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(54) A gas sensing alarm device

(57) An alarm device (1) has a circuit (10) with a microcontroller (11) which activates a green LED (4) to indicate normal operation, a yellow LED (6) to indicate if there is a fault, and a red LED (5) to indicate an alert arising from carbon monoxide concentration exceeding a volt. If the user presses a test/hush button (3) the microcontroller indicates the peak concentration since a memory was last reset. Continuing to press the button causes the memory to be reset. This provides peace of mind to the user.

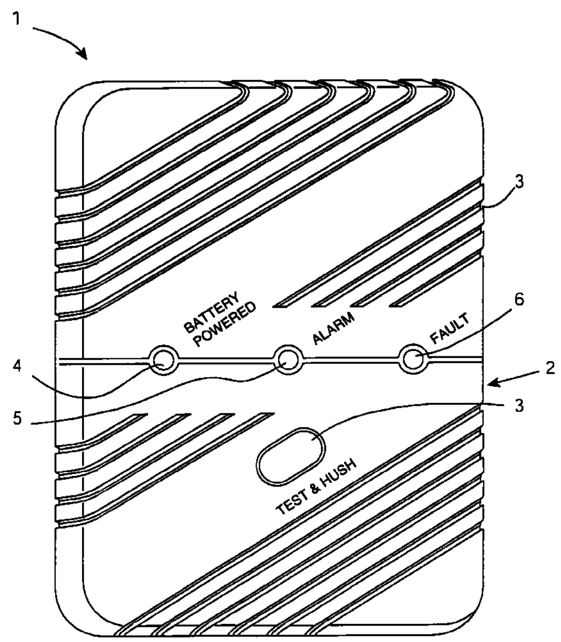

Fig. 1

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Description

[0001] The invention relates to an alarm device for generating alerts in response to presence of a toxic gas such as carbon monoxide (CO).

[0002] Much work had been carried out in development of gas sensors for use in such alarm devices. Such work is described in documents such as US5589046 and JP11083778. Many sensors are based on the principle of ramp heating a pair of metal oxide (such as SnO_2) elements and monitoring voltage response.

[0003] United States Patent Specification No. 5694118 describes an alarm device for generating alerts in response to CO presence. The device has a microprocessor, a sound buzzer, and different coloured LEDs to indicate sensing of toxic gas such as CO. This is apparently quite effective for providing alerts to users upon detection of CO, and a strobe light output is also provided. However, because and output is latched until reset, the alarm can be annoying to people who can hear it but not reset it, and the battery is likely to be rapidly depleted.

[0004] Also, the prior art alarm devices take little account of the nature of toxic gas concentration variations in domestic and light industrial environments and so it is difficult to identify the source of toxic gas and rectify it.

[0005] It is therefore an object of the invention to provide an alarm device which allows more effective control of toxic gas presence.

[0006] Another object is to provide for more versatile calibration of such alarm devices.

[0007] A still further object is to allow more effective testing of such alarm devices.

[0008] According to the invention, there is provided a gas sensing alarm device comprising a ventilated housing containing a circuit comprising a toxic gas sensor, a processor connected to the sensor, and an output device to provide an alert for a user, characterised in that,

> the processor comprises a memory, means for storing historical gas concentration data in the memory, and means for subsequently generating an alert according to the stored historical data.

[0009] In one embodiment, the processor comprises means for intermittently activating a light emitter at one of a plurality of discrete frequency levels, each associated with a gas concentration threshold.

[0010] In one embodiment, the processor memory is a register, and the processor comprises means for writing a flag to the register to indicate gas concentration.

[0011] Preferably, a flag for a previous peak concentration value since reset is over-written by a flag indicating a new peak since reset.

[0012] In another embodiment, the device further comprises a user input interface connected to the processor, and the processor comprises means for generating an alert based on historical data in response to a user input.

[0013] In one embodiment, the input interface comprises a button, and the processor comprises means for recognising depression of the button initially as an input to generate an alert based on historical data, and after a pre-set time duration of pressing the button as an input to reset the memory.

[0014] In another embodiment, the processor comprises means for also performing an automatic test in response to user depression of the button.

[0015] In a further embodiment, the processor comprises means for sampling sensor output at a higher frequency than for a normal mode when a user test instruction is detected.

