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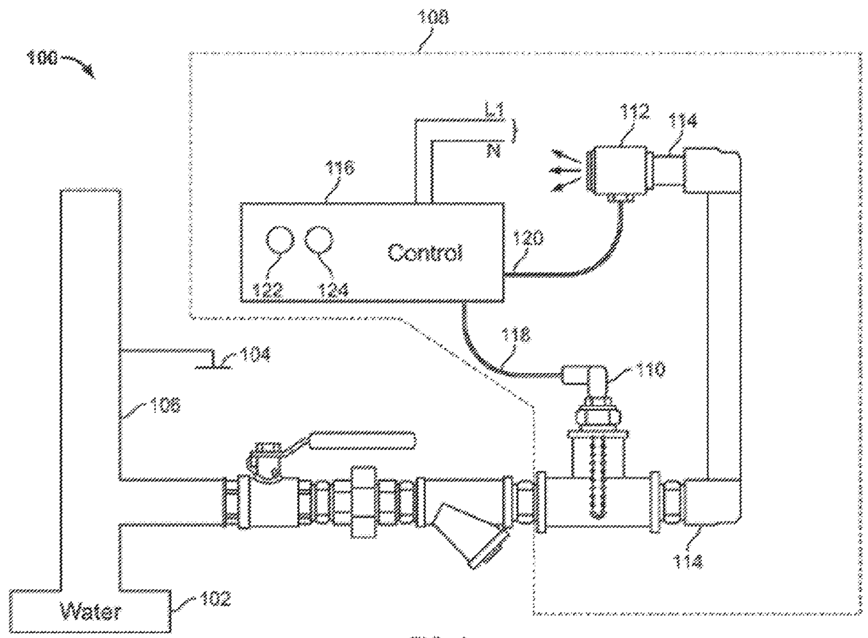

FIG. 1

(57) Abstract: A fire protection sprinkler system includes a water source; at least one sprinkler; a piping network interconnecting the water source and the at least one sprinkler, an automatic gas vent coupled to the piping network and configured to discharge gas from the piping network, the automatic gas vent including a sensor configured to sense a presence or absence of a liquid, and an electrically operated valve, the automatic gas vent configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid: and a photovoltaic power system electrically connected with the electrically operated valve and configured to provide electrical power for operation of the electrically operated valve. Associated methods of providing power to an electrically operated valve in a fire protection sprinkler system discharging gas from a fire protection sprinkler system are also described.

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LIQUID SENSING VALVE FOR A FIRE SPRINKLER SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is claims the benefit and priority of co-pending U.S. Provisional Patent Application Ser. No. 62/813,874 filed February March 5, 2019, the entire disclosure of which is hereby incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to electrically operated gas vents for fire protection sprinkler systems more particularly to systems and methods to provide electrical power to such vents.

BACKGROUND OF THE DISCLOSURE

[0003] This section provides background information related to the present disclosure which is not necessarily prior art.

[0004] Fire protection sprinkler systems are commonly used for suppressing fires with water upon detecting heat or smoke. These systems typically include a water source such as a source of city water, one or more sprinklers such as fusible sprinkler heads that are activated by heat, and a piping network interconnecting the water source and sprinkler heads. Various types of water based sprinkler systems are known, such as wet pipe sprinkler systems and dry pipe sprinkler systems, including preaction systems, water mist systems, water spray systems, etc.

[0005] The closed nature of fire protection sprinkler systems results in large volumes of trapped air at high points in the system. These trapped air pockets contain nearly 21% oxygen, which fuels an aggressive corrosion reaction, as discussed, for example in U.S. Patent Nos. 9,144,700 and 9,186,533, the entire disclosures of each of which are expressly incorporated by reference herein. NFPA 13, the Standard for the Installation of Fire Sprinkler Systems, requires a means of venting trapped air from new systems to alleviate corrosion due to the trapped air. Mechanical assemblies known as automatic air vents are designed to allow atmosphere to escape as the system fills, satisfying this requirement. They typically contain one or more float valves that close as the system fills, preventing water from leaking by and automatically resetting as the system is drained down. An example of mechanical assemblies of this general nature are described in U.S. Patent No. 8,636,023, the entire disclosure of which is incorporated by reference herein.

[0006] Current automatic air vents minimize leak risk using redundancy, such as two floats in-line, a single float and fusible-link failsafe, or a single float and a solenoid valve in conjunction with a liquid sensor. Examples of such redundant systems are described in the '023 patent and U.S. Patent No. 9,884,216, the entire disclosure of which is incorporated by reference herein.

[0007] In the case of vents that incorporate solenoids or other electrically powered valves, a reliable power source is required. Current power source options consist of hard-wiring a source from the grid-based building electrical system or using batteries that must be replaced regularly. Both of these options can present issues. Batteries used to operate the solenoids have relatively short life-cycles (6-12 months) due to the continuous-duty nature of their operation. In the case of a normally closed solenoid, a power failure due to a discharged battery results in the solenoid valve closing, causing corrosion damage to accumulate in the system due to the trapped oxygen. In the case of a normally open solenoid, a power failure due to a discharged battery results in the solenoid valve opening, causing a loss of redundancy or complete loss of the ability to stop water from exiting the vent assembly. Further, automatic air release assemblies are installed at high points of the system. This results in a location that is often hard to service while a facility is in operation, as servicing the equipment to replace the batteries may require a lift and associated safety equipment.

[0008] On the other hand, hard-wiring an automatic air release can carry additional labor and equipment cost, and the same power loss issue applies as in the previous example. A loss of power to the building or the circuit breaker being opened will cause the vent to become non-functional, trapping air within the system and leading to the accumulation of corrosion damage. Thus, in the case of either battery-powered or hard-wired systems there is a greater possibility of power loss, as well as cost and logistical issues.

SUMMARY

[0009] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

According to one aspect of the present disclosure, a fire protection sprinkler system includes a water source, at least one sprinkler, a piping network interconnecting the water source and the at least one sprinkler, an automatic gas vent coupled to the piping network and configured to discharge gas from the piping network, the automatic gas vent including a sensor configured to sense a presence or absence of a liquid, and an electrically operated valve, the automatic gas vent configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid, and a photovoltaic power system electrically connected with the electrically operated valve and configured to provide electrical power for operation of the electrically operated valve.

