(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
04 January 2024 (04.01.2024)

WIPO | PCT

(10) **International Publication Number**
WO 2024/005952 A1

(51) **International Patent Classification:**
A62B 15/00 (2006.01) ***G16Y 40/10*** (2020.01)
A62B 13/00 (2006.01) ***G16Y 40/30*** (2020.01)
G16Y 20/10 (2020.01)

(21) **International Application Number:** PCT/US2023/022222

(22) **International Filing Date:** 15 May 2023 (15.05.2023)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
63/356,996 29 June 2022 (29.06.2022) US
63/359,882 11 July 2022 (11.07.2022) US

(71) **Applicant: RESCUE AIR SYSTEMS, INC.** [—/US]; 751 Laurel Street, Suite 416, San Carlos, CA 94070 (US).

(72) **Inventor: TURIELLO, Anthony, J.**; 1760 Terra Bella Drive, Westlake, TX 76262 (US).

(74) **Agent: ABHYANKER, Raj**; Legalforce RAPC Worldwide, 446 E Southern Avenue, Tempe, AZ 85282 (US).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** METHOD, DEVICE AND SYSTEM OF A SENSOR INTEGRATED COMPUTING PLATFORM OF A FIREFIGHTER AIR REPLENISHMENT SYSTEM FOR REMOTE MONITORING AND ACCESS THEREOF

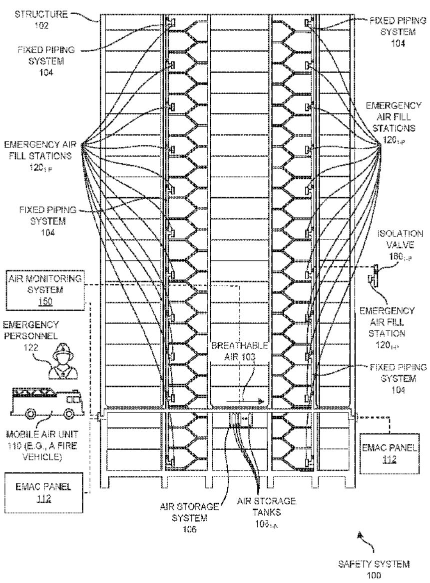

FIG. 1

(57) **Abstract:** Disclosed are a method, a device and a system of a sensor integrated safety system based computing platform. The computing platform is executed on a data processing device and integrated with a set of sensors associated with components of a safety system In accordance therewith, the data processing device collects a number of parameters of the components of the safety system and/or of access thereof through detection of the number of parameters via the set of sensors. The number of parameters includes one or more parameter(s) related to breathable air from a source within the safety system supplied thereacross via a fixed piping system implemented therein and/or access of the breathable air. The data processing device also monitors the safety system and/or one or more components thereof based on the collected number of parameters.

WO 2024/005952 A1

METHOD, DEVICE AND SYSTEM OF A SENSOR INTEGRATED COMPUTING PLATFORM OF A FIREFIGHTER AIR REPLENISHMENT SYSTEM FOR REMOTE MONITORING AND ACCESS THEREOF

CLAIM OF PRIORITY

[0001] This Application is a conversion application of, and claims priority to, U.S. Provisional Patent Application No. 63/356,996 titled CLOUD-BASED FIREFIGHTING AIR REPLENISHMENT MONITORING SYSTEM, SENSORS AND METHODS filed on June 29, 2022 and U.S. Provisional Patent Application No. 63/359,882 titled REMOTE MONITORING AND CONTROL OF A FIREFIGHTER AIR REPLENISHMENT SYSTEM THROUGH SENSORS DISTRIBUTED WITHIN COMPONENTS OF THE FIREFIGHTER AIR REPLENISHMENT SYSTEM filed on July 11, 2022. The contents of each of the aforementioned applications are incorporated herein by reference in entirety thereof.

FIELD OF TECHNOLOGY

[0002] This disclosure relates generally to emergency systems and, more particularly, to a method, a device and/or a system of a sensor integrated computing platform of a safety system of a structure for remote monitoring and access thereof.

BACKGROUND

[0003] A structure (e.g., a vertical building, a horizontal building, a tunnel, marine craft) may have a Firefighter Air Replenishment System (FARS) implemented therein. The FARS may have an emergency air fill station therein to enable firefighters and/or emergency personnel access breathable air therethrough. The FARS may have other components relevant to critical functioning thereof. However, tracking parameters (e.g., pressure of the breathable air supplied) of the FARS critical to the functioning and/or the maintenance thereof may be difficult due to a monolithic and/or a standalone implementation of the components of the FARS.

SUMMARY

[0004] Disclosed are a method, a device and/or a system of a sensor integrated computing platform of a safety system of a structure for remote monitoring and access thereof.

[0005] In one aspect, a method of a safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system is disclosed. The method includes executing a computing platform on a data processing device, and integrating the computing platform with a set of sensors associated with a number of components of the safety system. In accordance with the execution of the computing platform on the data processing device and the integration thereof with the set of sensors, the method also includes, through the data processing device, collecting a number of parameters of the number of components of the safety system and/or of access thereof through detection of the number of parameters via the set of sensors. The number of parameters includes one or more parameter(s) related to the breathable air and/or access of the breathable air. Further, the method includes monitoring the safety system and/or one or more component(s) of the number of components thereof based on the collected number of parameters.

[0006] In another aspect, a data processing device of a safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system is disclosed. The data processing device includes a memory including instructions associated with a computing platform stored therein, and a processor communicatively coupled to the memory. The processor executes the instructions associated with the computing platform to integrate the computing platform with a set of sensors associated with a number of components of the safety system, and, in accordance with the integration, collect a number of parameters of the number of components of the safety system and/or of access thereof through detection of the number of parameters via the set of sensors. The number of parameters includes one or more parameter(s) related to the breathable air and/or access of the breathable air. The processor also executes the instructions associated with the computing platform to monitor the safety system and/or one or more component(s) of the number of components thereof based on the collected number of parameters.

[0007] In yet another aspect, a safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system is disclosed. The safety system includes a data processing device executing a computing platform thereon, and a set of sensors associated with a number of components of the safety system. The execution of the computing platform on the data processing device integrates the computing platform with the set of sensors associated with the number of components of the safety system. In accordance with the execution of the computing platform on the data processing device and the integration thereof with the set of sensors, the data processing device collects a number of parameters of the number of components of the safety system and/or of access thereof through detection of the number of parameters via the set of sensors. The number of parameters includes one or more parameter(s) related to the breathable air and/or access of the breathable air. The data processing device also monitors the safety system and/or one or more component(s) of the number of components thereof based on the collected number of parameters.

[0008] Other features will be apparent from the accompanying drawings and from the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The embodiments of this invention are illustrated by way of example and not limitation in the figures of the accompanying drawings, in which like references indicate similar elements and in which:

[0010] **Figure 1** is a schematic and an illustrative view of a safety system associated with a structure, according to one or more embodiments.

[0011] **Figure 2** is a schematic view of the safety system of **Figure 1** with elements thereof integrated therewithin in detail, according to one or more embodiments.

[0012] **Figure 3** is a schematic view of the air monitoring system of the safety system of **Figures 1-2**, according to one or more embodiments.

[0013] **Figure 4** is a schematic view of an emergency air fill station of the safety system of **Figures 1-2**, according to one or more embodiments.

[0014] **Figure 5** is a schematic view of an air storage system of the safety system of **Figures 1-2**, according to one or more embodiments.

[0015] **Figure 6** is a schematic view of a computing platform relevant to the safety system of **Figures 1-2** implemented through a server, according to one or more embodiments.

[0016] **Figure 7** is a schematic view of a data processing device of **Figures 2-6**, according to one or more embodiments.

[0017] **Figure 8** is an example user interface view of a component of the computing platform of **Figure 6** executing on the data processing device of **Figures 2-7**.

[0018] **Figure 9** is a process flow diagram detailing the operations involved in realizing a sensor integrated computing platform of a safety system of a structure for remote monitoring and access thereof, according to one or more embodiments.

[0019] Other features of the present embodiments will be apparent from the accompanying drawings and from the detailed description that follows.

DETAILED DESCRIPTION

[0020] Example embodiments, as described below, may be used to provide a method, a device and/or a system of a sensor integrated computing platform of a safety system of a structure for remote monitoring and access thereof. Although the present embodiments have been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the various embodiments.

[0021] **Figure 1** shows a safety system 100 associated with a structure 102, according to one or more embodiments. In one or more embodiments, safety system 100 may be a Firefighter Air Replenishment System (FARS) to enable firefighters entering structure 102 in times of fire-related emergencies to gain access to breathable (e.g., human breathable) air (e.g., breathable air 103) in-house without the need of bringing in air bottles/cylinders to be transported up several flights of stairs of structure 102 or deep thereinto, or to refill depleted air bottles/cylinders that are brought into structure 102. In one or more embodiments, safety system 100 may supply breathable air provided from a supply of air tanks (to be discussed) stored in structure 102. When a fire department vehicle arrives at structure 102 during an emergency, breathable air supply typically may be provided through a source of air connected to said vehicle. In one or more embodiments, safety system 100 may enable firefighters to refill air bottles/cylinders thereof at emergency air fill stations (to be discussed) located throughout structure 102. Specifically, in some embodiments, firefighters may be able to fill air bottles/cylinders thereof at emergency air fill stations within structure 102 under full respiration in less than one to two minutes.

[0022] In one or more embodiments, structure 102 may encompass vertical building structures, horizontal building structures (e.g., shopping malls, hypermarts, extended shopping, storage and/or warehousing related structures), tunnels, marine craft (e.g., large marine vessels such as cruise ships, cargo ships, submarines and large naval craft, which may be "floating" versions of buildings and horizontal structures) and mines. Other structures are within the scope of the exemplary embodiments discussed herein. In one or more embodiments, safety system 100 may include a fixed piping system 104 permanently installed within structure 102 serving as a constant source of replenishment of breathable air 103. Fixed piping system 104 may be regarded as being analogous to a water piping system within structure 102 or another structure analogous thereto for the sake of imaginative convenience.

[0023] As shown in **Figure 1**, fixed piping system 104 may distribute breathable air 103 across floors/levels of structure 102. For the aforementioned purpose, fixed piping system 104 may distribute breathable air 103 from an air storage system 106 (e.g., within structure 102) including a number of air storage tanks $108_{1\text{-}N}$ that serve as sources of pressurized/compressed air (e.g., breathable air 103). Additionally, in one or more embodiments, fixed piping system 104 may interconnect with a mobile air unit 110 (e.g., a fire vehicle) through an External Mobile Air Connection (EMAC) panel 112.

