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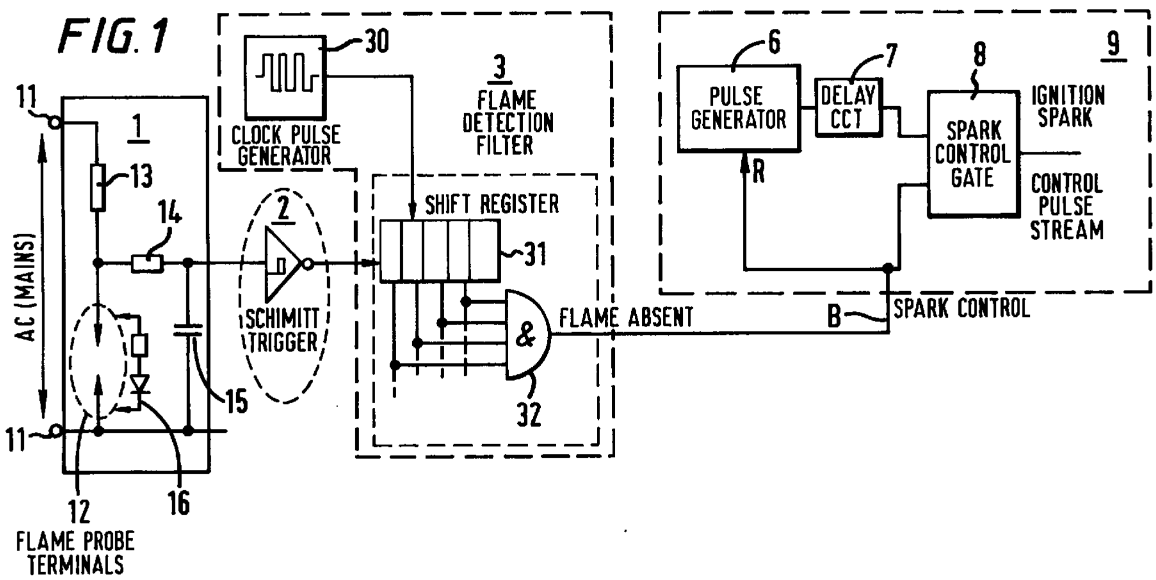
(54) Flame detection and flame ignition circuit

(57) A flame detection circuit has means (1) for producing a flame signal indicative of the presence of a flame. The flame signal is converted to binary, two level, form by an inverting Schmitt trigger 2 whereby a logic "1" level indicates nominal flame failure. The binary flame signal is sampled at a sampling rate set by a clock pulse generator (30) and four successive samples stored in a shift register (31) of a flame signal filter (3). The filter filters out spurious indications of flame failure. An AND gate (32) produces a flame failure signal only if all four samples in the shift register have logic value "1". In this way individual "1"s do not produce spurious flame failure indications. An ignition circuit (9) responds to the flame failure signal to reignite the flame.

FIG. 1



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Description

The present invention relates to a flame detection circuit. The present invention also relates to a flame ignition circuit.

In for example, gas-fired appliances such as cookers, heaters and boilers it is necessary to detect failure of a flame to prevent leakage of gas. Upon detection of a flame failure, the flame may be reignited by an ignition circuit responsive to the flame failure indicator.

However in circumstances such as poor flame stability, or if the flame is liable to disturbance due to draughts, flame detection circuits produce spurious indications of flame failure resulting in the igniter operating even in the presence of a flame which results in the user of an appliance thinking that the appliance is faulty and calling out maintenance engineers unnecessarily.

It has previously been proposed to provide a filter circuit to filter the flame failure signal to reduce the spurious indications but previously proposed filters can result in a long response time in the event of flame failure leading to undesired leakage of gas.

According to one aspect of the present invention, there is provided a flame detection circuit comprising means for producing a flame signal indicative of the presence of a flame, and means for filtering the flame signal to reduce spurious indications of flame failure, the filtering means having means for sampling the flame signal at a predetermined rate and means for producing a signal indicative of flame absence or failure in dependence upon the values of a plurality of successive samples.

By sampling the flame signal and producing the flame failure signal in dependence upon the values of a plurality of successive samples, the effect of individual samples (which individually indicate nominal flame failure) is at least diminished.

Also because the samples are produced at a known rate and the flame failure signal is produced in response to a known number of samples, the response time is uniform and predictable and can be reduced compared to previously proposed filters.

