TECHNICAL DESCRIPTION

MARCONI-E.M.I. SYSTEM OF TELEVISION

PART 5. THE PICTURE CHANNEL

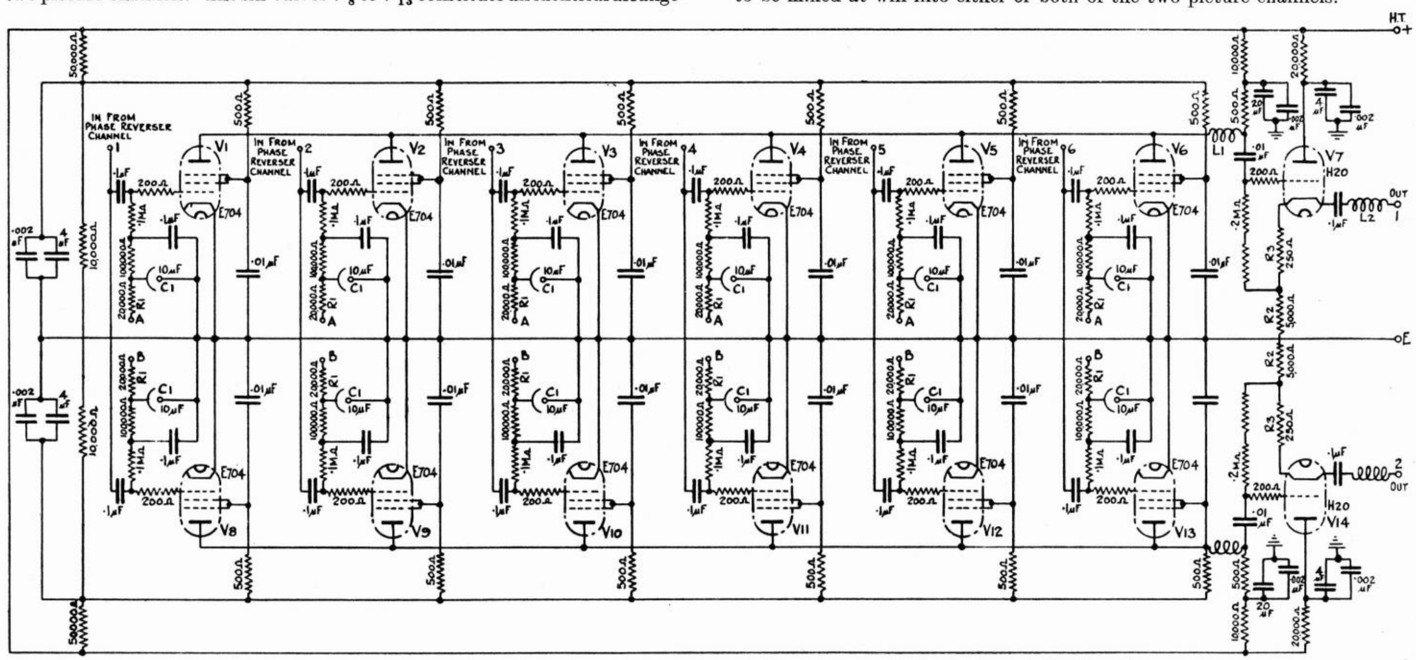
CONTENTS

THE FADING AND MONITORING MIXER

At the output of the phase reverser unit there appear the six individual picture signals produced by the six emitron cameras. Apparatus must be provided whereby any single picture or combination of pictures may be faded into the transmitter circuit. At the same time it is necessary to provide an additional circuit which may be used to preview the picture which is, according to the needs of presentation, next to be applied to the transmitter. These two channels are described, respectively, as the *transmitter* and *preview* channels. It is, of course, necessary to be able to apply any picture or combination of pictures to the preview channel, as in the case of the transmitter channel, but provision for fading the picture on to the preview channel is not necessary, and a simple switching operation is all that is required. On the other hand, there is no objection to the picture input to the preview channel being controlled by a fading operation, and in some installations this is done. For instance, in the equipment associated with Studio 1 at the London Television Station, the preview channel is controlled by a switching operation, whereas in the equipment associated with Studio 2 and in the mobile scanning equipment, fading is preferred. Where fading is employed it is evident that the control of both channels is identical, and in the event of a breakdown of the transmitter picture channel the preview channel may be used as a spare, the preview facility then being not available.

In order to avoid loss of the preview facility in the event of a picture channel breaking down, a third picture channel may be provided, as is done, for instance, in the equipment associated with Studio 1 at the London Television Station. In this case it must be possible to apply any camera channel or combination of camera channels to any of the three picture channels, and the Fading and Monitoring Mixer becomes a more elaborate unit. The principles of operation remain entirely the same, however, and it will suffice to describe only one type of Fading and Monitoring Mixer, namely, that associated with the control of six camera channels and two picture channels.

The unit contains 14 valves designated V_1 to V_{14}, as shown in the circuit diagram, and the principle employed is as follows. Valves V_1 to V_6 have their anodes connected in parallel, and have a common anode mpedance. Thus, any signal appearing on the grid of any of these six valves will appear in the anode circuit. The anode circuit is connected to one of the two picture channels. The six valves V_8 to V_{13} constitute an identical arrangement, and feed the second picture channel. The picture output from any one of the six channels of the phase reverser is connected to one valve in each of the above pairs of six. For example, emitron channel 1 is applied to the grid of valves V_1 and V_8, emitron channel 2 being connected to the grids of valves V_2 and V_9 and so on. All the valves V_1 to V_6 and V_8 to V_{13} are variable μ valves, and means are available to apply variable negative grid bias to their grids, so that the amount of signal appearing in their anodes can be controlled. Thus, if the output from emitron channel 1 is required on picture channel 1, the grid bias on V_1 will be reduced. If simultaneously a mixture of emitron channels 2 and 3 are required on picture channel 2, then the grid bias on valves V_9 and V_{10} would be reduced, thus permitting both valves to offer the signals on their grids to the common anode circuit. It will be seen that this arrangement permits any emitron channel or combination of channels to be mixed at will into either or both of the two picture channels.



A—Points to which Variable Bias is supplied for Remote Stud Switches, for Camera Fading in Transmission Channel.
B—Points to which Fixed Bias is supplied or removed by Key Switches on Fish Plate, for selecting Cameras for Previewing Channel.

The valve V_7 receives the common output from the valves V_1 to V_6, and constitutes a cathode follower for feeding the output line to the first picture channel at low impedance. The valve V_{14} is a similar stage for feeding the second channel.

Coming now to detailed circuit considerations, the valves V_1 to V_6, which we will assume to be connected to the transmission picture channel and must therefore have fading facilities, are supplied with negative bias at the points A in the attached diagram, variable in 12 steps, each step causing a 4 db. drop in level except in the final step which gives the necessary cut-off. The necessary stud switches are on a remote control panel situated on the deck occupied by the vision mixing operator. Thus, by varying the position of the stud switches, the operator can introduce the six emitron channels into the transmission channel in the desired proportions.

In the case of valves V_8 to V_{13}, which are assumed to be connected to the previewing picture channel, fading facilities are not required, and the bias is introduced at the points B in the attached circuit diagram by means of key switches, which either cut the camera channel out by application of excessive bias or give the full gain by application of the minimum bias.

The negative bias is introduced in both channels via the resistances R_1 and the large condensers C_1. The combination $C_1 R_1$ has a long time constant, and there is a slight delay from the time the stud switch is operated to the time when the negative bias has taken up its final value on the grid of one of the valves V_1 to V_6. This delay is provided as the sudden removal of bias caused by the swift operation of a stud switch would impose a very large low frequency transient impulse on the picture channel, which would cause overloading and general dislocation. However rapidly the operator rotates his stud switch, the fade cannot be executed in less than about 2½ seconds, (2½ secs.) thus ensuring that no transient can occur. At a later point in the chain a certain amount of bass suppression is introduced in order to allow the fading time to be as short as even ½ (½ secs.) seconds, as otherwise as much as 10 seconds might be required, a length of time which is inconvenient from the presentation viewpoint. Otherwise the circuits associated with the valves V_1 to V_6 and V_8 to V_{13} are perfectly straight. The common anode circuit of the valves V_1 to V_6 is coupled to V_7 by a resistance coupling, the inductance L_1 being inserted as usual, so that the coupling has the form of a ~~band-pass~~ low-pass filter.

As has been mentioned, the valve V_7 constitutes a cathode follower. The cathode impedance of this valve consists of the two resistances R_2 and R_3 in series. The valve is provided with correct grid bias by returning the grid to the junction of R_2 and R_3 while the anti-phase voltage for the cathode following action is developed across the whole of the impedance consisting of R_2 and R_3 in series, and is fed back via the anode impedance of the valves V_1 to V_6 in parallel. The inductance L_2 holds off the capacity of the cable. V_{14} is an identical cathode follower stage for the other channel. If it is desired to change over the functions of the two picture channels, this can be done by interchanging the grid connections of the output valves V_7 and V_{14}.

The output of this unit therefore constitutes the input of the two picture channels.

The maximum gain through any channel is about unity.

THE 'B' AMPLIFIER

The function of the ' B ' amplifier is to receive and amplify the vision signals from the fading and monitoring mixer. Each output of the fading and monitoring mixer feeds a separate ' B.' The maximum gain of each ' B ' is approximately 45 db ± 1 db. at all frequencies up to 4 Mc/s.

The ' B ' amplifier has four single-valve stages, the first three of which are used for amplification, and the fourth as a cathode follower presenting a low impedance to line.

Gain control is effected at the input stage which comprises the variable-mu valve V_1; variable grid-bias is derived from a − 120 volt supply, and applied across the potentiometer R_1, which is in the form of a manual control designated **Gain**. The grid-bias supply is decoupled by C_2, R_2, C_3 and R_3 and the anode of V_1 by C_4, R_4, C_5 and R_5.

The valves V_1 and V_2 are coupled by the usual low-pass filter, comprising the inductance L_2; the filter is terminated by the anode resistance R_6. This termination is made more exact by the inclusion of a further inductance L_1 which gives the termination R_6L_1 a rising characteristic, corresponding in magnitude (though not in angle) more closely to the impedance characteristic of the intervalve filter which also rises with frequency.

It is shown in the section on 'The Camera' that in order to be able to suppress microphony introduced in these units owing to their mobile nature, a low-frequency lift is applied in the emitron-head amplifier coupling, so that if, later, low-frequency suppression is applied, microphony, which occurs mostly at very low frequencies, will be removed together with excessive low frequencies. In addition, the various anode decoupling circuits in the whole vision chain between the camera and distribution amplifier tend to give collectively a certain amount of unwanted low-frequency lift, together with an incorrect phase angle. This effect, if uncorrected, leads to prevalence of streaking in the reproduced picture. Low-frequency suppression, together with an associated modification of phase angle which approximately covers the above two conditions, is introduced by the elements C_6, R_7, and R_8. R_7 and R_8 reduce the level at all frequencies by normal potentiometer action; the condenser C_6 by-passes the middle and upper frequencies to the grid of V_2.

The second and third amplifying stages function on lines similar to the first, but in the case of V_3 feedback is applied by the unshunted resistance R_{10} in order to lengthen the valve characteristic.

V_4 is a cathode-follower output stage, strong feedback being derived from the unshunted resistance R_{11}, while correct grid-bias is secured by returning the grid leak R_{12} to the junction of R_{11} with the further cathode resistance R_{13}.

Valve feeds are measured by the meter M in conjunction with the measuring points M_1, M_2, M_3 and M_4.

Resistances in the circuit diagram having no specified values are given values differing from amplifier to amplifier. The inductance values are not precise, but again are adjusted to suit each amplifier. However, it may be said that the average value of the filter inductance L_2, L_4 and L_6 lies between 60 and 110 μH, and the value of the terminating inductances L_1, L_3 and L_5 are approximately 30 to 50 μH. The sense of the incoming signals is that whites act positively; the sense of the emergent signals is that whites act negatively. This is indicated by the symbols P+ (picture positive) and P− (picture negative).

In the intervals between lines and frames, the emergent signals are accompanied by spurious pulses which are in the white direction and have an amplitude about twice as great as that of the normal vision signals. The spurious signals are produced by the emitron as a result of the abrupt cut-off of its beam by the black-out pulses in the intervals between lines and frames. They are dealt with quite normally in the ' B ' amplifier and cause no special problem.

