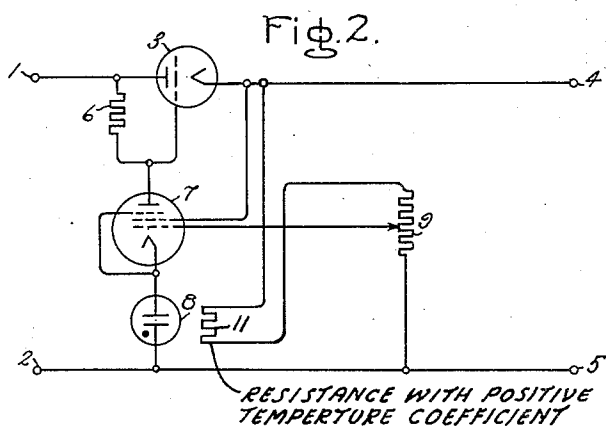
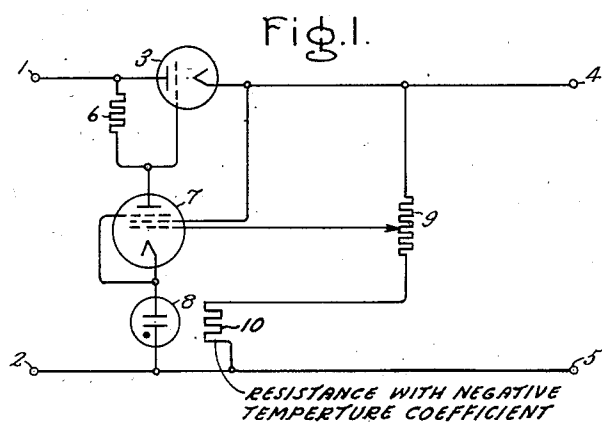


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REGULATING SYSTEM

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REGULATING SYSTEM

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Our invention relates to regulating systems and more particularly to electron tube regulators utilizing a source of reference potential which varies in voltage in accordance with ambient temperature.

In a common system for regulating a load characteristic as, for example, load voltage, a series connected electron discharge device is placed between a unidirectional voltage source and a load circuit and the grid bias controlled in accordance with output voltage. This is accomplished by providing a current path across the supply voltage source comprising a resistance, an electron discharge device, and a source of reference voltage in series relation. The grid of the latter device is connected to a potentiometer connected across the load circuit so that the total effective grid bias applied thereto is determined by the difference between the selected portion of load voltage and the constant reference voltage.

The above mentioned voltage regulator constitutes a negative feedback system wherein the difference between output voltage and the desired regulated value is fed back to the control circuit in degenerative phase. Inasmuch as the system always tends to cause the value of this difference voltage to approach a specific value, the system output is influenced by any changes in the voltage of the reference source. Since the reference voltage sources normally used have some variation in voltage with temperature, temperature changes produce a variation in regulating output voltage. In particular, in the case of gas discharge devices ordinarily used as a source of reference voltage a voltage variation with temperature of the order of .0005 per °C. takes place whereas batteries used for this purpose have a voltage variation with temperature of the order of .00015 per °C.

It is the object of our invention to provide a regulator which operates substantially independently of temperature variations at the source of reference potential.

It is a further object of our invention to provide an improved regulator wherein the effects of temperature variations at the gas discharge tube or battery used as a source of reference potential are compensated by other circuit changes.

In general, our invention resides in providing a temperature sensitive resistance physically disposed to partake of the temperature of the source of reference voltage and electrically connected to introduce a compensating voltage sufficient to balance the changes in reference voltage with temperature. In the specific embodiments of our

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invention disclosed herein this is accomplished by providing a resistance in the potentiometer connected across the output circuit of a voltage regulator, thereby altering the effective electrical position of the roving terminal of the potentiometer in accordance with the temperature conditions at the source of reference voltage.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following disclosure taken in connection with the accompanying drawings in which: Fig. 1 is a schematic diagram of a regulator circuit embodying the invention in which a resistance having a negative temperature coefficient is utilized; and Fig. 2 is a schematic diagram of an alternative regulator circuit in which a resistance having a positive temperature coefficient is utilized.

