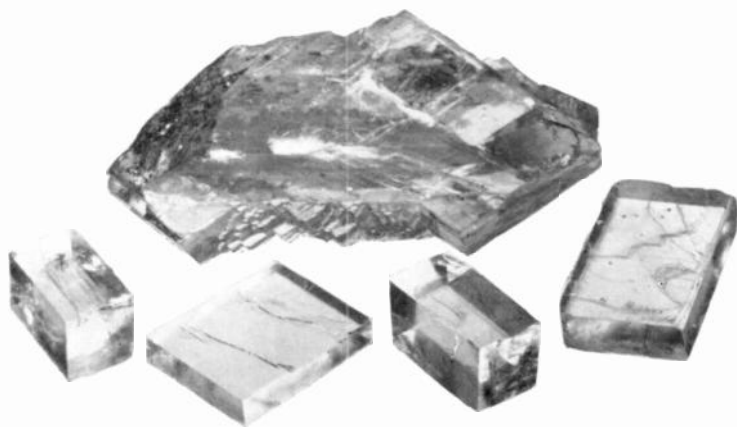
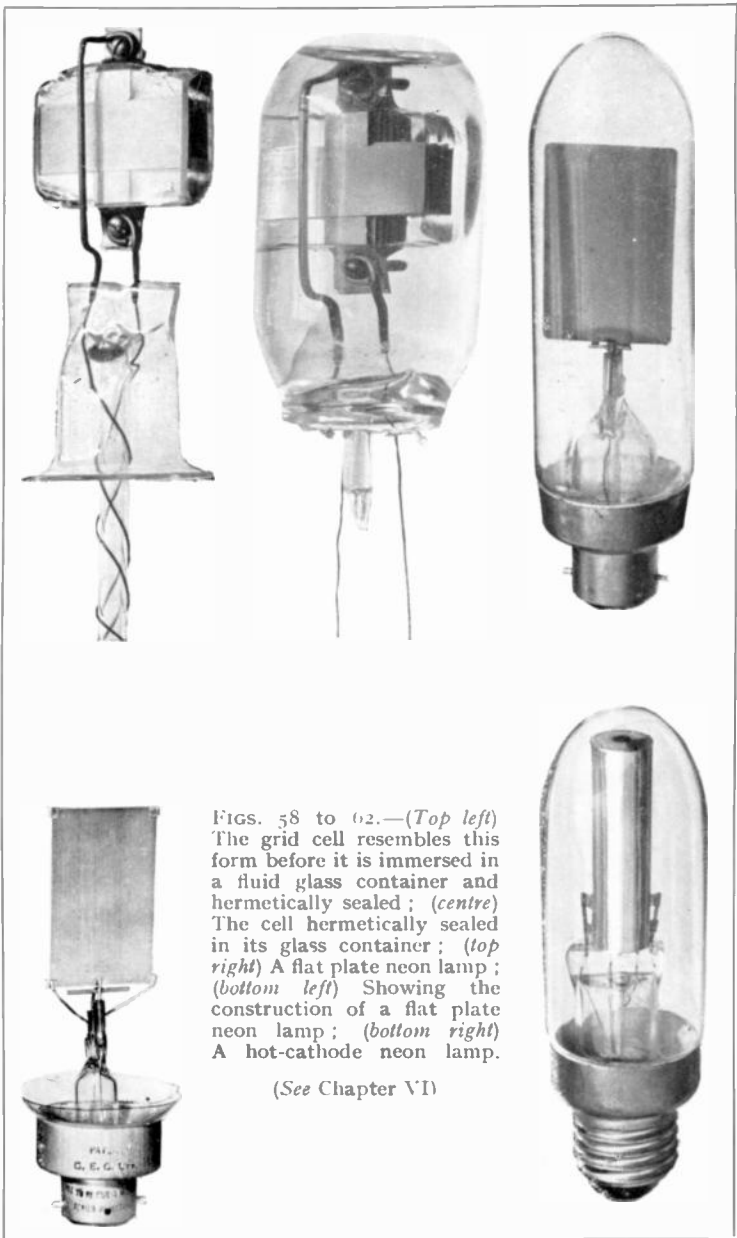


FIG. 57.—Representative samples of Iceland spar.
(See Chapter VI)



FIGS. 58 to 62.—(Top left) The grid cell resembles this form before it is immersed in a fluid glass container and hermetically sealed; (centre) The cell hermetically sealed in its glass container; (top right) A flat plate neon lamp; (bottom left) Showing the construction of a flat plate neon lamp; (bottom right) A hot-cathode neon lamp.

(See Chapter VI)

LIGHT MODULATION FOR TELEVISION

cut and joined together in a certain manner. When light is passed through this device it is polarised, and if we arrange one such prism on each side of the Kerr cell and arrange the prisms so that the light is "crossed," we shall be able to control the light passing by varying the voltage applied across the cell. The scheme is shown diagrammatically in Fig. 47, and if one of these complete cells is examined it will be found that the light viewed through it may be varied by turning one prism. The cell, however, avoids the necessity of moving any part of the apparatus, and it distorts the light which is passed in such a manner that with only a small applied voltage the light may be controlled from minimum to maximum. The light source used with this device is generally a powerful projection lamp, such as is used in small cinema apparatus, and has a power of 100 watts. When the light comes from the cell it is directed by

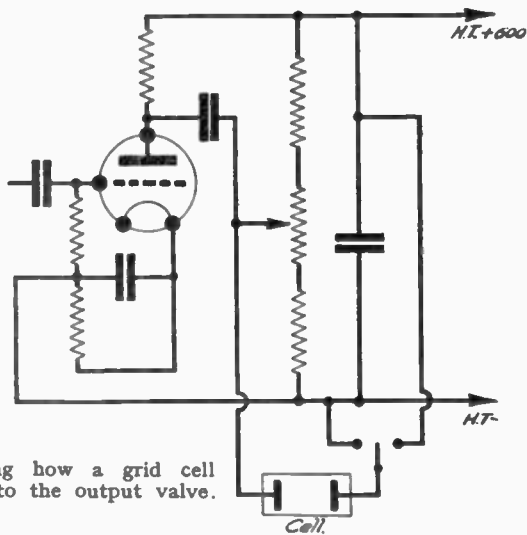


FIG. 63.—Indicating how a grid cell can be connected to the output valve.

means of a mirror-drum on to a screen, and thus provides a large, brilliant picture. An experimental form of this apparatus is shown in Fig. 56, and this possesses many advantages not found in the original Kerr-cell Nicol-prism combination. When zero voltage is applied across the cell the light passed is at a minimum, and is at a maximum when approximately 550 volts is applied to it. The circuit in Fig. 63 shows how the cell should be connected to the output valve so as to enable the applied voltage to be finely controlled, and thus obtain maximum modulation effects.

CHAPTER VII

TALKING-FILM TELEVISION

ONE important advantage of adapting television transmission in such a way that human subjects are replaced by those of talking films is that a greater amount of light is available for activating the solitary photo-electric cell required. In spite of much that is said to the contrary, there is really no further practical simplification of problems that arise. Once the light and shade have been converted to electrical equivalents, the latter have to pass through identical amplifiers and other transmitting equipment before entering

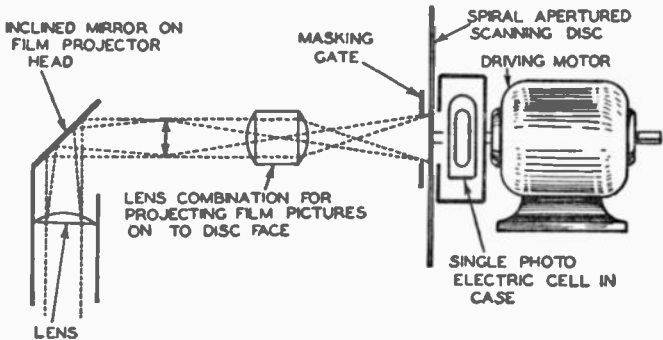


FIG. 64.—Showing how the industrial film pictures are projected through the apertured disc for scanning.

(at whatever distance away it may be) identical receivers, there to be re-translated into terms of light and shade for the image that finally presents itself.

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

TALKING-FILM TELEVISION

intermittent forward movement of the film is carried out 24 times a second, as explained in Chapter I.

Continuous Motion for Film Television.—For television purposes, however, the motion of the film forward must be absolutely smooth and continuous, quite apart from any gearing arrangement required for the standard low-definition image-rate of $12\frac{1}{2}$ per second. In the case of the projector first successfully used for purposes of television the film was fed through at a constant and uniform speed, while an arrangement of lenses and mirrors caused two appropriate adjacent pictures to merge together at any one time, and no matter how slowly the film was run there was not the slightest trace of flicker.

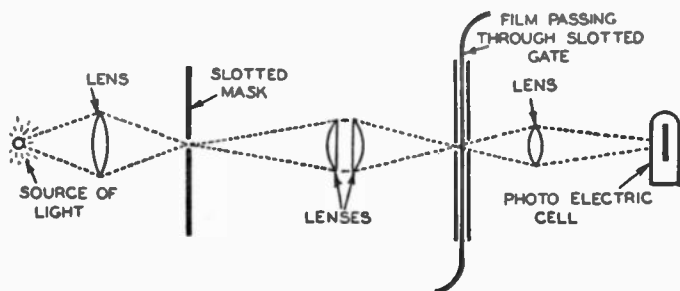


FIG. 65.—The arrangement adopted for reproducing the sound on the film as an electrical signal.

Flickerless film pictures were accordingly projected and focused on to a rotating scanning disc with its series of 30 equi-angularly spaced apertures arranged in the form of a spiral. The projected picture on the disc face was not much larger than the original picture on the film.

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

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An aperture gate ensured that only one aperture was scanning the picture at any particular moment, and also masked off the synchronising signal at the top of each light strip, the momentary breaks in the scanning between any two strips producing 375 synchronising signals in each second. To take full advantage of films with sound-tracks incorporated, an auxiliary sound-head arrangement was added to the equipment, whereby a means was provided for the sound-track to pass between an independent source of light and its appropriate single small photo-electric cell in the normal way.

With only 30-line scanning the nature of the film subjects which could be transmitted was very restricted, consisting mainly of head-and-shoulder photographs. A subsequent improvement provided 48 scanning lines and 25 pictures per second, necessitating an increased sideband for radio transmission.

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

Transmitting Ordinary Films.—When it is wished to transmit an ordinary modern talking film complete, instead of head-and-shoulders, or simple black-and-white subjects, it is necessary to increase greatly the number of scanning strips into which the image is divided. The Baird Company recently employed modern high-definition methods for this purpose. The film passes through a gate at a steady speed of 25 pictures per second, the intermittent shutter movement of the ordinary film projector being, of course, absent. An arc light source and an optical system of lenses projects in turn each individual film picture on the top section

TALKING-FILM TELEVISION

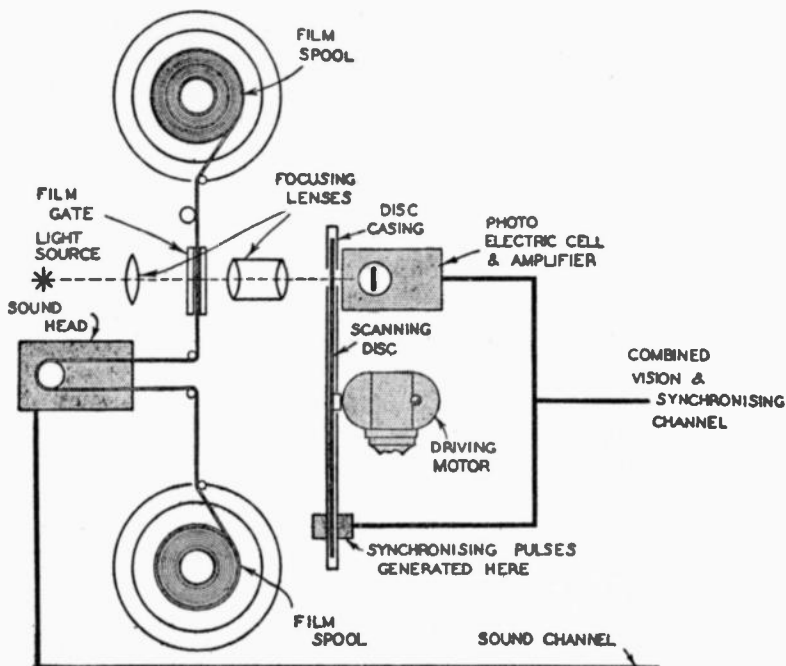


FIG. 66.—Pictorial diagram showing how talking films are televised by the high definition process.

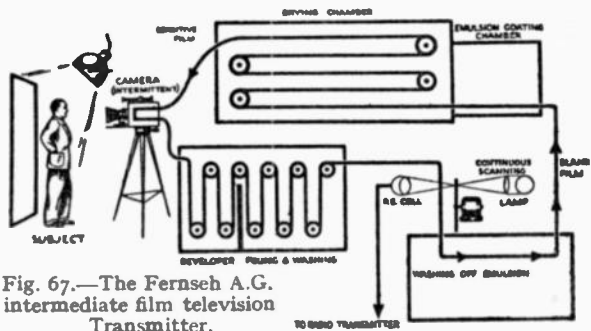


Fig. 67.—The Fernseh A.G. intermediate film television Transmitter.

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of an encased scanning disc rotating at a speed of 3,000 revolutions per minute. Near its periphery is a circle (not a spiral) of 90 minute holes angularly spaced, 4 degrees apart. The disc rotating at 50 revolutions per second, and the film traversing at the rate of 25 pictures per second, it follows that each separate picture is scanned by 180 horizontal lines. A single small projection lamp and cell

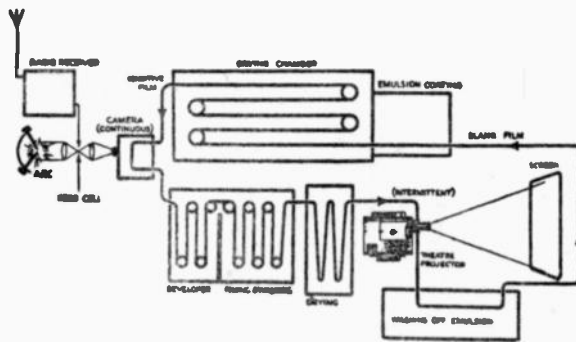


FIG. 68.—Indicating how the received television signals are recorded and finally projected on to a large screen.

work in conjunction with the normal means of providing voltage variation, for the purpose of generating the requisite synchronising pulses, which are superimposed upon the picture signal and combine to modulate the carrier wave generated by the ultra-short-wave radio transmitter. At the same time the film passes through a standard film projector sound-head. At the receiving end, as far as the television signals are concerned, images are obtained by using a cathode-ray tube.

CHAPTER VIII

TELEVISION RECORDING

FOR as long as television transmissions are few and far between and of short duration, some form of "synthetic" transmission will be welcomed by the experimenter in order that he may test and observe the operation of his set or sets at whatever hour of the day or night it may appeal to him to do so.

Successful results have been obtained by making records of television transmissions in similar form to gramophone records. In this case, photo-electric cells are connected to

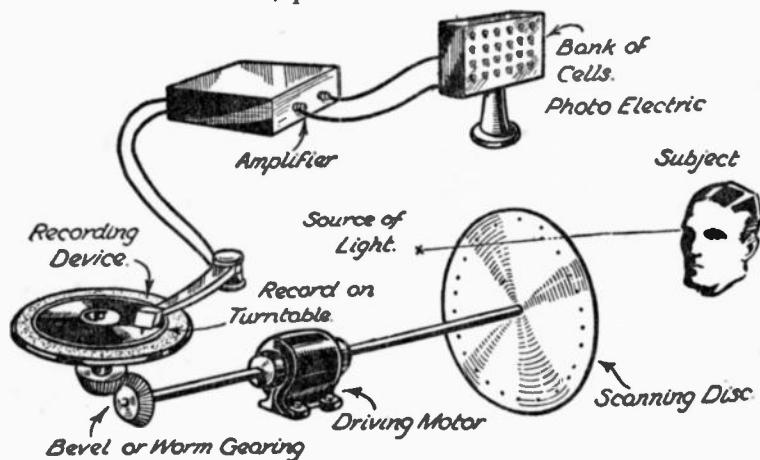


FIG. 69.—A diagram illustrating pictorially how a record of a television transmission can be made in a studio.

an amplifier, and this in turn is connected to a recording device. Fluctuations in the electrical circuit are transmitted to a cutting stylus which records their wave motion in exactly the same way as the wave motion of sound is recorded on a gramophone disc. Sound waves recorded on a disc can be reproduced in the form of sound waves. Similarly, television signals recorded on a disc can be reproduced as television signals. By playing the resulting record through the normal pick-up and amplifier, the variations

TELEVISION AND SHORT-WAVE HANDBOOK

may be applied to a standard neon lamp, a picture being thereby produced which can be viewed through a scanning disc.

Gramophone Analogy.—In other words the microphone of the gramophone recorder is replaced by the photo-electric cell of the television-signal recorder, and the loud-speaker of the reproducing gramophone is replaced by a neon or similar apparatus to translate the television signals into terms of light and shade for the production of the actual image.

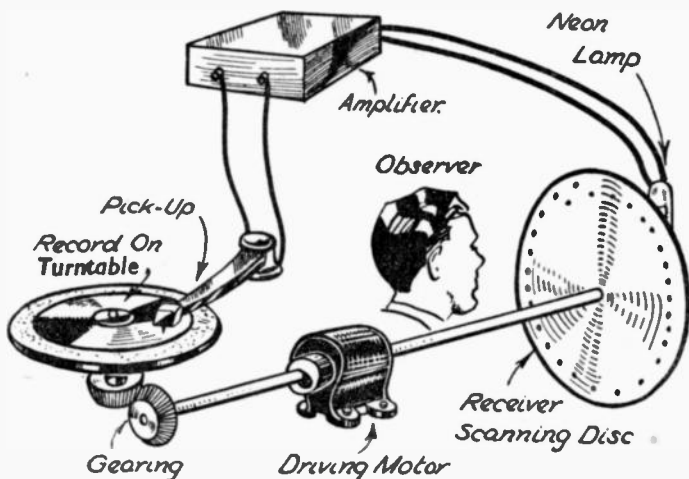


FIG. 70.—A partial duplication of the system shown in Fig. 69 is undertaken when reproducing the recorded image.

Unfortunately, a difficulty arises due to the lack of frequency response which may be accommodated on a standard record. A high-class output is essential, and this cannot be guaranteed with records and pick-ups as at present used. The spacing of the grooves on the former, and the response curve of the latter, present serious complications. Furthermore, design of the amplifier must be meticulous, and a suggestion as to the form it should take is shown in Fig. 71. Capable of giving good results both for recording and for reproducing, standard resistance capacity coupling is employed.

Talking Pictures.—At the expense of halving the running time of the record, a double pick-up head may be

TELEVISION RECORDING

employed so that two grooves are traversed simultaneously, one for sound and one for vision.

Some form of stroboscopic speed indicator is necessary, both for recording and reproducing purposes. This may well take the form of suitable paint-marks on the edge of the turntable used, illuminated by a neon lamp connected to the A.C. mains. The lamp should be screened from other direct A.C. illumination or it may be difficult to discern the movements of the stroboscopic segments.

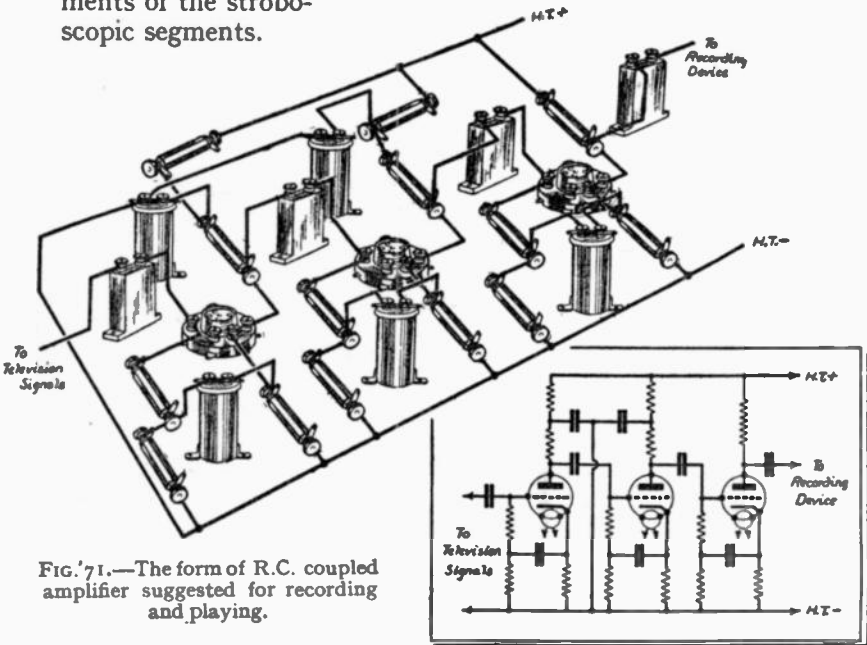


FIG. 71.—The form of R.C. coupled amplifier suggested for recording and playing.

It will be realised that even at the present stage, the adjustment of quality amplifiers, loud-speakers, pick-ups, and similar equipment may be rendered easier by the employment of the means just outlined, and there is no doubt whatever that there will be important developments in this direction. There is no reason, for instance, why talking pictures of the future should not be recorded in the form of two *continuous* wave-bands instead of one wave-band and a comparatively clumsy and *disjointed* series of separate photographs.

CHAPTER IX

TELEVISION SIDE LINES

THE ability to convert a picture or an image into electrical impulses renders a number of novel inventions practicable, and, in fact, certain experiments which have been made in the past have shown that there are some very useful inventions already to be used, so soon as the present television systems are perfected. At present, the image is transmitted as varying degrees of light and shade, and therefore with a neon lamp there are only possible the peculiar orange or red pictures, the brightest parts of the picture appearing as a light orange tint, and the dark parts as very nearly black. This is not a very pleasing tone to look at for long

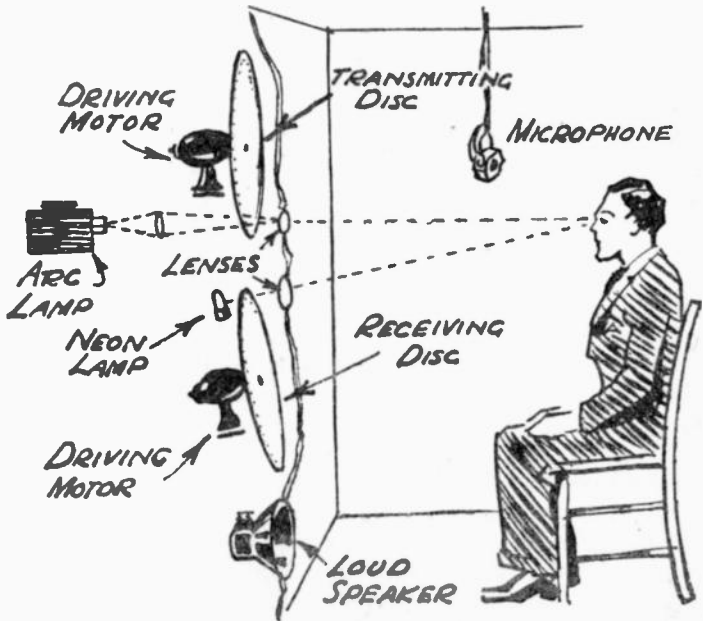


FIG. 72. — Showing the equipment arrangement in the New York experiment described.

TELEVISION SIDE LINES

periods at a time, and it has furthermore the disadvantage that a darkened room is necessary in order to see the picture with its full brilliancy. With the mirror-drum or mirror-screw a white light is used at the source and thus the picture takes on an almost black-and-white effect, a slight dis-

INCOMING TELEVISION SIGNALS

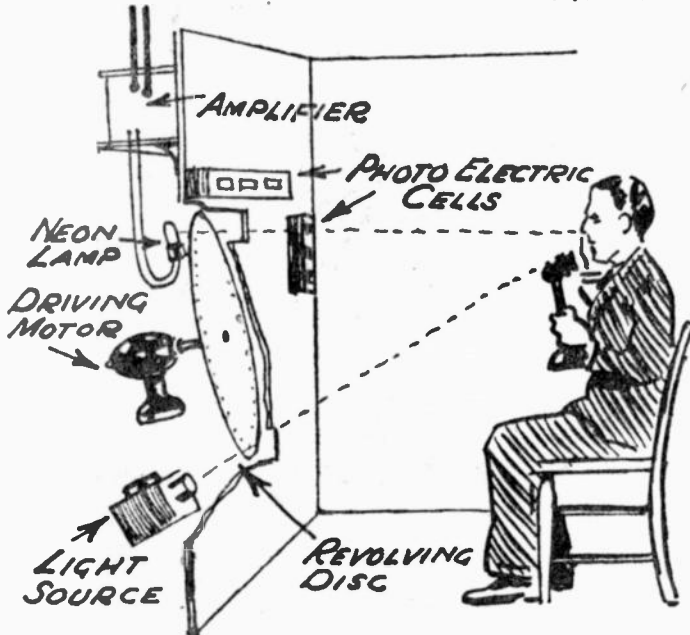


FIG. 73.—A schematic impression of the Berlin demonstration of two-way vision and telephony.

colouring being apparent, due to the passage of the light through the necessary modulating source. With the cathode-ray tubes the colour of the screen is normally a peculiar green, although there is a possibility of changing this to a tint which is very nearly white. With all of these schemes, we have animation in the artist or person being broadcast, and this is accompanied by sound from the loud-speaker, which gives an illustration of life. This is spoilt, however, by the fact that the image is small and in monochrome. Obviously, it will be necessary in the future to transmit a picture with all the colours of nature if it is to be at all

TELEVISION AND SHORT-WAVE HANDBOOK

real, and although the cinema film is not perfected to-day in which colours are reproduced correctly, experiments which have been made by Mr. Baird have shown that it is possible to transmit images in colour by present television systems.

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

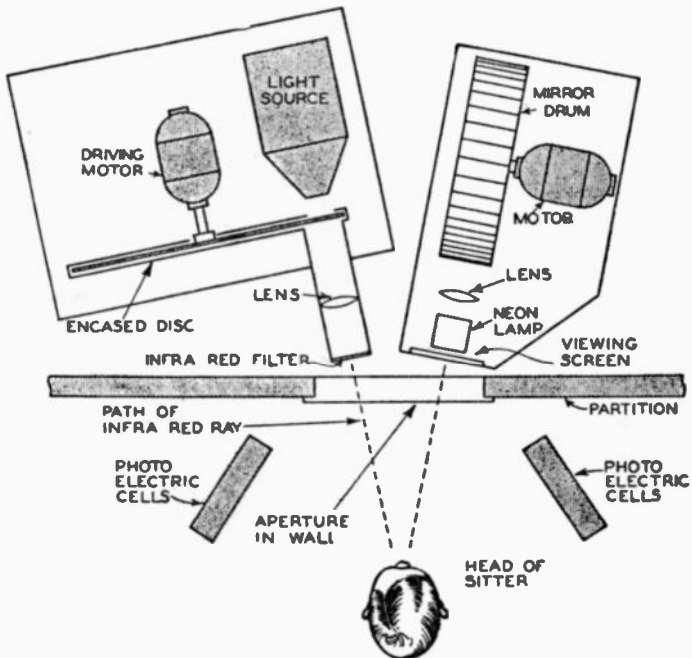


FIG. 74.—Showing how the principles of noctovision were employed in the Paris demonstration of viso-telephony.

separate colours and transmit these, amalgamating them at the receiver end, we should be able to see our picture in colour. The splitting up is carried out by using three light filters, and the scanning disc is provided with three sets of spiral holes. Behind these are arranged three colour filters, the necessary colours being thus filtered as the object is scanned. Three banks of photo-electric cells, each sensitive

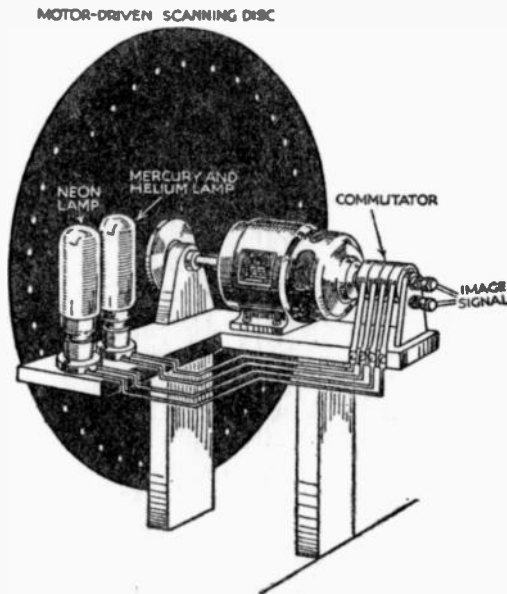
TELEVISION SIDE LINES

to one particular colour, are used, and thus the complete scanning almost amounts to three separate scans, one in each colour. These are transmitted in the normal fashion, and at the receiver end a similarly punched disc is employed and behind this are placed the colour lights. These are essentially of the type which will respond to the signal fluctuations and thus a neon lamp is used for the red light source ; a mercury and helium lamp for the blue and green source. To split these lamps into their necessary colour tones in conjunction with the scanning holes and the transmitted image, a special form of commutator was employed, and thus it was a fairly simple matter to ensure that as the blue light was illuminated the necessary scanning holes passed across the lamp and thus the complete image built up to form a picture in colour. Unfortunately, there are difficulties, not the least of which is the loss of light which necessarily arises owing to the three sets of holes. Furthermore, the light sources are not brilliant enough to give full strength to the brighter parts of the image, but sufficient has been said to show that the possibilities of television in colour are not beyond reason, and no doubt the time will come when a monochrome image will be a thing of the past.

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

TELEVISION AND SHORT-WAVE HANDBOOK

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



IG. 75.—Using a commutator to enable switching from one lamp to the other to take place.

Telephones and Television.— A further development, and one which has been carried out in the experimental stage, is that of the combination of television and the telephone. Thus, a television transmitter and receiver is built into a telephone box, and when the subscriber places his coins in the box he is able to see the person at the other

TELEVISION SIDE LINES

end, and two-way conversations are made much more interesting. This experiment has been carried out both in America and in France, and the arrangement of the necessary equipment is shown in Fig. 74 where it is seen that a transmitting disc is arranged on one side of the caller, and a mirror-drum receiver on the other side. Banks of photo-electric cells are arranged in the box, and the action of calling a subscriber switches on the necessary power and starts the

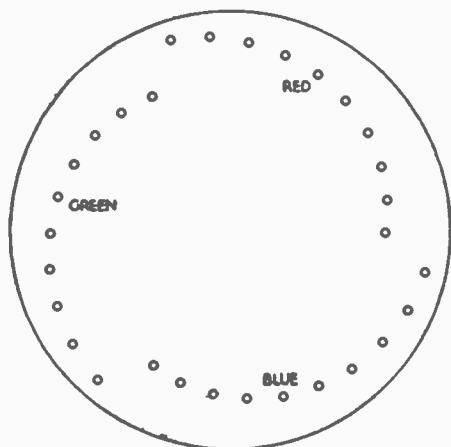


FIG. 76—A triple spiral scanning disc with red, green and blue filter apertures.

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

CHAPTER X

WILL MY SET OPERATE A TELEVISION RECEIVER ?

THIS apparently simple question cannot be answered directly, since the reply depends upon several important points. Briefly summarised these are : the type of television receiver which it is proposed to employ—disc, mirror-drum, mirror-screw, or cathode-ray; the type of radio receiver, and the voltage of the available high-tension supply.

Generally speaking, the output required to operate a disc instrument is less than that in the case of the other types of television equipment. Additionally, in the case of the mirror-drum and mirror-screw types, an H.T. or polarising voltage of approximately 400 is essential. This latter requirement generally limits the practical application of such equipment to use in conjunction with A.C.-operated receivers. This point is still further emphasised by the fact that a signal

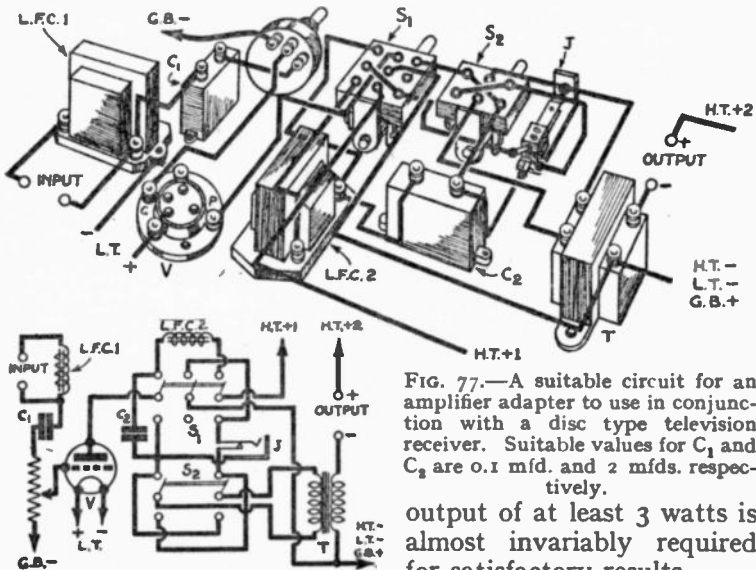


FIG. 77.—A suitable circuit for an amplifier adapter to use in conjunction with a disc type television receiver. Suitable values for C_1 and C_2 are 0.1 mfd. and 2 mfd. respectively.

output of at least 3 watts is almost invariably required for satisfactory results.



FIG. 78.—Showing a cathode-ray tube fitted with an eight contact base.

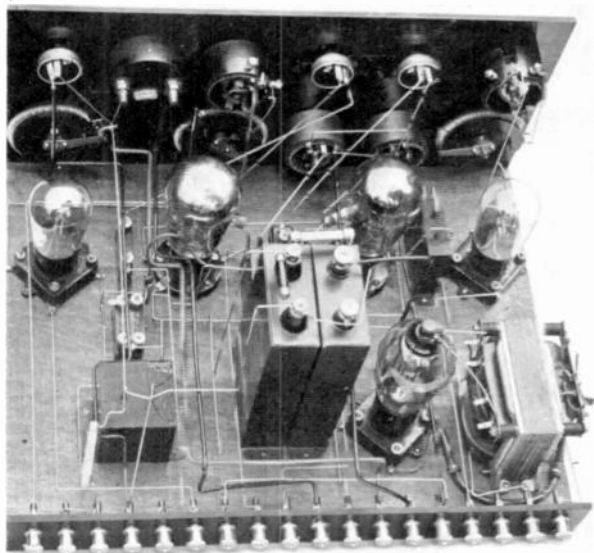


FIG. 79.—An example of a well-designed time base for controlling the cathode ray beam movement.
(See Chapter III)

FIG. 80 (*right*).—A photograph of an atmospheric. Stop, $f/3.5$; exposure, duration of atmospheric.

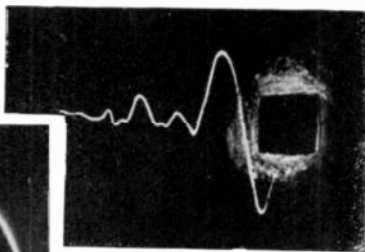
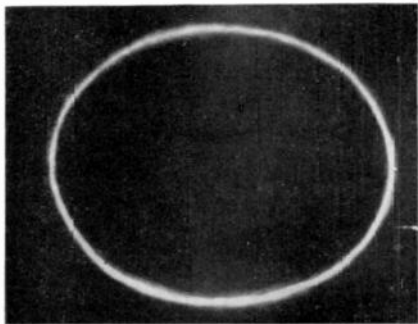


FIG. 81 (*left*).—An A.C. ellipse. Note that the spot has travelled many times round its orbit, hence the woolly line. Stop, $f/6.3$; exposure $\frac{1}{2}$ sec.

FIG. 82 (*right*).—Waveform of an ordinary broadcast taken from a sustained note of a tenor voice.

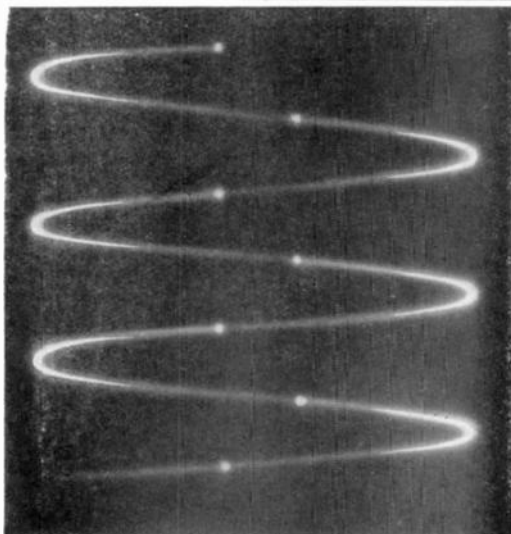
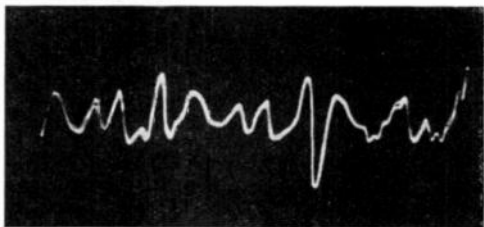


FIG. 83 (*left*).—A graph showing the rise and fall of voltage, which is shown vertically, whilst the passage of time is shown horizontally.

(See Chapter 111)

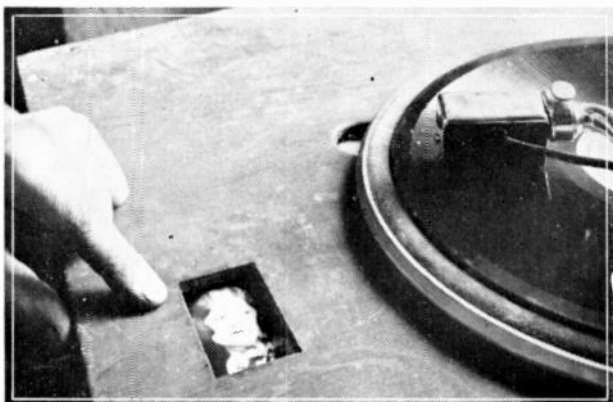


FIG. 84. — Showing how the "bottled image" appears in the television receiver when "played back from the record."



FIG. 85.—An actual phonovision disc record. When "played" on the appropriate apparatus, instead of song or music being heard, the movements of an artist can be watched in the vision apparatus.

(See Chapter VIII)

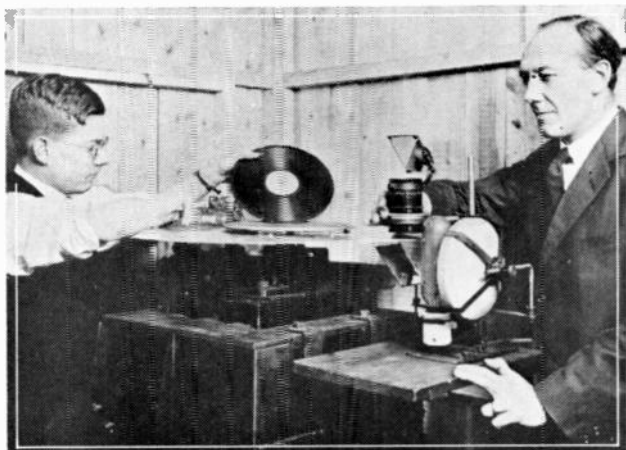


FIG. 86.—Getting ready to play over a phonovision record so that the "bottled television" will be visible in the receiving apparatus.



FIG. 87.—A dummy's head acting as a subject for making a test phonovision record, this latter process being visible in the foreground.

(See Chapter VIII)

WILL MY SET OPERATE A TELEVISION RECEIVER ?

On the other hand, a disc receiver can satisfactorily be operated from even a good battery-fed set, since the signal output of $1\frac{1}{2}$ watts is sufficient for the production of satisfactory images, and a voltage of 200 is sufficient for polarising the neon lamp employed.

In addition to the specific requirements stated above, it should be taken as a definite rule that the receiver, whatever its type, must be capable of extremely high quality reproduction ; this is because the effects of distortion are far more pronounced in a picture image than in the sound delivered by a loud-speaker. It is not only that the television apparatus

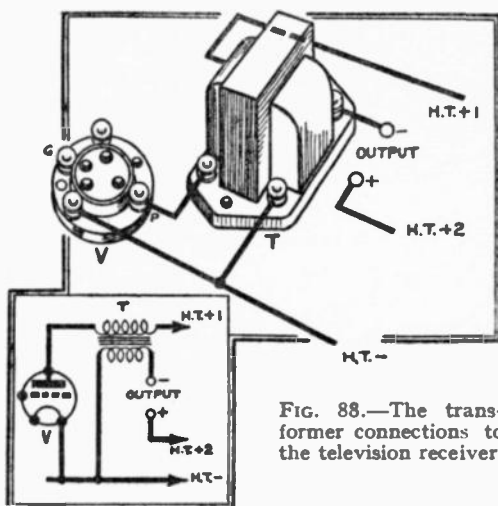


FIG. 88.—The transformer connections to the television receiver.

is more "critical" than a loud-speaker, but that the ear is far more accommodating than is the eye.

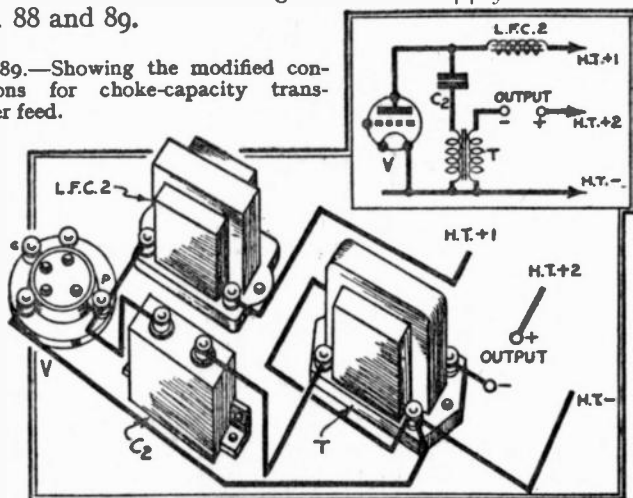
It was stated above that an output of approximately $1\frac{1}{2}$ watts was desirable for feeding a neon lamp used in a disc machine. This statement may be amplified by saying that the neon can actually be modulated with fair success by supplying it with a signal output of only 500 milliwatts (or a $\frac{1}{2}$ watt). On the other hand, however, considerably better images are to be obtained by increasing the power up to at least 1 watt. In giving these figures, therefore, no note has been taken of the synchronising apparatus which is always desirable and practically essential if a steady picture

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is to be maintained over a reasonable length of time. For satisfactory energisation of the electro-magnets, which, along with the tooth wheel, comprise the synchronising gear, an output of between $1\frac{1}{2}$ and 2 watts is particularly desirable.

There is a further point to be considered when operating a disc television receiver from the battery set. This concerns the necessary 200 volts required for polarising the neon lamp. Most battery valves function at optimum efficiency when a voltage of between 120 and 150 is applied to their anodes ; because of this it becomes necessary either to use a separate source of H.T. voltage for feeding the neon lamp, or to connect a second H.T. battery in series with that used for the valves in order to secure the 200 volts mentioned. The methods of connecting the H.T. supply are shown in Figs. 88 and 89.

FIG. 89.—Showing the modified connections for choke-capacity transformer feed.



As mentioned above, when using a television instrument of the mirror type a voltage of not less than 400 is required to polarise the Kerr cell or grid cell. For this reason it is usually best to use a receiver of the A.C. type, whose high-tension is supplied by a Class C rectifier ; this latter gives an output of 500 volts at 120 m/A.

When using cathode-ray type of instrument a time base (see Fig 79.) is required in addition to the ordinary wireless receiver. The latter should also give an undistorted signal output of not less than 3 watts.

CHAPTER XI

BUILDING A DISC VISOR

CONTRARY to popular belief it is cheaper to build a television receiver than an ordinary telephony receiver. It is necessary, of course, to make quite certain that the receiver to which the visor is to be coupled is capable of yielding the output necessary, as fully detailed in Chapter X. The design described herewith is of the simplest character and can be made for little more than five pounds.

The Chassis.—This is $\frac{5}{8}$ in. thick, while the dimensions are 27 in. long by 9 in. wide. With the aid of a key-hole saw, cut a slot as shown, 18 in. long by $1\frac{1}{2}$ in. wide, with one edge of the slot $2\frac{3}{4}$ in. from one long edge of the baseboard. This is to allow the 20-in. diameter disc to run freely when rotating at its normal speed of 750 revolutions per minute. In order to prevent the disc from fouling the table, the baseboard is raised 5 in. by means of thick wooden sidepieces screwed to the underside.

The instrument to be described is shown in the perspective line drawing, Fig. 91, and it is this illustration to which the description refers.

It is necessary to pay particular attention to all the dimensions given in the drawings, at least in so far as the motor, neon lamp and lens assembly are concerned, for, unless this is done, the resultant image will be masked off and the full benefit of the machine not obtained. First mark off a centre line across the baseboard and arrange the centre of the metal motor support over this with the front edge 1 in. from the baseboard front. This will eliminate any tendency for the motor shaft to "whip" when the disc is mounted in place. Note also that the brass bush of the motor must be at the front.

Completing the Assembly.—The height of the shaft centre above the top of the baseboard is 5 in., and, in consequence, both the horizontal centre line of the lens box assembly and the plate of the neon lamp must coincide with this. With the lamp-holder and motor bracket in use this is

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automatically provided, the lamp-holder being specially designed. Be sure to mark off the screw holes accurately as in the dimensioned plan, and have the bakelite neon lamp-holder turned round to such a position that the neon window is parallel to and nearest the disc. The connections to this holder are made through the baseboard, and in consequence two holes to accommodate the wires must be drilled for this purpose.

