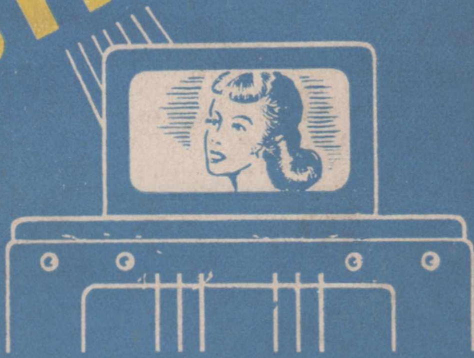
# TELEVISION CONSTRUCTORS



# manual

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# TELEVISION CONSTRUCTORS MANUAL

by

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# INTRODUCTION

The circuits and experiments described in this Manual were designed to investigate the possibilities of building, under home workshop conditions, simple and relatively cheap television receivers. The programme value aspect, as distinct from novelty value, was kept well in view, and much of the work was performed using a 6″ tube, the picture sizes being graded down to a point where programme value could be said to vanish. It was found that a perfectly good picture, suitable for one or two viewers, could be produced on an ordinary 3″ oscilloscope tube, sizes smaller than this suffering from the fact that the size of the spot on the tube screen does not decrease with the size of the tube, so that detail and apparent focussing can never be so fine on the smaller tube as on the larger.

This does, however, mean that for home experiments and televiewing quite small tubes will suffice, with a consequent saving also in power pack and timebase equipment.

So far as the vision receiver proper is concerned, saving is not quite so simple, although in the author's case no time base amplifiers are used. However, by making each valve play its full part, a smaller receiver than is usual can give very good results.

Once again it is emphasised that the circuits to be described are built up round the electrostatic oscilloscope tube, such as can be obtained at any good radio house. Naturally, magnetic deflecting tubes cannot be obtained in such sizes, but again the expense and undoubtedly troublesome adjustment of the deflecting coils and time base amplifiers were avoided.

The fact that the oscilloscope type of tube gives a green trace, and therefore a green picture, need deter no prospective builder, since the writer has found by trial that the effect is pleasing rather than otherwise, and adequate contrast is obtainable.

The work was carried out in a good reception area about five miles from Alexandra Palace, so that it was difficult to estimate the actual reception range of the receivers built. The T.R.F. circuit is, however, certainly suitable for a wide area, but where great sensitivity is required the superhet. is almost essential.

Some effort was made to lose efficiency at the receiving end by using an inefficient aerial situated indoors without any real insulation or care in running the feeder line. Since the receivers worked perfectly, it is felt that their possibilities for wide range reception is distinctly good, especially when used with a good aerial erected well in the open.

Great attention must be paid to circuit details as outlined here, since television technique differs in many respects from broadcast or even short wave reception, whilst in addition to this the time base and general power supply circuits will be unfamiliar to many home constructors.

For these reasons, therefore, as well as for the reason that good reception of the signal is greatly dependent on local conditions, there can be no absolute guarantee that these circuits will produce the same results in other hands. Bernards (Publishers), Ltd., however, are always prepared to give what help they can in answer to technical questions (which should be accompanied by return postage), and point out that the circuits described have been thoroughly tested, only those giving consistently good results being passed for publication.

The present writer wishes to express his indebtedness to the work of many authors published at times in the technical press, and for much instruction gained therefrom.

A short bibliography is appended, listing works which have a direct bearing on the reception of television signals.

RADIOTRICIAN.

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## CHAPTER 1.

## THE TELEVISION SIGNAL.

It is necessary completely to understand the nature of the television signal before discussing the methods of receiving and using it, for in many ways the modulated television carrier differs widely from the ordinary broadcast signal.

To transmit a scene in terms of light, with all the variations of light and shade and detail that implies, it will at once be obvious that the scene cannot be transmitted as a whole at any given instant. This would be analogous, in sound broadcasting, to transmitting a whole symphony in one beat of musical time. A scene, to the eye, contains innumerable changes of light values which a complex organ like the eye can receive all at once by the use of a lens and a vast array of sensitive devices behind the lens, known as the rods and cones. From each sensitive device a message relating to the amount and colour of the light at one particular point in the scene is transmitted to the brain, the myriad messages making up the mental image of the scene before the eye.

This human system relies entirely, however, on the huge number of light sensitive devices in use at one time inspecting the scene, together with the equally large number of nerve fibres carrying the information.

In television plainly only one " nerve fibre " is available in place of many thousands, this " nerve fibre " being the carrier wave linking transmitter and receiver. Clearly, also, only one piece of information can be sent along the link at a time, which means that the scene to be televised must be inspected portion by portion. The light intensity of each small portion, therefore, must be translated into an equivalent electrical intensity. This must be transmitted, received and influence the receiver to cause a proportionally strong light output, and at the same time the receiving system must put this speck of light into its correct place in the scene. Thus the scene will be rebuilt on the viewing screen piece by piece in exact accord with the manner in which it is being inspected at the transmitting end.

Such an inspection of a scene to be televised, the ordered examination of a picture piece by piece, is known as scanning, and in Fig. 1 is shown the method by which a single spot of light can be made to traverse and illuminate a whole scene. The spot starts at point A and crosses to point B at a constant set speed. It then returns to C at a greatly increased speed (in television parlance it " flies back ") and then crosses at its normal speed from C to D. If sufficient traverses of a small spot are made the whole scene will be lit by the one spot of light in a series of lines. Now consider the same scene to be evenly illuminated from an ordinary light source, such as a lamp, and replace the spot of light by a purely imaginary light sensitive device of very small size, giving an electrical output when light falls upon it. On its travels from C to D the light sensitive device will respond strongly to the bright portion of the scene, its response will then drop or cease altogether as it traverses the dark arm of the cross, and will then rise again as it reaches the second light portion.

Thus a graph of the electrical output from the light sensitive device would appear as in Fig. 2, and clearly these signals, used to modulate the

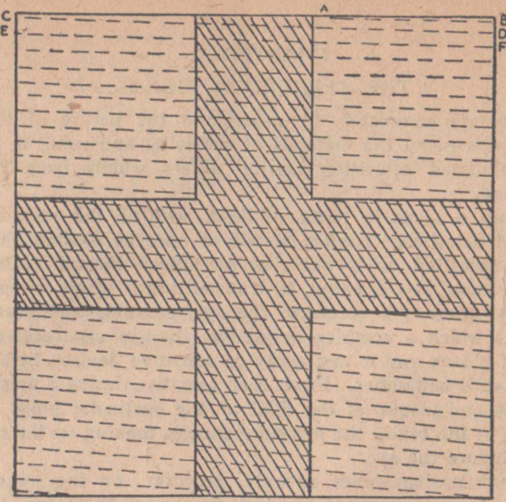


Fig. 1

strength of a spot of light moving across the viewing screen of a receiver would rebuild the scene in facsimile as long as the light sensitive device and the modulated spot of light remained exactly in step each with the other.

It is now necessary to consider the efficiency of the system so far. A scene illuminated only by a single spot of light would certainly appear only very dimly lit, whilst in addition the rapid movement of the spot would cause flicker to appear in the action of any moving object. Moreover, there would be intensity flicker—the persistence of vision of the eye would retain the image of the top of the scene whilst the spot moved downward on its succes-

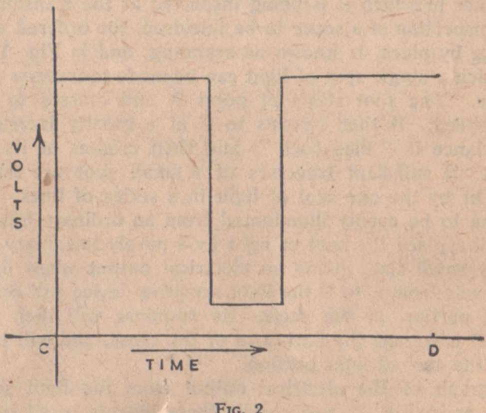


Fig. 2

sive traverses. When the spot reached the bottom of the scene the top would seem to be very dim indeed as the persistence effect wore off. A better way of sweeping the spot over the scene, however, would be to interlace the lines along which the spot travels in the manner shown in Fig. 3. In this way the spot still covers the scene in the same time, but the intervals between illumination of the top and bottom areas is not so great. It will be seen from the diagram that the spot crosses from A to B as usual, and then flies back to C, but now C is twice the distance below A. The spot moves from C to D, then from E to F, and so on, until it reaches the point N, this complete travel having scanned half the scene, due to the lines being separated from each other by twice the spot diameter. The spot then flies back from N to O, whence it recommences to scan from O to P, from Q to R, and so on to the last line. It then recommences at A once more.

At this point we must leave the theoretical spot of light and discuss modern practice, remarking in passing that in the old 30-line Baird system a flying spot of light actually was used in the studio. For modern high definition, however, the scene is constantly floodlit with banks of very bright lighting, and our moving spot of light is replaced by an electron spot moving over a light sensitive screen.

Fig. 4 shows in diagram form the essentials of the "Emitron Camera," as used by the B.B.C., which has in external appearance much the same form as a film studio camera. The heart of the camera is the tube, an "Iconoscope," or similar device, which consists of an electron gun at A, a deflecting system at B, a special photo sensitive screen at C, all contained in an evacuated glass envelope, with a lens system at D. The lens projects an image of the scene to be televised on to the screen, C, and focussing is

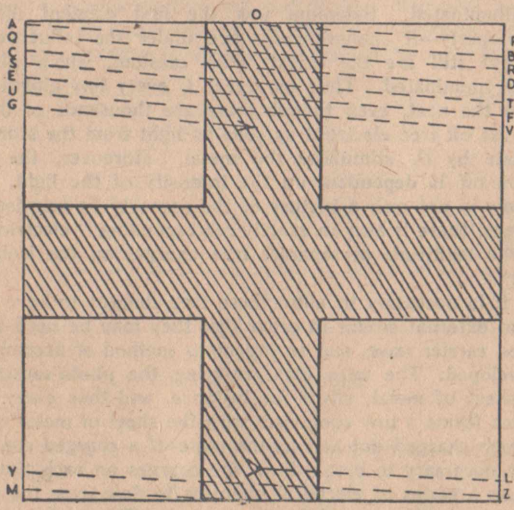


Fig. 3

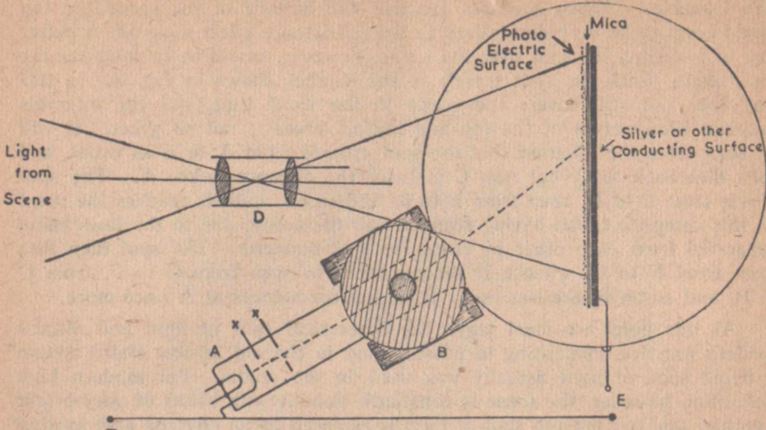


FIG. 4

facilitated for the camera operator by an identical lens mechanically coupled to D, which projects an image on to a translucent screen. The operator, by watching the translucent screen, can see the same picture as that being projected on to the sensitive screen, C, thus focussing and controlling the camera.

The photo-sensitive screen C is made up of tiny globules of a photo-sensitive metal, such as caesium, mounted on to a mica plate. A photo sensitive metal is an element, relatively rare, which changes its electrical state when illuminated. Selenium was the first element discovered to exhibit this property—it changes resistance under the influence of light—but more useful still are the metals, like caesium, which give off free electrons when illuminated. Thus on screen C every tiny globule, each one insulated from the next, even though there are thousands of them on the mica plate, gives off free electrons as soon as light from the scene, focussed on to the plate by D, stimulates the metal. Moreover, the number of electrons given off is dependent on the intensity of the light, so that on the screen there is not only a picture of the scene to be televised, focussed there by the lens, there is also an exactly corresponding " electrical picture " made up of the multitude of separate free charges on the isolated photo-sensitive dots.

Naturally it is necessary to allow these free charges to have some effect or other on an external circuit in order that they may be used to modulate the transmitted carrier wave, and an ingenious method of accomplishing this has been developed. The mica plate carrying the photo-sensitive dots is backed by a sheet of metal, silver for instance, and thus every dot on one side of the mica forms a tiny condenser with the sheet of metal on the other side. Thus each charged dot acts as the plate of a charged condenser, and it is now only necessary to break down the charges on each tiny condenser in turn to cause a series of electrical impulses to flow from the metal sheet forming the plate common to all the condensers. This is done by sweeping an electron beam across the mica sheet, the beam originating from the electron gun A and being controlled by the deflecting coils B. In other words, the plate is scanned, and a series of charges are led away through the lead E for amplification.

In this way, then, the studio scene is translated into terms of electricity.

The scanning of the mica plate through the agency of the electron gun and deflecting system (both of which are dealt with in detail in Chapter 2) is carried out in the manner already described. The ratio of width to height of the picture is as shown in the diagrams, namely 5:4, and the scanning lines are interlaced to give two half pictures which, occurring in rapid succession, make up the whole picture.

The number of lines which make up the whole picture has been fixed at 405, a compromise giving very reasonable detail without too great a complication of scanning apparatus, so that there are 202.5 lines to each half picture.

An average eye has a persistence of about one-twelfth of a second, but this would be too slow a scanning rate to overcome flicker, and that chosen is 25 complete pictures per second, which, to cause two interlaced scans, means that the frame time base must run at double this rate, i.e., at 50 scans per second. This figure was chosen with the frequency of the A.C. mains supply in mind, for reasons to be made plain later.

So far, then, it is established that the dot of light at the receiving end must travel in exact step with the transmitter scanning, from side to side of the picture 405 times per second and from top to bottom 50 times per second. To keep the receiver in step with the transmitter is, therefore, no light task, and to facilitate the process a synchronising signal of very definite characteristics is transmitted at the end of each line with a synchronising signal of different characteristics at the end of each frame. Circuits at the receiving end are arranged to distinguish between these " sync " signals and

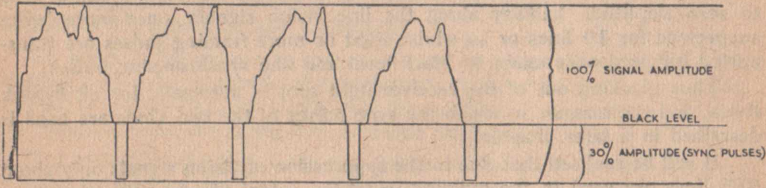


FIG. 5a

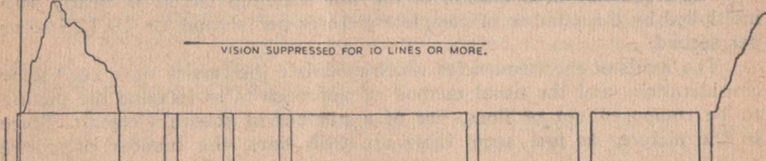


FIG. 5b

to feed impulses to the two deflecting systems which keep them in step with those at the transmitter.

To see how these sync signals are arranged with the actual picture voltages from the camera it is now necessary to look at Fig. 5.

It will straightaway be noticed from the diagram, which shows the television signal as given by the detector or demodulator of the vision receiver, that the modulation is " positive," that is that black in the picture corresponds to 30 per cent. modulation of the carrier, whilst white corresponds to 100 per cent. modulation. Below the black or 30 per cent. level lies the area known for obvious reasons as " blacker than black," and it is in this area that the synchronising signals are accommodated.

Fig. 5a shows four lines of the signal at the centre of the picture. At the end of each line the picture signal falls to black level for 0.5 per cent. of the total line time, drops further to zero amplitude for 10 per cent. of the total line time and then returns to black level for another 5 per cent. of the line time before picture intelligence is again passed. The sync. signal consists of the very sharply defined drop to zero amplitude, and altogether 15.5 per cent. of the line time is taken up by black and sync. signals. The levelling off to black, both before and after the sync. pulse, not only assists the circuits to respond to the wide variations of amplitude, but also blacks out the receiver spot during its flyback time, so that it does not appear across the picture.

Synchronising the vertical or frame time base is not so simple a matter, however, due to the necessity of maintaining the interlacing of lines. At the end of an even frame, that is at the end of line No. 405, the vision signals are suppressed for 10 lines or more, while about eight wide frame pulses are transmitted. Black level is then resumed before the picture signals recommence, as shown in Fig. 5b, the line sync pulses being transmitted to pull the line scanning circuits back into synchronisation should they have been disturbed during the framing pulses.

At the end of odd frames, that is, at line 203, the picture signal falls to zero amplitude halfway along the line vision signals, once more being suppressed for 10 lines or so whilst eight or more framing pulses are transmitted followed once again by black level and line synchronising pulses.

Thus blacking out of the receiver light spot is automatic for all flyback times, and the manner in which the sync pulses of the two kinds are used is described in a later chapter.

It will be realised that due to the suppression of vision signals only about 385 lines are used in the building up of the actual picture, the other lines being used for the essential sync intelligence.

The frequency of operation of the line scanning circuit is clearly 405 multiplied by the number of complete pictures per second, or 10,125 scans per second.

The limits of the frequencies which modulate the carrier wave need some consideration, and the usual method of approach is to imagine the picture to be composed not of lines, but of a number of square elements. Since in the picture, as just seen, there are 385 lines, the number of square elements can be said to be the ratio of picture width to height, $\frac{5}{4}$ multiplied

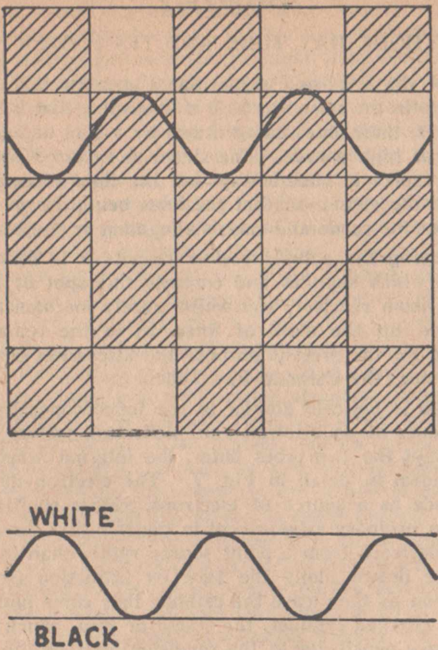

Fig. 6.—Showing how a Sine Wave may be said to embrace two square elements per cycle.

by the square of the lines, or $385^2$. The product of this equals 185,000, and, allowing for 25 pictures a second, the number of elements to be transmitted per second is thus 4,620,000.

To imagine the picture as being built up of square elements, however, assumes a modulated signal, after detection, to consist of a square wave, whereas in actual fact the signal may be considered as a sine wave with one complete cycle embracing two elements as in Fig. 6.

The actual modulation frequency at its maximum limit may therefore be said to be one half of the element frequency, or 2,310,000, i.e., 2.31 mcs. per sec. This is still a very high frequency indeed, especially when it is compared with the maximum broadcast frequency of 9 kcs. per sec., and for a carrier wave to be modulated with such frequencies it must be in the Very High Frequency spectrum. Vision signals, therefore, are transmitted at 45 mcs. (6.6 metres), whilst the associated sound signals are transmitted at 41.5 mcs. (7.2 metres).

Since both sidebands are transmitted the total bandwidth of the vision signal amounts to 5 mcs., and because of the wide bandwidths permissible at these frequencies the sound signals accompanying the vision are noted for their excellent tone and quality.

## CHAPTER 2.

## THE CATHODE RAY TUBE AND ITS POWER SUPPLY.

Discussion of the television signal has shown us that a picture at the receiver is built up in the same way as it is inspected, that is, it is constructed on a mesh of lines, these lines being drawn by a spot of light moving along controlled paths at high speeds. The signal as received obviously must be fed to the light source in such a way that the light intensity is modulated in sympathy with the signal, so that the lines being drawn are brightest in the bright parts of the scene and vanish altogether in the blackest parts.

Before discussing the actual receiver circuits it is necessary to understand the device which supplies and controls this spot of light, the whole heart of the television receiver, and whilst purely mechanical means can be employed to build up the mesh of lines, as in the remarkably effective Scophony system, for the present purpose the discussion must be limited to the electronic device, the Cathode Ray Tube.

The C.R. tube is basically similar to the Iconoscope already mentioned, consisting as it does of an electron gun, deflecting system and screen, but since in many ways the two tubes differ, the internal arrangements of the C.R. tube are shown in detail in Fig. 7. The electron gun consists of a heater and cathode as a source of electrons, rather similar to the heater and cathode of an ordinary valve except in the fact that the cathode is made so as to supply electrons from a point source rather than in broad streams. The electrons are drawn along the tube by attraction from the positive anodes, but as soon as they leave the cathode they come under the influence of the negatively charged cylinder, the shield or grid, which causes them to bunch into a narrow pencil due to the repulsion between the shield wall and the electrons. Any stray electrons are trapped by the first anode, the pencil passing through an aperture in the centre of the anode and coming under the influence of the second anode, which has a variable positive charge. The second anode is so shaped that the lines of force due to its charge have a

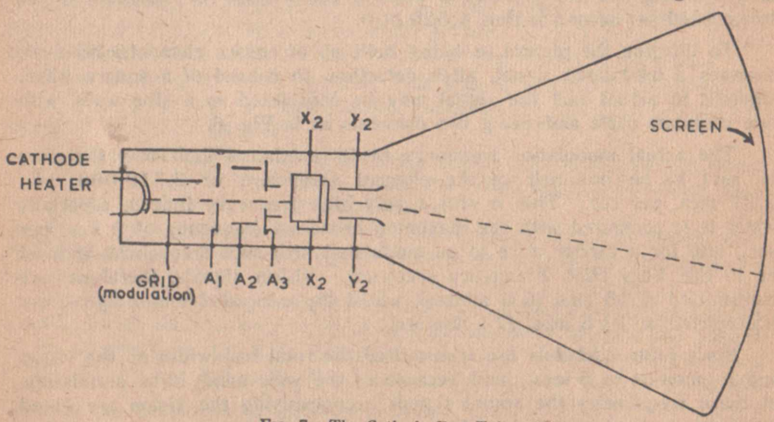


FIG. 7.—The Cathode Ray Tube

bending effect upon the electrons (which now tend to disperse), bringing them once more into a ray focussed on the screen at the far end of the tube. The third anode, generally at the same potential as the first, gives the electron beam a final acceleration, and following the anode system are the deflecting plates between which the beam passes at high speed. These plates are set in two pairs, one pair horizontally, the other vertically, and one pair is slightly further along the tube so that the beam is influenced twice. As it passes between the horizontal plates it will be attracted by one and repelled by the other according to whatever charges may be present on them, thus moving in a vertical direction, whilst charges on the vertical plates move the beam in a horizontal direction. Since the two directions of movement are analogous to the axes of an ordinary graph, it has been found convenient to style the horizontal movement of the beam the "X axis" and the vertical movement the "Y axis."

