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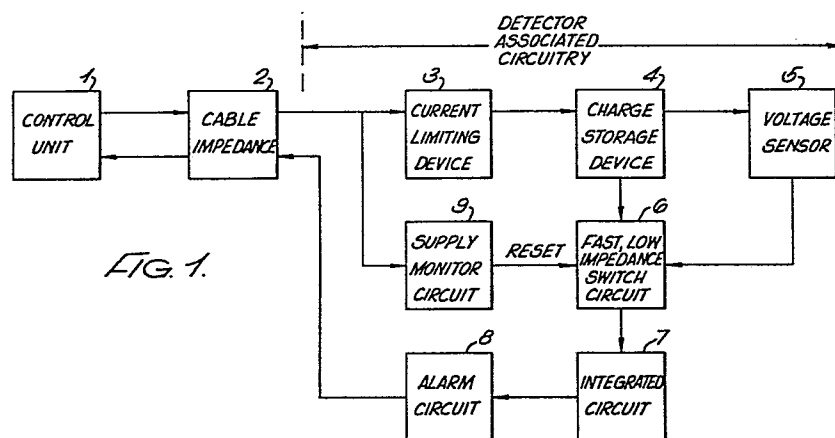
(54) **Circuitry including charge storage means for boosting a limited current supplied to a load.**

(57) The invention is applicable, for example, to fire or smoke detection circuitry where an integrated circuit (7) is separated by an appreciable cable impedance (2) from a remote current source (1). The source (1) provides a limited current which is normally sufficient to operate the integrated circuit (7), except when logic transitions occur requiring more than the amount of current available.

Charge storage means (4), such as a capacitor, is charged from the source and discharges into the integrated circuit (7) to provide the additional current during logic transactions. Switching means (6) responsive to the charge storage means (4) is connected to the integrated circuit (7). In the event of disconnecting and reconnecting the current source (1), the switching means (6) isolates the charge storage means (4) from the integrated circuit (7) until sufficient charge has been stored. Specific embodiments respectively employ a programmable unijunction transistor (PUJ 1) and a Schmitt trigger circuit (D5, D6; R7-R12; TR2-TR4; and C3).

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CIRCUITRY INCLUDING CHARGE STORAGE MEANS FOR BOOSTING A
LIMITED CURRENT SUPPLIED TO A LOAD

5 The invention relates to circuitry including charge storage means for boosting a limited current supplied to a load and more particularly, though not exclusively to electrical circuit arrangements forming part of a fire or smoke detector.

10 It is desirable from both economic and technical considerations that fire or smoke detectors designed to be powered and monitored by a remotely located control unit should have a low standby current requirement. This
15 requirement stems from an economic need to minimise power consumption, and from the commonly practiced technique of differentiating between standby and alarm states by arranging for the current taken by the detector to increase significantly when a fire is sensed. As there
20 may be many detectors connected to the same circuit it is usual and desirable for this current change to be in the order of $1:10^3$, i.e. from micro-amps to milli-amps. Higher currents are normally not practicable because of limitations imposed by cable resistance, supply
25 voltage restrictions, and the resistance of the control unit monitoring circuit.

Some detector types such as those which detect smoke by optical or ionising radiation means have incorporated in them significant electronic circuitry which can with
30 advantage be implemented, in total or in part, by low current technology integrated circuits such as CMOS. A feature of some types of these integrated circuits is that in the quiescent state they drain very little current, a few micro-amps or less. However, when the
35 circuit is 'active' it may drain many milli-amps, albeit for periods of only a few microseconds and less. This current drain can occur for instance during switching transitions between logical 1 and logical 0 states, when for an instant, at the point of transition between

the states, both source and drain conducting paths are simultaneously conductive and in series across the supply to the integrated circuit.

5 The current required during a switching transition is normally supplied either directly from the power supply, or by a local capacitor in circumstances where a significant impedance exists between the supply and the integrated circuit. When a capacitor is used, the charge
10 drawn from it during the switching transition is replenished by the control unit during the period between transitions. The capacitor essentially acts as a local power supply able to supply pulses of current and at the same time maintain a working voltage level across
15 the integrated circuit.

The capacitor technique described above usually proves satisfactory once the capacitor has been charged to the working voltage of the integrated circuit, but in certain
20 circumstances problems can arise when the circuit is first 'powered up'. Some integrated circuits, particularly those embodying an oscillator circuit or other astable circuit, can start to execute a switching transition before a working voltage level has been established. If
25 the impedance between the integrated circuit and the power supply prevents the integrated circuit from receiving sufficient current to meet the switching current demand, the transition may not be completed despite the presence of a capacitor. The integrated circuit settles
30 into a 'hung-up' state, conducting but inoperative.

