TECHNICAL DESCRIPTION

MARCONI-E.M.I. SYSTEM OF TELEVISION

PART 9. O.B. RADIO LINK RECEIVER

O.B. RADIO LINK RECEIVER

General Principles

In order to carry out an outside television broadcast from a site at which there exists no connection by means of a vision frequency cable to the London Television Station, the vision signals, having been generated by appropriate camera and scanning apparatus provided in a large van, are fed to a mobile transmitter situated in the second van. This operates upon a frequency of 64 Mc/s. The waveform radiated conforms to the same standards as that radiated by the London Television Station and the only difference between the two transmissions is that of the wavelength and the power. To receive these transmissions an elaborate receiver has been installed at the London Television Station.

It will at once be realised that this receiver has to operate under conditions of exceptional severity. It is required to operate upon a wavelength of approximately 5 metres and to work with an input as low as 400 μ-V peak carrier. At the same time it must exclude the radiations from the sound and vision transmitters of the London Television Station operating on frequencies of 41.5 Mc/s and 45 Mc/s, respectively. It is clearly desirable to have the receiving aerial as high as possible above earth and as it would be expensive and uneconomic to erect a separate mast for this aerial alone the receiving aerial has been placed at the top of the mast which carries the sound and vision transmitting aerials. Precautions are necessary to ensure that the receiver shall not deliver any output derived from these local transmissions, as otherwise the picture would be hopelessly mutilated and the complete circuit involving the 5-metre receiver and the two transmitters would develop the well-known phenomenon of ' howl back '. It has, however, been possible to eliminate all such effects.

It is considered desirable for the receiver to be fitted with automatic gain control, since although it is not expected that there will be any serious fluctuations of level during a transmission yet circumstances might arise which would influence the propagation on the 5-metre channel and necessitate a certain amount of manual adjustment of gain during a transmission. It will be realised, however, that automatic gain control of the type usually applied to sound transmission systems cannot be employed with a television signal conforming to the standard waveform, because such systems depend upon the existence of a steady value of carrier which in a television transmission operating under D.C. conditions is not available. A.G.C., however, can be applied to the signal provided it is controlled from some component of the signal which is intended always to remain constant. In a television transmission, although the picture component of the modulated radio frequency wave varies in amplitude, the synchronising signals remain constant and it is therefore possible to use these as a basis of control of an A.G.C.

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General Principles *(Contd)*

system. This receiver is consequently fitted with an A.G.C. system controlled by the level of the incoming synchronising signals. It should be emphasised here that the system differs fundamentally from a normal A.G.C. system in that the control is provided not by the portion of the radio frequency waveform which represents the synchronising signals but by the synchronising signals themselves obtained after demodulation.

The general schematic of the apparatus is as follows. The signals derived from the receiving aerial are passed through a network of filters to eliminate all radio frequency signals from the transmitting aerials, and are then applied to a superheterodyne receiver which provides an output consisting of mixed picture and sync impulses of normal D.C. characteristics. This signal is delivered to a further unit known as a Receiving Amplifier which performs certain operations on the signals and establishes certain conditions enabling the signal to be passed to three units. These comprise a Distribution Amplifier of normal type from which the signals may be fed to the transmitter and local picture monitors, a Peak Level Indicator, and apparatus for Automatic Gain Control.

The Receiver is provided with its own mains power units for H.T. and L.T., together with the usual stabilisers. There is also a rectifier known as a negative rectifier for generating a potential negative to earth and a dry battery.

The apparatus is built up in the form of two racks containing the following individual units :—

Aerial filters,
Picture and sync peak amplitude meters,
Receiver and A.G.C. amplifiers,
Receiving Amplifier,
Distribution Amplifier and Plug Panel,
Peak Indicator,
H.T. Stabiliser,
H.T. Stabiliser,
Battery Panel,
Waveform Monitor,
H.T. Power Unit,
L.T. Power Unit,
Negative Rectifier.

Of these various pieces of apparatus, the Distribution Amplifier, the H.T. Stabilisers and the Waveform Monitor are standard units which are described elsewhere. The H.T. and L.T. power units and the Negative Rectifier are of straightforward design, and do not warrant detailed treatment.

Only the following apparatus, therefore, is described, namely, the Aerial, the Aerial Filters, the Receiver, the Receiving Amplifier, the A.G.C. Amplifier, and the Peak Level Indicator.

The Aerial

The aerial consists fundamentally of a dipole mounted at the top of the mast carrying the main vision and sound transmitting aerials. This position in spite of its proximity to the transmitting aerials is probably the most satisfactory that could be found, for since the latter are designed to concentrate the radiation in a horizontal plane the field strength from them will be comparatively low in the ' end on ' direction.

The dipole must clearly be end-fed, but if its end impedance were great, the large transformation ratio necessary to match the impedance with that of the feeder would require a transformer the design of which would present difficulties in respect of maintenance of band width. The end impedance could be lowered by constructing a dipole in the form of a cylinder of fair diameter, but it is impossible to employ a dipole having physically the form of a cylinder as the wind resistance would be too great. Consequently the cylindrical form is simulated electrically by the use of a number of vertical wire dipoles equally spaced round the circumference of a circle. Although in theory the length of the dipoles should be a half wavelength, or 8′ 3″, the actual length is approximately 5′ 3″, because in theory the aerial as a cylinder has an electrical length roughly equal to its real length plus its diameter, while in practice its electrical length is somewhat greater than its physical length because its resistance reduces the velocity of propagation of waves along it. The end impedance is approximately 100 ohms.

The signals are transferred to the receiver room by means of a concentric feeder of small diameter, having a characteristic impedance of 80 ohms. It is therefore necessary to insert a transformer between the aerial and feeder to match the impedance. A quarter wave transformer is inadmissible because the end impedance of 100 ohms quoted above is only approximate and is variable over the frequency band, and there is also a reactive component. It is possible, however, to find a length of transforming feeder between a quarter and half wavelength long and of a certain value of characteristic impedance, which will modify the end impedance of the aerial so that it becomes an impedance of 80 ohms constant over a wide frequency band, but accompanied by a reactance. Such a transformer is fitted, and the final reactance is eliminated by means of what is electrically a parallel tuned circuit connected between the inner and outer of the feeder. As in the case of the main vision transmitting aerial, this in practice consists of a certain length of open-circuited and a certain length of short-circuited feeder connected in parallel to the main feeder, physically in the form of a cross.

The small length of wire between the upper end of the transforming section and the lower end of the aerial has an appreciable inductance, which is compensated for by modifying slightly the length of the transformation section. The union of the cross and feeder must be filled up with pitch to make it weatherproof. This increases the capacity at the junction so that

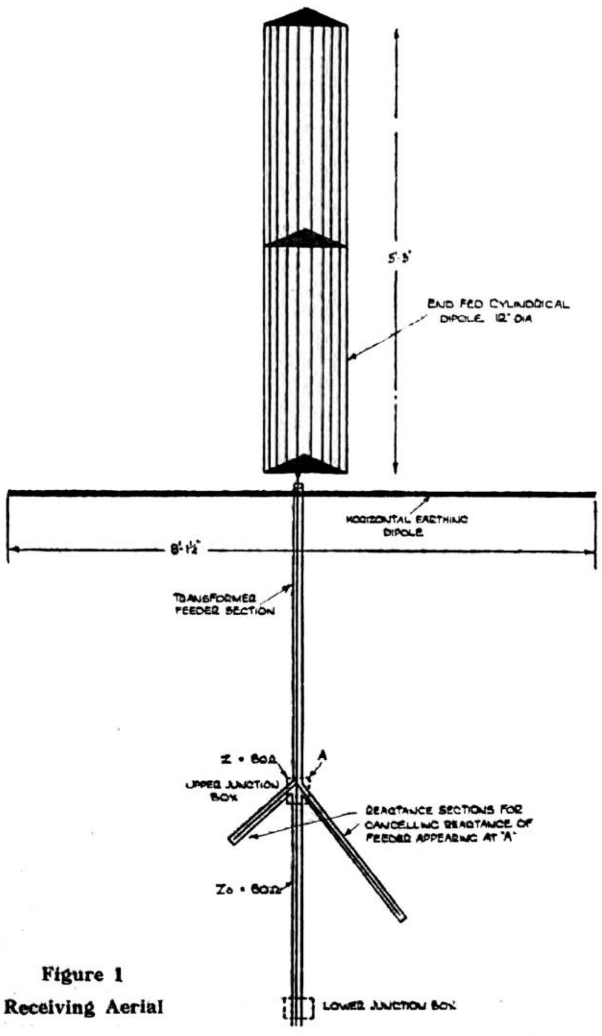

Figure 1
Receiving Aerial

the capacity of the capacitative arm of the cross must be appropriately reduced. From mechanical considerations there must be another junction box lower down, and the distance between the two boxes is deliberately made a quarter of a wavelength so that the irregularity so produced may be compensated by a further adjustment of the cross capacity.

