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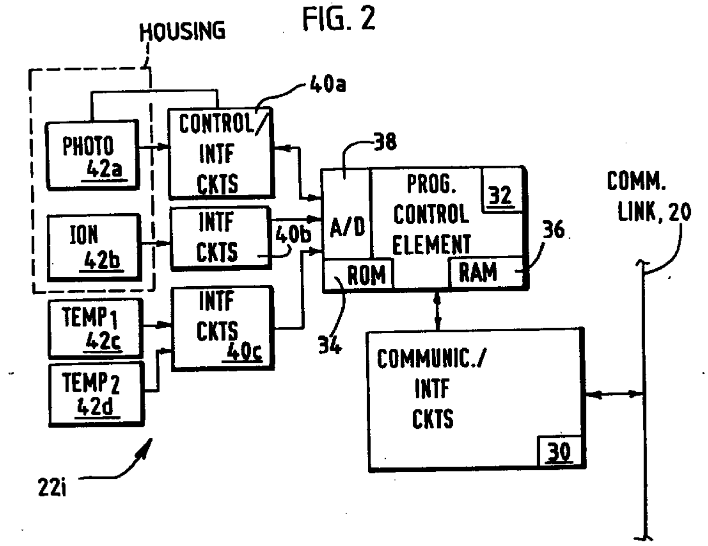
Remarks:
A request for correction of figure 4 has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) Multiple sensor detector and method of locally determining a potential alarm condition

(57) There is disclosed a variable sensitivity alarm condition detector which receives inputs from several different condition sensors, and provides an output to a control unit indicative of a locally determined potential alarm condition. The sensitivity levels of the sensors are automatically switched, from the most sensitive to the least sensitive, as the sensed parameter (such as smoke concentration or temperature) increases.

FIG. 2



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Description

Field of Invention:

The invention pertains to detectors for determining the presence of a selected condition based on a plurality of data inputs. More particularly, the invention pertains to a variable sensitivity, alarm condition detector which receives inputs from several different condition sensors and which provides an output to a control unit indicative of a locally determined potential alarm condition.

Background of Invention:

Various systems are known for the detection of alarm conditions. One particular form of such a system is a smoke or fire detecting system of a type generally illustrated in previously issued Tice et al. U.S. Patent 4,916,432. The Tice et al. patent is assigned to the same assignee, Pittway Corporation, and is incorporated herein by reference.

Upon receipt of inputs from a plurality of detectors a common control unit associated with this system is able to make a determination as to whether or not a fire condition is present in one or more regions of interest. A variety of techniques have in the past been used for purposes of making this determination.

One known technique has been to compare one or more of the outputs of one or more detectors to one or more pre-established thresholds. The use of multiple thresholds permits the evaluation of trend information from one or more detectors. Known systems carry out such processing at the common control unit.

Detection systems are expanding and are able to support larger numbers of detector such as 600 to 800 or more. In this environment, it becomes desirable and important to be able to analyze outputs from large numbers of detectors at a relatively high rate so as to provide timely information as to trends as well as actual alarm conditions.

It has also been recognized that there are advantages in using different types of detectors. For example, known detectors have incorporated photoelectric and ionization type smoke sensors into a common detector housing. Heat sensors have also been used in combination with smoke sensors.

In view of the need to support larger and larger members of detectors in a given system, there continues to be a need for detectors and methods of operating same which not only incorporate different types of sensors but which can carry out some local processing so as to reduce the amount of information which must be processed at the control unit. Preferably such detectors will be implementable at costs which are comparable to the cost of known detectors.

Summary of the Invention:

A variable sensitivity fire detector incorporates different methods for different sensitivity levels. The sensitivity levels are automatically switched, from the most sensitive to the least sensitive, as the smoke concentration and/or temperature increase.

In one aspect of the invention, five different sensitivity levels are provided. The detector is initiated at the highest sensitivity level.

