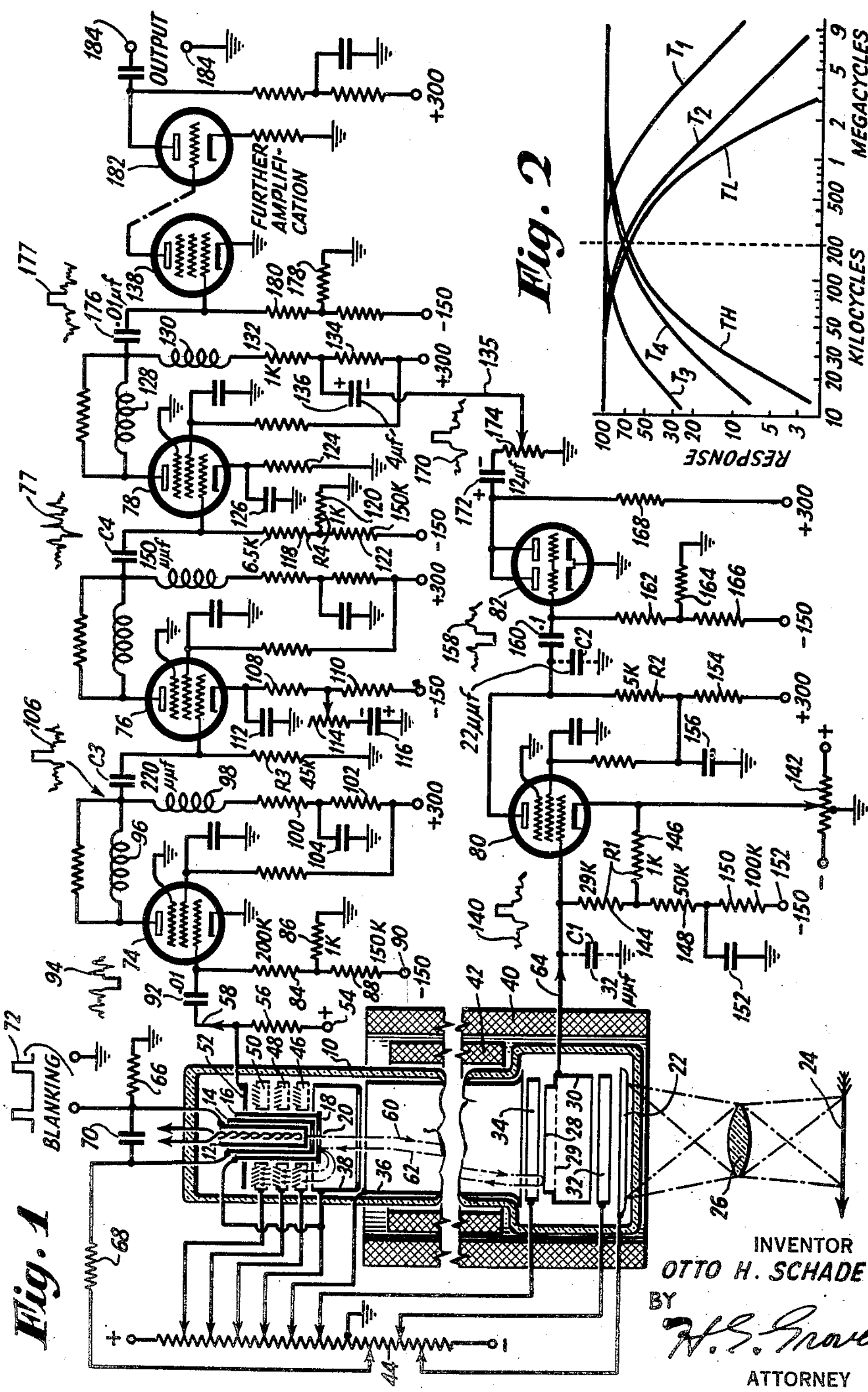
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VIDEO AMPLIFIER WITH SEPARATE CHANNELS FOR HIGH AND LOW FREQUENCIES

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VIDEO AMPLIFIER WITH SEPARATE CHANNELS FOR HIGH AND LOW FREQUENCIES

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The present invention relates to an improvement in video amplifiers to be used in connection with a television pick-up or camera tube of the Orthicon type wherein an electron multiplier is provided in the tube and wherein the video signals are derived both from the signal plate or target electrode of the Orthicon tube and from the final collector electrode of the electron multiplier within the tube.

In a television pick-up tube of the Orthicon type, a low velocity cathode ray beam is provided for scanning a target surface upon which a positive electrostatic charge image is produced. Only such electrons as are necessary to substantially cancel the positive electrostatic charge image at the target surface, or to bring the surface to a uniform datum potential level, are removed from the scanning cathode ray beam and the remaining electrons constituting the beam are returned through the tube along substantially the same path over which they travelled in reaching the vicinity of the target electrode. In certain types of Orthicon tubes, however, "lifter" plates have been provided in order that different paths may be traversed by the outgoing or scanning beam and the returned beam of electrons. Regardless of the actual path traversed by the returning beam of electrons, this returning beam is current modulated due to the subtraction of electrons from the scanning beam by the target surface to at least partially cancel the electrostatic charge image thereat, and the current modulation of the returning beam of electrons represents a source of video or image signals.

It is frequently desirable to incorporate within the Orthicon, one or more stages of electron multiplication in order to increase the video signal intensity so that the signal-to-noise ratio of the signal obtained from the Orthicon tube may be materially improved.

