TELEVISION SERVICING

FOR BEGINNERS

BOOK. I.

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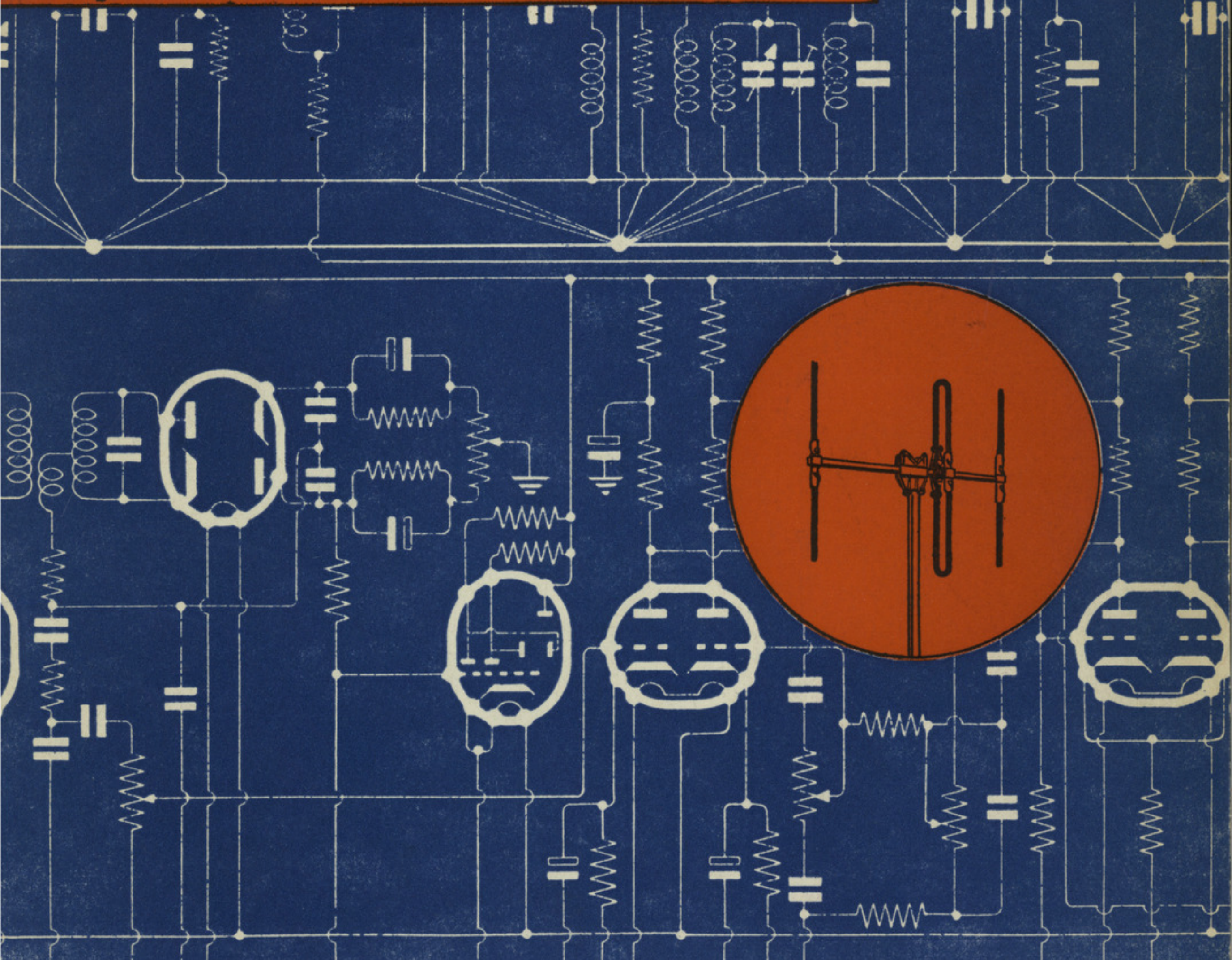
By L.G. Furley. A.M. Brit.I.R.E.



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TELEVISION SERVICING
FOR BEGINNERS
Book 1

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L.G.F.

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The Cathode Ray Tube—*G. Parr.*

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Timebases—*O. S. Puckle.*

Television Simplified—*M. S. Kiver.*

LIST OF ILLUSTRATIONS

TELEVISION SERVICING

CHAPTER 1

INTRODUCTION TO THE SIGNAL WAVEFORM AND T.V. RECEIVER CIRCUITS.

Before an attempt is made to service a T/V receiver an understanding of the Television waveform and the various circuits of the receiver must be understood.

The signal waveform is quite different to that for normal broadcasting, because the vision carrier is modulated by signals corresponding to picture detail, the mean level of illumination of the picture and the frame and line synchronising pulses.

This is arrived at by making a definite modulation level correspond to white and another black. The picture signal will always come between these two levels and the mean illumination level is dependent on these limits. At the end of every line and at the end of every frame there is a pause in the picture signal and during this short time the modulation changes beyond the black level to transmit the synchronising pulses.

The term " modulation " has a somewhat different meaning to that which is applied to normal sound transmissions. With sound transmission, the carrier frequency has a mean fixed amplitude, the modulation increasing and decreasing the amplitude at a rate which is dependent on the modulation frequency. A one hundred per cent modulation by a sine wave changes the carrier amplitude from zero to twice the mean value.

With television there is no fixed mean value of carrier amplitude, only the maximum value is fixed.

In the B.B.C. transmissions the white level corresponds to 100 per cent modulation, therefore the carrier is at its maximum, and the black level to 30 per cent of the maximum, the range between 30 per cent and zero modulation is reserved for the synchronising pulses.

The B.B.C. system uses 405 lines for each complete picture and twenty-five complete pictures a second with interlaced scanning giving fifty half pictures of 202.5 lines per second. The picture aspect ratio being 4:3. Fig. 1 shows the principle of interlaced scanning.

Imagine the spot travelling across the screen

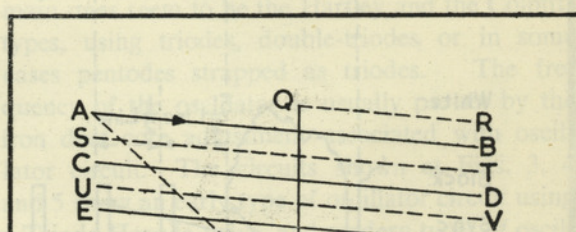

Fig. 1. Illustrating Principles of Interlaced Scanning.

from left to right tracing line A.B, it then returns by the line flyback to C and traces line C.D. similarly with line E.F., continuing until line M.N. is reached, the spot then returns to O and travels to P, whereupon it immediately returns to point Q and completes the line Q.R. The remaining lines are now scanned completing the picture to Y.Z. the spot returning to point A repeating the process again.

At the end of each line the modulation falls to the black level remaining there for 0.5 per cent of the total time for one line, it then falls to zero and remains for 10 per cent of each line time. It then rises to the black level remaining there for 5 per cent of the line time, and then the picture signal recommences.

Due to this loss of 15.5 per cent of the line time, picture signals are transmitted only during 84.5 per cent of each line. At the end of each frame ten lines are given to synchronising pulses and black signals. Therefore the number of effective lines per picture is 385 or 192.5 for each frame. The waveform of Fig. 2 is that of the vision frequency signal, that is of the detector output, which corresponds to the audio frequency of a sound signal.

The space of 0.5 per cent of a line is to allow the signal to return to the black level before synchronisation starts. Imagine that there is a white edge at the right-hand side of the picture, the modulation would be required to change from 100 per cent to 30 per cent instantly, to be ready for the synchronising pulses. As it cannot do this the space is inserted to give the modulation time to change to black before the synchronisation pulses start.

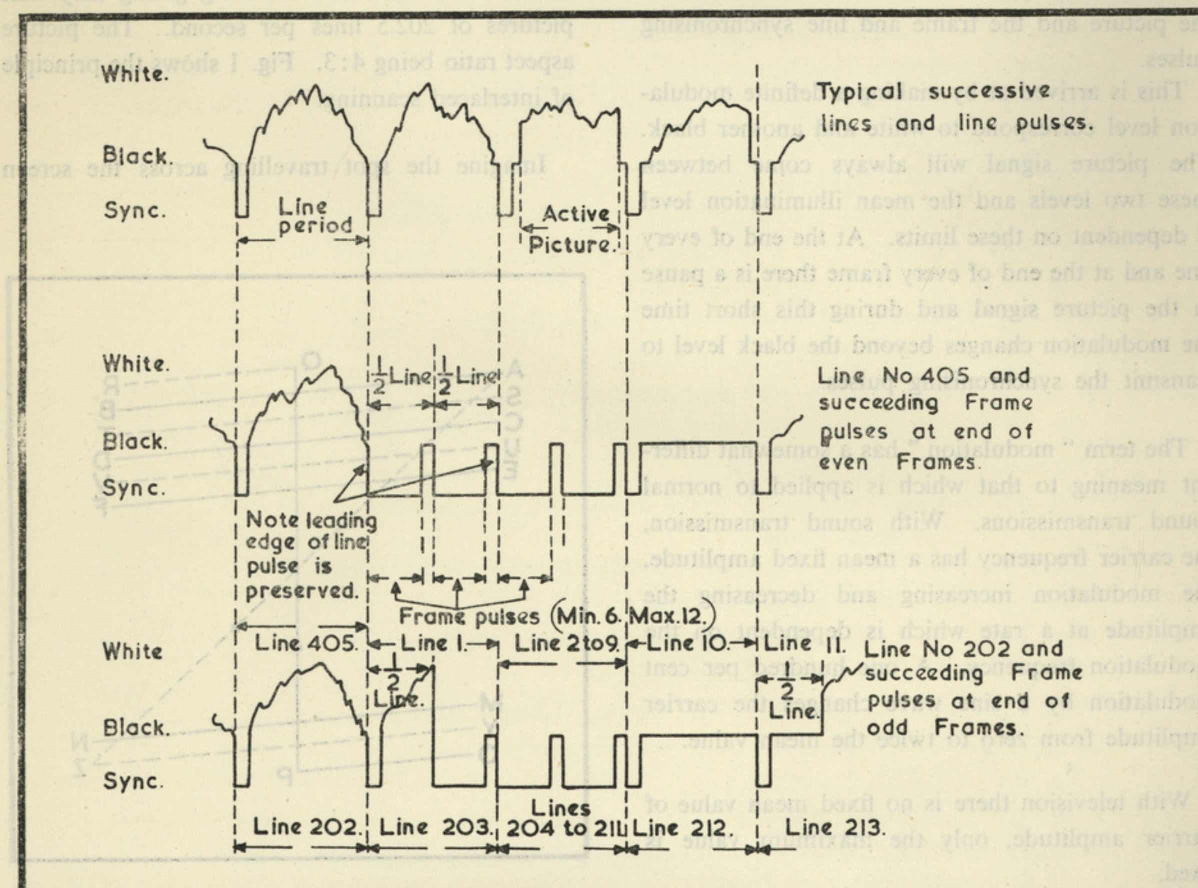

Fig. 2. Television Waveform showing Line and Frame Pulses.

There being fifty frames per second, the frame time base oscillator must operate at 50 cycles per second and the line oscillator at 10,125 per second ($25 \times 405 = 10,125$).

The important factors are the maximum rate of change of amplitude of the signal and its expression in terms of modulation frequency. A method of doing this is to regard the active area of the picture divided into squares alternately black and white, each square having a side equal to the width of one line, the vertical and horizontal resolution would then be equal. The number of squares per line is equal to the number of active lines multiplied by the aspect ratio which is 4:3.

$$\text{therefore} \quad \frac{385 \times 4}{3} = 513.33$$

Then the number of squares per picture will be

$$513 \times 385 = 197,505.$$

The modulation envelope will correspond to this number of squares for each picture at 25 pictures per second, and would be a square wave of frequency

$$\frac{197,505 \times 25}{2} = 4,937,625 \text{ per second}$$

Each white square would be the positive half cycle of the square wave and each black square the negative half cycle.

As the perfect square wave cannot be achieved due to the fact that the cathode ray tube spot is round and not rectangular, the square wave becomes resolved into a sine wave of an equal fundamental frequency without any serious reduction of resolution. A maximum modulation frequency of

$$\frac{4,937,625}{2}$$

or approximately 2.5 megacycles is necessary to give a picture of satisfactory resolution.

The amplifiers for the vision section must be capable of handling modulation frequencies up to 2.5 mc/s to fulfil this condition, which is termed the bandwidth of the amplifier. For this reason V.H.F. signals are employed for Band I and Band III transmissions, so as to accommodate the very wide bandwidth required without interfering with other stations.

Frequency Changer Circuits.

Most modern receivers use the superhetrodyne principle nowadays, and these circuits differ very little from their counterparts in normal superhet radio receivers.

In some older receivers the triode-hexode or the triode pentode were commonly used, and with the exception that the components associated with these circuits were very much smaller in value, the look of the circuit on paper was very much the same as for radio receivers.

A number of receivers employ an R.F. pentode as the mixer valve, using the grid and screen grid of the valve, as the grid and "anode" of the oscillator section; oscillator coupling being obtained from the grid to grid capacitance of the valve. The sound and vision I.F. signals appear at the anode of the mixer valve and are subsequently filtered off by the sound and vision I.F. transformers and handed on to the respective circuits.

Various R.F. oscillator circuits are used but the main ones seem to be the Hartley and the Colpitts types, using triodes, double-triodes or in some cases pentodes strapped as triodes. The frequency of the oscillator is usually pre-set by the iron dust core adjustment associated with oscillator circuit. The circuits shown at Figs. 3, 4 and 5 show an early type of oscillator circuit using a Triode-Hexode valve, and modern types of oscillators used in more recent practice.

The choice of frequency changer circuits and valves in the television receiver is dependent upon the gain, frequency stability and noise, these all affect the design of the circuit. The gain will obviously affect the design of the R.F., I.F. and video stages, although not of primary importance as gain can be obtained more economically in stages other than the frequency changer.

Frequency stability is somewhat important when considered in relation to the sound I.F. channel. Although a frequency drift of perhaps 100 Kc/s is

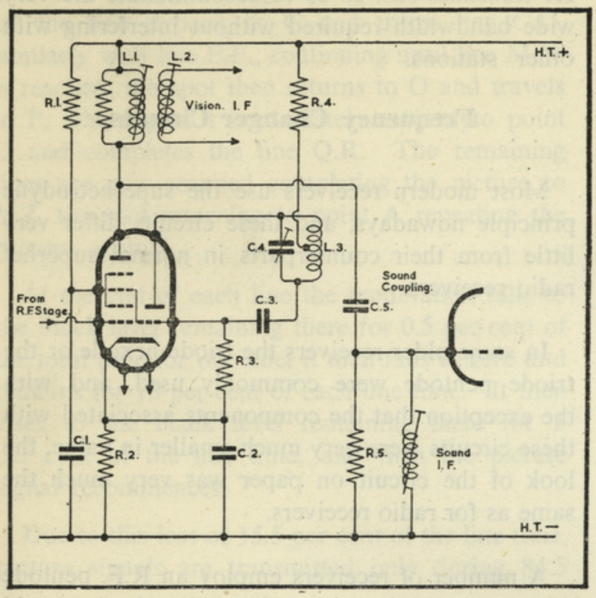

Fig. 3. Mixer Stage using Triode Pentode.

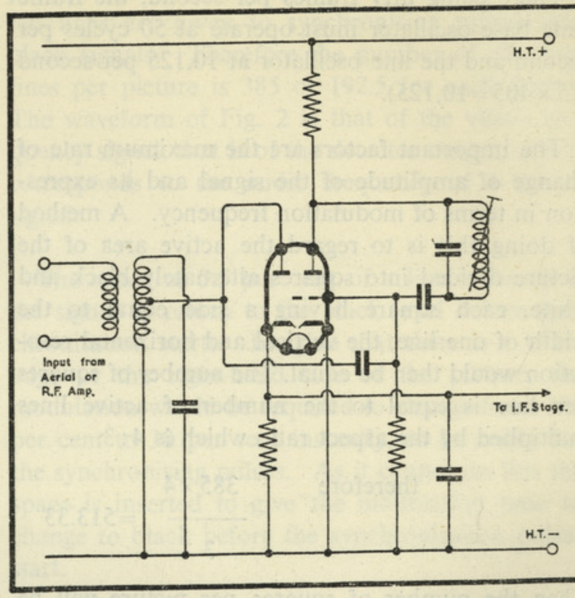

Fig. 5a. Diode-Triode Mixer Stage.

