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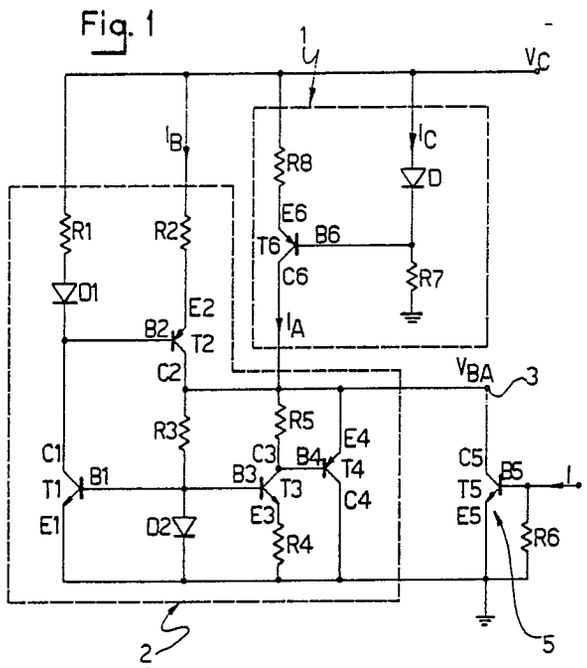
(54) A reduced turn-off current draw starter circuit for a stabilized band-gap voltage source in integrated circuits.

(57) A starter circuit (1) for a stabilized band-gap voltage source (2), being of a type adapted to maintain a minimum electric potential value (Vba) on an output terminal (3) of said source (2) by pulling voltage from a supply pole (Vc), comprises a current mirror connected between the supply pole (Vc) and the output terminal (3) to supply that terminal with a predetermined current value (Ia). The circuit affords a greatly reduced current draw on turning off the voltage source.

Fig. 1



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This invention relates to a starter circuit for a stabilized band-gap voltage source, being of a type adapted to maintain a minimum electric potential value on an output terminal of said voltage source by a voltage pull from a supply pole.

As is known, latest generation, integrated electronic circuits are also employed in low-voltage battery powered apparatus.

Accordingly, such circuits are required to operate within a broad range of supply voltages, typically between four and twenty volts, at a low current consumption rate which is near-constant or at least unrelated to the supply voltage as far as possible.

Furthermore, the integrated circuit operating voltage, as pulled from a given supply voltage, should be stable throughout a predetermined temperature range, and a means of cutting off the supply should be arranged to operate in an emergency situation, such as in the event of a high current demand from the electric load being driven by the integrated circuit or on the occurrence of an excessively high temperature which may be harmful for the circuit.

For clarity of illustration, it may be useful to regard an integrated circuit as comprised of a first circuit portion arranged to perform certain selected functions, and hence to output electric values which are dependent function-wise on the input values, and a second circuit portion arranged to supply the aforesaid stabilized voltage to the first portion.

As an implementation of the second circuit portion, the prior art has proposed that a so-called band-gap voltage source circuit be used. This band-gap circuit outputs a voltage value Vba which is unrelated to temperature if that voltage is made the equal of the band-gap potential of silicon, which is approximately 1.2 Volts.

While being in many ways advantageous and on the whole up to expectations, the band-gap circuit is deficient in that, when turned on, it may settle in either of two possible steady states of operation. The first of such states corresponds to a normal operating situation, whereas the second state corresponds to a situation whereby all of the circuit transistors are are cut off and the stable voltage Vba is held at a zero value. To obviate this problem, the band-gap is provided with a so-called starter circuit, effective to initially maintain a minimum potential of about 0.7 Volt on the output terminal for the stable voltage Vba. On turning on, however, such an initial condition is an unstable one of the band-gap circuit, which circuit will then drift toward the first of the two steady states, i.e. the correct operating state, and become disconnected on said state being reached. The circuit is also provided with a transistor having its collector connected to the output terminal for the voltage Vba and its base supplied with a driving current I which, under normal operating conditions -- i.e. with Vba equal approximately to 1.2 Volts --is null and holds that transistor off. On the contrary, where the band-gap circuit is to be switched to an off state, due to operation of the protection means, the driving current I attains a suitable value to bring said transistor to saturation, thus nearly nullifying the stabilized voltage Vba. In such a situation, however, the starter circuit is again connected in, and the driving current I should be enabled to attain values which may be quite high and depend on the supply, in order to ensure that the transistor is saturated, which transistor should be suitably dimensioned, moreover.