It is now quite a simple matter to add the semi-fixed resistance R , and the variable resistance R_1 , in position as shown, using the small right-angled bracket to hold

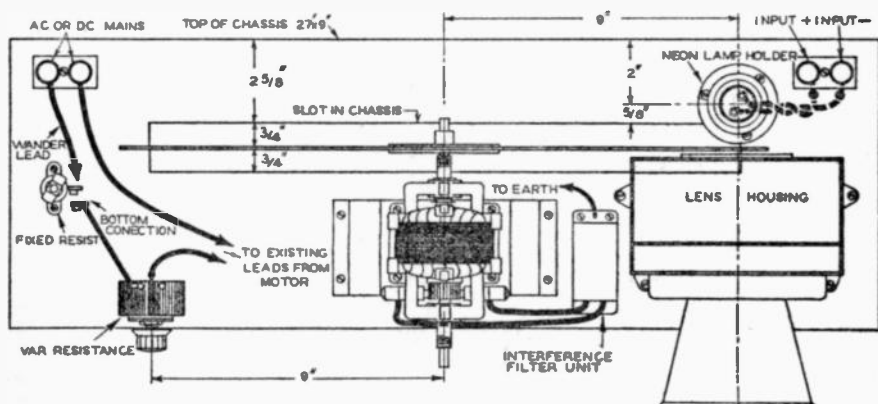
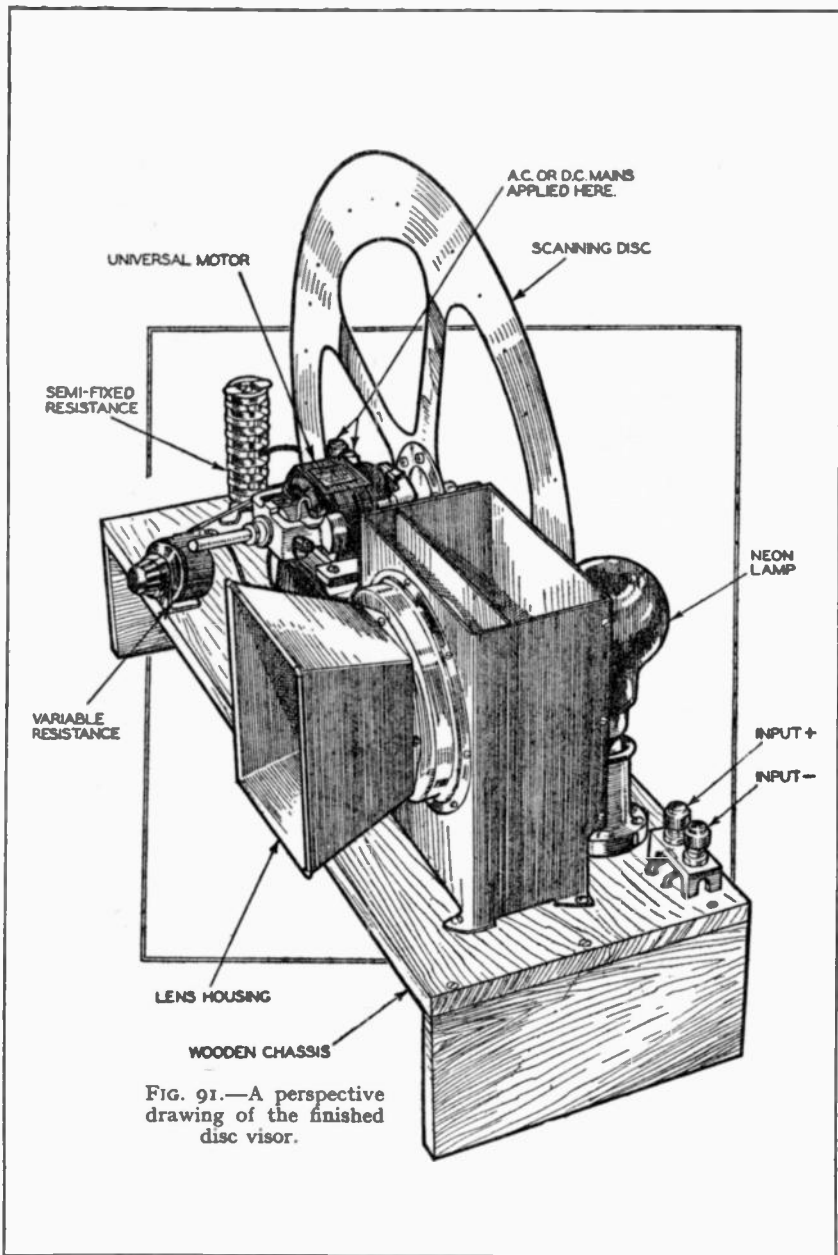


FIG. 90.—The wiring plan and layout of components for the disc visor.

the last-named. Add the interference suppressor unit and the terminals on their mounts. The wiring can readily be followed by making reference to the illustration and theoretical diagram. The theoretical diagram (Fig. 95) will help here, and, as far as the interference unit is concerned, the two red leads must be taken to the motor brushes. Just remove the end caps accommodating the brush springs and connect a lead to each holder so that a good electrical contact is made. The third lead of the unit must be taken to a convenient earth point.

Marking and Punching the Disc.—With the type of television transmission now broadcast by the B.B.C., 30-line scanning is used, the scanning being carried out vertically. It is, therefore, necessary to use a 30-hole disc



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with the apertures set round the edge of a single-turn spiral. Since there are 30 disc holes, it follows that the angular separation between each hole is 12 degrees, and in the aluminium discs sometimes supplied the radial markings are carried out so as to assist the amateur. It must be noted so that the radii have been scribed on the back of the disc. But as a completely punched disc ready for use is available (see specification) for a few shillings, it scarcely pays to make one.

Each hole is extremely small, actually 28/1000th in., with this 20-in. disc, and square in shape, so the first task is to make a suitable punch. Obtain a 1-in. length of 0.028 in. square silver steel rod, perfectly flat on each side and with sharp corners. This must be hardened and tempered, and fixed in a brass holder about 2 in. long with about $\frac{1}{4}$ in. of the punch exposed, as shown in Fig. 93. The simplest plan to adopt in marking out the hole positions is the following: Remove the aluminium boss from the disc, taking care to mark both disc and boss with a scribed line so that the latter will be replaced in exactly the same position. Stick a piece of paper over the bush hole of the disc and find the disc centre by continuing 2 or 3 radial lines towards the centre, noting their point of intersection.

Next take a strip of stiff cartridge paper and mark off on its edge a distance XY of 9.5 in., since the outside edge of the first hole is just $\frac{1}{4}$ in. inside the disc periphery. From one end of the marked distance of 9.5 in. measure off YZ of 0.84 in., and then divide this into 30 divisions of 0.028 in. each, as shown in Fig. 92.

With the disc flat on the table, having the scribed radii uppermost, place the point X exactly on the disc centre and lay the paper strip towards the left of the disc, and make a mark with the scribe on a radius where the point Y comes. This will correspond to the hole No. 1 shown in Fig. 94. Move the paper round in an anti-clockwise direction until the edge coincides with the next radius, and then, with the point X once more on the disc centre, scribe another mark one division in from Y. Repeat this with next radius, and so on, making the mark one division nearer to the centre for each consecutive radius, until all the 30 holes have been dealt with. The dotted lines in the diagram will show how each

BUILDING A DISC VISOR

hole position progresses towards the centre in a single-turn spiral.

Punching the Holes.—Having marked off the hole positions accurately, we proceed to punch out the apertures. Lay the disc perfectly flat (care must be taken not to "kink" or bend the aluminium, otherwise the disc will not scan truly) on a hard wood block. Place one edge of the punch along the radius for No. 1 hole, so that the outer edge of the punch is against the scribed mark. Holding the punch vertical, strike it sharply with a hammer so that a clean-sided hole is made. Repeat this operation for each hole.

To enable the disc to whip out flat when revolving at its

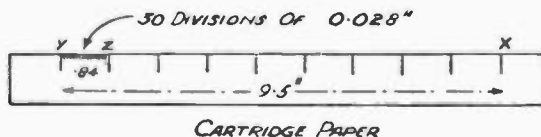


FIG. 92.—A strip marked as shown above will be required for marking off the disc.

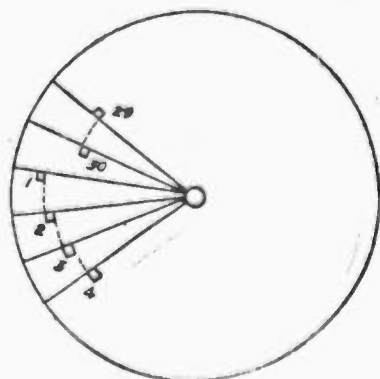


FIG. 94.—How to line up each successive hole. Discs ready punched may now be obtained so cheaply that it scarcely pays to make one.

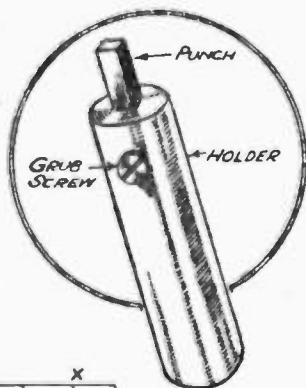


FIG. 93.—How the punch is constructed.

normal speed it is necessary to lighten it by cutting out 5 or 6 sections, as shown in the illustration, leaving "spokes" $1\frac{1}{2}$ in. wide and an outside rim of $2\frac{1}{2}$ in. where the holes are punched. Replace the boss on the disc in its former position so that the grub screw is on the same side as all the marking-out lines. Turn the disc over and give the $2\frac{1}{2}$ in. rim a coat of dead black paint, taking care that none of the paint gets inside the holes to obstruct them.

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It will now be possible to see that there is a correct alignment between the lenses, and mask assembly and neon lamp, for the scanning holes of the disc should pass over the neon lamp area and be observed clearly when looking into the tunnel. If any of the first or last holes are hidden, move slightly the lens box assembly or neon lamp until the holes are clearly visible.

Testing the Instrument.—In order to try out the receiver, join the 200/240-volt A.C. or D.C. mains leads to the appropriate terminals, and switch on. The disc should rotate in an anti-clockwise direction, and the speed may be adjusted by altering the variable resistance so that it runs at 750 revolutions per minute.

The output of the wireless receiver must now be joined to the input terminals of the television instrument and the neon lamp first of all made to glow with its characteristic orange-red colour by passing a current of suitable milli-ampereage through it. When the television signals broadcast by the London National station are tuned in on the radio set they will modulate the glowing neon lamp, and the television images can be seen by looking through the tunnel attached to the lens assembly.

COMPONENTS FOR THE DISC VISOR

One Universal Motor, complete with stand.

One 20-in. Disc, complete with boss.

Four Type " B " Terminals, marked A.C. Mains (two), Input + and Input —.

Two Terminal Mounts.

One Neon Lamp, with bakelite holder.

One Lens Box Assembly, complete.

One M.R. 12 Skeleton Mains Resistance.

One Interference Filter Unit.

One 150-ohm Rheostat.

One Wooden Chassis.

One Neon Lamp.

One Component-mounting Bracket.

Operating the Visor.—The operation of a television receiver is by no means difficult, and can quickly be mastered by anyone. In many ways it is, in fact, even easier than the tuning of a receiver for sound. The uninitiated will soon gain an understanding of the operations involved by studying the following instructions in adjusting the apparatus.

BUILDING A DISC VISOR

It is always advisable to start up the motor at least a quarter of an hour before the transmission is due to start, and the synchronous speed can be maintained by correct resistance adjustment.

The normal procedure is as follows: First of all tune in and check the television signals with the aid of a loud-speaker, and when the characteristic sound (something like a low-pitched whistle, with a varying and higher-pitched whistle superimposed upon it) is heard at full strength, transfer the output leads from the speaker of the radio set to the television receiver. If the speed has been correctly pre-determined by using a stroboscopic indicator (explained in later pages), no doubt an image will be seen at once. When this is not the case, a series of black lines will appear to be creeping upwards, if the motor is running too fast, or downwards, when too slow. The rheostat must be adjusted to rectify this. If the receiver is not provided with synchronising gear the rheostat will have to be manipulated throughout the whole duration of the television transmission in order to keep the image exactly within the lens frame mask.

Framing and Phasing.—It is advisable to use a synchronising device, however. The incoming television signals then pass through the coils and the synchronising pulses, operating 375 times per second, and superimposed on the main television signal function through the field coils and cogged wheel to maintain the speed constant. The action is something like an electrical brake performing its task in a manner similar to a flywheel on an engine.

When the true speed has been obtained, the image at first will nearly always be found to be out of phase and/or out of frame. For instance, if say a head and shoulder figure is seen it may appear as in Fig. 154 or 155. If split both vertically and horizontally, two operations are necessary

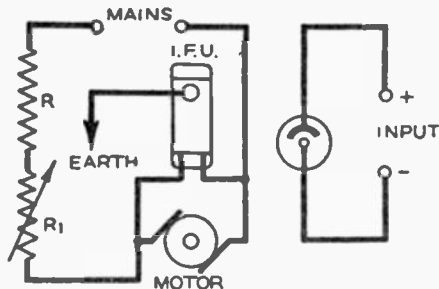


FIG. 95.—The theoretical circuit of the disc visor.

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to rectify it. First of all, to reframe it, the image must be moved bodily up or down, and this is done by rotating slightly the synchronising coils on the motor frame.

After this has been done, the image may appear as in Fig. 155, that is, cut into two sections by a vertical line. This is corrected by slowly altering the rheostat motor control to effect a slight speed change. The images will then start to move slowly upwards, and drift to the left if the speed is increased, or slowly downwards and drift to the right if speed is decreased. Let this drift continue until the double image resolves into a single one, and then quickly bring back the speed of the motor to normal.

Negative Images.—If at any one instant more light is reflected from the televised subject the current should increase through the neon lamp, and decrease when less light is reflected. This increase or decrease must perforce be a factor of the wireless set itself, and the majority of set users forget that reversals of current direction often take place stage-by-stage. As far as the reproduction of sound is concerned, this current reversal is immaterial, but not so with television. When signals are passing through a grid leak rectifier the mean anode current falls, but rises if an anode bend detector is employed. If the image is correctly shown with one method of detection, changing over to the other method will produce a negative image, that is, one in which shadows are high lights, and vice versa. The following are simple methods of changing a negative image into a positive one: (a) Change method of rectification, i.e., leaky-grid to anode bend or vice versa; (b) add (or subtract) a stage of resistance-capacity L.F. coupling; (c) reverse either the primary or secondary winding of the L.F. transformer if one is included in the set; (d) reverse either the primary or secondary connections to the output transformer. As a general rule, it may be taken that either an anode bend detector followed by an odd number of resistance-capacity coupled low-frequency stages, or a leaky-grid detector followed by an even number of resistance-capacity, low-frequency stages will give a positive image with the present type of television transmissions.

CHAPTER XII

BUILDING A MIRROR VISOR

INSTEAD of a plain scanning disc as in the machine described in the previous chapter, this vision receiver makes use of a mirror drum, the principles of which were fully explained in the chapter on Scanning Systems. A number of very novel features are included in this, designed to overcome the objections which have been levelled at mirror-drum receivers in general. These will be made clear by referring to the illustrations (Figs. 123-124), but first of all examine Fig. 100, which is a schematic diagram of the machine. Actually, the amount of wiring to be undertaken is almost negligible, the bulk of the labour involved being associated with construction and accurately lining-up the optical system.

The first feature is the light valve or Baird grid cell, which is made to operate by the received radio television signals passed on from the wireless set. Essentially, the cell itself consists of a number of very thin rectangular metal plates interleaved in very much the same way as the components of a fixed condenser.

This light valve is mounted into a holder, so that it is positioned between two light-polarising prisms having an aperture of about 8 millimetres. Furthermore, as an integral part of the attachment of this complete unit, an original type of lamp-holder is included. This permits the correct lining-up of the "bunched" filament in the 12-volt 100-watt lamp supplied. The lamp itself is shown in Fig. 127, together with the special base connector which has to be obtained separately.

Building up the Image.—Referring once more to Fig. 100 it will be noticed that the modulated light beam, once it has passed the double-prism light-valve combination, strikes an inclined mirror, is reflected and focused by a lens on to a mirror drum normally kept revolving at its correct speed of 750 revolutions per minute. The drum itself is illustrated in Fig. 122.

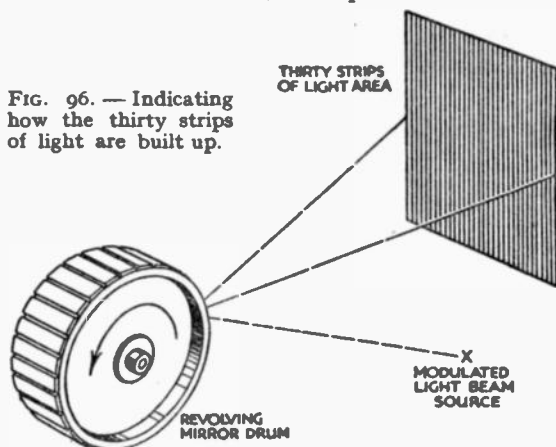
The Wooden Baseboard.—This can be obtained complete with the viewing tunnel and runners. The baseboard

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size is $20\frac{1}{2}$ in. by 10 in. by $\frac{5}{8}$ in., with a rectangular section cut out from the back edge $2\frac{1}{4}$ in. wide and 3 in. deep. One long edge of this section is 2 in. from the left-hand side of the baseboard facing the back, and is for the purpose of giving free movement to the base of the projection lamp when lining it up optically.

First mount the metal box which holds the grid cell unit.

Remove the shaped top of this box and mount the cell in place. The smaller vertical rectangular end has a 1-in. diameter hole, and into this must fit the cell. Take out the two screws, holding together the faces of the nickel and black-finished sections of the cell, and place the black-finished



cell-holder section into the box hole so that the cell is horizontal and projecting to the right when looked at from the back of the box. Mark the positions of the two mounting screw holes, drill clearance holes for the screws, and then screw the two parts together so that the faces grip the box front between them. This will leave the adjustable lamp-holder inside the box so that the levered portion can be moved vertically to clip in the lamp.

Lamp Connection.—Owing to the special character of the projection lamp filament, the lamp itself must be held vertically, and the section cut out of the baseboard at the back allows this to be done. The lamp has a screwed base, and, in consequence, it is necessary to have a special holder.

BUILDING A MIRROR VISOR

A leaf spring makes contact with the base of the lamp, while the two semicircular sections grip the screwed shank firmly. Attach the ends of the short length of heavy flex (this has to carry 8.5 amps, so ordinary flex is useless) to

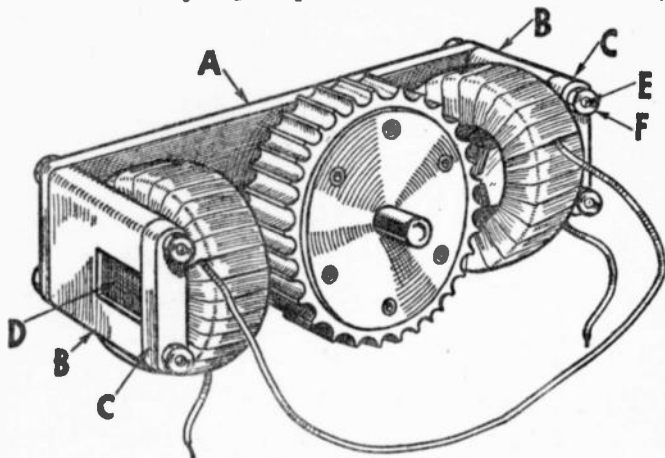
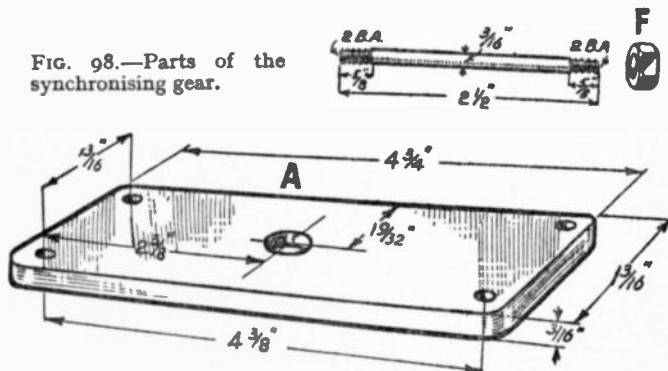


FIG. 97.—The assembly of the complete synchronising apparatus.
Note that the two magnetising coils are wired in series.

the shank and base terminal connections, leaving the other flex ends free for connecting to the mains transformer.

FIG. 98.—Parts of the synchronising gear.



Remove the back of the cell-box, clip the lamp into place, and screw the box to the baseboard so that it is positioned exactly as shown by the dimensions in the accompanying drawings. The important point is that the centre line of

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the box, in consequence of the beam of light passing out of the second Nicol prism of the cell, is parallel with the long baseboard edge (left one facing back), and 3 in. from it, being the optical axis. Screw on the back and top of the box with the screws provided, the slots cut out of the top being for the purpose of allowing a forced ventilation to be produced by the revolving mirror-drum, while the small "baffles" inside direct the cool air on to the lamp, and also prevent any direct light escaping from the box and reaching the screen to mar the image.

The Motor.—Attention must now be turned to the motor which revolves the drum. The one actually used in the mirror-visor, and shown in the illustrations, is supplied with

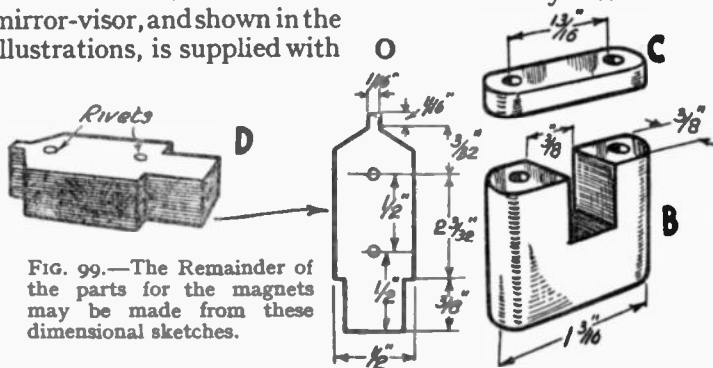


FIG. 99.—The Remainder of the parts for the magnets may be made from these dimensional sketches.

a shaped metal base. In order to accommodate it in its correct position on the baseboard, a block of wood must be prepared, $2\frac{1}{2}$ in. thick, 3 in. wide, and $7\frac{1}{2}$ in. long.

The height of the motor shaft centre from the baseboard when accommodated on the stand is $7\frac{3}{8}$ in.

At one end of the motor carcass is a brass boss through which passes the motor shaft. It is on this that the synchronising gear is mounted, and the locking nut must be removed and locked in place when the synchronising gear is in place.

The motor must now be mounted on the metal bracket. The actual position may be seen quite clearly in the diagrams shown herewith. The motor shaft will now be positioned over the cell-box, and the drum should be placed on the motor shaft and rotated slowly by hand to see that it does not in any way foul the box. If all is correct, fix the motor base firmly to the wooden block with four stout screws.

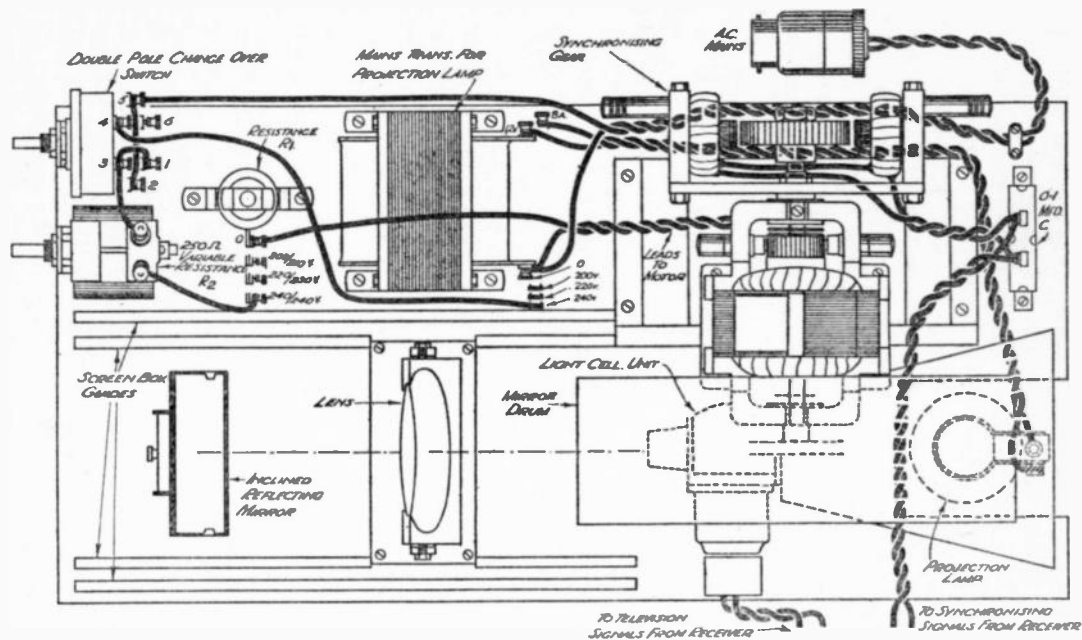


FIG. 100.—The wiring plan of the complete Mirror Visor.

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It is as well to point out here that the drum is placed on the motor shaft so that the flexible coupling is on the outside. Remember that the drum revolves in an anti-clockwise direction facing motor end and in a vertical plane parallel with the baseboard edge, and, in consequence, the motor shaft must be at right angles to the same edge.

It will be seen that the synchronising gear is fitted with small insulated handles and is therefore designed for manual operation. Should it be found desirable to arrange for this part of the complete apparatus to be operated from the outside of the complete cabinet, some form of drive will have to be provided and this may follow any individual preference, so long as a smooth and small movement may be provided. Obviously, therefore, a geared reduction drive will be required and there are many different ways in which this may be carried out.

Mounting the Lens.—Carefully measure the exact position for the lens-holder, and before mounting this file two vertical slots in the sides so that the lens may be raised and lowered and thus brought into its correct optical position. To enable the viewing tunnel to be moved backwards and forwards ordinary small hexagonal nuts should be fitted to the lens-holder in place of the wing nuts supplied with this part of the equipment. Next screw down the mirror, making absolutely certain that its centre is on the optical centre line of the complete equipment, and see that its axis is 3 in. inside the baseboard edge.

The Viewing Tunnel.—The viewing tunnel may be pulled forward to bring the image into focus and to maintain it in its correct position small runners are provided on the baseboard. Details are given in Fig. 102 for the running guides, and it will be seen that a small stop is provided to prevent the tunnel from being completely withdrawn. The tunnel itself is constructed from three-ply wood, the inside being coated with dead black (obtainable from any photographic dealers). The front is provided with the screen and there are several methods of preparing this screen. In its simplest condition it may consist of a sheet of thin butter paper, glued across the opening. This may easily be torn and it may therefore be protected by fastening a sheet of glass over the front. Reflection from the glass surface may

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spoil the received picture, and therefore a sheet of finely-ground glass (again the photographic accessory may be turned to account) with both sides ground will be found useful. Other ideas may present themselves to the constructor.

Mount the remainder of the components, taking the wiring diagram as a guide, and note carefully that the ends of the synchronising coils are anchored to the .1 mfd. condenser. The flexible leads which are connected to the mains, and the

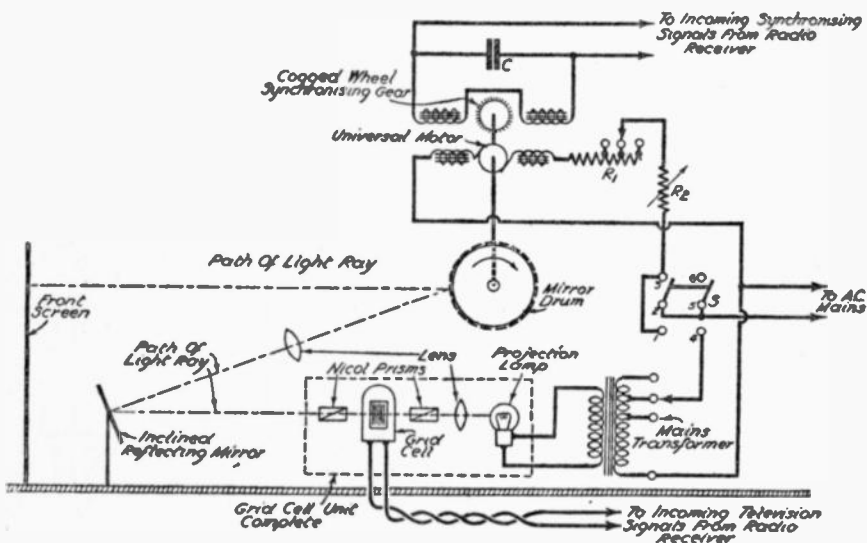


FIG. 101.—The schematic arrangement of the Mirror Visor.

output terminals from the wireless apparatus may be attached to the base of the visor by means of ordinary insulated bell staples, or small cleats made from metal or wood.

Wiring.—Wiring should be carried out with fairly thick wire in order that it may remain fairly rigid and thus prevent any troubles due to movement and consequent short-circuits, etc. The synchronising coils must be connected so as to produce opposite polarity, and therefore, in order to prevent any trouble due to wrong connection, before making the ends secure connect a small battery to each end and bring a small pocket compass to each pole piece. This will enable

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the polarity to be seen accurately. To prevent overheating, cut out the rear of the cabinet and attach a piece of open gauze across it. The lamp-house will keep cool by the movement of the mirror-drum.

Adjusting.—Before the visor can be used to receive pictures it is essential that the various optical parts be lined up accurately, and the following is the procedure to ensure that this is carried out correctly. Pull forward the viewing tunnel so that the screen is about 20 in. in front of the front edge of the mirror drum. Connect a source of supply

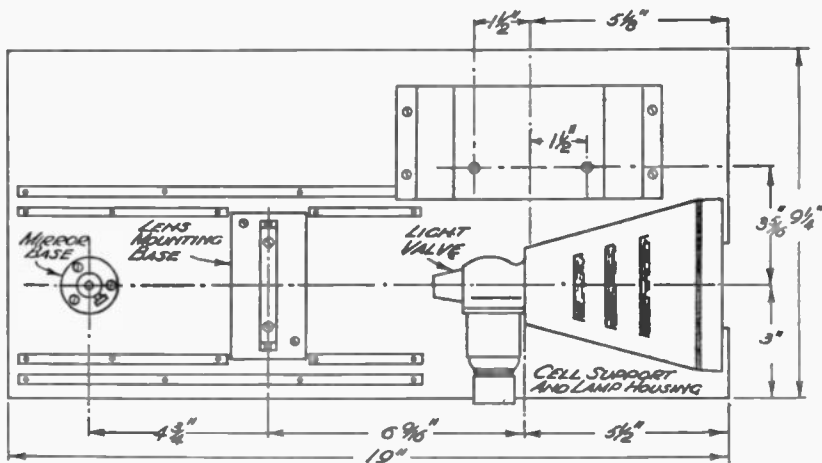


FIG. 102.—Details for mounting the respective parts on the base to maintain correct alignment.

to the lamp so that this receives its correct voltage. Next apply a voltage of about 400 to the leads of the grid cell, a variable resistance of approximately 10,000 ohms in series with one lead enabling adjustment of the applied voltage to be carried out. As soon as the lamp is switched on a bright spot of light will be thrown on to the mirror, and this should be inclined, and the lens moved at the same time so that the spot of light is focused on to one of the mirrors of the drum. The positions given in the lay-out will ensure accurate positioning, but the angles are just as important. The size of the light arc when correctly arranged will be such that approximately two mirrors are covered and thus

BUILDING A MIRROR VISOR

ample illumination is afforded to the user. When all is correctly set a bright clean-cut square of light will be projected on to the screen, when it is situated at the distance above-mentioned. A little movement of the screen backwards and forwards may be necessary to find the exact position. Turn the drum slowly until two light spots are seen on the screen from the first and last mirrors on the drum. The first will appear at the bottom right-hand corner of the screen and the last at the top left-hand corner. Should it be found that either of these spots is masked by the edge of the screen, loosen the grub-screw which attaches the drum to the motor spindle and slide the drum along its spindle until the two spots are within the compass of the screen. Then lock the screw.

When the drum is rotated an area of light should be seen on the screen, built up from the 30 mirrors and no extraneous light should be permitted from the lamp-house or the brilliancy of the picture will be affected.

The Receiving Apparatus.—For maximum results an output of from 4 to 5 watts must be fed into the visor, and therefore it must be employed with a suitable receiver or amplifier. The quality of the output must be sufficiently high to enable a distortionless picture to be received, and the various faults which are detailed in another part of this book may be corrected as there described.

TELEVISION DISC DATA FOR PRESENT TRANSMISSIONS

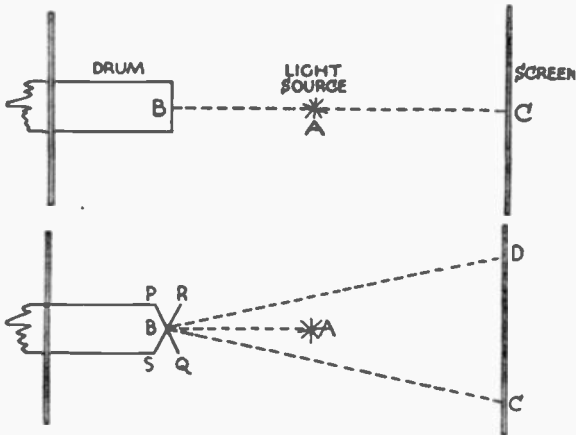
Diameter of Disc. Inches.	Radius for First Hole. Inches.	Size of Hole. Inches.	Picture Width. Inches.	Revolu- tions per Minute.
26	12.0	0.0358	1.0751	750
25	11.5	0.0343	1.0303	750
23	11.0	0.0328	0.9855	750
23	10.5	0.0313	0.9407	750
21	10.0	0.0299	0.8959	750
20	9.5	0.0284	0.8511	750
19	9.0	0.0269	0.8063	750
18	8.5	0.0254	0.7615	750
17	8.0	0.0239	0.7167	750
16	7.5	0.0224	0.6719	750

The above details are for thirty-line scanning, and the dimensions for hole sizes are worked to the nearest decimal point. To obtain actual figures the measurement in the second column should be multiplied by 0.08959 and the result divided by 30.

CHAPTER XIII

THE MIRROR DRUM

THE method by which a scanning disc builds up a light area in which the picture is seen is not very difficult to understand, as it is obvious that when the disc rotates each hole will, owing to what is known as persistence of vision, appear to form a strip of light, and as each hole is arranged immediately by the side of its neighbour the effect will be a broad band of light. It is, however, not so easy to see



FIGS. 103 and 104.—(Above) Showing the light reflection path for a mirror parallel to the drum axes; and (below) How the light beam direction is changed when the mirrors are inclined.

how the thirty mirrors arranged round the edge of a drum can have a similar effect. If the mirror-drum is examined it will be seen to consist of a metal casting (usually aluminium) with thirty surfaces to which clips are attached. If these thirty surfaces were perfectly flat, or in other words parallel with the axis of the drum, the effect of throwing a light on to the drum whilst it revolved would be to direct the light straight back to the light source. It is well known that the angle of incidence is equal to the angle of reflection,

THE MIRROR DRUM

and thus Fig. 103 shows how a parallel-sided drum would function. If, however, the mirrors are fitted at an angle, the reflected light will be thrown to one side, as shown in Fig. 104. In this illustration two mirrors are shown, PQ and RS. The light source is represented at A, and the reflected light rays will be as shown at BD and BC. Now let us imagine that these two mirrors are the first and last of a series of thirty. It is obvious that if we place twenty-eight similar mirrors between these, and arrange that the angle of each of these differs slightly from its neighbour so as to cover the area between the points D and C on the screen, we shall have a similar effect to that obtained with a perforated disc, and a light area will be built up. To obtain correct television pictures it is necessary to take into account not only the width of the light area, but the proportion of width to height, and the method in which this is carried out is shown by Fig. 105. If θ is the angle subtended between the two mirrors, and n represents the number of mirrors on the drum with x the distance OP, then

$$CD = a \times \theta \text{ (approximately).}$$

For the present B.B.C. television picture the ratio of height to breadth is as 7 to 3. Furthermore, if there are n mirrors round the circumference of the drum, then the dimension AB is given by the expression :

$$AB = 2 \times \tan \frac{\theta}{n}$$

But

$$\frac{AB}{CD} = \frac{7}{3} \text{ or } AB = \frac{7}{3} \times CD.$$

Therefore

$$2 \times \tan \frac{\theta}{n} = \frac{7}{3} \times 2 \times \theta.$$

Hence

$$\theta = \frac{3}{7} \tan \frac{\theta}{n}.$$

For approximate purposes, as the angles are quite small, we may say :

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$$\theta = \frac{3}{7} \tan \frac{2}{n}$$

Now if n is equal to 30 for the present B.B.C. transmissions, and converting the expression to ordinary degrees instead of radians, then

$$\theta = \frac{3}{7} \times \frac{360}{30} \times \frac{36}{7} = 5 \text{ degrees nearly.}$$



FIG. 105.—Refer to this diagram when following the calculations given in this chapter.

From the above calculations it will be seen that the angle between the first and last mirrors is only a very small one, and that between the individual mirrors in the case of the normal thirty-line drum is only one-sixth of a degree. This means that very skilful workmanship is called for, and there is no room for error. Consequently, the price of the present mirror drum is rather high, and it is rather difficult for the constructor to build up a drum having the requisite degree of accuracy.

CHAPTER XIV

CONNECTING A VISOR TO YOUR RECEIVER

To operate the light source of the visor, no matter whether it is of the simple neon lamp type or a complete grid cell, it is necessary to pass a current through that device. This means that it must be connected to the receiver so that a D.C. supply is available for the light source, and this is not always a simple proposition. Taking the simple disc machine first, this requires a neon lamp through which a D.C. of about 20 to 25 milliamps must be passed. The average output valve, especially of the ordinary mains broadcast receiver, normally passes a current somewhere about this

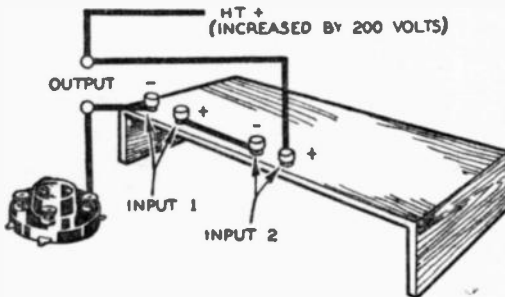


FIG. 106.—The normal connection is to insert a neon lamp and synchronising coils in series with the output valve.

value, and therefore this anode current may be used for striking purposes. That is to say, the neon may be joined direct in the output circuit and the passage of the normal anode current will cause the lamp to light up, the signal variations causing a variation in brilliancy and thus producing the picture as the lamp is viewed through the holes in the scanning disc. Therefore, if the receiver is of the type where the loud-speaker is normally joined direct in the anode circuit, the neon may be simply connected to the L.S. terminals, and no other change will have to be effected. There is one point which must be guarded against here, however, and that is, the drop in voltage which will be obtained due to the inclusion of the neon in place of the loud-speaker will render it necessary to augment the H.T.

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supply so that the valve receives its correct H.T. This point is of especial importance when the synchronising coils are also included in the series circuit. In Fig. 106 is shown the connections when this type of circuit is employed, and it will be seen that two pairs of terminals are provided, one pair for the lamp, and one for the synchronising coils. The additional H.T. is shown as 200 volts, but this figure may be modified according to the particular supply which is in use.

Using a Transformer.—With some receivers a device known as an output filter is included. That is to say, a low-frequency choke is included in the anode circuit and the loud-speaker is joined between the anode and earth, with the addition of a fixed condenser in this lead. Obviously

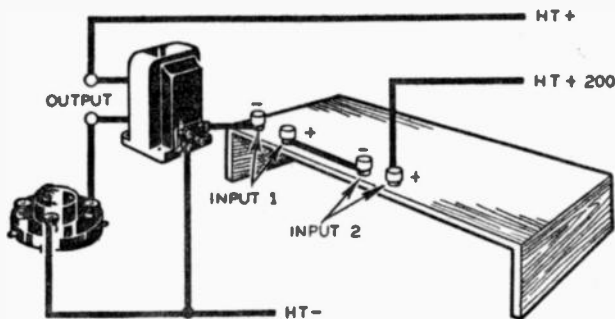


FIG. 107.—A direct transformer connection.

this prevents the direct passage of D.C., and it is therefore not possible to connect the neon in this part of the circuit. To enable a simple change-over to be effected without removing the filter a special transformer will have to be used. The ratio should be 1 to 1, and the primary should be joined to the normal L.S. terminals, and the neon then joined across the secondary, with a connection to H.T. plus and H.T. minus to complete the circuit. The scheme is illustrated in Fig. 107, and this scheme has the great advantage that the image may be reversed simply by changing over the connections to the primary or the secondary. A further advantage with this circuit is that one of the leads (preferably that to the negative H.T. supply) may be fitted with a variable resistance, and thus the actual current passing through the neon may be regulated and the brilliancy of

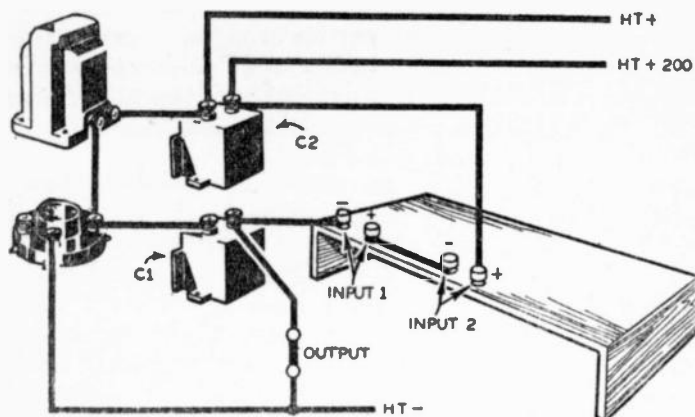


FIG. 108.—A choke capacity-coupled output. This can be joined up by shorting the output terminals of the set; add an additional fixed condenser C_2 , of the same capacity as C_1 , which is the one already in the set, and connect the leads as shown.

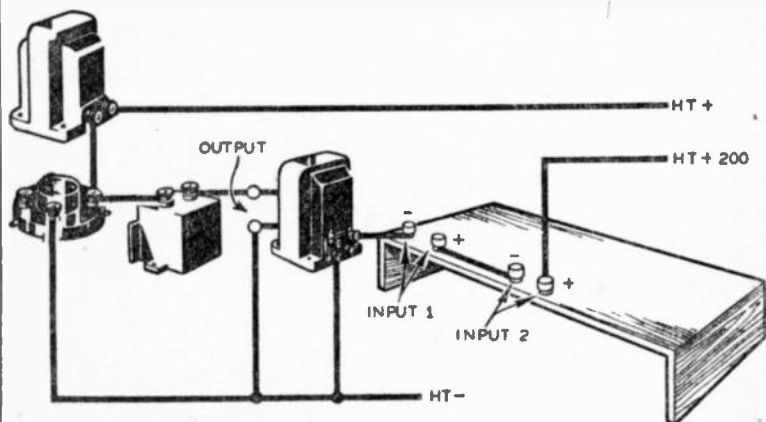


FIG. 109.—A transformer is used in the choke-output circuit and assists in reversing the image.

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the picture thus maintained at such a value that full modulation is obtained with the particular signal which is being received. The 1 to 1 transformer may, of course, be used direct in the anode circuit, to obtain the advantage of image

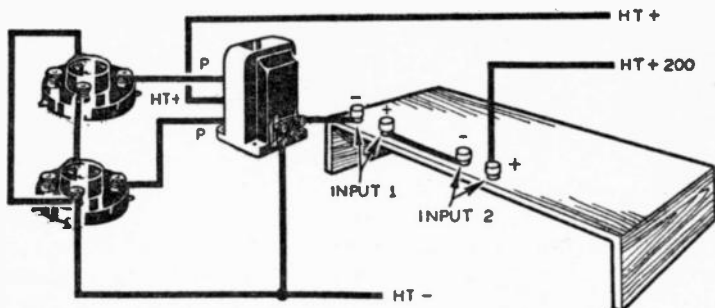


FIG. 110.—With this type of circuit a negative image may be reversed by changing over the transformer connections.

reversal, but it will also be necessary to include the extra connections to H.T. plus and minus in order to obtain the required striking voltage.

A Push-Pull Scheme.—When the output stage consists

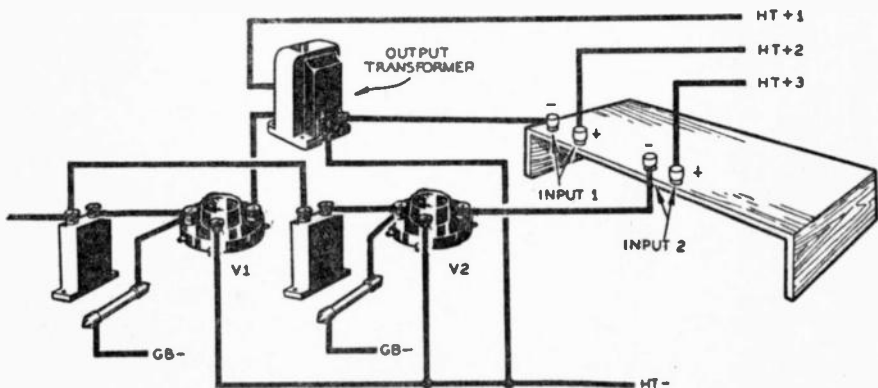


FIG. 111.—When two valves are used in a push-pull circuit this arrangement should be employed.

of a push-pull circuit extra precautions have to be taken in order not to unbalance the circuit. The best arrangement is shown in Fig. 111 where an output choke with a centre-tap is used. Again the synchronising coils and lamp are in

CONNECTING A VISOR TO YOUR RECEIVER

series. A simplification of the circuit is obtained if a separate valve is employed for the synchronising impulses, when the voltage loss is reduced, and a more straightforward arrangement can be applied.