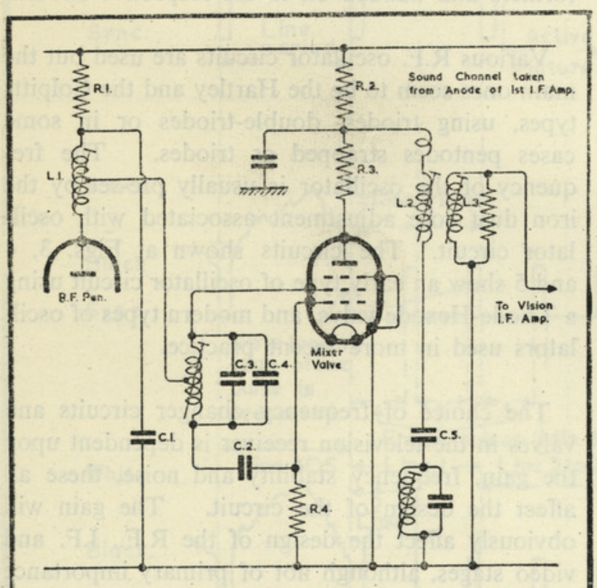

Fig. 4. Mixer Stage employed in "Portadyne" Model 517 Receiver.

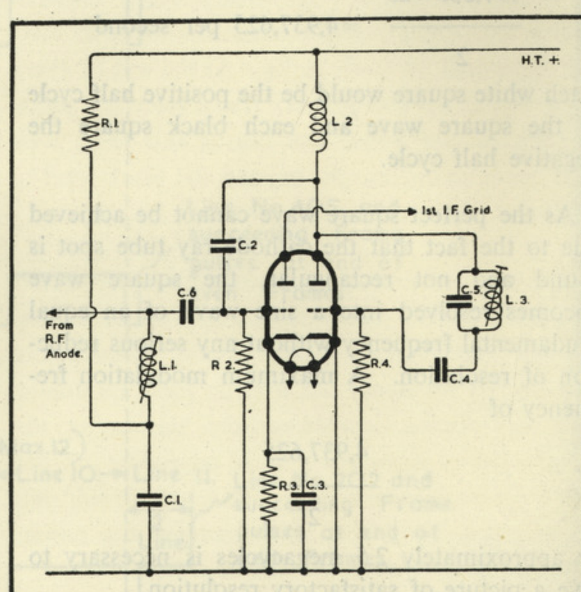

Fig. 5b. Typical Circuit using Double Triode as Oscillator, and Mixer.

not noticeable on the picture, it calls for a wide bandwidth in the sound channel, which is desirable when dealing with efficient noise limiting, but causes loss of gain.

The signal to noise ratio is of great importance, for if a lot of noise is introduced into a frequency changer, a high R.F. gain will be required at carrier frequency to ensure a good signal to noise ratio, in certain cases may call for the use of extra R.F. stages.

A simple frequency changer and one which introduces little noise, is the diode-triode, and illustrated at Fig. 5a. The picture signal and the voltage from the local oscillator are applied to the diode anode, the I.F. output appearing across the cathode resistor of the diode section. The main disadvantages are that the gain is always less than unity, and that adjustment to R.F. and I.F. circuits tend to disturb the oscillator frequency.

The main fault which can occur at this part of the receiver is no sound or picture but with a normal raster on the tube. It is very seldom that searching has to go beyond the stages which are common to sound and vision. As the timebases are free running, the absence of synchronisation does not affect the raster.

It is well to check the H.T. line to these circuits in case something has become disconnected, especially in receivers which use plugs and sockets for the connections. Also the aerial socket and cable should be checked for open circuit feeder.

The next step is to make sure that the valves are in order, this can be done with the help of a valve tester, and without removing the set from its cabinet.

Any fault in these stages can usually be traced by using a 400 cycle modulated signal generator which is set to the sound frequency, which will eliminate having to watch the screen. By injecting the signal into the grid of the valve having both vision and sound output, and proceeding in sequence of the valves concerned towards the aerial, when the faulty stage is reached the audio note will be either inaudible or very weak showing that this stage is not working under its correct conditions.

A faulty local oscillator will result in no signal conditions, and may either be not oscillating at all or completely off frequency. The method here is to measure the D.C. voltage at the oscillator grid with a valve voltmeter, the voltage here should be of the order of 10 volts. Should the voltage here be rather lower than 10 volts, unless otherwise stated in the valve manufacturer's figures, the H.T. to the valve may be too low, showing perhaps that the feed resistor has become high in value.

In the case of no voltage appearing at the oscillator grid the coil should be checked with an ohmmeter for open circuit. Another point which must not be overlooked is the possibility of a dry joint on the coil connections.

Capacitors in this stage which are short circuiting will cause a complete loss of signals, while a capacitor which is open circuit will permit the reception of weak signals, but if there is also misalignment of the R.F. or I.F. circuit, complete failure will occur.

Anode load resistors and screen grid resistors should be checked for open circuit conditions, also the grid resistor, but this is seldom at fault.

Similar checking should be applied to the R.F. stages, the causes here are probably open circuit resistors or short-circuiting capacitors.

Where sensitivity or contrast controls are fitted these must not be overlooked for possible open circuits.

Another type of fault which occurs in T.V. receivers is oscillator drift, which is the result of components changing their physical conditions due to heat. Although these changes are very small quite serious consequences can occur, for a small percentage change in value can cause the frequency to change considerably. Even a one per cent change at say, 50 megacycles can cause a change of 500 kilocycles, and should the oscillator frequency drift to the same extent the I.F., which is the result of beating the signal and oscillator frequencies together will drift in the same way.

Any drifting will cause some deterioration in picture quality, if referred to in terms of frequency only, but due to the very wide vision bandwidth it is rarely noticeable on normal domestic receivers.

Its effect on the sound channel would be similar to that on a normal broadcast receiver, it would be either right out of range or the side band hiss would be prevalent. On the other hand should the drift be upwards towards the vision carrier the frame synchronisation pulses would be heard in the receiver. The noise produced is characteristically hard and sounds very much like a loud mains hum.

Should the drift be in the opposite direction, the sound signals are outside the range of the sound rejector, and will be passed on to the vision circuits causing sound on vision. This is recognisable by broad dark bands appearing on the screen fluctuating in density and width in sympathy with the speech or music associated with it. This is a fault which can occur on the majority of receivers. In a well designed receiver these components are kept well away from any parts of the circuit where extreme heat is developed, such as in the rectifier circuit from the mains or the line output valve.

Many manufacturers use special components which are not affected by heat and very large oscillator coils of thick wire to counteract this drift, or again use components in pairs which have opposite characteristics to overcome this fault. Here it becomes necessary for the service engineer to use components which are identical in every respect when effecting repairs.

Sound on vision occurs from other faults other than oscillator drift, such as a mistuned sound rejector, or a microphonic valve, and anything that is loose can have the same effect. Again a faulty valve or a fractured core of the oscillator coil will give rise to sound on vision.

R.F. Amplifier Circuits.

Nearly all T/V receivers have an R.F. stage preceding the mixer valve, and are not very different from the normal type of R.F. amplifier, except that they must be capable of amplifying both the vision carrier and the sound carrier at the same time, therefore their frequency pass-band is wider than that of the vision I.F. amplifiers. The tuning curve of these circuits is much flatter than the I.F. circuits and there is a noticeable lack of response-curve shaping.

The gain controls are incorporated in these circuits and are, in the majority of cases, variable resistors in the cathode leads to the valves.

These controls are shown as the sensitivity and contrast controls. The sensitivity control is usually in the cathode circuit of the first R.F. valve, while the contrast is in the cathode circuit of one of the I.F. valves.

The sensitivity control is in most cases a preset type while the contrast control is brought out on the front of the cabinet for the owner to operate.

Tuning Circuits.

There are many forms which these circuits can have, ranging from the simple single tuned coil to a rather complicated band-pass arrangement.

The simplest of the R.F. circuits is the single tuned coil used mainly in T.R.F. receivers, where a number were used each one tuned to a different frequency to provide the necessary bandwidth for the received signal. These coils were shunted by a resistance of a value between 5 kΩ and 20 kΩ to provide damping to the coil, thereby lowering the overall efficiency of the circuit and enabling it to respond more easily to the wider bandwidth although sacrificing amplification. Therefore several of these stages had to be used to provide sufficient amplification before being passed on to the detector circuit and video stage. With "stagger tuning" in a T.R.F. receiver instability is unlikely as each circuit is working at a different frequency.

Fig. 6 shows some simple Radio Frequency circuits. The first at (a) the coil is directly in the anode circuit of the valve, the signal being fed to the following valve through the coupling capacitor C. At (b) is a similar coil shunted this time by a resistor and coupled to the preceding stage through C, while at (c) is a transformer coupled arrangement obviating the use of a coupling capacitor.

These circuits can be used in the R.F. stages or in the I.F. section as anode loads or in the grid circuits of valves and can take the form shown in the circuit of Fig. 7, where the first valve uses the damped coil fed by a capacitor into the grid of the second valve, which in turn has a transformer arrangement to feed the detector stage.

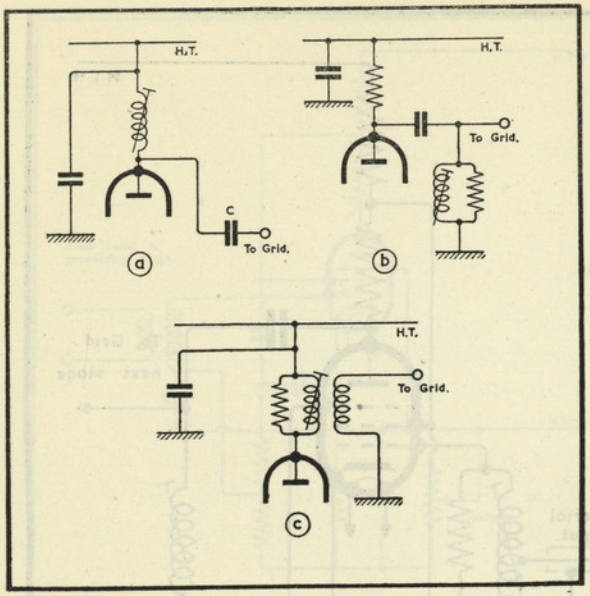

Fig. 6. Three types of Single Tuned Circuits found in T/V Receivers.

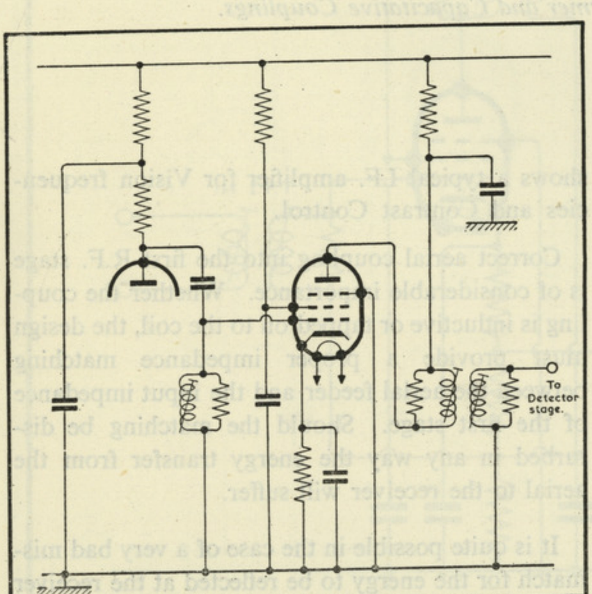

Fig. 7. Circuit using Single Damped Coil and Transformer Coupling.

The greatest difference between the components used for T/V and radio is their physical size and the frequency at which they operate. Decoupling capacitors for instance become anything between .001 μF and .005 μF instead of the more usual 4 μF and 8μF, while resistors have also lower values.

Connecting wires to all the components are kept as short as possible to avoid stray capacitance and inductance coupling between leads, and all components are therefore tightly bunched together at the respective valve bases.

R.F. and I.F. Amplifiers.

Very few television receivers use only radio frequency amplification, the majority being superheterodyne, and these have at least one stage of R.F. amplification to maintain a useful signal-noise ratio.

The difference between the R.F. amplifier and the I.F. amplifier of a T/V receiver, is that brought about by the higher frequencies used, the design of the coils for intervalve coupling is exactly the same.

Two R.F. stages are shown in Fig. 8 with the aerial coupled to the grid coil. This coil may or may not have a resistance across it, although it is common practice to shunt inductances with resistors in television receivers.

The anode load of the valve may be resistive or inductive. Popular practice appears to be transformer coupling, one or both coils being tuned by adjustable cores. Resistive loading is still found in R.F. stages the signal being passed on by a capacitance to a tuned grid winding.

Contrast is controlled by varying the R.F. gain of the receiver, this control can be likened to the volume control on a broadcast receiver. The contrast control is wired into the cathode circuit of the R.F. stage of a T.R.F. receiver or in the I.F. stage, when the set is of the superhet type.

Certain precautions have to be taken, any alteration of gain in the R.F. or I.F. stages,

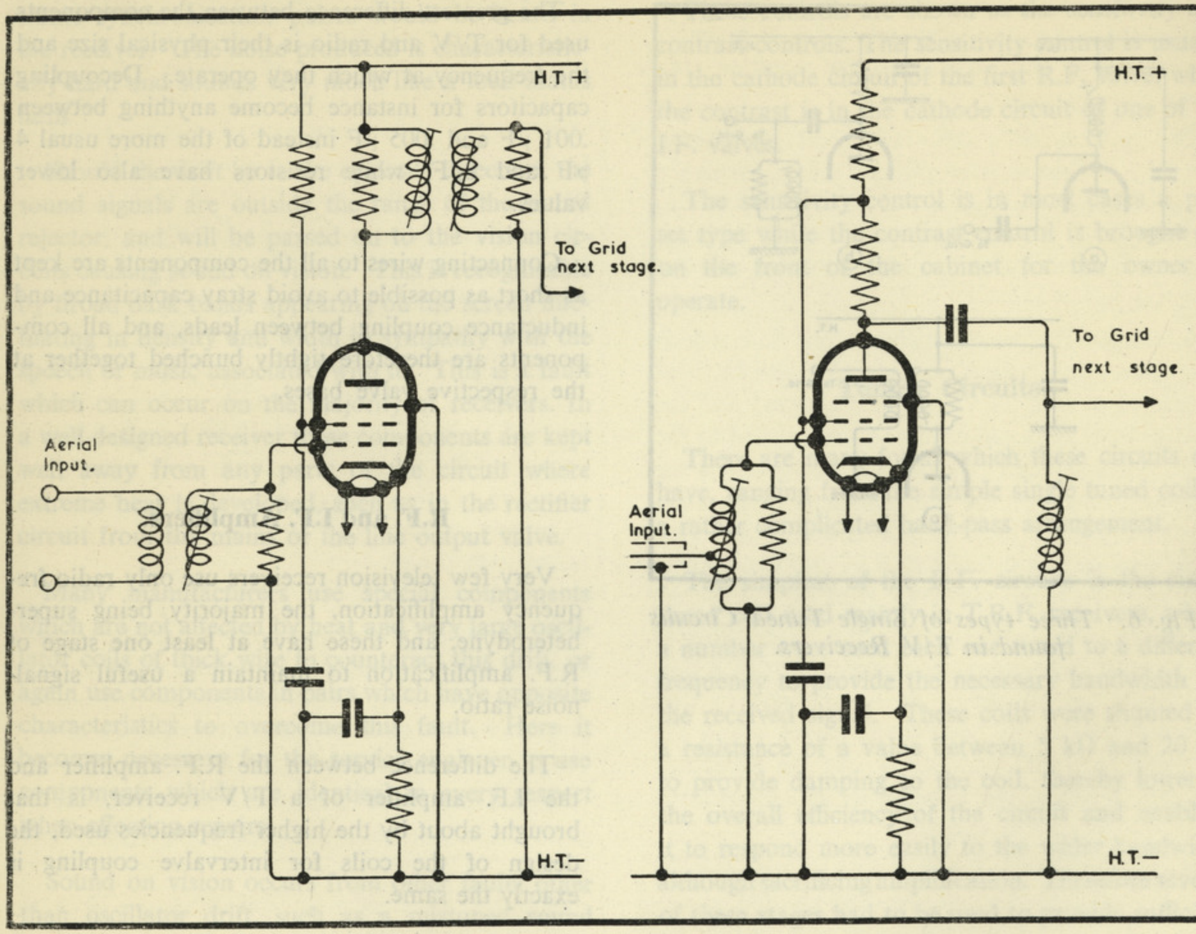

Fig. 8. R.F. Circuits with Transformer and Capacitative Couplings.

varying the cathode resistance for instance, alters the input capacity of the valve. As this is usually the main tuning capacity of the stage, any change in the valve's characteristics will result in a change of tuning. The mutual conductance of the valve can be reduced without a great change in input capacitance, by varying the bias on both the control and suppressor grids.

