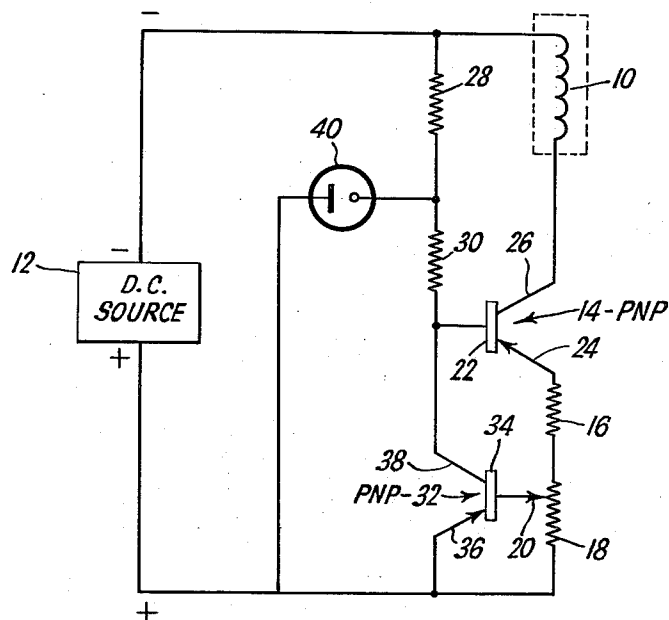


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CURRENT SUPPLY APPARATUS
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CURRENT SUPPLY APPARATUS

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This invention relates to a device for supplying a constant current to a load.

In the operation of various electrical circuits, it is often desirable or necessary to maintain a constant current through a portion of a circuit in spite of variations in the load impedance or circuit components which would cause a current change. Such a condition will exist due, for example, to extreme changes in temperature.

A specific example is found in the application of travelling wave tubes, where a solenoid is employed to radially compress the electron beam within the tube. The current required for such a solenoid can be of the order of several amperes. The solenoid resistance is temperature sensitive and varies as the solenoid temperature rises from its initial ambient value to a relatively high operating temperature. Such a resistance change decreases the current through the solenoid to such a value that the electron beam spreads radially and the tube will not function properly. As a consequence, the current must be manually readjusted to recompress the beam.

It is therefore an object of this invention to automatically maintain the current through a portion of a circuit constant despite changes in the resistance thereof.

It is another object of the present invention to provide a circuit capable of maintaining a current through a load at a constant value.

These and other objects of my invention will either be explained or will become apparent hereinafter.

In accordance with the principles of my invention, I provide a device for coupling a source of direct current to a load, the device comprising a first circuit and a second circuit.

The first circuit, in series with the load, is coupled to the output terminals of the current source and includes a current regulating means and a current variation sampling means. The regulating means is provided with input, output and control electrodes, the input-output path thereof being connected in series with the sampling means.

The second circuit is also coupled to the output of the current source and includes an impedance and a voltage sensitive device. This device is provided with input, output and control electrodes, the input-output path of said device being connected in series with said impedance. The control electrode of this device is coupled to a point on the sampling means intermediate its ends and the control electrode of the regulating means is coupled to the junction point of the impedance and the voltage sensitive device. These circuits constitute a closed loop negative feedback arrangement.

When the load current changes from a predetermined value, a voltage change will be produced across the sampling means and will vary the bias on the voltage sensitive device to vary the current flow in the second circuit. This variation in turn effects a change in the bias voltage on the regulating means in such manner as to substantially restore the load current to its predetermined value.

An illustrative embodiment of my invention will now be described with reference to the accompanying drawing.

Referring to the drawing, one side of a load 10 having a resistance varying with temperature as, for ex-

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ample a solenoid, is connected to the negative terminal of a source of direct current 12. The other side of the load is connected to the positive terminal of the source 12 through a first series circuit. This series circuit includes a current regulating means which may be first PNP transistor 14, an emitter stabilizing resistor 16, and a current variation sampling means which may be a potentiometer 18 having an arm 20. The transistor has control, input and output electrodes, in this example, base 22, emitter 24 and collector 26, respectively, the emitter being connected to the resistor 16 and the collector being connected to the load 10. It will be observed that the load and the emitter-collector current path of the first transistor are in series, so that a current passing through the load also passes through the first transistor.

This arrangement also includes a second series circuit coupled across the current source and including a resistor 28, an impedance 30, which may also be a resistor and a voltage sensitive device which may be a second PNP transistor 32. This transistor is also provided with control, input and output electrodes, comprising respectively a base 34, emitter 36 and collector 38. The emitter is connected to the positive leg of the current source 12. The collector is connected to the resistor 30 which is in series with the resistor 28; the other end of resistor 28 is connected to the negative terminal of the current source.

