(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 001 653 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.05.2022 Bulletin 2022/21

(21) Application number: **21195997.8**

(22) Date of filing: **10.09.2021**

(51) International Patent Classification (IPC):
F04D 13/06 *(2006.01)* ***F04D 13/08*** *(2006.01)*
F04D 13/12 *(2006.01)* ***F04D 15/00*** *(2006.01)*
F04D 15/02 *(2006.01)* ***F04B 23/02*** *(2006.01)*
F04B 49/06 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04D 13/068; F04B 23/021; F04B 49/065; F04D 13/086; F04D 13/12; F04D 15/0066; F04D 15/0218; F04D 15/0245

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **19.11.2020 US 202016952515**

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(54) **BILGE PUMP SYSTEMS**

(57) A pump system (10) comprises a bilge pump (12) powered by an electric motor (14) and a controller (16) controlling the electric motor (14). The controller (16) is configured to determine if the pump system (10) is malfunctioning. In response to determining that the pump system (10) is malfunctioning, the controller (16) is configured to control the electric motor (14) according to a predetermined routine configured to rectify the malfunction. A pump system (100) comprises a first bilge pump (12) including a first electric motor (14) configured to power the first bilge pump (12) and a first controller (16) controlling the first electric motor (14) and a second bilge pump (102) including a second electric motor (105) configured to power the second bilge pump (102) and a second controller (104) controlling the second electric motor (105). The first and second controllers (16, 104) are in signal communication with one another.

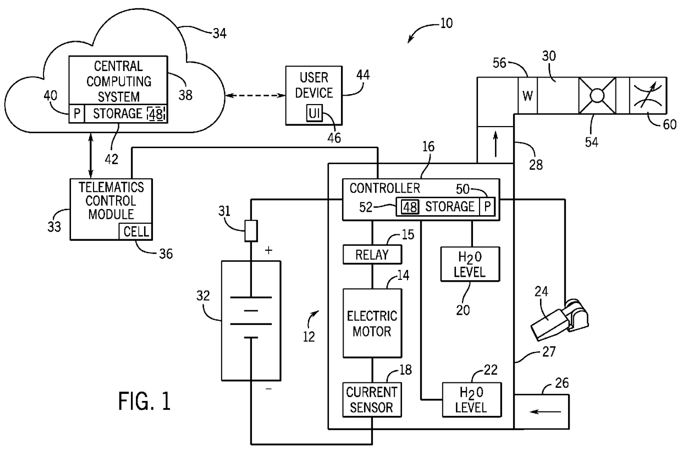

FIG. 1

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Description

FIELD

[0001] The present disclosure relates to drainage pump systems, and more specifically to drainage pump systems configured for use in a bilge of a marine vessel.

BACKGROUND

[0002] U.S. Patent No. 6,174,146 discloses an electric bilge pump for collecting liquid found in a bottom of a vessel or any other place. The pump is formed of three parts in axial alignment. The assembly is secured to a surface in substantially a horizontal position. An electric motor is enclosed in a cylindrical jacket and has an output shaft with an impeller at its distal end. A second part of the housing is tubular and defines a chamber with the impeller in the chamber. The chamber has an axial inlet with a tangential outlet. A filter is fitted over the inlet to filter out any unwanted debris.

[0003] U.S. Patent No. 6,729,847 discloses a bilge pump including an outer housing having an interior wall separating a first cavity and a second cavity, an on/off electrical switch located within the first cavity, and a single-piece float located within the second cavity and having a float body and an actuator arm extending outwardly therefrom, wherein the float operably connects the electrical switch through an aperture in the interior wall, and wherein the float is configured such that the aperture remains above a water line within the second cavity during operation of the pump. The bilge pump also includes a motor having a motor housing having a hub and a power shaft extending from the hub, wherein the motor is located within the first cavity of the outer housing such that the hub of the motor housing is located within a hub of the first cavity, and seal member having a centrally located aperture receiving the power shaft therethrough, wherein the seal member is closely received about the hub of the motor housing and within the hub portion of the first cavity, thereby providing a water-tight seal about the power shaft and between the outer housing and the motor housing.

[0004] U.S. Patent No. 9,121,399 discloses a straining device for a drainage pump, the straining device comprising a body defining an inner chamber; at least one straining element by which liquid may enter the chamber; and at least one outlet by which liquid may leave the chamber. The straining device further includes a liquid level sensor arranged to detect the level of a liquid in which said straining device is located during use and, upon determining that said liquid level exceeds a threshold, to cause an activation signal to be sent to said pump. The liquid level sensor comprises non-contact sensing means such as an electric field sensor. The sensor is located at the top of the straining device and arranged to project its sensing field upwardly.