After undergoing deflection the electron stream finally reaches the screen upon which it is focussed in a sharp point. The screen in the case of the C.R. tube, however, consists of a fluorescent chemical, such as zinc sulphide, coated on the interior wall of the glass tube, and wherever the electron beam strikes the coating an intense spot of light appears, appearing as a line or trace if the beam is moving. It must be said at once that the spot should never be allowed to remain stationary on the screen at an intensity. The bombardment is so great that the screen is easily burned, that is, rendered less sensitive at that point. Thus a burned area will afterwards always show as a darker or even a black patch against the rest of the picture. Even a bright line, if allowed to remain stationary on the screen for a length of time, will burn the coating, and due care must be paid, therefore, to the brilliancy control, especially when first testing circuits. It is always a good plan, however, to keep the brilliancy as low as is possible, since careful use of the tube will be repaid with several hours of the equipment's life.

The brilliancy of the trace is controlled by the negative potential on the shield or grid, and therefore this electrode is supplied from a variable biasing potentiometer contained in the power pack. Modulation is also applied to the grid, since rapid fluctuations of potential will cause corresponding fluctuations in the spot brilliancy on the screen. The degree of bias required by the tube is also a measure of the input needed from the receiver fully to modulate the tube and produce a correctly contrasted picture, so that if the tube requires 20 volts negative bias it also requires an input of the nature of 20 volts peak to peak.

A large value of bias potentiometer is shown in Fig. 8, giving provision for different types of tube and also ensuring a good bias voltage should it be required to black out the tube at any time.

The bias should always be turned to the maximum whenever viewing or testing has been completed, so that there is never any chance of burning the screen when next switching on.

The tube type, which contains its deflecting system in the form of plates, is known as the "electrostatic" tube, since the beam is deflected by potential charges. A second type of tube, the "magnetic," relies upon an external system of coils, two pairs of coils again being set at right-angles around the neck of the tube in a position roughly corresponding to the position of the pairs of plates in the electrostatic tube.

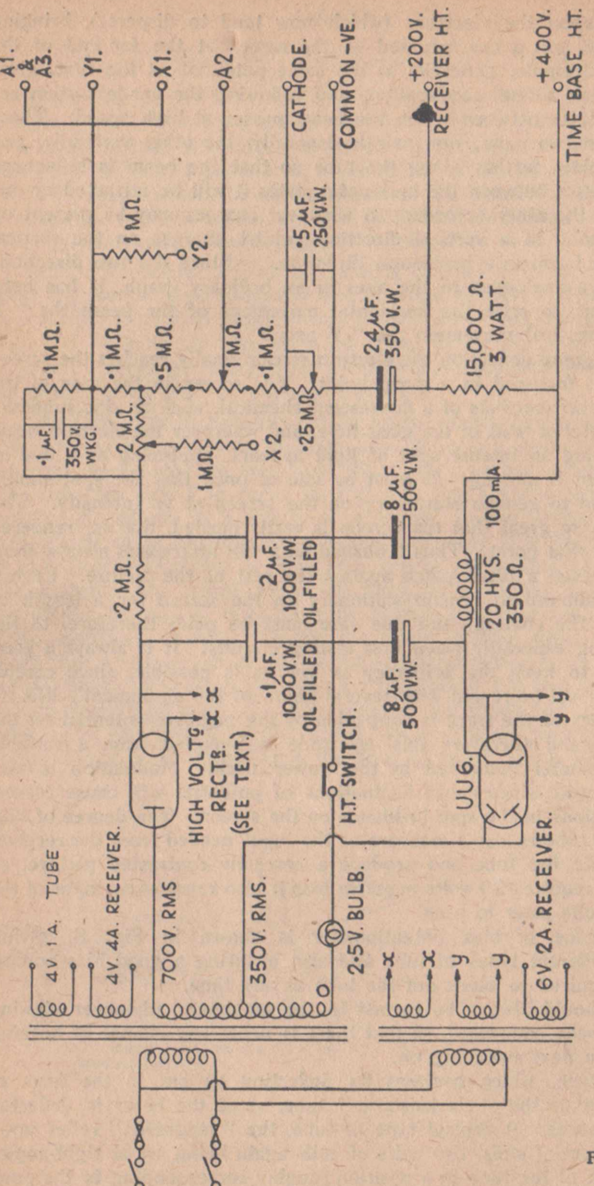


FIG. 8.
E.H.T. and H.T
Power Pack

The deflecting system of the Iconoscope, discussed in the previous chapter, is generally of this nature, and the great majority of commercially produced television receivers also use magnetic deflection. The system has undoubted advantage over electrostatic deflection, since slightly better spot focussing is obtained (only one anode is used, with a magnetic focussing coil round the neck of the tube), and the picture is possibly brighter. Magnetic tubes are not dealt with in this Manual, however, for, as already stated, the writer is here concerned only with the smaller types of electrostatic tube, the 3", or, better still, the 6" screen, diameter types, since these are far more suited for home experimental construction.

The colour of the trace or picture produced on the screen is entirely dependent on the material with which the tube is coated, and in the smaller tubes this is almost always of a green fluorescence. Some tubes, however, are manufactured to give a trace suitable for photographic purposes, their colour being a deep blue, and this is totally unsuitable for television work, not only on account of the lower visibility of the trace, but also by reason of the fact that the trace has a long afterglow characteristic which is of assistance when making an exposure.

It is to be hoped that small tubes will again be produced giving a black and white picture—they are obtainable in America in sizes down to 3" diameters—but a green picture has quite a pleasant appearance. A dark, or at least a well shaded, room is required for the green picture, but this is desirable for all sizes and types of viewing screens, since light in a room will illuminate what should appear as black or dark areas in the picture, and thus reduce the contrast.

Another type of tube quite unsuited for television work is the "gas focussed" tube. This tube has electrostatic deflection, but the anode and focussing system is simpler, since the tube is filled to a very low pressure with an inert gas. The passage of the electron beam through this gas gives rise to ionisation effects—the gas molecules in the path of the beam are bombarded and give up free electrons, leaving heavy positively charged ions in the beam. The free electrons on the outside of the beam repel it inwards, whilst the positive ions attract it inwards, and thus the beam is brought to a fine focus. This state of affairs holds good so long as the beam moves only slowly, but movement as rapid as is required for line scanning would remove the electron beam from an ionised path before it was properly focussed, and thus the picture would be built up by an irregular patch of light rather than by a sharply defined dot. Since the whole focus of the picture depends upon the focus of the dot, this type of tube is useless for the present purpose.

There are still some effects obtainable with the hard electrostatic tube, the type required, which deserve consideration, and these are listed below.

## BULB CHARGE.

After the electron beam has produced the spot on the screen the electrons disperse, travelling over the screen and down the sides of the tube, to be claimed by the anode system and passed out into the external circuit. Most tubes have a graphite or similar coating on the side walls to facilitate this flow, but should the anode voltage be low the electrons may gather on the screen surface. When this occurs a fluctuating, sharply-defined black patch appears on the screen, and this slowly increases in size until it is masking off the whole picture area. The actual effect is that the electron beam can no longer reach the screen, being cushioned off by the layer of electrons. The only remedy for the bulb charge is to increase the anode voltage.

## DEFLECTION SENSITIVITY.

The speed of the electron stream along the tube depends upon the anode voltage, the higher the voltage the higher being the speed of the stream. As the electron speed rises, however, the period of time during which it will come under the influence of the deflector plates falls and thus the deflection of the beam will be reduced. A high anode voltage, however, also gives a brighter picture due to the more vigorous bombardment of the screen, and thus with every tube a compromise has to be reached, balancing a satisfactory degree of deflection (upon which the picture size depends) with a suitably high anode voltage. Since the output of the time bases to the deflector plates is fixed the major adjustments will be to the anode supply system, the voltage never being allowed to fall to a level sufficiently low to give bulb charges. A further note appears in Chapter 3.

## TRAPEZIUM DISTORTION.

Trapezium distortion is that effect whereby the rectangular mesh of lines (generally known as the " raster "), upon which the picture is built, is pulled out of shape, with one or more sides sloping. The defect is inherent in the electrostatic tube, although much work has been done to minimise the degree of distortion introduced. The effect is apparent when the deflecting voltages are applied to only one plate of each pair, the second plate of each pair being grounded to the high voltage anode. It is always necessary to have a conducting path from each deflecting plate to the final anode in order to establish a mean working position for the spot. Omission of these conducting paths will result in the spot disappearing from the screen, attracted into one plate or another by stray charges.

When only one plate of each pair is fed with time base voltage the speed of the electron beam will be affected as the beam approaches that plate, since a positive charge above anode potential will tend to make the electrons accelerate. As the beam then passes the second pair of plates their deflection sensitivity will vary as the beam speed varies, so that a given deflecting voltage will cause less movement of the spot on one side of the screen than on the other. One method of overcoming the defect is to use push-pull amplification on one or both pairs of plates, so that as the potential on one plate rises that on the other plate falls. The overall field thus remains steady, giving no acceleration to the beam, but whilst this has been used to a great extent with electrostatic tubes, the writer was anxious to avoid the use of time base amplifiers if possible, particularly of push-pull amplifiers, which, with saw tooth voltages, are not easy to adjust to a correct working position.

Tubes with special deflecting systems are now obtainable, however, in which the trapezium distortion effect is practically obviated, and in tests with this type of tube it was found that special amplifiers were quite unnecessary even when the picture completely filled the screen.

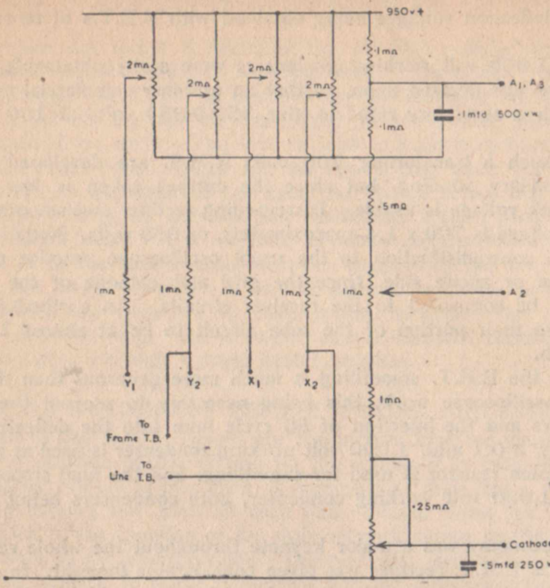


FIG. 9.—Bias Supply for all Deflector Plates

## FOCUS LOSS.

Loss of focus at the edges of the picture is again a feature of some electrostatic tubes, and is caused by voltage variations on the focussing anode due to the deflecting voltages. Again, one method of controlling the effect is to use push-pull deflection, but on any tube of reasonable length the loss of focus is not noticeable. A long tube should be chosen for television work, since the greater the distance between the deflecting system and the screen the greater will be the deflection for a given voltage. A biasing voltage applied to each deflector plate by a network as shown in Fig. 9 can help considerably in cases where loss of focus is experienced, but with the tube used by the author no precautions were taken and focus was maintained without trouble.

With the salient features of the C.R. tube in mind, it is now time to discuss the

## POWER SUPPLIES.

It has already been shown that upon the final anode voltage the extra high tension, or E.H.T. as it is called, depends the picture brilliance and deflection sensitivity of the tube. Obviously there are characteristics peculiar to each type and make of tube which require consideration, but in general the power supply described should be suitable for all 6″ tubes and more than adequate for 3″ tubes, although the final voltage will not be too high for the latter size. It was discovered that the E.H.T. required was of the order of 1,000 volts, a brighter picture but greatly reduced deflection for the same deflection voltages being obtained with E.H.T.s of more than this amount.

Since 1,000 volt working condensers were easily obtainable, a slightly lower figure was decided upon, so that an ordinary commercial mains transformer with a secondary rated to give 350-0-350 volts at 100 mA could be used.

With such a transformer 700 volts R.M.S. are developed across the whole secondary winding, but since the current taken is low practically the full peak voltage is usable. Disregarding rectifier and smoothing losses, the peak voltage is 700 x 1.4 approximately, or 980 volts. Negative earthing is used, in contradistinction to the usual oscilloscope practice of earthing the positive or anode side, since the grid and cathode of the C.R. tube require to be connected to the receiver circuits. An earthed final anode would cause their portion of the tube circuit to be at almost 1,000 volts below earth.

Again, the E.H.T. smoothing is much more generous than that usually found in oscilloscope work, this being necessary to prevent the formation of hum bars and the injection of 50 cycle hum into the deflecting system. Accordingly, a 0.1 mfd. 1,000 volt working condenser is used as a reservoir, a 0.2 megohm resistor is used for smoothing, and the final smoothing is by a 2 mfd. 1,000 volt working condenser, both condensers being of the oil-filled type.

Since economy was a major keynote throughout the whole receiver, the choice of the E.H.T. rectifier was given considerable thought. In some cases it is possible to use an ordinary mains triode as a high voltage rectifier where the current is extremely low, strapping the anode and grid to make the valve a diode. Flashovers occurred when such a valve was tried in the present circuit, however, but before a high voltage rectifier was procured an old D.W.2 rectifier was tested and found to be all that could be desired. It would appear that any directly heated rectifier of low emission might be used, but it must also be pointed out that in any doubtful cases it would be very false economy to skimp expense over the rectifying valve. This applies also to the condensers, for a breakdown in this section of the E.H.T. supply might easily ruin the whole power pack, including the transformer.

The D.W.2 used by the author has its anodes strapped together and shows no sign of distress whatever, but a series of tests on various types of rectifiers rated at both 350 and 500 volts working showed a high percentage of flashovers. An old valve of poor emission must be used, and it would appear that only the directly heated type are safe even then. For those who have no facilities for safe tests of this nature it is far better to obtain a good rectifier rated for 1,000 volt (or more) working than to run any risk of damaging the apparatus. Suitable valves are the Cossor 405 B.U., Mullard HUR2, Osram U17 or the Mazda U21 or U22, both of which have 2-volt heaters and are rated at 4,500 volts. The Osram GU50 may also be used, but since this is a mercury vapour rectifier the heater must be switched on at least 30 seconds before anode volts are applied, the delay preferably being through a thermal delay switch to ensure automatic operation.

The Mazda UD41 could also be used with the two halves of the valve (a voltage doubler) in series, but an inconvenience in this case would be the supply of two separate 4-volt heater supplies. Since the two cathodes are each connected to their respective heaters, separate heater supplies are necessary.

The author has found it desirable for all high voltage work to run rectifier heater supplies from a separate small transformer. It must be realised that since the E.H.T. is drawn from the heater or from a cathode connected to the heater, that the heater and its transformer winding are at a high voltage above earth. The inverse peak voltage from heater to earth is double the input peak voltage for the reason that when the rectifier is non-conducting on the negative half cycle the charge across the valve is in series with the charge on the reservoir condenser, a total peak voltage of practically 2,000 volts. It is not safe to make adjustments either to the power pack or to the tube circuits with the supply switched on, and at the same time the heater windings, if on the same transformer as the E.H.T. supply winding, are subjected to high voltage strains. The transformer should be obtained with this in view, and a separate transformer used whenever possible for high voltage heater supplies.

## ALWAYS SWITCH OFF BEFORE MAKING ADJUSTMENTS!

Included in the E.H.T. supply are the picture centring potentiometers. To vary the position of the picture on the screen it is only necessary to apply a biasing voltage to one plate of each pair of deflectors. The bias is obtained by making one plate of each pair variable about the final anode voltage, which is the function of the shift network shown in Fig. 8. Using the time bases to be described later, however, the writer found that shift need only be applied to the X deflectors, and the network actually used is shown in Fig 8.

As already explained, Fig. 9 shows a network capable not only of picture shift, but also of biasing all plates independently to provide for loss of focus at the picture edges.

## TIME BASE AND RECEIVER H.T. SUPPLIES.

Fig. 8 shows how the E.H.T. power pack also supplies the time base and receiver circuits with H.T., although these sections of the apparatus require less current than is sometimes the case. It has been found possible to limit the number of receiver valves to a minimum by reason of the relatively high signal strength obtaining at the author's location, and for a larger vision receiver it would be preferable to build a separate power pack. In the diagram, however, it is shown that the centre tap of the secondary is used to supply 350 volts R.M.S. to a second rectifier, the anodes again being strapped for half wave rectification, whilst the high value of the condenser on the receiver side of the supply entirely eliminates hum.

A separate power pack is used for the sound receiver, and built in as an integral part.

Any 50 cycle hum filtering through on to the grid of the C.R. tube will modulate the picture with a hum bar, either light or dark. The bar will remain perfectly steady whilst the picture is locked, and for this reason the supply to the receiver must be perfectly smoothed. No trouble was experienced in using halfwave rectification, however. The time bases must also be free from hum. The line time base, with spurious 50 cycle hum in the output will give a wavy edge to the picture, the curve being stationary whilst the picture is locked. Hum on the frame time base will cause faulty synchronisation, since the mains frequency is not necessarily in phase with the 50 cycle time base frequency, and it will be found difficult to frame the picture steadily.

In the author's equipment it has been found very convenient to connect the C.R. tube to the power supplies by an eight lead cable, the power pack having an ordinary octal socket into which the leads are connected via an octal plug. The receiver signal for modulation, together with the time base outputs, are also fed to the tube through the same sockets, as explained in a further note in Chapter 4.

After some consideration it has been thought advisable not to endeavour to list suitable Cathode Ray tubes. The conditions of supply, at the time of writing, are still fluctuating, and the disposal of war stocks may bring on to the market gear at present unlisted and unobtainable. In any case, the necessary characteristics of the ideal tube have already been noted—electrostatic focussing and deflection, green screen, low anode voltages and a low grid bias figure.

## CHAPTER 3.

## TIME BASES.

It has already been seen that the framework on which the television picture is built is the raster—a set of regularly spaced lines contained within an area whose sides are in the ratio of 5:4 with 405 lines interlaced. This requires the spot projected on to the screen of the tube always to be moving in two directions at once, from left to right at a frequency of 10,125 times per second and from top to bottom at a frequency of 50 times per second. Moreover, the flyback on each movement must be as rapid as possible, to be contained within the blackout time allowed by the transmitter, with the result that the " waveform " of the voltage applied to the deflector plates must be of the nature of that shown as a graph in Fig. 10, the well-known sawtooth voltage.

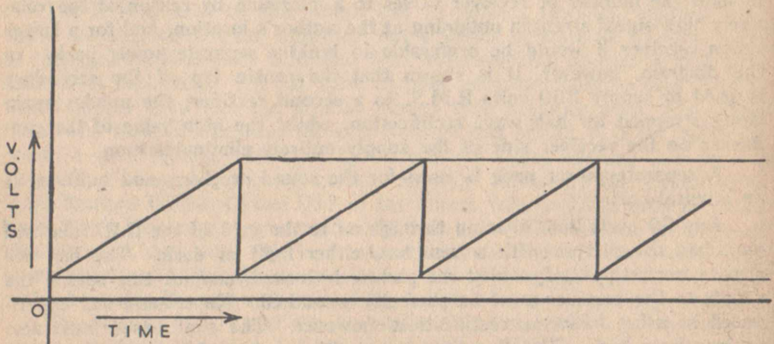


FIG. 10.—Sawtooth Voltage (Ideal)

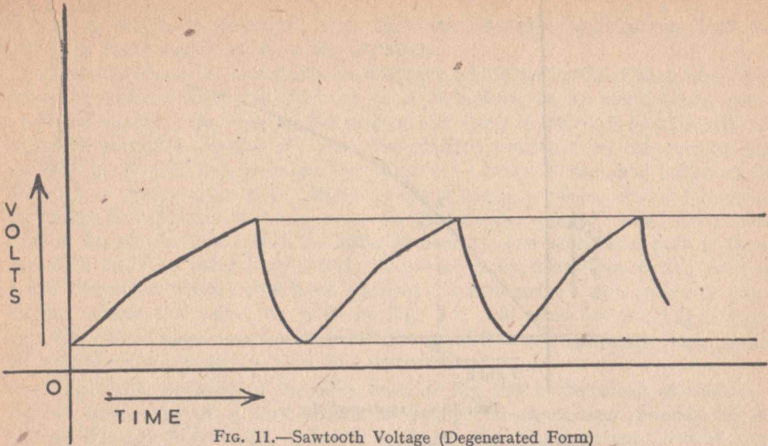

FIG. 11.—Sawtooth Voltage (Degenerated Form)

The curve waveform as shown in the figure is one with ideal characteristics. A uniformly rising voltage with an instantaneous cutoff would mean that when such a waveform was applied to a pair of deflector plates the spot would travel across the tube at uniform speed, returning to the commencement of its travel, i.e., flying back, instantaneously. In actual fact the devices used for the generation of sawtooth voltages have characteristics of such a nature that the ideal sawtooth tends to degenerate into the form shown in Fig. 11.

