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(54) **AIR QUALITY SENSOR/INTERRUPTOR**

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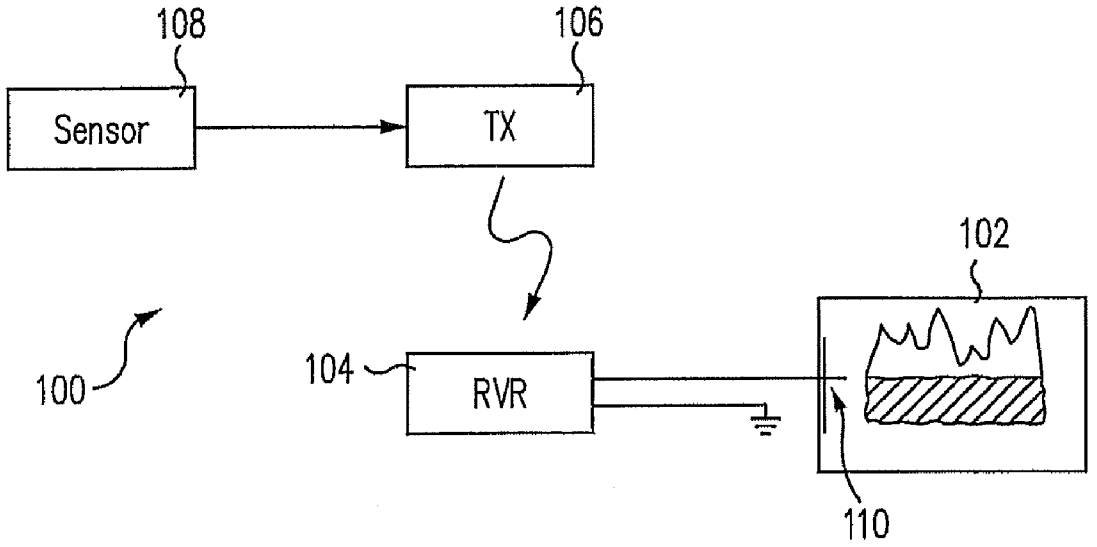
(57) **ABSTRACT**

An air quality sensor and interrupter system includes an air quality sensor to measure the air quality around a gas appliance and an appliance shut-off device to turn off the gas appliance in response to a signal from the sensor indicating unsafe air. An exhaust can also be activated to remove the unsafe air. Unsafe air can be indicated by a measurement of 18.5% or less oxygen in the air. If the sensor fails, an alarm can alert the user and the appliance shut off until the sensor is replaced or repaired. A bypass allows the user to keep the appliance turned on, but only for a limited amount of time. The user can keep utilizing the bypass to keep the appliance turned on for extended periods of time.



