

June 24, 1958

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2,840,760

POWER SUPPLY

Filed June 14, 1957

2 Sheets-Sheet 1

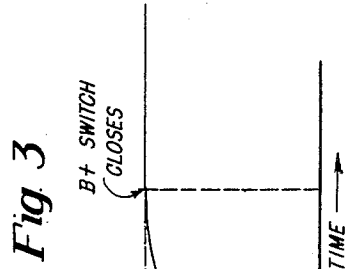
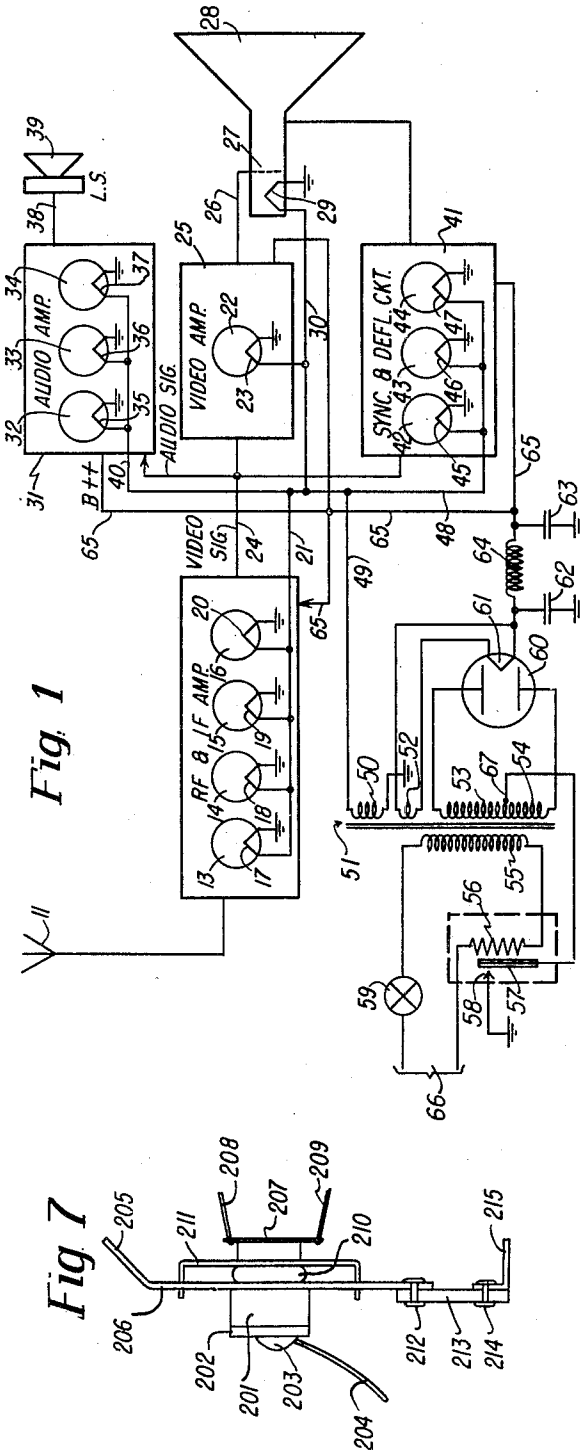


Fig. 2
THERMAL CONTROL DEVICE CHARACTERISTICS

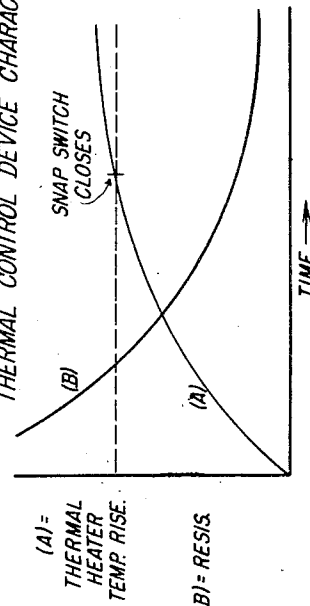


Fig. 3

(A) =
THERMAL
HEATER
TEMP. RISE.
(B) = RESIS.