Fig. 1 shows an electron tube voltage regulator of the above described type. In this regulator, input terminals 1 and 2 are connected to a source of unidirectional electromotive force, terminal 1 being connected to the positive side of the source and terminal 2 to the negative side. The anode of electron discharge device 3 is connected to terminal 1 and the cathode connected to positive output terminal 4. Negative output terminal 5 connects directly to negative input terminal 2. Resistance 6, electron discharge device 7, and gas discharge device 8 comprise a circuit across output terminals 4 and 5 in which current flow biases the grid of device 3 to alter the effective resistance thereof. Potentiometer 9 provides a means for applying a preselected portion of output voltage to the grid of amplifier device 7.

The circuit of Fig. 1 comprises a feedback system in which device 7 receives grid bias in accordance with the difference between the selected portion of output voltage across terminals 4 and 5 and the relatively constant voltage across gas discharge device 8. This bias voltage is amplified in device 7 and applied to bias the grid of device 3. By choosing device 7 and device 3, together with resistance 6, to have values giving a high degree of amplification in the feedback path, the difference between output voltage across terminals 4 and 5 and the desired output voltage is caused to be very small despite variations in the impedance across terminals 4 and 5 and the value of input voltage across terminals 1 and 2.

Inasmuch as the regulator of Fig. 1 acts to

maintain the selected portion of output voltage at a predetermined value with respect to the value of reference voltage at gas discharge device 8, any changes in the reference voltage are reflected as corresponding changes in output voltage. Actually, gas discharge tube 8 provides constant reference voltage only at a particular temperature, and if its temperature is changed, a corresponding voltage change appears at terminals 4 and 5. For this reason, the circuit of Fig. 1 does not provide exactly constant voltage but instead provides a voltage varying in accordance with the ambient temperature at gas discharge tube 8.

In accordance with the embodiment of our invention shown in Fig. 1, auxiliary resistance 10 is provided between the negative side of potentiometer 9 and the negative load terminal 5. This resistance is physically mounted close to gas discharge device 8 so that its temperature corresponds with the temperature of that tube. In addition, this resistor has a negative coefficient of resistance change with temperature so that as device 8 heats or cools in accordance with ambient temperature the value of resistance 10 decreases or increases accordingly. Since the total effective grid bias at amplifier device 7 is equal to the difference between the voltage of gas discharge device 8 and the combined voltage across resistance 10 and the preselected portion of the voltage across potentiometer 9, the decreased voltage at tube 8 associated with a temperature increase is compensated by a corresponding decrease in resistance 10 and the voltage thereacross accordingly reduced. Conversely, if the temperature of gas discharge device 8 decreases, thereby increasing the value of reference voltage, the value of resistance 10 increases and the voltage drop thereacross is correspondingly raised. In either event, the total effective grid bias at device 7 for a particular output voltage remains constant.

A further modification of our invention is shown in Fig. 2. In this modification, resistance 11 is provided between the positive terminal of potentiometer 9 and the positive load terminal 4. By physically locating this resistance to partake of the temperature of gas discharge device 8, and utilizing a resistance material having a positive resistance change with temperature, a compensating voltage is provided which maintains constant grid bias of tube 7 despite temperature changes at device 8. In this circuit, an increase in temperature at gas discharge device 8 causes the voltage thereacross to decrease while at the same time the increased value of resistance 11 produces a corresponding decrease in voltage across the preselected portion of the voltage drop across potentiometer 9. Hence the effective grid bias at tube 7 remains unchanged. Operation of the regulator is, therefore, independent of temperature changes at gas discharge device 8.

It will be evident to those skilled in the art that if the source of reference potential is a battery or other source wherein output voltage increases with rising temperature, the above described circuits may be applied except that resistance 10, Fig. 1, should have a positive coefficient of resistance change with temperature, and resistance 11, Fig. 2, should have a negative coefficient of resistance change with temperature.

While we have described our invention with reference to a particular voltage regulating circuit, it will be understood that it may be readily applied to other types of regulating circuits

whether adapted to maintain constant voltage across load terminals or to maintain some other characteristic such as motor speed, load current, temperature, etc., constant inasmuch as our invention in its broadest aspect contemplates the use of a resistance physically located to partake of the temperature of the reference voltage source and adapted to provide a compensating voltage which balances the change in reference voltage associated with temperature variations.

