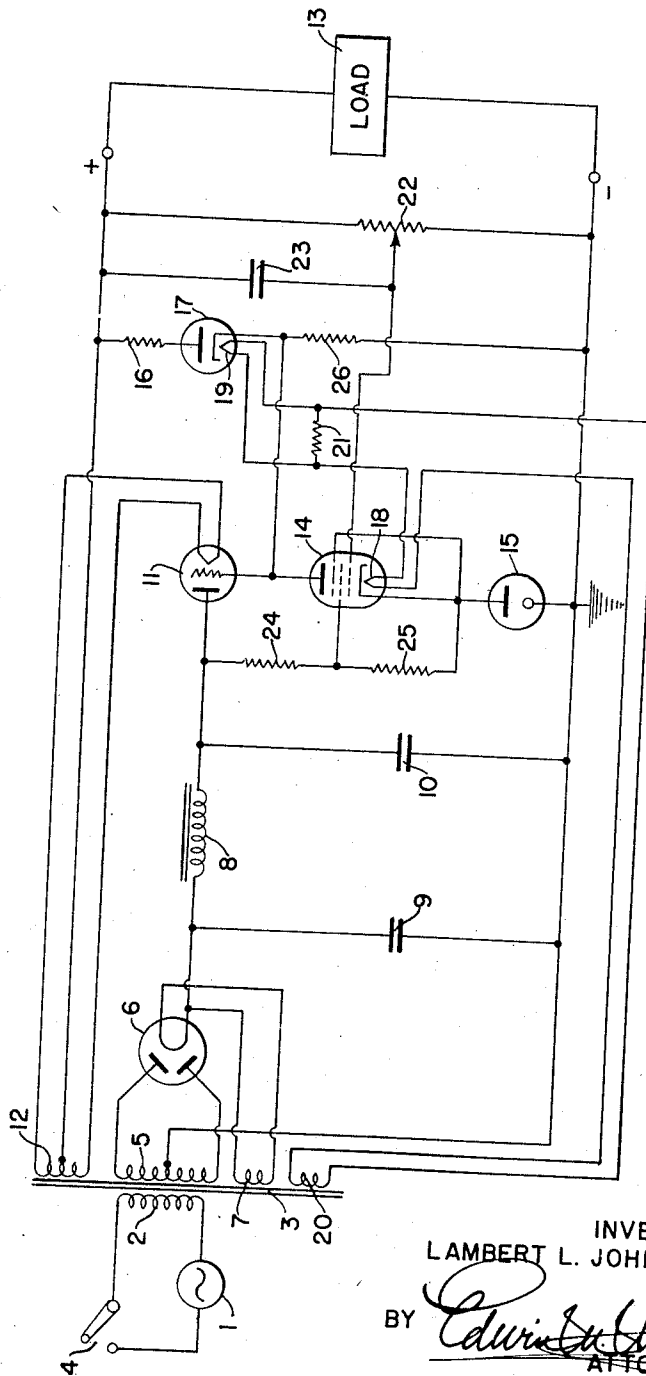


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VOLTAGE REGULATOR
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VOLTAGE REGULATOR

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2 Claims. (Cl. 171—312)

This invention relates to voltage regulating apparatus, and particularly to such apparatus employing thermionic tubes.

According to conventional practice, where it is desired to maintain a power supply at a substantially constant voltage, a voltage regulator employing one or more thermionic tubes frequently is used. In one such regulator there is provided a rheostat tube having its output circuit connected in series with one of the conductors supplying the voltage to be regulated. Another tube is employed for controlling the rheostat tube and is connected so that its input circuit is responsive to deviations of the voltage from the desired constant value. The control is effected by subjecting the input circuit of the rheostat tube to voltage variations occurring in the output circuit of the control tube as it responds to the deviations of the voltage to be regulated.

As is well understood in the art, however, it generally is desirable to employ as the rheostat tube, one which has a substantial current carrying capacity. One such tube which is particularly well suited for this purpose is equipped with a filamentary or directly heated cathode. A tube suited to the usual design of such apparatus for use as a control tube is provided with an indirectly heated cathode. Consequently, the rheostat tube is conditioned for operation substantially instantaneously upon the connection of power thereto. However, because of its indirectly heated cathode, the control tube requires some time to be operatively conditioned. Also, if during the operation of the voltage regulator the heater circuit of the control tube fails for any reason, this tube is rendered inoperative. During inoperative periods of the control tube the rheostat tube is ineffective to regulate the voltage of the power supply. Consequently, the voltage which is supplied to the load circuit exceeds considerably the voltage at which it is desired to maintain the power supply. For certain types of loads such an excessive voltage may cause damage to some of the apparatus.

An object of the present invention therefore is to provide means for maintaining the impedance of a rheostat tube employed in a voltage regulator at a value whereby the voltage of a power supply is prevented from exceeding a predetermined value during inoperative periods of a tube used for controlling the rheostat tube.

