June 7, 1966 F. VOLLNHALS 3,255,402

CURRENT CONTROL CIRCUITS

Filed Sept. 22, 1960

Fig.1

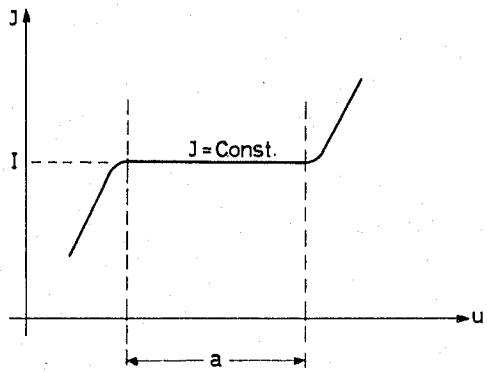


Fig.2

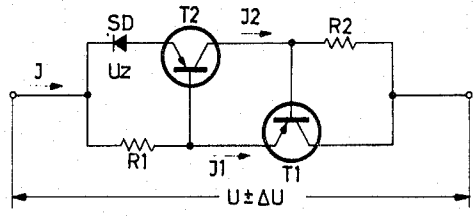
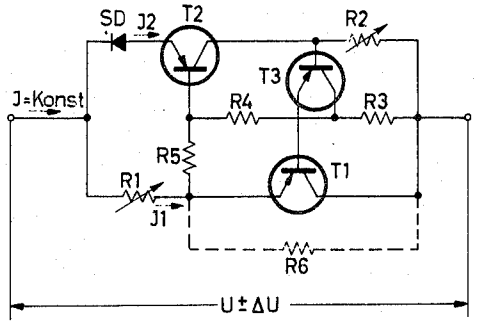


Fig.3



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CURRENT CONTROL CIRCUITS

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6 Claims. (Cl. 323—22)

This invention relates to current control circuits and is particularly concerned with an electronic two-terminal circuit arrangement having at least two transistors and a Zener diode for maintaining in a current branch constant current flow.

The arrangement according to the invention comprises a circuit extending between two terminals forming part of a current branch, said circuit comprising two arms extending in parallel, one arm containing in series relationship of a Zener diode, the emitter-collector path of a transistor and a resistor, and the other arm containing in series relationship a further resistor and the emitter-collector path of a further transistor, the base of the transistor contained in each arm being connected, either directly or over the emitter-base path of an auxiliary transistor, with the resistor in the respective other arm at the end thereof which faces the transistor in the respective other arm.

The advantage resulting from the above indicated arrangement resides in that the main current will flow over the arm which merely contains a resistor and a transistor while a considerably lower current, for example, <10 percent, will flow over the arm containing the Zener diode, thus protecting the diode and the transistor included in the corresponding arm against overload even in the presence of high total current flow obtaining in the associated current branch.

In accordance with another feature of the invention, at least the resistor included in the arm containing only the resistor and transistor, is variable. The magnitude of the current flow which is maintained constant can thus be controlled within wide limits.

The various objects and features of the invention will now be explained with reference to the accompanying drawing, in which

FIG. 1 is a diagram showing an ideal characteristic constant current curve; and

FIGS. 2 and 3 illustrate two embodiments of the invention.

Referring now to FIG. 1, letter *a* indicates the regulation range in which the current J is constant. The characteristic curve of a thermistor usually deviates more or less from the indicated ideal course. The current J does not remain constant in the regulation range but varies by an amount ΔI, increasing as a rule with increasing voltage U. The deviation $\Delta I/I$ is a criterion for the constancy of the current.

FIG. 2 shows the principal circuit of the electronic constant current device according to the invention. The arrangement constitutes a selfcontained regulation circuit in which the input current J remains constant within a given voltage range ΔU. The operation is as follows:

A current J1 flows through the resistor R1 and over the transistor T1. The voltage drop at R1, which is adjustable, shall be assumed to be such that the silicon diode SD just reaches its Zener voltage. The transistor T2 is thereby made somewhat conductive, and a slight current J2 ($J2 = << J1$) will flow through the resistor R2, the base of the transistor T1 thus receiving the required potential, which is adjustable by R2, to effect the current flow J1. In the event that J1 changes, for example, increases due to voltage increase in the current branch which is being controlled, the transistor T2 will be opened further and the collector voltage of T2, which also represents the emitter-base voltage for T1, will drop. Accordingly, the collector current of T1, which is equal to J1, will likewise drop and the total current $J = J1 + J2$ will remain substantially constant.