[0024] In one or more embodiments, EMAC panel 112 may be a boxed structure (e.g., exterior to structure 102) to enable the interconnection between mobile air unit 110 and safety system 100. For example, mobile air unit 110 may include an on-board air compressor to store and replenish pressurized/compressed air (e.g., breathable air analogous to breathable air 103) in air bottles/cylinders (e.g., utilizable with Self-Contained Breathing Apparatuses (SCBAs) carried by firefighters). Mobile air unit 110 may also include other pieces of air supply/distribution equipment (e.g., piping and/or air cylinders/bottles) that may be able to leverage the sources of breathable air 103 within safety system 100 through EMAC panel 112. Firefighters, for example, may be able to fill breathable air (e.g., breathable air 103, breathable air analogous to breathable air 103) into air bottles/cylinders (e.g., spare bottles, bottles requiring replenishment of breathable air) carried on mobile air unit 110 through safety system 100.

[0025] In **Figure 1**, EMAC panel 112 is shown at two locations merely for the sake of illustrative convenience. In one or more embodiments, an air monitoring system 150 may be installed as part of safety system 100 to automatically track and monitor a parameter (e.g., pressure) and/or a quality (e.g., indicated by moisture levels, carbon monoxide levels) of breathable air 103 within safety system 100. **Figure 1** shows air monitoring system 150 as communicatively coupled to air storage system 106 and EMAC panel 112 merely for the sake of example. It should be noted that EMAC panel 112 may be at a remote location associated with (e.g., internal to, external to) structure 102. In one or more embodiments, for monitoring the parameters and/or the quality of breathable air within safety system 100, air monitoring system 150 include appropriate sensors and circuitries therein. For example, a pressure sensor (to be discussed) within air monitoring system 150 may automatically sense and record a pressure of breathable air 103 of safety system 100. Said pressure sensor may communicate with an alarm system that is triggered when the sensed pressure is outside a safety range. Also, in one or more embodiments, air monitoring system 150 may automatically trigger a shutdown of breathable air distribution through safety system 100 in case of impurity/contaminant (e.g., carbon monoxide) detection therethrough yielding levels above a safety/predetermined threshold.

[0026] In one or more embodiments, fixed piping system 104 may include pipes (e.g., constituted out of stainless steel tubing) that distribute breathable air 103 to a number of emergency air fill stations 120_{1-P} within structure 102. In one example implementation, each emergency air fill station 120_{1-P} may be located at a specific level of structure 102. If structure 102 is regarded as a vertical building structure, an emergency air fill station 120_{1-P} may be located at each of a basement level, a first floor level, a second floor level and so on. For example, emergency air fill station 120_{1-P} may be located at the end of the flight of stairs that emergency fighting personnel (e.g., firefighting personnel) need to climb to reach a specific floor level within the vertical building structure.

[0027] In one or more embodiments, an emergency air fill station $120_{1\text{-}P}$ may be a static location within a level of structure 102 that provides emergency personnel 122 (e.g., firefighters, emergency responders) with the ability to rapidly fill air bottles/cylinders (e.g., SCBA cylinders) with breathable air 103. In one or more embodiments, emergency air fill station $120_{1\text{-}P}$ may be an emergency air fill panel or a rupture containment air fill station. In one or more embodiments, proximate each emergency air fill station $120_{1\text{-}P}$, safety system 100 may include an isolation valve $160_{1\text{-}P}$ to isolate a corresponding emergency air fill station $120_{1\text{-}P}$ from a rest of safety system 100. For example, said isolation may be achieved through the manual turning of isolation valve $160_{1\text{-}P}$ proximate the corresponding emergency air fill station $120_{1\text{-}P}$ or remotely (e.g., based on automatic turning) from air monitoring system 150. In one example implementation, air monitoring system 150 may maintain breathable air supply to a subset of emergency air fill stations $120_{1\text{-}P}$ via fixed piping system 104 through control of a corresponding subset of isolation valves $160_{1\text{-}P}$ and may isolate the other emergency air fill stations $120_{1\text{-}P}$ from the breathable air supply. It should be noted that configurations and components of safety system 100 may vary from the example safety system 100 of **Figure 1**.

[0028] **Figure 2** shows safety system 100 with elements thereof integrated therewithin in detail, according to one or more embodiments. In one or more embodiments, safety system 100 may include air monitoring system 150 discussed above communicatively coupled to fixed piping system 104, to which emergency air fill stations $120_{1\text{-}P}$ are also coupled. In one or more embodiments, as seen above, the source of breathable air 103 may be air storage system 106. In one or more embodiments, safety system 100 may also include an isolation and bypass control system 202 that is constituted by a set of electrical, mechanical and/or electronic components working together to automatically include and/or bypass one or more emergency air fill station(s) $120_{1\text{-}P}$ based on detection of anomalous air parameters, as will be discussed below. For the aforementioned purpose, in one or more embodiments, isolation valve(s) $160_{1\text{-}P}$ associated with the aforementioned emergency air fill stations $120_{1\text{-}P}$ may be controlled (e.g., by opening or closing one or more of said isolation valves $160_{1\text{-}P}$) by isolation and bypass control system 202. In other words, in one or more embodiments, the one or more isolation valves $160_{1\text{-}P}$ may be opened or closed to control the flow of breathable air 103 from the source thereof to a corresponding one or more emergency air fill stations $120_{1\text{-}P}$ in response to detection of anomalous air parameters or collection of the air parameters (e.g., parameters 304, parameters 404, parameters 508 to be discussed below).

[0029] Further, in one or more embodiments, safety system 100 may include a backup power unit 204 (e.g., an electrical power system with electronic integration) to ensure uninterrupted power to components of safety system 100 during emergencies (e.g., a power cut, a mains power issue, a fire accident effected power issue). For the aforementioned purpose, in one or more embodiments, backup power unit 204 may be switched on in the case of a power related emergency with respect to a main power unit 206 (e.g., Alternating Current (AC) mains power, Direct Current (DC) power) associated with safety system 100.

[0030] In one or more embodiments, one or more or all of the abovementioned components of safety system 100 may be integrated with sensor(s) to detect parameters of use therewithin. In one or more embodiments, one or more of the aforementioned components may be communicatively coupled through a computer network 208 (e.g., a Local Area Network (LAN), a Wide Area Network (WAN), a cloud computing network, the Internet, a short-range communication network based on Bluetooth®, WiFi® and the like) to a remote server 210 (e.g., a network of servers, a single server, a distributed network of servers, a command room server associated with safety system 100 and so on). As will be discussed below, in one or more embodiments, server 210 may obtain said parameters of use and other data from safety system 100 and perform analysis (e.g., predictive, non-predictive) thereof.

[0031] In addition, in one or more embodiments, safety system 100 may include a data processing device 212 (e.g., a mobile phone, a tablet, an iPad®, a laptop, a desktop) also communicatively coupled to one or more components or each component of safety system 100 and server 210 through computer network 208. Thus, in one or more embodiments, one or more components or each component of safety system 100 may have interfaces (not explicitly shown) for wireless communication through computer network 208. Also, as will be discussed below, in one or more embodiments, wherever possible, elements (e.g., handheld Thermal Imaging Cameras (TICs), portable TICs, aerial TICs, video cameras, output audio devices, output light devices, one or more or all sensors discussed herein) may be Internet of Things (IoT) devices capable of collecting and feeding data to server 210 through computer network 208. In one or more embodiments, IoT devices (or IoT enabled devices) may be devices and/or components with programmable hardware that can transmit data over computer networks (e.g., computer network 208 such as the Internet and/or other networks); said IoT devices may include or be associated with edge devices (not shown) to control data flow at the boundaries to computer network 208.

[0032] **Figure 3** shows air monitoring system 150, according to one or more embodiments. In one or more embodiments, air monitoring system 150 may include one or more air parameter sensors $302_{1\text{-}R}$ configured to sense parameters 304 associated with breathable air 103 such as pressure, temperature, oxygen content, carbon monoxide content, hydrocarbon content and moisture content; other parameters (e.g., air quality parameter(s), non-air quality parameter(s)) are within the scope of the exemplary embodiments discussed herein. In one or more embodiments, air monitoring system 150 may include a processor 306 (e.g., a microcontroller, a processor core, a single processor) communicatively coupled to a memory 308 (e.g., a volatile and/or a non-volatile memory); **Figure 3** shows air parameter sensors $302_{1\text{-}R}$ interfaced with processor 306. In one or more embodiments, data sensed by the aforementioned air parameter sensors $302_{1\text{-}R}$ may be part of sensor data 310 stored in memory 308; parameters 304 sensed may be part of sensor data 310.

[0033] In one or more embodiments, threshold values/ranges (e.g., threshold parameters 312) for parameters 304 sensed may also be stored in memory 308. In one or more embodiments, detecting through processor 306 in conjunction with one or more air parameter sensors $302_{1\text{-}R}$ that one or more parameters 304 is outside (e.g., below, above, outside) threshold parameters 312 may cause communication of anomalies (e.g., detected anomaly data 314 stored in memory 308) to server 210 through computer network 208 in accordance with the IoT capabilities discussed above. **Figure 4** shows an emergency air fill station $120_{1\text{-}P}$, according to one or more embodiments. Again, in one or more embodiments, emergency air fill station $120_{1\text{-}P}$ may include one or more environment sensors $402_{1\text{-}B}$ integrated therewith configured to sense parameters 404 (e.g., temperature, ambient light) of an environment (e.g., external environment 450) in an immediate vicinity of emergency air fill station $120_{1\text{-}P}$. In one or more embodiments, environment sensors $402_{1\text{-}B}$ may also sense access (e.g., access parameters 406 that are part of parameters 404 in **Figure 4**) of emergency air fill station $120_{1\text{-}P}$ by emergency personnel 122 (e.g., maintenance personnel, firefighters, emergency responders). Example access parameters 406 may include but are not limited to identifier 452 of emergency personnel 122, date of access 454 mapped to identifier 452, time of access 456 mapped to identifier 452, a frequency of access 458 and fill pressures 460 (e.g., pressures to which breathable air 103 is filled in air bottles/cylinders discussed above) mapped to identifier 452, time of access 456 and/or date of access 454.

