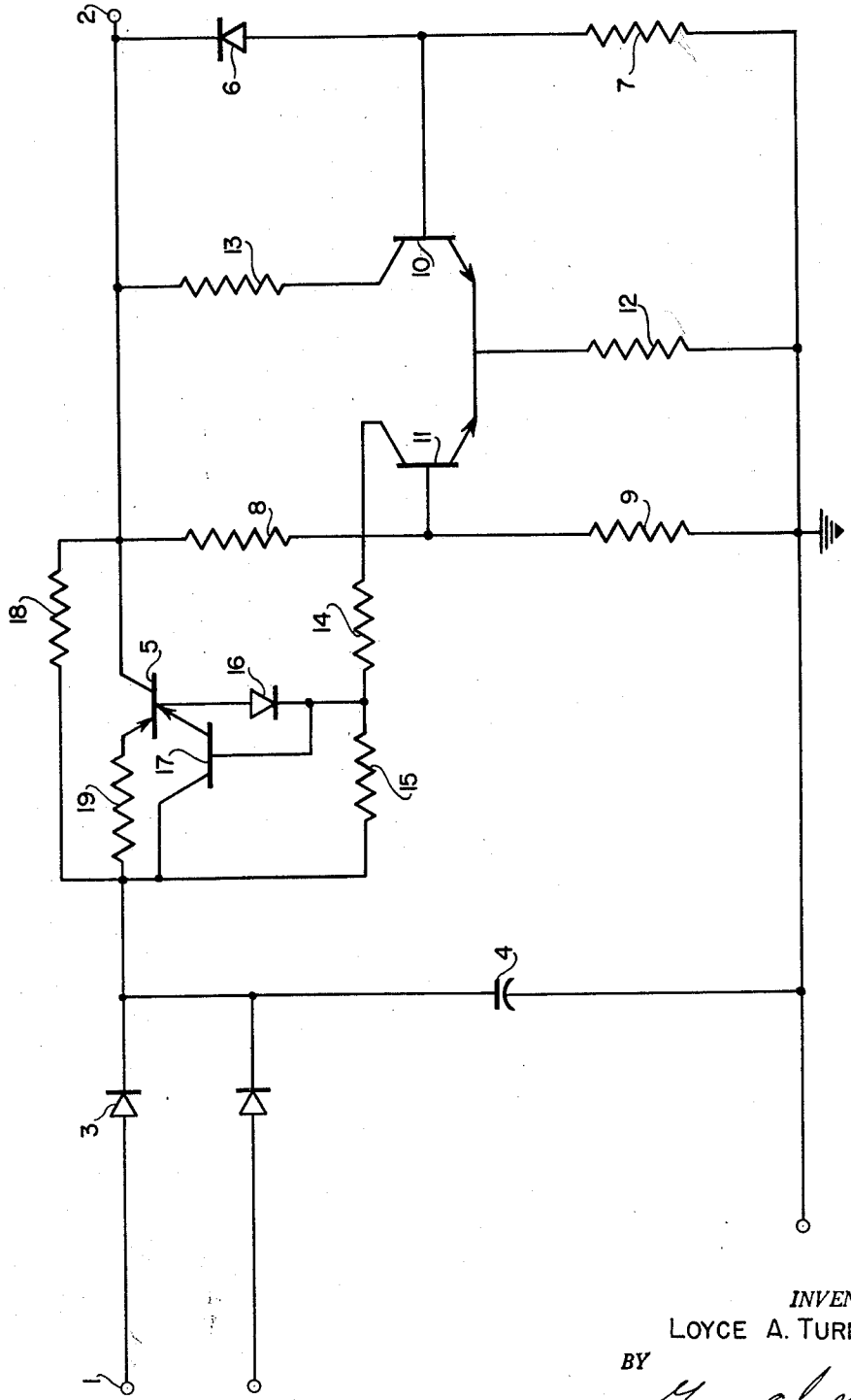
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TRANSISTORIZED VOLTAGE REGULATOR WITH AUTOMATIC COLLECTOR LEAKAGE COMPENSATION MEANS

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INVENTOR.

