

Aug. 17, 1943.

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2,326,907

TELEVISION SYSTEM

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2 Sheets-Sheet 1

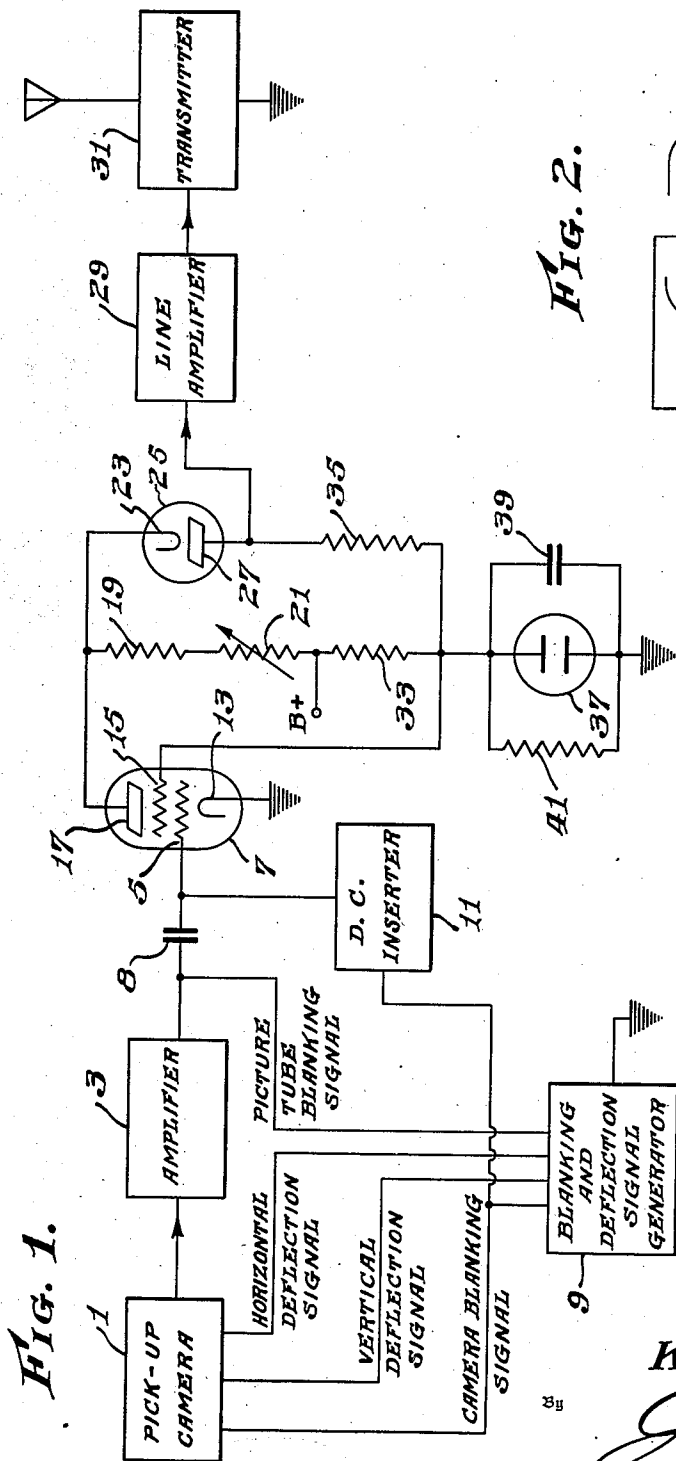
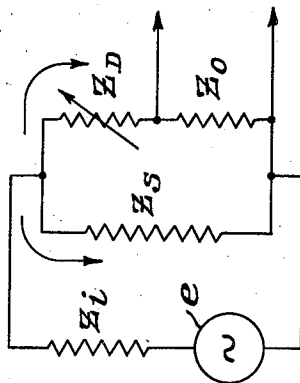


Fig. 2.