[0010] According to another aspect of the present disclosure, the photovoltaic power system further includes at least one photovoltaic cell, a rechargeable battery connected with the photovoltaic cell, and an inverter connected with the rechargeable battery and with the electrically operated valve.

[0011] According to another aspect of the present disclosure, an automatic gas vent assembly for a fire protection sprinkler system is disclosed. The fire protection sprinkler system includes a water source and at least one sprinkler. The automatic gas vent assembly includes a sensor configured to sense a presence or absence of a liquid in the automatic gas vent assembly, an electrically operated valve, and at least one photovoltaic cell in electrical communication with the electrically operated valve. The automatic gas vent assembly is configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid. The photovoltaic cell is configured to provide the electrically operated valve with electrical power.

[0012] According to a further aspect of the present disclosure, there is provided a method of providing electrical power to an electrically operated valve in a fire protection sprinkler system that includes a water source, at least one sprinkler, a piping network interconnecting the water source and the at least one sprinkler, and wherein the electrically operated valve is part of an automatic gas vent coupled to the piping network and configured to discharge gas from the piping network, the automatic gas vent including a sensor configured to sense a presence or absence of a liquid, and an electrically operated valve, the automatic gas vent configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid, including the steps of connecting an inverter with the electrically operated valve, connecting at least one photovoltaic cell with the rechargeable battery, and transmitting electrical power from the photovoltaic cell to the rechargeable battery and from the rechargeable battery to the electrically operated valve.

[0013] According to yet another aspect of the present disclosure, a method of discharging gas from a fire sprinkler system is disclosed. The fire sprinkler system includes a water source and a piping network connected to the water source. The method includes providing an electrically operated valve with electrical power from at least one photovoltaic cell, sensing a presence of a gas within the piping network with a sensor, actuating the electrically operated valve in response to the sensor sensing the presence of gas within the piping network, and discharging the gas through the electrically operated valve.

[0014] Various aspects of this disclosure may provide benefits such as a redundant power supply to minimize likelihood of operational interruption of vents and resulting corrosion damage to the fire protection sprinkler system, simplified installation and maintenance, eliminating external power source requirements, and minimizing battery replacement requirements.

[0015] Further aspects and areas of applicability will become apparent from the description provided herein. It should be understood that various aspects of this disclosure may be implemented individually or in combination with one or more other aspects. It should also be understood that the description and specific examples herein are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0016] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0017] FIG. 1 is a block diagram of a fire protection sprinkler system including an automatic gas vent assembly according to one example embodiment of the present disclosure.

[0018] FIG. 2 is a block diagram of a fire protection sprinkler system including an automatic gas vent assembly having a redundant gas vent and a pressure-operated valve according to another example embodiment of the present disclosure.

[0019] FIGS. 3A and 3B are schematic diagrams of an example electrical control for the automatic gas vent assemblies shown in FIGS. 1 and 2.

[0020] FIG. 4 is a block diagram of the fire protection sprinkler system of FIG. 2 coupled to an inert gas source according to another embodiment of the present disclosure.

[0021] FIG. 5 is a schematic diagram of a photovoltaic power source for a fire protection sprinkler system according to an embodiment of the present disclosure.

[0022] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0023] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0024] Example embodiments are provided so this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[0025] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms “a,” “an,” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The methods, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0026] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0027] Spatially relative terms, such as “inner,” “outer,” “beneath,” “below,” “lower,” “above,” “upper,” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0028] A fire protection sprinkler system according to one example embodiment of the present disclosure is illustrated in FIG. 1 and indicated generally by reference number 100. As shown in FIG. 1, the system 100 includes a water source 102, a sprinkler 104 and a piping network 106 interconnecting the water source 102 and the sprinkler 104. The system 100 further includes an automatic gas vent 108 coupled to the piping network 106 and configured to discharge gas from the piping network 106. In the particular example shown in FIG. 1, the automatic gas vent 108 is configured as an assembly for coupling to the piping network 106 as a single unit.

[0029] As shown in FIG. 1, the automatic gas vent assembly 108 includes a sensor 110 configured to sense a presence or absence of a liquid and an electrically operated valve 112. The automatic gas vent assembly 108 is configured to open the electrically operated valve 112 in response to the sensor 110 sensing the absence of a liquid and close the electrically operated valve 112 in response to the sensor 110 sensing the presence of a liquid.

[0030] The automatic gas vent assembly 108 allows gas to be automatically discharged from the piping network 106 via the electrically operated valve 112 (as indicated by the arrows in FIG. 1) without also discharging water. This is because the electrically operated valve 112 is automatically opened in response to the sensor 110 sensing the absence of water, and automatically closed in response to the sensor 110 sensing the presence of water (e.g., when the piping network 106 is being filled with water, or after a gas bubble moves past the sensor 110).

[0031] The sensor 110 may be any type of sensor adapted to sense the absence or presence of a liquid, including, for example, an electrical conductance probe, a magnetic float sensor (Reed switch), a pneumatic level sensor, an electrode level sensor, a float level sensor, or an optical interface measurement sensor, among others. In the particular example shown in FIG. 1, the sensor 110 is an electrical conductance probe. Thus, low (including no) conductance indicates the absence of liquid and high conductance indicates the presence of liquid. Additionally, while only one sensor 110 is illustrated in FIG. 1, more than one sensor may be employed without departing from the scope of the present disclosure. The sensor 110 (and additional sensors, if employed) may be positioned at any suitable location in the system 100.

[0032] The electrically operated valve 112 is preferably a normally closed valve so the valve 112 will automatically close when electric power is lost. In this manner, the valve 112 will not allow water to escape from the piping network 106 when electric power is removed from the automatic gas vent assembly 108 (e.g., during a power outage). In the particular example shown in FIG. 1, the valve 112 is a normally closed, solenoid-operated valve.