The basic capacitor technique also has the disadvantage that the initial current required to charge capacitors can also be falsely sensed by the control unit as a fire
35 alarm signal. The introduction of resistive elements to reduce the switch-on current to below the alarm threshold exacerbates the switch-on problem associated with switching transitions in the integrated circuit.

The present invention seeks to provide a solution to this type of problem.

The present invention broadly provides circuitry having a load which is connectable to a current source with a limited output whereby the load can normally be supplied with a limited current, said circuitry including charge
5 storage means chargeable from said source and discharge-able into said load when said load requires, for a limited period, more than said limited current, characterised by switching means responsive to the charge stored by said charge storage means, said switching means being
10 operative such that said charge storage means is disconnected from said load, in the event that said source is disconnected, to enable said charge storage means to recover at least a predetermined charge, when said source is reconnected, before said charge storage means
15 is reconnected to said load.

An advantage of the invention is more reliable circuit operation, i.e. to avoid malfunction when the current source is reconnected to the load and the load requires more than the limited current to reach an operative state.
20 Preferably, the switching means includes voltage sensing means connected to the charge storage means whereby the switching means is conditioned to enable the passage of current from the charge storage means to the load
25 when the voltage across the charge storage means exceeds a predetermined value.

The switching means may comprise a gate control rectifying device, such as a programmable unijunction resistor, or it may comprise a Schmitt trigger.
30 Means may be provided to discharge the charge storage means when the voltage thereacross falls below a predetermined value.

The circuitry is particularly applicable to a fire or
35 smoke detector wherein the limited current is due at least to cable impedance between a fire or smoke detecting head and a remote station.

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Embodiments of the invention will now be described with reference to the accompanying schematic drawings in which:

Fig.1 is a schematic block diagram of a device incorporating circuitry according to an embodiment of the invention;

Fig.2 is a circuit diagram, in greater detail, of a specific embodiment which employs a programmable unijunction transistor, and

Fig.3 is a circuit diagram of another specific embodiment of the invention which employs a Schmitt trigger.

Figure 1 shows a schematic example of the invention. A control unit 1 is connected to one or more detectors by cable impedance 2. This impedance is not critical and may vary from zero to a value limited by factors other than those giving rise to the problem outlined above. Such a factor may be the maximum impedance for reliable signalling of an alarm condition. Each detector contains or is associated with a current limiting device 3 such as a resistor or constant current semiconductor device. The device limits the charging current to a charge storage circuit 4 to a value below the alarm current signal threshold but above the average current need to operate the detector's integrated circuit 7. The voltage and hence charge available from the charge storage device is monitored by a voltage sensor 5. When a preset voltage above the minimum working voltage of the integrated circuit 7 is attained the voltage sensor triggers a fast, low impedance switch circuit 6. The impedance of the switch circuit must be low enough to supply from the charge storage device any current demanded by the integrated circuit during a 'switching transition'.

A problem can occur with the arrangement so far discussed and disclosed if the control unit is switched off and then switched on again. When the control unit is switched off the integrated circuit will for a time continue to
5 be powered by the charge in the charge storage device but both charge and voltage will gradually decay. If the voltage is allowed to fall below the minimum safe working voltage, the integrated circuit may not be able to complete a switching transition. Charge will be
10 drained from the charge storage device until the current demanded by the integrated circuit falls to a low level. After this has occurred the rate of voltage decay will be reduced to a low level. If the control unit is now reconnected the detector will not power up as previously
15 described because the fast, low impedance switch is in the wrong state and still conductive. It is therefore evident that the switch should be reset before the voltage across the integrated circuit falls to an unsafe level. This can be achieved by using a switch with voltage
20 hysteresis such as a Schmitt trigger, or by resetting the switch when the supply to the detector is disconnected. The latter method is shown schematically in figure 1. A supply monitor circuit 9 resets the fast, low impedance switch circuit 6 if the supply voltage is
25 disconnected or falls below a safe level.

Alarm signals originating from the integrated circuit 7 may be transmitted to the control unit via an alarm circuit 8 using conventional techniques. It may be nec-
30 essary to a.c. couple the integrated circuit to the alarm circuit in order to minimise current demand from the charge storage device.

