

March 5, 1946.

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2,396,023

TELEVISION SIGNAL AMPLIFIER

Filed April 26, 1943

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FIG. 1

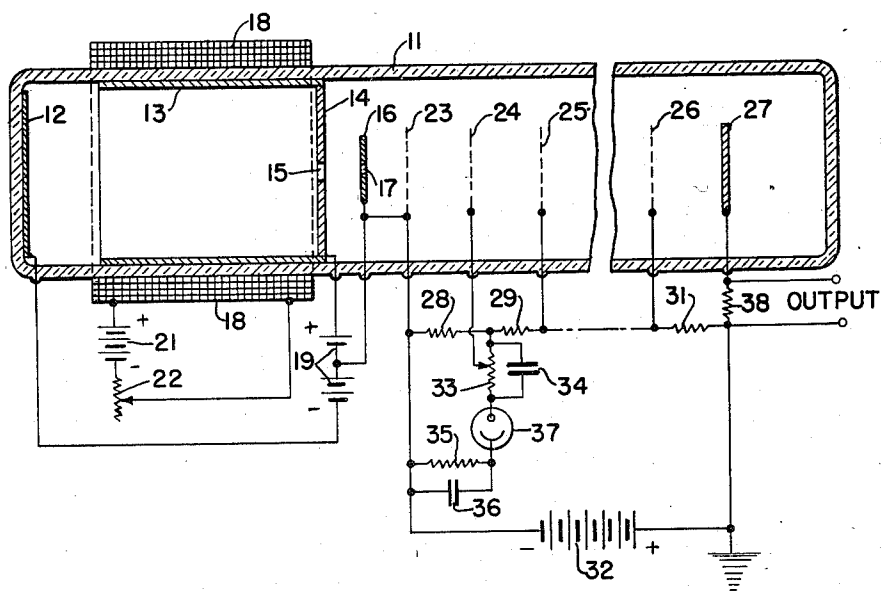
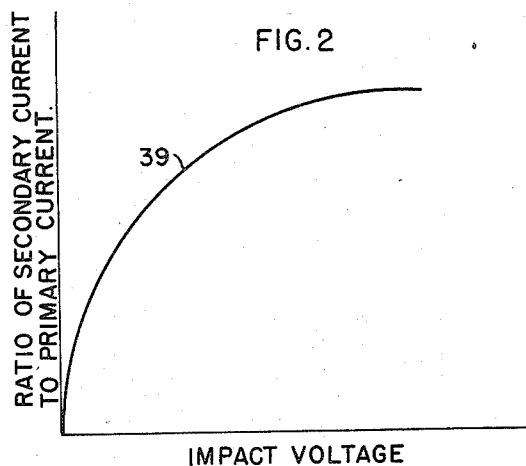


FIG. 2



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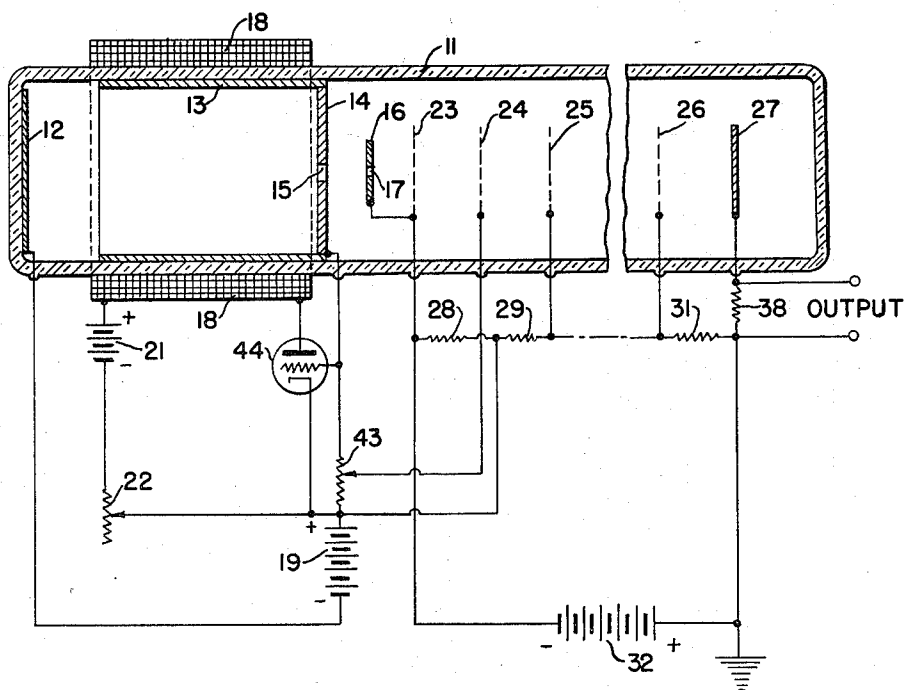
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FIG. 3