[0033] As shown in FIG. 1, the assembly 108 includes space (e.g., in the piping 114) between the sensor 110 and the electrically operated valve 112 for containing a pressurized air bubble. For example, suppose the piping network 106 is initially dry and filled only with air. During this time, the electrically operated valve 112 will be open. When the piping network 106 is subsequently filled with water, the electrically operated valve 112 will close in response to the sensor 110 sensing the presence of water. As a result, an air bubble will be trapped by the electrically operated valve 112 in the space between the sensor 110 and the valve 112. The water pressure in the piping network 106 will compress and reduce the volume of the trapped air bubble until the pressure of the air bubble reaches the water pressure in the piping network 106.

[0034] Conversely, when the fire protection system 100 is drained, the trapped air bubble will decompress and expand in volume to help remove water from around the sensor 110, causing the sensor 100 to sense the absence of water. This, in turn, will cause the electrically operated valve 112 to open and essentially reset the automatic gas vent assembly 108 before the piping network 106 is filled again with water.

[0035] As shown in FIG. 1, the automatic gas vent assembly may also include an electrical control 116 coupled to the sensor 110 (e.g., via cable 118) and coupled to the electrically operated valve 112 (e.g., via cable 120). The electrical control 116 is configured to open the electrically operated valve 112 in response to the sensor 110 sensing the absence of a liquid, and close the electrically operated valve 112 in response to the sensor 110 sensing the presence of a liquid.

[0036] The electrical control 116 may be powered by 110 VAC, as shown in FIG. 1, or any other suitable AC or DC power source. More particularly, in one advantageous embodiment, the electrical control 116 is connected with a photovoltaic power system 400 as shown in FIG. 5. The photovoltaic power system 400 may include at least one photovoltaic cell 404, a rechargeable battery 406 that is charged by the flow of power from the photovoltaic cell 404, and an inverter 408 that converts direct current produced by the photovoltaic cell 404 to alternating current for electrical controls 116 that require A/C. However, for electrical controls 116 that are able to operate on a direct current supply, an inverter 408 may not be necessary. As used herein, the photovoltaic cell 404 may encompass a single cell or an array of cells and may include a solar panel array.

[0037] In a preferred embodiment, the photovoltaic power system 400 is integrated with the automatic gas vent assembly 108. In such embodiments, this arrangement results in a self-powered unit that may be installed and removed if necessary as a single device. The photovoltaic cell 404 is positioned on an exterior surface of the integrated unit in order to expose the photovoltaic cell 404 to light sources within the building, more specifically, interior building lighting sources, although exterior light sources, including sunlight, may also provide light to the photovoltaic cell 404.

[0038] In alternate embodiments, the photovoltaic power system 400 or some components thereof maybe located remotely from the automatic gas vent assembly 400 and connected electrically with the electrical control 116.

[0039] In either case in which the photovoltaic cell 404 is located locally or remotely, the photovoltaic power system 400 may be used to power single or multiple automatic gas vent assemblies 108

[0040] The rechargeable battery pack 406 may also be suitable to store excess power produced by the photovoltaic cell 404 for use by the electrical control 116 at other times. The system may also include a charge controller or charge regulator to regulate voltage supplied to the battery pack 406 to prevent overcharging while allowing charging when required. In another embodiment, the system 400 may also be provided with a backup generator 410 to provide power to the electrical control 116 during periods of low system 400 output or increased demand.

[0041] The photovoltaic power system 400 may also be configured to operate in tandem with a standard grid-based power source from the building electrical system. In these embodiments, the photovoltaic power system 400 may be operated as either the primary or an auxiliary power source. These embodiments may include an auto transfer switch to switch the system back and forth between photovoltaic power and grid power as needed. Further, the inverter 408 may be a grid-tie inverter. In these embodiments, the photovoltaic power system 400, in combination with the building power supply, provides a reliable redundant power source that will provide for consistent operation of the automate gas vent assembly 108 and minimize the likelihood of corrosion damage or uncontrolled release of water from the fire protection sprinkler system due to a power failure.

[0042] Embodiments of the photovoltaic power system 400 and/or automatic gas vent assembly 108 may further include various sensors and visual or audible indicators to allow monitoring of at least one operational status of the system 400. A power or charge level sensor and indicator 412 may be used to monitor the current power level of the battery 406 and whether the battery 406 is properly recharging. A malfunction sensor and indicator 414 may be used to monitor proper electrical/electronic functioning of the photovoltaic power system 400 and/or the electrical control 116. These indicators may be locally or remotely located. For example, the indicators may be located within a central control panel for the fire protection sprinkler system so that an inspector or other operator may quickly check – or be alerted to – the functioning of the vent power system along with other aspects of the fire protection sprinkler system quickly at the same time.

[0043] Embodiments of the system also may allow for simplified installation requirements, with no extra wiring required, particularly in those embodiments in which the photovoltaic cell 404 is integrated with the automatic gas vent assembly 108. The system 400 may operate without the need for an external power source. Because of the rechargeable nature of the battery 406 used, the need for battery replacement is minimized.

[0044] The electrical control 116 is configured to produce an electrical output indicating a state of the electrically operated valve 112. This output may be provided, e.g., to one or more visual, audible, or other indicators (e.g., LEDs or sounders) for indicating whether the electrically operated valve is open or closed. In the example embodiment shown in FIG. 1, the electrical control 116 includes two visual indicators 122, 124. The indicator

122 is activated (e.g., turned on) when the electrically operated valve 112 is open, and the indicator 124 is activated when the electrically operated valve 112 is closed. In this embodiment, indicator 122 is red and indicator 124 is green.

[0045] FIG. 2 illustrates a fire protection sprinkler system 200 having an automatic gas vent assembly 208 that is similar to the assembly 108 shown in FIG. 1, but further includes an optional pressure-operated valve 226 as well as an optional redundant gas vent 228.

[0046] The pressure-operated valve 226 is in fluid communication with the electrically operated valve 112 and has a pressure setting that may be set in the factory or manually in the field. The pressure-operated valve 226 is configured to prevent an ingress of air into the system 200 through the pressure-operated valve 226. In other words, the pressure-operated valve 226 operates as a one-way valve that allows gas to exit the system 200 (as indicated by the arrows in FIG. 2) while preventing gas (including oxygen-rich air that may cause corrosion) from entering the system 200.