While we have illustrated particular embodiments of our invention, it will of course be understood that we do not wish to be limited thereto since various modifications, both in the circuit management and in the instrumentalities employed, may be made, and we contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. A voltage regulator comprising in combination, a source of unidirectional electromotive force, a load connected thereto, a source of substantially constant reference voltage having decreasing voltage with increasing temperature, a temperature sensitive resistance mechanically disposed adjacent said source so as to be maintained at substantially the same temperature as said source of reference voltage, said resistance having a temperature coefficient producing decreasing resistance with increasing temperature, a second resistance, means connecting said first and second resistances in series relation across said load, and means to control the voltage of said first mentioned source in accordance with the difference between the voltage of said source of reference voltage and the total voltage across said first resistance and at least a portion of said second resistance, thereby to maintain constant the electromotive force at said load, said first resistance having a resistance change with temperature such that temperature changes at said source of reference voltage are substantially prevented from influencing the voltage output of said regulator.

2. A voltage regulator comprising in combination, a source of unidirectional electromotive force, a load connected thereto, a source of substantially constant reference voltage having decreasing voltage with increasing temperature, a temperature sensitive resistance mechanically disposed adjacent said source so as to be maintained at substantially the same temperature as said source of reference voltage, said resistance having a temperature coefficient producing increasing resistance with increasing temperature, a second resistance, means connecting said first and second resistances in series relation across said load, and means to control the voltage of said first mentioned source in accordance with the difference between the voltage of said source of reference voltage and the voltage across at least a portion of said second resistance, thereby to maintain constant the electromotive force at said load, said first resistance having a resistance change with temperature such that temperature changes at said source of reference voltage are substantially prevented from influencing the voltage output of said regulator.

3. A voltage regulator comprising in combination, a source of unidirectional electromotive force a load connected thereto, a source of substantially constant reference voltage having increasing voltage with increasing temperature, a

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temperature sensitive resistance mechanically disposed adjacent said source so as to be maintained at substantially the same temperature as said source of reference voltage, said resistance having a temperature coefficient producing decreasing resistance with increasing temperature, a second resistance, means connecting said first and second resistances in series relation across said load, and means to control the voltage of said first mentioned source in accordance with the difference between the voltage of said source of reference voltage and the voltage across at least a portion of said second resistance, thereby to maintain constant the electromotive force at said load, said first resistance having a resistance change with temperature such that temperature changes at said source of reference voltage are substantially prevented from influencing the voltage output of said regulator.

4. A voltage regulator comprising in combination, a source of unidirectional electromotive force, a load connected thereto, a source of substantially constant reference voltage having increasing voltage with increasing temperature, a temperature sensitive resistance mechanically disposed adjacent said source so as to be maintained at substantially the same temperature as said source of reference voltage, said resistance having a temperature coefficient producing increasing resistance with increasing temperature, a second resistance, means connecting said first and second resistances in series relation across said load, and means to control the voltage of said first mentioned source in accordance with the difference between the voltage of said source of reference voltage and the total voltage across said first resistance and at least a portion of said second resistance, thereby to maintain constant the electromotive force at said load, said first resistance having a resistance change with temperature such that temperature changes at said source of reference voltage are substantially prevented from influencing the voltage output of said regulator.

5. The combination, in a voltage regulator, of a voltage source, a load connected across said source through an impedance, two paths across said load, one including a constant voltage gaseous discharge device and the other including resistance, means responsive to the difference in voltages across said gaseous discharge device and a part of said resistance to vary said impedance

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thereby to maintain the voltage across said load substantially constant, and means to prevent said voltage across said load from being affected by variations in voltage across said gaseous discharge device produced by ambient temperature variations, said means comprising a resistance element included in one of said paths and positioned closely adjacent said discharge device so as to be subject to the same ambient temperature variations as said gaseous discharge device, said element having a resistance coefficient varying therewith in a direction tending to maintain said difference in voltage independent of said ambient temperature.

6. A voltage regulator comprising in combination, a source of unidirectional electromotive force, a load connected thereto, a source of substantially constant reference voltage having voltage variations with temperature changes, a temperature sensitive resistance mechanically disposed adjacent said source so as to be maintained at substantially the same temperature as said source of reference voltage, said resistance having a temperature coefficient producing a resistance change with temperature change, a second resistance, means connecting said first and second resistances in series relation across said load, and means to control the voltage of said first mentioned source in accordance with the difference between the voltage of said source of reference voltage and the voltage across at least a portion of said second resistance, thereby to maintain constant the electromotive force at said load, said first resistance having a resistance change with temperature such that temperature changes at said source of reference voltages are substantially prevented from influencing the voltage output of said regulator.

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