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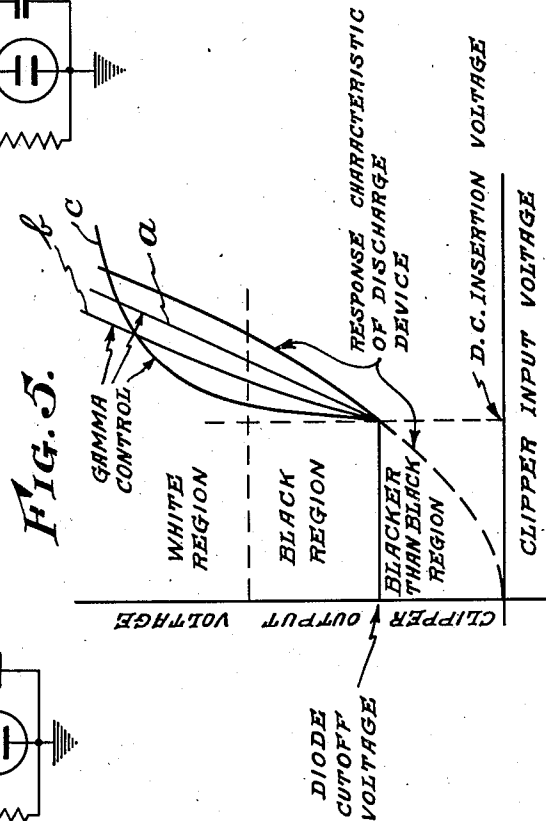
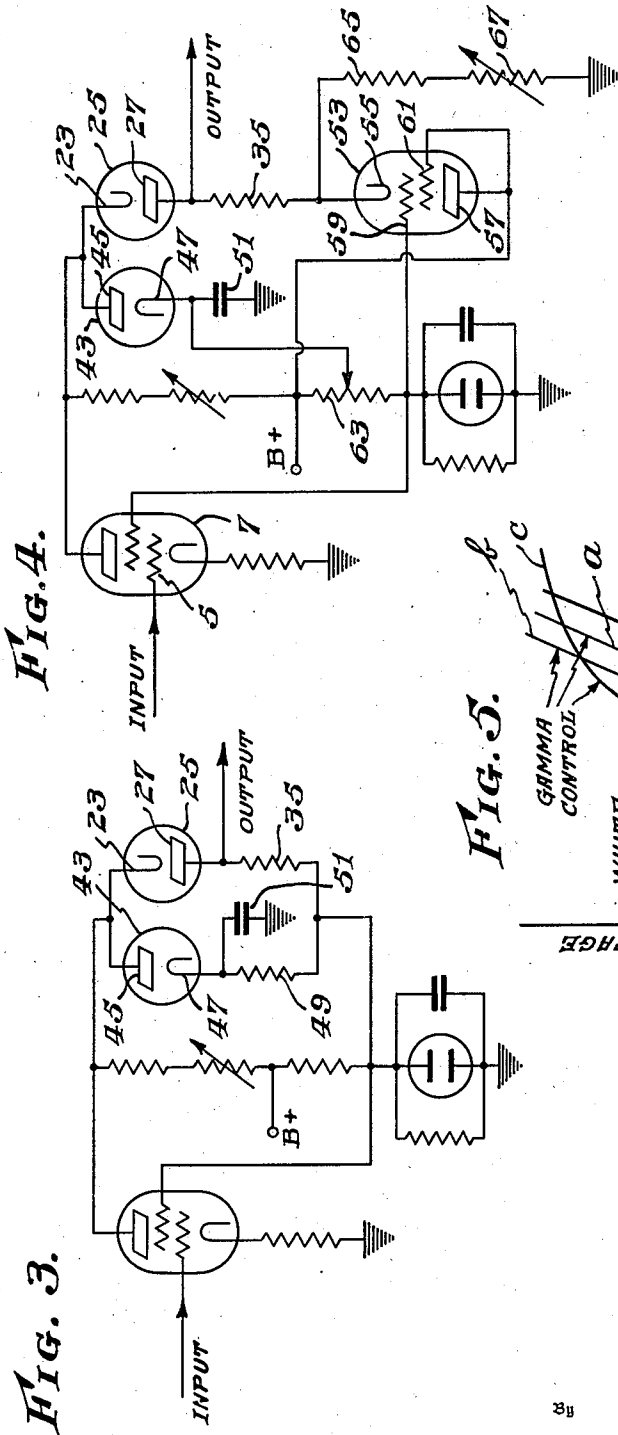
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2 Sheets-Sheet 2



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TELEVISION SYSTEM

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Application November 27, 1940, Serial No. 367,324

7 Claims. (Cl. 178—7.1)

This invention relates to television systems and more particularly to picture transmission systems.

