Oct. 4, 1949. M. S. CORRINGTON 2,483,755

VOLTAGE REGULATOR

Filed Dec. 28, 1945

Fig. 1.

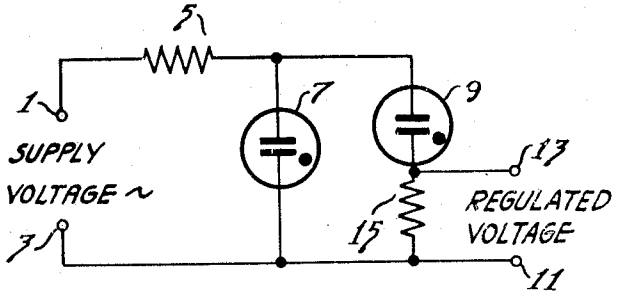


Fig. 2.

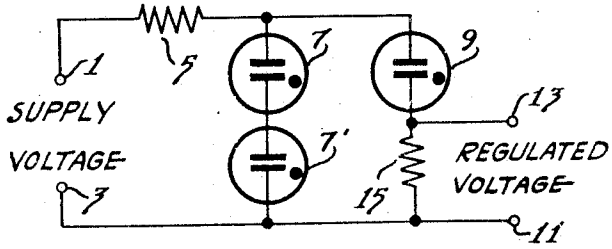


Fig. 3.

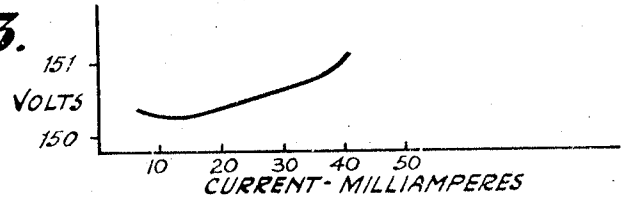


Fig. 4.

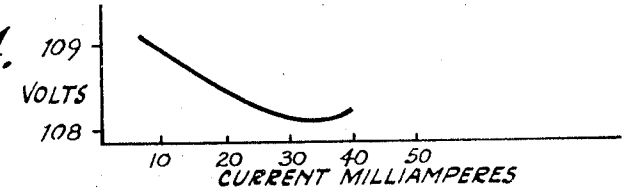
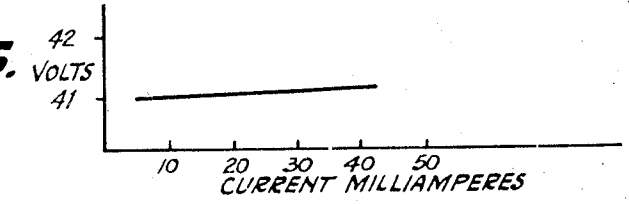


Fig. 5.



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VOLTAGE REGULATOR

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3 Claims. (Cl. 323—79)

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This invention relates generally to electrical power control circuits and more particularly to an improved voltage regulation network providing differential voltage regulation as a function of the control action of two different types of regulator elements.

Heretofore various types of thermionic or gaseous discharge regulator tubes have been employed for the purpose of obtaining stabilized voltages for the operation of electronic or other apparatus. Such regulator tubes usually have a slightly rising or falling voltage-current characteristic within the normal operating range. Various feedback systems have been employed heretofore to compensate for such undesired slope in the operating characteristic.

The instant invention contemplates the use of two different types of conventional gaseous-discharge voltage regulator tubes in a bridge circuit wherein the rising voltage-current characteristic of one tube is compensated by the falling voltage-current characteristic of the other tube in the same operating range. The circuit is particularly advantageous for supplying regulated voltages to circuits requiring considerably lower voltage than is normally obtainable directly from conventional line voltage sources.

Briefly, the improved voltage regulating circuit according to the invention comprises a first gaseous-discharge regulator tube connected in shunt with the supply voltage source and a second gaseous discharge regulator tube, having a lower operating voltage than the first regulator tube, connected in series between the supply voltage source and the load. The load voltage thus derived is the regulated difference voltage between the operating voltages of the two regulator tubes. A series resistor, or voltage-dropping impedance, connected between the supply voltage source and the regulator tubes determines the operating characteristic of the tubes and prevents overload currents which might otherwise be applied thereto. If desired, a second resistor may be connected across the load terminals to determine the minimum effectively regulated load current. Various combinations of series- or parallel-connected gaseous regulator tubes may be employed for controlling the load voltage derived from various supply voltage sources.

Among the objects of the invention are to provide improved methods of and means for regulating the voltage supplied to a load from an unregulated supply voltage source. Another object is to provide an improved voltage regulating network utilizing a pair of gaseous discharge regulator tubes having different operating potentials. An additional object is to provide an improved voltage regulator circuit employing at least two gaseous regulator tubes having different operating control potentials wherein the regulated load voltage is the difference voltage between the operating control voltages of the regulator tubes. A further object is to provide an improved voltage regulator circuit employing at least two gaseous discharge regulator tubes having different operating-voltage characteristics and having voltage-current static characteristics with opposite slopes wherein said opposing static characteristics are substantially complementary so that the load voltage is constant and equal to the difference of the operating voltages of the tubes. A still further object of the invention is to provide an improved voltage regulator circuit including a plurality of serially-connected regulator tubes effectively connected across a supply voltage source and at least one regulator tube of a different operating voltage characteristic connected between the supply voltage source and the load terminals.

