

[54] **AUTOMATIC BRIGHT SOURCE
PROTECTION CIRCUIT AND POWER
SUPPLY CIRCUIT FOR AN IMAGE
INTENSIFIER**

[75] Inventor: **Sen-Te Chow**, Fairfax, Va.

[73] Assignee: **The United States of America as
represented by the Secretary of the
Army**, Washington, D.C.

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315/10**

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315/10, 11; 323/1, 4, 9; 331/113**

[56] **References Cited**

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Primary Examiner—James W. Lawrence

Assistant Examiner—D. C. Nelms

Attorney—Harry M. Saragovitz, Edward J. Kelly,
Herbert Berl et al.

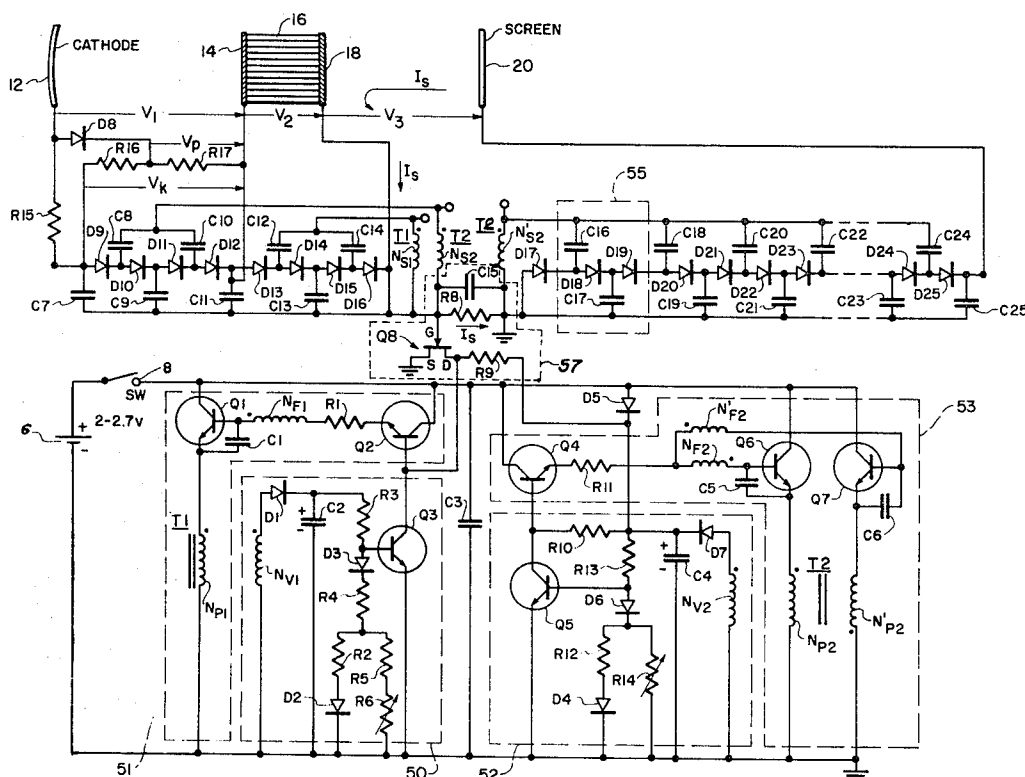
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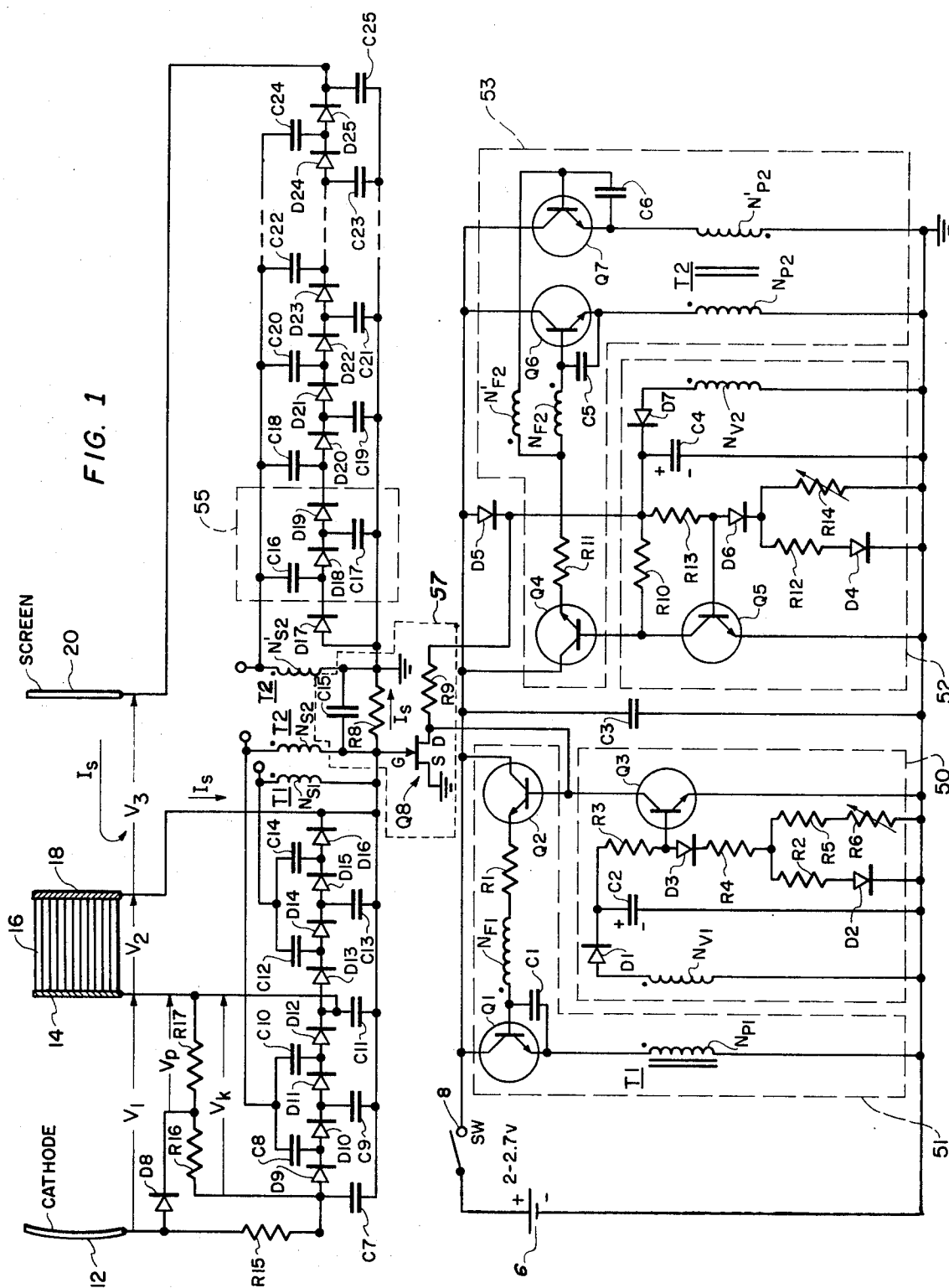
ABSTRACT