The Quality.—No matter what device has to be adopted for connecting the lamp, it is essential that the quality of the signal with which it is supplied is of such a high standard that full justice is done to the broadcast picture. Thus, the amplification of the L.F. side must be above reproach. Resistance-capacity coupling should be substituted for any cheap transformers which are at present in use, although provided the component is of really high class and manufactured by a reputable manufacturer, it is capable of good results. There is a slight difficulty to be found, however,

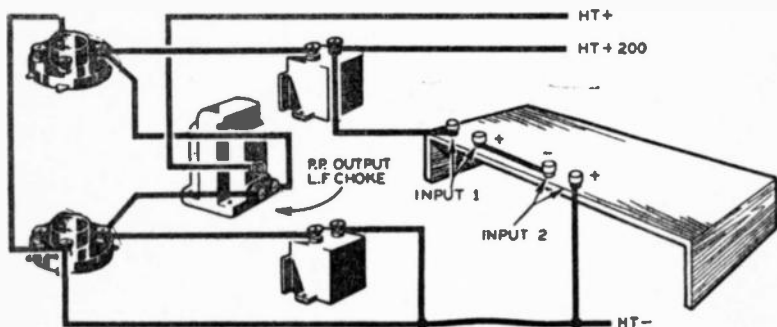


FIG. 112.—To keep the disc in synchronism a separate valve may be used as shown.

regarding saturation of the iron circuit, and generally speaking it pays with television apparatus to exclude iron as much as possible. To obtain a correct image, three R.C.C. stages should be employed, and the rectifier should be of the anode-bend type. Under these conditions the image will be positive. Modifications may, however, be made and the output transformer relied upon for image reversal. If any L.F. distortion is present in the amplifier light fringes will be seen round a person's head, for instance, or other blemishes will appear. In another chapter some good illustrations of the various forms of distortion which may be obtained are shown, and the correction is obvious, when once the cause is known.

SYNCHRONISERS AND THEIR MECHANISMS

EVEN reasonably good television demands in the first place that the motor operating the visor shall run at a speed of 750 revolutions per minute, and that that speed shall remain perfectly constant. Let that point be borne in mind before the equally important consideration is explored that any one revolution must commence at a definite instant in time. We have long been in the habit of speaking of "instantaneous" photography to imply that an "instant" occupies a twenty-fifth of a second or even more, but where television is concerned we must look on time through a microscope as it were. Just as to the imaginary inventor in a recently published story, an object falling normally in space due to gravity appeared to be almost stationary, owing to his own quickened perceptions, so must we

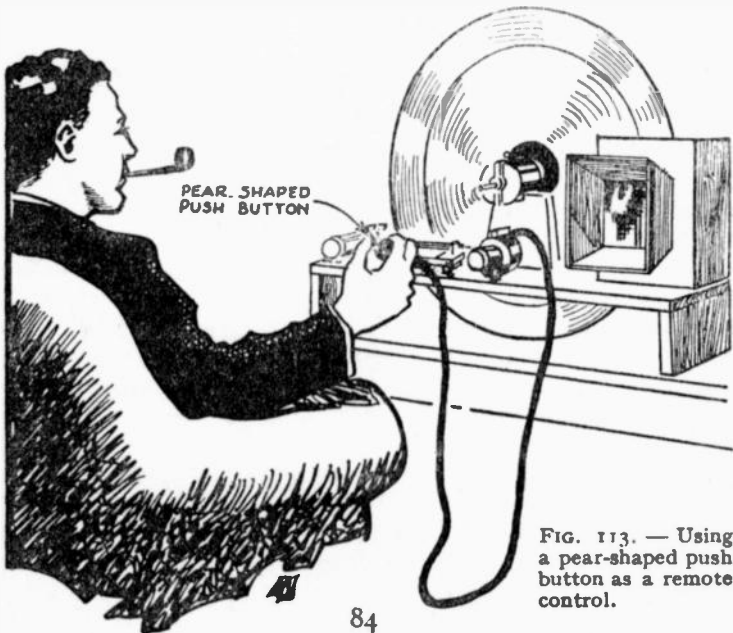


FIG. 113. — Using a pear-shaped push button as a remote control.

SYNCHRONISERS AND THEIR MECHANISMS

imagine that we are able to study a normally revolving visor which yet appears to us to move with the speed of, say, the minute hand of a clock. The instant that the visor at the transmitting end is in its twelve o'clock position, so must the visor at the receiving end be at its twelve o'clock position, the two visors keeping perfect time together as they move round.

Cogged Wheel Synchronisation. — Synchronising can be brought about in a number of ways. In the cogged-wheel synchronising equipment a cogged-wheel having thirty teeth

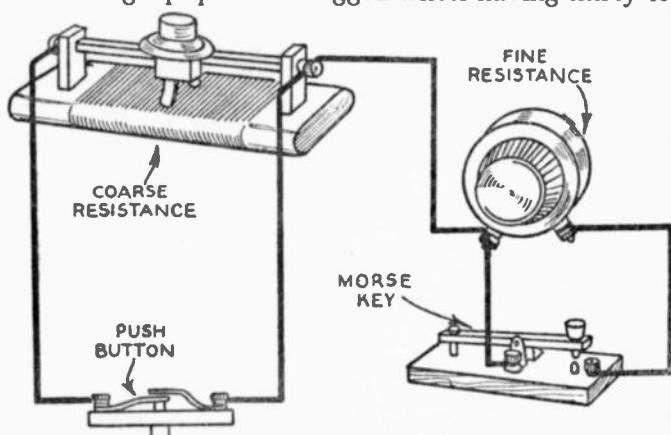


FIG. 114.—A push button is connected across the coarse resistance and a morse key across the fine resistance, as shown.

is attached to the motor spindle and revolves with it. Since the speed is 750 revolutions per minute it follows that the teeth pass by any fixed point near the circumference at the rate of 375 per second. A strong synchronising pulse or signal having a frequency of 375, is sent out from the transmitting station superimposed upon the ordinary television signal. In addition to passing through the neon lamp to produce the image, this pulse or signal is fed into two polarised field coils joined in series placed appropriately near the circumference of the cogged-wheel, and a pulsating magnetic field is set up. Provided that the cog-wheel is revolving at its correct speed the action of this pulsating field has no effect. With any slight deviation of this speed however, a retarding or accelerating effect, whichever

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is appropriate, immediately operates on the revolving cogged-wheel, and tends to restore its correct motion.

Variable-Resistance Methods.— The cog-wheel system of synchronising is a Baird patent, but there are many variations bearing on the same principle with which it

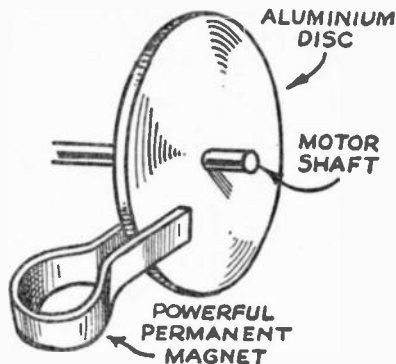


FIG. 115.—Using the familiar eddy brake.

may be wished to experiment. By using two variable resistances in series, for instance, one of coarse adjustment and one of fine, speed control can be adjusted to fine enough limits for it to be possible to keep the image stationary and in its correct position by counteracting any tendency to motion by suitably varying the fine resistance.

This method may be adapted to permit control by a push-button in conjunction with a morse key by substituting for the fine resistance two other resistances in the proportion of roughly 5 to 1, and allowing contact at the push-button to short-circuit the higher resistance, and contact at the morse key to short-circuit the lower resistance. Depressing or releasing the push-button counteracts violent fluctuations, while operation of the morse key corrects tendencies of slight image slip.

Remote Control.— Alternatively, the short-circuiting device against the coarser resistance can be dispensed with entirely, a push-button to short-circuit the finer resistance being relied upon entirely. Using a pear-shaped push-button, a handy form of remote control is thus available.

Entirely mechanical control of speed is not, generally

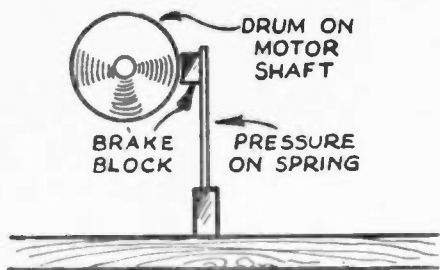


FIG. 116.—A mechanical form of push button control for governing the speed of the motor.

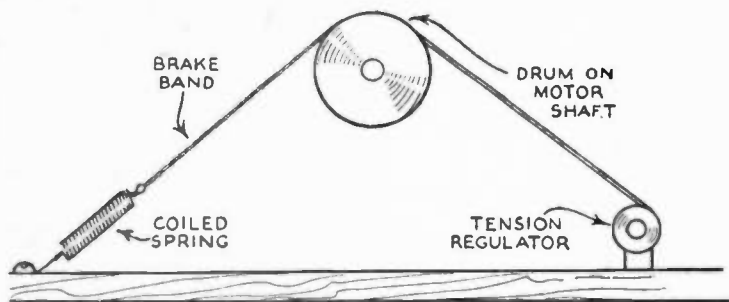


FIG. 117.—Using a brake band or cord to vary the motor speed.

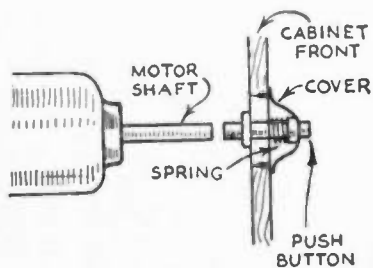


FIG. 118.—Another variation is the adaptation of a brake block or cork pad working direct on to a drum fitted to the motor shaft.

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speaking, as successful as electrical control. An ordinary push-button with its reverse surface bearing or not, at the will of the operator, on the end of the motor-spindle is a straightforward method, a spring normally keeping the device in the off position. The motor in this case must be arranged to revolve slightly faster than its correct speed. Or a brake-band, the tension of which may be varied at will, passing round a drum mounted on the spindle may be similarly used. By substituting a brake-block for a brake-band yet another similar method suggests itself.

An Eddy-Current "Fly-Wheel".—Reverting to wholly electrical methods, an eddy-current brake arrangement

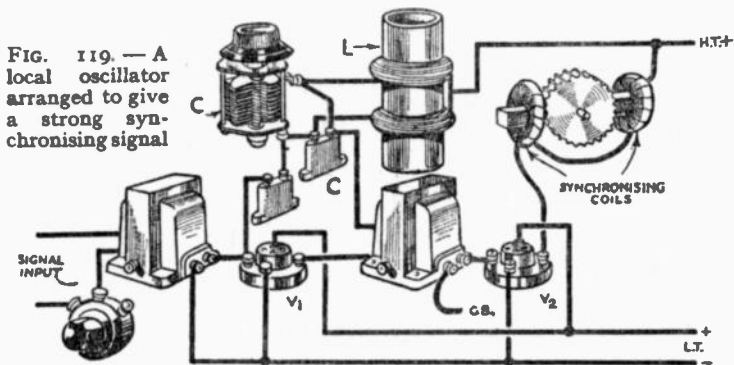


FIG. 119.—A local oscillator arranged to give a strong synchronising signal

may be tried. In this an aluminium disc mounted on the motor spindle rotates between the narrow-gapped poles of a powerful permanent magnet. This merely tends to check any *sudden* retardation or acceleration of the motor owing to a principle of eddy current generation in the disc, and has the limitations implied, but may prove exceedingly useful in cases where speeds continually fluctuate, and may well be used in conjunction with one of the other devices.

There are various modifications of the Baird cogged-wheel synchronising equipment. An ebonite or fibre wheel having thirty steel strips at right-angles to the plane of the wheel equally spaced along its circumference, or, alternately, an ebonite or fibre wheel having thirty equally spaced turns of wire wound between a series of concentric holes and the rim of the wheel may be used in place of a cogged-wheel, the principle of operation remaining the same.

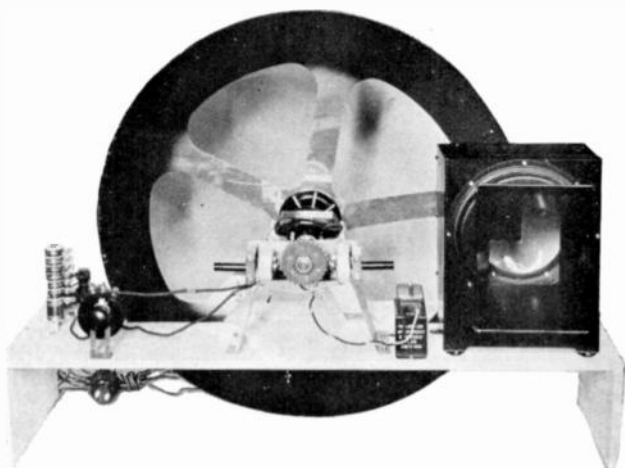


FIG. 120.—A front view of the Visor, showing the viewing tunnel synchronising gear and the position of other components.

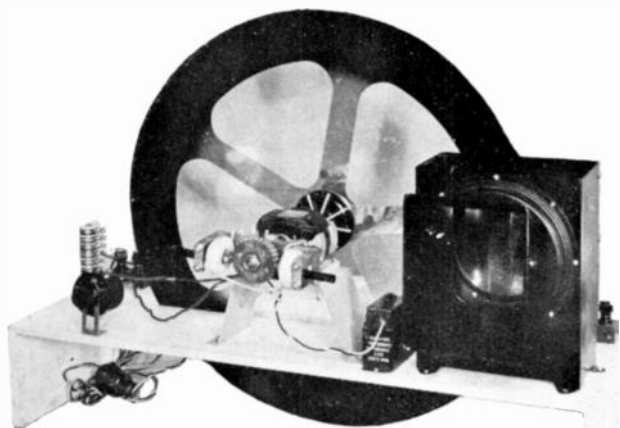


FIG. 121.—A three-quarter front view of the Visor, showing its neat and attractive layout.

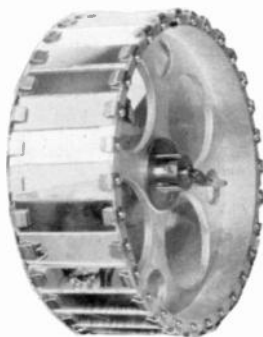


FIG. 122. — Showing very clearly the construction of the Mirror Drum and indicating how the individual mirrors are positioned round the periphery.

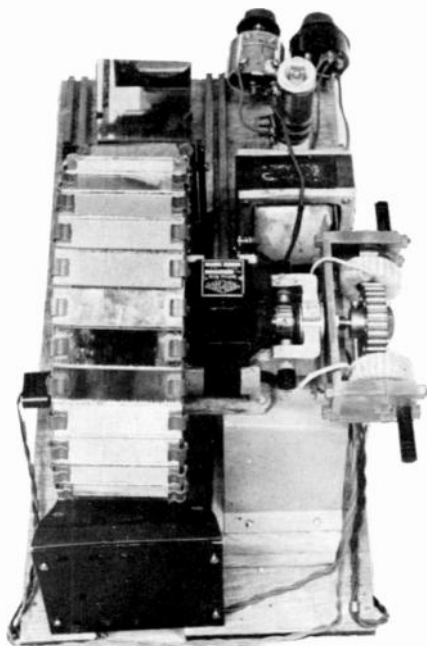


FIG. 123.—A plan view of the Mirror Visor.

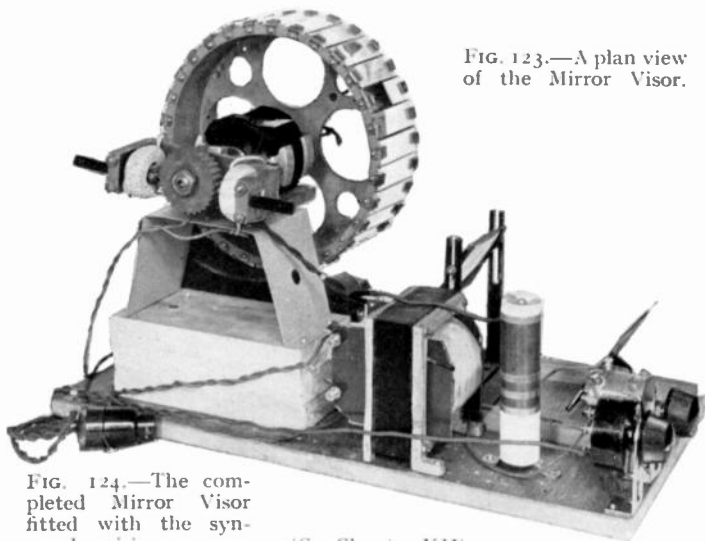


FIG. 124.—The completed Mirror Visor fitted with the synchronising gear.

(See Chapter XII)



FIG. 125.—A photograph of a Baird grid cell or light valve, used in the Mirror Visor described in this book.

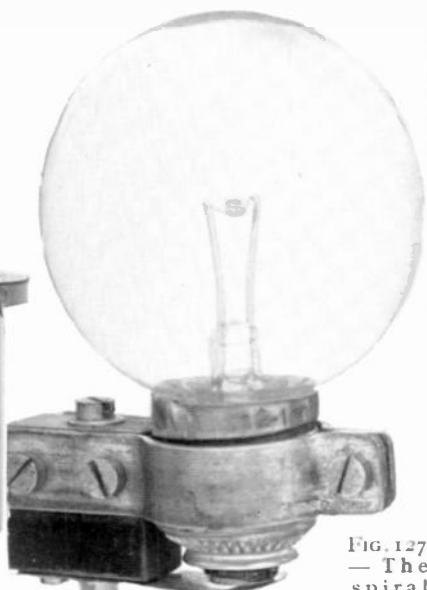


FIG. 127 — The spiral type of 100-watt bunch filament projector lamp used in the Mirror Visor.

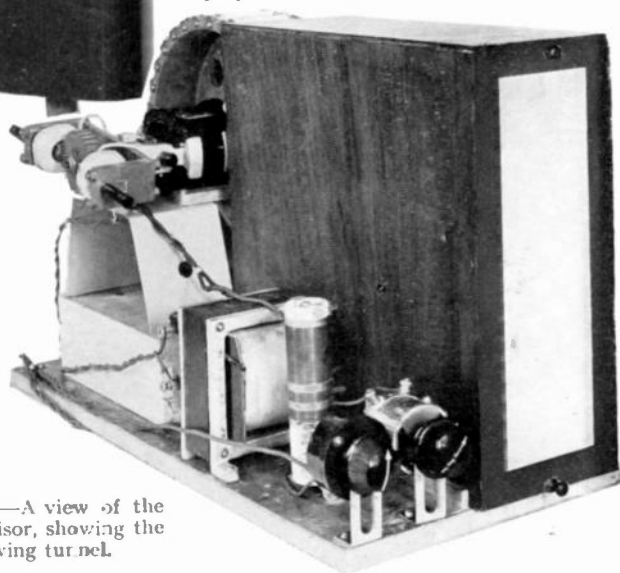


FIG. 126.—A view of the Mirror Visor, showing the viewing tunnel.

(See Chapter XII)



FIG. 128. — A photograph of an actual television transmission being carried out. On the left may be seen a portable transmitter.

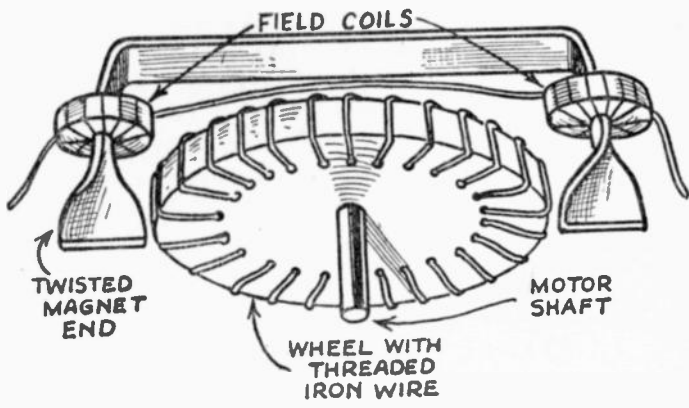


FIG. 129.—A cheap form of synchroniser.

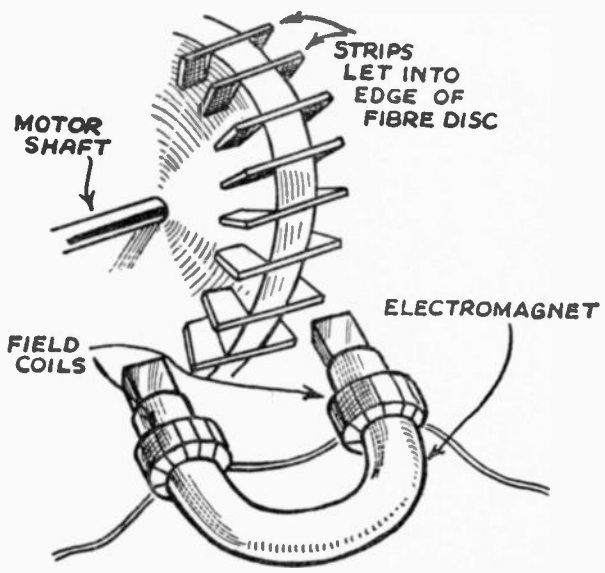


FIG. 130.—Another form of synchronising regulator, working electrically.

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Two-Valve Generator. — Yet another method consists of a two-valve generator (shown diagrammatically in Fig. 119). The first valve is the oscillator, while the second valve acts as a combined "detector" and amplifier, having a high negative grid bias. In order that it may have a frequency of 375 when tuned, the coil L must have a large inductance and be of the air-core type, a fixed and variable condenser in parallel effecting the tuning. Normal synchronising pulses from the radio set pass to the input L.F. transformer, and control the oscillations in the circuit, LC, so that when they are brought into tune, a strong signal is finally fed to the field coils of the synchroniser from the valve V_2 . Phasing can be carried out readily by bringing the local oscillator off tune, allowing the image to drift.

Power Derived from the Signal. — Motors specially

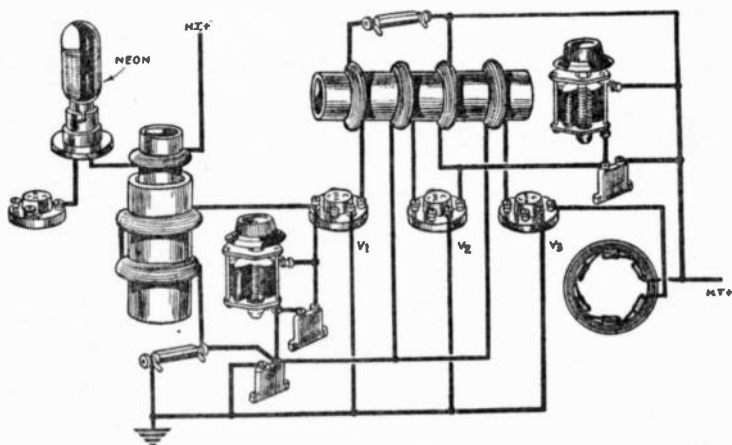
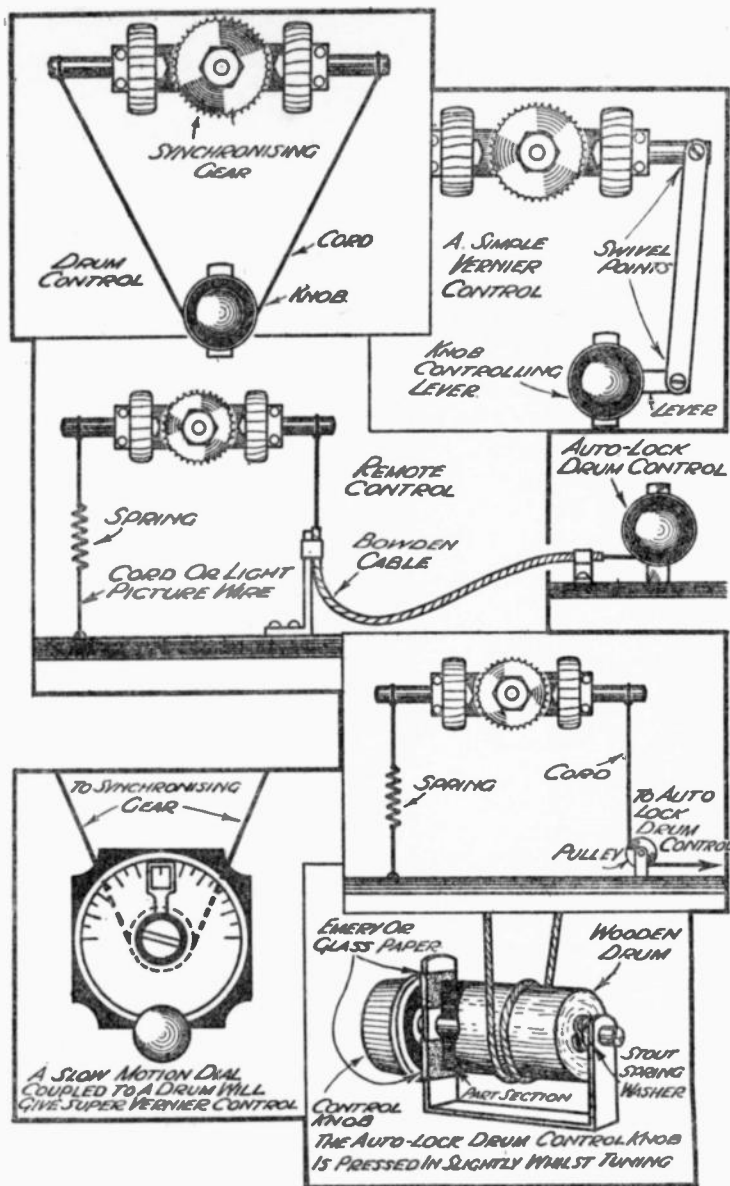


FIG. 131.—Drive valve oscillator and amplifier for supplying a control frequency to drive a phonic wheel motor.

adapted for the purpose make it possible for the synchronising signal itself to supply the only power required to drive the disc (see Fig. 131). To the grid of V_1 an oscillatory circuit tuned to 375 cycles and having low damping is connected. There is also coupled a coil in series with the



Figs. 132 to 137.—Various synchronising controls.

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pulse. This arrangement acts as a drive for the oscillating valve V_2 , having an anode circuit tuned to 375 and back-coupled to a coil (receiving the driver pulse), in the grid circuit of the same valve. High-tension supply is derived throughout from a mains unit, automatic biasing being included. Adjustment is such that the variable condenser of the generator circuit of V_2 corresponds as nearly as possible to the 375 strip frequency. The coupling coil, which is variable with the grid circuit of the controlling valve V_1 , is then adjusted and the fine tuning regulated. The synchronous motor is of the phonic-wheel type, possessing thirty teeth. This motor is not self-starting, and must be brought up to a synchronous speed by means of a friction wheel or small auxiliary motor. It will be understood that the oscillating valve V_2 generates the necessary power for driving the disc after that power has been passed to the third valve, in the anode circuit of which is the stator winding of the synchronous motor.

A Synchronising Unit.—Where a standard type of motor is to be used, the constructor will be spared much trouble if a complete synchronising unit is purchased. It is now possible to obtain all the separate parts for a unit of this nature, and the actual constructional work is reduced to a very small amount. The pole pieces are built up from laminations and these are firmly held together, as also is the thirty-toothed wheel. The bobbins are ready wound, and the large connecting plate is ready drilled at its exact centre for mounting on the motor. The actual method of mounting this will, however, depend upon the particular model which is in use. Certain motors made specially for television purposes are provided on each end of the motor carcass, with a neat brass one-hole fixing bush, as well as a spindle which projects an equal amount at each end of the motor. With these the mounting of the synchronising mechanism is extremely simple. With ordinary motors it will, however, be necessary to arrange a mounting bush in such a manner that the synchronising unit may freely rotate without shake about a true centre.

COMBINED SOUND AND VISION

MANY people quite wrongly imagine that they need only make minor alterations to their existing broadcast receiver in order to be able to enjoy the television transmissions as well as the sound transmissions. At present vision is transmitted on the London National wavelength, and sound from that of the Midland Regional, and so, of course, in order to see the picture and hear the sound accompaniment simultaneously, it is necessary to receive two stations at one and the same time. It might seem that the obvious solution to that difficulty is to provide oneself with two sets appropriately tuned, but that, generally speaking, is far from being the case. Certainly, dual transmissions may be received if a portable receiver can usefully be employed for the sound. Being compact it may be placed close to the

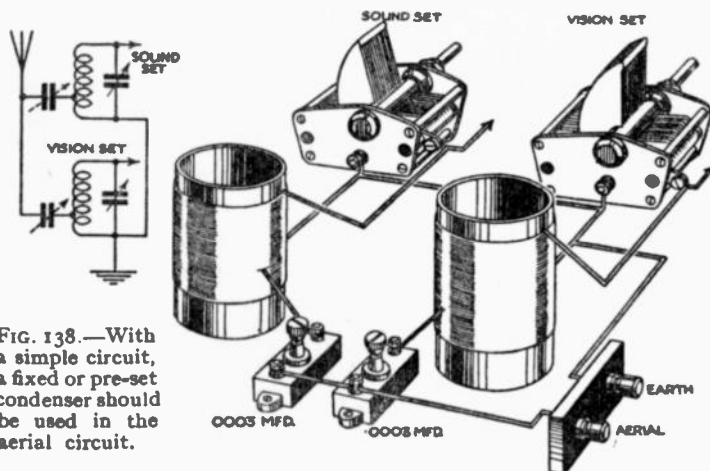


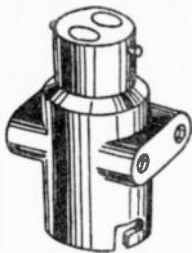
FIG. 138.—With a simple circuit, a fixed or pre-set condenser should be used in the aerial circuit.

vision apparatus, and thus give the desired effect that the sound actually emanates from the images that are being regarded. There are, however, few places where a portable

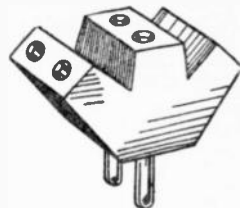
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set will give adequate signal strength to rise above the sound made by the television apparatus itself.

Multi-Plugs.—Again, in most cases the vision apparatus is mains-operated, and it will be desirable to eliminate batteries. This means that two plugs will be necessary,



FIGS. 139 and 140.
— Two Types of multi-contact plugs which can be used to accommodate both the receiver and television apparatus plugs.



or failing that a multi-plug must be obtained. Fortunately, many such are on the market, some, indeed, suitable for insertion in lamp sockets. Too great a load must not be put on the wiring circuit that is being used. In the case of the usual 5-amp. lighting circuit, the total load of both sound

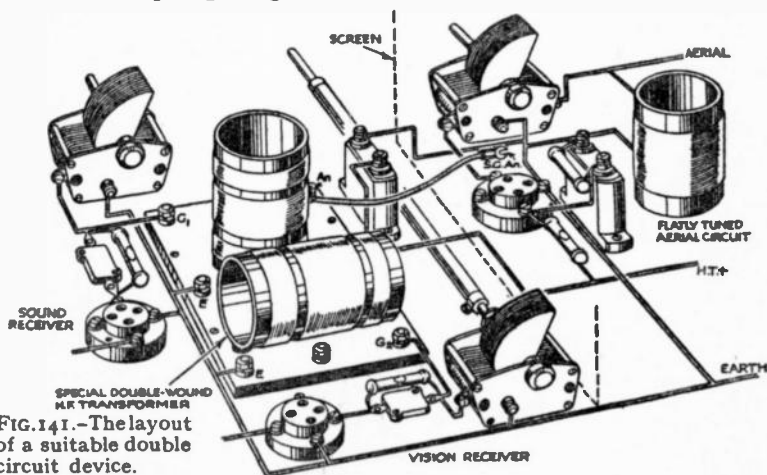


FIG. 141.—The layout of a suitable double circuit device.

receiver and vision receiver must not exceed that figure. Where convenient, 10-amp. or 15-amp. power circuits should be employed.

The attachment of aerial and earth leads presents a further difficulty. Two aeriels are not necessary. If the aerial

COMBINED SOUND AND VISION

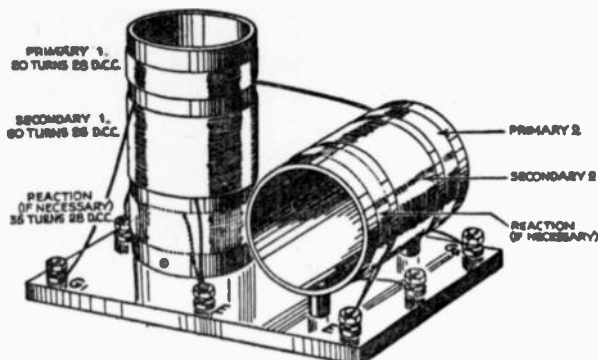
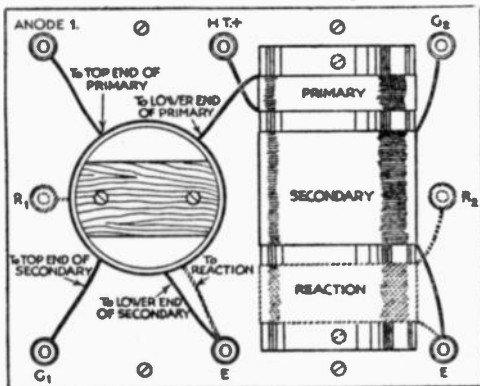


FIG. 142.—Construction details of the special units referred to in this chapter.

circuit of each receiver is of the simple tapped aerial coil type, fed through a small fixed condenser, the two aerial terminals may be joined together and the aerial lead taken to either. The earth lead in this case may be similarly connected to the two earth terminals joined together. The arrangement is shown in Fig. 138. It will be found that either set having been adjusted to the required wavelength, adjustment of the other will have no material effect upon that of the first.

Alternative Methods.—Alternatively a flatly-tuned aerial circuit tuner may be coupled to an H.F. valve, the anode circuit being fitted with a special double-wound



COIL FORMERS 4" LONG x 2" DIAMETER

FIG. 142A.—Wiring details of the unit shown above.

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transformer. This arrangement (shown in Fig. 141) will be found excellent for listeners who are at a long distance from the transmitters, or who wish to economise in equipment. A simple detector stage may follow this H.F. valve, which thus serves both receivers and removes the necessity for one complete H.F. stage. There is no reason why the H.F. transformer should not be home-made, and details are shown in Figs. 142 and 142A. The employment of dual-range coils is not necessary, though reaction may be applied to both coils if desired, as indicated. In some commercial receivers employing band-pass tuning ordinary bottom-capacity coupling is used, and if the second receiver is of the simple type that employs a tapped aerial coil, it might, in certain cases, be possible to short-circuit the band-pass coupling condenser, thereby upsetting the ganging of the receiver, and perhaps preventing reception.

Interference from the Motor.—It may be found that the motor in the television apparatus gives rise to quite a lot of interference, both radiated and mains fed. The latter may not be very troublesome, but where it is found that this is pronounced, two special H.F. chokes in the mains lead *to the motor* will prevent the noise being passed to the set. Radiated interference may be more difficult to remove, but to take a particular case all trace was removed by the following means: the normal broadcast receiver employed for the vision reception was fed from a special anti-interference aerial system consisting of an impedance-matching transformer, mounted at the rear of the cabinet, and with the metal screen "earthed." The sound receiver, a small commercial superhet, was connected to the aerial terminal on the vision receiver by means of metal-screened flex, the same material also being employed for connecting the earth terminals of the two receivers. The metal braiding was finally connected to the earth terminal on the impedance-matching transformer.

CHAPTER XVII

SOUND-VISION SWITCHING

ALTHOUGH for the complete enjoyment of the television programmes as at present broadcast it is necessary to employ two separate receivers (one for sound and one for vision); many listeners prefer to experiment simply with the vision transmission, or alternatively, use a small receiver for the reception of sound, and adapt the normal home receiver for the vision. This latter method is probably the best to adopt, as it may be assumed that the receiver which is normally used for broadcast reception has been built by the listener to obtain the very best results, and it will, therefore, be a receiver capable of giving good vision results. The sound accompaniment to the television transmission is subsidiary and, therefore, a small portable or other low-powered receiver will be sufficient, and the only problem which arises is how to convert the normal receiver so that it will operate the visor instead of the existing loud-speaker. It is obvious that some form of switching must be adopted, but certain precautions will have to be taken to avoid the overloading of valves, etc.

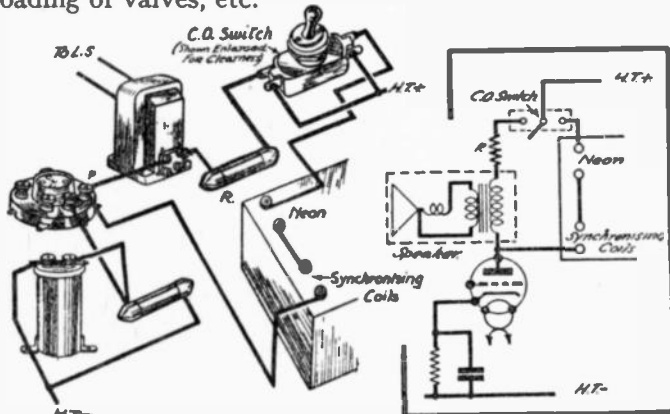


FIG. 143.—The method of switching from "sound" to "vision" when the apparatus is wired in series with the anode of the output valve.

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A Simple Scheme.—Dealing first with the simple disc-tube visor, we will have to arrange for the neon lamp to be included in the output circuit instead of the loud-speaker.

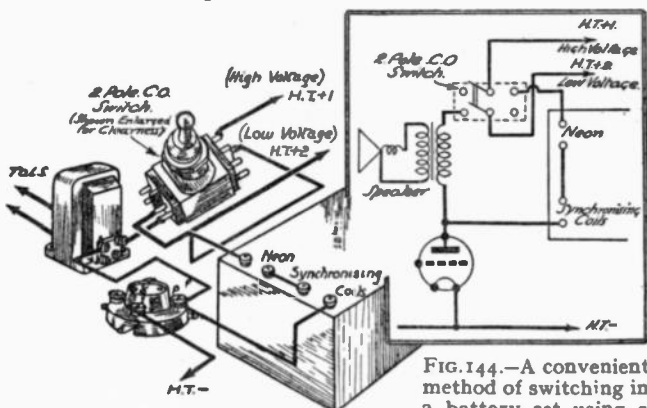


FIG. 144.—A convenient method of switching in a battery set using a single output valve, and where the apparatus is series-fed.

Provided that sufficient H.T. is available, a simple two-pole switch could be used. Unfortunately, however, the neon lamp requires a very heavy current to operate it, and consequently, there is a considerable voltage drop across it. When, moreover, it is employed in series with the syn-

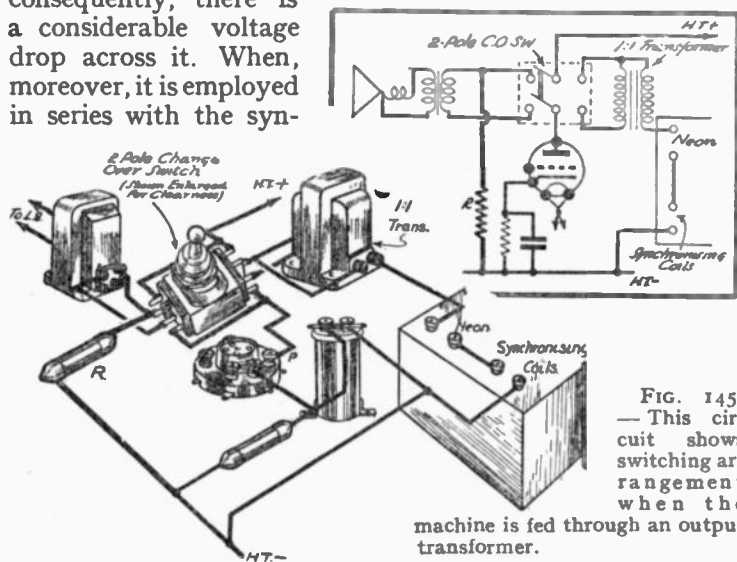


FIG. 145.—This circuit shows switching arrangement when the machine is fed through an output transformer.

SOUND-VISION SWITCHING

chronising coils (as is usual), there is a further drop, which under normal circumstances would prevent the output valve from functioning correctly. We must, therefore, arrange for a greatly increased initial voltage with some device to lower it when the loud-speaker is employed. In Fig. 143 the simplest method is illustrated, and it will be seen that we only require a suitable resistance in series with the loud-speaker (or speaker transformer), and this is brought into circuit when the switch is operated. Care will have to be exercised in the choice of the resistance, both from the value and from the current-carrying point of view.

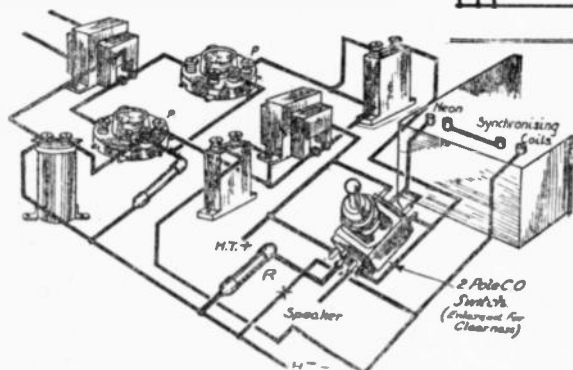
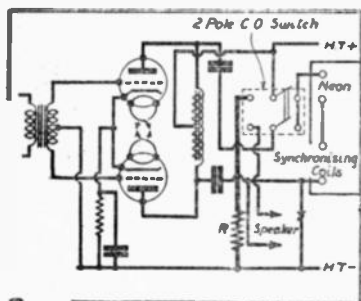


FIG. 146.—The switch connections in a push-pull output circuit. With this arrangement there might be some loss in volume, in which case the lead marked X should be broken by means of an on-off switch.

An Alternative Scheme.—Another method of avoiding the use of too much H.T. is shown in Fig. 144, where the H.T. supply source, whether battery or mains, is designed to provide a total suitable for the neon and synchronising apparatus, but the maximum is only employed when vision reception is required. Thus, a lower tapping is provided for the speaker, and by using a two-pole switch the change-over automatically brings the extra H.T. into use. When a mains unit is employed for the H.T. supply, some difficulty might be experienced by this method owing to the fact that the output voltage is governed by the current drain (or the load), and, therefore, the change to sound reproduction might

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result in a rise in voltage, and some damage due to surges, etc., might arise. To avoid this we can connect a resistance across the sound portion of the apparatus, and choose this resistance so that the current taken is equivalent to that of the neon and synchronising coils. This arrangement is shown in Fig. 145. The value of the resistance is, of course, ascertained by dividing the excess voltage by the current

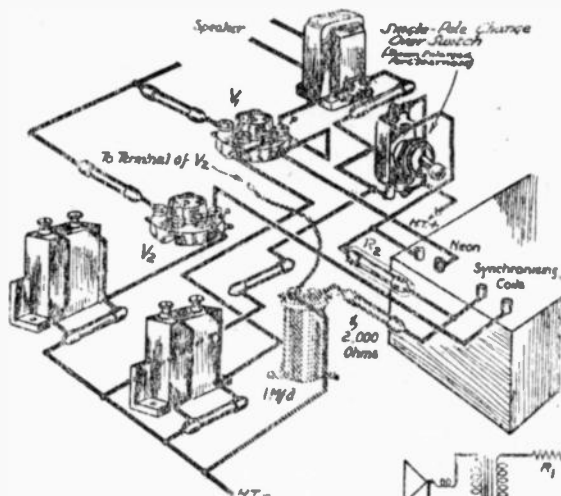
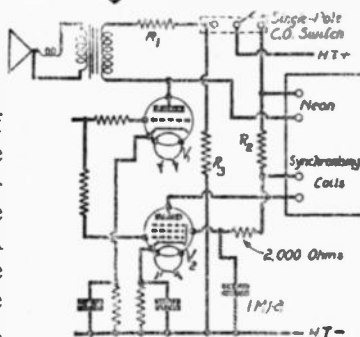


FIG. 147. — A switching arrangement for an all-mains set which incorporates a separate synchronising valve.

passed by neon and coils. If the voltage is in volts and the current is expressed as a decimal fraction of an amp., the answer will be in ohms. A millimeter in series with the neon circuit will enable the exact current to be ascertained.

In this diagram it is shown that instead of connecting the neon circuit in series with the anode of the valve, it may be joined across the entire H.T. supply, and the alternating component in the anode circuit is then fed to the neon through a transformer. This has the advantage that the total current passed through the neon may be greater than when it is in series with the anode, and also enables the valve



SOUND-VISION SWITCHING

to function more efficiently. If the output valve is of the type requiring a very high anode voltage, it may be desirable to connect a variable resistance in series with the neon circuit in order to avoid overloading the lamp.

Push-Pull Circuits.—When using push-pull arrangements it becomes necessary to modify the output arrangements already described, and if a simple centre-tapped output choke is in use the method shown in Fig. 146 will prove most satisfactory. Again, the artificial load is introduced by means of the resistance R , and it might be found necessary also to break the lead to H.T. at the point marked X. It might be mentioned at this point that the average resistance of the neon lamp and synchronising coils in series is in the neighbourhood of 8,000 to 10,000 ohms, and this will provide some indication of the value required for the load resistance.

Improving Synchronisation.—It will be found that the picture may be held more steady if a separate valve is employed

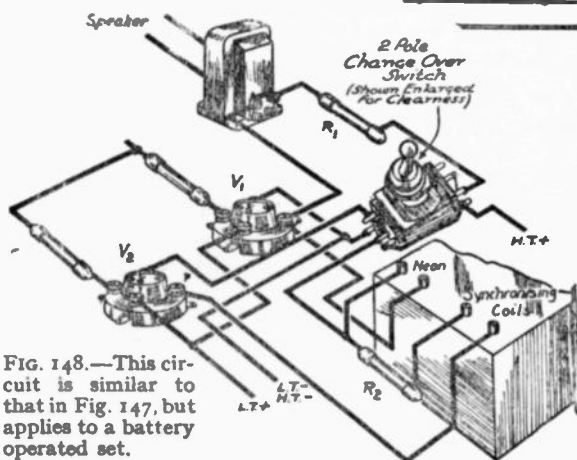
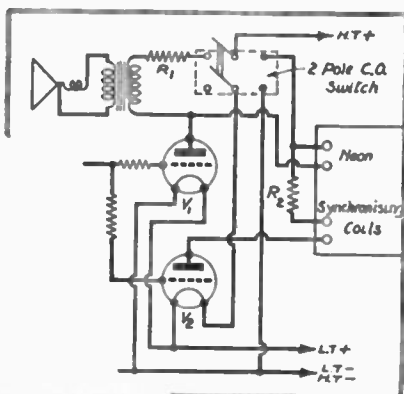


FIG. 148.—This circuit is similar to that in Fig. 147, but applies to a battery operated set.