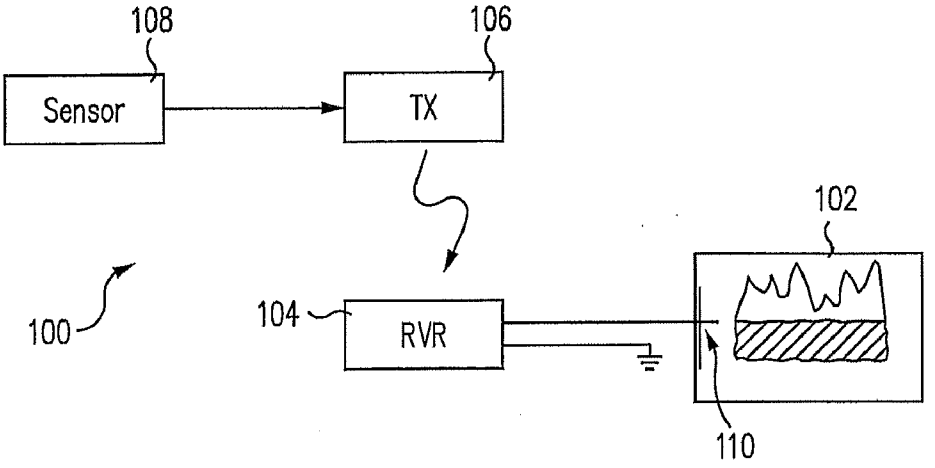

108
106
Sensor
TX
102
100
104
RVR
110

FIG. 1

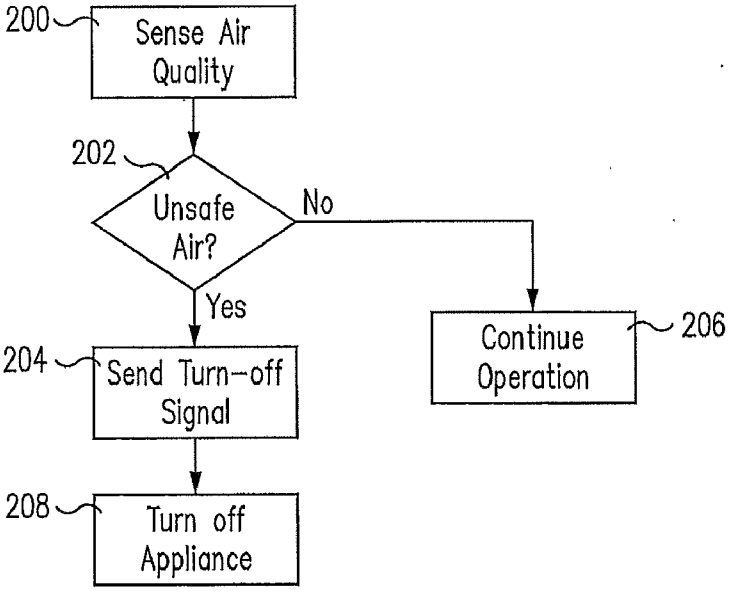

200
Sense Air Quality
202
Unsafe Air?
No
Yes
204
Send Turn-off Signal
Continue Operation
206
208
Turn off Appliance

FIG. 2

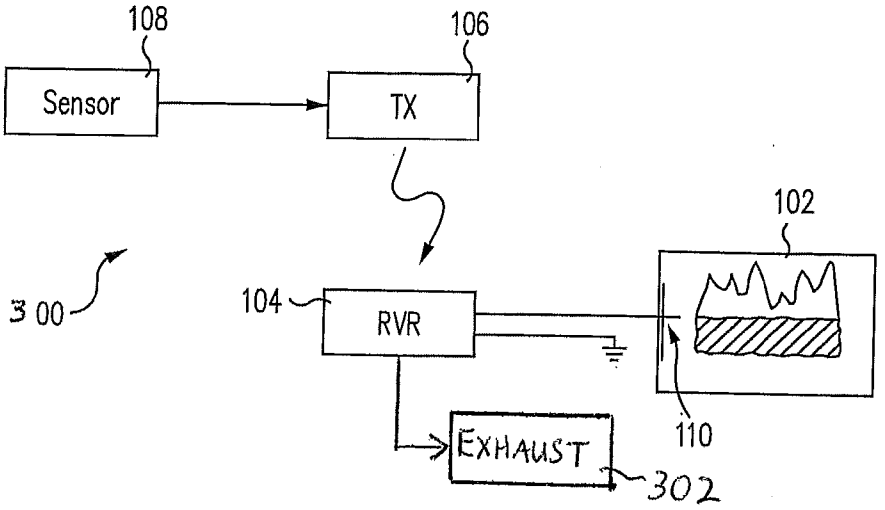

108
106
Sensor
TX
102
300
104
RVR
110
EXHAUST
302

FIG. 3

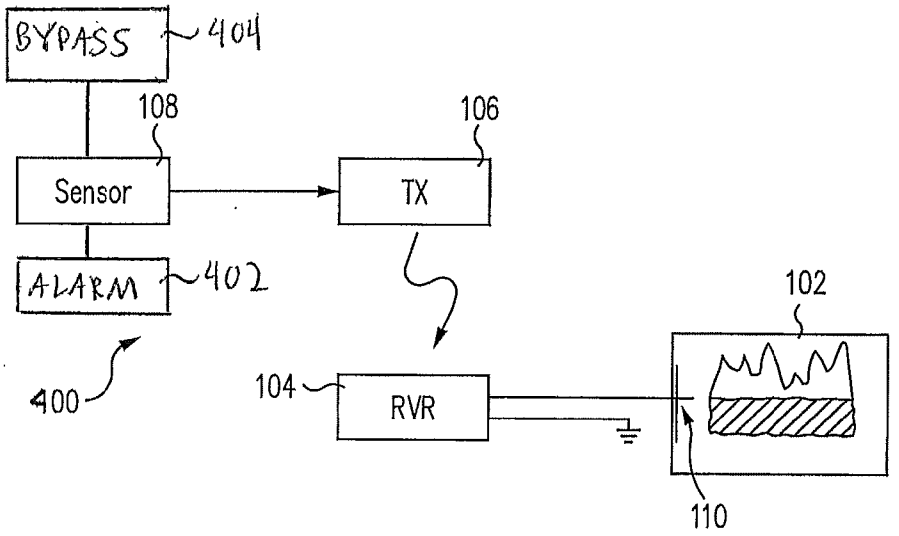

BYPASS
404
108
106
Sensor
TX
ALARM
402
102
400
104
RVR
110

FIG. 4

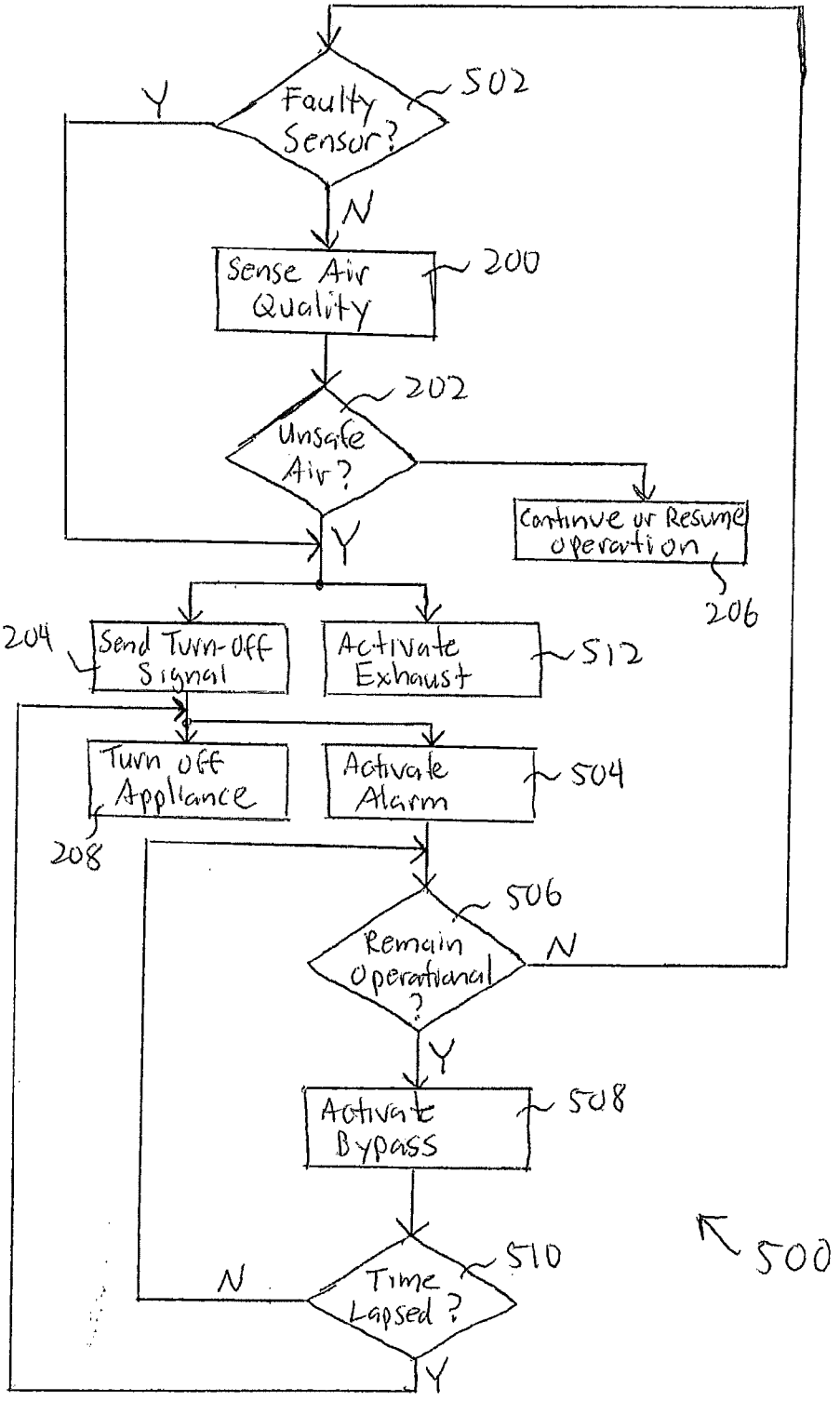

Faulty Sensor?
502
Y
N
Sense Air Quality
200
Unsafe Air?
202
Continue or Resume operation
206
Y
204
Send Turn-Off Signal
Activate Exhaust
512
Turn off Appliance
208
Activate Alarm
504
Remain Operational?
506
N
Y
Activate Bypass
508
Time Lapsed?
510
N
Y
500

Fig. 5

AIR QUALITY SENSOR/INTERRUPTOR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present invention is a continuation-in-part application of U.S. patent application Ser. No. 11/404,313, filed Apr. 14, 2006, which claims priority to U.S. Provisional Application Serial No. 60/671,952, filed Apr. 15, 2005.

BACKGROUND

[0002] 1. Field of Invention

[0003] The present invention relates generally to air quality detection systems, and in particular, to such systems that take action based on the air quality detected.