Processing is carried out on signals from one or more different types of smoke detectors and perhaps a heat detector. If the smoke concentration or combined heat and smoke level are higher than the initial sensitivity level, the detector will generate a level one status code and continue processing for a second or lower level of sensitivity. After the processing steps have been carried out, if the concentration of smoke or smoke in combination with heat exceed the second level of sensitivity, a level two status code will be generated and the processing will continue to determine whether or not the smoke concentration or smoke combined with temperature exceeds the next higher sensitivity level. Once the detector reaches the lowest sensitivity level that is not exceeded, the latest status indicator can be forwarded to a central control unit, such as a fire alarm panel, for further processing in combination with signals returned from one or more additional detectors.

In yet another aspect of the invention, averaging or time delays can be introduced into the processing. The signals can be detected off of the sensors for each processing interation at a given sensitivity level. Alternately, a single reading can be made and the same signal values can be used as inputs for each of the sensitivity levels.

The invention involves the use of different methods for different sensitivity levels. These levels are automatically switched (from most sensitive to least sensitive) as the smoke concentration increases.

In the new invention, a processing method is established for each of, for example, five different levels. In the most sensitive setting, the processing method is executed and if the smoke concentration is higher than a preset level 1, then the method for the second level is executed. After execution, and if the smoke concentration is higher than a preset level 2, then the method for the third level is executed. This continues through level 5.

The detector will output a value that indicates what level it is at. The common control panel can make an alarm determination based upon which level is "set" as the alarm level. For example, if level 1 = .5%ft, level 2 = 1%ft, level 3 = 2%ft, level 4 = 3%ft and level 5 = 4%ft. If the panel is set to alarm at level 4, then the smoke concentration will need to be 3%ft or greater to get an alarm.

Numerous other advantages and features of the present invention are described in the following detailed description of the invention along with the accompanying drawings.

A Brief Description of the Drawing:

Figure 1 is an overall block diagram of a fire alarm system in accordance with the present invention;
Figure 2 is a block diagram of a multiple sensor detector useable with the fire alarm system of figure 1.
Figure 3 is a flow diagram of a method in accordance with the present invention; and
Figure 4 is a flow diagram illustrating further details of a method in accordance with the present invention.

Detailed Description:

While this invention is susceptible of embodiment in many different forms, there are shown in the drawing and will be described herein in detail specific embodiments thereof with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the specific embodiments illustrated.

With respect to figure 1, an ambient condition detection system 10, which could be for example a fire alarm system, includes a common control unit 12. The control unit 12 includes a programmed processor 14, which could be a microprocessor of a commercially available variety as well as memory or storage 16. The storage circuits 16 could be read-only memory circuits or read-write memory circuits. The particular details of the processor 14 or the storage element 16 are not a limitation of the present invention.

The control unit 12 is coupled to a bidirectional communication link 20. Coupled to the link 20 is a plurality of control or detector units 22.

The members of the plurality 22a--22n can be used to detect ambient conditions in the vicinity of the respective detector. Signals from the respective detector can be communicated to the control unit 12 via the bidirectional communication link 20. The processor 14 in turn analyzes the signals from one or more of the detectors from the plurality 22, in order to make a determination as to whether or not a potential or an actual alarm condition is present.

Figure 2 illustrates a block diagram of an exemplary detector 22i from the plurality 22. The detector 22i is coupled to the bidirectional communication link 20 by communication and interface circuits 30.

The communication and interface circuits 30 translate commands and data between the link 20 and a programmed control element 32 in the detector 22i. The control element 32 can be implemented using a commercially available microprocessor.

The element 32 will include read-only memory 34 for program storage as well as read-write memory 36, which could be implemented as random access memory for storage of data, as well as information or commands received from the control unit 12 via the link 20. For example, the read-write memory 36 can include a plurality of parameter values, or related functions, used to establish several different sensitivity levels at the detector 22e.

The control element 32, based on received ambient condition signals, and under control of the program in read-only memory 34, is capable of automatically switching from a higher sensitivity level to a lower sensitivity level. The control element 32 which can include an analog-to-digital converter circuit 38 is in turn coupled to sensor interface circuits 40a, 40b and 40c.

