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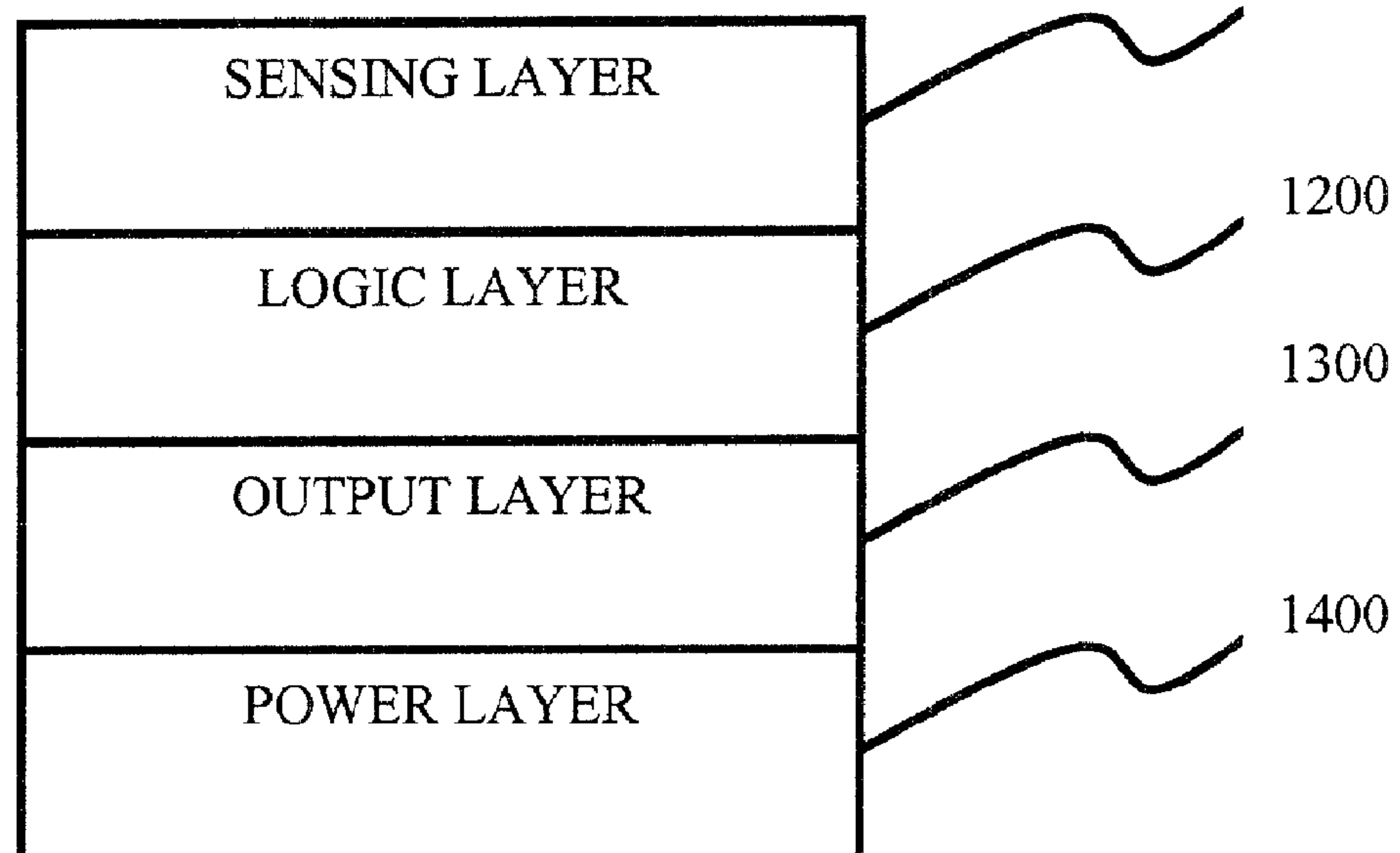
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(54) Titre : METHODE, APPAREIL ET SYSTEME DE DETECTION D'INCENDIE

(54) Title: METHOD, APPARATUS AND SYSTEM FOR FIRE DETECTION

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(57) Abrégé/Abstract:

An apparatus for detecting and indicating the presence of combustion products comprising a first combustion product monitor for monitoring for the presence of a first combustion product and quantifying said first product; a second combustion product monitor



(57) **Abrégé(suite)/Abstract(continued):**

for monitoring for the presence of a second combustion product and quantifying said second product; and, an alarm connected to the first and second combustion product monitors for triggering an alarm when an alarm condition is satisfied, said alarm condition being at least one of the group consisting of the quantified presence of the first combustion product exceeding a first-product threshold level and the quantified presence of the second combustion product exceeding a first second-product threshold level; and, the quantified presence of the second combustion product exceeding a second second-product threshold level.

1 **ABSTRACT**

2 An apparatus for detecting and indicating the presence of combustion products
3 comprising a first combustion product monitor for monitoring for the presence of a first
4 combustion product and quantifying said first product; a second combustion product
5 monitor for monitoring for the presence of a second combustion product and
6 quantifying said second product; and, an alarm connected to the first and second
7 combustion product monitors for triggering an alarm when an alarm condition is
8 satisfied, said alarm condition being at least one of the group consisting of the
9 quantified presence of the first combustion product exceeding a first-product threshold
10 level and the quantified presence of the second combustion product exceeding a first
11 second-product threshold level; and, the quantified presence of the second combustion
12 product exceeding a second second-product threshold level.

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METHOD, APPARATUS AND SYSTEM FOR FIRE DETECTION

The present invention relates to a method, apparatus and system for fire detection. In particular, the present invention relates to a method, apparatus and system for fire detection having a plurality of sensory inputs.

BACKGROUND OF THE INVENTION

[0001] Annually, fires are responsible for extensive property damage and loss of life. Various fire detection systems have been employed in an attempt to reduce the extent of property damage and the likelihood of loss of life.

[0002] Residential buildings are often equipped with fire detectors that use one type of sensing method to detect for the presence of fire. For example, a smoke detector employing an ionization sensor may trigger an alarm if the sensor detects an increase in the density of air borne particulate matter. Ionisation sensors are known to have a high rate of false positive readings in the presence of dust and cooking vapours in particular. As a result, smoke detectors of this type are often disabled, thereby increasing the risk of property damage and loss of life.

[0003] Some fire detector systems, such as described in Weimeyer (US5,726,633), employ two sensors and as such two sensory inputs to detect for the presence of fire. However, these systems often employ complex algorithms (such as fuzzy logic) and microprocessor technology to process the sensory inputs to determine when an alarm

1 condition has occurred. As a result, solutions of this type are often unnecessarily
2 complex and expensive for sensing fire in residential settings.

3 [0004] There remains a need for a simple, low cost system, method and apparatus
4 for detecting fire and the products of combustion.

5

6 SUMMARY OF THE INVENTION

7

8 [0005] The present invention provides a method for detecting and indicating the
9 presence of combustion products comprising the steps of monitoring for the presence of
10 a first combustion product and quantifying said first product; monitoring for the
11 presence of a second combustion product and quantifying said second product; and,
12 triggering an alarm when an alarm condition is satisfied, said alarm condition being at
13 least one of the group consisting of the quantified presence of the first combustion
14 product exceeding a first-product threshold level and the quantified presence of the
15 second combustion product exceeding a first second-product threshold; and, the
16 quantified presence of the second combustion product exceeding a second second-
17 product threshold.

18 [0006] In an alternate embodiment, the present invention provides a method for
19 detecting and indicating the presence of combustion products comprising the steps of
20 monitoring for the presence of a combustion gas and quantifying the combustion gas;
21 monitoring for the presence of an air borne particulate matter and quantifying the air
22 borne particulate matter; measuring an ambient temperature and quantifying a change
23 in the ambient temperature; and, triggering an alarm when an alarm condition is

1 satisfied, said alarm condition being at least one of the group consisting of the
2 quantified presence of the combustion gas exceeding a threshold combustion gas level
3 and the quantified presence of the air borne particulate matter exceeding a first
4 threshold air borne particulate matter level; the quantified presence of the air borne
5 particulate matter exceeding a second threshold air borne particulate matter level; and,
6 the quantified rate of change in the ambient temperature exceeding a threshold
7 temperature change level.

8 [0007] The first combustion product may be a combustion gas, selected from the
9 group consisting of CO, CO₂, HCN, HCl, SO_x, NO_x, and combinations thereof.

10 [0008] The second indicator of combustion may be air borne particulate matter,
11 such as smoke particles.

12 [0009] The present invention also provides a system for detecting and indicating the
13 presence of combustion products comprising a first combustion product monitor for
14 monitoring for the presence of a first combustion product and quantifying said first
15 product; a second combustion product monitor for monitoring for the presence of a
16 second combustion product and quantifying said second product; and, an alarm in
17 communication with the first and second combustion product monitors for triggering
18 an alarm when an alarm condition is satisfied, said alarm condition being at least one of
19 the group consisting of the quantified presence of the first combustion product
20 exceeding a first-product threshold level and the quantified presence of the second
21 combustion product exceeding a first second-product threshold level; and, the
22 quantified presence of the second combustion product exceeding a second second-
23 product threshold level.

1 [0010] In an alternate embodiment, the present invention provides a system for
2 detecting and indicating the presence of combustion products comprising a
3 combustion gas monitor for monitoring for the presence of a combustion gas and
4 quantifying the combustion gas; an air borne particulate matter monitor for monitoring
5 for the presence of an air borne particulate matter and quantifying the air borne
6 particulate matter; a temperature monitor for measuring an ambient temperature and
7 quantifying a rate of change for the ambient temperature; and, an alarm in
8 communication with the combustion gas monitor, air borne particulate matter monitor
9 and temperature monitor for triggering an alarm when an alarm condition is satisfied,
10 said alarm condition being at least one of the group consisting of the quantified
11 presence of the combustion gas exceeding a threshold combustion gas level and the
12 quantified presence of the air borne particulate matter exceeding a first threshold air
13 borne particulate matter level; the quantified presence of the air borne particulate
14 matter exceeding a second threshold air borne particulate matter level; and, the
15 quantified rate of change in the ambient temperature exceeding a threshold
16 temperature change level.

17 [0011] The first-product monitor may be a micro-electronic gas sensor.

18 [0012] The second-product monitor may be a photo-electric particle detector.

19 [0013] The present invention further provides an apparatus for detecting and
20 indicating the presence of combustion products comprising a first combustion product
21 monitor for monitoring for the presence of a first combustion product and quantifying
22 said first product; a second combustion product monitor for monitoring for the
23 presence of a second combustion product and quantifying said second product; and, an
24 alarm connected to the first and second combustion product monitors for triggering an

1 alarm when an alarm condition is satisfied, said alarm condition being at least one of
2 the group consisting of the quantified presence of the first combustion product
3 exceeding a first-product threshold level and the quantified presence of the second
4 combustion product exceeding a first second-product threshold level; and, the
5 quantified presence of the second combustion product exceeding a second second-
6 product threshold level.

7 [0014] In an alternate embodiment, the present invention provides an apparatus for
8 detecting and indicating the presence of combustion products comprising a combustion
9 gas monitor for monitoring for the presence of a combustion gas and quantifying the
10 combustion gas; an air borne particulate matter monitor for monitoring for the
11 presence of an air borne particulate matter and quantifying the air borne particulate
12 matter; a temperature monitor for measuring an ambient temperature and quantifying
13 a rate of change for the ambient temperature; and, an alarm connected to the
14 combustion gas monitor, air borne particulate matter monitor and temperature monitor
15 for triggering an alarm when an alarm condition is satisfied, said alarm condition being
16 at least one of the group consisting of the quantified presence of the combustion gas
17 exceeding a threshold combustion gas level and the quantified presence of the air borne
18 particulate matter exceeding a first threshold air borne particulate matter level; the
19 quantified presence of the air borne particulate matter exceeding a second threshold air
20 borne particulate matter level; and, the quantified rate of change in the ambient
21 temperature exceeding a threshold temperature change level.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other features of the preferred embodiments of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings wherein:

[0016] Figure 1 is a schematic drawing of the architecture of a fire detector according to an embodiment of the present invention;

[0017] Figure 2 is a schematic drawing of an apparatus for detecting the presence of fire and products of combustion according to an embodiment of the present invention;

[0018] Figure 3 is a schematic drawing illustrating a system for detecting and indicating the presence of combustion products according to an embodiment of the present invention;

[0019] Figure 4 is a flow chart illustrating a method for detecting and indicating the presence of combustion products according to an embodiment of the present invention;

[0020] Figure 5 is a schematic drawing illustrating an apparatus for detecting and indicating the presence of combustion products according to an alternate embodiment of the present invention;

[0021] Figure 6 is a schematic drawing illustrating the apparatus in Figure 5 according to a further alternate embodiment of the present invention;

[0022] Figure 7 is a schematic drawing illustrating a system for detecting and indicating the presence of combustion products according to an alternate embodiment of the present invention;

1 [0023] Figure 8 is a schematic drawing illustrating the system in Figure 7 according
2 to a further alternate embodiment of the present invention; and

3 [0024] Figure 9 is a schematic drawing illustrating a method of detecting and
4 indicating the presence of combustion products according to an alternate embodiment
5 of the present invention.

6 7 DESCRIPTION OF THE PREFERRED EMBODIMENTS

8 [0025] Referring to Figure 1, a schematic representation of the architecture 1000 of a
9 fire detector according to a preferred embodiment of the present invention is illustrated.
10 The fire detector includes a sensing layer 1100, a logic layer 1200, an output layer 1300
11 and a power layer 1400.

12 [0026] In a first embodiment, the sensing layer 1100 consists of opto-electronic and
13 electronic devices that detect and quantify the presence of air borne particulate matter,
14 such as smoke particles, and specific gases of combustion, such as CO₂, CO, HCN, HCl,
15 SO_x, NO_x and combinations thereof. In a preferred embodiment of the present
16 invention, the sensing layer 1100 further includes a thermal sensor to detect and
17 quantify any change in the ambient temperature. The thermal sensor is preferably a
18 thermistor.

19 [0027] The logic layer 1200, in a preferred embodiment, uses electronic circuitry to
20 prioritize the sensory outputs of the sensing layer 1100. The sensory outputs of the
21 sensing layer 1100 are assessed to determine whether the conditions that indicate the

1 presence of a fire have been satisfied. The logic layer 1200 uses electronic circuitry to
2 prioritize the sensory outputs of the sensing layer 1100.

