Oct. 30, 1951 W. B. BERNARD 2,572,832

TUBE PROTECTION CIRCUIT

Filed May 24, 1948 2 SHEETS—SHEET 1

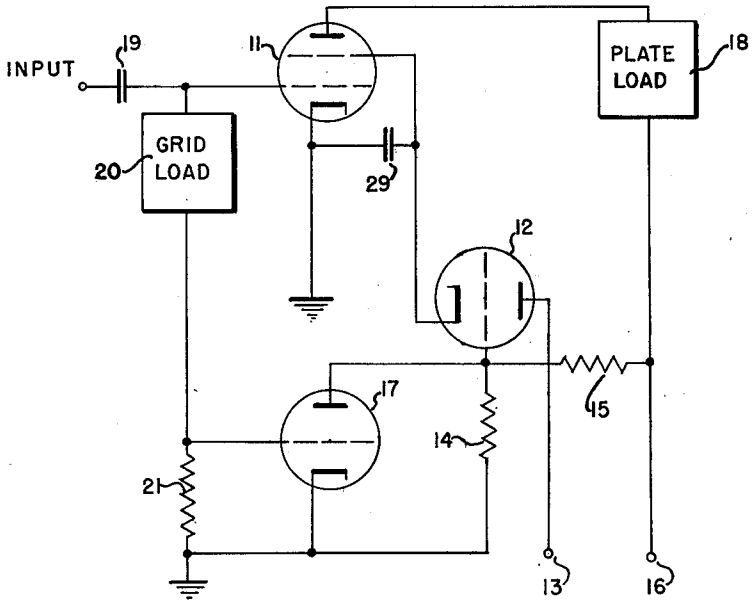


FIG. 1

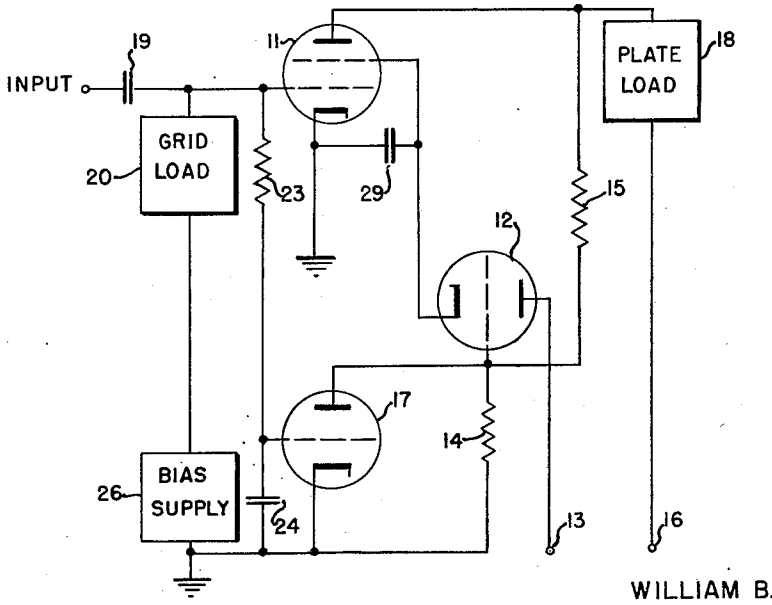


FIG. 2

INVENTOR
WILLIAM B. BERNARD

BY

ATTORNEY

Oct. 30, 1951 W. B. BERNARD 2,572,832

TUBE PROTECTION CIRCUIT

Filed May 24, 1948 2 SHEETS—SHEET 2

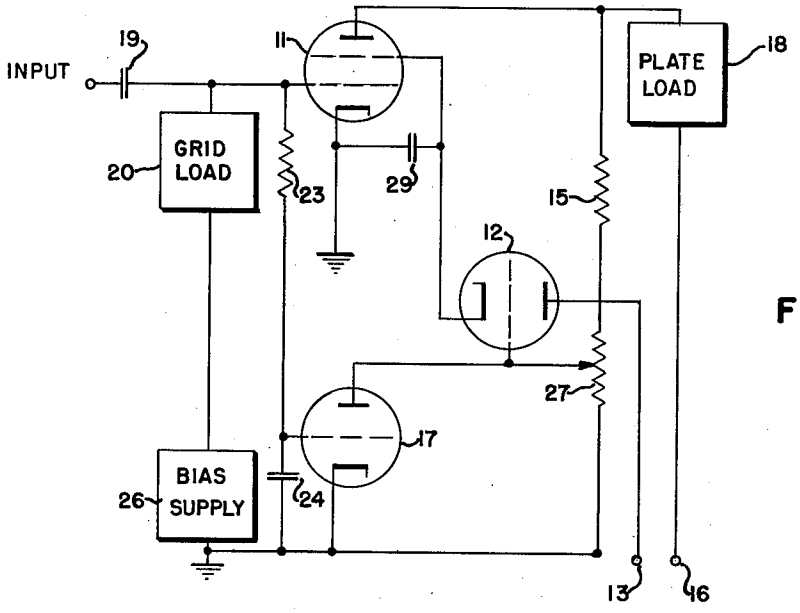


FIG. 3

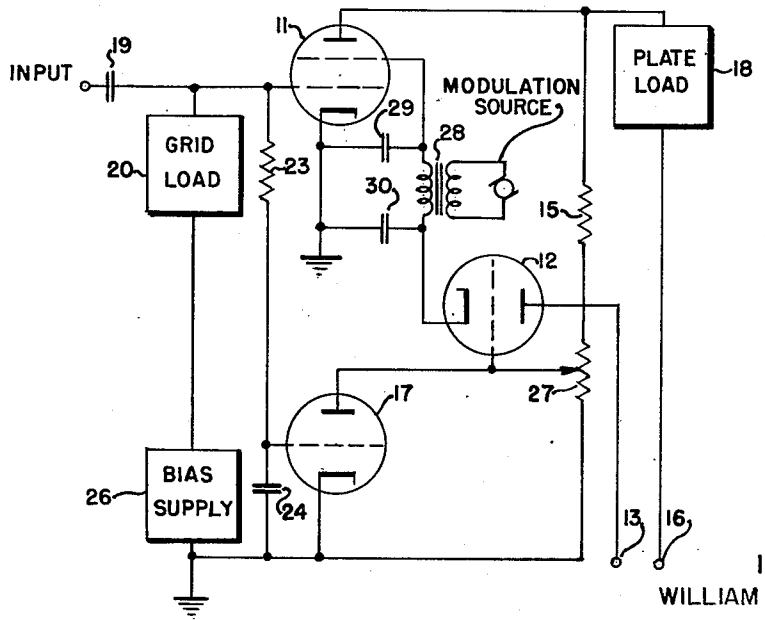


FIG. 4

INVENTOR
WILLIAM B. BERNARD

BY

ATTORNEY

Patented Oct. 30, 1951

2,572,832

UNITED STATES PATENT OFFICE

2,572,832

TUBE PROTECTION CIRCUIT

William B. Bernard, Portsmouth, N. H.

Application May 24, 1948, Serial No. 28,960

7 Claims. (Cl. 250—27)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

This invention relates in general to electron tubes and, more particularly, to the control of electrode potentials of such tubes.

Electron tubes in general are designed with heavy cathode and anode structures, since in normal operation these two elements carry the largest currents passing through the tube. Grid structures, on the other hand, since they are usually employed merely as controlling elements and are not required to conduct heavy currents, are of lighter construction. Further, as the purpose of a grid is to control the passage of electrons to an anode, they must of necessity be made of mesh or spaced turns of wire. Since grids are inherently incapable of passing large currents, they must be protected from the inadvertent application of voltages which might cause them to draw large currents that would result in their destruction and thus render the tube inoperative.