The receiving dipole must, of course, be end-fed with respect to earth so that it is necessary to establish an efficient earth at the aerial end of the transforming section. This is provided by making use of the well known fact that the centre of a dipole constitutes a point at approximately earth potential with respect to its natural frequency. This statement deserves some explanation.

If we take a quarter wave aerial we find that it simulates a series acceptor circuit at its resonant frequency, as may be understood by regarding the aerial as having an end capacity to earth which is series resonating with its inductance. Its impedance, therefore, as measured from one end, will be entirely resistive, and consists largely of its radiation resistance, which is 40 ohms. If we connect two such quarter wave aerials in parallel at their fed ends, and arrange them in opposite directions, we have constructed a centre fed dipole. It might now be thought that the impedance as measured at the centre feeding point would be that of the two quarter wave aerials in parallel, i.e. 20 ohms, but owing to the physical layout of the two quarter wave aerials their respective currents are mutually moving in opposite directions. The radiation of one therefore cancels that of the other, and the power radiated is zero, from which it automatically follows that the radiation resistance of the dipole is zero, and as there is no reactive component the total impedance also is zero.

Such a point therefore constitutes an admirable earth for a system whose fundamental frequency is the resonant frequency of a dipole. The upper end of the impedance transformer therefore is effectively earthed by attaching it to the centre of a horizontal dipole.

The aerial is illustrated in Figure 1.

The Aerial Filters

The signals from the aerial feeder are applied to the input of the aerial filter panel, which contains three filters in cascade. The function of this unit, as has been explained, is to remove from the incoming signal any components other than those belonging to the mobile transmitter operating on 64 Mc/s, and notably to exclude signals from the London Television Station transmitters and their harmonics. Since the receiver is a superheterodyne with an I.F. of 7 Mc/s it will be open to second channel interference, which will consist of a band of frequencies centred about 78 Mc/s, and the filter must accordingly exclude incoming frequencies in this band.

Network 1 is a band-elimination filter whose attenuating band extends

The Aerial Filters (*Contd*)

from 41.5 Mc/s to 47 Mc/s approximately. This therefore removes radio frequencies due to the main sound and vision transmitters.

Network 2 is a band-elimination filter having an attenuation band extending from 75 Mc/s to 88 Mc/s. This filter therefore increases the existing attenuation applied to second channel interference and to the second harmonic of the main sound transmitter.

It has been found possible for frequencies centred round a band of 86.5 Mc/s to enter the receiver. These are due to the fact that radio frequencies from the main vision aerials can be picked up by the main sound aerials and pass via the sound feeder down to the modulated amplifier of the sound transmitter. Since this amplifier has a non-linear characteristic, sum and difference frequencies will be formed by inter-modulation of the vision and sound radio frequencies. The difference frequencies are of little importance, but the sum frequencies being located around a central frequency of 86.5 Mc/s, can be picked up by the receiving aerial, and have been observed to cause interference patterns in the received picture. Such frequencies may also be produced by a similar inter-modulation in the modulated amplifier of the main vision transmitter due to signals picked up by the main vision aerials from the main sound aerials. Such frequencies are clearly attenuated by networks 2 and 3.

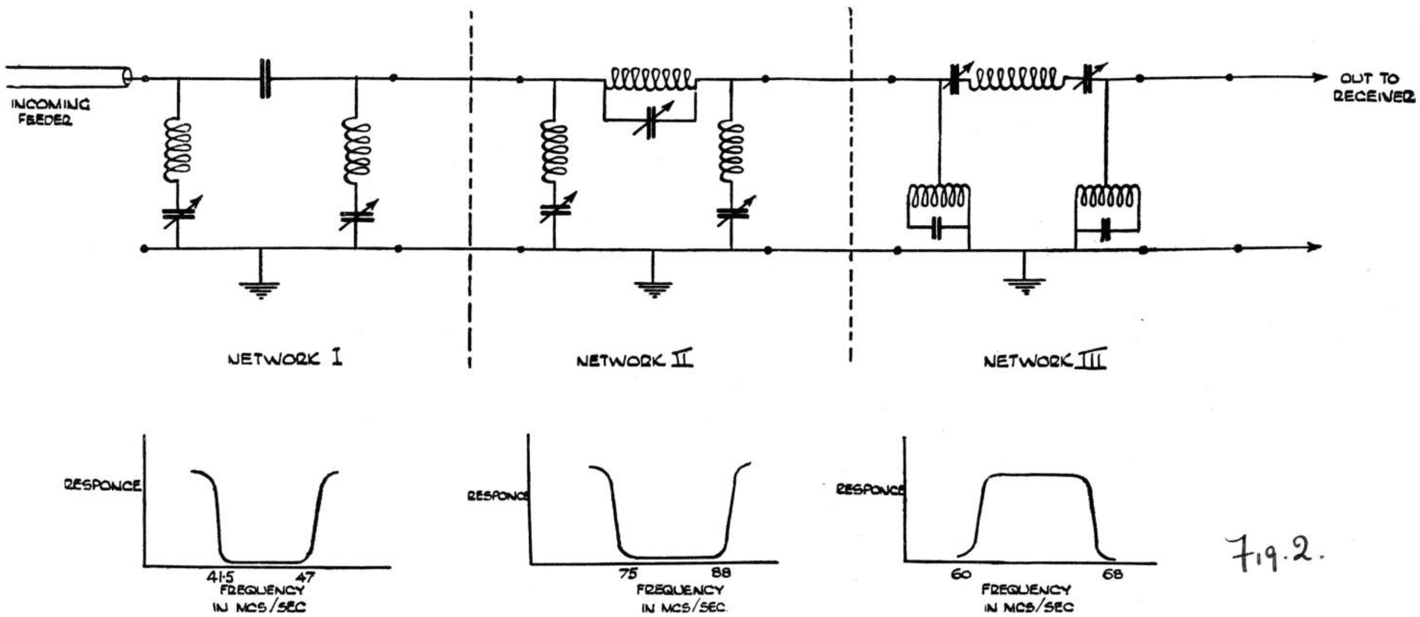

Fig. 2.

Network 3 is a band-pass filter having a pass band from 60 Mc/s to 68 Mc/s which therefore passes the signals from the mobile transmitter together with sidebands having a width of 4 Mc/s on either side of the carrier. The sidebands actually do not extend to more than about $2\frac{1}{2}$ Mc/s on either side of the carrier, but the filter must not introduce any phase distortion over the range of effective sidebands of the mobile transmission, and must therefore have cut-off frequencies located well away from the sidebands corresponding to the highest effective modulation frequency. This filter clearly attenuates severely frequencies corresponding to the second channel and harmonics of the main transmitters.

These networks are illustrated in Figure 2. The output from network 3 is applied to the receiver.

The Receiver

The radio receiver is an elaborate unit, the circuit of which is shown in Fig. 8.* The radio frequency output from the filter panel centred around 64 Mc/s is applied to the grid of the valve V_2 via terminal A and the circuit L_1 C_1. This circuit effectively simulates a perfect transformer in which the two halves of L_1 are the primary and secondary windings and the condenser C_1 tunes out the leakage inductance.

The valves V_1 and V_2 together constitute a frequency changer, V_1 being a separate oscillator and V_2 a mixer. The valve V_1 is connected to form a Hartley oscillator having a frequency range of from 62 Mc/s to 82 Mc/s. The intermediate frequency is fixed at 7 Mc/s so that the frequency range of the oscillator enables a carrier frequency of between 55 Mc/s and 75 Mc/s to be received. In the ordinary way, of course, to receive the mobile transmission which is on a frequency of 64 Mc/s the oscillator frequency will be adjusted to 71 Mc/s.

The oscillations generated by the circuit associated with V_1 are tapped off from the main inductance L_2 and applied to the grid of V_2 via the condenser C_2. They are therefore applied effectively in parallel with the signal frequencies. The intermediate frequency appears in the anode circuit of V_2, and is applied to the grid of V_3. The valves V_3 to V_{12} form a 10-stage intermediate frequency amplifier, which is designed in a somewhat unusual manner. The orthodox manner of designing an intermediate frequency amplifier is, of course, to couple the constituent valves together by band-pass filters usually consisting of over-coupled tuned circuits damped by resistances. Such circuits, however, have fairly sharp cut-off frequencies and are liable to introduce phase distortion into the signal, and it has been found preferable to seek some form of coupling which avoids the use of resonant circuits. In this receiver therefore the necessary I.F. band width is obtained in the following manner. The valve couplings are designed on principles normally employed for vision frequency amplifiers, that is to say, they have the form of low-pass filters. Their cut-off frequency is located at a much higher figure, viz., 10 Mc/s, it having been found possible to reach this frequency by the use of low-pass filter technique. Arrangements are incorporated to suppress all frequencies below 4 Mc/s so that the effective band width of the amplifier is from 4 Mc/s to 10 Mc/s, that is to say a band width of 3 Mc/s on either side of the central intermediate frequency of 7 Mc/s. Thus, an intermediate frequency amplifier is effectively created by taking a vision frequency amplifier, extending its band width to include the highest modulation component of the intermediate frequency which it is desired to reproduce, and introducing bass suppression to prevent any response at frequencies lower than the lowest modulation component of the desired intermediate frequency band.