In television systems wherein a cathode ray tube is used to transform an optical image into a train of signal energy representative of the optical image, it is necessary to amplify the train of signal energy in order to increase its power to an amount necessary to modulate a radio transmitter. This is usually accomplished by passing the signals through an alternating current amplifier. It is well known, however, that, when a train of signals, such as picture signals which vary in magnitude and not in polarity, are passed through an alternating current amplifier with its associated capacity coupling, an alternating current axis is established, and it depends for its position on a reference established by zero signal.

In the case of a train of signals representing an optical image, the established alternating current axis in the amplifier is therefore not controlled by the predetermined reference light unit necessary for the proper background or average overall illumination in the reproduced picture, but is caused to vary in accordance with the overall amplitude of the signal.

It has been proposed to insert a predetermined reference signal voltage representing a "black" picture during the short period of time that the electron beam is extinguished by reason of the camera blanking signal. This is done to establish background control. It is very difficult to produce a reference voltage which remains constant (that is, which does not, for example, have noise superimposed thereon) for the period of time necessary to produce a uniform background. However, this has been attempted with some success. It has been proposed to establish a reference voltage which represents "blacker than black" and, in addition, provide a clipping circuit to clip the signal uniformly at a voltage representing a substantially "black" picture. This method eliminates any noise that may be present in the "blacker than black" region. One example of this method is described in Bedford Patent No. 2,192,121. The said method as practiced in the system described in the present application and as applied to a low velocity beam pickup tube is described and claimed in application Serial No. 367,888, filed Nov. 30, 1940, in the name of Alva V. Bedford, and entitled "Television systems." Heretofore, the clipping circuit comprised a multielement tube which did not have a uniform response due to the inherent

curvature, particularly in the lower portion of its response characteristic curve. So, by using only the upper portion of the response curve, a more uniform amplitude response may be had.

According to this invention, the direct current reference voltage representing a "blacker than black" picture is inserted previous to a clipping circuit which comprises the combination of a clipper tube and a diode in series with the anode circuit of the clipper tube. The anode potential and the bias across the diode is so adjusted that the diode cuts off the current flow in the output circuit when the impressed signal is in the curved region of the response curve of the clipper tube. By such combination only the straight portion of the response curve is utilized whereby all signals within the desired range are passed uniformly and, furthermore, the uniformity may be controlled in order to produce what is known as gamma correction.

In order to have satisfactory gamma control, it is necessary to provide a system having maximum nonlinearity in the region of maximum gain. Heretofore, gamma control devices have used a number of tubes in parallel, each of the tubes having a different cut-off voltage. By so doing, it was possible to produce the desired maximum nonlinearity in the region of maximum gain.

According to this invention, this is accomplished in a single tube by using a tube connected in an inverted manner as an impedance device.

Accordingly, the primary object of this invention is to improve a transmitted video signal.

Another object of this invention is to provide the video signal with a uniform direct current component.

Another object of the invention is to remove spurious signals in the region of "blacker than black."

Still another object of this invention is to provide a method and means for controlling the contrast of the transmitted signal.

Other and incidental objects of this invention will be apparent to those skilled in the art from a reading of the following specification and an inspection of the accompanying drawings, in which

Figure 1 is a block diagram of a television signal transmission system including a circuit diagram of one form of this invention,

Figure 2 is an equivalent circuit diagram show-

ing the fundamental operation of one form of this invention,

Figure 3 is a circuit diagram showing another form of this invention,

Figure 4 is a circuit diagram showing still another form of this invention, and

Figure 5 is a graphical illustration showing the operation of this invention.