3 [0028] The output of the logic layer 1200 is sent to the output layer 1300. If the
4 conditions that indicate the presence of a fire have been satisfied, the output layer 1300
5 activates an alarm indicating the presence of a fire. The alarm may be a visual alarm,
6 such as flashing lights, an audible alarm, such as a siren, or any combination of audio
7 and visual outputs that may indicate to an individual that the fire detector has detected
8 a fire.

9 [0029] The fire detector is powered by the power layer 1400, which delivers electrical
10 power to the components of the sensing layer 1100, logic layer 1200 and output layer
11 1300. The power layer 1400 may be energized by alternating current voltages and direct
12 current power.

13 [0030] Referring to Figure 2, an apparatus 300 for detecting and indicating the
14 presence of combustion products according to a preferred embodiment of the present
15 invention is illustrated. The apparatus 300 is comprised of a first combustion product
16 monitor 301, which monitors for the presence of a first combustion product and
17 quantifies the first product. In a preferred embodiment, the first combustion product
18 monitor is a combustion gas monitor 301 for monitoring for the presence of a
19 combustion gas and quantifying the combustion gas. The apparatus 300 is also
20 comprised of a second combustion product monitor 303, which monitors for the
21 presence of a second combustion product and quantifies the second product. In a
22 preferred embodiment, the second combustion product monitor 303 is an air borne
23 particulate matter monitor 303 for monitoring for the presence of an air borne
24 particulate matter and quantifying the air borne particulate matter. An alarm 307 is

1 connected to and in communication with the combustion gas monitor 301 and air borne
2 particulate matter monitor 303 for triggering an alarm response when an alarm
3 condition is satisfied.

4 [0031] The combustion gas monitor 301 may be a micro-electronic gas sensor 309, as
5 is known to those skilled in the art, such as the F-2 CO sensor, as manufactured by
6 Teledyne Analytical Instruments of City of Industry, California USA. In a preferred
7 embodiment, the micro-electronic gas sensor 309 is the model TGS 203 as manufactured
8 by Figaro USA Inc. of Glenview, Illinois USA, but any gas sensor known to those skilled
9 in the art that is able to monitor for the presence of and quantify a combustion gas may
10 be employed. The combustion gas may be selected from the group consisting of CO,
11 CO₂, HCN, HCl, SO_x, NO_x and combinations thereof. In a preferred embodiment, the
12 selected combustion gas is CO.

13 [0032] The gas sensor 309 monitors for the presence of the selected combustion gas
14 and quantifies the level of the selected gas. In the present embodiment, the gas sensor
15 309 quantifies the concentration of the selected gas. The gas sensor 309 measures a
16 change in electrical resistance, that is proportional to the concentration of the gas being
17 detected, to generate a voltage signal. In an alternate embodiment, the gas sensor 309
18 measures optical absorption or transmission at one or more optical wavelengths to
19 generate a voltage signal that is proportional to the concentration of the gas being
20 detected. In a preferred embodiment, the gas sensor 309 measures the change in
21 electrical resistance to generate a voltage signal proportional to the concentration of the
22 gas being detected.

23 [0033] The gas sensor 309 generates a signal that corresponds to the quantified level
24 of the selected gas. The generated signal may be a digital or analog indicator of the

1 selected gas level. In a preferred embodiment, the generated signal is a gas voltage
2 signal corresponding to the quantified gas level, which is sent to a gas comparison stage
3 311. The gas comparison stage 311 determines if the generated signal exceeds a
4 threshold gas level; in the present embodiment, if the received gas voltage signal
5 exceeds a threshold gas level. In a preferred embodiment, the gas comparison stage 311
6 is an analog comparator of the type known to those skilled in the art. In alternate
7 embodiments of the present invention, the comparison stage 311 may be a digital
8 comparator, an operation amplifier that filters or amplifies an input signal and
9 generates an output signal from only a subset of possible inputs, or a logic device
10 operating under a programmed control, such as a microprocessor, compact
11 programmable logic device or a field programmable gate array. Any other means
12 known to those skilled in the art that can receive an input signal that corresponds to the
13 quantified level of the selected gas, compare the input signal to a reference value
14 corresponding to a gas concentration above a threshold level and generate an output
15 signal if a threshold condition is satisfied may be employed.

16 [0034] If the quantified gas level exceeds the threshold gas level, the generated gas
17 voltage signal is sent to a signal combiner 313. The signal combiner 313 is configured to
18 receive and combine signals generated by the combustion gas monitor 301 and the air
19 borne particulate matter monitor 303 and to determine if an alarm condition has been
20 satisfied. In a preferred embodiment of the present invention, the gas signal is sent to
21 an AND logic gate 315 of the combiner 313.

22 [0035] The air borne particulate matter monitor 303 monitors for the presence of air
23 borne particulate matter. In a preferred embodiment, the air borne particulate matter is
24 smoke particles.

1 [0036] The air borne particulate matter monitor 303 may be a photo-electric particle
2 detector 317, as is known to those skilled in the art, that incorporates an emitter, such as
3 model IRLED-E23 or IRLED-E24 manufactured by Gilway Technical Lamp, and a
4 detector, such as model PDB -C134 (F) manufactured by Photonic Detectors Inc. of Simi
5 Valley, California, USA. In a preferred embodiment the photoelectric detector 317
6 incorporates an emitter model PDI -E808 and a detector model PDB -C134 (F) both
7 manufactured by Photonic Detectors Inc. of Simi Valley, California, USA, but any air
8 borne particulate matter monitor known to those skilled in the art that is able to
9 monitor for the presence of and quantify the level of air borne particulate matter may be
10 employed.

11 [0037] The photoelectric particle detector 317 monitors for the presence of the
12 selected air borne particulate matter and quantifies the level of the selected matter. In a
13 preferred embodiment, the photo-electric particle detector 317 quantifies the
14 concentration and density of the smoke particles.

15 [0038] The particle detector 317 generates a signal that corresponds to the measured
16 level of the selected air borne particulate matter. The generated signal may be a digital
17 or analog indicator of the air borne particulate matter level. In a preferred embodiment,
18 the generated signal is a particle voltage signal corresponding to the air borne
19 particulate matter level, which is sent to a particle comparison stage 319. The particle
20 comparison stage 319 includes a "low" particle comparison stage 321 and a "high"
21 particle comparison stage 323, each of which receive the particle voltage signal. The
22 "low" particle comparison stage 321 determines if the received particle voltage signal
23 exceeds a "low" particle threshold level and the "high" particle comparison stage 323
24 determines if the particle voltage signal exceeds a "high" particle threshold level.

1 [0039] In a preferred embodiment, the particle comparison stage 319 is an analog
2 comparator of the type known to those skilled in the art. In alternate embodiments of
3 the present invention, the particle comparison stage 319 may be a digital comparator, an
4 operation amplifier that filters or amplifies an input signal and generates an output
5 signal from only a subset of possible inputs, or a logic device operating under a
6 programmed control, such as a microprocessor, compact programmable logic device or
7 a field programmable gate array. Any other means known to those skilled in the art
8 that can receive an input signal that corresponds to the quantified level of the selected
9 particle, compare the input signal to a reference value corresponding to a threshold
10 particle level and generate an output signal if a threshold condition is satisfied may be
11 employed.

12 [0040] If the quantified air borne particulate matter level exceeds the "low" particle
13 threshold, the generated "low" particle voltage signal is sent to the combiner 313. In a
14 preferred embodiment of the present invention, the "low" particle voltage signal is sent
15 to the AND logic gate 315 of the combiner 313. If the quantified air borne particulate
16 matter level exceeds the "high" particle threshold level, the generated "high" particle
17 voltage signal is sent to the combiner 313. In a preferred embodiment of the present
18 invention, the "high" particle voltage signal is sent to a OR logic gate 325 of the
19 combiner 313.

20 [0041] The signal combiner 313 is configured to receive signals from the gas
21 comparison stage 311 and particle comparison stage 319, respectively. The AND logic
22 gate 315 is configured to receive signals from the gas comparison stage 311 when the
23 gas comparison stage 311 determines that the gas threshold level has been exceeded.
24 The AND logic gate 315 is also configured to receive signals from the "low" particle

1 comparison stage 321 when the "low" particle comparisons stage 321 determines that
2 the "low" particle threshold level has been exceeded.

3 [0042] The OR logic gate 325 is connected to and in communication with the AND
4 logic gate 315 and is also connected to and configured to receive signals from the "high"
5 particle comparison stage 323 when the "high" particle comparison stage 323
6 determines that the "high" particle threshold level has been exceeded.

7 [0043] The OR logic gate 325 is further connected to the alarm 307, which is
8 triggered when an alarm condition is satisfied, the alarm condition being satisfied when
9 at least one of the following occurs:

10 [0044] (a) the quantified presence of the combustion gas exceeds the combustion gas
11 threshold level and the quantified presence of the air borne particles exceeds the "low"
12 particle threshold level (i.e., a first threshold air borne particulate matter level); and,

13 [0045] (b) the quantified presence of the air borne particles exceeds the "high"
14 particle threshold level (i.e., a second threshold air borne particulate matter level).

15 [0046] In the event that the first alarm condition (a) is satisfied, an alarm signal is
16 sent from the AND logic gate 315, through the OR logic gate 325, to the alarm 307, at
17 which point an alarm signal is generated indicating the presence of a fire. In a preferred
18 embodiment of the present invention, the AND logic gate 315 communicates a voltage
19 signal to the alarm 307.

20 [0047] In the event that the second alarm condition (b) is satisfied, an alarm signal is
21 sent from the OR logic gate 325 to the alarm 307, at which point an alarm signal is

1 generated indicating the presence of a fire. In a preferred embodiment of the present
2 invention, the first OR logic gate 325 communicates a voltage signal to the alarm 307.

3 [0048] In a preferred embodiment, the first combustion monitor 301, second
4 combustion monitor 303, alarm 307, comparison stage 311 and combiner 313 are
5 mounted in a housing 399. The housing 399 includes access points, which provide the
6 monitors 301 and 303 with access to the outside environment in order to monitor for the
7 presence of the first and second combustion products, respectively.

8 [0049] Referring to Figure 3, a system 400 for detecting and indicating the presence
9 of combustion products according to an embodiment of the present invention is
10 illustrated. The system 400 is comprised of a first combustion product monitor 401,
11 which monitors for the presence of a first combustion product and quantifies the first
12 product. In a preferred embodiment, the first combustion product monitor 401 is a
13 combustion gas monitor 401 for monitoring for the presence of a combustion gas and
14 quantifying the combustion gas. The system 400 is also comprised of a second
15 combustion product monitor 403, which monitors for the presence of a second
16 combustion product and quantifies the second product. In a preferred embodiment, the
17 second combustion product monitor 403 is an air borne particulate matter monitor 403
18 for monitoring for the presence of an air borne particulate matter and quantifying the
19 air borne particulate matter. An alarm 407 is in communication with the combustion
20 gas monitor 401 and the air borne particulate matter monitor 403 for triggering an alarm
21 response when an alarm condition is satisfied.

22 [0050] The combustion gas monitor 401 may be a micro-electronic gas sensor 409, as
23 is known to those skilled in the art, such as the F-2 CO sensor, as manufactured by
24 Teledyne Analytical Instruments of City of Industry, California USA. In a preferred

embodiment, the micro-electronic gas sensor 409 is the model TGS 203 as manufactured by Figaro USA Inc. of Glenview, Illinois USA, but any gas sensor known to those skilled in the art that is able to monitor for the presence of and quantify a combustion gas may be employed. The combustion gas may be selected from the group consisting of CO, CO₂, HCN, HCl, SO_x, NO_x and combinations thereof. In a preferred embodiment, the selected combustion gas is CO.

[0051] The gas sensor 409 monitors for the presence of the selected combustion gas and quantifies the level of the selected gas. In the present embodiment, the gas sensor 409 quantifies the concentration of the selected gas. The gas sensor 409 measures a change in electrical resistance, that is proportional to the concentration of the gas being detected, to generate a voltage signal. In an alternate embodiment, the gas sensor 409 measures optical absorption or transmission at one or more optical wavelengths to generate a voltage signal that is proportional to the concentration of the gas being detected. In a preferred embodiment, the gas sensor 409 measures the change in electrical resistance to generate a voltage signal proportional to the concentration of the gas being detected.

[0052] The gas sensor 409 generates a signal that corresponds to the quantified level of the selected gas. The generated signal may be a digital or analog indicator of the selected gas level. In a preferred embodiment, the generated signal is a gas voltage signal corresponding to the quantified gas level, which is sent to a gas comparison stage 411. The gas comparison stage 411 determines if the generated signal exceeds a threshold gas level; in the present embodiment, if the received gas voltage signal exceeds a threshold gas level. In a preferred embodiment, the gas comparison stage 411 is an analog comparator of the type known to those skilled in the art. In alternate

1 embodiments of the present invention, the comparison stage 411 may be a digital
2 comparator, an operation amplifier that filters or amplifies an input signal and
3 generates an output signal from only a subset of possible inputs, or a logic device
4 operating under a programmed control, such as a microprocessor, compact
5 programmable logic device or a field programmable gate array. Any other means
6 known to those skilled in the art that can receive an input signal that corresponds to the
7 quantified level of the selected gas, compare the input signal to a reference value
8 corresponding to a threshold gas level and generate an output signal if a threshold
9 condition is satisfied may be employed.

10 [0053] If the quantified gas level exceeds the threshold gas level, the generated gas
11 voltage signal is sent to a signal combiner 413. The signal combiner 413 is configured to
12 receive and combine signals generated by the combustion gas monitor 401 (i.e., gas
13 sensor 409) and the air borne particulate matter monitor 403 and to determine if an
14 alarm condition has been satisfied. In a preferred embodiment of the present invention,
15 the gas signal is sent to an AND logic gate 415 of the combiner 413.

16 [0054] The air borne particulate matter monitor 403 monitors for the presence of air
17 borne particulate matter. In a preferred embodiment, the air borne particulate matter is
18 smoke particles.