A basic circuit is shown at Fig. 9 which will satisfy both R.F. and I.F. conditions. The suppressor grid is earthed, and therefore biased back to the full cathode bias, whilst the control grid is connected to a network, and receiving only a fraction of the bias voltage available. Fig. 10 shows a typical I.F. amplifier for Vision frequencies and Contrast Control.

Correct aerial coupling into the first R.F. stage is of considerable importance. Whether the coupling is inductive or tapped on to the coil, the design must provide a proper impedance matching between the aerial feeder and the input impedance of the first stage. Should the matching be disturbed in any way the energy transfer from the aerial to the receiver will suffer.

It is quite possible in the case of a very bad mismatch for the energy to be reflected at the receiver terminals so that it travels back along the aerial to cause " ghost images " on the screen.

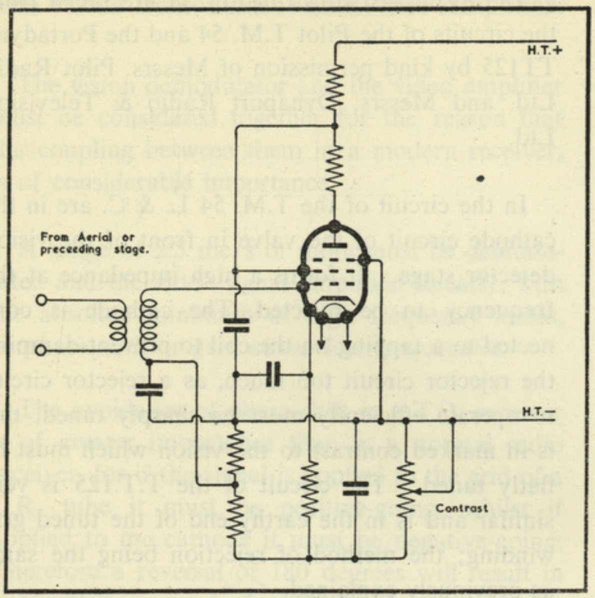

Fig. 9. Contrast Control Circuit for R.F. or I.F. Stage.

Rejector Circuits.

In the modern receiver there is bound to be a sound rejection circuit to prevent the sound frequencies reaching the vision stages, and is usually inserted in the cathode lead of one of the I.F. stages. The sound channel is taken off somewhere around the first or second I.F. stage, and fed into the sound receiver circuits.

The term rejector is applied to any circuit which is intended to obstruct the passage of a certain signal through the receiver. Two kinds of circuit are used for this purpose, and they operate in exactly the opposite manner. One is a parallel tuned circuit which offers a high impedance at the frequency to which it is tuned, the other offers a virtual short circuit at the frequency to which it is tuned and is the series tuned rejector.

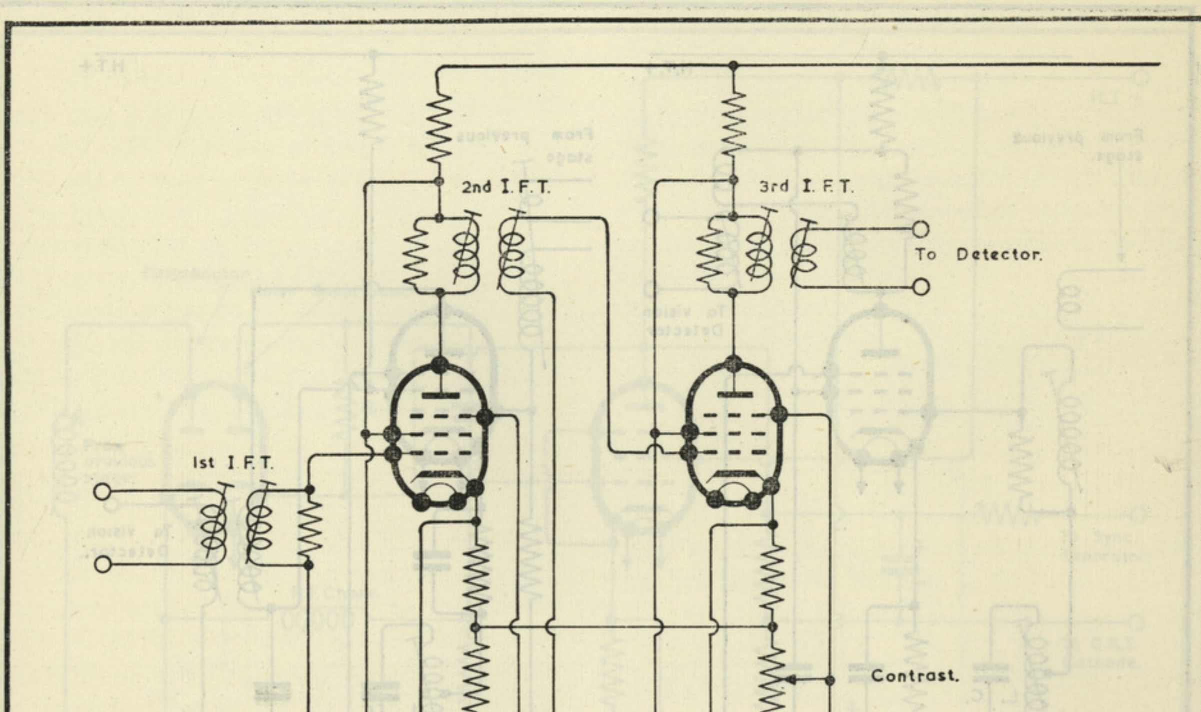

Fig. 10. I.F. Amplifier for Vision Frequencies with Contrast Control.

Mostly the parallel tuned circuit is the one used to tune a sound radio receiver. At the resonant frequency the reactances of the inductor and capacitor are equal, the impedance of the circuit is then very high and by that means selects the wanted frequency, it is therefore a rejector circuit. With the series tuned filter the reactances at resonance are again equal, but this time the impedance is very low. This then is an acceptor circuit which "rejects" its natural frequency by offering a virtual short circuit path to earth.

Sound rejectors in T/V circuits take on several forms. They are nearly always placed in the cathode circuit of one of the I.F. valves or in the vision detector circuit. Again they may be incorporated in series with the tuning circuit of a stage, inserted in series with the coupling between stages or in some cases shunted across a tuning circuit.

The examples shown in Fig. 11 are taken from the circuits of the Pilot T.M. 54 and the Portadyne TT125 by kind permission of Messrs. Pilot Radio Ltd. and Messrs. Dynaport Radio & Television Ltd.

In the circuit of the T.M. 54 L. & C. are in the cathode circuit of the valve in front of the vision detector stage. It forms a high impedance at the frequency to be rejected. The cathode is connected to a tapping on the coil to prevent damping the rejector circuit too much, as a rejector circuit to operate efficiently must be sharply tuned, this is in marked contrast to the vision which must be flatly tuned. The circuit of the T.T.125 is very similar and is in the earthy end of the tuned grid winding; the method of rejection being the same as previously explained.

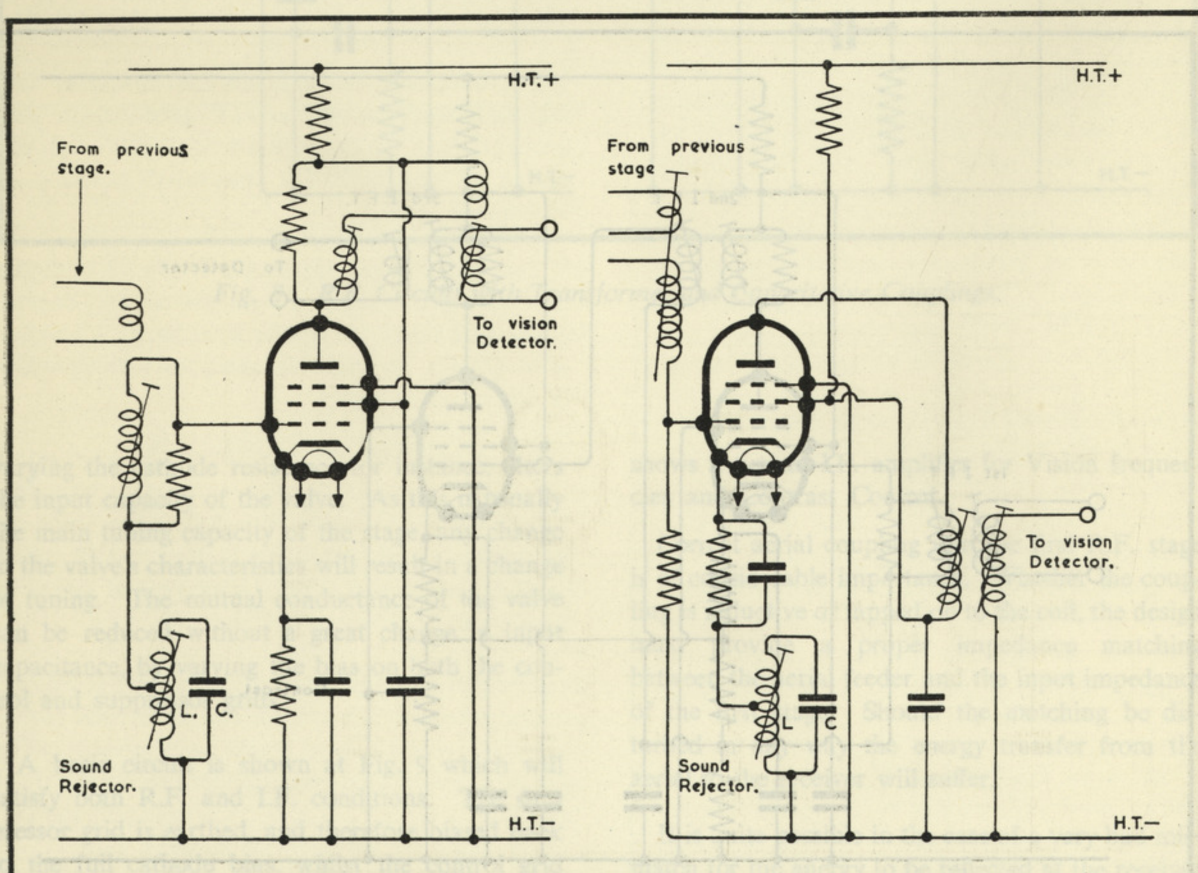

Fig. 11. Left. Sound Rejector Circuit Pilot Radio Model T.M. 54.
Right. Sound Rejector Circuit Portadyne Radio Model T.T.125.

The Vision Demodulator and Video Amplifier.

The vision demodulator and the video amplifier must be considered together for the reason that the coupling between them in a modern receiver, is of considerable importance.

A range of 2.5 mc/s or more must be demodulated and the video signal amplified linearly, with the absolute minimum of high frequency losses, or phase shift or gain at the low frequencies.

The avoidance of phase shift in a T/V receiver is of greater importance than in a normal radio receiver, for if the signal is applied to the grid of a C.R. tube it must be positive-going, whilst if applied to the cathode it must be negative-going. Therefore a reversal of 180 degrees will result in a complete reversal of picture from a positive to a negative. To avoid the possibility of phase shift direct coupling is used from the video amplifier.

At some point in the video amplifier circuit compensation must be made for the high frequency losses. As the frequency rises in any valve amplifying circuit the losses increase, the reason being that the impedance presented to the signal by the valve's input and, especially, output capacitances, is reduced, the overall gain of the circuit therefore falls as the frequency rises.

To overcome this effect, the circuit must be given a characteristic which supplies greater gain over the higher freqencies. The losses are caused by capacitance, extra gain can be obtained by introducing an inductance at some point of the circuit. The impedance of an inductance rises with frequency, so a greater signal voltage will be set up across the inductance by the high frequencies.

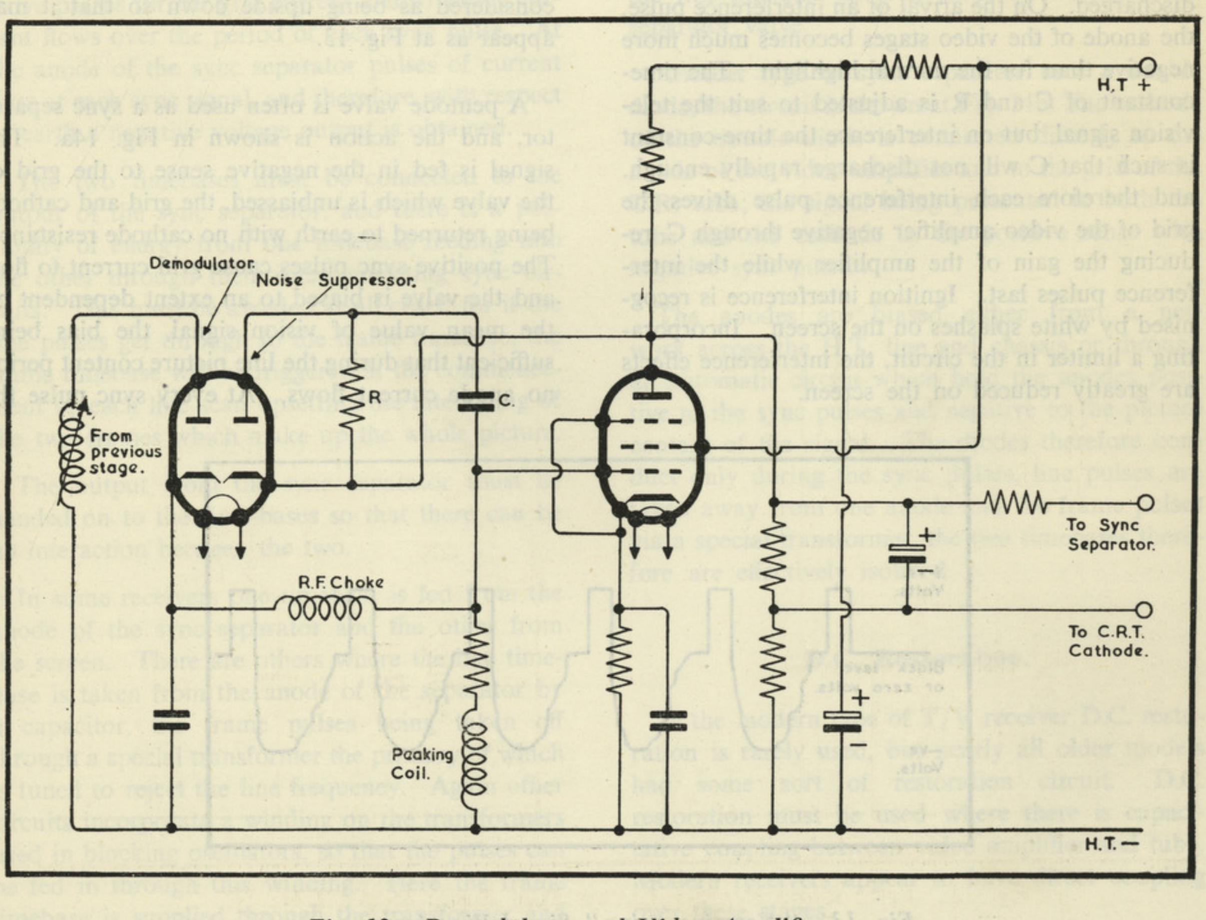

Fig. 12. Demodulator and Video Amplifier.

It was common practice in earlier models to find what was known as a " peaking coil " as part of the video amplifiers anode load, but it is usually incorporated in the video amplifier grid circuit Fig. 12. This peaking coil must not be confused with the choke coil used in coupling the detector and the video amplifier. The choke coil is tuned to prevent any R.F. which may still be present on the demodulated signal reaching the video stage. In the case of a T.R.F. receiver the choke will be tuned to 45 mc/s and in the case of a superhet to the I.F. frequency.

A noise or interference limiter is also shown in Fig. 12. The second half of the double diode acts as the limiter together with capacitor C and resistor R.