Obviously, some type of protection is of extreme importance when expensive transmitting tubes are used. Heretofore, systems of relays were employed as protective devices. These systems were objectionable for several reasons. The original cost was high; the circuits were often complex; and the protection provided was not of a positive nature due to the fact that the contacts of the relays become damaged from arcs set up when they opened and closed.

The present invention has several distinct advantages over prior protective circuits. It is inexpensive, since common electronic tubes of the receiving type are the major components. Maintenance is a negligible factor, amounting only to occasional tube replacement. Finally, the protection provided is positive for the tube being protected is not endangered even by a failure of the protective circuit itself.

Accordingly, it is the general object of this invention to provide an electronic circuit for limiting the grid voltages of an electron tube to safe values in the absence of correct voltages on the other electrodes of the electron tube.

It is a further object of this invention to prevent damage to an electron tube by reducing electrode potentials in the absence of an input signal to the electron tube.

These and other objects will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a schematic illustration of one form of the invention;

Fig. 2 is a schematic illustration of a second form of the invention showing an alternative biasing arrangement;

2

Fig. 3 is a schematic illustration of a modification of the circuit diagram of Fig. 2 providing means for voltage adjustment; and

Fig. 4 is a schematic illustration of a modification of the circuit diagrams of Fig. 1 and Fig. 3, providing means for modulation.

The embodiments of the invention as shown in all accompanying figures have several features in common. In each of these figures, which will be discussed first in general terms, the screen grid of tube 11 is the grid being protected. It will also be noted that tube 12 is connected in series between the screen grid of tube 11 and the screen grid positive potential supply at terminal 13. The action of tube 12, as determined by the potential on its control grid is one of the major factors of circuit operation. The potential on the control grid of each tube 12 is dependent upon, first, the voltage obtained from the dividers composed of resistors 14 and 15 (Figs. 1 and 2) and resistor 15 and potentiometer 27 (Figs. 3 and 4) connected between plate potential supply terminal 16 and ground; and, second, the state of conduction of each tube 17. Thus, since the divider voltage is determined by the plate voltage of tube 11 as applied at terminal 16, then by means of the control grid of tube 12 the voltage applied to the screen grid of tube 11 is controlled. Further, if the control grid potential of tube 12 is also controlled by the conduction of tube 17, which is in turn controlled by the voltage on, or the excitation to the grid of tube 11, the screen grid voltage of tube 11 becomes responsive to the action of tube 17.

Referring now specifically to Fig. 1, tube 11, the tube being protected, is connected in a substantially conventional manner, with its cathode grounded, its plate energized from the terminal 16 of a suitable high voltage direct current supply. The output circuit of tube 11 is designated by plate load 18. The input circuit to the grid of tube 11 is composed of series capacitor 19, the grid load 20, and resistor 21. The screen grid voltage is supplied from an independent source at terminal 13, and is connected to the plate of control tube 12, the cathode of which is connected to the screen grid of tube 11. The control grid of tube 12 is connected to the junction of the voltage divider formed by series connected resistors 14 and 15, as well as to the plate of tube 17. The cathode of tube 17 is grounded. The control grid of tube 17 is connected to the ungrounded side of resistor 21 which is in turn connected to the control grid of tube 11 through grid load 20.

In normal operation, excitation is applied to the grid of tube 11 and a rectified current flows through the grid load 20 and resistor 21, causing a negative voltage to be developed between this grid and ground. This negative voltage concurrently appears on the grid of tube 17 and cuts off the flow of plate current in that tube. If desired, resistor 21 may be replaced by a battery or other suitable potential source having its positive terminal grounded and its negative terminal connected to the control grid of tube 17 and the grid load 20. This change will provide fixed negative bias. A combination of fixed and self bias may also be used. Resistors 14 and 15, connected between plate supply terminal 16 and ground, are of such values that when no current is drawn from the junction of these two resistors, the voltage at this point approximates the operating voltage of the screen grid of tube 11, and when moderate current is drawn from this junction, its voltage will be very low. No current is drawn from this junction under normal conditions with tube 17 cut off, leaving this junction, and therefore the grid of tube 12 at a positive voltage. The application of a sufficiently high positive voltage on the plate of tube 12 under these conditions causes the cathode of tube 12 to come to a voltage slightly more positive than that of the grid of tube 12. Thus, since the cathode voltage of tube 12 is the screen grid voltage of tube 11, control of the grid voltage of tube 12 effectively controls the screen grid voltage of tube 11.