Another object of the invention is to provide, in a voltage regulator, a thermal responsive device for controlling the regulating effectiveness of a

rheostat tube during periods when a tube used for controlling the rheostat is inoperative.

A further object of the invention is to provide a circuit using a rectifier tube for modifying a power supply voltage limiting bias potential which is applied to a rheostat tube during inoperative periods of a tube used for controlling the rheostat tube.

In accordance with the present invention there is provided a direct current power supply and thermionic apparatus for regulating the voltage thereof. This apparatus includes a rheostat tube connected to the power supply and provided with an input circuit for controlling the regulating effectiveness thereof. In order to prevent the voltage from exceeding a predetermined value, there is provided means for applying to the input circuit of the rheostat tube a biasing potential. The apparatus also includes a control means which is adapted to be operatively conditioned to subject the input circuit of the rheostat tube to a control potential for maintaining the voltage at a substantially constant value. There also is provided a means operable during the operative periods of the control means for rendering ineffective the means by which the bias potential is applied to the input circuit of the rheostat tube.

In the illustrated embodiment of the invention the bias potential is applied to the input circuit of the rheostat tube by a permanently connected circuit which includes a relatively large impedance. The control potential to which the input circuit of the rheostat tube is subjected is derived from a relatively small load impedance connected in the output circuit of a thermionic control tube. The input circuit of the control tube is connected for response to deviations of the voltage to be regulated from a predetermined constant value. The rheostat tube is provided with a directly heated cathode and the control tube is equipped with an indirectly heated cathode. By reason of this arrangement the bias potential is applied to the input circuit of the rheostat tube during periods when the cathode of the control tube is insufficiently heated to render this tube operative. There also is connected in the output circuit of the control tube, a diode rectifier tube which is provided with an indirectly heated cathode. The heater elements of the control tube and the diode rectifier tube are connected together so that, when the control tube is operatively conditioned, the rectifier tube also is conditioned for operation. When both of these tubes are rendered operative the relatively low impedance output circuit of the control tube is completed to render

ineffective the bias potential for subsequent control of the rheostat tube.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the accompanying drawing:

The single figure is a circuit diagram of a voltage regulator embodying the instant invention.

Referring now more particularly to the drawing, there is shown schematically a rectifier circuit for converting alternating current to produce a direct current power supply. The circuit also includes a thermionic voltage regulator for maintaining the voltage of the power supply at a substantially constant value.

Energy from an alternating current source 1 is supplied to the primary winding 2 of a transformer 3 upon the closure of a switch 4. The terminals of a rectifier secondary winding 5 are connected to the respective anodes of a full wave rectifier tube 6. This tube may be provided with a filamentary cathode to render the device instantaneously responsive to the closure of the switch 4. The cathode of the rectifier tube is connected to a secondary filament winding 7 and to a filter network comprising a series choke coil 8 and two shunt condensers 9 and 10. The circuit from the cathode of the rectifier tube is extended further to the anode of a regulator or rheostat tube 11. This tube is a triode and also is provided with a directly heated filamentary cathode which may be connected to the terminals of a filament secondary winding 12 of the transformer 3. The mid-point of the filament winding 12 is connected to the positive output terminal of the regulated voltage supply. The mid-point of the rectifier winding 5 is connected to the negative output terminal and a load circuit 13 is connected between the positive and negative output terminals.

The regulating effectiveness of the rheostat tube 11 is governed by a control tube 14. This tube is a pentode having an indirectly heated cathode which is connected through a voltage regulating tube 15 to the grounded negative terminal of the power supply. The anode of the control tube is connected to a load circuit including a relatively low impedance resistor 16 and a diode rectifier tube 17 which, when operative, connects the load circuit to the positive terminal of the power supply. The control tube 14 and the diode 17 are provided respectively with heater elements 18 and 19, which are connected in series and to the terminals of a heater winding 20 of the transformer 3. The heater element 19 is shunted by a small resistor 21.

The control grid of the control tube 14 is connected to a point on a resistor 22 which is connected between the positive and negative terminals of the power supply. An auxiliary filter condenser 23 is connected between the control grid of the tube 14 and the positive terminal of the power supply. The screen grid of the tube 14 is connected through a resistor 24 to the positive potential of the anode of the rheostat tube 11. The suppressor grid of the tube 14 is connected to the cathode of this tube, and these two elements are connected through a resistor 25 and the resistor 24 to positive potential at the anode of the rheostat tube 11.

The control grid of the rheostat tube 11 is connected to the anode of the control tube 14, whereby to be subjected to voltage variations occurring

in the output circuit of the control tube during operative periods thereof. The control grid of the rheostat tube is also connected through a relatively high impedance resistor 26 to the grounded negative terminal of the power supply.