The signal at the video amplifier is negative going, that is the highlights are negative, so the diode conducts only on the highlights C being normally discharged. On the arival of an interference pulse, the anode of the video stages becomes much more negative than for the normal highlight. The time-constant of C and R is adjusted to suit the television signal, but on interference the time-constant is such that C will not discharge rapidly enough, and therefore each interference pulse drives the grid of the video amplifier negative through C, reducing the gain of the amplifier while the interference pulses last. Ignition interference is recognised by white splashes on the screen. Incorporating a limiter in the circuit, the interference effects are greatly reduced on the screen.

The Sync Separator.

The time-base circuits are controlled through the sync separator by the receiver, that is by pulses which appear at the anode of the video amplifier, it must be remembered that the output from this valve has a waveshape as shown at Fig. 2, and this waveform is applied to the grid of the sync separator as well as for modulating the tube.

The waveform must be negative-going if it is to be applied to the cathode of a C.R. tube. The white signals must be more negative than the black or weaker vision signals, because for a white signal the beam through the tube must increase to cause a brighter fluorescence, therefore the cathode becomes less positive than the grid of the tube. Here then the highlight signals may be considered as negative and the black signals as zero potential, with the synchronisation pulses running positive. The waveform of Fig. 2 may in fact be considered as being upside down so that it may appear as at Fig. 13.

A pentode valve is often used as a sync separator, and the action is shown in Fig. 14a. The signal is fed in the negative sense to the grid of the valve which is unbiassed, the grid and cathode being returned to earth with no cathode resistance. The positive sync pulses cause grid current to flow and the valve is biased to an extent dependent on the mean value of vision signal, the bias being sufficient that during the line picture content period no anode current flows. At every sync pulse the

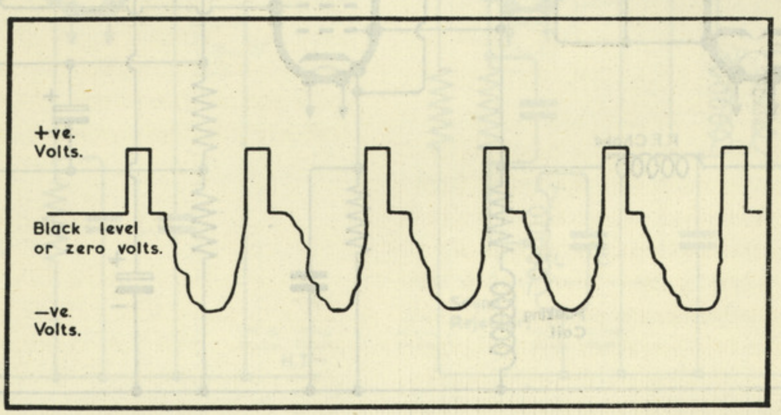

Fig. 13. " Negative going " Signal Waveform.

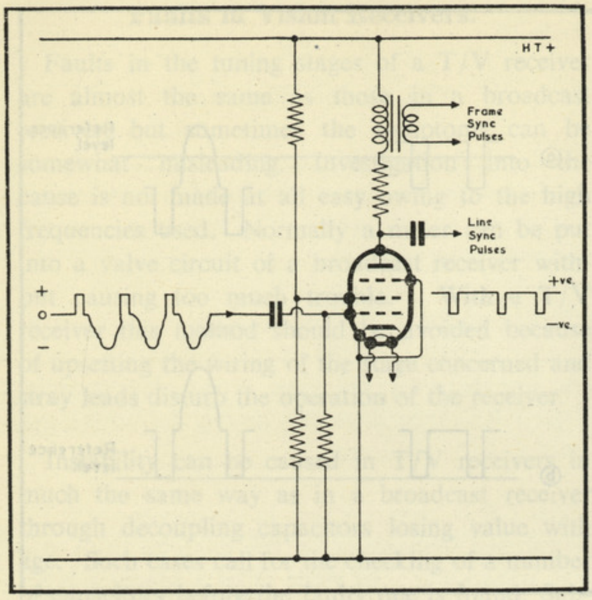

Fig. 14a. Pentode Sync. Separator.

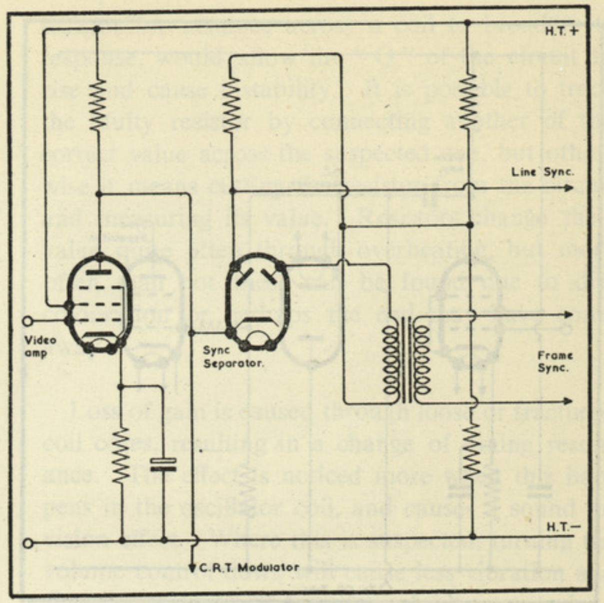

Fig. 14b. Diode Sync. Separator.

valve passes further grid current and so anode current flows over the period of each sync pulse. At the anode of the sync separator pulses of current pass at each sync signal, and therefore, with respect to earth a negative voltage output is obtained.

The two timebases must be connected to the output of the sync separator, and there is a possibility of energy from one timebase feeding into the other through their interconnecting sync circuits. This must be avoided at all costs; for if the line pulses get through to the frame timebase, the frame timebase will be triggered at the commencement of each line scan upsetting the interlacing of the two frames which make up the whole picture.

The output from the sync separator must be handed on to the time-bases so that there can be no interaction between the two.

In some receivers one timebase is fed from the anode of the sync separator and the other from the screen. There are others where the line timebase is taken from the anode of the separator by a capacitor, the frame pulses being taken off through a special transformer the primary of which is tuned to reject the line frequency. Again other circuits incorporate a winding on the transformers used in blocking oscillators, so that the pulses can be fed in through this winding. Here the frame timebase is supplied through the transformer and the line timebase directly from the anode of the separator valve.

Another type of sync separator uses a double diode, the circuit is shown at Fig. 14b. The cathode of the double diode is connected directly to the anode of the video amplifier and to the grid of the C.R. tube; the signal being presented to both the tube and the cathode in the positive sense with negative sync pulses.

The anodes are biased either from a network across the H.T. line and chassis or through an automatic circuit which hold the anodes positive to the sync pulses and negative to the picture content of the signal. The diodes therefore conduct only during the sync pulses, line pulses are taken away from one anode and the frame pulses via a special transformer, the two timebases therefore are effectively isolated.

D.C. Restoration.

In the modern type of T/V receiver D.C. restoration is rarely used, but nearly all older models had some sort of restoration circuit. D.C. restoration must be used where there is capacitative coupling between video amplifier and tube. Modern receivers appear to have direct coupling over these stages.

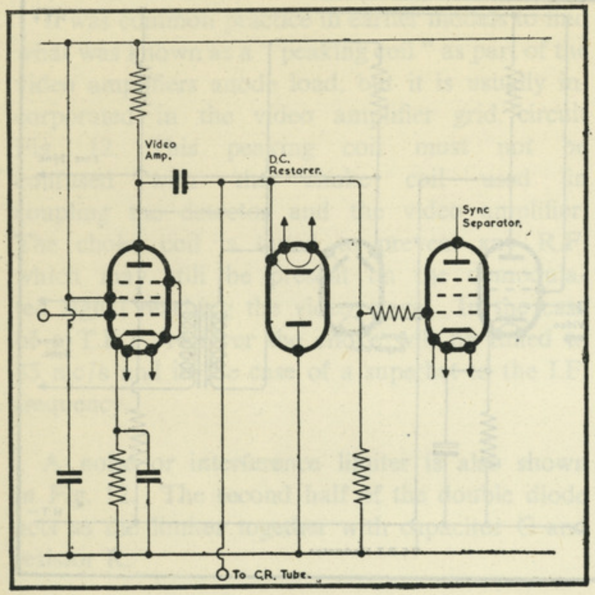

Fig. 15. D.C. Restoration Circuit.

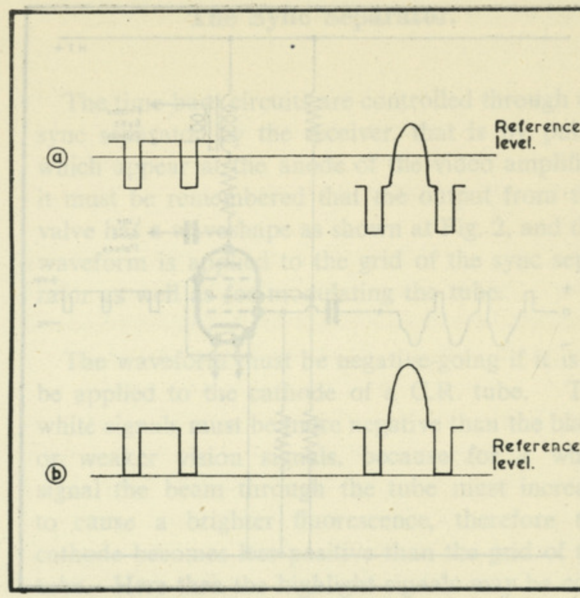

Fig. 16. D.C. Restoration Waveform.

The circuit shown at Fig. 15 is one which might be found in some of the older types of receivers. The sync separator must also be fed from the D.C. restorer to maintain that the sync pulses are all on the same level.

Diagram 16(a) shows where the D.C. component has been lost through capacitative coupling, and the signal therefore centres itself around the reference level according to the signal content. Fig. 16(b) shows the same signal with the D.C. component restored, the second waveform is obviously the one which must be applied to the tube and to the sync separator for correct operation.

The circuit at Fig. 15 has the diode cathode coupled to the tube and the sync separator via the capacitor C, the anode being at chassis potential. The signal is applied to the restorer in the positive sense, therefore during the vision period of each line the cathode is driven positive and the valve does not conduct. When the sync pulse arrives, the cathode loses the positive potential and is sent negative and therefore conducts charging up the capacitor C, the charge being dependent on the picture content. The picture content will determine how the signal centres itself around the reference line, and a bright scene will produce a large charge on the capacitor, because each sync pulse at the end of a line with bright picture content will drive the cathode well down into the negative region, while a dark scene leaves very little charge on the capacitor due to the much lower negative charge.

The final charge on the capacitor is positive, for now the diode conducts, therefore assisting in making the diode non-conductive, these charges therefore counteract the D.C. component loss through the capacitor bringing the bottoms of the pulses nearly to the same level.

Faults which are likely to occur in a D.C. restoration circuit are leaking coupling capacitor, or a breakdown in the grid resistor of the sync separator, this resistor which acts as the diode load would upset the circuit operation, as sync pulses would be lost.

Loss of emission in the restoring valve, will lead to poor picture quality and synchronisation. Poor contact in the valveholder and dirty valve pins will cause intermittent working which will give a flickering effect on the picture, with the accompanying loss of sync pulses.

Faults in Vision Receivers.

Faults in the tuning stages of a T/V receiver are almost the same as those in a broadcast receiver, but sometimes the symptoms can be somewhat misleading. Investigation into the cause is not made at all easy owing to the high frequencies used. Normally a meter can be put into a valve circuit of a broadcast receiver without causing too much trouble. With a T/V receiver this method should be avoided because of upsetting the wiring of the stage concerned and stray leads disturb the operation of the receiver.

Instability can be caused in T/V receivers in much the same way as in a broadcast receiver through decoupling capacitors losing value with age. Such cases call for the checking of a number of capacitors before the faulty one is found. Substitution with one of known quality is probably the best method, keeping in mind that the lead out wires must be kept as short as possible. One of the main faults which occurs in T/V components is an internal disconnection or bad contact, this can only be found by gently moving the components with a plastic trimming tool. This can be done while the set is still, switched on so that the fault has a chance of showing itself more readily.

It must be stressed here that when substituting components the length of leads is very important and that the lead out wires must be kept to an absolute minimum. Instability, when it is extremely violent can cause the screen to go peak white and defocussed similar to incorrect bias or heater to cathode breakdown in a C.R. tube, or perhaps in a milder form a very poor picture with an interference pattern on it. Other capacitors, other than those used for decoupling, can cause faults to occur, but in this case the effect is usually loss of gain, and the previous method can be applied. Capacitors which are short circuiting are perhaps the more easier to locate, except where the fault happens to be intermittent, here a simple continuity test will reveal the faulty one except when connected across an inductor. Resistor faults can be traced in a similar way but here the fault may be that the resistor has become extremely high in value and this is not uncommon in T/V receivers. An increase in value of a damping resistor for instance across a coil to broaden its response, would allow the " Q " of the circuit to rise and cause instability. It is possible to trace the faulty resistor by connecting another of the correct value across the suspected one, but otherwise it means cutting the resistor from the circuit and measuring its value. Resistors change their value quite often through overheating, but more often than not these can be found due to discolouration or perhaps the end may have come away.

Loss of gain is caused through loose or fractured coil cores, resulting in a change of tuning resonance. The effect is noticed more when this happens in the oscillator coil, and causes a sound on vision effect. Where this is suspected, turning the volume control down will cause less vibration and the core will not vibrate, if the fault were to be a break through of sound on vision the volume control would have no effect.

Where patterning is prevalent on a picture it can be caused through a nearby station interfering, or bad earth connections on screening cans, or poor bonding of screening cans to chassis. The only thing to do here is to make sure that pressure is good on screening can bondings and to fit shakeproof washers under the nuts clamping them making sure that the shakeproof washers bite into the material and make good contact.

Vision Detector Faults.

Quite a number of modern T/V receivers have crystal diodes for demodulation purposes, these are very reliable and there is very little to go wrong with them, unless they are seriously over-run.

To prevent damage to a crystal diode a resistor of a few hundred ohms is inserted in the lead to the grid of the video stage. This is to protect the crystal from damage should the operator while working, probing inside the set with a screwdriver accidently touch an H.T. point with the screwdriver touching the crystal. A large current is likely to flow should this happen and burn out the delicate point contact and so ruin the diode.

A continuity test will show whether the diode is open circuit or not and also give an indication of its rectifying qualities. The reading should be less than 1000 in the forward direction and at least ten times higher in the reverse direction. Obviously this will not show its qualities at the signal frequencies, as this can only be checked by replacement.

Here perhaps a word of warning when soldering a crystal diode into position, extreme heat can quite easily damage a crystal diode, and a heat shunt should be used or the crystal feed wire held in a pair of pliers close to the body of the crystal to absorb the heat travelling along the wire.

Any of the chokes which are used in various parts of the circuit of a T/V receiver can cause trouble which is sometimes difficult to detect. These chokes are sometimes wound on rather high value resistors, some, such as those which are in the anode circuit of a video valve are wound with wire which will carry a fairly heavy current, others are wound with much finer wire, and these sometimes become open circuit, not only through having a too heavier current passed through them but maybe due to corrosion at the point where the choke wire is soldered on to the lead out wires from the resistor. Again a continuity check will prove whether the coil is open circuit or not. A choke of this nature should have a resistance, depending on its position in the circuit of between 5Ω and 50Ω, should the ohmmeter show values much higher than this then the choke must be suspected.

The actual fault may be masked by the presence of the D.C. path offered by the resistor, but usually loss of gain at the detector giving a poor picture and erratic sync control with a loss of contrast are the usual symtoms apparent.

Where thermionic diodes are used the heater voltage should be checked, and should there be a signal at the detector without there being a satisfactory one at the C.R. tube, the aerial input should be short circuited to prove that what signal there is, is coming in from the aerial, as the detector can show a voltage even when it is caused by instability.

The Sound Receiver.

The sound which accompanies the vision signal is radiated, in the case of the London transmitter on 41.5 megacycles, which is 3.5 megacycles lower than the vision channel.

Nearly all the modern types of receivers use the superhet circuit for both sound and vision channels, but there are still some of the older models of the T.R.F. type, especially among the home constructed T/V receivers.

The T.R.F. receivers vary in the number of R.F. stages used, dependent on the distance from the local transmitter. In some cases a separate R.F. amplifier is fitted either internally or externally when receiving at extreme distances.