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TELEVISION SIGNAL AMPLIFIER

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Application April 26, 1943, Serial No. 484,583

7 Claims. (Cl. 178—7.2)

This invention relates to gain control apparatus and particularly to a means for varying automatically the amplifying characteristics of an electron multiplier associated with a television image analyzing tube in accordance with the average light intensity incident upon the tube.

According to conventional television practice, it is customary to provide means for maintaining a predetermined range of video signals irrespective of the average light intensity incident upon the image analyzing tube. One expedient is to vary the size of the aperture through which the light that is reflected from the subject is admitted to the image analyzing tube. Such an adjustment usually is made manually since the auxiliary equipment necessary to effect it automatically is undesirably complicated. Another device employed is one for automatically controlling the gain of a thermionic amplifier upon which the generated video signals are impressed.

As is well understood in the art, however, there are instances where it is desirable to control automatically the gain of an electron multiplier type of amplifier. Such a control is particularly desirable in television transmitting apparatus which is to be controlled from a remote point.

An object of the present invention, therefore, is to provide a novel automatic gain control means for an electron multiplier.

Another object of the invention is to provide novel automatic gain control apparatus for an electron multiplier used in conjunction with an image dissector type of analyzing tube.

In accordance with the invention, there is provided, in association with an electron multiplier including a plurality of secondary emissive electrodes, a means responsive to the average intensity of light incident upon a television image analyzing device. The light responsive means is employed in a novel manner to adjust automatically the potential applied to one of the multiplier electrodes, whereby to vary the overall amplification factor of the multiplier inversely to a variation of the average incident light intensity.

More specifically, there is provided, in accordance with the illustrated embodiments of the invention, a light responsive device having a photoelectric cathode and an anode. This device may be either a photoelectric tube, or, where an analyzing tube of the image dissector type is employed, the photoelectric cathode of the dissector tube may be employed as the light responsive device. In either case, there is included in circuit

with the light responsive device a resistor through which the current is varied under the control of the light responsive device in accordance with the average light intensity incident upon the image analyzing tube. A voltage developed in the resistor is applied to one of the multiplier electrodes to control the gain of the multiplier stages immediately preceding and succeeding this electrode in a manner to vary the overall amplification of the amplifier inversely to a variation of the average incident light intensity.

Where the photoelectric current of the dissector tube is employed to control the electron multiplier gain, there also is provided a means for varying the focusing of the electron image to compensate for the variation of electrode potentials of the tube resulting from the voltage drop in the resistor produced by the photoelectric current.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a diagrammatic illustration of one form of the invention embodied in an electron multiplier associated with an analyzing tube of the image dissector type;

Fig. 2 is a graphical representation of typical operating characteristics of the electron multiplier electrodes; and,

Fig. 3 is a diagrammatic illustration of another form of the invention embodied in an electron multiplier associated with an image dissector tube, in which the photoelectron current of the dissector tube is utilized to control the multiplier gain.

Referring now more particularly to Fig. 1 of the drawings, there is shown a unitary arrangement of an image dissector tube and an electron multiplier included within an evacuated envelope 11. It will be understood that the relative arrangements of the dissector tube and the electron multiplier are merely diagrammatic and that the forms of the various illustrated elements thereof are also diagrammatic. The present illustration is merely for the purpose of simplifying the disclosure as much as possible. A typical structural arrangement of the apparatus may be as disclosed in Patent No. 2,264,630, granted to Philo T. Farnsworth on December 2, 1941 and entitled "Dissector tube."

