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SAFETY CIRCUIT ARRANGEMENT FOR MULTIPLIER TUBES

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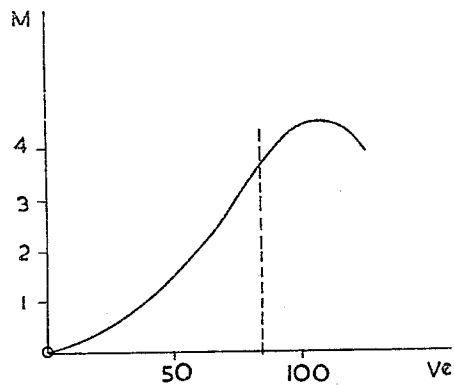


FIG.1

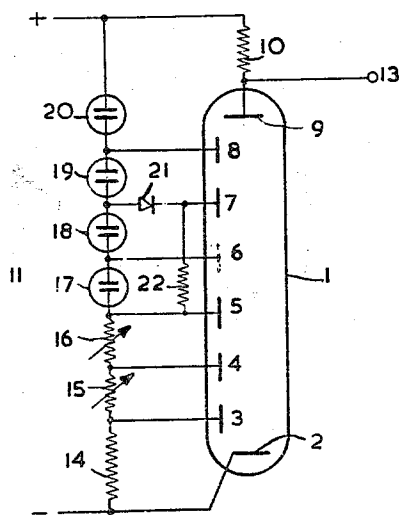


FIG.2

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SAFETY CIRCUIT ARRANGEMENT FOR
MULTIPLIER TUBES

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5 Claims. (Cl. 250—207)

In amplifiers containing a multiplier tube it is frequently of advantage to use means for preventing overloading of this tube. Such overloading may, for example, be produced by overdriving the tube.

As an example of the use of multiplier tube amplifiers mention may be made of light-spot scanners for stationary pictures or for cinematographic films.

Usually the amplification of these amplifiers is controlled by hand or automatically, when dark and bright pictures, for example diapositives or film parts, are scanned in succession. This amplification control is usually produced by varying the voltage across a few multiplier stages which are chosen within the middle-range of the series of stages. When a very bright picture is scanned after a dark one or when the scanned film is suddenly finished or interrupted, the current in the last stages or in the anode circuit may become very large and may be likely to damage the multiplier tube because of the fact that the setting-back of the amplification-control always becomes operative with some time delay.

The invention relates to safety circuit arrangements for a multiplier tube. It is an object of the invention to provide a circuit arrangement, by which the tube is automatically protected against overload which may be due to overdriving.

According to the invention, at least one secondary emission electrode of the tube is connected to the cathode of a diode and also, through a resistance, to a point of considerably lower potential, the anode of the diode being connected to a terminal of a voltage-supply source, which terminal is positive with respect to the cathode of the tube, so that the current flowing through the diode is reduced by the value of the current from the said electrode, and that, when the current from the electrode exceeds a predetermined value, the diode is cut off and the voltage across the resistance is increased.

The invention will now be described more fully with reference to the accompanying drawing, in which:

Fig. 1 shows the electron multiplication characteristic curve of a secondary-emission electrode, and

Fig. 2 shows the circuit arrangement of one embodiment of the circuit in accordance with the invention.

The embodiment shown in Fig. 2 contains a multiplier tube 1 having a photo-cathode 2, six secondary emission electrodes 3, 4, 5, 6, 7 and 8 and an anode 9. Through a load resistance 10, the anode 9 is connected to the positive terminal of a voltage supply source 11 of, for example, 600 volts, the negative terminal of which is directly connected to the photo-cathode 2. In addition, the anode 9 is connected to an output terminal 13. A voltage divider is connected between the positive terminal of the source 11 and the cathode 2. This voltage divider comprises a resistor 14 of fixed value, two rheostats 15 and 16 and four voltage stabilizing gas-discharge tubes 17, 18, 19 and 20. All these components together form a series-circuit and the electrodes 3 to 8 are each connected to a suitable junction of two successive parts of the voltage

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divider. The electrode 7 is connected to the junction of the discharge tubes 18 and 19 through a diode 21, for example a germanium diode, the anode of which is connected to the said point. The electrode 7 is also connected, through a resistor 22, to the junction of the rheostat 16 and the discharge tube 17, and also to the electrode 5.

The curve shown in Fig. 1 is a typical example of the electron multiplication characteristic of a secondary emission electrode. It will be seen that the multiplication factor M gradually increases with increase of the voltage V_0 between this electrode and the preceding electrode and that, when this voltage reaches a pre-determined value (for example 85 volts), the multiplication factor M increases in a lesser degree and even decreases at still higher voltage (for example 110 volts), a state of saturation being reached.

When the value of the rheostat 15 is reduced, the voltage between the electrodes 3 and 4 and the electron multiplication on the electrode 4 decreases. The same holds for the rheostat 16, the voltage between the electrodes 4 and 5 and the electron multiplication on the electrode 5. A decrease of the voltage across the rheostats 15 and 16 entails an increase of the voltage across the resistor 14. However, the electron multiplication on the electrode 3 can only slightly increase and decreases again at even higher voltages, so that the overall amplification of the circuit arrangement decreases.

