

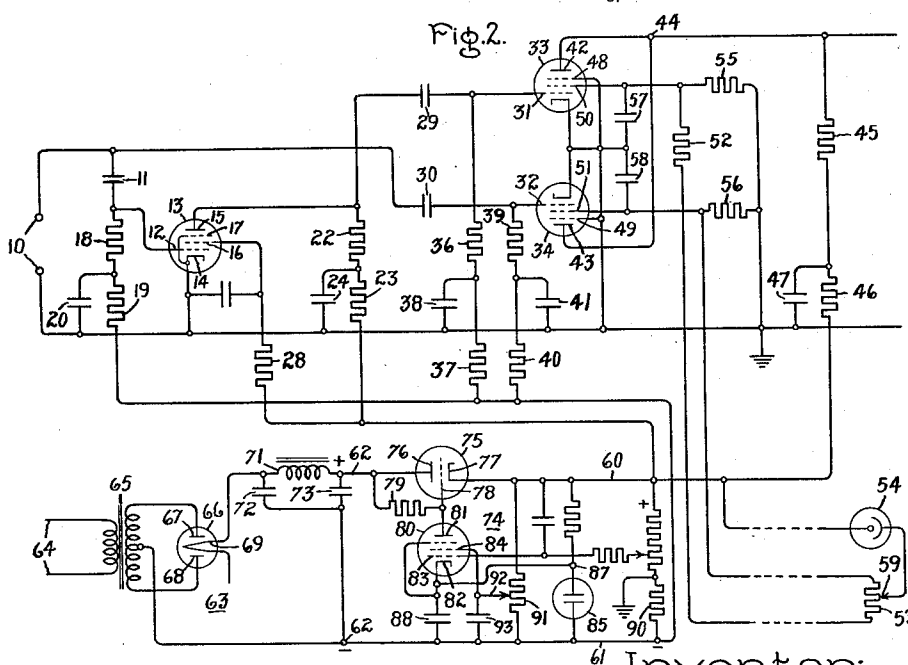
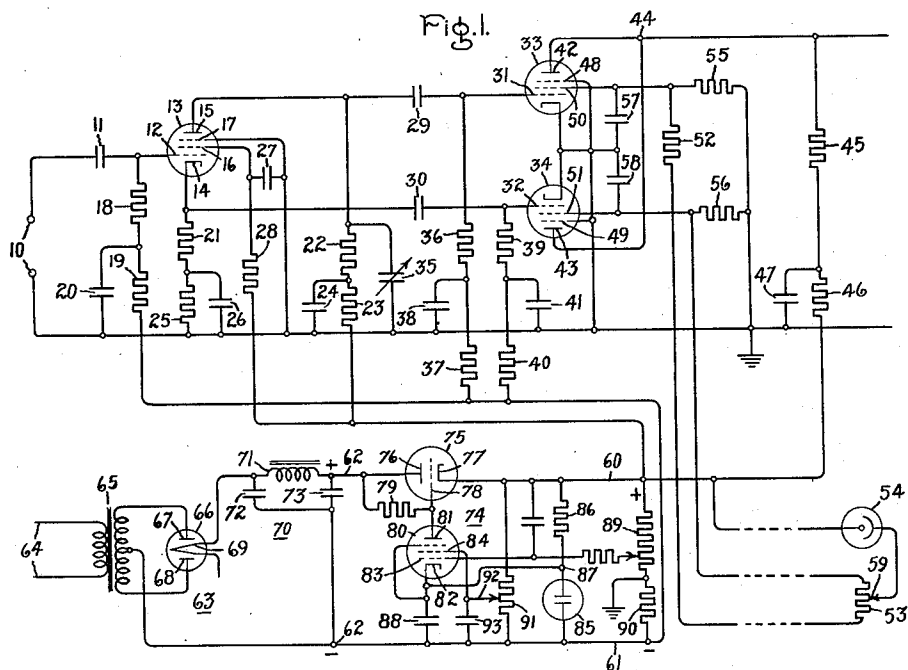
Jan. 30, 1945.

