United States Patent

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[72] Inventor **Robert E. Jehle**
Woodhaven, N.Y.

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[73] Assignee **The United States of America as represented by the Secretary of the Navy**

[54] **DC POWER SUPPLY REGULATED BY A SHUNT TRANSISTOR WHOSE BIAS VOLTAGE IS VARIED BY TRANSISTOR MEANS TO STABILIZE LOAD VOLTAGE**
4 Claims, 4 Drawing Figs.

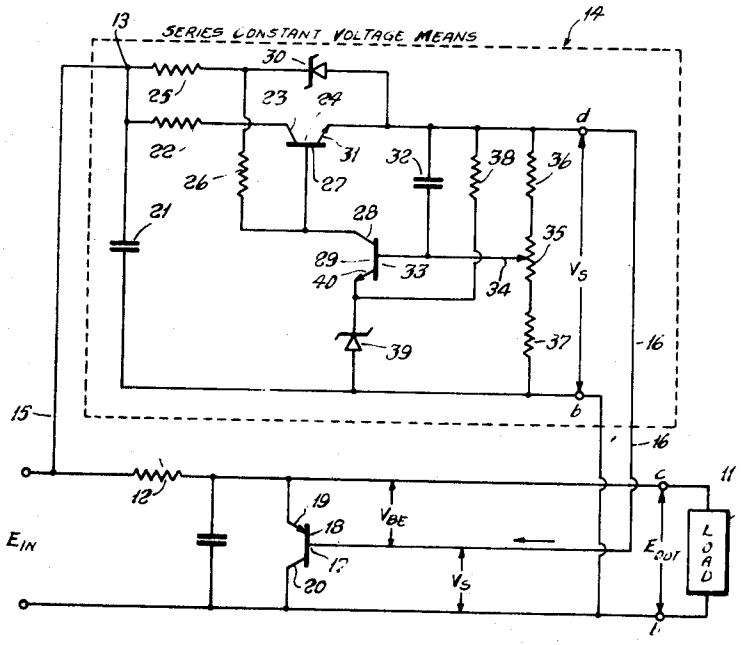
[52] **U.S. Cl.** ..... **323/22 T,** 307/297, 323/38
[51] **Int. Cl.** **G05f 1/60**
[50] **Field of Search** ..... 323/4, 9, 16–22, 22 T, 7, 8, 38; 307/297

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Primary Examiner—Gerald Goldberg
Attorneys—Louis A. Miller, Louis B. Applebaum and Ernest F. Weinberger

ABSTRACT: An adjustable DC power supply regulated by the combination of a voltage dropping resistor in series between the DC source and the load, a transistor shunting the load, and other transistor circuitry that monitors the load voltage while drawing very little current, and responds to any load voltage change to adjust the bias on the shunt transistor in a direction to change the current drawn by the shunt transistor and thereby to change the voltage drop across the voltage dropping resistor to oppose change in load voltage.