Each of the sensor interface circuits 40a, 40b, and 40c receives inputs from a respective sensor. For example, control/interface circuity 40a receives signals indicative of a detected level of smoke concentration from a photoelectric smoke sensor 42a. Interface circuity 40b receives signals indicative of a sensed concentration of smoke from ionization smoke sensor 42b. Interface circuity 40c receives temperature information from temperature sensors 42c and 42d which could be implemented as their thermistors.

Signals received from the plurality of sensors 42, when processed by the interface circuits 40, can in turn be analyzed by the programmed control element 32 on a digital basis.

In accordance with the present invention, the control element 32, at the start of each processing cycle, will first read signals from each of the sensors 42. The signals from the sensors 42 are then used to created updated respective average values or base lines for each of the signals according to the following equation:

$$\text{Base}_N = ((255 * \text{Base}_{N-1}) + (\text{new value}))/256$$

The control element 32 then carries out a plurality of trouble checks to determine whether or not updated base line signals from the photo sensor 42a, and ionization sensor 42b are within low and high limits, which is indicative of proper operation. If not, respective low and high trouble condition indicators are set and forwarded, via the communication/interface circuits 32 and the link 20 to the control unit 12.

Subsequently, the control element 32 runs through a plurality of thermal checks to establish, via output signals from temperature sensors 42c, 42d whether or not the sensed temperature exceeds a pre-determined threshold, such as 135 degrees fahrenheit for a predetermined period of time, such as 5 seconds. If not, temperature rise is checked to determine whether or not the temperature is increasing at an excessive rate, such as 15 degrees fahrenheit per minute for 5 seconds. If either temperature check indicates an affirmative result, the detector 22i generates a level 5 output alarm indication to the control unit 12.

The detector 22i starts a processing cycle by determining whether or not the signals from the sensor 42 in combination or alone exceed a first or highest sensitivity level. For example, in the first level, sensitivity for the photoelectric smoke sensor 42a could be set at 1% per foot, the ionization detector 42b could be set at a sensitivity of .5% per foot. In the event that the signals received from the sensors 42 indicate that the smoke level is below the level 1 sensitivity, the processing sequence is terminated and sensors are read again. On the other hand, if the signals from the sensors 42 indicate that there is a higher than acceptable temperature gradient or that the smoke levels exceed that for the level 1 sensitivity, the processor 32 will automatically increase the sensitivity level, for example to 2% per foot for the photoelectric and ionization detectors 42a, 42b and then make a determination as to whether or not the signals received therefrom exceed the level 2 or the next, lessor sensitivity level.

The detector 22i will output a sensitivity level indicator via interface 30 to the communication link 20 as it passes through each of the sensitivity levels, going from level 1, the most sensitive level, to level 5, the least sensitive level, indicative of continually increasing levels of smoke and/or temperature or both.

Figure 3 illustrates the steps of a method in accordance with the present invention. In a step 60 the control element 32 initiates a processing sequence by reading current output values from each of the sensors 42. In a step 62, the base lines for each type of sensor are updated as previously discussed. Additionally, in the step 62, the updated base line values for at least the photoelectric detector 42a and the ionization detector 42b are compared to lower and upper limit values to determine that the sensors appear to be operating properly. If the limits are exceeded, in the case of the upper limit or not met, in the case of a lower limit, appropriate status messages are generated by the control element 32 and forwarded via the link 20 to the control panel 12.

Assuming that the base line values are within acceptable limits, in a step 64 the temperature values received from the sensors 42c, 42d are checked against both an upper limit and against an acceptable gradient. If excessive temperature is indicated or an excessive rate of increase of temperature is indicated, a level 3 output message is produced by the control element 32. If not the output status is set at level 0, corresponding to no detected smoke or fire condition.

Averaged values of signals from the sensors 42 are then compared in a set of steps 66a, 66b, 66c to appropriate thresholds established by the control element 32 to establish if the sensed and averaged values indicate a higher level of smoke or smoke and temperature taken together for a pre-determined time interval, exceed the level 1 sensitivity. For example, a sum can be formed from average values from each of the types of sensors 42. Averaging can be accomplished using the following equation:

$$Avg_N=((3*Avg_{N-1})+(\text{new value}))/4$$

This sum of average values can then be compared, in step 66a to a level 1 sum threshold ST1. This value need not be a constant but could in fact be a function of signal values read from the sensors 42 as well as time. In an exemplary embodiment, ST1 could correspond to 125%. In the event that the sum exceeds the preset threshold, in a step 68, the control element 32 sets its output status to level 1.