In all cases whether T.R.F. of superhet, the passband of the stages preceding the " take off " point for the sound must be wide enough to accommodate both the vision and sound frequencies, the response curve will therefore be wider than those used for the normal sound and vision channels.

With superhet receivers care has to be taken in selecting an Intermediate Frequency whose harmonics will not interfere or interact with the vision signal. Rather more careful screening must be used than in normal broadcast receivers. Intermediate frequencies in T/V receivers seem to vary between 10 megacycles and 19.5 megacycles.

The sound channel is fed to the sound receiver either by a very small capacitor from the frequency changer anode, or through an extra winding on one of the I.F. transformers. Amplification methods being well known, the signal now following normal A.F. amplification procedure, it need not be discussed here.

CHAPTER II

TIME BASE CIRCUITS

To understand the operation of a time base consideration must be given to the most simple type known, that is the charge and discharge of a capacitor through a resistance. The product of C and R (where C in Farads and R in megohms) is known as the time constant of the circuit.

The time base causes the spot either to move across the screen of a C.R. tube in a horizontal direction or to move vertically from top to bottom of the screen.

At the end of each trace the spot must be made to travel back to the starting point in the shortest time possible, to trace out a second line. This is done by discharging the capacitor rapidly by some method such as a very low value resistor or by a special valve known as a gas discharge valve.

A simple time base is shown in Fig. 17 which consists of a resistor R and a capacitor C with the discharge valve connected across C in series with a low value resistor.

Connecting the H.T. supply the capacitor will not immediately acquire a full charge, but will charge up relatively slowly depending on the value of R and the capacitance of the capacitor. An increase in value of either of the components will cause the charging time to be longer.

The voltage then builds up on the capacitor to its peak value, and if this voltage is applied to the tube circuits the spot will move slowly across the screen. To make the operation repeat, the capacitor must first be discharged. The discharge valve across the capacitor, is a triode valve which contains a proportion of inert gas within the envelope usually neon, argon or helium, will discharge the capacitor by " firing " when its anode has reached a certain voltage to allow current to pass and vertually short-circuit the capacitor.

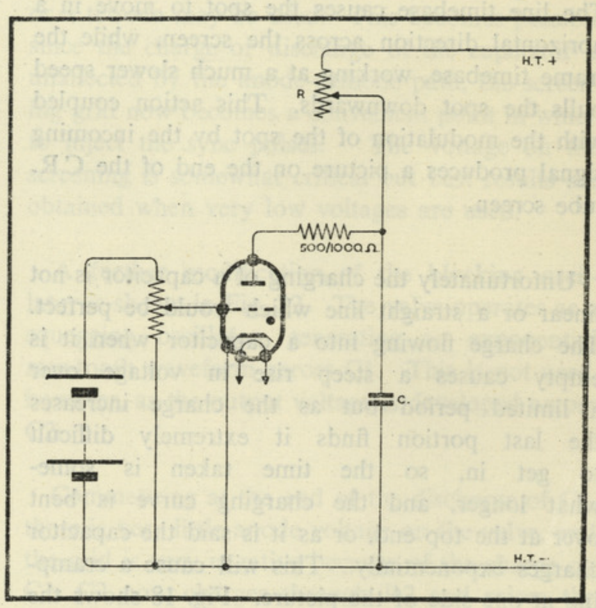

Fig. 17. Simple Timebase.

Consider the valve with sufficient negative volts on the grid to prevent current flowing. If the anode volts are raised the negative effect of the grid will be reduced and a point will be reached at which current flows. In a normal type of valve the current would start off very small increasing to maximum as the anode volts were increased. In the case of a gas discharge valve the electrons flowing from cathode to anode collide with molecules of gas, and being at low pressure readily ionise. Each collision causes more electrons to be released and these in turn collide with other molecules and release further electrons, so that a very rapid build up of current is obtained and the discharge valve becomes almost a short-circuit.

Once ionisation has started and current is flowing, it will continue to do so until the anode voltage is reduced to a value below the ionisation potential of the gas. The grid of the valve having no effect in stopping the discharge once it has started.

The charging process then recommences immediately after the valve has discharged the capacitor, and repeats the movement of the spot again.

This is just what is wanted for T/V purposes. The line timebase causes the spot to move in a horizontal direction across the screen, while the frame timebase, working at a much slower speed pulls the spot downwards. This action coupled with the modulation of the spot by the incoming signal produces a picture on the end of the C.R. tube screen.

Unfortunately the charging of a capacitor is not linear or a straight line which would be perfect. The charge flowing into a capacitor when it is empty causes a steep rise in voltage over a limited period but as the charge increases the last portion finds it extremely difficult to get in, so the time taken is somewhat longer, and the charging curve is bent over at the top end, or as it is said the capacitor charges exponentially. This will cause a cramping at one side of the picture. Fig. 18 shows the charging curve of a capacitor of charge against time.

To overcome this non-linearity a pentode valve is sometimes used shown at Fig. 19, this being a constant current device. In this circuit the charg-

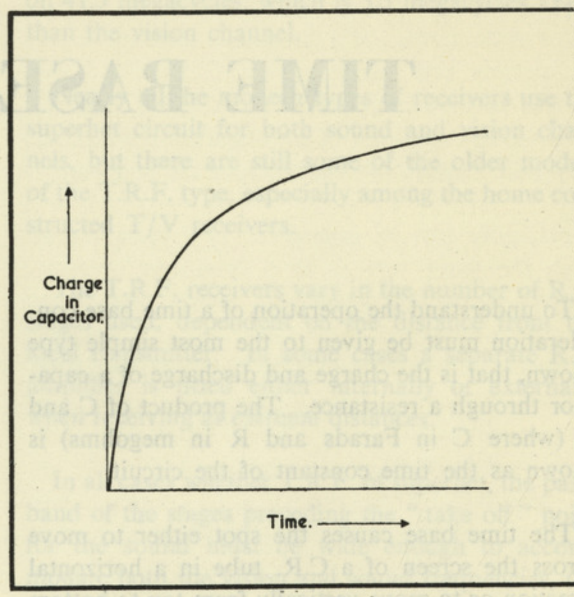

Fig. 18. Charging Curve of a Capacitor.

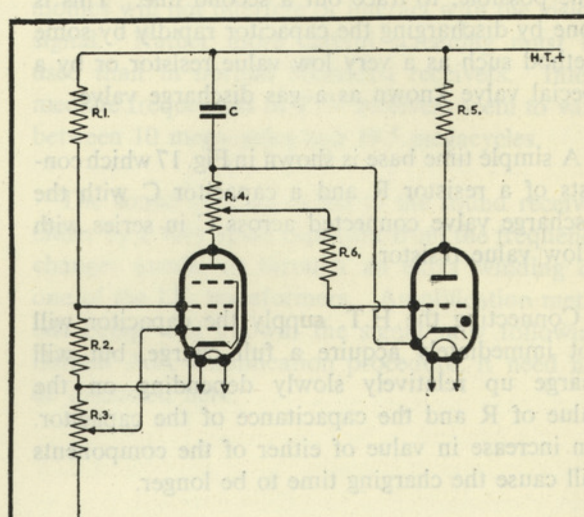

Fig. 19. Pentode Charging Circuit.

ing current is varied by altering the negative voltage applied to the grid of the pentode by potentiometer R3. As the cathode of the valve is connected a little way up the resistance chain across the H.T. supply, the grid will always be negative with respect to the cathode.

Bias for the discharge valve is obtained by connecting the grid to the slider of the potentiometer between the cathode of the discharge valve and the anode of the pentode. During the charging time current will flow in capacitor C, and as this current is constant the voltage drop across the potentiometer R4 will also be constant, and therefore any portion of this voltage may be tapped off as bias for the discharge valve. When the discharge valve strikes the voltages fall, due to the discharge already started and which will not stop until the voltage on the anode falls practically to zero, that is until the capacitor has been discharged. The spot moves across the screen during the charging period, the flyback operating during the discharge time. These types of time bases are used mainly for oscillograph work and rarely in T/V receivers. Modern receivers use the hard valve type of time base for line and frame scanning, the main types being the

a. Grid blocking oscillator.
b. The Multivibrator.
c. The Transitron.

each of these will be described so that each one may be clearly recognised.

A hard valve oscillator of the squegging-valve or blocking oscillator is shown in Fig. 20. It is similar to that of an ordinary grid detector with reaction, except for convenience in obtaining the output, the positions of L.2 and that of C and R are interchanged. The coupling between L1 and L2 is very tight so that the valve will oscillate violently. Heavy grid current flows and charges up C and the grid rapidly goes very negative and the valve no longer oscillates.

The capacitor C then discharges exponentially through R, until the grid potential becomes normal for the valve to start oscillating again.

In a case such as this the scanning stroke is supplied by the discharge of C and the flyback provided by the charge. As shown the circuit will not function properly for T/V working as the output

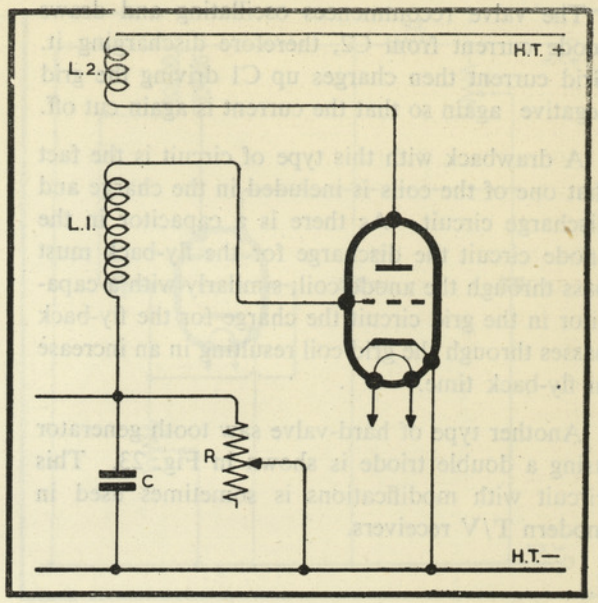

Fig. 20. Basic Blocking Oscillator Circuit.

is very non-linear, this fortunately can be overcome by returning R to the positive H.T. The output will be the same as before, but the voltage acting in the circuit is now the capacitor voltage plus the H.T. voltage. A modified circuit is shown at Fig. 21(a) and here it will be seen that a pentode or a tetrode may be used. This becomes possible since the charge or discharge of the capacitor is unaffected by the anode-cathode path, the screening grid now becomes a convenient point in which to inject the sync pulses. The voltage on the screening is somewhat critical but best results are obtained when very low voltages are used.

A further modification of the blocking oscillator is shown in Fig. 22. The valve operates as a squegging oscillator, generating an exponential saw-tooth waveform across C1. This is not used, however, as the output voltage is developed across C2.

Commencing at the end of the discharge of C2, there is very little anode voltage on the valve, and the grid is very negative because of the charge on C1, C2 now charges through R2 and raises the anode voltage, at the same time C1 discharges through R1 making the grid potential lower.

The valve recommences oscillating and draws anode current from C2, therefore discharging it. Grid current then charges up C1 driving the grid negative again so that the current is again cut off.

A drawback with this type of circuit is the fact that one of the coils is included in the charge and discharge circuit. As there is a capacitor in the anode circuit the discharge for the fly-back must pass through the anode coil; similarly with a capacitor in the grid circuit the charge for the fly-back passes through the grid coil resulting in an increase in fly-back time.

Another type of hard-valve saw tooth generator using a double triode is shown in Fig. 23. This circuit with modifications is sometimes used in modern T/V receivers.

It is a circuit in which one triode acts as a squegging oscillator with the frequency of the oscillation controlled by C1 and R1. The capacitor C2 and the resistor R2 are decoupling components, C2 being rather large in value so that the change in voltage across it between the conductive and non-conductive periods is small.

The grid of the second triode is connected to the grid of the first.

Oscillating as a squegging oscillator, an exponential waveform is developed, and when the potential on the grid of the valve is sufficient to make the valve non-conductive, capacitor C3 charges through R3, this capacitor discharging when the valve becomes conductive. In its action

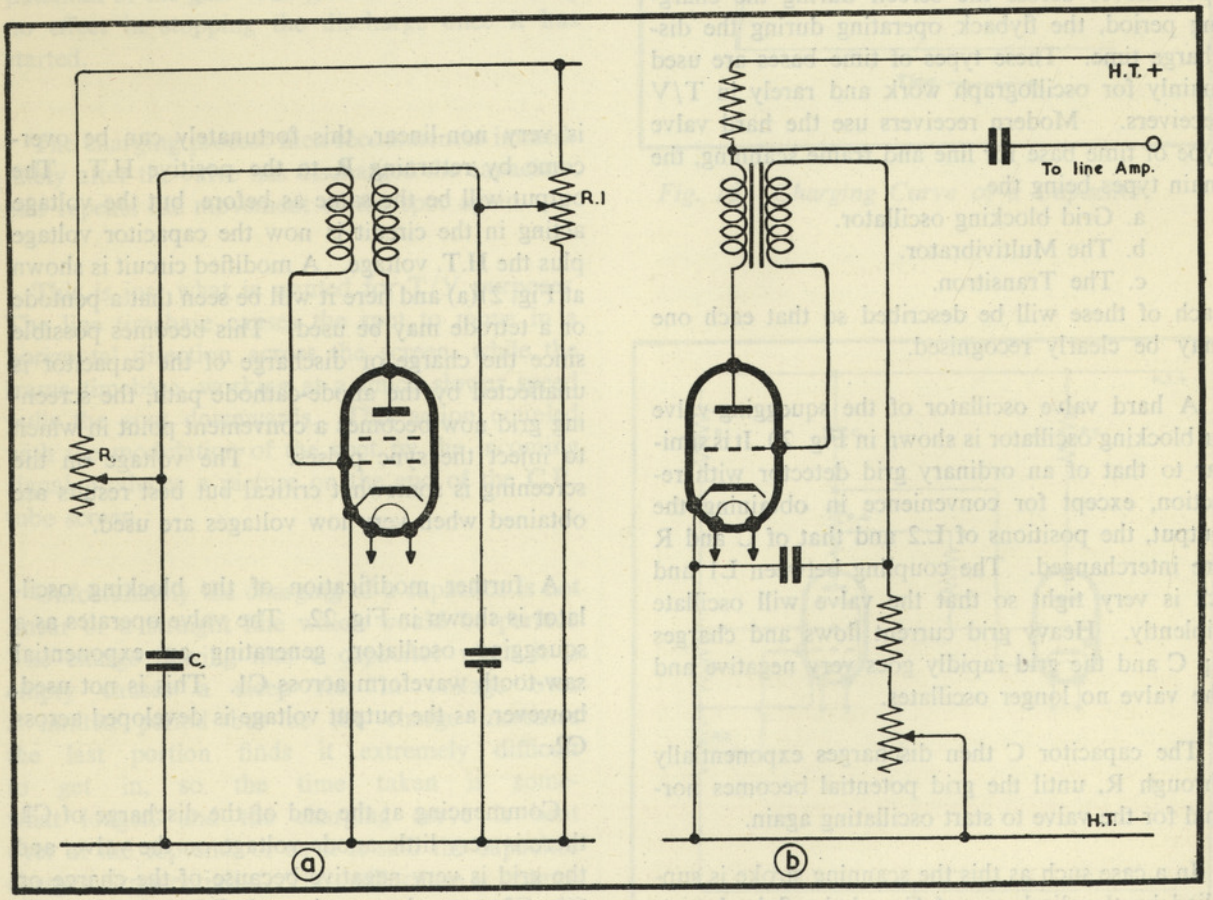

Fig. 21a. Modified Blocking Oscillator giving more linear Output.
Fig. 21b. Employed as Line Oscillator in Masteradio Model TE4T/3.