Referring in more detail to Figure 1, a pickup camera 1, which may be of the type such as described by Iams and Rose in an article entitled, "Television pickup tubes with cathode ray beam scanning," published in the Proceedings of the Institute of Radio Engineers, August, 1937, feeds a train of signals representative of the picture being televised to amplifier 3 which in turn impresses the amplified signal upon the control electrode 5 of the discharge device 7 through the coupling condenser 8.

A blanking and deflection signal generator 9 supplies a camera blanking signal to the pickup camera 1 which extinguishes the electron beam during that period of time which is occupied by the process of returning the electron beam to a position where it is ready to start its next scanning line or frame. This signal is utilized to prevent any light interference on the image during the "return time" of the cathode ray electron beam.

The blanking and deflection signal generator 9 also furnishes the pickup camera 1 with a horizontal deflection signal and a vertical deflection signal.

The blanking and deflection signal generator also supplies the output of amplifier 3 with a picture tube blanking signal which is utilized to extinguish the electron beam in the picture receiving tube during "return time." This operation, designed for the picture tube, is similar to the operation of the camera blanking signal on the pickup camera.

The blanking and deflection signal generator performs still another function in supplying a signal like that of the camera blanking signal to a D.-C. inserter circuit 11, such as shown and described in my copending application Serial No. 362,311, filed October 23, 1940, whose output is also applied to the control electrode 5 of the discharge device 7. The D.-C. inserter supplies a reference voltage to the video signal at a time during which the electron beam is extinguished by the camera blanking signal. This reference voltage is preferably chosen to be equivalent to a signal voltage that would produce a "blacker than black" picture at the receiver, that is, the signal voltage is greater in the "black" direction than is necessary to produce a black image. As explained in my above-identified copending application, the potential on the control electrode 5 is the same at the start of each scanning line.

The discharge device 7 includes a cathode 13, an auxiliary electrode 15, and an anode 17. The anode 17 is supplied with a D.-C. potential through resistance 19 and variable resistance 21. The output signal of the anode 17 of the discharge device 7 is impressed upon the cathode 23 of the diode discharge device 25, whose anode 27 is connected to the line amplifier 29 which is in turn connected to the transmitter or transmission system 31.

A positive potential is also supplied to the auxiliary electrode 15 through resistance 33 and to the anode 27 of the diode 25 through output resistance 35. The potential on the auxiliary elec-

trode 15 and the potential on the anode 27 is maintained at a constant potential by the circuit including voltage regulator tube 37, filter condenser 39, and resistor 41.

The operation of this form of the invention will now be explained in more detail. When the pickup camera 1 is focused on an optical scene, the deflection signals from the blanking and deflection signal generator 9 causes the electron beam in the pickup camera 1 to scan the light-sensitive mosaic and provide a train of picture signals which are amplified in the amplifier 3 and impressed on the control electrode 5 of the discharge device 7. The picture tube blanking signal is inserted in the signal prior to the coupling condenser 8, and the D.-C. inserter 11 supplies the train of picture signals with a predetermined reference voltage between the coupling condenser 8 and the control electrode 5.

As previously explained, the reference voltage supplied by the D.-C. inserter 11 is such that the optical image represented thereby would be a "blacker than black" image. The signal applied to the control electrode 5 is preferably such that "black" is in the negative direction.

It will thus be understood that, as the signal increases in the "white" direction, the current flowing through the discharge device 7 will increase by reason of the fact that the potential on the control electrode 5 increases in a positive direction. It follows that the potential on the anode 17 will drop or go in a negative direction because of the increased voltage drop through the resistances 19 and 21 under a larger current flow.

The potential of the cathode 23 of the diode 25 will follow the potential of the anode 17 and, as the potential drops or goes more negative, the diode 25 will become conducting when the potential of the cathode 23 goes more negative than the potential of the anode 27.

The relative potentials on the cathode 23 and anode 27 are so adjusted by variable resistance 21 that they will become equal when the signal voltage impressed upon the control electrode 5 is equivalent to that voltage which is necessary to produce a "black" picture at the receiving station.