In Orthicon tubes where the returning cathode ray beam traverses substantially the same path as the outgoing or scanning cathode ray beam, the first secondary electron emitter of the electron multiplier (i. e., the first stage of the electron multiplier) is generally positioned relatively adjacent the electron gun structure and, in some instances, is a part of the beam forming electrode of the electron gun structure. This beam forming electrode is provided with a very small aperture (of the order of a few mils in diameter) in order to reduce the spot size of the scanning cathode ray beam. In spite of this location of the first stage of the electron multiplier, the returning beam of electrons does not continuously impinge upon the identical area of the surface of this emitter but, instead, moves about to a certain extent in accordance with the horizontal and vertical scanning deflections of the scanning beam. The returning beam of electrons, therefore, actually scans a very small and reduced portion of the surface of the first stage of the electron multiplier even though this surface is located very closely adjacent to, and frequently forms a portion of the beam forming aperture of the electron gun structure. This small movement or scanning action of the return beam over the surface of the first stage of the electron multiplier produces undesired variations in the current intensity of the electrons derived from this emitter of the multiplier other than those current variations brought about by reason of the current modulations of the returning cathode ray beam. This undesired variation is by reason of the fact that different portions of the surface of the secondary emitter are not absolutely uniform or identical in emission response and as the returning cathode ray beam moves slightly over the surface of this first stage of the multiplier, undesired variations occur in the amount of current obtained from this emitter.

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If the surface of the first stage of the electron multiplier were absolutely uniform in its secondary emission response, then the current variations of the electrons produced by this emitter would be proportional to the current modulations of the returning cathode ray beam. Under such conditions, no undesired modulations would exist and no undesired dark spot signal would be present. When an undesired modulation in the current obtained from the first stage of the multiplier (as a result of the non-uniform emission characteristics over the surface of the emitter) is superimposed upon the video signals, this undesired current modulation produces a dark spot in the resultant image. In previous circuit arrangements, this undesired dark spot has been substantially eliminated by dark spot compensation injection signals as is conventional practice where pick-up tubes of the Iconoscope type are employed. Such a method of reducing the effects of the dark spot signal is entirely satisfactory, however, rather than reduce the undesired dark spot to a negligible value by shading signal injection, it is preferable to effectively eliminate the production of the dark spot signal and thus preclude its presence in the video signals thereby

obviating the necessity of compensating for dark spot by shading control signal injection.

The United States Patent 2,525,105, issued to Paul K. Weimer on October 10, 1950, discloses an arrangement of and method for operating a television camera or pick-up tube of the Orthicon type wherein it is possible to produce video signals in which undesired dark spot signals are not present even though an electron multiplier is used in the tube. As explained in the above referred to Weimer patent, the undesired dark spot signals are eliminated from the video signal by obtaining from the electron multiplier only such video signals as fall in a frequency spectrum in which no undesired dark spot signals are inherently present. Since the dark spot signals are represented by relatively low frequencies, if the video signals that are derived from the final collector electrode of the electron multiplier are confined to that portion of the frequency spectrum above, for example, 200 kilocycles per second, then no dark spot signal will be present since the signals representing the dark spot are substantially entirely confined to freuencies lower than 200 kilocycles per second. In order to supply those portions of the video signal spectrum below, for example, 200 kilocycles per second, the above mentioned Weimer application proposes deriving such a portion of the video signal from the signal plate of the target electrode of the Orthicon tube. No dark spot signals are present at this electrode since in the Orthicon, no secondary electrons are produced by the scanning action of the scanning cathode ray beam. The low frequency components of the video signals are, therefore, obtained from the signal plate of the target electrode whereas the high-frequency components of the video signals are obtained from the final collector electrode of the electron multiplier in the Orthicon pick-up tube. Such an arrangement does not defeat the purpose of the electron multiplier since the decidedly improved signal-to-noise ratio may still be maintained in the high-frequency components where an improvement in the signal-to-noise ratio is most desirable.

The low and high frequency components so obtained from the television camera or pick-up tube are then combined and in combining the signals it is necessary that they be combined in proper relative amplitudes and that the phase relationship of the combined signals be proper in order that there will be present no phase distortion or phase shifting throughout the entire video spectrum. After the signals have been so combined, they are then applied to further video amplifiers and the video signal is then used to modulate a radio frequency carrier after the necessary blanking, synchronizing and other pulses have been added in a manner well known to those skilled in the art.

The present invention is, therefore, concerned primarily with the combining of the low and high frequency components of the video spectrum in order that the relative amplitudes of the signals in these two portions as well as their phase relationship will be proper so that no distortion or undesired effects will be produced. By reason of the presence of the electron multiplier, the high frequency components of the video signals (i. e. those over, for example, 200 kilocycles per second) will have an intensity as derived from the tube considerably in excess of the intensity of the low frequency components of the video signals as derived from the signal plate of the target electrode. The low frequency components will, therefore, require amplification before the signals can be combined.

As a matter of fact, a complete video signal series is obtainable from both the signal plate and from the collector electrode of the electron multiplier. No undesired shading signals are present in the video signals from the signal plate. However, as stated above, undesired dark spot signals are frequently present in the video signal series as derived from the electron multiplier. In the present invention signals from each of these two sources are applied to two separate amplifiers which have different frequency characteristics and which operate to amplify and attenuate different portions of the video signal spectrum. For example, the amplifier to which the video signals derived from the signal plate of the target electrode are applied is in effect a low pass amplifier, in which signals below approximately 200 kilocycles per second are amplified and passed through the amplifier whereas signals above 200 kilocycles per second are attenuated. The amplifier to which are applied the video signals as derived from the electron multiplier is in effect a high-pass amplifier where signals up to approximately 200 kilocycles per second are attenuated whereas signals above 200 kilocycles per second are amplified and are permitted to pass through the amplifier. The overall gain of each of the two amplifiers is so adjusted with respect to each other that the output of each amplifier (i. e. those portions of the video signal spectrum that are passed by each amplifier) bear a proper relative signal intensity so that they may be satisfactorily combined. Some provision is naturally made whereby the relative amplitudes of the signals at the outputs of the amplifiers may be regulated and controlled.