Another aspect of the invention provides an ignition circuit comprising a flame detection circuit according to the said one aspect and means responsive to the flame absence or failure signal to ignite the flame.

The flame detection circuit will automatically detect the absence of a flame at switch-on of an appliance. The flame absence signal produced by it then causes the igniter circuit to ignite the flame.

In principle the samples could be analog samples of the flame signal and the flame failure signal could be produced depending on a predetermined combination of the plurality of successive samples.

In preferred embodiments of the invention described herein the samples are binary samples (having value logic 1 or logic 0) and the flame failure signal producing means forms a logical combination, e.g. logic AND, of the plurality of successive samples. The logical combination responds to a plurality of successive samples each nominally indicating flame failure to produce the flame failure signal. In an alternative embodiment a counter is arranged to count only samples indicative of nominal flame failure. When a plurality (e.g. 2 or more) of successive such samples is counted, the counter produces the flame failure signal.

For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a schematic block diagram of a flame ignition circuit including a flame detection circuit according to one embodiment of the invention;
Figure 2 is a diagram showing illustrative variations in a flame signal;
Figure 3 is a block diagram of a flame detection circuit according to an alternative embodiment of the invention;
Figure 4 is a block diagram of a modification of the flame detection filter of Figure 1; and
Figure 5 is a block diagram of a modification of the flame detection filter of Figure 3.

Referring to Figure 1 a flame detection circuit 1 produces a flame signal indicative of the presence of a flame. In this example the circuit 1 comprises terminals 11 for receiving AC mains, a pair of flame probe terminals 12 between which the flame occurs, resistors 13 and 14 and a capacitor 15. The resistor and the flame probe terminals 12 are in series between the AC mains terminals 11.

A flame is modelled as the equivalent of a resistor in series with a diode as indicated at 16. In the absence of a flame, the circuit comprises the series connection of the resistors 13, 14 and capacitor 15 to which AC means is applied, and no net charge occurs on the capacitor. In the presence of a flame due to the rectification effect of the flame, a net negative charge relative to ground is accumulated on the capacitor 15.

Referring to Figure 2, the flame may be unstable for a variety of reasons, and the charge on the capacitor may vary considerably even though the flame is present. Reduction of charge to near e.g. zero as indicted by a threshold level Th would erroneously indicate flame failure: that is referred to herein as "nominal flame failure".

The flame signal of the flame detector circuit 1 (i.e. of the capacitor 15) is applied to a comparator 2 which in this example is a Schmitt trigger. The flame signal is compared with a threshold, and converted to a two level binary signal represented by logic 1 and logic 0. The circuit 1 and the Schmitt trigger are arranged to produce logic 1 representing nominal flame failure and logic 0 representing presence of the flame.

The binary flame signal is supplied to a filter 3. This example of the filter comprises a clock pulse generator

30, shift register 31 and logic gate 32. The binary flame signal is sampled at a preset sampling rate set by the clock pulse generator 30. The sampling rate is preferably in the range 0.5 to 10kHz. The clock rate is chosen according to the design of the burner producing the flame. The samples are supplied to a shift register having at least two stages: in this example 4 stages. There may be more than four stages if desired, but increasing the number of stages will increase the response time to flame failure.

The four stages are connected to a logic AND gate 32 which produces a flame failure signal when all 4 samples in the shift register are logic 1.

The truth table for gate 32 is

	Inputs	AND	Denotes
	1 1 1 1	1	Flame failure
in any order	0 1 1 1	0	Flame present
in any order	0 0 1 1	0	Flame present
in any order	0 0 0 1	0	Flame present
	0 0 0 0	0	Flame present

As 1 denotes nominal flame failure, the AND gate responds to produce the flame failure signal only if all four successive samples in the shift register denote nominal flame failure. If there are 3 or fewer logic 1's in the shift register in any order then the gate indicates the flame is present. Thus spurious indications of flame failure are at least reduced, it being assumed that if four successive samples all denote nominal failure the flame has indeed failed, it being unlikely that the flame, if present, would produce four successive logic 1 samples at the shift register 31.

In Figure 1, the flame failure signal is supplied as a spark control signal B to an ignition circuit 9 which produces ignition sparks to reignite the flame.