LOYCE A. TURNER

BY

George A. Sullivan

Agent

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TRANSISTORIZED VOLTAGE REGULATOR WITH AUTOMATIC COLLECTOR LEAKAGE COMPENSATION MEANS

Loyce A. Turner, Smyrna, Ga., assignor to Lockheed Aircraft Corporation, Burbank, Calif.

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This invention relates to transistorized voltage regulator and more particularly to such a regulator incorporating a transistor in series between the power source and load and having provision for temperature and extreme voltage stabilization.

Voltage regulators utilizing transistorized circuits have been produced and operated quite successfully where the supply source is reasonably uniform and varies within certain prescribed limits. However, for the extreme variations of the source and situations of high ambient or operating temperatures, prior art circuits have relatively poor regulation and are subject to temperature "runaway" conditions in which the output voltage is uncontrolled.

Accordingly, an object of the present invention is to provide a series transistor voltage and/or current regulator having excellent regulation in the presence of extreme source variation and/or high temperatures.

Another object of the invention is to provide regulation with extreme variation in load or supply voltage to the regulator.

A further object of the invention is to provide compensation for transistor collector leakage current.

These and other objects will become apparent from the following description and drawings in which the single FIGURE is a schematic circuit diagram of a preferred form of the invention.

Referring now to the single figure, a variable input voltage is applied to input terminal 1, and appears at output terminal 2 as a very closely regulated supply. The input may be an alternating current supply if desired, the rectifier 3 and filter capacitor 4 being ample to provide the direct current voltage required as the input voltage source.

A transistor 5 of the PNP type is series connected between the supply terminal 1 and output terminal 2, and with the associated control circuit provides a variable current to stabilize the output and provides the necessary voltage drop to maintain the output voltage substantially constant.

A zener diode 6 and series resisance 7 are connected across the load terminals to provide a reference voltage for the power supply. A voltage divider consisting of series resistances 8 and 9 is connected across the output or load side of transistor 5, A pair of NPN type transistors 10 and 11 form an emitter coupled amplifier, the resistance 12 functioning as coupling impedance for this stage and the load of transistor 10.

The base electrode of transistor 10 is connected to the junction of the zener diode and resistance 7, and the collector electrode is connected through resistance 13 to the output terminal. The base electrode of transistor 11 is connected to the voltage divider between resistances 8 and 9, and the collector electrode forms an output from the amplifier stage to the series transistor 5.

The collector of transistor 11 is connected through resistances 14 and 15 to the input terminal 1, and a diode 16 is connected from the base of transistor 5 to the junction of resistances 14 and 15. A transistor 17 has its emitter electrode coupled to the base of transistor 5, its collector is coupled to the input terminal and its base is coupled to the junction between resistances 14 and 15. Shunt resistance 18 provides a small initial voltage to start

operation of the regulator, and series resistance 19 functions as a voltage source for transistor 17.

The regulator circuit has shown good regulation with from 14 to 60 volts input and 12 volts output. A reason for this unusual performance is believed to be as follows. The series transistor 5 has a high power rating (of the order of 50 watts) and this amount of power causes the transistor to run quite hot, resulting in a high collector-base leakage current. If this leakage current should be greater than the drive signal from transistor 11, the circuit will be unable to regulate and the output voltage will increase. This "thermal runaway" can be prevented or at least reduced by the insertion of a series resistance 19 in the emitter of transistor 5, providing a voltage drop of approximately 2 volts. To be effective, the base of transistor 5 must be returned to the input side of resistance 19 through a resistance which in this case is resistor 15. Thermal stability is improved as resistance 15 is reduced in value to zero ohms; however, the drive current required from transistor 11 becomes excessive at values of resistor 15 below about 2000 ohms. The addition of diode 16 and transistor 17 solves the problem.

In normal operation, transistor 17 is biased to cutoff and transistor 5 is driven by transistor 11 through diode 16. Transistor 11 also provides the current drawn by resistance 15, which is about 1 ma. Resistance 14 is a current limiter for transistor 11. Should the unit become too hot and transistor 5 show excess collector to base leakage, the condition is reached wherein diode 16 is biased to cutoff and transistor 11 ceases to deliver drive current; transistor 17 starts conducting and acts as an emitter follower to produce a low impedance path from the base of transistor 5 to the input. Transistor 17 is a high beta transistor and with the base current of 1 ma. provided by resistance 15, it can handle a leakage current of nearly 100 ma. Thus the circuit acts as if resistance 15 were only 20 ohms as seen by the leakage current but 2000 ohms as a load for transistor 11.