In steps 66b and 66c comparisons are made between averaged values from the ionization sensor 42b to a preset threshold IT1 as well as average values from photo sensor 42a to a preset threshold PT1. In the event that the averaged values exceed the preset thresholds, for present time intervals, Δ1, Δ2 (such as 30 seconds) in the step 68 the output status is set to a level 1 indication by the control element 32. In the event that none of the averaged sensor values exceed the preset thresholds, for the required time interval(s), the control element 32 returns to the step 60 and initiates the read process again.

Where the level 1 sensitivity level has been exceeded, the control element 32 compares the sensor output values in a series of steps 70a, 70b, 70c to level 2 thresholds, which also could be variable and could be altered by the control element 32 over a period of time. While the steps 70a-70c can be carried out with respect to averaged values, in view of the fact that the control element 32 has now switched to a lower level of sensitivity, for example 2% per foot of smoke, it is preferable to compare the current, unaveraged, values from the sensors 42 to the preset thresholds ST2, IT2 and PT2, to determine whether or not sufficient smoke and temperature rise are present to warrant generating a level 2 output status in a step 72. If not, the control element 32 returns to the step 60 and re-reads the sensors. In the event that the level 2 sensitivity has been exceeded, similar steps are carried out with respect to a level 3 sensitivity in steps 74a, 74b, 74c. In the event that the level 3 sensitivity has been exceeded indicating, for example, 4% per foot smoke from the photo sensor 42a and/or 2% per foot smoke from the ionization sensor 42b, the control element 32 will generate a level 3 output status indicator in a step 76. It will then return to read the sensors again in the step 60.

Figure 4 is a flow diagram for a method in accordance with the present invention wherein 5 different sensitivity values are used. Steps from Figure 4 that correspond to steps from Figure 3 have been assigned the same identification numerals.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein in tended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

Claims

1. A multiple sensor, variable sensitivity, ambient condition detector comprising:

   at least first and second different ambient condition sensors; and

   a control element adjacent to and coupled to said sensors wherein said element includes circuity for receiving outputs from said sensors and for determining, based on a first sensitivity, if at least one of said outputs indicates the presence of a first pre-established condition and in response thereto, subsequently determining, based on a second sensitivity, if at least one of said outputs indicates the presence of a second pre-established condition and for establishing an output indicium indicative of a respective one of said pre-determined conditions.

2. A detector as in claim 1 which includes a common housing wherein said sensors and said control element are carried by said housing

3. A detector as in claim 2 wherein said control element includes a plurality of storage locations and wherein a plurality of sensitivity determining parameters are stored therein.

4. A detector as in claim 3 wherein said first sensor is a smoke sensor and said second sensor is a temperature sensor.

5. A fire condition detector comprising:

   a housing;
   first and second, different, fire condition sensors wherein each of said sensors generates a respective output in response to an ambient condition;
   control circuity carried by said housing, coupled to said sensors, wherein said circuity automatically alters a sensitivity parameter in response to said outputs.

6. A detector as in claim 5 wherein said control circuity includes locations for storing a plurality of sensitivity specifying parameters.

7. A detector as in claim 6 wherein said control circuity includes a programmed processor.

8. A detector as in claim 7 which includes an analog-to-digital converter for converting each of said outputs from a first form to a digital representation and wherein said processor selects a sensitivity parameter from said plurality of parameters in accordance with a pre-determined criterion in response to said representations.

9. A detector as in claim 5 wherein said sensors correspond to an ion-type sensor and a photoelectric-type sensor.

10. A detector as in claim 5 wherein said control circuitry combines said signals and wherein said circuitry indicates a comparator for comparing said combined signals to a pre-stored threshold value.