In addition to the requirement that the relative amplitudes of the video signal output from the amplifiers be properly related, it is also necessary that each amplifier exhibit inverse characteristics insofar as phase distortion of the signals is concerned so that if any undesired phase displacement occurs in one of the amplifiers, it is compensated by an equal and opposite phase displacement in the other amplifier (in the frequency region of overlap of the two amplifiers). Furthermore, the phase shifting in the amplifiers must be so compensated that, when the two portions of the entire video spectrum from the two amplifiers are combined, any phase shift that may be present in the combined video signals will be directly proportional to frequency so that no distortion will be introduced. After the signals are combined, the entire spectrum of the video signals is again present in a single channel and these signals may be applied to a further amplifier and, ultimately, the signals may be used to amplitude or frequency modulate a radio frequency carrier after the necessary blanking and synchronizing impulses and other necessary controls have been exercised on the video signal series.

It is, therefore, one purpose of the present invention to provide, in a television transmitter where a television camera pick-up tube of the Orthicon type is employed and in which the pick-up tube includes an electron multiplier, a pair of pass-band amplifiers to each of which is applied individually, video signals from the signal plate of the pick-up tube and video signals from the electron multiplier of the pick-up tube.

Another purpose of the present invention resides in the use of separate high-pass and low-

pass video signal amplifiers for amplifying video signals obtained from two separate video output conductors associated with an Orthicon tube in which the amplifiers provide video signals of proper relative amplitudes and of proper phase relationship so that they may be combined.

Still another purpose of the present invention resides in applying similar and related television video signals to two separate amplifiers in which one amplifier operates to increase the intensity of one portion of the video spectrum while the other amplifier operates to increase the intensity of the other portion of the video spectrum together with circuit arrangements whereby the relative amplitudes and phase relationship of the signals available from the outputs of the two amplifiers are such that the amplified signals may be combined to a normal signal.

A still further purpose of the present invention resides in the provision of two amplifiers each of which are capable of amplifying different portions of the spectrum of a video signal series and in which the degree of undesired phase displacement present in the amplifiers is substantially compensated so that signals available at the outputs of the amplifiers may be combined without introducing phase distortion.

Various other purposes and advantages of the present invention will become more apparent to those skilled in the art from the following detailed description particularly when considered in connection with the drawing, wherein:

Figure 1 represents a preferred form of the present invention; and

Figure 2 represents curves used in explaining the theory of operation of the present invention.

Referring now to the drawings, and, more particularly, to Figure 1 thereof, there is shown an Orthicon camera or image pick-up tube 10 of the image intensifier type. The tube includes an electron gun structure having a cathode 12, a control electrode 14 and an accelerating electrode 16. This electron gun structure is positioned at one end of the tube and functions to generate a narrow focussed cathode ray beam. The accelerating electrode 16 is provided at its forward end with a flat surface 18 which is in fact the first emitter of an electron multiplier as will be described later. The end surface 18 is provided with a small aperture (of the order of 2 or 3 mils in diameter) which functions as the beam forming aperture of the electron gun structure.

The opposite end of the Orthicon tube is provided with an electrically conducting light responsive surface 22 upon which an optical light image of an object area 24 is projected by means of a lens system 26. Behind the light responsive surface of the photo-cathode 22 is a target electrode 28 generally made of a wafer of very thin glass. Adjacent one face of the target electrode 28 is a fine mesh screen 29 which forms a signal plate. This conducting screen or signal plate is in electrical contact with the photo-electron accelerating electrode element 30. The accelerating electrode 30 and the conducting screen or signal plate are normally operated at a substantially fixed potential generally at or near ground potential. The conducting photo-cathode 22 is operated at a negative potential with respect to the signal plate and intermediate the photo-cathode 22 and the signal plate (or target electrode 28) is an electrode 32 which is maintained at an intermediate potential. The electrode 32 is, therefore, positive with respect to the photo-cathode yet negative with respect to the signal plate. When an optical image is projected upon the photo-cathode 22, photo-electrons are emitted from the surface of the photo-cathode in an amount depending upon the intensity of the optical image. These photo-electrons are then accelerated in order that they impinge upon the front surface of the target electrode with sufficient velocity to generate secondary electrons, which in turn are absorbed by the screen 29 associated with electrode 30. By reason of the emission of photo-electrons an electronic current image is present between the photo-cathode and the target electrode and since secondary electrons of a ratio greater than unity are produced at the target electrode due to the impacting photo-electrons, an intensified positive electrostatic charge image is produced over the surface of the target electrode corresponding to the optical image projected on the photo-cathode.

Intermediate the target electrode 28 and the electron gun structure are additional electrodes 34, 36 and 38 to which are applied potentials in an increasing positive polarity. The potentials of these electrodes assist in maintaining proper velocity of the scanning cathode ray beam at the target electrode as well as to accelerate and direct the return beam of electrons to the first emitting surface 18 of the electron multiplier. The path of the outgoing scanning cathode ray beam 60 and the return cathode ray beam 62 is represented by broken lines in Figure 1 of the drawing.

Surrounding the image Orthicon tube 10 is a focussing coil 40 to which is applied a direct current for producing an electromagnetic field extending through and parallel to the axis of symmetry of the tube. This electromagnetic field assists in maintaining a desired focal condition of the scanning and return cathode ray beams. Positioned between the focussing coil 40 and the pick-up tube 10 are the deflection coils 42. These coils surround only a portion of the length of the Orthicon tube and to these coils are applied appropriate horizontal and vertical deflection voltage variations from appropriate deflection generators (not shown). The deflection coils produce alternating electromagnetic fields in both horizontal and vertical directions at different rates in order to affect the desired scanning operation as is well known to those skilled in the art. The resultant field produced by the combination of the field produced by the deflecting coils and the field produced by the focussing coil bring about the desired deflection in the cathode ray beam, yet the desired focal condition of the beam is maintained during its travel to and from the target surface. Appropriate relative potentials may be applied to the various electrodes included within the Orthicon tube 10 by means of a potential divider 44 or by any other appropriate means.