Maintenance Data

The following voltages, currents, and gains may be expected at appropriate points with the main control set to maximum :—

	Cathode Current	*Anode Voltage after decoupling*	*Screen Voltage*	*Cathode Voltage*	*Anode Voltage*
V_1	2.5 mA	90 v	90 v	0	90
V_2	7 mA	225 v	100 v	2.2 v	220
V_3	11 mA	170 v	180 v	4.4 v	150
V_4	16.5 mA	190 v	190 v	38 v	190

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(*Figure 1 attached*)

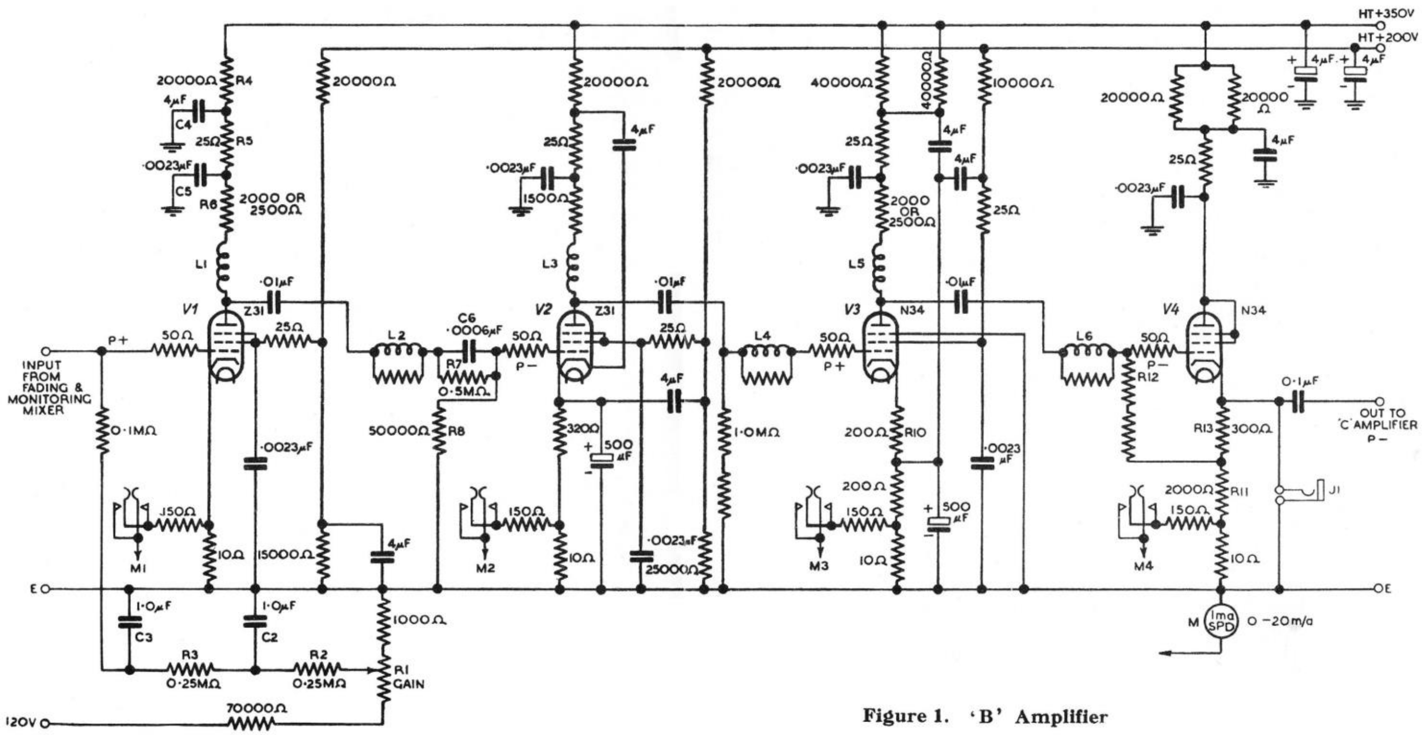

Figure 1. 'B' Amplifier

THE 'C' AMPLIFIER

The output from the 'B' amplifier, in each picture channel, is further amplified by means of the 'C' amplifier which has three single-valve stages. The first two are amplifying stages and the last a cathode-follower output stage. The maximum gain is 25 db. for all frequencies up to 4 Mc/s.

The input is applied to the grid of the valve V_1 whose grid leak R_1 has a low value in order to suppress transients produced by camera fading. The input consists of negative picture signals accompanied in the black-out intervals by a large negative spurious signal in the negative sense. The operating point of V_1 is set low down on the characteristic so that much of the negative spurious signal is lost around the bottom bend of the valve characteristic. The comparatively large range of linear valve characteristic in the positive sense will accommodate the vision signal satisfactorily.

At the grid of V_2, white signals are positive and are accompanied by positive spurious signals of comparatively large amplitude. As with V_1, the operating point of V_2 is set low down on the characteristic, but this time for quite a different reason. The spurious signal is now acting positively and therefore cannot be reduced by the bottom bend of the valve characteristic and it must therefore be normally amplified. The operating characteristic must be long enough so that the spurious signals and the vision signals are all linearly amplified, which implies that no part of the input signals must fall on the bottom bend of the valve characteristic. The overall signal amplitude has now reached a magnitude of 20 volts and this cannot be accommodated at the grid of V_2 without feedback of a greater degree than normal to give the required length of valve characteristic. This feedback is provided by means of the unshunted cathode resistances R_3 and R_4.

Misplacement of the operating point on the characteristic of V_2 due to a fault condition has such important effects on the system that it is necessary to discuss this condition at some length. If the operating point on the characteristic is set too low down then the negative vision signals corresponding to the lower tonal values in the picture, i.e. black to mid-grey, will be placed on the bottom bend of the valve characteristic and gradation in this region of picture tonality will be restricted and the reproduction of these tones will be very poor. The effect is that there is little gradation in tone between black and mid-grey ; black will be reproduced and so will the medium greys, but there will be little in between.

If the operating point on the characteristic is set too high up (i.e. with the grid bias too small) then the positive tips of the spurious signal will cause grid current and there will be inadvertent restoration of D.C. During flyback periods the grid side of the coupling condenser C_1 will receive a negative charge which will increase the bias of V_2 so that the scanning of the subsequent line will start with V_2 biased somewhat excessively. This bias will seep away
133 during the scanning of the line and the resulting change of anode current will impose the equivalent of a spurious line tilt on the picture. No ill effect will be noticed, however, since this tilt will automatically be cancelled when the operator shades the picture by means of his tilt adjustment and it is immaterial whether this tilt originates in the emitron or in the 'C' amplifier.

Now, although the operating point of V_2 is normally fixed by the constants of the circuit, the actual operating point may vary for the following reason. The amplitude of the spurious signal will be constant for a given emitron beam current and the amplitude of the vision signals will be constant if so controlled in the 'A' amplifier, but as the camera faces changing scenes the D.C. component of the picture will change and although this component has, for the time being, been lost by the various A.C. couplings the waveform will constantly readjust itself about the datum line to preserve its A.C. characteristic in the absence of the D.C. component. At the grid of V_2, therefore, the whole vision waveform will be moving a little up and down with reference to the datum line which at this point is the standing grid-bias. The operating characteristic must be large enough to accommodate this movement without the tips of the spurious signal ever driving the valve into grid current.

Let us suppose, however, that this is not so and that, on viewing a certain scene, the whole waveform moves bodily in the positive direction causing grid current and D.C. restoration at those instances when the spurious signal is exciting the grid. Then during this scene artificial line tilt will be introduced as already explained, but there will be no other ill effect, always assuming that the characteristic is long enough to accommodate all the signal in its operating position on the characteristic as set by the D.C. restoration.

Suppose now that the scene changes once more so that the waveform at the grid of V_2 moves down and the spurious signal ceases to produce grid current. There is now no spurious line tilt, and since that which was introduced in the previous scene was corrected by suitable shading adjustment a new shading adjustment must now be sought.

The important point to notice is that the presence of this condition gives rise to an unnecessary number of shading operations and is responsible for poorly-shaded pictures.

If, for example, a camera is being panned from scene to scene, a condition in which previewing and adjustment of shading before transmission of the new scene produced by panning is impossible, then it is almost impossible to radiate perfectly shaded pictures. If, however, the characteristic can accommodate all the signal linearly and without D.C. restoration despite any movement due to change in the D.C. component, then changes of shading adjustment for a given camera are at a minimum. This is because, basically, the amount of tilt and bend waveforms which must be injected depends mostly on such factors as emiton beam current and emitron mosaic irradiation.

The intervalve coupling between V_1 and V_2 must now be considered. It will be noticed that no serious inductance is interposed between the two valves, but instead there are two inductances in series and coupled together in the anode circuit of V_1. Disregarding for the moment the fact that the inductances are coupled we can see from the arrangement of the circuit that L_2 constitutes the inductive element of a π section low-pass filter between V_1 and V_2 co-operating with the anode-earth capacity of V_1 on the input side and with the grid-earth capacity of V_2 on the output side. This filter is terminated at the output or grid end by means of the resistance R_2 (which also forms the anode resistance of V_1) together with the inductance L_1 which gives the termination a rising frequency characteristic, the termination then being a better match than if the resistance R_2 were used alone.

The provision of coupling between L_1 and L_2 has the effect of modifying the values of these inductances. If the coils are coupled their inductance is increased or decreased depending upon whether the coupling is in the aiding or opposing sense ; the maximum increase or decrease according to fundamental theory being equal to twice the mutual inductance of the coupling. In this coupling therefore, we have a ready means of adjusting the inductance values and hence the frequency characteristic. The coupling between V_2 and V_3 is similar to that between V_1 and V_2.

V_3 finally delivers an amplified signal with whites in the negative sense at an amplitude of 16 volts and blacks in the positive sense with 20 volt amplitude, together with 70 volt negative spurious signals.

Resistances in the circuit diagram having no specified values are given values differing from amplifier to amplifier. The inductance values are adjusted by the coupling to give a linear frequency characteristic and to show no loss up to 4 Mc/s.

Maintenance Data

The following voltages, currents, and gains may be expected at appropriate points with the main control set to maximum :—

	Cathode Current	*Anode Voltage after decoupling*	*Screen Voltage*	*Cathode Voltage*
V_1	5 mA	245 v	185 v	~~235 v~~ 6·25 v.
V_2	12 mA	160 v	170 v	~~140 v~~ 4·92 v.
V_3	17 mA	230 v	230 v	~~230 v~~ 3·96 v.

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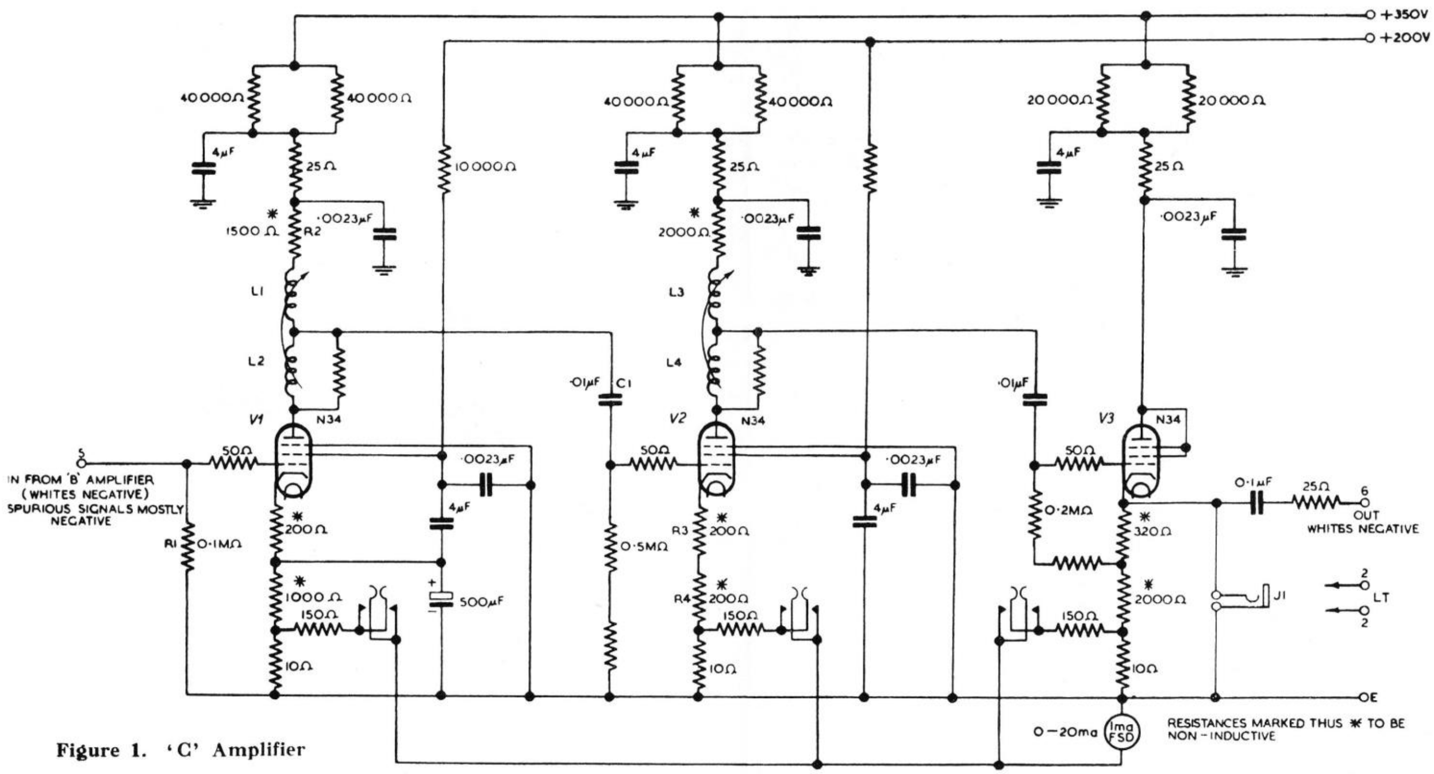

Figure 1. 'C' Amplifier

THE SUPPRESSION MIXER

The suppression mixer is a unit inserted in each of the two picture channels at a point immediately following the 'C' amplifier. It will be recollected that the output of the 'C' amplifier consists of picture signal having an amplitude of some 16 volts for a white picture, the sense of the picture signals being negative, and that in the intervals both between lines and between frames when the emitron beam is returning to commence another scan, there are spurious and entirely meaningless and unwanted signals which are generated in the emitron and which are filling up the space finally intended for the synchronising signal. From my technical notes on the 'B' and 'C' Amplifiers it will be seen that a certain amount of limitation of the somewhat large amplitudes of these spurious signals has been effected in these amplifiers, but it is now necessary to adopt measures which will entirely clear the intervals between lines and between frames of these spurious signals. These intervals must be left absolutely silent, i.e. black, so that the correct synchronising signal of proper amplitude may be later injected. This important function is performed by the suppression mixer. At the output of the 'C' amplifier the spurious signals have an amplitude of some 70 volts in the negative direction, and about 20 volts in the positive direction.