[0005] U.S. Patent No. 10,737,753 discloses a bilge pump monitoring system for a bilge pump on a marine vessel including a current sensor configured to measure a current draw of the bilge pump, and a bilge pump monitor module executable on a processor. The bilge pump monitor module is configured to receive current draw measurements by the current sensor and determine a pump diagnosis of the bilge pump based on the current draw measurements. The pump diagnosis is then wirelessly communicated to a user located remotely from the marine vessel.

[0006] The above-noted patents are hereby incorporated by reference herein in their entireties.

SUMMARY

[0007] This Summary is provided to introduce a selection of concepts that are further described below in the Detailed Description. This Summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter.

[0008] The invention is defined by the independent claims. The dependent claims define advantageous embodiments.

[0009] According to one example, a pump system comprises a bilge pump powered by an electric motor and a controller controlling the electric motor. The controller is configured to determine if the pump system is malfunctioning. In response to determining that the pump system is malfunctioning, the controller is configured to control the electric motor according to a predetermined routine configured to rectify the malfunction.

[0010] According to another example, a pump system comprises a first bilge pump including a first electric motor configured to power the first bilge pump and a first controller controlling the first electric motor and a second bilge pump including a second electric motor configured to power the second bilge pump and a second controller controlling the second electric motor. The first and second controllers are in signal communication with one another.

BRIEF DESCRIPTION OF DRAWINGS

[0011] Examples of pump systems for a bilge of a marine vessel are described with reference to the following Figures. The same numbers are used throughout the Figures to reference like features and like components.

Fig. 1 illustrates one example of a pump system for a bilge of a marine vessel.

Fig. 2 shows a table with a number of pump malfunction diagnoses.

Fig. 3 is a graph showing current measurements during various operation stages of an exemplary bilge pump.

Fig. 4 is a graph depicting current draw measurements over an exemplary pump cycle.

Fig. 5 illustrates another example of a pump system for a bilge of a marine vessel.

Fig. 6 illustrates an example of a method for a bilge pump according to the present disclosure.

Fig. 7 illustrates an example of a method for a bilge pump system according to the present disclosure.

DETAILED DESCRIPTION

[0012] Marine vessels, which are valuable assets, are often left unattended on moorings or at docks, and thus are often vulnerable to the elements and the malfunctioning of onboard equipment. For example, all marine vessels accumulate water in the bilge area. Bilge pumps, which are activated to pump water out of the bilge once the water level in the bilge area reaches a certain level, are standard. Various water-level monitoring systems and bilge pump activation systems exist that automatically activate the bilge pump when a threshold amount of water accumulates in the bilge. Once the bilge pump has evacuated the water, the bilge pump is automatically turned off. If any element in the system, including the switch, the power system to the bilge pump, or the bilge pump itself stops operating properly, or if any portion of the pump system, including the inlet, the outlet, or the hoses are blocked, then the marine vessel can take on excess water and be damaged. Furthermore, a falsely triggered bilge pump or an airlocked bilge pump results in the pump running without having any effect on water level, which runs down the vessel's power supply unnecessarily. Absent vessel owners often have limited resources for monitoring the condition of their bilge pump system, and thus the water-level condition on their vessel.

[0013] Accordingly, the present inventors have recognized a need for a bilge pump monitoring system and method that self-diagnoses any malfunctions. Moreover, the inventors have recognized that a bilge pump monitoring system and method are needed that, in addition to determining whether a bilge pump is operating or not operating, is able to diagnose problems with a bilge pump system with specificity and accuracy, to attempt to rectify such malfunctions, and to provide such information remotely to the user. Additionally, the inventors have recognized that a bilge pump monitoring system and method are needed that can automatically and remotely operate the bilge pump that is malfunctioning or another bilge pump on board the vessel to prevent water damage.