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to feed the coils. This stage, as described elsewhere in this book, may be fed from a peaked transformer, and thus strength will be added to the synchronising impulse. The extra synchronising valve will not be required when sound reception is desired and, therefore, the supply voltages will have to be interrupted. In the case of mains valves the scheme shown in Fig. 147 will prove ideal, and the slight alteration in voltage output due to the extra current drain is again taken care of by the resistance R_1 . In the case of battery operation, it is possible to switch out the extra valve by interrupting the filament circuit, and an extra pole is provided on the switch for this purpose. The arrangement is shown in Fig. 146. To obtain the added advantage of a pentode output valve, this may be employed for the synchronising circuit and the extra voltage for the priming grid may be obtained by voltage-dropping resistances, arranged as shown by broken lines in Fig. 147.

Protecting Components.—In view of the very high voltages which are being dealt with in television apparatus, it becomes necessary to safeguard many components against damage due to the surges which occur when the apparatus is suddenly switched from one arrangement to another. All condensers, for instance, must be of very high voltage ratings, much higher than the actual applied voltage, and this is especially important if the apparatus is to be switched whilst valves are alight. If the apparatus is to be switched off each time a change-over is made, the point is not quite so important, but at least double the applied voltage should be considered as the safe working rating of the condensers. There are methods of arranging the switch so that before a circuit is completely broken a ballast resistance is joined in circuit to take care of any excess current, and this will enable the various components to be protected so that no damage will occur. This is a safeguard worth while taking with any apparatus no matter whether it is of the television type or for normal broadcast reception.

FAULTS IN TELEVISION RECEPTION

IN order to view the television image correctly it is essential that it should be positioned accurately in the viewing frame. Unfortunately, there is no definite way of ensuring that when the apparatus is switched on, the picture will be in its correct position. Firstly, the relation between the holes in the receiving disc, or the mirrors on the drum, must be in the same relation as those at the transmitting end at any one instant. If this is not so, then the picture, although correctly formed, will be in a different position from the original and thus the looker-in will observe the picture split either about its centre horizontally, or vertically, or both. If when the apparatus is switched on, therefore, and this state of affairs is obtained, it will be necessary to move the motor round on its bearings in order to enable the picture to come into its correct position. This procedure is known as "framing." If the apparatus is fitted with synchronising gear, it will only be necessary to move this part of the apparatus and it will automatically move the picture.

Synchronising.—Apart from this procedure it is also essential that the speed of the apparatus should be exactly the same as the transmitting apparatus, and to keep the two in step the synchronising apparatus is fitted. It is described in another chapter and, as described there, it maintains the motor at its correct speed. Any variation in speed will result in the picture moving bodily upwards or downwards, according to the speed of the motor. If the motor is running too fast, the picture will travel upwards, whilst if too slow it will travel downwards. Thus adjustment of the speed and position of the picture are carried out at one and the same time.

Distortion.—In addition to difficulties experienced in correct framing, there is the question of distortion of the image due to imperfections or wrong design of the apparatus which feeds the television receiver, and this may take the form of a poor image, an image marred by lines and other

TELEVISION AND SHORT-WAVE HANDBOOK

blemishes, or even by an image which is received in reverse. That is to say, places which were light on the original will appear dark, and *vice versa*. This is known as a negative image, and it may be reversed in several ways. Firstly, the method of rectification may be changed from grid leak to anode bend, or *vice versa*. Secondly, the method of L.F. coupling may be changed from resistance-capacity to transformer (or *vice versa*), and thirdly, an output transformer may be used and the connections to the secondary or primary may be reversed. The latter method will enable the picture to be reversed without modifying the actual receiving apparatus. For the correct reception of pictures as at present transmitted an anode-bend rectifier followed by three stages of resistance-capacity coupled amplifiers will be required. If the design of the amplifier is sound all high lights and shadows should be received in their correct balance and no distortion should be present. If, however, the low-frequency response of the apparatus is poor, the image will be accompanied by deep shadows and loss of detail. A kind of trailing shadow will follow all light portions, and the image will be difficult to distinguish. An excess of high-frequency response, or an amplifier which has resonances in the upper part of the frequency scale will result in the picture being surrounded by halos. All dark portions will also carry a white fringe and this may obviously extend into the next part of the image and thus break up the image. It will be seen, therefore, that to preserve all tones in their correct proportion, the frequency response of the amplifier must be very good.

External Interference.—Apart from distortion caused in the above manner there will be the risk of distortion due to disturbances caused by external electrical apparatus as well as from the actual motor used in the visor. Sparking at the motor brushes will result in spots of light flickering over the whole of the image, and a similar effect, only more regular in pattern, will result from oscillation or the excessive use of reaction. Should the receiver used with the visor be oscillating a fine chequered pattern will appear all over the picture and will appear to travel slowly across from one side to the other. Vertical lines travelling slowly from right to left will denote that L.F. instability is present, and



FIG. 140.—If the receiver gives undue high-frequency response, the image will be accompanied by white patches surrounding the dark sections, somewhat after the manner shown in this illustration.



FIG. 150.—A poor low-frequency response will result in dark patches beneath the chin and loss of detail in the face as shown here.



FIG. 151.—Interference such as may be caused by local oscillation will produce a chequered pattern as shown.



FIG. 152 —L.F. instability produces dark lines passing across the picture as represented in this illustration.



FIG. 153.—The received image should bear a close resemblance to this illustration, all half-tones being well presented.



FIG. 154.—A common fault experienced when first tuning in the transmission.



FIG. 155.—Another fault which occurs, due to the lack of synchronism.



FIG. 156.—If the signals are too weak, or the lamp is too brightly illuminated from a separate source, the received image will appear like this.



FIG. 157—
Untouched
photographs
showing actual
images repro-
duced by a tele-
vision receiver.
Image-splitting
which is ex-
plained in a
later chapter is
shown in the
two small photo-
graphs.



FIG. 158 (left).— One of the first experimental "all-in" television receivers. FIG. 159 (below). A small cinematype screen upon which television images have been projected

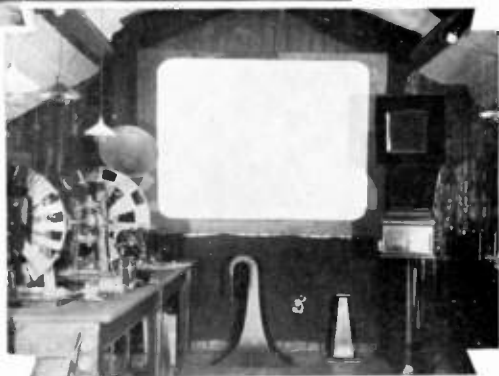
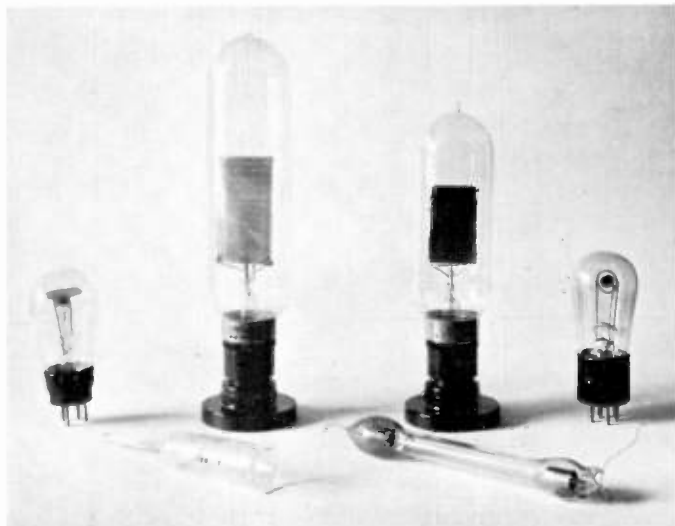


FIG. 160 (below). A series of neon lamps, all of which have their application in television.



FAULTS IN TELEVISION RECEPTION

decoupling will have to be included in order to stabilise the circuit.

Signal Strength.—In order to prevent loss of brilliancy it is also essential that the strength of the signal fed into the light source should be sufficient to afford ample modulation. Where the apparatus permits, the brilliance of the light source may be reduced if it is found that the signal strength cannot be increased, but this will naturally lead to a weak image. Similarly, if the signal is too strong the relation between light and shade will be over-emphasised and half-tones will be lost. A volume control in the amplifier will enable the signal strength to be controlled accurately.

Super-Hets.—With a good superheterodyne having two I.F. stages it is possible to compensate for signal variations up to about 300 to 1 by fairly simple means. When considering a very simple type of set such as that described in *Practical Wireless* dated November 4th, 1933, the A.V.C. action cannot be expected to be complete on any signals whose aerial-voltage ratio exceeds about 15 to 1, but even this apparently small degree of compensation is extremely useful.

One other point (and an important one) should be made clear in connection with A.V.C. This is that the control does not—*cannot*, in fact—*increase* the strength of fading signals; it can only *reduce* the strength when the signal voltages become greater than some particular value. It is therefore useless to expect A.V.C. to be of any appreciable value in a comparatively insensitive receiver.

The only other solution to the fading difficulty rests with the wider use of short waves, and those readers who are D.X. (long-distance) "fans" would do well to build a short-wave receiver for reception during the summer months.

CHAPTER XIX

A UNIVERSAL AMPLIFIER

To obtain maximum results from a mirror-drum or similar type of television receiver, it is absolutely essential to supply it with a signal which is not only distortionless, but is of sufficient power adequately to operate the grid cell or other mechanism, as well as to maintain synchronism. This is not such a simple matter when an ordinary broadcast receiver is employed, but if a separate amplifier is built up, to be used especially for the television programmes, it is possible to

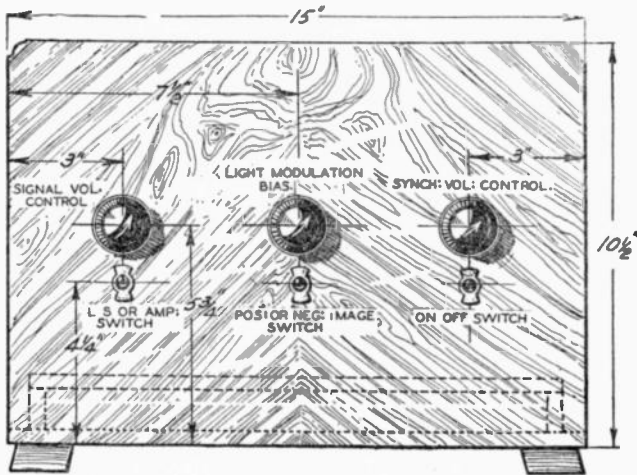


FIG. 161.—Details for drilling out the cabinet front.

obtain such results that the expense and labour of building the amplifier are fully justified. Synchronism especially, is very important, and it is really worth while to employ a separate valve for this purpose, and to ensure that it gives maximum amplification at the synchronising frequency, namely, 375 c.p.s., this valve should be used in conjunction with a transformer designed so that it peaks at that frequency. Thus, a suitable television amplifier would have one stage designed on these lines for the synchronising

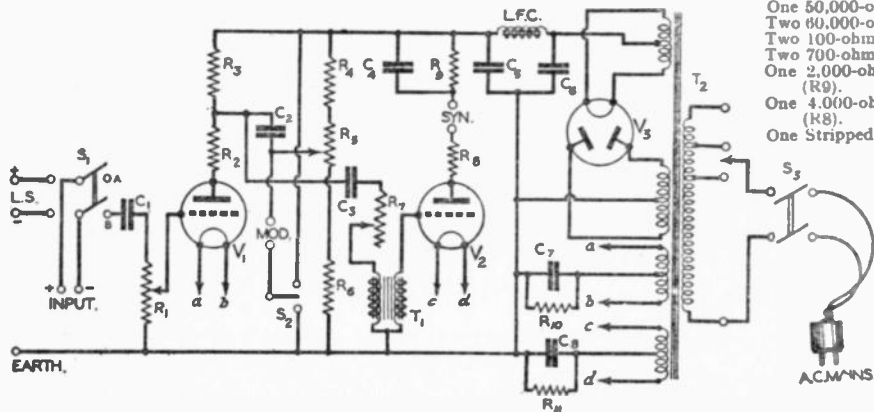


FIG. 162.—The circuit diagram of the universal amplifier described.

COMPONENTS REQUIRED

- Three Skeleton Chassis-mounting Valveholders.
- Two $\cdot 01$ mfd. Mica Condensers (C1 and C3).
- One 250,000-ohm Potentiometer (R1).
- One 100,000-ohm Potentiometer (R5).
- One 50,000-ohm Potentiometer (R7).
- Two 60,000-ohm 1-watt Resistances (R4 and R6).
- Two 100-ohm 1-watt Resistances (R2 and R3).
- Two 700-ohm 3-watt Resistances (R10 and R11).
- One 2,000-ohm 7-watt Non-inductive Resistance (R9).
- One 4,000-ohm 15-watt Non-inductive Resistance (R8).
- One Stripped Mains Transformer (T2).
- One Low-frequency Choke (L.F.C.).
- Two 0.5 mfd. Fixed Condensers (C7 and C8).
- One 1 mfd. Fixed Condenser (C4).
- One 2 mfd. Fixed Condenser (C2).
- Two 4 mfd. Fixed Condensers (C5 and C6).
- One 375-cycle Tubed Synchronising Transformer (T1).
- Three Right-angled Brackets.
- One Metaplex Chassis and Cabinet.
- One Double-pole 2-way Toggle Switch (S1).
- One Single-pole Change-over Toggle Switch (S2).
- One Double-pole On-Off Toggle Switch (S3).
- One Fuseplug.
- Nine Insulated Terminals, marked LS+, LS-, Input-, Input+, Mod (2), Sym (2), and Earth.
- Five Terminal Mounts.
- Two D.O.24 Valves.
- One 460 B.U. Rectifying Valve.

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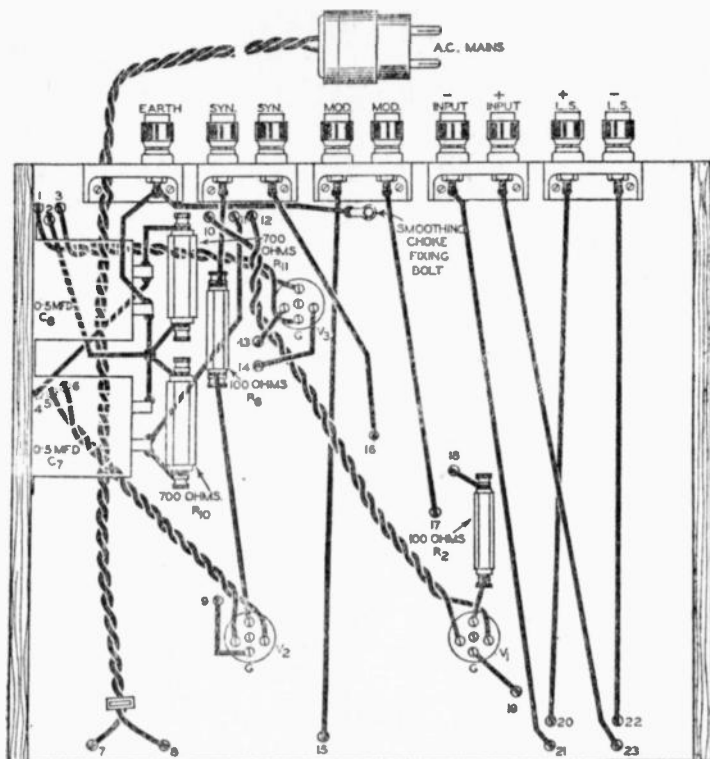


FIG. 163.—An underneath chassis wiring plan.

apparatus, with a separate stage designed to hand on high-quality signals for the grid-cell or similar device. A circuit utilising these two stages is shown in Fig. 162, and it will be seen that the first valve employs resistance-capacity coupling in the interests of quality, whilst the second, the synchronising stage, uses the special transformer.

The Circuit in Detail.—On the input side we find a useful switch of the double-pole double-throw type, which is joined to the output or loud-speaker terminals of the broadcast receiver and thus enables a rapid change-over to be made from broadcast to television. It will be noted that there is no connection to terminal marked A on this switch, and between this point and terminal B must be joined an

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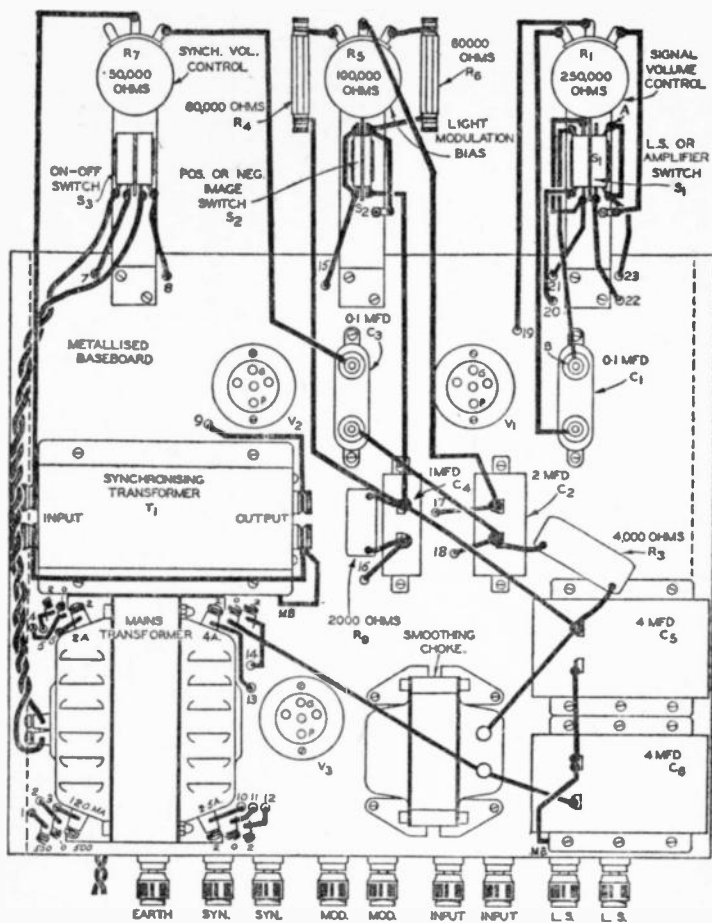


Fig. 164.—An above chassis wiring plan and lay-out of components.

impedance of such a value that it accurately matches the output valve of the broadcast receiver. A simple resistance may be used, although probably better results will be obtained if a good iron-cored choke is employed. The resistance should be of the same value as the speaker, and then no alteration in the H.T. applied to the valve will be made when the change-over is effected. R_1 is a volume control in

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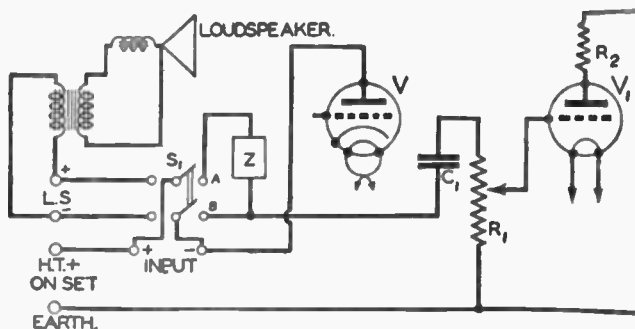


FIG. 165.—The change-over switch and the volume control connections.

the form of a potentiometer, which ensures that the signal passed on to the first valve of the amplifier shall only be sufficient to fully load the valve and thus prevent distortion due to overloading. The anode circuit of valve V_1 includes a decoupling resistance as well as a coupling resistance, and thus the L.F. transformer feeding valve V_2 is resistance-capacity coupled.

Connections for the Grid Cell.—To enable the correct operating voltage to be applied to the grid cell two terminals are provided on the amplifier and these are marked "MOD" in the circuit diagram. It will be seen that one of these terminals is joined to the arm of a potentiometer connected across the H.T. supply, and thus it is possible to tap off the desired voltage, switch S_2 being joined to the other side of the grid-cell terminals so that when required a change in polarity may be made, and thus a positive image is at all times possible. Resistances R_4 and R_6 are joined in series with the potentiometer so that a maximum of control is obtained over the necessary limits, and this avoids the use of a very large potentiometer which would not give the same smooth control. Before passing to the transformer a further volume control, R_7 , is employed, and this controls the strength of the synchronising signal and avoids overloading the output valve. The synchronising coils are joined direct in the anode circuit of valve V_2 , resistance R_8 being simply included for the purpose of preventing parasitic oscillation. Voltage supplies for these two valves are taken

A UNIVERSAL AMPLIFIER

from a mains unit which incorporates a valve rectifier and separate heater windings for the two valves, to the centre-tap of which windings the necessary automatic biasing resistances are joined. Thus the complete amplifier is entirely self-contained and is simple to operate.

Using the Amplifier.—To use the amplifier, the special inductance must be joined to terminals A and B, and to ensure high quality it is recommended that this component be of the constant-inductance type. The grid cell should then be joined to the terminals marked "MOD" whilst the synchronising coils should be connected to the "SYN" terminals. Join the Earth terminal on the amplifier to the earth terminal on the receiver, and connect the loud-speaker to the L.S. terminals. Plug the mains connector into a suitable socket and switch on. The switch for this purpose will be found on the extreme right-hand side of the panel or cabinet front. Next, raise the left-hand switch to its upper position, and a picture of some kind should be seen on the screen. If a negative image is observed, the centre switch should be operated, when the image will change to a positive. The control immediately above this central switch controls the voltage on the cell and this must be carefully regulated to preserve the right balance between high lights and shadows in the image and thus preserve the definition. If the picture refuses to remain steady, but floats up and down, the extreme right-hand control should be slowly turned, when a position will be found where the picture remains perfectly steady, although perhaps not accurately framed. This adjustment is carried out on the actual visor and is explained elsewhere in this book. The strength of the picture is controlled by the left-hand control which is adjusted much after the manner of the main volume control on a standard broadcast receiver, and once the picture has been correctly framed and the synchronising adjustments have been made, the whole operation will consist of adjusting this control to preserve the balance of tone and thus obtain a picture which, according to the distance of the transmitter and the power of the receiving set, is of the right quality for entertainment purposes.

A Warning.—It has been stated repeatedly that high quality is the most desirable feature for the television signals,

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and naturally this amplifier is designed with this end in view. There might be a temptation, therefore, for some constructors to employ this amplifier in conjunction with a loud-speaker in order to obtain better signals than are at present heard with their existing apparatus. Unfortunately, this cannot be done. Firstly, to connect a loud-speaker across the terminals marked "SYN" would lead to distortion due to the peaked transformer which would emphasise all notes and harmonics of a frequency of 375 c.p.s., and thus completely ruin musical items. Across the terminals marked "MOD" it would certainly be possible to obtain some sort of results, but it would be necessary to include some load across the "SYN" terminals in order to avoid the voltage rise which would occur when this valve was out of circuit, as it would be if the anode circuit was broken. The potentiometer arm (R5), would also have to be disconnected in order to avoid short-circuiting the loud-speaker, so that when all points are considered it is not advisable to endeavour to use this particular amplifier for any purpose other than that for which it was designed.

Fuses.—For the benefit of those who wish to fit some form of protection to avoid damage should a short-circuit or other breakdown occur, fuses may be included at the following points. Firstly, in the mains input side, that is, either in the leads from the mains plug to switch S3, or between the switch S3 and the input terminals on the mains transformer. This is all one circuit, and therefore the actual position would be immaterial. A single 1-amp. fuse in one lead, or a similar fuse in each lead (a special double-fuse holder may be obtained from any good radio store, or a special mains plug, in which two fuses are incorporated may be employed to avoid alteration of the wiring). On the output side of the mains transformer, a single .5-amp fuse may be included in the H.T. negative lead, preferably immediately next to the centre tap terminal on the secondary of the mains transformer. This should afford complete protection for the receiver side of the unit.

SHORT-WAVE SECTION

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7 AND 8

CHAPTER XX

AN INTRODUCTION TO SHORT WAVES

NOTWITHSTANDING the fascination of short-wave reception, the entertaining programmes to which one may listen and which are transmitted by amateurs, and in spite of the vast amount of interesting experiment which can be carried out on wavelengths of 6 to 100 metres, very few home-constructors take an active interest in this special branch of radio telephony. It used to be considered that the short waves are extremely difficult to receive and that reception was uncertain and marred by background mush and parasitic noises. Whilst this used to be true it is by no means the case to-day, and it is possible with a well-designed receiver to receive programmes clearly and regularly.

Receivers which are specially designed for the broadcast wave-band are usually unsuitable for the short waves. It is possible, of course, by means of a simple short-wave adaptor to receive the short waves on a broadcast receiver, but the result is seldom equal to the first-class performance obtainable from a receiver specially designed for short-wave work. Problems which do not arise in connection with the broadcast wave-band are present with short-wave work, but it can be said that short-wave receivers are considerably simpler to construct even if they are a little more difficult to operate. As with every other branch of radio the simpler the receiver the better the result.

Short-Wave Programmes.—There is no paucity of programmes on the short-wave band, for there are vastly more stations operating on wavelengths between 15 metres and 100 metres than there are over the 200–2,000 metre range. Of course, these programmes do not give regular entertainment, but there are dozens of them which provide a regular musical entertainment. There is, too, the ever-present pleasure of receiving and identifying some unknown amateur in some distant part of the world who is transmitting an experimental programme. An important feature of short-wave transmission is that as such may be received

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circuit diagrams it may be mentioned that the reaction condenser is not connected in the usual manner, but is between one end of the reaction winding and the earth lines. This arrangement is known as "throttle" control, because the condenser is used to "throttle" the oscillations produced by the valve. This means that the condenser, instead of increasing reaction as its capacity is increased, has the reverse effect, since it by-passes some of the H.F. current from the anode circuit of the valve to earth.

It is here appropriate to describe the construction of the short-wave coil, and short-wave H.F. choke. The former is wound on a ribbed ebonite tube 2 inches in diameter, and

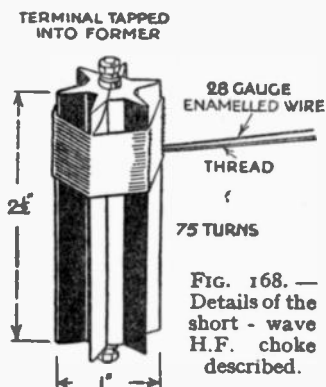


FIG. 168.—
Details of the
short - wave
H.F. choke
described.

as is shown in Fig. 167, consists of three windings, one of which is in 16-gauge bare wire, the other two being in 26-gauge enameled wire. The illustration makes it clear that the coil is intended to be mounted on the baseboard, and two long terminals or lengths of screwed brass rod are provided for that purpose. The ends of the winding are brought out to terminals which are mounted in a line between two ribs on

the former. A wavelength range of approximately 15 to 30 metres is provided by the coil described, when tuned by means of the condenser above specified. Of course, other wavelength range could conveniently be covered by modifying the number of turns given.

The H.F. Choke.—The method of making the choke calls for very little explanation and the main details of construction are shown in Fig. 168. It will be seen that the former upon which the windings are placed is of 1-inch overall diameter and is wound with 75 turns of 28-gauge enameled wire. As an alternative to the ribbed former shown it is quite permissible to employ a glass or paxolin tube of 1-inch diameter. In order to reduce the capacity between the turns a length of thread is wound on the former along with the wire and this serves to space the adjacent turns.

AN INTRODUCTION TO SHORT WAVES

The Tuning Condenser.—After the components just dealt with the tuning condenser is most important. This should preferably be of a type specially made for short-wave use, but it is often possible to employ a modified '0005 mfd. component by removing approximately one-third of the total number of vanes, re-assembling the remainder, and fitting double spacing washers. Because of the very delicate condenser adjustments which are called for in short-wave reception, it is always advisable to make use of a really good slow-motion drive; this for preference having a reduction gear of approximately 50 to 1. This component should be of a really good type, having a smooth movement entirely free from backlash. Instead of using a slow-motion dial it is quite possible to make use of a "band-spread" arrangement in which two condensers are connected in parallel; one of these may be of '0005 mfd. capacity, and the other from '00005 mfd. to '0001 mfd. The idea is that the larger condenser is used for making the preliminary rough tuning adjustment, the smaller then being employed as a vernier.

Almost any kind of air-spaced condenser can satisfactorily be made use of for the reaction control. It is better that this should have a slow-motion drive, that is not generally essential, provided that it is fitted with a large knob or dial. It might be mentioned in passing that there is on the market one special reaction condenser intended for short-wave work which has a reduction drive giving a ratio of approximately 10 to 1, and this is very suitable for the purpose in question.

Building the Receiver.—The arrangement of components shown in Fig. 166 can satisfactorily be followed in assembling the parts on the chassis or baseboard to be employed. It is, as a matter of fact, best to use either metal or metallised chassis, since either of these is useful in minimising any possible hand-capacity effect. In addition it is

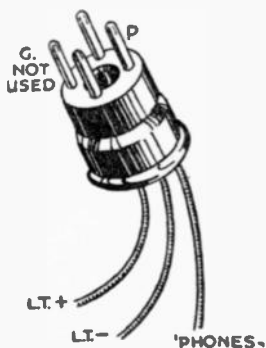


FIG. 169.—This sketch shows how an old valve-base can be used as a plug when the short-wave receiver is being used as an adaptor.

TELEVISION AND SHORT-WAVE HANDBOOK

frequently worth while to make use of a metal panel also, but this is often quite unnecessary when the components are correctly arranged.

The two variable condensers should be mounted on the panel as near as possible to the tuning coil, so that their

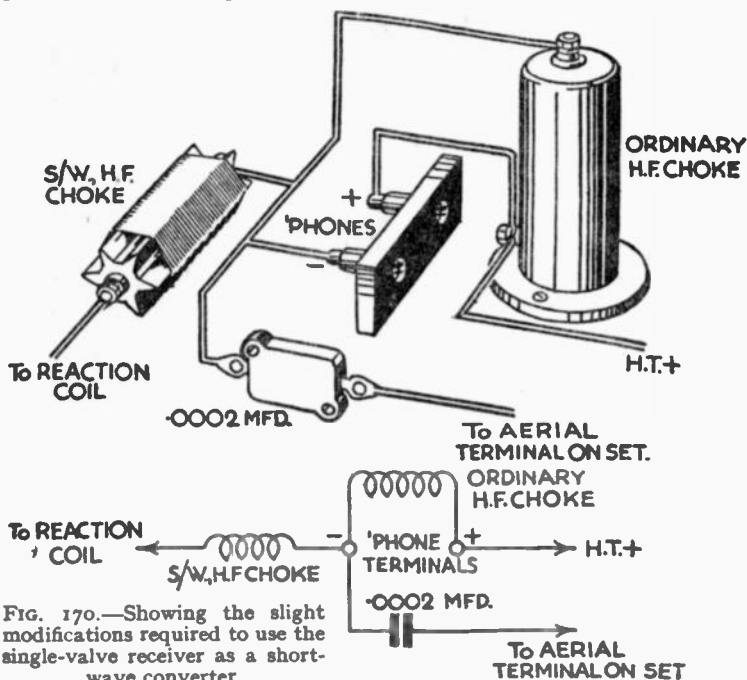


FIG. 170.—Showing the slight modifications required to use the single-valve receiver as a short-wave converter.

connecting wires may be kept short. The coil should preferably be mounted with its axis parallel to the panel, and immediately behind the variable condensers. The valve-holder should be of the usual chassis mounting type, and should have a low self-capacity.

The best type of valve for a receiver such as that being dealt with is one of the "super detector" or L.F. type. When more than one valve is available it will be found worth while to experiment in order to find the one which is the most suitable; that is the one which goes most smoothly into and out of oscillation as a reaction condenser is manipulated.

AN INTRODUCTION TO SHORT WAVES

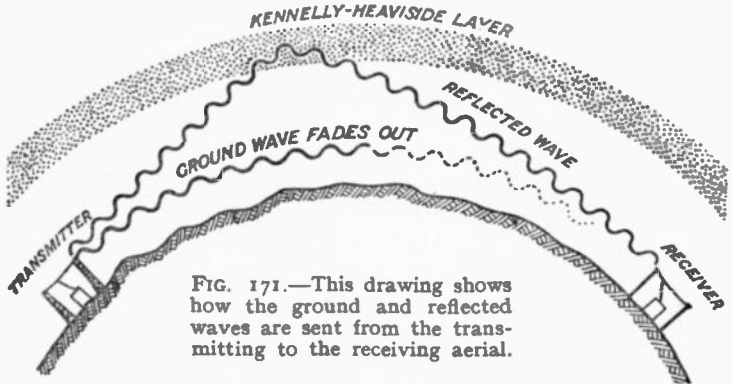
A Short-Wave Adaptor.—Although designed essentially as a complete receiver the instrument in question can also be used very efficiently (in conjunction with any existing receiver) as a short-wave adaptor. It is only necessary to join the L.T. terminals to the corresponding ones on a valve-holder on a set, remove the detector valve from its holder and take a wire from the negative telephone terminal to the anode terminal on the detector valve-holder. It is more convenient to use a plug for this purpose, and this can conveniently be made from an old valve base, as shown in Fig. 169. When this system is adopted the plug is simply used to replace the detector valve in the receiver.

In addition to its use as an adaptor the instrument can also be employed as an efficient converter in conjunction with any battery receiver having H.F. amplification. To do this an H.F. choke of the standard broadcast type should be wired between the telephone terminals, and a lead should be taken from the negative telephone terminal through a .0001 mfd. fixed condenser to the aerial terminal on the receiver. The positive high-tension wander-plug on the short-wave unit must still be inserted into a suitable tapping socket on the H.T. battery, and the low-tension leads must be joined to the corresponding terminals on one of the valve-holders in the set. The use of the unit in this manner actually converts the set into a short-wave superheterodyne, the H.F. stages functioning together as an intermediate-frequency amplifier. Because of this the tuning condenser and wave-change switch on the receiver should be adjusted to give a wavelength of about 2,000 metres. Once this has been done the normal receiver need not be touched again, since all tuning operations may be carried out on the single valve short-wave unit.

SKIP DISTANCE AND FADING

THOSE readers whose interest in wireless dates only from last winter may have been surprised and rather perturbed that during summer the reception afforded by their receivers is now considerably worse than it was a few months ago. The longer periods of daylight are largely responsible, so there is no need to start to dismantle the set with the idea that it has suddenly developed a fault. There is, in fact, very little that can be done except to add a H.F. amplifying stage or to erect a new and more efficient aerial, but both of these points should be considered.

The reason for the falling-off in strength of the more distant stations is very similar to that which accounts for



fading, a phenomenon which is often more pronounced in winter than in summer. To understand the cause of fading and reduced signal strength in summer it is necessary to consider how wireless signals actually travel from the transmitting to the receiving aerial. Although we speak rather loosely of wireless waves, there are really two sets of waves, one of which travels parallel to the surface of the earth—called the ground wave—and one which is sent upwards into

SKIP DISTANCE AND FADING

space. The latter is called the reflected wave, for reasons which will be explained.

The Reflected Wave.—It is known that the upward set of waves is reflected back to earth again in the manner represented diagrammatically in Fig. 172A, and reflection takes place at what has come to be called the Heaviside Layer. This is a layer of gas situated some 60 miles above the surface of the earth, the condition of which depends upon the strength of the sun's rays upon it. When the rays are strong the Heaviside Layer is a very poor reflector, and it absorbs the greater portion of the wireless waves which strike it. When it is in darkness, however, this layer of ionised gas acts as a very good reflecting surface, and so "returns" the waves to earth.

Reflection and Wavelength.—Not only does the effect of the Heaviside Layer vary with the amount of sunlight falling upon it, but also with the wavelength of the high-frequency wireless waves which strike it. The conditions of reflection stated above apply most accurately to medium-wave broadcast signals, for waves shorter than 100 metres or so are reflected very little by the Heaviside Layer, and pass through it. The "transparency" of the Layer increases rapidly as the wavelength is reduced, so that wavelengths of 20 metres or less pass through it almost without hindrance. The shorter waves, however, *are* reflected back to earth, but from a much greater height—that of the so-called Appleton Layer, which is thought to be nearly 160 miles above the earth's surface.

How Fading Arises.—It is now possible to understand exactly how fading takes place. Consider for the moment a medium-wave transmission and assume that the ground and reflected waves are approximately equal in intensity. During darkness the receiving aerial will pick up both sets of waves, although the ground waves become very weak after travelling for a comparatively short distance, due to the fact that they are fairly readily "absorbed" by metallic objects, hills and buildings. The reflected waves, however, are strong, and therefore produce good signals. If the surface of the Heaviside Layer remained perfectly still, signals would be received at uniform strength so long as darkness prevailed. But it is considered (no one has yet produced a definite proof), that

TELEVISION AND SHORT-WAVE HANDBOOK

the layer is in constant movement, with a result that the degree of reflection varies from one moment to the next. At one moment the signals from any particular station might be directed right at the receiving aerial, but shortly afterwards the angle of reflection would have changed so that the signals were not received so well.

Phase Difference.—There is another point to consider, which is in relation to the "phase" of the ground and reflected rays. Supposing that both waves were in the same "phase," as shown in Fig. 172, then they would be added together, the signal strength being equivalent to the combined effect of the two. On the other hand, if the two were of opposite "phase" (see Fig. 172A), the effect upon the

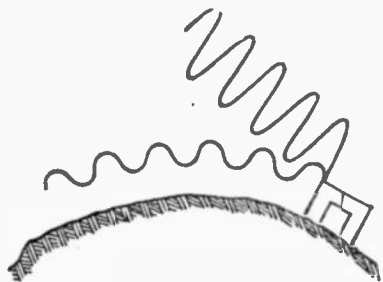
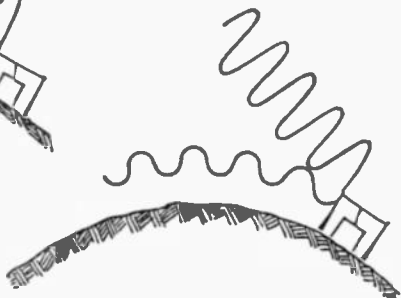


FIG. 172 (left).—When the ground and reflected waves are in correct phase, as shown, signal strength is at maximum.

FIG. 172A (right).—This drawing shows condition of minimum signal strength, the ground and reflected waves being out of phase.



receiving aerial would only be equivalent to the difference in strength between them.

It is not difficult to imagine what would be the combined effect of changes in the reflective angle and also the changes of phase! Nor is it difficult to understand why signals from any particular (distant) station may vary from full strength to inaudibility in a few minutes.

Fading on Long and Short Waves.—Before considering methods of preventing fading, we must see what happens on wavelengths other than those generally referred to as "medium" and being between 200 and 600 metres. On long waves, for instance, fading is almost entirely absent. This is because the transmission is almost entirely confined

SKIP DISTANCE AND FADING

to the ground waves ; any upward waves that there might be would be completely absorbed by the Heaviside Layer. It is also worthy of note that there is less absorption of the ground wave, and therefore the distance over which the signals can be sent without any trace of fading and with a given power is greater on long than on medium waves.

It has been explained that short waves are reflected from the Appleton Layer, and the effect is very similar to the reflection of medium waves from the Heaviside Layer. The principal difference is that on the shorter wavelengths the ground wave is almost non-existent, due to the fact that it is so rapidly absorbed by metallic objects. Thus, the reflected wave gives somewhat more steady reception because there is no question of phase difference. It is also very important to note that the Appleton Layer is not so greatly affected by daylight and darkness ; in fact, wavelengths in the region of 20 metres can generally be received better in daylight than after dark.

Beam Transmission.—One method of overcoming fading is to direct the transmission along a narrow beam, and although this has proved a very effective method it has the great disadvantage that the signals can only be picked up by aërials situated in the line of that beam. The only other method of preventing the *effects* of fading is to fit an automatic volume control device to the receiver itself. At the same time a warning should be given that constructors should not expect too much of A.V.C. It is possible to design a receiver the output volume of which will remain constant for signal ratios of 1,000 to 1, but such results cannot be expected from a simple set modified to incorporate an A.V.C. arrangement. The average modified receiver of the type having a couple of H.F. stages and fitted with an A.V.C. unit can scarcely be expected to provide a uniform output for signal ratios in excess of 50 to 1 or so on the medium waves. In other words, if the signal voltages applied to the aerial exceed a value which is fifty times greater or fifty times less than the average value, the output volume will be affected.

CIRCUITS FOR THE SHORT WAVES

ALTHOUGH the "straight" circuit will generally be found most productive of consistent and good results on the short-waves there are many other circuits which will be found to produce very good results, and in some cases, when the correct values of component and valves have been selected, will, indeed, be found to give better results than an equivalent number of valves arranged in a more orthodox manner.

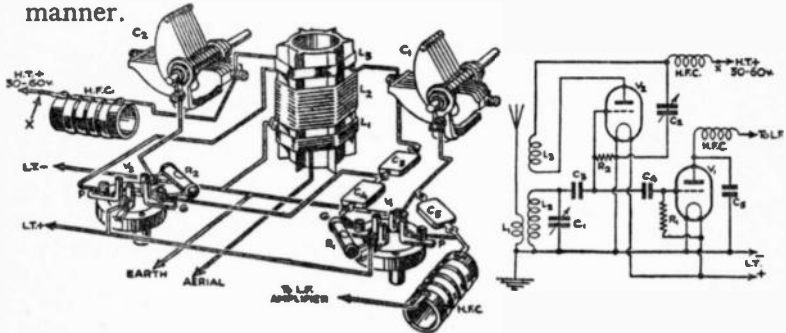


FIG. 173.—Using a separate valve for reaction purposes.

The detector valve, followed by one or more L.F. stages gives a definite standard upon which to work, and in the majority of cases it will be found unnecessary to employ an H.F. stage. The H.F. valve will not give the same amplification as is found on the normal broadcast wave-band and although, if an aperiodic aerial circuit is employed, some slight gain may be introduced before the signal is detected, it may be found worth while to use the extra valve for a much more useful purpose. Naturally, the exclusion of the H.F. stage will result in a rather heavy use of reaction and although the normal detector valve may be used with reaction, the employment of an extra valve for the purpose will be found to give more stable results and will enable the reaction control to be advanced slightly beyond that which is usually obtained in a simple detector stage.

CIRCUITS FOR THE SHORT WAVES

In Fig. 173 a circuit and practical diagram is given showing this type of receiver, and it will be seen that instead of connecting the reaction coil in the anode circuit of the detector valve, it is included in the anode circuit of the extra valve and that this is joined in parallel with the detector valve. The H.T. applied to the "reactor" valve may be adjusted to provide the smoothest reaction effects, whilst the H.T. on the detector valve may be adjusted to give the best rectification properties. In addition to the benefits accruing from smooth reaction control it will be found that a much more silent background is obtained when this circuit is employed.

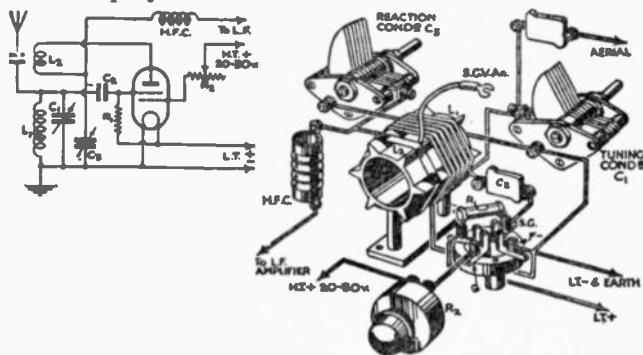


FIG. 174.—A novel way of using a screen-grid valve in a detector circuit.

An S.G. Detector.—Whilst dealing with the question of reaction control it would be advisable to mention the use of a normal screen-grid valve for rectification purposes, the additional screening grid being utilised for reaction control. In Fig. 174 it will be seen that the normal reaction winding is included in the anode circuit, but a potentiometer is joined in the control-grid lead and the voltage applied to this grid is thereby adjusted to provide smooth reaction control. This arrangement is productive of very good results, and the additional amplification obtained with an S.G. valve is often found worth while. The only precaution necessary in this type of circuit is to be found in the lay-out and wiring of the separate components. Instability is easily introduced, and therefore the value of the components used should be as follows: C_3 —0.00025 mfd.; R_2 —250,000

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ohms. Other components may have normal values, and if it is found difficult to obtain sufficient reaction over the entire tuning range of L_1 , the reaction coil (L_2) should be increased.

The Ultra-audion Circuit.—In the early days of wireless reception a circuit which proved very popular for single-valve receivers employed what was known as the "ultra-audion" arrangement. In this scheme, instead of including the tuned circuit between the grid and the filament (cathode)

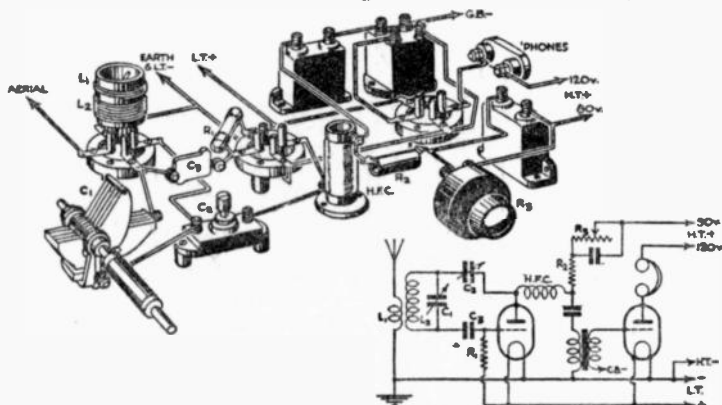


FIG. 175.—The popular ultra-audion circuit.

it is joined between grid and anode. The feed-back or reaction effect is thus produced in the valve itself and a small condenser is joined in the anode lead in order to control the degree of feed-back. A suitable circuit for the short-wave experimenter is given in Fig. 175, and it will be seen that an aperiodic aerial coil is also employed, and that this is joined in the customary manner between aerial and earth. The usual H.F. choke is also included in the anode circuit, and for maximum results it will probably be found preferable to employ a parallel-fed L.F. circuit following this detector stage. The great disadvantage of this type of circuit is that the tuning condenser, as well as the reaction condenser is above earth potential and consequently hand-capacity troubles can be very pronounced. However, this may be overcome by utilising a second panel, spaced about 4 or 5 inches from the main control panel, and the two condensers

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by the simple process of rotating the (slow-motion) dial of the .0003 mfd. tuning condenser.