Figure 1
Line Signal Emerging from "C" Amplifier

Fig. 1 is a representation of the nature of the composite signal leaving the 'C' amplifier and applied to the input of the suppression mixer. There has meanwhile been generated in a unit known as the suppression generator a set of pulses known as the suppression pulses. These are of the form shown in Fig. 2. As will be seen, they consist of square topped pulses appropriately synchronised with the rest of the system, and such that short pulses of the type shown at A are occurring during the line return stroke of the emitron, and also longer pulses of the type shown at B
137 are occurring during the frame return stroke of the emitron. The frequency of the pulse labelled A is, of course, the same as the number of lines per second, i.e. 10,125, and the frequency of the pulse labelled B is correspondingly that of the number of frames per second, i.e. 50, and the composite waveform of Fig. 2 has clearly been produced by mixing a continuous supply of A pulses with a supply of B pulses. If the purpose of the suppression pulses were solely to suppress the spurious signals, it would be sufficient for their duration to be equal to that of the spurious signals, which is in turn equal to the duration of the black-out pulses, but the suppression pulses are required for other purposes, which are dealt with in my note on the Suppression Pulse Generator (Item 2.4). It will be remembered that the duration of the line suppression pulse is 15 μ secs and that of the frame suppression pulse 2,000 μ secs or 1,400 μ secs as required.

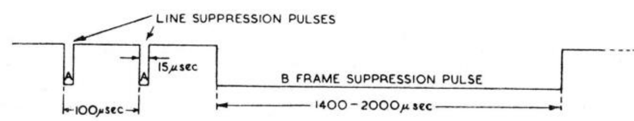

Figure 2. Negative Suppression Pulses

Figure 3. Positive Suppression Pulses

From the suppression generator there is also available an output of suppression pulses identical with those in Fig. 2, but reversed in sense and appearing, therefore, as in Fig. 3. The pulses in Fig. 2 are known as negative suppression pulses and those in Fig. 3 positive. The negative pulses are adjusted to a fixed amplitude of 6 volts, and the positive pulses $4\frac{1}{2}$ volts.

The general principle of spurious signal suppression, as carried out in the Suppression Mixer, can now be explained. Referring to Fig. 14, picture signals are applied to the grid of the valve V_2 in such a sense as to make the grid negative on whites. At the same time positive suppression pulses are applied to the grid of V_3. The anode circuits of V_2 and V_3 are common, and thus constitute a mixing circuit in which there appear amplified picture and spurious signals reversed in sense, i.e. so that the picture signals are now acting positively on whites and the spurious signals largely positively. Mixed with these are, of course, suppression signals, also reversed so as to appear as in Fig. 2, i.e. negative suppression signals. Under these circumstances the signal has an appearance, very roughly, as shown in Fig. 4, where the spurious signals S are sitting at the bottom of the suppression pulses P during both the line and frame periods. Consequently, by cutting neatly through the suppression pulses along the line XY, the spurious signal, together with any remaining unwanted suppression pulse, will be electrically chopped off, and the suppression period consequently left clear. The line XY may be made to coincide with the level represented by black, so that the intervals instead of being filled with spurious signal, are now intervals of black. This electrical chopping action is achieved at the grid circuit of V_4, to which the mixture of picture and suppression signals is applied, the valve characteristic being so adjusted that a sharp cut-off may be obtained along the line XY of Fig. 4. Thus, at the anode circuit of V_4, there appear clean picture signals which are applied to V_5, a cathode following output stage.

Considering the circuit in detail, it will be seen that the broad principle outlined above is somewhat elaborated in practice. In order that the circuit will work properly it is necessary to effect a restoration of D.C. in both the picture and suppression signals. If we wish to annihilate the spurious signal by cutting neatly and specifically along the line XY in Fig. 4, then the line XY must always bear the same relationship to every part of the signal. If we attempt to do this without effecting a restoration of D.C. to the signals which are to be so cut along XY, then, owing to variations in the picture and spurious signals, the datum line, which we wish to coincide always with the line of cut XY, would be constantly moving about in order to preserve the true characteristic of an A.C., viz. that the area of a repetitive cycle must be equal on both sides of the datum line. For instance, if the amplitude of the signal increased generally over a cycle owing to a line or frame containing a high proportion of white, then the area of the signal on the upper side of the line XY in Fig. 4 would increase, and the datum line would move upwards to restore equality of areas. This would mean that the line of cut XY now coincided with the different reference level in the signal. In this specific case the line of cut XY would move up to a position somewhere in the greys, instead of remaining at black. The result would, of course, be that the greys would be rendered black, and all detail in them would be lost, and thus the picture would be spoilt.

It is clearly essential, therefore, to hold the position of the line of cut XY constant, no matter what the variations in the picture may be. It is for this reason that the restoration of D.C. to the picture signals is effected. It is necessary, however, to arrange the circuit for D.C. restoration to the

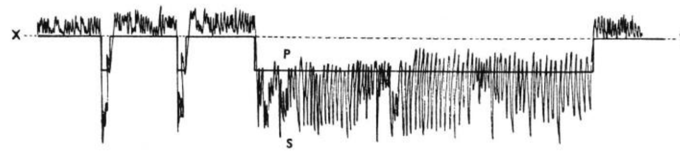

Figure 4. Mixture of Picture and Spurious Signals with Suppression Pulses

Figure 5. Line Signals at Grid of V_2 having D.C. component

Figure 6. Line Signals at Anode of V_2

Figure 7. Suppression Pulses at Anode of V_3

picture with some care, as the datum line of the restored D.C. must be prevented from varying in response to variations of the amount of spurious signal. If this were allowed to happen, then the line of cut XY would vary and the result would be as bad as if we had not restored D.C. at all. In other words, D.C. must be restored with reference to the picture signal, and the picture signal alone, and must not be affected by the amount of spurious signal. What is required, therefore, is that the D.C. should be restored, but the restoring action suspended during the spurious noise period. This is effected by the circuit involving V_1. The composite picture signal, with picture acting negatively and the spurious signal largely negatively, is applied to the anode of V_1, which, during the period of picture signals, acts as a diode. In conjunction with the output condenser of the 'C' amplifier the effect, of course, is that no positive amplitude can exceed that voltage at which V_1 draws anode current, as under these circumstances a negative charge equal to the excess will be placed on the output condenser of the 'C' Amplifier. Thus, the whole of the voltage excursion of the picture signal will be measured negatively from the tips of the black signals, which are tending to drive V_1 positive. As will be seen, V_1 is not a simple diode, but a pentode so connected that its control grid receives negative suppression pulses as shown in Fig. 2. As these pulses coincide with the spurious signal period, they make the control grid sufficiently negative during this period to destroy the conductivity of the valve V_1. Thus, it cannot act as a diode during the spurious signal period and the restoration of D.C. is suspended. The composite signal at the grid of V_2 now appears roughly as in Fig. 5. In order to make sure that the diode V_1 does conduct properly during the picture signal period, its suppressor grid is given as slight potential by connecting it to the junction of the cathode resistances R_1 R_2.

At the grid of V_2, therefore, which is connected to the anode of V_1, we have D.C. signals appearing as in Fig. 5. These are amplified and reversed by V_2, so that the picture and spurious signals are both acting positively, as shown in Fig. 6. The anode inductance L_1 is provided for the preservation of the upper frequencies The cathode inductance L_2 is added to provide a correction, which consists essentially in reducing slightly the upper frequencies. At first sight this may seem rather strange, when every effort is being made in the amplification chain to preserve such frequencies. It will, however, be noticed that the cathode circuit of V_2 contains the unshunted resistance R_{13}. This is provided to give automatic grid bias to V_2. R_{13} being unshunted by a large capacity, there is feed-back to the grid, which, by lengthening the characteristic, enables V_2 to accept without overloading the full amplitude of the picture and spurious signals. Such overloading would otherwise interfere with the restoration of D.C. There are, of course, shunt capacities across R_{13}, the impedance of which at the highest frequencies would be negligible if R_{13} were of a lower value, but for the purpose of straightening the characteristic, R_{13} has to be as high as 1000 ohms Consequently, the shunt capacities form with R_{13} a cathode correction circuit, which tends to increase the amplification of the highest frequencies. To preserve linearity, therefore, this increase must be counteracted, and L_2 is inserted for this purpose. Its action is to increase the impedance of the cathode circuit at the higher frequencies, with the result that the anti-phase feed-back is increased, and the amplification of these frequencies cut down.

Meanwhile, the positive suppression pulses, i.e. those in Fig. 3 are applied to the grid of V_3, and in view of the fact that an input condenser C_1 is fitted, and that the grid leak is returned direct to the cathode, thereby giving the valve no grid bias, it is in a position to draw grid current. Thus D.C. is restored along the datum line MN of Fig. 3. In order to limit excessive flow of grid current, the series grid resistance R_{14} is given a much higher value than is usual when it is required for anti-parasite purposes alone. These signals are amplified and reversed by V_3, and in the anode constitute negative suppression signals having the appearance shown in Fig. 7. Since the anode circuits of V_2 and V_3 are common, the negative suppression and composite picture and spurious signals are mixed, and have thus the form of Fig. 4. As the D.C. component must not be lost at this juncture, the common anode circuit is D.C. coupled to the grid circuit of V_4. Whereas the amplitude of the signals is suitable for application to the grid of V_4, the standing anode potential of V_2 and V_3 is much too high to be similarly applied, and would, of course, set the grid of V_4 strongly positive. This condition might be offset by additional automatic bias derived from the cathode circuit of V_4, but this is inconvenient, so the potentiometer formed by the resistances R_3, R_4 and R_5 is fitted suitably to cut down the standing anode potential of V_2 V_3. ~~while the full picture and other signals are by-passed across~~ $\cancel{R_3}$ ~~to the grid of~~ $\cancel{V_4}$ ~~by the condenser~~ $\cancel{C_2}$. The usual elements L_3 R_6 are added so that the intervalve coupling may take the form of a low pass filter.

The working point of V_4 is adjusted by means of the automatic bias provided by the fixed resistance R_7, and the variable resistance R_8, so that it is on the lower bend of the characteristic. The anode current is therefore nearly cut off, and has a value of between 0.5 and 1.0 mA when no input is applied. Consequently, any spurious signals, together with most of the suppression pulse, constituting in fact all those signals lying below the line XY in Fig. 4, are cut off or suppressed by the bend of the characteristic of V_4. Clearly, by variation of the resistance R_8, the position of the line XY can be so adjusted that the suppression occurs at black level as in Fig. 8, above black level as in Fig. 9, or below black level as in Fig. 10. The intervals between lines and frames are now, as was desired, quite clean and ready for the injection of the synchronising pulses. These clean signals, amplified, appear in the anode of V_4, which is direct coupled to the grid of V_5, the usual elements L_4 and R_9 being introduced so that the coupling

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constitutes a low-pass filter. The excessive positive anode potential is reduced, as before, by the potentiometer R_{10} R_{11}, the whole of the picture signals being applied via the condenser C_3.

The valve V_5 is a cathode follower. The elements C_5 and R_{15} are added for the preservation of the upper frequencies. The line is, of course, fed at low impedance by V_5, the condenser C_4 holding off the unwanted positive potential across the cathode circuit. The inductance L_5 holds off the capacity of the line. It will be noticed that the D.C. component is lost by the condenser C_4; it is admittedly required in the next piece of apparatus to which the signal is fed, but it would be accompanied by the full positive cathode potential of V_5, which is undesirable. Accordingly, the insertion of C_4 loses both the wanted D.C. component and the unwanted cathode potential, but the former can, of course, be restored as required.

