

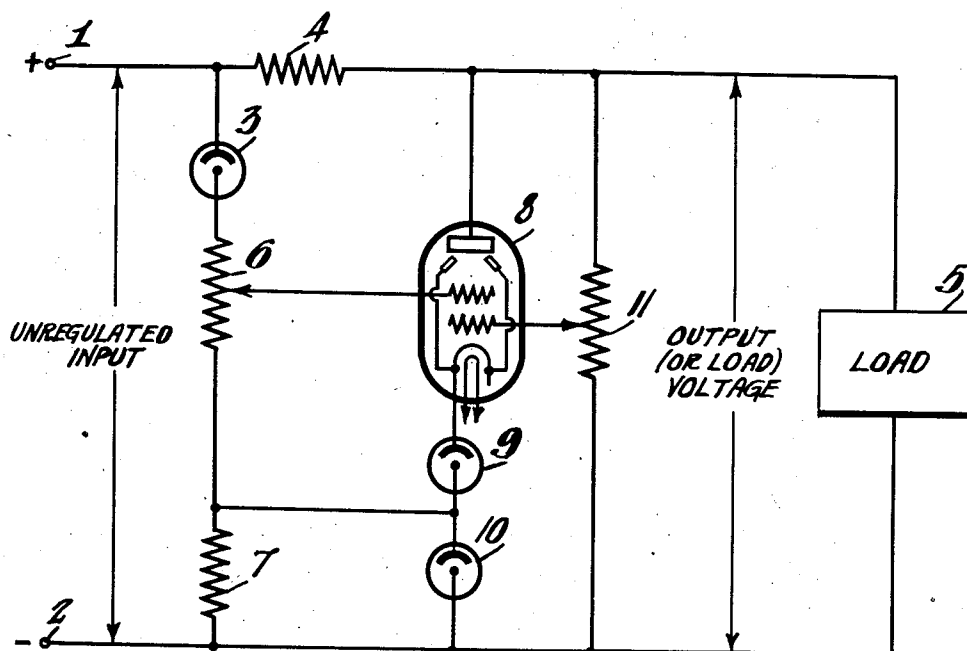
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VOLTAGE REGULATOR

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VOLTAGE REGULATOR

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This invention relates generally to voltage regulating apparatus and more particularly to a voltage regulator for a source of direct voltage wherein the voltage is regulated by duplex control of a variable impedance connected across the output of the voltage regulating circuit.

Conventional voltage regulators have included variable impedance devices, such as thermionic tubes, connected across the output of the voltage regulating circuit and responsive to a portion of the output voltage for controlling the shunt impedance provided by a variable impedance path.

The instant invention contemplates a unique improvement upon existing systems whereby the voltage control circuit includes a series resistor between the voltage source and the load; the applied voltage is regulated by a conventional gaseous discharge voltage control device in shunt therewith; a multi-control electrode thermionic tube is connected in shunt with the load; and gaseous discharge voltage regulators may be included in the cathode circuit of the thermionic tube. A portion of the regulated applied voltage is applied to one of the control electrodes of the thermionic tube to control the shunt impedance provided thereby which, in turn, varies the voltage drop across the series resistor. Additional voltage control is provided by applying a portion of the output voltage across the load to a second control electrode of the thermionic tube to provide additional degenerative control of the current through the shunt connected thermionic tube which, in turn, provides additional control of the voltage drop across the series resistor.

Applicant's improved system provides voltage control within extremely narrow limits notwithstanding considerable variations in applied voltage. For example, a 45 percent change in the input voltage may be regulated by the instant system to provide less than $\frac{1}{4}$ of 1 percent variation in output voltage applied to the load. For low power voltages of the type employed in conventional receiver circuits, the variable shunt impedance regulator tube may be a beam pentode in which the screen electrode is employed as a balancing electrode, and the control grid is employed as the degenerative electrode. It should be understood that these electrodes may be interchanged within the spirit and scope of the invention.

Among the objects of the invention are to provide an improved voltage control circuit for a source of direct potential. Another object of the invention is to provide an improved method of and means for regulating direct voltages wherein

a variable impedance is connected in shunt with the voltage applied to a load and the voltage across a series resistor in the voltage supply circuit is varied by controlling the conductivity of the shunt impedance. Another object of the invention is to provide an improved voltage control circuit which includes a series resistor in the voltage supply circuit, means for regulating the voltage applied to the input of said resistor, means for regulating voltage derived from the output of said resistor, means responsive to a portion of the regulated input voltage for controlling the voltage drop across the series resistor and means responsive to a portion of the output regulated voltage for controlling degeneratively the impedance of the shunt impedance path.

The invention will be described in further detail by reference to the accompanying drawing of which the single figure is a schematic circuit diagram of one embodiment thereof.

Referring to the drawing, a source of unregulated direct input voltage, not shown, is connected to the input terminals 1, 2, the terminal 1 being at positive potential. One terminal of a gaseous discharge type voltage regulator 3 such as, for example, the RCA type VR-150, is connected to the input terminal 1 and to one terminal of a series resistor 4. The remaining resistor terminal is connected to one terminal of a load device 5. The remaining terminal of the voltage regulator 3 is connected through the resistive element of a potentiometer 6 to one terminal of a second resistor 7. The remaining terminal of the second resistor 7 is connected to the negative input terminal 2, and to the remaining terminal of the load device 5.