Accordingly, during the time that the reference voltage is being established at "blacker than black," or during that time in which the signal voltage applied to the control electrode 5 is held in the region of "blacker than black" in order to remove extraneous interference or noise, the potential on the control electrode 5 is sufficiently great in the negative direction to cause small current flow through the discharge device 7, with a corresponding large positive potential on anode 17 and cathode 23, so that no current flows between the cathode 23 and anode 27 by reason of the fact that the potential on the cathode 23 exceeds, in a positive direction, the potential on the anode 27. Therefore, it may be seen that only signals representing a picture between the range of "black" and "white" are transmitted through the diode 25, and all those signals representing a picture in the region of "blacker than black" are eliminated.

It has been known prior to this invention that a diode can be utilized as a signal limiter. The response characteristic of the diode is, however, curved in a manner somewhat similar to that of the multielement discharge device. According to this invention, however, a diode is used in combination with a multielectrode discharge de-

vice providing a clipper circuit to give a uniform response over the entire range of amplitude of signals to be transmitted. This may best be explained by reference to the equivalent circuit diagram shown in Figure 2. Let e , a source of potential, represent the discharge device 7 of Figure 1, and Z_1 the impedance of the discharge device 7. The voltage in the source e is supplied to a shunt circuit which comprises impedance Z_s and representing the anode resistors 19 and 21 of Figure 1. Z_s is connected in parallel with a series circuit comprising an output impedance Z_o , resistance 35, and the impedance representing the diode 25Zd. The current flowing through the circuit is divided between the legs comprising impedance Z_s and the series circuit comprising impedances Z_d and Z_o . Impedances Z_d and Z_s are greater than the sum of Z_d and Z_o , and consequently most of the current flows through the leg including the impedances Z_d and Z_o . It follows that any change in impedance Z_d would therefore have little effect on the amount of current flowing through Z_d and Z_o .

Therefore, even at low levels of input signals, the diode acts as substantially a linear clipper because the inherent change in impedance of a diode operating in the range of low signal level has less tendency to cause amplitude distortion.

Turning now to Figure 3, there is shown another form of this invention, wherein like numerals represent similar parts. As the potential on the cathode 23 of the diode 25 exceeds in the positive direction the potential on the anode 27, there is no current flow through the diode 25. It is, therefore, possible for this potential on the cathode 23 to greatly exceed in a positive direction the potential on the anode 27 during the time the "blacker than black" signal is being clipped off. Due to the interelectrode capacity of the diode, the high frequency portion of this spurious signal is passed on to the line amplifier 29. In order to eliminate this interference, a diode 43 is connected in parallel with the input circuit to the diode 25 so that the anode 45 is connected to the diode 23, and the cathode 47 is connected through resistance 49 to the voltage supply source and to the end of a resistor 35 opposite to that end of the resistor which is connected to anode 27. A bypass condenser 51 is inserted from the cathode 47 to ground.

As the potential on the cathode 23 exceeds in a positive direction the potential on the anode 27, so that the anode 45 of the tube 43 becomes substantially positive relative to its cathode 47, the diode 43 will become conducting to provide a low impedance path to ground, preventing the voltage on the cathode 23 from exceeding by a great amount in the positive direction the voltage on the anode 27.

Referring now to Figure 4, there is shown still another form of this invention in which an auxiliary discharge device 53 is included in the circuit to provide gamma control. Tube 53 contains a cathode 55, an anode 57, a control electrode 59 and an auxiliary electrode 61. The cathode 55 is connected to the output resistor 35 at the end opposite to that end which is connected to the anode 27 of the diode 25.

The cathode 47 of the diode 43 is connected to the variable tap of a potentiometer 63. Condenser 51 is connected between the cathode 47 and ground. Resistance 65 and variable resistance 67 is connected between the cathode 55 and ground. A source of potential is supplied to the anode 57 and the auxiliary electrode 61.

The operation of the gamma control circuit may be explained by an illustration of what occurs at various input signal amplitudes.

The circuit constants are so adjusted that when, for example, a signal representing a black picture is impressed upon the control electrode 5, there is no potential difference between the cathode 23 and the anode 27 of the diode 25. It, therefore, follows that there is no current flowing through the resistor 35 and the only current flowing through the tube 53 is that predetermined current which flows through the tube 53 and resistances 65 and 67. The amount of current flowing through the tube 53 under conditions of a black picture may be adjusted by variable resistance 67.