The electron multiplier includes as its first emitting surface the end 18 of the accelerator 16 of the electron gun structure and the secondary electrons emitted at this surface are directed upon the second stage 46 of the electron multiplier. The electrode 38 assists in "persuading" or directing these secondary electrons upon the second stage 46 of the multiplier and this stage of the multiplier is annular in construction and surrounds the electron gun structure. Naturally, the emitting surface of this stage of the multiplier is maintained at a potential more positive than the first emitter 18. The secondary electrons available from the second stage 46 of the multiplier

are directed against the third stage 48 where additional secondary electrons are produced and these in turn are directed against the fourth stage 50 of the multiplier where the produced secondary electrons are directed against a collector electrode 52. In the multiplier shown in the drawing, four stages, each including secondary electron emitters having a ratio greater than unity, are provided and these stages are represented at 18, 46, 48 and 50. It, is, of course, obvious that a greater or lesser number of stages may be included in the electron multiplier. The collector electrode 52 is, of course, maintained at the most positive potential and between the collector electrode 52 and the positive terminal 54 of a source of potential is a load resistance 56 across which video signals may be obtained. Conductor 58 is provided for obtaining the video signal series from the electron multiplier portion of the Orthicon tube.

When the cathode ray beam is directed toward the target electrode 28 and when a positive electrostatic charge image is present at that electrode, a certain number of electrons constituting the beam will be utilized in neutralizing at least a portion of the electrostatic charge image while the remaining electrons are returned and directed upon the first emitter 18 of the electron multiplier. By reason of this removal of a continually varying number of electrons from the scanned beam 60, a current modulation is present in the return beam 62 and this current modulation is representative of the light values of the optical image provided on the photo-cathode 22. Due to the scanning action, video signals are also available from conductor 64 which is connected to the conducting surface or signal plate on the front side of the target electrode 28.

In television pick-up tubes of the Orthicon type where the video signals are derived solely from the returning cathode ray beam, with or without an electron multiplier, and where no video signals are derived from the signal plate of the target electrode, blanking during beam return time is normally accomplished by applying a voltage variation of rectangular waveform to the target electrode. This voltage variation is represented as negative pulses which occur in phase with the horizontal and vertical return deflections of the scanning cathode ray beam, and, inasmuch as they extend in a negative direction, they preclude the absorption of any of the electrons constituting the scanning cathode ray beam during both the horizontal and the vertical return strokes. A correct black level is, therefore, established in the signal series. In the subject invention, however, such a form of blanking cannot well be employed since video signals are derived from the signal plate associated with the target electrode. If the above referred to type of blanking were employed, a rather objectionable voltage variation would be introduced into the amplifier associated with the signal plate of the target electrode. Since it is preferable not to inject such a signal into that amplifier, blanking in the present invention is accomplished by modulating both the cathode and control electrodes of the electron gun structure. In order that a modulation may be simultaneously applied to these two electrodes of the gun structure, the cathode 12 of the electron gun is connected to ground (or a point of fixed potential) by means of a resistance or impedance 66 and a further resistance or impedance 68 is included between the control electrode and the source of biasing potential. A condenser 70 is connected between the control electrode 14 and the cathode 12. Blanking potentials of a waveform such as represented at 72 are then applied between the cathode 12 and ground (or the point of fixed potential) and by reason of the presence of the condenser 70 these same blanking impulses are applied to the control electrode 14. The presence of resistances or impedances 66 and 68 permit the potentials of these two electrodes to be modulated. The blanking impulse is in a positive direction and as a result the velocity of the generated cathode ray beam is reduced during both the horizontal and vertical return deflections. Accordingly, by so reducing the velocity of the beam it is precluded from coming sufficiently close to the target electrode to permit any electrons to be absorbed therefrom during the fly-back time. It is desirable that both the cathode and the control electrode be simultaneously modulated by substantially the same extent in order that the current intensity of the cathode ray beam will not be altered during the blanking interval since it is imperative that the current intensity of the developed cathode ray beam be maintained substantially constant. If the current intensity of the cathode ray beam were altered during the blanking interval, then a corresponding disturbance on signals would be generated in the video signal series as derived from the electron multiplier by way of conductor 58 since the current modulation of the generated cathode ray beam would be reflected into the amplifier by the electron multiplier. Accordingly, by modulating both the cathode and the control electrode of the electron gun structure in a positive direction during both the horizontal and vertical return strokes of the cathode ray beam, an effective blanking impulse can be applied to the Orthicon and a true black level signal will be obtained from both conductors 58 and 64 during the blanking interval. Technically, the extent to which the cathode and control electrode are pulsed in a positive direction during blanking should not be identical since a change in the cathode potential in a positive direction effectively amounts to a change in the screen grid potential in a negative direction. Accordingly, the extent to which the control electrode is pulsed in a positive direction might, in some instances, be preferably less than that of the cathode.

As explained above, the returning cathode ray beam 62 does not continuously impinge upon the same area of the first stage 18 of the electron multiplier but instead actually scans a small area or portion of this electrode in accordance with the deflection forces applied to the scanning cathode ray beam. Since the surface 18 is not entirely uniform insofar as its secondary electron emission ratio is concerned, an undesired variation in the number of secondary electrons produced at the first emitter 18 takes place which results in an undesired modulation of the current from this emitter. The frequencies of this undesired modulation are relatively low and if eliminated by the amplifier associated with the conductor 58 will result in the elimination of the undesired dark spot signal. Accordingly, the amplifier including tubes 74, 76 and 78 to which the video signals are applied from the electron multiplier by way of conductor 58, has a characteristic such that it amplifies that portion of the video signal spectrum above approximately 200 kilocycles per second with the result that

signals having a frequency corresponding to the undesired dark spot are attenuated or substantially eliminated. A second amplifier which includes tubes 80 and 82 is provided and is associated with conductor 64. This amplifier is, therefore, supplied with the video signals obtained from the signal plate of the target electrode 28 and is effective, primarily, for amplifying that portion of the video signal series below approximately 200 kilocycles per second.