[0004] 2. Related Art

[0005] Gas appliances can generate unsafe levels of various gases, such as carbon monoxide (CO), into the air. Such gases need to be detected so that people within the air space do not get ill or suffer any other health-related problems. For example if a burner system in a gas appliance is not burning properly, unsafe levels of combustion by-products are released into the environment because of incomplete combustion.

[0006] One type of gas detection system uses the oxygen detection safety-pilot (ODS) technology on gas appliances. A typical ODS pilot system includes an oxygen-sensitive pilot burner that regulates flame characteristics, a thermocouple positioned in the mantle of the pilot flame, and a safety shut-off valve. The pilot flame is designed to be stable within a very narrow operating range. The thermocouple responds to changes in the pilot flame characteristics and, when heated, generates a voltage, e.g., in the millivolt range, which keeps the gas supply valve in the open position.

[0007] However, if low levels of oxygen are detected by the ODS system, the flame extinguishes. The loss of flame causes the thermocouple to cool. This cooling reduces the voltage, which causes the gas valve to return to its normally closed position, thus turning off the fuel supply to the appliance. The unit will not operate until the space is properly ventilated and adequate oxygen is introduced, and the appliance is restarted.

[0008] Although relatively effective, there are several inherent problems with ODS systems. These include, but are not limited, to susceptibility to drafts, pilot positioning, gas supply, orifice sizing, and heating value of the gas. Due to the nature of the ODS pilot system, it is subject to nuisance shutdowns from overheating conditions on the thermocouple cold junction.

[0009] Non-pilot light based systems, such as described in U.S. Pat. No. 4,482,311, address some of the deficiencies of ODS pilot systems. However, the system of the '311 patent and known systems for automatic shut-off of a heating system based on carbon monoxide detection, such as described in U.S. Pat. No. 5,793,296, do not go much beyond shutting off the system. With these systems, when a sensor/detector fails, the system is no longer functional. In addition, when low oxygen is detected, the system simply shuts off the heating system. However, dangerous amounts of low oxygen may still be present.

[0010] Therefore, there is a need for an air quality detection system that overcomes the disadvantages of conventional systems discussed above.