[0034] In one or more embodiments, again based on sensed parameters 404 being outside (e.g., more than, less than, outside a range) threshold values/ranges (e.g., threshold parameters 408) based on the IoT capabilities discussed herein, anomalies in parameters 404 may be detected and collected at emergency air fill station $120_{1\text{-}P}$ and transmitted to server 210 through computer network 208. In one or more embodiments, as shown in **Figure 4**, emergency air fill station $120_{1\text{-}P}$ may include a processor 472 (e.g., a microcontroller, a processor core, a single processor) communicatively coupled to a memory 474 (e.g., a volatile and/or a non-volatile memory). In one or more embodiments, environment sensors $402_{1\text{-}B}$ may be interfaced with processor 472 and all of the abovementioned data/parameters may be stored in memory 474, as shown in **Figure 4**.

[0035] **Figure 4** also shows TICs 410 as part of safety system 100 and in external environment 450 of emergency air fill station $120_{1\text{-}P}$, according to one or more embodiments. In one or more embodiments, TICs 410 may be infrared cameras that sense infrared energy of objects to render images/video frames thereof corresponding to surface temperatures of said objects. In one or more embodiments, emergency personnel 122 may employ said TICs 410 to detect obstacles on the paths to/around emergency air fill stations $120_{1\text{-}P}$ under low visibility; this may enable emergency personnel 122 perform rescue operations efficiently. As discussed and implied above, TICs 410 may be integrated with IoT capabilities to transmit data to server 210 through computer network 208. Said data may be part of access parameters 406 or separate data (e.g., TIC use data 412) transmitted to server 210.

[0036] It should be noted that the sensing, detection and/or transmission of data to server 210 discussed above with regard to emergency air fill station $120_{1\text{-}P}$ may also be performed at a device external to emergency air fill station $120_{1\text{-}P}$. In such implementations, the external device itself may obviously be a component of safety system 100 with IoT/wireless communication capabilities. All reasonable variations are within the scope of the exemplary embodiments discussed herein.

[0037] **Figure 5** shows air storage system 106, according to one or more embodiments. Again, as discussed above, in one or more embodiments, air storage system 106 may have IoT/wireless communication capabilities embedded therein or in a device external thereto that is communicatively coupled to air storage system 106. In one or more embodiments, air storage system 106 may include a processor 502 (e.g., a microcontroller, a processor core, a single processor) communicatively coupled to a memory 504 (e.g., a volatile and/or a non-volatile memory). Again, in one or more embodiments, air storage system 106 may include one or more sensors $506_{1\text{-}C}$ configured to sense parameters (e.g., parameters 508 stored in memory 504) associated with air storage system 106; sensors $506_{1\text{-}C}$ are shown interfaced with processor 502 Example parameters 508 sensed may include but are not limited to system pressure 552 (e.g., pressure at which breathable air 103 is output from air storage system 106), leakage 554 (e.g., leakage of breathable air 103 from air storage tanks $108_{1\text{-}N}$) and output flow rate 556 (e.g., rate of flow of breathable air 103 out of air storage system 106). In one or more embodiments, parameters 508 may be transmitted to server 210 through computer network 208 for processing and/or analysis thereat.

[0038] Again, in one or more embodiments, anomalies based on parameters 508 being outside thresholds/ranges (e.g., threshold parameters 510 stored in memory 504) may be detected through sensors $506_{1\text{-}C}$ (e.g., flow rate sensors, pressure sensors). **Figure 5** shows anomaly data 512 relevant to the aforementioned detected anomalies also transmitted to server 210 through computer network 208, according to one or more embodiments.

[0039] It should be noted that **Figures 3-5** merely relate to example components of safety system 100 with which sensors/IoT devices are integrated and that integration of sensors/IoT devices with any other component (e.g., backup power unit 204 to sense frequency and/or duration of use thereof, isolation and bypass control system 202 to sense a frequency of bypass/isolation of emergency air fill stations 120_{1-p}, turning on/off of isolation valves 160_{1-P} and so on) thereof conceivable is within the scope of the exemplary embodiments discussed herein. Referring back to **Figure 4**, identifier 452 within access parameters 406 relevant to access of emergency air fill station 120_{1-P} may also encompass a key fob based identification, a Radio Frequency Identification (RFID) based access, a Non-Fungible Token (NFT) based access, keys and/or access through an application component (e.g., component 706 to be discussed below) executing on data processing device 212. All reasonable variations are within the scope of the exemplary embodiments discussed herein.

[0040] **Figure 6** shows a computing platform 600 relevant to the FARS of safety system 100 implemented through server 210, according to one or more embodiments. In one or more embodiments, server 210 may be a distributed (e.g., across a cloud) network of servers, a cluster of servers or a standalone server. As shown in **Figure 6**, server 210 may include a processor 602 (e.g., a processor core, a network of processors, a single processor), communicatively coupled to a memory 604 (e.g., a volatile and/or a non-volatile memory). In one or more embodiments, memory 604 may include a safety engine 606 associated with the FARS stored therein and executable through processor 602. **Figure 6** shows memory 604 as including data (e.g., detected, sensed, anomalies) from one or more components of safety system 100; the limited amount of data shown must not be considered as limiting the scope of the exemplary embodiments discussed herein. In one or more embodiments, safety engine 606 may have one or more predictive and/or non-predictive algorithms (e.g., predictive and/or non-predictive algorithms 608) including Artificial Intelligence (AI)/Machine Learning (ML) based algorithms stored therein.

[0041] In one or more embodiments, execution of predictive and/or non-predictive algorithms 608 through processor 602 may involve taking the abovementioned data and profiling the FARS implemented as safety system 100. It should be noted that each of the aforementioned data (e.g., parameters 304, parameters 404, access parameters 406, parameters 508, anomaly data 314, anomaly data 512) may be real-time data from elements of safety system 100. In one or more embodiments, analysis of the data may result in beneficial decision making with regard to maintenance of safety system 100, safety of safety system 100 and/or efficiency thereof. For example, anomalies discussed above may be analyzed based on date, time and/or frequency thereof to predict that a specific duration of time in a winter season is associated with diminished characteristics of a component of safety system 100. All possible analyses are within the scope of the exemplary embodiments discussed herein.

[0042] In one or more embodiments, server 210 may also be utilized to remotely test and/or trigger operations of one or more components of safety system 100. **Figure 6** shows a trigger signal 610 communicated to air monitoring system 150 to get data thereof discussed above from processor 306, according to one or more embodiments. In some implementations, the components of safety system 100 may automatically transmit data thereof to server 210 and in some others, server 210 may transmit trigger signals (e.g., trigger signal 610) therefor. **Figure 6** also shows results of analysis/prediction through safety engine 606 as analysis results data 612, prediction results data 614 and plot data 616 (e.g., related to graphically plotting the results of analyses). Further, **Figure 6** shows data processing device 212 communicatively coupled to server 210 through computer network 208 as part of computing platform 600, according to one or more embodiments.

[0043] **Figure 7** shows data processing device 212 (e.g., a mobile phone, a tablet, a smart device, a laptop) in detail, according to one or more embodiments. In one or more embodiments, again, data processing device 212 may include a processor 702 (e.g., a single processor, a processor core) communicatively coupled to a memory 704 (e.g., a volatile and/or a non-volatile memory). In one or more embodiments, memory 704 may include a component 706 of safety engine 606 stored therein and enabled/provided through processor 602 of server 210. **Figure 7** shows component 706 as a fire safety application 750 merely for example purposes. Again, in one or more embodiments, access to the data of one or more components of safety system 100 may be available to data processing device 212 via component 706 (e.g., through computer network 208 via safety engine 606 of server 210). **Figure 7** also shows capabilities to control components of safety system 100 through data processing device 212 via trigger signals; **Figure 7** specifically shows a trigger signal 708 to initiate collection of data from air monitoring system 150 merely for example purposes. Again, in some implementations, data may be automatically communicated to data processing device 212 and in some others, data processing device 212 may trigger (e.g., through trigger signal 708) collection thereof.

[0044] In one or more embodiments, access of emergency air fill station 120_{1-P} through component 706 may cause collection of identifier 452 discussed above as part of access parameters 406. **Figure 8** shows an example user interface 800 provided via component 706 (e.g., fire safety application 750) executing on data processing device 212. Here, user interface 800 shows plot data 616 discussed above that may be based on one or more examples of data discussed above and/or analysis results data 612; plot data 616 in **Figure 8** is an evolution of system pressure 552 over a scale of time. Obviously, emergency personnel 122 and/or other users associated with data processing device 212 may access user interface 800 after authentication thereof via computing platform 600 and/or navigating to user interface 800. All reasonable variations are within the scope of the exemplary embodiments discussed herein.

[0045] Thus, exemplary embodiments discussed herein provide for an integrated FARS computing platform (e.g., computing platform 600) that enables collection and/or analysis of real-time data from one or more components of safety system 100 and/or control (e.g., remotely; in one scenario, one or more isolation valves 160_{1-P} may be opened or closed through server 210/data processing device

212/isolation and bypass control system 202 to control the flow of breathable air 103 from the source thereof to a corresponding one or more emergency air fill stations 120_{1-P} in response to collection of air parameters (e.g., parameters 304, parameters 404, parameters 508)) thereof. Further, the integrated FARS computing platform may provide for profiling of safety system 100 and/or emergency personnel 122 and/or remote management of requirements associated with safety system 100. For example, the profiling may involve utilizing (e.g., through safety engine 606) historical data (e.g., historical data 618 stored in memory 604 of server 210) from one or more components of safety system 100 and/or generic safety systems data (e.g., safety systems data 620 stored in memory 604 of server 210) from one or more safety systems other than safety system 100 to arrive at parts of analysis results data 612, prediction results data 614 and/or plot data 616. Again, as discussed above, in one or more embodiments, the integrated FARS computing platform may provide for quick decision making on the part of maintenance personnel, administrative personnel and/or emergency personnel (e.g., emergency personnel 122) associated with safety system 100; statistical analyses and/or data gathering and/or predictive and/or non-predictive analyses may also be enabled through the integrated FARS computing platform.