The junction between the resistors 28 and 30 is connected to a voltage regulator device 40 to maintain the voltage constant at this point, thus maintaining the operation of the circuit substantially independent of supply voltage fluctuation; the device may be, for example, a voltage regulator tube or a Zener diode. The base 22 of the first transistor is connected to the collector 38 of the second transistor. The base of the second transistor is connected to the arm 20 on the potentiometer. The two series circuits constitute a negative feedback loop, as will be clear from the description of operation.

The circuit operates in the following manner. The arm on the potentiometer is initially set so that a predetermined current flows through the load. When the load current decreases as, for example, when the load resistance increases due to a temperature change of the load, the voltage drop across the potentiometer 18 decreases. Consequently, the base-emitter voltage on the second PNP transistor 32 also decreases, making the base less negative with respect to the emitter. This will, in turn, reduce the current flow through the transistor 32 and thus the voltage drop across the resistor 30 decreases. As a result, the base-emitter potential on the first PNP transistor 14 is increased making the base more negative with respect to its emitter, thus increasing the current through the first transistor 14 and therefore through the load 10. The action is one, therefore, which opposes the change producing it, thereby maintaining the current in the load substantially constant.

A similar feedback action is produced if the current through the load tends to increase rather than to decrease. My circuit will also automatically compensate for changes in the characteristics of the transistor 14 which would vary the current through the load, whether such changes result from temperature variations, transistor aging, and the like.

The potentiometer 18 is a current change sampling resistor. The voltage across the potentiometer must vary only with current variations through the load so that a reference voltage is produced. Hence, the potentiometer must be temperature insensitive.

The first transistor 14 should be of the power transistor type in order to pass the current required by the

load 10. The second transistor may be of the medium power type. Although my circuit has been described using type PNP transistors, type NPN transistors may also be employed if the power supply is reversed in polarity. In either case, however, both transistors must be of the same type, i.e. both PNP or both NPN, for satisfactory operation. The values of the potentiometer 18 and the collector resistor 30 are important since such values determine the amount of bias change applied to each transistor. Accordingly, a potentiometer of only a few ohms, depending upon the load current required and upon the characteristics of the second transistor 32, and a collector resistor of approximately 1000 ohms, depending also upon the characteristics of the second transistor, would be typical.

While I have shown and pointed out my invention as applied above, it will be apparent to those skilled in the art that many modifications can be made within the scope and sphere of my invention.

What is claimed is:

1. A device for coupling a source of direct current to a load, said device comprising first and second transistors of corresponding types; each transistor having an emitter, a collector and a base; a potentiometer; means for connecting said load, the emitter-collector path of said first transistor, and said potentiometer in series to form a first series circuit, said first circuit being coupled across said source; a resistor, means for connecting the emitter-collector path of said second transistor in series with said resistor to form a second series circuit, said second circuit being coupled across said source, means for connecting said base of said second transistor to a movable contact on said potentiometer and means connecting said base of said first transistor to the junction between said resistor and the collector of said second transistor.

2. Apparatus for maintaining substantially constant, an electric current flow through a load, comprising, a source of direct current having positive and negative terminals; an electrical load; a first transistor having a collector, an emitter and a base; a first resistor; means connecting said load, the collector-emitter path of said first transistor and said first resistor in series with said positive and negative terminals; a second resistor; a voltage regulating device; mean connecting said second resistor and

said voltage regulating device in series with said positive and negative terminals; a third resistor connected to the junction of said second resistor and said voltage regulating device and to the base of said first transistor; a second transistor having an emitter, a base and a collector; means adjustably connecting the base of said second transistor to said first resistor and means connecting the emitter-collector path of the second transistor in series with said first resistor and the emitter and base of said first transistor.

3. Apparatus for maintaining substantially constant the electric current flow through a solenoid, the resistance of which varies with changes in temperature, comprising, a source of direct current having positive and negative terminals; means connecting one terminal of said solenoid to the negative terminal of said source; a first transistor having an emitter, a collector and a base; means connecting the collector of said first transistor to the other terminal of said solenoid; a first resistor having one terminal connected to said emitter of said first transistor and another terminal connected to the positive terminal of said source; a second resistor; a two electrode voltage regulating device, said second resistor having one terminal connected to the negative terminal of said source and its other terminal to one electrode of said voltage regulating device, the other electrode of said device being connected to the positive terminal of said source; a third resistor, one terminal of said third resistor being connected to the junction between said second resistor and said voltage regulating device, the other terminal of said third resistor being connected to the base of said first transistor; and a second transistor having an emitter, a base and a collector, the collector of the second transistor being connected to the base of the first transistor, the emitter of the second transistor being connected to the positive terminal of said source and the base of said second transistor being connected to said first mentioned resistor.

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