F. M. DEERHAKE

2,368,453

REMOTE GAIN CONTROL FOR VIDEO AMPLIFIERS

Filed July 28, 1942



Inventor:  
Franklin M. Deerhake,  
by *Harry E. Dunham*  
His Attorney.

## UNITED STATES PATENT OFFICE

2,368,453

REMOTE GAIN CONTROL FOR VIDEO  
AMPLIFIERSFranklin M. Deerhake, Schenectady, N. Y., as-  
signor to General Electric Company, a corpo-  
ration of New York

Application July 28, 1942, Serial No. 452,575

5 Claims. (Cl. 179—171)

My invention relates to signaling systems and in particular to the video system of a television transmitter. It is an object of my invention to provide an improved circuit for controlling the gain of a video amplifier from a remote point.

In the operation of television transmitters, it is a common practice to locate studio video amplifiers at a point remote from the operator who controls the gain of these amplifiers. In such operations, it is desirable to control the gain of the amplifiers without introducing low frequency transients which would be observable in the output. It is likewise desirable to have a gain control which will allow the gain of the amplifier to be reduced to zero without producing distortion. While such distortion may be unobjectionable in radio receivers and similar amplifiers, in video amplifiers for television apparatus such distortion is observable and hence impairs the quality of the television signals. Diverting the signal from the amplifier to a gain control at the operator's position and back to the amplifier is unsatisfactory because of loss of signal level and because of the difficulty of proper line termination. It is a further object of my invention, therefore, to provide a gain control for a video amplifier which allows variation of the characteristics of a plurality of amplifying tubes in such fashion that low frequency transients are balanced out and distortion is reduced to a minimum.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 diagrammatically illustrates a circuit embodying the basic principles of my invention and Fig. 2 diagrammatically illustrates a modification of the circuit of Fig. 1.

In the portion of the amplifier illustrated in Fig. 1, video signals appearing across the terminals 10, which may originate in the cathode ray device employed as a camera tube, and which may be amplified in the preceding portion of the amplifier, not shown, are supplied by means of the coupling capacitor 11 to control electrode 12 of electron discharge device 13 acting as a phase inverter. As illustrated, device 13 has, in addition to the control electrode 12, a cathode 14, an anode 15 and second and third control electrodes 16 and 17. Control electrode 12 is connected by means of resistors 18 and 19 to a point

of fixed bias, the common point of resistors 18 and 19 being bypassed to ground by capacitor 20. Resistors 21 and 22 in the anode and cathode circuits respectively of the electron discharge device 13 have substantially equal ohmic values and produce video voltages equal in value, but of opposite polarity, whenever a signal is applied to control electrode 12. Resistor 23, connected to a source of regulated potential, and capacitor 24, connected to a source of fixed potential, form a high frequency decoupling network in the anode circuit. In the cathode circuit resistor 21 is connected to the point of fixed potential by means of resistor 25 and bypass capacitor 26. Control electrode 16 may be coupled to the cathode by means of capacitors 27, 26 and resistor 21 and to the source of regulated potential by means of resistor 28 to act as the usual screen grid. Control electrode 17 may be connected to the cathode 14 by means of bypass condenser 26 and resistors 25 and 21, in a well known manner, to act as the usual suppressor grid.

Signals derived from the anode and cathode currents of the phase inverter 13 are supplied by means of coupling capacitors 29 and 30 to control electrodes 31 and 32 respectively of the electron discharge devices 33 and 34. In order that the signals supplied to the control electrodes of electron discharge devices 33 and 34 be identical in magnitude but 180° out of phase, the anode and cathode of discharge device 13 should be balanced with respect to the point of fixed potential. To secure such balance resistor 23 should be small as compared to resistor 22 and should have a value substantially equal to the ohmic value of resistor 25 minus the low frequency resistance of the regulated power source. Likewise the capacity of condenser 24 should be substantially equal to that of condenser 26 and variable capacitor 35 should be adjusted so that the anode to ground capacity of device 13 equals its cathode to ground capacity. If device 13 is of a type having an appreciable screen grid current, the ratio of resistor 21 to resistor 22 should be proportional to the ratio of the anode current to the sum of the anode and screen grid currents. Resistors 25, 23 and capacitors 24, 26 should be similarly proportional.