The technical problem that underlies this invention is to provide a starter circuit for a band-gap voltage source, to be incorporated to an integrated circuit and exhibiting such structural and performance characteristics as to afford a low current draw on turning off and make it possible, as a result, to use an inexpensive cut-off means which requires but a low driving current.

This problem is solved by a circuit as indicated being characterized in that it comprises a current mirror connected between said pole and said terminal to supply said terminal with a predetermined current value.

In a preferred embodiment, that current mirror comprises a transistor having its emitter connected to said pole via a resistor and its collector connected to said terminal, the base of said transistor being connected to said pole via a diode and to ground via a resistor.

The features and advantages of the starter circuit according to the invention will be more clearly apparent from the following detailed description of an exemplary embodiment thereof, to be taken by way of illustration and not of limitation in conjunction with the accompanying drawings.

In the drawings:

Figure 1 shows, in diagram form, a starter circuit according to the invention;

Figure 2 is a block diagram of an integrated circuit incorporating the circuit of Figure 1;

Figure 3 shows, in diagram form, the circuit of Figure 1 under a different operating condition thereof; and

Figure 4 is a wiring diagram of a modified embodiment of the inventive circuit.

With reference to the drawing views, generally and schematically indicated at 1 is a strater circuit according to the invention.

The circuit 1 is incorporated to an integrated circuit 10 and is associated with, and connected to, a voltage source circuit 2 of the so-called band-gap type for outputting a stabilized voltage value Vba to

be supplied to the remaining portion 4 of the integrated circuit 10.

Merely for completeness of illustration, note should be taken of that the voltage source circuit 2 pulls a voltage from a supply pole Vc via a transistor T1 of the npn type which has its emitter E1 grounded and its collector C1 connected to that pole Vc via a serial arrangement including a diode D1 and a resistor R1.

Also connected to the pole Vc, with the interposition of a resistor R2, is the emitter E2 of a pnp-type transistor T2 which has its base B2 connected to the collector C1 of the first-mentioned transistor T1.

The voltage source has an output terminal 3 whereat the stabilized voltage value Vba appears. Connected to said terminal 3 is the collector C2 of the second-mentioned transistor T2, being also connected to the base B1 of the transistor T1 via a resistor R3. In operation, a current Ib will flow through the collector C2 to the terminal 3.

The base B1 is connected to ground through a diode D2, as well as connected to the base B3 of an npn-type transistor T3 which has the emitter E3 grounded via a resistor R4. The collector C3 of the transistor T3 is connected to the output terminal 3 through a resistor R5, and to the base B4 of an pnp-type transistor T4 which has its collector C4 connected to ground and emitter E4 connected to the terminal 3.

Provided between the voltage source 2 and the portion 4 of the integrated circuit 10 to be powered is an electronic protection switch consisting of an npn-type transistor T5 which has the emitter E5 grounded and the collector C5 connected to the output terminal 3. A resistor R6, moreover, interconnects the base B5 of said transistor with ground. The base B5 is further connected to an output from the portion 4 of the circuit 10 which is adapted to supply that base B5 with a driving current I to drive the switch 5 to make.

The starter circuit 1, associated with the voltage source 2, advantageously includes a transistor T6 of the pnp type which has the emitter E6 connected to the supply pole Vc through a resistor R8. The collector C6 of that transistor T6 is connected to the terminal 3, while the base B6 of that transistor is both connected to ground, via a resistor R7, and to the pole Vc via a diode D which biased forwardly toward that pole. In operation, a current Ic flows through the diode D.

The diode D and transistor T6 form essentially a current mirror circuit having the output connected to the terminal 3 for supplying the latter with a current Ia output by the collector C6.

With specific reference to the example shown in Figure 4, the structure of a modified embodiment of the circuit 1 is shown therein which is a duplicate of the one previously described. In this variation, a transistor T7 of the npn type has the emitter E7 connected to ground via a resistor R9 and the collector C7 connected to the collector C1 of the transistor T1 of the circuit 2.

The base B7 of the transistor T7 is both connected to the supply pole Vc, via a resistor R10, and to ground via a diode D3.

The function of the voltage source circuit 2 is, as mentioned, that of producing a stabilized voltage Vba, at about 1.2 Volts, on the terminal 3 by pulling power from the supply pole Vc, which is likely to undergo variations in absolute value even of substantial magnitude.