[0047] The pressure setting of the pressure-operated valve 226 is preferably below the water pressure of the water source 102. As a result, the water pressure of the water source 102 will be sufficient to discharge gas through the pressure-operated valve 226 as the piping network 106 is being filled with water. In some embodiments, the pressure setting of the pressure-operated valve 226 is about forty pounds per square inch gauge (PSIG).

[0048] Additionally, the pressure-operated valve 226 may increase the amount of air compressed in the space (e.g., in the piping 114) between the sensor 110 and the electrically operated valve 112 when the piping network 106 is filling with water. Initially, when the electrically operated valve 112 is open, the air in the space between the sensor 110 and the valve 112 will compress and reach the pressure setting of the pressure-operated valve (e.g., about forty PSIG) before air begins to exit the system 200 via the pressure-operated valve 226. Thus, a compressed air bubble will already exist in the space between the sensor 110 and the electrically operated valve 112 while the valve 112 is still open. When the electrically operated valve 112 closes in response to the sensor 110 sensing the presence of water, the water pressure in the piping network 106 will further compress and reduce the volume of the trapped air bubble until the pressure of the air bubble reaches the water pressure in the piping network 106. Thus, a larger volume of air may be trapped and compressed in the system 200 of FIG. 2 as compared to the system 100 of FIG. 1, due to the pressure-operated valve 226.

[0049] Consequently, when the fire protection system 200 is drained, the trapped air bubble will decompress and expand in volume to a greater extent than in the system 100 of FIG. 1. Therefore, in terms of removing water from around the sensor 110 so the electrically operated valve 112 will open during draining, the system 200 of FIG. 2 may perform better than the system 100 of FIG. 1.

[0050] In some embodiments, the pressure-operated valve 226 may emit an audible indicator when the pressure-operated valve 226 is discharging gas from the system 200.

[0051] In the particular embodiment shown in FIG. 2, the pressure-operated valve 226 is a pressure relief valve. Alternatively, any other suitable type of pressure-operated valve may be employed including, e.g., a check valve, etc.

[0052] The redundant gas vent 228 shown in FIG. 2 is configured to vent gas and retain liquid, and is preferably positioned between the sensor 110 and the electrically operated valve 112. The redundant gas vent 228 provides additional assurance that no water will be discharged from the system 200 during normal operation, and also ensures no water will be discharged from the system 200 due to a failure of the sensor 110 and/or the electrically operated valve 112.

[0053] The redundant gas vent 228 may be any suitable gas vent, and is preferably a passive mechanical gas vent to ensure no water will be discharged from the system during a power outage, even if the electrically operated valve 112 malfunctions. In the particular example shown in FIG. 2, the redundant gas vent 228 is a float operated valve of the type made by Apco.

[0054] FIGS. 3A and 3B illustrate one example embodiment of the electrical control 116 shown in FIGS. 1 and 2. As shown in FIG. 3A, the example electrical control 116 includes a board level controller 302 coupled to the sensor 110 (e.g., an electrical conductance probe), and a relay 304 coupled to the electrically operated valve 112 and the visual indicators 122, 124.

[0055] When the sensor 110 senses the absence of water, the sensor 110 presents an open circuit to the board level controller 302, as shown in FIG. 3A. In response, the board level controller 302 energizes the coil of the relay 304. As a result, the relay 304 provides power to the electrically operated valve 112 to open the valve 112, and also provides power to the "open" indicator 122, as shown in FIG. 3A.

[0056] Conversely, when the sensor 110 senses the presence of water, the sensor 110 presents a closed circuit to the board level controller 302, as shown in FIG. 3B. In response, the board level controller 302 deenergizes the coil of the relay 304. As a result, the relay 304 removes power from the electrically operated valve 112, causing the valve 112 to close, while providing power to the “closed” indicator 124, as shown in FIG. 3B.

[0057] In the example embodiment shown in FIGS. 3A and 3B, the relay 304 is a double pole, double throw (DPDT) relay.

[0058] FIG. 4 illustrates a fire protection sprinkler system 400 according to another example embodiment of this disclosure. The system 400 of FIG. 4 is similar to the system 200 of FIG. 2, but further includes an inert gas source 430 coupled to the piping network 106. The inert gas source 430 may include a nitrogen generator, nitrogen bottle(s), or the like. The inert gas source 430 may be used to displace oxygen in the piping network with an inert gas (i.e., a gas that does not react with system components), such as nitrogen, to minimize corrosion in the system 400.

[0059] In various embodiments of automatic gas vent assemblies consistent with the present disclosure, the liquid sensor 110, solenoid 112, float valve, and pressure retention device 226 may be utilized in various combinations and arrangements. For example, the automatic gas vent assembly may utilize the liquid sensor and the solenoid, wherein the liquid sensor and solenoid may be positioned in any order. Alternatively the gas vent assembly may utilize a liquid sensor, solenoid, and pressure retention device, again, with the liquid sensor being positioned either before or after the solenoid. In another version, the gas vent assembly includes a liquid sensor, solenoid, and float valve, with the liquid sensor, solenoid, and float valve positioned in any order. Further, the gas vent assembly may incorporate all four elements – liquid sensor, solenoid, float valve, and pressure retention device – again with the liquid sensor, float valve, and solenoid installed in any order relative to one another.

[0060] The fire protection systems described herein may be any suitable type of water-based fire protection sprinkler systems such as, for example, wet pipe sprinkler systems, dry pipe sprinkler systems, etc.

[0061] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A fire protection sprinkler system comprising:

a water source;

at least one sprinkler;

a piping network interconnecting the water source and the at least one sprinkler,

an automatic gas vent coupled to the piping network and configured to discharge gas from the piping network, the automatic gas vent including a sensor configured to sense a presence or absence of a liquid, and an electrically operated valve, the automatic gas vent configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid; and

a photovoltaic power system electrically connected with the electrically operated valve and configured to provide electrical power for operation of the electrically operated valve.

2. The fire protection sprinkler system as set forth in any claim herein, wherein the photovoltaic power system further includes:

at least one photovoltaic cell;

a rechargeable battery connected with the photovoltaic cell;

an inverter connected with the rechargeable battery and with the electrically operated valve.