Control electrode 31 is connected to a source of negative bias by means of resistors 36 and 37 and resistor 37 is bypassed to ground by means of capacitor 38. In a similar manner control electrode 32 is connected to the bias source by means of resistors 39 and 40, resistor 40 being bypassed to ground by means of capacitor 41.

In order to maintain the symmetry of the signals supplied to electrodes 31 and 32 with respect to ground, the above-outlined biasing circuits for the devices 33 and 34 should be balanced to present equal impedances to the control electrodes.

As illustrated in Fig. 1, the amplifying devices 33 and 34 have, in addition to the above described balanced input circuits, a common output circuit. Thus the anodes 42 and 43, connected together at the point 44, have a common circuit comprising the load resistance 45 connected by means of the coupling resistance 46 to the source of regulated potential and bypassed to the point of fixed potential by means of capacitor 47. The cathodes of the two amplifiers are connected together at ground potential and control electrodes 48 and 49 of amplifiers 33 and 34 respectively are connected directly to the cathodes, in well-known manner, to act as the usual suppressor grids.

If the devices 33 and 34 are accurately matched when they are operated under identical conditions, the video signals they produce in the common load resistor 45 cancel each other and the output is zero. If, however, the gain of one of the devices is increased and that of the other decreased, an output signal will appear across resistor 45. One means of varying the gain of these devices is by controlling the voltages applied to the screen electrodes 50 and 51 of the devices. As a means so to control the potential applied to the screen electrodes, these electrodes are connected together through resistances 52 and 53 and a variable point on resistance 53 is connected to a source of operating potential through the slider 59 thereon and the discharge device 54. The discharge device 54 is preferably one of the type in which constant voltage exists between its electrodes, notwithstanding variation in current through the device over a relatively large range. The screen electrodes 50 and 51 are also connected by means of resistors 55 and 56 respectively to a point of fixed potential. Capacitors 57 and 58 provide an alternating current by-pass between the screen electrodes and the cathodes. As shown, resistance 53 is of the type having an arm 59 for varying the point of connection from device 54 thereto. If resistances 55 and 56 are equal in magnitude and resistances 52 and 53 are equal in magnitude, when contact 59 is adjusted at the junction of resistances 52 and 53, the devices 33 and 34 have equal gain. When the arm 59 is moved to the junction of resistance 53 and resistance 56, the gain of device 34 is increased and the gain of device 33 is reduced. By proper selection of the values of these resistors, this change in gain may be accomplished without appreciable variation of the average plate current of the two devices, hence without the introduction of undesirable low frequency transients across load resistor 45. By "average value" of current is meant that value of current which will be shown by an instrument indicating the value of direct currents, said instrument having a period longer than the period of any alternating currents passing through the instrument. Thus the term "average current" excludes R. M. S. values of current.

Operating potential for the above described circuit is provided from a regulated power supply source comprising conductors 60 and 61, in turn supplied by means of an electronic voltage regulator, from the direct current supply circuit 62. The direct current supply circuit 62 may be energized by any suitable translating apparatus, such as a bi-phase rectifier 63, which is energized

from a suitable source of alternating current 64 through a transformer 65 and an electric discharge device 66 having a pair of anodes 67 and 68 and a cathode 69. A filter circuit 70 comprising an inductance 71 and capacitors 72 and 73 may be connected between the rectifier 63 and the direct current supply circuit 62. Since the rectifier circuit 63 constitutes an appreciable impedance, the voltage of the direct current supply circuit 62 will vary appreciably with variations in load transmitted by the system.

An electronic voltage regulator 74 is provided between the direct current load circuit 60, 61 and the direct current supply circuit 62. This electronic voltage regulator comprises an electronic discharge device 75, preferably of the high vacuum type, having an anode 76, a cathode 77 and a control electrode 78. The anode-cathode circuit of the device 75 is connected in series relation with conductors of corresponding polarity of the direct current load circuit and the direct current supply circuit, and operates as a variable impedance device to control the voltage impressed on the direct current circuit, including conductors 60 and 61. A suitable impedance element, such as a resistance 79, is connected between the direct current supply circuit 62 and the control electrode 78 of the electronic discharge device 75. In series with the resistance 79 is provided a second electronic discharge device 80, also preferably of the high vacuum type, having a pair of principal electrodes, such as an anode 81, a cathode 82, and control means, such as a pair of control electrodes 83 and 84. The electronic discharge device 80 conducts a variable amount of current through the resistance 79 to control potential of the control electrode 78 of discharge device 75.