The action of the protective circuit is effected, first, if the plate voltage supply fails. The voltage at the junction of the control grid of tube 12 and the divider drops to zero, and the conduction of tube 12 is decreased to such an extent that the voltage on its cathode and thereby the voltage on the screen grid of tube 11 is reduced to a value below that which would cause the grid to draw excessive current.

The second action of the protective circuit is effected when the grid excitation to tube 11 fails. Tube 17 loses its negative bias which was previously obtained from the passage of rectified signal current through resistor 21. Tube 17 then becomes conductive, causing the voltage at its plate, and hence, on the control grid of tube 12 to drop to a low value. This dropping of voltage on the control grid of tube 12 causes its conduction to be decreased, and, as in the first action of the protective circuit, the voltage on the cathode of tube 12 and the screen grid of tube 11 is reduced to a safe value.

Referring to Fig. 2, which is an embodiment in most respects similar to that of Fig. 1, resistor 15 is now connected directly to the plate of tube 11 rather than to terminal 16 of the plate voltage supply as before. The protective circuit will function to reduce the screen voltage of tube 11, in the manner previously described when the plate supply fails or if the plate load should become open-circuited. Since resistor 15 is of a high value, relatively little power will be dissipated therein. The other circuit changes involve the grid input circuit. In this figure, a resistor 23 is connected between the grid of tube 11 and the grid of tube 17. A capacitor 24 is connected between the grid of tube 17 and ground, and no direct connection is made to the grid bias supply 26. All other connections remain the same as in Fig. 1. In normal operation of tube 11, capacitor 24 acquires a negative charge on the plate that is connected to the grid of tube 17. This charge is obtained from the bias supply 26 and is sufficient to maintain tube 17 in a non-conductive state. The protective circuit will now function if the grid load 20 becomes open-circuited, at which time capacitor 24 will discharge causing the grid of tube 17 to become less negative. Tube 17 will then conduct current and the screen voltage on tube 11 will be reduced in the manner described in reference to Fig. 1.

Fig. 3 illustrates a circuit similar to that of Fig. 2 with the exception that resistor 14 of Fig. 2 has been replaced by potentiometer 27, the tap of which is connected to the plate of tube 17 and the control grid of tube 12. The voltage divider remains the same as Fig. 2; the tap merely has been made variable by the substitution of potentiometer 27. All other connections remain the same as in Fig. 2. By means of the potentiometer 27, adjustment of the control grid voltage of tube 12 is possible and thus, the screen grid voltage on tube 11 can be varied. The action of the protective circuit remains the same as that described in reference to Fig. 2.

Fig. 4 illustrates a circuit similar to that of Fig. 3, except that provision for modulation of the screen grid of tube 11 has been made by the insertion of the secondary of the modulation transformer 28 between the cathode of tube 12 and the screen grid of tube 11. Capacitors 29 and 30, connected from each terminal of the secondary of transformer 28 to ground, are used as bypass capacitors, capacitor 29 acting as a bypass for audio frequencies and capacitor 30 a bypass for radio frequencies as is well known in the modulation art. All other connections remain as described in reference to Fig. 3. The protective action of the circuit of Fig. 4 as a whole remains the same as that described in reference to Fig. 3, with the added advantages that the screen grid direct potential may be varied, and that screen grid modulation may be used.

The invention may be applied to other types of control circuits where it is desired to protect any elements from excessive voltage being applied to them. Only particular embodiments of the invention have been described. However, it will be apparent to those skilled in the art that numerous modifications may be made that will fall within the scope of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for government purposes without the payment of royalty thereon or therefor.