SUMMARY

[0011] According to one aspect of the invention, an air quality sensor/interrupter includes an air quality sensor and a means of interrupting the operation of the appliance when a low air quality is detected. In one embodiment, when the oxygen level is approximately 18.0% or lower, a signal is sent to the shut-down mechanism to shut down the gas appliance.

[0012] The air quality sensor/interrupter is a device that measures air quality in a confined space, and if unsafe air is detected, shuts down the appliance(s) affecting the air in the monitored space. The sensor may communicate to the interrupter or shut-down mechanism by a wired or a wireless system. Upon receipt of the signal, the interrupter will stop the flow of power, gas, or electricity to the heating element of the appliance(s). In one embodiment, the interrupter may shut down only the heater or burner element of the system and allow the rest of the appliance to function, such as blowers and lights. The appliance is not turned back on until the interrupter or system is reset, either by the user or automatically upon detection of "safe" air.

[0013] Thus, because the air quality sensor/interrupter measures the actual air quality in the space and shuts down the appliance based on a detection of unsafe air, the present invention does not have many of the inherence problems of conventional ODS systems.

[0014] When unsafe air is detected, the system also activates an exhaust to clear away the unsafe air. The exhaust may be a fan or any conventional exhaust device. Once the system is reset, either with a "safe" air detection or by the user, the exhaust is turned off. This ensures the space proximate the sensor does not retain unsafe air, which is especially desirable in areas with human or animal contact.

[0015] In another embodiment, if the sensor/interrupter fails, the gas supply to appliances connected to the system will be shut off and an alarm will be activated to let the user know of the faulty device. Once a new and operational device is installed, the system opens up the gas supply, assuming the air quality is safe. However, if a new device is not readily available, the system may be equipped with a user-enabled bypass switch, which allows gas to flow to the appliances for operation. In one embodiment, when the bypass switch is enabled, the switch is only operational for a set period of time, such as 36 hours. After 36 hours, the gas supply is shut off again to the appliances, although the user may again trigger the bypass switch. Such a mechanism enables the appliances to operate even without a functional sensor/interruptor, but does not allow continuous operation unless a functional sensor/interruptor is installed.

[0016] Thus, features of the present invention provide a safer detection and shut-off system, as unsafe air is automatically removed upon an unsafe air detection and the user is warned when the detection mechanism fails, while still allowing the connected appliances to operate.

BRIEF DESCRIPTION OF THE DRAWING

[0017] FIG. **1** is a block diagram of an air quality detection/shut-down system according to one embodiment;

[0018] FIG. **2** is a flow chart showing steps for shutting down an appliance when unsafe air is detected according to one embodiment;

[0019] FIG. **3** is a block diagram of an air quality detection/shut-down system with an automated exhaust system according to one embodiment;

[0020] FIG. **4** is a block diagram of an air quality detection/shut-down system with a faulty detector warning system according to one embodiment; and

[0021] FIG. **5** is a flow chart showing steps for removing unsafe air when unsafe air is detected and/or warning the user of a faulty detection mechanism.

[0022] Embodiments of the present invention and their advantages are best understood by referring to the detailed description that follows.

DETAILED DESCRIPTION

[0023] According to one embodiment of the present invention, a sensor is used to measure the quality of air in a room or area. If the measurement indicates unsafe air, a signal is sent to a shut-down device, which then shuts down the appliance or appliances in the monitored air space.

[0024] The sensor may employ one of several known technologies and products, such as electromechanical, semiconductor, catalytic bead, and zirconia lambda. Suitable sensors or detectors include the TX-2000 Toxic Gas and OX-2000 Oxygen Intrinsically Safe series of detectors from Enmet Corporation of Ann Arbor, Mich. These detectors are capable of continually monitoring toxic gases or oxygen and indicating when a certain gas is detected or a certain gas has reached a threshold, such as by an audio alarm or visual display. Gases that can be monitored include, but may not be limited to chlorine (Cl_2), carbon monoxide (CO), hydrogen (H_2), hydrogen sulfide (H_2S), ammonia (NH_3), nitrogen oxide (NO), nitrogen dioxide (NO_2), oxygen (O_2), and ozone (O_3).