The amplifier tube 74 includes at least a cathode, a control electrode and an anode. The cathode is preferably connected to ground potential while the control electrode is connected to ground through resistors 84 and 86 in series. In order to apply proper biasing (of approximately 1 volt) to tube 74, a resistor 88 is connected between the junction of resistors 84 and 86 and a source of negative potential 90. Since, in a television transmitter including the equipment described herein, a source of negative potential of 150 volts is available, the values of resistances 86 and 88 are so chosen that when a negative potential of 150 volts is applied to terminal 90, a resultant negative potential of approximately 1 volt is applied to the control electrode of tube 74 with respect to its cathode. It is to be understood, of course, that any other method of obtaining the desired bias on the control electrode of tube 74 could, in fact, be employed.

Video signals present on conductor 58 (which include the black level signals and undesired dark spot signals) are applied to the control electrode of tube 74 by way of condenser 92. The video signals derived from this conductor are represented in general by the curve 94 and signals representative of white extend in a positive direction whereas signals representative of black extend in a negative direction. These signals are amplified by the tube 74 and appear in reverse polarity in the anode circuit of tube 74 which includes a series of peaking coil 96, a shunt peaking cathode 98 and a load impedance 100. A decoupling resistor 102 and condenser 104 is also included in the anode circuit and a source of positive potential is applied to this circuit. The amplified signals represented by the curve 106 are then applied to the control electrode of tube 76 by way of condenser C3. The wave form of the signal after passing through the condenser C3 is somewhat different from that shown by curve 106 due to the loss of the lower frequencies. At this point in the amplifier, white in the video signal extends in a negative direction whereas black extends in a positive direction. The tube 76 includes at least a cathode, a control electrode and an anode and the cathode is connected to a source of negative potential by way of resistances 108 and 110. The cathode is also connected to a point of fixed potential by condenser 112 while the junction of resistances 108 and 110 is connected to ground by way of an adjustable resistance 114 and a relatively large condenser 116. This condenser, in combination with condenser 112, is a high peaking circuit that functions by variable degeneration of gain in tube 76 to compensate in a normal manner for the input capacitance effects of the grid circuit of tube 74. The time constant of the peaking circuit is adjusted by the variable resistance 114. The control electrode of tube 76 is connected to ground by grid resistor R3. The anode circuit of tube 76 includes a peaking arrangement similar to that associated with tube 74 so that amplified video signals are present at the junction of the series and shunt peaking coils associated with the tube 76. These amplified video signals, represented at 77, are then applied to the control electrode of tube 78 through coupling condenser C4 and the control electrode of tube 78 is maintained at proper operating potential with respect to its associated cathode by a circuit arrangement similar to that associated with the control electrode of tube 74. The control electrode is connected to ground by two series resistances 118 and 120 both of which, taken together, are designated as R4. The potential drop across resistance 120, which is connected in series with resistance 122, affords the necessary biasing for the control electrode of tube 78. To afford a little further biasing, the cathode of tube 78 is connected to ground by way of resistance 124 which is by-passed by condenser 126. The anode circuit of tube 78 includes series peaking coil 128, shunt peaking coil 130 and series resistances 132 and 134. A conductor 135 is connected to the junction of resistances 132 and 134. A conductor 135 is connected to the junction of resistances 132 and 134 by way of a coupling condenser 136. Amplified video signals are, therefore, present at the anode of tube 78 with the signals representing white extending in a negative direction and with the signals representing black extending in a positive direction.

Since the output from the low frequency component amplifier is combined (by way of conductor 135) with the output from the amplifier just described, and since the combined outputs from these amplifiers are applied to a further amplifying tube 138, the low frequency component amplifier will now be described.

Video signals derived from conductor 64 associated with the signal plate and target electrode of the Orthicon tube are applied to the control electrode of tube 80. Signals available at this point are represented by the curve 140 in which signals representative of white extend in a negative direction while signals representative of black extend in a positive direction. The tube 80 includes at least a cathode, a control electrode and an anode and the cathode of tube 80 is connected to a movable terminal of a potentiometer 142. A point along this potentiometer is connected to ground while positive and negative potentials of low intensity are applied to each end of the potentiometer 142 for a purpose which will be explained later. The control electrode of tube 80 is connected to the cathode by means of series resistances 144 and 146 which together are designated as R1. The junction of these two resistances 144 and 146 is connected to a source of negative potential by way of resistances 148 and 150. A secondary condenser 152 is connected between the junction of these two last named resistances and ground. Proper biasing potential is applied to tube 80 by means of the potential drop across resistance 146 which is connected to the negative terminal 152 in series with the resistances 148 and 150. A certain amount of distributed capacity is present between conductor 64 and ground and this distributed capacity is represented by the capacitor C1. The anode circuit of tube 80 includes load resistance R2 and decoupling resistance 154 and condenser 156. Amplified video signals are, therefore, present at the anode of tube 80 and these signals are represented in general by the curve 158 in which signals representing black extend in a negative direction. These signals are applied to the control electrode of tube 82 by way

of coupling condenser 160. The distributed capacity present between ground and the input circuit of tube 82 is represented by the condenser C2. The tube 82 includes at least a cathode, a control electrode and an anode and the cathode of this tube is connected to ground. The control electrode of tube 82 is connected to ground by way of grid resistances 162 and 164 while the junction of these resistances is connected to a source of negative potential by way of resistance 166. The potential drop across resistance 164, therefore, affords the necessary biasing for tube 82. The anode of tube 82 is connected to a source of positive potential by means of resistance 168 and, accordingly, amplified video signals are present at the anode of tube 82 as represented in general by curve 170 with signals representative of white extending in a negative direction and signals representing black extending in a positive direction.