[0046] Also, in one or more embodiments, analogous analyses and/or prediction may also be performed at data processing device 212 based on enablement thereof through component 706. Further, it should be noted that detection of anomalies (e.g., anomaly data 314, anomaly data 512) may be performed through server 210 based on execution of safety engine 606 discussed above instead of or in addition to the detection thereof at the respective components. Last but not the least, as computing platform 600 may be enabled through the execution of safety engine 606, which, in turn, may enable component 706, both safety engine 606 and component 706 may be interpreted as computing platform 600 executing on server 210 and data processing device 212 respectively. All reasonable variations are within the scope of the exemplary embodiments discussed herein.

[0047] **Figure 9** shows a process flow diagram detailing the operations involved in realizing a sensor integrated computing platform (e.g., computing platform 600, safety engine 606, component 706) of a safety system (e.g., safety system 100) of a structure (e.g., structure 102) for remote control and access thereof, according to one or more embodiments. In one or more embodiments, operation 902 may involve executing the computing platform on a data processing device (e.g., server 210, data processing device 212). In one or more embodiments, operation 904 may involve integrating the computing platform with a set of sensors (e.g., air parameter sensors $302_{1\text{-}R}$, environment sensors $402_{1\text{-}B}$, sensors $506_{1\text{-}C}$) associated with a number of components (e.g., air monitoring system 150, emergency air fill station $120_{1\text{-}P}$, air storage system 106) of the safety system.

[0048] In one or more embodiments, operation 906 may then involve, in accordance with the execution of the computing platform on the data processing device and the integration thereof with the set of sensors, through the data processing device, collecting a number of parameters (e.g., parameters 304, parameters 404, parameters 508) of the number of components of the safety system and/or of access (e.g., access parameters 406) thereof through detection of the number of parameters via the set of sensors. In one or more embodiments, the number of parameters may include one or more parameter(s) (e.g., system pressure 552, leakage 554, output flow rate 556, fill pressures 460) related to breathable air (e.g., breathable air 103) from a source (e.g., air storage system 106) within the safety system supplied thereacross via a fixed piping system (e.g., fixed piping system 104) implemented therein and/or access of the breathable air.

[0049] In one or more embodiments, operation 906 may also involve monitoring the safety system and/or one or more component(s) of the number of components thereof based on the collected number of parameters.

[0050] Although the present embodiments have been described with reference to specific example embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the various embodiments.

[0051] A number of embodiments have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the claimed invention. In addition, the logic flows depicted in the figures do not require the particular order shown, or sequential order, to achieve desirable results. In addition, other steps may be provided, or steps may be eliminated, from the described flows, and other components may be added to, or removed from, the described systems. Accordingly, other embodiments are within the scope of the following claims.

[0052] The structures and modules in the figures may be shown as distinct and communicating with only a few specific structures and not others. The structures may be merged with each other, may perform overlapping functions, and may communicate with other structures not shown to be connected in the figures. Accordingly, the specification and/or drawings may be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method of a safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system, comprising:

   executing a computing platform on a data processing device;

   integrating the computing platform with a set of sensors associated with a plurality of components of the safety system; and

   in accordance with the execution of the computing platform on the data processing device and the integration thereof with the set of sensors, through the data processing device,

   collecting a plurality of parameters at least one of: of the plurality of components of the safety system and of access thereof through detection of the plurality of parameters via the set of sensors, the plurality of parameters comprising at least one parameter related to at least one of: the breathable air and access of the breathable air; and

   monitoring at least one of: the safety system and at least one component of the plurality of components thereof based on the collected plurality of parameters.

2. The method of claim 1, comprising the data processing device being a server remote from the safety system of the structure, the server being one of: a standalone server, a distributed network of servers and a cluster of servers.

3. The method of claim 1, comprising the computing platform being a component of another computing platform executing on a server communicatively coupled to the data processing device.

4. The method of claim 1, wherein monitoring the at least one of: the safety system and the at least one component through the data processing device comprises at least one of:

predictively and non-predictively analyzing the plurality of parameters collected; and

profiling the safety system in accordance with the at least one of: the predictive and the non-predictive analysis of the plurality of parameters collected.

5. The method of claim 1, further comprising at least one of:

collecting at least one anomaly in the plurality of parameters based on detecting, at least one of: through the data processing device and at least one sensor of the set of sensors, that a corresponding at least one parameter of the plurality of parameters is outside a predetermined threshold; and

triggering the collection of the plurality of parameters via a user interface provided through the computing platform executing on the data processing device.

6. The method of claim 3, comprising the component being an application executing on the data processing device.

7. The method of claim 1, further comprising, in accordance with the executing of the computing platform on the data processing device, one of: opening and closing at least one valve in the safety system to control a flow of the breathable air from the source to at least one emergency air fill station within the safety system in response to collecting the plurality of parameters.

8. The method of claim 1, comprising the at least one component of the plurality of components of the safety system being Internet of Things (IoT) enabled.

9. A data processing device of a safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system, comprising:

a memory comprising instructions associated with a computing platform stored therein; and

a processor communicatively coupled to the memory, the processor executing the instructions associated with the computing platform to:

integrate the computing platform with a set of sensors associated with a plurality of components of the safety system,

in accordance with the integration, collect a plurality of parameters at least one of: of the plurality of components of the safety system and of access thereof through detection of the plurality of parameters via the set of sensors, the plurality of parameters comprising at least one parameter related to at least one of: the breathable air and access of the breathable air, and

monitor at least one of: the safety system and at least one component of the plurality of components thereof based on the collected plurality of parameters.

10. The data processing device of claim 9, wherein the data processing device is a server remote from the safety system of the structure, the server being one of: a standalone server, a distributed network of servers and a cluster of servers.

11. The data processing device of claim 9, wherein the processor executes the instructions associated with the computing platform to monitor the at least one of: the safety system and the at least one component based on at least one of:

at least one of: predictively and non-predictively analyzing the plurality of parameters collected, and

profiling the safety system in accordance with the at least one of: the predictive and the non-predictive analysis of the plurality of parameters collected.

12. The data processing device of claim 9, wherein the processor further executes instructions associated with the computing platform to collect at least one anomaly in the plurality of parameters based on detecting, in conjunction with at least one sensor of the set of sensors, that a corresponding at least one parameter of the plurality of parameters is outside a predetermined threshold.

13. A safety system of a structure having a fixed piping system implemented therein to supply breathable air from a source across the safety system, comprising:

a data processing device executing a computing platform thereon; and

a set of sensors associated with a plurality of components of the safety system,

wherein the execution of the computing platform on the data processing device integrates the computing platform with the set of sensors associated with the plurality of components of the safety system, and

wherein, in accordance with the execution of the computing platform on the data processing device and the integration thereof with the set of sensors, the data processing device:

collects a plurality of parameters at least one of: of the plurality of components of the safety system and of access thereof through detection of the plurality of parameters via the set of sensors, the plurality of parameters comprising at least one parameter related to at least one of: the breathable air and access of the breathable air, and

monitors at least one of: the safety system and at least one component of the plurality of components thereof based on the collected plurality of parameters.

14. The safety system of claim 13, wherein the data processing device is a server remote from the safety system of the structure, the server being one of: a standalone server, a distributed network of servers and a cluster of servers.

15. The safety system of claim 13, wherein the computing platform is a component of another computing platform executing on a server communicatively coupled to the data processing device.

16. The safety system of claim 13, wherein the data processing device executes the computing platform to monitor the at least one of: the safety system and the at least one component based on at least one of:

at least one of: predictively and non-predictively analyzing the plurality of parameters collected, and

profiling the safety system in accordance with the at least one of: the predictive and the non-predictive analysis of the plurality of parameters collected.

17. The safety system of claim 13, wherein at least one of:

the data processing device further executes the computing platform to collect at least one anomaly in the plurality of parameters based on detecting, at least one of: through the data processing device and at least one sensor of the set of sensors, that a corresponding at least one parameter of the plurality of parameters is outside a predetermined threshold, and

the computing platform executing on the data processing device provides a user interface to trigger the collection of the plurality of parameters therethrough.

18. The safety system of claim 15, wherein the component is an application executing on the data processing device.

19. The safety system of claim 13, wherein the data processing device executes the computing platform to one of: open and close at least one valve in the safety system to control a flow of the breathable air from the source to at least one emergency air fill station within the safety system in response to the collection of the plurality of parameters.

20. The safety system of claim 13, wherein the at least one component of the plurality of components of the safety system is IoT enabled.