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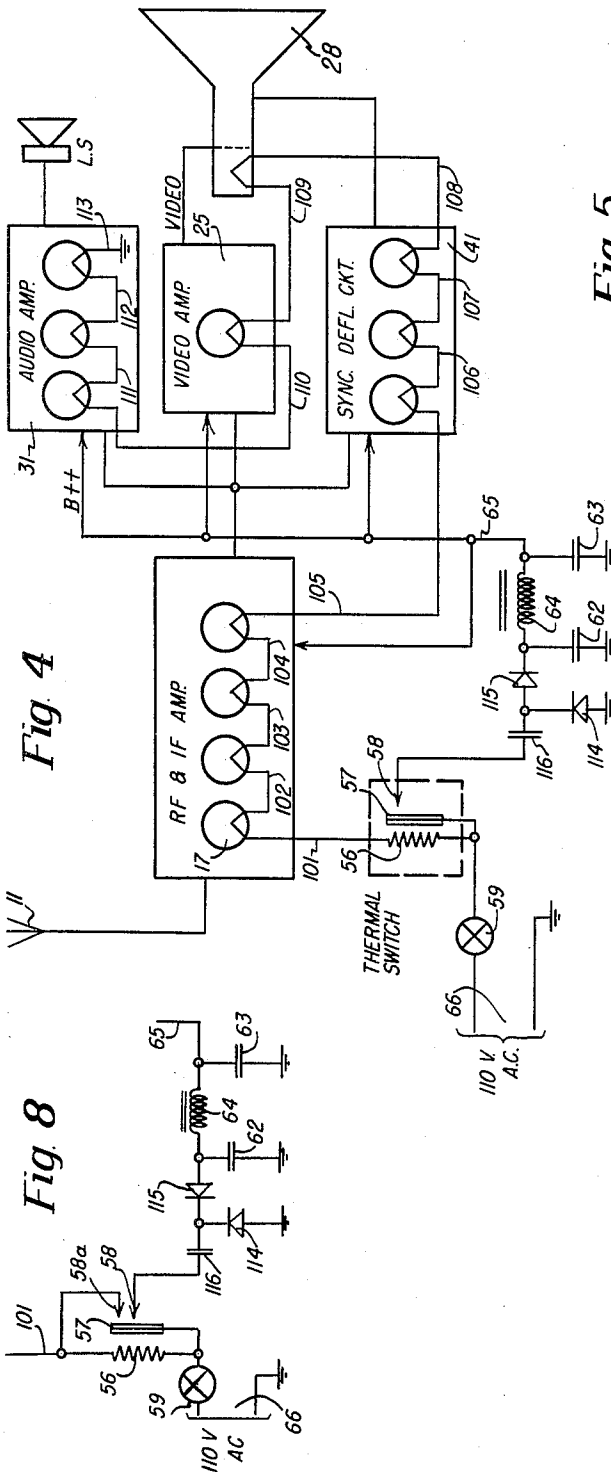


Fig. 4

Fig. 8

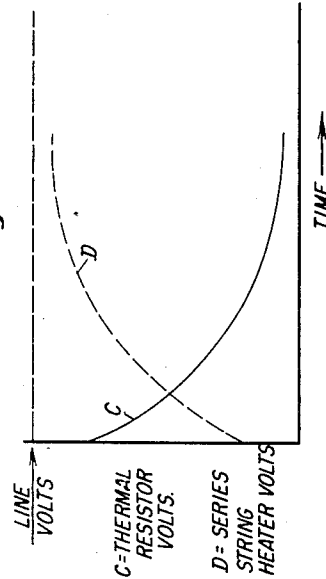


Fig. 5

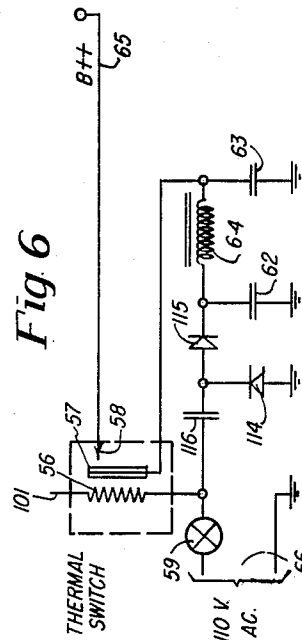


Fig. 6

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POWER SUPPLY

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10 Claims. (Cl. 315—104)

This invention relates to controlled power supplies for electronic equipment and more specifically to power supplies for television receivers.