The image dissector tube includes, in the en-

velope 11, a photoelectric cathode 12 which may be in the form of a thin end wall coating, an accelerating anode 13 which may be in the form of a side wall coating, a target anode 14 having an aperture 15 and an electrode 16 having a defining aperture 17 of a magnitude corresponding to an elemental scanning area. Surrounding the dissector tube on the exterior of the envelope 11 is an electromagnetic focusing coil 18. Deflecting coils, also forming a part of a complete image dissector tube, have not been shown since they are conventional and are not necessary to an understanding of the present invention. The accelerating anode 13 is connected to the target anode 14 which in turn is connected to the positive terminal of a source of direct current such as a battery 19. The negative terminal of this battery is connected to the photoelectric cathode 12. The battery is for the usual purpose of impressing a difference of potential between the cathode and anode of the dissector tube. The electrode 16 may be connected to an intermediate point on the battery 19, whereby it is maintained at a slightly less positive potential than the target electrode 14. The focusing coil 18 is connected to a source of direct current such as a battery 21 through an adjustable resistor 22, whereby the current through the coil may be adjusted as desired.

The remainder of the envelope 11 is occupied by the electron multiplier which comprises a plurality of secondary emissive electrodes such as 23, 24, 25 and 26, and a collector electrode 27. The multiplier electrodes are connected to points in a bleeder circuit or voltage divider comprising resistors 28, 29, 31, etc. The terminals of the voltage divider are connected respectively to the positive and negative terminals of a source of direct current such as a battery 32. These connections are such that each electrode of the electron multiplier is maintained at a higher positive potential than the immediately preceding electrode.

Connected between the junction point of resistors 28 and 29, to which the multiplier electrode 24 normally would be connected, is a resistor 33 shunted by an alternating current bypass condenser 34. A resistor 35 which is shunted by an alternating current bypass condenser 36 is connected to a more negative point on the voltage divider such as the negative terminal of the battery 32. There is provided a photoelectric tube 37 connected in series with the resistors 33 and 35. The multiplier electrode 24 is connected to a preselected point on the resistor 33. The collector electrode 27 of the electron multiplier is connected through a load resistor 38 to the positive terminal of the battery 32. The amplified video signals are derived from the resistor 38 and are impressed upon an output circuit in a well known manner.

Referring now to the operation of the device illustrated in Fig. 1, it is assumed that light reflected from the subject is directed onto the photoelectric cathode 12 of the dissector tube and concurrently upon the photoelectric cathode of the tube 37. For the purposes of this disclosure, it is assumed that the end wall of the envelope 11 has suitable optical characteristics so that the reflected light is directed onto the cathode 12 from the left as viewed in the drawings. Also, it is assumed that the cathode layer is sufficiently thin and uniform to emit electrons in the necessary quantities. The current, which is conducted through the photoelectric tube 37 and the re-

sistors 33 and 35, is directly proportional to the average light intensity incident upon the cathode 12 of the dissector tube. The second electron multiplier electrode 24, which is connected to the preselected point on the resistor 33, is maintained at a potential relative to the potentials of the first and third multiplier electrodes 23 and 25 respectively, such that the signals derived from the multiplier output resistor 38 are within a predetermined amplitude range.

Assume that the average light intensity incident upon the dissector tube cathode 12 increases. The number of primary electrons impinging upon the first multiplier electrode 23 also increases and thereby increases accordingly the number of secondary electrons derived from this stage. However, since the average light intensity which is incident upon the photoelectric tube 37 also is increased, there is effected a corresponding increase in the current flowing through resistors 33 and 35. Consequently, there is produced a corresponding decrease in the positive potential applied to the second multiplier electrode 24. Since the number of secondary electrons emitted by this electrode is a function of the number of electrons impinging thereon and the potential of this electrode with respect to the source of the impinging electrons, it is seen that the ratio of the number of secondary electrons to the number of impinging electrons is decreased. Of course, since the first and third multiplier electrodes 23 and 25 respectively are maintained at constant potentials, there is effected a corresponding increase of the potential difference between electrodes 24 and 25. However, by reason of the emission characteristics of the multiplier electrodes, there is effected a net decrease in the amplifier gain between the first and third multiplier stages.