A bright source protection circuit and regulated power supply for an image intensifier tube in which the amount of screen current is sensed at the gate of an enhanced mode FET and the FET, in turn, controls voltage regulated oscillators in which the outputs of the oscillators furnish bias voltages to the cathode, to the electrodes on the microchannel plate, and to the screen within the image intensifier wherein these bias voltages change inversely to any change in the screen current. Since screen current flows in direct proportion to the amount of illumination emanating from the source being viewed, the brightness of the source being viewed by an operator looking through the image intensifier remains constant at the output of the image intensifier tube.

A clamping circuit between the cathode and the input electrode of a microchannel plate clamps the cathode operational voltage within the stable region of the cathode current-voltage characteristics. Pulsing outputs of the voltage controlled oscillators are transformer coupled to three voltage multipliers that provide separate direct current voltages to the cathode, to the input and to the output electrodes of a microchannel plate, and to the screen.

7 Claims, 2 Drawing Figures





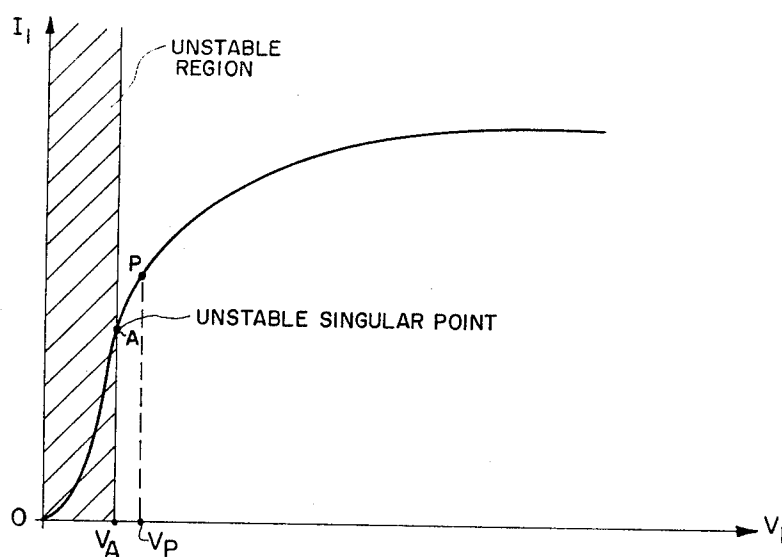


FIG. 2

AUTOMATIC BRIGHT SOURCE PROTECTION CIRCUIT AND POWER SUPPLY CIRCUIT FOR AN IMAGE INTENSIFIER

The invention described herein may be manufactured, used, and licensed by or for the Government for governmental purposes without the payment to me of any royalty thereon.

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a bright source protection circuit and regulated power supply for an image intensifier tube in which a clamping circuit is connected between the cathode and the input electrode of a microchannel plate amplifier for limiting cathode voltage and current. Also, voltage regulated oscillators are transformer coupled to three voltage multipliers for amplifying the pulsating oscillator output peak-to-peak voltages to larger direct current (DC) voltages. These DC voltages are the bias voltages that are connected to electrical elements within the image intensifier. The voltage regulated oscillators are controlled by an enhanced mode FET that has its gate connected between the output electrode of the microchannel plate and the screen. The gate is connected on the opposite side from ground to a sensing resistor through which the screen current flows. When the source being viewed becomes brighter, the screen current increases and the FET gate voltage increases. The voltage on the drain terminal of the FET decreases and, since the drain terminal of the FET is connected to the base of the voltage regulated N-P-N transistor oscillators, the peak-to-peak outputs of the oscillators are reduced. The amplitude of the DC voltages at the output of the voltage multipliers are decreased and the screen current is reduced accordingly, thus maintaining the apparent brightness of the source constant when viewed through the image intensifier.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of the automatic brightness control circuit and regulated power supply; and

FIG. 2 illustrates typical voltage-current curves of the cathode circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates a schematic of the automatic bright source protection circuit and regulated power supply circuit for an image intensifier tube. The power supply circuit consists of two base control regulated N-P-N transistor oscillator circuits 51 and 53. Oscillator 51 is a microchannel power supply, and oscillator 53 is a cathode and screen power supply. A first constant current source 50 supplies base current to oscillator 51, and a second constant current source 52 supplies base current to oscillator 53. A voltage source 6 is connected across the oscillator circuits and the constant current sources when switch SW is closed on terminal 8. Voltage source 6 has a value of from 2 volts to 2.7 volts. With switch SW closed on terminal 8, the voltage of battery 6 is sufficiently large enough to break down diode D5, called the starting diode, and apply the 2 volts or more to the base of transistors Q2 and Q4 through resistors R9 and R10, respectively. Transistors Q2 and Q4 are made conductive by this positive voltage applied to their bases. When Q2 and Q4 are con-