It will be appreciated that the flame failure signal also indicates absence of a flame. Thus at initial switch-on of an appliance including the circuit of Figure 1, the circuit will operate to initially ignite the flame.

The ignition circuit includes a pulse generator 6, a delay circuit 7, and a control gate 8. The pulse generator responds to the spark control signal B to produce, for a set time A, pulses used by a spark generator (not shown) to produce ignition sparks. The number of pulses per unit time may be programmable for reliable ignition and for EMC reasons. The pulses are delayed in circuit 7 by a delay time d. The delay time allows adequate gas flow prior to re-ignition thereby improving the probability of ignition with first spark. The spark control signal produced by gate 32 is shown having a duration B, B being greater than A by at least the time difference d. The spark control signal B remaining at logic 1 as long as no flame is detected. Because of the delay d, the control gate 8 opens in response to the spark control signal B before the pulses reach it.

Figure 3 shows an alternative flame detection circuit.

A flame detector circuit 1 and Schmitt trigger 2 are constructed and operate exactly as shown in Figure 1. The filter 3 of Figure 3 comprises a binary modulo 4 counter 35, which counts the clock pulses produced by the clock pulse generator 30. Counting is disabled by logic 'O' denoting a flame present and produced at the output of the Schmitt trigger 2. The counting is enabled when a logic '1' is output by the Schmitt trigger 2 denoting nominal flame failure. The count = 4 output of the counter becomes logic 1 when a count of four is reached, in other words only if four successive samples indicate flame failure. When the count of four is reached the counter is reset.

The modified flame detector filter 3 of Figure 4 comprises the shift register 31 and AND gate 32 as described above. The filter 3 of Figure 4 additionally comprises an AND gate 37 with inverting inputs and a latch 33 which validate the presence/absence of a flame. When the register 31 is full of logic '1's indicating flame failure/absence, the AND gate 32 sets the latch to produce logic '1' at its output as signal B. Once the flame is re-established/established the register fills with logic 'O'. The gate 37 then resets the latch to logic 'O'. The filter 3 of Figure 4 may also include a timer 38. The timer acts to produce a signal for shutting off the gas supply if the flame is absent for a preset period. The time is set to start timing the preset period by the output of AND gate 32 indicating flame failure/absence. The time is reset by the output of the gate 37 indicating the presence of the flame. If the timer is not reset within the preset period it produces the shutdown signal.

Figure 5 replaces the shift register and gates 32 and 37 of Figure 4 by two counters 35 and 36. Counter 37 is identical to counter 35 but is enable to count clock pulses by the inverted output of the schmitt trigger. Counter 36 resets the latch 33 and timer 38 when it counts four successive clock pulses when enabled by a signal indicating the presence of a flame.

The advantages of the systems described herein are:

- A shift register (or counter) ensures response time is consistent (i.e. a defined number of clock cycles).
- The response to a flame failure can be much quicker than conventional analog systems (which necessarily employ long time constant filters as a result of the very high flame resistance and other associated circuit values).
- The effects of electrical and other noise are significantly reduced because of the synchronous nature of the circuit.

The sampling rate can be chosen to match the filter response to the design of the burner. Thus the filter of the present invention is easily adaptable to a wide variety of burners.

In the example given in Figure 1, the shift register has to clear all stages down (with logic e.g. no flame) signals prior to any action being taken by the system.

This technique offers the following advantages over the above more convention equivalents:

- Resistant to flame flicker - System is only "fooled" if flicker occurs on precisely four consecutive clock pulse edges.
- If a "genuine" flame failure occurs (e.g. flame blown out by door opening) the system will react quickly and predictably - i.e. re-ignition spark generation is activated in a defined period (number of clock cycles), reducing unwanted gas escape.
- The system discriminates reliably between flame "flicker" and "failure" and can therefore be used as part of a safety shutdown system. The result is a high integrity, fast acting flame detection system. Various modifications may be made to the circuit of Figures 1 and 3:
- The Schmitt trigger may be non-inverting.
- The flame failure detection signal may be used to cut-off the supply of fuel e.g. gas to the flame when the flame fails.
- The shift register 31 may have more than four stages, or the counter 35 may count to a number greater than four.
- The circuit 1 for producing the flame signal may use techniques other than flame rectification to detect the flame.
- The flame detection circuit may be used in domestic and industrial gas-fired appliances such cookers, heaters and boilers.