19 [0055] The air borne particulate matter monitor 403 may be a photo-electric particle
20 detector 417, as is known to those skilled in the art, that incorporates an emitter model
21 IRLED-E23 or IRLED-E24 manufactured by Gilway Technical Lamp and a detector
22 model PDB -C134 (F) manufactured by Photonic Detectors Inc. of Simi Valley,
23 California, USA. In a preferred embodiment the photoelectric detector 417 incorporates
24 an emitter model PDI -E808 and a detector model PDB -C134 (F) both manufactured by

1 Photonic Detectors Inc. of Simi Valley, California, USA, but any air borne particulate
2 matter monitor known to those skilled in the art that is able to monitor for the presence
3 of and quantify the level of air borne particulate matter may be employed.

4 [0056] The photoelectric particle detector 417 monitors for the presence of the
5 selected air borne particulate matter and quantifies the level of the selected matter. In a
6 preferred embodiment, the photo-electric particle detector 417 quantifies the
7 concentration and density of the smoke particles.

8 [0057] The particle detector 417 generates a signal that corresponds to the measured
9 level of the selected air borne particulate matter. The generated signal may be a digital
10 or analog indicator of the air borne particulate matter level. In a preferred embodiment,
11 the generated signal is a particle voltage signal corresponding to the air borne
12 particulate matter level, which is sent to a particle comparison stage 419. The particle
13 comparison stage 419 includes a "low" particle comparison stage 421 and a "high"
14 particle comparison stage 423, each of which receive the particle voltage signal. The
15 "low" particle comparison stage 421 determines if the received particle voltage signal
16 exceeds a "low" particle threshold level and the "high" particle comparison stage 423
17 determines if the particle voltage signal exceeds a "high" particle threshold level. In a
18 preferred embodiment, the particle comparison stage 419 is an analog comparator of the
19 type known to those skilled in the art. In alternate embodiments of the present
20 invention, the particle comparison stage 419 may be a digital comparator, an operation
21 amplifier that filters or amplifies an input signal and generates an output signal from
22 only a subset of possible inputs, or a logic device operating under a programmed
23 control, such as a microprocessor, compact programmable logic device or a field
24 programmable gate array. Any other means known to those skilled in the art that can

1 receive an input signal that corresponds to the quantified level of the selected particle,
2 compare the input signal to a reference value corresponding to a threshold particle level
3 and generate an output signal if a threshold condition is satisfied may be employed.

4 [0058] If the quantified air borne particulate matter level exceeds the "low" particle
5 threshold, the generated "low" particle voltage signal is sent to the combiner 413. In a
6 preferred embodiment of the present invention, the "low" particle voltage signal is sent
7 to the AND logic gate 415 of the combiner 413. If the quantified air borne particulate
8 matter level exceeds the "high" particle threshold level, the generated "high" particle
9 voltage signal is sent to the combiner 413. In a preferred embodiment of the present
10 invention, the "high" particle voltage signal is sent to a OR logic gate 425 of the
11 combiner 413.

12 [0059] The signal combiner 413 is configured to communicate with and receive
13 signals from the gas comparison stage 411 and the particle comparison stage 419,
14 respectively. The AND logic gate 415 is configured to receive signals from the gas
15 comparison stage 411 when the gas comparison stage 411 determines that the gas
16 threshold level has been exceeded. The AND logic gate 415 is also configured to receive
17 signals from the "low" particle comparison stage 421 when the "low" particle
18 comparison stage 221 determines that the "low" particle threshold level has been
19 exceeded.

20 [0060] The OR logic gate 425 is in communication with the AND logic gate 415 and
21 is also in communication with and configured to receive signals from the "high"
22 particle comparison stage 423 when the "high" particle comparison stage 423
23 determines that the "high" particle threshold level has been exceeded.

1 [0061] The OR logic gate 425 is further in communication with the alarm 407, which
2 is triggered when an alarm condition is satisfied, the alarm condition being satisfied
3 when at least one of the following occurs:

4 [0062] (a) the quantified presence of the combustion gas exceeds the combustion gas
5 threshold level and the quantified presence of the air borne particles exceeds the "low"
6 particle threshold level (i.e., a first threshold air borne particulate matter level); and,

7 [0063] (b) the quantified presence of the air borne particles exceeds the "high"
8 particle threshold level (i.e., a second threshold air borne particulate matter level).

9 [0064] In the event that the first alarm condition (a) is satisfied, an alarm signal is
10 sent from the AND logic gate 415, through the OR logic gate 425, to the alarm 407, at
11 which point an alarm signal is generated indicating the presence of a fire. In a preferred
12 embodiment of the present invention, the AND logic gate 415 communicates a voltage
13 signal to the alarm 207.

14 [0065] In the event that the second alarm condition (b) is satisfied, an alarm signal is
15 sent from the OR logic gate 425 to the alarm 407, at which point an alarm signal is
16 generated indicating the presence of a fire. In a preferred embodiment of the present
17 invention, the OR logic gate 425 communicates a voltage signal to the alarm 407.

18 [0066] Referring to Figure 4, a flow chart diagram illustrates a method for detecting
19 and indicating the presence of combustion products according to an embodiment of the
20 present invention. The method begins at step 100, where the presence of a first
21 combustion product is monitored for and quantified. The first combustion product may
22 be a combustion gas, such as CO, CO₂, HCN, HCl, SO_x, NO_x, and combinations thereof.
23 In a preferred embodiment of the present invention, the combustion gas is CO. The

1 combustion gas may be monitored for and quantified by any gas sensor known to those
2 skilled in the art, such as the F-2 CO sensor, as manufactured by Teledyne Analytical
3 Instruments of City of Industry, California USA. In a preferred embodiment, the micro-
4 electronic gas sensor is the model TGS 203 as manufactured by Figaro USA Inc. of
5 Glenview, Illinois USA, but any gas sensor known to those skilled in the art that is able
6 to monitor for the presence of and quantify a combustion gas may be employed.

7 [0067] At step 200, the presence of a second combustion product is monitored for
8 and quantified. In a preferred embodiment, the second indicator of combustion is air
9 borne particulate matter, such as smoke particles. The smoke particles may be
10 monitored for and quantified by any smoke particle detector known to those skilled in
11 the art, that incorporates an emitter model IRLED-E23 or IRLED-E24 manufactured by
12 Gilway Technical Lamp and a detector model PDB -C134 (F) manufactured by Photonic
13 Detectors Inc. of Simi Valley, California, USA. In a preferred embodiment the smoke
14 detector incorporates an emitter model PDI -E808 and a detector model PDB -C134 (F)
15 both manufactured by Photonic Detectors Inc. of Simi Valley, California, USA.

16 [0068] At step 300, the outputs of steps 100 and 200 are compared to a first alarm
17 triggering condition to determine if the first alarm condition has been satisfied. The
18 first alarm condition is satisfied when the quantified presence of the first combustion
19 product exceeds a first-product threshold level and the quantified presence of the
20 second combustion product exceeds a first second-product threshold.

21 [0069] At step 400, the output of step 200 is compared to a second alarm triggering
22 condition to determine if the second alarm triggering condition has been satisfied. The
23 second alarm condition has been satisfied when the quantified presence of the second
24 combustion product exceeds a second second-product threshold.

1 [0070] At step 500, an alarm is triggered when at least one alarm condition is
2 satisfied.

3 [0071] Referring to Figure 5, an apparatus 100 for detecting and indicating the
4 presence of combustion products according an alternate embodiment of the present
5 invention is illustrated. The apparatus 100 is comprised of a combustion gas monitor
6 101 for monitoring for the presence of a combustion gas and quantifying the
7 combustion gas; an air borne particulate matter monitor 103 for monitoring for the
8 presence of an air borne particulate matter and quantifying the air borne particulate
9 matter; a temperature monitor 105 for measuring an ambient temperature and
10 quantifying a change in the ambient temperature; and, an alarm 107 connected to and in
11 communication with the combustion gas monitor 101, air borne particulate matter
12 monitor 103 and temperature monitor 105 for triggering an alarm response when an
13 alarm condition is satisfied.

14 [0072] The combustion gas monitor 101 may be a micro-electronic gas sensor 109, as
15 is known to those skilled in the art, such as the F-2 CO sensor, as manufactured by
16 Teledyne Analytical Instruments of City of Industry, California USA. In a preferred
17 embodiment, the micro-electronic gas sensor 109 is the model TGS 203 as manufactured
18 by Figaro USA Inc. of Glenview, Illinois USA, but any gas sensor known to those skilled
19 in the art that is able to monitor for the presence of and quantify a combustion gas may
20 be employed. The combustion gas may be selected from the group consisting of CO,
21 CO₂, HCN, HCl, SO_x, NO_x and combinations thereof. In a preferred embodiment, the
22 selected combustion gas is CO.

23 [0073] The gas sensor 109 monitors for the presence of the selected combustion gas
24 and quantifies the level of the selected gas. In the present embodiment, the gas sensor

1 109 quantifies the concentration of the selected gas. The gas sensor 109 measures a
2 change in electrical resistance, that is proportional to the concentration of the gas being
3 detected, to generate a voltage signal. In an alternate embodiment, the gas sensor 109
4 measures optical absorption or transmission at one or more optical wavelengths to
5 generate a voltage signal that is proportional to the concentration of the gas being
6 detected. In a preferred embodiment, the gas sensor 109 measures the change in
7 electrical resistance to generate a voltage signal proportional to the concentration of the
8 gas being detected.

9 [0074] The gas sensor 109 generates a signal that corresponds to the quantified level
10 of the selected gas. The generated signal may be a digital or analog indicator of the
11 selected gas level. In a preferred embodiment, the generated signal is a gas voltage
12 signal corresponding to the quantified gas level, which is sent to a gas comparison stage
13 111. The gas comparison stage 111 determines if the generated signal exceeds a
14 threshold gas level; in the present embodiment, if the received gas voltage signal
15 exceeds a threshold gas level. In a preferred embodiment, the gas comparison stage 111
16 is an analog comparator of the type known to those skilled in the art. In alternate
17 embodiments of the present invention, the comparison stage 111 may be a digital
18 comparator, an operation amplifier that filters or amplifies an input signal and
19 generates an output signal from only a subset of possible inputs, or a logic device
20 operating under a programmed control, such as a microprocessor, compact
21 programmable logic device or a field programmable gate array. Any other means
22 known to those skilled in the art that can receive an input signal that corresponds to the
23 quantified level of the selected gas, compare the input signal to a reference value
24 corresponding to a threshold gas level and generate an output signal if a threshold
25 condition is satisfied may be employed.

1 [0075] If the quantified gas level exceeds the threshold gas level, the generated gas
2 voltage signal is sent to a signal combiner 113. The signal combiner 113 is configured to
3 receive and combine signals generated by the combustion gas monitor 101, air borne
4 particulate matter monitor 103 and temperature monitor 105 and to determine if an
5 alarm condition has been satisfied. In a preferred embodiment of the present invention,
6 the gas signal is sent to an AND logic gate 115 of the combiner 113.

7 [0076] The air borne particulate matter monitor 103 monitors for the presence of air
8 borne particulate matter. In a preferred embodiment, the air borne particulate matter is
9 smoke particles.

10 [0077] The air borne particulate matter monitor 103 may be a photo-electric particle
11 detector 117, as is known to those skilled in the art, that incorporates an emitter model
12 IRLED-E23 or IRLED-E24 manufactured by Gilway Technical Lamp and a detector
13 model PDB -C134 (F) manufactured by Photonic Detectors Inc. of Simi Valley,
14 California, USA. In a preferred embodiment the photoelectric detector 117 incorporates
15 an emitter model PDI -E808 and a detector model PDB -C134 (F) both manufactured by
16 Photonic Detectors Inc. of Simi Valley, California, USA, but any air borne particulate
17 matter monitor known to those skilled in the art that is able to monitor for the presence
18 of and quantify the level of air borne particulate matter may be employed.

19 [0078] The photoelectric particle detector 117 monitors for the presence of the
20 selected air borne particulate matter and quantifies the level of the selected matter. In a
21 preferred embodiment, the photo-electric particle detector 117 quantifies the
22 concentration and density of the smoke particles.

1 [0079] The particle detector 117 generates a signal that corresponds to the measured
2 level of the selected air borne particulate matter. The generated signal may be a digital
3 or analog indicator of the air borne particulate matter level. In a preferred embodiment,
4 the generated signal is a particle voltage signal corresponding to the air borne
5 particulate matter level, which is sent to a particle comparison stage 119. The particle
6 comparison stage 119 includes a "low" particle comparison stage 121 and a "high"
7 particle comparison stage 123, each of which receive the particle voltage signal. The
8 "low" particle comparison stage 121 determines if the received particle voltage signal
9 exceeds a "low" particle threshold level and the "high" particle comparison stage 123
10 determines if the particle voltage signal exceeds a "high" particle threshold level. In a
11 preferred embodiment, the particle comparison stage 119 is an analog comparator of the
12 type known to those skilled in the art. In alternate embodiments of the present
13 invention, the particle comparison stage 119 may be a digital comparator, an operation
14 amplifier that filters or amplifies an input signal and generates an output signal from
15 only a subset of possible inputs, or a logic device operating under a programmed
16 control, such as a microprocessor, compact programmable logic device or a field
17 programmable gate array. Any other means known to those skilled in the art that can
18 receive an input signal that corresponds to the quantified level of the selected particle,
19 compare the input signal to a reference value corresponding to a threshold particle level
20 and generate an output signal if a threshold condition is satisfied may be employed.

21 [0080] If the quantified air borne particulate matter level exceeds the "low" particle
22 threshold, the generated "low" particle voltage signal is sent to the combiner 113. In a
23 preferred embodiment of the present invention, the "low" particle voltage signal is sent
24 to the AND logic gate 115 of the combiner 113. If the quantified air borne particulate
25 matter level exceeds the "high" particle threshold level, the generated "high" particle

1 voltage signal is sent to the combiner 113. In a preferred embodiment of the present
2 invention, the "high" particle voltage signal is sent to a first OR logic gate 125 of the
3 combiner 113.

4 [0081] The temperature monitor 105 measures the ambient temperature and
5 quantifies any change in the ambient temperature. The temperature monitor 105 may
6 be a thermistor 127, as is known to those skilled in the art, such as the model
7 NTSAOHXH103_E1BO as manufactured by Murata Manufacturing Company Ltd of
8 Kyoto, Japan. In a preferred embodiment of the present invention, the thermistor 127 is
9 the model MLX 90247 LRA-C as manufactured by Melexis Microelectronic Integrated
10 Systems of Concord, New Hampshire USA, but any temperature monitor known to
11 those skilled in the art that is able to measure ambient temperature and quantify
12 ambient temperature changes may be employed.

