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VACUUM TUBE CIRCUIT

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FIG. 1

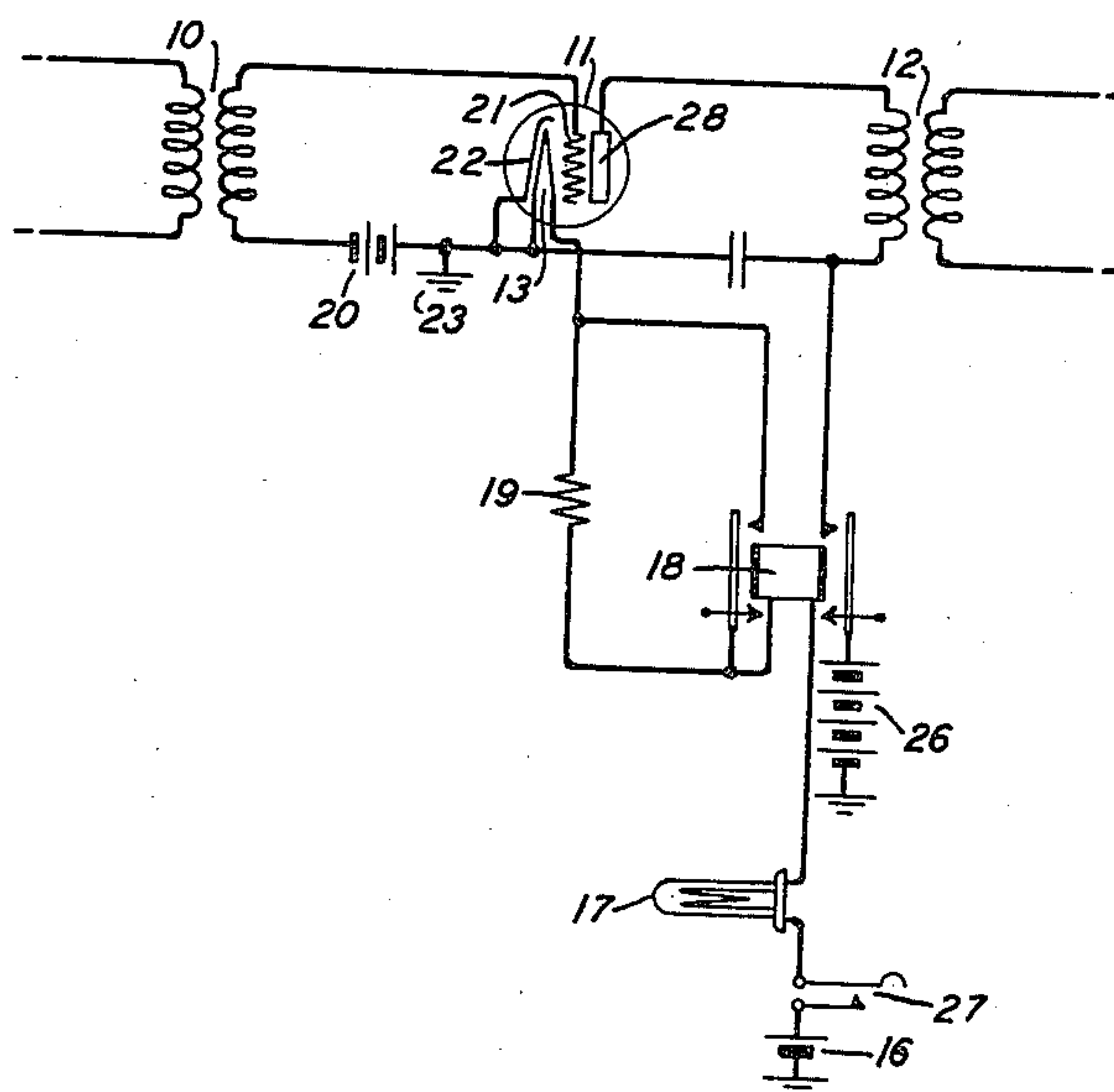
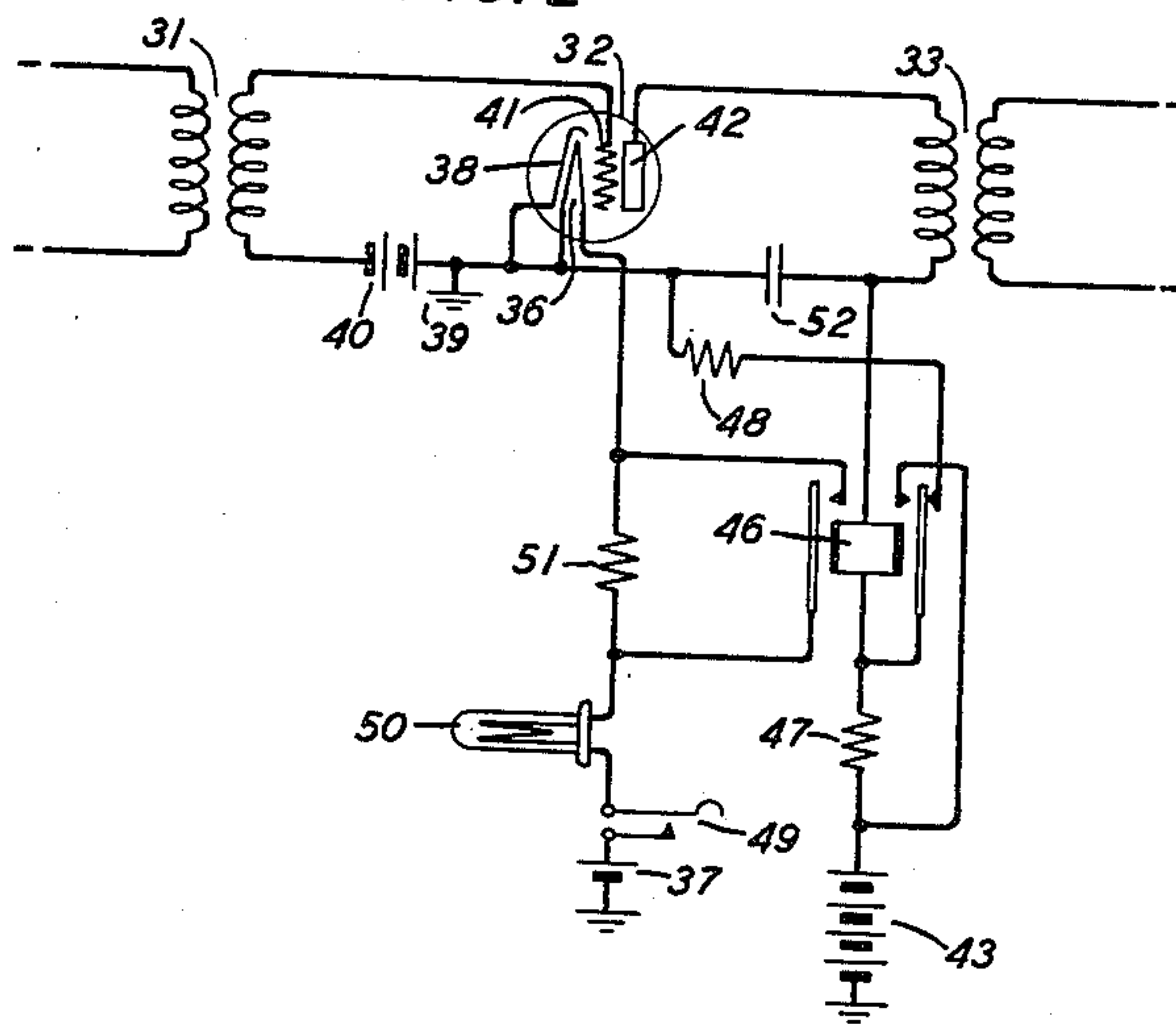