The same (or an additional) counter/Shift Register can be used to validate flame removal/extinguishing.

Claims

1. A flame detection circuit comprising

   means for producing a flame signal indicative of the presence of a flame, and
   means for filtering the flame signal to reduce spurious indications of flame failure, the filtering means having
   means for sampling the flame signal at a predetermined rate and
   means for producing a signal indicative of flame failure in dependence upon the values of a plurality of successive samples.

2. A circuit according to claim 1, wherein the flame failure signal producing means forms a combination of the plurality of successive samples.

3. A circuit according to claim 1, wherein the flame signal producing means comprises

   means for comparing the flame signal with a threshold value to produce a binary flame signal having a first level if the flame signal exceeds the threshold indicating the presence of a flame and a second level if the flame signal does not exceed the threshold indicating nominal flame failure.

4. A circuit according to claim 1, wherein the comparing means is a Schmitt trigger circuit.

5. A circuit according to claim 3 or 4, wherein the sampling means comprises

   a clock pulse generator defining the sampling rate and
   storage means coupled to receive the binary flame signal and responsive to the generator to store the said plurality of successive samples.

6. A circuit according to claim 5, wherein the storage means is a shift register having a plurality of stages.

7. A circuit according to claim 3, 4, 5 or 6 wherein the flame failure signal producing means forms a logical combination of the said plurality of successive samples.

8. A circuit according to claim 7, wherein the logical combination is logical AND of the samples indicating nominal flame failure to produce the flame failure signal.

9. A circuit according to claim 3, 4, 5 or 6 wherein the flame failure signal producing means comprises counting means arranged to count successive samples of the level indicating nominal flame failure and to produce the flame failure signal in response to the occurrence of the said plurality of successive such samples.

10. A circuit according to any of the preceding claims wherein the said plurality of successive samples is at least two.

11. A circuit according to claim 10 where the said plurality of successive samples is four.

12. An ignition circuit comprising a flame detection according to any of the preceding claims, and means responsive to the flame failure signal to ignite the flame.