ductive, the positive 2 volts are applied across resistor R1 and coil N_{F1} to the base of transistor Q1 of oscillator circuit 51 and across resistor R11 and coils N_{F2} and N'_{F2} to the bases of transistors Q6 and Q7, respectively, of oscillator circuit 53. Resistors R1 and R11 are current limiting resistors that are used to avoid a fast rush of initial current to coils N_{F1} , N_{F2} , N'_{F2} . A positive voltage is then built up at the bases of transistors Q1 and Q6 causing these transistors to momentarily become conductive and conduct a positive pulse to winding N_{P1} of transformer T1 and to winding N_{P2} of transformer T2. The polarity of the positive pulse on N_{F1} and N_{F2} and the corresponding polarity of the pulse on windings N_{P1} and N_{P2} of transformers T1 and T2, respectively, are as shown in FIG. 1. As can be seen, the voltage on the base of transistor Q7 is negative, or zero, at this instant with the voltage on winding N'_{P2} of transformer T2 having the polarity as shown. Coils N_{F1} , N_{F2} , N'_{F1} have about 10 percent more turns than winding N_{P1} , N_{P2} , and N'_{P2} , respectively associated with each other in the base and emitter circuits. The coils have 10 percent more turns than the windings so that the base will be driven harder than the emitter and oscillation will be sustained across capacitors C1, C5, and C6, respectively. Capacitors C1, C5, and C6 stop spurious oscillation due to the high capacitance of the voltage multiplier circuits at the instant of oscillation initiation. Oscillation 53 operates in push-pull while oscillator 51 operates with a single train of pulses at its output. Capacitor C3 reduces any ripples in the voltage from source 6.

Constant current sources 50 and 52 operate in the same manner, therefore, only source 52 will be discussed hereinbelow in reference to its operation with oscillator circuit 53. A voltage is developed across winding N_{V2} by transformer action from primary winding N_{P2} of transformer T2. Diode D7 passes only the positive voltages from N_{V2} through to capacitor C4, developing a positive voltage V_{C4} on capacitor C4. Voltage V_{C4} is larger than the voltage from battery 6. Therefore, starting diode D5 is back biased and does not conduct. Voltage V_{C4} further furnishes bias voltage to the drain terminal of FET Q8 within automatic brightness control circuit 57. Voltage V_{C4} is also applied to the base of Q4 through resistor R10 and is applied to the base of Q5 through resistor R13, thus rendering Q4 and Q5 conductive. Diodes D6 and D4, made of germanium, compensate for any temperature change of silicon transistor Q5 base-emitter junction voltage. The value of fixed resistor R12 and variable resistor R14 determine the amplitude of oscillator 53 output. The operation of the oscillator circuit 53 and constant current source 52 under changing bright source conditions will be explained hereinbelow with reference to the various voltage multiplier circuits and the automatic brightness control circuit 57.

The base controlled push-pull oscillator 53 steps up the low DC voltage of 2 volts to 500 volts peak-to-peak alternating current (AC) voltage on transformer T2 secondary winding N'_{S2} and to 100 volts peak-to-peak (AC) voltage on secondary winding N_{S2} . A 10-stage voltage multiplier steps up the 500 AC volts across winding N'_{S2} to about 5,000 DC volts. One voltage multiplier, represented by dashed line block 55, illustrates the arrangement of charging capacitor C16 and the summing capacitor C17, along with diodes D18 and D19. The diodes function to guide the positive voltages

to sum the 500 volt multiples along the other nine stages of the 10-stage multiplier. Diode D17 keeps the positive portion of the 500 peak-to-peak volts, applied across charging capacitor C17, guided toward summing capacitor C17. At the end of the 10-stage voltage multiplier, and across the last of the summing capacitors C25, a 5,000 DC volts potential is developed. This 5,000 DC volts is applied to screen 20 as a bias voltage.

The 100 peak-to-peak volts, across secondary winding NS2, is applied to a first two-stage voltage multiplier. The first two-stage voltage multiplier comprises charging capacitors C8 and C10 and summing capacitors C7 and C9, along with diodes D9, D10, D11, and D12. The first two-stage voltage multiplier steps up the 100 peak-to-peak volts to 200 DC volts to furnish a cathode bias. The 200 DC volts cathode bias is connected to cathode 12 through cathode current limiting resistor R15. A clamping circuit, comprising resistors R16 and R17, and diode D8, clamps the cathode voltage within its stable region of operation. The voltage between the input electrode 14 of microchannel plate 16 and cathode 12, represented by V_1 , is shown in the voltage-current curve of FIG. 2. A voltage of 300 to 500 peak-to-peak volts is produced across winding NS1 at the output of transformer T1. This 300 to 500 volts peak-to-peak voltage is applied to a second two-stage voltage multiplier. The second two-stage voltage multiplier comprises charging capacitors C12 and C14 and summing capacitors C11 and C13, along with diodes D13, D14, D15, and D16. The second two-stage voltage multiplier steps up the 300 to 500 peak-to-peak volts to 600 to 1,000 DC volts to furnish a bias across front electrode 14 and back electrode 18 of microchannel plate 16.