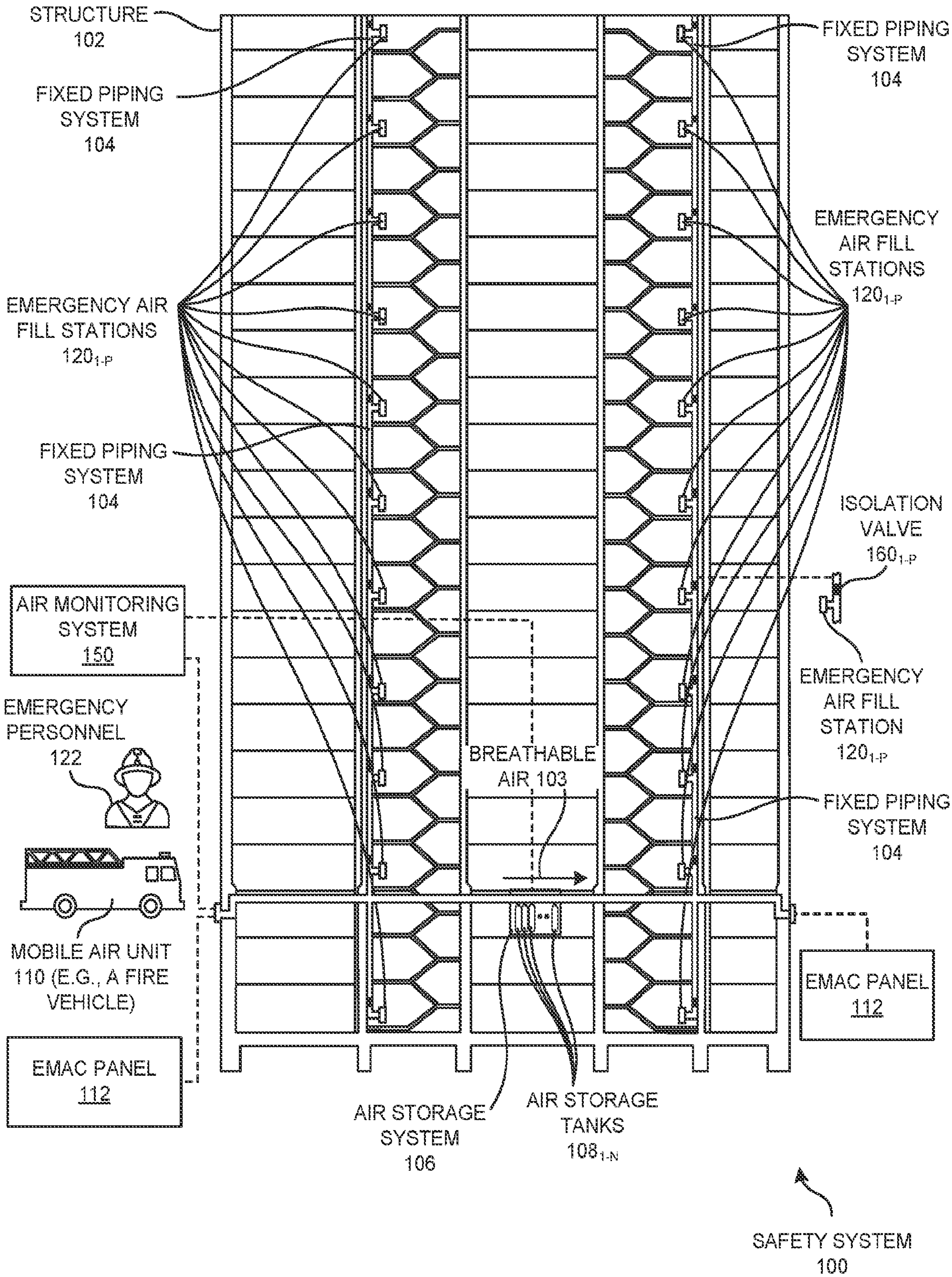
STRUCTURE 102
FIXED PIPING SYSTEM 104
FIXED PIPING SYSTEM 104
EMERGENCY AIR FILL STATIONS $120_{1\text{-}P}$
EMERGENCY AIR FILL STATIONS $120_{1\text{-}P}$
FIXED PIPING SYSTEM 104
ISOLATION VALVE $160_{1\text{-}P}$
AIR MONITORING SYSTEM 150
EMERGENCY AIR FILL STATION $120_{1\text{-}P}$
EMERGENCY PERSONNEL 122
BREATHABLE AIR 103
FIXED PIPING SYSTEM 104
MOBILE AIR UNIT 110 (E.G., A FIRE VEHICLE)
EMAC PANEL 112
EMAC PANEL 112
AIR STORAGE SYSTEM 106
AIR STORAGE TANKS $108_{1\text{-}N}$
SAFETY SYSTEM 100

FIG. 1

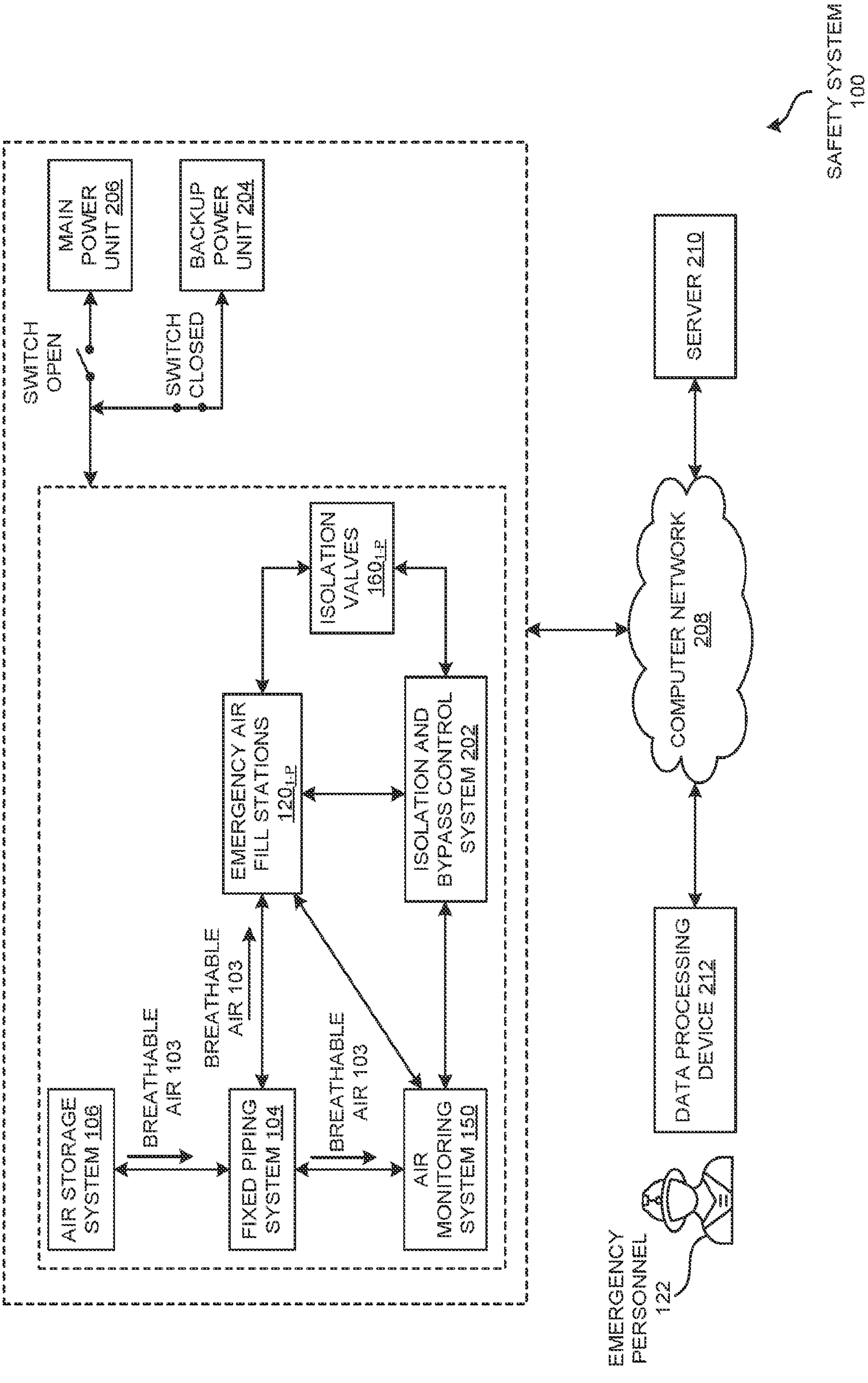
SAFETY SYSTEM
100
MAIN
POWER
UNIT 206
BACKUP
POWER
UNIT 204
SWITCH
OPEN
SWITCH
CLOSED
SERVER 210
ISOLATION
VALVES
160 1-P
EMERGENCY AIR
FILL STATIONS
120 1-P
ISOLATION AND
BYPASS CONTROL
SYSTEM 202
COMPUTER NETWORK
208
BREATHABLE
AIR 103
AIR STORAGE
SYSTEM 106
BREATHABLE
AIR 103
FIXED PIPING
SYSTEM 104
BREATHABLE
AIR 103
AIR
MONITORING
SYSTEM 150
DATA PROCESSING
DEVICE 212
EMERGENCY
PERSONNEL
122

FIG. 2

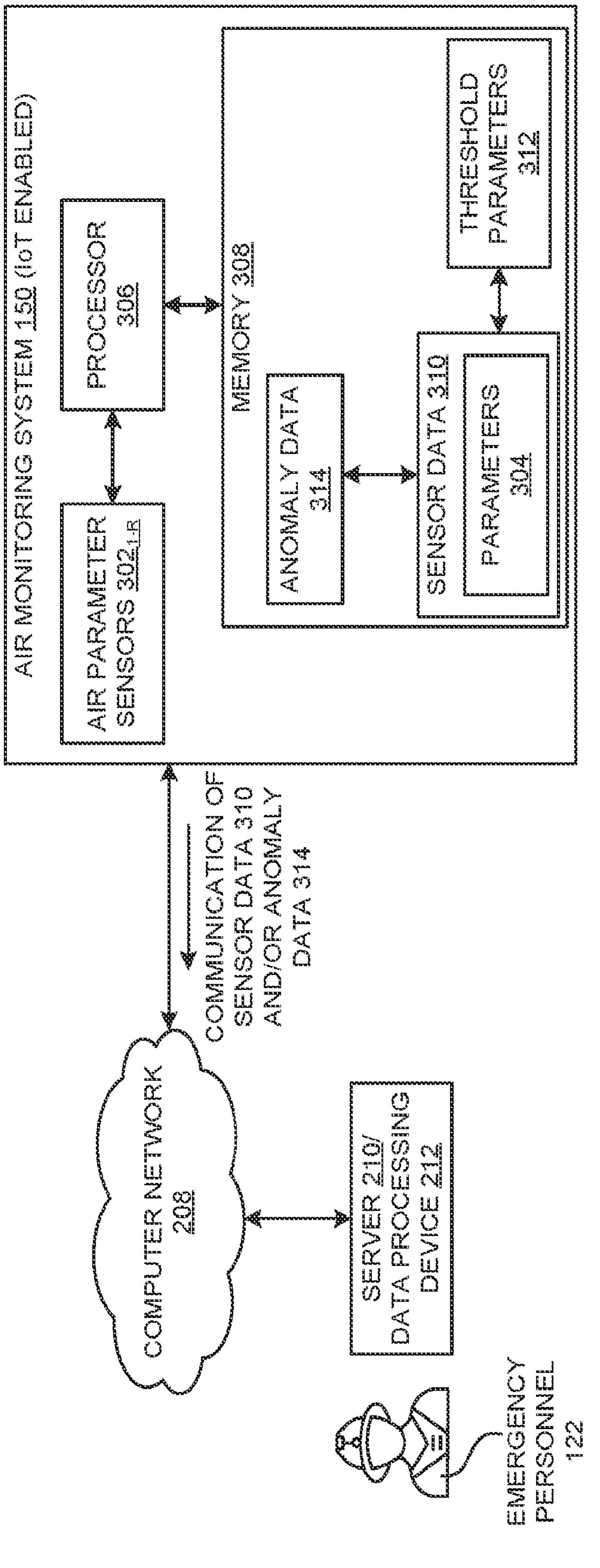
AIR MONITORING SYSTEM 150 (IoT ENABLED)
AIR PARAMETER SENSORS 302_{1-R}
PROCESSOR 306
MEMORY 308
ANOMALY DATA 314
SENSOR DATA 310
PARAMETERS 304
THRESHOLD PARAMETERS 312
COMMUNICATION OF SENSOR DATA 310 AND/OR ANOMALY DATA 314
COMPUTER NETWORK 208
SERVER 210/ DATA PROCESSING DEVICE 212
EMERGENCY PERSONNEL 122