It will be noticed that the lower end of the cathode resistance R_{12} is returned, not to earth, but to the upper end of the variable resistance R_8. This is done for the following reason. The adjustment of R_8 to secure the correct level for suppression alters the position of the operating point on the characteristic of the valve V_4. This, being direct coupled to the grid circuit of V_5, results in the operating point of V_5 varying as well, but inversely, whereas there is no reason to require the operating point of V_5 to vary. It would, in fact, be detrimental if the operating point did vary, because we require V_5 to deal linearly with its input. The connection of the lower end of R_{12} to the junction of R_7 and R_8 provides, however, that this movement can be corrected. If R_8 is increased and V_4 is biased back, the operating point will move downwards. The anode potential of V_4 increases, and a proportion of this increase is communicated via R_{10} and R_{11} to the grid of V_5, thus moving the operating point upwards. The increase of R_8, however, due to the method of connection employed, inserts extra resistance into the complete anode circuit of V_5, thus moving the operating point downwards once more.

Apart from the question of noise suppression, the picture may often be improved in quality by the judicious adjustment of the resistance R_8, which is termed the *lift* control. It may happen that a picture, or more particularly a film, as seen by the emitron may consist largely of whites and light greys, and the received picture will therefore be in general too light and somewhat 'washy.' Under these circumstances, it will be found that the waveform of the picture signal will appear to be somewhat as in Fig. 11, where W represents the white level and B the black level. By adjusting the 'lift' control so that the level of the suppression, i.e. the position of the line XY in Fig. 4, is lifted towards the whites as in Fig. 9. The picture may be considerably improved, as the points P in Fig. 11 are made to produce very little signal at all in the anode circuit of V_4. Since this condition corresponds to the transmission of black, the colour of the points P in Fig. 11 is reduced from grey to black. In fact the whole of the waveform of Fig. 11 has been moved down towards the black level B. The picture waveform now appears as in Fig. 12, and by increasing the gain in the 'A' Amplifier, may be expanded so as to take up the full amplitude range of the system, thus producing the normal picture waveform of Fig. 13.

In practice the term *lift* is used to signify that the picture is lifted with reference to the suppression, and not the suppression with reference to the

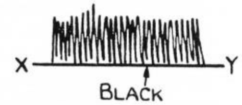

Figure 8

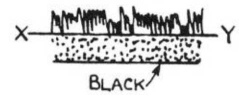

Figure 9

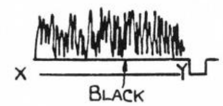

Figure 10

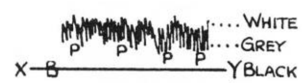

Figure 11

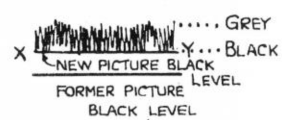

Figure 12

Figure 13

picture. That is to say, if the resistance R_8 is adjusted so as to produce lift the greys in the picture tend to become whites, and the blacks greys, i.e. the picture is being lifted above the level of the suppression pulses, an effect which may clearly be seen by examining the output of the Suppression Mixer on a cathode ray tube monitor. For the purpose of such examinations the jacks $\mathbf{J}_1$ and $\mathbf{J}_2$ are provided. As will be seen from the circuit diagram, $\mathbf{J}_1$ provides a point of examination for signals appearing on the grid of V_4, i.e. picture, spurious and suppression signals, before suppression has taken place, and $\mathbf{J}_2$ for the examination of the final output after suppression.

The output, of course, is in the negative sense, i.e. black in the positive direction and white in the negative direction, and the amplitude is 16 volts for a white signal. 140

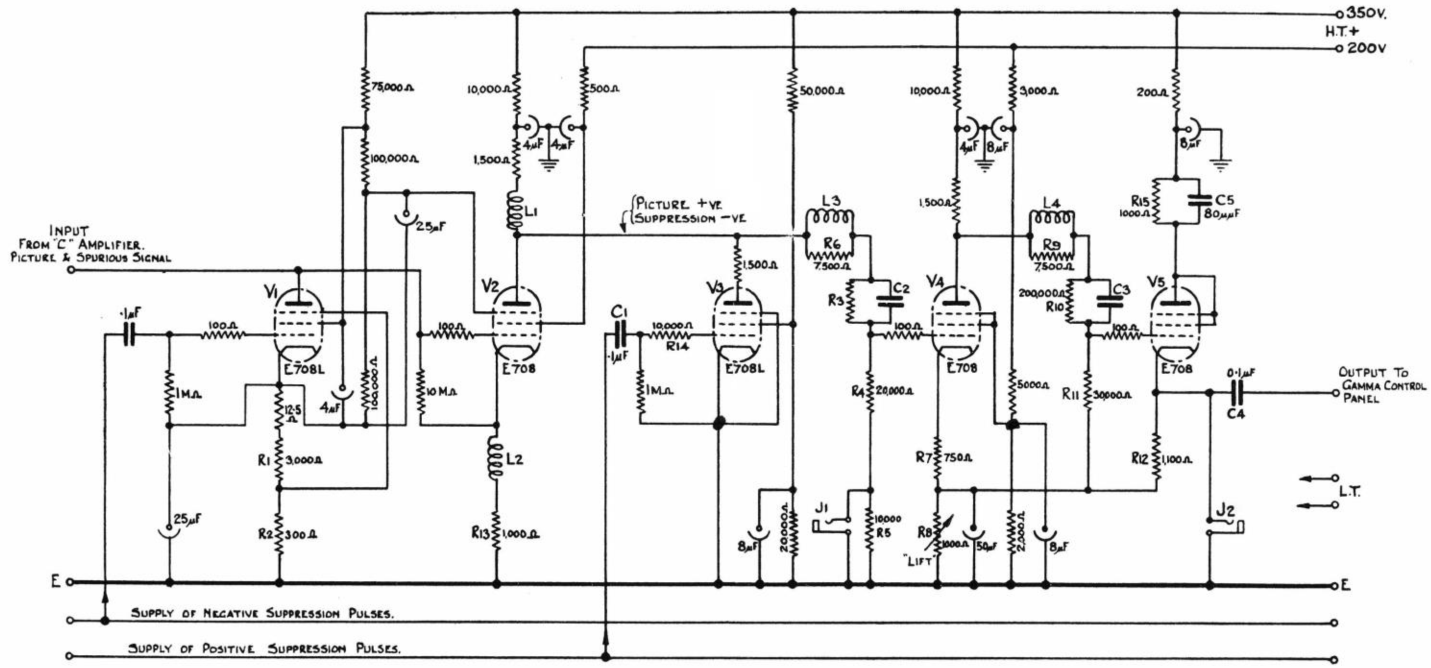

Figure 14. Circuit Diagram

THE GAMMA CORRECTOR

Definition of Gamma

The quantity denoted by the symbol γ is one which has arisen in the development of film technique. It is clearly necessary to have some measure of the density of a film produced by a given exposure so that its density can be expressed in figures. First of all, however, we must define the density of a film, and the most obvious way is to say that the term *density* expresses the ratio of a beam of light directed on to a film and that intensity which the film allows to be passed through. In order to allow densities to be added, the logarithm to the base 10 of this ratio is used just as in electrical technique decibels are used. If L_t is the light transmitted by the film, and L_i the light incident on the film, and D the optical density, then

$$D = \log_{10}\frac{L_i}{L_t} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Now it is found that the optical density D of a film is proportional to the logarithm to the base 10 of the intensity of the light to which the point was exposed at the time the picture was taken. Let L_e be the intensity of the light at the exposure, then

$$D \propto \log_{10} L_e$$

therefore

$$D = K \log_{10} L_e$$

It is customary to denote the constant K by the special symbol γ so we have

$$D = \gamma \log_{10} L_e \quad \ldots\ldots\ldots\ldots\ldots (2)$$

From (1) and (2)

$$D = \log_{10}\frac{Li}{L_t} = \gamma \log_{10} L_e \quad \ldots\ldots\ldots (3)$$

Putting $L_i = 1$, and consequently expressing the ratio $\frac{L_i}{L_t}$ as an ordinary number we have

$$\log_{10}\frac{i}{L_t} = \gamma \log_{10} L_e$$

Taking anti-logarithms, we get

$$L_t = L_e - \gamma$$

This, of course, applies to a negative print, and so for a positive we have the relation

$$L_t = L_e \gamma \quad \ldots\ldots\ldots\ldots\ldots (4)$$

This equation is a measure of the faithfulness of tonal reproduction given by a film since it expresses the ratio between the light acting on a point at the exposure and the light transmitted through the film for projection on the screen, and clearly the constant γ is a measure of the contrast ratio of the film, for if γ has a low value then various degrees of light L_e received from various points at the time of exposure would be reproduced by light values L_t having only a small mutual range of variation, whereas if γ is large differences between the L_e corresponding to various points of a picture will come out as mutually greatly magnified differences of L_t, the light transmitted through the film. Thus, a high γ means a high contrast ratio; a low γ on the other hand means a low contrast ratio.

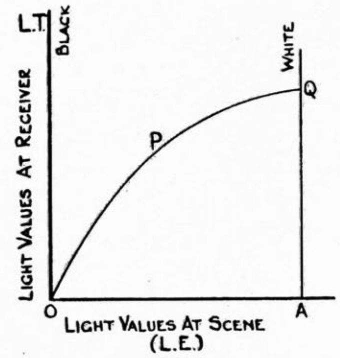

Figure 1

The Gamma of a Television System

Applied to television, gamma has just as much meaning except that the actual quantities are physically slightly different. L_e as before means the degree of light from any point in the scene being televised, and L_t means the light from corresponding points of the reproduced scene, and there is naturally a similar relationship between the contrast in the scene and the contrast in the received picture, which may be conveniently expressed in the same way by equation (4). It is therefore quite reasonable to speak of the gamma of a televised picture.

In theory the overall gamma between scene and received picture should be 1, so that a strict proportionality will exist between the light at any point in the scene and that in the corresponding points of the received picture. It is, however, a property of the M.-E.M.I. television system as a whole, particularly on film transmission, that the overall gamma is low, i.e. the contrast ratio is poor. The exact state of affairs is indicated in Fig. 1, which is a graph representing roughly the relationship between light values at the scene and light values at the receiver. It will be seen that the whites tend to fall off in intensity and do not become as bright as they should.

Figs. 2, 3 and 4 respectively show the relationship between L_t and L_c for values of gamma less than, equal to, and greater than 1, from which it will be seen that we can justly describe the state of affairs in Fig. 1 as being due to a low gamma, with the exception that the gamma changes more or

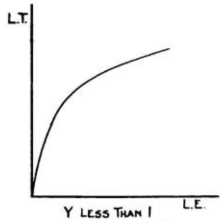

Figure 2

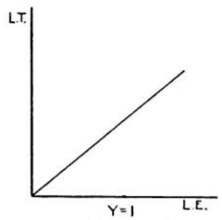

Figure 3

Figure 4

less suddenly at the point P. These graphs express the relationship between the light values at the transmitting and receiving ends.

The first step in the television chain is to convert the light values into electric currents proportional to them, so that the graphs of Figs. 1—6 in terms of electric currents represent amplitude characteristics. We may therefore express the matter in the familiar phraseology of sound transmission

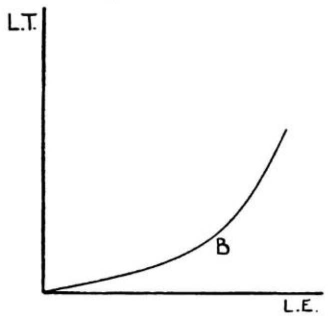

Figure 5

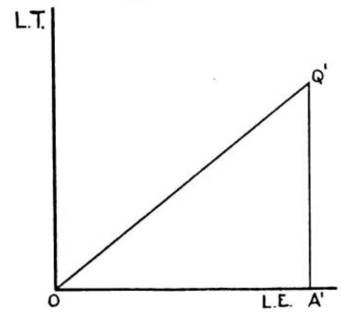

Figure 6

technique, and say that the television system as a whole suffers from amplitude distortion, or, as it is often known, *top-bending*. This amplitude distortion occurs partly in the amplification chain, and partly in the emitron and the receiving cathode ray tube. Clearly, then, if we can devise some form of distorting amplifier which will introduce into the chain a degree of amplitude distortion designed to offset all that occurring naturally in the chain, we shall be able to effect correction, and consequently the contrast ratio of the received picture, on the basis of Fig. 1, will be improved and made more brilliant and striking.

The Gamma Corrector, Figure 7, is a unit containing five valves, inserted between the Suppression Mixer and the Picture and Sync Mixer in each picture channel, and its function is to straighten the characteristic of Fig. 1 without, however, increasing the final amplitude of the white signals indicated by QA in Fig. 1. Thus, the result will appear as in Fig. 6, with the proviso that $Q'A' = QA$ of Fig. 1.

Originally it was a moot point whether this unit would be required or not, and so it is designed so that it makes no difference to the frequency characteristic or overall amplitude of the signals; it has no gain, and the signals come out in the same sense and with the same relative voltages as they enter, so that if necessary the unit need not be used and the Suppression Mixer can be linked directly to the Picture and Sync Mixer.