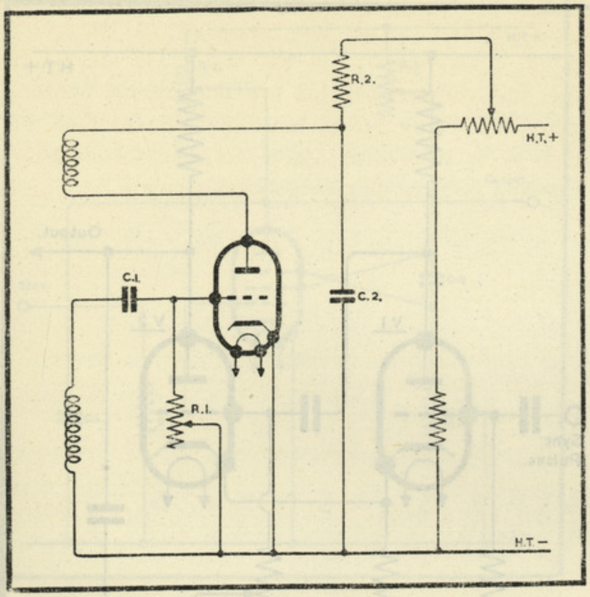

Fig. 22. *Triode Squegging Oscillator.*

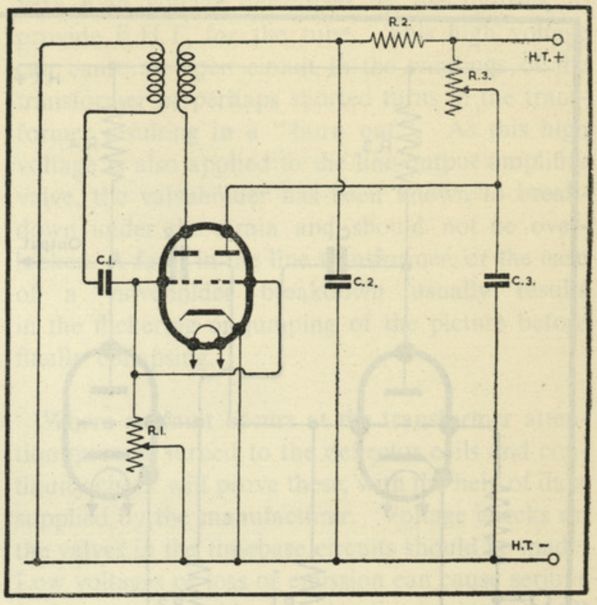

Fig. 23. *Sawtooth Oscillator using Double Triode.*

this circuit is the same as that described for Fig. 22 except that separate anode circuits are used for discharging the capacitor and coil current.

The Multivibrator Oscillator is sometimes used for the frame and line time bases and is becoming very popular. An example is shown at Fig. 24a consisting of two triodes or a double triode each having the anode coupled to the grid of the other through a capacitor with a grid leak to earth. Fig. 24b shows how it is coupled into a T/V receiver.

In operation when the anode current of V1 increases, a negative signal is passed to the grid of V2, due to the increased voltage drop across the anode load R3. The anode current of the second valve is therefore reduced, resulting in the grid of the first valve becoming more positive. The effect is then cumulative and the anode current in the first valve rapidly reaches a maximum, while the anode current in the second is cut off. This condition will remain until the charge in capacitor C1 has leaked away through R2, permitting anode current to flow once more in the second valve. When this occurs, the cumulative effect takes place again but in the reverse direction. The saw-tooth waveform being taken off from the anode of V2 for further amplification.

To synchronise the oscillator negative pulses are applied to the grid of V1. This is a disadvantage of the type of circuit shown in Fig. 24a, as a varying waveform appears at the grid which might possibly feed back into the sync separator circuits causing interaction between frame and line timebases.

A method of overcoming this disadvantage is to rearrange the couplings as shown at Fig. 24b. The capacitor coupling the anode of V2 to the grid of V1 has been removed and the valves are coupled together by a common cathode connection and resistor to chassis. The grid of V1 now does not have any working in the oscillation of the system and can be a convenient point in which to inject synchronising pulses.

A cathode coupled multivibrator is easily triggered, operating extremely efficiently as a frame timebase, being reliable, stable, and without bulky components.

Having dealt with the Gas Discharge valve timebase and the Blocking Oscillator and Multivibrator types the remaining one to understand is the Transitron Saw Tooth Oscillator. The circuit is shown at Fig. 25.

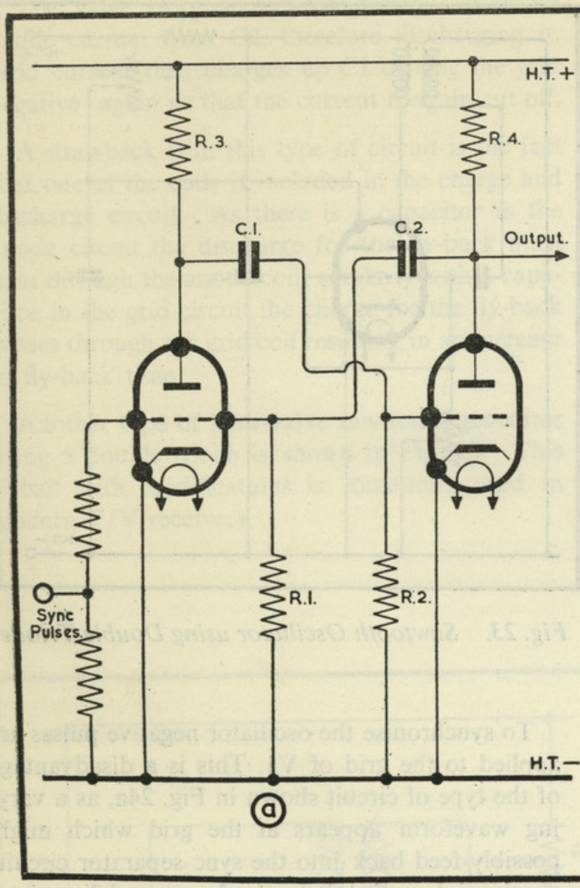

Fig. 24a. Basic Multivibrator Circuit.

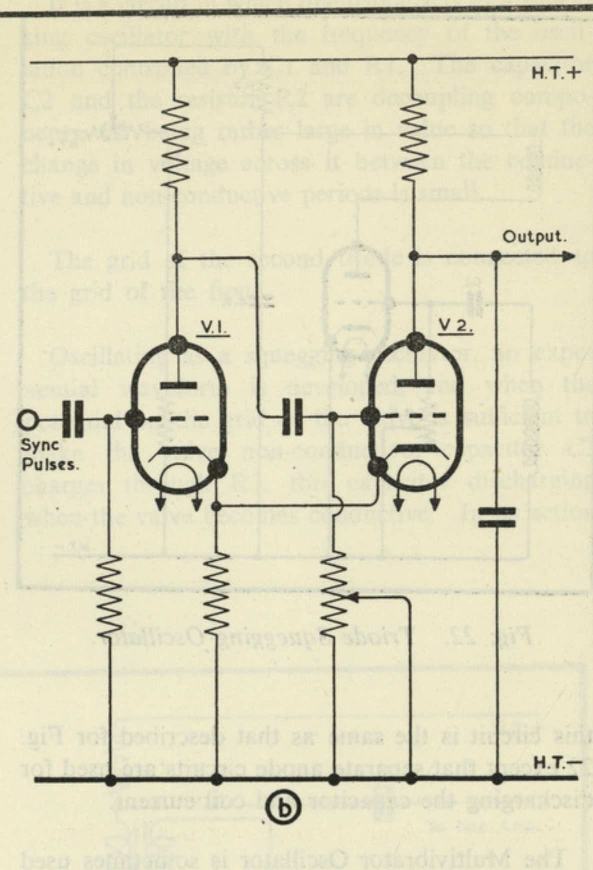

Fig. 24b. Cathode Coupled Multivibrator.

To understand the operation of such a circuit imagine that the suppressor is positive and the anode is taking current, at this time the anode current is considerably larger than the charging current through R2, and capacitor C2 is then discharging rapidly. As the anode voltage falls the anode current will remain nearly constant until the bend in the valves characteristic is reached, the current then starts to fall. The result is a rising screen current, a falling screen voltage and a falling suppressor voltage. This then reduces the anode current still more, the process becoming extremely rapid until the velocity is limited by the stray capacities of the circuit and the anode current therefore is suddenly cut off, while the suppressor grid is driven negative. The condition then remains until capacitor C is charged again through R2. Due to the capacitor charging the anode again regains its potential, and a point is reached where the anode begins to draw current which would otherwise pass to the screen. As this takes place the suppressor grid potential increases again, since both suppressor and screen are coupled, the anode then suddenly takes a large current thereby discharging C.

The discharging action is a cumulative one due to the increase of suppressor voltage with the resulting increase of anode current, since the anode and screen currents are out of phase the start of the discharge is therefore rapid.

To operate under the best conditions a valve having a high ratio of anode current to screen current so that during the discharging action the screen potential rises to a high value accelerating the discharge, for the higher the screen potential the larger is the anode current.

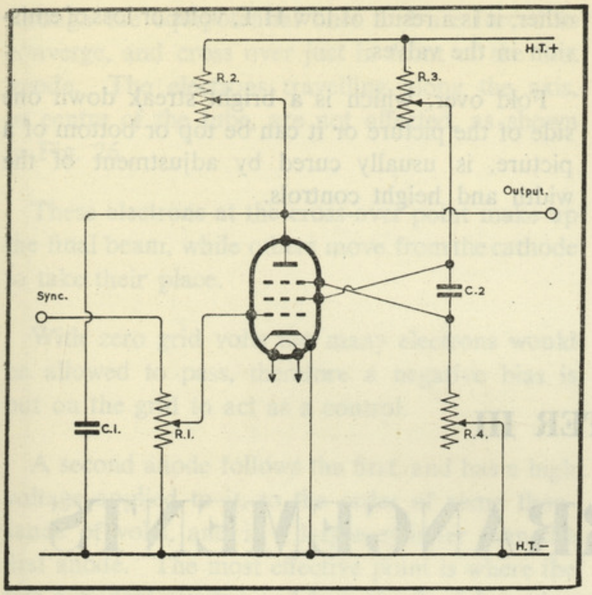

Fig. 25. Transitron Sawtooth Oscillator.

Synchronising pulses have to be provided for all time base circuits whether line or frame oscillators of a T/V receiver, or timebases in an oscilloscope, to keep the resulting picture steady.

In an oscilloscope a portion of the voltage under examination is fed on to the grid of the oscillator and so locks the frequencies. With regard to television, pulses for frame and line locking are provided in the transmission of the picture, but these have to be negative going and of small amplitude to give best results.

Timebase Faults.

In the case of a complete breakdown of a timebase, the effect produced on the screen is unmistakable, for the timebase which is operating will either produce a bright vertical line on the screen, showing that the line timebase has broken down, or a similarly bright horizontal line showing the frame timebase out of action.

When correcting faults on a completely broken down timebase, searching should commence at the transformer coupling the deflector coils, more especially when the line timebase is at fault. The line output transformer has to stand up to some very high voltage developed by the fly-back to provide E.H.T. for the tube. This high voltage can cause an open circuit in the windings of the transformer or perhaps shorted turns in the transformer resulting in a "burn out". As this high voltage is also applied to the line output amplifier valve, the valveholder has been known to breakdown under the strain and should not be overlooked. A fault in the line transformer, or the case of a valveholder breakdown usually results in the flickering or jumping of the picture before finally collapsing.

Where no fault occurs at the transformer attention must be turned to the deflector coils and continuity check will prove these, with the help of data supplied by the manufacturer. Voltage checks on the valves in the timebase circuits should be made. Low voltages or loss of emission can cause serious faults to arise, although the timebase may still operate. In cases such as this difficulty in locking the line or frame timebases usually occur, after thoroughly checking components such as resistors, for high resistance, or capacitors for leakage, a replacement of the valve concerned usually provides the answer.

Another check on the timebases is to replace the sync separator valve, as weak synchronising signals may be causing the timebases to operate inefficiently, but this should not be done in the event of complete failure of the timebases, as the valve may be damaged due to a component fault elsewhere. The substitution method should only be tried where the timebases are giving a short scan or loss of linearity or some other minor defect.

Cramping of the picture to one side or along the bottom or top is an indication of loss of linearity and an inspection should be made linearising circuits to the timebases.

Both timebases out of action will indicate a fault in the H.T. supply, resulting in a bright spot in the centre of the tube, the brilliance control must be rotated to blank out the spot and inspection made into the H.T. feed resistors and to any interconnecting plugs to the H.T. supply.

Intermittent working of either timebase is usually caused through poor connections in valveholders.

The potentiometers to these circuits must not be ignored as worn or pitted tracks cause trouble through intermittent changes of resistance.

Where the picture shows signs of shrinking in one direction, but holding correct size in the other, it is a result of low H.T. volts or loss of emission in the valves.

Fold over, which is a bright streak down one side of the picture or it can be top or bottom of a picture, is usually cured by adjustment of the width and height controls.

CHAPTER III

FOCUSSING ARRANGEMENTS

Electrostatic Focussing.

Although the present day tendency is to use permanent magnets for focussing, there are still a number of receivers employing the electromagnetic method on possibly some older models using the electrostatic method. The last mentioned will be described first and in considerable detail.

Electrostatic focussing can be likened to normal optical focussing as the properties which exist for optical focussing are present with the electrostatic method.

To focus a beam of light on an object, a series of glass lenses are used, and the property of being able to bend the rays of light is known as a refraction, and bring about a sharply focussed image at a predetermined distance depending on the focal length of the optical unit. A similar property exists between two metal cylinders, one slightly smaller than the other, and each at different potential levels.

When two metal cylinders, spaced apart but slightly overlapping, with different potentials applied to each, equipotential lines and lines of electrostatic force exist between them. The number of these lines depends upon the ratio between the potentials on the metal cylinders.

To understand the action of an electron lens, the theory is best taken step by step.

The C.R. tube consists of a heater element surrounded by a metal cylinder which is coated with a material, liberal in electrons when heated, this is known as the cathode. The control grid is next, but it is not the familiar wire mesh as in a normal valve, it is another small hollow cylinder with the end nearest the cathode partially closed. This is to restrict the area of the cathode and tends to add electrons to the beam, therefore helping in the final focussing of the beam.

The other end of the cylinder is entirely open and leads into the first anode; this is also a hollow cylinder with the end nearest the grid closed except for a very small hole in the centre. This also helps to bring the electrons together to make up the beam.

Combined the cathode, grid and first anode make up the first lens system.

When the cathode is heated electrons are liberated and due to the influence of the first anode, which has perhaps 500V applied to it and no negative control on the grid, the electrons are drawn towards the anode. In doing so they have to pass through the equipotential lines and are forced to converge, and cross over just in front of the first anode. The electrons travelling along the axis, or centre of the tube, are not affected, as shown in Fig. 26.

These electrons at the cross-over point make up the final beam, while others move from the cathode to take their place.

With zero grid volts too many electrons would be allowed to pass, therefore a negative bias is put on the grid to act as a control.

A second anode follows the first, and has a high voltage applied to it, to the order of some thousands of volts, and is a larger cylinder than the first anode. The most effective point is where the two cylinders overlap and here the final focussing takes place.

When the electrons are drawn away from the cross-over point some are not travelling parallel to the axis, the beam is therefore diverging. The diverging electrons are forced to alter their path meeting at another point along the axis, which is the screen. Again electrons travelling along the axis are not affected by the action of the lens.

The focussing action of the second lens system depends on the potential applied to the first anode, and the focussing of the spot is unaffected by variations in the control grid voltage as the first lens system—from the cathode to the first anode—is fixed.

Electromagnetic Focussing

Before discussing the actual method of magnetic focussing, it will be well perhaps to be reminded of some elementary magnetic theory of a wire carrying a current.

When a current flows through a wire a circular magnetic field is set up around the wire, due to the movement of electrons. If this wire carrying the current is placed in a magnetic field, and the wire is lying in the same direction as the magnetic field, Fig. 27a, no interaction of the fields will take place as the two fields are at right angles to one another.

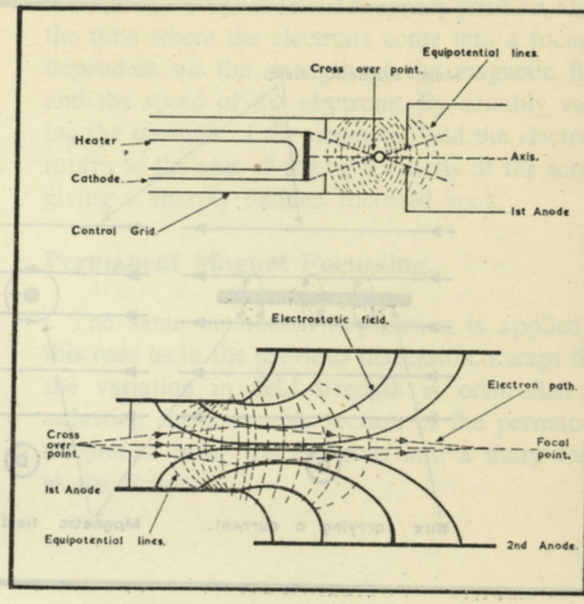

Fig. 26. Electron Lens System.