Referring to Fig. 8, it will be seen that all the I.F. couplings are practically identical, and it will therefore suffice to describe one of them. Considering the coupling between the valves V_3 and V_4, the inductance L_3 forms, in conjunction with the anode-earth capacity of V_3 and the grid-earth capacity of V_4, a prototype low-pass filter. As I have pointed out in my technical note on the 'A' Amplifier and Tilt Mixer, such a coupling must be properly terminated, but it is impossible to do so by the use of an M-derived half-section, and it is necessary in the ordinary way to design a coupling to have a cut-off frequency of about twice the value of the highest frequency that it is desired to reproduce, and to terminate it in a resistance equal to its iterative impedance, which is approximately constant from a frequency of 0 to half the cut-off frequency. In this case, however, the desired upper frequency of 10 Mc/s is already so high that it would be very difficult to design a filter to have a cut-off frequency as high as 20 Mc/s and still obtain any gain. If, however, the filter can be properly terminated at frequencies higher than half its cut-off frequency it will be possible to place the latter at a lower figure. The iterative impedance rises reaching an infinite value at the cut-off frequency and since the nature of the circuit will not permit of the use of an M-derived section, the best that can be done is to make use of a termination whose impedance, though sensibly constant over the lower end of the pass-band, has a rising characteristic at the upper end. Such a circuit is, of course, an inductance in series with a resistance. It will be seen that the filter is terminated at its output end by the inductance L_4 in series with the anode resistance R_1, the upper end of the latter being effectively earthed by the capacity C_3. The grid resistance R_2, which is essential to the proper working of the valve V_4, does not disturb the action of the coupling, as this resistance is much higher than the iterative impedance over the pass range. Similarly the coupling condenser C_5, being large compared with the grid to earth capacity of V_4, has no influence on the coupling. The elements R_3, C_3 and R_4, C_4 form an effective double decoupling circuit.

The necessary degree of bass suppression referred to above is provided by two methods. In the first place the cathode circuit of V_3 is provided with a minimum value of automatic bias by means of the resistance R_5, which is shunted by the condenser C_6, and this, instead of being made very large so as to exercise no frequency discrimination, is made small enough to create anti-phase feed back to the grid at lower frequencies. Secondly, the inductance L_5 associated with the grid of V_3 contributes a further amount of bass cut.

It was considered in the course of design that whilst it would no doubt be satisfactory to make the intervalve coupling of all the I.F. stages identical, it would nevertheless be of value to include possibly one coupling having its characteristics variable so that the response of the I.F. amplifier as a whole could be finely adjusted. Accordingly, whilst the couplings between

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* *Fig. 8 attached to page 15*

The Receiver *(Contd)*

the valves V_3 to V_{12} are fixed and identical, that between V_2 and V_3 is designed on entirely different lines, and is adjustable. The circuits associated with the anode of V_2 form a band-pass filter, the output of which is applied to the grid of V_3 via the condenser C_5, which does not form part of the band-pass coupling, but, together with the inductance L_5, supplies a certain amount of bass suppression, as described above.

The fundamental idea from which the anode circuit of V_2 is built up may be understood by reference to Fig. 3. Fig. 3a shows a valve between whose anode and earth there is a parallel-tuned circuit which may be assumed to be parallel fed. If this circuit is rather flat the response of the anode circuit will be as indicated in Fig. 3b. If now a series resonant circuit is

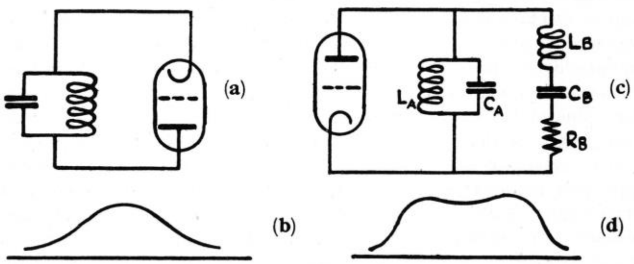


Figure 3

connected across the parallel circuit of Fig. 3a and tuned to resonate at the same frequency as the circuit of Fig. 3a, then a dip will be imposed on the peak of Fig. 3b, and the resulting characteristic will be of the shape shown in Fig. 3d. The circuit of Fig. 3c is the basis of the anode circuit of the valve V_2, though the actual practical circuit is somewhat different. The inductances $L_6 + L_7 + L_8$ in the anode circuit of V_2 collectively correspond to the inductance L_a of Fig. 3c, and resonate flatly with the total capacity due to that between the anode of V_2 and earth and that between the grid of V_3 and earth. The effective value of the latter component across the anode inductance is somewhat reduced by tapping the condenser C_5, that is to say, the output, up the anode coil. This is done to flatten the response and increase the total anode impedance so as to obtain greater gain. The total effective parallel capacity therefore corresponds to the capacity C_a of Fig. 3c.

The series acceptor circuit is not in practice connected across the whole of the parallel circuit, as the practical equivalent of C_b which it is desired to make variable would be too small for convenience, and instead it is connected to approximately the centre point of the parallel inductance L_a, that is to say, at the junction of the actual inductances L_6 and L_7 L_8. Due to imperfect coupling between L_6 and L_7 L_8, there is a residual leakage inductance which appears effectively in series with C_7 C_8, and this leakage inductance is used as the practical equivalent of the inductance L_b of Fig. 3c, and it is unnecessary deliberately to insert a coil to represent L_b. The condenser C_b of Fig. 3c is represented by the condensers C_7 and C_8, and the resistance R_b by the resistances R_6 and R_7. The complete circuit therefore represents a band-pass filter having the following three variable characteristics :—

(1) By varying the mutual inductance between L_7 and L_8 by means of the variable coupling provided, the location in the frequency spectrum of the band-pass region as a whole is changed.

(2) By varying the condenser C_7, the position of the dip imposed by the series circuit L_b C_b R_b upon the response of the parallel circuit L_a C_a is changed.

(3) By varying the resistance R_6 R_7 the amplitude of the dip is varied.

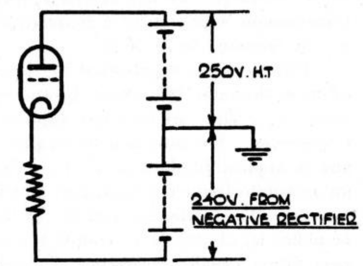


Figure 4

The vision signals therefore at intermediate frequency proceed through the various stages of I.F. amplification mentioned above, and appear in the anode circuit of V_{12}, from which they are applied via the transformer TR_1 to the double diode rectifier V_{13}. The load resistance of this rectifier is R_9, and across this is developed the vision frequency output. In view of the position of R_9 in the circuit the vision signals will appear with picture in the negative sense and the synchronising signals acting positively. The small condenser C_9 shunts away any unwanted products of rectification such as the second harmonic of the intermediate frequency which will be generated by the rectifier. From the top of the load resistance R_9 the vision output is applied to the grid of V_{14} via the usual correction circuit L_9 R_{10}. The valve V_{14} constitutes a cathode follower output stage, and its cathode circuit consequently includes the resistance R_{11}. If the lower end of R_{11} were returned to earth, the vision signals across it would operate negatively from a standing high positive potential, which is an unsatisfactory condition from the point of view of the apparatus to which the output will be delivered, and it is desired to reduce the standing cathode potential of V_{14}. To achieve this, a separate voltage, negative with respect to earth, is provided from a unit known as the 'Negative Rectifier', and the lower end of R_{11} is returned to this supply. The essentials of the H.T. circuit of V_{14} are therefore as shown in Fig. 4, from which it will be seen that although the normal H.T. supply of 250 V. to this valve is augmented to 490 by the addition of 240 V. from the negative rectifier, the standing potential of its cathode will be greatly reduced, and should have a value of 9.2 V. when no I.F. is being delivered to V_{13}. The valve V_{14}, being a cathode follower, does not reverse the sense of the signals applied to its grid, which is negative. Therefore the above figure of +9.2 V. represents the voltage corresponding to the troughs of the synchronising signals, and the whole of the vision waveform will be negative with respect to this value. Under normal conditions this value will descend to −0.5 V. for a peak white signal. The meter M_1, designated **Signal Level**, is provided to read the standing value of cathode potential when setting up the receiver and before applying I.F. Its reading will be modified by the application of the vision signal, but will have no particular meaning since it will merely read the mean value of the output voltage.