11. A detector as in claim 6 wherein said control circuitry combines said signals and wherein said circuitry indicates a comparator for comparing said combined signals to a pre-stored threshold value wherein said threshold value is selected from a plurality of threshold values from said storing locations.

12. A detector as in claim 6 wherein said sensor outputs can be averaged over a pre-determined period of time prior to further processing.

13. A method of detecting a selected condition using at least first and second, different, ambient condition sensors comprising:

   providing the first and second sensors;
   exposing the sensors to an ambient condition;
   producing an output from each sensor indicative of the sensed ambient condition;
   establishing a series of ordered, pre-determined sensitivity levels;
   selecting a first sensitivity level as the current level; and
   processing the outputs to determine if the current sensitivity level has been exceeded, if not, then return to the producing step, if the current level has been exceeded, replace it with the next member of the series and return to the processing step.

14. A method as in claim 13 wherein an output indicium is generated after the processing step, if the current level has been exceeded.

FIG. 1

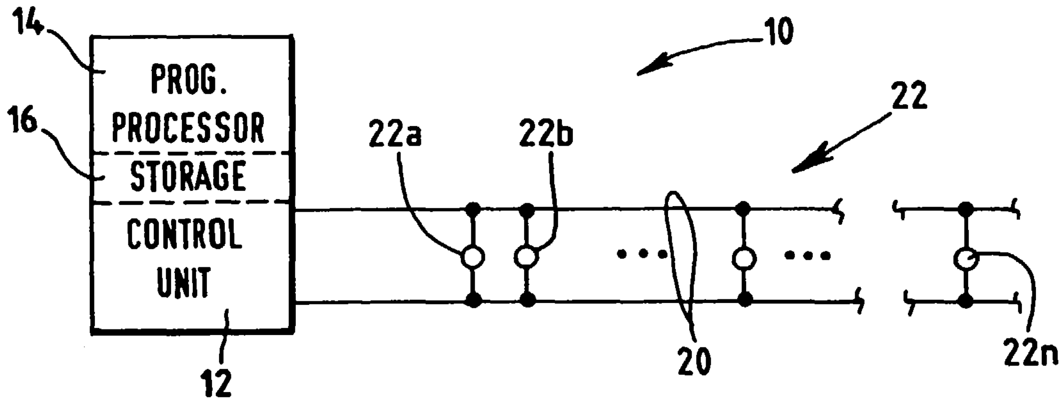

14
16
PROG.
PROCESSOR
STORAGE
CONTROL
UNIT
12
10
22
22a
22b
20
22n

FIG. 2

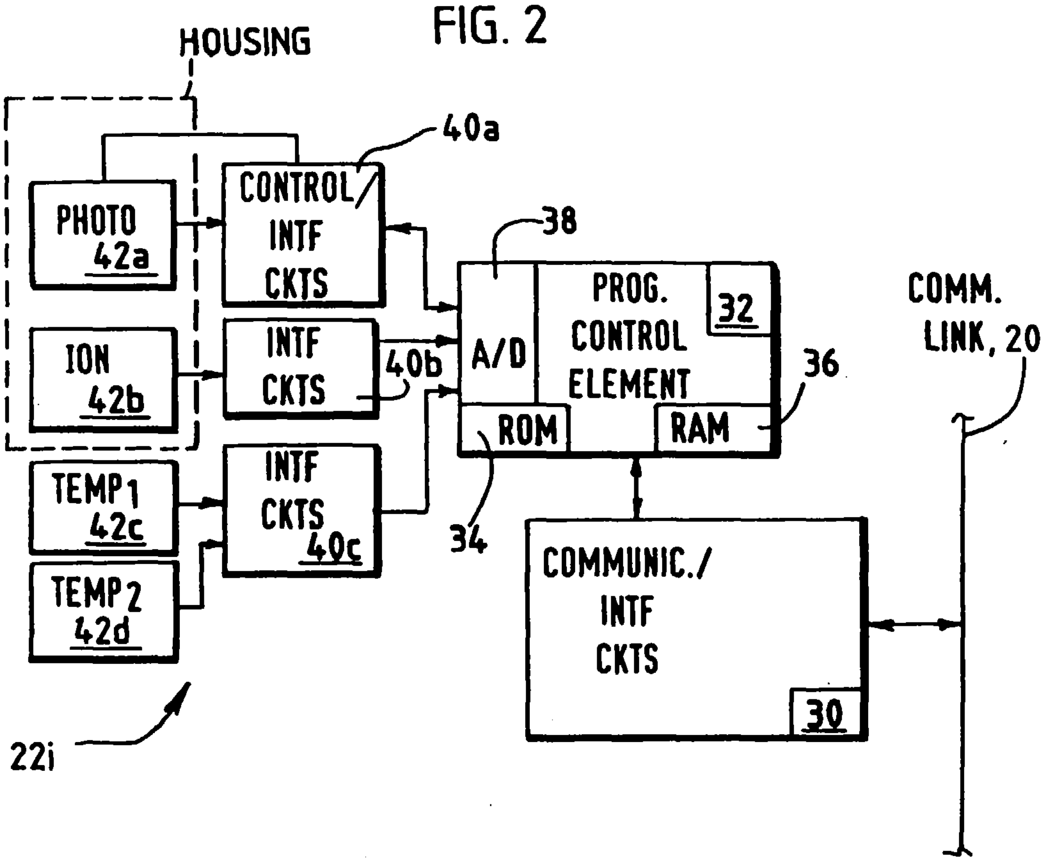

HOUSING
40a
PHOTO
42a
CONTROL/
INTF
CKTS
ION
42b
INTF
CKTS
40b
TEMP1
42c
TEMP2
42d
INTF
CKTS
40c
38
A/D
PROG.
CONTROL
ELEMENT
32
ROM
RAM
36
34
COMM.
LINK, 20
COMMUNIC./
INTF
CKTS
30
22i