Placing the wire at 90° to the direction of the main magnetic field, the two magnetic fields are now in the same plane.

Looking at Fig. 27b it will be seen that the top half of the magnetic field of the wire is travelling in the same direction as the main field, and therefore there will be a distortion set up in the main magnetic field, and the lines of force will add together.

The lower half of the magnetic field is travelling in the reverse direction to the main magnetic field and tend to weaken it, Fig. 27c. As line of magnetic flux prefer to travel along the shortest possible path a force will be exerted on the wire, and if it is free to move, in the case shown the wire will move in a downwards direction.

Applying a similar theory to electrons travelling in a magnetic field, and knowing that an electron has to be moving before it will create a magnetic field, where an electron moves away from the parallel path in a magnetic field, the force exerted
parallel path in a magnetic field, the force exerted
on it will bring the electron back to the axis at a more distant point.

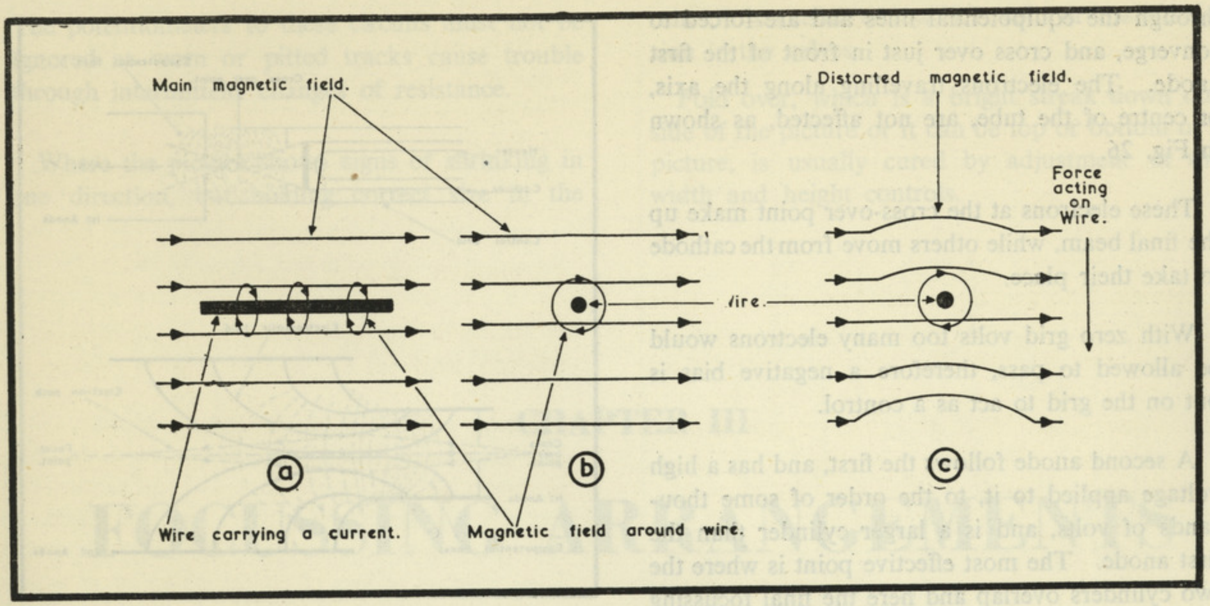

Fig. 27. Lines of Magnetic Force around a Conductor in a Magnetic Field.

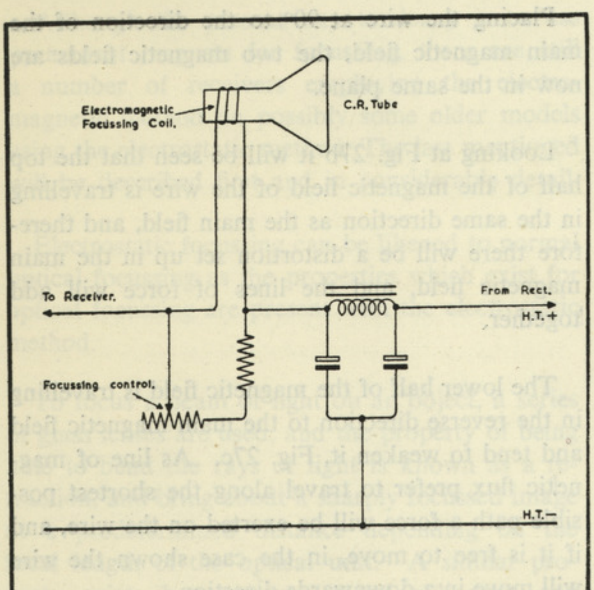

Fig. 28. Circuit showing method for Electromagnetic Focussing.

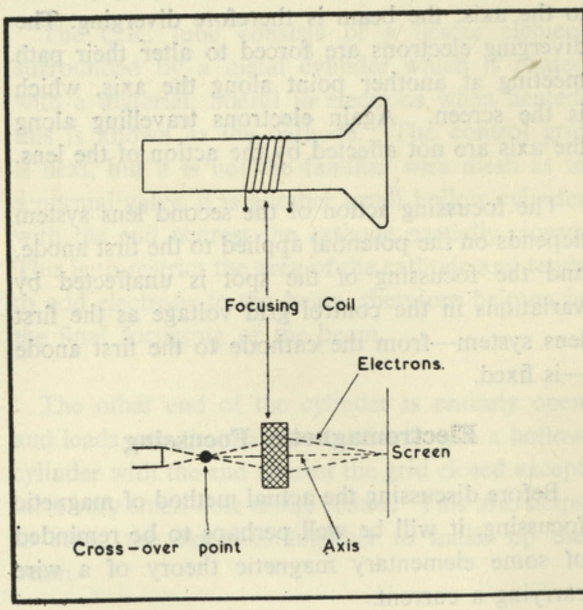

Fig. 29. Electromagnetic Focussing.

A focussing coil is fitted around the neck of a tube just beyond the first anode, Fig. 28. The first lens system is almost the same as for an electrostatic tube, the electrons being made to converge at the cross-over point. From this point the electrons then spread outwards and the action of the magnetic field comes in to play.

C.R. tubes using magnetic focussing have a coating of aquadag around the tube and this is given a high positive potential. The high voltage accelerating the electron beam.

The field of the focussing coil is parallel with the axis of the tube and is created by a direct current flowing through the coil. Electrons leaving the cross over point and travelling along the axis of the tube are not affected by the magnetic field. However, as many electrons spread out or diverge beyond the cross-over point, these electrons moving at even a small angle to the magnetic field are forced back towards the axis (Fig. 29). As the electrons are moving forward instead of travelling in a straight line, a spiralling movement is performed in reaching the actual focus point on the screen of the tube. The exact position along the tube where the electrons come into a focus is dependent on the strength of the magnetic field and the speed of the electrons. By suitably varying the strength of the magnetic field the electrons return to the axis of the tube exactly at the screen giving a sharply defined focussed spot.

Permanent Magnet Focussing.

The same theoretical application is applied in this case as in the previous discussion, except that the variation in field strength is controlled by adjusting the moveable section of the permanent magnet to bring the electrons into a sharp focus at the screen.

CHAPTER IV

BEAM DEFLECTION METHODS

Electrostatic Deflection.

Very few receivers use this method of deflection, but it is widely used in oscilloscope working, a short discussion on the method will not be out of place.

To deflect the beam a pair of parallel plates are incorporated in the construction of the tube and are placed a short distance beyond the final anode. When the electron beam passes between them it will be influenced by the deflecting force of the potential between them. Another pair at right angles to the first, but placed a short distance in front of the first pair control the beam at right angles to the original pair.

The deflecting plates are referred to as the " X and Y " deflecting plates, indicating the axes of the deflection of the beam. The four plates are brought out to terminals at the base of the tube, to be connected to timebase circuits or any other voltage for visual inspection. The " X " pair are usually connected to the timebase, while the " Y " pair are used for vertical movement of the beam.

Electromagnetic Deflection.

Two pairs of coils are used and placed at right angles to one another, mounted on the tube neck where the electron beam leaves the focussing system.

The pair comprising the line scan coils are placed opposite one another and connected in series, the frame coils are set at right angles to the line coils, connected in series and overlap the line coils, in order to take up the least possible room on the tube neck.

The pulsating current due to the frame and line timebase oscillators causes a pulsating magnetic field around the deflecting coils and moves the spot across or from top to bottom of the screen tracing a desired pattern or picture in its travel.

Confusion between the action of the focussing and deflection coils may arise here. It possibly may appear that while one coil (the focussing coil) bends the beam round so that it is focussed on the screen, the other coils only cause the beam to move from left to right or up and down. The action of all coils is the same, the main difference being that the focussing coil having its magnetic flux parallel to the axis of the tube any electrons moving away from the axis are turned back towards the axis.

The magnetic fields of the deflection coils are at right angles to the electron beam, therefore the magnetic force is applied at right angles to the forward motion of the electrons. Here the effect is not so concentrated as at the focussing coil, the beam merely being deflected rather than bent around into a circular path.

The C.R. Tube Screen.

Cathode ray tube screens are made of fluorescent materials which emit light when excited by some outside source. The exciting agent in this case is the electron beam impinging on the screen. The fluorescent coating is spread evenly over the inner surface of the tube face, the thickness being such, that the resultant light emitted after the bombardment by electrons, is not in any way lost.

On striking the flourescent screen the electrons lose their energy. Part of the energy is lost in knocking out slower moving electrons from the screen, the remainder of the energy being converted into light by the flourescent material.

Mostly C.R. tubes for T/V reception are black and white, because the picture appears more natural and is less tiring to the eyes. The fluorescent screen must not emit light for any lengthy period, otherwise double images will be seen, although a certain amount of light persistence is desirable, this being governed by the speed with which the beam scans the tube. The light from one point must be entirely extinguished before the beam reaches that point again.

A high light efficiency is desirable, for less wattage is necessary for a given amount of light, thereby reducing the size of the power supply to the receiver.

CHAPTER V

POWER SUPPLIES

Before commencing discussion about power supplies for T/V receivers it must be remembered that *all* power supplies are dangerous and must be treated with respect. Some of the earlier models have 50 cycles H.T. and E.H.T. supplies, a shock from this type is lethal and can cause a fatal accident.

The A.C. Voltage from an A.C. mains source has to be converted to produce a steady supply of direct current and voltage, that is voltage and current with a polarity positive and negative.

For all radio and T/V equipment a supply of of ripple free direct current is required, to be applied to the various circuits, this excludes the heaters to the valves which may be operated from an A.C. source.

This conversion from A.C. to D.C. is known as power rectification.

The Half-Wave Rectifier.

In the case of the Half-Wave Rectifier this can either be fed by a mains transformer or coupled to the mains by a voltage dropping resistance.

The transformer system isolates the actual mains supply from any other part of the circuit, while with the voltage dropping resistance one side of the mains supply is connected to chassis.

A single Diode rectifier is used for half-wave rectification, a circuit for such an arrangement is shown at Fig. 30a, when supplied from the mains by a transformer.

The action is such that the transformer provides the correct voltages for both the anode and the heater supplies, and due to the fact that the diode possesses a property of only passing current when the anode is positive with respect to the cathode, pulses of current flow through the cathode circuit, the negative half cycle having been suppressed.

A filter circuit follows the rectifier to smooth out the pulses and produce and steady direct current and voltage. The capacitor C1 charges up at each pulse from the rectifier and during the short time elapsing where the A.C. changes direction C1 discharges through the choke Ch1. As the choke is iron cored at each discharge from C1 a back e.m.f. is set up across Ch1, tending to prevent the discharge, thus endeavouring to smooth out the ripple in the H.T. line. Capacitor C2 then receives a charge and then discharges into the load circuit. The current being almost smooth when it reaches C2, the final current into the load is almost lacking in ripple voltage. The action shown in Fig. 30b.

The action of the rectifier in an AC/DC circuit is exactly the same for A.C. working. When on D.C. mains the rectifier offers a low resistance path for the D.C. current. A circuit for AC/DC mains operation is shown at Fig. 30c.

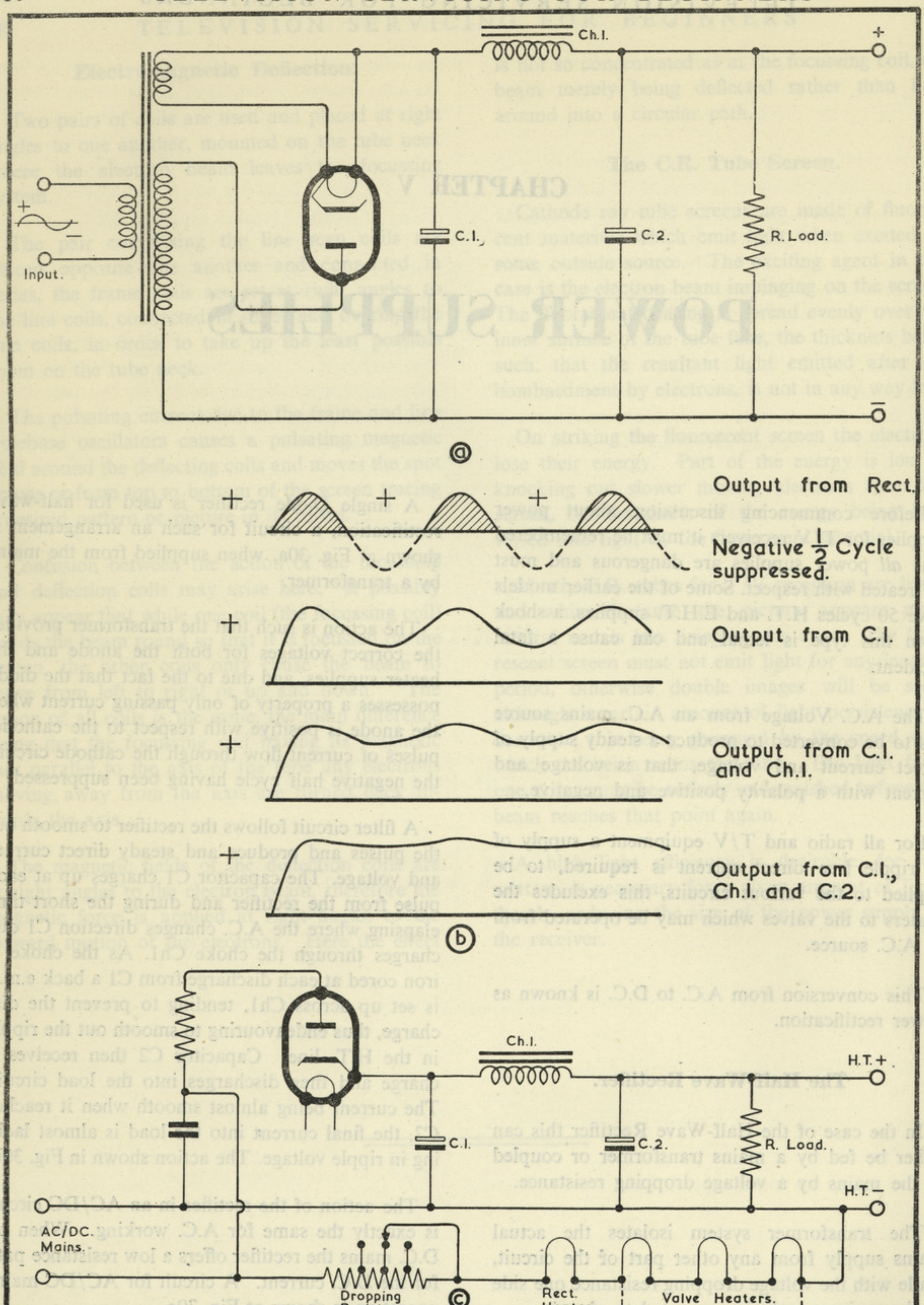

Fig. 30. A.C./D.C. Half-Wave Rectification Circuits.

The Full Wave Rectifier.

A full wave rectification system can only be operated from A.C., and using a double diode rectifier. The smoothing problems in this type of circuit are not great as with the half-wave system. Capacitors C1 and C2 in Fig. 31 need be only 8μF each and together with the smoothing choke Ch1 provide ample smoothing as the filter circuit now receives pulses from the rectifier twice for every complete cycle of A.C. instead of once for every cycle.

