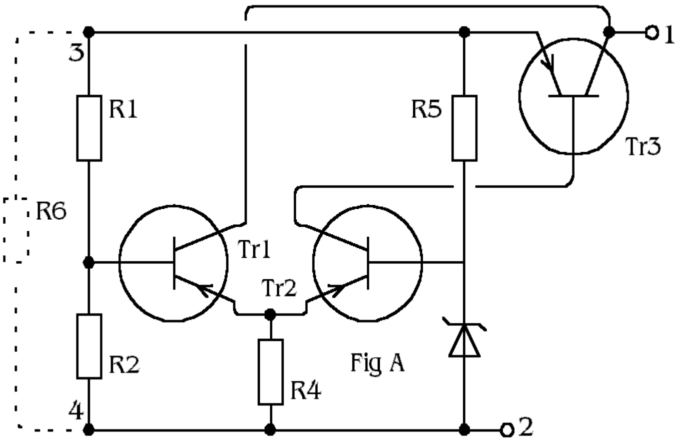
Constant-Current Circuits

I HAVE been very fascinated by the constant-current circuits described by G. Watson in his article in the August issue, and by P. Williams in a letter published in the September issue.

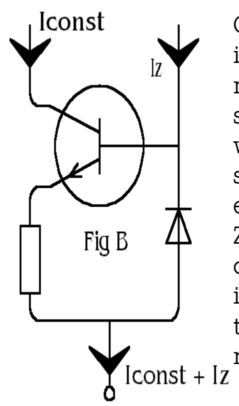
The common feature of these circuits is that they are true two-terminal circuits, powered, so-to-speak, by their own constant current. They require no separate d.c. supply lines, and could, indeed, be made, using micro-miniature techniques, as very small sealed components with only two leads.

Whilst Mr. Watson's circuit looks novel and unfamiliar drawn his way, it is interesting to find that his Fig. 1 circuit can alternatively be drawn as in my Fig. A. This shows that the circuit is really a known form of stabilized power supply circuit [1] [2] except for, the rather trivial difference that Tr1 collector, in a power supply, would normally be taken to Tr3 collector. When the voltage between terminals 1 and 2 is varied, the stabilizer circuit holds the voltage across points 3 and 4 nearly constant, so that the current taken by R1, R5-, and extra load R6 if added, is also nearly constant, thus requiring an almost constant current to be supplied to terminal 1.



The resistor R in Mr. Watson's Fig. 2 applies positive feedback to the " error amplifier," which is a known means of improving the performance of a stabilized power supply circuit.

The Fig. 1 circuit in Mr. Williams's letter is most elegant-I feel this must be the simplest and most straightforward solution to the problem. It seems to me rather misleading, however, to regard it as an application of positive feedback; there would seem to be significant positive feedback only during the short time between switching on the supply and the Zener diodes catching.

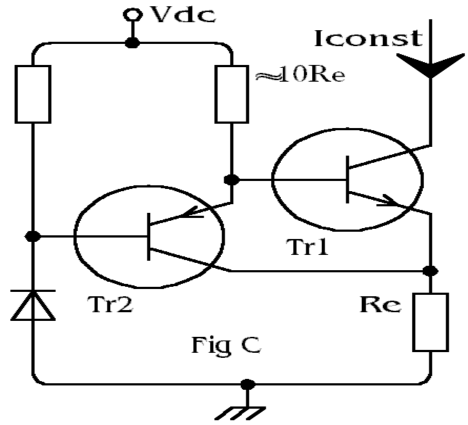


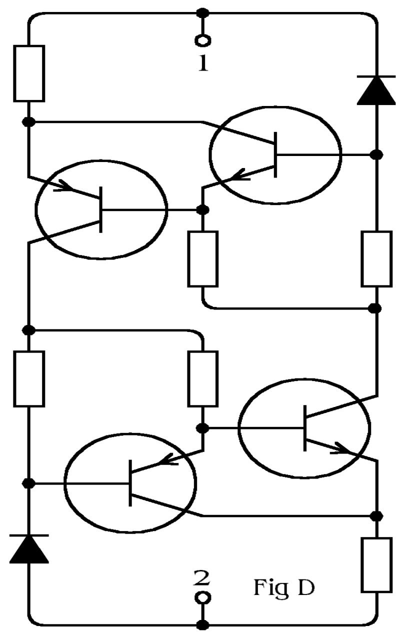
Once the Zener diodes are conducting, it seems to me that the circuit is best regarded simply as a combination of the simple constant-current circuit of Fig. B with a complementary version of the same circuit, the constant current of each circuit being used to energize the Zener diode of the other. The total constant current of the complete circuit is the sum of the constant currents of the individual circuits, which need not necessarily be equal.

Whilst the circuit of Fig. B is quite a good constant-current circuit, it is not perfect because of the effects of collector voltage variation on the ratio of division of emitter current between base and collector, and on the emitter-base voltage. Also, temperature variations affect the current because of their influence on current gain, emitter-base voltage and collector-base leakage current.

A circuit which is almost free from most of these defects is described in detail by E. W. Shallow and myself in a recent issue of the *I.E.E. Electronics Letters*[3], and essentials are shown here in Fig. C.

A differential output resistance of about 50 MΩ is typical when operating at 1 mA. The effect of collector-base -capacitance in Tr1, which shunts the output in the Fig. B circuit, is degenerated in the Fig. C circuit, and output capacitance values of well under 1 pF are obtained.





Two circuits of the Fig. C type could be connected together as shown in Fig. D to produce a two-terminal constant-current circuit. Whilst this would give a higher degree of current constancy than Mr. Williams's attractively simple circuit, it has the shortcoming that it would not work with such a low voltage between terminals 1 & 2.

PETER J. BAXANDALL
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(1) P. J. Baxandall, " Transistor Crystal Oscillators and the Design of a 1-Mc/s Oscillator Capable of Good Frequency Stability," *Radio and Electronic Engineer*, Vol. 29, No. 4, April 1965.,

(2) F. J. U. Ritson and R. C. Foss, "Transistor Power Supplies with Limited Overload Current," *Electronic Engineering*, Vol. 34, No. 414, August 1962.

(3) P.]. Baxandall and E. W. Shallow, " Constant-Current Source-with unusually High Internal Resistance and Good Temperature Stability," *I.E.E. Electronics Letters*, Vol. 2, No. 9, p. 351, Sept. 1966.