This may be seen by referring to Fig. 2 in which the curve 39 represents the ratio of secondary electron current to primary electron current of the secondary emissive multiplier electrodes as determined by the impact voltage of the primary electrons. The curve has a constantly decreasing slope as the impact voltage is increased. Consequently, even though the impact voltage of the electrons impinging upon the third multiplier electrode 25 of Fig. 1 is increased in an amount equal to the decrease of the impact voltage of the electrons impinging upon the second multiplier electrode 24, the increase in the ratio of secondary to primary electron currents with respect to the electrode 25 is appreciably less than the decrease in the ratio of secondary to primary electron current with respect to electrode 24 for given voltage increment. Thus, as a result of a decrease of the voltage impressed upon the electrode 24, the net gain for the two stages is decreased.

The amplifier gain per stage, for stages succeeding that including the electrode 25, remains constant. Therefore, since there is effected a net decrease of amplifier gain in the first stages of the multiplier there necessarily is effected a net decrease in the overall amplifier gain of the multiplier.

As the incident light decreases, the potential applied to the multiplier electrode 24 is increased in an obvious manner in view of the foregoing description, whereby to effect an overall increase in the gain of the multiplier to compensate for the average light variation.

Referring now to Fig. 3 of the drawings, there is shown an image analyzing tube of the dissector type having an electron multiplier asso-

ciated therewith similar to that illustrated in Fig. 1. Corresponding parts of the apparatus shown in the two figures have been given like characters of reference. In the modification depicted in Fig. 3, however, the target anode 14 is connected to the positive terminal of the battery 19 through a resistor 43. The junction point of the voltage divider resistors 28 and 29 is connected to the positive terminal of the battery 19 and the second multiplier electrode 24 is connected to a preselected point on the resistor 43.

There is also connected in series with the energizing circuit for the focusing coil 18 the space discharge path of a vacuum tube 44. The input circuit of this tube is arranged to be responsive to the current flowing in the photoelectric current circuit of the dissector tube. This arrangement is made by connecting the grid of the tube to the junction point of resistor 43 and the anode 14, and by connecting the cathode of the tube to the positive terminal of the battery 19.

Referring now to the operation of the apparatus illustrated in Fig. 3, there is produced a flow of photoelectric current through the external circuit connected to the dissector tube including the resistor 43 in accordance with the average intensity of the light incident upon the cathode 12. The voltage developed in this resistor, including the portion between the positive terminal of the battery 19 and the point of connection of the multiplier electrode 24, is representative of the photoelectric current in the circuit, and thereby representative of the intensity of the average light which is incident upon the photoelectric cathode 12 of the dissector tube. The electron multiplier functions to develop video signals in the output resistor 38 having the predetermined range of amplitudes.

Assume that there is an increase in the average intensity of light which is incident upon the photoelectric cathode 12 of the dissector tube. There is produced a corresponding increase in the photoelectric current flowing in the external circuit which effects the development of a less positive potential at the point of resistor 43 to which the multiplier electrode 24 is connected. There is thus produced a net decrease in the amplifier gain between electrodes 23 and 25, whereby the overall gain of the electron multiplier is decreased correspondingly to maintain the amplitudes of the video signals derived from the resistor 38 within the predetermined range.

If the intensity of the average light which is incident upon the photoelectric cathode 12 of the dissector tube decreases, there is a corresponding increase effected in the overall amplifier gain of the multiplier, whereby to maintain the amplitude range of the video signals derived from the resistor 38 constant.

It is evident that, by reason of the inclusion of the impedance represented by the resistor 43 in the external photoelectron current circuit, the target anode 14 is subjected to voltage variations with respect to the photoelectric cathode 12. As a result, the electron current between the cathode 12 and the anode 14 is modified in a manner to necessitate an adjustment of the focusing coil current.

The additional current flowing through the external circuit of the dissector tube causes the development of an increased voltage across the resistor 43, whereby the grid of the tube 44 is rendered increasingly negative with respect to its associated cathode. The impedance of the space discharge path of the tube is increased, thereby

to reduce the current flowing through the focusing coil 18. By suitable adjustment of circuit constants the focusing coil current may be reduced in value in the amount necessary to effect the required decrease in the intensity of the focusing field.

It is obvious that, when the average light intensity falls below normal, the tube 44 responds to the decrease of current flowing in the external circuit of the dissector tube to increase the intensity of the focusing field to a compensatory degree.