3. The fire protection sprinkler system as set forth in any claim herein, wherein the photovoltaic power system further includes a charge controller connected with the rechargeable battery.

4. The fire protection sprinkler system as set forth in any claim herein, wherein the electrically operated valve is a solenoid-operated valve.

5. The fire protection sprinkler system as set forth in any claim herein, wherein the automatic gas vent is also connected with a building power supply system and wherein the inverter is a grid-tie inverter connected with both the building power supply system and with the rechargeable battery.

6. The fire protection sprinkler system as set forth in any claim herein, wherein the photovoltaic power system is the primary power source for the electrically operated valve.

7. The fire protection sprinkler system as set forth in any claim herein, wherein the building power supply system is the primary power source for the electrically operated valve.

8. The fire protection sprinkler system as set forth in any claim herein, wherein the photovoltaic power system is connected with a backup generator.

9. The fire protection sprinkler system as set forth in any claim herein, wherein the photovoltaic power system further includes at least one sensor for monitoring at least one operational status of the photovoltaic power system and at least one indicator connected with the at least one sensor and configured to display a signal indicative of the at least one operational status.

10. The fire protection sprinkler system as set forth in any claim herein, further comprising an electrical control coupled to the photovoltaic power system, the sensor, and the electrically operated valve, the photovoltaic power system configured to provide power to the electrical control, and the electrical control configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid.

11. The fire protection sprinkler system as set forth in any claim herein, wherein the electrical control comprises a relay.

12. The fire protection sprinkler system as set forth in any claim herein, further comprising a visual or audible indicator for indicating whether the electrically operated valve is open or closed.

13. A method of providing electrical power to an electrically operated valve in a fire protection sprinkler system that includes a water source, at least one sprinkler, a piping network interconnecting the water source and the at least one sprinkler, and wherein the

electrically operated valve is part of an automatic gas vent coupled to the piping network and configured to discharge gas from the piping network, the automatic gas vent including a sensor configured to sense a presence or absence of a liquid, and an electrically operated valve, the automatic gas vent configured to open the electrically operated valve in response to the sensor sensing the absence of a liquid and close the electrically operated valve in response to the sensor sensing the presence of a liquid, comprising the steps of:

connecting an inverter with the electrically operated valve;

connecting at least one photovoltaic cell with the rechargeable battery; and

transmitting electrical power from the photovoltaic cell to the rechargeable battery and from the rechargeable battery to the electrically operated valve.

14. A method of discharging gas from a fire protection sprinkler system that includes a water source, at least one sprinkler, a piping network interconnecting the water source and the at least one sprinkler, and at least one electrically operated valve configured to vent gas from the piping network, comprising the steps of:

providing the electrically operated valve with electrical power from at least one photovoltaic cell;

sensing a presence of a gas within the piping network with a sensor;

actuating the electrically operated valve in response to the sensor sensing the presence of gas within the piping network; and

discharging the gas through the electrically operated valve.

