

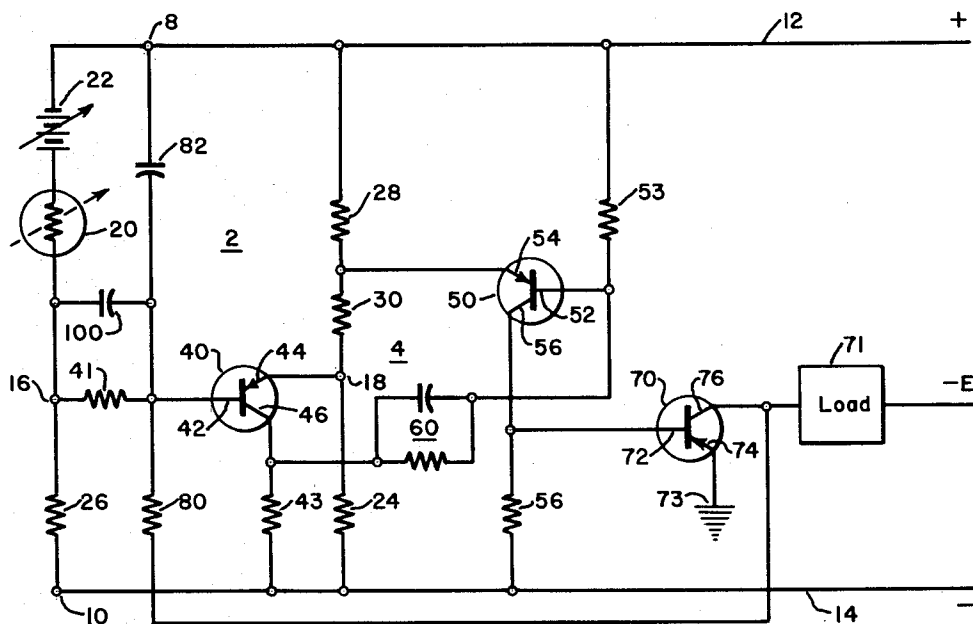
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TEMPERATURE CONTROL SYSTEM

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WITNESSES

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TEMPERATURE CONTROL SYSTEM

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The present invention relates to temperature control systems and more particularly relates to a temperature control system capable of developing an analog type signal.

Temperature control systems utilizing static switching means and required to develop large power outputs provide much more suitable performance when the transistors are utilized only in a switching mode. However, many applications for temperature control systems require an analog type of control system to maintain critical temperatures within close tolerances.

It is an object of the present invention to provide a temperature control system utilizing transistors in a switching mode while furnishing an analog type output.

Another object of the present invention is to provide a temperature control system allowing a wide degree of control temperature variations from a desired temperature level.

Other objects and advantages of the present invention will be apparent from the following detailed description taken in conjunction with the drawing, in which, the sole figure is a schematic diagram of an illustrative embodiment of the invention.

Referring to the figure, there is illustrated a bridge circuit 2 adapted to provide a signal voltage to a bistable trigger circuit 4 which controls the operation of a load switching circuit 6.

More particularly, the bridge circuit 2 is illustrated with its input terminals 8 and 10 connected to a positive direct current bus bar 12 and a negative direct current bus bar 14, respectively. The bridge circuit 2 comprises four impedance legs connected with output terminals 16 and 18. The first impedance leg comprises a thermal sensing device 20 having an impedance which varies with temperature, connected in series circuit relationship with an adjustable direct current voltage source 22. Shown diametrically opposite the first impedance of the leg is a resistive element 24. The remaining two impedance legs comprise a resistive element 26, and resistive element 28 and 30 connected in series circuit relationship, respectively.

The bridge circuit 2 is thus connected across the positive and negative direct current buses 14 and 18 so as to provide a signal voltage across the output terminals 16 and 18, which signal voltage is a measure of the unbalance of the bridge circuit 2 due to variations of the impedance of the thermal sensing device 20. The signal voltage resulting from the bridge circuit 2 is supplied to the bistable trigger circuit 4 comprising transistors 40 and 50 connected in a Schmitt trigger configuration.