[0025] In one embodiment, when the sensor detects low oxygen levels, such as at 18.0% or less, an alarm will sound and a signal will be sent to a shut-down device or interrupter. The signal can be sent along a wired channel, such as along a wire, or through a wireless communication. An example of a wireless shut-down device is a RR-1 or RR-1A remote system receiver and transmitter from the Robert H. Peterson Company, the City of Industry, Calif. The RR-1 or RR-1A system can be modified to act as transmitter and receiver grounding device.

[0026] Thus, once a signal is received indicating that the quality of the air has dropped below an acceptable level, the grounding circuit will activate or close and either directly ground the thermocouple/thermopile/battery or magnet power circuit. This would then result in the magnet/valve dropping out or shutting off, causing the gas appliance to shut down. Alternatively, a remote transmitter may be activated to send a signal to a grounding system which would shut down the gas appliance.

[0027] FIG. **1** is a block diagram showing one embodiment of the just-described invention. In FIG. **1**, an air quality sensor and control system **100** is shown in use with a gas appliance **102**. Gas appliance **102** is shown as a gas log system, although any suitable gas appliance can be used with the present invention. Gas appliance **102** is connected to a receiver **104**, which operates to receive signals and in response to the signals, turn gas appliance **102** off or on. Receiver **104** receives signals transmitted by a transmitter **106**. Signals can be transmitted wireless or over a wired connection. Receiver **104** and transmitter **106** are conventional components to a system, such as the Model # RR-1 or RR-1A kit from the RH Peterson Co. of the City of Industry. An oxygen sensor **108** is connected to transmitter **106**. The sensor may be located in the whole house or room area dependent on the sensitivity of the detector. Multiple detectors may be required in a whole house situation.

[0028] When oxygen sensor **108** detects low oxygen, e.g., 18.0% or lower, or a toxic gas, it sends a signal to transmitter **106**. In response, transmitter **106** sends a turn-off signal to receiver **104**. Receiver **104** then turns off gas appliance **102**, such as by closing a hot lead/ground circuit **110** in gas appliance **102**. In one embodiment, only the burner or gas supply is shut down, while leaving other components of the appliance functional. In other embodiments, all functions or components of the appliance are shut down upon receiving indication of low oxygen environment or toxic air quality.

[0029] FIG. **2** is a flowchart illustrating steps for shutting down a gas appliance, according to one embodiment of the present invention. In step **200**, the quality of the air proximate to the gas appliance is sensed or measured. Sensing can be with any conventional air quality sensor to detect oxygen levels in the air or to detect the presence of toxic gas. In step **202**, a determination is made whether the air quality is safe. In one embodiment, unsafe air quality occurs when the oxygen level is approximately 18.0% or lower. If an unsafe air quality is detected, as determined in step **202**, a signal is sent, in step **204**, to a device or system for turning off the gas appliance. The device or system may comprise of a transmitter/receiver pair or a single transceiver. If the air quality is not classified as unsafe, then no signal is sent and the gas appliance continues its normal operation in step **206**. In step **208**, upon receipt of a signal indicating unsafe air quality, the gas appliance is shut down or turned off, either in whole or only specific parts, such as the gas burners. The gas appliance remains shut down until the quality of air is no longer unsafe.

[0030] As a result, the gas appliance does not continue generating fire or producing unsafe air, such as with an excess of carbon monoxide, when unsafe air is detected without being dependent on the pilot light. Consequently, reliance on the pilot light is eliminated, thereby eliminating disadvantages of conventional systems using the pilot light.

[0031] FIG. **3** is a block diagram of an air quality detection/shut-down system **300** with an automated exhaust system according to one embodiment. System **300** is the same as system **100** described above, but includes an exhaust system **302** in communication with receiver **104**. Note that in other embodiments, exhaust system can be in communication directly with transmitter **106**. When oxygen sensor **108** detects unsafe air, receiver **104** turns off the gas supply to gas appliance **102**, as described above. With this embodiment, when oxygen sensor **108** detects unsafe air, exhaust system **302** also receives a signal, either through transmitter **106** or receiver **104**. In response, exhaust system **302** removes the unsafe air surrounding sensor **108** and/or appliance **102**. As a result, the corresponding surrounding area is made safe to humans, animals, or anything in contact with the area.