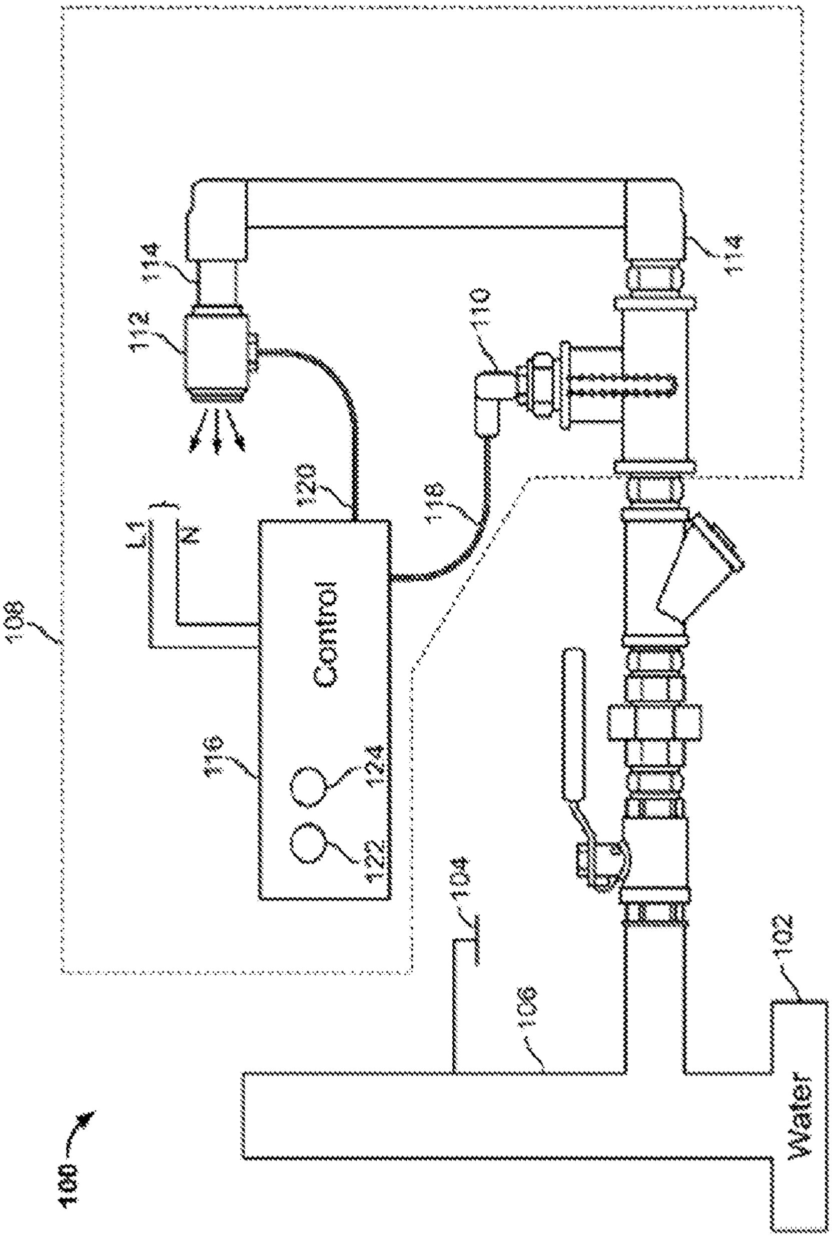
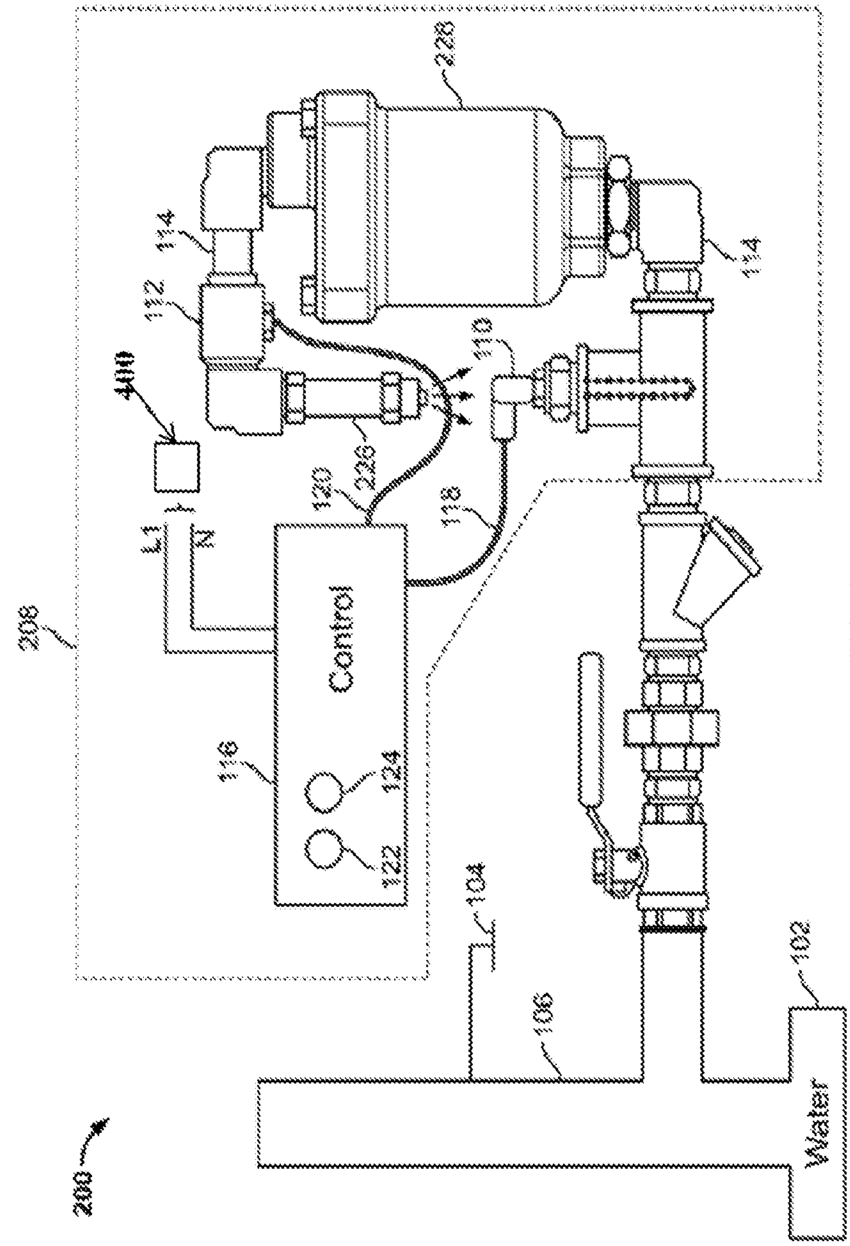

100
108
112
114
114
110
120
118
L1
N
Control
116
122
124
104
106
102
Water

FIG. 1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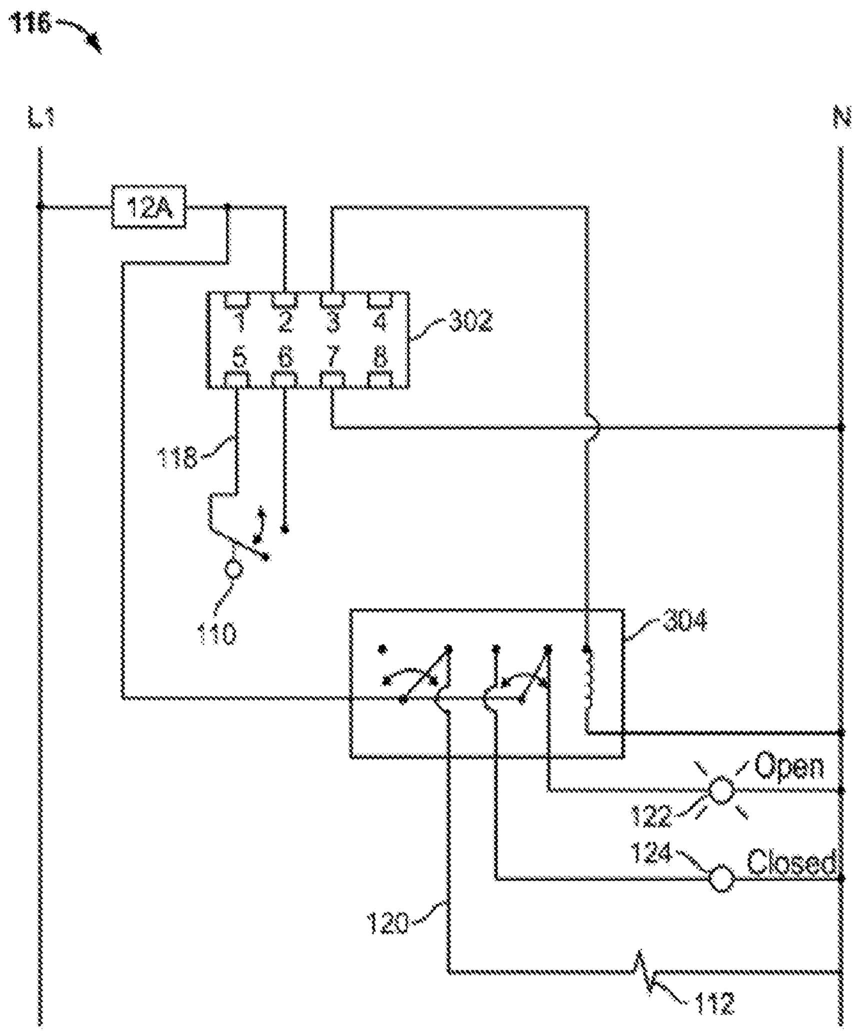
208
228
114
112
114
400
110
226
120
118
L1
N
Control
116
124
122
104
106
102
Water