On the integrated circuit 10 being turned on, the inventive circuit 1 will supply a current Ia to the terminal 3 which adds to the current Ib from the voltage source 2 through the collector C2 of the transistor T2.

The current Ia from the circuit 1 can be made much smaller than the current Ib from the circuit 2, as well as little affected by variations in the supply value Vc, by suitably increasing the value of the resistor R8.

More specifically, it may be shown that a variation in the current Ia resulting from a variation in the current Ic with the supply obeys the relation

$\Delta Ia/Ia = Vt/(R8*Ia + Vt)*\Delta Ic/Ic$

where Vt = 26 mV.

The value of this invention is best appreciated when the switch 5 comprising the transistor T5 is closed. In this situation, the voltage Vba on the terminal 3 will be substantially null, and Figure 3 shows diagramatically the equivalent circuit relative to such a situation.

The collector current which flows through the transistor T5 is the current output by the circuit 1, which current can be made as low as a few microamperes for any variation in the supply? Accordingly, the transistor T5 can be held in a saturated state for a very low draw of driving current I from the portion 4 of the integrated circuit 10.

To summarize, the starter circuit of this invention has a major advantage in that it affords a low current draw on turning off the stabilized voltage source circuit.

An additional advantage comes from that said circuit is less demanding in terms of the off transistor, and has a simple construction with a limited number of components.

Claims

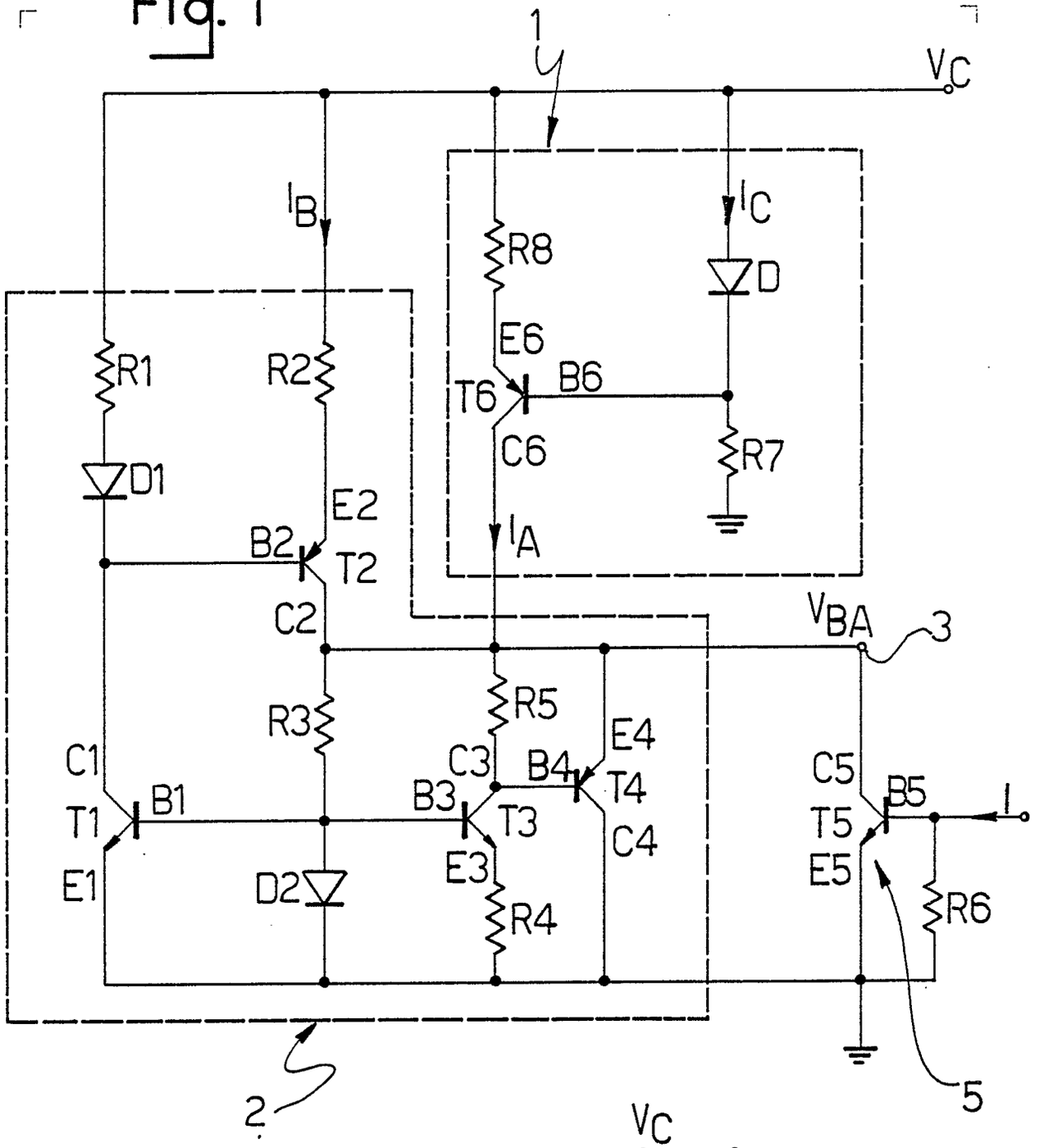
1. A starter circuit (1) for a stabilized band-gap voltage source (2), being of a type adapted to maintain a minimum electric potential value on an output terminal (3) of said voltage source by a