In order to maintain the potential of one of the principal electrodes, such as cathode 82 of electronic discharge device 80, substantially constant, there is provided a constant voltage device, such as a glow discharge valve or device 85, which is an element of a voltage divider connected across the direct current load circuit 60, 61. Glow discharge device 85 furnishes a substantially constant reference voltage due to its non-linear current impedance characteristic. A suitable impedance element, such as a resistance 86, is connected in series relation with the glow discharge valve 85 across conductors 60 and 61 and the common juncture 87 is connected to cathode 82. To assist the glow discharge device 85 in maintaining a substantially constant reference voltage, a capacitance 88 is connected across the terminals thereof. A voltage divider comprising serially connected resistances 89 and 90 is connected across the direct current load circuit 60, 61 to impress on the control electrode 83 a voltage which varies in accordance with the voltage of the direct current load circuit. In like manner, means is provided for impressing on the control electrode 84 a voltage which varies in accordance with the voltage of the direct current load circuit comprising a voltage divider connected across the conductors 60 and 61 and including a resistance 91 having an adjustable intermediate tap 92. A capacitance 93 may be connected across a portion of the resistance 91 to provide a low impedance path for alternating currents from electrode 84 to conductor 61. The capacitance 93, acting in conjunction with the resistance 91, serves to by-pass high frequency variations in voltage which may be transmitted from the source of direct current thereby stabilizing the potential of the control electrode 84.

The operation of the regulated power supply will be explained by considering the supply when it is operating under variable load conditions. Due to the impedance of the rectifier circuit 63 and the filter circuit 70 under variable load conditions, the voltage of the direct current supply circuit 62 will vary appreciably. The electronic regulator 74 operates to control the conductivity of the electronic discharge device 75 so that the voltage impressed on the direct current load circuit remains substantially constant. The electronic discharge device 75 operates as a variable impedance or a variable resistance element to maintain the load voltage substantially constant. Variable amounts of unidirectional current are transmitted to the resistance 79 by the electronic discharge means 80 to control the potential of control electrode 18 of discharge device 75. This unidirectional current flows through a circuit including the positive terminal of the direct current supply circuit 62, resistance 79, the anode-cathode circuit of electron discharge device 80, glow discharge device 85, and the negative terminal of the direct current supply circuit 62. The glow discharge device 85 and the associated resistance 86 and resistances 89 and 90 operate as a voltage responsive bridge to control the potential difference between the cathode 82 and the control electrode 83 in response to the variation in voltage of the direct current load circuit. In like manner, the glow discharge device 85 and the associated resistance 86 and the resistance 91 operate as a voltage responsive bridge to control the potential difference between cathode 82 and control electrode 84 in accordance with the average variations of the load circuit.

When the above described regulated power source is connected through discharge device 54 to the resistances interconnecting the screen electrode devices 33 and 34, these electrodes are maintained at fixed potentials determined by the position of the variable arm 59 on resistance 53. When this arm is moved to the junction of resistances 52 and 53, devices 33 and 34 have equal gain and zero output. By moving variable arm 59 to the junction of resistances 53 and 56, the gain of device 34 is increased and that of device 33 is reduced. The respective gains of the devices may be varied as greatly as seems practical from the point of view of introduction of distortion and low frequency surges.