It will be seen that the voltage rise here is in the form of a curve. The reason for this is that in practically all cases the rising voltage is drawn from a charging condenser, the fall to zero being accomplished by a sudden discharge of the condenser through a low resistance, the short-circuit being removed to allow the condenser to recharge at the correct time. The basic circuit of the time base, therefore, may be shown as in Fig. 12. The condenser charges through resistance R, the flow of current creating a voltage drop across the resistance which diminishes as the condenser charges and the current flow falls. Switch S discharges the condenser through a short

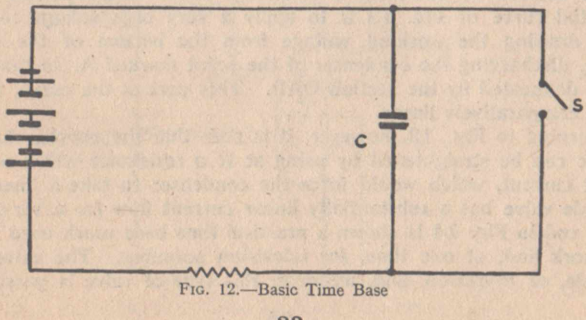

FIG. 12.—Basic Time Base

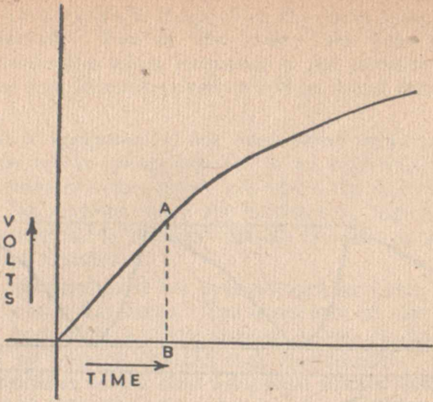


FIG. 13.—Expotential Curve

circuit as soon as it is closed, and when it is reopened the condenser will commence to charge again. Unfortunately, the condenser accepts charge in an expotential, rather than in a linear, way, the current flow into the condenser changing as noted above throughout the period of the charge, which means that the potential rise across the condenser will be as shown in Fig. 13.

Every circuit containing a condenser and resistance combination exhibits a property known as the time constant of the circuit. It is found that a condenser charges to 63 per cent. of its maximum possible charge in a time CR, where C is the capacity in microfarads and R is the resistance in megohms, the time being measured in seconds.

A linear potential change is necessary for both the vertical and horizontal sweeps that make up the raster. A sweep or scanning stroke which moved expotentially, that is, which began rapidly and slowed down as it crossed the tube horizontally (as would happen with the potential shown in Fig. 11) would result in serious cramping of the right hand side of the picture. The same type of sweep used for vertical scanning would result in a cramped bottom to the picture.

One method of obtaining a relatively linear characteristic from the expotential curve of Fig. 13 is to apply a very high voltage to the condenser, drawing the working voltage from the bottom of the curve, for example, discharging the condenser at the point marked A, so that the sawtooth is delineated by the section OAB. This part of the curve, as may be seen, ts comparatively linear.

Returning to Fig. 12, however, it is seen that the curved charge characteristic can be straightened by using at R a resistance which will pass a constant current, which would force the condenser to take a linear charge. A pentode valve has a substantially linear current flow for a varying anode voltage, and in Fig. 14 is shown a practical time base much used in oscilloscope work and, at one time, for television scanning. The valve V2 is a gas triode, or thyratron, and, although this type of valve is passing out of favour in television work, it is of such use in many applications that it merits a short explanation of its working.

The thyratron is essentially an ordinary triode valve filled to a very low pressure with an inert gas, such as neon or helium, or, in some cases, with mercury vapour. So long as the grid of the valve is maintained at a critical negative potential dependent upon the positive potential on the anode, no current at all will flow through the valve. As soon as the grid potential is allowed to move over the critical point towards positive, or, if the grid potential is held constant, as soon as the anode voltage rises above the critical figure, the gas within the valve ionises. A low resistance path is thus provided and the valve immediately becomes an excellent conductor, even a small thyratron being capable of passing a half-ampere. A condenser connected across the valve, as is C in Fig. 14, will thus be discharged very rapidly. Indeed, a resistance R of about 500 ohms generally has to be included in the circuit to limit the current flow.

The whole working of the time base of Fig. 14 is therefore as follows: At the beginning of a scan stroke or sweep the condenser commences to charge through V1, which, being a pentode, passes a constant current and linearises the charging of the condenser. As the condenser, C, is uncharged the cathode of V2 is practically at anode voltage and the grid, whose potential is tied down by the voltage divider across the supply, is highly negative. Consequently, V2 is in a non-conducting condition. As the charge on the condenser rises, however, the cathode potential of V2 falls until it approaches or passes the potential applied to the grid of the valve. The grid immediately loses control, the condenser discharges rapidly through V2 and the sweep and flyback are finished. The condenser discharges to a very low potential, whereupon the thyratron grid again takes control of the

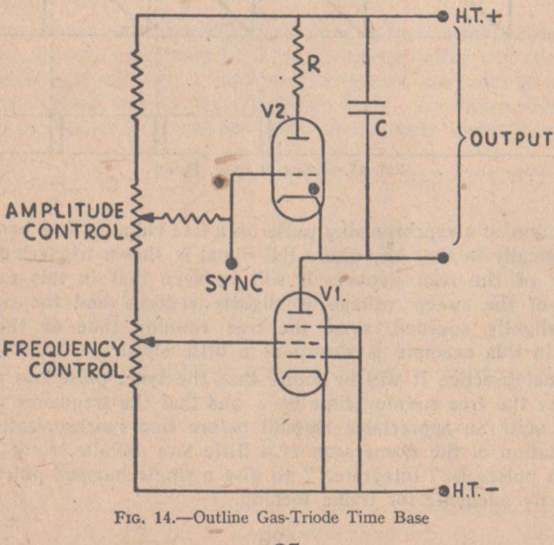


FIG. 14.—Outline Gas-Triode Time Base

valve as the cathode rises again to near anode potential, and the operation recommences.

At this point the operation of synchronising signals can be discussed. Synchronisation is the application to a repetitive operation of methods of control whereby the operations are always carried out in step with the controlling agency. As has been seen, the control in the case of a television time base consists of sharply defined pulses on the carrier wave. The pulses, separated in a way to be described later, can be fed to the time base at the point shown in Fig. 14, but the sync. signals will have no effect on the circuit when the thyratron grid is highly negative and the cathode highly positive. It is only as the valve approaches its triggering point and the potential difference between grid and cathode is diminishing to a sufficient degree that sync. pulses in a positive sense can swing the grid over the firing point and allow the condenser to discharge through the valve. Clearly the sync. pulses must be of the correct polarity to trigger the valve at the desired instant. Since, in the case of the thyratron, the grid requires to be made positive the sync. pulses must be of positive polarity. The shape of the sync. pulse can also affect the triggering of the valve, for whilst the pulses are transmitted as sharply defined signals, the receiver circuits can easily distort the rectangular pulse into a curved peak. For correct action the pulse requires to keep its sharp leading edge.

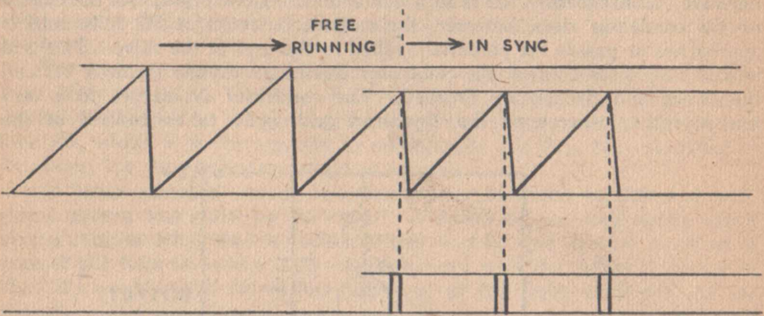


Fig. 15.—Effect of Sync. Pulses

The action of a synchronising pulse on a free running time base is shown diagrammatically in Fig. 15, where the signal is shown triggering the valve at the top of the scan stroke. It will be seen that in this example the amplitude of the sweep voltage is slightly reduced and the time of the scanning slightly speeded, since the free running time of the scanning generator in this example is shown as a little slow.

In actual practice it will be found that the sync. pulse has remarkable control over the free running time base, and that the frequency control can be varied quite an appreciable amount before line synchronisation is lost. Synchronisation of the frame scan is a little less definite, since a chain of eight or so pulses is " integrated " to give a single humped pulse, but it is still perfectly adequate for frame locking.

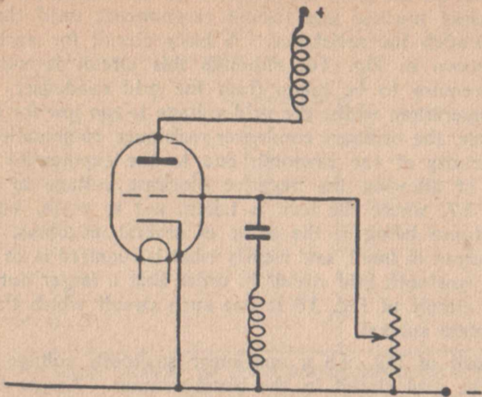

FIG. 16.—Basic Blocking Oscillator

The thyratron is seldom used in modern television receivers, since the gas ionisation tends to be a little erratic and the triggering point of the valve changes slightly from stroke to stroke, particularly when the valve is hot. Instead, hard valves, i.e., ordinary vacuum valves, are now widely used for time base work, and the writer has tested several circuits, always with an eye to good linearity and high output. Fortunately, the hard valve time base is generally at its best when required to work at its maximum output, and no amplifiers have been required to obtain a scan covering the working area of the 6" tube.

The usual hard valve scanning generator is the blocking oscillator, consisting generally of an ordinary high frequency oscillating circuit with closely coupled coils together with a condenser-resistance combination in the grid circuit, which gives rise to the blocking effect. The valve oscillates very fiercely, so that heavy grid current flows, immediately giving rise to a high

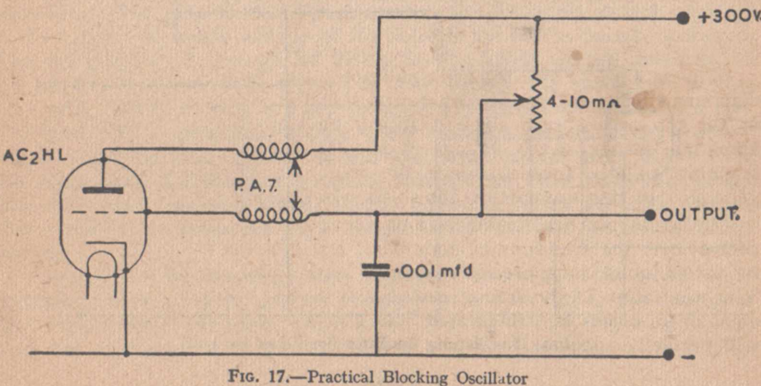


FIG. 17.—Practical Blocking Oscillator

negative potential on the grid, applied through the condenser. The oscillations are therefore blocked and cannot recommence until the charge has leaked away through the resistance. A basic circuit for such a sawtooth generator is shown in Fig. 16, although this circuit is not practicable. Output would require to be taken from the grid condenser, which would result in poor operation, whilst the grid voltage is too low for scanning purposes. Moreover, the ordinary condenser-resistance combination would give rise to non-linearity of the sawtooth due to the expotential working. A better method of allowing the negative blocking voltage to flow away is shown in Fig. 17, where the leak is taken, not to earth, but to positive H.T., the resistance being of the order of several megohms. Once again, however, the output is small, and clearly what is required is an anode circuit controlled by a sawtooth grid circuit in order that a larger output might be obtained. The circuit of Fig. 18 is one such circuit which the author has used with complete success.

In the circuit of Fig. 18 a non-linear sawtooth voltage is generated across C1 in the grid circuit in the usual manner. Across C2, however, when it is discharged, there is a low potential, the grid of the valve being highly negative. As C1 discharges to reduce this negative potential C2 charges through the anode resistor combination, bringing up the anode potential. When the grid charge is sufficiently reduced and the anode potential is high enough the valve bursts into oscillation when the anode immediately draws heavily on C2, discharging it rapidly whilst the grid is blocked by a fresh charge on C1 and the cycle of operaton is complete. The frequency of the operation is determined by the grid circuit constants, whilst the amplitude of the sawtooth output depends on the H.T. voltage derived from the potentiometer, and for the circuit to work well the time constant of the anode circuit must be greater than that of the grid circuit.

It was found that the potentiometer system could be dispensed with in the line time base, and a 250,000 ohm resistor straight to the H.T. line of 400 volts gave correct output for the 6″ tube.

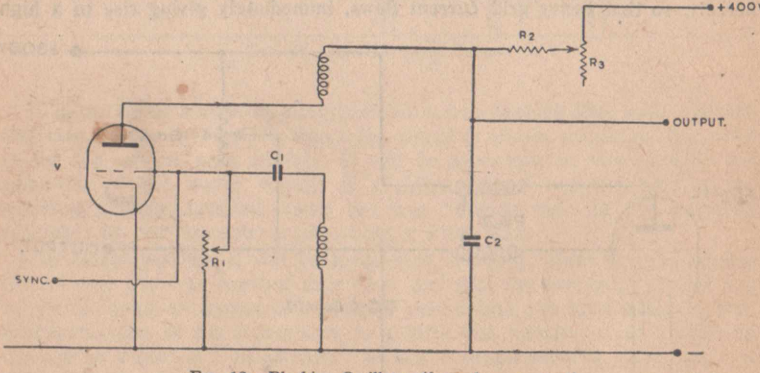


FIG. 18.—Blocking Oscillator (for values see text)

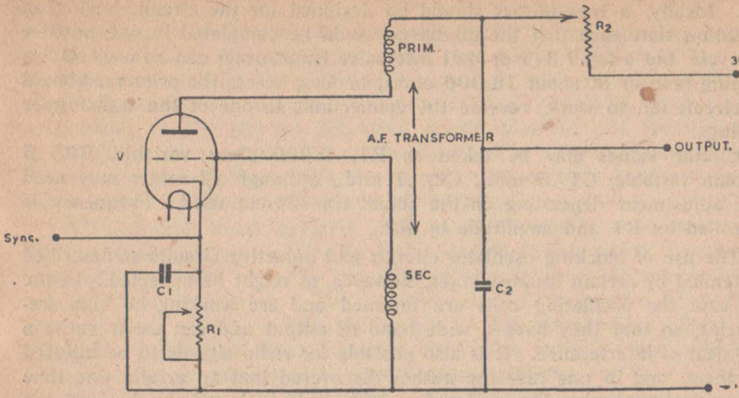


FIG. 19.—Blocking Oscillator for Frame Frequency (for values see text)

It is desirable to keep an amplitude control in the frame time base circuit, however, to enable the picture size ratio to be adjusted.

For the line generator the values of the components used by the writer were C1, .0003 mfd., C2, .001 mfd., R1 50,000 ohms variable, and R2, straight to H.T., 250,000 ohms.

For the frame generator the values were C1, .02 mfd., C2, .1 mfd., R1, .5 megohms, variable, R2, 250,000 ohms, R3, .5 megohms potentiometer.

In both line and frame time bases the oscillating coils were Wearite's PHF7, although the PHF6 was also used. The valves were both Mazda AC2HL.

The circuit of Fig. 19 is really suitable for frame scanning only, since in this case the oscillator coils are the windings of a small transformer. It is perhaps less simple to obtain linear working with this circuit, but the output is good and some experiment with damping resistors across the transformer windings may be carried out in order to give a corrected sawtooth waveform. The valve is biased back by the cathode circuit so that when C2 is discharged the anode voltage of the valve is too low to permit operation. The charging of C2 through R2 brings up the anode voltage, however, to the point where current is allowed to flow through the anode coil, setting up a back E.M.F. in that coil and inducing a potential across the grid coil. The grid coil is connected in such a way that the grid is driven positive, which causes the anode current to increase, extra current being drawn from the condenser. C2 discharges rapidly through the valve until the current flow diminishes, whereupon the induced potentials across the coils reverse their polarity, the anode current is cut off and the cycle of operations recommences.

Trouble can be caused by stray capacities across the coils which cause oscillation, both as anode current commences to flow and as the condenser discharges through the valve, which means that the flyback time is increased, since the discharge can only take place on the positive peaks of the oscillation. Ideally, a transformer should be designed for the circuit, having an oscillation time such that the discharge would be completed in one positive half cycle, but a small 3 :1 or 4 :1 intervalve transformer can be used with a damping resistor of about 10,000 ohms, or less, across the primary. Should the circuit fail to work, reverse the connections to one of the transformer windings.

Circuit values may be taken as R1, 2,000 ohms variable, R2, .5 megohm variable, C1 .5 mfd., C2, .1 mfd., although all values may need some adjustment depending on the actual transformer used. Frequency is controlled by R1 and amplitude by R2.

The use of blocking oscillator circuits and inductive circuits as described is attended by certain disadvantages, however, as might be expected. In the first case the oscillating coils are untuned and are working at high frequencies, so that they have a wide band of output and can easily cause a good deal of interference. It is also possible for radio signals to be injected into them, and in one case the author discovered that an erratic line time base was triggering on Morse signals, which could be heard clearly when the output of the generator was applied to headphones. For these reasons the coils used for blocking oscillators must be very well shielded, yet at the same time their oscillating qualities must not be impaired. Aluminium cans over the coils are not really sufficient, and a fairly large iron shield can is required. At the same time, there is a tendency for R.F. to leak into the receiver circuits, so that common H.T. lines must be well decoupled for high frequencies.

Synchronisation is shown injected into the grid in most cases, but here, again, R.F. can be fed back into the sync. separating valve, whilst operation of the time base can be impaired by the extra loading imposed. Applying the sync. pulses to the cathode, however, means that the pulse polarity must be reversed and that a cathode bias circuit must be included, which reduces output.

Flybacks time is a major consideration in the choice of the oscillator coils, since the discharge circuit must of necessity include the anode winding. Should the inductance of this be appreciably large the flyback will require a longer period, and it is for this reason that medium or short wave coils are chosen, since their secondaries, or anode coils, consist of only a few turns of wire. On the other hand, harmonic interference with the tuned receiver circuits then becomes easily possible.

It may seem from these remarks that the blocking oscillator time base is difficult to put into operation, but with correct attention to detail good results are obtained with quite simple triode circuits. It is advised, however, that if the blocking oscillator time bases are used they be mounted on a separate chassis apart from the receiver, and the power supply circuits should be amply decoupled if they are common to both time bases and receiver.

Study of the blocking oscillator circuits will show that in some cases, as in the basic circuit first discussed, a condenser is made to give a sawtooth output by being charged rapidly, the charge being allowed to leak away slowly in an expotential manner, the slope of the sawtooth thus representing the discharge. In other circuits, however, the condenser charges slowly through a resistance and is rapidly discharged by circuit action, the sawtooth slope in this case representing the charge. Either type of sawtooth may be used for the deflection of the C.R. tube beam, naturally, and should the deflection be in the wrong sense it only remains to reverse the connections to the pair of deflecting plates affected. If the picture is upside down, for example, the connections to the Y deflecting plates must be reversed and similarly with the X plates connections if the picture is from right to left rather than from left to right.

A remarkably linear negative going sawtooth voltage, as shown in Fig. 20, is obtained from a comparatively recent circuit which combines a transitron oscillator with the Blumlein integrator, more commonly known as the Miller integrator. The resulting time base can be most highly recommended, and is used by the author in preference to any other, since an easily synchronised linear sweep of very high output is available using only one valve per time base at normal anode voltages.

Since the working theory of the time base is rather complex a simplified explanation follows.

The Blumlein integrator, Fig. 21, utilises the Miller effect whereby the input capacitance of a valve changes as the amplification of the valve is made to change, since

$$C.in = C.ga\ (1 + A)$$

where C.in is the input capacitance, C.ga is the grid to anode capacitance and A is the voltage amplification of the valve.

Considering C1 in Fig. 21 as being fully charged and the valve to be passing anode current, the grid can be shown to be negative in respect to the cathode so that no grid current is flowing. The condenser, however, is discharging so that the grid potential becomes less negative, resulting in an increased anode current, the potential drop across the anode resistor R1 thus increasing, forcing down the anode potential towards the grid potential. Whilst the amplification of the valve is kept at a high value the condenser current through the leak R2 can be made very nearly constant instead of an expotentially varying current. For a totally constant

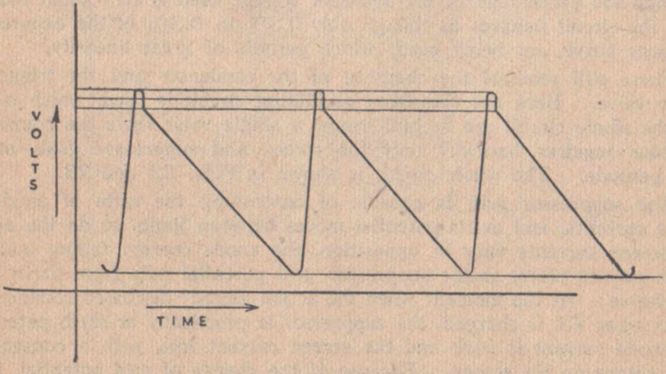


Fig. 20.—Linear "Negative going" Sawtooth

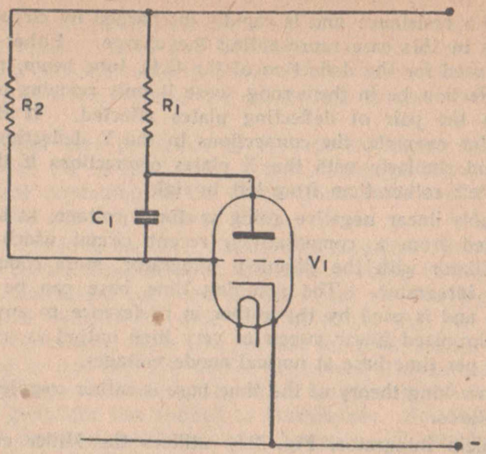


FIG. 21.—The Blumlein Integrator

current through R2, which would mean a totally linear discharge of the condenser and a totally linear scanning sweep the circuit would not operate since the grid potential would not vary, but whilst the potential drop across R1 approaches the potential difference between grid and anode and is also considerably greater than the grid's potential to earth the condenser discharge is very linear. So far as the discharge current is concerned the condenser appears to have a capacity 1 + A times its actual value, this also causing the anode voltage to behave as though it were A times its true value. The condenser, therefore, appears to be working not from a normal supply voltage but, so long as A is kept high, from an apparent voltage of several thousands of volts. It has already been seen that to obtain a linear output from a discharging or charging condenser it is sufficient to utilise the lowest portion of the expotential curve, and for an output of, for example, 50 volts the percentage of the apparent voltage used is very small indeed. Thus the circuit behaves as though only 0.3% to 0.5% of the expotential discharge curve was being used, which permits of great linearity.