FIG. 3

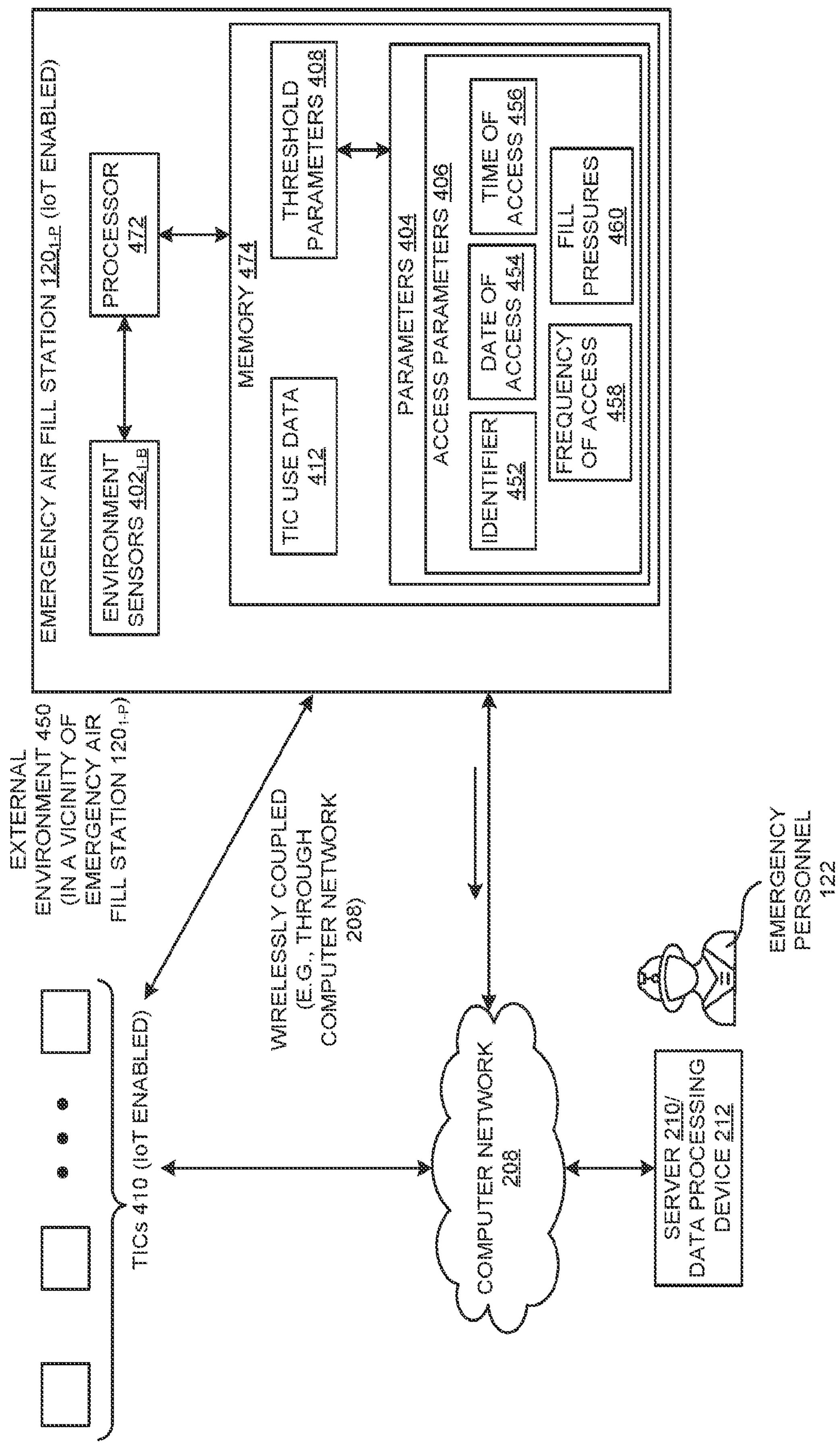
EMERGENCY AIR FILL STATION 120_1-P (IoT ENABLED)
ENVIRONMENT SENSORS 402_1-B
PROCESSOR 472
MEMORY 474
TIC USE DATA 412
THRESHOLD PARAMETERS 408
PARAMETERS 404
ACCESS PARAMETERS 406
IDENTIFIER 452
DATE OF ACCESS 454
TIME OF ACCESS 456
FREQUENCY OF ACCESS 458
FILL PRESSURES 460
EXTERNAL ENVIRONMENT 450 (IN A VICINITY OF EMERGENCY AIR FILL STATION 120_1-P)
TICs 410 (IoT ENABLED)
WIRELESSLY COUPLED (E.G., THROUGH COMPUTER NETWORK 208)
COMPUTER NETWORK 208
SERVER 210/ DATA PROCESSING DEVICE 212
EMERGENCY PERSONNEL 122

FIG. 4

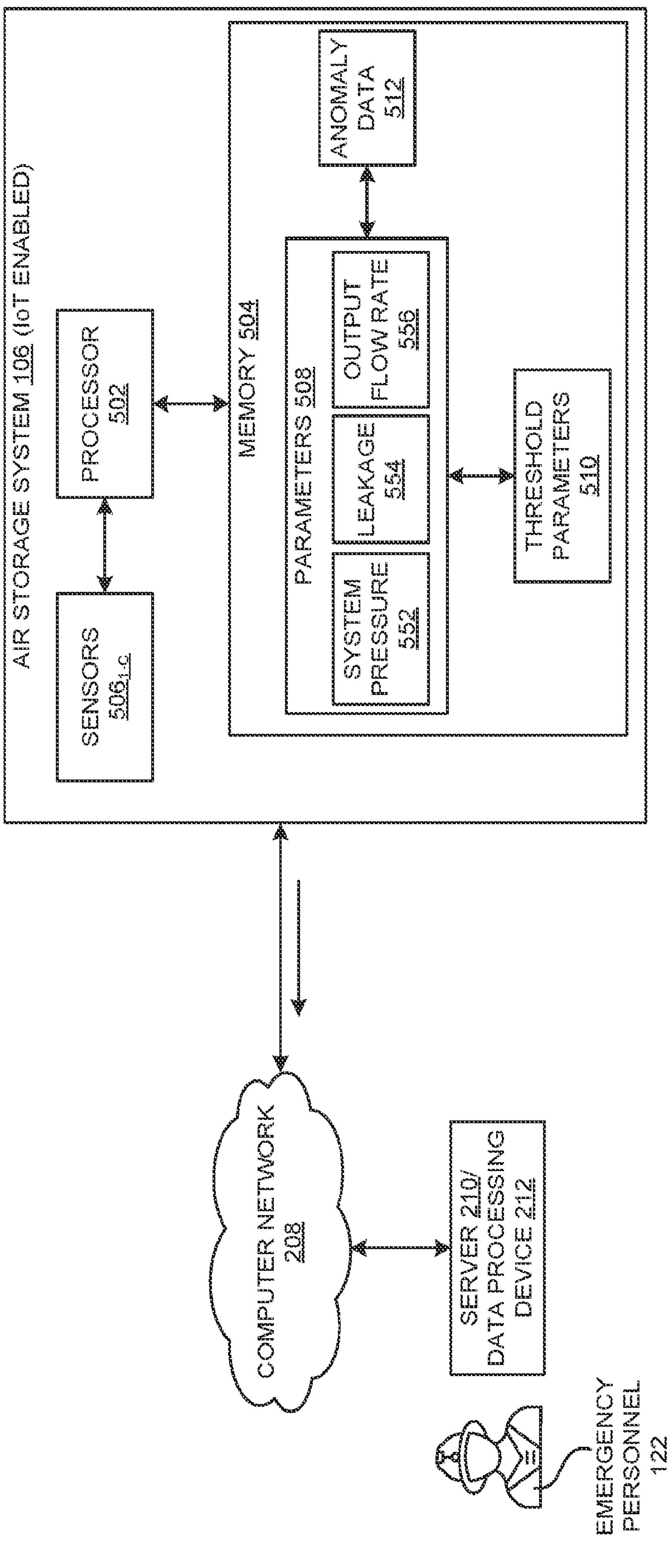
AIR STORAGE SYSTEM 106 (IoT ENABLED)
SENSORS 506$_{1-C}$
PROCESSOR 502
MEMORY 504
PARAMETERS 508
SYSTEM PRESSURE 552
LEAKAGE 554
OUTPUT FLOW RATE 556
ANOMALY DATA 512
THRESHOLD PARAMETERS 510
COMPUTER NETWORK 208
SERVER 210/ DATA PROCESSING DEVICE 212
EMERGENCY PERSONNEL 122