The principle of operation is that signals are applied to the valve V_3, D.C. being restored by the valve V_1, and over a range from black to the middle greys V_3 is a straight amplifier passing its output to V_4, which is inserted purely as a reversing valve to fulfil the condition mentioned in the previous paragraph, viz. that the signals should leave the unit in the same sense that they enter it. V_4 in turn feeds the output via the usual cathode follower V_5, and V_2 over this low intensity range of black to the middle greys (represented by the point P) is inoperative. Over the range PQ from the middle greys to the whites, however, it is arranged that V_2 draws anode current which is made to react back on the anode current of V_3. The application of a white signal to the grid of V_3 tends to reduce the anode current of V_3, and this reduction is enhanced by the action of V_2, but only for intensities greater than those corresponding to the point P in Fig. 1.

The detailed operation is as follows. The signal is applied to the grid of V_3 in such a sense that whites are tending to make it negative. The diode V_1, co-operating with the output condenser of the Suppression Mixer and the grid resistance R_1, forms a D.C. restoring circuit, which aligns all pulses corresponding to black at a certain fixed level. D.C. coupling exists from the anode of the valve V_3 through the rest of the picture channel, and so the operating points, and consequently the black levels, of the valves of all subsequent amplifiers in the picture chain, viz. the Picture and Sync Mixer and the Distribution Amplifier, will be determined by the grid potential of V_3, which must therefore be set accurately to the required value which will give the correct black level in it and all subsequent valves. Since the cathode circuit of V_3 contains comparatively high cathode resistances for another reason, the grid will be heavily biassed, and so this is offset by applying positive bias from the potentiometer P_1. The final grid potential of V_3 therefore, corresponding to black level, is the difference between the positive bias due to P_1 and the automatic negative bias due to its own cathode circuit. The correct black level therefore may be found by the adjustment of P_1, which is consequently labelled black level. The connection of the grid resistance R_1 from the grid of V_3 to its own cathode requires special explanation.

Since it is the load resistance of the D.C. restoring circuit, it should be in parallel with the diode, i.e. connected between the grid of V_3 and earth. If this were done, however, it would have to have a very high value, such as 10 megohms, in order to keep the time constant of the D.C. restoring circuit to a sufficiently high value.

It is found in practice that if valves of the type used for V_3 are operated in circuit with their grids only connected to earth by very high resistances, then spurious electronic currents within the valve tend to make the anode current waver. This would cause a variation in black level and bumping of the picture. In this case, however, the valve contains a fairly high cathode impedance and is therefore acting as a cathode follower in that the cathode potentials approximately follow those of the grid. Consequently the connection of R_1 between the grid of V_3 and its own cathode is equivalent to the connection of a very much higher resistance between the grid and earth. This is a particular artifice which may frequently be employed with success in conjunction with the cathode follower. It is obvious that if a resistance is connected between two points, one of which is varying in potential and the other is fixed, it will have a certain value, but we can artificially make this value seem different by causing the second point to make excursions of potential similar to those of the first. From the point of view, however, of the unwanted sporadic electronic currents in the valve, the grid is anchored to the cathode through the real ohmic value of R_1 only, which is sufficiently low to annul spurious effects. The condenser C_1 forms an easy path for the A.C. input so that it does not have to pass through any resistances.

The valve V_3 is a straight amplifier, the output being taken from the anode, and the cathode containing a high impedance in order that the resulting feed-back shall reduce the stage gain. It will be remembered that no gain is wanted in this unit. The high cathode impedance R_2 is sufficient to be comparable at the upper frequencies with the shunt capacities, and there is a tendency to raise the gain at these upper frequencies. This is offset by the insertion of the inductance L_1, which maintains the response level. L_1 is given a greater value than necessary, and the stray capacity augmented by the trimming capacity C_2, by adjustment of which therefore a level frequency characteristic may be obtained. The anode of V_3 is D.C. coupled to the grid of V_4, via the usual elements L_2, R_3 which give the coupling the form of a low-pass filter. The unwanted high positive potential from the anode of V_3 is reduced to a more reasonable figure by the potentiometer R_4 R_5. The vision frequency components, however, are by-passed to the grid of V_4 by the condenser C_3.

V_4 is a similar stage to V_3, the cathode resistance R_6 being high as in the case of R_2, and the inductance L_3 fulfilling the same purpose as L_1. V_4 is inserted purely as a reverser. Its anode is D.C. coupled to the grid of V_5 through the elements L_4 R_7, which as usual give the coupling the form of a low-pass filter. As before, the unwanted standing anode potential of V_4 is reduced by the potentiometer R_8 R_9, and the vision frequency components are by-passed to the grid of V_5 by the condenser C_4. The valve V_5 is a cathode follower output stage, and therefore contains the unshunted cathode resistor R_{10} to generate the necessary feed-back.

The alteration of amplitude characteristic and the consequent modification of gamma is performed entirely by V_2. It will be seen that the cathode of V_2, except for the small resistance R_{11}, is connected to that of V_3, and therefore the grid of V_2 receives automatic grid bias. The grid of V_2 is returned to the potentiometer P_2, upon which it finds a positive potential which is adjusted to be somewhat less than the negative potential produced by the automatic grid bias of the cathode circuit, so that under conditions of black V_2 is entirely cut out. When the signal rises to an intensity corresponding to a tone in the middle greys, the grid and cathode of V_3 become more negative. The cathode potential of V_2 also becomes, by direct connection, more negative, and the difference between this potential and that derived from the potentiometer P_2, which previously has been sufficient to bias V_2 out of action, is reduced, so that V_2 begins to draw anode current. This anode current passes down R_2, the cathode resistance of V_3, and therefore by ordinary automatic grid bias action makes the grid of V_3 more negative, i.e. the grid of V_3 is driven further in the way it already wishes to go, so that above a point somewhere in the middle greys any increase in amplitude, i.e. an increase in negative volts, applied to V_3 is exaggerated. Thus, the amplitude characteristic of V_3, with the co-operation of V_2, tends to appear roughly as indicated in Fig. 5, which naturally offsets the general amplitude characteristic of the system as illustrated in Fig. 1, and results in approximate linearity and an improvement of gamma. Clearly, the point at which the influence of V_2 begins to take effect, i.e. the point B of Fig. 5, may be adjusted by the potentiometer P_2, which is accordingly labelled **Gamma**, and may be adjusted to coincide with the point P of Fig. 1.

It is essential that the action of V_2 should not be interfered with by any amplitude limitation due to bad regulation of its anode current supply, so that its supply is specially stabilised by the stabiliser valves V_6 and V_7, which are supplied as usual from the series resistance R_{11}. As clearly two neons in series will not strike automatically, the resistance R_{12} is provided purely for striking purposes, and its effect is to cause the whole of the applied voltage to be initially developed across V_6. V_6 then strikes and the whole of the applied volts are then placed across V_7 and R_{12}, causing V_7 to strike, after which, during normal operation the effect of R_{12} is negligible. It is found, however, that these stabilisers tend to appear as a resistance in series with an inductance. This may readily be understood if it be remembered that all gas filled valves, if operated at high frequencies, show a lag, or inertia, which is precisely what is shown by an inductive circuit. Therefore they may be represented by a circuit containing inductance. Since this has an adverse effect on the frequency characteristic, it is built out to a constant resistance by means of the additional elements R_{13}, C_5.

The resistor R_{14} is connected to elevate the potentials of the cathodes of V_4 and V_5 for convenience in design, and its effect is eliminated at vision frequencies by the parallel condensers C_6 and C_7. If the Gamma Panel is not required it is turned off by the ganged switches S_1 S_2. The action of the switch member S_2 is to earth the lower end of the grid resistance of V_2, thus removing the positive bias formerly supplied from the potentiometer P_2, and allowing the grid to be biassed well beyond the cut-off by the automatic bias developed across the common cathode impedance R_2. The action of the switch member S_1 in the **off** position requires special explanation. It will be remembered that it is desired that the maximum amplitude of the whites without the Gamma Panel inserted (QA in Fig. 1) must be the same as their amplitude with the Gamma Panel inserted (Q' A' in Fig. 5). If the amplitude characteristic of the Gamma Panel is to have shape as in Fig. 5, then clearly its standing gain, to which the modifying action of V_2 is applied, must be less when the panel is on than when it is off. Accordingly, the switch member S_1 in the **off** position connects the cathode of V_3 to a point on the potentiometer composed of the resistances R_{15}, R_{16} and R_{17}. This has two effects, firstly the cathode of V_3 is connected to earth as regards vision frequencies by the resistance R_{17} in parallel with the resistance $R_{15} + R_{16}$. Thus, R_2 has now two additional resistances in parallel with it, the feed-back to V_3 is less and the gain is greater. Without this precaution it would be impossible to arrange that $Q'\ A' = QA$. From the point of view of the above requirement, the same result could be obtained if a single resistance were placed between the cathode of V_3 and earth, but this would alter the black level, and it is similarly desired that the black level should be the same whether the unit is switched on or off. By arranging, however, that the resistance placed between the cathode of V_3 and earth, from the point of view of modifying the standing gain, takes the form of the potentiometer R_{15}—R_{17}, it is impossible to apply, from the anode supply to V_2, a positive voltage via R_{15} and R_{16} to the cathode of V_3, which will maintain the black level. Thus, the black level in the **off** position is fixed by the values of the specially chosen resistances R_{15}, R_{16} and R_{17}, and the black level in the **on** position is adjusted to correspond by means of the potentiometer P_1.

The adjustment for gamma may conveniently be made by applying to the picture chain a plain tilt waveform accompanied by picture. If this be examined on the monitor, the flattening effect indicated in Fig. 1 can be seen. When the Gamma Panel is switched off it will be observed that, as is to be expected, the curve OPQ becomes straight. The best linearity is now obtained by adjustment of the gamma potentiometer P_2, which, as has been explained, enables the point B in Fig. 5 to be made to coincide with the point P in Fig. 1. This adjustment may also be carried out in another way. The unit is so designed that $Q'\ A' = QA$ accurately when $QA = 15$ volts as measured on the modulation meter fed from the Picture and Sync Mixer. To effect this adjustment a plain tilt waveform may be applied, adjusted to give 15 volts, on the modulation meter with S_1 S_2 in the **off** position, then, turning S_1 S_2 into the **on** position P_2 may be adjusted so that the modulation meter also reads 15 volts (it is now reading the value of Q' A'). Under these circumstances it should, of course, be found that the tilt waveform, as examined on the monitor, is linear.

It has been pointed out that there is D.C. coupling from the anode of V_3 as far as the transmitter modulator, and since the potentiometer P_1 adjusts the black level of the grid of V_3, then P_1 will adjust the black level throughout the Gamma Panel, the Picture and Sync Mixer, the Distribution Amplifier and parts of the Modulator. It is not, however, desired that the potentiometer P_1 on the Gamma Panel should be the specific means by which the black level in these various units is adjusted. As will be seen from my technical note on the Picture and Sync Mixer, a black level adjustment is provided on this unit. The function of the potentiometer P_1 on the Gamma Panel is rather to adjust the black level in this unit so that it is the same whether the unit is operative or not, the absolute value of black level sent to the transmitter being adjusted by means of the black level control on the Picture and Sync Mixer. Furthermore, the Gamma Panel is really an accessory to the vision chain and is not fundamentally necessary. The apparatus must therefore be designed so that the black level can be adjusted even if there were no Gamma Panel in the chain. Hence the provision of the adjustment in the Picture and Sync Mixer. The potentiometer P_1 on the Gamma Panel is adjusted so that there is no change in the black level when the Gamma Panel is switched in and out, and the black level control on the Picture and Sync Mixer is then adjusted so that the absolute value of black level sent to the transmitter is correct.

It will be seen that in the **off** position the switch S_1 connects the cathode of V_3 to the junction of the resistances R_{16} and R_{17}. This connection is removed when the switch is moved into the **on** or **test** positions. Since the black level will be influenced by any change of the cathode potential of V_3, it is essential that this should not alter when the switch S_1 is moved to the **off** position. Consequently the positive potential of the cathode of V_3 must be adjusted to be equal to that obtaining at the junction of the resistances R_{16} and R_{17} when S_1 is in the **on** or **test** position. When these potentials are so equalised there will be no change in the current down the potentiometer R_{15} R_{16} R_{17} when the switch S_1 is in any position. Consequently a metering position is provided at the bottom of this potentiometer by means of which the current through it may be ascertained, the particular key being that marked **+2.**

The adjustment procedure is therefore that, holding this key pressed, the potentiometer P_1 is adjusted so that the meter reading, i.e. the current in the potentiometer R_{15} R_{16} R_{17}, is the same whether S_1 is in the **off** or **test** position.

It should be noted that when the Gamma Panel is on, the output circuit of V_5, which contains no blocking condenser, is D.C. coupled to the grid of the first stage of the Picture and Sync Mixer so that under these circumstances the first valve of the latter unit does not need to function as a D.C. restorer as the signal is already in the form of D.C., and this valve is therefore idle.