13 [0082] The temperature monitor 105 generates a signal that corresponds to the
14 change in the ambient temperature. The generated signal may be a digital or analog
15 indicator of the ambient temperature. In a preferred embodiment, the generated signal
16 is a voltage temperature signal corresponding to the ambient temperature, which is sent
17 to a temperature comparison stage 129. The temperature comparison stage 129
18 determines if the quantified temperature change exceeds a threshold temperature
19 change; in the present embodiment, if the received temperature voltage signal exceeds a
20 threshold temperature level. In a preferred embodiment, the temperature comparison
21 stage 129 is an analog comparator of the type known to those skilled in the art. In
22 alternate embodiments of the present invention, the temperature comparison stage 129
23 may be a digital comparator, an operation amplifier that filters or amplifies an input
24 signal and generates an output signal from only a subset of possible inputs, or a logic

1 device operating under a programmed control, such as a microprocessor, compact
2 programmable logic device or a field programmable gate array. Any other means
3 known to those skilled in the art that can receive an input signal that corresponds to the
4 quantified temperature change, compare the input signal to a reference value
5 corresponding to a threshold temperature change and generate an output signal if a
6 threshold condition is satisfied may be employed.

7 [0083] If the quantified temperature exceeds the threshold temperature change, the
8 generated voltage temperature signal is sent to the combiner 113. In a preferred
9 embodiment of the present invention, the temperature signal is sent to a second OR
10 logic gate 131 of the combiner 113.

11 [0084] Referring to Figure 6, an alternate embodiment of a temperature monitor is
12 illustrated. The alternate temperature monitor 133 employs a first thermistor 135 and a
13 second thermistor 137. The first thermistor 135 is enclosed in a container or shroud 139,
14 which defines and enclosed shroud space 141 that is isolated from the atmosphere. The
15 shroud 139 is comprised of any insulative material known to those skilled in the art that
16 ensures that the temperature of the shroud space 141 does not vary significantly with
17 rapid variances in the temperature of the ambient atmosphere, as may happen in the
18 presence of a fire. Accordingly, the first thermistor 135 quantifies only the temperature
19 of the shroud space 141. The second thermistor 137 is exposed to the ambient
20 atmosphere. Accordingly, it is able to quantify the ambient atmosphere temperature.

21 [0085] The first thermistor 135 generates a signal that corresponds to the
22 temperature of the shroud space 141. The generated signal may be a digital or analog
23 indicator of the shroud space 141 temperature. In a preferred embodiment, the

1 generated signal is a voltage shroud temperature signal, which is sent to a temperature
2 difference monitor 145.

3 [0086] The second thermistor 137 generates a signal that corresponds to the
4 quantified ambient temperature. The generated signal may be a digital or analog
5 indicator of the ambient temperature. In a preferred embodiment, the generated signal
6 is a voltage ambient temperature signal, which is sent to the temperature difference
7 monitor 145.

8 [0087] The temperature difference monitor 145 compares the voltage shroud
9 temperature signal and the voltage ambient temperature signal to determine the
10 temperature difference, which is then sent to a temperature comparison stage 129. The
11 temperature comparison stage 129 determines if the temperature difference between the
12 shroud space 141 and the ambient atmosphere exceeds a threshold temperature
13 difference; in the present embodiment, if the received temperature voltage signal
14 exceeds a threshold temperature level. In a preferred embodiment, the temperature
15 comparison stage 129 is an analog comparator of the type known to those skilled in the
16 art. In alternate embodiments of the present invention, the temperature comparison
17 stage 129 may be a digital comparator, an operation amplifier that filters or amplifies an
18 input signal and generates an output signal from only a subset of possible inputs, or a
19 logic device operating under a programmed control, such as a microprocessor, compact
20 programmable logic device or a field programmable gate array. Any other means
21 known to those skilled in the art that can receive an input signal that corresponds to the
22 quantified temperature difference, compare the input signal to a reference value
23 corresponding to a threshold temperature difference and generate an output signal if a
24 threshold condition is satisfied may be employed.

1 [0088] If the temperature difference exceeds a threshold temperature difference, the
2 temperature difference signal is sent to the combiner 113. In a preferred embodiment of
3 the present invention, the difference signal is sent to the second OR logic gate 131 of the
4 combiner 113.

5 [0089] Referring to Figures 5 and 6, the signal combiner 113 is configured to receive
6 signals from the gas comparison stage 111, particle comparison stage 119 and the
7 temperature comparison stage 129, respectively. The AND logic gate 115 is configured
8 to receive signals from the gas comparison stage 111 when the gas comparisons stage
9 111 determines that the gas threshold level has been exceeded. The AND logic gate 115
10 is also configured to receive signals from the "low" particle comparison stage 121 when
11 the "low" particle comparison stage 121 determines that the "low" particle threshold
12 level has been exceeded.

13 [0090] The first OR logic gate 125 is connected to the AND logic gate 115 and is also
14 connected to and configured to receive signals from the "high" particle comparison
15 stage 123 when the "high" particle comparison stage 123 determines that the "high"
16 particle threshold level has been exceeded.

17 [0091] The second OR logic gate 131 is connected to the first OR logic gate 125 and is
18 also connected to and configured to receive signals from the temperature comparison
19 stage 129 when the temperature comparison stage 129 determines that the temperature
20 threshold level has been exceeded. In an alternate embodiment of the present
21 invention, the second OR logic gate 131 is configured to receive signals from the
22 temperature comparison stage 129 when the temperature comparison stage 129
23 determines that the temperature difference threshold between the first thermistor 135
24 and the second thermistor 137 has been exceeded. The second OR logic gate 131 is

1 further connected to the alarm 107, which is triggered when an alarm condition is
2 satisfied, the alarm condition being satisfied when at least one of the following occurs:

3 [0092] (a) the quantified presence of the combustion gas exceeds the combustion gas
4 threshold level and the quantified presence of the air borne particles exceeds the "low"
5 particle threshold level (i.e., a first threshold air borne particulate matter level);

6 [0093] (b) the quantified presence of the air borne particles exceeds the "high"
7 particle threshold level (i.e., a second threshold air borne particulate matter level); and,

8 [0094] (c) the quantified change in the ambient temperature exceeds a threshold
9 temperature change level.

10 [0095] In the event that the first alarm condition (a) is satisfied, an alarm signal is
11 sent from the AND logic gate 115, through the first and second OR logic gates (125,
12 131), to the alarm 107, at which point an alarm signal is generated indicating the
13 presence of a fire. In a preferred embodiment of the present invention, the AND logic
14 gate 115 communicates a voltage signal to the alarm 107.

15 [0096] In the event that the second alarm condition (b) is satisfied, an alarm signal is
16 sent from the first OR logic gate 125, through the second OR logic gate 131, to the alarm
17 107, at which point an alarm signal is generated indicating the presence of a fire. In a
18 preferred embodiment of the present invention, the first OR logic gate 125
19 communicates a voltage signal to the alarm 107.

20 [0097] In the event that the third alarm condition (c) is satisfied, an alarm signal is
21 sent from the second OR logic gate 131 to the alarm 107, at which point an alarm signal

1 is generated indicating the presence of a fire. In a preferred embodiment of the present
2 invention, the second OR logic gate 131 communicates a voltage signal to the alarm 107.

3 [0098] In a preferred embodiment, the first combustion gas monitor 101, airborne
4 particulate matter monitor 103, temperature monitor 15, alarm 107, comparison stage
5 111 and combiner 113 are mounted in a housing 199. The housing 199 includes access
6 points, which provide the monitors 101, 103 and 105 with access to the outside
7 environment in order to monitor for the presence of their respective combustion
8 products.

9 [0099] Referring to Figure 7, a system 200 for detecting and indicating the presence
10 of combustion products according an embodiment of the present invention is
11 illustrated. The system 200 is comprised of a combustion gas monitor 201 for
12 monitoring for the presence of a combustion gas and quantifying the combustion gas;
13 an air borne particulate matter monitor 203 for monitoring for the presence of an air
14 borne particulate matter and quantifying the air borne particulate matter; a
15 temperature monitor 205 for measuring an ambient temperature and quantifying a
16 change in the ambient temperature; and, an alarm 207 in communication with the
17 combustion gas monitor 201, air borne particulate matter monitor 203 and temperature
18 monitor 205 for triggering an alarm response when an alarm condition is satisfied.

19 [00100] The combustion gas monitor 201 may be a micro-electronic gas sensor 209, as
20 is known to those skilled in the artsuch as the F-2 CO sensor, as manufactured by
21 Teledyne Analytical Instruments of City of Industry, California USA. In a preferred
22 embodiment, the micro-electronic gas sensor 209 is the model TGS 203 as manufactured
23 by Figaro USA Inc. of Glenview, Illinois USA, but any gas sensor known to those skilled
24 in the art that is able to monitor for the presence of and quantify a combustion gas may

1 be employed. The combustion gas may be selected from the group consisting of CO,
2 CO₂, HCN, HCl, SO_x, NO_x and combinations thereof. In a preferred embodiment, the
3 selected combustion gas is CO.

4 [00101] The gas sensor 209 monitors for the presence of the selected combustion gas
5 and quantifies the level of the selected gas. In the present embodiment, the gas sensor
6 209 quantifies the concentration of the selected gas. The gas sensor 209 measures a
7 change in electrical resistance, that is proportional to the concentration of the gas being
8 detected, to generate a voltage signal. In an alternate embodiment, the gas sensor 209
9 measures optical absorption or transmission at one or more optical wavelengths to
10 generate a voltage signal that is proportional to the concentration of the gas being
11 detected. In a preferred embodiment, the gas sensor 209 measures the change in
12 electrical resistance to generate a voltage signal proportional to the concentration of the
13 gas being detected.

14 [00102] The gas sensor 209 generates a signal that corresponds to the quantified level
15 of the selected gas. The generated signal may be a digital or analog indicator of the
16 selected gas level. In a preferred embodiment, the generated signal is a gas voltage
17 signal corresponding to the quantified gas level, which is sent to a gas comparison stage
18 211. The gas comparison stage 211 determines if the generated signal exceeds a
19 threshold gas level; in the present embodiment, if the received gas voltage signal
20 exceeds a threshold gas level. In a preferred embodiment, the gas comparison stage 211
21 is an analog comparator of the type known to those skilled in the art. In alternate
22 embodiments of the present invention, the comparison stage 211 may be a digital
23 comparator, an operation amplifier that filters or amplifies an input signal and
24 generates an output signal from only a subset of possible inputs, or a logic device

1 operating under a programmed control, such as a microprocessor, compact
2 programmable logic device or a field programmable gate array. Any other means
3 known to those skilled in the art that can receive an input signal that corresponds to the
4 quantified level of the selected gas, compare the input signal to a reference value
5 corresponding to a threshold gas level and generate an output signal if a threshold
6 condition is satisfied may be employed.

7 [00103] If the quantified gas level exceeds the threshold gas level, the generated gas
8 voltage signal is sent to a signal combiner 213. The signal combiner 213 is configured to
9 receive and combine signals generated by the combustion gas monitor 201, air borne
10 particulate matter monitor 203 and temperature monitor 205 and to determine if an
11 alarm condition has been satisfied. In a preferred embodiment of the present invention,
12 the gas signal is sent to an AND logic gate 215 of the combiner 213.

13 [00104] The air borne particulate matter monitor 203 monitors for the presence of air
14 borne particulate matter. In a preferred embodiment, the air borne particulate matter is
15 smoke particles.

16 [00105] The air borne particulate matter monitor 203 may be a photo-electric particle
17 detector 217, as is known to those skilled in the art, as is known to those skilled in the
18 art, that incorporates an emitter model IRLED-E23 or IRLED-E24 manufactured by
19 Gilway Technical Lamp and a detector model PDB – C134 (F) manufactured by
20 Photonic Detectors Inc. of Simi Valley, California, USA. In a preferred embodiment the
21 photoelectric detector 217 incorporates an emitter model PDI – E808 and a detector
22 model PDB – C134 (F) both manufactured by Photonic Detectors Inc. of Simi Valley,
23 California, USA, but any air borne particulate matter monitor known to those skilled in

1 the art that is able to monitor for the presence of and quantify the level of air borne
2 particulate matter may be employed.

3 [00106] The photoelectric particle detector 217 monitors for the presence of the
4 selected air borne particulate matter and quantifies the level of the selected matter. In a
5 preferred embodiment, the photo-electric particle detector 217 quantifies the
6 concentration and density of the smoke particles.

7 [00107] The particle detector 217 generates a signal that corresponds to the measured
8 level of the selected air borne particulate matter. The generated signal may be a digital
9 or analog indicator of the air borne particulate matter level. In a preferred embodiment,
10 the generated signal is a particle voltage signal corresponding to the air borne
11 particulate matter level, which is sent to a particle comparison stage 219. The particle
12 comparison stage 219 includes a "low" particle comparison stage 221 and a "high"
13 particle comparison stage 223, each of which receive the particle voltage signal. The
14 "low" particle comparison stage 221 determines if the received particle voltage signal
15 exceeds a "low" particle threshold level and the "high" particle comparison stage 223
16 determines if the particle voltage signal exceeds a "high" particle threshold level. In a
17 preferred embodiment, the particle comparison stage 219 is an analog comparator of the
18 type known to those skilled in the art. In alternate embodiments of the present
19 invention, the particle comparison stage 219 may be a digital comparator, an operation
20 amplifier that filters or amplifies an input signal and generates an output signal from
21 only a subset of possible inputs, or a logic device operating under a programmed
22 control, such as a microprocessor, compact programmable logic device or a field
23 programmable gate array. Any other means known to those skilled in the art that can
24 receive an input signal that corresponds to the quantified level of the selected particle,

1 compare the input signal to a reference value corresponding to a threshold particle level
2 and generate an output signal if a threshold condition is satisfied may be employed.

3 [00108] If the quantified air borne particulate matter level exceeds the "low" particle
4 threshold, the generated "low" particle voltage signal is sent to the combiner 213. In a
5 preferred embodiment of the present invention, the "low" particle voltage signal is sent
6 to the AND logic gate 215 of the combiner 213. If the quantified air borne particulate
7 matter level exceeds the "high" particle threshold level, the generated "high" particle
8 voltage signal is sent to the combiner 213. In a preferred embodiment of the present
9 invention, the "high" particle voltage signal is sent to a first OR logic gate 225 of the
10 combiner 213.