FIG. 5

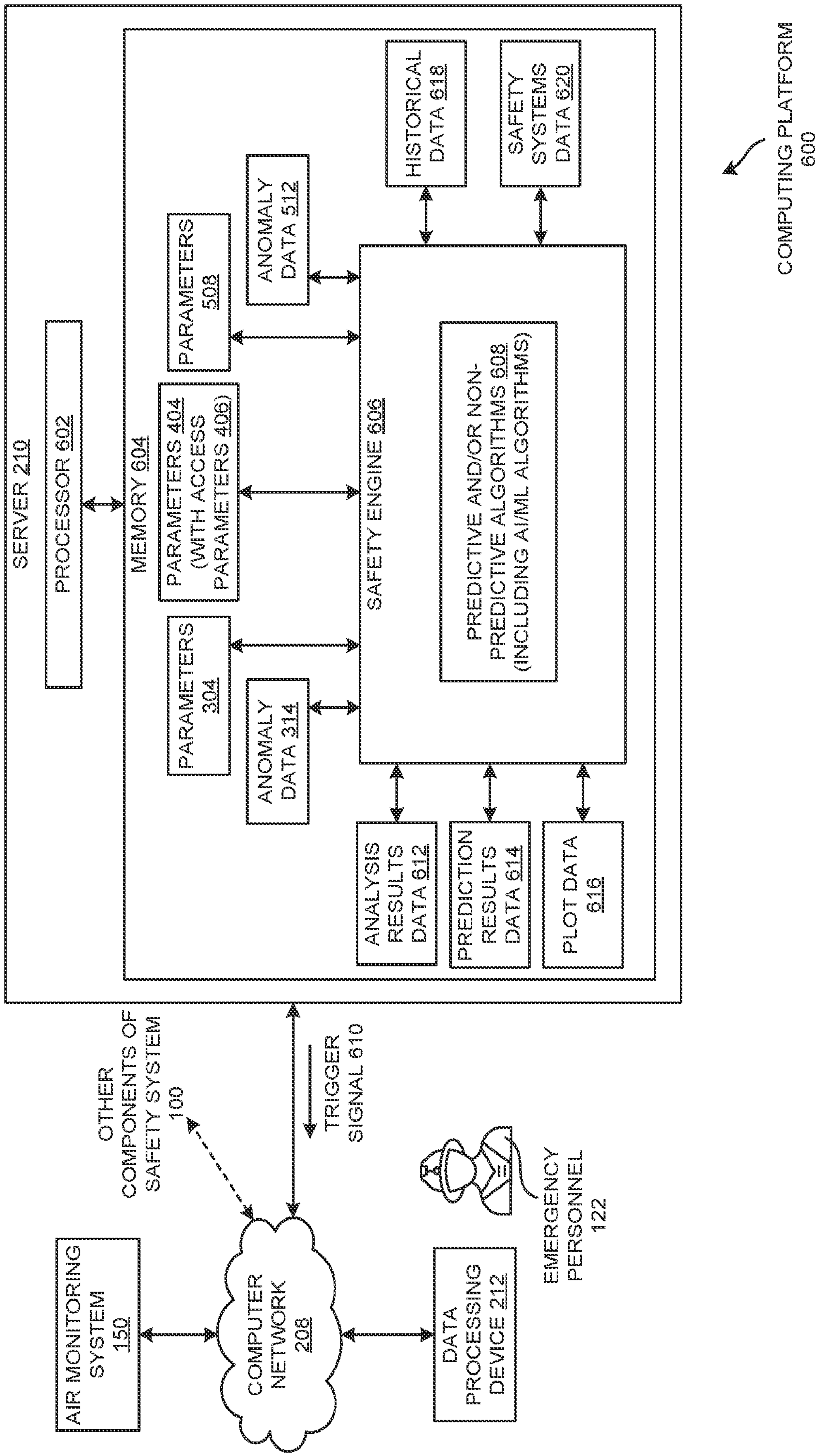
SERVER 210
PROCESSOR 602
MEMORY 604
PARAMETERS 304
ANOMALY DATA 314
PARAMETERS 404 (WITH ACCESS PARAMETERS 406)
PARAMETERS 508
ANOMALY DATA 512
HISTORICAL DATA 618
SAFETY SYSTEMS DATA 620
SAFETY ENGINE 606
PREDICTIVE AND/OR NON-PREDICTIVE ALGORITHMS 608 (INCLUDING AI/ML ALGORITHMS)
ANALYSIS RESULTS DATA 612
PREDICTION RESULTS DATA 614
PLOT DATA 616
COMPUTING PLATFORM 600
OTHER COMPONENTS OF SAFETY SYSTEM 100
TRIGGER SIGNAL 610
AIR MONITORING SYSTEM 150
COMPUTER NETWORK 208
DATA PROCESSING DEVICE 212
EMERGENCY PERSONNEL 122

FIG. 6

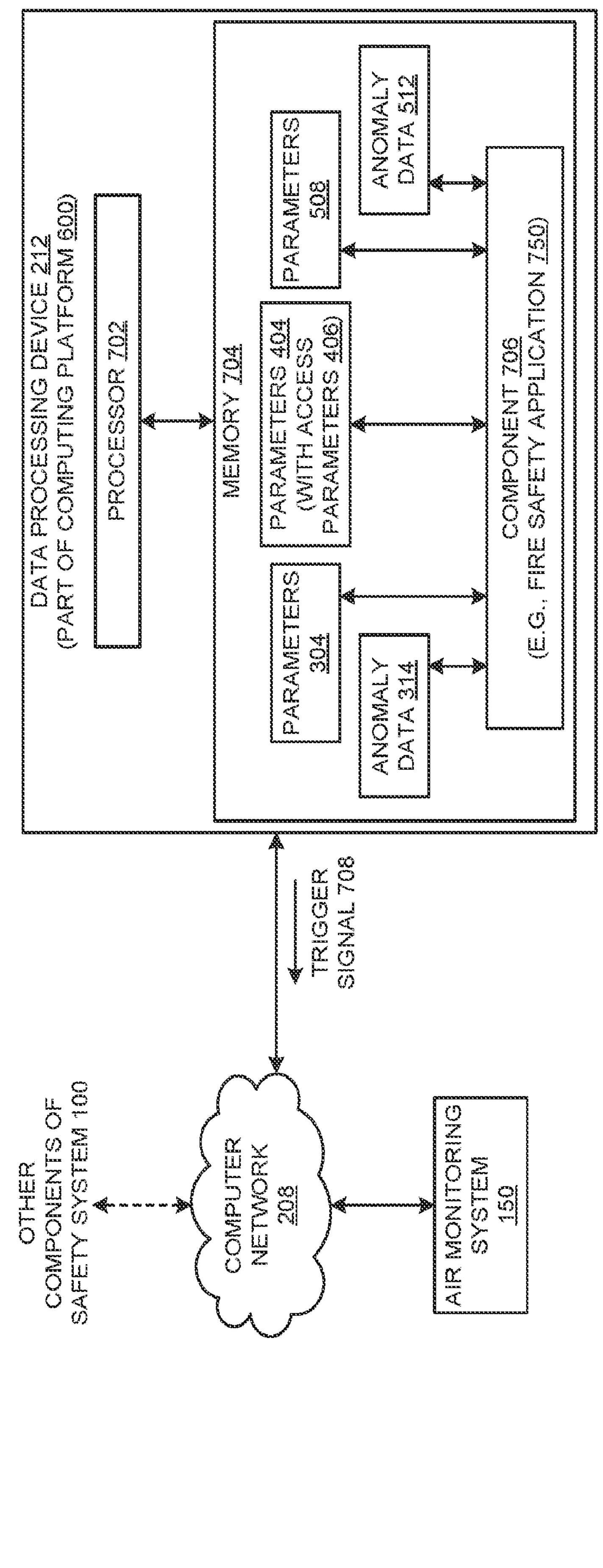
DATA PROCESSING DEVICE 212
(PART OF COMPUTING PLATFORM 600)
PROCESSOR 702
MEMORY 704
ANOMALY DATA 314
PARAMETERS 304
PARAMETERS 404 (WITH ACCESS PARAMETERS 406)
PARAMETERS 508
ANOMALY DATA 512
COMPONENT 706
(E.G., FIRE SAFETY APPLICATION 750)
TRIGGER SIGNAL 708
OTHER COMPONENTS OF SAFETY SYSTEM 100
COMPUTER NETWORK 208
AIR MONITORING SYSTEM 150

FIG. 7

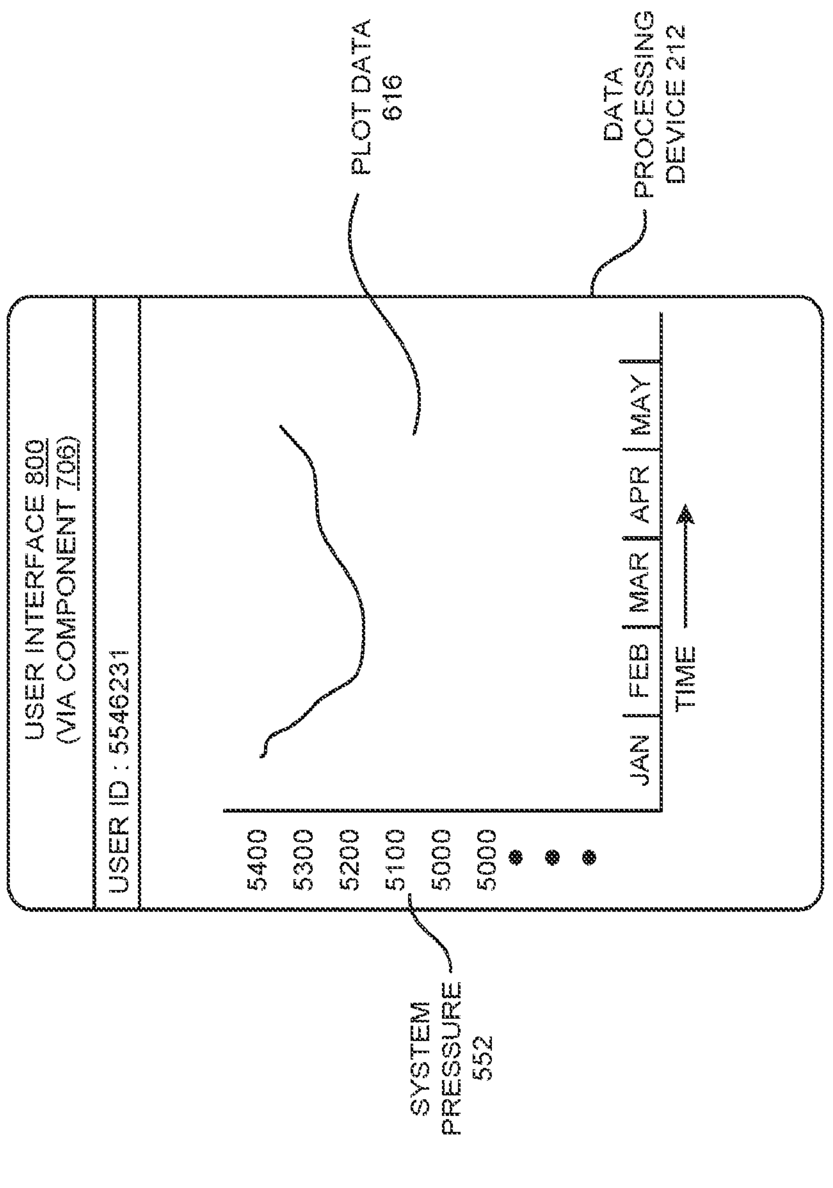
USER INTERFACE 800
(VIA COMPONENT 706)
USER ID : 5546231
5400
5300
5200
5100
5000
5000
JAN
FEB
MAR
APR
MAY
TIME
PLOT DATA
616
DATA
PROCESSING
DEVICE 212
SYSTEM
PRESSURE
552