Figure 7. Circuit Diagram, attached

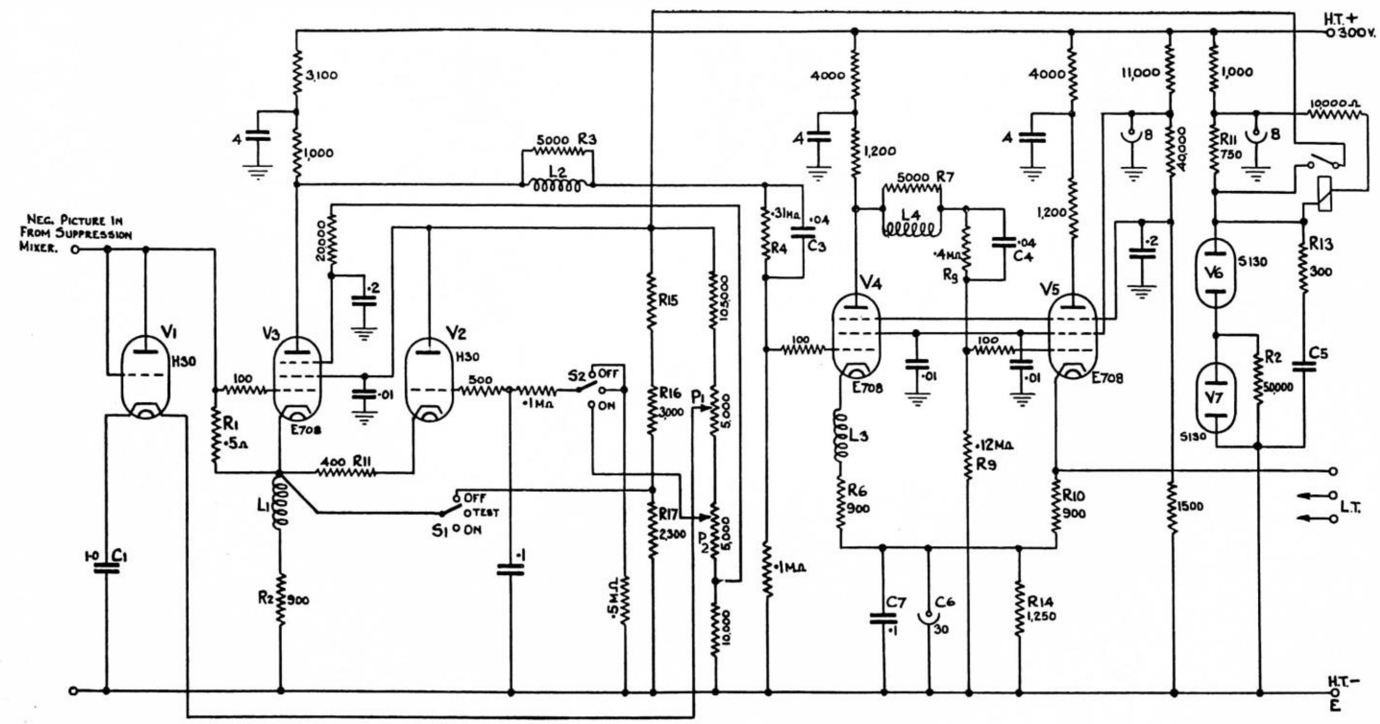

Figure 7. Circuit Diagram

THE PICTURE AND SYNC MIXER

The Picture and Sync Mixer is a unit inserted in each of the picture channels after the suppression mixer and, as its name implies, its function is to mix with the picture signals the synchronising signals which have been specially prepared in the synchronising signal generator. For some transmissions it is desirable to interpose between the suppression mixer and the picture and sync mixer another unit known as the Gamma panel, the function of which is described in a separate note, but as this does not materially alter the general type of the signals emerging from the suppression mixer, it will be considered for the purposes of this note that the picture and sync mixer receives its input from the Suppression Mixer. A further function of the Picture and Sync Mixer is to derive from the final signals a proportionate D.C. voltage, which may be applied to a remote moving coil instrument for measurement of signal level.

For the purpose of preliminary adjustments to the transmitter, it is desirable to have available some form of artificially generated signal which can be switched into circuit and radiated. Such a signal should enable the picture to be examined for high and low frequency performance and phase distortion and geometrical distortion. Thus, it should contain straight and sharp lines of demarcation between white and black and large areas of white and black. A satisfactory form of signal is a large black cross on a white background, and has the advantage that it is comparatively easy to generate electrically. This signal is generated in a unit known as the Bar Generator, and is referred to as artificial bars, abbreviated *art bars*. In the Picture and Sync Mixer unit is mounted a selector switch, enabling it to take either normal picture, art bars, or be switched off.

In order that the mixing may be properly effected, it is necessary that D.C. should be restored in both the picture and synchronising signals. In the present case both the picture and synchronising signals arrive from their respective sources in the form of alternating currents, but it is desired that they should ultimately both be direct currents, the picture signal acting only in the positive direction from a given base line, and the synchronising signal acting only in the other direction from the same base line. This point may be made clear by reference to the diagrams, in which Fig. 1 represents the picture signal during a line emerging from the Suppression Mixer. It is an alternating current. Fig. 2 represents a line synchronising signal as supplied to the Picture and Sync mixer. This is also an alternating current. The datum line XY of Fig. 1 and AB of Fig. 2 have so adjusted themselves that over one cycle the area of the curve on top of the line is equal to that underneath.

The final mixed picture and synchronising signal which is required is shown in Fig. 3, from which it will be seen that the picture signals are acting only on the positive side of the common datum line CD. Clearly, in order to achieve the proper mixture as in Fig. 3, we must first see that the picture waveform of Fig. 1 operates entirely on the positive side of its datum line EF as in Fig. 4. Similarly, the synchronising signal of Fig. 2 must be made to operate only on the negative side of the datum line GH, as in Fig. 4. Then,

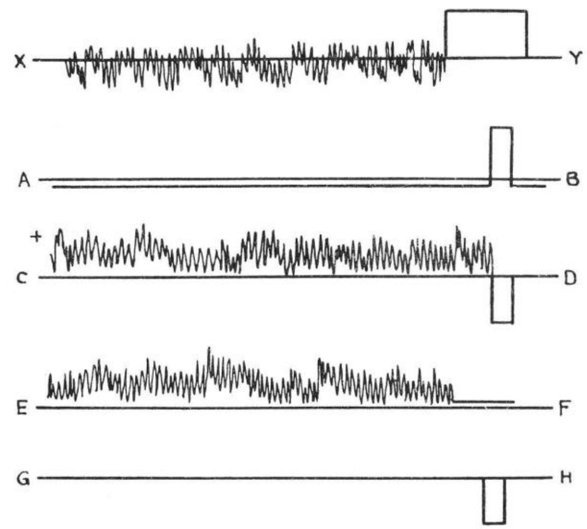

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

by making the datum lines EF and GH coincide we shall produce the correct mixture as in Fig. 3. The matter is all the more important as the position of the datum line XY in Fig. 1 will be continually varying in response to changes in the picture, and unless we fixed it permanently along the tips of the lower peaks of the picture signals as in Fig. 4, the line of demarcation between picture and synchronising signals would vary, with the result that it would be impossible to maintain what is a prime necessity in television, a rock steady transmission of synchronising signal at constant amplitude. Whatever changes may occur in the picture, the synchronising signal must go steadily on and be absolutely invariable. Furthermore, the picture itself would be effected, and the voltage corresponding to black at the receiver would vary with changes in the total amount of black and white. This would, of course, spoil the picture.

For these reasons, therefore, it is necessary to restore D.C. to the picture and synchronising signals.

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Considering the circuit diagram, the selector switch S applies picture or art bars in the negative sense, via the input condenser C_4 to the anode of the valve V_1 which acts as a diode. The effect, of course, is that no positive amplitude can exceed that voltage at which V_1 draws anode current, as under these circumstances a negative charge equal to the excess would be placed on the input condenser C_4. Thus, the whole of the voltage excursion of the picture signal will be measured negatively from the tips of the black signals, which are tending to drive V_1 positive. That is to say, the grid of the valve V_2 which receives the signals from the anode of V_1 will be only slightly negative during a black signal and much more negative during a white signal.

The resistance R_1 constitutes the load resistance of the diode V_1, and, as has been described, the signals from V_1 are applied directly to the grid of V_2, which receives automatic grid bias from the cathode resistor R_2. This resistance is unshunted by capacity in order that feed-back may be applied which will lengthen the characteristic of V_2, so that it can accept linearly the picture signals. At the anode of V_2 the picture signals have been reversed by normal valve action, whites tending to make the anode more positive. Due to the restoration of D.C., a black signal is now always represented by a certain fixed voltage at the anode of V_2. This voltage is known as the *black level*. The term black level does not, of course, specifically refer always to this particular voltage, but the black level at any point in the circuit is that voltage which in that circuit corresponds to a full black in the picture. It is, of course, a feature of signals in which D.C. has been restored that the black level, i.e. the volts corresponding to black in the picture, remain constant, no matter what changes there may be in the picture.

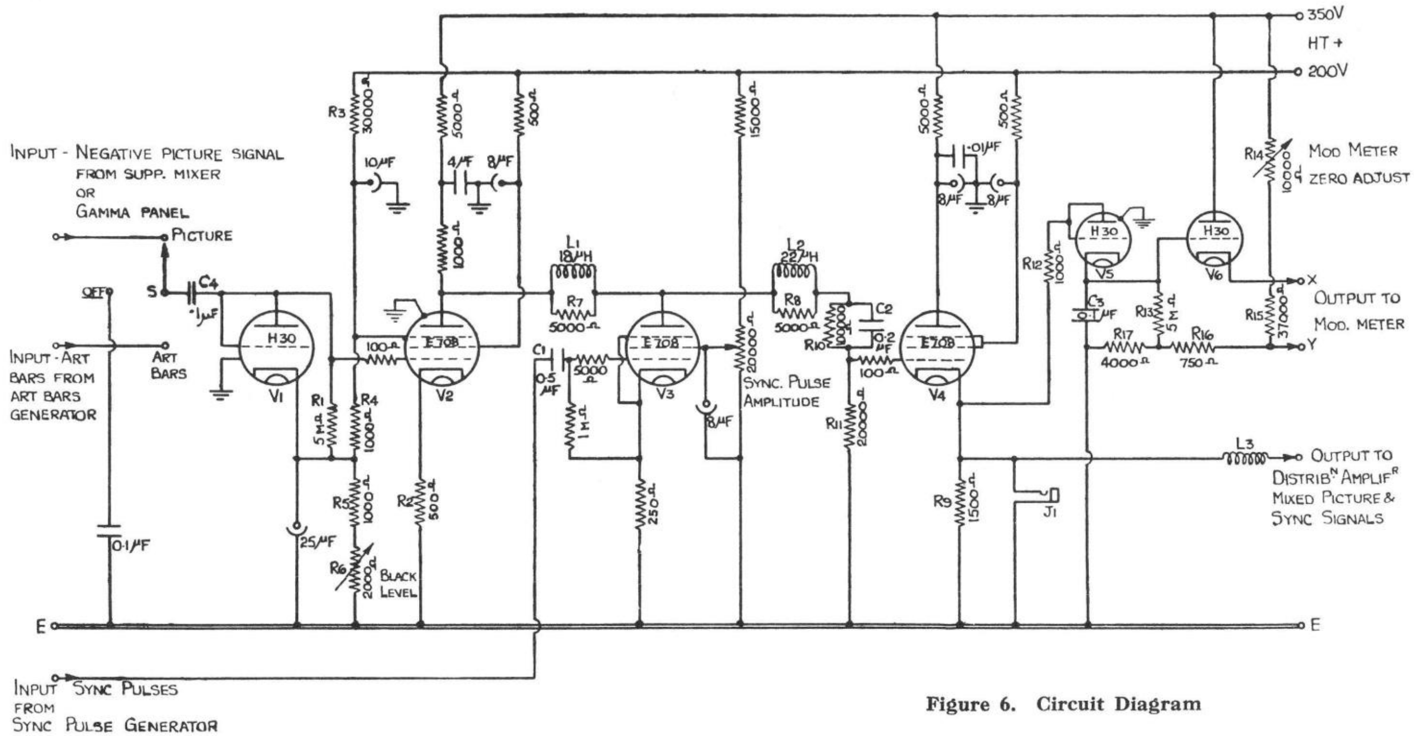

Figure 6. Circuit Diagram

The valve V_1 has restored D.C. for the last time in the Control Room apparatus ; the D.C. component will not be lost in any of this apparatus and the signal will be sent to the transmitter in the form shown in Fig. 3. Thus, at the output of the Control Room apparatus, the black level datum line CD of Fig. 3 will correspond to a certain voltage, and it is necessary, for the requirements of the transmitter, that this voltage be adjusted to a certain particular figure, viz. 10 volts.