The detector-oscillator feeds into the screen-grid intermediate frequency amplifier through an I.F. transformer of the type tuning to 150 kcs., this frequency being produced by the first valve operating on the autodyne principle. A second and similar I.F. transformer is used to couple the I.F. amplifier to the second detector which works on the usual leaky-grid system. A standard form of L.F. coupling is then used between the second detector and the pentode output valve.

A receiver of this kind can be made up very easily, and if the aerial coil and I.F. transformers are screened, the lay-out is by no means critical. It is best to employ a metalised chassis, placing the tuning circuits on top, with the filament, high-tension and L.F. components underneath. Standard valves are used throughout, and these may be those which have previously been employed in an ordinary broadcast receiver. In most cases it will be found best to apply a negative G.B. voltage of about 1.5 to the first valve, but alternative voltages up to 4.5 should be tried.

Initial Adjustments.—The initial adjustments consist of setting the reaction controls until the first valve is oscillating freely (generally indicated by the cessation of a faint "hissing" sound heard in the speaker), and setting the trimmers on the I.F. transformers until maximum signal strength is obtained from a station which is not normally subject to fading. A suitable signal is generally provided by Zeesen on 31.38 metres, or Rome on 25.4 metres. After these adjustments have been made, any number of stations can be tuned in, and sometimes the signal strength can be increased by making a final slight adjustment of reaction. It should be mentioned that nothing will be heard if the first valve is not oscillating, so that in some cases reaction will have to be increased as the condenser is set for the higher wavelengths. In any case reaction control is not critical and should present no difficulty whatever.

A Simple Converter.—When it is not proposed to construct a complete receiver, especially for short-wave use, it is still possible to use the superhet idea in the form of a converter which may be used in conjunction with the ordinary

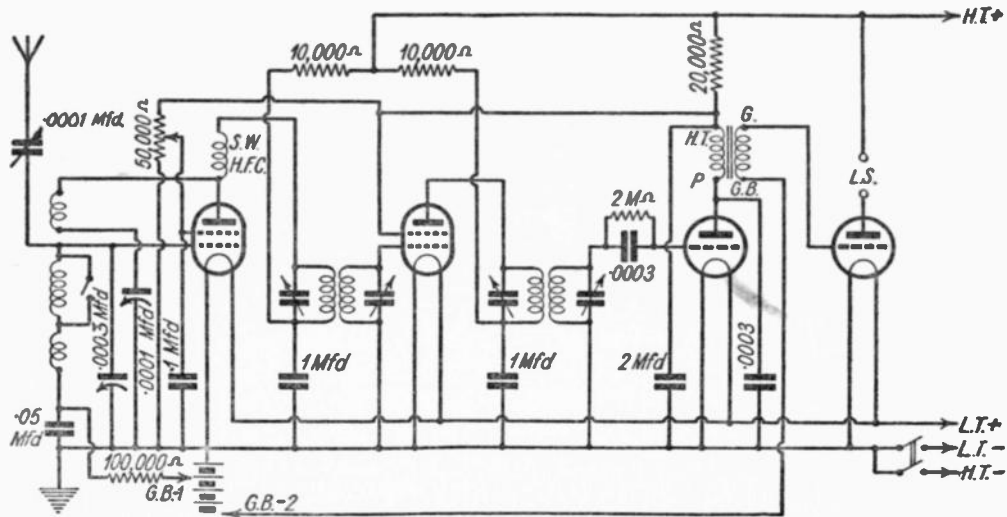


FIG. 178.—The circuit of an excellent 4-valve S.W. Superheterodyne ; this is referred to in the text.

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broadcast set. If the latter is provided with one or more H.F. stages, only a single valve will be required, and the circuit should be like that shown at Fig. 179. It will be seen that this is just the same as the first valve of the complete receiver previously discussed, and that the output lead is merely joined to the aerial terminal of the broadcast receiver. The two filament leads should be connected to the filament

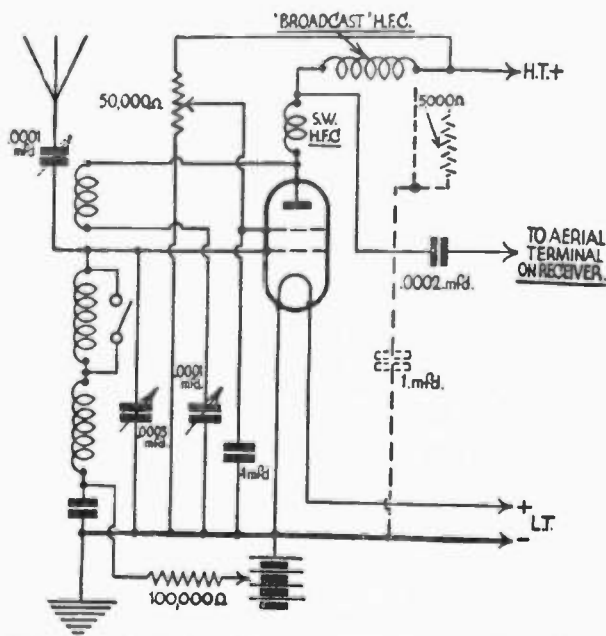


FIG. 179.—A simple S.W. Converter suitable for use with any broadcast receiver having an H.F. amplifier. The circuit is almost identical with that used for the first valve in Fig. 180.

terminals on one of the valve-holders in the set so that both set and converter can be switched on simultaneously. Intermediate-frequency amplification is carried out by the H.F. valves in the broadcast receiver, and coupling between the converter and first receiver valve will be on the tuned-grid system, the "broadcast" H.F. choke being used along with the .0002 mfd. fixed condenser for this purpose.

In use, the set is first tuned to about 2,000 metres, or the highest wavelength possible, and the reaction controls on the

SUPERHETS FOR SHORT-WAVES

converter are operated exactly as described before. The screening-grid potentiometer and anode-circuit lead from the converter are shown as being joined together and taken to a tapping on the H.T. battery, but in practice it will sometimes be found that better results are to be obtained by inserting a 5,000 ohm decoupling resistance and 1 mfd. condenser as shown by broken lines.

A Converter for Det.-L.F. Sets.—A converter of the type just described cannot be used in conjunction with a non-H.F. receiver, but it is a simple matter to add an I.F. amplifying stage to the converter as shown in Fig. 180. In this case the second valve is fed by a tuned-grid circuit, an ordinary broadcast coil being used in conjunction with a .0005 mfd. variable condenser. This latter may be of the bakelite-dielectric or pre-set pattern and can be mounted on a chassis, since it will not be altered after the preliminary adjustments have been made. The converter is connected to the set as described before, and after the receiver has been tuned to its highest wavelength the pre-set tuning condenser in the converter should be adjusted until signal strength attains a maximum on some particular station. After that, nothing but the aerial tuning condenser and (occasionally) the reaction controls need be touched. It ought to be mentioned that the reaction control on the broadcast receiver should always be set to give maximum signal strength, but once it has been adjusted it will "hold" over the complete wavelength range of the converter.

For Mains Sets.—The circuits given so far have been in respect of battery-operated converters, but all of them can readily be modified for mains working. A mains-operated converter using an indirectly-heated A.C. valve is given at Fig. 188, and this can be used very successfully in conjunction with almost any mains A.C. receiver having a H.F. amplifier. As a matter of fact the converter shown is ideal for use in conjunction with a powerful two-V.M. receiver like the "Quadpak," which was described in *Practical Wireless* dated December 2nd and December 9th, 1933. It will be observed that the unit shown is provided with its own mains supply equipment, and this might be considered superfluous. As a matter of fact, however, it is quite essential with most receivers, because the output of the mains equipment is



FIG. 181.—The attractive and neat appearance of the short-wave Three described in Chapter XXVI.

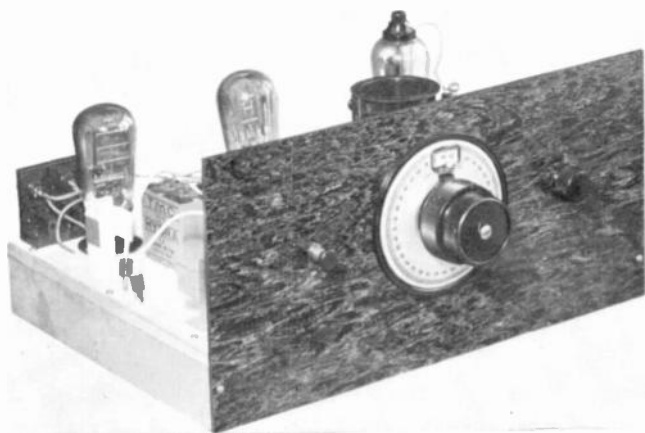


FIG. 182.—A three-quarter front view of the above set removed from the cabinet.



FIG. 183.—A three-quarter rear view of the short-wave Super Three. Note the neat arrangement of the components.

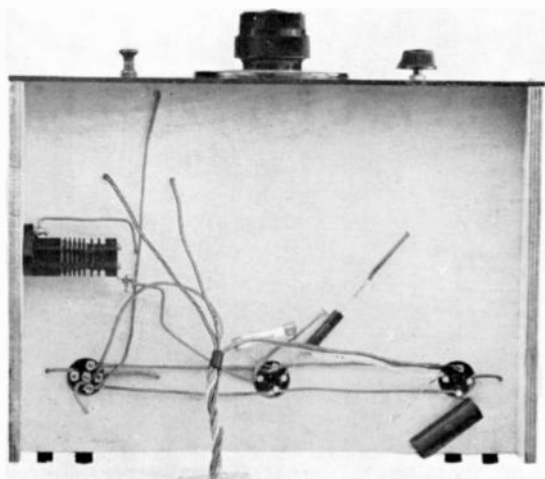


FIG. 184.—Very few connections are made underneath the chassis as will be seen from the above photograph.

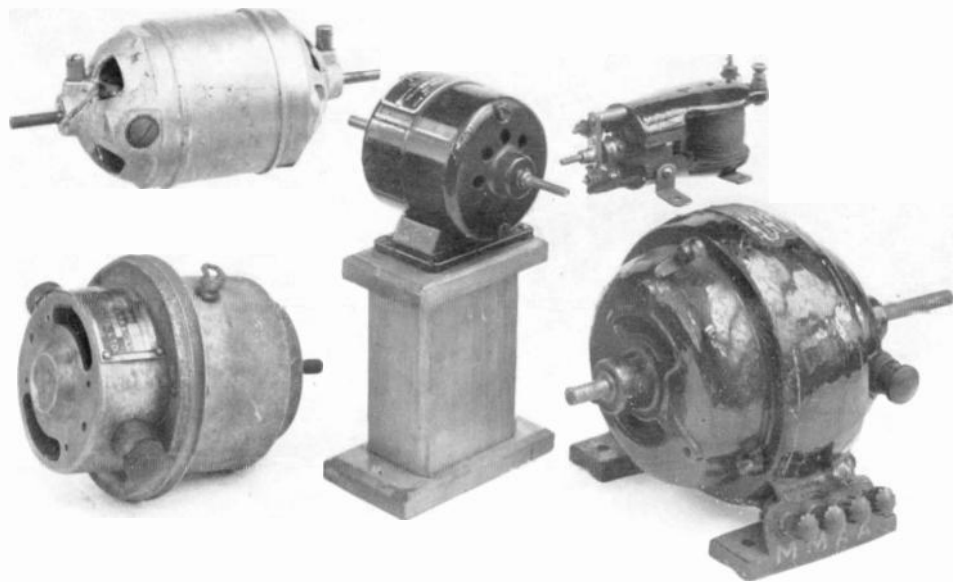
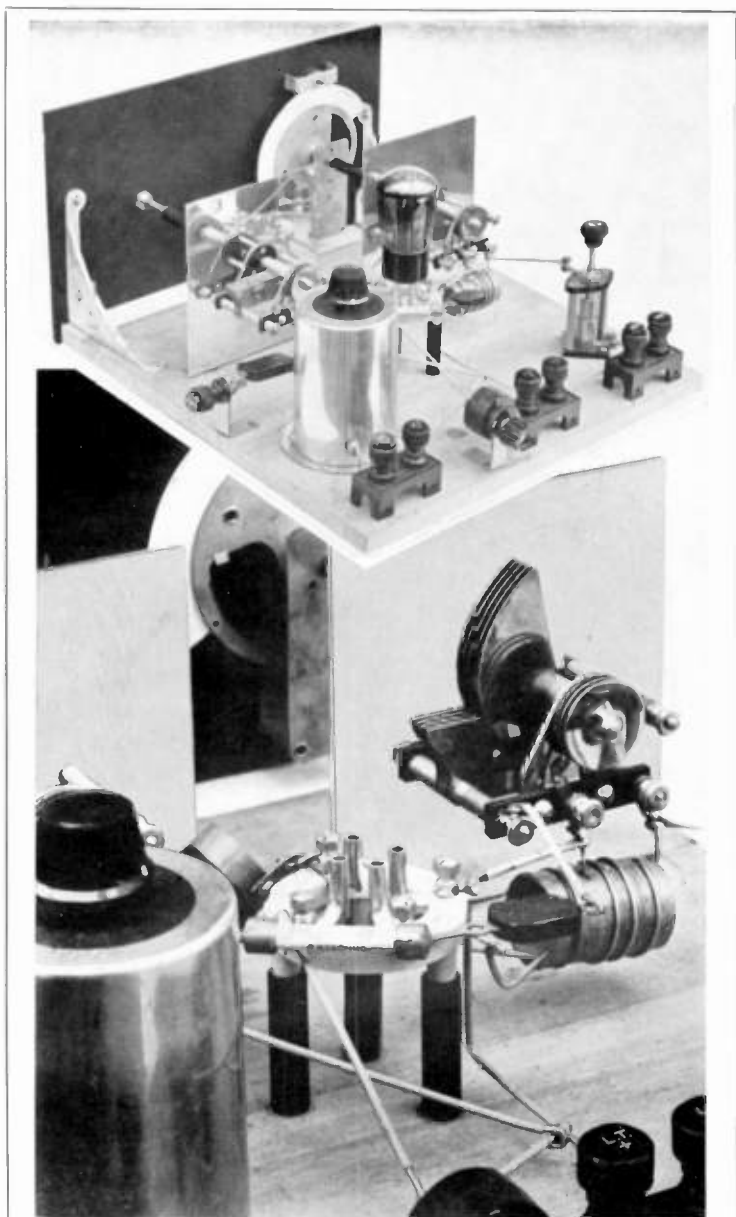


FIG. 185.—A few examples of the various types of motors which have been used for driving the television disc at the receiving end.



FIGS. 186 and 187.—Two views showing the neat design of the ultra-short-wave converter described in Chapter XXV.

SUPERHETS FOR SHORT-WAVES

several wave-bands and, not being in the nature of a compromise, can generally be made to be much more efficient. It is a simple matter to arrange a switch to transfer the aerial lead-in from the converter to broadcast receiver, and *vice versa*, and it is best to arrange things so that the anode and cathode circuits of the converter are connected to the supply source irrespective of whether the set is being used for short-wave or broadcast reception. The load on the mains transformer is thus maintained at a constant level, and this is frequently more important than the fact that a small amount of current is wasted when the short-wave section is not in use.

One disadvantage of the scheme just outlined is that it becomes necessary to have two tuning dials and an extra knob (for reaction) on the front of the set.

The very simplest form of superheterodyne receiver need have but two valves. Now, that may sound rather startling at first, but it is nevertheless quite correct, the valves being used in the sequence of (a) combined first detector and oscillator and (b) second detector—that is, the bare superheterodyne principle is used without employing any amplifying stage, either at high, low, or intermediate frequency, other than the amount of amplification which is given by these two valves themselves.

Adding a Pentode Output Stage.—Such a receiver, of course, is not of very much practical value, but by adding a power pentode output stage, a useful and extremely selective receiver can be made on these lines for use on the medium and long wave-bands, selectivity being the chief feature. However, for short-wave work, we are not particularly concerned with selectivity, and we require to use the superheterodyne system mainly for the increase in signal strength available and for the added ease of tuning, which this system does provide *in a way which no other type of receiver can*, and this is a very important point for short-wave reception, as any amateur who has had any experience at all of short-wave work will know.

A short-wave superheterodyne receiver does not need to be a costly affair, and a very satisfactory model for loud-speaker operation need not have more than five valves—if A.C. operation is required, this can often be cut down to four,

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taking advantage of the superior characteristics of mains valves. In a battery model, these valves may take the sequence of (a) combined first detector and oscillator; (b) intermediate-frequency amplifier (hereafter referred to as the I.F. amplifier); (c) the second detector; (d) the first L.F. amplifier; and (e) the power output stage. We can thus bring the number of valves down to a reasonable figure,

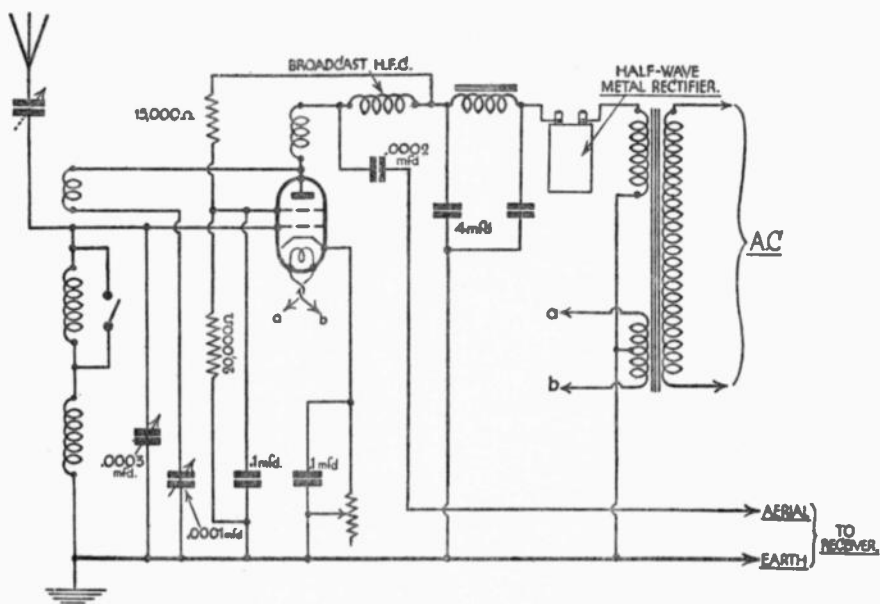


FIG. 188.—The circuit of an all-mains converter complete with its own power supply circuits.

and the final results from five valves arranged in this manner will certainly be vastly superior to those to be obtained from a "straight" receiver using the same number of valves.

If an even more powerful receiver is required, further amplifying stages can be added between (b) and (c), in the sequence referred to above, or high-frequency amplifiers can be added at signal frequency ahead of the first valve on the lines of a normal high-frequency amplifier for short-wave work.

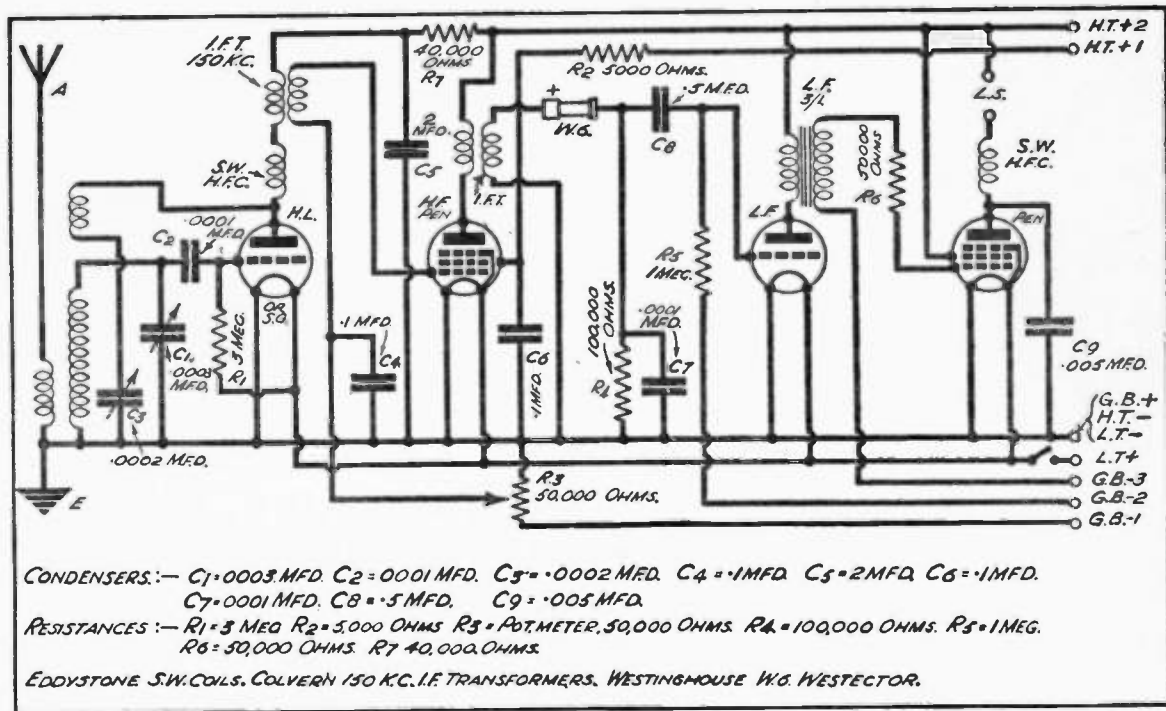


FIG. 189.—A four-valve short-wave superhet.

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Reception on 100 Metres.—For satisfactory reception up to about 100 metres, one valve and one tuned circuit can very satisfactorily do service for both the first detector and oscillator stages, provided that a fairly low I.F. is used. The output from this valve is fed directly to the I.F. amplifier, and it should be noted here that it is not essential to

use any of the accepted types of I.F. transformers. We can instead use almost any type of fairly compact tuning coil which is capable of being tuned to about 2,000 metres when used with a pre-set condenser of .0005 mfd. capacity. Fig. 189A indicates a receiver of this type, and the coils L₄, L₅, and L₆ are those referred to here. It will be appreciated, of course, that these coils must be shielded. The two I.F. coils are brought into step by means of the pre-set condensers C₁ and C₂.

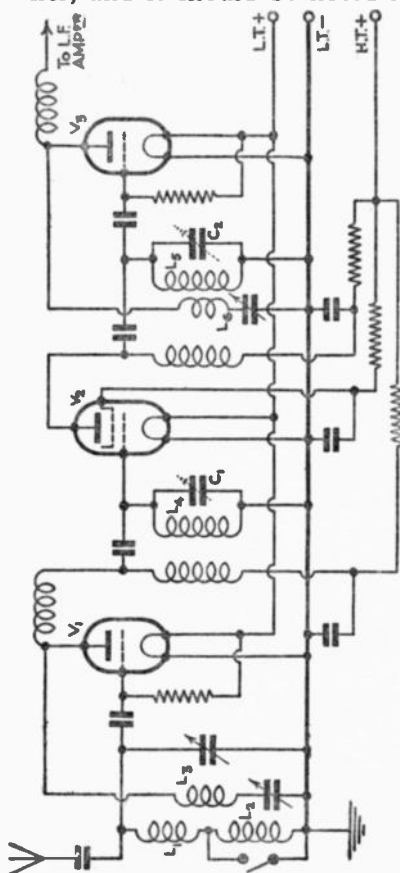


FIG. 189A.—Theoretical diagram for a three-valve short-wave superhet.

SHORT-WAVE COIL DATA

Inductance (Microhenries)	Parallel Capacity (Micro- microfarads).	Resonant Frequency (Megacycles).
67	42	3
20	80	4
14	70	5
13	60	6
10	53	7
9	44	8
8	49	9
7	36	10
5	22	15
4	16	20
3	12	25
2.5	11	30

A SHORT-WAVE ADAPTER

AN adapter such as the one shown in the sketches in this chapter will enable any broadcast set having two or more valves to be used as an efficient receiver capable of receiving stations in any part of the world. Moreover, no alterations need be made to the broadcast receiver and the change over to ultra-short waves can be made in but a few seconds. The change is effected by removing the detector

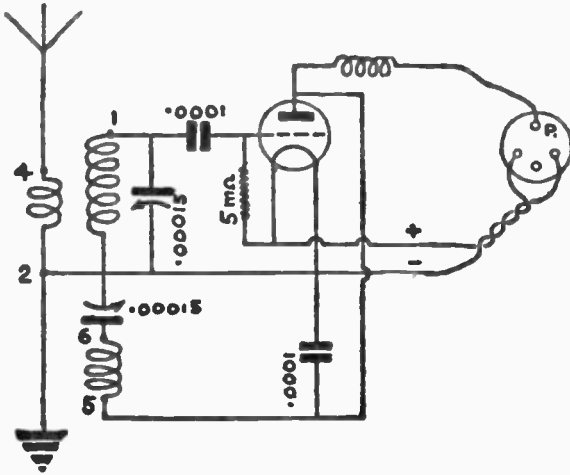


FIG. 190.—The circuit diagram of the short-wave adapter.

valve from its socket, replacing it with a plug, putting the valve into the holder on the adapter and transferring the aerial and earth leads to appropriate terminals on the adapter.

There may be some readers who are not aware of the fun to be gained by listening on short-waves, or who do not realise the tremendous number of stations to be heard in almost every country in the world. Those who do give short-wave reception a trial are very soon converted and

TELEVISION AND SHORT-WAVE HANDBOOK

more than a couple of hours or so. First prepare the panel ; it is made from a piece of oak-faced ply-wood and has five holes in the positions shown in the wiring plan. The two for the condenser bushes are $\frac{1}{2}$ inch in diameter, whilst those for the two fixing screws and dial pointer are $\frac{1}{8}$ inch. When the holes have been made, the wood should be stained and varnished, or may be given a duller finish with polishing wax.

Next, mount all the components on the baseboard and attach the panel. The positions can easily be duplicated by making reference to the scale-wiring plan on page 143. Both .0001 mfd. fixed condensers are alike when bought, and have long projecting soldering tags, but the ends are cut off the tags of the one used as grid condenser (connected between the grid terminal of valve-holder and terminal of coil base). The tags must be cut with a pair of pliers just past the holes because these are used for connecting to the terminals. Notice that the other .0001 mfd. condenser and also the 5 megohm grid leak are not fastened to the baseboard, but are supported by the wiring.

Wiring.—This is carried out principally in ordinary insulated wire. First make the wire quite straight by drawing it through a cloth tightly gripped in the left hand. Then measure off the length required for each lead by fitting approximately in position, add an extra inch and cut off. The one inch allows for baring half an inch of wire at each end for making a loop to fit the terminal. Two soldered connections are made to one .0001 mfd. fixed condenser, but, if preferred, two 4BA terminals could be fitted through the holes and the wires taken to these in the usual manner.

The flexible leads to the plug should be just long enough to reach the detector valve-holder of the broadcast receiver. Notice that one is marked + and the other — ; they should be connected to the valve plug so that they go to the positive and negative accumulator connections respectively. If any difficulty is experienced in tracing the accumulator leads, the wires should be tried both ways to find which gives better results. Be careful, however, that the wire marked " P " goes to the plate or anode pin of the plug, because any mistake in that respect might be the cause of a burnt-out valve.

When a ready-made valve plug is used the wire can be connected to the terminals provided, but when using an

A SHORT-WAVE ADAPTER

old valve base the procedure will be rather different. Remove all the glass and clean out the inside of the plug with an old knife, then pass the wires through the holes in the base and solder to the appropriate pins on the outside. To make the job look a little neater, fill the inside of the base with sealing-wax after the connections have been soldered.

Making the Coils.—The coils are wound on specially made low-loss formers, as shown in the drawing. The formers have notches at intervals of $\frac{1}{2}$ inch down the ribs, and these assist in keeping the windings even. The drawing shows that the aerial and grid windings are spaced by the distance between adjacent notches, but the reaction turns are wound side by side. A space of $\frac{1}{2}$ inch is left between the separate windings. The table shows the number of turns required for each winding for four wavelength ranges, but, actually, the two smallest coils will be most useful and the large ones need not be made unless it is desired to cover a maximum range of wavelength.

The coils are wound with Litzendraht wire, which is insulated flexible conductor consisting of a large number of strands of enamelled wire. Before attempting to solder the ends of the wire to the pins on the former each strand must be bared of its insulation, taking care that no strands are broken. This done, the ends should be twisted together and passed down the inside of the hollow pins, so that they project slightly from the end. A small spot of solder applied to the end of the wire and pin will then ensure a perfect contact. To prevent the windings from slipping it is a good idea to run a little sealing wax on them where they pass over the ribs. Chatterton's Compound may be used in place of sealing wax, if desired.

Using the Unit.—To put the adapter into use it must first be connected to the receiver as previously described. It might be added in passing that the most suitable valve is one of the "H," "H.L." or "DX" type, although almost any valve previously used as a detector will function.

Set the tuning condenser (large dial) to about its midway position, and *slowly* rotate the reaction knob until a "rushing" sound is heard. This is an indication that the valve is just oscillating and is thus in its most sensitive condition. Now rotate the tuning dial, by the slow-motion knob, until

TELEVISION AND SHORT-WAVE HANDBOOK

the carrier wave (whistle) of a station is heard. Then slightly slack off the reaction condenser until the whistle stops, at the same time slightly varying the tuning so as to bring the signals up to the loudest point. After a little practice it will be found quite easy to operate both tuning and reaction condensers simultaneously and so to keep the valve just on the point of oscillation. The operation is not difficult so long as one is careful to rotate the condensers as slowly as ever possible. The reason for this will be apparent when it is stated that a station can be received and tuned out again in less than half a degree of the tuning dial.

By the time that both knobs can be operated in step, station after station can be tuned in without difficulty.

LIST OF COMPONENTS

- One Plywood Panel, 9 inches by 6 inches.
- One Baseboard, 9 inches by 6 inches by $\frac{1}{8}$ inch.
- One Terminal Block with two terminals marked "A" and "E."
- One .00015 mfd. Variable Condenser with slow-motion drive.
- One .00015 mfd. Reaction Condenser.
- One Dial Pointer.
- One 6-pin Coil Base.
- Two or more 6-pin Coil Formers.
- Two .0001 mfd. Fixed Condensers.
- One 5-megohm Grid Leak.
- One S.W. Valve-holder.
- One S.W. High-frequency Choke.
- One Valve-plug Adapter.
- 2 oz. Litzendraht Wire.
- One Coil Connecting Wire, short length flex, and 1 doz. $\frac{1}{8}$ inch round head brass screws.

A CONVERTER FOR THE ULTRA-SHORT-WAVES

THE successful television transmissions on the ultra-short-waves has awakened interest in this branch of short-wave radio telephony, and this chapter deals with an ultra-short-wave converter which may be coupled to any existing receiver. It is well-known that there are many peculiarities when working on these high frequencies, that is to say, on wavelengths below 10 metres. In the first place the range of reception is extremely limited, and it is necessary for the

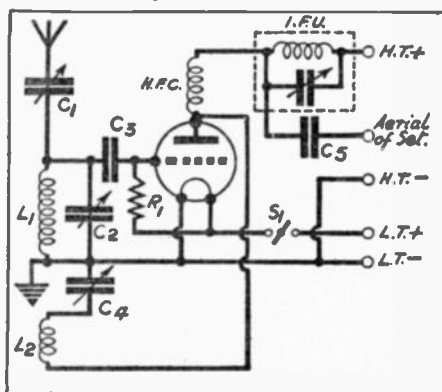


FIG. 193.—Circuit diagram of the ultra-short-wave converter described.

receiving station to be within 15 miles of the broadcasting station. The reason given is that these quasi-optical waves are those whose refracted rays seldom return to earth. They seem to bound into space and disappear. This means that radio communication by means of the ultra-short-waves is limited to the surface ray. Earth absorption at these high frequencies is fairly high, and the range of reception in some cases sometimes does not exceed the actual visible horizon. There are, of course, many amateur transmitters working on the 5 metre wavelength, and, of course, there are the independent experiments carried out by the Baird Company from the Crystal Palace on a wavelength of 6.25 metres. The

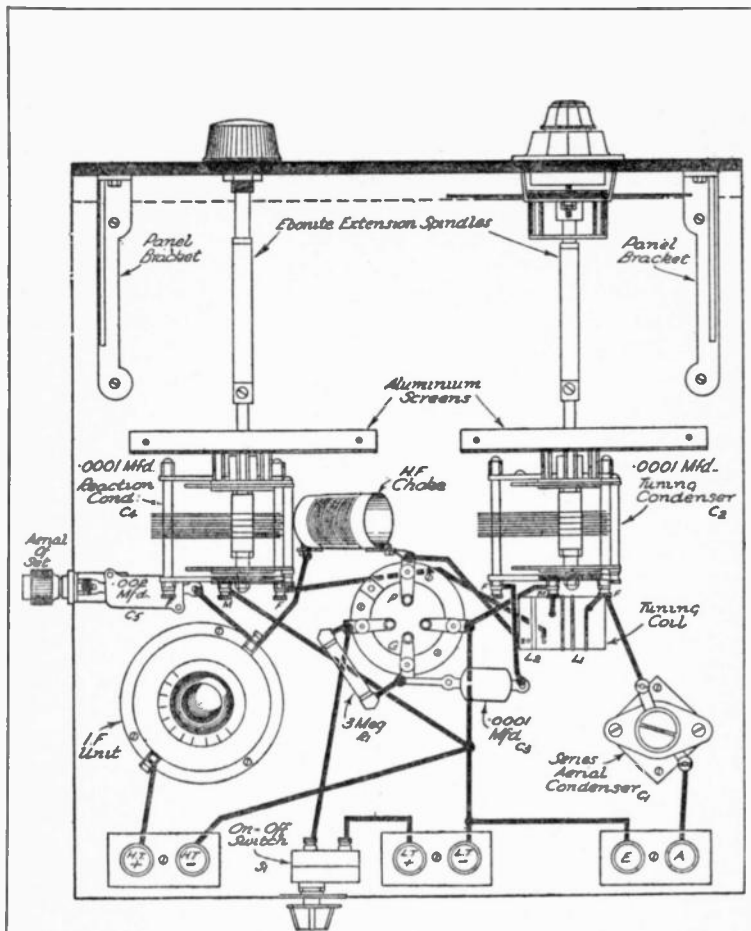


FIG. 194.—Complete wiring diagram (to scale) of a neat short-wave converter. The valve-holder should be supported on short ebonite distance pieces in order to avoid losses. A length of about $1\frac{1}{2}$ inches is suitable. Note also that the tuning coil is mounted close up to the tuning condenser to avoid long leads. The long extension handles to the main controls prevent hand-capacity effects and enable tuning to be carried out more exactly.

A CONVERTER FOR THE ULTRA-SHORT-WAVES

converter herein described is of the simplest possible character, as will be seen by inspecting the theoretical circuit Fig. 193, which indicates that it functions on the well-known superheterodyne principle. This means that it must be employed with a radio receiver having one or more stages of high-frequency amplification. Inspection of the circuit will show that the small variable condenser C1 is in series with the aerial lead, which arrangement serves a double purpose of reducing the load on the aerial tuning and has been found to overcome the defects sometimes experienced and known as "blind spots." The usual tuned grid feed is represented by L1 and C2 and unlike the usual broadcast wave-band practice the latter is only of .0001 mfd. capacity, and L1 has only three turns. C3 is the grid condenser having a capacity of .0001 mfd., whilst the grid leak R1 is of 3 megohms resistance. Reaction is provided by means of a .0001 mfd. condenser and the coil L2, which merely has two turns. An ultra-short-wave choke is used between the plate of the valve and the intermediate-frequency unit. This is a special unit obtainable for this converter and it must be tuned to the same frequency or wavelength as the receiver to which the converter is coupled. In this manner dead spots are entirely eliminated. A .002 mfd. condenser C5 provides the coupling link between the unit and the set to which it is attached.

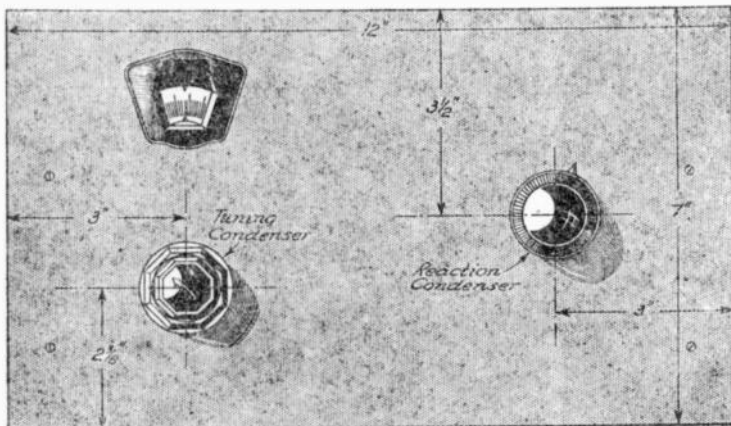


FIG. 195.—Panel dimensions.

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Constructional Details.—The arrangement of the components is indicated by Fig. 194. In wiring up this unit it is absolutely essential to keep all wires as short as possible and particularly those used in the tuned grid and plate circuits. For this reason the tuning inductance is attached direct to the variable condenser and, to avoid hand-capacity effects, the controls are attached by means of coupling rods, made of ebonite, some distance from the components themselves.

Layout and Wiring.—First of all take the baseboard and, after having mounted each condenser on its vertical aluminium screen, position the screens accurately according to the illustration in Fig. 194. Now mark out the positions of the three legs which support the valve-holder, drilling holes in the baseboard so that the holding screws may pass right through. Six of the terminals are accommodated on normal mounts but the aerial terminal, which has to be joined to the radio receiver, is held on a right-angled bracket (type E.H.5), as also is the filament switch. All this is shown in Fig. 194.

In wiring, note that both the grid leak and condenser are soldered direct to the grid connection of the valve-holder. The same remarks as to direct soldered connections apply to the ultra-short-wave high-frequency choke, the .002 mfd. coupling condenser, and the combined tuning and reaction coil. This coil, by the way, consists of three turns of No. 16 gauge wire wound on a 1-inch former, each turn being separated by $\frac{1}{4}$ inch. The reaction winding L_2 , separated $\frac{1}{4}$ inch from the last turn of the tuning coil L_1 , is just two turns of thin double-silk-covered wire. Solder the two ends of coil L_2 direct to tags on the variable condenser C_2 , and in this way support the coil just below the condenser back plate. The close-up of this section of the unit shown previously will indicate clearly how this is accomplished.

When every lead is in place and checked, proceed to drill the panel according to the dimensions given in Fig. 195. Having cut out the large hole to take the dial window, mount the vernier dial in place by following carefully the very explicit instructions given by the makers, and which need not be repeated here. Now add the condenser extension rods, panel brackets, and finally screw the panel into position.

A CONVERTER FOR THE ULTRA-SHORT-WAVES

See that proper alignment is given to the condenser drives via the rods, or the movement will tend to be erratic. If necessary, alter slightly the positions of the vertical screen mounts to ensure that this smooth movement takes place. In addition, the extension rod to the reaction condenser is not quite long enough and it is necessary to screw in a length of about $\frac{3}{4}$ -inch brass $\frac{1}{4}$ -inch diameter, to take the knob of the reaction condenser.

The Aerial System.—Join a 2-volt accumulator across the pair of L.T. terminals and a 100-volt H.T. battery across the two H.T. terminals. Disconnect the aerial and earth leads from the broadcast receiver and join them to the pair of converter terminals so marked. It will be necessary to link the combined H.T. — L.T. — points of both unit and set, and finally to join the aerial 1 terminal to the aerial terminal of the set. Bear in mind that if the broadcast set has a series aerial condenser it should be shorted out when employing this unit.

Between 10 and 15 feet of wire, as a rule, is ample for the aerial, and better results will sometimes be obtained by dispensing with the earth connection.

Operation.—The I.F. coupling unit should have a variable tuning range from 240 to 550 metres, and in consequence the set must be tuned to some setting within these figures. If the unit is marked at the top in terms of kilocycles, it is a very easy matter to convert wavelengths to kilocycles or *vice versa* from the well-known formula :

$$\text{Wavelength} = \frac{300,000}{\text{kilocycles.}}$$

Having chosen one setting on the receiver, preferably where no ordinary radio transmission can be heard, turn the I.F. unit knob to about the same setting and switch on the converter by means of the rotary on-off switch at the back. Set the tuning dial at zero and then turn the reaction control knob on the right. Remember that tuning on the ultra-short-waves is exceedingly fine and it is quite easy to miss transmissions.

TELEVISION AND SHORT-WAVE HANDBOOK

This was the main reason for including a two-ratio slow-motion dial, the outer knob giving an 8 to 1 reduction for "rapid" (this term is only used in a comparative sense) search, while the inner one gives a 150 to 1 reduction for very fine tuning. Each ultra-short-wave transmission will be heard in the loud-speaker at two distinct settings of the dial (this, as readers know, is usual in the superhet type of reception), and it may be found that one setting gives either better results or greater freedom from interference than the other.

LIST OF COMPONENTS FOR ULTRA-SHORT-WAVE CONVERTER

- One Ultra-Short-Wave Valve-holder.
- One I.F. Coupling Unit (I.F.U.).
- One Skeleton Short-Wave H.F. Choke (H.F.C.).
- One Combined U.S.W. Coil and Reaction Coil (L_1 and L_2).
- One Neutralising Condenser (C_1).
- Two .0001 mfd. Short-Wave "Special" Condensers (C_2 and C_3).
- Two 4 inch Extension Shafts.
- Two Right-angled Brackets, Type E.H.5.
- One .0001 mfd. Type 665 Condenser (C_3).
- One .002 mfd. Type 670 Condenser (C_4).
- Seven Type B Terminals, Aerial, Aerial 1, Earth, H.T. —, H.T. +, L.T. —, and L.T. +.
- One Rotary On-Off Switch (S_1).
- Two Aluminium Screen Brackets.
- One Two-Ration Slow-motion Dial.
- One Ebonite Panel, 12 inches by 7 inches by $\frac{1}{4}$ inches.
- One Wooden Baseboard, 13 inches by 12 inches by $\frac{1}{2}$ inch.
- One Pair Panel Brackets.
- One 3-megohm Grid Leak, Wire Ends (R_1).
- One PM 2DX Valve.

CHAPTER XXVI

A SHORT-WAVE THREE

THE usual type of short-wave receiver consists of a detector valve followed by one or more low-frequency stages, and although such a set is very efficient on the wavelengths for which it is intended, it calls for a fair amount of skill in operation. Additionally, a special aerial is often required in order to secure optimum results. These difficulties can generally be overcome by fitting a S.G. amplifying stage, but if this is of the usual type a second tuning control is called for, and this introduces a further difficulty, especially since accurate setting of the tuning condensers is extremely important on short-waves. Every one of the troubles referred to has been obviated in the present case by employing a S.G. amplifier of the so-called semi-aperiodic, or untuned type. Thus, the S.G. valve, besides giving a certain amount of useful amplification, simplifies tuning, removes the difficulty of employing a special aerial, and at the same time ensures a uniformity of efficiency over the complete range of wavelengths covered.

A point of special interest is that a wavelength range of 15 to 60 metres can be covered with a single plug-in coil, and without the use of any switching device. As a matter of fact, the eight-pin plug-in coil which is employed in the set covers a wavelength range of 15 to 30 metres when inserted in its holder in one position, and of 28 to 60 metres when it is reversed in its holder. This ingenious tuning unit has two complete and separate windings, so that there can be no "dead-end" effects, and therefore no loss of efficiency on the lower range.

Easy and accurate tuning is secured by means of a special low-loss .0002 mfd. short-wave variable condenser used in conjunction with a micrometer dial which is provided with a 100 to 1 reduction drive. In other words, the knob has to be rotated through a complete revolution to drive the hair-line pointer over rather more than three degrees of the 180-degree scale. Another advantage of this "Micro-Dial"

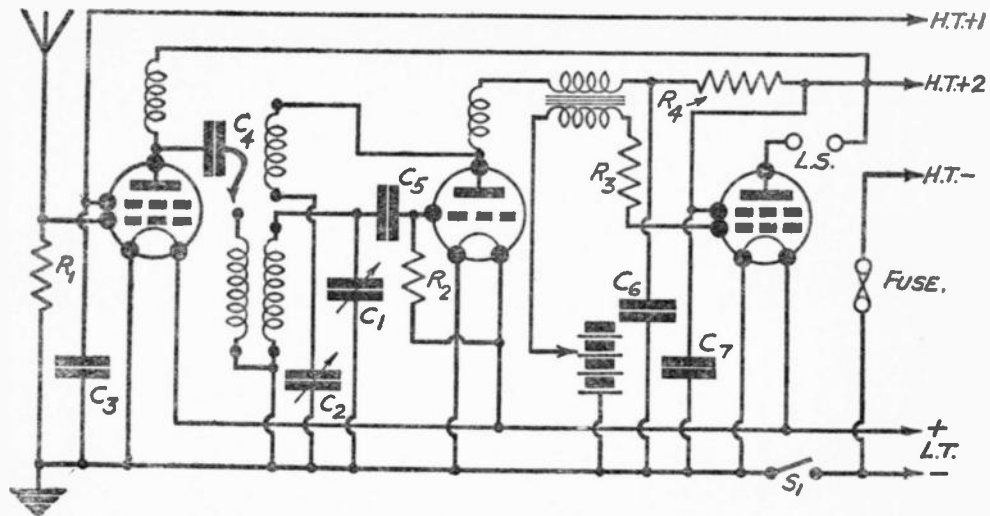


FIG. 196.—Circuit diagram of the Short-Wave Three. The priming grid is not shown in the pentode valve for the sake of simplicity and because no external connection is made to it.