It is important from the point of view of the correct operation of the receiving equipment as a whole that the datum level of 9.2 V. corresponding to the troughs of the synchronising signals at the cathode of V_{14} should be capable of exact adjustment. The operating conditions of V_{14} have therefore been arranged so that if the control grid of this valve is earthed the cathode takes up a potential of about 2.5 V. The control grid is returned not to earth, however, but to the slider of the potentiometer R_{12}, which enables a small variable positive potential to be applied to the grid. Since V_{14} is a cathode follower its cathode potential will become more positive if a positive potential is applied to the control grid, and the desired cathode potential of 9.2 V. may be found by correctly adjusting the potentiometer R_{12}. This does not interfere with the rectifying action of V_{13}, as the rectification circuit is a closed circuit on its own comprising the secondary of the transformer TR_1, the valve V_{13} and the load elements R_9 and C_9. The condenser C_{10} removes all A.C. components of the vision signals from the potentiometer R_{12}.

The output is available for monitoring at the jack J_1.

Gain control is effected by varying the grid bias of the valves V_4 to V_8. The gain of V_4 and of V_8 is arranged to vary only half as much for a given change of gain control as the gain of V_5, V_6 or V_7 in order, in the case of V_4 to minimise valve noise, and in the case of V_8 to avoid possible overloading. The necessary bias voltage, which may be manually or automatically controlled, is developed in a section of the receiving unit known as the A.G.C. Amplifier, which will not, however, be described at this juncture, as before admission to the A.G.C. Amplifier the signals are passed through the separate unit mentioned above as the Receiving Amplifier.

For certain valves in the Receiver and A.G.C. Amplifier an H.T. supply of 350 V. is required. The majority, however, including the valves V_1, V_2,
231 V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}, V_{11} and V_{14} require the supply to be at 250 V. This is produced by the valve V_{19}, which acts as a stabiliser. Its anode is supplied with H.T. at 350 V., and the necessary positive grid voltage of about 250 V. is supplied from a potentiometer comprising the resistances R_{13} to R_{19} inclusive. In addition a supply at 105 V. is required for the screened grids of the valves V_3, V_4, V_5, V_6, V_7, V_8, V_9 and V_{10}. This is provided by the second stabiliser V_{20}, whose anode is again connected to the 350 V. H.T. line, its positive grid bias being supplied from a suitable point on the potentiometer R_{13}—R_{19}.

The Receiving Amplifier

The output from the cathode of the valve V_{14} in the Receiver is applied to the input of the Receiving Amplifier, which performs several functions. We have seen that the output from the Receiver is in the form of vision signals in the negative sense, in which a voltage of −0.5 V. corresponds to a white element, and one of 9.2 V. corresponds to the troughs of the synchronising signals. The picture/sync ratio being, of course, 70/30, the black level at this point will be +5.9 V., all these voltages being measured with respect to earth potential. It is, however, desired that the receiving equipment as a whole should terminate in a standard Distribution Amplifier, so that the transmitter and various local monitors may be fed with signals in the same manner as in the case of studio or other sources. The Distribution Amplifier requires an input in which the picture/sync ratio is not 70/30, but 50/50, and in which a white element is represented by +50.5 V., black level by +33 V., and troughs of the sync signals by +15.5 V. The first function of the Receiving Amplifier therefore is to change the input derived from the Receiver into the form required by the Distribution Amplifier.

It is also desired to measure the levels of both picture and synchronising signals at the receiver, and a Peak Level Indicator is provided for the purpose, which requires an input of its own. The second function of the Receiving Amplifier is to provide this input.

The third function of this unit is to provide a suitable output for application to the A.G.C. Amplifier, which will effect the necessary automatic control of gain, and for this purpose it is necessary to effect a fundamental change in the nature of the output as provided by the Receiver. It has been explained in the previous note dealing with the Receiver that this output consists of the complete vision waveform acting in a negative sense from a fixed datum line corresponding with the peaks of the synchronising signals. It follows therefore that should there be a change in the strength of the radio frequency signal as received, the corresponding change in the vision frequency output delivered from the receiver will take place with reference to the peaks of the synchronising signals, the voltage of which will remain constant. Thus, the black level delivered from the Receiver will vary if the receiver signal strength changes.

As will be seen later from the description of the A.G.C. Amplifier, the operation of automatic volume control is effected by means of the

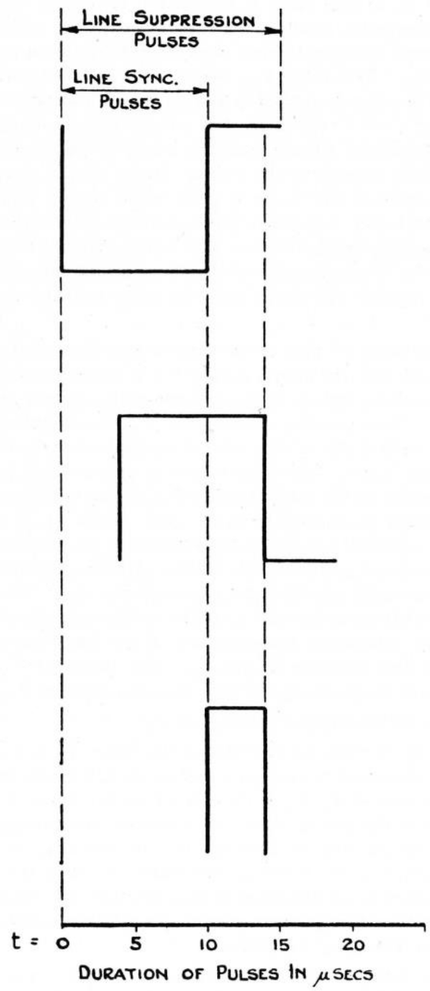
The Receiving Amplifier *(Contd)*

synchronising signals, which in that unit have to be separated from the complete waveform. The process of separation is carried out by applying the waveform to a valve circuit in such a way that the black level coincides with the voltage corresponding to the cut-off of the valve characteristic. It is clear that the separation circuit, and therefore the whole system of automatic gain control, must fail to operate if the black level of the input waveform is subject to variation. It is therefore necessary to arrange that in the waveform applied to the A.G.C. Amplifier the fixed datum, about which the picture and synchronising excursions are executed, corresponds with the black level, and not with the peaks of the synchronising signals. This operation is performed in the Receiving Amplifier by losing the existing D.C. component, the datum of which corresponds, as has been seen, with the peaks of the synchronising signals, and re-establishing it with a datum corresponding to the black level. It will be evident that this operation, which is primarily necessitated by the requirements of the A.G.C. Amplifier, may be arranged to suit the requirements of the Distribution Amplifier, already outlined, by correctly choosing the datum at which the black level is restored.

The circuit is shown in Fig. 6*, and it will be seen that it comprises six valves and their associated circuits. The vision signals derived from the cathode output of the valve V_{14} in the receiver are applied to the control grid of the valve V_1 in the Receiving Amplifier. This valve acts as a straightforward amplifier. Its cathode circuit contains the small resistance R_1, which provides the minimum automatic bias, and being unshunted straightens the valve characteristic. The valve V_1 is direct coupled to V_2, the coupling including the usual inductance L_1, giving the coupling the configuration of a low-pass filter and the elements L_2 and R_2 which form the termination for the filter. The standing D.C. potential on the anode of V_1 is reduced before application to the grid of V_2 by the potentiometer action of the resistances R_3 and R_4, the vision frequency components being by-passed by the condenser C_1. In order, however, that there shall be no loss of amplification of the lowest vision frequencies, including the D.C. component which will arise owing to the action of C_1 and R_3, the decoupling components $C_2 R_5$ are given the same time constant as C_1 and R_3, so that the amplification at the lowest frequencies and at D.C. will be linear. The sense of the signals on the control grid of V_2 is reversed so that white signals are acting positively.

The valves V_2, V_3 and V_4 constitute a D.C. Restoration circuit of the type which effects restoration by determining what potential shall exist at a given point in the circuit to correspond with black signals, instead of the more simple form of circuit which determines the potential which shall correspond to either the troughs of the synchronising signals or white elements. In this respect therefore this circuit differs from that used in certain other places, such as the Suppression, and Picture and Sync Mixers.

* *Fig. 6 attached to page 11.*



Line Sync Signal as applied to Anode of V_3

Line Sync Signal as applied to Grid of V_3

Figure 5

The circuit, however, although acting in respect of black signals, as does the circuit employed in the transmitter modulator, differs from the latter in that no provision is made to avoid the fall of the D.C. component along a line. Since the signals passing through the Receiving Amplifier will eventually have their D.C. component removed and restored with almost complete perfection in the modulator restoring circuit, it is unnecessary to provide such elaboration at this stage.

Clearly, if it can be arranged that at frequent intervals, say once per line, a standard period of black signal occurs and that in this period a predetermined potential is established at some point in the circuit, then the D.C. component will have been restored, since the excursion of the vision signal can only be in the positive direction with respect to the potential established to correspond with the black interval. The circuits associated with V_2 and V_3 are arranged to carry this out by imposing upon the grid of V_4 a certain predetermined potential during the last 4 micro-seconds of the line suppression pulse, which constitute a period of black signal recurring once per line.