Since all subsequent valve stages are D.C. coupled from the anode of V_2, this final adjustment of black level must be made by adjusting the particular voltage representing the black level at the anode of V_2. It is in fact necessary to be able to adjust the D.C. potential of the anode of V_2 without interfering with the operating point and characteristic of the valve. It is found that this may be satisfactorily done by returning the suppressor grid of V_2 not to its cathode, but to a point of positive potential variable at will. A potentiometer, therefore, formed by the resistances R_3, R_4, R_5 and R_6 is connected across the 200 volt H.T. supply, and the suppressor grid connected to the junction of R_3 and R_4. Variation of the positive potential of the suppressor grid, and hence of the anode, is performed by the variable resistance R_6. If there were not any provision for compensation, this would change the working point of the valve V_2. When R_6 is increased, the suppressor grid and anode potentials increase, more current flows through the valve, and a greater automatic grid bias is developed across the cathode resistor R_2, thus moving the operating point downwards. To counteract this, the grid is returned, not to earth, but to the junction of the resistances R_4 and R_5, and thus the normal grid potential existing between grid and cathode is the difference between the negative automatic bias potential developed across the cathode resistance R_2 and the positive potential existing across R_5 and R_6. When R_6 is increased therefore pushing the operating point downwards, the positive potential across R_5 and R_6 is increased, thus moving the point upwards again, and the circuit values are so adjusted that compensation is obtained.

Positive synchronising signals, i.e. signals with their peaks acting in the positive direction, are applied to the grid of the valve V_3 via the condenser C_1. The grid leak is returned to the cathode so that the valve has no grid bias, and is in a position to draw grid current. Consequently D.C. is restored with reference to a datum line coinciding with the tips of the synchronising signals, which appear in the anode circuit of V_3 reversed, and with the tips therefore acting downwards. Thus, the anode circuit of V_2 contains vision signals as represented in Fig. 4, and the anode circuit of V_3 contains synchronising signals as represented in Fig. 5. These two anode circuits are common except that the elements L_1 and R_7 are added so that the circuit simulates a low-pass filter, and the upper frequencies are preserved. At the common anode circuit, therefore, appear the mixed synchronising and picture signals as represented in Fig. 3.

These are applied to the grid of the valve V_4, the elements L_2 and R_8 being again added so that the coupling takes the form of a low-pass filter. The valve V_4 is a cathode follower output stage and therefore contains no anode impedance, but has an unshunted cathode resistance R_9. Since the common anode circuit of V_2 and V_3 is direct coupled to the grid of V_4 the standing positive potential would normally be applied as well, but this is reduced by the potentiometer $R_{10}R_{11}$. The pressure of C_2 across R_{10} produces a potentiometer circuit which has grid attenuation at low rather than at high frequencies. However, the anode load resistance, decoupling resistance and decoupling capacitors of the V_2, V_3 anode circuit are so proportioned that the voltage input to this potentiometer is increased at the low frequencies in order to counteract the increased attenuation at these frequencies.

The valves V_5 and V_6 are solely concerned with the operation of the modulation meter. The cathode of V_4 is connected to the anode and grid of V_5, which acts as a diode, R_{12}, being a stopper. Across the diode load resistance of R_{13}, in conjunction with the large condenser C_3, are developed voltages corresponding to the peaks of the amplitudes applied to V_5. The circuit involving V_5, C_3 and R_{13} is in fact a peak voltmeter. The load resistance R_{13} is returned to the junction of the resistances R_{16} and R_{17} on the potentiometer R_{14}, R_{15}, R_{16} and R_{17}, thus giving V_5 a slightly positive potential, and improving the rectification characteristic. Ordinarily, if the voltage to be measured were much greater, it would suffice to read it on an electrostatic voltmeter placed across R_{13}, but since the value is not in excess of 20 volts it is impossible to make an electrostatic voltmeter do this and the valve V_6 is fitted in order to enable a moving coil milliammeter to be used instead. The rectified envelope appearing across R_{13} is therefore applied to the grid of V_6, and a proportionate current flows in the cathode circuit of this valve. The modulation meter is connected between the terminals X and Y, Y being returned to the junction of the resistances R_{15} and R_{16}, a point of positive potential, in order to minimise the *no load* current flowing through the meter.

Adjustment

The Picture and Sync Mixer is a unit, the adjustment of which may be preset, and provided everything remains constant, will not require alteration over a period, that is to say, it is not continually adjusted during a transmission. The procedure for adjustment is as follows. The jack $\mathbf{J}_1$ across the cathode resistance of V_4 should be plugged into the D.C. position of the calibrated Signal Monitor, from which the volts causing any deflection may be measured against a scale. The selector switch **S** should be turned to the **off** position, and the **Sync Amplitude** potentiometer should also be turned to zero. The **Black Level** potentiometer R_6 should now be adjusted so that the voltage across R_9 and J_1 is 33, as read on the calibrated oscillograph.

As a check, the anode current of V_4, as read on the anode meter by pressing meter button **3**, will be about 22 milliamps. The **Mod Meter Zero Adj** should now be adjusted until the Modulation Meter reads zero. Finally, the **Sync Amplitude** should be turned up, when the synchronising signals will appear on the Signal Monitor, and should be adjusted until they have an amplitude of $17\frac{1}{2}$ volts, that is to say, their tops will be along the 33 volt level on the Signal Monitor, and their peaks will descend to a level of $15\frac{1}{2}$ volts. The mixer is now fully adjusted. A check can always be placed on the black level by connecting a high resistance voltmeter across $\mathbf{J}_1$. This should then read 33 volts.

When a picture signal is applied to the Picture and Sync Mixer, the modulation meter will begin to read. It reads, of course, the number of volts by which the cathode of V_4 rises above $+ 33$ due to a signal. The maximum voltage by which the cathode should rise for a full white signal is $16\frac{1}{4}$, its potential above earth then being $33 + 16\frac{1}{4} = 49\frac{1}{4}$. Under these circumstances, $16\frac{1}{4}$ volts will be read on the Modulation Meter ; this is full modulation, and must not be exceeded.

THE DISTRIBUTION AMPLIFIER

The function of the Distribution Amplifier is to receive from the Picture and Sync Mixer the complete vision waveform consisting of mixed picture and synchronising signals and to supply this to a number of receiving points. One such receiving point may be the transmitter itself, and the others will usually be various picture monitors. The Distribution Amplifier will be connected to the receiving points by means of concentric lines, which in general have an impedance of either 110 or 140 ohms, and in order to prevent undesirable reflections of energy forwards and backwards along these lines which would result in distortion of the vision waveform, such lines must be terminated in their characteristic impedance at both ends. The Distribution Amplifier is accordingly designed so that the output impedance which it presents to any line can be made equal to the characteristic impedance of that line.

A further requirement is that the input of the Distribution Amplifier must not apply more than a certain amount of capacity to the output of the Picture and Sync Mixer unit, since this would result in a loss of upper frequencies of the vision signals.

The Distribution Amplifier consists fundamentally of seven valves all connected as cathode followers. The last six valves are output stages which feed receiving points, and their circuits can be suitably designed to have a specific output impedance which can be made equal to the characteristic impedance of the outgoing lines. The inputs of these six valves are connected together, but even though they are cathode followers their collective input capacity would be somewhat greater than is desirable, and the first valve of the unit therefore consists of a further cathode follower which feeds the six output valves and isolates their input capacity from the Picture and Sync Mixer. The six output stages are not always designed and connected up in the same manner, but they can be set up in various ways according to the requirements of the outgoing circuits. For instance, they may all be connected as individual 140 ohm output stages for feeding 140 ohm lines. Alternatively, since it is generally found when feeding 110 ohm lines that an adequate linear excursion cannot be obtained unless two output valves are used in parallel, the amplifier can be arranged to feed three 110 ohm lines by connecting the six output valves as three pairs and designing the cathode circuits of each pair to provide an output impedance of 110 ohms. In general, a line impedance, and consequently a sending impedance, of 110 ohms is used for distribution to the transmitter, and an impedance of 140 ohms for distribution to picture monitors, but where a picture monitor is to be fed from a considerable length of line, it is usually desirable to use an impedance of 110 ohms.

It follows from these considerations that the Distribution Amplifiers in a vision system will not all be connected in precisely the same manner. While they are all of the same general design, and contain an isolation cathode follower followed by six output valves, and have the same hold-off and frequency correction arrangements (to be described later), the connection of the last six valves will vary with local circumstances. This description will accordingly be confined to a typical arrangement in which the amplifier is required to feed one transmitter line at 110 ohms and four monitor lines at 140 ohms. In this case two of the six output stages would be combined by parallel connection to feed the 110 ohm lines, while the four 140 ohm lines will each be fed by one output valve.

The circuit is illustrated in Fig. 7. The isolation cathode follower is V_1 and the six output stages are V_2 to V_7 inclusive. In the arrangement to be described, V_2 and V_3 are parallel-connected and are arranged to feed a 110 ohm output line, and V_4 to V_7 each feed a 140 ohm line. The input is applied to the control grid of V_1 and the cathode circuit of this valve feeds the control grid circuits of the six output valves. The black level on the control grid of V_1 is + 33V, and at the cathode + 37V with respect to earth.

If the control grids of the valves V_2 to V_7 were directly connected to the cathode of V_1, they would receive a black level of + 37V, and in order that they may be biased negatively with respect to their cathodes over the amplitude of the vision signals, it would be necessary to give each valve an automatic grid bias in excess of the maximum amplitude at white level (which will be of the order of + 50V). The value of the cathode resistances of these valves would therefore be determined from this consideration. It is, however, not possible to do this since the values of the cathode resistances must be chosen so that each valve generates the correct output impedance in accordance with the principles described in my technical note on the Cathode Follower (Item 1.3). The values of cathode circuit resistances derived from this impedance consideration would be considerably lower than are required for the necessary degree of automatic grid bias, and insufficient bias would be generated. The difference therefore must be made up by means of a negative grid bias or hold-off voltage generated by a separate source and inserted between the cathode of V_1 and the control grids of V_2 to V_7. In addition it will be remembered that the characteristics of the signal which are sent to the transmitter are not the same as those sent to monitors. The

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transmitter requires a signal having the following characteristics, which are expressed in voltages with respect to earth.

White level	..	+ ~~16.5V~~ 15.5V.
Black level	..	+ 10V
Sync level	..	+ ~~3.5V~~ 4.5V.

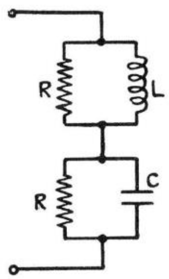


Figure 1

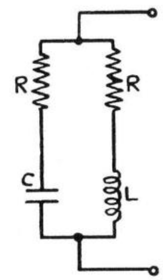


Figure 2

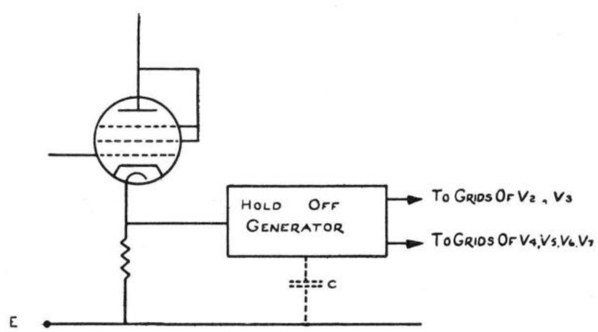


Figure 3

The monitors are in general fed with a signal having the following characteristics.

White level	..	+ ~~10V~~ 8V.
Black level	..	+ ~~3.5V~~ 2.5V
Sync level	..	0V

Since the valves V_2 and V_3 are supplying a signal to the transmitter, their cathode output circuit must generate signals of the first type with black level at + 10V. The valves V_3 to V_7, for supplying local monitors, must however provide at their cathode outputs signals of the second type, with a black level of + 3.5V. The valves V_4 to V_7 will therefore require more negative hold-off voltage than V_2 and V_3, and the hold-off generator must provide two separate hold-off voltages, both preferably adjustable.

Referring to Fig. 7, the negative hold-off voltage is generated by the rectifier comprising the transformer TR, the Westinghouse rectifiers W_1 and W_2, and the condensers C_1 and C_2, which together form a rectifier of standard type. The output is smoothed by the condenser C_3 and applied to two potentiometers R_1, R_2, R_3 and R_4, R_5, R_6. From the variable portions of these two potentiometers R_2 and R_5, two separate negative voltages may be taken off, a further smoothing effect being obtained by the resistances R_3 and R_6 in conjunction with the condensers C_4 and C_5.

Fundamentally, all that is now necessary is to connect the positive end of the rectifier, denoted by the point C, to the cathode of V_1, to connect one of the negative voltages (the point A) to the grids of V_2 and V_3, and to connect the other negative voltage (the point B) to the control grids of V_4 to V_7. Unfortunately this arrangement results in a loss of the upper frequencies since the general capacity of the rectifier circuit to earth acting across the cathode resistance of V_1 shunts away a portion of such frequencies. It is impossible to eliminate this capacity, and consequently it must be counteracted. This is done by making it a part of a constant impedance circuit of the type shown in Fig. 1. It will be remembered that in this type of circuit, if the element values are so chosen that $L = CR^2$, then the circuit will present an impedance which is equal to R at all frequencies.