voltage pull from a supply pole (Vc), characterized in that it comprises a current mirror connected between said pole and said terminal to supply said terminal (3) with a predetermined current value (Ia).

2. A circuit according to Claim 1, characterized in that said current mirror comprises a transistor (T6) having the emitter (E6) connected to said pole (Vc) via a resistor (R8) and the collector (C6) connected to said terminal (3), the base (B6) of said transistor (T6) being connected to said pole (Vc) via a diode (D) and to ground via a resistor (R7).

3. A circuit according to Claim 1, characterized in that it comprises a transistor (T7) having the base (B7) and emitter (E7) connected to ground via a diode (D3) and a resistor (R9), respectively, the base (B7) being also connected to said pole (Vc) via a resistor (R10), and the collector (C7) of said transistor (T7) being connected to the base (B2) of a transistor (T2) incorporated to said source (2) and having the collector (C2) connected to said terminal (3) to supply the latter with a predetermined current.

Fig. 1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D
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T6
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C6
R7
IA
R1
R2
D1
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B2
T2
C2
VBA
3
R3
R5
E4
C1
C3
B4
T4
C5
B5
I
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D2
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R6
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Fig. 2

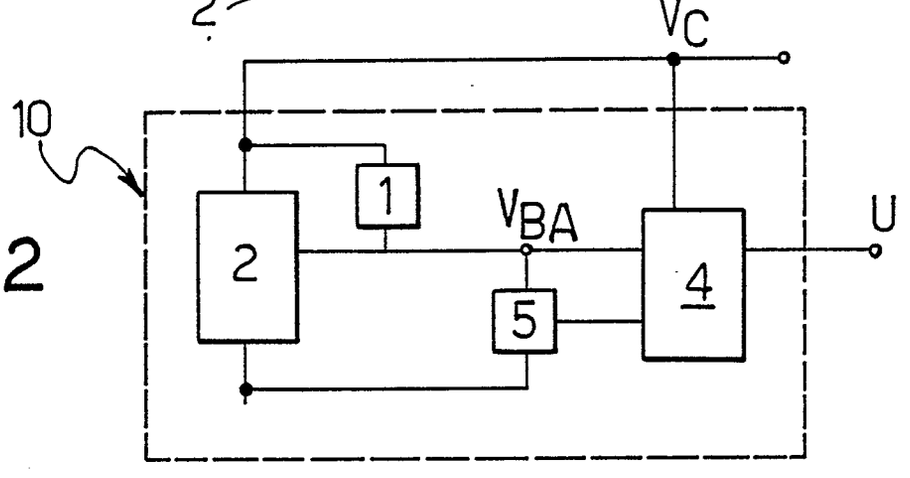
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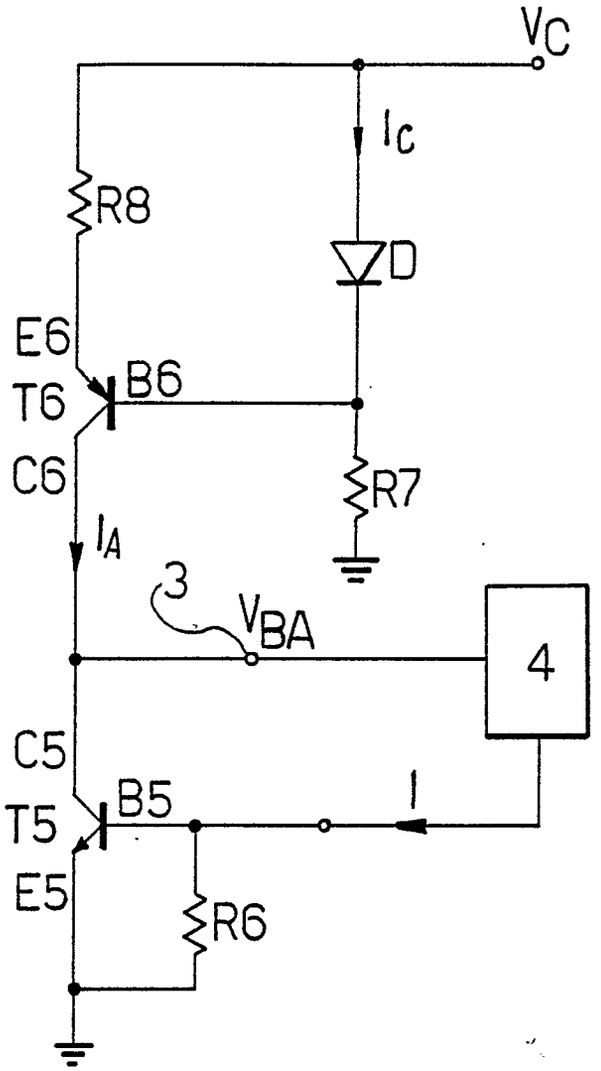
Fig. 3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Ic
R8
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E6
T6
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C6
R7
IA
3
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4
C5
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E5
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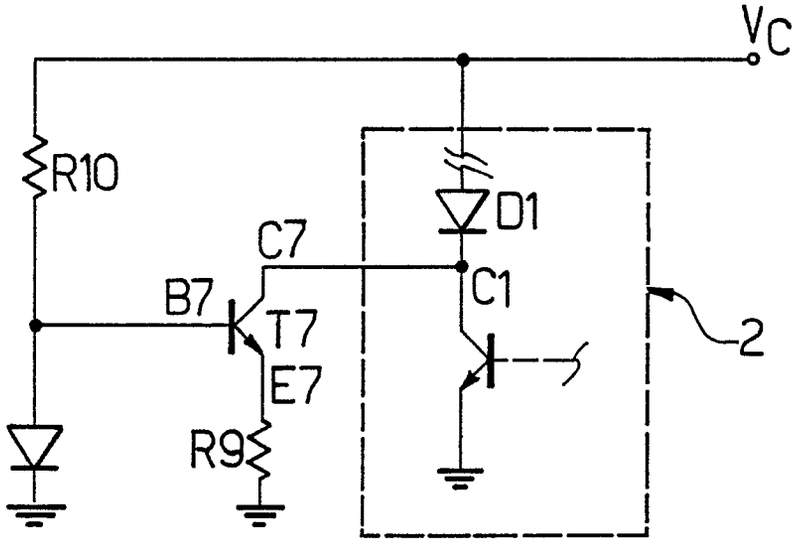
Fig. 4


Vc
R10
D1
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EUROPEAN SEARCH REPORT

Application Number

EP 89 11 1842

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 9, no. 227 (P-388)(1950) 13 September 1985, & JP-A-60 84616 (HITACHI SEISAKUSHO K.K) 14 May 1985, * the whole document * ---	1, 2	G05F3/30
X	US-A-4085359 (AHMED) * column 3, lines 3 - 47; figure 1 * ---	1, 2	
A	EP-A-0121287 (N.V. PHILIPS GLOEILLAMPENFABRIEKEN) * page 8, line 9 - page 9, line 7; figures 2, 3 * ---	1-3	
A	US-A-4348633 (DAVIS) * column 3, line 38 - column 4, line 23; figure 1 * ---	1-3	
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 198 (P-147)(1076) 07 October 1982, & JP-A-57 106915 (FUJITSU K.K) 3 July 1982, * the whole document * -----		TECHNICAL FIELDS SEARCHED (Int. Cl.5) G05F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	31 OCTOBER 1989	CLEARY F.M.

CATEGORY OF CITED DOCUMENTS

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