In practical application, it may be found desirable to locate the resistance 53 at a point remote from the video amplifiers and to connect it with the amplifier by means of a suitable cable. In such a system, since merely a source of direct current potential is supplied by the cable, the problem of proper line termination does not enter into consideration. Likewise, since the cable does not carry signals, the problem of attenuation is not present. In a usual type screen grid video amplifier, variation of a direct current voltage applied to the screen or control electrode of the discharge device produces a variation in gain, but it also produces an undesired low frequency transient. In addition, when the gain of the amplifier is reduced by reduction of the screen grid voltage to the point that the device operates off the linear portion of its characteristic curve, considerable distortion of a type observable in the output wave may be introduced. By means of my control, as described above, low frequency transients which are introduced by variation of the characteristics of the two tubes are balanced out and the above-mentioned distortion is reduced to a mini-

mum. Thus when no signal is present and the voltage applied to the control electrode 51 is increased, while that applied to control electrode 50 is decreased, the increase in the anode current of the device 34 substantially balances the decrease in the anode current of the device 33 so that the potential at the point 44 remains essentially constant.

In the modification of my invention shown in Fig. 2, signals from the source 10 are coupled directly by means of the capacitor 30 to the control electrode 32 of amplifier 34. Device 13 functions, not only as an amplifier having a gain of unity, but also to invert the phase of the signal applied to the control electrode 31 of device 33. Cathode 14 is connected directly to ground and to the control electrode 17. In all other respects, the circuit of this modification is the same as that of the amplifier shown in Fig. 1.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a signalling system in which low frequency disturbances are observable, the combination of, a source of signal voltages balanced with respect to a point of fixed potential, a pair of electron discharge devices having first and second control electrodes and a common output circuit, means for impressing said voltages on said first electrodes, equal resistances connected between said second electrodes and said point of fixed potential, a fixed resistance connected between said second electrodes, a source of constant potential connected to said fixed resistance, and means for varying the point of connection of said source of constant potential to said fixed resistance, thereby to increase the gain of one of said devices and decrease the gain of the other of said devices while maintaining the average value of the current in said output circuit substantially constant.

2. An arrangement for remotely controlling the gain of the video amplifier of television apparatus comprising, a pair of electron discharge devices having control electrodes and a common output circuit, means including an electronic phase inverter for supplying equal and opposite video signals to said control electrodes, and means for simultaneously increasing the output current of one of said devices and decreasing the output current of the other of said devices while maintaining the average current in said output circuit substantially constant, whereby transients introduced by such changes in currents are not reproduced in said system, said means comprising a resistance connected between said electrodes and a source of unidirectional potential connected to a variable point on said resistance.

3. An arrangement for remotely controlling the gain of the video amplifier of television apparatus comprising, a pair of electron discharge devices having first and second control electrodes and a common output circuit, means for supplying opposite signals to said first control electrodes, a resistance connected between said second control electrodes, a source of potential connected to said resistance, and means for varying the point of connection of said potential to said resistance to increase the output current of one

of said devices and to decrease the output current of the other of said devices while maintaining the average current in said output circuit substantially constant, thereby preventing transients introduced by such changes in current from being reproduced in said system.

4. In a video amplifier for television apparatus including a source of equal and opposite video signals, means including a pair of electron discharge devices for amplifying said signals, a common output circuit for said devices, and means for simultaneously increasing the gain of one of said devices and decreasing the gain of the other of said devices while maintaining the average current in said output circuit substantially constant, said last means comprising a control electrode in each of said devices connected together through a resistance, and means including a source of unidirectional potential connected to a variable point on said resistance for simultaneously increasing the magnitude of the potential supplied to the control electrode of one of said devices and decreasing the magnitude of the potential supplied to the control electrode of the other of said devices.

5. In a signalling system in which low frequency disturbances are visible, the combination of a source of signals, an amplifier comprising a pair of electron discharge devices having an anode, a cathode, and first and second control electrodes, means for supplying signals from said source to said first electrodes in opposite phase, a common output circuit connected between said anodes and cathodes, said devices being connected in parallel to said output circuit whereby signals amplified by said devices are reproduced in said output circuit in opposed relation, and means for increasing the gain of one of said devices while decreasing the gain of the other of said devices, thereby to vary the intensity of said signal in said output circuit while maintaining the average value of the current in said output circuit substantially constant, said last means comprising a resistance connected between said second electrodes and said cathodes, and a source of constant potential connected to a variable point on said resistance.