FIG. 2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L1
N
12A
1 2 3 4
5 6 7 8
302
118
110
304
Open
122
124
Closed
120
112

FIG. 3A

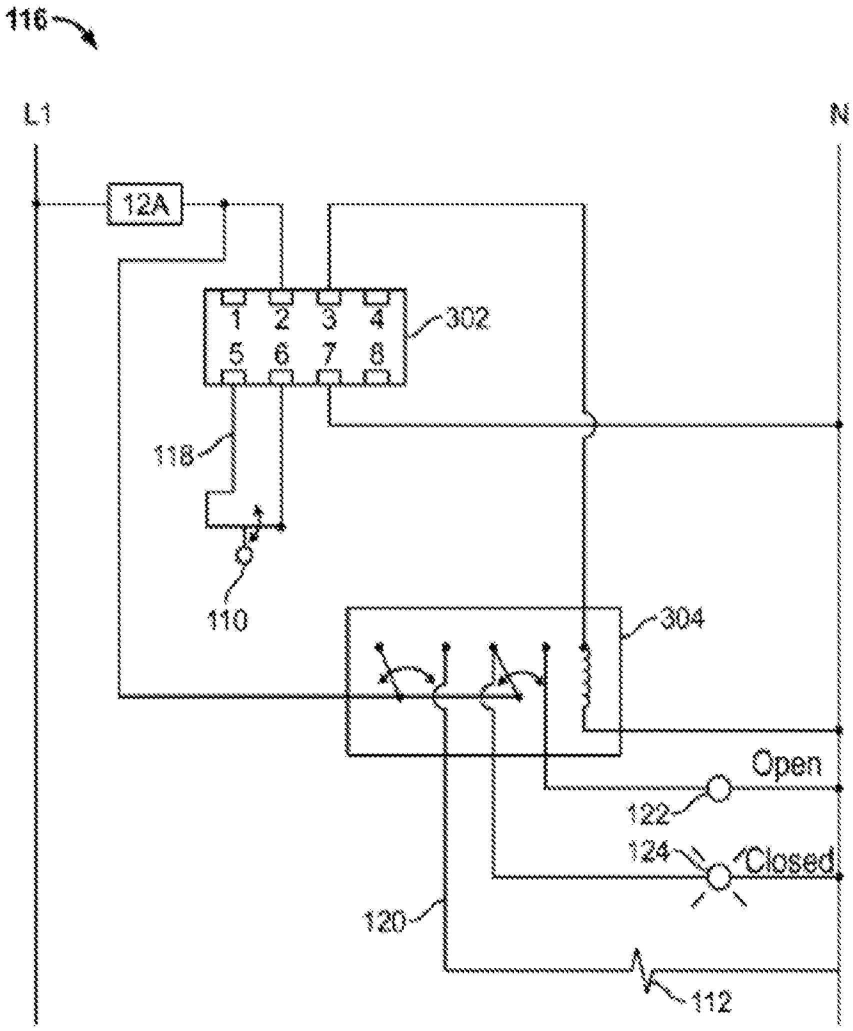
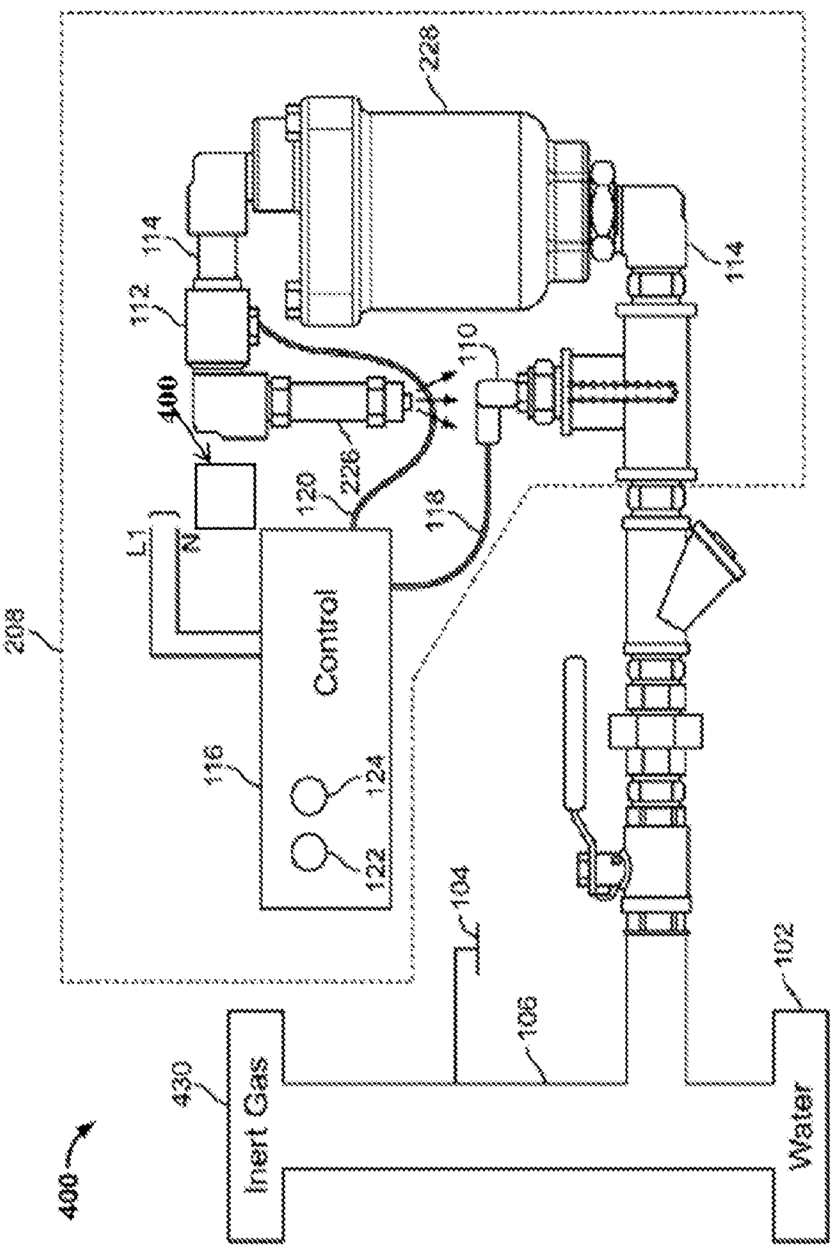