11 [00109] The temperature monitor 205 measures the ambient temperature and
12 quantifies any change in the ambient temperature. The temperature monitor 205 may
13 be a thermistor 227, as is known to those skilled in the art, such as the model
14 NTSAOHXH103_E1BO as manufactured by Murata Manufacturing Company Ltd of
15 Kyoto, Japan. In a preferred embodiment of the present invention, the thermistor 227 is
16 the model MLX 90247 LRA-C as manufactured by Melexis Microelectronic Integrated
17 Systems of Concord, New Hampshire USA, but any temperature monitor known to
18 those skilled in the art that is able to measure ambient temperature and quantify
19 ambient temperature changes may be employed.

20 [00110] The temperature monitor 205 generates a signal that corresponds to the
21 change in the ambient temperature. The generated signal may be a digital or analog
22 indicator of the ambient temperature. In a preferred embodiment, the generated signal
23 is a voltage temperature signal corresponding to the ambient temperature, which is sent
24 to a temperature comparison stage 229. The temperature comparison stage 229

1 determines if the quantified temperature change exceeds a threshold temperature
2 change; in the present embodiment, if the received temperature voltage signal exceeds a
3 threshold temperature level. In a preferred embodiment, the temperature comparison
4 stage 229 is an analog comparator of the type known to those skilled in the art. In
5 alternate embodiments of the present invention, the temperature comparison stage 229
6 may be a digital comparator, an operation amplifier that filters or amplifies an input
7 signal and generates an output signal from only a subset of possible inputs, or a logic
8 device operating under a programmed control, such as a microprocessor, compact
9 programmable logic device or a field programmable gate array. Any other means
10 known to those skilled in the art that can receive an input signal that corresponds to the
11 quantified temperature change, compare the input signal to a reference value
12 corresponding to a threshold temperature change and generate an output signal if a
13 threshold condition is satisfied may be employed.

14 [00111] If the quantified temperature exceeds the threshold temperature change, the
15 generated voltage temperature signal is sent to the combiner 213. In a preferred
16 embodiment of the present invention, the temperature signal is sent to a second OR
17 logic gate 231 of the combiner 213.

18 [00112] Referring to Figure 8, an alternate embodiment of a temperature monitor is
19 illustrated. The alternate temperature monitor 233 employs a first thermistor 235 and a
20 second thermistor 237. The first thermistor 235 is enclosed in a container or shroud 239,
21 which defines and enclosed shroud space 241 that is insulated from the local ambient
22 atmosphere. The shroud 239 is comprised of any insulative material known to those
23 skilled in the art that ensures that the temperature of the shroud space 241 does not
24 vary with variances in the temperature of the ambient atmosphere. Accordingly, the

1 first thermistor 235 quantifies only the temperature of the shroud space 241. The
2 second thermistor 237 is exposed to the ambient atmosphere. Accordingly, it is able to
3 quantify the ambient atmosphere temperature.

4 [00113] The first thermistor 235 generates a signal that corresponds to the
5 temperature of the shroud space 241. The generated signal may be a digital or analog
6 indicator of the shroud space 241 temperature. In a preferred embodiment, the
7 generated signal is a voltage shroud temperature signal, which is sent to a temperature
8 difference monitor 245.

9 [00114] The second thermistor 237 generates a signal that corresponds to the
10 quantified ambient temperature. The generated signal may be a digital or analog
11 indicator of the ambient temperature. In a preferred embodiment, the generated signal
12 is a voltage ambient temperature signal, which is sent to the temperature difference
13 monitor 245.

14 [00115] The temperature difference monitor 245 compares the voltage shroud
15 temperature signal and the voltage ambient temperature signal to determine the
16 temperature difference, which is then sent to a temperature comparison stage 229. The
17 temperature comparison stage 229 determines if the temperature difference between the
18 shroud space 241 and the ambient atmosphere exceeds a threshold temperature
19 difference; in the present embodiment, if the received temperature voltage signal
20 exceeds a threshold temperature level. In a preferred embodiment, the temperature
21 comparison stage 229 is an analog comparator of the type known to those skilled in the
22 art. In alternate embodiments of the present invention, the temperature comparison
23 stage 229 may be a digital comparator, an operation amplifier that filters or amplifies an
24 input signal and generates an output signal from only a subset of possible inputs, or a

1 logic device operating under a programmed control, such as a microprocessor, compact
2 programmable logic device or a field programmable gate array. Any other means
3 known to those skilled in the art that can receive an input signal that corresponds to the
4 quantified temperature difference, compare the input signal to a reference value
5 corresponding to a threshold temperature difference and generate an output signal if a
6 threshold condition is satisfied may be employed.

7 [00116] If the temperature difference exceeds a threshold temperature difference, the
8 temperature difference signal is sent to the combiner 213. In a preferred embodiment of
9 the present invention, the difference signal is sent to the second OR logic gate 231 of the
10 combiner 213.

11 [00117] Referring to Figures 7 and 8, the signal combiner 213 is configured to
12 communicate with and receive signals from the gas comparison stage 211, particle
13 comparison stage 219 and the temperature comparison stage 229, respectively. The
14 AND logic gate 215 is configured to receive signals from the gas comparison stage 211
15 when the gas comparison stage 211 determines that the gas threshold level has been
16 exceeded. The AND logic gate 215 is also configured to receive signals from the "low"
17 particle comparison stage 221 when the "low" particle comparison stage 221 determines
18 that the "low" particle threshold level has been exceeded.

19 [00118] The first OR logic gate 225 is in communication with the AND logic gate 215
20 and is also in communication with and configured to receive signals from the "high"
21 particle comparison stage 223 when the "high" particle comparison stage 223
22 determines that the "high" particle threshold level has been exceeded.

1 [00119] The second OR logic gate 231 is in communication with the first OR logic gate
2 225 and is also in communication with and configured to receive signals from the
3 temperature comparison stage 229 when the temperature comparison stage 229
4 determines that the temperature threshold level has been exceeded. In an alternate
5 embodiment of the present invention, the second OR logic gate 231 is configured to
6 receive signals from the temperature comparison stage 229 when the temperature
7 comparison stage 229 determines that the temperature difference threshold between the
8 first thermistor 235 and the second thermistor 237 has been exceeded. The second OR
9 logic gate 231 is further in communication with the alarm 207, which is triggered when
10 an alarm condition is satisfied, the alarm condition being satisfied when at least one of
11 the following occurs:

12 [00120] (a) the quantified presence of the combustion gas exceeds the combustion gas
13 threshold level and the quantified presence of the air borne particles exceeds the "low"
14 particle threshold level (i.e., a first threshold air borne particulate matter level);

15 [00121] (b) the quantified presence of the air borne particles exceeds the "high"
16 particle threshold level (i.e., a second threshold air borne particulate matter level); and,

17 [00122] (c) the quantified change in the ambient temperature exceeds a threshold
18 temperature change level.

19 [00123] In the event that the first alarm condition (a) is satisfied, an alarm signal is
20 sent from the AND logic gate 215, through the first and second OR logic gates (225,
21 231), to the alarm 207, at which point an alarm signal is generated indicating the
22 presence of a fire. In a preferred embodiment of the present invention, the AND logic
23 gate 215 communicates a voltage signal to the alarm 207.

1 [00124] In the event that the second alarm condition (b) is satisfied, an alarm signal is
2 sent from the first OR logic gate 225, through the second OR logic gate 231, to the alarm
3 207, at which point an alarm signal is generated indicating the presence of a fire. In a
4 preferred embodiment of the present invention, the first OR logic gate 225
5 communicates a voltage signal to the alarm 207.

6 [00125] In the event that the third alarm condition (c) is satisfied, an alarm signal is
7 sent from the second OR logic gate 231 to the alarm 207, at which point an alarm signal
8 is generated indicating the presence of a fire. In a preferred embodiment of the present
9 invention, the second OR logic gate 231 communicates a voltage signal to the alarm 207.

10 [00126] Referring to Figure 9, a flow chart diagram illustrates a method for detecting
11 and indicating the presence of combustion products according to an embodiment of the
12 present invention. The method begins at step 100, where the presence of a first
13 combustion product is monitored for and quantified. The first combustion product may
14 be a combustion gas, such as CO, CO₂, HCN, HCl, SO_x, NO_x, and combinations thereof.
15 In a preferred embodiment of the present invention, the combustion gas is CO. The
16 combustion gas may be monitored for and quantified by any gas sensor known to those
17 skilled in the art, such as the F-2 CO sensor, as manufactured by Teledyne Analytical
18 Instruments of City of Industry, California USA. In a preferred embodiment, the micro-
19 electronic gas sensor is the model TGS 203 as manufactured by Figaro USA Inc. of
20 Glenview, Illinois USA, but any gas sensor known to those skilled in the art that is able
21 to monitor for the presence of and quantify a combustion gas may be employed.

22 [00127] At step 200, the presence of a second combustion product is monitored for
23 and quantified. In a preferred embodiment, the second indicator of combustion is air
24 borne particulate matter, such as smoke particles. The smoke particles may be

1 monitored for and quantified by any smoke particle detector known to those skilled in
2 the art, that incorporates an emitter model IRLED-E23 or IRLED-E24 manufactured by
3 Gilway Technical Lamp and a detector model PDB -C134 (F) manufactured by Photonic
4 Detectors Inc. of Simi Valley, California, USA. In a preferred embodiment the smoke
5 detector incorporates an emitter model PDI -E808 and a detector model PDB -C134 (F)
6 both manufactured by Photonic Detectors Inc. of Simi Valley, California, USA.

7 [00128] At step 300, the ambient temperature is measured and any change in the
8 ambient temperature is quantified. A temperature monitor is used for measuring an
9 ambient temperature and quantifying a change in the ambient temperature. In a
10 preferred embodiment, the temperature monitor may be any thermistor known to those
11 skilled in the art, such as the model MLX 90247 LRA-C as manufactured by Melexis
12 Microelectronic Integrated Systems of Concord, New Hampshire USA, but any
13 temperature monitor known to those skilled in the art that is able to measure ambient
14 temperature and quantify ambient temperature changes may be employed.

15 [00129] In a preferred embodiment, the thermistor measures the temperature directly.
16 In an alternate embodiment, two thermistors are employed to measure a change in the
17 ambient temperature. A first themistor contained within a shroud of insulative material
18 measures a first temperature corresponding to the temperature within the space defined
19 by the shroud. A second thermistor, which is exposed to the ambient atmosphere,
20 measures a second temperature corresponding to the temperature of the ambient
21 atmosphere. The first temperature and second temperature are then compared to
22 determine a temperature difference.

23 [00130] At step 400, the outputs of steps 100 and 200 are compared to a first alarm
24 triggering condition to determine if the first alarm condition has been satisfied. The

1 first alarm condition is satisfied when the quantified presence of the first combustion
2 product exceeds a first-product threshold level and the quantified presence of the
3 second combustion product exceeds a first second-product threshold.

4 [00131] At step 500, the output of step 200 is compared to a second alarm triggering
5 condition to determine if the second alarm triggering condition has been satisfied. The
6 second alarm condition has been satisfied when the quantified presence of the second
7 combustion product exceeds a second second-product threshold.

8 [00132] At step 600, the output of step 300 is compared to a third alarm triggering
9 condition to determine if the third alarm triggering condition has been satisfied. The
10 third alarm condition has been satisfied when the quantified change in the ambient
11 temperature exceeds a threshold temperature change level.

12 [00133] At step 700, an alarm is triggered when at least one alarm condition is
13 satisfied.

14 [00134] Although the invention has been described with reference to certain specific
15 embodiments, various modifications thereof will be apparent to those skilled in the art
16 without departing from the spirit and scope of the invention as outlined in the claims
17 appended hereto.

CLAIMS:

1. A method for detecting and indicating the presence of combustion products for triggering an alarm comprising the steps of:
 - a. monitoring for the presence of a combustion gas and quantifying the combustion gas;
 - b. monitoring for the presence of an air borne particulate matter and quantifying the air borne particulate matter;
 - c. measuring an ambient temperature and quantifying a change in the ambient temperature;
 - d. determining if a first alarm condition has been satisfied, said first alarm condition being the quantified presence of the combustion gas exceeding a threshold combustion gas level and the quantified presence of the air borne particulate matter exceeding a first threshold air borne particulate matter level;
 - e. determining if a second alarm condition has been satisfied, said second alarm condition being the quantified presence of the air borne particulate matter exceeding a second threshold air borne particulate matter level, said second air borne particulate matter threshold being greater than said first air borne particulate matter threshold;
 - f. determining if a third alarm condition has been satisfied, said third alarm condition being the quantified change in the ambient temperature exceeding a threshold temperature change level;
 - g. triggering an alarm when at least one of said first, second and third alarm conditions has been satisfied.