[0016] In one embodiment, the test sampling rate is at least once every four seconds.

[0017] In a further embodiment, the processor comprises means for returning to the normal mode automatically after a pre-set time period had elapsed.

[0018] In one embodiment, the processor comprises a microcontroller having non-volatile memory storing calibration values in sequential location which are addressable after manufacture, and the memory includes addressable spare locations for storage of calibration values arising from re-calibration.

[0019] According to another aspect, the invention provides a method of programming an alarm device as defined above comprising the steps of writing a set of calibration values to a microcontroller memory sequence of locations, and if mis-calibrated, over-writing the used locations with a flag to cause the program to move to the next location.

[0020] In one embodiment, the used locations are over-written with a NOP flag.

[0021] According to a still further aspect, the invention provides a method of calibrating a CO sensing alarm device comprising the steps of:-

> mounting the device in a test container whereby a calibration circuit is connected to a device circuit,
>
> pumping a metered quantity of test gas into the container, and
>
> monitoring response of the device and writing calibration data to the device accordingly.

[0022] In one embodiment, the test gas comprises a mixture of CO and N_2.

[0023] Preferably, the mixture is approximately 10%CO: 90%N_2.

[0024] In another embodiment, the environment within the enclosure is controlled to 20°C +/- 2°C temperature and 50% +/- 5% relative humidity.

[0025] The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a perspective view of an alarm device of the invention; and

Fig. 2 is a circuit diagram of a control circuit of the device.

[0026] Referring to Fig. 1, there is shown an alarm device 1 of the invention. The alarm device 1 comprises a housing 2 having an upper sliding part 3 which may be slid upwardly to reveal a compartment for batteries. In an alternative embodiment, the sliding part 3 may be removed to reveal mains terminals in a mains-powered version of the alarm device.

[0027] The alarm device 1 also comprises a test/hush button 3 to allow a user to input instructions to the device 1. For output of user alerts, there is a horn (not shown in Fig. 1) behind a ventilated part of the casing, and LEDs as follows:

a green LED 4 to indicate that the device 1 is operational,

a red LED 5 to indicate a user alert, and

a yellow LED 6 to indicate a device fault.

[0028] In more detail, and referring to Fig. 2 a control circuit 10 is housed within the housing 2 and it comprises a PIC microcontroller 11 connected to the LEDs 4, 5, and 6, and to the test/hush button 3. The controller 11 is also connected to a sound emitter 12 which provides user alerts when carbon monoxide is detected. Primary batteries 13 provide rail voltage for the circuit 10. A carbon monoxide sensor 14 is used for sensing carbon monoxide. The circuit 10 also comprises a detector circuit 15 having two op-amps and eight pins 1-18.

[0029] The sensor 14 is of the type which operates on the fuel cell principle in which there is oxidation of the CO to form carbon dioxide. As the CO is oxidised, hydrogen ions and electrons are generated at the working electrode of the cell. The ions travel through the electrolyte to the counter electrode where they are consumed by reacting with oxygen from the surrounding air. The electrons are taken via the contact pins into the external circuit where they are amplified, measured and returned to the counter electrode to complete the circuit and fuel the reaction. The current generated is directly proportional to the concentration of CO at the working electrode. This current is converted by the circuit 10 to a voltage.

[0030] The current is typically 40nA per CO ppm. The electrode connected to Pin 2 of the circuit 15 goes negative. The output of the left-hand op-amp, at Pin 1, provides a positive voltage which causes a current to flow in a resistor R5. This maintains Pin 2 at a virtual 0V i.e. the same voltage as on Pin 3, the other input of the op-amp.

[0031] Two transistors Q4 and Q5 act s a current source for the rail and charge a capacitor C3. The potential of C3 appears at pin 5 of the circuit 15 and the potential of Pin 6 of the circuit 15 is set by the microcontroller 11.

[0032] To measure the gas concentration, the microcontroller sets a timing register and starts charging C3 with the current source (based on Q4 and 5). The voltage on Pin 1 of the circuit 15, which represents the gas concentration, is applied to pin 6 of the right hand side op amp through R3 and R7. When the op amp switches (it is just acting as a comparator) the microcontroller 11 senses it through its Pin 4. The time taken to charge C3 to this voltage represents the gas concentration.