There still remains the charging of the condenser and the triggering of the valve. Here the transitron oscillating circuit is used, which means that the whole circuit can be built round a single valve since the transitron oscillator requires basically only the screen and suppressor grids of an H.F. pentode. The whole circuit is shown in Figs. 22 and 23.

The suppressor grid is capable of controlling the ratio of anode to screen currents, and as its potential moves between limits so do the anode and screen currents vary in opposition, the anode current falling and the screen current rising as the suppressor grid potential falls from earth level to negative. At the moment when the action already discussed commences, that is when C1 is charged, the suppressor is practically at earth potential, the anode current is high and the screen current low, with a consequent high voltage on the screen. Because of the change of grid potential, however, this high screen potential falls although the condenser-resistance combination, C2 R4, prevents the suppressor from following the screen potential. Thus, whilst the current through the valve increases, the anode to screen current ratio is held until such time as the anode potential becomes sufficiently low to allow the screen to trap the greater part of the current. Immediately the screen's current flow rises and its potential falls, the voltage change through C2 causing the suppressor grid to move negatively. From this point the anode current falls further and the screen current rises further in a cumulative action till the anode current is cut off, the charge on C1 is reduced and the grid of the valve becomes positive, allowing the

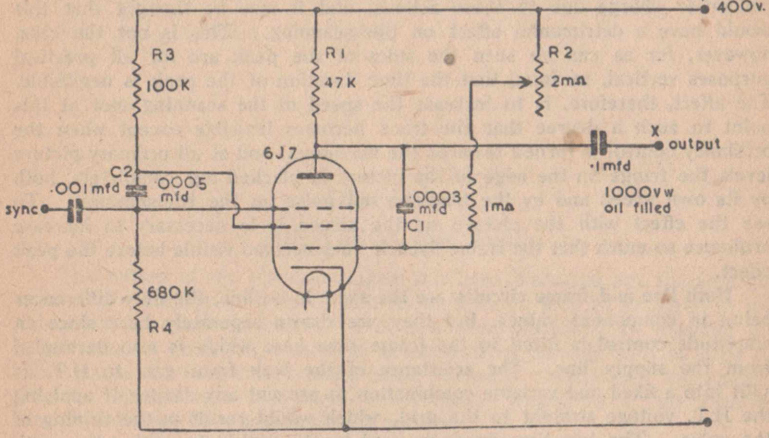


FIG. 22.—The Integrator Line Time Base

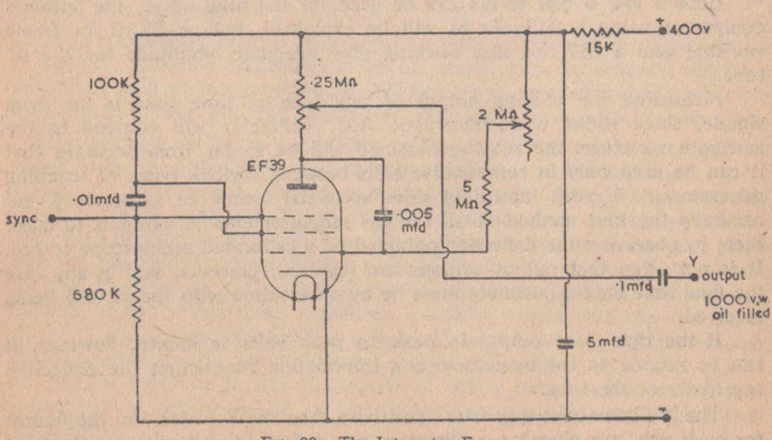


FIG. 23.—The Integrator Frame

condenser C1 to recharge. This is the flyback portion of the waveform, and the positive grid locks the action of the suppressor and screen grids for a moment, giving sufficient recharging time to the condenser.

As the condenser charges, however, the lock is removed slowly as the grid loses its positive potential, and the suppressor grid potential moves from its highly negative state towards zero. Immediately the anode once more draws current, forcing down the screen current until a second cumulative action swings the suppressor back to earth potential and the screen to minimum current and maximum voltage once more.

The waveform in Fig. 20 exhibits a peculiar peak at the moment of full condensor charge due to these actions, and it may be thought that this would have a detrimental effect on the scanning. This is not the case, however, for as can be seen the sides of the peak are for all practical purposes vertical, meaning that the time duration of the peak is neglibible. The effect, therefore, is to increase the speed of the scanning spot at this point to such a degree that the trace becomes invisible except when the brilliancy control is turned towards the maximum, and at all ordinary picture levels the fringe on the edge of the picture is blacked out completely, both by its own speed and by the blacking out pulse on the transmission. To see the effect with the picture on the screen it is necessary to increase brilliance so much that the frame flyback lines become visible before the peak effect.

Both line and frame circuits are the same in outline, the only differences being in component values, but they are drawn separately here since an amplitude control is fitted to the frame time base which is also decoupled from the supply line. The resistance of the leak from grid to H.T. is split into a fixed and variable combination to prevent any danger of applying the H.T. voltage straight to the grid, which would result in the ruining of the valve. The two time bases as used by the author in conjunction with the receiver described in the next chapter are shown in Figs. 22 and 23.

Both 4 and 6 volt valves can be used for the time bases, the author's equipment using both types as will be explained, but an EF39 for frame working and a 6J7 for line working give adequate amplitude for the 6″ tube.

Measuring the voltage output of any type of time base is far from simple, since whilst a rectifier type A.C. voltmeter will respond to the sawtooth waveform the reading obtained will be so far from accurate that it can be used only in comparative tests between various types of scanning generators. A peak indicating valve voltmeter would be satisfactory, but naturally the best method of all for any measurements required is to make them by observing the deflection obtained on a calibrated oscilloscope screen. It is not often that output voltages are required, however, and in any case the final time base adjustment must be by observation with the picture being received.

If the time base output in peak to peak volts is known, however, it can be related to the manufacturer's information concerning the deflection sensitivity of the tube.

The X plates have a greater sensitivity than the Y plates and the figures for each pair are given as millimetres per deflecting volt with a correcting factor introducing the final anode voltage. The sensitivity of a deflecting system written as $\frac{300}{V}$ mm. per volt would thus mean, V being taken as the final anode voltage, that with 1,000 volts applied to the tube one volt on the deflector plates to which the formula refers would result in a deflection of $\frac{300}{1,000}$ mm. or 0.3 mms. A 30 mm. deflection would thus require 100 volts, but at the same time it must be remembered that this is peak to peak deflection. In the case of a pure sine wave peak to peak value is 2.828 times the root mean square value so that the 30 mm. deflection would be obtained with a voltage which would read on a R.M.S. A.C. voltmeter as $\frac{100}{2.828}$ or 35.1 volts R.M.S.

## CHAPTER 4.

## THE VISION RECEIVER.

The nature of the television signal has been discussed and the arrangements by which the C.R. tube, with its time bases, may be prepared to use the signal has been explained. It is now time, therefore, to examine the vision receiver itself, in a form as economical as possible with as high an efficiency as can be obtained under home workshop conditions. The chapter may be divided into two parts—a theoretical dissection of the receiver circuits followed by a constructional section.

The diagram of the author's own television receiver is shown in Fig. 24, and all theoretical circuit references in the first part of this chapter will refer to this diagram.

To recapitulate, then, it is required to receive a signal on a carrier wave at 45 mcs., having a bandwidth of up to, say, 5 mcs., to separate out from the signal both picture intelligence and two types of synchronising pulse, to feed the C.R. tube with the one and the time bases each with its own pulse.

To perform all these operations with a fairly high signal strength six valves in seven stages are used. In areas further from the transmitter more valves will be required, but in any case the main considerations of this chapter will be with the Tuned Radio Frequency type of receiver rather than with the superhet. A review of the situation has convinced the writer that the superhet is a most difficult proposition for the amateur who requires to keep the cost of his equipment within reasonable bounds. This whole Manual, as has already been explained, has been written with this one object in view, and a superhet feeding into a 3″ or 6″ tube is not economical. Many manufacturers, however, have pinned their faith on to the T.R.F. or straight receiver, so that the matter of choice between the two types of circuit would appear to be of less importance than has sometimes been supposed.

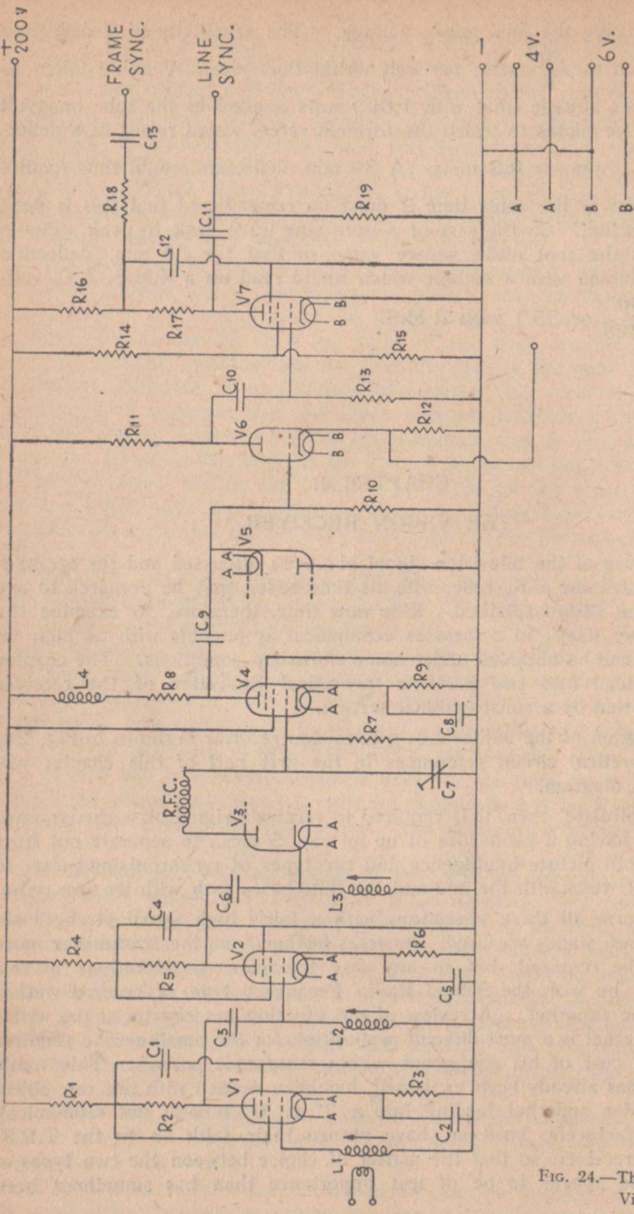


FIG. 24.—The T.R.F. Vision Receiver

Moreover, at the time of writing, even T.R.F. coils are unobtainable, and whilst the coils for the straight receiver can easily be made by following the directions given later, this is not the case with the unobtainable superhet equipment. I.F. coils are not on the market, and whilst these could be constructed for a sound receiver, the task presents almost insuperable difficulties when wide frequency bands require to be passed, as in the vision equipment. For the sake of completeness, a superhet circuit is outlined in Chapter 5, however, while the T.R.F. circuit, therefore, is the one dealt with here, and in Fig. 24 it may be said to be comprised of the first four valves of the receiver diagram.

To the amateur constructor of ordinary radio receivers many points of dissimilarity will at once be evident. In the first place there are no tuning condensers, whilst the anode loads of all the receiver valves are of lower resistance than is usually the case. A choke is included in the anode circuit of what would normally be the output valve, that is V4, whilst the output is actually drawn from the cathode circuit of the succeeding triode, connected in a cathode follower circuit. The output is thus taken in the form of a voltage rather than a power output.

An inverted diode is connected across the triode input, a totally new feature to the broadcast bands enthusiast, whilst V7, whose function is at first far from obvious, is the sync. pulse separator, fed from the anode of the triode, which is therefore not only a cathode follower, but also a phase splitter. For a complete discussion of all the circuit theories entering into the design for a vision receiver a great deal of space would be required, but the main considerations can be outlined stage by stage.

## THE R.F. STAGES.

At the receiver's location it was decided that only two R.F. amplifying stages would be required, allowing for the fact that the stage gain with a wide bandwidth at 45 mcs. is very low, of the order of 5 or 6 in place of the gain of several thousands obtainable at broadcast frequencies. The contributing factors to this state of affairs, first, the low input resistance of the valve at the working frequency (inversely proportional to the square of the frequency, and dependent on the valve's internal design and construction), secondly, the wide bandwidth necessary in the tuning circuits, and, thirdly, the stray circuit capacities, are almost uncontrollable by the constructor, so that the most efficient valve to suit this type of circuit is required. The Mazda SP41, developed for television reception, was chosen for this receiver. Whilst the method of coupling used is less efficient than other forms, it is simple to adjust and to build and gives adequate bandwidth without trouble.

Since the gain per stage falls as the grid circuit capacitance rises, the coils are made in such a way that they resonate at the required frequency by their own self-capacity, to which, of course, must be added the input capacitance of the valve and the circuit wiring stray capacities. It would also be possible to tune by a capacitance in the usual way and, by means of shunting resistors, regain the bandwidth which would be lost by conventional tuning, but this method would obviously introduce a series of losses and inefficiencies. The circuit, even as it stands, is effectively shunted by the anode resistor of the previous valve, so far as stages Nos. 2 and 3 are concerned, and the value of this resistor must be chosen with care to give both adequate bandwidth and also amplification. The tuning coil of the first stage is loaded quite heavily by the aerial and is therefore also damped to a suitable degree.

The low input resistance presented by the valves at 45 mcs. also assists in the circuit damping, and the anode resistances are selected to match with this resistance. In the circuit of Fig. 24 the value actually calculated for the anode resistances is 6,000 ohms, but since circuit losses must have an allowance made for them the value is increased to 10,000 ohms, a conventional figure for this type of circuit. The stages are coupled by .001 mfd. condensers, which at the operating frequency have a reactance so small as to be negligible. The coupling between all stages of a television picture receiver must receive considerable attention, since the picture, whilst almost unaffected by amplitude distortion, suffers seriously from any appreciable degree of phase distortion, in direct contrast to the normal sound receiver, where phase distortion causes no trouble over the greater part of the frequency range. In the first case the signal must be applied to the C.R. tube grid in the positive sense, that is, in a manner such that the fully modulated carrier, after detection, causes the bias of the tube to fall giving a bright spot. The detector, a diode in this case, as is usual for the sake of simplicity, must therefore be connected to give an output in the negative sense, since V4, a video amplifier, will introduce a phase reversal to bring the picture signal into the correct sense.

Picture signals applied to the tube in the wrong phase, therefore, would appear as a negative, and from this it can be seen that serious phase distortion could change the tone of parts of the picture corresponding to frequencies affected by the distortion. The usual effect, as seen on the screen, however, has been given the title of " plastic "—edges of objects take on a very sharp and distinct character, sometimes with a black band, although this latter effect can also be caused by faulty tuning in one of the circuits, whilst the whole picture takes on a sculptured effect. It has been obtained with the present circuit by deliberately introducing feedback into the R.F. circuits, a greater degree of feedback causing the picture to break up into vertical bars, whilst with the R.F. stages actually forced into oscillation the picture is obliterated and a bright raster only left visible.

The only likely cause of phase distortion in the circuit under discussion, therefore, is feedback between the coils of the R.F. and detector stages, or coupling between stage wiring or components. The author has found in the original model, however, that coils may be as close as 2 inches, without screening, and whilst the supply line is kept at 200 volts no trouble through feedback is obtained. The coils are tuned by moving brass plugs, and it is helpful to earth the tuning plug of the detector stage coil, but further coil and circuit details are left for thorough discussion in the second section of the chapter. It will be noticed that there is no gain control in the vision receiver to correspond to an audio receiver's volume control. The lack of such a control, which, on the picture, enables an adjustment to be made to the contrast as distinct from the brilliancy, has not been felt unduly, the circuit having been built to the signal strength available, but in most cases it will be thought necessary to have such an adjustment at hand. The method of controlling the gain of the vision receiver is to bias back the first one or two stages, but it must be born in mind that not only is the SP41 not a variable-mu valve, but also that working at the vision frequency a change in bias will completely upset the characteristics of the valve, detuning the grid circuit and reducing the bandwidth passed by altering the damping of the circuits. The input resistance and capacitance of the valve both change with a change in bias, but the changes in these factors are almost obviated by allowing the suppressor grid to follow the cathode bias, to a degree exceeding the grid bias by about 12 times or so. This is accomplished by means of a network shown in Fig. 25 added to the stages under consideration, both stages being biased to allow the degree of control exercised in each stage to be small. A simpler alternative which is now gaining favour is to alter the voltage applied to the screens of the R.F. stages. This is accomplished by feeding each screen through its own decoupling resistor and condenser from a potentiometer placed across the H.T. supply.

## THE DETECTOR STAGE.

The R.F. signal, then, is amplified by a broadband amplifier and passed on to the detector stage. Here one half of a DD41 is used, not only for the economy effected, but also to confound the critics! An improvement in the working of the receiver might be obtained by using a special television diode, but results have been so good that experiments on these lines have not been thought worth while. Since the DD41 is a double diode with inter-

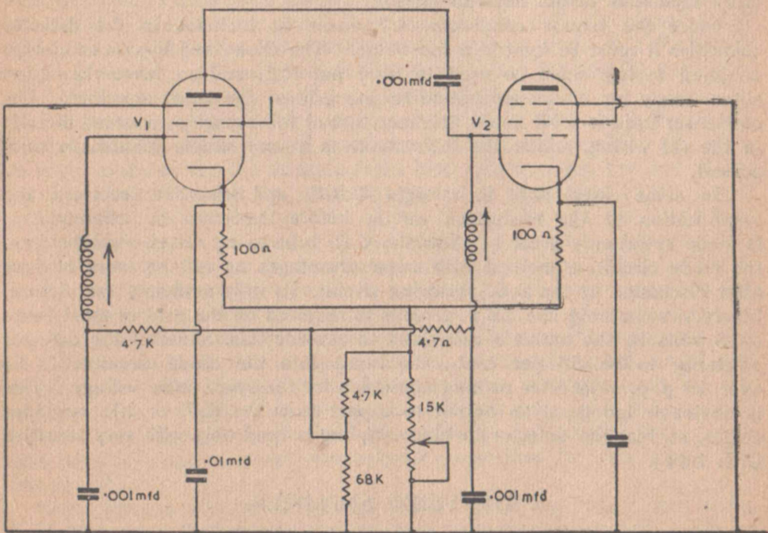


FIG. 25.—Bias Network for Gain Control on R.F. Stages

section screening and separate cathodes, the second half of the valve is used for stage No. 5.

Actually any normal type of detecting circuit can be used for vision signal working, and anode bend and grid detectors were tested in this receiver. The diode gave better results with less trouble, however, and was therefore adopted.

The effect of using a normal diode for this type of detector is to lose efficiency, due once again to the importance of stray capacities. In this stage, as before, the bandwidth is only maintained by using lower resistances throughout the circuit, so that the diode resistance requires to be decreased also. Special television diodes, such as the D1, are made with lower resistance, but even so nothing like broadcast band efficiency can be maintained. The diode load resistance, R7, is only 5,000 ohms, and naturally the efficiency of the detector would rise with an increase in the value of this resistance. Across the resistance, however, are the stray capacities of the valve and associated circuits and components, and the time constant of the system must be maintained at a value where the highest frequency it is required to pass suffers little attenuation. In actual fact, two time constants come into operation depending on whether the brilliancy of the affected portion of the picture is increasing or decreasing, due to the bias on the load capacity and resistance system of the diode, since on rising modulation the resistance of the valve acts in parallel with the load resistance. The net result is that a rising modulation—that is from darkness to brilliancy—is followed more faithfully, which, in turn, means that the right hand side of dark objects will appear to be more sharply focussed than the left. In practice, however, it does not appear difficult to avoid excessive stray capacities in the detector circuit.

Since the bypass condenser, C7, must be included in the detector capacities it must be kept at a low value. The choke and bypass condenser coupling system must be used to filter out R.F. and so leave the vision signal ready for direct application to the grid of the video amplifier. The condenser used is a 30 mmfd. trimmer, not at full capacity, mounted directly in the set wiring, whilst the R.F. choke is a very simple homemade component.

In some cases, both in straight T.R.F. and superhet receivers, the amplification of the modulated carrier before detection or demodulation is made sufficiently great to allow the C.R. tube to be driven straight from the diode circuit, a method with some advantages as will be more obvious after discussion of the D.C. restoring circuit. To fully modulate the picture, however, something like 22 p.-p. volts is required on the grid of most tubes —15 volts in the author's case—and to provide this, allowing the detector efficiency to be 50 per cent., the input into the diode requires to be over 40 p.-p. volts after making allowance for the sync. pulse voltage. This is obviously too great an output to expect from the R.F. or I.F. amplifier stages, so that the detector to tube coupling is used only with very sensitive C.R. tubes.

## THE VIDEO AMPLIFIER.

To overcome the difficulty of feeding a signal with an amplitude of 20 p.-p. volts or more to the tube, the video amplifier, V4 of Fig. 24, is used after the diode. The video (vision frequency) amplifier takes the place of the output stage in a sound receiver, supplying a potential rather than a power output.

Here the similarity stops, however, for where an audio output stage is called upon to handle frequencies of perhaps 30 to 10,000 cycles, the video stage, theoretically, requires to pass without phase distortion or frequency discrimination zero to 2.5 mcs. per second. The very lowest frequencies, however, are sacrificed, since only a D.C. amplifier without condensers and with a special H.T. supply could pass them, but the amplification must be maintained up to as high a frequency as possible if detail is to remain in the picture. The smaller the object in the picture the finer is the detail and the faster the fluctuations of light transmitted, which means that for the retention of detail the frequency must be high.

It will have been observed by most readers that in a wide band amplifier the anode load resistances of the valves fall in value as the frequency rises. This is for the reason that whilst the frequency changes, the stray capacities of the valves, input and output capacitances, wiring capacitances, and the like, remain the same. Their reactance falls as the frequency rises, so that a greater and greater proportion of the amplification is lost via these stray capacitances as the frequency enters into the higher kilocycle ranges. At frequencies of 2.5 mcs. the losses are very serious, and a value which will give, in combination with its associated circuits, a gain of perhaps 200 at a frequency of 5,000 cycles will have a gain of only 5 or so at 2.5 mcs. Such a circuit as it stands would be useless, since the picture brilliancy range would be distorted out of all proportion, but, fortunately, only a low gain is required. It is possible, therefore, to bring down the amplification of the lower frequencies until they balance with that of the higher frequencies by reducing the value of the anode load resistances, and, for example, the SP41 used as V4 in the figure would have a gain of about 8 if the anode load resistance was reduced to about 900 ohms, when the amplification over the whole frequency range would be substantially linear.