A sensing resistor R8 detects the screen current I_s flowing in its return path from electrode 18 back to screen 20. The voltage on the gate of FET Q8 is according to the voltage drop across resistor R8, which voltage drop is caused by the amount of screen current flowing through resistor R8, FET Q8, resistor R8, capacitor C15, and resistor R9 form an automatic brightness control circuit 57. Control circuit 57 functions to automatically maintain the output brightness of the image intensifier tube constant. The automatic brightness control circuit 57 operates in the following manner. When input brightness of a source increases, more electrons are emitted from cathode 12 and consequently more electrons flow through the image intensifier tube to screen 20. Screen current I_s increases and the voltage drop across sensing resistor R8 also increases, and thus FET Q8 conducts more readily. The voltage at drain terminal D decreases, approaching the ground potential at the source terminal. With the drain terminal connected directly to the base of transistor Q2, the base current of transistor Q1 is also reduced, thus reducing oscillator 51 peak-to-peak voltage. Reduction of the peak-to-peak voltage at the output of oscillator 51 reduces the output of the second two-stage voltage multiplier, and thus reduces the gain in the microchannel plate 16. Conversely, should the brightness of the source being viewed become less, FET Q8 will conduct less and oscillator 51 will drive harder, thus applying more voltage across microchannel plate 16. Capacitor C15 filters out any spurious or shot noise picked up on sensing resistor R8.

A bright source protection circuit connected between cathode 12 and electrode 14 of microchannel

plate 16, and comprising cathode current limiting resistor R15, diode D8 and resistors R16 and R17, is used to protect the cathode under bright source conditions. When the source being viewed becomes brighter, cathode current increases and cathode voltage V_1 decreases. Resistor R15 drops the cathode voltage and limits the cathode current. Diode D8 and resistors R16 and R17 keep the image intensifier operating in the stable region even when the source is at a very high input light level. Referring to FIG. 2, along with FIG. 1, the input current-voltage characteristics of the tube are shown. In the I_1 - V_1 tube characteristics curve of FIG. 2, the slope is very large at the low cathode voltage levels and saturates at the high cathode voltages. If the tube operating point Q is in the unstable region, shown by the shaded area of FIG. 2, say point A of the I_1 - V_1 curve, a slight disturbance in the input light of the source or a change in the power supply will drastically change the cathode current I_1 , flowing from electrode 14 to cathode 12. Such a drastic change of I_1 will cause the tube to flicker. This flicker, or instability, problem can be solved by clamping the cathode voltage at a value V_p or at stable point P on the I_1 - V_1 curve. Resistors R16 and R17 divide the cathode supply V_k , taken at the output of the first two-stage voltage multiplier. A typical value for resistor R16 is 66 megohms, and a typical value for resistor R17 is 0.62 megohms. The voltage across resistor R17 is then, by the voltage divider method, $V_p = R17 / R16 = R17 \times V_k$, or about 3 volts since V_k is about 200 volts. Also, diode D8 conducts at a value of $V_k = 3$ volts. Therefore, the voltage across resistor R17, which is represented by V_p in both FIGS. 1 and 2, remains clamped at 3 volts. This 3 volts is in the stable region of operation, therefore, the tube remains clamped in the stable region or operation.