FIG. 2



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VACUUM TUBE CIRCUIT

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13 Claims. (Cl. 250—27)

This invention relates to vacuum tube circuits and particularly to protective arrangements for use with such circuits.

It is an object of the invention to protect parts of a vacuum tube circuit from damage due to excessive voltage.

A more specific object of the invention is the protection of the anode of the vacuum tube and other parts of the anode circuit from damage due to excessive voltage.

When a vacuum tube used in an ordinary circuit, for example, an amplifier circuit, is in operating condition, i. e., when the cathode is emitting the normal number of electrons and the space current circuit has been established, the voltage actually applied to the anode of the tube is appreciably less than the full rated voltage of the anode battery this being due to the IR drop in the external anode circuit. The anode and other parts of the circuit are usually designed to operate with this reduced value of anode voltage. Now if the anode battery be left connected to the anode when the cathode is cold and the tube is inoperative, substantially the full voltage of the battery is applied to the anode and damage may result thereto as well as to the coils and other parts of the circuit.

In accordance with a feature of the invention no anode voltage, or only a fraction of the entire voltage of the anode battery, is applied to the anode until the cathode has become fully heated and the cathode to anode circuit has been established within the tube, whereupon the full voltage of the anode battery is applied to the anode circuit.

In certain instances where ballast lamps are included in vacuum tube circuits it is desirable that means be provided for protecting the ballast lamp from excess voltages during the initial heating period of the cathode.

In accordance with a further feature of the invention the means provided for protecting the anode circuit from excess voltages is effective also to protect the ballast lamp from damage due to excessive voltage.

In accordance with a specific embodiment of the invention, a slow operate relay is connected in series with the cathode heater, a resistance, the ballast lamp and the heater battery. The characteristics of the relay are preferably such that its operate time is equal to or slightly greater than the time required for the cathode to reach its full emission temperature. The relay therefore operates just as the cathode reaches the proper temperature to establish the space current path within the tube or soon thereafter and is effective by its operations (a) to shunt the resistance out of the heater circuit whereupon the full heater voltage is applied thereto and

(b) to connect the anode battery to the anode circuit of the tube.

In accordance with another embodiment of the invention, the anode battery is connected to the anode, during initial heating of the cathode, through two resistances, one in series with the anode supply circuit and the other in parallel thereto. Establishment of the space current path is effective to cause operation of a relay which by its operation (a) effectively removes the two resistances from the anode supply circuit and (b) shunts a resistance out of the heater circuit.

A full understanding of the invention and of its various desirable features may be gained from consideration of the following description in connection with the drawing in which:

Figure 1 shows a typical vacuum tube circuit including one embodiment of the invention; and

Fig. 2 shows a similar vacuum tube circuit including another embodiment of the invention.

Referring now to Fig. 1 a simple amplifier circuit is shown including an input transformer 10, the secondary of which is connected to the input circuit of vacuum tube 11. The output circuit of the tube is connected to the primary of output transformer 12. Vacuum tube 11 is of the heater cathode type, the heater element 13 being connected to a suitable voltage source 16 through a circuit which includes, as series elements, ballast lamp 17, winding of relay 18 and when relay 18 is unoperated, a resistance 19. Battery 20 provides a suitable negative bias for control electrode 21 while cathode 22 is connected in the circuit in the conventional manner including a connection to ground 23. Relay 18 is provided with two make contacts, one of which is effective when the relay operates to shunt resistance 19 out of the heater circuit and the other of which is effective to connect anode battery 26 to the anode circuit. A key 27 controls the closing of the heater energizing circuit.

Let us assume now for purposes of description that it be desired to set the vacuum tube circuit into operation and that for this purpose key 27 be moved to closed position. This action completes the energizing circuit for heater 13 which circuit may be traced from battery 16, make contact of key 27, ballast lamp 17, winding of relay 18, resistance 19 and through heater 13 to ground 23. Voltage is not applied to anode 23 at this time as the anode supply circuit is open at the right make contact of relay 18 which is unoperated.

Resistance 19, being connected in the heater supply circuit at this time, prevents excessive voltage which would otherwise be present in the circuit due to the low resistance of heater 13 when cold and thereby protects the filament of ballast lamp 17 from damage.

The characteristics of relay 18 are preferably such that the time required after energization for the relay to operate is the same as or greater than that required by cathode 22 to reach the temperature at which electrons are emitted to establish the space current path within the tube. Therefore, just at the time the space current circuit is established between cathode 22 and anode 23, or soon thereafter, relay 18 operates and is effective by its operation to (a) complete through its left make contact a circuit shunting resistance 19 out of the heater energizing circuit and (b) complete through its right make contact a circuit from anode battery 26 to anode 23.

The first-mentioned action, i. e., shunting resistance 19, does not result in a sufficient increase in the voltage of the heater circuit to damage the filament of the ballast lamp even though resistance 19 is removed inasmuch as heater 13 has by now nearly reached its normal temperature and, consequently, its normal high resistance, which resistance is sufficient to prevent an excessive voltage across the ballast lamp. The second-mentioned action results, of course, in supply of the proper potential to anode 23 and renders the circuit completely operative.