Television receivers of the type in general use and manufacture use a number of thermionic vacuum tubes which range from 15 to more than 20. It is necessary to supply each of these tubes with a source of power used to heat the cathodes and also a source of direct current power which is controlled to produce the sound and picture signals. The tubes generally in use are of a type having indirectly heated cathodes, in which the cathode consists of a sleeve having a coating which emits electrons when the sleeve is heated. The heating element is a separate unit enclosed within the cathode sleeve. The heating element is composed of a wire filament generally having a high positive value temperature coefficient, which means that as the temperature of the filament and cathode rises the resistance of the cathode heating element increases. This positive temperature coefficient has the effect of regulating the temperature of the cathode by controlling the current and hence the power supplied to the cathode. At normal room temperature the resistance of the heater element is very low so that when normal voltage is applied to the vacuum tube heaters a very large initial surge of current occurs making the thermal gradient in the region around the heater extremely high and having a destructive effect on the heater wire and surrounding insulation.

Each time the receiver is turned on, the vacuum tubes receive a similar thermal shock, which materially shortens the life of the vacuum tubes involved.

A second effect, which occurs in the power supply system generally in use for television receivers and which causes a further shortening of the life expectancy of the receiving tubes, is the application of the direct current anode potential, which is used to control the emitted electrons, before the cathode has reached a temperature at which sufficient electron emission can occur. The result of this is to destroy the coating on the cathode. In some cases material from the cathode migrates to other elements producing high secondary emission ratios and materially affecting the vacuum tube characteristics.

During the vacuum tube warm up period the current drawn from the direct current portion of the receiver power supply is considerably reduced due to the limited emission in the vacuum tubes. The decreased power supply drain causes the voltage of the supply to increase which may temporarily overrate some of the receiver components.

These effects taken together make it desirable to provide a new type of power supply which can provide a controlled current to the heaters during warm-up together with a delay in application of the power supply anode voltage, to prevent damage to both vacuum tubes and associated circuit elements.

Accordingly, it is an object of this invention to provide a power supply for a television receiver which will mate-

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rially increase the life of the receiver and minimize vacuum tubes failures.

Another object of this invention is to provide a power supply which supplies a tube heater voltage gradually increasing as the tubes warm up to minimize the heater thermal shock.

A further object of this invention is to provide a delayed application of the circuit voltage for the television receiver thereby eliminating inadvertent overloading of the circuit components and providing an extended life for the vacuum tubes.

A feature of this invention is the inclusion of a resistor element in series with the vacuum tube heater supply having a negative temperature coefficient and effectively reducing the current surge associated with the positive temperature coefficient of the vacuum tubes.

Another feature is the provision of a thermally activated time delay unit having a positive snap action to prevent contact arcing for delaying the connection of the direct current potential of the power supply to the television receiver circuits.

A further feature of this invention is the inclusion of a single unit having a thermal heater element having a negative temperature coefficient and used to control the current surge in the vacuum tube heater circuits combined with a thermally operated time delay switch responsive to the heater element for delayed application of the direct current potential to the vacuum tubes and associated circuits.

Yet another feature of this invention is the inclusion of a thermal resistor having a negative temperature coefficient and used to control the current surge in the vacuum tube heater circuits combined with a thermally actuated time delay switch having a positive thermally controlled switching action, with the resistor heating element mounted directly onto a heat dissipating element to provide a stabilized operating temperature for the resistor, and the heat sensitive delay switch mounted directly onto the heat dissipating element.