FIG. 3

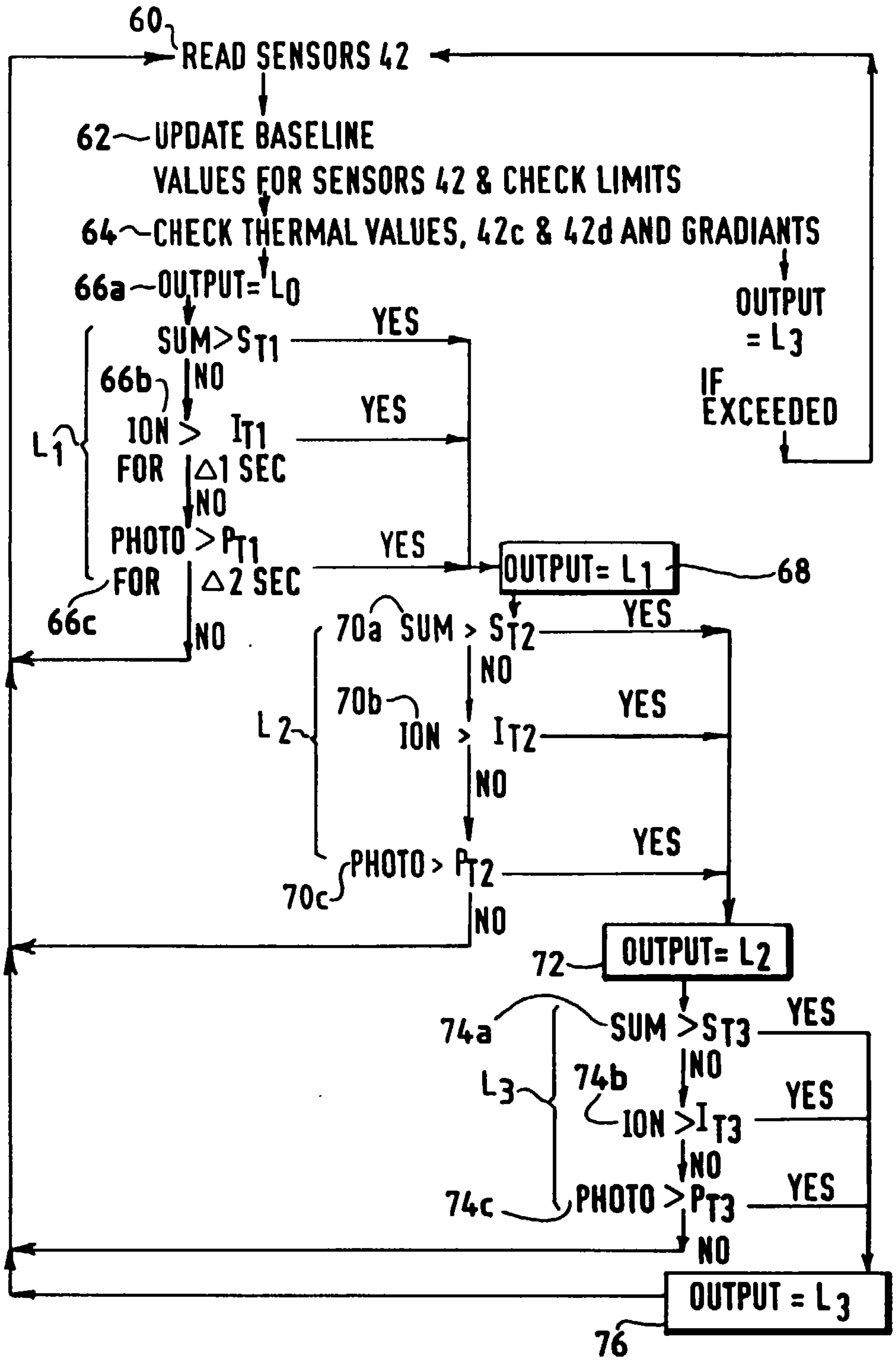