A SHORT-WAVE THREE

is that the scale is made of aluminium, and this acts as an effective screen and avoids hand-capacity troubles.

Simple Efficient Circuit.—A brief examination of the circuit employed will prove interesting. As mentioned before, the aerial circuit is untuned and consists simply of a 250,000-ohm fixed resistance. This feeds into the S.G. valve, which is coupled to the detector by the tuned-grid system, a short-wave H.F. choke being included in the anode circuit. The coupling condenser from the anode of the S.G. valve can be connected to one of two tappings on the grid coil in order to obtain two different degrees of selectivity.

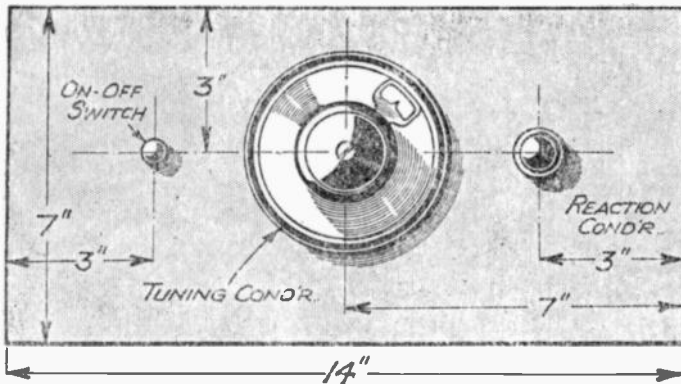
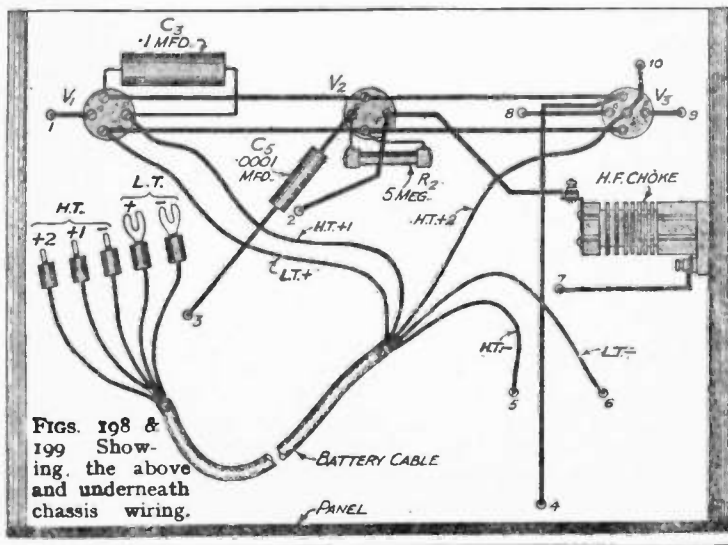
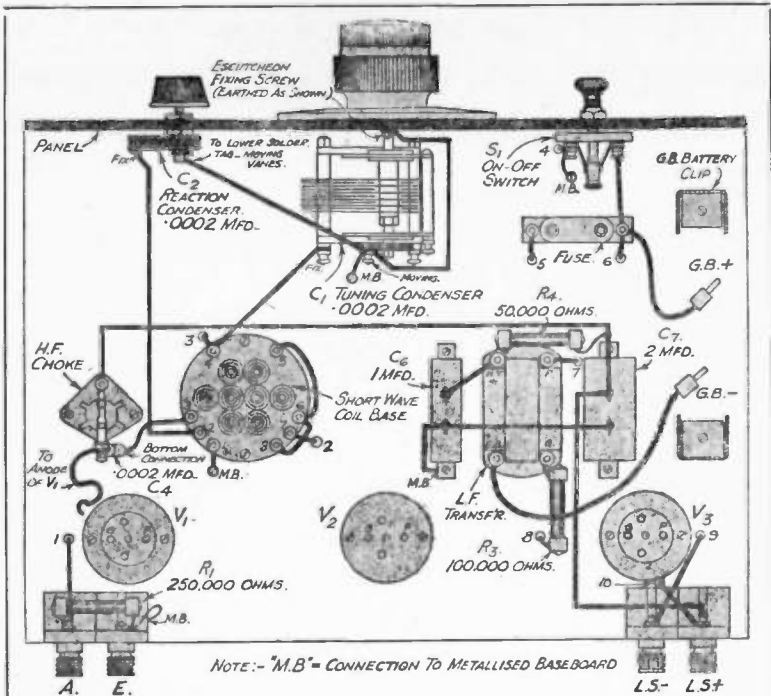


FIG. 197.—The positions of the panel holes are shown in the above diagram

When it is connected to terminal 3 a loose-coupled untuned winding is included between the anode and the detector grid circuit, and when it is transferred to terminal 4 a direct coupling is obtained.

The detector valve operates on the usual leaky-grid principle, but the values of grid condenser and leak are different from those employed in the usual broadcast receiver. A plain 5 to 1 L.F. transformer is used between the detector and pentode valves, and a "stopper" resistance of 100,000 ohms is included in the grid circuit of the latter to prevent the possibility of L.F. instability. A common H.T. positive tapping supplies the anodes of all three valves, the detector being de-coupled by means of a 50,000-ohm resistance and a



Figs. 198 & 199 Showing the above and underneath chassis wiring.

A SHORT-WAVE THREE

2-mfd. condenser, but a separate tapping is provided for the screening-grid of the first valve.

Simple Construction.—It will be seen that a metallised wooden chassis is employed in conjunction with an ebonite panel, the latter accommodating the three controls. The first step is to drill the panel to receive the condenser and dial. Three-hole mounting is employed for the condenser in order to ensure absolute rigidity, and it is best to make a template for this by making a slip of paper to fit over the spindle and then marking with a pencil the centres of the three screw holes. This can be laid on the panel and the positions of the holes easily transferred by means of a scribe or centre punch. Take care in drilling the holes, since absolute accuracy is of great importance. After making sure that the condenser fits properly, the special dial should be attended to. On unpacking this it will be found that there is a small envelope in the carton which contains a couple of washers, a large washer with stud, a short stud with a screwdriver cut in the end and a longer stud. The first two items are not required in the present case (they are provided for use with condensers of the single-hole fixing variety), but the two studs are used to attach the dial to the panel. First of all lay the aluminium scale in position so that the "O" mark is on the left and readings up to 180 follow on in a clockwise direction. Then mark off the centres of the two holes and drill holes $\frac{3}{16}$ inch diameter through the panel.

Little explanation is called for in respect to the mounting of the other components, all of which are clearly shown in the wiring plans. It might be mentioned that the tubular condensers and fixed resistances are not attached to the chassis, but are simply supported by the wiring. All wiring is carried out with ordinary push-back connecting wire and it might be mentioned that in using this wire there is no need to scrape off the insulation, since it can be pushed back the required distance by means of the finger and thumb. A number of soldered connections are used, and, as a matter of fact, it is well worth while to solder all wires in any short-wave set, since slightly loose connections can cause very serious crackling noises which are not always easy to trace.

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After the wiring has been completed, the valves can be inserted into their holders, arranging them in the order: S.G. detector and power from right to left. Connect the accumulator, speaker, G.B. and H.T. batteries and aerial and earth. In regard to the G.B. negative lead, this should be given about $4\frac{1}{2}$ volts bias. The H.T. + 1 plug should be placed in the battery at about 60 volts, H.T. +2 being given the full 120 volts. Insert the coil with the word "Long" toward the back of the chassis and switch on. The reaction condenser should then be operated until the set just begins to oscillate; this will be indicated by a faint "breathing" sound in the speaker. After that the tuning-knob can be rotated until a carrier-wave whistle is heard. The reaction setting should then be reduced and tuning slightly adjusted until the station is heard clearly. Those who are new to short-wave reception might be rather confused with the different whistles which are received; some of these are heard as steady sounds and represent telephony stations, but others sound like a series of "chirps," and these are morse transmissions which will probably be of no interest and will disappear as soon as the set stops oscillating.

As conditions on short-waves vary very considerably from time to time, it is often advisable to employ ear-'phones when first trying out the set. Even later, 'phones are to be preferred when long-distance reception of lower-power stations is required, although most of the European and many of the American stations can easily be received on the speaker under moderately good conditions. In most parts of the country there will be a number of amateur transmitters to be heard on Sunday mornings.

LIST OF PARTS FOR A SHORT-WAVE THREE

- One Ebonite Panel, 14 inches by 7 inches.
- One Metallised Chassis, 14 inches by 10 inches, with $1\frac{1}{2}$ inch runners.
- One .0002 mfd. Special Short-wave Condenser (C.1).
- One "Micro-Dial".
- One .0002 mfd. Reaction Condenser (C.2).
- One On-Off Switch (S.1).
- Two 4-pin Chassis-mounting Valve Holders, "Air-sprung."
- One 5-pin Chassis-mounting Valve Holder.

A SHORT-WAVE THREE

- One " Duplex " Short-wave Coil and 8-pin Holder.
- Two Short-wave H.F. Chokes.
- One 5 : 1 L.F. Transformer.
- One .1 mfd. Tubular Condenser (C.3).
- One .0002 mfd. Tubular Condenser (C.4).
- One .0001 mfd. Tubular Condenser (C.5).
- One 1 mfd. Fixed Condenser, 300 volts working (C.6).
- One 2 mfd. Fixed Condenser, 300 volts working (C.7).
- One 250,000-ohm Metallised Resistance (R.1).
- One 50,000-ohm Metallised Resistance (R.4).
- One 10,000-ohm Metallised Resistance (R.3).
- One 5-megohm Grid Leak (R.2).
- Two pairs Terminal Mounts.
- Four Terminals : marked " Aerial," " Earth," " L.S. + " and " L.S. —."
- One 100-ma. Fuse.
- One Pair Grid Bias Battery Clips.
- One 5-way Battery Cord.
- Five Wander Plugs : marked " H.T. + 1," "H.T. + 2," " H.T. —," " G.B. +," and " G.B. —."
- Two Spade Terminals : L.T. + and L.T. —.
- Push-back Connecting Wire, Screws, Flex, &c.
- One 120-volt H.T. Battery.
- One 9-volt G.B. Battery.
- One 2-volt Accumulator.
- Three Valves : S.G., Detector, and Power.
- One Loud-Speaker.
- One American-type Cabinet, 14 inches by 7 inches by 10 inches.

CHAPTER XXVII

A PORTABLE SHORT-WAVE RECEIVER

FOR some reason or other there are very few short-wave enthusiasts who make up a portable receiver, although such a set is extremely easy to make and capable of providing extremely good reception. Besides, since an aerial is of far less importance on the short waves, there is no need to employ a frame, or to go to the trouble of erecting an elaborate elevated aerial even though only a couple of valves are used. It is admitted that the average type of short-wave portable cannot provide the same kind of entertainment as, say, a standard "broadcast" portable, but for the experimenter it offers an extremely wide scope and the opportunity to make no end of interesting comparisons.

It is well known that locality, situation of the aerial, its direction, and so forth, have a tremendous bearing upon the

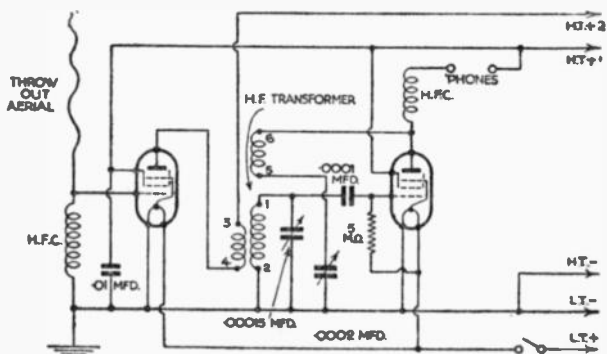


FIG. 200.—The excellent, though simple circuit described in this chapter.

results to be obtained on the shorter wavelengths, and a simple portable will enable a variety of tests to be made under convenient conditions.

Aperiodic H.F. Stage.—As with any type of set, the first problem which arises concerns the circuit arrangement to be adopted. Generally speaking, loud-speaker reception will be

A PORTABLE SHORT-WAVE RECEIVER

ruled out on the score of simplicity, and therefore a straightforward and simple two-valve arrangement will perhaps be most desirable. Shall it be of the Det.-L.F. type (which is still most popular for normal S.W. work), or will an H.F.-Det. prove more suitable. The latter is preferable for portable use, because it is rather more stable, less inclined to suffer from hand-capacity effects, and requires a lower H.T. voltage than does a circuit employing an L.F. stage. A complete two-valve circuit of the type recommended is given in Fig. 200, and from this it will be seen that use is made of two H.F. pentodes, one acting as amplifier and the other as detector. The input, or aerial, circuit is not tuned, but consists of a high-grade H.F. choke of the short-wave type. Tuned-transformer coupling is used between the two valves, and reaction is applied to this in the usual manner. Leaky-grid detection is used, and a small S.W. high-frequency choke is included in the anode circuit of the detector for reaction purposes and also to minimise hand-capacity effects.

By making use of H.F. pentodes it is possible to obtain good reception by employing no more than about 30 volts H.T., while moderately good results can be secured with even a lower voltage than this. The most convenient method of supplying the H.T. is by means of two 16-volt G.B. batteries wired in series, and ample L.T. may be obtained from one of the smallest types of unspillable, portable accumulators.

19 to 80 Metres.—It will be required to cover a total wavelength range of at least 19 to 80 metres, so that either the H.F. transformer must be tapped and used in conjunction with a switch, or two or three different transformers must be employed, and arranged to plug into a 6-pin coil holder of standard type. The latter course is generally to be preferred on the score of efficiency, and is therefore recommended. Suitable transformers can be bought ready-made or they can easily be made on standard $2\frac{1}{2}$ -inch diameter 6-pin formers, as shown in Fig. 201. Similar numbers of turns are used for both primary and secondary windings for each particular wave-range, and the approximate numbers of turns for 19-32, 30-60 and 55-90 metres are approximately 4, 6 and 9 respectively. In each case the reaction winding has one turn less than the other two.

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Making the Coils and Chokes.—Fig. 201 shows the disposition and distances apart of the three windings, and in order to keep the lengths of winding the same on all three coils the spacing between the turns should be varied. The wire used for the grid winding is 18-gauge enamelled, whilst 24-gauge enamelled wire is used for the other two windings.

The two chokes may conveniently be home-made, but it is best—in the interests of stability—to make them rather differently from each other. For instance, that in the grid circuit of the first valve may be made by winding 150 turns of 32-gauge single-silk covered wire in five $\frac{1}{8}$ -inch slots, made on an ebonite rod $\frac{3}{8}$ inch in diameter; the reaction choke

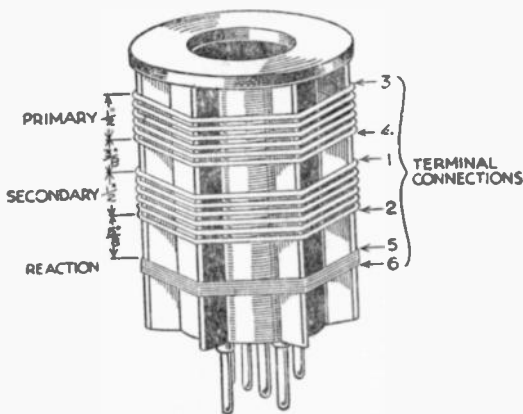


FIG. 201.— This drawing gives constructional details of the H.F. transformers. The figures refer to the pin connections and to the connections in Fig. 200.

should consist of a single-layer, 100-turn winding of similar wire on a $\frac{1}{8}$ -inch diameter paxolin tube.

The Screening Box.—Although the chokes are of somewhat different characteristics, it is best to arrange them as far apart as convenient and to mount them with their axes at right-angles to each other. It is not necessary to screen individual components, but it is wise to enclose the whole set in a metal box with the principal parts arranged somewhat as shown in Fig. 202. The coil and valves come through holes made in the lid of the box, so that the former can easily be changed, and in order to reduce the overall size as much as possible.

For convenience in mounting the parts, a wooden base-board can be fixed into the base of the box to hold the

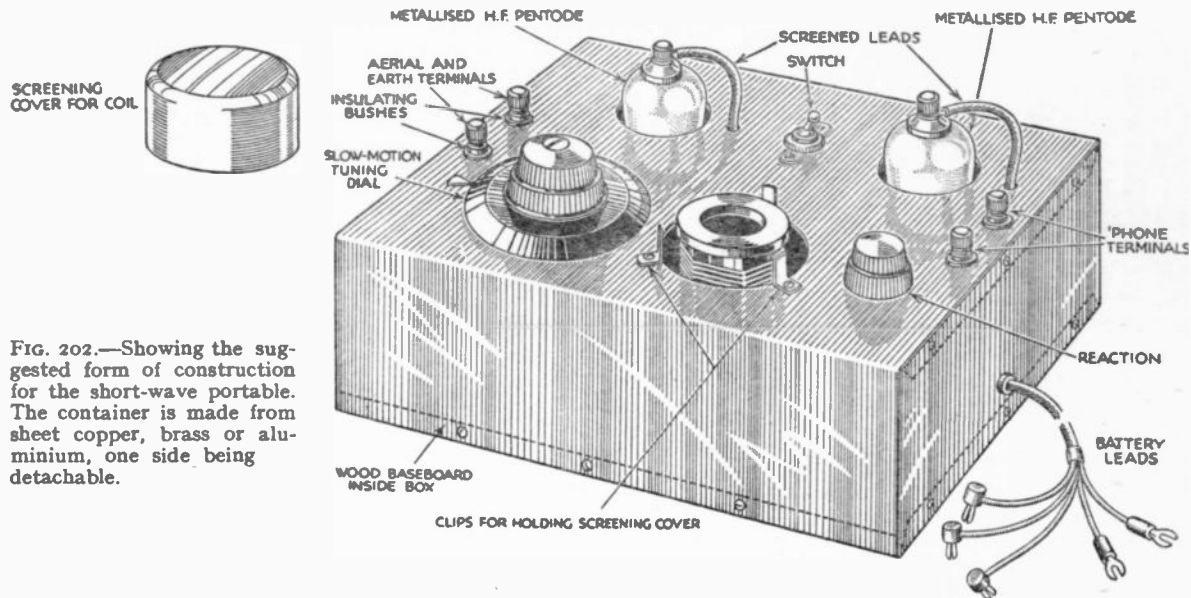


FIG. 202.—Showing the suggested form of construction for the short-wave portable. The container is made from sheet copper, brass or aluminium, one side being detachable.

TELEVISION AND SHORT-WAVE HANDBOOK

various components. It is scarcely necessary to emphasise the fact that all the sides of the box should be in perfect contact with each other; if they were not, the screening would be useless. It is also worth while, although not essential, to make a small "cap"—in the form of a lid—to fit over the top of the coil; this can most easily be held in place by bolting three small angle pieces of springy brass round the circumference of each hole, as shown.

Making the Screening Box.—There are a number of possible methods of making the metal box, but probably the best is to make the base, back and top from a single piece of copper or aluminium. This can be bent to the approximate shape, leaving flaps by means of which the ends can be attached with four B.A. nuts and bolts. Before fixing the ends, however, the terminals, condensers and switch should be mounted and long connecting wires attached to these.

All the other components should be mounted on the wooden baseboard and as much wiring done as possible, after which the baseboard can be fitted and held in place by a couple of screws passed through the bottom of the container. The front of the metal box may be attached to the edge of the baseboard by means of three screws after the wiring has been completed. It should also be fixed to the top so that there is good electrical connection between the two pieces of metal. One simple method of arranging for this is shown in Fig. 202 where a flap on the top comes over the front strip. If the box were made of copper or brass, however, it would be a simple matter to have the top flat inside the box, and brass nuts could be soldered to it, screws being passed into these through holes in the front piece. Since the valves and coil are accessible from the top there is no necessity to make provision for easy access into the case, and it is important to ensure that all pieces of metal from which it is made are in good contact with each other.

The finished set can conveniently be carried in a small attaché case, which will also be used as storage place for the batteries and 'phones, as well as for a 10 feet length of rubber-covered flex for use as aerial. If the set is generally to be used out-of-doors, it will also be a convenience to carry a short length of copper tube, which can be pushed into the ground to serve as an earth connection.

CHAPTER XXVIII

CALIBRATING THE SHORT-WAVE SET

ALTHOUGH a wavemeter is not a difficult piece of apparatus to construct, the majority of users of a short-wave receiver already possess a normal broadcast receiver which probably functions as the "home-entertainer" and this piece of apparatus may be turned to good account in providing a means whereby the short-wave set may accurately be calibrated. At first sight it might be thought that some drastic alteration might have to be made to the broadcast set, but actually this is not so, and the apparatus may be used exactly as it stands. The short-waves are so sharply tuned that the beginner often experiences great difficulty in knowing exactly what part of the frequency band he is covering at any moment, and it is therefore invaluable if a small calibrated chart or accurate frequency markings can be mounted on the panel, as by that means it is possible instantly to tune to any desired station, or alternatively, when a station is found during searching operations, it is a simple matter to ascertain what station it is without waiting for an announcement.

The Importance of Harmonics.—A normal broadcast receiver is generally supplied with a reaction circuit, and the nature of the oscillating valve is such that it is rich in harmonics. These make it possible to use the oscillations which are radiated for the purpose of a calibrating wave, and the broadcast receiver is, therefore, converted into a small transmitter for the purpose. When the valve oscillates, it will do so at a frequency dependent upon the characteristics of the tuned circuit with which it is used, and this will be known as the fundamental frequency. The second harmonic will have a frequency exactly twice that of the fundamental; the third harmonic will have a frequency three times the fundamental frequency, and so on. The total number of harmonics depends upon the power of the oscillating circuit and also upon the waveform of the fundamental, but this need not concern us here. If we take our

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standard broadcast receiver, and tune it to the London Regional station, which has a frequency of 877 or 342.1 metres, and then adjust the reaction control so that the receiver oscillates strongly, we shall be radiating an oscillation of that frequency. In addition, harmonics will be radiated having frequencies of 1754, 2631, 3408 k/cs., etc. The sixth harmonic is 5262 k/cs., and this corresponds to a wavelength of 57.05 metres, so that it is obvious that if we tuned our short-wave set to this wavelength, and arranged to pick-up the sixth harmonic of our oscillating broadcast receiver, we should have a definite setting on the short-wave dial corresponding to this wavelength. That is the method of calibrating the short-wave set from a broadcast receiver.

Precautions.—There are certain precautions which have to be taken to avoid interference with other receivers, and also to ensure that the exact required harmonic is received. To take an example, suppose we tuned to the *sixth* harmonic of the London Regional station, namely 5262 k/cs. On the medium-wave band there is also a frequency, the *fifth* harmonic of which would also be 5262 k/cs. Thus, this new frequency would be $\frac{5262}{5} = 1052.4$ k/cs. Therefore, if we leave the short-wave set at its setting of 5262 k/cs. and slowly rotate the tuning control of the broadcast receiver, we should be able to find this fifth harmonic at 1052.4 k/cs., and this would be heard in our short-wave receiver as a whistle, exactly similar to the preceding note. If we proceed further, and tune still lower on the broadcast set, we should hear another whistle when we tune to the *fourth* harmonic of 5262 k/cs., or 1315 k/cs. These additional points serve as checking points and enable the user to ascertain with certainty which harmonic is being received.

The short-wave receiver is joined up as though it is to be used for receiving signals, and the broadcast set is stood close to it, with preferably a short wire joined from the aerial terminal and placed near to the short-wave set. By this means the oscillations may be kept rather weak and yet will still be strongly received in the short-wave set but will be in less danger of travelling far and thus interfering with near-by sets. As the adjustments are made, resonance will be indicated by a whistle in the speaker or phones.

CALIBRATING THE SHORT-WAVE SET

Obviously, it is essential, before starting, to calibrate the broadcast receiver ; but with the many powerful broadcast stations which are available this is not a difficult proposition. As the reaction control on the broadcast set is turned, a whistle will be heard in the short-wave set and the reaction control should be turned until the whistle changes in pitch and finally disappears. At this point the short-wave tuner is adjusted until an alteration in the tuning condenser in either direction causes the whistle to reappear at a low pitch, rising as the condenser is further turned. Then, without touching the short-waver, the broadcast tuner is slowly tuned to a lower wavelength until another whistle is heard, great care being taken that no whistles are passed. This time, the broadcast set is adjusted to zero beat with the short-waver and the frequency to which it is tuned is read from the calibrated list. The tuning is then continued until a third, and if it is possible, a fourth, whistle is heard, and in each case the frequency of the broadcast receiver is noted. It is then necessary to find the *least common multiple* of the three medium-wave frequencies, and that is the frequency to which the short-wave receiver is tuned. A suitable note can then be made.

There are many sources of error, and it is therefore necessary to be most careful in locating the checking frequencies, and in limiting the power of the oscillations so that only weak whistles are heard. In this way no doubt will arise as to the exact settings. The point of zero beat is very critical, and no doubt must arise as to the exact point.

To complete the calibrations when one point has been determined, the broadcast receiver is re-tuned to the local station, or the first frequency, and left there whilst the short-wave set is slowly adjusted to a lower wavelength until the next whistle is heard and checked in the same way as the first point. This process is repeated throughout the range of the short-wave receiver.

A SHORT-WAVE WAVEMETER

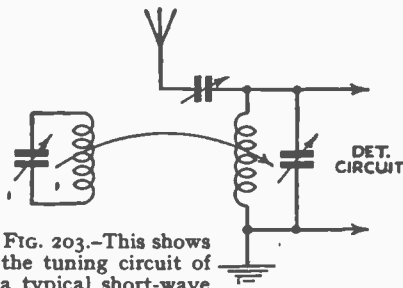
FINDING "landmarks" on the short-waves is always a difficult business owing to the extra care required in tuning the receiver, and also because of the experimental nature of many of the transmissions whose wavelengths consequently differ often from the published lists. As a rule it may be said that the owners of short-wave sets rarely possess a receiver permanent enough to calibrate. Some form of wavemeter, therefore, is more of a necessity than a luxury.

Of the more common types, the heterodyne is undoubtedly the most accurate, but it is the most expensive to construct; any change of valve also necessitates re-calibration. A buzzer wavemeter has the virtue of simplicity, but makes small pretence to accuracy by reason of its very flat tuning. Equally simple is the absorption circuit, which is the cheapest of all to construct and, if intelligently used, is accurate

enough for all normal purposes; in the hands of a tyro, however, it can be very unsatisfactory. Let us examine the requirements of a really good instrument.

FIG. 203.—This shows the tuning circuit of a typical short-wave receiver loosely coupled to the wavemeter

of which is loosely coupled to the wavemeter; the latter, it will be seen, consists of a tuning condenser and coil only. The constructional side of the instrument calls for little explanation; the important point to bear in mind is the absolute necessity for complete rigidity throughout; the condenser must be a really sound job—a few extra shillings spent on this will save future trouble and ensure permanence of calibration. Equally important is the coil, which can easily be made by winding about half a dozen spaced turns on a 3-in. ribbed former;



A SHORT-WAVE WAVEMETER

this, in conjunction with a .0002 mfd. condenser will tune from under 20 metres to 50 metres or more.

Calibration.—The actual calibration need present few difficulties. A piece of squared paper should be obtained, the vertical ordinate being marked off in wavelengths and the horizontal one in dial divisions, although it makes no difference if this is reversed. The receiver should then be tuned to a station whose wavelength is definitely known—one of the Empire broadcasting transmitters is suggested—and so tuned that the beat note caused by the oscillating detector is almost zero, thus indicating that the receiver is, for all practical purposes, dead on tune. The wave-

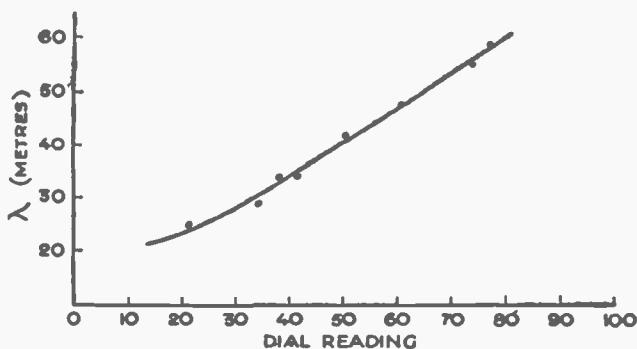


FIG. 204.—A representative calibration curve for the meter.

meter coil must then be brought neat to the receiver coil, but not closer than about 6 inches, and the dial slowly rotated; a point will be found where the receiver will probably stop oscillating, as denoted by a plop in the phones and a cessation of the beat note. If this happens, the wavemeter should be taken farther away from the receiver and the whole procedure repeated. The reason for this is that too much absorption by the meter causes "pulling" between the two circuits, a condition which militates against good calibration. A point will again be found where the two circuits are in tune, the indication this time being given by a sudden change in pitch in the beat note. This will give point number one on the graph. Other points may be obtained in a like manner by using other stations of known frequency. If the wavemeter condenser is of the

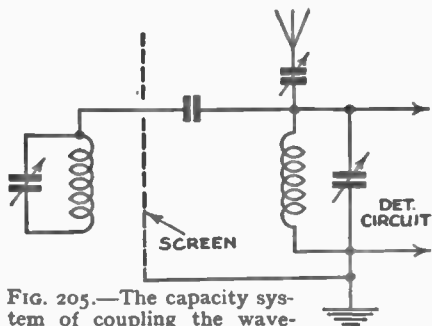


FIG. 205.—The capacity system of coupling the wave-meter.

disregarded as inaccurate. It would be as well to point out at this juncture that the proper way to draw a graph of this nature is not to join point to point, but an average line should be drawn which indicates the true graph, after allowing for the personal error and any other inaccuracies such as slight faults in condenser design.

Capacity Coupling.—As explained above, the greatest accuracy will be obtained by using the meter with a very weak coupling between the coils. Now, at the best of times, inductive coupling is always rather an uncertain quantity if made variable. Fig. 205 shows the capacity system. The wave-meter should be entirely screened so as to avoid incidental inductive coupling. The actual coupling condenser must be very small, and need be no more than the capacity afforded by the twisting together of two insulated wires.

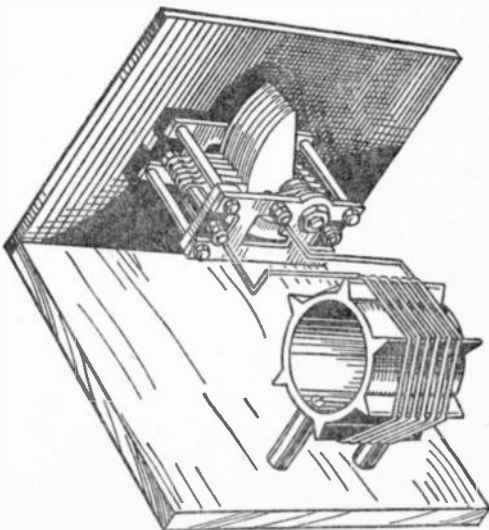


FIG. 206.—A pictorial view of the wave-meter described.

TRACING FAULTS IN SHORT-WAVERS

ALTHOUGH, on the whole, faults which occur in a short-wave receiver can be traced and cured in almost exactly the same manner as with a normal broadcast set, there are a few additional faults which call for rather special treatment. The beginner in short-wave work often overlooks these, and it is therefore the object of this chapter to point out where they may occur and various methods of overcoming them.

One of the most common troubles, particularly with sets of the simple detector-L.F. type, is uneven or difficult reaction control. This might make itself evident by the fact that the set suddenly bursts into oscillation as the volume is increased by gradually "turning up" the reaction knob. On the other hand, the trouble might be indicated by the fact that the receiver will oscillate only over certain parts of the tuning scale, or at some particular wavelengths.

It is frequently found that the receiver will not oscillate

below some particular wavelength, although it behaves quite correctly at all higher wavelengths. When this is the case, it might be an indication that some of the component values are wrong, that the parts are badly placed, so that there is too much capacity between them, or that the aerial in use is too long and therefore produces undue "damping." When the set has been made from some published design, it is unlikely that the component values will be incorrect and therefore this point can be overlooked. If the receiver

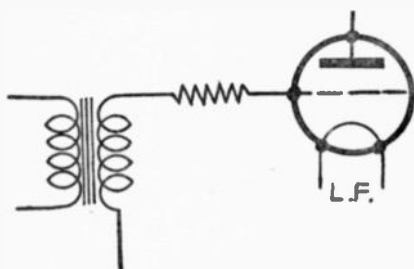


FIG. 207.—A method of preventing the leakage of H.F. currents into the L.F. amplifier. A "stopper" resistance is included in the grid circuit of the first L.F. valve.

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has been built to an experimental design of the constructor, however, it is well to remember that for wavelengths between about 20 and 100 metres the values of the tuning and reaction condensers should not exceed approximately one-third of their equivalents in a broadcast set. As an example of this, it might be stated that in place of the usual $\cdot 0005$ mfd. tuning condenser, one of about $\cdot 00015$ mfd. should be used ; in the same way, a reaction condenser of $\cdot 0001$ mfd. should be used instead of the customary $\cdot 0003$ mfd.

The Reaction Winding.—As might be expected, the size and disposition of the reaction winding have a pronounced effect upon oscillation. What is not always understood, however, is that too large a winding can give just as much, if not more, trouble than one which is too small. The reason is that the large winding sometimes "damps" the tuned winding, thereby "killing" oscillation over some wavelength ranges—often those which are harmonics of the wavelength to which the reaction winding itself would tune. In case of difficulty, therefore, it is always well worth while to spend a little time in modifying the number of turns used for reaction, although generally it will be found that the reaction winding should be about three-quarters the size of the grid or tuned winding. When this is done it might be necessary to use a larger reaction condenser but, generally speaking, there is no harm whatever in increasing this capacity up to $\cdot 00025$ mfd. or thereabouts.

Dead Spots.—Dead spots at some points in the tuning range may be due to bad arrangement of the reaction circuit, but they can more often be traced to the fact that the aerial-grid circuits are incorrectly designed. Whenever a long aerial is used, it is important that it should be coupled to the grid coil either through a fixed condenser of a low capacity (not more than $\cdot 0001$ mfd.) or by means of a small and loosely-coupled aerial winding. An alternative is to connect the aerial, through the small fixed condenser, to a tapping on the grid winding.

It is usual to apply reaction by the Reinartz system, in which coupling is effected by a coil and condenser in series between the anode of the detector valve and earth. This is not always the best system, however, and it will

TRACING FAULTS IN SHORT-WAVERS

frequently be found that a smoother control is obtained by connecting the reaction winding between the anode of the detector valve and the H.F. choke, and wiring the reaction condenser between the junction of the winding and the choke, to earth. This gives what is known as throttle-control reaction, due to the fact that, as the capacity of the reaction condenser is increased, the feed-back or reaction effect is decreased, or "throttled," and not increased, as is the case with the Reinartz circuit.

Another valuable method of improving reaction control is to replace the three-electrode detector valve by one of

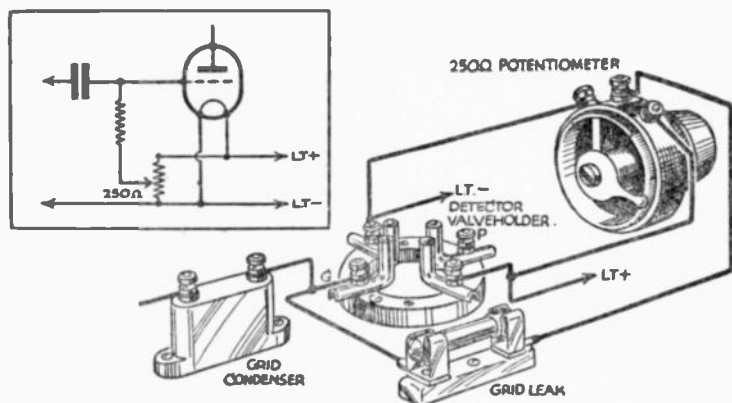


FIG. 208.—The connections for a grid leak potentiometer.

the screen grid or screened pentode type. This modification is perfectly simple and altered connections may be ascertained from Fig. 209.

Hand Capacity.—Another common difficulty experienced with many of the simple short-wave sets is that of hand-capacity; adjustment of the controls cannot be carried out accurately since tuning is affected as the hands move towards, or away from, the front of the set. Such trouble can often be traced to the use of an inefficient or unduly long earth lead. In such cases the cure is evident, whilst the fault can be verified by touching the earth terminal with a moistened finger; if this has any effect upon signal strength the earth connection is unsatisfactory.

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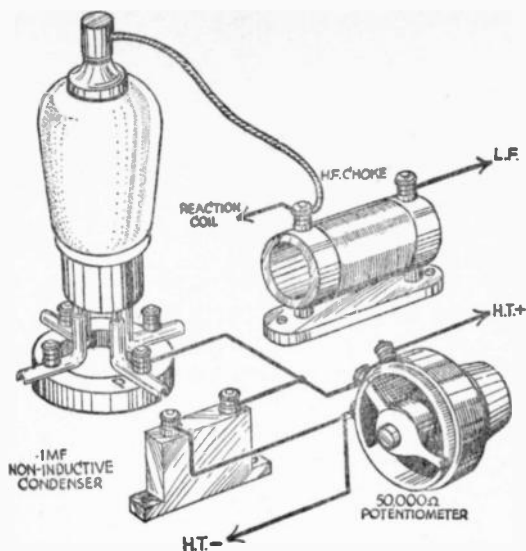


FIG. 209.—When using an S.G. valve as detector, reaction control can be improved by feeding the screening grid through a potentiometer.

Another cause of hand-capacity and also of a peculiar form of interaction is due to H.F. currents in the detector circuit leaking into the low-frequency amplifier. Such leakage can be cured in most cases by using a more efficient H.F. choke and by inserting a 100,000 ohm non-inductive fixed resistance between the grid of the first L.F. valve and the corresponding terminal of the L.F. transformer (see Fig. 207). Where these modifications prove ineffective, it is desirable to connect a fixed condenser of approximately .002 mfd. capacity between the anode terminal of the output valve and earth. In addition to this, a short-wave high-frequency choke should be inserted in the lead between the anode terminal of the last valve and the corresponding loud-speaker or phone terminal. The improvements just mentioned are clearly shown in Fig. 210.

Screening the Receiver. — Another cure for hand-capacity effects, which should only be employed when

TRACING FAULTS IN SHORT-WAVERS

every other has proved inadequate, is to house the complete receiver in a metal or metal-lined container, the metal being connected to earth. This screening should be applied not only to the cabinet itself, but also to the panel, where one is used. If the receiver is at present fitted into a wooden cabinet and is provided with an ebonite panel it is generally sufficient to line the cabinet with tin foil and also to glue sheets of foil to the rear surface of the panel. All the sheets

of foil so used must effectively be connected together and care must be taken that none of the components (particularly the bushes of those mounted on the panel), is short-circuited or earthed.

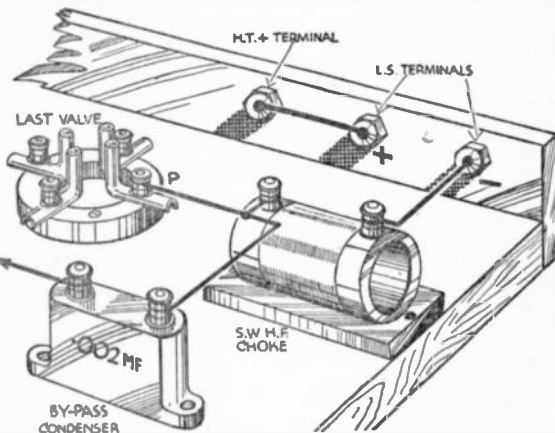
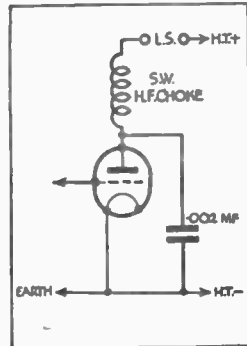


FIG. 210.—A "stopper" choke and by-pass condenser in the anode circuit of the output valve often prevent hand-capacity troubles.

AERIAL SYSTEMS

THERE are various types of short-wave aerials, the majority of which are of simple construction, and which may be used in conjunction with any type of short-wave receiver. As a rule, the magnitude of aerial experiments undertaken by the average amateur is governed by the amount of space in which to erect alternative aerials and the particular site of his house.

It is, of course, well known that almost any aerial, either long or short, will do for short-wave reception. It does not follow, however, that the results obtained will do justice to the capabilities of even the most ordinary receiver; therefore, if at all possible, the construction and erection of a special aerial suitable for short-wave reception should be considered.

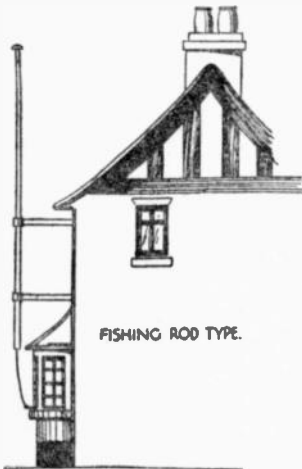


FIG. 211.—A "fishing rod" type of vertical aerial.

In placing before readers the suggestions outlined in this chapter, the circumstances in which the majority of short-wave enthusiasts carry out their DX and experimental work has been taken into account and suggestions are confined to those where unlimited space is not the ruling factor. Fig. 213 is, of course, given as an interesting example only, as very few enthusiasts will be fortunate enough to have the

amount of open space at their command which is necessary to erect the type of aerial shown.

In many instances, aerials consisting of a length of insulated wire laid behind a picture rail are in use. Whilst, no doubt, moderately satisfactory for broadcast reception, such an aerial leaves much to be desired so far as short-wave reception is concerned.

MAKING YOUR OWN SCREENED COILS

It is frequently considered that short-wave coils cannot properly be screened unless one is prepared to tolerate inefficiency, but this idea is entirely disproved by the component to be described, as well as by a number of the high-class short-wave tuners which are now on the market. As a matter of fact, I am of the opinion that screening is even more important in a short-wave set than in one designed for use on the higher wave-bands, and provided that it is properly and carefully arranged, screening is an undoubted advantage in so far as it eliminates unwanted hand-capacities. By so doing, it considerably simplifies the operation of the receiver and enables it to be used in its most sensitive condition, almost on the verge of oscillation.

The Tuning Ranges.—The tuner to be described is really two tuners in one, since it has been carefully designed to operate satisfactorily on two wave-bands. Actually, the approximate wavelength ranges covered, when a .0003 mfd. tuning condenser is employed, are from 14 to 30 metres and from 25 to 55 metres, and the positions and sizes of the windings have been so arranged that maximum efficiency is obtained over the whole of both bands. It might also be mentioned at this point that, if desired, a smaller tuning condenser (.0002 or .00025 mfd. can be used to cover a slightly narrower band of wavelengths, and to permit of rather easier tuning below 20 metres or so. Even when using the smallest condenser mentioned, there is a very slight "overlap" between the two ranges, so that there is no "break" between the ultra-short and normal short wave-bands.

By making reference to Fig 217 it will be noticed that there are actually six windings on the paxolin former, two each of which are for the aerial coil, grid coil, and reaction respectively. This arrangement has been found best in preventing "dead spots" and similar troubles, and makes the dual-range tuner quite as efficient as two separate coils of the more usual type. The two aerial windings are in series, and

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although they both remain in circuit on both wave-bands, one of them is ineffective on the lower range due to the fact that it is well away from the smaller grid winding. The same idea applies to the reaction winding, whilst a switch is connected across a portion of the grid coil so that it can be short-circuited when desired.

Parts Required.—For the benefit of those readers who may desire to make their own screened coils, it should be stated that the paxolin former, screen, and mounting bracket are to be obtained as a complete set from component manufacturers. The other materials required are: one piece of ebonite, measuring 3 inches by 2 inches; six 6B.A. terminals (also obtainable from component manufacturers,

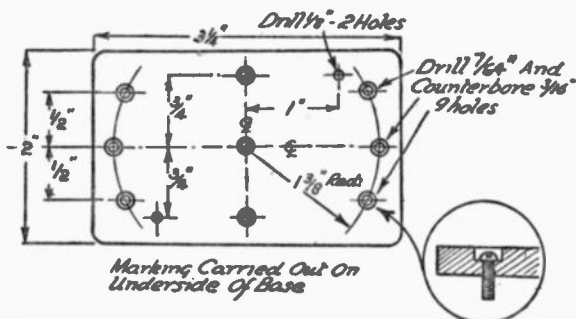


FIG. 216.—All the necessary dimensions for the ebonite base-plate are given in this drawing.

or any good radio stores), a few feet of 28-gauge d.c.c. wire, a length of systoflex sleeving, and a short length of insulated connected wire, such as that made specially for wireless purposes. It will be seen from this list that the total cost of the tuner will not exceed half-a-crown.

Winding the Tuner.—Having obtained the required parts, the first thing is to make a couple of small holes near one end of the paxolin former, anchor one end of the 28-gauge wire in these, leaving a length of about 4 inches projecting, and then wind on three turns. A single hole is then made near the end of the third turn and about 18 inches of wire passed through this. Another hole is then made lower down the former in the position clearly shown in Fig. 217, and the wire passed back through this and taken another four times

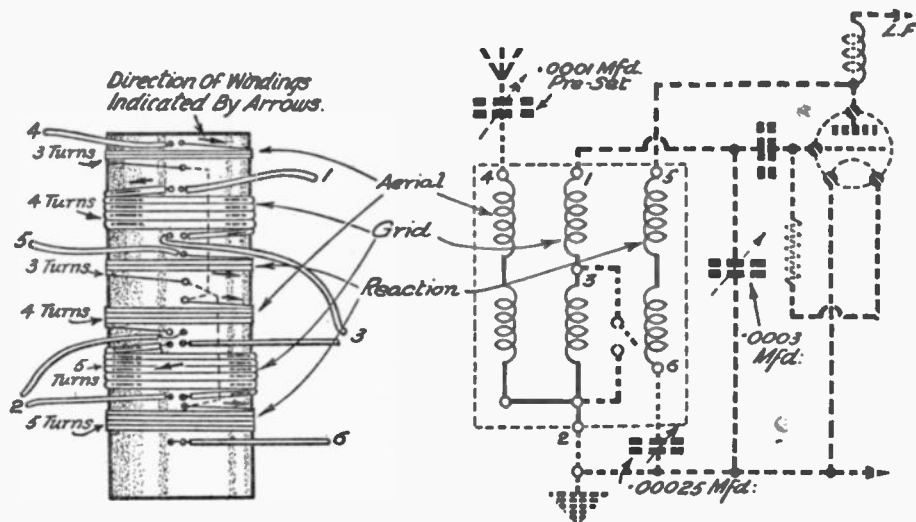


FIG. 217.—Details of the windings and connections for the dual-range short-wave tuner are clearly shown in this diagram.