Further objects and features of this invention will be apparent from a consideration of the following description and the accompanying drawings in which:

Fig. 1 is a block diagram of a television receiver having a transformer type power supply and incorporating the thermal voltage delay system of this invention;

Fig. 2 is a graph showing the temperature drop of the resistance unit with temperature and time, and the closing of the thermal time delay switch at a given temperature and time;

Fig. 3 is a graph showing the heater voltage as a function to time;

Fig. 4 is a block diagram of a television receiver incorporating this invention which uses series filament connection and a voltage doubler circuit directly connected to the power line for obtaining the necessary direct current voltages for operating the receiver;

Fig. 5 is a graph showing the voltage drop across the thermal resistance and the series string heater voltage as a function of time;

Fig. 6 is an alternate connection for the power supply delay switch connection in the voltage doubler type series filament receiver;

Fig. 7 shows the construction of the thermal resistor heat radiating elements and the thermally activated switch of the invention;

Fig. 8 shows an alternate form of the invention.

The improved power supply uses a thermal resistor which is connected in series between the power line and the TV power supply. However, since the thermal resistor has a negative temperature coefficient, at the moment the television receiver is turned on, and for a period of time following, the temperature of the thermal

heating element is near room temperature. At this temperature its resistance is relatively high and at the same time the vacuum tube heater element resistances are lower, due to their positive temperature coefficient and the fact that the receiver has just been actuated. The result is that a large part of the power line voltage appears across the thermal heating resistor thereby reducing the undesired initial current surge in the vacuum tube heating elements. At the same time the rapid heating filamentary type rectifier used in the power supply is heated supplying full direct current voltage for operating the receiver shortly after the receiver is turned on, and before the heater type tubes have reached operating temperature. This D. C. voltage may exceed rated voltage for the tubes and circuit elements. A time delay switch is attached to the thermal resistor and maintains the direct current voltage disconnected from the receiver until the temperature of both the vacuum tubes and the thermal resistor reach a specified value. When this temperature is reached the thermal switch, which has a positive snap action at a fixed temperature, moves rapidly to the closed position connecting the power supply voltage to the receiver circuits and activating the receiver.

Referring now to Fig. 1 the operation of a television receiver will be briefly described. The television signal is received by antenna 11 which is connected to the radio frequency selecting circuits and intermediate amplification circuits included in section 12. This section may include the vacuum tubes 13, 14, 15 and 16 each having a heater, 17, 18, 19 and 20 respectively, connected in parallel to lead 21. The video signal detected in the I. F. amplifier is conducted by lead 24 to the video amplifier 25 where it is amplified by a vacuum tube 22 having a heater 23. The amplified video signal is applied to control element 27 of the cathode ray display device 28 by lead 26. The cathode ray display device also has a heating element connected in parallel with the video amplifier heater circuit 23 by lead 30. Lead 24 may also connect the sound signal to the sound detector amplifier and output circuits shown in 31 having vacuum tubes 32, 33 and 34 with heating elements 35, 36 and 37 which are parallel connected and supplied with current through lead 40. The output of the sound power amplifier 34 is connected to loudspeaker 39 through lead 38.

Lead 24 may also supply synchronizing signals to the sync and deflection circuits 41 having vacuum tubes 42, 43 and 44 with heater elements 45, 46 and 47 connected in parallel on lead 48. The leads 48, 30, 40 and 21 are connected in parallel thereby connecting all vacuum tube heater elements in parallel on lead 49 which is connected to a source of voltage provided by winding 50 of transformer 51. The filament winding for power rectifier 60 having a directly heated cathode 61 also is located on transformer 51.

Windings 53 and 54 supply voltages to operate rectifier 60 as a full wave rectifier providing a unidirectional voltage to operate the vacuum tube circuits of the receiver. The rectifier 60 output voltage is filtered by capacitors 62 and 63 and choke 64 and applied to the space current electrodes of the vacuum tubes on lead 65. Winding 55 is the primary winding of power transformer 51, which supplies magnetic energy for operating all heater and power supply windings.