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The invention will be described in further detail by reference to the accompanying drawing of which Figure 1 is a schematic circuit diagram of a first embodiment thereof, Figure 2 is a schematic circuit diagram of a second embodiment thereof, Figures 3 and 4 are graphs showing typical voltage-current static characteristics of different types of gaseous regulator tubes, and Figure 5 is a graph indicating the regulated voltage derived from the circuit of Figure 1 when employing regulator tubes having characteristics as indicated in the graphs of Figs. 3 and 4. Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1 of the drawing, a first embodiment of the voltage regulator circuit in accordance with the invention includes input terminals 1, 3 connected to a supply voltage source, not shown. Input terminal 1 is connected through a first resistor or voltage-dropping impedance 5 to a first gaseous discharge regulator tube 7 (such for example as an RCA type OD-3/VR150), and to a second gaseous discharge regulator tube 9 (such for example as an RCA type OC-3/VR105). The remaining electrode of the first regulator tube 7 is connected to the remaining input terminal 3 and to one of the output terminals 11. The remaining electrode of the second regulator tube 9 is connected to the remaining output terminal 13. A second resistor 15 shunts the output terminals 11 and 13. Thus

the regulated output voltage which may be applied to a load, not shown, is equal to the difference of the operating voltages of the regulator tubes 7 and 9.

The series resistor 5 depends upon the supply voltage and controls the maximum operating current characteristics of the regulator tubes, and in the example illustrated should be selected to prevent the current in the first regulator tube 7 from exceeding approximately 40 milliamperes. The second resistor 15, connected across the load terminals 11, 13, provides a current through the second regulator tube 9 of the order of 5 milliamperes with an infinite load impedance. Thus, the regulated load voltage will be maintained substantially constant for load currents varying from zero to approximately 30 milliamperes. If the second resistor 15 is omitted, good regulation of the load voltage will be provided for load currents varying from 5 to 35 milliamperes. Since the first regulator tube has an operating voltage of approximately 150 volts and the second regulator tube an operating voltage of about 109 volts, the difference voltage applied to the load terminals will be of the order of 41 volts in the example described.

Other values of line and load operating voltages may be regulated in accordance with the invention by utilizing gaseous discharge tubes having different operating voltages from those indicated in the previous example. For example, if the operating voltage of the first regulator tube 7 is 105 volts and that of the second regulator tube 9 is 75 volts, the regulated load voltage will be 30 volts.

Figure 2 is similar in all respects to Fig. 1 with the exception that a third regulator tube 7' is serially connected with the first regulator tube 7. If the first and third tubes 7 and 7' each have operating voltages of 105 volts and the operating voltage of the second regulator tube 9 is 150 volts, then the regulated load voltage will be equal to 60 volts providing the supply voltage applied to the input terminals 1, 3 exceeds 210 volts.

The graph of Figure 3 indicates the voltage-current static characteristic of a typical type OD-3/VR150 gaseous discharge regulator tube indicating a rising characteristic with load current. The graph of Figure 4 indicates the falling voltage-current characteristic of a type OC-3/VR105 gaseous discharge regulator tube. The graph of Figure 5 indicates the substantially constant load voltage derived from the circuit of Fig. 1 when the tubes indicated in the examples shown in Figs. 3 and 4 are employed.

Thus, the invention comprises an improved voltage regulator circuit wherein normally opposing voltage-current static characteristics of two or more gaseous discharge regulator tubes are combined in a circuit to provide a substantially constant regulated load voltage having a magnitude corresponding to the difference in the operating voltages of the regulator tubes.

I claim as my invention:

1. A voltage regulator circuit for connection between a source of supply voltage and a load including a voltage-dropping impedance in series with said supply voltage, a pair of voltage-regulating devices having different voltage drops which vary in opposite sense as a function of the series currents therethrough, and means for connecting a load to said voltage-regulating devices whereby the load voltage is proportional to the regulated difference voltage between said two regulating devices.

2. A voltage regulator circuit for connection between a source of supply voltage and a load including a voltage-dropping impedance in series with said supply voltage, a pair of voltage regulating devices having different voltage drops which vary in opposite sense as a function of the series currents therethrough, means connecting one of said devices in series with said resistor and said load, means connecting the other of said devices in shunt with said one device and said load, and means for connecting a load to said voltage regulating devices whereby the load voltage is proportional to the regulated difference voltage between said two regulating devices.

3. A voltage regulator circuit for connection between a source of supply voltage and a load including a first resistor in series with said supply voltage, a pair of voltage regulating devices having different voltage drops which vary in opposite sense as a function of the series currents therethrough, means connecting one of said devices serially between said resistor and said load, means connecting the other of said devices in shunt with said one device and said load, a second resistor connected in series with said one device, and means for connecting a load in shunt with said second resistor whereby the load voltage is proportional to the regulated difference voltage between said two regulating devices.

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