Whilst high gains are not required, however, a gain of 8 is scarcely sufficient, and it remains to find some compensating system which will allow the load resistance to stay at some fairly high figure, whilst the loss of the high frequencies through the stray capacitances is made good by a " boosting " circuit. This is the function of the choke following the anode load resistance, which, by presenting an increasing impedance as the signal frequencies rise, maintains a fairly constant output at all frequencies with an increased stage gain of perhaps 15 or more. The coil must have little self capacity and care is needed in the calculation of its size, since, in theory at least, there will be a tendency for the coil, tuned by its self capacity, to give an oscillatory kick at certain frequencies or on sharply rising modulation characteristics. By trying several different types of inductances at this point, however, the writer has satisfied himself that quite large discrepancies give no effect apparent to the eye. Accordingly, an ordinary tuning coil, easily obtained and of small dimensions, is specified for this choke, the Wearite PA2.

Other circuits with the inductance in the output lead rather than in the anode load, or with two inductances, one in each position and tuned by small capacitances, are sometimes used, but in each case there are critical adjustments, and inductance values vary as the stray capacities vary. It is not easy, therefore, to specify values for a circuit which will be built up in different ways, and the single anode load coil, holding good over a much greater range of varying characteristics, and thus more suitable for inclusion in a home built receiver, is advised.

The C.R. tube came be fed directly from the anode of the video amplifier, but it is felt that the method is undesirable, and is therefore not shown. The valves following the video amplifier each have their own definite function to perform, and whilst one of them could be dispensed with, its use in the circuit makes it an economical proposition. This is the phase splitter and tube feed valve, V6, but before further discussion on this stage the working of the inverted diode, V5, the second half of the DD41, must be examined and explained.

## THE D.C. RESTORER.

To return to the practice of sound amplification again, it is generally known that sound or audio waves may be transmitted through an electrical circuit as an A.C. waveform. The chief characteristic of such a waveform is that, in the case of a pure tone, for example, it may be considered as a pure wave oscillating about a central datum line which corresponds to electrical zero. In other words, the wave carrying audio frequencies may be represented as in Fig. 26a.

Such a wave may be transmitted through a condenser without any difficulty, since to A.C. a condenser appears merely as an impedance. Thus in Fig. 26a the wave is shown passing through a condenser without being changed, it being supposed that the condenser is of a suitable value.

This is not the case with the video signal, however, which must be considered not so much as an A.C. waveform, but as a varying unidirectional wave. Such a wave is shown in the first half of Fig. 26b entering the

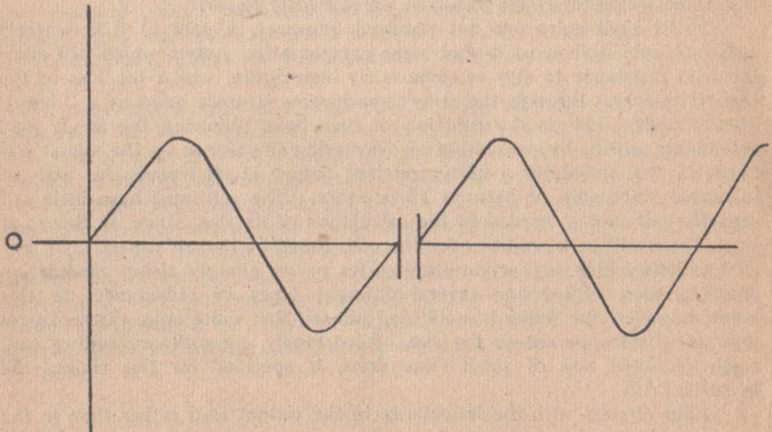


FIG. 26A.—Audio A.C. Waveform

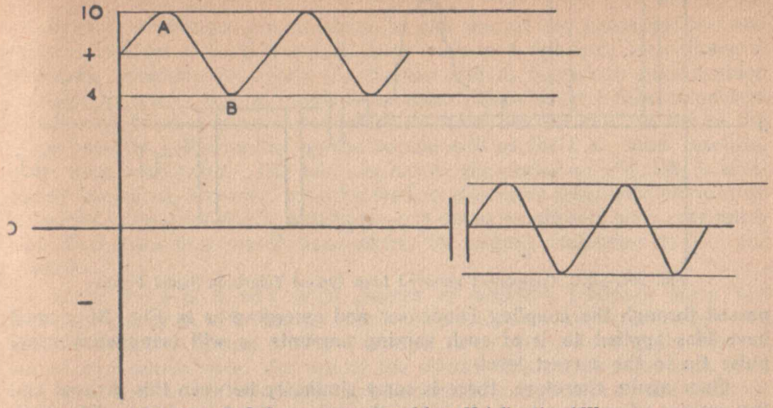


FIG. 26B.—D.C. Component removed from Uni-directional Wave

condenser, and it will be seen that the wave has a D.C. component—that is, the whole wave is above the zero potential line, crest A being 10 volts above zero and crest B 4 volts above. Consider what happens, however, when such a signal is transmitted from one stage to another via a coupling condenser. The D.C. component disappears since the condenser will pass the A.C. component only, and the signal takes the form shown in the second half of the figure. The wave has become an A.C. wave, varying either side of zero.

In an audio amplifier this state of affairs actually is found, since the first half of Fig. 26b corresponds to the signal on the anode of one stage, the D.C. component being supplied by the H.T. on the anode, whilst the second half of the figure represents the voltage on the grid side of the coupling condenser to the next stage, the condenser having blocked the D.C. Audio and television practice again diverge, however, and in Fig. 26c is shown the state of affairs after the coupling condenser from the video stage anode to the grid of the C.R. tube. The video signal loses its D.C. component, but, moreover, since it is not a sine wave the waveforms take up positions about the zero line such that the area of the waveform on one side of zero is equal to the area on the other side. The sync. pulses are below zero at widely differing depths and the picture intelligence peaks are above zero at widely differing heights, clearly an unusable signal which would allow neither synchronisation nor picture to be correct for one instant.

Upon the D.C. component of the vision signal depends the overall brightness of the scene transmitted. The waveform modulates the raster with picture detail, but without the D.C. component the picture takes on a strangely uniform greyness, so that whilst detail is present the whole picture is flat and dull. At the same time, the tips of the sync. pulses, being at varying heights pictorially in Fig. 26c, are at varying potentials, so that the time bases are fired erratically. The sync. pulse tips must be maintained at the same level so that the true 30 per cent. modulation level can be used as the black reference level, and to do this the signal, after being

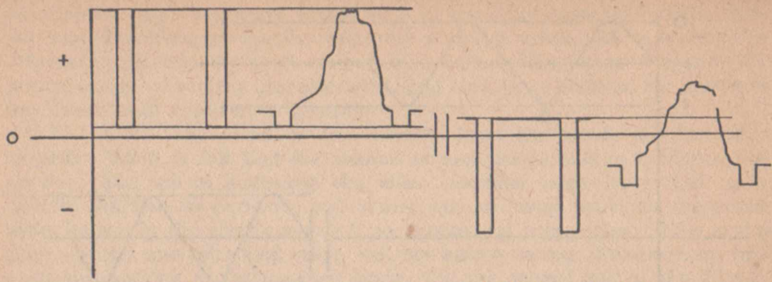

FIG. 26c.—D.C. Component removed from typical Television Signal Forms

passed through the coupling condenser and emerging as in Fig. 26c, must have bias applied to it of such varying amounts as will bring each sync. pulse tip to the correct level.

Once again, therefore, there is some similarity between this process and the process of passing an audio wave through a sound amplifier. The D.C. component is removed from the audio wave as it passes from the anode of one stage to the grid of the next, where it appears as an audio frequency wave varying either side of the zero potential line. An A.C. input to the valve is not suitable, however, so that, in a sense a D.C. component is restored to the audio signal by biasing the valve. This results in the grid becoming so negative that the A.C. wave cannot run it into the positive region.

In the case of the audio amplifier the bias can be constant and therefore is easily supplied by the valve itself. For the television signal, as has been seen, the bias must vary to suit the waveform, and one may therefore suppose that the signal itself controls its own bias. This is the case, and the picture is held by a degree of bias such that the video signals are always positive, black level falling at the zero line, whilst the sync. pulses are negative. The diode V5 performs this operation in conjunction with the coupling condenser C9 between the video amplifier anode and the grid of V6. Since 30 per cent. modulation, the black level, is taken as the reference line the video signals may be considered as being in the positive sense with the sync. signals in the negative sense. Whilst video signals are being transmitted from V4 to V6, therefore, the cathode of V5 is positive, and since the valve is a diode it does not conduct. During the negative sync. pulse the valve will conduct, and in this period of time the condenser C9 is charged, the cathode of V5 thus being left with a positive potential on it. This positive potential has an amplitude which is dependent on the degree to which the sync. pulse drives the cathode negative, thus allowing the condenser to charge, and the sync. pulse, in turn, is dependent on the video signal. A pulse after a white video peak, for example, will drive the cathode of V5 more negative than will a pulse after a black line, resulting in its being left more positive, and in this way an automatic bias is applied which has the effect of bringing the content of all types of line to the same level.

During each line the charge left by a proceeding line leaks away through the resistance R10.

## THE PHASE SPLITTER.

Several advantages are obtained by the use of the phase splitter and cathode follower, V6. If the C.R. tube were not fed from its cathode it would be necessary to couple the picture grid to the anode of the video amplifier by one of several possible methods. The danger is always present that by the breakdown of a condenser or valve the full H.T. as fed to the vision receiver will thus be applied to the grid of the C.R. tube, resulting in its total breakdown. The tube, as fed by the circuit of Fig. 24, is completely protected, however, and the feed is also more adaptable since stray capacities across the output resistance of a cathode follower have very much less effect than they would have across the output resistance of V4, for example.

Since there is a very great degree of negative feedback along the cathode resistance, V6 has an almost distortionless curve, although the amplification then drops to slightly below unity—there is a slight loss in output consequent upon the use of the circuit. The input capacity is very low, as is the output resistance, and so the stray capacities in the coupling between the cathode of V6 and the C.R. tube grid can rise to a considerable figure before high frequency attenuation becomes apparent.

The output at the cathode is in the same phase as the input to the grid of the valve, whilst by making the anode load resistance equal the cathode load resistance the same voltage output is obtained at the anode only in opposite phase. Thus at the cathode the video signals will be positive with negative sync. pulses and at the anode the video signals will be negative with positive sync. pulses. The anode output is therefore suitable for feeding to the sync. separator, for another phase reversal in V7 will bring the sync. pulses back into the negative sense, in which form they are required for the Blumlein integrator time bases.

It has been found quite suitable to run the phase splitter with equal anode and cathode resistances, but in some cases it may be desirable to have a rather larger output available for the sync. separator, V7. If such a case it is only necessary to increase the anode resistance by, say, 50 per cent., and if desired the cathode resistance can be reduced as well. Excellent synchronisation has been obtained with the circuit as it stands, however.

## THE SYNC. SEPARATOR.

In the coupling to V7 it will be seen that the D.C. component so necessary to correct synchronisation has again been lost, but in this case the sync. valve acts as its own D.C. restorer. Since it is unbiased, the cathode being returned straight to the chassis, and the signal is applied to the grid in the opposite phase to that in which it is applied to the cathode of V5, the grid and cathode of V7 act as a D.C. restorer diode and the sync. pulses are brought to a proper working level once more. A lower resistance as the leak has been found desirable in this case, however, and R13 has a value of only 0.1 megohm.

The sync. separator is so arranged that the anode current cuts off almost immediately the grid is driven negative, and since the signal is applied with the video portion in negative phase, the valve cuts off during the duration of the picture along each line. At the end of the line, however, the sync. pulse is applied to the grid in the positive sense, so that the anode circuit passes current in a pulse following the shape of the sync. pulse. During the sync. pulse, therefore, the anode potential falls due to the passage of current through the anode load, so that in respect to earth the output is in the negative sense, correct for the integrating time bases.

Two types of circuit are required to feed the two different sync. pulses to their respective time bases, the line time base being fed through the differentiating network, C11, R19, and the frame time base through the integrating circuit, C13, R18, assisted by the anode network R16, R17, C12. As may be expected from their names, these circuits are responsive to different frequencies in different ways. The differentiating circuit will not pass low frequencies, whilst the integrating circuit will respond hardly at all to a single pulse or a high frequency, its response rising for a chain of slower pulses as are supplied for the synchronisation of the frame time base.

The great necessity for avoiding interaction between the two time bases must be stressed at this point, and feedback from one time base to the other, via the differentiating and integrating circuits, must be prevented, the most likely form of the trouble being in the premature firing of the frame time base by feedback from the line time base. With the networks shown here, the trouble has not occurred throughout a long period of testing, and interlacing has also been better than was expected. Other circuits are possible for the supply of the frame sync. pulse and the integrator does not always give good results due to the rounded type of pulse which it supplies, but with this receiver there has been no trouble at all on odd or even frames. The lines of the picture, during testing, should be closely inspected for loss of interlacing, since a common fault of an improperly working sync. circuit is to run the two sets of lines close together in ensuing half pictures, so that lines appear to be bunched in pairs, with wider spaces between the pairs. No loss of interlacing in this manner has been experienced with these circuits, however.

## SOUND INTERFERENCE.

When using a T.R.F. receiver for vision signals sound breakthrough on the picture is sometimes experienced. The tuning circuit response is so broad that on well modulated signals the sound carrier is also received, generally on the edge of a sideboard, with the result that fluctuating bars, or ripples, pass across the picture, chiefly in the vertical direction. With the coils, to be described, the effect has not been noticed and it has not been necessary to include a sound wave trap in the circuit. If for any reason the trouble does occur it can be eliminated in the aerial circuit, and is dealt with in the chapter on aerials.

## CONSTRUCTIONAL DETAILS.

First and foremost it must be remembered at all stages of the building of a vision receiver that not only are the circuits more broadly responsive than those of the broadcast receiver, but also that stray capacities and losses

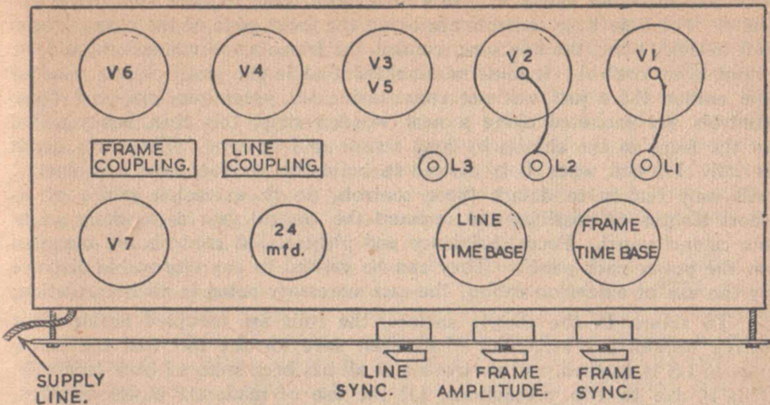


Fig. 27.—Chassis Top Surface Layout

of all types cannot be allowed. Again, the receiver is to work on the very high frequency band, so that feedback and inefficient spacing of components, as well as long, indirect wiring, must always be avoided.

The author has decided that in his own case separate chassis are advantageous, one carrying the power supplies, one for the sound receiver and one for the vision receiver and time bases. This last chassis is the unit for discussion here, since the arrangement of the power supply chassis must depend on the equipment to hand whilst the sound receiver is dealt with in another chapter.

The original receiver, built to the circuit of Fig. 24, together with the two time bases, is all on a chassis 9½″ x 4″ x 2″, an achievement which immediately led to the receiver being christened the " Multum in Parvo." The development work was done on a much larger chassis with the circuits more scattered for easy experimenting and adaptation, and there can be no doubt that with the condensed result the picture is a little clearer and brighter. Such a small chassis is not recommended to workers without high frequency experience, however, and a more easily handled size would be the 10″ x 8″ x 2½″. The chassis *must* be of non-ferrous metal, preferably copper, but aluminium is perfectly suitable, the gauge being stout for rigidity. Provided that a chassis punch of 1⅛″ is available, the chassis is best bought undrilled so that the valveholders can be laid out to suit the circuit. Chassis punches or cutters are most useful tools, and all home workshops should be possessed of at least one. Tank cutters of the adjustable type are also valuable tools for work in wood and all metals.

The top surface chassis layout is shown in Fig. 27. Along the rear edge of the chassis the first 5 valves are spaced equidistantly, it being remembered that V3 and V5 are two separate diodes contained in the same envelope. Along the front edge are V7, the sync. separator, so positioned that it is close to its feed valve, V6, a smoothing condenser of the chassis mounting can type, and, finally, the two time bases, spaced a little more than are the other valves to give a little more room to their sub-chassis circuits. The time base controls are along the front edge of the chassis, from left to right, being the line sync. control, the frame amplitude control and the frame sync. control. It must be admitted that in the small chassis used by the author there just was not room inside for potentiometers, and these controls are mounted along a neat wooden strip, this then being bolted to the front of the chassis by long screws and spacers. The extra depth is only 1", and when it is desired to build the receiver into a cabinet it will only remain to detach these controls, to fit extension cables of as short lengths as possible, and remount the control gear as a whole on to the cabinet panel. Focus, brilliancy and picture shift controls are mounted on the power pack panel. They can be carried to any reasonable distance by the use of extension cables, the care necessary being in their insulation.

To return to the chassis surface, the coils are mounted beside their valves without any screening whatsoever, save for the fact that the screw plug in L3 is earthed, and no trouble at all has been suffered from feedback. This is due to two precautions, (1) the use of moderate power supplies, 200 volts only, and (2) to very careful circuit wiring and the use of common earthing points for each stage. A common stage earthing point means that every earth wire in each stage is taken to one single point in the stage. By this means there are no circulation R.F. currents in the chassis, and all the components for each stage are lumped beneath the valveholder, not straying about. Each stage should be a compact set of components, the only wires coming out being the heater and H.T. feeds and the feed to the next stage, which, in any case, should be carried immediately through a hole in the chassis and taken direct to the grid or hot side of the next coil.

The last two components on the chassis surface are the two oilfilled condensers supplying the time bases with sawtooth voltage. They are surface mounted for the reason that they are of the bath tub type, and room for them could not be found underneath. In the larger chassis advised this point would not arise.

At this point a note concerning the specified valves must be made. It will be seen that both 4 and 6 volt valves are used, the reason being that, like most home constructors, the author's valve stocks consisted of both types and the stocks were rather strained in the building of the receiver. Since both 4 and 6 volts were available from the power pack it was decided to use the two types together, and no complications have arisen from so doing. After much consideration it was also decided to specify the valves in this way, simply for the reason that other builders will undoubtedly be in the same position, and will be glad to draw on all their available valves. The receiver valves proper must be of the types specified, that is, SP41 and DD41, but for those who require to use 4 volt valves instead of the 6 volt types, for V6 and V7, the 6C5 may be replaced by practically any triode, the 354V being very suitable, whilst the EF39 may be replaced by another SP41. No change in the circuit need be made in either case.

For the time bases the 6 volt valves may both be replaced by TSP4's, or practically any H.F. pentode without circuit changes, but it has been found that the 6 volt valves as chosen give slightly better results, and it is advised that they be retained if possible.

If 4 volt valves are used throughout the whole circuit the heater load is rather heavy, something like 7½ or 8 amps for the vision receiver and time bases alone. In the author's case a special heater transformer was wound, to supply the high insulation heater windings for the rectifiers and also to supply the 6 volt valves, whose consumption is only 1.2 amps. The construction of such a transformer is not too difficult a job, given care and patience, and details are to be found in Bernard's Coil and Transformer Manual, No. 48. Alternatively, heater transformers are often advertised in the technical press, and with so many valves to supply with current, such a transformer would be a good investment. No one transformer should be expected to carry the whole H.T. and heater load.

In the assembly of the chassis the valve holes should first be drilled or punched out in positions as shown, and the valve holders fitted below the chassis surface. Since all heaters are returned to earth on one side (reference to earth in all receiver contexts here means the chassis, which is common to the negative supply line), a hole should be drilled at each coil position and two soldering tags bolted to the chassis, one above and one below, beside each valveholder. This provides each stage's common earthing point, and one side of each valve's heater is taken to the sub-chassis tag. In the circuit from V5 onwards it is not so important to have common stage earthing points, so that the heaters from V6 up to the time bases can be returned to a tag under ons of the valveholder bolts if desired. Common earth points, however, make the stages neat and self-contained.

The live heater wire is run next—two separate circuits when 4 and 6 volt valves are being used, of course—this wire being well insulated and kept tight against the chassis undersurface to be out of the way, as well as to avoid the slight chance of feedback. Earthing one heater wire is not always sufficient at very high frequencies, but there has been no trouble in this receiver.

The coil positions should now be established—the coils are to be soldered to the tags already bolted to the chassis—and a hole drilled for the lead from the preceding stage to each of coils L2 and L3. The next component to fit to stages 1 and 2 are the coupling condensers of 0.001 mfd. capacity, which should be fitted close under the valveholders so that on one side they are directly connected to the anode pin and on the other have their leads (extended and insulated) passing directly across to the holes just drilled and up to the hot ends of the coils.

The bias resistances and condensers come next, narrow tubular condensers being chosen. They are fitted together, the resistance being soldered directly across the condenser and the combination being taken from the cathode pin direct to the common earth for their stage. All resistors are mounted directly downwards from their pins, and since they are practically all of ½ watt size this means that they will be a standard distance from the chassis, so that H.T. supply leads can run in neat, straight lines from stage to stage. Decoupling resistors are mounted in the supply leads themselves, horizontally, the decoupling condensers running once again directly from the junction of load and decoupling resistors to the common earthing points, thus adding to the rigidity of the wiring and component assembly.

Whilst it may be regarded in some quarters as a bad practice, the author drilled the chassis as the work proceeded, larger components being fitted as their stage was reached. In this way each stage was regarded as a separate unit and no false holes were made, whilst at the same time no stage was crowded over into the space belonging rightly to another. Provided the drilling is carried out with sensible care, no harm is caused by working in this way, and if the wiring already finished cannot stand a little vibration the work would be better for more care in the soldering!