We have seen that amplified vision signals are applied to the grid of V_2 in the positive sense. The anode of V_2 feeds a delay network comprising the inductances L_3 to L_{11} and the capacities C_3 to C_{11} inclusive. The network is terminated at its distant end by the resistance R_6, and at the sending end by the resistance R_7, both of these being equal to the iterative impedance of the network, which is 2,500 ohms. This is therefore the value of the anode impedance of V_2. The network has a cut-off frequency of about 640,000 c.p.s., and will therefore reproduce well as regards both amplitude and phase frequencies up to some 300,000 c.p.s. It is intended to act mostly upon the synchronising signals, and its action on the vision signals is of no importance. In fact it is obvious that a large portion of the upper frequency range is entirely suppressed. The total delay of the network is 4 micro-seconds, so that across the resistance R_6 there appear synchronising signals acting positively owing to having been once more reversed by V_2, and delayed by 4 micro-seconds with respect to the instant of their appearance in V_2. The relative disposition of this pulse is shown in Fig. 5.

An output is also taken from the cathode of V_2, the cathode resistances R_8 and R_9 being provided for this purpose. This output is, of course, in the positive sense with synchronising signals acting negatively. It is applied to the control grid of V_4 and this connection constitutes a portion of the path of the vision signals through the Receiving Amplifier. The condenser C_{12}, however, loses the D.C. component, and the signals on the grid of V_4, being an A.C., can now have their D.C. component re-established with reference to any convenient datum line.

The cathode of V_2 is also applied to the anode of V_3, at which point we are interested largely in the synchronising signals, which are acting negatively. The output across R_6 is simultaneously applied to the control grid of V_3, and in this case the synchronising signals, as we have seen, are acting positively and are delayed 4 micro-seconds with respect to those on the anode. The operating conditions of V_3 are so adjusted that it is non-conductive unless the anode is energised by a positive potential and the grid is not more negative than a certain potential. During that portion of the time of a line devoted to vision signals V_3 is non-conductive, because even though its anode is energised positively its grid is energised negatively.

Referring now to Fig. 5, at a time $t = 0$ the synchronising signal energises the anode negatively, and vision signals are still acting negatively at the grid, so that the valve is not conductive. At a time $t = 4$ micro-seconds, the grid is energised positively by the synchronising signals, but the anode is still held negative by them, so that the valve is still non-conductive. This state of affairs holds until a time $t = 10$ micro-seconds, when the synchronising signal applied to the anode ceases, but that acting on the grid (positively) is still present owing to its having been delayed by the delay network. The valve is now conductive therefore, and remains so between this time and a time equal to $t = 14$ micro-seconds, when the positive synchronising signal acting on the grid ceases. There is then no further conductivity until the above cycle repeats itself at the end of the next line. It will be seen therefore that during the period extending between the 10th and the 14th micro-second of the line suppression pulse (which is, of course, a recurring period of black signal at the end of each line) the valve V_3 becomes conductive, and during that time connects the point x on the potentiometer formed by the resistances R_{10}, R_{11}, R_{12} and R_{13} to the control grid of V_4. This potential, therefore, is the black level at the control grid of V_4, and is adjustable by means of the resistance R_{13}, which control is therefore designated **Black Level.**

The valve V_4 contains no anode impedance and constitutes a cathode follower, the necessary feed-back being generated by the cathode resistance R_{14}. At its cathode the sense of the signals is positive, and the picture/sync ratio which has so far not been influenced by any of the previous operations, is 70/30, and it is now desired to change it into the 50/50 ratio required by the Distribution Amplifier. This is performed in the following manner. The output from the cathode of V_4 is applied to the diode V_5, whose cathode is connected to a point on the potentiometer R_{15} R_{16} R_{17} R_{18} such that its black level potential can be made equal to the black level potential of the cathode of V_4. In order that these two potentials can be equalised exactly, a manual control is provided in the shape of the variable resistance R_{15}, which exercises control of the current passing through the cathode resistance R_{18} of V_5, and so determines the cathode potential of this valve. This resistance is designated **Adj. Ratio Control.**

The diode V_5 will only conduct when its anode potential is more positive than that of its cathode, so that if its cathode potential is that of the black level applied to it, then only current corresponding to the vision signals

The Receiving Amplifier *(Contd)*
will flow in the anode circuit of V_5, and synchronising signals will be eliminated. Included in its anode circuit is the potentiometer R_{19}, across which therefore potentials corresponding to the vision signals alone are generated. Since the incoming picture/sync ratio is greater than that which is required, it will be possible to find a setting of the potentiometer R_{19} at which the picture/sync ratio has fallen from 70/30 to 50/50, and this potentiometer is consequently designated **Picture/Sync Ratio.**

The output from V_5 is applied to the valve V_6, which constitutes a cathode follower output stage whose cathode circuit feeds a standard Distribution Amplifier. Since the cathode of V_4 is direct coupled to the grid of V_6, the black level of the cathode of V_6 will be determined by the setting of the black level potentiometer R_{13}, and the constants of the circuit are so proportioned that the black level on the cathode of V_6 is that which is required by the input of a standard Distribution Amplifier, viz., +33 V.

The cathode output of V_6 also supplies the Peak Level Indicator.

In order to supply the A.G.C. Amplifier an additional output is taken from the anode of V_6 by insertion of the anode resistance R_{20}. In this case the sense of the signals is negative, and the standing level of the signals is, of course, much greater, the peaks of the synchronising signals occurring at ~~+225 V~~. + 230V.

The A.G.C. Amplifier

It will have been understood from preceding references that the function of the A.G.C. Amplifier is to derive from an input consisting of mixed picture and synchronising signals a steady D.C. bias depending upon the amplitude of the synchronising signals alone, and to provide this bias in such an amplitude and form that it may be used for automatic gain control of the receiver. This bias operates on the valves V_4 to V_8 of the receiver, and the gain of the valves V_4 to V_8 is required to vary only half as much for a given change of gain control as that of V_5, V_6 and V_7. The A.G.C. Amplifier must therefore provide two bias voltages, one known as **Full A.V.C.** being applied to the control grids of the valves V_5, V_6 and V_7, and the other known as **½ A.V.C.** operating between reduced limits and being applied to the control grids of the valves V_4 and V_8.

It has been convenient to include the A.G.C. Amplifier in the Receiver unit, and its diagram is given in Fig. 8*. It receives an input from the Receiving Amplifier consisting of picture and synchronising signals in the negative sense with black level at + 210 V. The synchronising signals have an amplitude of some 20 V and their peaks thus reach a voltage of + 230. This input is applied to the first valve of the A.G.C. unit, V_{15}, the function of which is to reverse the synchronising signals and establish certain circuit conditions by means of which they may be used to provide the A.G.C. bias.

The input is applied to the potentiometer involving the resistances R_{34}, R_{35}, R_{36} and R_{20} and the condensers C_{14} and C_{15}. The lower end of the potentiometer R_{20} is returned not to earth, but to a negative supply from the Negative Rectifier at − 120 V. The combined effect of this negative supply and of the potentiometer action existing between R_{34}, R_{35} and R_{36} R_{20} is to reduce the black level at the control grid of V_{15} to − 4 V under normal working conditions. The condensers C_{14} and C_{15}, however, pass the full amplitude of the synchronising signals to the grid, and they therefore still have their original amplitude of 20 V. They appear amplified and reversed at the anode of V_{15}, at which electrode the black level under normal working conditions is + 180 V and the amplitude of the synchronising signals 80 V in, of course, the negative direction.

It is now necessary to derive from the synchronising signals a D.C. voltage proportional to their amplitude and which will be proportional to the strength of the incoming radio frequency signals. This function is carried out by the rectifier V_{16}. Its anode is connected by the load resistance R_{22} to the junction of the resistances R_{23} and R_{24}, where there is a potential of + 50 V. At the same time the black level at the anode of the valve V_{15} is applied to the potentiometer R_{25} R_{26} R_{27}, and at the junction of R_{26} and R_{27} the black level is, under normal conditions, reduced to some 65 V., while the condensers C_{10} and C_{11} pass to this junction the full amplitude of the synchronising signals, which is some 80 V. The troughs of the synchronising signals therefore carry the potential of this point to some 15 V. negative with respect to earth. It will be seen that under conditions of black level the cathode of V_{16} is 15 V. more positive than the anode and V_{16} cannot conduct. When, however, a synchronising signal arrives at the cathode of V_{16}, it drives the potential of this electrode down to − 15 V., under which conditions the anode is now 65 V. positive with respect to the cathode, and the valve can conduct.

During the period of the synchronising signals, therefore, V_{16} conducts and charges up the condenser C_{12}, which takes up a potential of some − 15 V. relative to earth. Superimposed on this, however, there is a small saw-toothed amplitude due to the fact that the condenser is charged suddenly by the synchronising signal, and discharges slowly through the load resistance R_{22}. At the anode of V_{16} therefore we have a voltage which is negative with respect to earth and of about the right order for employment as an A.G.C. voltage. This voltage is now applied to the grid of the cathode follower V_{17}, which serves as usual to isolate the A.G.C. circuits from the somewhat delicate circuits associated with the valves V_{15} and V_{16}. The necessary feed-back is provided by the cathode resistances R_{28} and R_{29}, but they cannot be returned to earth in the normal manner as the resulting cathode voltage would be positive above earth and could not be used for A.G.C. purposes. Accordingly they are returned to the output of the negative rectifier which is at − 240 V. to earth, the constants of the circuit being so adjusted that the cathode potential will be the value that is required for A.G.C. purposes, i.e. 0 to −20 V. relative to earth.