It will be observed that the polarity of the video signals present in the anode circuit of tube 82 corresponds identically to the polarity of the signals present in the anode circuit of tube 78. The video signals present at the anode of tube 82 are applied to conductor 135 by way of coupling condenser 172 and their intensity may be altered by means of the potentiometer 174. Signals present on conductor 135 from the potentiometer 174 associated with the low frequency component amplifier including tubes 80 and 82 are, therefore, combined with the high frequency components of the video signal series by injection into the anode circuit of tube 78 through condenser 136. There are, therefore, present at coupling condenser 176, frequencies representative of the complete video signal series and this complete signal series is represented by curve 177 and is applied to the control electrode of tube 138. Proper biasing for tube 138 is provided by means of the potential drop across resistance 178 and the control electrode of this tube is connected to ground through series resistances 178 and 180. The output from tube 138 may then be applied to further stages of amplification, terminating with tube 182 where the amplified complete video signal series including the entire spectrum of frequencies may be made available between output terminals 184 associated with tube 182.

Tubes 74, 76, 78 and 138 are preferably pentodes of a type similar to the type 6AK5 while tube 80 is preferably of the type 6AC7 and tube 82 may be of the type 6J6, which is a dual triode, with the tube operated by connecting the elements in parallel. It is not intended to imply that only these specifically mentioned tube types may be employed since it is obvious that different types of tubes may be used so long as their characteristics are such as will afford and produce the desired results.

For practical purposes, it is desirable that the amplifiers above described for individually amplifying the high-frequency components and the low-frequency components of the entire video signal series possess the desired pass-band characteristics. To accomplish this purpose, the resistance-capacitance filters or networks which form a part of the amplifier circuits are very carefully chosen. The high-pass filter action of the amplifier to which signals are supplied from the multiplier by way of conductor 58, is obtained by decreasing the grid circuit time constant of tubes 76 and 78. The time constant associated with the grid circuit of tube 76 is determined by C3 and R3 while the time constant of the grid circuit of tube 78 is determined by C4 and R4. For the purpose of convenience, these two time constants will be designated as T3 and T4 respectively. The low pass filter action of the amplifier to which signals are supplied from conductor 64 is obtained by normal load resistances-tube capacitances in the amplifier. The first load resistance is R1 (resistances 144 and 146 in series) and the associated condenser C1 (the input tube capacitance of tube 80, together with some small distributed capacity between the wiring and ground) form a time constant circuit which will be designated as T1. Similarly, the load resistance R2 of tube 80 together with the input capacitance C2 of tube 82 form a second time constant circuit T2. The input resistance R1 and the time constant T1 are so chosen as to obtain a signal-to-noise ratio throughout the band of frequencies passed by this amplifier which is equivalent to or greater than that obtained from the electron multiplier in this particular range.

It has been found that to accomplish the desired results a particular relationship must exist between the time constants T1, T2, T3 and T4. This relationship may be expressed as a ratio in which T1:T2=T3:T4. In other words, the product of T1 and T4 should approximately equal the product of T2 and T3. In addition to this mathematical relationship, the values of the time constants must be so chosen that each amplifier will pass the desired bands of frequencies. For the particular values of circuit elements shown in Figure 1, the cut-off frequencies of the two amplifiers is chosen at approximately 200 kilocycles per second, as is shown in Figure 2 of the drawing. In this figure, a series of curves are shown representing the characteristics of the two amplifiers. The curve TL, for example, shows the response of the amplifier used to amplify the low frequency components of the video signal series while the curve TH represents the response of the amplifier associated with the electron multiplier of the Orthicon tube for amplifying the high frequency components. It will be observed that these two curves TL and TH cross at approximately 200 kilocycles per second and that the response of each amplifier is ½ or 70.7% at this point. The characteristics of the high-frequency component amplifier must also be so chosen that an effective rapid decay of black level signals from the multiplier during retrace time will result in order to prevent the black level setter or clamp circuit, included in further stages of amplifier, from responding to the signal intensity of signals obtainable from the multiplier and the high frequency amplifier. It is desirable for proper black level setting that the clamp circuit respond to signals obtained from the target electrode over conductor 64 and the low-frequency component amplifier. To assure that a proper black level is established, it may in some instances, be necessary to delay the clamp action so that it occurs during the latter portion of the retrace interval and during the latter portion of the time that a blanking impulse is applied to the cathode and a control electrode of the electron gun in the Orthicon or camera tube. The blanking interval may be of the order of 6 microseconds to assure that the black level is determined by the signal intensity obtained from the target electrode and low frequency component

amplifier, at which time the amplitude of the black level pulse passed by the high-frequency component amplifier has decayed to a negligible value due to the characteristics of that amplifier. Consideration of these particular problems, together with a satisfaction of the above mentioned relationship of the time constants, fairly definitely establish the permissible values of circuit parameters that constitute the various time constant circuits. As regards the matter of phase relationship, it will be observed that series and shunt peaking is employed in the amplifier associated with the multiplier of the Orthicon tube while no similar peaking is employed in the amplifier for amplifying the low-frequency components of the video signal series. The single high-gain stage including tube 80 of the low-pass amplifier, without the use of peaking coils, facilitates an exact match of complementary frequency and phase deviation in the two amplifiers.