The coils, as home made articles, must now be described. It may be possible in the near future to obtain television coils ready-made once more, and provided they are slug tuned and designed especially for the vision signal there should be no reason why such coils should not be fitted to this circuit. There is no difficulty in constructing the coils, however, and they are shown in Fig. 28.

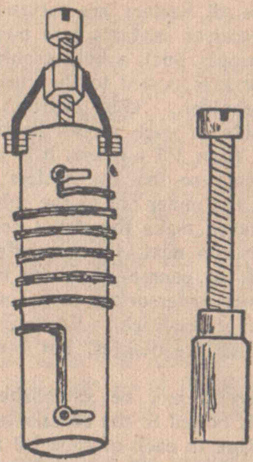

FIG. 28.—Coil and Tuning Slug

## THE TUNING COILS.

Each coil is wound on a paxolin cylindrical former of $\frac{9}{16}$" outside diameter, the former being 2" high. Old broadcast coil formers of the same outside diameter could be used, and would have the necessary soldering tags fitted to them already. The coils are tuned finely by brass slugs or plugs, which are a convenient by-product from the potentiometers. Long spindle potentiometers are obtained and $\frac{3}{4}$" lengths from the surplus spindle cut for the tuning slugs. At the top of each coil, as may be seen in Fig 29, are fitted two soldering tags, held by the smallest nuts and bolts obtainable, these tags being bent as shown until a 4 B.A. hexagonal nut fits snugly between them. The nut is then sweated in place, taking care to position it so that a screw passed through it will run dead centrally to the former.

The slug is prepared by sweating a second 4 B.A. nut to the top of the $\frac{3}{4}$" length of brass rod, leaving the thread inside the nut clear of solder. A $\frac{3}{4}$" machine screw, 4 B.A., is then run through the fixed nut on the former and the slug screwed and tightened home on the end of it. The former is then ready for winding.

Each coil is wound with 14 S.W.G. D.C.C. copper wire, L1 having seven full turns, L2 having six full turns and L3 having seven full turns. L1 also carries the aerial coupling coil and is so wound that the first two turns of the grid coil are spaced by their own diameter to allow two turns of 20 S.W.G. enamelled copper wire to be wound between them. The rest of the turns of L1 are spaced by half their own diameter. L2 has its turns spaced by their own diameter throughout. L3 is close wound, that is, the turns are touching. In each case the winding starts as near the top of the coil as possible to allow the slug moving internally to exert its effect over the whole coil. The end of the winding on each coil is carried down vertically to a soldering tag at the bottom of the coil, and the coil is mounted by soldering this tag to the common earthing tag for its stage mounted on the top of the chassis. The mounting is not extremely robust, and each builder may use his favourite method if desired, but in practice the coils are perfectly firm, and in any case they should not be built on to the chassis until the whole receiver is finished. The inter stage couplings are connected to the top of the coil, at the starting tag, as is also the valve grid lead, except in the case of V3, where the coupling from V2 runs directly to the valve-holder of V3. Remember that in this case it is desirable to run a wire from the tuning slug assembly to the common earth, taking the connection from one of the supporting arms of the top nut and keeping it a ¼" at least from the windings. The ends of the aerial coil on L1 both pass through ½" of sleeving to keep the two turns tight on the former, and are left free for direct connection to the feeder.

## POWER AND FEED LINES.

Since the output to the tube is via a cathode follower and no great care needs to be exercised in keeping the C.R. grid line short and direct, it was decided to use the power pack as a central junction and distribution point. Accordingly, two octal valveholders are fitted to the power pack panel, one as supply point for the tube and one for the receiver. Inside the receiver chassis all supplies and feeds are grouped on a small paxolin board at the end of the chassis opposite to the aerial input point, from which run the eight lines which, by means of an octal valve base, are plugged into their socket in the power supply. The two sockets are interconnected for line and frame sawtooth outputs, and for the picture output to the C.R. tube grid, and a multiplicity of connecting cables between the units has been obviated by this simple scheme, outlined in Fig 29.

## ALIGNING THE RECEIVER.

The receiver can be trimmed directly on the television signal if desired, but working with a very high frequency signal generator is much simpler. It is supposed that not many constructors will have such an instrument to hand, but the author's development work was carried out with the aid of a simple one-valve super-regenerator, which later on became the basis of the sound receiver. Preliminary alignments are not made on the tube, but on headphones coupled across the cathode load resistor of V6. Tuning slugs should be screwed half way into the coils to commence with.

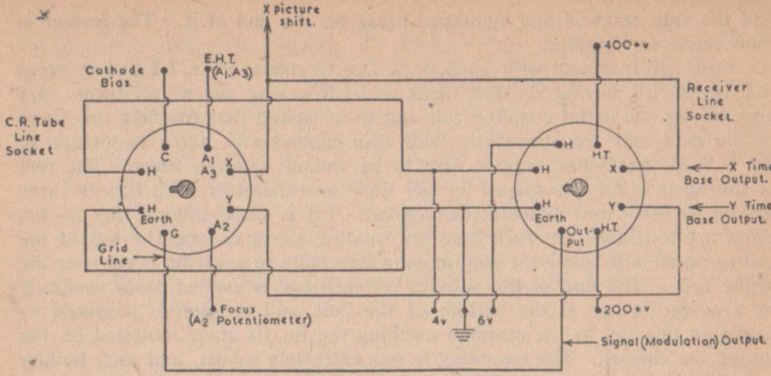


FIG. 29.—Receiver and Tube Supplies (*Note*—Deflector Plates $X^1$ $Y^1$ and leak from $Y^2$ are connected to $A^1$, $A^3$ inside C.R. tube holder

Using the super-regenerator, couple it to as short an aerial as can be used for the reception of the vision signal on 45 mcs. and tune to the video signal, which will be found at about half condenser capacity with the circuit of Fig. 30, which shows the author's arrangement. With the aerial coupled to the vision receiver, and with the time base valves removed, a hissing should be heard in the headphones, due to the transmitted super-regenerating action of the signal generator. *Because of this the super-regenerator should not be used during actual programme transmission times.* Serious interference may be caused to any nearby vision receivers. Trim up at first out of transmission times, and check results on the programmes later.

Commencing with L3, open the turns of the coil slightly (i.e., separate the turns from one another a little) to strengthen the signal. If this weakens the signal an extra turn is required, which should not be the case. Adjust the coil until maximum volume is heard, then transfer the attentions to L2, opening or closing the turns for maximum volume. Finish by adjusting L1, where the turns may require some little opening according to the efficiency of the aerial—it may be necessary to remove a turn, but should not be.

When this preliminary adjustment is completed, tune the coils from L3 to L1 for fine trimming by means of the slugs. If at any time the receiver breaks into oscillation (except when the hand is directly touching a coil and thus introducing feedback capacitively) there are stray capacities or poor component arrangements causing feedback, and the circuits probably require attention to these details. It should not be necessary to reduce the H.T. below 200 volts to avoid feedback. At this supply level the prototype receiver is absolutely stable.

The final trim can be given with the receiver operating the tube. Make all connections and switch on the mains switch, leaving the H.T. switch off for a half minute or so to allow the heaters to warm up. When the H.T. switch is closed there should be a faint high-pitched whistle from the line time base. The brilliancy control should, of course, have been turned down to black out the tube completely.

As brilliancy is turned up there might be, with luck, a picture on the tube, but more probably there will be a flickering maze of bars. Turn the line sync. control until the picture suddenly " clicks " in as the sync. takes effect and holds the line steady. The picture will most likely be rolling up or downwards. This is stopped by the frame sync control, and picture height adjusted by the amplitude control. If any trouble is experienced in holding frame locking steadily, wonders are sometimes worked by reversing the mains power plug.

Note how the frame flyback lines are blacked out as the picture comes into lock, and also how the line flyback can be moved back to the right-hand side by fine adjustment of the line sync. (Line flyback appears as a faint mist across the picture.)

In non-transmission periods, line scan linearity can be inspected by means of the super-regenerator. A series of bars can be produced, 5 or 6 of them running vertically down the picture area as the super-regenerator is tuned through 45 mcs. The distance between the bars should be the same for each of them.

If the picture is mirrorwise, the line scan voltages are being applied to the wrong X plate of the tube, and for an upside down picture the frame scan is being applied to the wrong Y plate—so long as the tube is not inverted too!

## EXTENDING THE RANGE.

So far the author's own receiver has been dealt with, a circuit capable of giving good results at 5 miles from Alexandra Palace on a decidedly poor aerial. It is much regretted that a scale of distances to receiver styles cannot be given, but that is impossible even for the greatest authority on the subject. Reception can vary not from town to town but even from street to street, and the number of R.F. stages required for any given location is impossible to estimate with anything like certainty.

At 10 miles from the transmitter, however, it can be said that while 2 R.F. stages may still give good results, 3 R.F. stages should certainly be

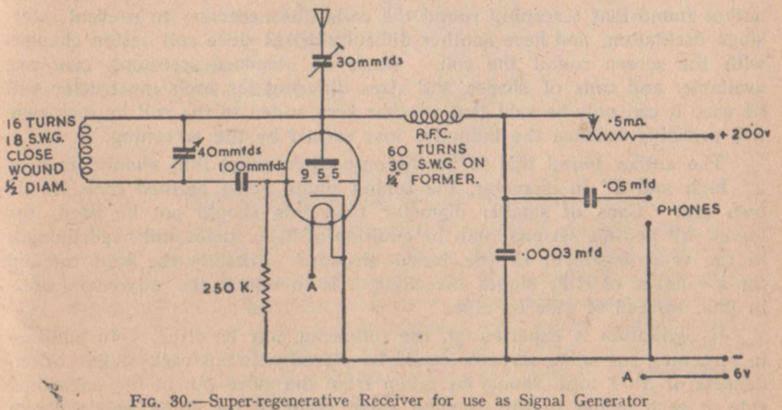


FIG. 30.—Super-regenerative Receiver for use as Signal Generator

adequate, and, given a good aerial, should also be suitable for greater distances. An estimation might be made using a small receiver like that of Fig. 30 to judge the signal strength audibly, but the only real instruction of any value which can be made is that relating to the addition of R.F. stages to the existing circuit. An alternative circuit is shown in Fig. 31.

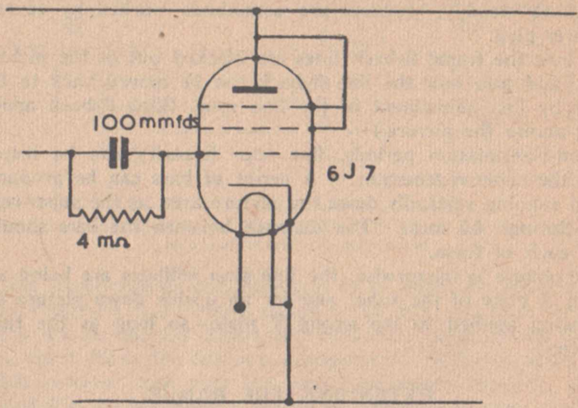


FIG. 31.—Method of connecting 6J7 to substitute for Acorn in Fig. 30, using positive grid drive

The trouble lies in the ever-increasing tendency to feed-back as the number of stages is increased. Each stage should be of the form of stage No. 2 of the circuit shown in Fig. 24, with a coil made as L2, the stages being inserted between stage 1 and stage 2 of this receiver.

So long as extreme care is taken with subchassis wiring it might be possible to work 4 stages before the diode detector, but such a circuit is only for the experienced home constructor. Even with 3 R.F. stages the author found that screening round the coils was necessary to prevent inter-stage oscillation, and here another difficulty arises since coil design changes with the screen round the coil. Since no standard screening cans are available, and cans of shapes and sizes differing for each constructor will be used it can only be said that another turn added to the coil in each case will probably balance the inductive loss caused by the screening.

The author found this to be the case when using thin aluminium cans 2″ high and 2″ in diameter, the tuning plugs being earthed each via its own can. Cans of smaller diameter than this should not be used, for losses will become serious, and the addition of R.F. stages will need thought in the re-arrangement of the tuned circuits. Possibly the best method for a number of R.F. stages exceeding 2 is to mount the valves and coils in line, instead of side by side.

If oscillation is experienced, the following may be tried. In addition to screening the coils, screens should be placed between each stage. Condensers of .001 mfd. should be taken from the valve pin of the unearthed side of each heater to the common earth point of the stage, and a choke consisting of about 7 turns of wire wound round a pencil may be inserted in each heater circuit; these chokes may be wound in the actual connecting wire used for wiring the heater circuits. If this is of no avail, screen stopping resistors of 100 ohms should be soldered into the screen circuits as close to the valve pins as possible, and as a last resort a slight reduction of H.T. volts or the introduction of 400 to 800 ohm grid stoppers may help. The last two methods should not be used until all else has failed, since they both result in a loss of gain.

An experimental layout before final construction is obviously a necessity, however, but the final results are well worth working for.

Components for the Vision Receiver of Fig. 24:—

| | | |
|---|---|---|
| L1, L2, L3. | | See Text. |
| L4. | | P.A.2. Wearite. |
| R.F.C. | | 60 turns 30 S.W.G. enam. ¼" diameter. |
| C1, C2, C4, C5. | | 0.01 mfd. Tubular. |
| C3, C6. | | 0.001 mfd. Mica. |
| C7. | | 30 mmfd. Trimmer. |
| C8, C13. | | 0.05 mfd. Tubular. |
| C9, C10, C12. | | 0.1 mfd. Tubular. |
| R1, R4. | | 1,000 ohms, ½ watt. |
| R2, R5, R11, R12, R13, R15, R17. | | 10,000 " " |
| R3, R6. | | 220 " " |
| R7, R8. | | 4,700 " " |
| R9. | | 47 " " |
| R10. | | 1 megohm. " |
| R14. | | 100,000 ohms, " |
| R16. | | 20,000 " " |
| R18. | | 47,000 " " |
| R19. | | 33,000 " " |
| V1, V2, V4. | SP41. | |
| V3 with V5. | DD41. | |
| V6. | 6C5. | |
| V7. | EF39. | |

4 Mazda Octal holders.
2 International Octal holders.
Chassis, etc.

## CHAPTER 5.

## THE SUPERHETERODYNE RECEIVER.

It has already been stated that a T.R.F. receiver will give good results over a wide area served by the television transmitter, and there is no reason why the simpler receivers should not give excellent service around each station as the transmitter chain is extended throughout the country. It is on the fringe of the roughly circular area round each transmitter where the signal strength will be found either too low or too fluctuating in value to allow a straight receiver to be used, and it is here that the superheterodyne is of chief value.

The circuit which is the subject of these notes on superhet design and working for vision signals is shown in Fig. 32, and is reproduced here by the kind permission of the designer, W. T. Cocking, and of the publishers of the "Wireless World," Messrs. Iliffe and Sons, Ltd. The circuit was first published under the heading "Magnetic Television Receiver" in "Wireless World," dated July 9th, 1939, and also pointed out the advantage of the circuit types used as V6 and V7 of Fig. 24.

Despite the lapse of time, the receiver can still be regarded as a model for home constructional purposes, and a components list is included in the chapter. The coils as originally used are listed, since it is hoped that such components will again be on the market in not too long a time.

Only the stages up to and including the video amplifier are shown since the remaineder of the receiver circuits can be exactly similar to those of the receiver in Chapter 4, using a single diode for V5 with the valves for V6 and V7 as shown in Fig. 24, together with similar time bases.

The superhet in the diagram is a very sensitive receiver, designed in such a way that the R.F. stage or an I.F. stage could be omitted for areas with fairly strong signals. The circuit may be split into four broad sections :—

1. The R.F. stage;
2. The Oscillator-Mixer;
3. The I.F. stage; and
4. The Demodulator and Video output stage.

The fourth section can be dismissed in a few words by comparing it to the T.R.F. detector and output stage. Rather more elaborate filtering through L8 and L9 is provided to remove any intermediate frequencies which might filter through into the output, a special television diode being used for the highest possible efficiency. The diode load and video emplifier anode load are lower in resistance values than those shown in the author's circuit, but here again the utmost efficiency in passing all the picture frequencies is obtained. The degree of bandwidth is possibly higher than is necessary for a small tube, and it is probable that with the spot size of a 6" C.R. tube no serious effects would be observed if these resistances were increased a little in value.

Stage 1.—The R.F. stage is included in the circuit to assist the working of the oscillator-mixer stage. With the valve specified there is practically no gain in the mixer stage at 45 mcs., and for this reason the signal to noise ratio of the stage is poor. In other words, the noise introduced into the circuit by the valve itself is of almost the same amplitude as a weak signal, so that the two receive the same amplification throughout the rest of the receiver circuits. To put up the signal to noise ratio, the R.F. valve is included in the circuit, although it can be omitted when the receiver is used in a good signal strength area.

Stage 2, the oscillator-mixer stage, follows quite conventional lines, as can be seen, although in the oscillator section it is most necessary to have excellent screening and very short connections. The oscillator coil as specified contained its own tuning condenser—condenser tuning can be used in this stage alone, slug tuning being adopted for the other stages—

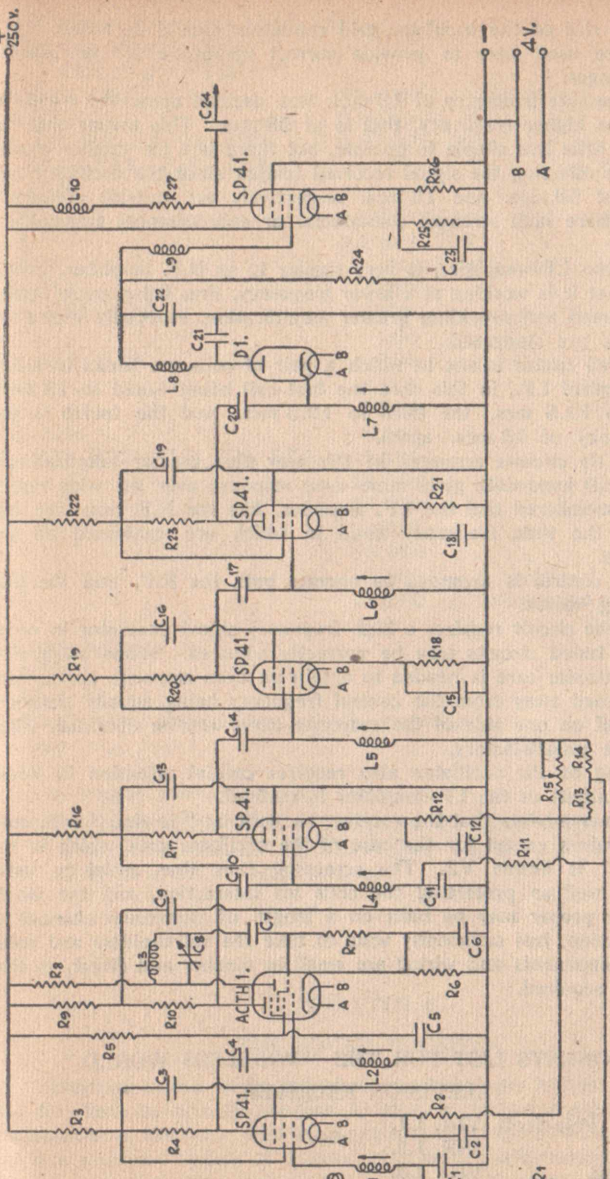


Fig. 32.—
W. T. Cocking's Television Superhet.
By kind permission of *Wireless World*

but the small size of the oscillator grid condenser should be noted. Only 10 mmfds. are used here to provide correct amplitude of the injected oscillator voltages.

An intermediate frequency of 13 mcs. was decided upon, the oscillator working at the higher frequency, that is at 58 mcs. This means that the oscillator is a little less simple to operate, but there is a far smaller chance of interference affecting the signal received images since the oscillator and I.F. circuits at 58 mcs. and 13 mcs. respectively are outside commonly used bands where high strength commercial or entertainment transmitters are working.

Stage 3, the I.F. amplifier, is very similar to an R.F. amplifier, except for the fact that it is working at a lower frequency, thus being more stable, more easily tuned and providing greater amplification, especially where the tuning circuits are staggered.

A staggered circuit is one in which a pair of coils are tuned to either side of the central I.F., in this case the first coil being tuned to 13 mcs., the second to 13.5 mcs., the third to 12.5 mcs., and the fourth to the middle frequency of 13 mcs. again.

Not only do circuits arranged in this way give greater amplification, but their overall bandwidth gives more even response over the wide range. It must be remembered that the I.F. amplifier, like the R.F. amplifier, has still to pass the wide frequency band in which are contained all the picture signals.

The gain control is arranged to operate both the R.F. and the first I.F. amplifying valves.

Aligning the circuit requires a high frequency signal generator in order that the I.F. tuned circuits may be correctly adjusted. When staggering the circuits extreme care is needed to obtain an even response curve, with the circuits tuned away from the central frequency being equally detuned. A sharp cut-off on one side of the response curve can be obtained, when results will be unsatisfactory.

The tuning of the oscillator also requires careful attention in order that the full output of the I.F. amplifier is realised.

The designer advises that the receiver be built up "in line," with coils between the valves except for the case of the oscillator coil, which in the original model is beside V2. The screening cans thus assist in valve screening, as well as protecting the coils for interaction, and the whole vision receiver proper may be built on a length of aluminium channel of inverted U section, just sufficiently wide to take the valveholders and coils. Sub chassis components and wiring are small in number and direct, so that little space is required.

## COMPONENTS LIST FOR THE "WIRELESS WORLD" TELEVISION RECEIVER.

| | | |
|---|---|---|
| 1 Aerial coil, | Peto-Scott | VIA. L1. |
| 1 R.F. coil, | ,, | VIR. L2. |
| 1 Oscillator coil, | ,, | VIO. L3. |
| 4 I.F. coils, | ,, | VIIF. L4—L7. |

1 R.F. choke, Eddystone 1011. L9.
1 Coil L8, Wearite, PA6.
1 ,, L10, ,, PO7.

| | |
|---|---|
| C7, C21, C22, | 10 mmfds., Ceramic. |
| C1, C11, | 0.001 mfd. Mica. |
| C2, C3, C5, C6, C9, C12, C13, C15, C16, C18, C19, | 0.01 mfd. Mica. |
| C23, | 0.02 mfd. Tub. |
| C24, | 0.1 mfd. Tub. |
| R26, | 50 ohms, ½ watt. |
| R2, R12, | 100 ,, ,, |
| R18, R21, R25, | 150 ,, ,, |
| R6, | 200 ,, ,, |
| R9, R19, R22, | 500 ,, ,, |
| R10, | 1,500 ,, ,, |
| R24, | 2,000 ,, ,, |
| R3, R16, | 4,000 ,, ,, |
| R1, R11, R13, R17, R20, R23, | 5,000 ,, ,, |
| R4, | 10,000 ,, ,, |
| R5, | 25,000 ,, ,, |
| R7, R8, | 50,000 ,, ,, |
| R14, | 75,000 ,, ,, |
| R27, | 3,500 ,, 2 watts. |
| R15, | 15,000 ,, Wirewound graded potentiometer. |

5 SP41 Mazda.
1 ACTH1 ,,
1 D1 ,,
5 Mazda Octal Valveholders, chassis mounting.
1 7-pin ,, ,, ,, ,,
1 D1 ,, ,, ,, ,,
Chassis, topcap connectors, wire, solder, etc.