* *Fig. 8 attached to page 15.*

The potentiometer R_{20} is provided so that the various circuit conditions detailed above can be accurately set. This action is to provide an adjustment of the input black level over the range from -2 to -18 V., in which circumstances the black level at the anode of V_{15} ranges from 170 to 260 V., and that at the cathode of V_{16} from 60 to 100 V. If R_{20} is set so that the input black level is more negative than normal, that is to say, than -4 V., owing to normal valve action the potential corresponding to black level at the anode of V_{15} will rise, and the corresponding potential at the cathode of V_{16} will also increase. The absolute value of potential to which the troughs of the synchronising signals will drive the cathode of V_{16} will be more positive than before, and since the potential of the anode of V_{16} is fixed by direct connection to the junction of R_{23} and R_{24} the amplitude of the synchronising signals during which V_{16} is conductive will be reduced. The D.C. bias derived from them will therefore be reduced, and the gain of the I.F. amplifier which the A.G.C. action will maintain will be greater. It should be noted that when such an adjustment is made to the input black level, a subsidiary effect will occur, of which it is desirable to be aware in operating the receiver, but which is not of importance as regards the behaviour of the circuits. The cut-off of the grid characteristic of V_{15} is so situated that at the normal setting the input black level is at the positive side of this cut-off point, and the valve passes the whole of the synchronising waveform and some of the picture waveform as well. Since at the anode circuit of V_{15} such picture waveform will appear entirely as voltages more positive than the black level, it cannot influence the operation of the circuit associated with V_{16}, and its presence is of no importance. When R_{20} is so adjusted as to make the input black level more negative, the range of adjustment is such that the black level can be set to the left of the cut-off of the valve characteristic, and of the vision waveform, and a portion of the synchronising waveform is suppressed. This fact is purely a side issue, as the fundamental action of R_{20} in adjusting the gain maintained by the A.G.C. circuit is due to its influence upon the black level at the cathode of V_{16}, and the fact that such an adjustment suppresses that portion of the synchronising waveform adjoining the black level is totally obscured by the elevation of the black level at the cathode of V_{16} which, of course, prevents the part of the synchronising waveform in question from causing this valve to conduct.

If A.G.C. is to be used, then the selector switch S_1 is placed in the **A.G.C.** position, which passes the voltage at the cathode of V_{17} to the potentiometer R_{30} R_{31} R_{32}, from which, as will be seen from Fig. 8, the correct voltage for *Full A.V.C.* line is derived by tapping off from the junction of R_{30} and R_{31}, while that for the ½ **A.V.C.** line is similarly derived from the junction of R_{31} and R_{32}.

235 In the event of the received signals being very weak, the amplitude of the synchronising signals derived from the anode of V_{15} may fall below the minimum value of 43 V. which is required to make the diode of V_{16} conduct, in which circumstances there will be no negative potential at its anode or at the grid, and consequently the cathode of V_{17} will in view of the necessary circuit values become somewhat positive. The A.G.C. voltage would thereupon be positive, which is undesirable, as excessive emission would be drawn from the controlled valves in the I.F. amplifier, and to avoid this the diode V_{18} is provided, which becomes conductive if the A.G.C. voltage developed across the potentiometer R_{30} R_{31} R_{32} becomes positive, and any such voltages are thus shunted to earth.

It may be required to control the gain of the receiver manually instead of automatically. In this case the selector switch S_1 is placed in the **Manual** position, and the bias, instead of being derived from the cathode of V_{17}, is now derived from the negative rectifier via the potentiometer R_{33} R_{34} R_{35}. The section R_{35} is brought out as a manual control, and is accordingly designated **Manual Gain Control.**

If it is desired to suppress the vision and synchronising signals entirely while yet keeping the receiver generally operative for test purposes, the selector switch S_1 is placed in the position designated **Off**, whereupon an excessive bias having a value of 40 V., derived from the junction of the resistances R_{33} and R_{34} is applied to the controlled I.F. valves. This is sufficient to suppress the I.F. amplifier entirely.

The value of the generated bias voltage applied to the potentiometer R_{30} R_{31} R_{32}, whether it be automatic, manual or the excessive value corresponding to suppression of the I.F.amplifier is read by means of the meter M_1, which is designated **A.G.C. Level.**

The response of the A.G.C. bias to variations in signal strength is determined by the time constant formed by the resistance R_{22} and the condenser C_{12}. If this time constant is very long, the A.G.C. bias will, in the event of a change in the signal strength, take too long to adjust itself to the appropriate new value. If the time constant is too short, the A.G.C. voltage would tend to alter between lines, due to the fact that the condenser C_{12} is charged up to a certain value by a synchronising signal, and then proceeds to discharge through R_{22} to a low value, until the arrival of the next synchronising signal which restores it to its original value. This is the reason for the existence across C_{12} of a saw-toothed component at line frequency, and of about one or two volts amplitude superimposed upon the steady bias voltage at this point of some 10 to 20 volts amplitude. The values chosen (5 megohms and .0005 μF.) give a time constant equal to the duration of some 25 lines, which is satisfactory in practice. The saw-toothed irregularity must, of course, be smoothed away from the A.G.C. voltage, and this is performed by the resistance R_{30} and the condenser C_{13}.

One further correction to the A.G.C. circuit is necessary. The condenser C_{12}, as has been mentioned, is charged up by the synchronising signals, and discharges during the intervals between them. If there were

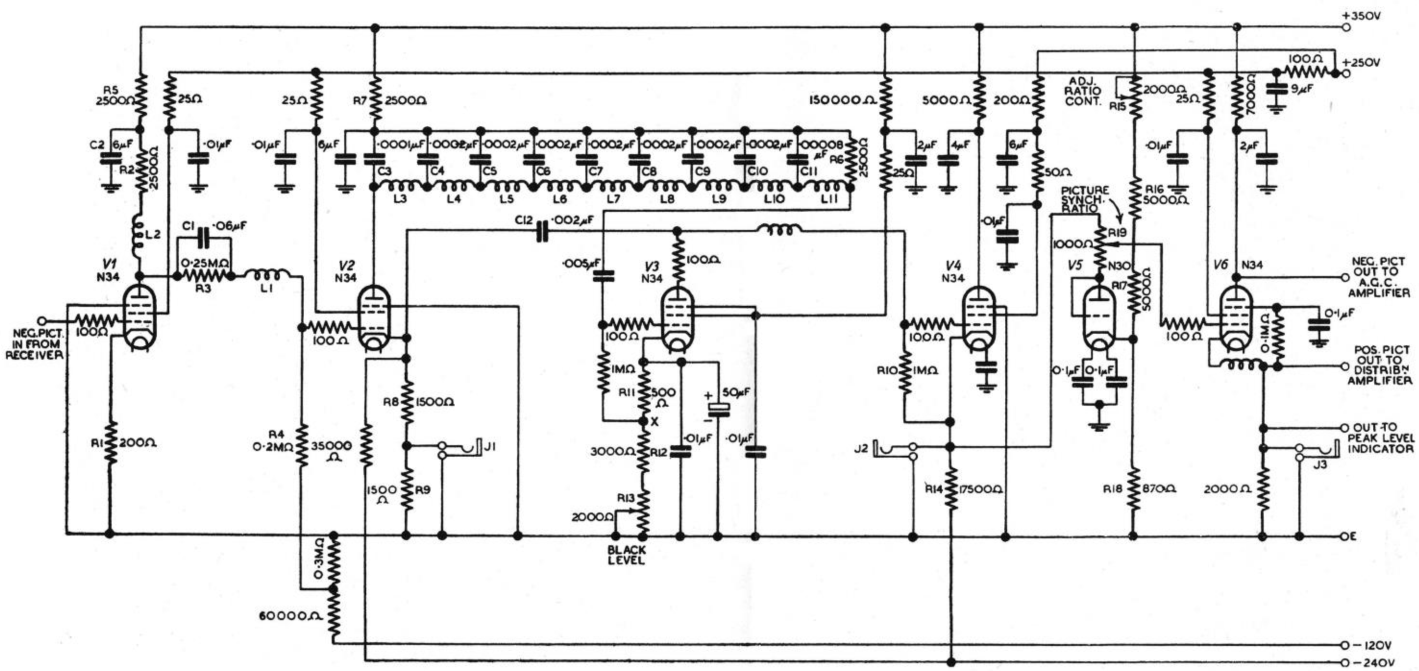


Figure 6. The Receiving Amplifier

The A.G.C. Amplifier (*Contd*)

nothing but line synchronising signals, the A.G.C. voltage for a constant radio frequency signal strength would be steady. The presence of the frame synchronising components, however, introduce an irregularity.