[0014] Fig. 1 shows a pump system 10 comprising a bilge pump 12 powered by an electric motor 14. A controller 16 controls the electric motor 14, such as by way of a relay 15. The controller 16 is located on or within a housing 27 of the bilge pump 12, such as, for example, as a component on an integrated circuit. The pump system 10 also includes at least one of the following in electrical communication with the controller 16: a current sensor 18 configured to sense a current flowing through the electric motor 14 and a water-level sensor 20, 22, 24 configured to be actuated by a presence and/or absence of water in the bilge. The water-level sensor could be located in the pump housing 27, like water-level sensors 20, 22, or could be located outside the pump housing 27, like water-level sensor 24. The water-level sensors 20, 22 can be non-contact sensors such as electromagnetic field sensors, radio-frequency sensors, capacitive sensors, ultrasonic sensors, or magnetic sensors. The controller 16 is configured to turn the bilge pump 12 on when the water-level sensor 20 detects water, and to turn the bilge pump 12 off when the water level drops below the water-level sensor 22. The water-level sensor 24 can be a float switch, as shown, that is actuated when the level of water in the bilge reaches a predetermined height, in response to which actuation the controller 16 turns the bilge pump 12 on. The water-level sensor 24 can be located remote from the pump housing 27 or within the pump housing 27, both as known. The relay 15, current sensor 18, and/or water-level sensors 20, 22 can be located on the integrated circuit with the controller 16.

[0015] The pump 12 has an inlet 26, which may be covered with a grate/strainer, and an outlet 28, which may be connected to a hose 30, which carries water from the bilge pump 12 to an outlet that drains the water overboard. A power source, such as a battery 32, provides power to the electric motor 14. When the relay 15 is activated, current is provided from the battery 32 to the electric motor 14, which rotates to output a torque to an impeller or to move a diaphragm in order to pump standing water from the bilge, thorough the inlet 26, and to the outlet 28, as is known in the art. The relay 15 can be an electromechanical or solid-state relay. The electric motor 14 can be a brushed or brushless DC motor. The battery can be the marine vessel's main battery or a battery provided specifically for the bilge pump 12.

[0016] The pump controller 16 is in signal communication with a telematics control module 33, which communication can be wired (such as by way of direct wiring or by way of a serial bus) or wireless (such as by way of transceivers). Exemplary wireless protocols that could be used for this purpose include, but are not limited to, Bluetooth®, Bluetooth Low Energy (BLE), ANT, and ZigBee. The telematics control module 33 relays information from the bilge pump 12 and/or water-level sensor 24 to the cloud 34 via a mobile broadband network (e.g., via 3G or 4G broadband cellular network technology). The telematics control module 33 includes a cell chip 36 enabling such cellular communication with a central computing system 38 in the cloud 34, such as for transferring information provided by controller 16 and/or water-level sensor 24. In other embodiments, other communication means may be employed between the telematics control module 33 and the central computing system 38, such as via satellite internet service. Such communication means may be provided as an alternative to, or in addition to, the cell chip 36 providing cellular network access.

[0017] The central computing system 38 includes a processing system 40 and a storage system 42 accessible by the processing system 40. The central computing system 38 is able to communicate with a user device 44, which may be any computing device accessible by a user to communicate with the central computing system 38 (or, in certain embodiments, directly with the telematics control module 33), such as a cell phone, laptop, or other personal computing device. The user device 44 includes a user interface 46 that presents information to the user, such as a pump malfunction diagnosis and/or other information about the bilge pump 12, as will be described further herein below.

[0018] The pump controller 16 includes a bilge monitor module 48, which is a set of software instructions executable to monitor the bilge pump 12, determine a pump diagnosis, and execute a routine to rectify the malfunction, as described herein below. The pump controller 16 also includes a processing system 50 and a storage system 52 accessible by the processing system 50. The bilge monitor module 48 may be a set of software instructions stored within the storage system 52 and executable by the processing system 50 to operate as described herein, including determining a pump malfunction diagnosis and/or to control the bilge pump 12 to rectify the malfunction as described herein. In other embodiments, the bilge monitor module 48 is located in the storage system 42 of the central computing system 38 in the cloud 34. In still other embodiments, portions of the software instructions for the bilge monitor module 48 are located in the storage system 52 and executed by the processing system 50 in the controller 16, and portions of the software instructions for the bilge monitor module 48 are located in the storage system 42 and executed by the central computing system 38 on the cloud 34.