Primary winding 55 is connected to a source of A. C. power 66 through the main on-off switch 59 and thermal dropping resistor 56. Before switch 59 is closed thermal resistor 56 is at normal room temperature and contacts 57 and 58 thereof are open, keeping the center tap 67 of transformer 51 disconnected from ground and opening the rectifier circuit path so that the voltage on lead 65 remains essentially zero. When switch 59 is closed the vacuum tube heaters having low resistance tend to draw a heavy current which must be supplied to primary

winding 55 through thermal resistor 56. Since thermal resistor 56 initially has a high value of resistance a large part of the power source voltage appears across resistor 56 thereby minimizing the voltage available for the transformer winding 55 and limiting the heater current surge through winding 50 and lead 49.

Referring now to Fig. 2 it can be seen in curve B, showing the variation of the resistance component with time, that after the set has been turned on the resistance value of the thermal heater drops rapidly reducing the ratio of the voltage across resistor 56 to the voltage across the transformer and providing a heater voltage as shown in Fig. 3. At the same time, the temperature of resistor 56 is rising as shown in A of Fig. 2 until the temperature is reached at which contacts 58 and 57 close and power is applied activating the receiver.

When the switch is closed the effect of the thermal resistor and delay switch is to prevent the initial heater current surge thereby preventing damage to the cathode ray tube heaters and also preventing application of the vacuum tube plate voltage until the heaters reach operating temperature.

Referring now to Fig. 4, this shows a television receiver having a voltage doubler type power supply circuit and a series filament heater string. The main sections of the receiver operate in the same manner as in Fig. 1 and will not be described again in detail.

The heater circuits for all vacuum tubes contained in these circuits are connected in series to ground by leads 102 to 113 inclusive and the heater element 17 of tube 13 is directly connected to thermal resistor 56. When power switch 59 is closed the voltage is applied to the series heater string in series with the thermal resistor 56.

Referring now to Fig. 5: when switch 59 is closed, the heater voltage shown in curve D is low limiting the current in the heaters while the voltage across the thermal resistor shown in curve C is high. The voltage across resistor 56 drops rapidly as shown by curve after the switch 59 has been closed and the voltage on the heaters approaches line voltage as shown in curve D. The direct current voltage for the receiver is supplied by a full wave voltage doubler circuit including diode rectifiers 114 and 115 which may be of any convenient type such as selenium, germanium or silicon. The output voltage of the voltage doubler circuit is filtered by capacitors 62 and 63 together with choke 64. When switch 59 is closed contacts 57 and 58 are initially open preventing the development of direct current operating voltage on lead 65. When the voltage on the series heater string rises to a predetermined value, the temperature of thermal resistor 56 is sufficient to close contact 57 and 58 supplying voltage to lead 65 and activating the receiver.

Fig. 6 shows an alternate connection for the thermal time delay switch in the voltage doubler supply in which power is applied to the voltage doubler when switch 59 is closed but connection of the power supply output to the receiver circuits is delayed by the thermal time delay switch.

Referring now to Fig. 7, in this figure a mechanical arrangement of the thermal resistor and time delay switch is shown. This unit may be used in the system shown in Figs. 1, 4 and 6. The cylindrical thermal resistor element 201 has a conductive surface 202 to which is soldered at point 203 a terminal lead 204 for resistor element 201. The element 201 is mechanically attached to a heat radiating plate 206 having an electrically conductive surface which forms a second terminal of the resistor element 201. The heat conductive plate 206 serves the double purpose of a heat stabilizing sink for resistor 201 as well as electrical terminal. Also attached to plate 206 and placed directly adjacent to thermal resistor 201 is the time delay switch 207 held in place by spring clip 211 which engages flange 210 on switch 207. Terminals 208 and 209 of the switch 207 are connected to the time delay contacts 57 and 58

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(Fig. 6). The heat radiating plate 206 also forms a means of mounting the unit on Bakelite terminal strip 213, to which it is affixed by rivets 212. The Bakelite strip may also mount additional terminal points and may be mounted to the chassis by means of bracket 215 and rivets 214.