2. The method for detecting and indicating the presence of combustion products according to claim 1, wherein the combustion gas is selected from the group consisting of CO, CO₂, HCN, HCl, SO_x, NO_x and combinations thereof.
3. The method for detecting combustion according to claim 2, wherein the air borne particulate matter is smoke.
4. The method for detecting and indicating the presence of combustion products according to claim 3, wherein the combustion gas level is measured as parts per million.
5. The method for detecting and indicating the presence of combustion products according to claim 4, wherein the air borne particulate matter level is a percentage of obscuration.
6. The method for detecting and indicating the presence of combustion products according to claim 5, wherein the temperature change level is measured as at least one of degrees Fahrenheit, degrees Celsius and degrees Kelvin.
7. The method according to claim 1 further comprising the step of accounting for rate of change variances in the measured quantified change in the ambient temperature.
8. The method according to claim 7 further comprising the step of comparing an input signal of the measured quantified change in the ambient temperature to a reference value corresponding to a threshold temperature change.
9. A system for detecting and indicating the presence of combustion products for triggering an alarm comprising:
 - a. a combustion gas monitor for monitoring for the presence of a combustion gas and quantifying a level of the combustion gas;

- b. an air borne particulate matter monitor for monitoring for the presence of an air borne particulate matter and quantifying a level the air borne particulate matter;
- c. a temperature monitor for measuring an ambient temperature and a quantifying a change for the ambient temperature;
- d. a gas comparison stage in communication with said combustion gas monitor for receiving said quantified level of said combustion gas and generating a gas signal when a gas threshold level has been met;
- e. a particulate matter comparison stage in communication with said air borne particulate matter monitor for receiving said quantified level of said air borne particulate matter and generating a particulate matter signal when a particulate matter threshold level has been met;
- f. a temperature comparison stage in communication with said temperature monitor for receiving said quantified change in ambient temperature and generating a temperature change signal when a temperature change threshold has been met;
- g. a combiner in communication with said gas comparison stage, particulate matter comparison stage and temperature comparison stage for receiving said gas signal, particulate matter signal and temperature change signal;
- h. an alarm in communication with said combiner for triggering an alarm when an alarm condition is satisfied, said alarm condition being at least one of:
 - i. the quantified presence of the combustion gas exceeding a threshold combustion gas level and the quantified presence of the air borne particulate matter exceeding a first threshold air borne particulate matter level;

- ii. the quantified presence of the air borne particulate matter exceeding a second threshold air borne particulate matter level, said second air borne particulate matter threshold being greater than said first air borne particulate matter threshold; and,
 - iii. the quantified change in the ambient temperature exceeding a threshold temperature change level.
- 10. The system for detecting and indicating the presence of combustion products according to claim 9, wherein the combustion gas is selected from the group consisting of CO, CO₂, HCN, HCl, SO_x, NO_x and combinations thereof.
- 11. The system for detecting and indicating the presence of combustion products according to claim 10, wherein the air borne particulate matter is smoke.
- 12. The system for detecting and indicating the presence of combustion products according to claim 11, wherein the combustion gas monitor is a micro-electronic gas sensor.
- 13. The system for detecting and indicating the presence of combustion products according to claim 12, wherein the air borne particulate matter monitor is a photo-electric particle detector.
- 14. The system for detecting and indicating the presence of combustion products according to claim 13, wherein the temperature monitor is a thermister.
- 15. The system according to claim 9, wherein rate of change variances are accounted for in the measured quantified change of the ambient temperature.
- 16. The system according to claim 15, wherein an input signal of the measured quantified change in the ambient temperature is compared to a reference value corresponding to a threshold temperature change.

17. An apparatus for detecting and indicating the presence of combustion products for triggering an alarm comprising:
- a. a combustion gas monitor for monitoring for the presence of a combustion gas and quantifying a level of the combustion gas;
 - b. an air borne particulate matter monitor for monitoring for the presence of an air borne particulate matter and quantifying a level the air borne particulate matter;
 - c. a temperature monitor for measuring an ambient temperature and quantifying a change in the ambient temperature;
 - d. a gas comparison stage connected to said combustion gas monitor for receiving said quantified level of said combustion gas and generating a gas signal when a gas threshold level has been met;
 - e. a particulate matter comparison stage connected to said air borne particulate matter monitor for receiving said quantified level of said air borne particulate matter and generating a particulate matter signal when a particulate matter threshold level has been met;
 - f. a temperature comparison stage connected to said temperature monitor for receiving said quantified change in ambient temperature and generating a temperature change signal when a temperature change threshold has been met;
 - g. a combiner connected to said gas comparison stage, particulate matter comparison stage and temperature comparison stage for receiving said gas signal, particulate matter signal and temperature change signal ;
 - h. an alarm connected to said combiner for triggering an alarm when an alarm condition is satisfied, said alarm condition being at least one of:

- i. the quantified presence of the combustion gas exceeding a threshold combustion gas level and the quantified presence of the air borne particulate matter exceeding a first threshold air borne particulate matter level;
 - ii. the quantified presence of the air borne particulate matter exceeding a second threshold air borne particulate matter level, said second air borne particulate matter threshold being greater than said first air borne particulate matter threshold; and,
 - iii. the quantified change in the ambient temperature exceeding a threshold temperature change level.
18. The apparatus for detecting and indicating the presence of combustion products according to claim 17, wherein the combustion gas is selected from the group consisting of CO, CO₂, HCN, HCl, SO_x, NO_x and combinations thereof.
 19. The apparatus for detecting and indicating the presence of combustion products according to claim 18, wherein the air borne particulate matter is smoke.
 20. The apparatus for detecting and indicating the presence of combustion products according to claim 19, wherein the combustion gas monitor is a micro-electronic gas sensor.
 21. The apparatus for detecting and indicating the presence of combustion products according to claim 20, wherein the air borne particulate matter monitor is a photo-electric particle detector.
 22. The apparatus for detecting and indicating the presence of combustion products according to claim 21, wherein the temperature monitor is a thermister.
 23. The apparatus according to claim 17, wherein rate of change variances are accounted for in the measured quantified change of the ambient temperature.

24. The apparatus according to claim 23, wherein an input signal of the measured quantified change in the ambient temperature is compared to a reference value corresponding to a threshold temperature change.