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SHEET 1 OF 3

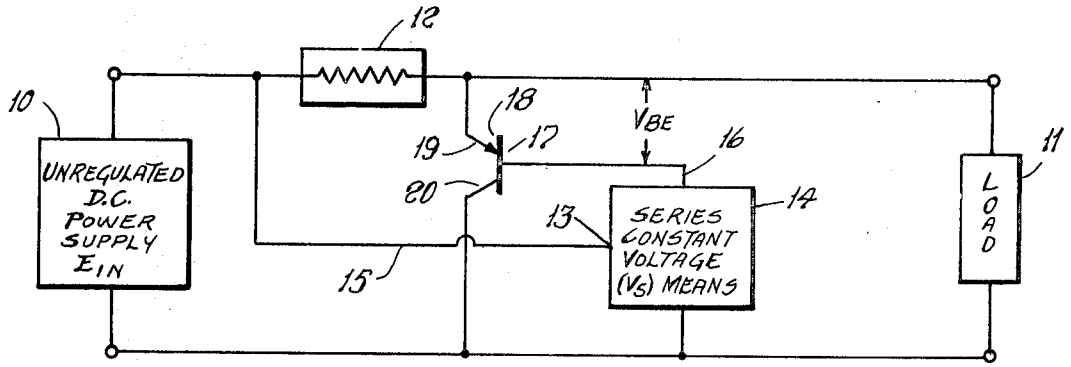


Fig. 1

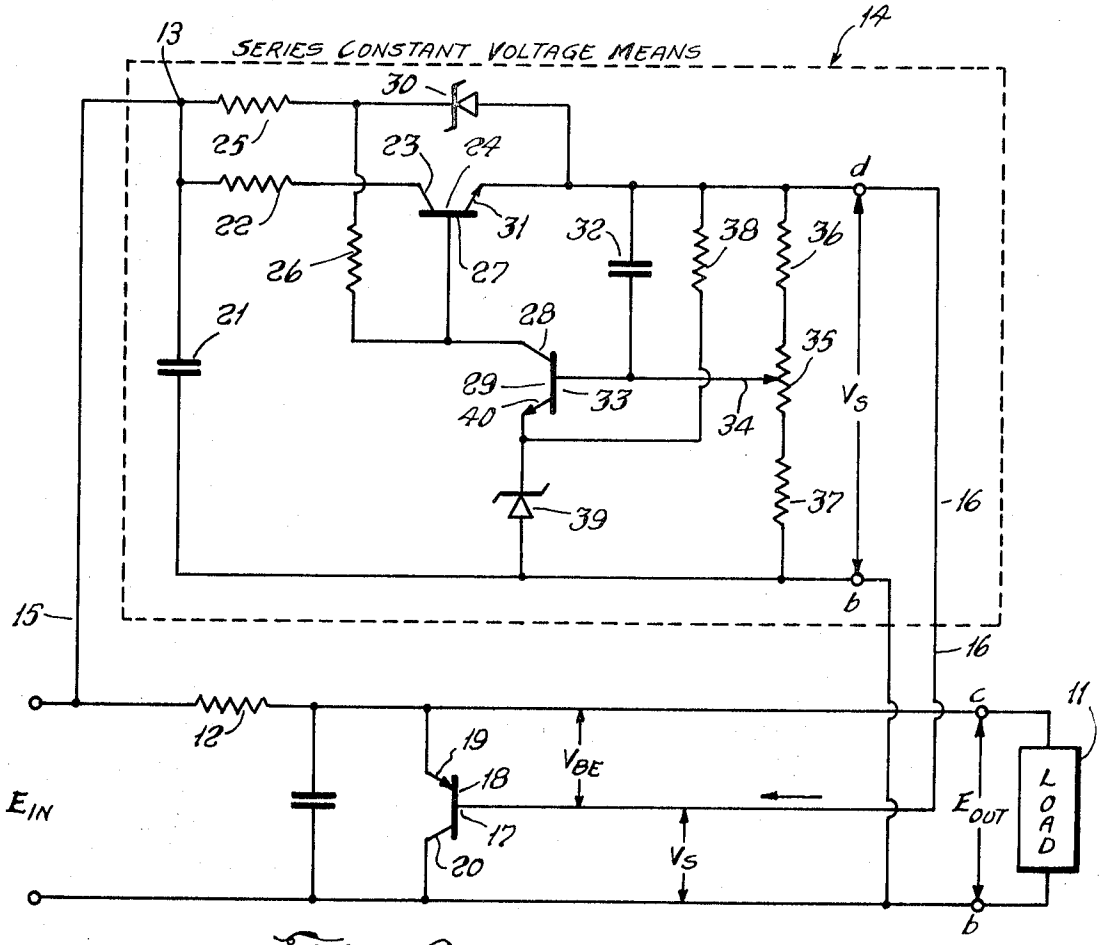


Fig. 2

INVENTOR.
ROBERT E. JEHLE
BY Ernest J. Weinberger
Lon B. Eggleston
ATTORNEYS

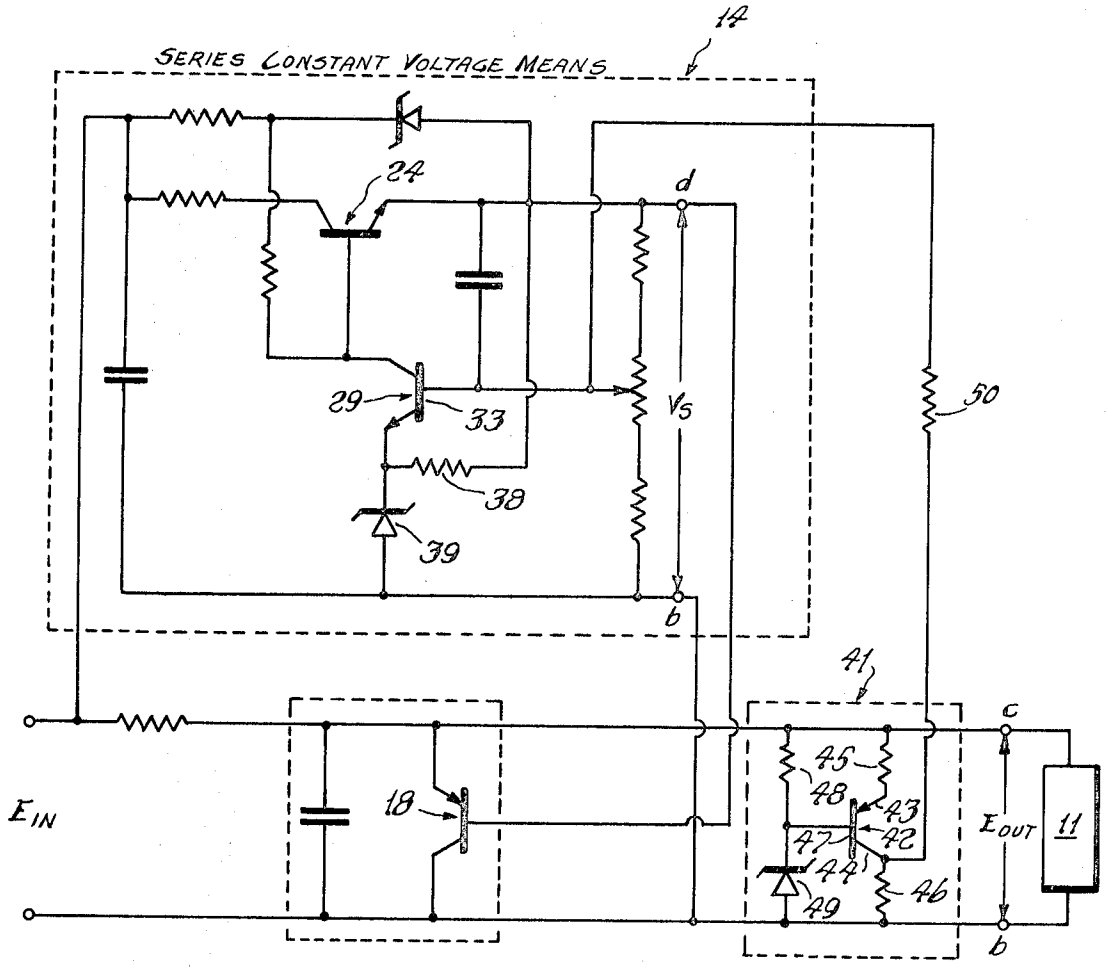


Fig. 3

INVENTOR.
ROBERT E. JEHLE

BY Ernest J. Weinberger
Lon B. Applebaum
ATTORNEYS

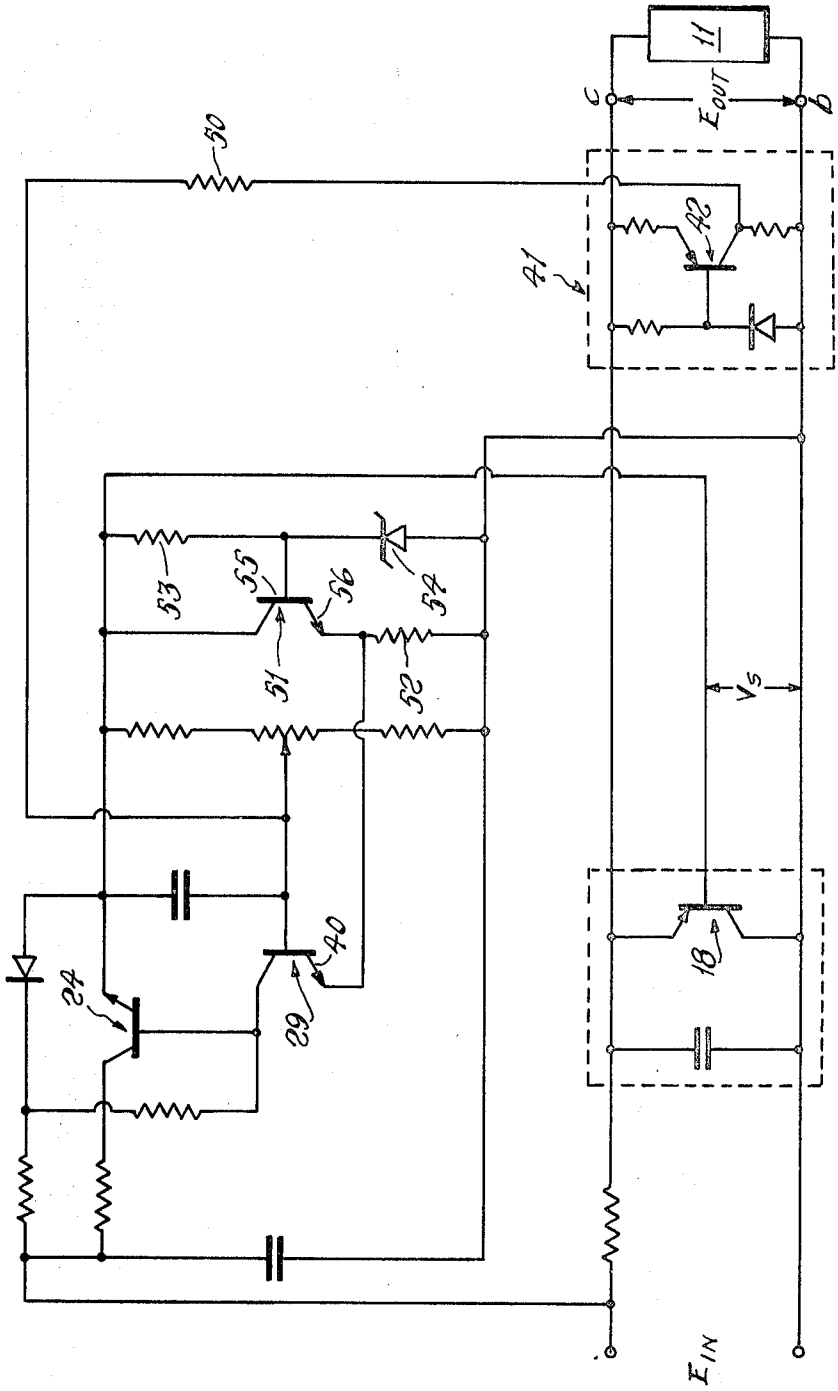


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INVENTOR.
ROBERT E. JEHLE
BY Ernest J. Weinberger
Lon B. Eggleston
ATTORNEYS

DC POWER SUPPLY REGULATED BY A SHUNT TRANSISTOR WHOSE BIAS VOLTAGE IS VARIED BY TRANSISTOR MEANS TO STABILIZE LOAD VOLTAGE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to electronic power supplies and more particularly to highly accurate adjustable regulated direct current supplies wherein there is included a voltage dropping resistor in series between the unregulated source and the load, and a transistor shunting the load to draw variable current through the voltage dropping