Referring now to Fig. 8, in this figure the voltage doubler output lead 65 is connected to the vacuum tube circuit as shown in Fig. 4, the lead 101 may be the series heater string also shown in Fig. 4. The thermal resistor 56 has connected to the bi-metal switch a second contact 58a which provides a short circuit path around heater element 56. When the switch 59 is closed current flows through lead 101 to the vacuum tube heaters and also through heater element 56 since contacts 57, 58 and 58a are open during the warm-up period of heater element 56. When the bi-metal element 57 reaches the correct operating temperature the contacts 57, 58 and 58a close. This closing action may be made rapid so that the bi-metal element changes abruptly from the open to closed position to prevent contact arcing. When contacts 57, 58 and 58a close the heater element 56 is shortened and the vacuum tubes are operated at nearly full power line voltage. When the contact 58a shorts the heater element 56, sufficient heat is developed by current flowing through the bi-metal element to maintain it in a closed position. When the contacts 58 close which may occur after the closing of 57 and 58a, the doubler circuit is activated operating the receiver.

By using the extra contact 58a, heater element 56 no longer needs to have a negative temperature coefficient and therefore can be formed with a simple wire wound resistor element.

When the device of Fig. 8 is used with a power transformer circuit of Fig. 1 it is necessary to insulate the direct current control contacts from the bi-metal arm.

By using the thermal time delay device a considerable increase in tube life occurs since the effects of heater current surge are suppressed as well as the destructive effects of the application of direct current plate voltage when the heater has not reached operating temperature.

I claim:

1. In a power supply system for operating equipment containing at least one thermionic vacuum tube having electrodes defining a space current path and a cathode heater element, and which power supply system includes direct current voltage providing means for the electrodes and heating current providing means for the heater element, the combination including, a control unit having therewith resistor means, a thermally activated switch, and means for mounting said resistor means and said switch in said control unit to provide heat transfer therebetween whereby said switch is activated by heat from said resistor means, a first circuit including said resistor means in said control unit connecting the cathode heater element to the heating current providing means, said resistor means initially presenting a substantial impedance to limit current flow to the cathode heater element and such impedance being reduced in response to heat produced by current flow through said resistor means, said thermally activated switch in said control unit including circuit changing means having a first unactivated position and a second position assumed thereby in response to heat from said resistor means, and a second circuit including said circuit changing means for applying the direct current voltage to the electrodes of the tube, said circuit being open when said circuit changing means is in said first position so that the electrodes of the tubes are unenergized and being completed when said circuit changing means assumes said second position to thereby apply the direct current voltage to the vacuum tube electrodes to energize the same, said circuit changing means assuming said second position after said resistor means reaches a predetermined temperature whereby the energization of

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the electrodes is delayed for the period required for said resistor means to reach the predetermined temperature.

2. In a power supply for operating equipment containing thermionic vacuum tubes having indirectly heated cathodes, heater elements for said cathodes having a positive value of resistive temperature coefficient, and anodes for drawing electrons from said cathodes, and which power supply includes a rectifier circuit for providing a direct current voltage and a source of heating current for said heater elements, the combination including a circuit for connecting the heater elements to the source of heater current including a resistive heating element having a negative value of resistive temperature coefficient, said resistive heating element being connected to minimize current changes in said vacuum tube heater elements resulting from said positive resistive temperature coefficient thereof and a thermally activated switch having contacts normally open and closed in response to heat from said resistive heating element, said switch contacts being connected in the rectifier circuit for controlling the application of the direct current voltage of the power supply to the anodes of the tubes, said switch operating to prevent application of the direct current voltage to the vacuum tube anodes until said resistive heating element reaches a predetermined temperature and completing the rectifier circuit to apply the direct current voltage to the tube anodes when said resistive heating element reaches the predetermined temperature.

3. In electronic apparatus containing thermionic vacuum tubes having indirectly heated cathodes, and heater elements for said cathodes having a positive value of resistive temperature coefficient, a power supply for providing direct current voltage for the tubes including in combination, a transformer having primary and secondary windings providing voltage step-up, a full wave rectifier circuit connected to said secondary winding, means for providing heating current for said heater elements including an additional secondary winding on said transformer, and means for controlling the application of the direct current voltage and the heating current to the tubes including, a resistive heating element connected in series with said transformer primary winding, said resistive heating element having a negative value of resistive temperature coefficient tending to minimize current changes in said vacuum tube heater elements resulting from said positive temperature coefficient thereof, a thermally activated switch responsive to heat from said resistive heating element and connected in said full wave rectifier circuit, said switch delaying the application of said direct current voltage to said vacuum tubes until said resistive heating element reaches a predetermined temperature and completing the rectifier circuit to apply the direct current voltage to said vacuum tubes when said resistive heating element reaches the predetermined temperature.