The current constancy may be further improved by reducing the reciprocal action of T1 with respect to T2 and providing a return connection to the compensation of J2. FIG. 3 shows a corresponding circuit arrangement.

Referring now to FIG. 3, there is provided a transistor T3 for decoupling T2 to a far reaching extent from T1. The return connection is formed by resistors R3, R4 and R5. It is possible to obtain with this arrangement a current constancy over the entire regulation range, amounting to J better than 0.5 percent. The adjustment of the current J is effected by the resistor R1 and the adjustment of the regulation range is effected by the resistor R2. The maximum current J_{max} is given by the permissible loss action of the transistor T1. The loss action may be kept small with respect to the transistor T1, by parallel connection of a suitably dimensioned resistor R6, shown in FIG. 3 in dash lines, without affecting the regulation operation and the current constancy of the arrangement. The maximum regulation range is limited by the permissible collector voltage of the transistors less the Zener voltage of the silicon diode. The circuit arrangement is with appropriate Zener voltage to a far reaching extent temperature independent.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

I claim:

1. An electronic two-terminal circuit arrangement having an input terminal and an output terminal, connected in a current-traversed branch for maintaining the current in such branch constant, comprising a first resistor and a first transistor having an emitter, a base, and a collector, means connecting said first resistor in a first series circuit with the emitter-collector path of said first transistor operatively extending between said input terminal and said output terminal, a Zener diode, a second transistor of the same type as said first transistor, said second transistor having an emitter, a base, and a collector, a second resistor, means connecting said Zener diode, the emitter-collector path of said second transistor and said second resistor in a second series circuit operatively extending between said input terminal and said output terminal, and with said first series circuit forming parallel current paths in said current-traversed branch, means connecting the base of said first transistor with the collector of said second transistor, and means connecting the base of said second transistor with the emitter of said first transistor.

2. An electronic two-terminal circuit arrangement according to claim 1, wherein the first and the second resistors are adjustable.

3. An electronic two-terminal circuit arrangement having an input terminal and an output terminal, connected in a current-traversed branch for maintaining the current in such branch constant, comprising a first resistor and a first transistor having an emitter, a base, and a collector, means connecting said first resistor in a first series circuit with the emitter-collector path of said first transistor operatively disposed between said input terminal and said output terminal, a Zener diode, a second transistor of the same type as said first transistor, said second transistor having an emitter, a base and a collector, and a second resistor, means connecting said Zener diode, the emitter-collector path of said second transistor and said second resistor in a second series circuit and with said first series circuit forming parallel current paths in said current-traversed

branch, operatively extending between said input terminal and said output terminal, a third transistor of the same type as said first and second transistors, said third transistor having an emitter, a base and a collector, a third resistor, a fourth resistor and a fifth resistor, means connecting the base of said second transistor across said fifth resistor with the emitter of said first transistor, means connecting the base of said third transistor with the collector of said second transistor, means connecting the emitter of said third transistor with the base of said first transistor, and means connecting the collector of said third transistor across the fourth resistors with the base of the second transistor and across said third resistor with said output terminal.

4. An electronic two-terminal circuit arrangement according to claim 3, wherein the first and the second resistors are adjustable.

5. An electronic two-terminal circuit arrangement having an input terminal and an output terminal, connected in a current-traversed branch for maintaining the current in such branch constant, comprising a first resistor and a first transistor having an emitter, a base, and a collector, means connecting said first resistor in a first series circuit with the emitter-collector path of said first transistor operatively extending between said input terminal and said output terminal, a Zener diode, a second transistor of the same type as said first transistor, said second transistor having an emitter, a base and a collector, and a second resistor, means connecting said Zener diode, the emitter-collector path of said second transistor and said second resistor in a second series circuit operatively extending between said input terminal and said output terminal, and with said first series circuit forming parallel current paths in said current-traversed branch, a third transistor of the same type as said first and second transistor, said third

transistor having an emitter, a base and a collector, a third resistor, a fourth resistor and a fifth resistor, means connecting the base of said second transistor across said fifth resistor with the emitter of said first transistor, means connecting the base of said third transistor with the collector of said second transistor, means connecting the emitter of said third transistor with the base of said first transistor, and means connecting the collector of said third transistor across the fourth resistor with the base of the second transistor and across said third resistor with said output terminal, a sixth resistor and means connecting said sixth resistor between the emitter and the collector of said first transistor.

6. An electronic two-terminal circuit arrangement according to claim 5, wherein the first and the second resistors are adjustable.

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