[0032] The exhaust system can be any conventional exhaust, including vacuum systems that suck in and/or filter the air and fan systems that blow out the unsafe air. The exhaust systems may be activated upon immediate receipt of the unsafe air detection signal and may operate simultaneously with the appliance shut off system. However, simultaneous operation is not required. Furthermore, multiple

exhaust systems or devices may be utilized, depending in part on various factors, including the number of sensors **108**, the size of the affected area, the efficiency of the exhaust systems, and the urgency or time requirements for removing the unsafe air upon an unsafe air detection. After the unsafe air is removed, system **300** resets itself. System reset can be triggered in any number of ways, including when sensor **108** detects safe air again, the user manually resetting the system, or after the exhaust system has been operating for a specified period of time.

[0033] FIG. **4** is a block diagram of an air quality detection/shut-down system **400**, in which an alarm system **402** and a bypass system **404** are in communication with sensor **108**. In system **400**, when sensor **108** fails or otherwise becomes inoperative, such as accuracy falls below a set threshold, alarm system **402** notifies the user. Notification can be provided using various methods, including an audio alarm, a visual alarm, a combination of the two, and an automated message sent to a user's cell phone or computer. This gives the user instant notification for sensor failure, which minimizes the time required to fix or install a new sensor **108**. As a result, the time that system **400** is not functioning properly can be greatly reduced. Note that when alarm system **402** is triggered, a signal is sent to transmitter **106** and/or receiver **104** to shut down gas to appliance **102** and any other connected appliances. These appliances remain shut down until sensor **108** is replaced or repaired.

[0034] There may be situations where the faulty sensor cannot be readily fixed or replaced, but that appliances connected to system **400** still need to be operable. In this situation, bypass system **404** enables the user to manually bypass appliance shut down and start or maintain the flow of gas to appliance **102**. In one embodiment, the bypass is only in effect for a specified period of time, such as **36** hours. Other periods of time may be set by the user, depending on system needs and uses. The user may continually restart the bypass system, but must do so no later than the specified period of time. This allows the system to continue functioning, but also requires the user to monitor the system as well. Consequently, a level of safety is maintained due to the necessity for user intervention. When sensor **108** is repaired or replaced, system **400** begins normal operation again. Note that alarm system **402** and/or bypass system **404** may be used in conjunction with exhaust system **302**.

[0035] FIG. **5** is a flow chart **500** illustrating steps for operating the systems of FIG. **3** and **4** according to one embodiment. In step **502**, a determination is made as to whether the air sensor is faulty. Faulty can mean that the sensor has failed or that its accuracy has dropped below a minimum threshold. If the air sensor is functioning properly, the air quality is sensed at step **200**. Steps **200** to **208** are the same as in FIG. **2** and thus their description will not be repeated. However, if as determined in step **502** that the air sensor is faulty, a turn off signal is sent (step **204**) and the appliance is turned off (step **208**). Next, or simultaneously, an alarm is activated in step **504**. Alarm activation may include a visual alarm, an audio alarm, a combination of the two, and/or a call sent to the user, such as via a cell phone or computer.

[0036] In step **506**, the user determines whether the appliances are to remain operational. If not, appliances remain shut off until a functional sensor is in place. However, if the appliances are to remain operational, a bypass is activated to resume or maintain gas flow to the appliance in step **508**. Step **510** determines whether the appliances have been operational more than a specified period of time after the bypass was activated. If so, the appliances are turned off at step **208**. However, if the specified period of time has not passed, the user may activate the bypass again in step **508** to continue operation of the appliances. Once the air sensor has been repaired or replaced, normal operation resumes at step **200** with air quality sensing or detection.