4. In electronic apparatus including thermionic vacuum tubes having indirectly heated cathodes, and heater elements for said cathodes having a positive value of resistive temperature coefficient, a power supply system including in combination, means providing direct current voltage for the tubes including at least one semiconductor type rectifier for connection to a source of alternating current voltage, means for connection to the alternating current source for applying current therefrom as a source of power for heating said vacuum tube heater elements, and means for controlling the application of the direct current voltage and the heating current to the tubes including, a resistive heating element connected in series with said heater elements for said vacuum tubes, said heating element having a negative value of resistive temperature coefficient tending to minimize current changes in said vacuum tube heater elements resulting from said positive resistive temperature coefficient, a thermally activated switch responsive to said resistive heating element and having normally open contacts connected in said rec-

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tifier circuit to prevent application of said direct current voltage to said vacuum tube circuits, said switch contacts closing in response to heat from said heating element after said resistive heating element reaches a predetermined temperature.

5. In electronic apparatus containing thermionic vacuum tubes having indirectly heated cathodes, and electrical heaters for said cathodes, a power supply including first means providing a direct current voltage for the tubes and second means for providing heating current for the tube heaters, the means for controlling the application of the direct current voltage and the heating current to the tubes including in combination, a first circuit portion including a resistance heating element connecting the tube heaters to the second power supply means, said resistive heating element having a negative value of resistive temperature coefficient for initially reducing the current flow to the vacuum tube heaters, a heat radiating element connected to said resistive heating element and supporting the same, a thermally activated switch supported adjacent said heat radiating element and responsive to the heat therefrom, and a second circuit portion including said switch for applying the direct current voltage to the tubes, with said switch operating to delay the application of the direct current voltage to said vacuum tubes until said resistive heating element is heated to a predetermined temperature to activate said switch and apply the direct current voltage to said vacuum tubes.

6. In a power supply for operating equipment containing thermionic vacuum tubes having cathodes including heater elements, and anodes for drawing electrons from said cathodes, and which power supply includes rectifier means for providing a direct current voltage and a source of heating current for said heater elements, the combination including, a circuit for connecting the heater elements to the source of heater current including a resistive heating element, said resistive heating element being connected to initially reduce current flow to said vacuum tube heater elements, a thermally activated switch having a first pair of contacts normally open and closed in response to heat from said resistive heating element, a first circuit portion including said contacts for applying the direct current voltage of the power supply to the anodes of the tubes, said switch operating to apply the direct current voltage to the vacuum tube anodes after said resistive heating element reaches a predetermined temperature, said switch having a second pair of contacts normally open and closed in response to heat from said resistive heating element, and a second circuit portion including said second pair of contacts for bridging across said resistive heating element after said resistive heating element has reached a predetermined temperature, so that the effect of said resistive heating element to reduce the current flow to said vacuum tube heater elements is lessened.

7. In a power supply for operating equipment containing thermionic vacuum tubes having indirectly heated cathodes, heater elements for said cathodes, and anodes for drawing electrons from said cathodes, and which power supply includes rectifier means for providing a direct current voltage and a source of heating current for said heater elements, the combination including a first circuit portion for connecting said heater elements to said source of heater current including a resistive heating element, said resistive heating element being connected to initially reduce current flow to said vacuum tube heater elements, a bi-metal switch element having a first pair of contacts normally open and closed in response to heat from said resistive heating element, a second circuit portion including said contacts for applying the direct current voltage of the power supply to the anodes of the tubes, said switch operating to apply the direct current voltage to the vacuum tube anodes after said resistive heating element has reached a predetermined temperature,

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said switch having a second pair of contacts normally open and closed in response to heat from said resistive heating element, and a third circuit portion including said second pair of contacts and said bi-metal switch element for bridging across said resistive heating element after said resistive heating element has reached a predetermined temperature, said third circuit portion having a current flowing therein to increase the current flow to said vacuum tube heater elements, said current flowing in said bi-metal switch element operating to heat the same to maintain said first and second pairs of contacts in a closed position.