Referring again to Figure 2, curve T1 represents the frequency response of the low-frequency component amplifier as a result of a time constant T1 while the curve T2 represents a response of the same amplifier as the result of the time constant T2. When both these time constant circuits are included in the amplifier, the resultant overall frequency response characteristic is such as that represented by the curve TL. Similarly, the curve T3 represents the response of the high-frequency component amplifier as a result of the time constant circuit T3 and the curve T4 represents the response of the circuit to the action of the time constant circuit T4. When both these time constants are included in the amplifier, the overall response may be such as that represented by the curve TH. The overall response of both amplifiers, when their outputs are combined, is represented by the straight horizontal line at the top of Figure 2.

Values of the various circuit parameters as indicated in Figure 1 of the drawing, are given by way of example only, since it is conceivable that some degree of selection is possible even though certain rather stringent conditions must be met. Furthermore, the values of these elements, and especially the values of the elements that constitute the time constant circuits referred to, depend considerably upon the cut-off frequency that is chosen. If a frequency other than 200 kilocycles per second were chosen, then naturally the values of the resistances and condensers constituting the time constant circuits would naturally be altered by a commensurate amount.

When two amplifiers are provided such as indicated in Figure 1, the output from the low frequency component amplifier may be combined with the output from the high frequency component amplifier by plate circuit injection as represented in Figure 1 and in the particular instance shown this is accomplished by coupling condenser 136 associated with the anode load circuit of tube 78 of the high frequency component amplifier. Although this specific type of signal injection is shown, it is conceivable that different types of signal injection or signal combining may be exercised. For example, it is possible to apply the signals from the low frequency component amplifier to the high frequency component amplifier by injection into the cathode circuit of tube 78. Under this circumstance, however, and in view of the low impedance associated with the cathode circuit of tube 78, the circuit parameter associated with tube 82 must also be altered in order that a proper impedance match may result.

The choice of the cut-off frequency of approximately 200 kilocycles per second appears to be desirable although a higher or lower frequency cut-off value could be employed. If a higher frequency were used an even more complete elimination of undesired spurious dark spot signals could be accomplished although there is a limit to a shifting of the cut-off frequency in this direction by reason of the signal-to-noise ratio at the grid of tube 89 as compared with the advantages obtained through the use of the electron multiplier portion of the Orthicon tube. If a lower frequency cut-off were employed, the undesired shading signal would not so completely be eliminated, but, on the other hand, a higher signal-to-noise ratio would result in the low frequency component amplifier.

From the above, it may, therefore, be seen that undesired dark spot signals may be eliminated from an Orthicon tube employing an electron multiplier through the use of two parallel operating amplifiers which are supplied with video signals individually from the electron multiplier portion of the Orthicon camera tube and from the target electrode of the same tube. It may also be seen that signals from these two sources may be passed through appropriate amplifiers having desired band pass characteristics and that the amplifiers described herein permit the combining of the signals passed thereby in proper amplitude and phase relationship so that substantially no distortion occurs in the entire video signal series.

I claim:

1. A pair of parallel operated band pass amplifiers for amplifying television video signals comprising a first amplifier to which is applied a video signal series for amplifying the low frequency components of the video signals, said amplifier including at least one amplifying stage having an input load resistance-tube capacitance time constant T1, said amplifying stage having an output load resistance-tube capacitance time constant T2, a second amplifier to which is applied a substantially similar video signal series for amplifying the high frequency components of the video signals, said second amplifier including at least two amplifying stages, each stage having elements constituting grid circuit time constants T3 and T4, the parameters of the two amplifiers being such that the product of the time constants T1 and T4 is substantially equal to the product of the time constants T2 and T3, and in which time constants T3 and T4 are of the order of ten times the time constants T1 and T2, respectively, and means for combining the outputs from the two amplifiers to produce a composite series of video signals.

2. A pair of parallel operated amplifiers for amplifying television video signals comprising a first amplifier for amplifying the low frequency components of an applied video signal series, said amplifier including an amplifying stage having an input load resistance-tube capacitance circuit constituting time constant T1 and an output load resistance-tube capacitance circuit constituting time constant T2, a second amplifier for amplifying the high frequency components of a substantially similar applied video signal series, said second amplifier including two amplifying stages, grid circuit elements associated with each amplifying stage constituting time constants T3 and T4, the values of said load resistances and grid

circuit elements being such that the product of the time constants T1 and T4 is substantially equal to the product of the time constants T2 and T3, and in which time constants T3 and T4 are of the order of ten times the time constants T1 and T2, respectively, and means for combining the outputs from the two amplifiers to produce a complete composite series of video signals.

3. A television video signal amplifier including a pair of parallel operated band pass amplifiers for amplifying video signals comprising a first amplifier for amplifying the low frequency components of the applied video signal series, said amplifier including at least one amplifying stage, the load resistance for the applied video signals and the distributed capacity constituting a time constant T1, an output load resistance for said amplifying stage, the load resistance and the tube capacitance of the amplifying stage constituting a second time constant T2, a second amplifier for amplifying the high frequency components of the applied video signal series, said second amplifier including at least two amplifying stages, each stage having an input coupling condenser and an associated grid resistance constituting time constants T3 and T4, the parameters of the time constant circuits being such that the ratio of the time constant T1 to the time constant T2 is substantially equal to the ratio of the time constant T3 to the time constant T4, and in which the time constants T1 and T2 have a value of the order of one-tenth the time constants T3 and T4, respectively, and means for combining the video signals available at the outputs of the two amplifiers into a single composite series of video signals.