What is claimed is:

1. A protective circuit for a first electron tube having a cathode, plate and a grid, a first voltage source for energizing said plate and a second voltage source for energizing said grid, said circuit comprising a second electron tube having a cathode, plate and control grid and connected serially between said first tube grid and said second voltage source, means for energizing said control grid of said second tube from said first voltage source, whereby failure of said first voltage source substantially instantaneously reduces the voltage on the grid of said first tube.

2. A protective circuit for a first electron tube having a cathode, a plate, control grid and auxiliary grid, a first voltage source for energizing said plate and a second voltage source for energizing said auxiliary grid, said circuit comprising, a second electron tube having a cathode, plate, and control grid and connected serially between said auxiliary grid of said first tube and said second voltage source, means for energizing

said control grid of said second tube from said first voltage source, means for substantially de-energizing said control grid of said second electron tube, said first-mentioned means being responsive to voltages appearing on said plate of said first electron tube, and said last-mentioned means being responsive to voltages appearing on said control grid of said first electron tube.

3. A protective circuit for a first electron tube having a cathode, a plate, a control grid and a screen grid, a first voltage source for energizing said plate, a second voltage source for energizing said screen grid, said circuit comprising a second electron tube having a cathode, a plate and a control grid and connected serially between said first electron tube screen grid and said second voltage source, a third electron tube having a cathode, a plate and a control grid, means for energizing said control grid of said second electron tube and said plate of said electron tube from said first voltage source, means for energizing said control grid of said first electron tube and said control grid of said third electron tube, whereby failure of said first voltage source or failure of said last-mentioned means substantially instantaneously reduces the voltage on said screen grid of said first electron tube.

4. A protective circuit for a first electron tube having a cathode, a plate, a control grid and a screen grid, a first voltage source for energizing said plate, a second voltage source for energizing said screen grid, a third voltage source for biasing said control grid, said circuit comprising a second electron tube having a cathode, a plate and a grid and connected serially between said first electron tube screen grid and said second voltage source, a plate load impedance connected serially between said plate of said first electron tube and said first voltage source, a grid load impedance connected serially between said first electron tube control grid and the negative terminal of said third voltage source, a third electron tube having a cathode, a plate and a grid, a large resistor connected serially between said first tube control grid and said third tube grid, a large capacitor connected serially between said third tube grid and the positive terminal of said third voltage source, means for energizing said second tube control grid and said third tube plate from said first tube plate, whereby failure of said first voltage source or said third voltage source substantially instantaneously reduces the voltage on the screen grid of said first electron tube.

5. Apparatus as in claim 4 and including a modulation transformer serially connected between said second electron tube and said first tube screen grid, and means for energizing said transformer for modulating the output of said first tube.

6. A protective circuit for an electron tube having at least a control grid and an auxiliary grid, a first voltage source for energizing said auxiliary grid, a second voltage source for energizing said control grid, means connected in series between said first voltage source and said auxiliary grid for limiting the voltage applied to said auxiliary grid, and means responsive to failure of said second voltage source for actuating said limiting means.

7. A protective circuit for an electron tube having at least a plate and an auxiliary grid, a first voltage source for energizing said auxiliary grid, a second voltage source for energizing said plate, means connected in series between said first voltage source and said auxiliary grid for limiting the voltage applied to said auxiliary grid, and means responsive to failure of said second voltage source for actuating said limiting means.

WILLIAM B. BERNARD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,129,088	George	Sept. 6, 1938
2,163,670	Ditcham	June 27, 1939
2,303,357	Hoovery	Dec. 1, 1942
2,305,543	McCarty	Dec. 15, 1942
2,341,232	Norton	Feb. 8, 1944
2,377,500	Johnson	June 5, 1945
2,398,916	Brewer	Apr. 23, 1946

OTHER REFERENCES

The Radio Amateur's Handbook, 1946 ed.