During the greater part of the frame, when there are line synchronising signals but no frame synchronising signals, the condenser C_{12} is charged during the duration of a line synchronising signal, i.e. 10 micro-seconds, and has all the time of a line devoted to picture, i.e. 90 micro-seconds, in which to discharge. When, however, a broad pulse arrives, the condenser C_{12} is charged for 40 micro-seconds and is discharged only for 10 micro-seconds. The charging impedance is low, so that the potential reached during the longer period of charge is no greater than that reached during the shorter period of a line synchronising signal. However, since the discharge time constant is long, the condenser does not discharge so much in the 10 micro-second discharge period as it does in the 90 micro-second discharge period following the line synchronising signal. The result is that the grid of V_{17} is a little more negative after the frame synchronising signals have ceased than during the longer period of line synchronising signals. If this were not corrected, the picture would appear to be darker at the top than at the bottom owing to the increased value of A.G.C. during the period corresponding to the upper parts of the picture. To avoid this the elements R_{26} and C_{11} are inserted, the effect of which is, in co-operation with the resistance R_{27}, to introduce a bass loss into the synchronising pulses, which charge the condenser C_{12} via the diode V_{16}. The duration of the frame signals is therefore reduced and the picture appears of uniform brightness.

It will be realised that whereas the figures quoted in the above description for black level in various parts of the circuit will be correct in all circumstances, those quoted for the amplitudes of synchronising signals are necessarily values applying to a particular input field strength. Naturally if the input field strength is weak, the amplitude of the synchronising signals will be less than the quoted figure of 80 V. at the anode of V_{15}, and the D.C. bias generated will be correspondingly lower. The value of this bias, which is read on the meter designated **A.G.C. Level,** is of the order of — 12 V. for a good average signal. A signal which sets the A.G.C. voltage to a value less than — 8 V is found to be too weak to be suitable for re-radiation.

The Peak Level Indicator

The function of the Peak Level Indicator is to measure separately the amplitude of the synchronising signals and the peak amplitude of the picture signals at the point where they emerge from the Receiving Amplifier and enter the Distribution Amplifier. In both cases the amplitude at this point is required to be 17½ volts.

These levels are read on two moving coil meters mounted on a separate panel, and they are fed from valve circuits located in the unit known as the Peak Level Indicator, the circuit of which is given in Fig. 7. It will be seen that there are four valves, of which V_1 and V_3, a diode and cathode follower respectively, are used for measuring the synchronising signals, and V_2 and V_4, a similar pair are provided for measuring the picture signals.

An input derived from the output cathode follower of the Receiving Amplifier is connected to terminal 5 of the Peak Level Indicator, and assuming the switch S to be in the position designated **Operate,** the input is applied simultaneously to the cathode of V_1 and the anode of V_2.

The section of the unit which deals with picture signals will first be considered. The cathode of the valve V_2 is taken via the high resistance R_2 to the point A on the potentiometer R_3, R_4, R_5, R_6, R_7, where it finds a positive potential of about 25 volts. The black level at the anode of V_2 will be that obtaining at the output of the Receiving Amplifier, viz. + 33 V., so that under black level conditions there will be a few volts difference of potential between the anode and cathode of V_2, and a small current will flow through this valve. Since under these conditions the impedance of V_2 will be comparatively low, whereas R_2 is a very high resistance, the cathode of V_2 will take up the same potential as that of its anode, namely, the input black level of + 33 V. This is applied to the grid of V_4, to which the cathode of V_2 is connected. The cathode of the latter valve is connected to the picture meter, the other side of which is returned to the point B on the potentiometer R_8 R_9 R_{10} R_{11}, this point being so chosen that a positive potential is imposed upon the cathode of V_4 which is greater than the black level of + 33 V. existing at the grid by an amount sufficient to bias V_4 nearly to its bottom bend. The dial of the picture meter is calibrated in volts from zero to 25, and a reading of zero corresponds to the passage of a certain fixed current through the meter. This minimum current depends upon the point to which V_4 is biased, and is controlled by the potentiometer R_8, which is accordingly designated **Picture Zero.** If now a picture signal appears at the input, the voltage on the anode of V_2 will rise to + 50½ in the case of a full white signal. This additional voltage will appear across R_2, and will therefore be applied to the grid of V_4, the current through which will be increased. The picture meter will therefore read.

The resistance R_2 is shunted by the condenser C_2, the time constant of C_2 R_2 being 5 seconds, this comparatively long time constant enabling the general order of picture peak amplitude to be measured while passing over more rapid changes of an unimportant nature.

Considering now the arrangements for measuring the amplitude of the synchronising signals, the anode circuit of the diode V_1 contains the high load resistance R_1, which is returned to the junction of the resistances R_4 and R_5, and finds there a positive voltage of somewhat over + 200 V. Under black level conditions the cathode of V_1 is at + 33 V., and so there is a continuous flow of current through V_1. Owing to the impedance of this valve being small compared with R_1, its anode takes up the same potential as its cathode, namely, the input black level of + 33 V. This anode potential

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is applied to the grid of V_3. As in the case of the picture meter arrangements, the cathode of V_3 supplies the sync meter, the other side of which is returned to the point C on the potentiometer $R_{12}\,R_{13}\,R_{14}\,R_{15}$. The potential at this point, which is adjustable by means of R_{12}, is arranged to be approximately the same at black level as that of the grid of V_3, so that this valve is on the point of drawing grid current. In these circumstances therefore it is passing a comparatively large current, and the sync meter is fully deflected. Its dial, however, is calibrated so that under these conditions the reading is

It will be noted that in view of the fact that at black level the operating point of the valve V_4 is at, or very near, its bottom bend, the valve cannot be energised by a signal appreciably negative with respect to black level. It is not therefore influenced by the synchronising components of the input. Similarly, the operating point at black level of V_3 is such that the valve is just about to take grid current, and it cannot be energised by a signal positive with respect to black level, as owing to the presence of the high resistance R_1,

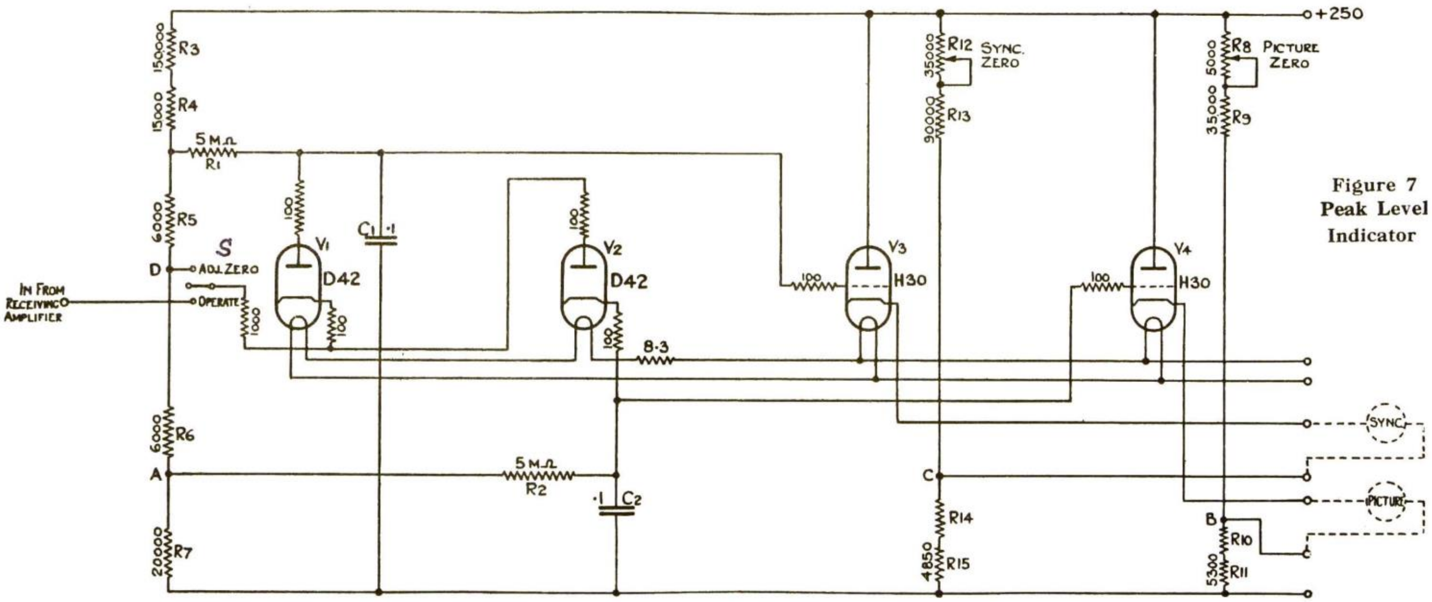

Figure 7
Peak Level Indicator

zero, and a reduction in current through the meter will give rise to an apparent increase of its reading. The standing current through the meter is adjusted by means of R_{12}, which is consequently designated **Sync Zero.** When the synchronising signal appears at the input, the cathode potential of V_1 will be reduced, and the current through this valve will increase. Owing to the presence of the anode resistance R_1, the anode potential of V_1, which is also the grid potential of V_3, will drop. The current through V_3 will now decrease, and a reading will appear on the sync meter. The presence of the large condenser C_1 between the anode of V_1 and earth gives the circuit a time constant of 5 seconds, as in the case of the picture measuring circuit.

no voltage corresponding to such a signal would be developed at its grid. This therefore prevents it from being energised by the picture signals.