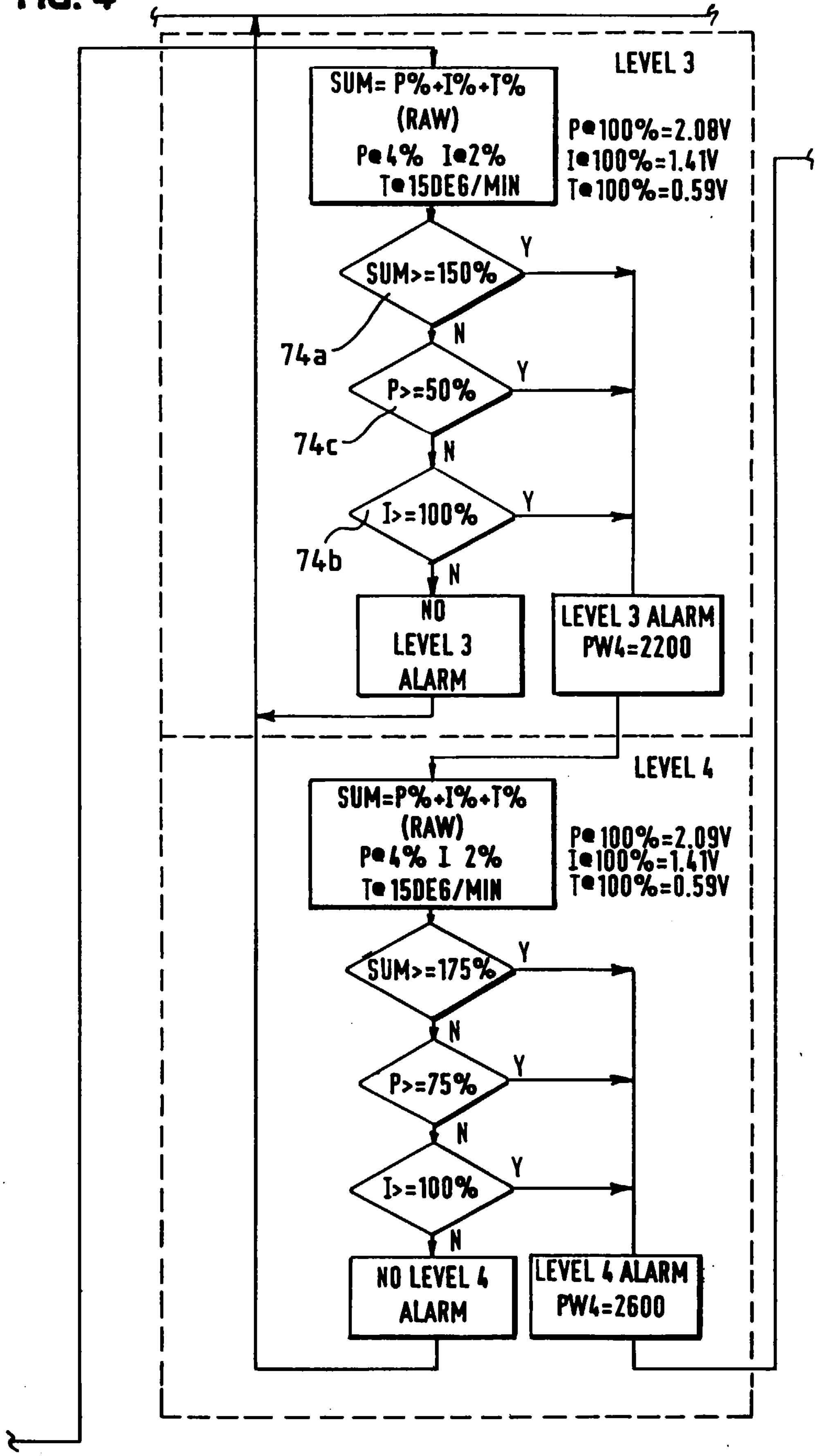