Referring now to the operation of the apparatus embodying the present invention, when the switch 4 is first closed to energize the primary winding 2 of the transformer 3, the alternating current is converted substantially instantaneously into a direct current power supply through the action of the secondary winding 5 and the rectifier tube 6. The filament winding 12 and the heater winding 20 are energized at this time and, by means of the former, the filamentary cathode of the rheostat tube 11 is heated substantially instantaneously to the electron emission temperature. Consequently, this tube is operatively conditioned. However, the control tube 14 and the diode 17 are not in condition for operation at this time since some time is required before the respective heater elements 18 and 19 are effective to produce the necessary electron emission temperatures of the respective cathodes. The resistor 21 still further delays the heating of the diode cathode until after the control tube is at its maximum effectiveness.

The high negative potential which is applied to the control grid of the rheostat tube through the resistor 26 produces an impedance of this tube which is relatively high, whereby to increase the effectiveness of the tube to decrease the voltage which is developed at the positive and negative output terminals. As soon as the control tube 14 and the diode 17 become operatively conditioned by the heating of their respective cathodes, the output circuit of the control tube is completed. The resistors 16 and 26 then are arranged to form in effect a voltage divider connected between the positive and negative output terminals.

Since the resistor 16 is of a low impedance as compared to the resistor 26, the potential which is applied to the control grid of the rheostat tube is considerably less negative than heretofore. During the subsequent operation of the voltage regulator the bias potential derived through the resistor 26 is rendered ineffective for the control of the rheostat tube 11. The input circuit of this tube then is subjected only to the control of the tube 14. The potentials which are applied to the grid of the rheostat tube vary in accordance with the conductivity of the control tube. Conditions in this tube depend upon deviations of the voltage of the direct current power supply from a predetermined value as determined by the point on the resistor 22 to which the control grid of the tube 14 is connected.

It will be noted that the apparatus in accordance with the instant invention is effective, not only to prevent the voltage from exceeding a predetermined value during the initial heating period of the control tube 14, but also at any time during the operation of the apparatus when the control tube or the diode 17 may be rendered inoperative by reason of a failure of either or both of the heater elements 18 and 19. In such a case the output circuit of the control tube 14 is opened and permits the high negative bias potential derived through the resistor 26 to control the rheostat tube 11, whereby to increase the impedance of this tube sufficiently to prevent the voltage from exceeding a predetermined value.

While it will be understood that the circuit specifications of the voltage regulator may vary according to the design for any particular appli-

cation, the following circuit specifications for a voltage regulator employed to maintain the voltage of a direct current power supply at a value of substantially 250 volts are as follows:

Tube 11.....	2A3	5
Tube 14.....	6SH7	
Tube 15.....	VR-150	
Resistor 16.....	68,000 ohms	
Tube 17.....	6H6 (1 section)	10
Resistor 21.....	40 ohms	
Resistor 22.....	300,000 ohms	
Condenser 23.....	0.11 microfarad	
Resistor 24.....	12,500 ohms	15
Resistor 25.....	8,000 ohms	
Resistor 26.....	10 megohms	

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a voltage regulator, a direct current supply, a rheostat tube for regulating the voltage of said supply, an input circuit for said rheostat tube including a directly heated cathode and operable to govern the regulating effectiveness of said rheostat tube, a low impedance element and a high impedance element connected to the input circuit of said rheostat tube, said high impedance element also being connected to one terminal of said direct current supply to supply a bias voltage to the input circuit of said rheostat tube for preventing the voltage of said direct current supply from exceeding a predetermined value, means including a diode having a heater type cathode and operable for connecting said low impedance element to the opposite terminal of said direct current supply to supply a control

voltage to the input circuit of said rheostat tube effective to overcome said bias voltage, a control tube having an input circuit including a heater type cathode connected to said direct current supply for response to voltage deviations thereof from said predetermined value, the heaters of said diode and of said control tube being connected in series, and an output circuit for said control tube connected to said low impedance element and operable to control the input circuit of said rheostat tube.

2. In a voltage regulator, a direct current supply, a rheostat tube for regulating the voltage of said supply, an input circuit for said rheostat tube including a filamentary cathode and operable to govern the regulating effectiveness of said rheostat tube, a low impedance resistor and a high impedance resistor connected to the input circuit of said rheostat tube, said high impedance resistor also being connected to the negative terminal of said direct current supply to supply a bias voltage to the input circuit of said rheostat tube for preventing the voltage of said direct current supply from exceeding a predetermined value, means including a diode having a heater type cathode and operable for connecting said low impedance resistor to the positive terminal of said direct current supply to supply a control voltage to the input circuit of said rheostat tube effective to overcome said bias voltage, a control tube having an input circuit including a heater type cathode connected to said direct current supply for response to voltage deviations thereof from said predetermined value, an output circuit for said control tube connected to said low impedance resistor and operable to control the input circuit of said rheostat tube, and respective cathode heater elements for said diode and said control tube connected in series to render said diode operative only during operative periods of the output circuit of said control tube.

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