Capacitors C1 in the half-wave system would be at least 16μF while C2 would be from 24μF to 32μF to provide an equal amount of smoothing.

A.C. Operated E.H.T. Supplies.

The circuit is that for a normal half-wave rectification system, the operation also being identical. The circuit, however, changes considerably, instead of having 200 volts to 250 volts on the anode of the rectifier, this has now increased to perhaps 4000 volts or more. This means that the transformer must be extremely well insulated between layers and between sections, also having a high insulation value between the turns and the core.

A 4000 volt transformer will give an output from the reservoir capacitor (C1 in Fig. 32) of about 5500 volts, since the capacitor charges up almost to the peak value, which is 1.414 times the R.M.S. voltage. As half-wave rectification is used, on the non-conducting period when the rectifier anode is negative, a total potential difference is made up of the 5500 volts across the capacitor C1, with a further 5000 volts across the valve making approximately 11,000 volts, which is the Peak Inverse Voltage. Fig. 32 shows two circuits with slightly different connections, together with the peak inverse voltages shown for each circuit.

At (a) the Peak Inverse Voltage appears between anode and cathode of the rectifier, therefore the insulation between the H.T. windings and the heater windings must be of a very high order. In (b) the Peak Inverse Voltage appears between the windings of the transformer and the iron core

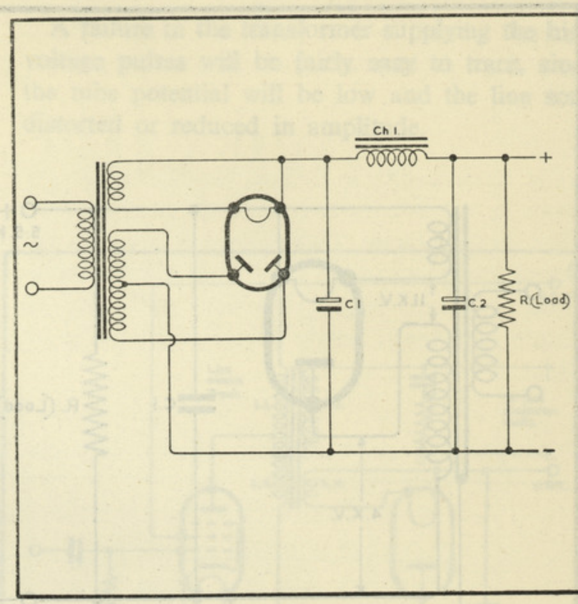

Fig. 31. Full Wave Rectification Circuit.

and here again the insulation must be extremely good.

The regulation of this type of power supply unit must be better than perhaps sometimes thought, as the current flowing is very small, a smaller reservoir capacitor can be used, for the capacitor discharges very slowly; normal values are between 0.005μF and 0.1μF. An important point to remember is that the current drawn by the tube, which is the current from the capacitor, constantly varies with the frequency range of the picture content, the deflection sensitivity of the tube depending entirely on the voltage of the final anode. If this varying of frequency range causes any voltage fluctuation, the picture size will alter sufficiently rapidly to affect portions of the picture—a bright patch on the screen means a higher beam current. In a badly regulated system where a loss of anode voltage occurs, an increase in deflection sensitivity is brought about, the bright area increasing and also the picture focus would change.

The chief factor governing the regulation of the power pack is the internal resistance; the capacitance of the reservoir being sufficient to give a suitable time constant over the whole circuit, this

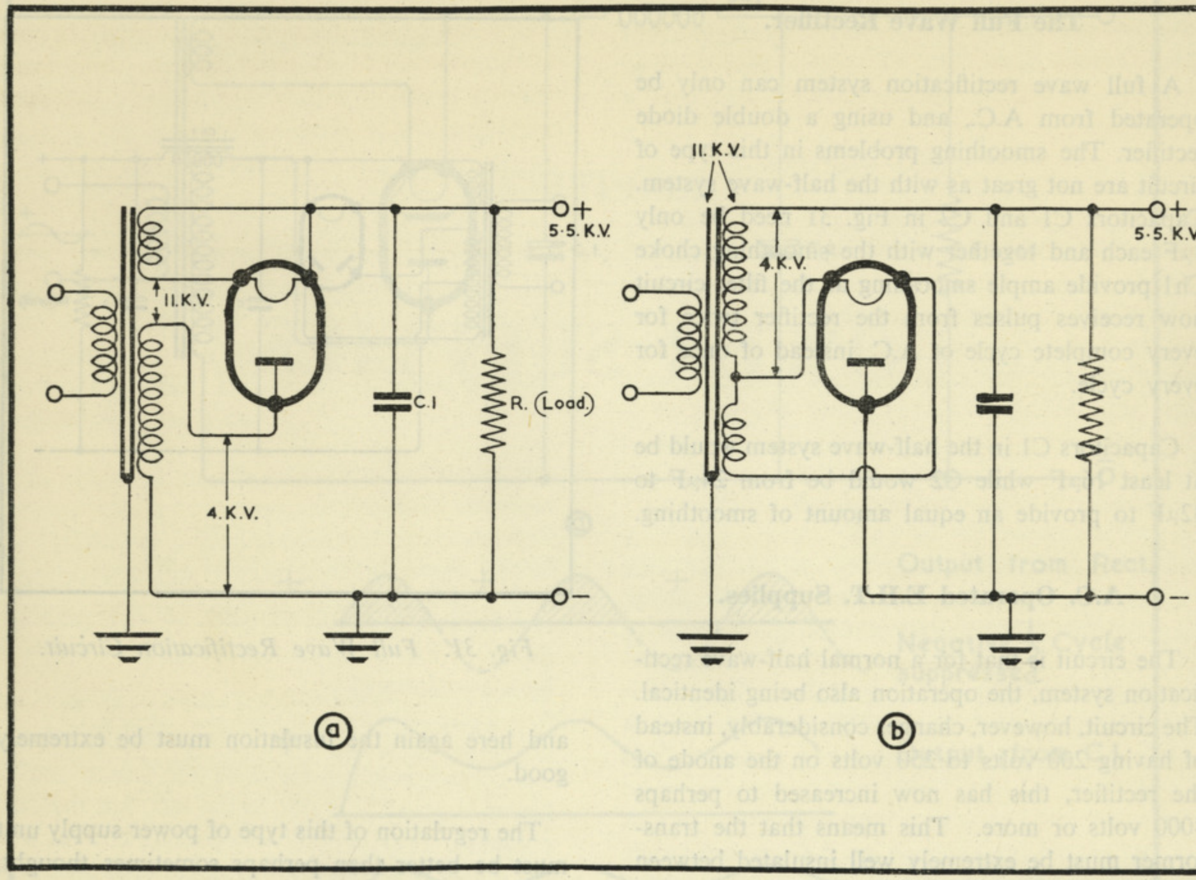

Fig. 32. Indicating where Peak Inverse Voltages Appear.

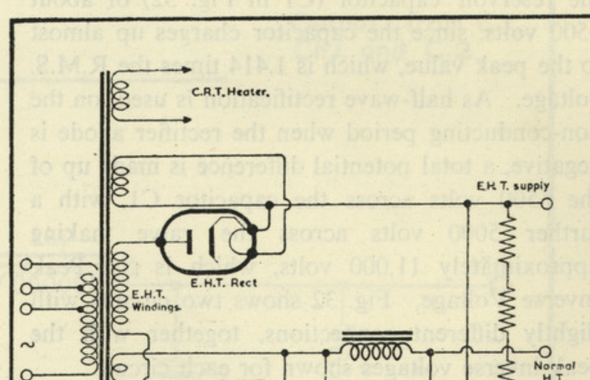

Fig. 33. Combined E.H.T. and H.T. Power Unit.

time constant being greater than the time taken for one frame scan. Any replacements to components here must be made in accordance with the receiver manufacturer's data to obtain and maintain the original conditions.

In the case of a reservoir capacitor becoming open circuit, the E.H.T. potential will fall, so that the picture brilliance and size will change, the picture increasing in size together with a change in focus, also a 50 cycle bar will modulate picture and perhaps throw it off centre.

A typical combined H.T. and E. H. T. circuit is shown at Fig. 33.

The greatest drawback of the transformer E.H.T. system is the bulkiness of the mains transformer and the high cost of manufacture.

Line Flyback E.H.T.

R.F. and Flyback E.H.T. power packs are now most common in T/V receivers. The pentode valve of the line output amplifier stage is operating at the line scan frequency of 10,125 cycles per second, at this frequency and as the waveshape is sawtooth a high back E.M.F. is generated across the primary of the transformer on the flyback of each scan stroke. The potential set-up may be to the order of 2000 volts and appears across L1 in Fig. 34. If a diode were connected to the anode of the pentode nearly 2000 volts would be developed for E.H.T. but as a much higher voltage is required the transformer is overwound, shown by L3 in the diagram and the primary now acts as a step up transformer to give the required voltage to operate the tube. L4 is the heater windings to the E.H.T. rectifier, L.2 being the secondary section feeding the line deflection coils.

One great advantage of such a system is that it is not lethal should the E.H.T. line be accidentally touched, although a shock will be felt or perhaps a skin burn, the circuit being so loaded on contact the voltage drops immediately.

It is obvious that it is of no use trying to measure the voltage with an ordinary type of voltmeter, as the loading on the circuit by the meter will instantly kill the E.H.T. voltage.

A failure in the transformer supplying the high voltage pulses will be fairly easy to trace, since the tube potential will be low and the line scan distorted or reduced in amplitude.

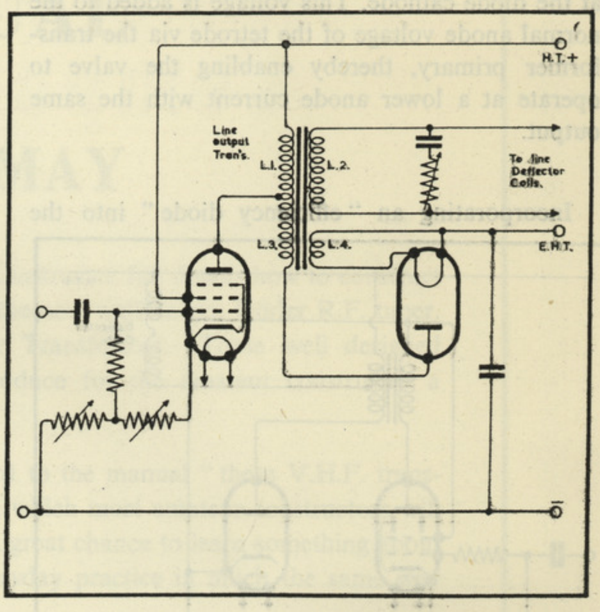

Fig. 34. E.H.T. Generator.

Efficiency Diode.

The use of the AC/DC circuit is now the most used in T/V receivers, the modern tendency towards the cathode ray tubes with large deflection angles and high anode voltages, makes for the highest efficiency in the line scanning circuits.

A lot of the energy from the scanning circuit is lost as heat, but by using a diode to absorb the energy during the overshoot of the flyback, the flyback energy is made to contribute to the scan.

Fig. 35 shows the basic circuit for such a requirement. Imagine a positive going sawtooth waveform applied to the tetrode grid, producing at the anode a sawtooth current which is fed to the deflector coils by the transformer. The voltage waveform at the coils consists of a large semi-sinusoidal negative pulse corresponding to the current flyback, and a positive voltage with a linear slope corresponding to the forward current stroke.

The diode conducts during the forward stroke absorbing the overshoot and charge the capacitor at the diode cathode. This voltage is added to the normal anode voltage of the tetrode via the transformer primary, thereby enabling the valve to operate at a lower anode current with the same output.

Incorporating an "efficiency diode" into the line output circuit reduces the losses of the stage considerably.

The usual method is to incorporate the efficiency diode with the line flyback method of E.H.T. generation, together with a complete line output stage.

In the circuit shown at Fig. 36 which is used by Messrs. Portadyne Radio and Television Ltd., it will be noticed that the line linearity control is in series with the main deflector coils to avoid irregularities to the E.H.T. supply, the E.H.T. diode heater being fed from the winding on the E.H.T. transformer in the normal manner.

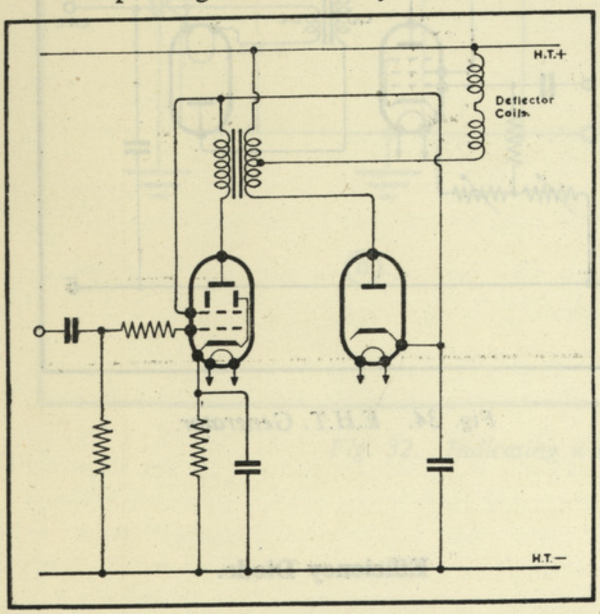

Fig. 35. Efficiency Diode Circuit.

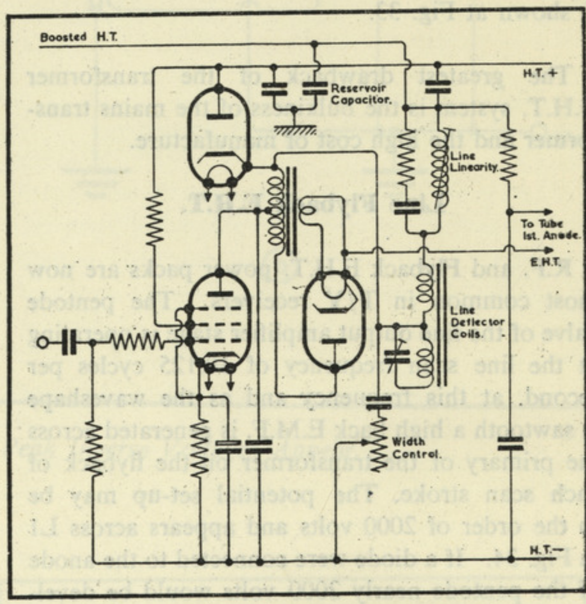

Fig. 36. Line Output Stage incorporating E.H.T. Generator and Efficiency Diode.

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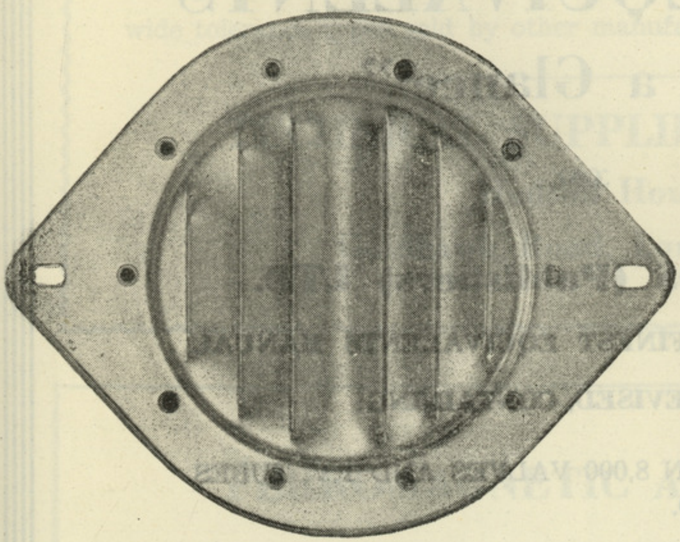

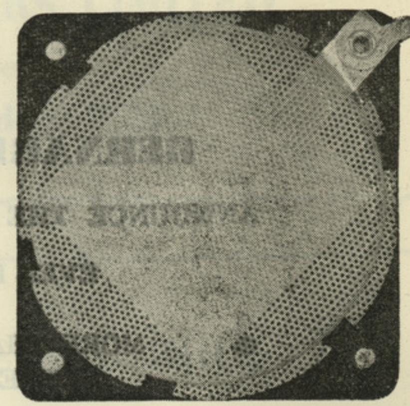

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