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round the former. Two holes are made near the end of the fourth turn and the end of the wire anchored in these. It is important to make sure that the turns in both halves of the winding go in the same direction, since if they do not the halves will be in "opposition."

So much for the aerial winding. The grid winding comes next, and is again in two halves, one of four and the other of five turns. The thicker connecting wire is used for this winding, and the end should be bared for a length of 4 inches or so. Two small holes are made in the position indicated in Fig. 217, and the bared end of the wire is anchored by passing it through them. Put on the necessary four turns, placing them side by side. Instead of passing a length of wire through a hole to the second portion of the winding it is better (due to the thickness of the insulated connecting wire), to terminate the first section by baring the end and anchoring it in a couple of holes. At this juncture it should be explained that, although the turns are close together, there is actually a space between the wire forming one turn and that forming the next, which is produced by the insulating material. In the case of the particular wire specified above, and which is of 22-gauge, the thickness of the insulation gives a space between the actual turns which is equivalent to three times the diameter of the wire. Thus, the self-capacity is reasonably low and, since the insulating material has very low losses, the efficiency of the finished coil is quite as high as would be the case if the much more difficult method of using bare wire and spacing the turns were employed. The second portion of the grid winding should next be wound on in the correct position, and it should carefully be noted that the turns forming the grid coil are put on in the *opposite direction* to any of the others. This is important, for if the turns were wound in the opposite direction correct coupling between the various windings would not be obtained.

After completing the grid coil the reaction winding can be dealt with, and the positions for the two halves of this can again be obtained from Fig. 217. This winding consists of eight turns in all, of which three constitute the upper and five the lower sections. Both windings are continuous, the wire being passed through holes in the former from the end of one to the beginning of the other. In Fig. 217 all the holes

MAKING YOUR OWN SCREENED COILS

for anchoring the ends of the various windings are shown as being one above the other ; this is only for clarity in the drawing, and it is much better in practice to arrange them at different points on the circumference, so that the connections can more easily be recognised and connected to their appropriate terminals. This particular point will perhaps be more readily understood by making reference to the illustration of the actual coil described, which is shown at Fig. 217.

Mounting the Coil.—On completion of the windings, the ebonite base and screen must be prepared. Drawings which give the necessary details of this part of the construction are shown in Fig. 217 on page 183, and a diagram showing the layout of the baseplate is reproduced at Fig. 216. It will be seen that there are six holes for terminals and three for mounting screws, and that each of these is first drilled $\frac{7}{8}$ -inch diameter and then counterbored $\frac{3}{8}$ -inch diameter, so that the heads of the terminals are slightly recessed and cannot short-circuit on to a metallised chassis.

A soldering tag, is fitted under the clamping screw of each terminal for taking the coil connections, whilst a second tag is fitted to terminal 2 to make contact with the " lid " of the screening can in order to earth it. (See Fig. 218.) All the leads are cut off to such lengths that they will just reach the terminal soldering tags and are then passed through suitable lengths of systoflex sleeving. In judging the lengths of the leads it is well to rotate the former until all leads are as near to their respective terminals as possible, and at the same time care must be taken that the leads are long enough to loop sufficiently to allow the screening cover to be fitted without pressing against them. The correct terminal connections are shown in Fig. 218, and it is best to make soldered joints, although, if this presents any very great difficulty, the bared ends of the leads can be gripped tightly underneath the tags.

Connecting to the Tuner in Circuit.—The more experienced readers will find all the information they require for connecting up the tuner in the theoretical circuit at Fig. 217, but for the benefit of others who are not so accustomed to circuits, the pictorial wiring plan given at Fig. 219 will be

CONDENSERS FOR SHORT-WAVE RECEIVERS

THE selection of condensers, fixed and variable, is of greater importance when designing a short-wave receiver than when selecting similar parts for a broadcast receiver. In addition to the efficiency which will be obtained when the correct components are selected, the satisfaction which arises from the knowledge that no improvement can be obtained will well repay the time spent in making the choice.

The tuning circuit is that part of the short-wave receiver which differs most considerably from a standard broadcast receiver, and the difference is to be found in the frequencies which are used on the short-waves. Without going into figures it may be briefly stated that there are almost as many stations in one degree of a normal tuning dial on the short-waves as there are on the entire dial of a broadcast receiver. It will thus be seen that great accuracy is required in order to separate adjacent stations. Therefore, in addition to an extremely low value, the condenser must be fitted with some form of slow-motion drive. Furthermore, the very high frequencies which are in use render it very desirable to take every precaution to prevent losses which will arise from capacities existing between components and earth.

Tuning Condenser Values.—It may be stated broadly that a maximum value of $\cdot 0003$ mfd. is the highest which should be used for a tuning condenser, and if it is desired to build a receiver for use on wavelengths below 20 metres, $\cdot 0001$ should be taken as the maximum. For ultra-short-wave work $\cdot 00005$ mfd. will be found desirable, and even then some form of high-g geared slow-motion drive will have to be used. The dielectric for these tuning condensers must be air and on no account should one of the condensers having a bakelite or similar material for the dielectric be used. The insulation of the condenser should be of the highest and if it can be afforded this should be of porcelain, steatite, or some similar material, although good-quality ebonite will probably be found sufficient if the remaining components

CONDENSERS FOR SHORT-WAVE RECEIVERS

are not chosen with the same degree of efficiency. Connection between the moving vanes and the terminal should be carried out with some form of pigtail; a friction bearing should not be used. The pigtail should be insulated, otherwise noises will arise from variations in the electrical circuit caused as the adjacent turns come into contact. In addition to the use of a slow-motion drive, it will very often prove of

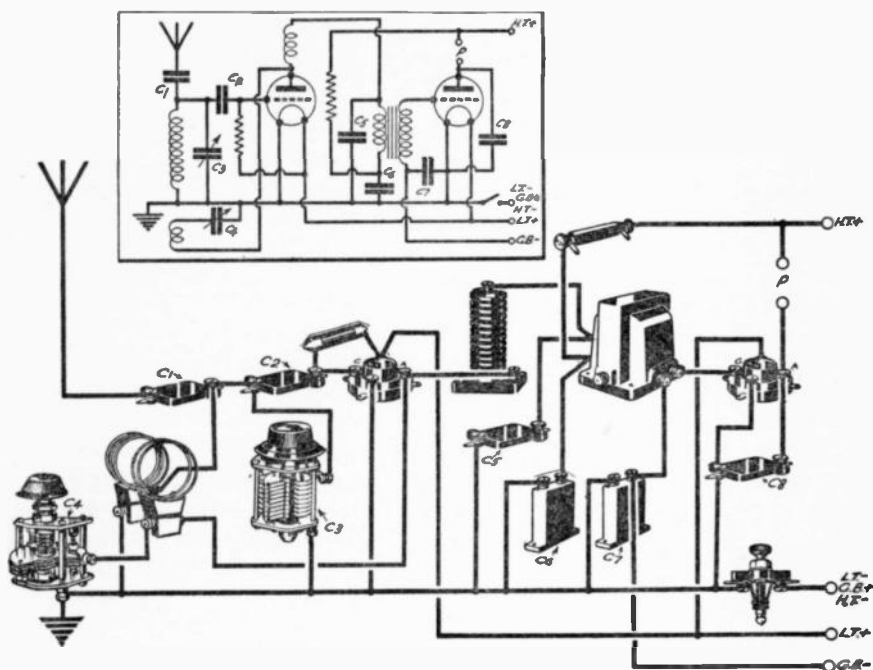


FIG. 220.—This typical two-valve short-wave receiver circuit shows the various condensers and illustrates their importance.

value to mount the condenser on a sub-panel, with the drive mounted on a further panel, the connection between drive and condenser being carried out by means of an ebonite rod. Special extension spindles, as they are called, are obtainable from a number of wireless component manufacturers.

Reaction Condenser Values.—The reaction circuit does not call for quite the same high degree of efficiency, and

TELEVISION AND SHORT-WAVE HANDBOOK

therefore, generally speaking, any of the standard types of reaction condenser may be employed in this part of the circuit. The maximum value, again, will be $\cdot 0003$, but it is quite possible to use a lower value condenser, provided the reaction circuit is suitably designed. Although not essential, a slow-motion drive will also be found of use in order to obtain a smooth control of reaction, although when the suitable valve is chosen and the value of H.T., grid leak and associated components are accurately employed, reaction should be quite smooth and controllable, with a standard dial.

In the aerial circuit it is often found worth while to include a small condenser and air should be used as the dielectric. Special small-value variables are obtainable for use in this part of the circuit, although two small pieces of metal may easily be adapted for use by mounting them so that a space of about $\frac{1}{8}$ inch separates them.

The grid condenser is very vital with some circuits, and any value between $\cdot 00005$ and $\cdot 0003$ mfd. should be tried in order to find the most suitable value for the particular circuit and valve which is being used. The value of the grid leak has a great bearing on the condenser value.

H.F. By-pass Condenser.—Where a by-pass condenser must be used in short-wave sets it would generally be found that a value of $\cdot 0005$ mfd. is quite adequate for the purpose, and there is no need to employ condensers having a higher value. The accompanying illustration shows a typical two-valve circuit employing a standard reacting detector followed by one low-frequency stage, in which the condensers have been identified by a number and which should be studied in conjunction with the above notes. C1 is the series aerial condenser and normally a value of $\cdot 00005$ mfd. will be found suitable, although, as already mentioned, a higher or lower value may be found suitable with some aerials, and therefore some means of adjustment should be provided. C2 is the grid condenser, whilst C3 and C4 are the tuning and reaction condensers respectively. C5, C7, and C8 are H.F. by-passing condensers and $\cdot 0005$ mfd. will be found a suitable value.

SHORT-WAVE BROADCASTING STATIONS

This list includes stations which broadcast regularly on wavelengths below 100 metres. Where ascertainable the times of operation are given in G.M.T.

m.	kc/s.	kw.	Station.
84-87	3543	0-15	Mozambique (East Africa), CR7AA. Mon., Thurs., Sat., 6.30-8.30 p.m.
83-8	3600	0-05	Ponta Delgada (Azores), CT2AJ. Wed., Sat., 10 p.m.-12 midnight.
80	3750	0-5	Lisbon (Portugal), CT1CT. Sun., 2-4 p.m.
78	4110	0-5	Quito (Ecuador), HCJB. Daily (ex. Tues.), 12.45-3 a.m.
70-2	4278	20	Kharbarovsk RV15.
58-81	5145	..	Prague OK1MPT. Experimental.
52-7	5692	0-5	Tananarive (Madagascar) FIQA. Daily (ex. Sun.), 8-8.45 a.m.; 3-4 p.m.; Sat. 5.30-7 p.m.; Sun., 7.30-8 a.m.
50-42	5950	..	Medellin (Colombia) HJ4ABE. 12 midnight-4 a.m.
50-28	5969	10	Vatican City (Italy) HVJ. Daily, 7-7.15 p.m.; Sun., 10-10.30 a.m. also.
50-08	5990	..	Caracas (Venezuela) YV4RC.
50	6000	0-3	Barcelona Radio Club (Spain) EAJ25. Sat., 8.30-9.30 p.m.
		20	Bucharest (Romania).
49-06	6005	2-5	Moscow RW59. 9-11 p.m.
		..	Montreal, VE-DR. Daily (ex. Sun.), 12.30 p.m.-5 a.m.; Sun., 5.30 p.m.-4.15 a.m.
49-02	6010	..	Montreal VE9DN. 4-6 a.m.
		..	Havana (Cuba) COC. 2.30-3 p.m., 9-10.15 p.m.
49-9	6012	..	Singapore (S.S.) ZHI. Mon., Wed., Thurs., 10.40 p.m.-1.10 a.m.; Sun., 3.40-6.10 a.m.
49-83	6020	8	Zeesen (Germany) DJC. 10.30 p.m.-3.45 a.m.; 5-9.30 p.m.
		2-5	Boston (Mass.) W1XAL. 10.45 p.m.-12.15 a.m.; Sun., 12.30-2.30 a.m.
49-67	6040	2-5	Miami Beach (Florida) W4XB. 1 p.m.-5 a.m.
		..	Sourabaya (Java), PDB.
49-59	6050	20	*Davenport GSA.
		10	Cincinnati W8XAL. 12 noon-1 a.m.; 4-6 a.m.
49-5	6060	0-5	Nairobi (Kenya) VQ7LO. Daily, 4-7 p.m. (Sat. to 8 p.m.)
		0-25	Mon., Wed., Fri., 10.45-11.15 a.m. Tues. 8-9 a.m.; Thurs 1-2 p.m.
49-43	6069	1	Philadelphia (Pa.) W3XAU. 1-4 a.m.
		0-007	Skamlebaek (Denmark) OXY. From 6 p.m.
49-42	6070	0-02	Santo Domingo (D.R.) HIX. Tues., Fri., 1-3 a.m.; Sun. at 12.40 p.m.
		0-5	Vancouver (B.C.) VE9CS. Sat., 4.30-5.45 a.m.; Sun., 4 p.m.-4 a.m.
49-4	6072	0-02	Maracaibo (Venezuela) YV5RMO. 5-6 p.m., 10.30 p.m.-3 a.m.
49-34	6080	0-5	Vienna Experimental ORR2. Daily, 2-10 p.m.
		0-5	Chicago (Ill.) W9XAA. 3 p.m.-6 a.m.
49-26	6090	0-1	La Paz (Bolivia) CP8. 12 midnight-3.30 a.m.
49-22	6095	0-5	St. John (New Brunswick) VE9BJ. Daily, 12 midnight-1.30 a.m.
		..	Bowmanville (Canada) VE9GW. Mon., Tues., Wed., 3 p.m.-5 a.m. Thurs., Fri., Sat., 12 midnight-5 a.m.; Sun., 6 p.m.-2 a.m.
49-18	6100	35	Bound Brook (N.J.) W3XAL. Mon., Wed., and Sat., 9.30 p.m.-6 a.m.
		5	Chicago (Ill.) W9XF. 9.30 p.m.-7 a.m.
49-1	6109	0-5	Calcutta (India) VUC. Daily (ex. Fri. and Sat.), 3.30-6 p.m.; Fri., 2.30-3 p.m.; Sat., 5.45-9 p.m.
49-09	6110	0-2	Halifax (N.S.) VE9HX. Sat. and Sun., 10 p.m.-4 a.m.; Week-days, 2.30-5 p.m.; 9 p.m.-4 a.m.
49-08	6112	0-2	Caracas (Venezuela) YV2RC. Daily (ex. Sun.), 4.30 p.m.-2.30 a.m.; Sun., 2 p.m.-3.30 a.m.
49-02	6120	..	Wayne (N.J.) W2XE. 11 p.m.-4 a.m.
49	6122	5	Bandoeng (Java) Y.D.A.
		..	Johannesburg (S.A.) ZTJ. Daily (ex. Sun.), 4.45-5.30 a.m.; 8.30-12 noon; 2-8 p.m. (9.45 p.m. Sat.), Sun., 1-8.15 p.m.; 5.30-8 p.m.
48-9	6130	..	Kuala Lumpur (Fed. Malay States) ZGE. Sun., Tues. and Fri., 11.40 a.m.-1.40 p.m.
48-86	6140	40	Pittsburgh W8XK. 9.30 p.m.-6 a.m.
48-78	6149	2	Winnipeg (Canada), CJRO. Daily (ex. Sun.), 1.5 a.m.; Sun., 1-3.30 a.m.
48-47	6150	..	Caracas (Venezuela) YV3RC. 8.30 p.m.-1.30 a.m.
48-78	6250	..	Bogota (Colombia) HJ8ABF.
47-5	6316	..	Santo Domingo (D.R.) HIZ.

m.	kc/s.	kw.	Station.
46-69	6425	18	Bound Brook (N.J.) W3XL. Experimental. 4.15 - 6 p.m.; 11 p.m.-3 a.m.
46-58	6447	0-3	Barranquilla (Columbia) HJ1ABB. Daily, 3.45-4.45 p.m.
46-3	6480	..	Call (Columbia) HJ5ABC.
45-38	6610	10	Moscow RW72 (Russia).
45-31	6620	..	Riobamba (Ecuador) PRADO. Fri., 2-4 a.m.
45	6667	0-15	Guayaquil (Ecuador) HC2RL. Sun., 10.45 p.m.-12.45 a.m.; Wed., 2.15-4.15 a.m.
43	6976	0-2	Constantine (Algeria) 8KR.
41-9	7150	0-2	Madrid EA4AQ. Tues., Sat., 10 p.m.
41-8	7177	0-5	Manizales (Columbia) HJ4ABB.
41-6	7211	0-2	Lobito (Angola) CR6AA. Wed., Sat., 7.30-9.30 p.m.
40-3	7444	..	Teneriffe Radio Club EA8AB.
38-48	7797	20	Radio Nations (Switzerland) HBQ.
37-83	8935	10	Radio Nations (Switzerland) HBP. Sat., 10.30-11.15 p.m.
31-58	9500	15	Rabat (Radio Maroc) CNR. Sun., 8-9 p.m.
31-55	9510	20	Rio de Janeiro (Brazil) PRF5., 10.30-11.15 p.m.
31-48	9530	40	*Daventry GSB.
31-45	9540	1	Melbourne (Australia) VK3ME. Wed., 10-11.30 a.m.; Sat. 10 a.m.-12 noon.
31-38	9560	8	Schenectady (N.Y.) W2XAF. 12.30-4 a.m.
31-36	9565	4-5	Jeloy (Norway) LCL.
31-35	9570	10	Zeeson (Germany) DJA. 1-4.30 p.m.; 10.15 p.m.-2.15 a.m.; Sun., 9-10.30 a.m.
31-32	9580	20	Bombay (India) VUB. 4.30-5.30 p.m.
31-28	9590	1	Springfield (Mass.) W1XAZ. Daily, 12 noon-6 a.m.
31-27	9595	18	*Daventry GSC.
31-25	9600	..	Lindhurst (Victoria Australia) VK3LR. Daily, (ex. Sun.), 8.15 a.m.-12.30 p.m.
30-67	9780	20	Philadelphia (Pa.) W3XAU. 5 p.m.-1 a.m.
30-43	9860	20	Sydney (Australia) VK2ME. Sun., 6.8 a.m., 9.30 a.m.-1.30 p.m. 2-4 p.m.
29-04	10,390	20	Radio Nations (Switzerland) HBL. 10.30-11.15 p.m.
28-98	10,360	..	Lisbon (Portugal) CT1AA. Tues. and Fri., 9.30 p.m.-12 midnight.
28-86	10,578	..	Mexico City XETE. 7 p.m.-7 a.m.
25-65	11,695	0-2	Rome (Italy) 2RO. Mon., Wed., Fri., 11.30 p.m.
25-6	11,720	15	Madrid (Spain) EAQ. 10.30 p.m.-12 midnight; Sat., 5-7 p.m.
25-57	11,780	20	Ruysselede (Belgium) ORK. 7.45-9.30 p.m.
25-53	11,760	20	Buenos Aires LSX. Daily, 8-9 p.m.
25-51	11,760	8	Paris (France) FYB. Time Sig., 8.26 a.m. and 8.56 p.m.
25-47	11,770	2	Caracas (Venezuela) YV3RC.
25-45	11,790	5	Radio Colonial (Paris) FYA. Midnight 3 a.m.; 4-6 a.m.
25-4	11,810	9	Findhoven (Holland) PHI. 1.30-4.30 p.m.
25-36	11,890	5	*Daventry GSD.
25-29	11,860	20	Zeeson (Germany) DJD. 5-9.30 p.m.
25-27	11,870	40	Winnipeg (Canada) CJRX. Daily, 1.5 a.m. Sun., 1-3.30 a.m.
25-2	11,905	15	Boston (Mass.) W1XAL, 11p.m.-12.30 a.m.
25	12,000	20	Rome (Italy) 2RO.
24-88	12,082	0.5	Wayne (N.J.) W2XE. 8-10 p.m.
23-39	12,825	10	*Daventry GSE.
19-84	15,123	10	Pittsburg W8XK. 10.15 p.m.-3 a.m.
19-82	15,140	15	Radio Colonial (Paris), FYA. 4.15 p.m.-7.15 p.m.; 8-11 p.m.
19-74	15,200	8	Moscow (Russia) RNE. Sun., 3-4 a.m.; 11 a.m. to 12 noon; 3-4 p.m.
19-72	15,210	40	Lisbon (Portugal) CT1CT. Sun., 12 noon-2 p.m.; Thurs., 9-11 p.m.
19-71	15,220	20	Rabat (Radio Maroc) CNR. Sun., 11.30 p.m.
19-68	15,243	15	Vatican City (Italy) HVJ. 10-10.15 a.m.
19-67	15,250	5	*Daventry GSF.
19-66	15,260	15	Zeeson (Germany) DJB. 1-4.30 p.m. Sun., 9-10.30 a.m.
19-66	15,270	5	Pittsburg W8XK. 3-10.15 p.m.
19-66	15,390	25	Eindhoven (Holland), PCJ. 1.30-4.30 p.m.
19-47	15,410	..	Radio Colonial (Paris), FYA. 12 noon-4 p.m.
17-83	17,310	20	Boston (Mass.) W1XAL. 3.50-6.30 p.m.
16-89	17,760	8	Daventry GSI.
16-87	17,780	35	Wayne (N.J.) W2XE. 4-6 p.m.
16-86	17,790	15	Schenectady W2XAD. Daily, 7.30-8.30 p.m.
13-97	21,470	15	Riobamba (Ecuador) PRADO. Sun., 10-11 p.m.
13-93	21,530	51	Bound Brook (N.J.) W3XL. 4-10 p.m.
			Zeeson (Germany) DJE. 4.30-7 p.m.
			Bound Brook (N.J.) W3XAL. 3-9 p.m.
			*Daventry GSG.
			*Daventry GSH.
			Daventry GSI.

* The Empire Transmitters are occasionally interchanged.

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A

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

Abronsheim System.—See *Telekino System*.

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

From the Greek, *aktis*, a ray.

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

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

See *Zinc silicate, Calcium tungstate, Zinc phosphate*, etc.

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

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

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

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

The Alexanderson system, which was first publicly demonstrated at Schenectady in 1930, is stated to have given a picture the brightness of which was approximately one-half that of the usual cinema-screen image. (See illustration on page 194.)

Alkali Metals.—Name given to the group of alkali-producing

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metals—*Lithium, Sodium, Potassium, Rubidium and Cæsium*—which, owing to their more or less pronounced photo-electric properties, provide the active material for many types of photo-electric cells used in television.

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

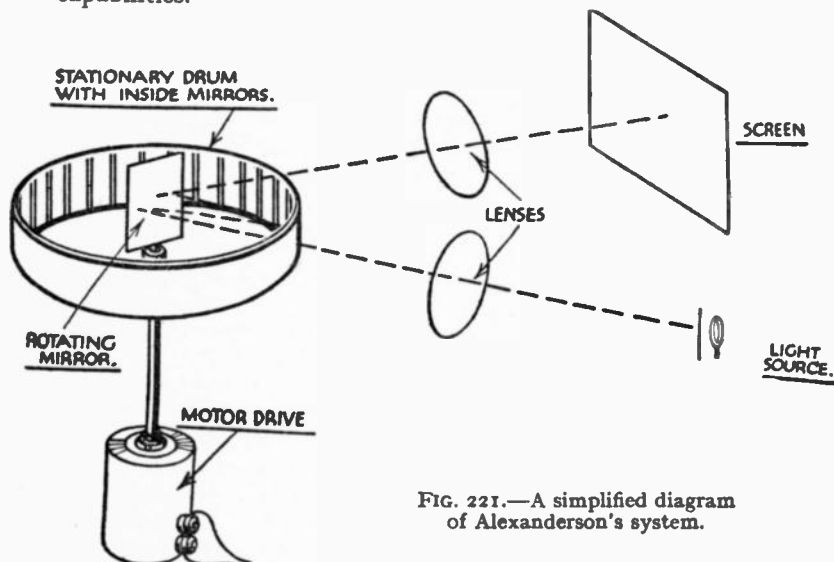


FIG. 221.—A simplified diagram of Alexanderson's system.

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

Abbreviation: A.U.

Anode.—In photo-cell terminology, this term signifies the positively-charged electrode which attracts to it and collects the stream of electrons emitted from the cathode under the influence of light.

See *Cathode*.

Anomalous Dispersion.—Term used in connection with optical matters. When light rays of short wave-length and those of longer wave-length (as, for instance, violet and red rays), pass

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from one transparent medium to another transparent medium of a different density, the rays of shorter wave-length (the violet rays) are refracted to a greater extent than those of a longer wave-length. In the case of some mediums, however, this "law" is not followed. In all such instances, therefore, the varying light rays are said to undergo "anomalous dispersion."

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

See *Lens Disc*.

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

See *Lens Drum*.

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

Argon.—Chemical symbol: A. Atomic weight: 40. A colourless, odourless, inert gas discovered in 1894 by the late Sir William Ramsay in the earth's atmosphere in which it is present to the extent of 0.93 per cent. It is commercially produced for various electrical uses by the careful selective evaporation of liquid air.

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

From the Greek, *argos*, inert.

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

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

Axis.—In reference to the various optical systems used in television working, the axis of a lens is the imaginary straight line which passes through its centre and through the centre of

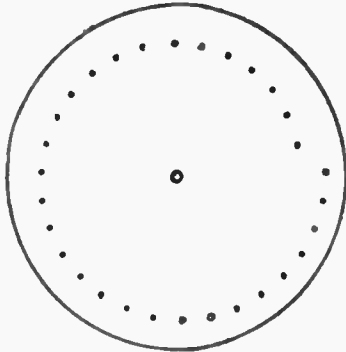


FIG. 222.—One of the simplest types of scanning disc.

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its radius of curvature. This is known as the "principle axis" of the lens. Any other imaginary straight line passing through the centre of the lens is known as a "secondary axis."

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

B

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

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

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

Becquerel Cells.—See *Liquid Cells*.

Becquerel Effect.—Name given to the production (first noticed by Becquerel) of a minute current when two metal plates, one of which is strongly illuminated, are suspended in certain chemical solutions. Many different types of "liquid cells" which operate in virtue of the Becquerel effect are known.

See *Liquid Cells, Photo-electrolytic Cell*.

Beehive Lamp.—Name sometimes applied to the ordinary commercial form of neon lamp in which a spiral or "beehive" of wire encloses a flat metal disc, these forming the electrodes of the lamp. For simple experiments in television, "beehive" neon lamps are quite suitable after the resistance mounted in the base has been removed. (See illustration on page 197.)

Belin and Holweck's System.—One of the earlier systems of television devised in France by MM. Belin and Holweck. In this system two vibrating mirrors set at right-angles to each other caused a reflection of the image to be televised to fall upon a light-sensitive cell. The fluctuating current from this cell

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was transmitted to the receiving apparatus by landline, where, by an electro-magnetic device, it was made to control the intensity of the light-spot in a cathode-ray tube, thus setting up a very crude reproduction of the original image.

Belt Drum.—See *Belt Scanner*.

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

Synonym : *Belt Drum*.

See *Film Scanner*.

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

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

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

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

Several variations of Bidwell's cell are known.

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

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

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



FIG. 223.—The "bee-hive" lamp so called because of the shape of the electrode.

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

See *Iridescence*.

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

“**Bottled**” Television.—See *Phonovision*.

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

See *Cathode-ray Tube*.

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

C

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

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

Cadmium Cell.—See *U-type Cell*.

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

Cæsium.—Chemical symbol: Cs. A member of the alkali group of metals. Atomic weight, 132. Melting point, 28.5°C. Specific gravity, 1.903.

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

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

Calcite.—See *Iceland Spar*.

Calcium Tungstate.—Chemical formula: CaWO_4 . A calcium salt of tungstic acid. Used in the preparation of fluorescent

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screens for cathode-ray and other tubes. Under cathode-ray excitation it fluoresces with a bluish colour.

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

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

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

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

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

Bright sunlight	50,000–60,000 c.p.
Arc lamp	250– 6,000 „
Electric filament lamp (household type)	10– 120 „
Limelight	100– 600 „
Magnesium ribbon	100– 200 „
Incandescent Gas-mantle	40– 60 „
Gas flame (Batswing burner)	8– 16 „
Oil lamp (flat-wick type)	6– 10 „
Light of Full Moon	1/500th approx.
	(varies)

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

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

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

Case Cell.—See *Thalofide Cell*.

Caselli's Apparatus.—See *Pantelegraph*.

Cathode.—Used in connection with photo-cell construction, this term refers to the negative electrode of the cell upon which the light-sensitive surface is formed, and from which a stream of electrons is emitted by the action of light.

See *Anode*.

Cathode Rays.—Name given to a stream of electrons which are emitted from the cathode, or negative electrode, of an

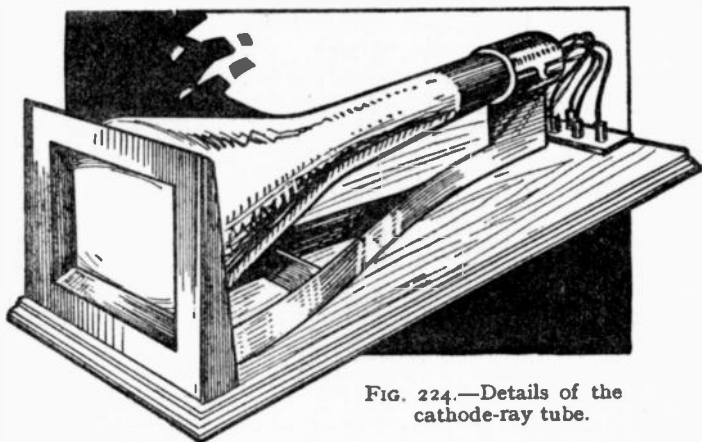


FIG. 224.—Details of the cathode-ray tube.

electric discharge tube exhausted to a high degree of vacuum. They were first discovered by Sir William Crookes.

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

Cathode-ray Tube.—A tube which consists essentially of a negative filament or cathode which is treated with an electron-emitting substance. Near the cathode is an anode, or "gun," as it is sometimes termed, consisting of a circular plate perforated with a central aperture. This is maintained at a high positive

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potential. As a result, the electrons which are emitted from the heated filament or cathode are violently attracted to the anode. Some of them pass right through the hole in the centre of the anode and thereafter travel in the form of a beam outwards from the anode (being on their way controlled as regards direction by passage between two pairs of "deflector plates") until they reach the flattened end of the tube, where, by impinging upon a screen of specially prepared fluorescent material, they manifest their presence visibly by causing the fluorescent material to glow strongly.

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

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

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

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

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

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

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

Synonym: *Light Chopper*.

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

See *Sclerotic*.

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

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

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

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

See *Fine Scanning*.

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

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

Cogged-wheel Synchroniser.—See *Toothed-wheel Synchroniser*.

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

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

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

From the Greek, *kolla*, glue.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

It is found that the contrast sensitivity of the eye decreases with low intensities of illumination and, also, when the field of vision is severely restricted—two factors which militate against

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clear television reception on very small screens and with poor illumination intensities.

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

Copper Pyrites.—A natural ore of copper, containing copper, iron and sulphur. Approximate chemical formula: CuFeS_2 or $\text{Cu}_2\text{SFe}_2\text{S}_3$.

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

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

From the Latin, *corneus*, horny.

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

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

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

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

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

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

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

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

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

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

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

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D

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

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

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

Referring to television systems, the terms "High-definition" and "Low-definition" are self-explanatory.

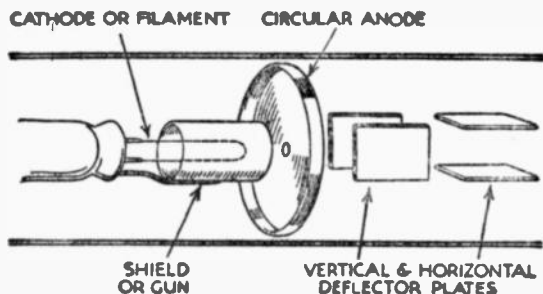


FIG. 225. — The arrangement of the electrode assembly for a standard cathode-ray tube.

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

See *X plates*, *Y plates*.

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

Diaphragm.—A metal partition of variable circular aperture, which is placed between the components of a lens in order to

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regulate the amount of light passing through the lens, and also to vary the "depth of focus" of the latter. Diaphragms are also known as "stops."

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

Disc Prism.—See *Jenkins' System*.

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

Drum Scanner.—Another name for the Mirror-Drum, which see.

Duration of Vision.—The length of time during which a light stimulus must be given to the retina of the eye in order to set up the sensation of vision. This time-length has not been accurately determined. It is, however, an exceedingly minute fraction of a second, as may be judged from the fact that an electric spark discharged from a Leyden jar condenser has a duration of only 0.00000866 of a second, yet it is plainly visible to the eye.

E

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

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

See *Scophony*.

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

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

See *Mechanical Scanning*.

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

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

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Electro-Luminescence.—A scientific term applied to all cases of fluorescence and phosphorescence which are caused by cathode rays, X-rays, and by radio-active compounds. The fluorescence developed by the electron stream on the screen of a cathode-ray tube is, strictly speaking, an instance of electro-luminescence.

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

See *Sabine's Cell*, *Minchin's Cell*.

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

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

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

Most of the photo-electric cells employed in television working are of this general type.

See *Photronic Cell*.

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

Exploring Spot.—See *Scanning Spot*.

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

See *Striking Voltage*.

F

Faraday Cell.—See *Faraday Effect*.

Faraday Effect.—Name applied to the rotational effect of a powerful electro-magnetic field upon a beam of polarised light

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electrons which enable the cathode-ray tube, the valve, the photo-electric cell and other electronic devices to function.

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

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

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

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

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

G

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

See *Time Base, Gas-discharge Triode.*

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

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

In cells of this type, the free electrons which are emitted from the sensitive cathode under the influence of light collide with the molecules of gas existing within the cell, the result being that further electrons are detached from the gas particles.

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

See *Vacuum Cell*.

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

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

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

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

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

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

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

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

H

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

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

See *Hertz Effect*.

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

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

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

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

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

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

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

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

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

See *Hallwachs' Effect*.

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

See *Vertical Scanning*.

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

Hydrides.—Name applied to compounds of metals with the gas, hydrogen.

Certain metallic hydrides, notably those of potassium, rubidium and caesium, are highly photo-electric and, as such, are often used in place of the pure metals in the construction of photo-electric cells.

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

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

I

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

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

Synonym: *Calcite*.

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

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thereupon flows through an external circuit where it is amplified and transmitted in the usual manner.

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

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

Image Intensification.—See *Intensifying Circuit*.

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

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

See *Emergent Ray*.

Indirect Transmission.—See *Direct Transmission*.

Infinite Rays.—Term sometimes applied to light rays coming from a very great distance and which to all practical intents and purposes are parallel rays of light. Daylight, for instance, coming as it does from the sun, forms an example of "infinite rays." Starlight provides a still better example of these rays.

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

Certain types of photocells which are very sensitive to infra-red rays are known. It is by means of such cells that "Noctovision," or infra-red television, is possible.

See *Noctovision*.

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

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

See *Velocity Modulation*.

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

Invisible Rays.—Expression commonly used to denote the infra-red rays of light, but, nevertheless, equally applicable to

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other invisible forms of radiation, as, for instance, ultra-violet rays, X-rays, etc.

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

See *Ionisation*.

Ionic Oscillation.—See *Fringing Effects*.

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

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

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

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

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

From the Greek, *iris*, a rainbow.

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

From the Greek, *iris*, a rainbow, in reference to the variety of colourations to be seen in the iris.

Irregular Reflection.—See *Reflection*.

Isochronism.—See *Synchronism*.

J

Jenkins' Disc.—See *Jenkins' System*.

Jenkins' System.—An American system of television first demonstrated by Mr. C. Francis Jenkins in 1925. The scanning device employed in this system was a "prismatic disc," i.e., a glass disc the edge of which was ground into a prismatic section of

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mechanism these lamps are lighted in rapid succession by the incoming currents from the television transmitting station, thus giving a coarse but at the same time brilliant reproduction of the original image.

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

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

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

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

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

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

See *Apertured Disc*.

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

The lens drum is a development of the apertured drum.

See *Apertured Drum*.

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

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

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

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

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

Light Chopper.—See *Chopper Wheel*.

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

Light Elements.—See *Picture Elements*.

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

Light Pencil.—See *Pencil of Light*.

Light-Quanta.—See *Quantum Theory*.

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

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

Lines.—See *Scanning Lines*.

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

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

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

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It may be prepared by heating any of the other varieties of selenium above 200°C. It is a greyish-black material having a metallic sheen and appearance.

Metalloid.—A term used with increasing frequency to denote an element which is half a metal and half a non-metal.

The light-sensitive element, selenium, is often erroneously described as being a metal. At the most, however, it is merely a metalloid, in which only non-metallic features preponderate.

Tellurium and antimony are typical "metalloids."

Metre-Candle.—See *Lux*.

Mica.—The well-known transparent material of laminated structure and of high insulating powers. Among many electrical uses, it is employed in the construction of some types of selenium cells.

Mica is the name given to a group of minerals. They all contain silicon combined with varying amounts of magnesium, sodium, potassium, lithium, aluminium and iron.

Microlux.—One-millionth of a lux. A unit employed in the measurement of extremely minute illumination intensities.

See *Lux*.

Micron.—A term signifying a thousandth of a millimetre. It is used in expressing the wave-length of light.

Middleton's Instrument.—An early form of television apparatus, first experimentally demonstrated by its inventor before the Cambridge Philosophical Society on 8th March, 1880. The transmitter consisted of a bank or mosaic of small thermo-electric couples which were connected up to a similar mosaic of couples on the receiving instrument. A crude illuminated image was projected upon the transmitting mosaic and the minute thermo-electric currents thus set up generated heat in the receiving couples, the radiant heat thus created being manifested by means of reflection from a special form of mirror.

Millilux.—One-thousandth of a lux. A unit used in the measurement of small illumination intensities principally in Television research.

See *Lux*.

Millimicron.—The thousandth part of a micron. A term used for expressing small wave-lengths of light.

Minchin's Cell.—An electrolytic type of selenium cell first constructed in 1895 by the Irish physicist, Professor Minchin. It consisted of a short length of aluminium wire, flattened and selenium-coated at one end and enclosed in an open-ended glass tube, which latter was immersed in *œnanthol* (an organic liquid), in close proximity to a platinum electrode.

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This cell, like Sabine's cell (which see), produced its own current when properly adjusted and illuminated.

Mirror-Drum.—A scanning device employed in some television systems. Essentially, it consists of a drum-shaped wheel having fixed upon its periphery or outer edge a number of mirrors, each mirror being tilted at a slightly different angle from that of the preceding mirror. A beam of light is suitably focused upon the edge of the mirror-drum, which is rapidly rotated, thus causing a light spot to be flashed in successive lines over the image or object to be televised.

In a similar way, also, the mirror-drum is made to assemble the televised picture at the receiving end.

The main advantage of the mirror-drum is that it allows a more intense spot of light to be focused upon the object.

Mirror Effect.—A form of "reversed image" which sometimes occurs on the screen of a television receiver, the televised image appearing with the left and right sides of the original transposed, thus giving rise to a "mirror effect." Mirror-drum receivers which are incorrectly adjusted are prone to give rise to this type of reversed image.

Mirror-Screw.—A television scanning device comprising a number of mirrors arranged on a frame in the form of a screw spiral. Unlike the mirror-drum (which see) the mirrors are not separately tilted in relation to one another, the directing of the light spot on the screen or on the object to be televised being effected by the suitable and exact positioning of the mirrors on the spiral.

The mirror-screw brings about exactly the same result as does the mirror-drum. It has, however, the advantage of greater compactness.

Mirror-Wheel.—See *Mirror-Drum*.

Mixed-layer Cell.—A photo-electric cell containing a layer of light-sensitive material throughout which has been forcibly

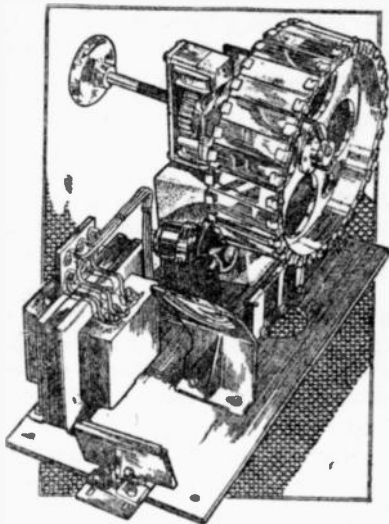


FIG. 227.—A typical mirror drum receiver.

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diffused traces of a "foreign" metal, such as silver, the foreign metal particles functioning by assisting the replacement of electrons which have been emitted by the light-sensitive particles.

Mixed-layer cells of this nature are still in the experimental stage, but will, no doubt, in time, become more generally used for television purposes.

See *Selenium*.

Moore Lamp.—A special type of neon lamp which was devised for the Jenkins' television system by Dr. D. MacFarlan Moore. It comprises a neon tube, the two electrodes of which are set concentrically and are separated by a glass cylinder, an arrangement which enables the glow discharge of the lamp to be concentrated about the centre of the positive electrode. In this manner, a much brighter source of light is obtained.

Moser's Theory.—A theory of the light-sensitivity of selenium first put forward by Moser in 1881. This theory suggested that the effect was brought about by heat which rendered more complete and effective the contact between the selenium element of the cell and its electrodes. The theory is now untenable.

Moving-tape Transmitter.—A modification of a film television transmission devised by the Marconi Company for the purpose of transmitting printed characters. The messages are printed on a tape by means of a special typewriter, after which they are televised in a manner roughly similar to that in which a film television transmitter operates.

The Moving-tape Transmitter is not applicable to the television of pictures.

Multiple Scanning.—Expression referring to television systems in which two scanning devices, as, for example, two mirror-drums, reflect the televised picture on to a screen, the object of these methods being to increase the intensity of the illumination on the screen.

Systems of multiple scanning are also applicable to methods of television transmission.

Multi-spiral Disc.—A type of scanning disc perforated with more than one spiral series of apertures. Discs of this type have been produced by several inventors. Some of them, as for example, the Sanabria disc, give rise to a scanning principle in which the image is scanned in non-adjacent rows. Multi-spiral discs are, however, still in the experimental stage and their practical value has yet to be proved.

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N

Natural Colour Television.—See *Colour Television*.

Naumannite.—A rare mineral containing selenium, chiefly in the form of selenide of silver. Named after its discoverer, Dr. C. F. Naumann, a German mineralogist.

Negative Image.—An image resembling that shown by a photographic negative, i.e. one in which the light parts of the original picture are dark and the dark portions of the original are light. It is the opposite to a positive image.

Some television receivers will give rise to negative images on their screens when a fault or maladjustment is present in the electrical circuit of the receiver.

See *Positive Image*.

Neon.—Chemical symbol: Ne. Atomic weight: 20. A colourless, odourless, inert gas discovered in 1894 by the late Sir William Ramsay.

Neon is present in extremely small proportions in ordinary air, one volume of neon being present in nearly 90,000 volumes of air. For electrical purposes, neon is manufactured by selectively distilling large quantities of liquid air.

From the Greek, *neos*, the new one.

Neon-Mercury Lamp.—A type of gas discharge lamp containing neon gas and mercury vapour under low pressure. Lamps of this nature give a high-efficiency glow discharge, particularly when the lamp is so made that the glow is confined to a small area.

Neon Time Base.—Name given to a time-base circuit in which a neon lamp provides the means of providing a periodic voltage across one pair of deflector plates in a cathode-ray tube.

See *Time Base*.

Newton's Disc.—A disc of cardboard or other material around which are painted in equal sectors the colours of the spectrum—Violet, Blue, Green, Green, Yellow, Orange and Red. When the disc is rapidly rotated, the various colours blend together forming (under ideal conditions) a white appearance. In practice, however, owing to the difficulty of matching the colours accurately, the resulting appearance of the whirling disc is greyish-white rather than pure white.

Newton's disc serves to illustrate the fact that white light is a composite of all the coloured rays of the spectrum.

Newton's Rings.—Name applied to rings of colour which appear when two ordinary flat surfaces of glass are pressed together. The name is used in remembrance of Sir Isaac Newton, who conducted many experiments with the phenomenon.

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Newton's rings are due to the light-interference effects of a thin layer of air existing between the two surfaces of glass which are not *perfectly* flat. If the glass surfaces were absolutely flat, the Newton's rings would disappear.

The production and disappearance of Newton's rings forms a very delicate optical test for perfect flatness. Such a test is used in the making of "optical flats" for the construction of mirrors and colour-filters of extreme accuracy for television and other scientific purposes.

Nickel.—Chemical symbol: Ni. Atomic weight: 59. A silvery-white metal, which, although hard, is malleable and ductile. It is slightly magnetic.

In television and radio construction, nickel is used extensively for the making of the "metalwork" of cathode-ray tubes, neon lamps, valves and other similar devices.

Nicol Prism.—An optical device used in some television systems in conjunction with the Kerr cell, or light-valve. It consists of two specially prepared crystals of Iceland Spar cemented together in such a way that a ray of light passing through the prism is split up into two parts. One of these, the "ordinary" ray, is turned aside and led out of the prism. The remaining ray—the "extraordinary" ray—which is polarised, is utilised for the purpose required.

The device derives its name from its inventor, an ingenious optician named Nicol.

Nipkow Disc.—Name sometimes given to the scanning disc employed in many television systems. It was originally the invention of the Polish scientist, Paul Nipkow, in 1884. Nipkow employed it in the crude shadowgraph transmitters with which he experimented at the end of the last century.

See *Scanning Disc*.

Nitro-benzene.—Chemical formula: $C_6H_5NO_3$. A pale-yellow liquid prepared by treating benzene with a mixture of nitric and sulphuric acids. It possesses a powerful almond-like odour.