[0019] As described herein below, the controller 16 is configured to determine if the pump system 10 is malfunctioning, and in response to determining that the pump system 10 is malfunctioning, the controller 16 is configured to control the electric motor 14 according to a predetermined routine configured to rectify the malfunction. Types of malfunctions that the pump system 10 might have include an air-locked state of a hose (e.g., hose 30, another hose downstream of hose 30, within pump 12, or inlet 26) in fluid communication with the bilge pump 12, a stalled state of the electric motor 14, a blockage in the bilge pump 12 (e.g., debris stuck in the impeller) and/or the hose (e.g., a hose upstream of inlet 26, hose 30, a hose downstream of hose 30), and a blown fuse 31 between the battery 32 and the electric motor 14. This list is not exhaustive, and the controller 16 may be able to identify other malfunctions in the pump system 10. For example, Fig. 2 includes a table of malfunctions that the controller 16 may be able to diagnose, including a failed wire harness, poor grounding, a failed or intermittent water-level switch, or a major leak in the system.

[0020] There are many possible sources of information which the controller 16 can use to determine if the pump system 10 is malfunctioning. In some examples, the controller 16 uses information from at least one of the current sensor 18 and the water-level sensor 20, 22, 24 to determine if the pump system 10 is malfunctioning. For example, as shown in Fig. 2, the controller 16 can use a reading from the water-level sensor 20, 22, 24, a current draw from the motor 14 as sensed by the current sensor 18, and a timer (which determines the duration for which the bilge pump 12 is turned on) to diagnose a number of conditions. Further sources of information include a flow meter 54 and/or a water sensor 56 in the hose 30. The flow meter 54 can be an ultrasonic flow meter or a vortex flow meter so as not to impede the flow of water. The water sensor 56 can be a single- or dual-probe sensor.

[0021] As mentioned, the controller 16 receives and analyses the current draw measurements made by the current sensor 18. Such current draw measurements can be used to determine information about the current operation of the bilge pump 12. Fig. 3 provides a graph illustrating current measurements for an exemplary bilge pump 12 during various operation stages. When the bilge pump 12 is off, or is not drawing sufficient current for operation, the current draw measurements will be around 0, or at least less than a first threshold T_1. Thus, if the current sensor 18 is measuring a current draw that is less than threshold T_1, then it can be determined that the bilge pump 12 is off, or at least that the electric motor 14 is not operating.

[0022] If the electric motor 14 is operating, then the current draw measurements will be greater than or equal to the first threshold T_1. As shown in Fig. 3, the current draw by the bilge pump 12 exceeds the first threshold T_1 when the electric motor 14 is running but no water is present, and thus the bilge pump 12 is not pumping water through the outlet 28 and out of the output hose 30. The current draw of the bilge pump 12 increases further, such as above a second threshold T_2, when the bilge pump 12 is operating to pump water out of the marine vessel. Thus, it can be determined based on the current draw whether water is in the bilge that is being pumped by the bilge pump 12. If no water is sitting in the bilge, and the bilge pump 12 is operating, then the current draw will be between the first threshold T_1 and the second threshold T_2. If water is in the bilge and the bilge pump 12 is operating to remove it, then the current draw by the bilge pump 12 will exceed the second threshold T_2.

[0023] The current draw will not exceed a third threshold T_3 unless there is a problem with the bilge pump 12. For example, a staled motor or jammed impeller may cause a sudden spike in current draw as the electric motor 14 consumes more current in an attempt to continue its pumping operation. As exemplified in Fig. 3, if the current draw exceeds the third threshold T_3, the controller 16 can diagnose that the bilge pump 12 has a seized (e.g., stalled, jammed) motor. The various threshold and operating current values are for example purposes only. The actual threshold and operating current values for a particular application will vary depending on the particular bilge pump and pump system arrangement being monitored. In certain embodiments, the current draw thresholds may, instead of being pre-set thresholds, be normal thresholds determined based on previous operating cycles as described above. Thereby, the current draw thresholds can adjust as the pump ages and the current draw changes.

[0024] Accordingly, a bilge pump diagnosis may be determined by comparing the current draw measurements measured by the current sensor 18 during an ongoing pump cycle, and how those current draw measurements compare to one or more thresholds. The thresholds may be preset values, such as based on the pump model being monitored and/or the power configuration therefore. Additionally, the controller 16 may be configured to determine one or more normal operating values for the bilge pump 12 based on acquired current draw measurements over time—i.e., over multiple pump cycles executed during the normal operation of the bilge pump 12. Outside of extenuating circumstances, such as a major leak or heavy rain allowing abnormally high amounts of water into the bilge, the bilge pump 12 will run at a fairly regular cycle. For example, if the bilge pump 12 is operating in an automatic mode such that a water-level sensor 20, 22, 24 is controlling the cycling of the bilge pump 12 on and off, the bilge pump 12 will cycle on and off at a fairly regular interval. Accordingly, a normal cycle interval for a given bilge pump can be determined based on the current draw information gathered over a period of time, such as a period of days or weeks.