[0033] The battery voltage is measured in a similar fashion (this is needed so that a low-battery beep signal can be given at the appropriate time). Pins 6 and 7 of the microcontroller 11 apply essentially the battery voltage across R6 and R7. A portion of this voltage (from potential divider R6 and R7) is applied to pin 6 of the right hand side op-amp of the detector circuit 15.

[0034] The temperature is measured by letting a thermistor TH1 charge C3 and measuring the time to charge to a known voltage. This voltage is derived from the battery voltage and so will change as the battery depletes from 4.5V to 3.0 Volts. This is allowed for by charging C3 through R17. The time taken to charge when the supply is 4.50 volts is stored in memory at the calibration stage in the factory. The microcontroller can therefore allow for changes in the battery voltage.

[0035] The transistors Q1 and Q2 are provided for modulating the sound emitter 12 under control of the microcontroller 11.

[0036] The gas concentration is measured every 40 seconds and is indicated on Pin 1 (of the left hand op-amp).

[0037] If the concentration exceeds a lower threshold of 100ppm the microcontroller increments a register. If gas is detected over 20 minutes the unit sounds the horn 12 and flashes the red LED 5 with on flash every 2 seconds. A flag is set in a register so the unit "remembers" that it has seen over 100ppm CO for 20 minutes.

[0038] If the concentration exceeds 300ppm the microcontroller 11 increments a register, and if the gas is present for three minutes the microcontroller 11 sounds the horn 12 and the red LED 5 flashes twice per second. A flag is set in a register so the microcontroller remembers that it has seen over 300ppm CO for three minutes. This over-rides the 100ppm CO flag.

[0039] Thereafter, if the user presses the test/hush button 3 the microcontroller 11 automatically performs a test of the sound emitter 12 and also checks if either the

100ppm CO flag or the 300ppm CO flag is set. If no flag is set the horn sounds and the green LED flashes. If the 100ppm CO flag is set the red LED 5 flashes (instead of the green) at every 2 seconds. If the 300ppm CO is set the red LED flashes twice per second. This indicates if the unit has sensed CO and, if so, approximately at what level.

[0040] Thus, if a user has been out of the building for a period of time, he or she can simply check if carbon monoxide concentrations rose to the threshold above levels by simply pressed the button 3 and watching the LED 5. If the user continues to hold the test button 3 for a period of 30 seconds, the memory is then reset. If the device 1 is currently sensing a carbon monoxide concentration above a threshold it will continue to activate the LED 5 as if the button 3 were not being pressing.

[0041] The memory feature of the alarm device is very important as it gives peace of mind to the user, and it will be appreciated that this is achieved without the need for complex circuitry with digital data displays etc. It also improves user-friendliness as the user is much more likely to get into the habit of regularly checking the historical sensing while he or she was absent. This aspect also helps in identification of the source of CO because it is not essential that the user be present when the gas is detected.

[0042] The unit may be periodically tested in the field. Such testing is difficult with prior art units because previously a test sample of CO needs to be kept in the unit for up to 30 minutes for testing with 150 ppm CO or up to 6 minutes with 350ppm CO. To do this, it is typically necessary to remove the unit from where it is mounted and keep it in a sealed container with the CO test sample for the required time.

[0043] In the present invention, this problem is overcome by the microcontroller 11 speeding up the gas sensing routine to once every 4 seconds and continuing for about 2 minutes. If it senses CO during this period it will immediately (within 4 seconds) flash the red light at the appropriate rate corresponding to the level sensed and sound the horn just three times. After sensing the gas (or after 2 minutes whichever is shorter) it returns to normal standby. This allows the device to be rapidly tested (for example in less than 30 seconds, after allowing the gas to enter the unit). For example, a cigarette or incense stick could be held below it or a simple plastic cover could be held over it and CO injected into the cover.

[0044] Another aspect of the device 1 is that the microcontroller 11 is used for storing calibration parameter values such as the CO sensitivity level and the low battery level. Thus, there is no need for a separate electrically erasable programmable read only memory (EEPROM). However, in high volume production a small number of units may be mis-calibrated due to, for example, poor test pin contacts. In these circumstances, scrappage of the unit is avoided by storing the initial values in a RETLW XX instruction at a specified location, where XX is the calibration value (8 bits). When the program needs this value it jumps to this location, executes the RETLW XX instruction, and returns with the XX value in the W (working) register.