The circuit arrangement described may, for example, be used for television image-viewing purposes, as an amplifier in a light-spot scanner for stationary pictures or for cinematographic films. With normal irradiation of the photo-cathode 2, the resistor 22 passes a current which is determined by the value of this resistor and by the voltage across the discharge tubes 17 and 18. However, the diode 21 passes a current which is equal to the current through the resistor 22 reduced by the value of the current from the electrode 7. So long as the diode is conductive, the voltage on the electrode 7 remains substantially equal to the stabilized voltage at the junction of the discharge tubes 18 and 19. When the irradiation of the photo-cathode increases sharply, with constant amplification on the electrodes 4 and 5 the current in the stages 7—8, 8—9 and in the anode circuit might exceed the maximum permissible value. However, the value of the resistor 22 is chosen such that, at a voltage equal to that of the discharge tubes 17 and 18, it just passes a current the value of which is considered to be the permissible maximum for the electrode 7. When the current to the electrode 7 reaches this value, no current flows any more through the diode 21. Consequently, this diode is cut off, so that the voltage on the electrode 7 is no longer stabilized. As a result, this voltage increases with increase in the current passing through the resistor 22 and the amplification on the electrode 7 slightly increases with the voltage and subsequently decreases in accordance with the curve shown in Fig. 1. In contradistinction thereto, the amplification on the next following electrode 8 decreases considerably so that the overall amplification of the tube decreases and the current in the stages 7—8 and 8—9 and in the anode circuit is held at a safe level.

The operation of the circuit arrangement described amounts to a high degree of negative feedback which is only produced in the resistor 22 when a pre-determined current level is exceeded. This negative feedback is higher as the value of the resistor 22 increases. Thus, it is of advantage to connect the end of the diode 21 remote from the resistor 22 to a point the potential of which is considerably lower than that of the electrode (for example electrode 6) preceding the secondary-emission electrode concerned (for example electrode 7). Consequently

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ly, in the circuit arrangement described, the said end of the resistor 22 might be connected to the electrode 4 or 3 or even to the cathode 2. It might alternatively be connected to the electrode 6, in which case the automatic protection would be less effective.

In the case of a multiplier tube having only one secondary-emission electrode, or if the currents in the last amplification stage and in the anode circuit alone are to be limited, the voltage V_e between the single or last secondary-emission electrode and the preceding electrode (for example the cathode) must be chosen such that the electron multiplication factor M on the said secondary-emission electrode reaches about its maximum value under normal conditions (for example 4.5 at $V_e=110$ volts in Fig. 1).

When a pre-determined value of the electron current to the secondary emission electrode is exceeded, the voltage V_e increases and the amplification M decreases, so that the current in the last stage and in the anode circuit of the tube is limited to a safe value.

What is claimed is:

1. A safety circuit for an electron multiplier tube having a cathode, an anode, and at least one secondary emission electrode, said circuit comprising a voltage supply source having negative and positive terminals respectively connected to said cathode and anode and having a first intermediate voltage terminal and a second voltage terminal which has a negative polarity with respect to said first intermediate voltage terminal, a rectifier having an anode connected to said first intermediate voltage terminal and having a cathode connected to said secondary emission electrode; and a resistance connected between said secondary emission electrode and said second voltage terminal, said resistance having a value such that said rectifier is conductive during normal operation of said tube and becomes nonconductive when the current from said secondary emission electrode exceeds a predetermined value.

2. A safety circuit for an electron multiplier tube having a cathode, an anode, and at least two secondary emission electrodes arranged to have electrons from a first one

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thereof multiplied by a second one thereof, said circuit comprising a voltage supply source having negative and positive terminals connected respectively to said cathode and anode and having a first intermediate voltage terminal, a second voltage terminal having a negative polarity with respect to said first voltage terminal, and a third voltage terminal having a negative polarity with respect to said second voltage terminal, means connecting said second secondary emission electrode to said first voltage terminal, a rectifier having an anode connected to said second voltage terminal and having a cathode connected to said first secondary emission electrode, and a resistance connected between said first secondary emission electrode and said third voltage terminal, said resistance having a value such that said rectifier is conductive during normal operation of said tube and becomes nonconductive when the current from said first secondary emission electrode exceeds a predetermined value.

3. A circuit as claimed in claim 2, including means for stabilizing the voltages at said second and third voltage terminals with respect to the voltage at said first voltage terminal.

4. A circuit as claimed in claim 2, in which said tube includes a third secondary emission electrode arranged to supply electrons to said first secondary emission electrode, and means connected to bias said third secondary emission electrode at a voltage intermediate in value to the voltages at said second and third voltage terminals.

5. A circuit as claimed in claim 4, including means for stabilizing the voltages at said second and third voltage terminals with respect to the voltage at said first voltage terminal.

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