The current flowing through both the picture and sync meters must be so adjusted that at black level they read zero. In order to make this adjustment, the switch S is turned to the **Adj. Zero** position, when the cathode of V_1 and the anode of V_2 are both connected to the point D, where there is a fixed potential of + 33 V., i.e. an artificial black level. In this condition the resistances R_8 and R_{12} are adjusted to give a zero reading on the picture and sync meters, and the circuit will then read correctly if the incoming black level has been properly restored to +33 V. in the Receiving Amplifier.

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Adjustment and Operation

(1) Switch on the 240 V. A.C. supply to the equipment.

(2) Switch on the L.T. and H.T. units. Also switch on the Waveform Monitor.
Owing to the action of a thermal delay circuit the H.T. itself will not be connected until about one minute has elapsed. The apparatus should now be left on for 5 to 10 minutes to warm up.

(3) Check the H.T. Stabiliser output voltages.
No. 1 Stabiliser should have output voltage at push button 4 of 300 V.
No. 2 Stabiliser should have output voltages at push button 4 of 350 V. and at push button 3 of 250 V.

(4) Adjust the Peak Level Indicator.
The selector switch on this apparatus should be set to **adj. zero.** If the apparatus is already correctly adjusted and thoroughly warmed up, the **picture** and **sync** meters will read zero. If they do not do so the **sync zero** and **picture zero** controls of this panel should be adjusted until the meters read zero, after which the selector switch is returned to **operate**.

(5) Operate the **gain control** switch on the Receiver to the **off** position.

(6) Adjust the **signal level adjustment** potentiometer until the **signal level** meter reads + 9 V.

(7) Adjust the Receiving amplifier.
In the first place it must be set so that the new black level to which black is restored is + 33 V. at the output. Secondly, it must be so adjusted that the control designated **picture sync ratio** acts truly as a potentiometer across the vision part of the signal only, and not across the synchronising components. This is achieved by ensuring that the cathode potentials of V_4 and V_5 in this unit are the same at black level.
The adjustment procedure for carrying this out is as follows.

(*a*) With the **gain control** switch **off,** the potentiometer designated **adjust ratio** control should be turned fully anti-clockwise.

(*b*) The potentiometer designated **picture sync ratio** should be turned fully clockwise.

(*c*) The **black level** control is adjusted until the peak indicators both read zero.

(7)(*d*) The **picture sync ratio** potentiometer should be turned fully anti-clockwise and no change should be noted on the **peak** indicators.

(*e*) The **adjust ratio** control should be rotated until about + 1 V. is indicated on the **sync** meter and a corresponding reading of – 1 V. is indicated on the **picture** meter. Both these readings will, of course, be beyond the respective zeros.

(*f*) The **black level** control is adjusted to give zero once more on both peak voltmeters.
It is now a good practice to obtain an input from the transmitter of black level and synchronising signals. If this can be done, the **gain control** switch on the Receiver should be adjusted to **manual** and the **manual gain control** potentiometer should be adjusted until 17½ V. of synchronising signal is read on the **sync** meter. Upon turning the **picture sync ratio** control to the extreme clockwise position corresponding to maximum picture amplitude, no reading should be recorded on the **picture** meter since the input consists only of black level and synchronising signals. If, however, a small reading is obtained on the **picture** meter, this will indicate a slight error of adjustment of the black level; the **black level** potentiometer on the Receiving Amplifier should therefore be readjusted accordingly.

(8) A normal input consisting of Art Bars or picture should now be obtained, and the following final adjustments made.

(*a*) The tuning should be checked so that it corresponds with the minimum reading on the **signal level** meter. If the signals are being examined on the Signal Monitor from the jack **J1** on the Receiver, this condition should correspond with a maximum amplitude of the Signal Monitor.

(*b*) The reading of 17½ V. on the **sync** meter should be finally checked and adjusted by means of the **manual gain control** potentiometer if the receiver is being used with manual control, or by means of the **A.G.C. level adjustment** control if the receiver is being operated with automatic gain control.

(*c*) The **picture sync ratio** control should be adjusted to give 17½ V. on the **picture** meter.

(*d*) A final check of black level should be made by returning the **gain control** switch to the **off** position, and adjusting the **black level** potentiometer to give zero on both **picture** and **sync** meters.

(*e*) On returning the **gain control** switch to either the **manual** or **automatic** positions, whichever is being used, the receiver is now completely adjusted.

Maintenance and Testing

The Receiver. The following anode feeds should be obtained when the Receiver is in normal operation and correctly tuned.

Key No.	*Meter Reading*	*Anode Current* mA
1	7	7
2	4.5	4.5
3	4.4	4.4
4, 5, 6, 7 & 8	2.2	2.2
9	4.9	4.9
10	4.1	4.1
11	4.5	4.5
12	3.1	31
13	5 — 5.5	10 — 11 (According to the setting of the **signal level adjustment potentiometer.**)
14	2.5 — 9.5	5 — 19 (With switch in **off** position, this reading varies with the setting of the **A.G.C. level adjustment** potentiometer.)
15	2	2

The Receiving Amplifier. With no input applied, i.e. with the **gain control** switch on the Receiver in the **off** position, so that + 9 V. is applied to the input of the Receiving Amplifier, the feeds of the valves should be as follows.

Valve	*Meter Reading*	*Anode Current* mA
V 1	30	60
V 2	3.6	3.6
V 4	28.5	28.5
V 6	16.5	16.5

When the apparatus is in use for receiving signals, the jack **J1** in the cathode circuit of V_2 should show 12 V. of sync signals accompanied by picture signals according to ratio. The jack **J2,** connected to the cathode circuit of V_4, should show 20 V. of synchronising signals accompanied by picture signals according to ratio. The third jack **J3,** connected to the cathode of V_6 should show 17.5 V. of sync signals, accompanied by 17.5 V. of picture signals.

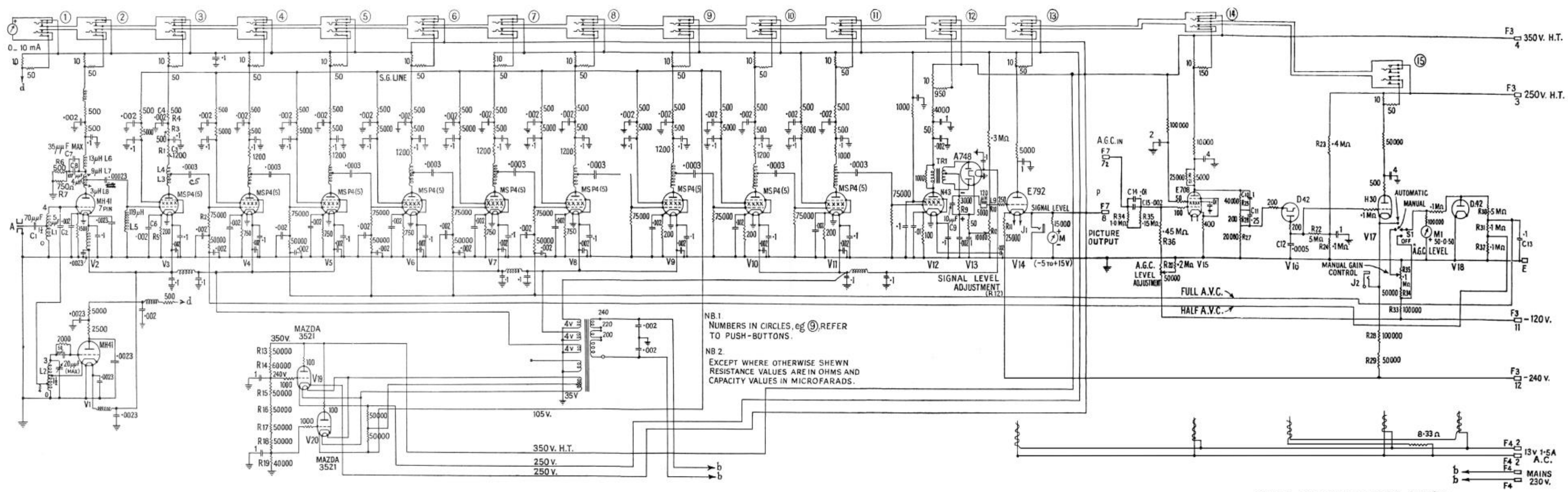

Figure 8. The Receiver and A.G.C. Amplifier