[0025] The normal cycle interval may vary based on external conditions, such as seasonal conditions or based on varying locations of the marine vessel. Thus, the normal cycle interval determined based on the normal current draw values may vary over an extended period of time, such as weeks or months. For example, the normal cycle interval may vary based on seasonal conditions or a change in a geographical location of the marine vessel-i.e., based on changes in the amount of rainfall. The normal cycle interval calculation can remain sufficiently updated by, for example, constraining the amount of data the controller 16 uses to calculate the normal cycle interval. For example, the normal cycle interval may be calculated based on a predetermined number of previous pump cycles, or based on the current draw measurements gathered over a predetermined amount of time (such as based on the previous few days' worth of data). Other normal operating values may likewise be calculated.

[0026] Fig. 4 illustrates current draw measurements acquired over two pump cycles, where a pump cycle represents a full on/off interval of the bilge pump 12. A pump cycle may be divided into a pump-on duration 70 and a pump-off duration 72, where the pump-on duration is the period of time for which the current draw exceeds the first threshold T_1 indicating that the bilge pump 12 is on. The pump-off duration 72 is the period of time during which the bilge pump 12 is turned off, such as from the time that the current draw measurement falls below the first threshold T_1 until the bilge pump 12 turns back on and the current draw rises back above the first threshold T_1. In the depicted example, the current draw is provided over time, measured in minutes. The pump-on duration 70 is approximately 3.5 minutes. The pump-off duration is much longer, and in the depicted example is 96.5 minutes. Thus, the total cycle interval for the first pump cycle is 100 minutes, where the pump is operated for only 3.5% of the interval period. The next pump cycle is approximately the same as the first pump cycle. This is typical of normal automatic operation, where the water-level sensor 20, 22, 24 turns on the bilge pump 12 when a threshold amount of water enters the bilge, and the bilge pump 12 evacuates the water at a constant rate every cycle. Accordingly, by averaging the current draw values and cycle values over numerous pump cycles, a consistent and reliable set of normal operating values can be determined.

[0027] The normal operating values are determined based on the values calculated for the pump cycles in the analysis set, such as for each of the predetermined number of pump cycles used in the running normal calculation. The normal operating values determined for a bilge pump 12 based on the current draw measurements over numerous pump cycles may include a normal cycle interval, a normal pump-on duration, a normal pump-off duration, a normal peak current draw, a normal minimum current draw, a normal average current draw, etc. For example, a normal peak current draw may be determined by averaging the peak current draw for each pump cycle in the analysis set. A normal minimum current draw may be determined for each pump cycle, which may represent the average current draw during the running period for which no water was present (see Fig. 3). Thus, the normal minimum current draw may represent the amount of current that the bilge pump 12 is drawing during the portion of a normal run cycle where no water is present in the bilge. A normal average current draw can be calculated, such as by determining a current draw average for each pump cycle, and then averaging those average values determined for each interval in the set. A normal cycle interval may be determined by averaging the total pump cycle times for each pump cycle in the analysis set, which is the time between the start points of each cycle. A normal pump-on duration may be calculated as an average of the pump-on duration 70 for each pump cycle, and a normal pump-off duration may be calculated as an average of the pump-off durations 72 for each pump cycle in the analysis set. In certain embodiments, a water evacuation duration 74 may also be determined for each pump cycle, which is the period of time, based on the current draw measurements, for which the bilge pump 12 is operating to evacuate water. For example, the water evacuation duration 74 may be the period during which the current draw measurements are between the second threshold T_2 and the third threshold T_3. In certain embodiments, a normal water evacuation duration may be determined by averaging the water evacuation durations 74 for each of the pump cycles in the analysis set. Alternatively or additionally, a normal current draw pattern may be determined for a pump cycle, which may be determined by lining up the current draws for each measurement cycle and averaging the values at corresponding time points.