116
L1
N
12A
1 2 3 4
5 6 7 8
302
118
110
304
Open
122
124
Closed
120
112

FIG. 3B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228
114
112
400
110
226
120
118
L1
N
Control
116
124
122
104
106
430
Inert Gas
102
Water
114

FIG. 4

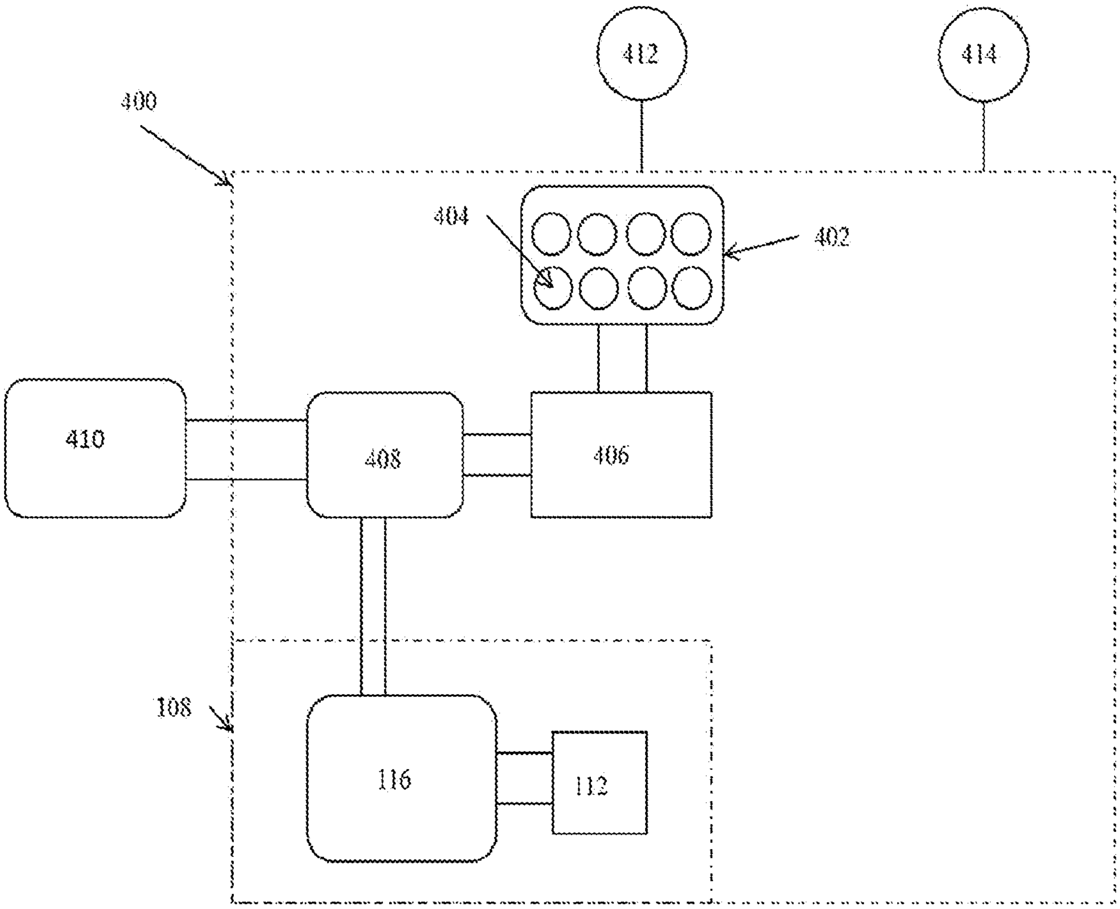

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2020/020934

A. CLASSIFICATION OF SUBJECT MATTER

A62C 35/60(2006.01)i, A62C 37/36(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A62C 35/60; A01G 25/02; A01G 25/16; A62C 37/00; B08B 3/02; E04D 13/00; E04H 9/16; F24D 11/00; F24D 3/00; H02S 50/00; A62C 37/36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: fire protection sprinkler, water source, piping network, gas vent, photovoltaic power system, valve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
DY	US 9884216 B2 (ENGINEERED CORROSION SOLUTIONS LLC) 06 February 2018 column 3, line 42 - column 5, line 54, claims 1,4,17-19, and figures 1-2	1-14
Y	CN 205727405 U (YANGGU POWER SUPPLY COMPANY OF STATE GRID SHANDONG ELECTRIC POWER COMPANY) 30 November 2016 paragraphs [0015]-[0017] and figure 1	1-14
A	US 2018-0128497 A1 (MOSHE BLUMENFELD) 10 May 2018 paragraphs [0089]-[0091] and figures 15-16	1-14
A	JP 2016-089491 A (MAMPO KIKAKU CO., LTD.) 23 May 2016 paragraphs [0014]-[0017] and figure 1	1-14
A	US 2017-0036246 A1 (BOE TECHNOLOGY GROUP CO., LTD. et al.) 09 February 2017 paragraphs [0026]-[0042] and figure 1	1-14

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 June 2020 (30.06.2020)	**01 July 2020 (01.07.2020)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2020/020934

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