The second multiplier stage electrode 24 has been chosen for illustrative purposes as the electrode upon which the gain control voltage is impressed. Obviously, the invention may be practiced by varying the potential of any of the other electrodes. More effective results may be obtained, however, by selecting an electrode of one of the lower multiplier stages.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention and, therefore, it is aimed in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an electron multiplier having a plurality of secondary emissive electrodes, said dissector tube and said multiplier being arranged for the transfer of electron energy from said tube to said multiplier, an impedance device connected in circuit with said dissector tube cathode, means for deriving from said impedance device voltages developed by the flow of photoelectric current through said device varying in magnitude in accordance with the average intensity of light reflected from a television subject, and means for impressing said voltages upon one of said multiplier electrodes, whereby to vary the amplification factor of said multiplier inversely to a variation of the average intensity of said reflected light.

2. In an image analyzing apparatus, a dissector tube having a photoelectric cathode and an anode, an electron multiplier having a plurality of secondary emissive electrodes, said dissector tube and said multiplier being arranged for the transfer of electron energy from said tube to said multiplier, a circuit including a resistor connecting said dissector tube cathode and anode, and means for impressing voltages developed in said resistor by the flow of photoelectric current therethrough upon one of said multiplier electrodes, whereby to adjust automatically the amplification factor of said multiplier in accordance with the magnitude of said photoelectric current.

3. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an anode and an electron image focusing device, an electron multiplier including a secondary emissive electrode and associated with said dissector tube for the amplification of electron energy derived from said tube, means for developing voltages varying in magnitude in accordance with the average intensity of the light incident upon said dissector tube cathode, means for impressing said voltages upon said multiplier electrode

to vary the amplification factor of said multiplier inversely to a variation of the average intensity of the incident light, and means for impressing said voltages upon said focusing device to maintain the electron image in focus in said dissector tube.

4. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an anode and an electro-magnetic electron image focusing coil, an electron multiplier having a plurality of secondary emissive electrodes and associated with said dissector tube for the amplification of electron energy derived from said tube, means for developing voltages from the photoelectric current derived from said dissector tube, said voltages varying in magnitude in accordance with the average intensity of the light incident upon said dissector tube cathode, means for impressing said voltages upon one of said multiplier electrodes to vary the amplification factor of said multiplier inversely to a variation of the average intensity of the incident light, and means controlled by said photoelectric current for adjusting the field intensity produced by said focusing coil to maintain the focus of the electron image in said dissector tube.

5. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an anode and an electro-magnetic electron image focusing coil, an electron multiplier having a plurality of secondary emissive electrodes and associated with said dissector tube for the amplification of electron energy derived from said tube, an impedance device connected in circuit with said dissector tube cathode and anode for the development of voltages varying in accordance with variations produced in the photoelectric current resulting from variations of the average intensity of the light incident upon said cathode, means for impressing voltages derived from said impedance device upon one of said multiplier electrodes, whereby to vary the amplification factor of said multiplier inversely to a variation of the average incident light intensity, and means controlled by

voltages developed in said impedance device for automatically adjusting the current through said focusing coil, whereby to adjust the focusing of the electron image in said dissector tube to compensate for the altered potential of said anode with respect to said cathode produced by the voltage variation in said impedance device.

6. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an anode and an electro-magnetic electron image focusing coil, an electron multiplier having a plurality of secondary emissive electrodes and associated with said dissector tube for the amplification of electron energy derived from said tube, a circuit including a source of direct current energy and a resistor for impressing a difference of potential between said anode and said cathode, means including a connection between said resistor and one of said multiplier electrodes for varying the potential of said electrode in accordance with the photoelectric current flowing in said resistor, and a space discharge device having an output circuit connected to control the current in said focusing coil and an input circuit connected to said resistor, whereby to vary the focusing coil current inversely to variations of the photoelectric current.

7. In an image analyzing apparatus, a dissector tube having a photoelectric cathode, an electron multiplier having a secondary emissive electrode, said dissector tube and said multiplier being arranged for the transfer of electron energy from said tube to said multiplier, means coupled to said cathode for developing voltages corresponding to the flow of photoelectric current varying in magnitude in accordance with the average intensity of light reflected from a television subject, and means for impressing said voltages upon said multiplier electrode, whereby to vary the amplification factor of said multiplier inversely to a variation of the average intensity of said reflected light.

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