[0028] Returning to Fig. 2, the table provided therein illustrates and exemplifies analysis that may be performed by the controller 16 to generate a pump diagnosis based on the current draw measurement, including based on a comparison of current draw measurements for an ongoing pump cycle to normal operating values. Specifically, the table illustrates exemplary thresholds and logic that may be executed by the controller 16 to diagnose a malfunction in the pump system 10 based on the current draw values as compared to preset operating thresholds and normal operating values. In the example, the normal operating value is exemplified as the pump-on duration 70. In certain embodiments, the water evacuation duration 74 may be used in place of the pump-on duration 70. Other normal operating values may also be used as an alternative to or in addition to the pump-on duration 70.

[0029] The controller 16 compares the current draw for an on-going pump cycle to one or more thresholds to make an initial determination regarding pump functioning. As described above, the threshold values are determined based on a particular pump and electrical configuration on a particular marine vessel. In the depicted example, if the current draw is less than a threshold of 1 ampere, then an assumption is made that the bilge pump 12 is not running. In that case, the diagnosis may be determined as one or all of a blown fuse 31, a failed electric motor 14, a failed wire harness, or a poor ground. In certain examples, voltage measurements at various locations in the wire harness (between the battery 32 and the bilge pump 12) may provide additional information as to the location of the problem.

[0030] If the current draw for the ongoing pump cycle is between 1 amp and 2 amps, then an assumption is made that the bilge pump 12 is running, but water is not present. Because the water-level sensor 20, 22, 24 should turn off the bilge pump 12 if water is not present, then the continued operation of the pump could indicate that the water-level sensor 20, 22, 24 has failed and thus is not turning the bilge pump 12 off. Alternatively, the inlet 26 to the bilge pump 12 may be clogged such that water is not getting to the bilge pump 12. In certain embodiments, the diagnosis may be set as indicating that either one of the failed water-level sensor or clogged inlet condition has occurred. In other embodiments, further tests may be conducted to determine which diagnosis is more accurate. For example, to further test if a clogged inlet 26 is the problem, the water sensor 56 installed at the outlet 28 and/or along the hose 30 can be used to determine if water is flowing out of the bilge pump 12. If water is detected in the bilge by the water-level sensor 20, 22, 24, the bilge pump 12 is running, and no water is detected at the outlet 28 or hose 30, the controller 16 can determine that a clogged inlet 26 is the problem. In still other embodiments, the controller 16 may default to indicate one or the other diagnosis, such as setting the diagnosis equal to failed water-level sensor.

[0031] As further shown in Fig. 2, if the current draw measurements are between 2 and 4 amps, then the bilge pump 12 is operating to evacuate water from the bilge. In addition to the current draw threshold comparison, the current draw of the ongoing pump cycle, or values calculated based thereon, are compared to corresponding normal operating values. In the depicted example, the pump-on duration calculated for an ongoing pump cycle (i.e., an ongoing pump-on duration) is compared to the normal pump-on duration. If the current draw is within the normal operating range of 2-4 amps, and the pump-on duration is shorter than a normal pump-on duration, then an assumption is made that water is present, but that the bilge pump 12 is turning off too quickly. Specifically, since the location of the water-level sensor 20, 22, 24 is fixed, the water level at the start of operation is known, or at least approximately known. Based on the normal operating values calculated previously, it is known how long the bilge pump 12 needs to operate in order to evacuate that amount of water. If the bilge pump 12 operates for less time, something is likely wrong because the bilge pump 12 generally operates at a consistent speed and is only capable of evacuating water at a set rate. Thus, the most likely cause of the problem is improper operation of the water-level sensor 20, 22, 24 to turn off the bilge pump 12 before all of the water is removed from the bilge. Thus, the diagnosis may then be set to failed water-level sensor.

[0032] If, on the other hand, the current draw is 2 to 4 amps and the pump-on duration for the ongoing pump cycle is the same as the normal pump-on duration, or within a predetermined range of the normal pump-on duration, then the bilge pump 12 is determined to be operating correctly and the diagnosis is set to normal.