resistor to oppose change in voltage across the load and a transistorized series network that monitors the load voltage and operates to vary the bias of the shunt transistor to stabilize the load voltage while drawing current that is a minute percentage of the load current.

2. Description of the Prior Art

In the field of regulated power supplies, it has been the general practice to employ series connected supplies wherein a fault element controls or cuts off a series component under extreme load conditions. This inherently demand that high load currents are carried by the series component. The output drop initiates the prevention of damage to the series component. Such devices have been unsatisfactory in that high currents or the entire load current passes through a particular component producing an excessive drop, inefficient operation, and unstable outputs.

SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a highly stable and accurate variable power supply that has all the advantages of similarly employed prior art devices and has none of the above described disadvantages. To attain this, the present invention provides a unique arrangement of circuits wherein a DC power source is connected in series with a current-limiting resistor and the load, a shunt transistor has its emitter-collector in parallel with the load and its base connected to receive the output of a series connected constant voltage means, which means receives said source as its input, whereby instability and inaccuracy are avoided.

An object of the present invention is to provide an inexpensive, highly accurate, simple regulated variable power supply having overload protection.

Another object is to provide a series—shunt regulated variable power supply wherein only an extremely minute fraction of the load current passes through the series regulation circuit.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, in which like reference numerals designate like parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an embodiment illustrating the principle of this invention;