An embodiment of the invention is shown diagrammatically
35 in figure 2. Power from the control unit is supplied to the detector via terminals 1 and 6. Resistor R2 and zener diode ZD1 protect the remainder of the circuitry from line born high voltage electrical transients. The

integrated circuit ID1 and resistor R7 form a bipolar constant current source which limits the rate of charging of capacitors C3 and C4. The constant current can be set by adjustment of R7. Zener diode ZD2 and resistor R8 form a voltage level sensor and voltage reulator. When the voltage on the capacitors C3 and C4 exceeds the zener voltage of ZD2 a bias voltage appears across R8 and triggers programmable unijunction transistor PUJ 1. This device has a fast switching characteristic because of internal regenerative action, and a low on state impedance. When the PUJ 1 is triggered, charge is shared between capacitors C3 and C4 and capacitors C5 and C6. The voltage appearing across C5 and C6, also appears across CMOS integrated circuit IC2. The integrated circuit IC2 is shown connected to a circuit arrangement suitable for the detection of smoke using an infra-red light emitting diode IR LED 1 and a photo-voltaic cell PVC1. IC2 periodically pulses the visible LED 1 via capacitor C9. If IC1 is not operating correctly the periodic pulses are inhibited via diode D3.

If smoke is detected SCR1 is triggered into conduction via resistor R12. When SCR 1 conducts current flows through R2 and R3 and substantially increases the current drained by the detector. This increase in current can be detected by a suitable control unit. Transistor TR1 is turned on when SCR 1 conducts and causes LED 1 to illuminate continuously via R6 and R2. An output alarm signal may also be taken from terminal 4 via diode D1 and resistor R1.

If the supply to the detector is reduced or interrupted, the gate of P-channel field effect transistor FET 1 will become negatively biased. This will switch the FET to a conducting state and discharge capacitors C3 and C4. PUJ 1 will become reversed biased and will switch to a non-conducting state. When voltage is re-applied to the detector the circuit will switch on correctly.

Capacitors C5 and C6 may also discharge via D2 and
F E T 1. This is not strictly necessary but to do so
does ensure that identical conditions are present every
time a supply is connected to the detector irrespective
5 of the length of time for which the detector has previously
been switched off.

Figure 3 shows a diagrammatic representation of an alter-
native form of circuit in which P U J 1 and F E T 1 in
10 Fig. 2 have been replaced by a Schmitt trigger circuit
formed by components D5, R7, R8, TR2, R9, TR3, R10, R11,
TR4, C3, D6, and R12.

As the operation of the Schmitt trigger circuit will
15 be familiar to those skilled in the art, only a brief
description of circuit function will be given.

When the voltage across capacitor C2 exceed the break-
down voltage of Zener diode D5, transistor TR2 is made
conductive, whereby transistor TR3 switches on via resis-
20 tor R8. Transistor TR4 then becomes conductive. When
transistor TR4 is conductive, there is a low impedance
path between capacitor C2 and integrated circuit IC1.
The network C3, R12, D6 and R10 provides positive feed-
back to transistor TR2 to give a fast switching action
25 to TR2 and in association with resistor R11, to give a
voltage hysteresis effect to the switching action of
the Schmitt trigger circuit.

Optionally, a capacitor C6 may be connected as shown
30 by the broken line in Fig.3 for further charge storage
if required.

Other components shown in Figs 2 and 3 which have not been
described in detail form part of the smoke or fire detec-
35 ting circuit as will be apparent to those skilled in the
art.

Whilst the circuitry of Figs 2 and 3 has been described
in connection with a fire or smoke detector, the invention

may be applied to other types of circuit in order to boost a limited current supply for a predetermined period, i.e. with regard to the current drain and the capacity of the charge storage capacitors.

CLAIMS

1. Circuitry having a load which is connectable to a current source with a limited output whereby the load can normally be supplied with a limited current, said circuitry including charge storage means (4) chargeable from said source and dischargeable into said load (7) when said load (7) requires, for a limited period, more than said limited current, characterised by switching means (6) responsive to the charge stored by said charge storage means (4), said switching means (6) being operative such that said charge storage means (4) is normally connected to said load (7), and such that said charge storage means (4) is disconnected from said load (7), in the event that said source is disconnected, to enable said charge storage means (4) to recover at least a predetermined charge, when said source is reconnected, before said charge storage means (4) is reconnected to said load (7).
2. Circuitry according to claim 1, characterised in that switching means (6) includes voltage sensing means (5) connected to said charge storage means (4) whereby said switching means (6) is conditioned to enable the passage of current from said charge storage means (4) to said load (7) when the voltage across said charge storage means (4) exceeds a predetermined value .
3. Circuitry according to claim 1 or 2, characterised in that said switching means (6) comprises a gate controlled rectifying device.
4. Circuitry according to claim 3, characterised in that said gate controlled rectifying device is a programmable unijunction transistor (PUJ 1).
5. Circuitry according to claim 2, characterised in that said switching means (6) is a Schmitt trigger (D5, D6; R7-R12; TR2-TR4; and C3).