For voltage variations, the zener diode provides a reference which is applied to the base of transistor 10, which is in turn impressed on the emitter of transistor 11 through the common coupling resistor 12. The output or regulated voltage is impressed on the voltage divider 8—9, and applied to the base of transistor 11. Inasmuch as bias for transistor 11 is established on resistance 12 from the zener diode through transistor 10, the net output from transistor 11 will be effectively a differential current, depending on whether the regulated output is too high or too low. The circuit regulates at approximately the voltage at which the drop across resistance 8 equals the drop across the zener diode.

In a similar manner, the regulator responds to load variations. It therefore accordingly is apparent that the circuit of this invention provides substantially a constant output from an unregulated source in which extremes of high voltage and temperature may exist.

While a specific embodiment of the invention has been shown and described, it should be understood that certain alterations, modifications and substitutions may be made to the instant disclosure without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A regulator of the voltage or current sensitive type comprising a source of unregulated voltage, a load circuit, a transistor series connected between said source and load to provide a substantially constant current, a driver circuit including an element responsive to said load current and a reference for providing a drive current for said series connected transistor, a load resistor coupled to said driver circuit for providing drive to said

series transistor, means responsive to excess leakage current in said series transistor for opening said driver circuit and additional means responsive to excess leakage current in said series transistor for providing a low impedance path for said series transistor base current.

2. In combination with a direct current unregulated source and a load circuit, variable impedance means in series relationship between said source and load circuit, a voltage reference means, means responsive to said reference and the voltage of said load for producing a control signal, means for applying said control signal to said variable impedance means to vary the impedance thereof, load resistor means for said signal producing means, said load resistor means being normally associated with said variable impedance means, means responsive to excessive reverse current of said variable impedance means for bypassing said load resistor with respect to said variable impedance.

3. A circuit arrangement for providing a regulated supply to a variable load from an unregulated source comprising a series transistor which is subject to excessive voltage and temperature series connected between said source and said load, means comparing a voltage proportional to said load with a reference and providing a control signal, means responsive to said control signal for varying the bias on said transistor to provide a variation of the impedance thereof, a variable impedance associated with the emitter base circuit of said transistor, means responsive to excessive leakage current of said transistor for controlling said variable impedance to thereby vary the emitter to base impedance of said transistor whereby said transistor output is temperature stabilized.

4. A circuit arrangement for providing a regulated voltage or current to a variable load from an unregulated source, comprising a series transistor series connected between said source and load, a zener diode for providing a reference, an emitter coupled amplifier responsive to said reference and said regulated voltage for providing a drive signal for said transistor, a load resistor for

said amplifier normally connected in the emitter to base circuit of said transistor, means responsive to excessive leakage current of said transistor for bypassing said resistor to thereby reduce the impedance of said emitter to base circuit.

5. A circuit arrangement for providing automatic compensation for collector leakage current comprising a current source a first transistor connected for passage of a current therethrough, a series resistance between the current source and transistor emitter, a second transistor having its emitter connected to the base of said first transistor and its collector connected to the current source ahead of said series resistance, a drive signal, a diode for applying said drive signal to the base of said first transistor, the base of the second transistor connected to the signal source ahead of said diode, and a resistance connected between said current source and base of the second transistor.

6. A circuit arrangement for providing a regulated supply to a variable load from an unregulated source comprising an unregulated source, a variable load, a series resistance and transistor connected between said source and load, a voltage divider connected across said load for developing a first voltage corresponding to said load variations, a zener diode for developing a second voltage characterized as a referenced voltage, an emitter coupled amplifier for comparing said first and second voltages and providing a control voltage, a unidirectional device for applying said control voltage to the base of said series transistor, resistance means for connecting the signal input of said diode to the source, a normally cut off transistor having the collector-emitter path connected between the source and the base of said series transistor, and having its base connected to the signal input side of said diode.

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