As the signal impressed upon the control grid changes to a signal representing a white picture, the diode 25 is made conducting by reason of the potential on the cathode 23 increasing in a negative direction with respect to the potential on the anode 27. This causes a drop in a negative direction of the potential on the anode 27. Part of this potential drop occurs across the resistor 35, and the remainder on the cathode 55 of tube 53, which is therefore operating as a portion of the output impedance of tube 7. As is well known in the art, the impedance looking into the cathode of a discharge device is approximately equal to the reciprocal of the mutual conductance of the device in parallel with the actual resistor (65 and 67 in this case) occurring between the cathode and ground. Also, as is well known, the mutual conductance varies in a nonlinear manner with the cathode current of the device. In the present case, the current through tube 53 is the controlling parameter, and the impedance of tube 53 is therefore controlled by the current through it. The greatest change or maximum nonlinearity occurs near cut-off of tube 53, which occurs at black level, which is a desired condition for proper gamma correction. Tube 53 therefore functions as a nonlinear output impedance for tube 7 with the maximum nonlinearity occurring in the black region. Therefore, a small increment of signal is amplified much more in the "black" region than in the "white" region. The nonlinearity is controlled by the value of resistor 67. If desired, the value of resistor 35 may be reduced to zero, such that the entire output impedance occurs in tube 53. This will decrease the gain in the white region, but affect the gain in the blacks only slightly, thus increasing the nonlinearity of the device.

The point at which the diode 43 starts to function by reason of its anode 45 going positive with respect to its cathode 47 may be adjusted by varying the potentiometer 63. In a preferred form of the system, the cathode 47 may be set approximately 2 volts positive relative to the potential of cathode 55 under no-current conditions through diode 25. This voltage, comprised of initial velocity and contact potentials in diodes 25 and 43, allows current to start flowing through diode 43 at approximately the same voltage as current ceases in diode 25.

Referring now to Figure 5, the nonlinearity of the response characteristic of a multiple element discharge device is clearly indicated and the position at which the diode cut-off voltage intersects the response characteristic curve of the discharge device is shown to form a relatively sharp corner at the point of intersection so that it may be seen that the portion of the response

characteristic curve above the diode cut-off voltage is more nearly a straight line.

It can be seen that, by the addition of the gamma control tube, the curve may be shaped to increase the contrast of the transmitted signal, as shown by lines *b* and *c*, for example, or, as shown by the line *a*, it may be adjusted to produce a straight response characteristic, thus producing a uniform amplification over the range of picture signals representing a picture from black to white.

While several systems for carrying this invention into effect have been indicated and described, it will be apparent to one skilled in the art that this invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of this invention as set forth in the appended claims.

I claim as my invention:

1. In a picture transmission system including means for transforming an optical image into a train of picture signals having a predetermined reference level, a peak voltage limiting circuit comprising the combination of a diode having a cathode and a diode anode, means for impressing said train of picture signals between said cathode and a point of fixed potential, means for maintaining a predetermined bias voltage on said diode anode whereby only those of said signals which are in one direction of polarity from said predetermined reference level appear on said diode anode and means to prevent the potential on said cathode from exceeding in a positive direction, the potential of said diode anode.

2. In a picture transmission system including means for transforming an optical image into a train of picture signals and synchronizing pulses having a predetermined reference level, a peak voltage limiting circuit comprising the combination of a rectifier having input and output circuits, means for impressing said picture signals and synchronizing pulses on said input circuit, said rectifier having an output circuit and adapted to pass current to its output circuit only when the voltage across its associated output circuit is greater than the voltage across its associated input circuit, means in shunt with said rectifier input circuit adapted to pass current only when the voltage across said rectifier input circuit is greater than the voltage across said rectifier output circuit, and means for maintaining a predetermined bias voltage across said rectifier output circuit whereby only those of said signals which are in one direction of polarity from said predetermined reference level appear in said rectifier output circuit.