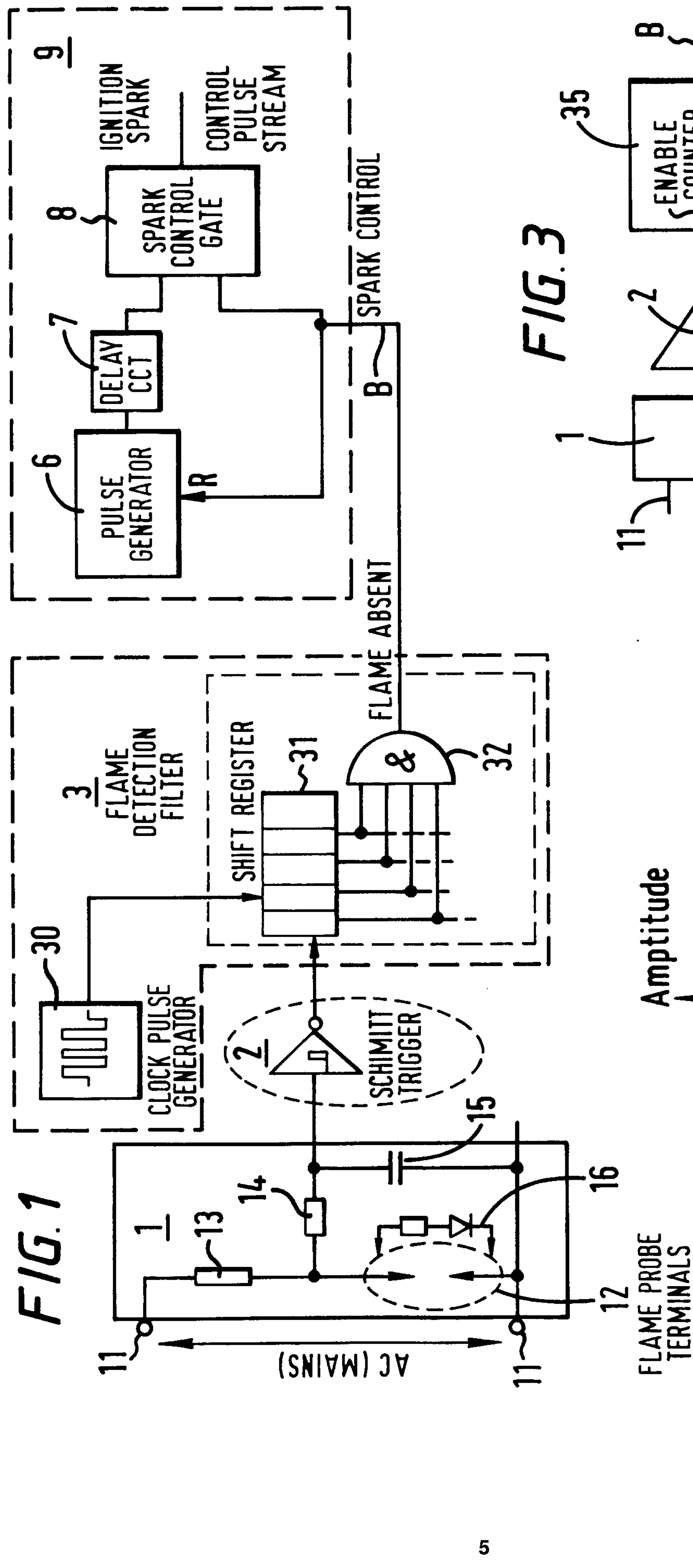


FIG. 1
1
11
11
AC (MAINS)
FLAME PROBE TERMINALS
12
13
14
15
16
2
SCHIMITT TRIGGER
CLOCK PULSE GENERATOR
30
3
FLAME DETECTION FILTER
SHIFT REGISTER
31
&
32
FLAME ABSENT
B
SPARK CONTROL
9
PULSE GENERATOR
6
R
DELAY CCT
7
SPARK CONTROL GATE
8
IGNITION SPARK
CONTROL PULSE STREAM