In television technique, nitro-benzene finds a use in the construction of Kerr cells.

Noctovision.—Name applied by the Baird Company to a system of television by means of infra-red rays. The individual to be televised is placed before the televisor in a darkened room. His features are then flooded with infra-red light to which his eyes are practically insensitive so that, at the most, all that he perceives is a very faint dull-red glow. The subject of the television is scanned in the usual manner by revolving disc or

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mirror-drum, the infra-red rays being picked up by photo-electric cells of a special pattern which are highly sensitive to infra-red rays. In this manner, an individual seated in apparent darkness may be televised and his image will appear on the receiving screen just as though the televised subject were subjected to normal white light illumination.

Other very interesting applications of the principle of Noctovision are possible.

Noctovisor.—Term employed by the Baird Company to denote its infra-red ray television transmitter.

See *Noctovision*.

O

Objective.—A frequently used term which denotes the image-forming or projecting lens of an optical instrument, as, for instance, the projecting lens of a television or film-television apparatus.

Optical Axis.—See *Axis*.

Optical Flat.—Name given to a piece of glass one or both surfaces of which are perfectly and uniformly flat. Skilled optical working is required to make an optical flat. "Flats" are used in the construction of mirror reflecting surfaces of extreme accuracy and, also, in the making of the highest grade colour-filters.

See *Newton's Rings*.

Origin Distortion.—A type of image distortion which is set up on the fluorescent screens of some low-voltage cathode-ray tubes under certain conditions.

Below a certain critical potential of the deflector plates (about 10 to 12 volts) the path of the electron or cathode-ray beam is not uniformly deflected by the voltage changes on the deflector plates. The consequence is that the beam apparently drags or slows down, thereby giving rise to an area or line of brighter glow on the fluorescent screen, and thus setting up a distortion of the image.

Origin distortion is sometimes termed "Threshold Effect."

Oscillatory Scanning.—Name given to scanning methods by means of which the light spot oscillates or travels forwards and backwards over the image to be televised. After each complete oscillation the light spot shifts laterally thus enabling a new area of the picture to be scanned. Oscillatory scanning possesses many practical disadvantages.

Oscillogram.—Name given to the wave-like pattern, representing the graphical form of an alternating current, which is

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traced out by the light spot on the fluorescent screen of a cathode ray oscillograph tube.

Oscillograph.—See *Cathode-ray Tube*.

Out of Frame.—The state of a televised image when, as seen on the screen of the receiver, it is divided horizontally or vertically, the two portions of the image appearing in opposite positions. The image is correctly "framed" by the manipulation of a small control which influences the synchronising gear of the receiver.

Oxygen.—Chemical symbol: O. Atomic weight: 16. The well-known colourless, odourless, life-giving gas which constitutes about 23 parts by weight of the earth's atmosphere.

Small traces of pure oxygen are sometimes introduced into certain types of photo-electric cells in order to modify their response to light action. Cæsium-oxygen cells, for instance, are specially sensitive to red light.

P

Pantelegraph.—Name given to an early picture-transmitting apparatus demonstrated in this country by the Abbé Caselli, an Italian, in 1856. Between 1865 and 1869 Caselli's apparatus was in actual operation between Paris and Amiens.

Caselli's Pantelegraph was a modification of the chemical telegraph recorder, a metal stylus at the receiving end tracing out a pattern or a drawing on paper sensitised by potassium cyanide.

Parabolic Reflector.—Name given to a light reflector, usually of highly polished metal, which, being shaped to a parabolic curve (a parabola is the section of a cone cut parallel to one of its sloping sides) causes a beam of parallel rays to be reflected from an illuminating source placed in the focus of the reflector.

Parabolic reflectors are frequently used for obtaining strong beams of parallel light rays in optical experiments connected with illuminating and light-projecting matters.

Parallel Rays.—Light rays which travel parallel to one another, as, for instance, the light rays reflected from a parabolic reflector.

Light rays coming from a very distant object, such as the sun, are always parallel from a practical standpoint, although, in strictest truth, they are very slightly divergent.

Pencil of Light.—Name given to a narrow beam of light rays which diverges from or converges to a given point or area. The "flying spot" of a disc television transmitter is, for example, created by a pencil of light.

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Pentane Lamp.—A type of standard lamp which, in this country, has been adopted by the Board of Trade as a standard light source.

In the pentane lamp coal gas is passed over the surface of pentane (a constituent of petrol) and is then burned at a special burner of the Argand type, precautions being taken to keep the gas pressure and the height of the flame constant. A pentane lamp usually emits a light of one standard candle-power, although lamps of this type can be obtained which will develop a light of 10 c.p.

In scientific work associated with light comparisons, etc., the pentane lamp has not been much used.

Persistence of Vision.—When light rays impinge upon the retina of the eye the impression which they make does not cease immediately the light rays stop. On the contrary, it persists for an appreciable time afterwards, this effect being known as "persistence of vision," or "visual persistence."

It is upon this "lag of the retina," as persistence of vision is sometimes called, that we are able to build up a reproduction of motion on the television or cinema screen, in both instances a series of successive pictures (each differing slightly from the preceding one) being formed or thrown on a screen so rapidly that the eye is not able to get rid of the impression made by the one picture or image before the next one arrives.

Persistence of vision lasts for approximately one-twelfth of a second. Hence, if a series of varying images are projected upon a screen at a minimum rate of twelve per second, the effect of motion will be obtained.

It should be noted that persistence of vision is a phenomenon which is attached to the actual *retention* of the image on the retina of the eye. The *perception* of the image by the retina in the first place is, so far as we can tell, instantaneous.

Phase Shift.—A condition in television reception in which, owing to stray circuit capacities in the receiver, the fluctuations in voltage do not keep in step with those originally transmitted, particularly at high and at low frequencies. This results in some of the details of the televised picture being received at a later instant of time than the remainder of the picture, thereby setting up a displacement or distortion of the televised image.

Synonyms: *Phase Displacement, Phase Distortion.*

Phonic Drum.—An early synchronising device employed by television workers. It was the invention of M. la Cour.

The phonic drum comprises a hollow drum made of wood or of some non-magnetic material, such as aluminium or copper, on the outer edge of which are fixed at regular distances apart

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a series of iron strips. By being caused to rotate in close proximity to the poles of an electro-magnet which is fed with alternating or fluctuating current, the phonic drum of M. la Cour can be employed as a simple type of synchronous motor.

Phonovision.—A word coined by the Baird Company to designate a process by which a televised picture or image may be stored up in the form of a gramophone record and subsequently "released" as often as desired.

In the phonovision system the electrical impulses from the transmitting photo-cells are led to a recording pick-up which traverses a wax blank on an ordinary gramophone recording machine. In this way the varying electrical pulses are stored up in the form of variations of the groove.

When it is desired to reproduce the image or picture thus "bottled-up" the record is played over with a pick-up, the output current from which, after being amplified, is led to a neon lamp in front of which revolves a scanning disc. An observer looking through the disc will see a reproduction of the original image.

If desired both light impulses and music or speech may be stored up in the same record, a double track record being made.

Phonovision, at the present day, is merely a scientific curiosity, but it has many interesting possibilities.

Photo-Cell.—An abbreviation of "Photo-electric" cell, which see.

Photo-conducting Cell.—An electrical cell whose electrical resistance varies according to the intensity of the illumination which impinges upon its sensitive surface.

Selenium cells, which do not actually generate current, but merely change in electrical resistance under light influence, are typical examples of photo-conducting cells.

Photo-Conductivity.—Term used to describe the electrical conducting powers of a body under the influence of light.

Photo-electric Cell.—A light-sensitive device which, by emitting a stream of electrons under the influence of light rays and in proportion to the amount of light falling upon it, enables light to be turned into electricity.

Photo-electric cells are of two kinds, viz.: the *Emission* type and the *Photronic* or *Self-generating* type.

See *Emission Cell*, *Photronic Cell*.

Photo-Electric Effect.—See *Hertz Effect*.

Photo-Electrics.—Term applied to denote certain substances which, by a mechanism of electron emission, create minute electric currents when light falls upon them. Many metals, as well as other more complex materials, fall under this category.

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It is upon the properties of such materials that the now many types of photo-electric cells are based.

Photo-electrolytic Cell.—A light-sensitive cell whose action depends upon the production of the "Becquerel Effect," i.e. the setting up of a current when two metal plates, one of which is strongly illuminated, are suspended in certain chemical solutions.

"Liquid cells" are well-known examples of photo-electrolytic cells.

See *Liquid Cells, Becquerel Effect.*

Photo-Electrons.—Name sometimes applied to the stream of electrons which are liberated from certain bodies under the influence of light.

Photo-electric cells operate in virtue of the presence within them of a stream of photo-electrons whenever they are illuminated by light rays.

Photo-Emission.—The emission of electrons from bodies under the influence of light.

Photo-Luminescence.—A scientific term which denotes the emission of light from a substance under the action of light. The term is a general one, including all cases of *fluorescence* and *phosphorescence*, which see.

Photo-Sensitive.—Term signifying "sensitive to light." Photo-electric cells, selenium cells, certain chemical solutions, photographic plates, films, papers, etc., are all photo-sensitive articles, although in different instances the photo-sensitivity is manifested in varying ways.

Photo-Telegraphy.—Name applied to various systems whereby a photograph or image is transmitted and received by wireless or by means of a landline communicating channel. Photo-telegraphy is, in some respects, "slow-motion television," for by means of it the picture is transmitted slowly, piece by piece, and reassembled at the receiving end at a similar rate, whereas in systems of true television the breaking up and re-assembly of the picture is accomplished with extreme rapidity.

Photo-Voltaic Cell.—Name given to a type of light-sensitive cell in which a potential difference is set up across the rectifying junction of a metal and certain semi-conductors when the contact is strongly illuminated.

Photronic Cell.—A type of photo-electric cell in which the sensitive surface, under the influence of light, generates sufficient current to flow through an external circuit connected up to the cell. This general type of photo-electric cell is also known as the *Self-generating cell.*

Photronic cells are more sensitive than the Emission types of

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photo-electric cells, and they are a more recent development than the latter.

See *Emission Cell*.

Picture Elements.—Name given to the minute areas into which a picture, portrait, or scene which is to be televised is split up by one means or another. The picture elements are all of the same size, but they differ in brightness. Each picture element is projected in its turn upon the light-sensitive cell, thus giving rise to a current pulsation corresponding in intensity to the degree of brightness of the picture element.

Picture Intensification.—See *Intensifying Circuit*.

Picture Points.—See *Picture Elements*.

"Plane" Cell.—A type of gas-filled photo-electric cell.

Plate Neon Lamp.—Name applied to a neon lamp or tube in which the glow appears at the surface of a rectangular metal plate. Neon lamps of this type (of which there are many different varieties) are largely used in television receiving systems.

Point Neon Lamp.—A type of neon lamp in which the glow is concentrated upon a very small surface. In some lamps of this description the glow can be concentrated into an area having a diameter of very little more than a millimetre. Lamps of this type provided a light source of high efficiency for certain television uses.

Polarisation.—Applied to light rays the term denotes the cutting off of all the rays in a beam of light except those which vibrate in one plane. Light consisting of these one-plane vibrations is said to be "polarised," and, in such a condition, it possesses peculiar properties of its own. Light rays are usually polarised by passing them through certain crystals, such as Iceland Spar, which effect the process automatically.

Positive Image.—The image as it is normally seen on a television screen. A photograph or any other type of illustration is a positive image, the lights and shades of it being a true or approximate reproduction of those of the original. A positive image is, as its name implies, the opposite to a negative image.

See *Negative Image*.

Potassium.—Chemical symbol: K (from the Latin, *Kalium*). A member of the alkali group of metals. Atomic weight: 39. Melting point: 65.5°C. Specific gravity: 0.859.

Potassium metal has properties very similar to those of metallic sodium. It is a very soft metal, highly oxidisable, and, like sodium, it will decompose water with the evolution of hydrogen.

Metallic Potassium, and also potassium hydride, KH, are highly photo-electric and are used in the construction of certain types of light-sensitive cells for television working.

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Potassium Iodide.—Chemical formula: KI. A white crystalline substance which liberates free iodine under the influence of an electric current. This electro-chemical action is made use of in several systems of photo-telegraphy, or picture transmission, a moving metal stylus traversing a sheet of potassium iodide-treated paper, which has been wrapped round a revolving cylinder and liberating free iodine in the pores of the paper in accordance with fluctuating currents derived from the transmitting end of the apparatus, in this manner building up a replica of the original picture in brown iodine.

Presbyopia.—Physiological term denoting long-sightedness associated, also, with lack of the power of distinguishing near objects clearly. It is the "sight of old age."

Presser's Cell.—A selenium cell comprising a circular slab of steatite (soapstone) covered with platinum and ruled with concentric grooves something after the fashion of a gramophone record. The surface thus created was covered with a thin layer of selenium.

Primary Current.—A term used in connection with gas-filled photo-electric cells to signify the actual minute current set up by the impact of light upon the sensitive cathode of the gas-filled cell.

Prism.—A triangular-shaped piece of glass or other transparent material used in practical optical work for bending rays of light through a right-angle, and also, in the spectroscope, for splitting up rays of light into their component colours.

Prismatic Disc.—See *Jenkins' System*.

Pupil.—The circular aperture in the centre of the iris of the eye which has the appearance of a dark spot and through which light passes on its way to the retina.

See *Iris*.

Q

Quantum Theory.—A theory of radiation and energy originally put forward by Planck in 1901. According to the quantum theory, no form of radiation is continuous, but, like matter, it consists of small, indivisible units, or "quanta."

Light radiation is not emitted from a body in a continual stream of rays, but is made up of "bundles," or units of energy (known as "light-quanta"), which are released from the luminous body at regular intervals in much the same way as a stream of bullets is released from a machine-gun.

The quantum theory, despite the fact that it affords a reasonable explanation of many phenomena connected with light and

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other electro-magnetic radiation, is by no means universally accepted by physicists. It is, however, a theory which should be grasped by all students of light energy and its effects.

Quartz.—Chemical formula : SiO_2 . Silicon dioxide. A common form of silica, also known as *Rock Crystal*. It freely transmits ultra-violet rays. Selected specimens of quartz are, therefore, sometimes ground into lenses to be used for purposes in which the free transmission of ultra-violet light is essential.

Ordinary glass lenses absorb a considerable proportion of the shorter ultra-violet rays. Hence any future system of television transmitting entirely by the invisible ultra-violet rays will have to make use of lenses ground from clear quartz or rock crystal.

Quartz Lamp.—Another name for a mercury vapour lamp, which see.

Quinine Sulphate.—A well-known compound which, in addition to being strongly fluorescent when dissolved in suitable solvents, is also light-sensitive. Dissolved in water containing a trace of sulphuric acid, quinine sulphate will generate a minute current under the influence of light when contained in a special cell made for the purpose.

R

Radio-Photography.—A name sometimes applied to systems of photo-telegraphy which employ a wireless communicating channel.

Recurrent Vision.—Name given to the phenomenon of an image recurring one or more times to the eye after the actual light rays from the object have been cut off.

Recurrent vision was first noted by Young, in 1801, who observed that after an object had been intensely illuminated by an electric spark, the image recurred to the eye several times after the spark had passed, the image becoming fainter with each successive recurrence.

Red Selenium.—A form of selenium having the appearance of a brick-red powder. It is a high insulator, and only becomes light-sensitive after careful and prolonged heating.

Reflection.—The recoil of light rays from the surface on which they impinge.

Reflection is said to be *regular* when, as in the case of a mirror, the light rays are reflected back in an orderly and unbroken manner. Reflection is said to be *irregular* when, as in the case of light reflected from a whitewashed wall or a sheet of white paper, the reflected rays do not travel back in an orderly manner, but are broken up and scattered by the reflecting surface.

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Reflection is a very important factor in television science for the reason that most of the light dealt with in the televising of an image is of the reflected variety.

Although glass mirrors form the most usual type of reflectors, the most perfect reflectors are made from the highly-polished surfaces of various alloys of copper, zinc and silver, these forming what are known as *speculum metals*.

There are two well-known "Laws of Reflection":—

- (1) The incident light ray (i.e. the original ray), the reflected ray, and the imaginary perpendicular line drawn from the surface of the reflector are all in one and the same plane.
- (2) The angle of incidence of the light ray (i.e. the angle which the original or entering ray makes with the reflecting surface) and the angle of the reflected ray are equal.

These laws operate universally in all cases of reflection. They ought, therefore, to be fully understood by all amateurs who are concerned with the optical side of television working.

Reflection Factor.—The extent to which a surface reflects light. In daylight, white paper has a reflection factor of approximately 80 per cent, whilst grey, yellow, blue and red papers have reflection factors of about 65, 60, 40 and 20 per cent respectively.

Since the light dealt with in normal television transmission is of the reflected variety, a study of the reflection factors of various materials and colours under different kinds of illumination is of the utmost importance to television transmitting efficiency.

Refrangible.—Term meaning "refractible," i.e. that which may be bent or turned aside.

Light rays are capable of refraction and are, therefore, sometimes said to be *refrangible*, the rays at the violet end of the spectrum, which are capable of greater bending, being more refrangible than those at the red end of the spectrum.

Regular Reflection.—See *Reflection*.

Resolving Power.—The ability of the eye or of a lens to determine detail.

The resolving power of the eye is lessened by intermittent lighting and also by feeble illumination—two facts which have to be taken into consideration in the design of an efficient television reception screen.

Retina.—The membrane at the back of the eye, upon which the objects viewed are focused by the lens of the eye. The retina is made up of a very fine mosaic of exceedingly minute cells—the rods and cones—which are filled with a purple dye which is bleached under the influence of light. This bleaching

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action is communicated to the brain along the optic nerve, there giving rise to the sensation of light.

From the Latin, *rete*, a network.

See *Rods and Cones*, *Visual Purple*.

Reversed Image.—A reversed image on the screen of a television receiver may manifest itself in two varieties. It may take the form of a negative image, similar to that seen in a photographic negative, in which the white parts of the original picture appear black and *vice versa*, or the image may be laterally reversed, i.e., one in which the right side of the original appears on the left side of the television screen and the left side of the original on the right side of the screen, this type of reversed image giving rise to the term "mirror effect."

Reversed images in television reception are nearly always associated with faulty adjustments, either electrical or mechanical, of the apparatus, and they are remedied without much difficulty.

Rhodamine.—A light-sensitive dye which, in a specially constructed cell, yields up a minute current when illuminated by strong light.

Righi's Cell.—A form of selenium cell, dating from 1888 or thereabouts. It consisted of a series of thin selenium discs held between wire gauze.

Ring Cell.—A type of photo-electric cell in which the cathode consists of a layer of the light-sensitive material deposited on the cell walls the anode consisting of a gauze-covered metal ring fixed above the cathode layer.

Rods and Cones.—Anatomical expression used to denote the exceedingly minute cells which comprise the active surface of the retina of the eye. Spaced over the retina of the eye there are approximately five million of these cells, each of which is filled with a light-sensitive pigment ("visual purple").

The "rods," or rod-like cells, are sensitive to low intensity illuminations, the "cones," or cone-shaped cells, being sensitive to average and to high-intensity illuminations. The rods and cones are not situated equally in all areas of the retina, there being a super abundance of cones towards the centre of the retina. Hence the retina is more sensitive to average and high illumination intensities at its centre than it is at its margins.

See *Retina*, *Visual Purple*.

Rosing's Apparatus.—An early form of television apparatus, first devised by Boris Rosing, a Russian, in 1907. Rosing employed in his transmitter an arrangement of revolving mirrors, which threw an image of the object to be televised on to the surface of a selenium cell. The pulsating current from the selenium cell was transmitted along a wire to the receiving

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instrument in which it charged up a series of condenser plates, which exerted a deflecting action upon a beam of cathode rays in a cathode-ray tube. Rosing's television receiver constitutes a very early use of the cathode rays as a means of practical television.

Rubidium.—Chemical symbol: Rb. A member of the alkali group of metals. Atomic weight: 85. Melting point: 39°C. Specific gravity: 1.525.

A silvery-white metal similar in properties to sodium and potassium, but much rarer than the two latter.

Metallic rubidium and, also, rubidium hydride, RbH, are extremely photo-electric, and they enter into the construction of some light-sensitive cells.

Ruhmer's Cell.—A cylindrical type of selenium cell first constructed by Ruhmer in 1902. It comprised an inner cylinder, or column of steatite, which was wound with wire and subsequently coated with fused selenium. Several patterns of this cell were forthcoming.

S

Sabine's Cell.—A fluid type of selenium cell consisting of a metallic plate, varnished on the one side and selenium coated on the other, which was placed opposite to a similar plate in a weak acid or salt solution.

Under the influence of strong light, this cell, unlike other selenium cells, was found to generate its own current. Cells of this type are sometimes known as "electrolytic selenium cells."

Sale's Theory.—An early theory of selenium's light-sensitivity, first propounded by Sale, in 1873. The theory ascribes the light-sensitivity of selenium as being due to electro-magnetic waves in the ether, which penetrate the selenium atoms and so increase the conductivity of the entire mass of selenium. This theory is open to several disadvantages.

Sanabria System.—A method of television transmission and reception devised by Ulysses A. Sanabria of Chicago. The Sanabria transmitter operates upon well-known television principles of scanning. The receiver, in virtue of a special type of neon lamp, is enabled to throw an image of considerable size upon a screen.

Scanning.—Term given to an important principle of television working in which the whole area of the picture or image to be televised is "scanned" or scrutinised piece by piece in a series of straight lines or strips (vertical or horizontal), by means of a rapidly moving light spot. The image is thus translated into

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a sequence of areas of light, shade and darkness, which sequence is converted into pulsating electrical currents by means of a light-sensitive cell.

Scanning Disc.—Name given to a metal disc accurately perforated with a series of holes or apertures in spiral or circular formation, the apertures being sometimes filled up with lenses. The disc is caused to revolve at a high speed in front of the object to be televised, the result being that a narrow beam or spot of light is made to "scan," or to traverse rapidly in a series of "sweeps" or "lines," each portion of the picture.

Scanning discs, in one form or another, constitute the basis of the simplest mechanical methods of television transmission and reception.

See *Nipkow Disc, Apertured Disc, Lens Disc.*

Scanning Lines.—Term referring to the vertical or horizontal lines in which a scanning spot sweeps over an image. Other factors being equal, the greater the number of "lines" the more detail there will be in the received image.

"30-line scanning" means that the scanning spot sweeps over the image to be televised in 30 lines before returning to its original position and beginning the sequence of events again. In the same way, "120-line scanning" denotes that the scanning spot sweeps over the image in 120 separate lines.

Scanning Spot.—The small light spot which, by one method or another, is made to sweep continuously over every portion of the picture or image to be televised, thus enabling the picture to be split up into a large number of small areas, or "picture elements."

Other factors being equal, the smaller the scanning spot, the finer in detail will be the televised image, for a small scanning spot will enable the light and shade (in order words, the detail) of the picture to be picked up and transmitted with precision, a task which becomes more and more impossible with increase in size of the scanning spot.

Synonyms: *Tracing Spot. Exploring Spot.*

Scansion.—The operation of scanning.

Sclerotic.—The outer coat of the eye which completely surrounds it, and which, at the front of the eye, has a white opalescent appearance, thus giving rise to the "white of the eye."

From the Greek, *skleros*, hard.

See *Choroid.*

Scophony.—A television system invented by Mr. G. W. Walton. The image to be transmitted is projected on to a specially constructed "stepped" or *échelon*, prism or reflector, which so displaces the image laterally that the picture is spread out into a continuous line. This line is then scanned by means of

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some vibrating light spot, the picture elements thus created being passed through the photo-electric cell and transmitted in the usual manner.

At the receiving end of the Scopphony apparatus a line of light is created and modulated in exact accordance with the incoming current impulses derived from the transmitter. By means of another stepped prism or mirror-reflector this line of light is built up into a reproduction of the transmitted picture.

The word "Scopphony" is compounded of "telescope" and "telephone," it being intended by the inventor to receive both light and sound by means of the instrument.

Screen.—In connection with cathode-ray tube working this term refers to the flattened end of the cathode-ray tube which is coated with a fluorescent material, and which provides a screen which glows brightly under the impact of the rays, and upon which the picture is formed.

Selective Absorption.—When white light falls upon the surface of an opaque object, the object absorbs from the white light all its constituent colours except the one which it reflects. The coloured object, therefore, selectively absorbs certain colours from the white light, reflecting the remainder.

A green object, for instance, selectively absorbs all the colours of white light except green, which it reflects.

The same applies to the selective absorption of light rays by transparent colour filters.

Some photo-electric cells selectively absorb light rays of one wave-length or colour.

Selenide.—Name given to compounds of metals with selenium, as, for example, lead selenide, PbSe.

The presence of selenides in selenium has the effect of very considerably reducing the light-sensitivity of the latter. Hence care should be taken to expose heated selenium as little as possible to metallic surfaces when making selenium cells.

Selenium.—Chemical symbol: Se. Atomic weight: 79. Melting point: 217°C. Specific gravity: 4.28-4.80 (varies).

A non-metallic element, closely allied to sulphur in many of its properties. Selenium exists in a number of different forms, some of which are light-sensitive, and are used in the construction of selenium cells.

The light-sensitivity of selenium was first noticed by a Mr. May, a telegraph operator in the employ of the Telegraph Construction Company, in 1873, when experimenting with high resistances composed of selenium at the Cable Station on Valentia Island, off the south-west coast of the Irish Free State.

The name selenium (from the Greek, *selenē*, the moon) was

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given to the element by its discoverer, J. B. Berzelius, the great Swedish chemist, in 1817, owing to its resemblance in some respects to the metal tellurium (Latin, *tellus*, the earth), which had been discovered some years previously.

Senlecq's Apparatus.—See *Telectroscope*.

Shadowgraphs.—Name applied to the shadow outlines of images which were transmitted electrically from one point to another by various television pioneers and notably to those transmitted at the end of the last century by Nipkow, a Polish physicist.

Shield.—Name given to a small metal cylinder which, in some cathode-ray tubes, encloses the filament or cathode and extends nearly as far as the anode. The shield is given a negative electrical bias, thus enabling it to repel any of the electrons emitted from the filament which may happen to come near it. It acts in much the same manner as the grid of a valve, its function being to concentrate the electron stream from the filament or cathode into a narrow beam, which will pass almost uninterruptedly through the central aperture of the "gun," or positively charged anode.

The shield of a cathode-ray tube is sometimes known as a Wehnelt cylinder, after its inventor.

Siemens' Cell.—The first of all selenium cells to be constructed.

The invention of W. Siemens, in 1876—three years after the discovery of the light-sensitive nature of selenium—it comprised two platinum wires, spirally wound and secured to a mica sheet. The wire surface was then coated with selenium, the active "face" of the cell subsequently being "formed" by heating the entire cell to a temperature of 200°C. for four or five hours.

Siemens' Theory.—A theory of the light-sensitivity of selenium first put forward by Siemens in 1875. On this theory there are two forms of selenium, *a-selenium* and *β-selenium*—existing side by side in equilibrium within a mass of the material. *a-selenium* is a poorly conducting variety, whilst *β-selenium* is a good conductor. Under the influence of light a physical change takes place within the selenium, whereby a quantity of the poorly conducting *a-selenium* is converted into the better-conducting *β-selenium*, thus increasing the conductivity of the mass of selenium. On the cessation of the illumination the *β-selenium* thus generated automatically changes back again into *a-selenium*. This change is not instantaneous. Hence the "time lag" which is present in all selenium cells.

This theory of selenium's light action has been a much favoured one, it having been ascribed to by Berndt, Biltz, Hesehus, Pfund, Marc, Browne, and other scientists.

"Slow-Motion Television."—See *Photo-telegraphy*.

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Soapstone.—See *Steatite*.

Sodium.—Chemical symbol: Na (from the Latin, *Natrium*). A member of the alkali group of metals. Atomic weight: 23. Melting point: 97°C. Specific gravity: 0.972.

Sodium is a silvery-white metallic element, so soft in character that it can be cut through with a knife. Sodium decomposes water violently with the evolution of hydrogen gas. The metal is highly oxidisable, rapidly becoming coated with a white film of oxide when exposed to the air.

Metallic sodium and, still more, its hydride (NaH) are photoelectric, and are employed in the construction of light-sensitive cells. Some gaseous discharge tubes also contain sodium, these tubes glowing with a yellowish-white light.

Sparkling Voltage.—A term used in connection with photo-cell technique to denote the anode voltage of a gas-filled photoelectric cell, which so greatly ionises the gas contained within the cell that a continuous discharge passes through the cell. The applied voltage should never reach this critical point, for the electrical discharge through the cell quickly destroys its efficiency.

Synonym: *Sparkling Potential*.

Spectrum.—Name given to the multi-coloured band of light which can be thrown on to a screen after passing a beam of white light through a prism, or light-splitting device.

The colours of the spectrum are seven in number. In order they are: violet, indigo, blue, green, yellow, orange and red. Beyond the violet and the red ends of the spectrum are, respectively, the ultra-violet and the infra-red rays, both of which are invisible to the human eye. It is from combinations of the various coloured rays of the spectrum that all kinds of visible light are made up. The exact constitution of the light used is very often a matter of greatest importance in television technique.

From the Latin, *specere*, to see.

Spermaceti.—Chemical formula: $C_{16}H_{33}O.CO.C_{15}H_{31}$. A white waxy substance, which is obtained, mixed with oil, from the head of the Sperm whale. Among many of uses it is employed for the making of the British Standard Spermaceti candle, whose flame gives an illumination of one candle-power.

See *Candle-Power*.

Spherical Aberration.—A defect inherent in some lenses of poorer quality whereby all the rays of light transmitted by the lens are not focused accurately in the one plane, the light rays passing through the margins of the lens coming to a different focus from those passing through the centre of the lens. The

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fault is due to the spherical or semi-spherical surface of the lens. It is a defect which is corrected in all good quality lenses.

Spherical Cell.—A type of photo-electric cell in which the electrodes are contained in a spherical bulb.

Spider Disc.—Name applied to television scanning discs in which the outer rim is secured to the centre area or boss by means of metal strips or spokes.

Spiral Scanning.—A scanning system, of American origin, in which the travelling light spot, commencing at the centre of the picture to be televised, describes an expanding spiral outwards to the borders of the picture and, having arrived there, traces a contracting spiral until it reaches the centre of the image again. This succession of expanding and contracting spirals is performed with great rapidity by means of an ingenious arrangement of an eccentrically mounted mirror.

Spiroidal Scanning.—The American name for the system of spiral scanning recently devised in the United States.

See *Spiral Scanning*.

Split-Picture.—Term referring to the state of affairs in a television receiver when, owing to faulty synchronisation adjustment, the received picture is split down the middle and displaced to both sides.

Sputtering.—Term used to designate a phenomenon which sometimes occurs in neon and other gas-discharge tubes. The positively charged ions of gas (which are formed as a result of the electric bombardment of the particles of neon gas within the tube) travelling at high speed, bombard the surface of the negative electrode, or cathode, of the tube, sometimes causing an atom of the cathode metal to disintegrate and to fly off. Such a disintegrated atom will stick to the glass wall of the tube, and it will embed with it also an atom of the neon gas. As a result of this metallic "sputtering" the neon gas content of the tube becomes lower and lower, the vacuum of the tube increasing in proportion, until, eventually, the vacuum becomes so high that the electric discharge refuses to pass through the tube.

In modern neon and other discharge tubes the effects and possibilities of sputtering are minimised and eliminated to as great a degree as possible.

Staggered.—In television terminology this expression refers to the arrangement of the holes on a scanning disc. The holes are set in the disc at equal intervals, and they are "staggered" by being placed on successive concentric circles so that they form a portion of a spiral.

Stationary Mirror-Drum.—A television scanning device due to Denes von Mihaly, the well-known Hungarian television

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experimenter. It consists of a circular frame around the inside of which are arranged a series of mirrors. A beam of light is reflected round these stationary mirrors from a revolving mirror set in the centre of the drum.

Steatite.—Another name for soapstone. A form of talc having a peculiar soapy feel. It consists chiefly of magnesium silicate, and, on account of its high insulating nature, it has been extensively used in the construction of certain types of selenium cells.

Stereoscopic Television.—Television in which the received image stands out in stereoscopic relief. As attempted by the Baird Company, a form of stereoscopic television has been achieved by the use of a dual scanning system and of two entirely distinct transmitters, the two images thus transmitted being viewed at the receiving end through a stereoscope apparatus.

From the Greek, *stereos*, solid, *skopein*, to see.

Stixograph.—The name given by its originator, Mr. G. W. Walton, to an elongated, or ribbon-like development of an image. In Mr. Walton's apparatus the stixograph is caused to move over the scanning aperture of the televisor by means of an extremely light moving optical part, thus presenting the image in successive stages.

Cinematograph films can be taken by an application of the stixograph method, the images being spread out into a continuous ribbon on a film of narrow width which moves through the gate of the projector at a comparatively slow speed.

Stops.—See *Diaphragm*.

Striking Voltage.—Term used in connection with neon lamps and tubes to denote the initial voltage which must be applied across the electrodes in order to start the electrical glow-discharge within the tube. Once this has been commenced, the applied voltage can be reduced considerably with stopping the glow.

Synonym : *Firing Voltage*.

See *Extinguishing Voltage*.

Stroboscope.—A device by means of which the periodic motion of a mechanism may be rendered apparently stationary.

A stroboscopic disc is a disc of metal, card, or other material, specially marked, and which, when rotated under intermittent illumination (as for instance, that of an A.C. incandescent lamp) appears stationary when its rate of revolution attains a certain pre-calculated degree. On account of this effect, stroboscopic discs of varying patterns and forms of construction are used extensively for speed measurement purposes.

From the Greek, *strobos*, a turning, *skopein*, to see.

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in America by Abronheim, in which, by means of a colour-filter disc geared to the scanning disc, the various colours of the image to be transmitted are sorted out and made to impinge upon a bank of photo-electric cells, each of these cells possessing a selective response to one colour only. At the receiving end the picture is projected or viewed through a similar colour-filter disc, an approximation to the original colours being the result.

Telelogoscopy.—A term applied to the television transmission of printed characters on a moving tape or band.

Television.—It is not strictly correct to define television as the art of seeing at a distance. A telescope enables us to see at a distance, but such an instrument does not fall into the category of television apparatus.

Television is best defined as the electrical transmission and reproduction at a distance of light rays constituting views, scenes or objects, fixed or moving, the electrical transmission being effected either by wire or wireless.

Television Eye.—A popular name sometimes applied to the light-sensitive cell of a television transmitter.

Television Resonator.—A crude television device, the invention of the late Dr. E. E. Fournier d'Albe, in which the image to be televised was broken up (according to its lights and shades) into areas of different musical frequencies. This was effected by a band of perforated paper which was wound in front of the picture. The intermittent light thus produced was concentrated upon a selenium cell, the output current from which was then transmitted to the receiving apparatus.

At the receiving end the incoming signals were turned into sound by means of a loud speaker. The loud-speaker note was "analysed" by means of a composite "television resonator," which consisted of a specially designed rectangular box having a reed of silvered mica at one end. The reed, vibrating in virtue of the resonance of the box, reflected a light spot on to a screen, the position of the light spot varying in accordance with its degree of vibration, which, in its turn, was dependent ultimately upon the amount of light and shade "picked up" from the picture at the transmitting end. In this way a crude reproduction, in coarse patches of light and shade, of the original picture was obtained at the receiving end of the apparatus.

Television Telephone.—An experimental system inaugurated in America by means of which two telephone users may both see and hear each other. The telephone cabinets are illuminated by arc lights, the television controls being situated at the rear of the cabinet and under the supervision of a special operator.

The television telephone working on the above lines is the only

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one of its kind in the world and is, therefore, the pioneer of a system which may, in due course, become well-nigh universal.

Telewriter.—Name applied to a form of writing telegraph by means of which outline pictures, sketches and handwriting could be transmitted over two landlines. A pencil at the transmitting end was carried by two arms, the movements of these arms operating variable resistances which varied the currents transmitted over the lines. At the receiving end two magnetised bars pulled against light springs. To the bars were attached light arms carrying between them a pencil which traced out the movements of the pencil at the transmitting end. The Telewriter attracted considerable attention about the year 1880.

Telorama.—A word suggested some years ago by Dr. D. McFarlan Moore, the distinguished American scientist and electrician, in place of the now universal term, "television." The expression, however, is now rarely come across.

Tetrachlorfluorescein.—A light-sensitive dye which, in solution, generates a minute current under the influence of light. Liquid "light cells" containing this material have been made.

Thallium.—Chemical symbol: Tl. Atomic weight: 204. A heavy, lead-like metal, first discovered by Sir William Crookes in 1861. Some thallium compounds, notably thallium oxo-sulphide, are light-sensitive.

From the Greek, *thallos*, a green twig—in reference to the characteristic spectrum line of thallium and its compounds.

Thalofide Cell.—A light-sensitive cell containing thallium oxo-sulphide. It was first constructed in 1920 by T. W. Case. Thalofide cells, like selenium cells, are of the "photo-conducting" type, i.e., they decrease in electrical resistance under the influence of light. Thalofide cells are specially sensitive to infra-red rays.

Thermionic Photo-Electric Cell.—A type of photo-cell, due originally to Dr. V. Zworykin, of America, which combines a photo-electric cell and an amplifying valve. It thus delivers an amplified current under the influence of light.

Threshold Effect.—See *Origin Distortion*.

Time Base.—Name applied to the fluctuating voltage applied across one pair of deflector plates of a cathode-ray tube in order to vary the lateral position of the light spot on the fluorescent screen of the tube. So-called because the side to side variations in the position of the light spot which occur at every succeeding instant appear as if the voltage on one pair of deflector plates had been charted against a time basis.

A "Time Base Circuit" is an electrical circuit, the purpose of which is to vary the voltage impressed upon a pair of deflector plates and thus to set up the horizontal motion of the light spot

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across the fluorescent screen of the cathode-ray tube. Time base circuits are of several types.

Time-Lag.—This term, usually, in television terminology, applied to light-sensitive cells, signifies the lapse of time between the impact of the light ray on the cell and the setting up of the

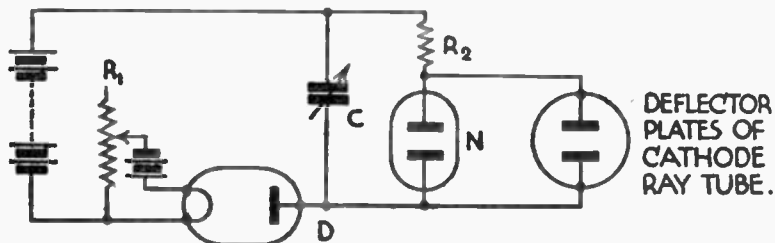


FIG. 229.—A simple form of electrical time base.

electrical effect which results. Also, to the time intervening between the cessation of the light action and that of the electrical effect.

Selenium cells have an appreciable time-lag. Photo-electric cells, on the other hand, are devoid of time-lag, being instantaneous in action. Hence they are used exclusively for practical television purposes.

Abbreviation : *Lag*.

Toothed-wheel Synchroniser.—A method of synchronising a television transmitter and receiver which has been evolved by the Baird Company. It comprises a small steel wheel provided with teeth set at equal intervals on its circumference. At opposite sides of the wheel are set two electro-magnets, their poles nearly touching the teeth on the wheel. The synchronising signals from the transmitter are led to the electro-magnets and any variation in the frequency of these incoming synchronising signals causes the toothed wheel to slow down or to accelerate, thus keeping the driving motor of the television receiver in perfect step or synchronisation with the motor of the transmitter.

Tracing Spot.—See *Scanning Spot*.

Translucent.—Name applied to describe a body which allows some light rays to pass through it but which reflects and absorbs others. Tissue-paper, "frosted" glass, etc., are translucent materials.

Tribo-Luminescence.—Term signifying the emission of light which is sometimes effected when certain solid bodies, such as sugar crystals, quartz, etc., are rubbed together in the dark.

From the Greek, *tribein*, to rub.

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Trichromatic.—Three-colour. Trichromatic television is now an accomplished feat.

See *Colour Television*.

Triple Scanning.—A system by which the image to be televised is scanned three times by means of a disc containing three sets of scanning holes, the series of holes being covered with red, green and blue colour-filters respectively. Such a triple scanning disc is employed in conjunction with the Baird experimental system of colour television.

See *Colour Television*.

Tuning-Fork Interrupter.—A synchronising device employed by Denes von Mihaly in his earlier television transmitters. A magnetised tuning-fork placed within the influence of a strong electro-magnet was used to produce pulsating synchronising currents of constant frequency

U

Ultra-Red Rays.—Another name for Infra-red Rays, which see.

Ultra-Violet Rays.—Name given to the invisible rays of the spectrum which lie beyond the violet rays. They are extremely active chemically, and are present in sunlight and in many artificial forms of light, such as the arc light, the light of the mercury vapour lamp, that of burning magnesium ribbon, etc. A considerable proportion of ultra-violet rays are stopped by ordinary glass. Hence photo-cells which are made to be specially sensitive to ultra-violet rays are constructed from quartz, or from special types of glass which are reasonably transparent to the rays.

U-type Cell.—A type of photo-electric cell which is specially sensitive to ultra-violet rays. Cells of this type have a cathode, the sensitive surface of which is composed of cadmium. Owing, also, to the fact that ordinary glass is more or less opaque to ultra-violet light, U-type photo-cells are equipped with a window of special glass, which is transparent to rays of ultra-violet light.

Uviol.—Name given to a certain type of glass which, being reasonably transparent to ultra-violet rays, is frequently employed in the construction of photo-electric cells.

V

Vacuum.—A space from which all matter has been removed.

There is, of course, no such thing as a perfect vacuum. Nevertheless, the degree of vacuum obtained by modern methods in

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some of the electrical tubes used in connection with television working is extremely high, the residual gaseous pressure in many such tubes being reduced to approximately one hundred-millionth of the normal atmospheric pressure.

Electrical tubes in which the degree of vacuum is very high are termed "hard" tubes; those whose vacuum is of a lower order are called "soft" tubes.

In many instances the vacuum of an electric tube or bulb is deliberately lowered by the introduction of a small quantity of an inert gas such as neon or nitrogen. These constitute the "gas-filled" tubes and lamps.

The most perfect degree of vacuum so far obtained was one in which it was estimated that no less than 99,999,999,990 per cent of the air existing within an electric tube had been removed.

From the Latin, *vacuus*, empty.

Vacuum Cell.—Name given to a type of photo-electric cell in which the electrodes are surrounded by a high vacuum, the electron stream emitted from the cathode under the influence of light being entirely dependent upon the strength of the light. Cells of this type are extremely constant in action and reliable in operation.

See *Gas-filled Cell*.

Valve Time Base.—A time-base circuit which employs radio valves as a means of providing a periodic voltage across a pair of deflector plates in a cathode ray tube.

See *Time Base*.

Variable-speed Scanning.—See *Velocity Modulation*.

Velocity Modulation.—A method of modulating the output current of a television transmitter by means of which the scanning spot moves quickly over the dark portions of the picture to be televised and slowly over the bright parts of the picture. Velocity modulation, or variable-speed scanning, is only applicable to cathode-ray systems of television.

See *Intensity Modulation*.

Velocity of Light.—Light rays do not travel from point to point instantaneously. Their rate of travel, however, is so enormous that for any distance on the earth's surface, normal observation is unable to detect any appreciable time-interval between the transmission of a light ray and its reception.

It has been shown, however, by several different methods that light travels through space with a speed of approximately 186,830 miles per second.

Vertical Scanning.—Term referring to scanning methods in which the light spot, beginning at the bottom right-hand corner of the picture or image to be televised, covers it rapidly in a series

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of vertical traces or "sweeps," each successive sweep of the scanning spot being to the left of the previous one.

Vertical scanning is employed by the Baird Company in its B.B.C. transmissions.

See *Horizontal Scanning*.

Viewing Lens.—As provided on most television receivers, this takes the form of a simple double-convex lens which is placed

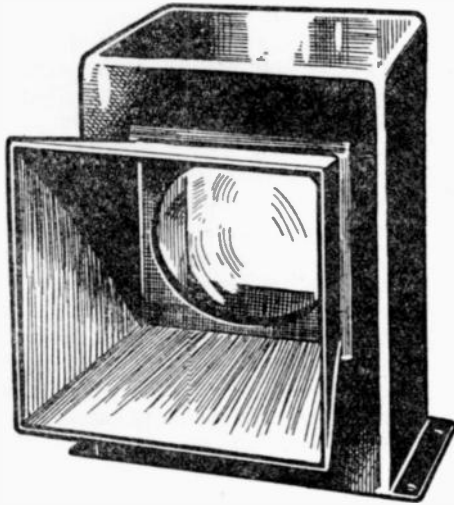


FIG. 230.—Details of a viewing tunnel.

in front of the scanner and which suitably magnifies the received image or picture.

Viewing Tunnel.—Name sometimes given to the recess which is formed on some television receivers at the end of which is placed the viewing lens of the instrument.

Vision.—The sense of sight. The act of seeing.

For clear vision, four conditions must be fulfilled, viz. :

1. The image must be well-focused on the retina of the eye.
2. It must be sufficiently illuminated.
3. It must have sufficient size.
4. It must act upon the retina for a sufficient duration of time.

Visual Acuity.—Term signifying the degree of ability to distinguish detail in any given illumination.

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Zone Television.—A method of television due, originally, to the Gramophone Company, Ltd. In the H.M.V. method, the picture to be televised is divided up into five separate portions or "zones," each of which is separately scanned and televised through separate channels, the picture "zones" being assembled together into the complete televised picture by the receiving apparatus.

Zone television on principles such as the above is purely experimental in character, despite the fact that good results have been obtained by the method.

The name also applies to a system developed by the Baird Company in which a large image or picture is split up into several areas or zones, each of which is separately transmitted and received.

Zorgite.—A scarce ore of Selenium containing also lead, copper and cobalt. Named after the town of Zorge in Saxony.

Zworykin Cell.—See *Thermionic Photo-electric Cell*.

Zworykin System.—A television system due to Dr. V. Zworykin, of the Westinghouse Company of America. It makes use of his two specially designed cathode-ray tubes—the "Iconoscope" and the "Kinescope," which see.

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