3. In a picture transmission system including means for transforming an optical image into a train of picture signals, a peak voltage limiting circuit comprising the combination of a rectifier having input and output circuits, means for impressing said train of picture signals on said input circuit, said rectifier having an output circuit and adapted to pass current to its output circuit only when the voltage across its associated output circuit is greater than the voltage across its associated input circuit, a diode connected in shunt with said rectifier input circuit and adapted to pass current only when the voltage across said rectifier input circuit is greater than the voltage across said rectifier output circuit.

4. In a picture transmission system including means for transforming an optical image into a train of picture signals having a predetermined

reference level, a peak voltage limiting circuit comprising the combination of a discharge device having input and output circuits, means for impressing said signals on said input circuit whereby said signals appear in said output circuit, a rectifier having an input circuit connected to said output circuit, said rectifier having an output circuit and adapted to pass current to its output circuit only when the voltage across its associated output circuit is greater than the voltage across its associated input circuit, means for maintaining a predetermined bias voltage across said rectifier output circuit whereby only those of said signals which are in one direction of polarity from said predetermined reference level appear in said rectifier output circuit, an auxiliary discharge device having a cathode, an anode, and a control electrode, the cathode-anode impedance of said auxiliary discharge device being connected in series with said rectifier and said rectifier output circuit with the cathode of said auxiliary discharge device connected to said rectifier output circuit, means for maintaining the anode of said auxiliary discharge device at a constant potential, and means for maintaining the control grid of said auxiliary discharge device at a constant potential which is negative with respect to said constant anode potential.

5. In a picture transmission system including means for transforming an optical image into a train of picture signals having a predetermined reference level, a peak voltage limiting circuit comprising the combination of a discharge device having input and output circuits, means for impressing said signals on said input circuit whereby said signals appear in said output circuit, a rectifier having an input circuit connected to said output circuit, said rectifier having an output circuit and adapted to pass current to its output circuit only when the voltage across its associated output circuit is greater than the voltage across its associated input circuit, means in shunt with said rectifier input circuit adapted to pass current only when the voltage across said rectifier input circuit is greater than the voltage across said rectifier output circuit, means for maintaining a predetermined bias voltage across said rectifier output circuit whereby only those of said signals which are in one direction of polarity from said predetermined reference level appear in said rectifier output circuit, and an auxiliary electron discharge device connected in shunt with said rectifier output circuit and adapted to change its internal impedance in accordance with the signals appearing in said rectifier output circuit.

6. In a picture transmission system including means for transforming an optical image into a train of picture signals having a predetermined reference level, a peak voltage limiting circuit comprising the combination of a discharge device having input and output circuits, means for impressing said signals on said input circuit whereby said signals appear in said output circuit, a rectifier having an input circuit connected to said output circuit, said rectifier having an output circuit and adapted to pass current to its output circuit only when the voltage across its associated output circuit is greater than the voltage across its associated input circuit, means in shunt with said rectifier input circuit adapted to pass current only when the voltage across said rectifier input circuit is greater than the voltage across said rectifier output circuit, means for maintaining a

predetermined bias voltage across said rectifier output circuit whereby only those of said signals which are in one direction of polarity from said predetermined reference level appear in said rectifier output circuit, and an auxiliary electron discharge device having a cathode, a control electrode and an anode means for maintaining constant the potential of the said control electrode and anode of said auxiliary device and a connection between the said cathode of said auxiliary device to said rectifier output circuit.

7. A limiting circuit comprising in combination, a discharge device having a cathode, an anode and a control electrode, means for applying a signal between said cathode and said control electrode, a load impedance for said discharge device, means for applying an operating

potential between said load impedance and said cathode, said load impedance having connected in parallel therewith a series circuit including an output impedance and a rectifying device polarized by a bias voltage to pass current serially through said output impedance and said rectifying device, said bias voltage having a value such that the rectifying device will not pass current when said signal exceeds a predetermined voltage level, and said load impedance having connected in parallel therewith a surge limiting circuit including an impedance serially connected with a second rectifying device biased and polarized to pass current through said second rectifying device when said first mentioned rectifying device ceases to pass current.

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