The terminal of the series resistor 4 which is connected to the load device 5, is also connected to the anode of a thermionic electron discharge tube 8, such as for example, a beam pentode tube. The movable contact of the potentiometer 6 is connected to the screen electrode of the beam pentode tube 8. The cathode of the beam pentode tube 8 is connected through a second gaseous discharge type voltage regulator 9 to the junction of the terminals of the potentiometer 6 and the second resistor 7. A third gaseous discharge type voltage regulator tube 10 is connected across the second resistor 7. The resistive element of a second potentiometer 11 is connected across the terminals of the load device 5. The movable contact of the second potentiometer 11 is connected to the control electrode of the beam pentode tube 8. It should be understood that any

other type of multi-grid tube may be substituted for the beam pentode 8, providing the operating characteristics thereof are suitable for the particular voltages and power ratings involved.

In operation, the beam pentode tube 8 provides a current path in shunt with the load device 5 whereby the currents to the load device 5 and tube 8 both pass through the series resistor 4. It will be seen that variations in impedance of the tube 8 will therefore provide variations in the voltage drop across the series resistor 4. The unregulated input voltage applied to the input terminals 1, 2 is smoothed partially by means of the gaseous discharge type regulator 3 connected across the input terminals. The portion of the initially regulated input voltage derived from the potentiometer 6 and applied to the screen electrode of the beam pentode tube 8 varies the conductivity of the tube 8 in a manner which provides reasonably fine regulation of the voltage drop across the series resistor 4 and hence the output voltage applied to the load device 5. The screen potential is adjusted to the order of the rated value for the tube. However, some objectionable variations in the output voltage will still result from relatively large variations in the voltage applied to the input terminals 1, 2. These residual voltage variations are partially compensated by the second and third gaseous discharge type voltage regulators 9, 10 which are connected in series with the cathode of the beam pentode tube 8. The gaseous discharge regulators 9, 10 reduce the total voltage applied between anode and cathode of the tube 8 to the order of the rated value thereof. The effect thereof is to provide an improved percentage of regulation over the regulation which would be possible if the total output voltage were applied across the control tube 8. However, additional control of the output voltage applied to the load device 5 is obtained by deriving a portion of said output voltage from the second potentiometer 11 and applying this voltage to the control electrode of the beam pentode tube 8. If the voltage balance provided by the potentials applied to the screen electrode is imperfect, the voltages derived from the second potentiometer 11 and applied to the control electrode will operate in a degenerative fashion to minimize the output voltage variations applied to the load device 5.

If the extremely fine voltage regulation mentioned heretofore is not required, or if the voltage to be regulated is of the order of the rated voltage for the control tube 8, it may be found desirable to eliminate one or more of the gaseous discharge type voltage regulators described. In this event, the dual control of the tube 8 will still provide much improved voltage regulation over existing systems utilizing a single thermionic type voltage regulator stage.

Thus the invention described comprises an improved voltage regulator circuit for direct voltages wherein the ordinary voltage regulation of a thermionic tube connected across a load device is supplemented by the degenerative action of a portion of the output voltage applied to a supplemental control electrode of the regulator tube.

I claim as my invention:

1. A voltage regulator for a source of D. C. potential comprising a transmission circuit includ-

ing a series resistor, means for applying said potential to the input of said circuit, means for deriving an output voltage from said circuit, an electron discharge tube having at least an anode, a cathode and a plurality of control electrodes, means connecting said anode and said cathode of said tube across the output of said circuit, means connected to one of said control electrodes and responsive to a portion of said applied potential for controlling the impedance of said tube, and means connected to another of said control electrodes and responsive to a portion of said derived voltage for degeneratively controlling the current through said tube.

2. A voltage regulator for a source of D. C. potential comprising a transmission circuit including a series resistor, means for applying said potential to the input of said circuit, means for deriving an output voltage from said circuit, an electron discharge tube having at least an anode, a cathode and two control electrodes, means connecting said anode and said cathode of said tube across the output of said circuit, means connected to one of said control electrodes and responsive to a portion of said applied potential for controlling the voltage drop across said series resistor and means connected to the other of said control electrodes and responsive to a portion of said derived voltage for degeneratively controlling the current through said tube.

3. A voltage regulator for a source of D. C. potential comprising a transmission circuit including a series resistor, means for applying said potential to the input of said circuit, means for connecting a load device to the output of said circuit, a first voltage divider connected across said input of said circuit, a second voltage divider connected across said output of said circuit, an electron discharge device having at least an anode, a cathode and two control electrodes, means connecting said cathode and said anode across said output of said circuit, means connecting one of said control electrodes to said first voltage divider and means connecting another of said control electrodes to said second voltage divider.

4. Apparatus of the type described in claim 3 including a gaseous discharge voltage regulator, and means connecting said gaseous regulator in series with said first voltage divider connected across said input of said circuit.

5. Apparatus of the type described in claim 3 including a gaseous discharge voltage regulator, and means connecting said gaseous regulator in series with said cathode of said tube connected across said output of said circuit.

6. Apparatus of the type described in claim 3 including a first gaseous discharge voltage regulator, means connecting said gaseous regulator in series with said first voltage divider connected across said input of said circuit, a second gaseous discharge voltage regulator, and means connecting said second gaseous regulator in series with said cathode of said tube connected across said output of said circuit.

7. Apparatus of the type described in claim 3 including a load device connected across said output of said circuit.

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