60
READ SENSORS 42
62 UPDATE BASELINE
VALUES FOR SENSORS 42 & CHECK LIMITS
64 CHECK THERMAL VALUES, 42c & 42d AND GRADIANTS
OUTPUT = L3
IF EXCEEDED
66a OUTPUT= L0
SUM>ST1
YES
NO
66b
ION > IT1
FOR Δ1 SEC
YES
NO
L1
PHOTO >PT1
FOR Δ2 SEC
YES
66c
NO
OUTPUT= L1
68
70a SUM > ST2
YES
NO
70b
ION > IT2
YES
L2
NO
PHOTO > PT2
YES
70c
NO
OUTPUT= L2
72
74a
SUM >ST3
YES
NO
L3
74b
ION >IT3
YES
NO
74c
PHOTO >PT3
YES
NO
OUTPUT = L3
76

FIG. 4


LEVEL 3
SUM= P%+I%+T%
(RAW)
P@4% I@2%
T@15DEG/MIN
P@100%=2.08V
I@100%=1.41V
T@100%=0.59V
SUM>=150%
Y
N
74a
P>=50%
Y
N
74c
I>=100%
Y
N
74b
NO
LEVEL 3
ALARM
LEVEL 3 ALARM
PW4=2200
LEVEL 4
SUM=P%+I%+T%
(RAW)
P@4% I 2%
T@15DEG/MIN
P@100%=2.09V
I@100%=1.41V
T@100%=0.59V
SUM>=175%
Y
N
P>=75%
Y
N
I>=100%
Y
N
NO LEVEL 4
ALARM
LEVEL 4 ALARM
PW4=2600

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 5065

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.6)
Y	GB 2 188 725 A (HOCHIKI K.K.) * abstract; figures 1,2,6,7 * * page 1, line 120 - line 130 * * page 2, line 79 - line 83 * * page 2, line 130 - page 3, line 28 * * page 4, line 50 - line 64 * ---	1,4,5,8, 10,11,13	G08B17/00
Y	US 4 088 986 A (BOUCHER) * abstract; figures 1,2 * * column 6, line 3 - line 8 * ---	1,4,5,8, 10,11,13	
A	EP 0 039 761 A (CERBERUS AG.) * figure 1 * * page 7, line 24 - line 28 * ---	9	
A	GB 2 161 966 A (HOCHIKI CORP.) * abstract; figure 1 * ---	12	
A	DE 34 15 786 A (MATSUSHITA ELECTRIC WORKS,LTD.) * abstract; claim 2; figures 1,5 * -----	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G08B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	26 November 1996	Danielidis, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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& : member of the same patent family, corresponding document