The value of the cathode current limiting resistor R15 is typically 50 gigaoohms when using the above mentioned values of resistors R16 and R17. At low input light levels, diode D8 will be reverse biased since the cathode current will be lowered. Conversely, at the bright source condition, cathode current will increase and cathode voltage V_1 will decrease. The most salient feature of this clamping circuit is that of clamping cathode voltage V_1 at a value high enough to be outside the unstable region of operation. For example, whenever V_1 decreases to the value of V_p and diode D8 is assumed to be ideal, the diode will conduct and cathode 12 voltage will be clamped to voltage V_p . Thus, tube flicker will not occur. Using an actual diode in the conductive mode of operation, however, there is a forward voltage drop V_f across diode D8 and some reverse leakage current I_r flowing back through D8. The actual clamping voltage of the tube when D8 is conducting is then $V_1 = V_p - V_f$. In the nonconducting mode, the effective impedance in series with the cathode is resistor R15 in parallel with the reverse resistance of diode D8. It is therefore preferable to select a low reverse leakage current characteristic diode for D8.

1. An automatic bright source protection and power supply circuit for holding the output of an image intensifier constant, the circuit comprising:

a direct current voltage source;

a microchannel plate power supply oscillator for converting said direct current voltage source at its input to an output alternating current voltage;

a cathode and screen power supply oscillator for converting said direct current voltage source at its input to an output alternating current voltage;
 a first constant current source for supplying base current to said microchannel plate power supply oscillator;
 a second constant current source for supplying base current to said cathode and screen power supply oscillator;
 a first two-stage voltage multiplier for converting said alternating current voltage at the output of said cathode and screen power supply oscillator to a direct current voltage connected between said cathode and a microchannel;
 a second two-stage voltage multiplier for converting said alternating current voltage at the output of said microchannel plate power supply oscillator to a direct current voltage connected across the microchannel plate;
 a 10-stage voltage multiplier for converting said alternating current voltage at the output of said cathode and screen power supply oscillator to a direct current voltage that is applied to the screen of said image intensifier tube;
 a first transformer coupling means for coupling and amplifying the alternating current voltage output from said microchannel plate power supply oscillator to the input of said second two-stage voltage multiplier and to the input of said first constant current source;
 a second transformer coupling means for coupling and amplifying the alternating current voltage output from said cathode and screen power supply oscillator to the inputs of said first two-stage voltage multiplier and said 10-stage voltage multiplier and to the input of said second constant current source;
 a clamping circuit connected between said cathode and the input to said microchannel plate for limiting the voltage therebetween to a value which limits the cathode to operate only in its stable region; and
 an automatic brightness control circuit wherein said automatic brightness control circuit monitors the amount of screen current and controls the direct current voltage input to the image intensifier inversely to the amount of screen current for keeping

the screen current and the output of the image intensifier constant.

2. An automatic bright source protection and power supply circuit as set forth in claim 1 wherein said microchannel plate power supply oscillator said cathode and screen power supply oscillator comprise base control voltage regulated N-P-N transistors.

3. An automatic bright source protection and power supply circuit as set forth in claim 2 wherein the input to said second two-stage voltage multiplier from said first transformer coupling means is 300 to 500 peak-to-peak volts that is converted to 600 to 1,000 direct current volts.

4. An automatic bright source protection and power supply circuit as set forth in claim 3 wherein the input to said first two-stage voltage multiplier from said second transformer coupling means is 100 peak-to-peak volts that is converted to 200 direct current volts.

5. An automatic bright source protection and power supply circuit as set forth in claim 4 wherein the input to said 10-stage voltage multiplier from said second transformer coupling means is 500 peak-to-peak volts that is converted to 5,000 direct current volts.

6. An automatic bright source protection and power supply circuit as set forth in claim 5 wherein said automatic brightness control circuit comprises a FET having its gate connected to a sensing resistor that detects the amount of screen current and its source terminal at ground potential with its drain terminal connected to the base of said base control voltage regulated N-P-N transistor of said microchannel plate power oscillator.

7. An automatic bright source protection and power supply circuit as set forth in claim 6 wherein said clamping circuit comprises a cathode current limiting resistor connected between said cathode and said first two-stage voltage multiplier and a serially connected diode and resistor in parallel with said cathode current limiting resistor with a resistor connected between the input electrode of the microchannel plate and the junction of the serially connected diode and resistor for limiting the voltage between said cathode and the input electrode of said microchannel plate whereby any change in source brightness being viewed by said image intensifier tube does not change the cathode operating characteristic to an unstable condition.

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