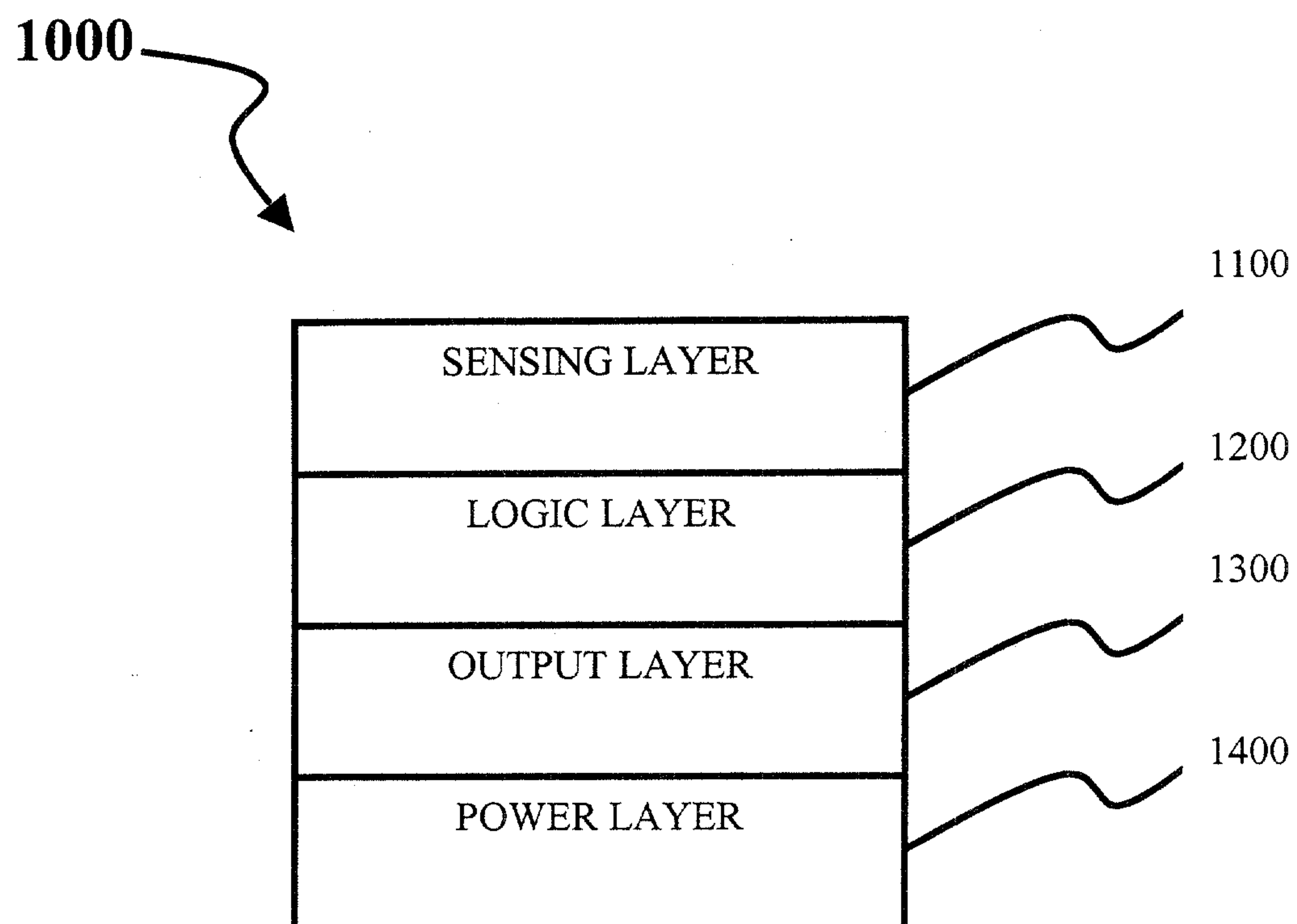


FIG. 1

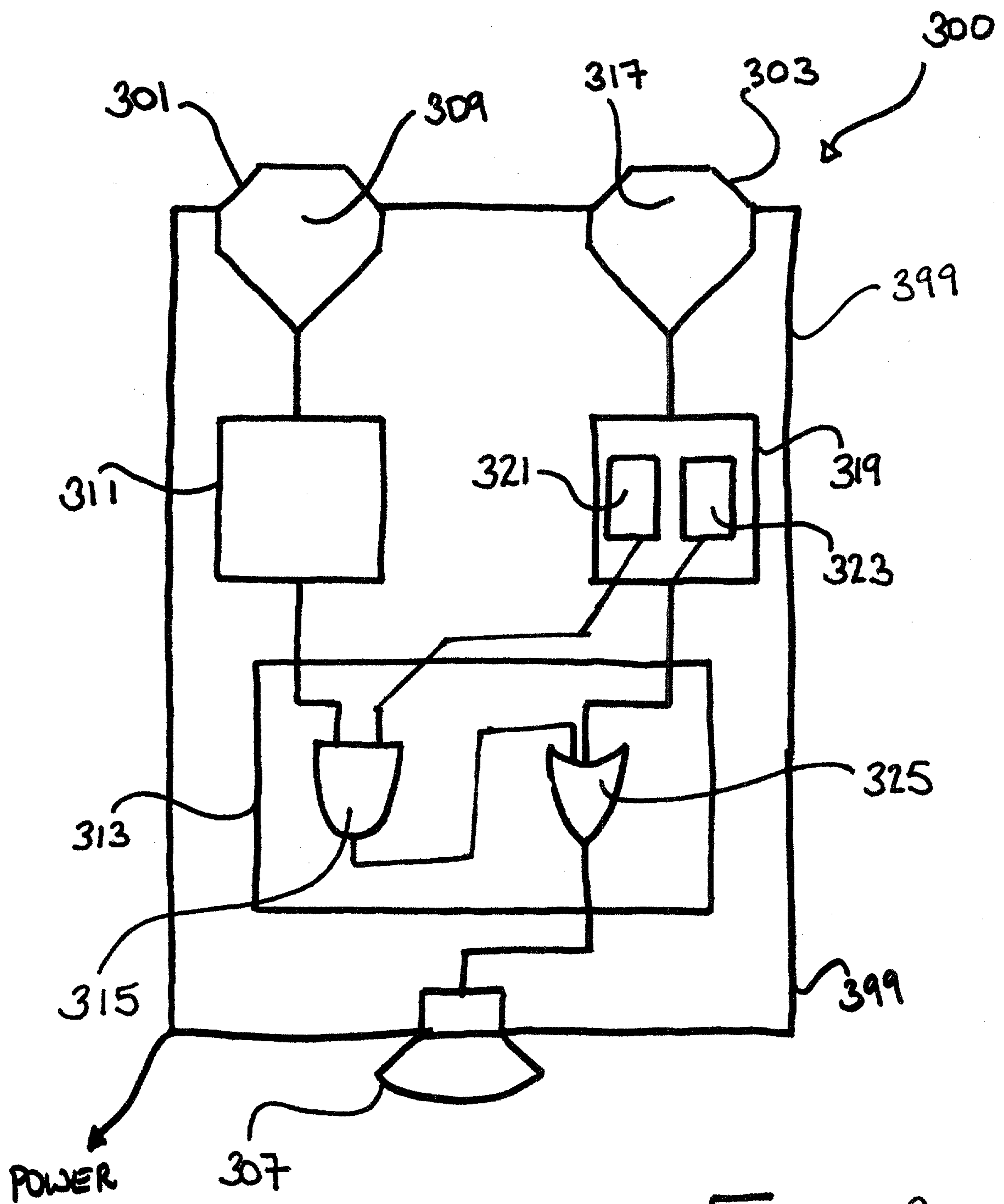


FIG. 2

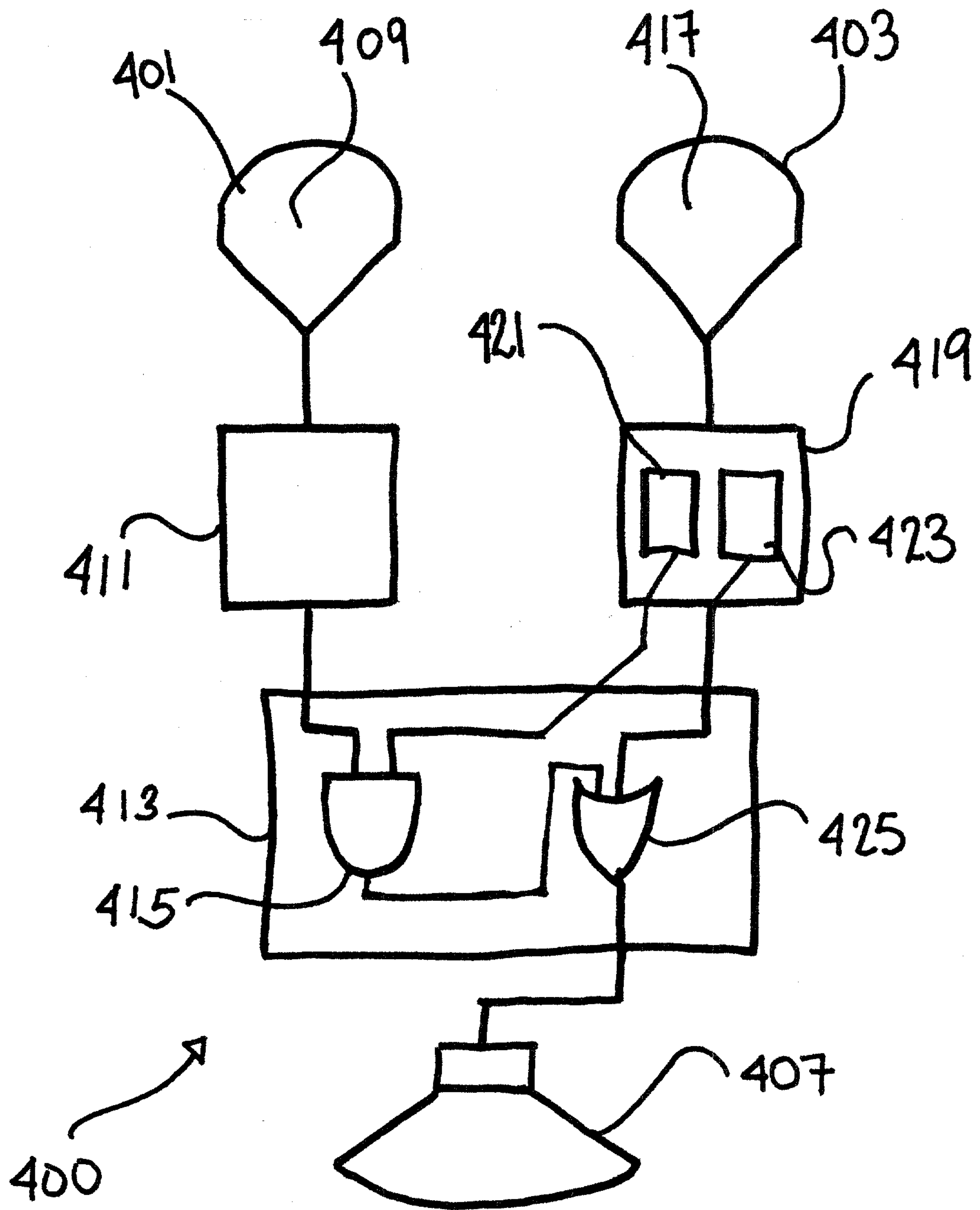
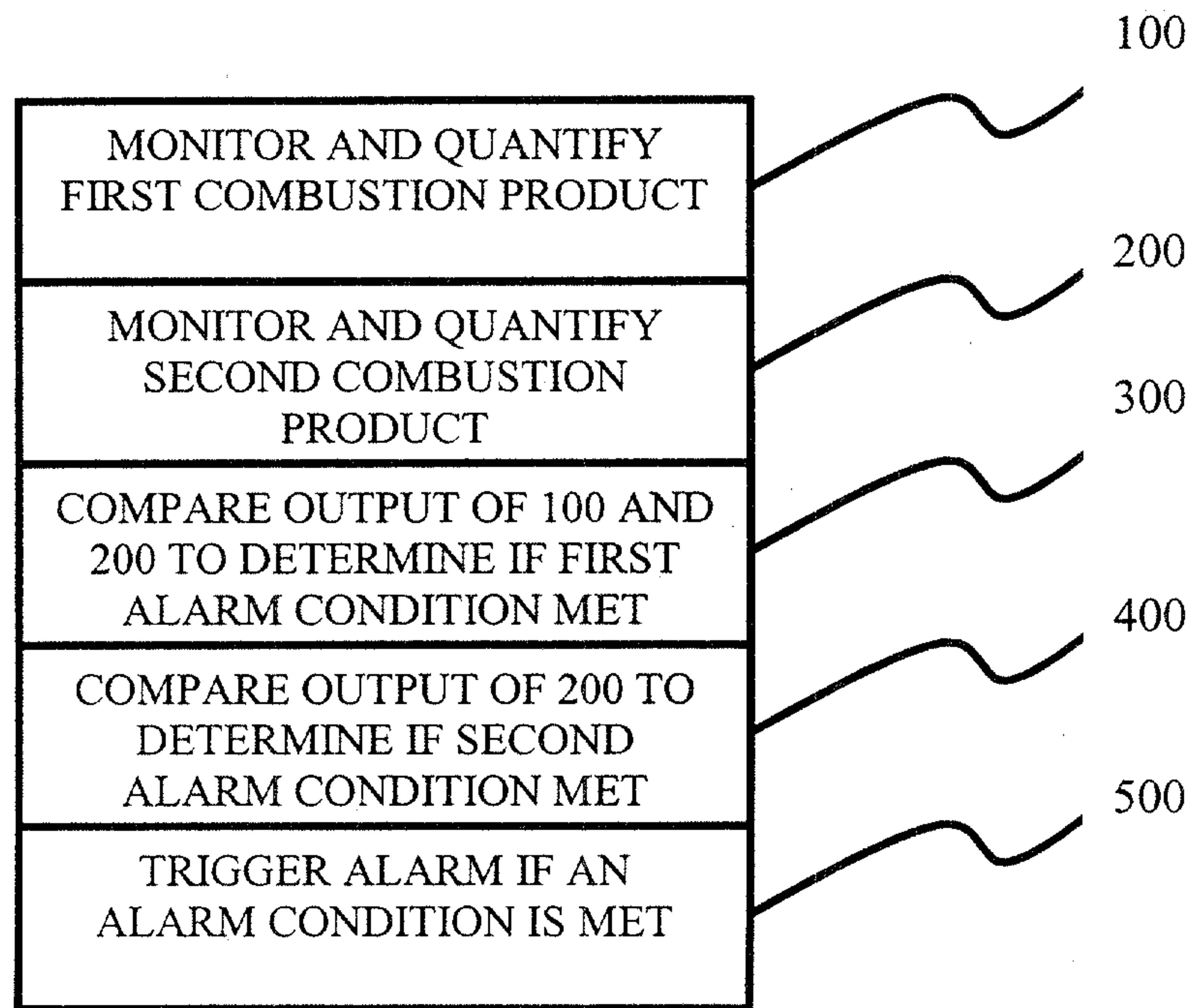