4. A television video signal dual channel amplifier including a pair of parallel operated amplifiers for amplifying substantially identical video signals comprising a first amplifier for amplifying the low frequency components of the applied video signals, said amplifier including an amplifying stage, a load resistance for the applied video signals, which, together with the distributed capacity constitutes a time constant T1, an output load resistance for the amplifying stage, which, together with the tube capacitance constitutes a second time constant T2, a second amplifier for amplifying the high frequency components of the applied video signals, said second amplifier including two amplifying stages, each stage having an input coupling condenser and an associated grid resistance constituting time constants T3 and T4, the values of the resistances and capacitances of the two amplifiers being so chosen that the ratio of the time constant T1 to time constant T2 is substantially equal to the ratio of the time constant T3 to the time constant T4, and in which the time constants T1 and T2 have a value of the order of one-tenth the time constants T3 and T4, respectively, whereby, when the video signals available at the output of the two amplifiers are combined into a single composite series of video signals, the composite signals will contain substantially no phase distortion.

5. A television video signal amplifier including a channel for amplifying the low frequency components of an applied video signal series and a parallel operated channel for amplifying the high frequency components of a substantially similar applied video signal series, said low frequency component amplifier including at least one amplifying stage having an input load resistance-tube capacitance time constant circuit T1 to which the video signals are applied and an output load resistance-tube capacitance time constant circuit T2 to which the signals passed by said amplifying stage are applied, said high frequency component amplifier including at least two amplifying stages, each of said amplifying stages being preceded by grid time constant circuits T3 and T4, each time constant circuit comprising a series coupling condenser and a shunt grid resistance, the values of the elements constituting the various time constant circuits being so chosen that the product of the time constant circuits T1 and T4 is substantially equal to the product of the time constant circuits T2 and T3, and in which the time constants T3 and T4 are approximately ten times as large as time constants T1 and T2, respectively, and means for combining the amplified video signals available from both of the amplifying channels to produce a composite series of video signals which is substantially free of phase distortion.

6. A television video signal amplifier including a pair of parallel operated amplifying channels, one channel for amplifying the low frequency components of a video signal series and the other channel for amplifying the high frequency components of a substantially similar video signal series, said one channel including an amplifying stage having an input load resistance-tube capacitance time constant circuit T1 to which the video signals are applied and an output load resistance-tube capacitance time constant circuit T2 to which the video signals passed by said amplifying stage are applied, said other channel including two amplifying stages, each amplifying stage being preceded by a series coupling condenser and a shunt grid resistance constituting time constant circuits T3 and T4, the values of the elements constituting the various time constant circuits being so chosen that the product of the time constant circuits T1 and T4 is substantially equal to the product of the time constant circuits T2 and T3, and in which the time constants T3 and T4 are approximately ten times as large as time constants T1 and T2, respectively, and means for combining the amplified video signals available from both of the amplifying channels to produce a composite series of video signals which is substantially free of phase distortion.

7. A television transmitting system wherein an Orthicon image pickup tube having a target electrode and an electron multiplier is provided and wherein television video signals are derived from both the target electrode and the electron multiplier, comprising a low frequency component amplifier to amplify the low frequency components of the television video signals available from the target electrode including at least one amplifying stage, the load resistance-tube capacitance circuit for the video signals available from the target electrode constituting a time constant circuit T1 and the load resistance-tube capacitance circuit to which the amplified signals are applied constituting a time constant circuit T2, a high frequency component amplifier to amplify the high frequency components of the television video signals available from the electron multiplier including at least two stages, each stage including input grid circuit time constant circuits T3 and T4 comprising series capacitances and shunt resistances, the values of the elements constituting the various time constant circuits being so chosen that the ratio of the time constant T1 to the time constant T2 is substantially equal to the ratio of the time constant T3 to the time constant T4, and in which the time constants

T1 and T2 have a value approximately one-tenth as large as the time constants T3 and T4, respectively, and means for combining the amplified video signals available from the outputs of the two amplifier channels whereby a single composite series of video signals will be produced.

8. A television transmitting system wherein an Orthicon image pickup tube is used to provide video signals and wherein the tube has a target electrode and an electron multiplier with provisions whereby television video signals may be derived from both the target electrode and the electron multiplier, comprising two parallel operated amplifying channels having different band pass characteristics, one of which is effective to amplify the low frequency components of the television video signals available from the target electrode and the other of which is effective to amplify the high frequency components of the television video signals available from the electron multiplier, said low frequency component amplifier including one amplifying stage, a load resistance-tube capacitance circuit constituting a time constant circuit T1 to which the video signals available from the target electrode are applied, a load resistance-tube capacitance time constant circuit T2 to which the signals amplified by the stage are applied, said high frequency component amplifier including at least two stages, each stage including series capacitances and shunt resistances constituting input grid circuit time constant circuits T3 and T4, the values of the elements constituting the various time constant circuits being so chosen that the ratio of the time constant T1 to the time consant T2 is substantially equal to the ratio of the time constant T3 to the time constant T4, and in which the time constants T1 and T2 have a value approximately one-tenth as large as the time constants T3 and T4, respectively, and means for combining the amplified video signals available from the outputs of the two amplifier channels whereby a single composite series of video signals will be produced.

9. A pair of parallel operated band pass amplifiers for amplifying television video signals comprising a first amplifier to which is applied a video signal series for amplifying the frequency components of the video signal up to approximately 200 kilocycles per second, said amplifier including at least one amplifying stage having an input load resistance-tube capacitance time constant T1 and an output load resistance-tube capacitance time constant T2, a second amplifier to which is applied a substantially similar video signal series for amplifying the high frequency components of the video signals above approximately 200 kilocycles per second, said second amplifier including at least two amplifying stages, each stage having elements constituting grid circuit time constants T3 and T4, the parameters of the two amplifiers being such that the product of the time constants T1 and T4 is substantially equal to the product of the time constants T2 and T3, and in which time constants T3 and T4 are of the order of ten times the time constants T1 and T2, respectively, and means for combining the outputs from the two amplifiers to produce a composite series of video signals, whereby the desired band pass characteristics are present and whereby a substantially distortion free composite series of video signals will result.

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