[0033] If the current draw is 2-4 amps and the ongoing pump-on duration exceeds the normal pump-on duration, such as by at least a threshold amount of time, then an assumption is made that water is present in the bilge, but that the water is not being evacuated as quickly as usual. Thus, the diagnosis is determined to be one of a clogged pump outlet 28, excess water due to heavy rain or a major leak, or the bilge pump 12 is airlocked. The increased or continued run time of the bilge pump 12 may indicate that water is accumulating in the bilge, which could be due to heavy rain, a severe leak, non-operation of the bilge pump 12, or air in the hose 30 downstream of the outlet 28. Logic can be executed as described herein to determine whether the bilge pump 12 is operating. Furthermore, to further test if airlock is the problem, the water sensor 56 installed at the outlet 28 and/or along the hose 30 can be used to determine if water is flowing therethrough. If water is detected in the bilge by the water-level sensor 20, 22, 24, the bilge pump 12 is running, and no water is detected by the water sensor 56 at the outlet 28 or hose 30, the controller 16 can determine that airlock is the problem. In such a case, the controller 16 may not need to know that the bilge pump was also on for longer than a normal duration. To further test if a clogged outlet 28 or hose 30 is the problem, the pump system 10 may utilize the flow meter 54 at or near the outlet end of the hose 30. If the reading from the flow meter 54 shows that the water flow is less than would otherwise be indicated given the reading from the water-level sensor 20, 22, 24, the controller 16 may diagnose the malfunction as a clogged outlet 28 or hose 30.

[0034] If the current draw for the ongoing pump cycle exceeds 4 amps, then it is determined that the bilge pump 12 is drawing too much current, and the diagnosis is set equal to a stalled motor or stuck impeller (which may be one or both of the diagnoses). Namely, a current draw above a certain high threshold is an indication of a seized rotor, meaning that the motor output shaft is not turning. This is most likely caused by something being caught in the pump's impeller or diaphragm, such as debris, or by a downstream blockage that imparts a heavy load on the output shaft of the electric motor 14.

[0035] Referring to Fig. 6, once the controller 16 determines that the pump system 10 is malfunctioning (step 600) and is able to diagnose the malfunction at least with some degree of specificity (step 602), the controller 16 is configured to control the electric motor 14 according to a predetermined routine configured to rectify the malfunction (step 604). According to the present disclosure, the predetermined routine comprises at least one of the following: (a) stopping the bilge pump 12 and subsequently restarting the bilge pump 12; and (b) operating the bilge pump 12 at a different flow rate than a flow rate at which the bilge pump 12 was operating when the controller 16 determined the pump system 10 was malfunctioning. The predetermined routine may further include determining if the malfunction has been rectified after performing at least one of (a) and (b) (step 606) and repeating at least one of (a) and (b) in response to determining that the pump system 10 is still malfunctioning (i.e., if NO at step 606, return to step 604). The predetermined routine may also comprise-only after repeating at least one of (a) and (b) a predetermined number of times (e.g., five times) or for a predetermined period (e.g., ten minutes)— stopping the bilge pump 12 in response to determining that the pump system 10 is still malfunctioning (step 608). On the other hand, the predetermined routine may also include determining if the malfunction has been rectified after performing at least one of (a) and (b) (step 606); and in response to determining that the malfunction has been rectified (YES at step 606), resuming operation of the bilge pump 12 according to parameters at which the bilge pump 12 was operating before the controller 16 determined that the pump system 10 was malfunctioning (step 612). In other words, the controller 16 will not continue to run the rectifying routine.

[0036] By way of one particular example, if the controller 16 determines that a hose 30 downstream of the bilge pump 12 is airlocked, the controller 16 may stop the bilge pump 12, and after a predetermined period of time (e.g., one minute) has elapsed, re-start the bilge pump 12. The controller 16 may then determine the current running through the electric motor 14 using the current sensor 18, and if this current draw does not indicate the bilge pump 12 is operating properly, again stop the bilge pump 12, wait a predetermined period of time, and again re-start the bilge pump 12. After the controller 16 has repeated this sequence a predetermined number of times or for a predetermined period and still does not sense that the current flow is normal, the controller 16 may stop the bilge pump 12 and not re-start it again until after a user override. On the other hand, such repeated stopping and starting of the bilge pump 12 may be enough to force the air out of the system, in which case the controller 16 will sense that current flow through the bilge pump 12 is normal and will command the bilge pump 12 to resume normal operation, i.e., to operate at the parameters it was operating at before the malfunction was detected.