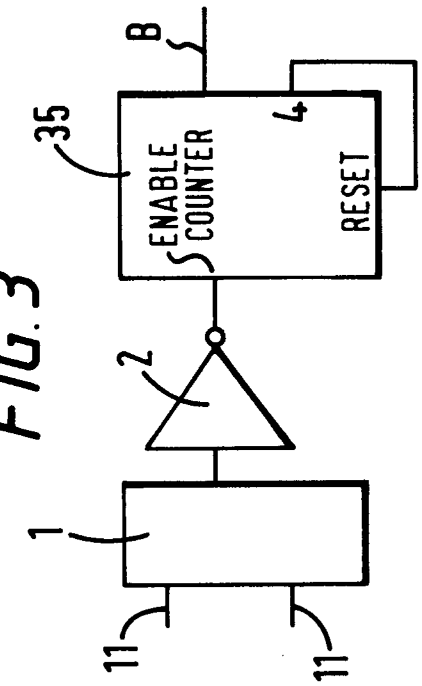


FIG. 3
35
ENABLE COUNTER
4
RESET
B
2
1
11
11

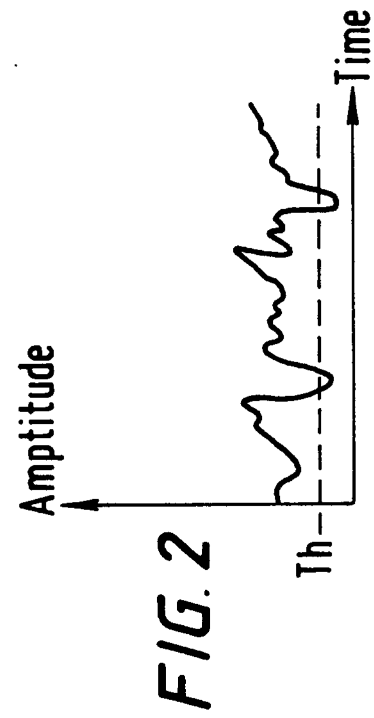


FIG. 2
Amptitude
Time
Th

FIG. 4

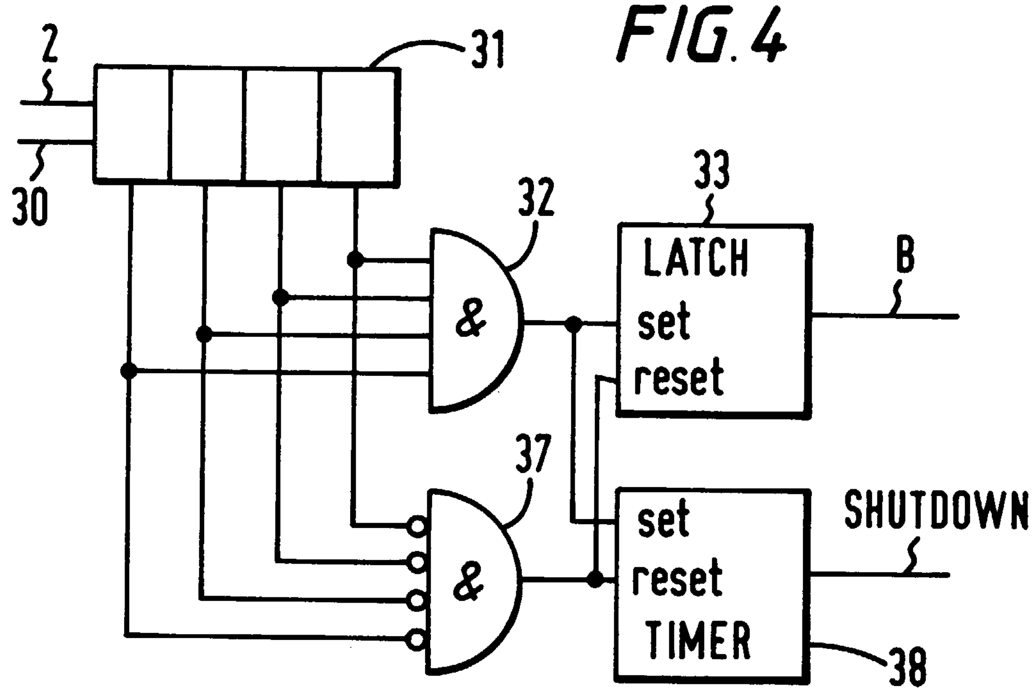
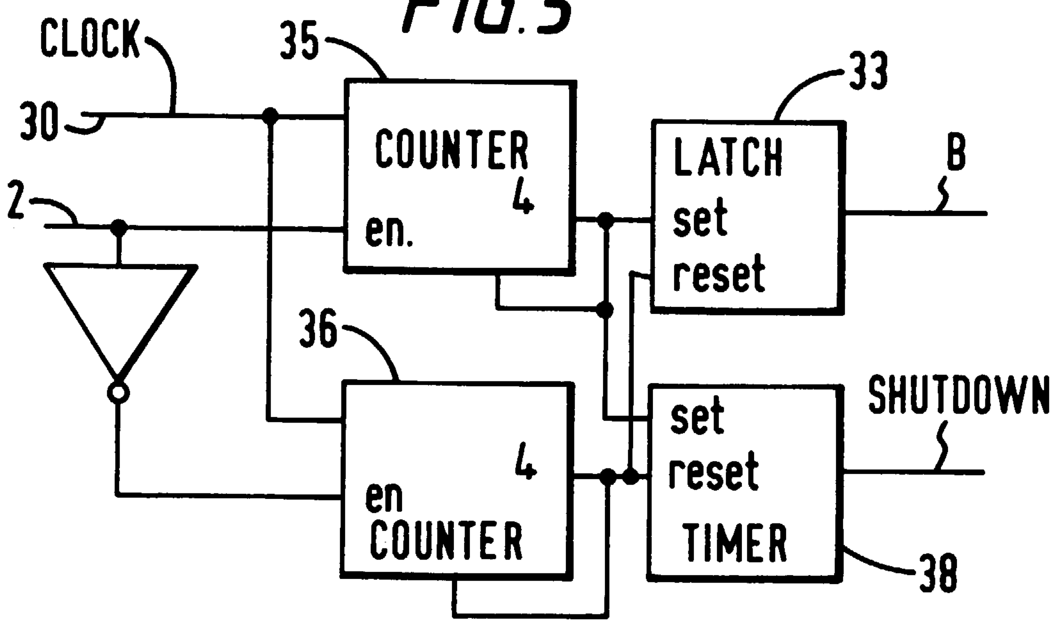

2
31
30
32
33
LATCH
set
reset
B
&
37
&
set
reset
TIMER
SHUTDOWN
38

FIG. 5


CLOCK
35
30
2
COUNTER
4
en.
33
LATCH
set
reset
B
36
4
en
COUNTER
set
reset
TIMER
SHUTDOWN
38