Referring now to Fig. 2, a similar vacuum tube circuit is shown including another embodiment of the invention. Here we have an input transformer 31, the secondary winding of which is connected to the input circuit of vacuum tube 32. The output circuit of the tube is connected to the primary winding of output transformer 33. Tube 32 is of the heater cathode type, heater element 36 being provided with a suitable source of voltage 37. Cathode 38 is connected in the circuit in the conventional manner including a connection to ground 39. Battery 40 provides a suitable negative bias for control electrode 41. Anode 42 is provided with a suitable source of voltage 43, the winding of relay 46 being connected in series with the anode energizing path. Resistances 47 and 48 are also included in the anode circuit under certain conditions which will be referred to in detail subsequently.

A key 49 is provided for closing the heater energizing circuit, ballast lamp 50 being included in this circuit as a series element. Resistance 51 is also included as a series element when relay 46 is unoperated.

Assuming now that it be desired to set the circuit into operation and that key 49 be moved to closed position. This action completes the heater energizing circuit which may be traced from battery 37, make contact of key 49, ballast lamp 50, resistance 51, and through heater 36 to ground 39. Resistance 51 being in series with the circuit prevents damage to the filament of ballast lamp 50 due to excessive voltage.

At this time voltage is supplied from battery 43 to two paths, one a series path traced from battery 43, resistance 47, winding of relay 46, primary of output transformer 33 to anode 42 and the other a parallel path traced from battery 43, resistance 47, right break contact of relay 46, resistance 48 to ground 39. By virtue of the current flow in the second path and the consequent IR drop across resistance 47, the voltage applied to anode 42 over the first path at this time is obviously considerably less than the full rated voltage of battery 43.

Relay 46 does not operate at this time as completion of the operating circuit thereof is prevented on the one hand by condenser 52 and on the other hand by the noncompletion of the

space current path within the tube. However, after heater 36 reaches its approximate normal emission temperature and the cathode to anode circuit within the tube is established, an operating circuit for relay 46 is established which circuit may be traced from battery 43, resistance 47, winding of relay 46, primary winding of output transformer 33 to anode 42 and thence to cathode 38 and ground 39, relay 46 therefore operating.

Operation of relay 46 is effective (a) to complete through its left make contact a circuit shunting resistance 51 out of the heater energizing circuit and (b) to shunt by a circuit through the right make contact resistance 47 out of the operating circuit of relay 46 over which voltage is supplied to anode 42 and to open the parallel circuit referred to above through resistance 48.

The first-mentioned action, i. e., shunting resistance 51, does not result in a sufficient increase in the voltage to damage the filament of ballast lamp 50 inasmuch as heater 36 has now reached its approximate normal operating temperature and the resistance is sufficiently high to prevent a damaging voltage.

The second action resulting from operation of relay 46, i. e., shunting resistance 47 and opening of the circuit through resistance 48 results, of course, in application of the full voltage of battery 43 to the anode circuit. However, inasmuch as the space current path has now been established and the circuit is fully operative the voltage is sufficiently reduced due to IR drop to prevent damage to any parts of the circuit.

It will be apparent from the above description that applicant's invention provides simple and efficient means for preventing damage to the anode or other parts of the vacuum tube due to application of the full anode potential before the space current path within the tube has been established. While certain specific embodiments of the invention have been selected for detailed description the invention is not, of course, limited in its application to the embodiments described. For example, while the invention has been illustrated in connection with circuits including a ballast lamp and means for preventing damage thereto, it is equally as applicable in connection with the protection of excessive voltage in the anode circuit alone in the instance of circuits using no ballast lamp. Further, the invention is applicable in connection with circuits utilizing a plurality of vacuum tubes rather than only one and is applicable in connection with other types of tubes than that illustrated. In short, the embodiments should be taken as illustrative rather than as restrictive.

What is claimed is:

1. In a vacuum tube circuit, a vacuum tube, a heater element and an anode for said tube, a source of energy for said heater, a source of energy for said anode, a ballast lamp and a resistance connected in series with said heater element and said heater energy source, and means for simultaneously shunting said resistance out of the heater circuit and for connecting said anode energy source to said anode.