6. Circuitry according to any one of the preceding claims, characterised in that means (9) are provided for monitoring the supply voltage and for discharging said charge storage means (4) when the charge on said charge storage means (4) falls below a predetermined value.

7. Circuitry according to any one of the preceding claims, characterised in that the load (7) includes an integrated circuit containing logic elements which execute transitions whereby more than said minimum operating current is demanded.

8. Circuitry according to any one of the preceding claims, characterised in that it is part of a fire or smoke detector wherein the limited current is due at least to cable impedance (2) between a detecting head (3-9) and a remote station (1).

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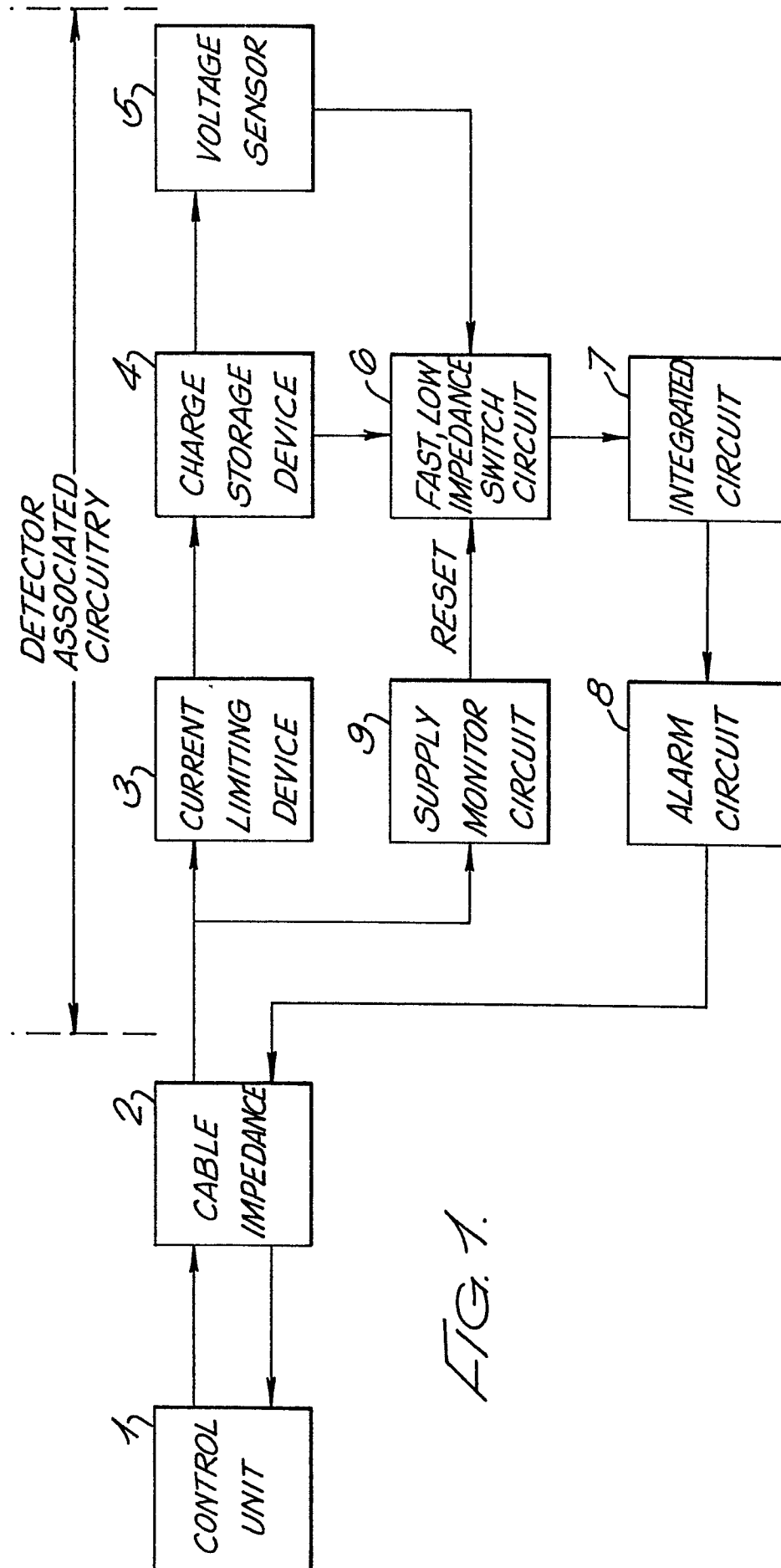
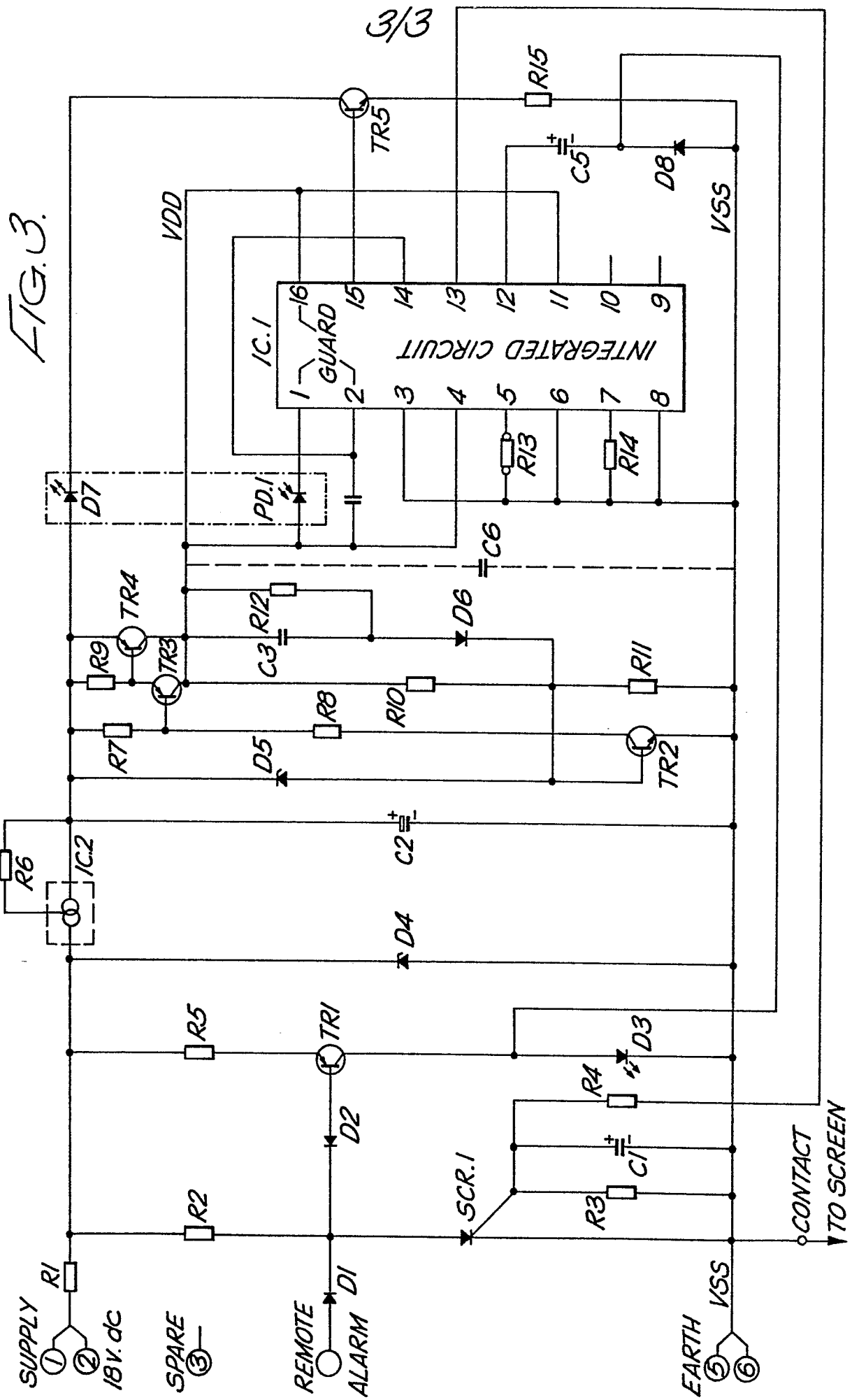


FIG. 1.





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. 3)
A	FR-A-2 364 671 (SOLOMON) *Page 3, line 10 to page 7, line 7; figures 1 to 6* & GB - A - 1 593 185 -----	1	G 08 B 17/10 G 05 F 1/62
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			G 08 B 17/00 G 05 F 1/00
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 29-07-1982	Examiner ZAEGEL B.C.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	