N.B.—CONDENSERS NOT APPEARING IN LIST ARE INCLUDED IN COIL ASSEMBLIES AS SUPPLIED—C4, C10, C14, C17, C20 and C.8, all of 0.001 mfd. capacity.

## CHAPTER 6.

## THE SOUND RECEIVER.

Television sound is recognised to be of the very highest quality simply for the fact, as already mentioned, that a greater station bandwidth is permissible at the very high frequencies. It is worth while, therefore, to build a receiver capable of dealing with high quality sound, remembering at the same time that real quality requires no great volume for ordinary levels of reproduction, so long as a reserve of power is held to deal with transients, etc. A simple receiver feeding into a high-class quality amplifier would meet the situation, but here volume would be far greater than is necessary. A very definite psychological balance exists linking the size of picture to the volume of the reproduced sound, and it is most undesirable to have a small group of, perhaps, actors on a 6″ screen speaking in voices which reverberate with all the power of 8 watts!

The receiver for the present purpose, then, may be designed with a single valve output stage. The choice of the loudspeaker is also of the greatest importance—in all probability constructors have speakers which they intend to use, but should the loudspeaker be mounted in the same cabinet as the television apparatus the cone diameter must not be too large or the whole proportion of the cabinet will be thrown out of gear. A 10″ or 12″ speaker, the front of the cabinet being made to present adequate baffling, will quite dwarf the screen, yet a 5″ or 6″ speaker, of about the same diameter as the tube itself, and thus most suited, physically, to combination with the screen on one panel, will only give the required tone if it is a really high-grade instrument.

If the speaker and C.R. tube are to be mounted close together, it is of the utmost importance to ascertain whether the speaker has any stray magnetic fields set up around it, for these might distort the picture very seriously. Loudspeakers differ widely in this respect, and the only solution to the problem is to bring the speaker close to the tube whilst the receiver is still in the constructional stage, so determining whether the speaker distorts the raster or not.

The author has taken the simple way out by having the sound receiver quite separate from the vision apparatus, using at one time an ultra short wave receiver which is also suitable for amateur work with the speaker on its baffle some little way behind the vision receiver. The speaker is actually above the level of the screen and about 3 feet behind it, but the illusion of sound from the picture is still perfectly satisfactory.

So far, then, the receiver has an output stage with the speaker mounted as is most suitable for its size and type. The output valve may be a triode, a power pentode or a beam tetrode, the latter valves requiring rather less grid swing and thus less amplification before the last stage, so that in some cases it may be possible to drive them directly from the detector.

So far as the detector stage is concerned, a reacting detector can be used for television sound reception with surprisingly good results, since at very high frequencies reaction can be advanced to a high degree without loss of quality.

At the author's location, R.F. amplification in front of the detector is not really necessary, and the first sound receiver used during the early experimental stage consisted merely of the super-regenerator already shown in Fig. 30 feeding into a two-stage amplifier, the complete circuit being as shown in Fig. 33.

Constructors with experience of the super-regenerator may be surprised to read of its being used for the reception of quality signals, but with the regenerative control, R3, well retarded the circuit is capable of good sound reproduction. The condition appears to be that the carrier wave is sufficiently powerful to reduce all chance of quenching action, the quenching circuit nevertheless keeping the receiver open to a wide bandwidth. Naturally the

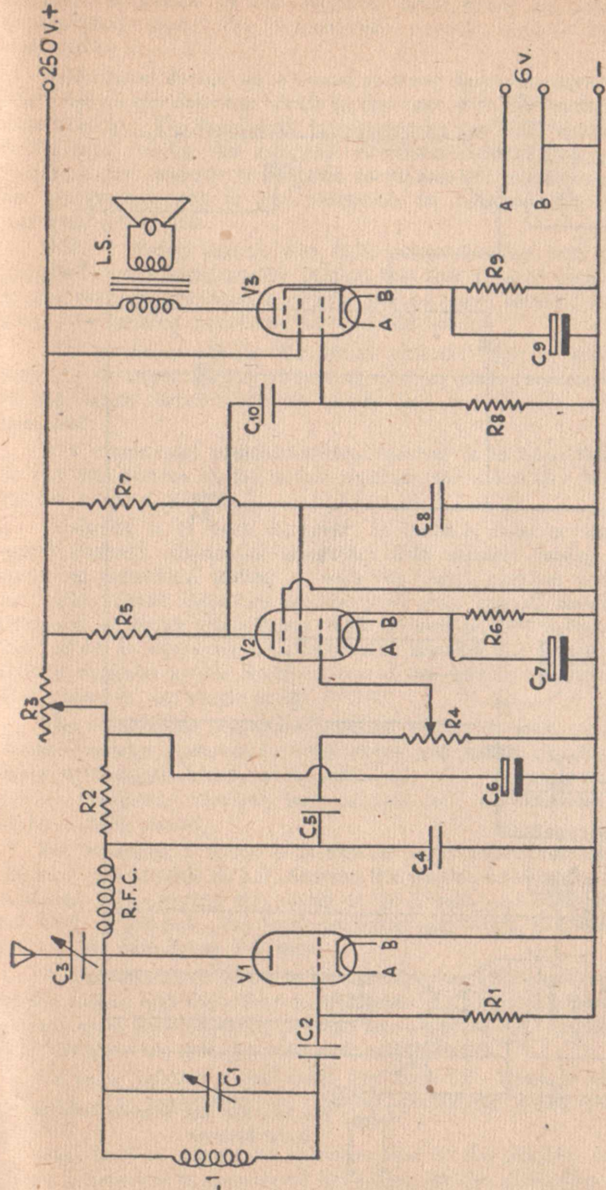


FIG. 33.—
Oscillating Detector
Sound Receiver

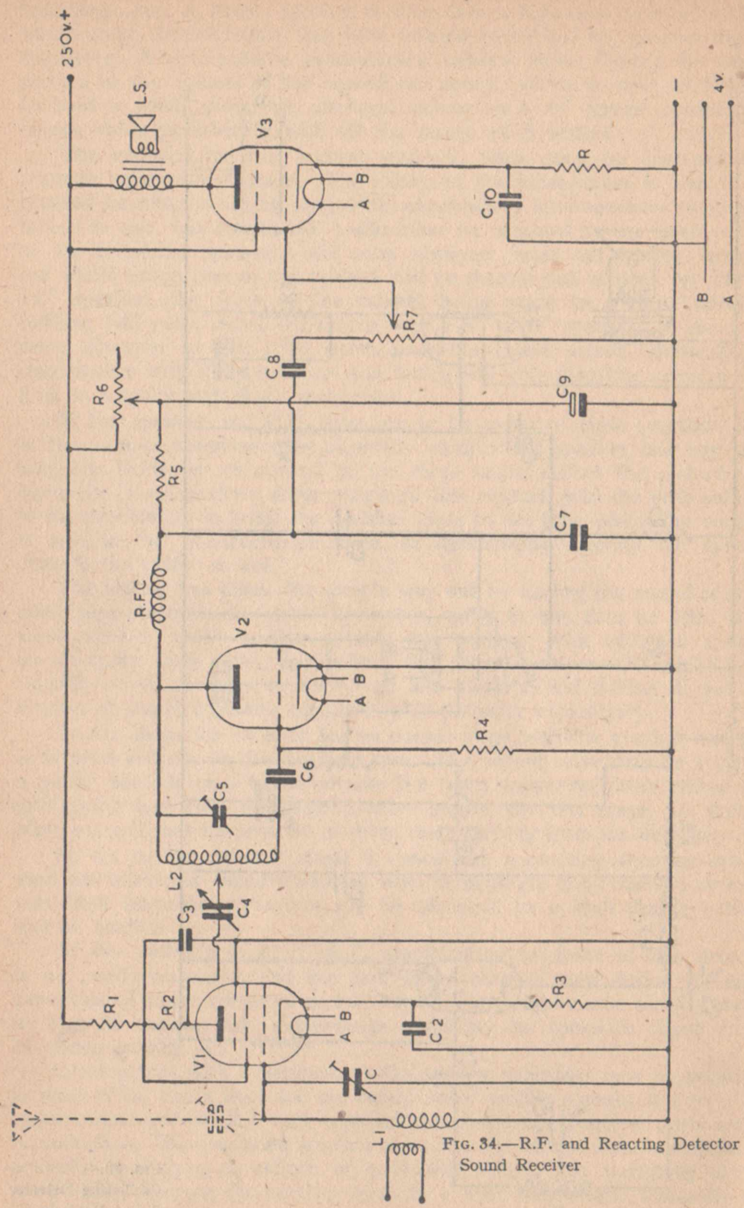


FIG. 34.—R.F. and Reacting Detector Sound Receiver

receiver, as shown in the diagram, must never be allowed to run in regeneration since the interference would render picture reception impossible.

The second design for a sound receiver, however, uses a high frequency stage before the detector, which in this case still has reaction but not super-regeneration. The bandwidth is retained by the coils being damped by the R.F. stage, whilst the reacting circuit is isolated from the aerial. If, therefore, the detector is put into oscillation for any reason, the aerial has no energy fed into it and reception or neighbouring receivers is not disturbed.—Fig. 34.

With a strong signal, two R.F. stages feeding into a diode detector provides a very high quality output, but this type of receiver is restricted in use, whereas the former circuits can be made suitable for general work, simply by making provision for variable tuning.

The efficiency of the R.F.-diode detector type of sound receiver can naturally be made greater than that of the vision receiver for the damping of the tuned circuits can be much less and detector efficiency can be improved.

If a commercial communications receiver is to hand this, naturally, can be put into service as the sound receiver, the selectivity being set to broad for the sake of quality.

Generally it is best, however, to build a receiver especially for the sound channel, dispensing altogether with variable tuning, and even with trimming capacities, tuning as with the vision receiver solely by slugs in the coils. Small capacities on the grid coils can of course be used, but trimmers of larger capacitance than 30 mmfds. are definitely undesirable. The SP41 is again an excellent valve for the R.F. stage or stages, but if it is required to use 6-volt valves at the carrier frequency, probably the best choice is the single-ended EF50.

The commercial television superhet generally uses an R.F. stage and Mixer-Oscillator common to both vision and sound circuits, the tuning of these first stages being made sufficiently wide to pass both bands. The mixer, therefore, receives both signals and discriminates between them in its output circuit.

For example, a mixer with injected local oscillations at a frequency of 58 mcs. will provide an I.F. bearing the picture intelligence at 13 mcs. with a second I.F. carrying the sound at 16.5 mcs. Alternatively, for a vision I.F. still at 13 mcs. the local oscillator may work at 32 mcs., the sound I.F. in this case being 9.5 mcs.

The anode circuit of the mixer contains two I.F. transformers, one tuned to the vision and the other to the sound I.F. signals, the two frequencies passing from then onwards through two separate I.F. amplifiers, each to be dealt with by its own detector and output stages.

In some relatively few cases the first I.F. stage is common to both channels, the separation and further amplifying being performed subsequently.

This method cannot be recommended to the amateur constructor even where a superhet is considered desirable, for the difficulties attendant upon

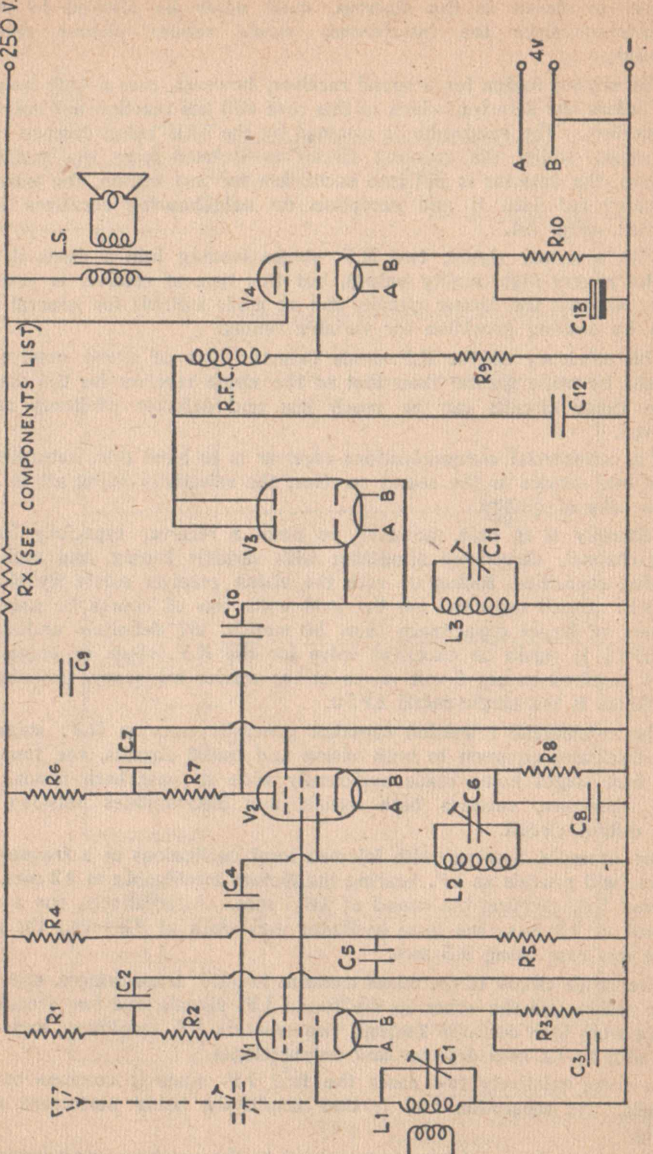


FIG. 35.—High Quality Sound Receiver for good reception areas

the arranging of the circuits to produce the double I.F. are by no means small. The separate receiver is more simple, both to build and operate, and need be no more expensive if a power pack is constructed with ample reserves and good decoupling to feed both units.

## CONSTRUCTIONAL DETAILS.

In Figs. 33-35 are shown circuits of the types mentioned as being suitable for sound reception, and component lists are appended. There remains but little to say concerning the construction of these circuits, for they should be given the same treatment as the vision receiver, in that they are built on aluminium or copper chassis, each stage has a common earthing point and care is taken to avoid any long wiring or component spacing which introduces either stray capacities or feedback from a later to an earlier stage.

In Fig. 33 the usual trimmer condenser is shown replaced by a Raymart VC40X variable condenser, when a 16-turn coil of ½" diameter will cover both the television stations and the amateur 10 metre band, but the receiver will then almost necessarily be isolated from the vision receiver for convenience.

If the circuits are built up on an inverted U section of aluminium channel, as advised for the superhet circuit of the preceding chapter, it will be possible to fit the whole sound unit into any odd corner the cabinet presents, since after trimming the only control is that for volume which can be extended on a screened cable. All the circuits may be driven from a conventional power supply such as that shown in Fig. 36.

Little further requires to be said about these circuits, since they are all simple to build and operate. The "in-line" method of building should present sufficient screening to the circuits to protect the R.F. stage from feedback where an oscillating detector is used—the author has had no trouble from this—but should there be any instability the absence of variable or ganged tuning controls allows very simple screening to be arranged. All that is necessary is to fit an aluminium screen straight across the chassis between the R.F. and detector stages, the screen to be as wide as the chassis and as high as the mounted overall height of the valves.

It will be noticed in Fig. 34 that the coupling between stages is via a variable condenser which is tapped on to the detector coil. The coupling is thus widely adjustable so that it can be suited to the reacting stage. The second stage is so heavily damped by the first that this coupling must be variable in order that the detector circuit can oscillate. The variable resistance control in the anode should be set to a low value, whilst the coupling is adjusted, so that increasing the resistance will carry the valve into the non-oscillating, sensitive portion of the characteristic.

All the circuits can be aligned either by a signal generator working on 41.5 mcs. or on the sound signal itself, although the receiver should not be allowed actually to oscillate when receiving the programme. Once the trimming condensers, or, if slug tuned coils are used, the slugs, are set the receiver should need no further adjustment.

Slug tuned circuits will not be quite so simple to adjust on the sound signal since, due to the lighter damping on the coils, the bandwidth will be narrower

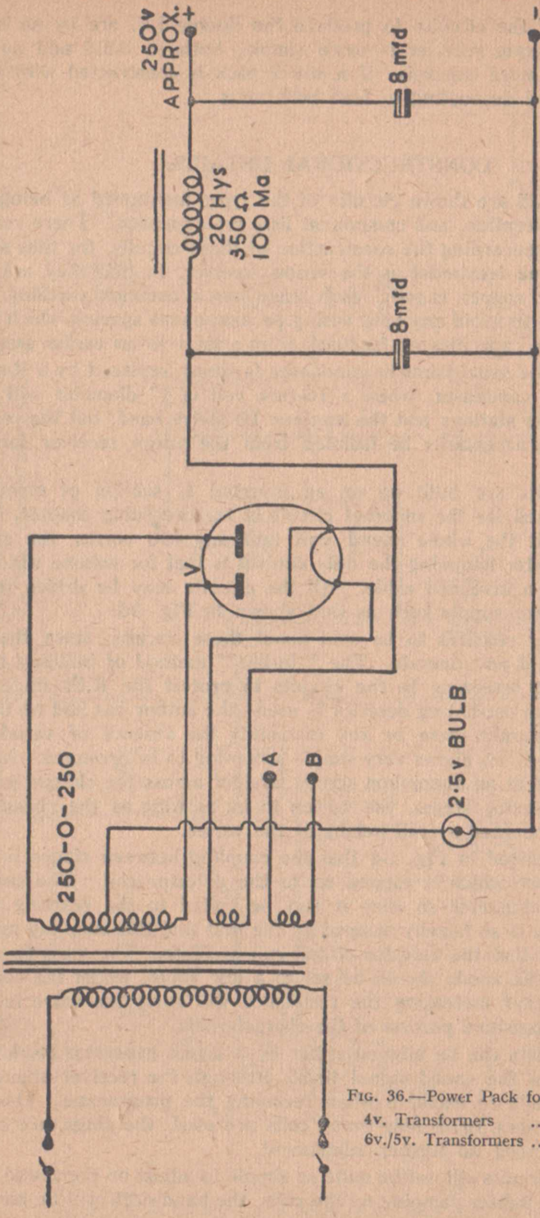


FIG. 36.—Power Pack for Sound Receiver

4v. Transformers ... ... V = UU6

6v./5v. Transformers ... ... V = 5Y3

and the signal more sharply tuned. The same technique as that adopted for the vision receiver is used, however, the first adjustment to the coil being by squeezing the turns tighter or spacing them somewhat more broadly to bring in the station, the final trim being given with the slug, which should be positioned centrally at the commencement of the operation.

It has been found that the coils for all stages of the receiving circuits shown can be made in the same way, the different capacitance loads presented by the different valves being compensated for by the adjustment of the coil turns in the trimming process.

Where tuning by means of a 30 mmfd. trimmer is adopted, the coils are wound on a paxolin former $\frac{9}{16}$″ in diameter (or, having been wound on a $\frac{1}{2}$″ diameter former they can be slipped off and used as air wound coils, supported by their end leads across the condenser), each coil consisting of 7 turns of 16 S.W.G. D.C.C. copper wire, the turns being spaced, to start with, by their own diameter.

For slug wound coils the stray capacitances of the associated circuits will have more effect, and the number of turns as given here may require a turn added or subtracted to make tuning satisfactory, depending on the construction of the circuit. The author has found 15 turns of 16 S.W.G. D.C.C. copper wire on a $\frac{9}{16}$″ paxolin former to be an average figure, the tuning slug being constructed as shown in the coil data for the vision receiver.

Components for the circuit of Fig. 33.

| | |
|---|---|
| L1. | 16 turns 18 S.W.G. closewound $\frac{1}{2}$″ diameter. |
| R.F.C. | 60 turns 30 S.W.G. enam. on $\frac{1}{4}$″ rod. (a wire-ended 1 meg. insulated resistor mat to be used as former). |
| C1. | 40 mmfd. Variable condenser, Raymart VC40X. |
| C2. | 100 mmfd. Ceramic. |
| C3. | 30 mmfd. Trimmer. |
| C4. | 0.005 mfd. Mica. |
| C5, C10. | 0.05 mfd. Tubular. |
| C6. | 8 mfd. 350 v.w. |
| C7, C9. | 25 mfd. 12 v.w. |
| C8. | 0.5 mfd. Tubular. |
| R1, R5, R8. | 220,000 ohms, $\frac{1}{2}$ watt. |
| R2. | 33,000 ohms, $\frac{1}{2}$ watt. |
| R3. | 0.5 meg. Variable. |
| R4. | 0.25 meg. Vol. Control. |
| R6. | 1,800 ohms, $\frac{1}{2}$ watt. |
| R7. | 1 meg., $\frac{1}{2}$ watt. |
| R9. | 150 ohms, 1 watt. |

V1, 955, V2, EF39, V3, EL33.

1 Acorn holder.

2 International Octal holders, chassis mounting.

1 Extension spindle for C1.

Chassis, wire, etc.

Components for circuit of Fig. 34.

| | |
|---|---|
| L1, L2. | See Text. |
| R.F.C. | 60 turns 30 S.W.G. enam. on ½" former. |
| C1, C5. | 30 mmfd. Trimmer. |
| C2, C3. | 0.01 mfd. Tubular. |
| C4. | 0.0003 mfd. Variable. |
| C6. | 0.0001 mfd. Mica. |
| C7. | 0.0003 mfd. Mica. |
| C8. | 0.05 mfd. Tubular. |
| C9. | 8 mfd. 350 v.w. |
| C10. | 50 mfd. 12 v.w. |
| R1. | 10,000 ohms, ½ watt. |
| R2, R5. | 33,000 ohms, ½ watt. |
| R3. | 470 ohms, ½ watt. |
| R4. | 220,000 ohms, ½ watt. |
| R6. | 0.5 meg. Variable. |
| R7. | 0.25 meg. Vol. Control. |
| R8. | 220 ohms, 1 watt. |

V1, SP41, V2, 354V, V3, Pen45.
1 5-pin holder.
2 Mazda Octal holders.
Chassis, etc.