FIG. 2 is a schematic wiring diagram of the embodiment shown in FIGS. 1; and

FIGS. 3 and 4 are schematics of alternate embodiments made in accordance with the principle of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the illustrated embodiment of FIG. 1, a DC supply **10** is connected in series with a load **11** and a current limiting resistor **12**. The DC supply **10** is also connected via line **15** to the input **13** of a series variable impedance constant output voltage source **14** which has its output **16** tied to the base **17** of shunt transistor **18**. The algebraic sum of the emitter **19** base **17** impedance and the base **17** collector **20** impedance of transistor **18** is in shunt with the load **11**. The voltage across the load **11** is equal to the algebraic sum of the output voltage V_s of the series means **14** and the emitter-base voltage V_{BE} of the shunt transistor **18**. As a general rule, V_{BE} is relatively small, as for example, 0.2 to 0.5 volts compared to V_s which is usually in excess of 25 volts. The series means **14** provides a constant voltage V_s at its output no matter how the input E_{in} varies since it includes a feedback loop as will be explained hereinafter. In the event of a short circuit across the load, the series resistor **12** will limit the current drawn from the DC supply **10** while only a small fractional part thereof will flow in the series means **14** and the major portion will flow through the shunt transistor **18**.

In the illustrated embodiment of FIG. 2, the series means **14** comprises an input shunt capacitor **21** for filtering and smoothing the DC input E_{in}. A resistor **22** connects input **13** to the collector **23** of series regulating transistor **24**. Resistors **25** and **26** provide the base **27** bias via the collector **28** of control amplifier transistor **29**. Zener diode **30** insures that a relatively constant voltage is supplied at the emitter **31** of transistor **24**, which also maintains a constant voltage for transistor **29**. Capacitor **32** reduces the noise present at the base **33** of transistor **29**, which is tied to the movable arm **34** of potentiometer **35**, which, with arm resistors **36** and **37**, forms a voltage divider connected across the output of the emitter-base of transistor **24**. Limiting resistor **38** and zener diode **39** provide a constant reference voltage at the emitter **40** of control amplifier transistor **29**, which is relatively independent of changes in the output V_s.

The series constant voltage means operates generally as follows: The variable output voltage V_s is selected by adjusting the arm **34** of the potentiometer **35**. If, however, the voltage V_s should thereafter change, the voltage at the divider arm and so the base (33) voltage at the control amplifier transistor **29** will be altered. Since this transistor is an amplifier, this change in V_s is amplified and appears directly at the base **27** of the series regulating transistor **24**. The base voltage change effectively alters the collector-emitter resistance and thereby compensates for the change in V_s to return to the originally selected voltage.

It should be noted that this series circuit is a closed loop in that the output V_s is fed back to a series control while the shunt circuit (transistor **18**) is an open loop configuration.

Referring now to the embodiment illustrated in FIG. 3, the series voltage means **14** and the shunt transistor circuit are identical to those previously described. Bearing in mind that the regulated output E_{out} is the sum of the series voltage V_s and the base-emitter voltage V_{BE} of the shunt transistor **18**, it is clear that small changes in V_{BE} have not been entirely compensated, although they are of a small magnitude. In order to provide such compensation, a second shunt circuit **41**, which comprises a transistor **42** whose emitter **43** and collector **44** are connected across the load **11** via resistors **45** and **46** is provided. The base **47** is connected to the junction between the parallel connected combination of resistor **48** and zener diode **49**. The voltage across the load E_{out} is equal to the sum of the drop V_z across the zener diode **49** and the drop V_R across the resistor **48**. Since V_z is a reference or fixed value, than any change in E_{out} appears entirely across the resistor **48** and therefore at the base **47** of transistor **42**, which in turn changes (amplifies) the voltage at the collector **44**. This change is reflected across resistor **46** and via resistor **50** is coupled to the base **33** of control amplifier transistor **29**, which in turn is reflected to the series regulator **24** to alter V_s to compensate for changes in V_{BE} of the shunt transistor. (It should be noted that in this embodiment the shunt is a closed loop in that a voltage change therein is fed back to control V_s in the series means **14**.)

Considering for the moment the reference or fixed voltage at zener diode **39**, it is clear that this diode has passing therethrough the emitter-collector current of transistor **29**, which is functionally an amplifier. Thus, as the base voltage (or V_s) changes, this change is amplified and appears in the emitter-collector current which passes through reference

diode 39. Although under ordinary conditions a zener diode will maintain a constant voltage, if the current therethrough changes (depending on operating region) the voltage will be slightly altered, since this voltage as well as the change is in the emitter-base circuit it amplified. It has been found that for a certain specific zener diode, a current difference from 1 to 2 milliamperes results in a voltage change from 10.00 to 10.05 volts. In order to overcome this inherent limitation, an additional transistor 51 is inserted in series with emitter resistor 52 across the divider circuit. The voltage across resistor 52 is coupled as the fixed reference voltage to the emitter 40 of control transistor 29. The junction between resistor 53 and zener diode 54 is tied to the base 55 of transistor 51. These two elements are also in parallel with the divider so that the change in current through the zener is relatively small and the reference potential is at the emitter 56 (across resistor 52).