FIG. 3

**FIG. 4**

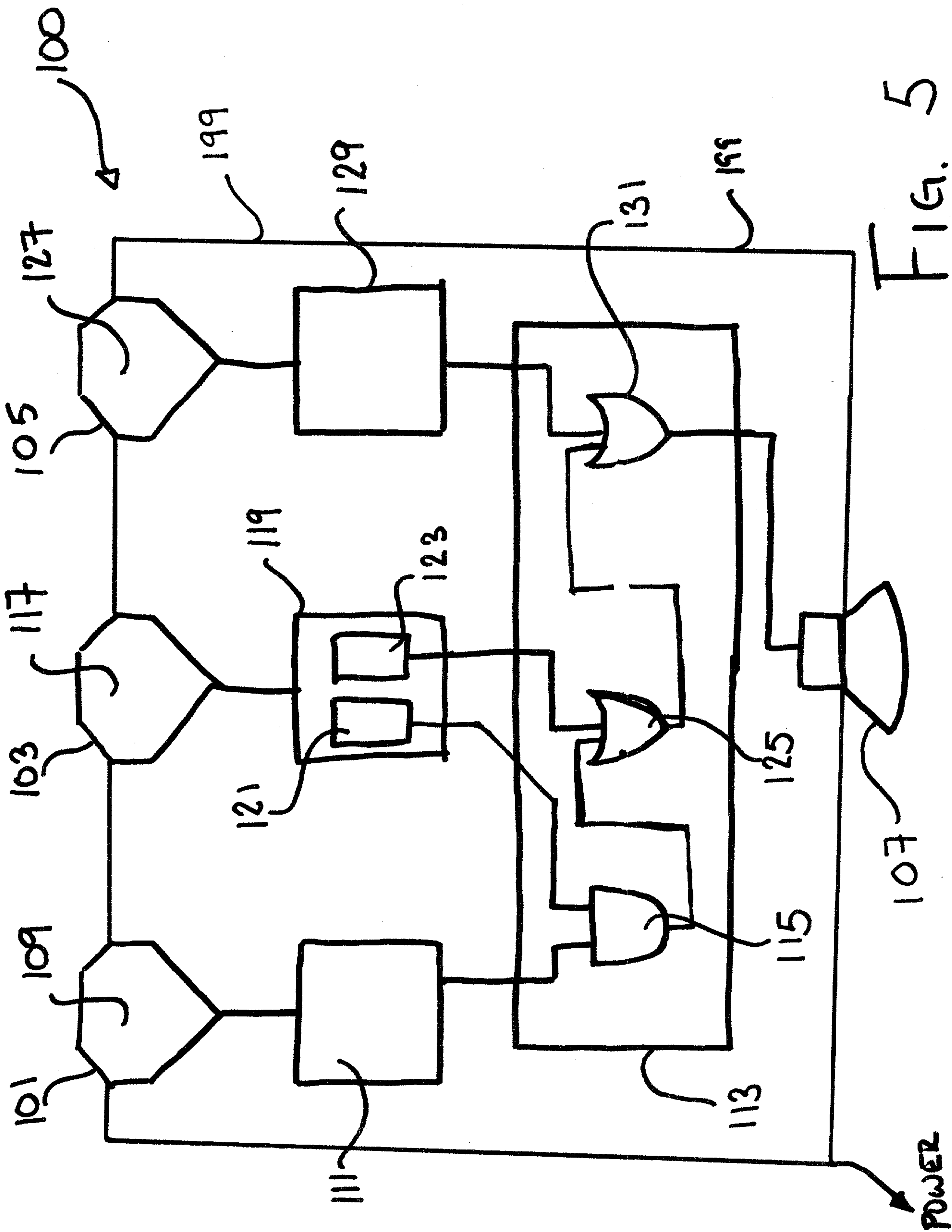


FIG. 5

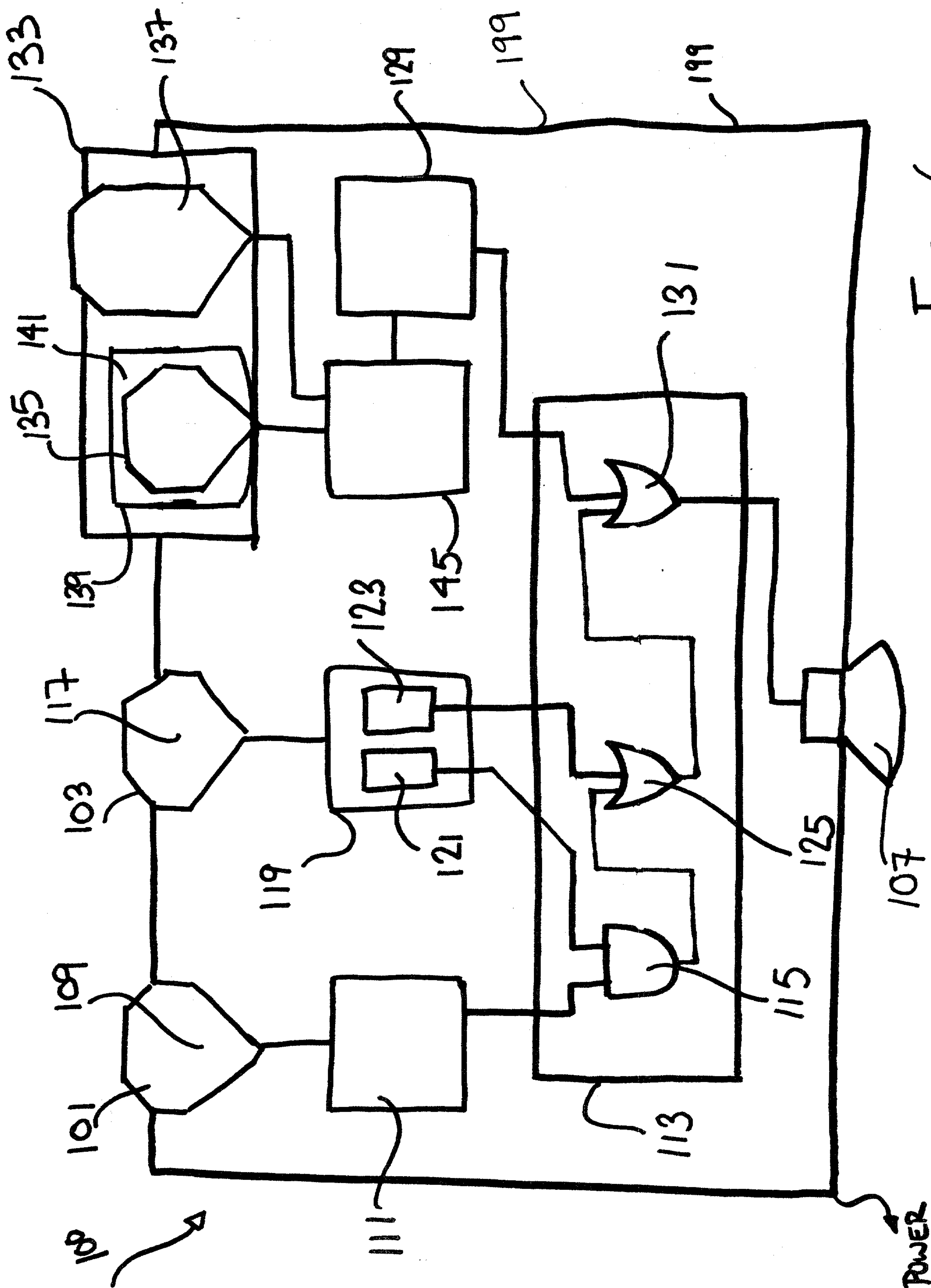


Fig. 6

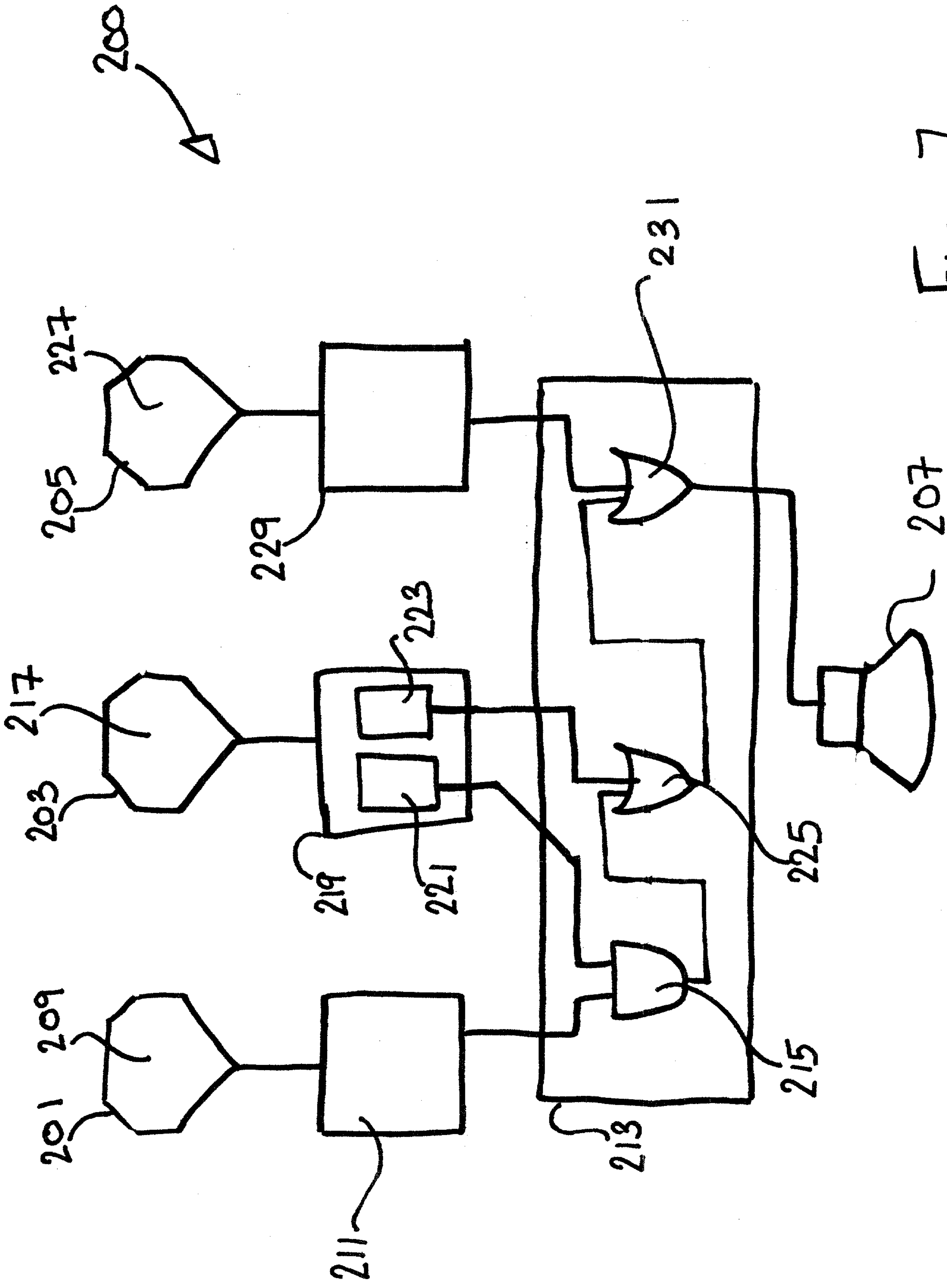


Fig 7

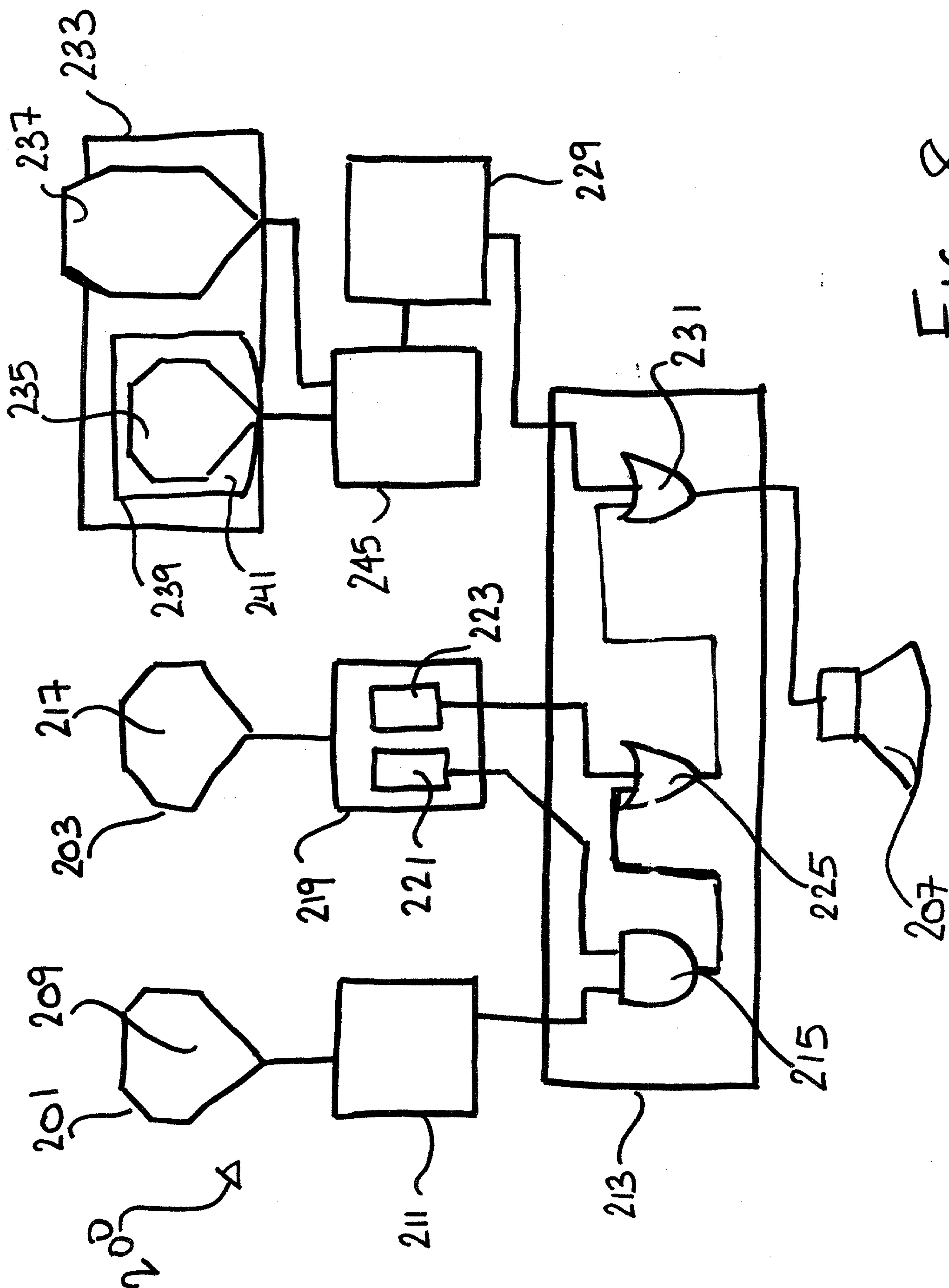
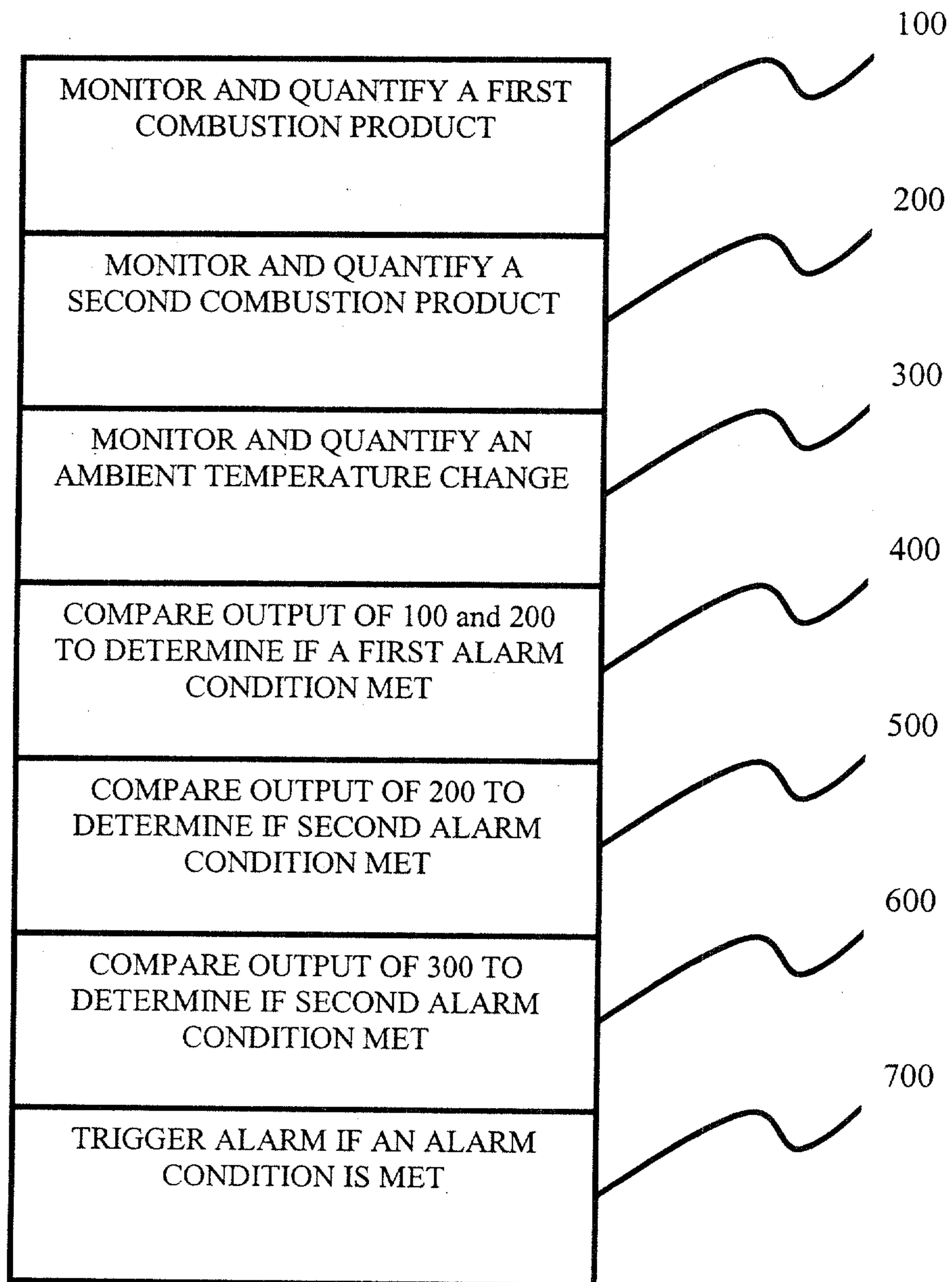
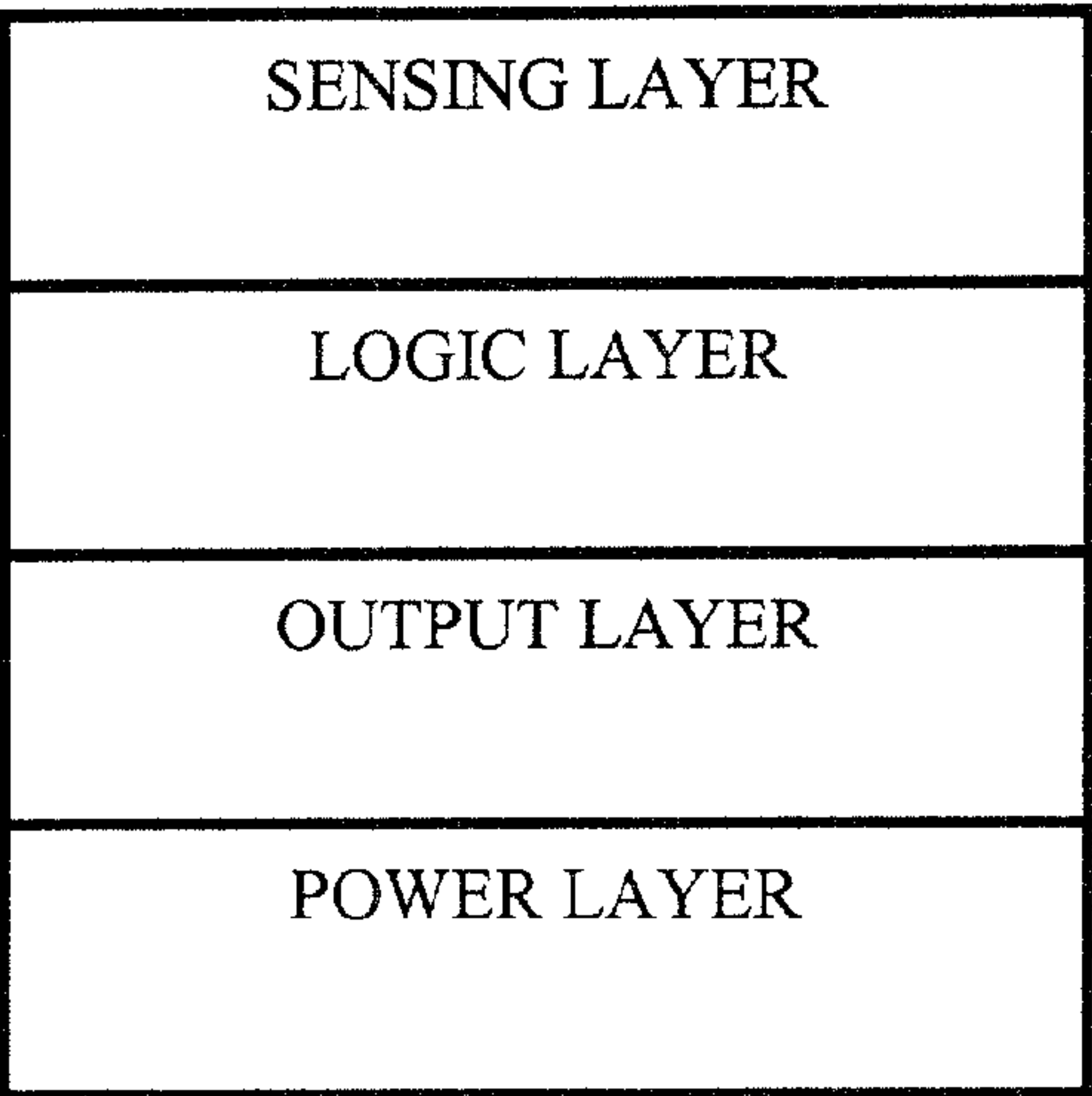


Fig. 8

**FIG. 9**

1000



SENSING LAYER

LOGIC LAYER

OUTPUT LAYER

POWER LAYER

1100

1200

1300

1400