Returning to Fig. 7, the cathode of V_1 would normally be provided with a single cathode resistance of 1,500 ohms, as shown in Fig. 3, across which would be the capacity of the hold-off generator. This circuit at once shows a resemblance to the lower portion RC of Fig. 1, but clearly its impedance will decrease at the upper frequencies. If between the cathode of the valve and its resistance we add an inductance in parallel with a resistance, the circuit will now have been built out to appear exactly as in Fig. 1, and, if the relationship $\frac{L}{C} = R^2$ is followed, the impedance between the cathode of the valve and earth will be constant at all frequencies, at 1,500 ohms. Returning to Fig. 7, the resemblance between the cathode circuit of V_1 and the circuit of Fig. 1 can now be seen. The inductance L of Fig. 1 is represented by the collective inductance of the coils L_1, L_2 and L_3, all coupled, as shown in Fig. 7. The two 1,500 ohm resistances of Fig. 1 are represented in Fig. 7 by R_7 and R_8, and across R_8 is the effective capacity to earth of the hold-off generator.

It will be seen that though we have successfully held off the capacity C of Fig 1 from influencing the frequency characteristic of the cathode circuit, we have been obliged to connect the hold-off generator not to the cathode but to the centre point of the circuit. At low frequencies, L shorts R_7 and the impedance of C is high compared with R_8, so that the cathode impedance of V_1 consists entirely of R_8; the vision frequency potentials will be developed across this resistance and will be transferred to the grids of V_2 to V_7 via the hold-off generator which is connected between the top of this resistance and these grids. At the upper frequencies, however, C shorts R_8

(*a*) *is equivalent to* (*b*)

Figure 4

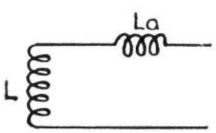


Figure 5

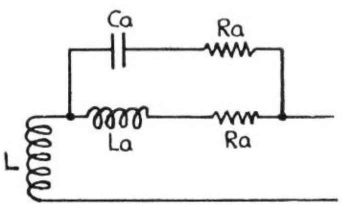


Figure 6

and the impedance of L is high compared with R_7, so that the cathode impedance of V_1 consists entirely of R_7 and the vision frequency potentials will be developed across this resistance. Its lower end, however, is effectively earthed by the capacity C, consequently none of the upper frequencies can be transferred via the hold-off generator to the grids of V_2 to V_7.

Since the use of the constant resistance circuit prevents us from obtaining access to the cathode of V_1, some other connection must be provided for transferring the potentials existing at this point to the grids of the subsequent valves. Such a connection is provided by the inductance L_2 in the case of the grids of V_2 and V_3, and L_3 in the case of the grids of V_4 to V_7. From the point of view of the constant resistance circuit, L_1, L_2 and L_3 collectively behave as one inductance L connected across R_7, but, being tightly coupled, the excursions of potential at the top ends of L_2 and L_3 are the same as those at the top end of L_1, and the upper vision frequencies are therefore successfully transferred to the subsequent grids. The D.C. component and lower frequencies are developed, as has been shown, across R_8 and C, and are passed to the output from the junction of R_7 and R_8. At the intermediate frequencies a gradual changeover from one method of transference to the other takes place.

In practice the circuit cannot yet be regarded as satisfactory. The coupling between L_1, L_2 and L_3 is not ideal, since there are leakage inductances effectively in series with L_2 and L_3. This is illustrated in Fig. 4 in which, for example, the effect in the circuit involving L_2 only is considered. The non-ideal transformer L_1, L_2 may be re-written as an ideal transformer $L^1{}_1$, $L^1{}_2$, with a small leakage inductance L_a in series with the secondary. $L^1{}_1$ and $L^1{}_2$ now constitute an ideal 1 : 1 transformer, and may be replaced by one inductance L, as shown in Fig. 5. The existence of the leakage inductance L prevents the circuit from having a constant impedance at all frequencies, and to get over this, certain other elements are added so that with L_a they form a further constant impedance circuit of the type shown in Fig. 2. By adding in series with L_a a resistance R_a, and connecting across them the capacity C_a and the resistance R_a, the impedance of the circuit involving these four elements is constant if $L_a = C_a R_a{}^2$. This is shown in Fig. 6.

We can now see how this is applied in the Distribution Amplifier. In series with L_2 there is a leakage inductance not shown. L_2 also has an ohmic resistance of 25 ohms. The leakage inductance and this ohmic resistance respectively constitute the elements L_a and R_a in Fig. 6. The condenser C_6 and the resistance R_9 are added in Fig. 7, and correspond to the components C_a and R_a of Fig. 6, thus completing the constant resistance circuit. The values of C_6 and R_9 are chosen so that the value of the leakage inductance in L_2 divided by the capacity of C_6 is equal to the square of the resistance R_9. The elements C_7 and R_{10} perform the same function in connection with the inductance L_3. Note particularly that the condensers C_6 and C_7 are not connected to the top of L_2 and L_3, for such a connection would not, as it were, get outside the leakage inductance and include it in the constant resistance circuit. It is difficult to visualise the arrangement as a constant resistance circuit because C_6 and C_7 appear to be connected back to the separate inductance L_1. This connection is, however, possible owing to the equivalence of Figs. 4 and 5, and is made as being the only connection which will not exclude the leakage inductance L_a.

Turning to the remainder of the circuit, the valve V_1, the hold-off rectifier and the hold-off network provide at D an output of vision signals having a black level suitable for the requirements of the parallel connected valves V_2 and V_3. At E there similarly exists an output of vision signals with a lower value of black level suitable for the grids of V_4 to V_7. These two points are therefore directly connected to the appropriate grids.

The anode circuits of all seven valves contain a negligible impedance, namely, 50 ohm anti-parasitic resistances and 10 ohm resistances used in connection with the meter M_1 by which the individual anode currents are measured. Pentodes, with the anode suppressor grid and screened grid connected together, are used instead of triodes, as they behave under these conditions as very good triodes having a high value of mutual conductance.

The actual impedance generated by the valves V_4, V_5, V_6 and V_7, by virtue of cathode following action, is some 90 ohms, which is too low. The output jacks J_1 are therefore connected so as to include in series the 50 ohms resistance R_{14}, which raises the impedance to 140 ohms. Similarly, the impedance generated by the valves V_2 and V_3 is parallel to

$$\frac{r_a}{2\,(1 + \mu)} = \frac{1920}{2\,(1 + 25)} = 37\Omega$$

and the series resistors R_{11} and R_{12}, in parallel total 77.5 ohms, raising this value 114.5 ohms. The presence of R_{13} reduces the total to 112 ohms. Each cathode circuit is provided with two jacks, one for the outgoing line, and the other for waveform monitoring purposes. It is desirable that the cathode should be returned to earth when the outgoing line is disconnected, and the 5,000 ohm resistances (R_{13}, R_{15}, etc.) are provided for this purpose.

The amplitudes of the signals at the various jacks have the values given at the beginning of this description only when the appropriate outgoing line is plugged in, and moreover, when the line is terminated at its distant end in its characteristic impedance. That is to say, if the signal at J_1 is to have a white level of $+16.5$ V, a black level of $+10$ V, and a sync level of $+3.5$ V, a 110 ohm line terminated in 110 ohms at its distant end must be plugged into J_1. The same consideration applies to the 140 ohm circuits.

Adjustment and Operation

To adjust the Distortion Amplifier, the **Sync Amplitude** control on the Picture and Sync Mixer should be turned to zero, when, if the black level on this unit has been properly adjusted, the anode current passed by V_1 of the Distribution Amplifier should be 25 mA. The cathode resistance of V_1 being fixed, it is not possible to adjust its anode current by means of any control on the Distribution Amplifier, but provided the apparatus is working normally, correct adjustment of the Picture and Sync Mixer should result in this figure of anode current being obtained in V_1. The following anode current should be obtained in the valves V_2 to V_7 under the above black level conditions without sync :

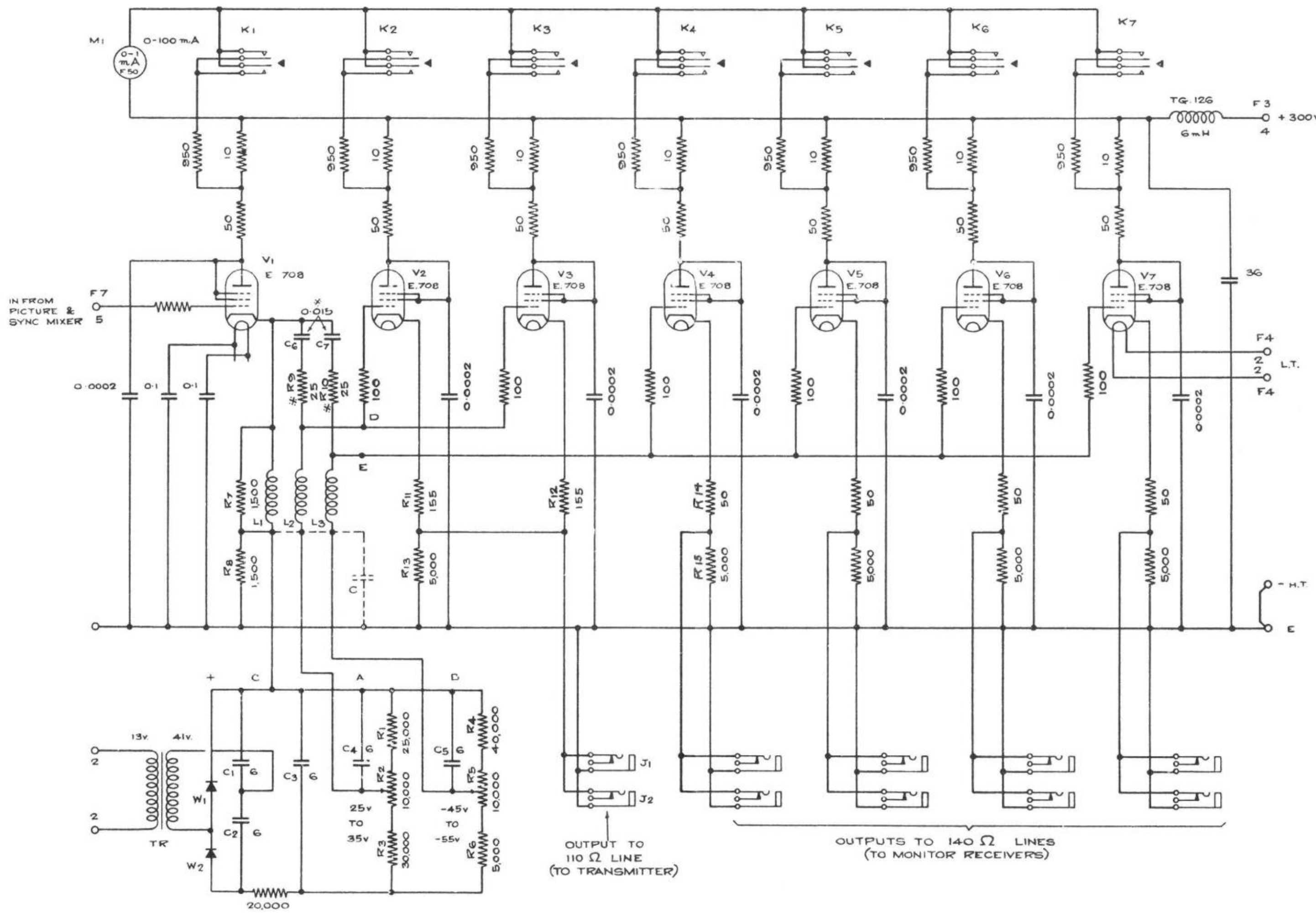
V_2 .. 47 mA.
V_3 .. 47 mA.
V_4 .. 25 mA.
V_5 .. 25 mA.
V_6 .. 25 mA.
V_7 .. 25 mA.

Should these values not be obtained, the potentiometer R_2 should be adjusted in the case of V_2 and V_3, and the potentiometer R_5 in the case of V_4 to V_7.

It is frequently convenient to examine the readings of the Distribution Amplifier when the Picture and Sync Mixer is sending normal black level and synchronising signals. The corresponding anode currents will be :

V_1 .. 23 mA.
V_2 .. 44 mA.
V_3 .. 44 mA.
V_4 .. 23 mA.
V_5 .. 23 mA.
V_6 .. 23 mA.
V_7 .. 23 mA.

All the above measurements should, of course, be made with a line of appropriate impedance, or a testing resistance of the appropriate value, plugged into the jack of the valve which is being examined. It will be appreciated that if no impedance whatever is plugged into the output jacks, then the output valves are each subjected to automatic bias derived from the 5,000 ohm cathode resistances which are now in circuit, and very low anode current readings will be obtained.



X APPROX. VALUES ONLY - ADJUSTABLE ON TEST.

Figure 7. The Distribution Amplifier