Components for circuit of Fig. 35.

| | |
|---|---|
| L1, L2, L3. | See Text. |
| R.F.C. | 60 turns 30 S.W.G. enam. ¼" diam. |
| C1, C6, C11. | 30 mmfd. Trimmer. |
| C2, C3, C7, C8. | 0.01 mfd. Tubular. |
| C4, C10. | 0.001 mfd. Mica. |
| C5, C9. | 0.1 mfd. Tubular. |
| C12. | 0.0001 mfd. Mica. |
| C13. | 50 mfd. 12 v.w. |
| R1, R6. | 10,000 ohms, ½ watt. |
| R2, R7. | 33,000 ohms, ½ watt. |
| R3, R8. | 470 ohms, ½ watt. |
| R4. | 47,000 ohms, ½ watt. |
| R5, R9. | 100,000 ohms, ½ watt. |
| R10. | 220 ohms, ½ watt. |

RX Used as a voltage dropper in the case of slight instability, value to be found by experiment. 5,000 ohms is used in original receiver.
V1, V2, SP41, V3, DD41, V4, Pen45.
4 Mazda Octal holders.
Chassis, etc.

Note.—If desired, R9 can be used as a volume control in the usual manner, by substituting a potentiometer for the fixed resistor.

## CHAPTER 7.

## THE TELEVISION AERIAL.

The television receiver with its allied equipment is now complete and requires only its aerial to produce results. Unlike the modern broadcast receiver, however, which is connected to any odd length of wire, the televisor requires a properly planned and constructed aerial in order to give a good picture, the aerial necessarily becoming somewhat more efficient as the distance from the transmitter increases. The television carrier wave is at a very high frequency and is thus subject to absorption and reflection to a considerable degree, which means that the decline in field strength as the distance from the transmitter increases is relatively rapid. The aerial, therefore, follows usual high frequency design in being actually a tuned unit in itself.

A wire in free space is tuned to a wavelength of twice the length of the wire, and will resonate electrically at that wavelength either as a transmitter, when supplied with power from an oscillating circuit, or when in an oscillating electrostatic field. Voltage and current distributions along the wire are such that the current reaches its maximum at the centre of the wire, whilst the potential is at a minimum at either end, one end being positive and one negative at any given instant. Thus at the centre of the aerial is an area of high current—low voltage, or a region of low resistance, whilst the ends of the aerial, being a high voltage and low current, may be considered as regions of high resistance.

When the aerial is used for reception its energy must be coupled to the receiver in some way or another, and it is possible to make the coupling with either high or low resistance characteristics so that the aerial may be coupled to the receiver either at its end or in the centre.

The wire, to be tuned to any particular frequency, is only a half wave length in free space. As soon as supports, insulators and, in particular, a capacity to earth are introduced, the transmission time of the currents in the wire are increased so that to respond to the free space frequency the wire must be a little shorter. The amount of the shortening is, on the average, about 5 per cent., and a simple formula can be evolved which gives the length of the aerial in feet as

$$L = 1.56 M$$

where M is the wavelength of the signal in metres.

Immediately it may be seen that the wavelength of the vision signal being 6.66 metres, the optimum length of the television aerial is 10′ 5″, which is a quite convenient length.

The resistances, or, more correctly, the impedances at the centre and ends of a half wave aerial may be considered as being 70 ohms at the centre and 2,500 ohms at either end, this values being substantially the same for half wave lengths of wire resonant to any frequency. Depending on whether the feed is to be taken from centre or ends, this same impedance must be presented at the input point of the receiver unless considerable

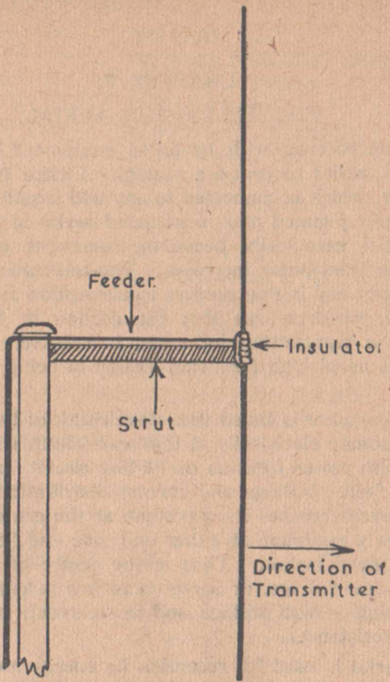


FIG. 37.—Simple Halfwave Dipole

energy losses are to occur, or, in other words, the aerial and input circuit of the receiver must be matched one to another. If it were possible to bring the aerial directly to the receiver this would be a simple matter, but in all ordinary cases it is required to erect the aerial well in the open, transferring its received energy to the receiver through a " lead in " of some sort. The " lead in," therefore, must also be matched to the same impedance if it is not to absorb the energy intended for the receiver, and some form of coupling link between the tuned circuits and the aerial with an impedance of about 70 ohms is thus necessary. A feeder is the solution to the problem, consisting of twin wires so insulated and spaced that to the frequencies under discussion they appear to have an impedance of the required amount.

The characteristic impedance of a feeder system depends on the radius of the wires, their spacing in either air or in an insulator in which they are both imbedded and a constant figure, the losses in the feeder being increased with its length as might be supposed. A high impedance feeder can be matched to the 70 ohms impedance at the centre of a half wave aerial by any of several methods which may be compared to the impedance matching obtainable with a transformer, but the most convenient method of feeding from a television aerial is to use a length of feeder made commercially by several firms which has a characteristic impedance of 70-80 ohms. It must not be thought that the impedance rises with the length of the feeder; to high frequencies the impedance of the feeder is a constant so long as the feeder is more than a half wave length long. Accordingly, the distance from the aerial to the receiver may be 20 feet or 20 yards, the only difference being that the longer feeder will result in rather greater losses in the energy transferred from aerial to receiver.

The most convenient half wave aerial, then, consists of 10′ 5″ of wire, or, much better, copper or aluminium tube, rigid and self-supporting, cut dead centrally and separated by an insulator which also acts as the aerial mounting support. To either side of the bisected aerial, at the insulator, is attached one of the feeder wires, the feeder itself running away from the aerial perpendicularly for a short run before being run parallel with the aerial. The arrangement is shown in Fig. 37, and is the simplest efficient aerial possible. As the distance from the transmitter increases, the aerial should, if possible, be increased in efficiency. A longer or larger aerial is out of the question, as has been seen, although increasing the aerial height has a very beneficial effect. Since an aerial may either receive or transmit energy, however, there would appear to be a possibility of erecting a second half wave aerial beside the first, the second aerial receiving its share of energy from the transmitter and then re-radiating it to reinforce that induced in the original aerial. Such a system is known as a reflector, and is illustrated in Fig. 38. The reflector has no connections made to it, and is so positioned that the aerial proper is directly between it and the transmitter. It is, moreover, slightly longer than the half wave aerial, being approximately 10′ 8″ long for television purposes, and is spaced $\frac{1}{4}$ to $\frac{3}{8}$ of a wavelength behind the true aerial. Thus, for all practical purposes, the distance between the aerial and reflector may be 5′ 6″ and the two elements may be mounted on the ends of a centrally supported cross bar, as shown in the diagram. The gain of the system is roughly two, that is, about twice as much pickup is obtained as with the plain dipole.

This is not the only benefit, however. Since the reflector is behind the aerial the system responds strongly to waves coming towards it, but only weakly to signals approaching from the rear, thus reducing the chance of interference. Interference can be caused in several ways, the most usual type being that from motor vehicles or electrically driven vehicles, such as trams and trolleybuses. Receivers situated in the vicinity of a busy road should always be provided with the reflector type aerial, positioned in such a way, wherever possible, that the reflector is presented towards the road, thus screening the aerial from the interference. If such positioning is not possible (since it depends on the direction of the transmitter), the aerial must be erected at as great a height as possible.

A serious form of interference is sometimes experienced from the signal itself, however, and whereas the ordinary ignition interference shows up as " snow "—bright spots across the screen—this second form of interference takes the shape of a " ghost image "—a second picture duplicated over the main picture and displaced from it by a short distance to the right.

It is caused by reflection of the television carrier from some large object, such as a steel framed building or gasometer, the reflected wave being

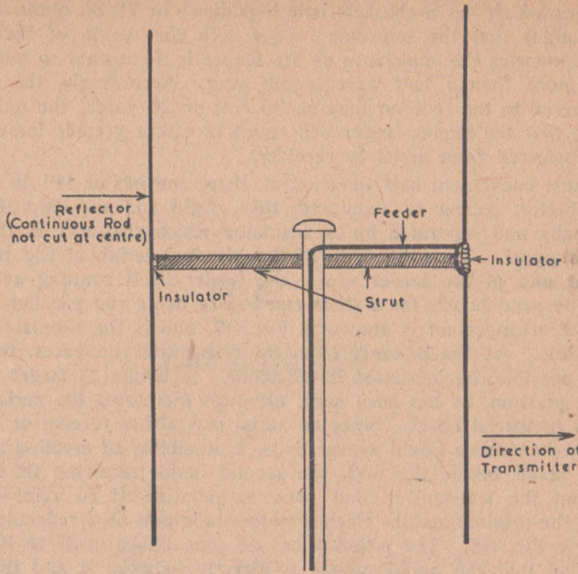


FIG. 38.—Halfwave Dipole with reflector

received on the aerial together with the direct ray. Since the reflected wave has travelled a longer distance, however, its picture intelligence arrives late, causing two pictures to appear in place of one. The ghost, moreover, might be a negative instead of a positive picture, depending on whether the wave arrives in or out of phase with the direct ray.

Obviously the only method of combating such an effect, should it arise, is to vary the aerial positioning and to fit a reflector. Generally it is not too difficult to remove the ghost, and the effect is not frequently met with.

Another type of ghost is caused by a mismatch between the feeder and the receiver tuned circuit. Energy from the aerial is not totally transferred to the receiver and a portion returns to the aerial, is reflected there, returns to the receiver, causing a ghost image, and so on. This brings us to the matching of feeder impedance into the receiver input terminals, and the aerial reflected ghost should never arise with care in the matching of feeder to receiver.

In the chapter describing the vision receiver it was stated that the aerial coil, wound between the turns of the first tuned circuit coil, should be of two turns of wire. This may require some slight amendment, depending on the exact characteristics of the coils wound by each constructor, together with any peculiarities of his aerial and feeder system. The two turns of wire, as stated, is the correct starting point, however, and will be found to suit the vast majority of cases, whilst any experiment in varying

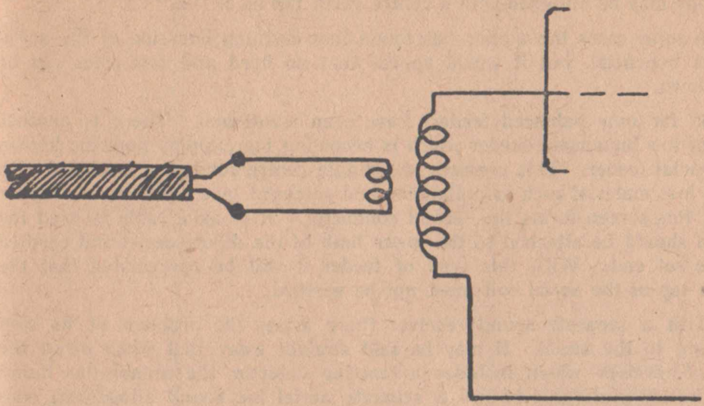

Fig. 39a.—Feeder Connections to the Aerial Coil

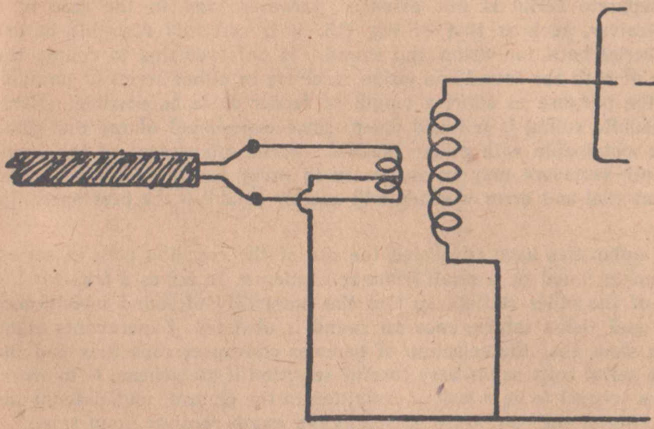

Fig. 39b.—Feeder Connections to the Aerial Coil

the number of turns should be confined within narrow limits between 1 and 3 turns. In Fig. 39 are shown two methods of coupling the feeder to the coil, that of " a " being the usual practice, although slightly better methods may be obtained with a centre earth tap as at " b."

In some cases the author has found that earthing one side of the aerial coil is beneficial, but it would appear that no hard and fast rules can be laid down.

So far only balanced feeders have been mentioned. There is another type of low impedance feeder which is becoming increasingly popular, known as co-axial feeder. This consists of a single centre conductor insulated with a low loss material such as pollathene and screened by a close woven copper braid, this screen forms the second conductor. If co-axial cable is used the screen should be attached to the lower limb of the dipole aerial and earthed at the set end. With this type of feeder it will be appreciated that the centre tap of the aerial coil must not be earthed.

With a separate sound receiver there arises the problem of its own coupling to the aerial. It may be said straight away that when using the type of receiver which includes a reacting detector the author has found it definitely preferable to use a separate aerial for sound altogether, consisting of a 10′ 6″ length of wire coupled to the anode of V1 in Fig. 33, or the grid of V1 in Figs. 34 and 35 via a 30 mmfd. trimmer. This sound aerial does not require to be nearly so elaborate as the vision aerial, and in any area of reasonable signal strength it can be run round a convenient picture rail. A longer aerial can also be used if desired.

The separate aerial is not essential, however, and in the case of a straight receiver, such as that of Fig. 35, it is certainly desirable to use the same aerial both for vision and sound. It only remains to couple the input coils of both the sound and vision receivers in either series or parallel, using for the purpose as short a length of feeder cable as possible. Here, again, a definite ruling is not laid down, since experiment shows that good results are obtainable with either method. Some adjustment of the input coils to both receivers may be necessary in order to obtain correct aerial loading, but trial and error working will quickly establish the best operating conditions.

Some authorities have advocated the use of the coupling coils in series, each coil being tuned by a small trimmer condenser to act as a trap for the frequency of the other station, so that the possibility of sound interference on vision, and vision interference on sound is obviated. Experiments along these lines show that the selection of trimmer condenser capacities and the size of the aerial coils needs very careful selection if the scheme is to work, whilst there seemed to be a loss of definition in the picture, undoubtedly due to a narrowing of the bandwidth passed by the vision receiver input stage.

Naturally, aerials other than the dipole as described, with or without reflector, can be used for television purposes, but in no case do they seem as efficient. The " J " aerial consists of an unbroken half wave aerial with the feeder taken to the end. Thus the feeder has to be matched to a high impedance via a matching stub, which is not really simple to erect,

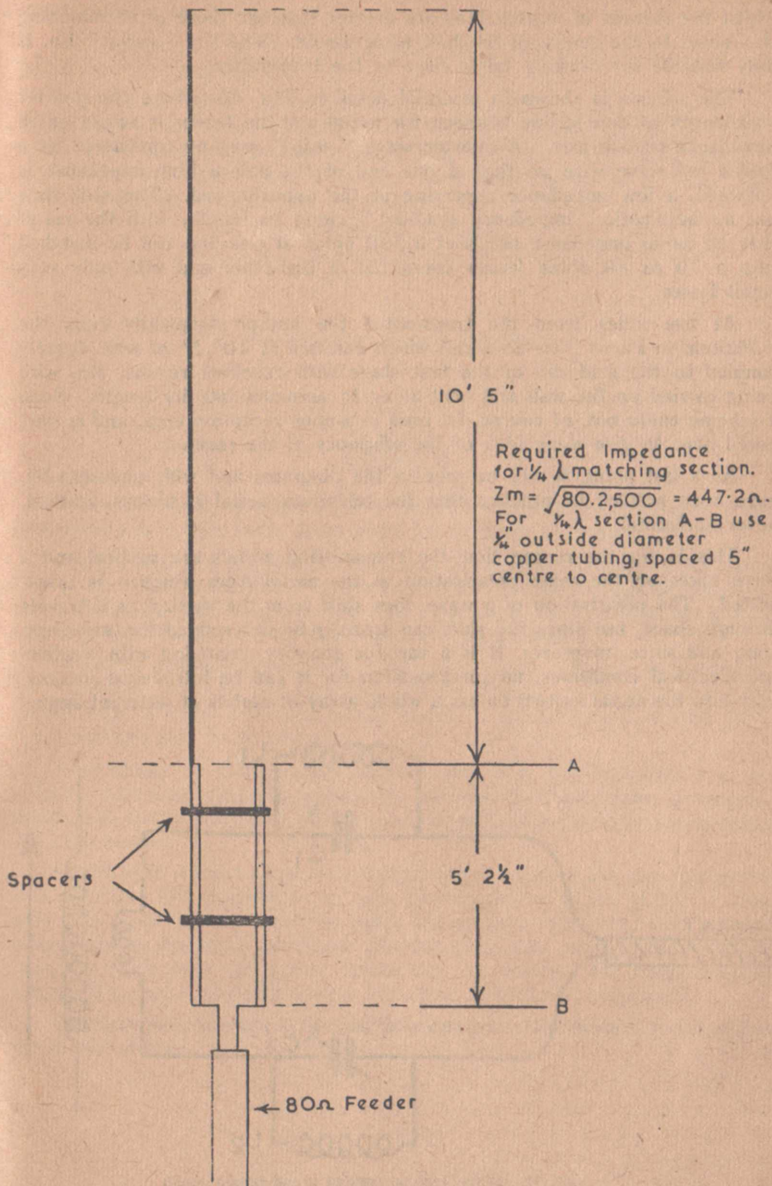


FIG. 40.—The J Aerial

whilst the chances of mismatching are greater than are those of mismatching the feeder to the centre of the half wave dipole. The " J " aerial, also, is only suitable for working fairly close to the transmitter.

The scheme is shown in essential detail in Fig. 40, where the quarter wavelength of double line between the aerial and the feeder is acting as an impedance transformer. A quarter wave " stub " may be considered as a folded half-wave wire, so that at one end of the pair a high impedance is obtained, a low impedance appearing at the opposite end. The stub thus has an automatic " impedance gradient " along its length, with the result that an aerial impedance of about 2,500 ohms at one end can be matched into a 70 or 80 ohms feeder connected at the other end with only very small losses.

At five miles from the transmitter the author frequently runs the " Multum in Parvo " on an aerial which consists of 10′ 5″ of wire directly coupled to the grid cap of the first stage with excellent results, the wire being carried up the wall and bent along to accommodate its length. Such a scheme could not, of course, be used in a poor reception area, and is only noted here to give some idea of the efficiency of the receiver.

As a last point, it will be seen in the diagrams and will, undoubtedly, have been noticed in practice that the television aerial is always vertical, never horizontal.

This is for the reason that the transmitting aerials are vertical and a wave takes on the same polarisation as the aerial from which it is transmitted. The polarisation of a wave does shift from the vertical as it travels through space, but since the shift can scarcely be determined for any given area, and since, moreover, it is a variable quantity, changing with weather and electrical conditions, no compensation for it can be introduced success fully into the aerial system unless a whole array of aerials at different angles

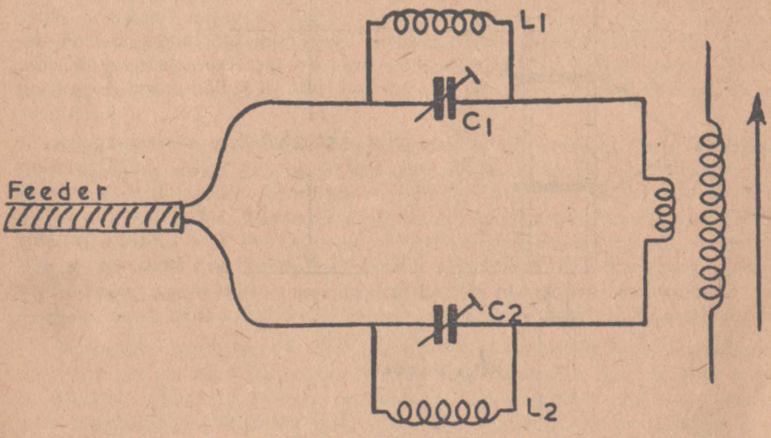


FIG. 41.—Wave Trap to prevent sound breakthrough

to the vertical are erected, the correct aerial for the conditions obtaining being selected day by day.

The compromise of the plain vertical aerial is thus universally adopted and works perfectly successfully.

Fig. 41 shows a method of fitting a wave trap to the feeder to deal with a case of sound breakthrough on to vision. To maintain feeder balance a small coil-condenser system is fitted into each line, both being tuned to trap any sound signal breakthrough. Care must be taken in order that picture brilliancy or detail are not affected.

$C_1 = C_2$, 30 mmfd. Trimmer.

$L_1 = L_2$, 4 turns air wound, $\frac{1}{2}''$ diam.

# ENVOI

It may be held by some that a technical manual, even of such small pretensions as is this book, is no place for criticism or praise.

It is the author's opinion, however, that the science (or art?) of Television cannot be discussed without reference to the material which is televised, nor without mention of those who now daily work the technical miracle of bringing up-to-the-second moving pictures into the home.

Since the post-war resumption of Television much criticism and comment has appeared, both in the technical and lay Press, and it appears to the author that a word from one whose tastes in entertainment are no more than ordinary may be in place.

Accordingly he here thanks heartily, not only the inventors and developers who have given us Television, but also the technicians, producers, artists and studio personnel who are instrumental in building and presenting the programmes.

Faults have occurred and always must occur, but they are very infrequent and doubtless will diminish to an even smaller degree as the B.B.C. station gets into its stride, and a service which can produce everything from outside broadcasts to the most ambitious Shavian play with such clarity and life that the view even on a tiny screen can be watched for hours without fatigue is surely a service at a very high level of technical attainment.

One may look forward to the full development of the powers of Television which lie ahead.

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