8. In a power supply system for operating equipment containing at least one thermionic vacuum tube having electrodes defining a space current path and a cathode heater element, with the cathode heater element having a positive value of resistive-temperature-coefficient whereby there is a current surge when the heater element is energized, and which power supply system includes direct current voltage providing means for the electrodes and heating current providing means for the heater element, the combination including, a resistive heating unit in a first circuit connecting the cathode heater element to the heating current providing means, said resistive heating unit having a negative value of resistive-temperature-coefficient so that said resistive heating unit initially presents a substantial impedance to limit the current surge to the cathode heater element and is responsive to heat produced by current flowing through said resistive heating unit whereby the impedance to current flow is reduced as the temperature rises, a thermally activated switch positioned relative to said resistive heating unit so as to be responsive to heat therefrom, means for mounting said switch and said resistive heating unit to provide the positioning which accomplishes heat transfer therebetween, said switch including circuit changing means having a first unactivated position and having a second position assumed thereby in response to heat from said resistive heating unit, and a second circuit including said circuit changing means for applying the direct current voltage to the electrodes of the tube, said second circuit being open when said circuit changing means is in said first unactivated position so that the electrodes of the tube are unenergized and said circuit being completed when said circuit changing means assumes said second position to thereby apply the direct current voltage to the vacuum tube electrodes and energize the same, said circuit changing means of said thermally activated switch assuming said second position after said resistive heating unit reaches a predetermined temperature whereby the energization of the electrodes is delayed for the period required for said resistive heating unit to reach the predetermined temperature.

9. In electronic apparatus containing at least one thermionic vacuum tube having electrodes defining a space current path and a cathode heater element with a positive value of resistive-temperature-coefficient whereby there is a current surge when the heater element is energized, a power supply for providing direct current voltage and heater current for the tube including in combination, a transformer having primary and first and second secondary windings, means for connecting said primary winding to an alternating current supply, a rectifier circuit connected to said first secondary winding for providing the direct current voltage, heating current providing means for said heater element including said second secondary winding, and control means for controlling the application of the direct current voltage and the heating current to the tube, said control means including therewith a resistive unit and a thermally activated switch, means connecting said resistive unit in series with said transformer primary winding, said resistive unit initially presenting a substantial resistance to reduce current flow to said transformer and thereby reduce the current surge

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in said heater element, said resistive unit being responsive to heat produced by current flow therein to decrease such resistance and thereby tend to minimize changes in current flow in said heater element resulting from said positive temperature coefficient thereof, said thermally activated switch including normally open contacts connected in said rectifier circuit, said switch being responsive to heat produced by current flow in said control means to close said contacts when said switch reaches a predetermined temperature and thereby delay the application of said direct current voltage to said electrodes of the vacuum tube.

10. In electronic apparatus including at least one thermionic vacuum tube having a cathode heater element with a positive value of resistive-temperature-coefficient whereby there is a current surge when the heater element is energized, a power supply system including in combination, current supply means for connection to an alternating current source, means providing direct current voltage for the tube including at least one semi-conductor type rectifier connected to said current supply means, means for providing current for the vacuum tube heater element from said current supply means, and means for controlling the application of the direct current voltage and the heating current to the tube including control means having therewith a resistive unit and a thermally activated switch, means connecting said resistive unit in series with the heater element of said vacuum tube, said resistive unit initially presenting a substantial resistance to reduce the current surge in the heater element and

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being responsive to current flow therethrough to reduce such resistance and thereby tend to minimize current changes in said vacuum tube heater element resulting from said positive resistive temperature coefficient, said thermally activated switch having normally open contacts connecting said rectifier to the tube to delay the application of said direct current voltage to the vacuum tube, said switch being responsive to heat produced by current flow in said control means to close said contacts when said thermally activated switch reaches a predetermined temperature to thereby apply said direct current voltage to said vacuum tube.

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