The transistor 40 has a base electrode 42, an emitter electrode 44 and a collector electrode 46. The base electrode 42 is connected through a biasing resistor 41 to the output terminal 16, while the emitter electrode 44 is connected to the other output terminal 18. The collector electrode is connected through a current limiting resistor 43 to the negative direct current bus bar 14.

The transistor 50 has a base electrode 52, an emitter electrode 54, and a collector electrode 56. The emitter electrode 54 is connected to the emitter electrode 44 through the resistor 30, which resistor 30 is also a part of the bridge circuit 2 as described previously. The emitter electrode 54 is positively biased through the resistor 28, also a part of the bridge circuit 2. The collector electrode 56 is negatively biased through the current limiting resistor 51 and the base electrode 52 is positively biased through the biasing resistor 53. The base electrode 52 is also connected to the collector electrode 46 through an RC network 60.

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The load switching circuit 6 comprises a transistor 70 having a base electrode 72, an emitter electrode 74, and a collector electrode 76. The collector electrode 76 is connected to a negative direct current source, E, of substantial magnitude through a load 71, representative of heating elements, while the emitter electrode 74 is grounded at 73. Controlling the switching action of the power transistor 70 is the base electrode 72 which is connected to the collector electrode 76 of the bistable trigger circuit 4.

In operation, the circuit is adjusted so that the transistor 40 is "off" but just on the verge of operation. The transistor 50 is "closed" and transistor 70 is "open." The slight negative change on the base electrode 42 of the transistor 40 resulting from an unbalance in the bridge circuit 2 will trigger the bistable trigger circuit 4 so that the transistor 40 will "close" and transistor 50 will "open." Upon the transistor 50 opening, the base electrode 72 of the switching transistor 70 is negatively biased to cause the switching transistor 70 to switch "on" connecting the load 71 across the negative bus to ground 73.

As the bistable trigger circuit switches states as a result of the slight negative change on the base electrode 42, a bucking signal is fed back by means of the feedback resistor 80 connected across the collector electrode 76 to the base electrode 42, which is of such a magnitude as to tend to cause the transistor 40 to switch "off." However, capacitor means, shown as the capacitor 82 and connected in shunt relation with the biasing resistor 41 connected in series circuit relationship with the first impedance leg, will be unable to discharge immediately and hence the Schmitt bistable trigger circuit 2 will return to its original output state only upon expiration of the time delay determined by the combined system RC time constant. It is to be noted that should the signal voltage be of sufficient magnitude, the temperature control system will stay "on" or "off" and the feedback means will be of no effect. For driving signals of magnitude intermediate the two predetermined levels, the resultant output from the temperature control system will have an average which will vary from zero to full output.

The output of the temperature control system is a function of the input current to the base electrode 42 of the transistor 40. The input current is a function of the relative magnitude of the biasing resistor 41 as well as the impedance characteristics of the thermal sensing device 20 with respect to temperature. The RC circuit 60 is utilized to decrease the switching time of the monostable trigger circuit 4 thereby minimizing dissipation in the output circuit.

A capacitor 100, connected across the biasing resistor 41, minimizes over-shooting of the temperature control circuit by applying a signal to the base electrode 42 of the bistable triggering circuit 4, which signal is a function of the rate of change of the potential difference developed across the output terminals 16 and 18 of the bridge circuit 2 and hence a function of the rate of change of temperature sensed by the thermal sensing device 20. Of course, when desired the capacitor 100 may be omitted so that the signal voltage to the bistable trigger circuit 4 is a measure of bridge circuit unbalance as described previously.

The advantages gained by the present invention include the relative simplicity of design; the attainment of an analog type output with switching circuit efficiency; and a switching rate which may be varied over a wide range, restricted only by the size of the capacitor 82 on the low

scale of the switching rates and the switching speed of the bistable trigger circuit 4 on the high scale of the switching rate of the temperature control system.