Typical operating differences in regulation between the circuits of FIGS. 2, 3 and 4 are as follows:

Input	Output E_{out}		
	FIG. 2	FIG. 3	FIG. 4
±10% change in E_{in}	25±0.5v.	25±0.06v	25±0.005v.
0 load current to max	25±0.5v.	25±0.01v	25±0.0005v.

All of these circuits can be short circuited at the output without any damage to the components and by proper selection of the specific transistors and diodes temperature compensation can be readily incorporated.

I claim:

1. A transistor regulated DC power supply which comprises:
a source of electrical energy,
a current limiting resistor,
a pair of output terminals,
a series loop circuit having therein said source, said resistor and said output terminals,
a shunt transistor having its emitter electrically connected intermediate said resistor and one of said pair of terminals and its collector connected to the other of said pair of terminals,
an input capacitor connected across said emitter and collector of said shunt transistor,
electrical means connecting the output of said voltage means to the base of said shunt transistor,
a series-regulating transistor having an emitter, collector and a base element,
a voltage divider means having an adjustable output arm intermediate the ends thereof,
a control amplifier transistor having an emitter, collector, and a base element,
a second series loop circuit including therein said source, said emitter, said collector of said regulating transistor and said voltage divider means,
first electrical means connecting said adjustable arm to said base of said control transistor,
a series combination of a first resistor and a zener diode connected intermediate said emitter of said regulating transistor and said collector of said control amplifier transistor,
a second electrical means connecting said emitter of said control transistor and the junction of said zener diode and said first resistor, and
third electrical means connecting said emitter of said regulating transistor to said base of said shunt transistor.

2. The regulated supply accordingly to claim 1, further including:
a secondary shunt transistor having an emitter, collector and a base element,
an emitter resistor,
a collector resistor,
a series network including said emitter resistor said secondary shunt transistor emitter and collector, and said collector resistor connected across said pair of output terminals,
a second series combination of a second resistor and a second zener diode connected intermediate said pair of output terminals and having said base of said secondary shunt transistor connected to the junction of said second resistor and zener diode, and
a coupling resistor connected intermediate said collector of said secondary shunt transistor and said base of said control transistor,
a second electrical means connecting said emitter of said control transistor and the junction of said zener diode and said first resistor and
third electrical means connecting said emitter of said regulating transistor to said base of said shunt transistor.

3. A transistor regulated DC power supply which comprises:
a source of electrical energy,
a current limiting resistor,
a pair of output terminals,
a series loop circuit having therein said source, said resistor and said output terminals,
a shunt transistor having its emitter electrically connected intermediate said resistor and one of said pair of terminals and its collector connected to the other of said pair of terminals,
electrical means connecting the output of said voltage means to the base of said shunt transistor,
an input capacitor connected across said emitter and collector of said shunt transistor,
a series-regulating transistor having an emitter, collector and a base element,
a voltage divider means having an adjustable output arm intermediate the ends thereof,
a control amplifier transistor having an emitter, collector and a base element,
a second series loop including therein said source, said emitter, said collector of said regulating transistor, and said voltage divider means,
first electrical means connecting said adjustable arm to said base of said control transistor, and connecting said collector thereof to said base of said regulating transistor,
a reference transistor having an emitter, collector and a base element,
an emitter resistor,
a base resistor,
a reference zener diode,
second electrical means connecting in parallel across said divider means two circuits, one of said circuits including in series said collector, emitter and said emitter resistor of said reference transistor, the other of said circuits including in series said base resistor and said zener,
third electrical means connecting the junction of said reference zener and said base resistor to said base of said reference transistor,
fourth electrical means connecting said emitters of said control and reference transistors, and
fifth electrical means connecting said emitter of said regulating transistor to said base of said shunt transistor.

4. The regulated supply according to claim 3, further including:
a secondary shunt transistor having an emitter, collector and a base element,
a emitter resistor,
a collector resistor,
a series network including said emitter resistor, said secondary shunt transistor emitter and collector, and said collector resistor connected across said pair of output terminals,
a second series combination of a second resistor and a second zener diode connected intermediate said pair of output terminals and having said base of said secondary shunt transistor connected to the junction of said second resistor and zener diode, and
a coupling resistor connected intermediate said collector of said secondary shunt transistor and said base of said control transistor.