2. In a vacuum tube circuit, a vacuum tube, a heater element and an anode for said tube, a source of energy for said heater, a source of energy for said anode, a ballast lamp and a resistance connected in series with said heater element and said heater energy source, and means controlled by current in the heater circuit for

simultaneously shunting said resistance out of the heater circuit and for connecting said anode energy source to said anode.

3. In a vacuum tube circuit, a vacuum tube, a heater element and an anode for said tube, a source of energy for said heater, a source of energy for said anode, a ballast lamp and a resistance connected in series with said heater element and said heater energy source, and means controlled by current in the heater circuit for simultaneously shunting said resistance out of the heater circuit and for connecting said anode energy source to said anode, said means comprising a slow-to-operate relay.

4. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a ballast lamp and a resistance connected in series with the cathode heating source, and means effective at the time the cathode reaches its normal operating temperature for simultaneously shunting said resistance out of the cathode heating circuit and for connecting said anode energy source to said anode.

5. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a heater for said cathode, a source of energy for said heater, a source of energy for said anode, a ballast lamp and a resistance connected in series with said heater and said heater energy source, and means for simultaneously shunting said resistance out of the heater circuit and for connecting said anode energy source to said anode, said means comprising a relay, the operate time of which is substantially equal to the time required for said cathode to be heated to its normal operating temperature.

6. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a ballast lamp and a resistance connected in series with the cathode heating source, a resistance connected in series with said anode energy source, and means for simultaneously shunting said first mentioned resistance out of the cathode heating circuit and for shunting said second mentioned resistance out of the anode circuit.

7. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a ballast lamp and a resistance connected in series with the cathode heating source, a resistance connected in series with said anode energy source and said anode, a resistance connected in parallel to said anode energy source and said anode, and means for simultaneously shunting said first mentioned resistance out of the cathode heating circuit, for shunting said second mentioned resistance out of the anode circuit and for opening the circuit through said third mentioned resistance.

8. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a ballast lamp and a resistance connected in series with the cathode heating source, a resistance connected in series with said anode energy source, and means for simultaneously shunting said first mentioned resistance out of the cathode heating

circuit and for shunting said second mentioned resistance out of the anode circuit, said means comprising a relay, the operating circuit of which is controlled by the space current circuit within the vacuum tube.

9. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a ballast lamp and a resistance connected in series with the cathode heating source, a resistance connected in series with said anode energy source, and means for simultaneously shunting said first mentioned resistance out of the cathode heating circuit and for shunting said second-mentioned resistance out of the anode circuit, said means comprising a relay, the operating winding of which is connected in series with said anode and said anode energy source and the operating circuit of which is controlled by the space current circuit within the vacuum tube.

10. In a vacuum tube circuit, a vacuum tube, a heater element and an anode for said tube, a source of energy for said heater, a source of energy for said anode, said anode being adapted when operative to have substantially the full potential of said anode energy source connected thereto, a ballast lamp and a resistance connected in series with said heater element and said heater energy source, and means for simultaneously shunting said resistance out of the heater circuit and for connecting substantially the full potential of said anode energy source to said anode.

11. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a resistance connected in series with said anode energy source and said anode, a resistance connected in parallel to said anode energy source and said anode, and means for simultaneously shunting said first-mentioned resistance out of the anode circuit and for opening the circuit through said second-mentioned resistance.

12. In a vacuum tube circuit, a vacuum tube, a cathode and an anode for said vacuum tube, a source of energy for heating said cathode, a source of energy for said anode, a resistance connected in series with said anode energy source and said anode, a resistance path to ground in parallel to said anode energy source and said anode, and means for simultaneously shunting said resistance out of the anode circuit and for interrupting said parallel resistance path to ground.

13. In a vacuum tube circuit, a vacuum tube, a heater element and an anode for said vacuum tube, a source of energy for said heater element, a source of energy for said anode, said anode being adapted when operative to have substantially the full potential of said anode energy source connected thereto, a ballast lamp and a resistance connected in series with said heater element and said heater energy source, and a relay effective when in normal position to prevent connection of substantially the full potential of said anode energy source to said anode and effective when in operated position to simultaneously shunt said resistance out of the heater circuit and to connect substantially the full potential of said anode energy source to said anode.

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