FIG. 8

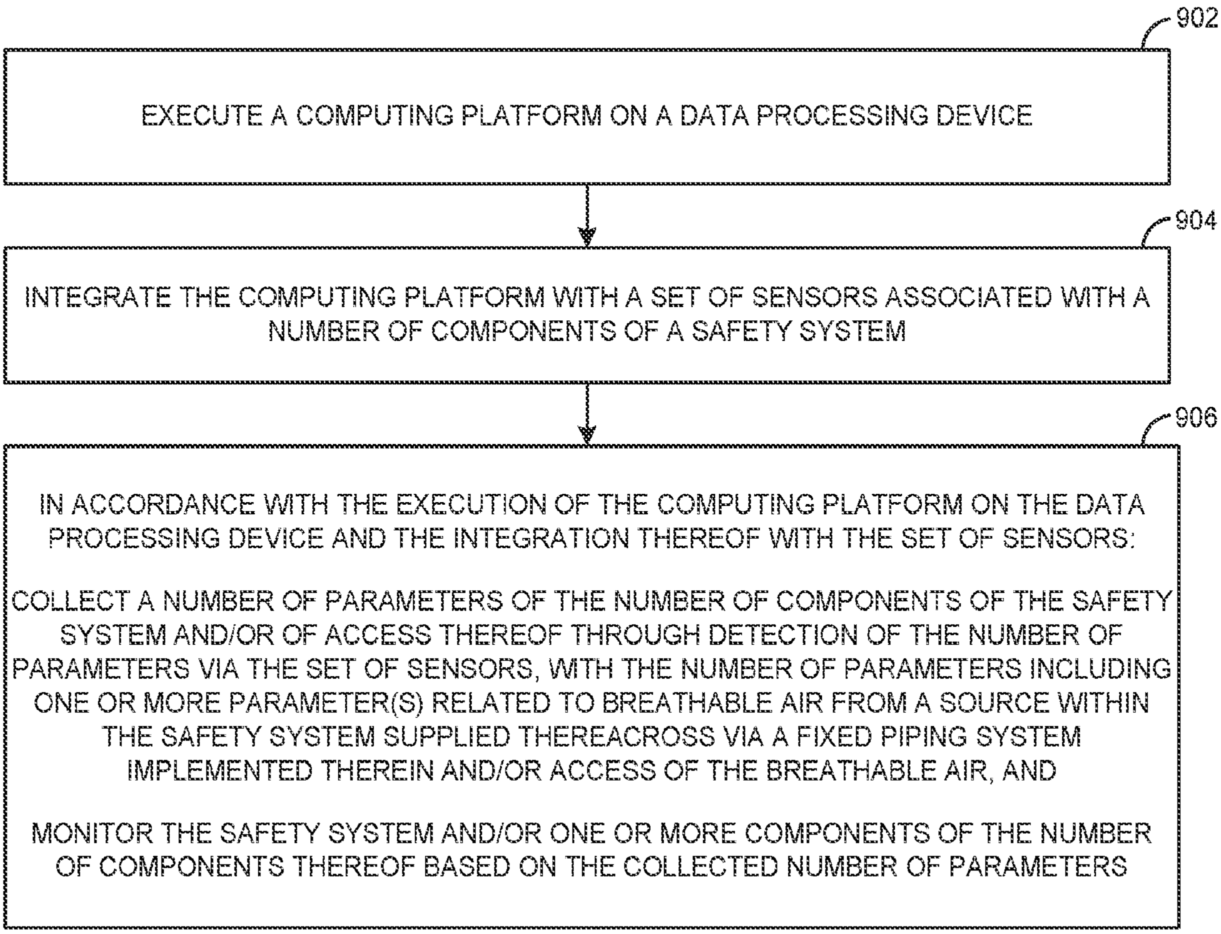
902
EXECUTE A COMPUTING PLATFORM ON A DATA PROCESSING DEVICE
904
INTEGRATE THE COMPUTING PLATFORM WITH A SET OF SENSORS ASSOCIATED WITH A NUMBER OF COMPONENTS OF A SAFETY SYSTEM
906
IN ACCORDANCE WITH THE EXECUTION OF THE COMPUTING PLATFORM ON THE DATA PROCESSING DEVICE AND THE INTEGRATION THEREOF WITH THE SET OF SENSORS:
COLLECT A NUMBER OF PARAMETERS OF THE NUMBER OF COMPONENTS OF THE SAFETY SYSTEM AND/OR OF ACCESS THEREOF THROUGH DETECTION OF THE NUMBER OF PARAMETERS VIA THE SET OF SENSORS, WITH THE NUMBER OF PARAMETERS INCLUDING ONE OR MORE PARAMETER(S) RELATED TO BREATHABLE AIR FROM A SOURCE WITHIN THE SAFETY SYSTEM SUPPLIED THEREACROSS VIA A FIXED PIPING SYSTEM IMPLEMENTED THEREIN AND/OR ACCESS OF THE BREATHABLE AIR, AND
MONITOR THE SAFETY SYSTEM AND/OR ONE OR MORE COMPONENTS OF THE NUMBER OF COMPONENTS THEREOF BASED ON THE COLLECTED NUMBER OF PARAMETERS

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2023/022222

A. CLASSIFICATION OF SUBJECT MATTER

A62B 15/00(2006.01)i; **A62B 13/00**(2006.01)i; **G16Y 20/10**(2020.01)i; **G16Y 40/10**(2020.01)i; **G16Y 40/30**(2020.01)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)

A62B 15/00(2006.01); A62B 23/02(2006.01); A62B 7/00(2006.01); A62B 7/02(2006.01); A62B 7/10(2006.01); F17D 1/00(2006.01); F17D 1/04(2006.01); G01N 33/00(2006.01); G08B 21/04(2006.01); G08B 21/10(2006.01); G08B 21/12(2006.01)

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: firefighter, breathable air, valve, safety system, Internet of Things, air parameter sensor, predictive, non-predictive, anomaly, monitor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8701718 B1 (TURIELLO, ANTHONY J.) 22 April 2014 (2014-04-22) column 5, line 6 - column 8, line 58, column 11, line 56 - column 12, line 10, claim 20, and figures 1A-13A	1-7,9-19
Y		8,20
Y	KR 10-2277919 B1 (MIRICO CO., LTD.) 16 July 2021 (2021-07-16) paragraph [0031] and figures 1-2	8,20
A	US 2010-0031955 A1 (TURIELLO, ANTHONY J.) 11 February 2010 (2010-02-11) paragraphs [0035]-[0048] and figures 1-13	1-20
A	US 2012-0266889 A1 (ROBERTS, RICK) 25 October 2012 (2012-10-25) paragraphs [0019]-[0030] and figures 1-8	1-20

☑ 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
24 August 2023	**24 August 2023**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office **189 Cheongsa-ro, Seo-gu, Daejeon** **35208, Republic of Korea**	**PARK, Tae Wook**
Facsimile No. **+82-42-481-8578**	Telephone No. **+82-42-481-3405**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017-0236397 A1 (TOTAL SAFETY U.S., INC.) 17 August 2017 (2017-08-17) paragraphs [0017]-[0074] and figures 1A-6C	1-20

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2023/022222

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	8701718	B1	22 April 2014	AU	2007-284343	A1	21 February 2008
				AU	2007-284343	B2	27 March 2014
				BR	PI0715894	A2	30 July 2013
				BR	PI0715894	B1	02 October 2018
				BR	PI0715894	B8	22 June 2021
				CA	2660884	A1	21 February 2008
				CA	2660884	C	06 October 2015
				CN	101534887	A	16 September 2009
				CN	101534887	B	20 March 2013
				CN	201775882	U	30 March 2011
				EP	2068987	A2	17 June 2009
				EP	2068987	B1	10 December 2014
				HK	1132692	A1	05 March 2010
				JP	2010-500899	A	14 January 2010
				JP	2013-226428	A	07 November 2013
				JP	5682044	B2	11 March 2015
				KR	10-1472781	B1	15 December 2014
				KR	10-2009-0043564	A	06 May 2009
				MX	2009001724	A	28 April 2009
				TW	201034714	A	01 October 2010
				TW	I574713	B	21 March 2017
				US	2008-0041376	A1	21 February 2008
				US	2008-0041377	A1	21 February 2008
				US	2008-0041378	A1	21 February 2008
				US	2008-0041379	A1	21 February 2008
				US	2009-0178675	A1	16 July 2009
				US	2009-0283151	A1	19 November 2009
				US	2010-0084043	A1	08 April 2010
				US	2010-0089489	A1	15 April 2010
				US	2010-0154922	A1	24 June 2010
				US	2011-0030838	A1	10 February 2011
				US	7527056	B2	05 May 2009
				US	7621269	B2	24 November 2009
				US	7673629	B2	09 March 2010
				US	7677247	B2	16 March 2010
				US	7694678	B2	13 April 2010
				US	8375948	B2	19 February 2013
				US	8381726	B2	26 February 2013
				US	8413653	B2	09 April 2013
				US	8443800	B2	21 May 2013
				US	8733355	B2	27 May 2014
				WO	2008-021538	A2	21 February 2008
				WO	2008-021538	A3	20 November 2008
				ZA	200901076	B	26 May 2010
KR	10-2277919	B1	16 July 2021	KR	10-2021-0071585	A	16 June 2021
US	2010-0031955	A1	11 February 2010	US	8371295	B2	12 February 2013
				WO	2010-011572	A2	28 January 2010
				WO	2010-011572	A3	15 April 2010
US	2012-0266889	A1	25 October 2012	CA	2815201	A1	26 April 2012
				CA	2815201	C	22 August 2017

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2023/022222

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
		EP 2629875 A1	28 August 2013
		EP 2629875 A4	16 August 2017
		EP 2629875 B1	30 November 2022
		US 10124196 B2	13 November 2018
		US 2015-0068518 A1	12 March 2015
		US 8840841 B2	23 September 2014
		WO 2012-054634 A1	26 April 2012
US 2017-0236397 A1	17 August 2017	CA 2964959 A1	26 May 2016
		EP 3221759 A1	27 September 2017
		EP 3221867 A1	27 September 2017
		EP 3221867 A4	05 December 2018
		US 2018-0340991 A1	29 November 2018
		WO 2016-081821 A1	26 May 2016
		WO 2016-081844 A1	26 May 2016