[0045] A number of sequential memory locations are left vacant and the first is used for the first calibration. If it needs to be re-programmed, the first location is over-written (to all 0's). This changes the RETLW instruction to a NOP instruction. A NOP instruction is one which does nothing, it just causes the program to move to the next instruction. The next location is then programmed with a RETLWXY instruction, where XY is the new calibration value. When the basic program needs this value it jumps to the first location. This now contains a NOP instruction, so the program just goes to the next location containing the RETLWXY instruction. It executes the RETLW XY instruction returning to the main program with XY in the W register. The device 1 can thus be re-calibrated as many times as there are spare memory locations.

[0046] The calibration values which are stored in these memory locations are developed using calibration equipment which consists of an airtight box with two doors on the front of it. There are eight test heads inside the box, each of which calibrates one device. Each test head contains a PCB with calibration circuitry. The test head PCB is connected to the device through pneumatic test pins which engage when the unit is placed in the fixture. There is also a mass flow controller attached to the box. This is a device which meters a know mass of 10%CO/90%N_2 mixture into the box for calibrating the units. This is below the explosive limit for CO and therefore the enclosure does not need switches and other fittings rated for explosive environments. Also, the environment is controlled to 20°C +/- 2°C and 50% +/- 5% RH.

[0047] The calibration circuitry consists of a PIC microcontroller connected to the device through buffer circuitry. The microcontroller writes a calibration mode code to the device. This causes the device to write the CO level it measured to its memory. When this has been done, the microcontroller then calculates the average of several CO readings and writes the average reading to the calibration value location of the devices memory.

[0048] The invention is not limited to the embodiments described but may be varied in construction and detail within the scope of the claims.

Claims

1. A gas sensing alarm device comprising a ventilated housing (2) containing a circuit (10) comprising a toxic gas sensor (14), a processor (11) connected to the sensor (14), and an output device (12, 4, 5, 6) to provide an alert for a user, characterised in that,

   the processor comprises a memory, means for storing historical gas concentration data in the memory, and means for subsequently generating an alert according to the stored historical data.

2. A gas sensing alarm device as claimed in claim 1, wherein the processor (11) comprises means for intermittently activating a light emitter (5) at one of a plurality of discrete frequency levels, each associated with a gas concentration threshold.

3. A gas sensing alarm device as claimed in claim 1 or 2, wherein the processor memory is a register, and the processor comprises means for writing a flag to the register to indicate gas concentration.

4. A gas sensing alarm device as claimed in claim 3, wherein a flag for a previous peak concentration value since reset is over-written by a flag indicating a new peak since reset.

5. A gas sensing alarm device as claimed in any preceding claim, wherein the device further comprises a user input interface (3) connected to the processor, and the processor (11) comprises means for generating an alert based on historical data in response to a user input.

6. A gas sensing alarm device as claimed in claim 5, wherein the input interface comprises a button (3), and the processor (11) comprises means for recognising depression of the button initially as an input to generate an alert based on historical data, and after a pre-set time duration of pressing the button as an input to reset the memory.

7. A gas sensing alarm device as claimed in claim 6, wherein the processor comprises means for also performing an automatic test in response to user depression of the button.

8. A gas sensing alarm device as claimed in any preceding claim, wherein the processor (11) comprises means for sampling sensor output at a higher frequency than for a normal mode when a user test instruction is detected.

9. A gas sensing alarm device as claimed in claim 8, wherein the test sampling rate is at least once every four seconds.

10. A gas sensing alarm device as claimed in claims 8 or 9, wherein the processor (11) comprises means for returning to the normal mode automatically after a pre-set time period had elapsed.

11. A gas sensing alarm device as claimed in any preceding claim, wherein the processor comprises a microcontroller (11) having non-volatile memory storing calibration values in sequential location which are addressable after manufacture, and the memory includes addressable spare locations for storage of calibration values arising from re-calibration.

12. A method of programming an alarm device as claimed in any preceding claim comprising the steps of writing a set of calibration values to a microcontroller memory sequence of locations, and if mis-calibrated, over-writing the used locations with a flag to cause the program to move to the next location.