[0037] So, the above enables the air sensor to be continually monitored for proper operation and for the appliances to be turned off in the event of air sensor failure. However, the appliances can remain operational by a user bypass, although the bypass is only for a specified period of time, which can be continually reset by the user for uninterrupted operation.

[0038] In step **512**, after unsafe air is detected, an exhaust system is activated, which can be in response to the turn-off signal in step **204**, to a separate signal from sensor **108**, or to the appliance being turned off. The exhaust system is deactivated when the air quality is detected to be safe or when the user deactivates the system. Note that step **512** can be performed in parallel with or before step **208** and does not need to sequentially follow step **208**. The exhaust system may remain activated until safe air is detected or when the user manually turns off the exhaust system.

[0039] The above features provide a system that is safer than conventional systems, while still allowing the user the flexibility to maintain operation of the appliances if desired.

[0040] Having thus described embodiments of the present invention, persons skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention.

What is claimed is:

1. An air quality sensor and interrupting system, comprising:
- an air quality sensor configured to measure the quality of air proximate to a gas appliance and generate a signal when unsafe air is detected;
- a gas shut off device configured to turn off at least one portion of the gas appliance in response to the signal sent from the air quality sensor; and
- an exhaust configured to remove the unsafe air when unsafe air is detected.

2. The system of claim **1**, wherein the exhaust is a vacuum device.

3. The system of claim **1**, wherein the exhaust is a blowing device.

4. The system of claim **1**, further comprising a bypass configured to allow a user to keep the gas appliance turned on if the air quality sensor fails.

5. The system of claim **4**, wherein the bypass only allows the gas appliance to be turned on for a set period of time without additional user input.

6. The system of claim **1**, further comprising an alarm to notify the user when the air quality sensor fails.

7. The system of claim **6**, wherein the alarm is an audio alarm, a visual alarm, or an audio and visual alarm.

8. An air quality sensor and interrupting system, comprising:
- an air quality sensor configured to measure the quality of air proximate to a gas appliance and generate a signal when unsafe air is detected;
- a gas shut off device configured to turn off at least one portion of the gas appliance in response to the signal sent from the air quality sensor; and
- an alarm coupled to the sensor, wherein the alarm notifies a user when the sensor fails.

9. The system of claim **8**, further comprising a bypass configured to allow the user to keep the gas appliance turned on if the air quality sensor fails.

10. The system of claim **9**, wherein the bypass only allows the gas appliance to be turned on for a set period of time without additional user input.

11. An air quality sensor and interrupting system, comprising:

an air quality sensor configured to measure the quality of air proximate to a gas appliance and generate a signal when unsafe air is detected;

a gas shut off device configured to turn off at least one portion of the gas appliance in response to the signal sent from the air quality sensor; and

a bypass configured to allow a user to keep the gas appliance turned on if the air quality sensor fails.

12. The system of claim **11**, wherein the bypass only allows the gas appliance to be turned on for a set period of time without additional user input.

13. A method for operating a gas appliance, comprising:

sensing an air quality of air proximate to the gas appliance;

determining whether the air quality is unsafe;

turning off at least a portion of the gas appliance if the air quality is unsafe; and

removing the unsafe air.

14. The method of claim **13**, wherein the removing comprises vacuuming.

15. The method of claim **13**, wherein the removing comprises blowing.

16. The method of claim **13**, further comprising notifying a user when the sensing fails.

17. The method of claim **16**, wherein the notifying is with an audio alarm, a visual alarm, or an audio and visual alarm.

18. A method for operating a gas appliance, comprising:

sensing an air quality of air proximate to the gas appliance;

determining whether the air quality is unsafe;

turning off at least a portion of the gas appliance if the air quality is unsafe;

notifying a user if the sensing fails; and

turning off at least a portion of the gas appliance if the sensing fails.

19. The method of claim **18**, further comprising allowing the user to bypass turning off the gas appliance when the sensing fails to keep the appliance turned on.

20. The method of claim **19**, wherein the appliance is turned on only for a limited amount of time when the bypass is used.

21. The method of claim **18**, further comprising removing unsafe air when the air quality is determined unsafe.

* * * * *