Although particular embodiments of the invention have been shown for the purpose of illustration, it is to be understood that the invention is not limited to the specific arrangement shown, but includes all equivalent embodiments, modifications and substitutions within the spirit and scope of this invention. The transistors have been illustrated to be of the P-N-P type but N-P-N type transistors may be used with suitable changers in polarity within the temperature control system.

I claim as my invention:

1. In a temperature control system, heating means adapted to be connected across a power supply, a thermal sensing impedance device, bridge means responsive to the impedance of said thermal sensing device for providing a signal voltage, a Schmitt triggering circuit responsive to a predetermined polarity and magnitude of said signal voltage for providing an output signal, transistor means responsive to said output signal for connecting said heating means across said power supply, and feedback means operatively connected to said transistor means for providing a bucking signal capable of overcoming said signal voltage and returning the Schmitt triggering circuit to its original state when the magnitude of said signal voltage is below a predetermined level.

2. In a temperature control system, heating means adapted to be connected across a power supply, a thermal sensing impedance device, bridge means responsive to the impedance of said thermal sensing device for providing a signal voltage, a Schmitt triggering circuit responsive to a predetermined polarity and magnitude of said signal voltage for providing an output signal, transistor means responsive to said output signal for connecting said heating means across said power supply, and feedback means operatively connected to said transistor means for providing a bucking signal capable of overcoming said signal voltage and returning the Schmitt triggering circuit to its original state when the magnitude of said signal voltage is below a predetermined level, said feedback means including time delaying means for delaying the application of said feedback signal.

3. In a temperature control system, heating means adapted to be connected across a power supply, a thermal sensing impedance device, a bridge circuit comprising four impedance legs and including input terminals and output terminals, said input terminals adapted to be connected across a direct current source of constant potential, one of said impedance legs comprising said thermal sensing impedance device and means for establishing a reference potential for said bridge, said output terminals having a signal voltage thereacross as a function of the relative unbalance of said bridge, a first and a second transistor connected in a Schmitt triggering circuit arrangement

adapted to be bias connected to said direct current source and each having a base electrode, collector electrode and emitter electrode, the base-emitter circuit of said first transistor connected across said output terminals, said Schmitt triggering circuit capable of changing output states upon said signal voltage being of predetermined polarity and exceeding a predetermined magnitude, means responsive to the output state of said Schmitt triggering circuit for connecting said heating means across said power supply, and feedback means operatively connected to said last mentioned means for providing a negative feedback signal opposing said signal voltage so as to cause said Schmitt triggering circuit to return to its original output state when the signal voltage is less than a predetermined level, said feedback means including time delaying means for delaying the application of said feedback signal.

4. In a temperature control system, heating means adapted to be connected across a power supply, a bridge circuit comprising four impedance legs and including input terminals and output terminals, said input terminals adapted to be connected across a direct current source of constant potential, one of said impedance legs comprising a thermal sensing impedance device connected in series circuit relationship with an adjustable direct current potential source, said output terminals having a signal voltage thereacross as a function of the relative unbalance of said bridge, capacitor means connected in shunt relation with said one of said impedance legs, a first and a second transistor connected in a Schmitt triggering circuit arrangement adapted to be bias connected to said direct current source and each having a base electrode, collector electrode and emitter electrode, the base-emitter circuit of said first transistor connected across said output terminals, said Schmitt triggering circuit changing output states upon said signal voltage being of predetermined polarity and exceeding a predetermined magnitude, transistor means responsive to the output state of said Schmitt triggering circuit for connecting said heating means across said power supply, and feedback means operably connected to said transistor means and responsive to said output signal for providing a feedback signal opposing said signal voltage, said capacitor means having a predetermined discharge rate and connected to oppose said feedback signal, said Schmitt triggering circuit returning to its original state when the signal voltage is less than a predetermined level.

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