13. A method as claimed in claim 12, wherein the used locations are over-written with a NOP flag.

14. A method of calibrating a CO sensing alarm device comprising the steps of:-

mounting the device in a test container whereby a calibration circuit is connected to a device circuit,

pumping a metered quantity of test gas into the container, and

monitoring response of the device and writing calibration data to the device accordingly.

15. A method as claimed in claim 14, wherein the test gas comprises a mixture of CO and N_2.

16. A method as claimed in claim 15, wherein the mixture is approximately 10%CO: 90%N_2.

17. A method as claimed in any of claims 13 to 15, wherein the environment within the enclosure is controlled to 20°C +/- 2°C temperature and 50% +/- 5% relative humidity.

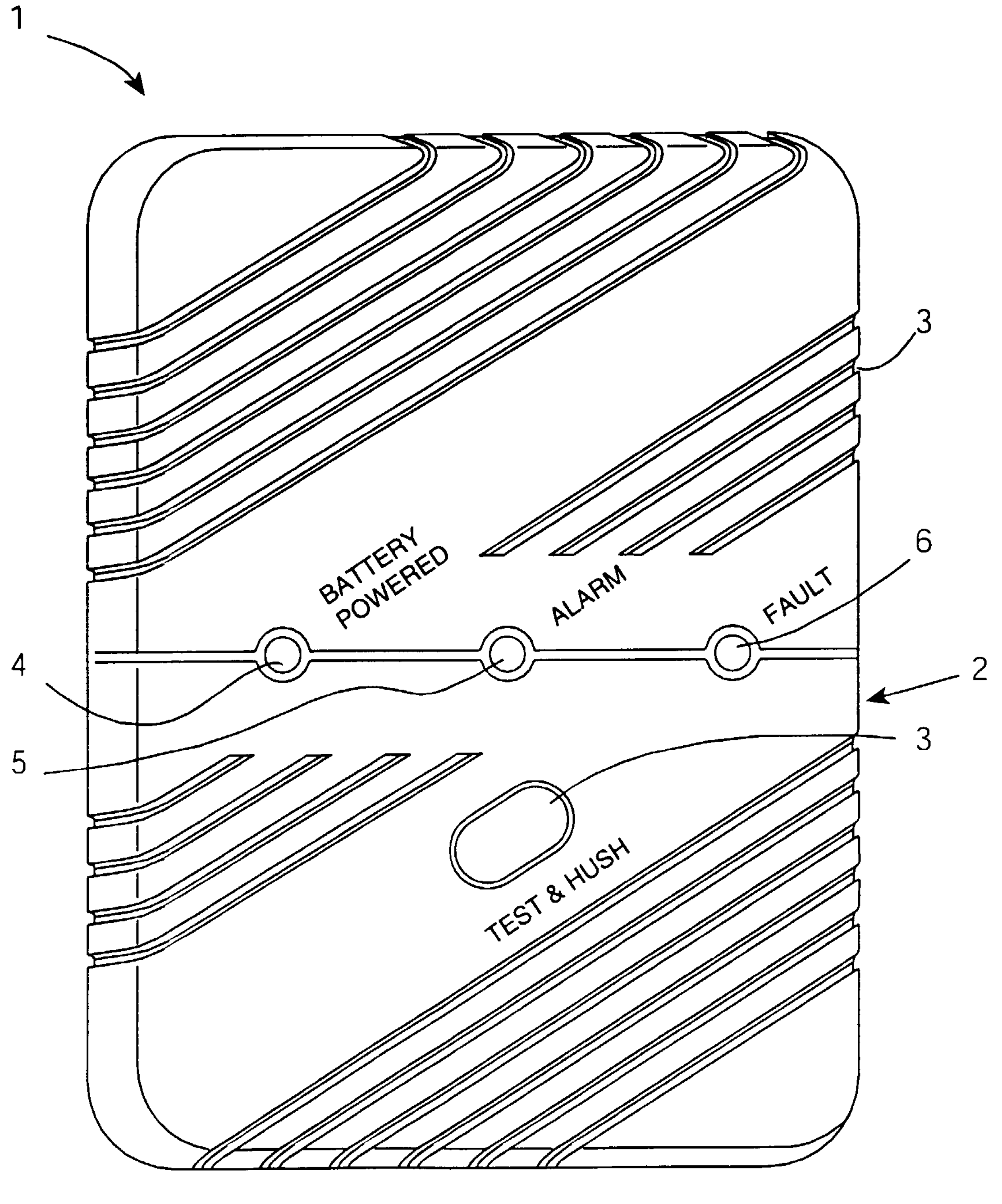

Fig. 1

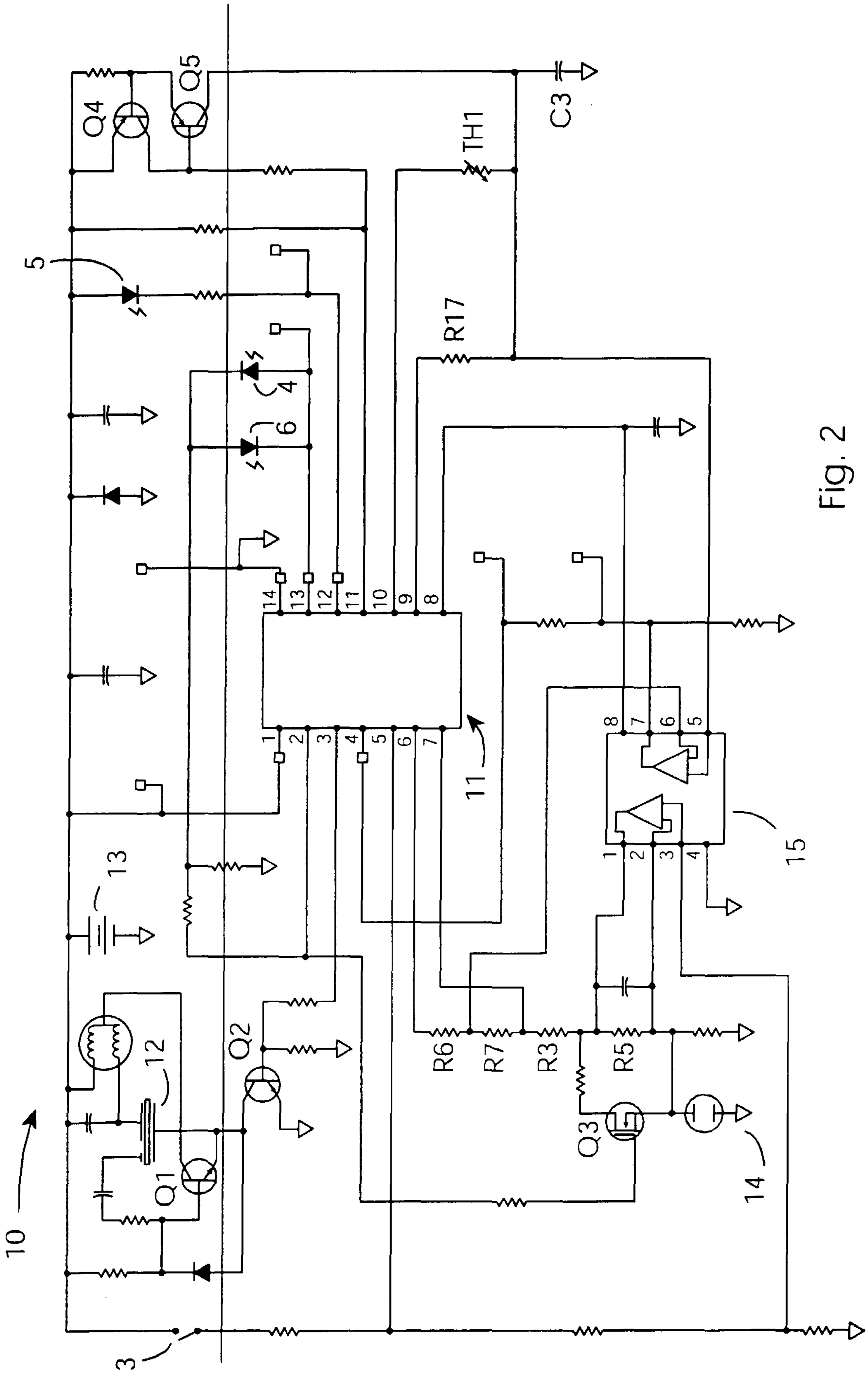

Fig. 2