[0037] By way of another particular example, if the controller 16 determines that the bilge pump 12 is blocked at the inlet 26 or outlet 28, the controller 16 may run a clearing routine, which may include running the bilge pump 12 at a slower flow rate than normal. This could be done if the electric motor 14 is a variable speed electric motor by applying varying currents and/or voltages thereto. Additionally or alternatively, an electrically controlled variable orifice 60 could be provided downstream of the outlet 28, which the controller 16 could control to adjust flow rate from the bilge pump 12. The controller 16 could decrease and then increase flow rate in an attempt to adjust backpressure in the bilge pump 12 and jog loose the obstruction. If repeated attempts at changing flow rate do not rectify the malfunction (i.e., the sensed current flow is still not normal), the controller 16 can then turn off the bilge pump 12. Alternatively, if the flow meter 54 and or water sensor 56 downstream of the bilge pump 12 show that the blockage is not a full blockage, and some water is still being evacuated, the controller 16 can run the bilge pump 12 at a slower flow rate to counteract the backpressure from the blockage, while still safely evacuating the bilge. On the other hand, if the controller 16 determines that the clearing routine(s) is/are effective (i.e., the sensed current flow has returned to normal), the controller 16 may then resume operation of the bilge pump 12 at the parameters it was operating at before the malfunction was detected.

[0038] The controller 16 may further be configured to communicate details of the malfunction and whether the predetermined routine was able to rectify the malfunction to a display device, such as the user interface 46 on user device 44 (step 614). This is especially important if the predetermined routine was not able to rectify the malfunction and the bilge pump 12 was therefore turned off (step 608), in which case the alert might be a push notification. On the other hand, the alert may be a more passive alert, such as an email or text message, if the malfunction was able to be rectified (YES at step 606). However, sending an alert even after the malfunction was rectified allows the user to determine if any further action needs to be taken to check that the bilge pump 12 is still in good working order. Such alerts may be sent via the telematics control module 33 and cloud 34 to the user device 44. In other examples, the controller 16 sends the alerts to a hub computing system onboard the marine vessel, especially those alerts that require more timely intervention.

[0039] In yet another example, the controller 16 is configured to determine when a component of the pump system 10 is nearing its end of life and to communicate an alert to a display device, such as user interface 46 or a display on a vessel's hub computing system, in response to same. For example, if the controller 16 determines that the electric motor 14 has stalled a predetermined number of times, the controller 16 may alert the user that the electric motor 14 or a part thereof needs to be replaced. If the controller 16 determines that the impeller or diaphragm is jammed a predetermined number of times, the controller 16 may alert the user that a replacement part may be needed. If the controller 16 determines that the inlet 26, outlet 28, or hose 30 is clogged a predetermined number of times, the controller 16 may alert the user that a new strainer, tube, or hose is required. Because the controller 16 is uniquely associated with the bilge pump 12, the controller 16 can also be preprogrammed with end-of-life estimates for components subject to failure, based on information collected from the same pump model via the cloud 34. The central computing system 38 and/or controller 16 could automatically place an order to replenish that part when collected data indicates it is nearing its end of life, or at least send a link to a website to the user where the user can purchase the replacement part. This could be done by consulting a reference table in the storage system 42 that links the pump's serial number to replacement parts therefore.

[0040] Even if the user is able to receive a push notification or similar type of alert regarding the bilge pump 12 malfunctioning, the present inventors realized that there still may be nothing the user can do about the malfunction or the controller's inability to rectify same until he or she returns to the marine vessel. In such a case, the pump system 100 of Fig. 5 is helpful. The pump system 100 in Fig. 5 comprises a first bilge pump 12 including a first electric motor 14 configured to power the first bilge pump 12 and a first controller 16 controlling the first electric motor 14. The pump system 100 also includes a second bilge pump 102 including a second electric motor 105 configured to power the second bilge pump 102 and a second controller 104 controlling the second electric motor 105. Furthermore, a third bilge pump 108 with an electric motor 109 and controller 110 can also be provided. According to the present disclosure, the first, second, and third controllers 16, 104, 110 are in signal communication with one another, such as by way of a serial bus 106. The serial bus 106 can be a controller area network ("CAN") bus utilizing a NMEA 2000 ("N2K") communications standard, as is common for marine applications. The pump system 100 also includes a water-level sensor 24 (here, a float switch) in electrical communication with the first, second, and third controllers 16, 104, 110 via the serial bus 106, and the first, second, and third controllers 16, 104, 110 are configured to control the first, second, and third bilge pumps 12, 102, 108 respectively, in response to the water-level sensor 24 sensing the presence and/or absence of water. In fact, any number of pumps and/or sensors can be provided and connected to the serial bus 106.

[0041] The serial bus 106 is connected via a gateway or bridge 114 to another serial bus 116, and then to a telematics control module 33, which operates as noted herein above to communicate with the cloud 34. Other devices and/or modules, such as a digital switching module and/or a multifunction display and/or a keypad (not shown) can also be connected to the serial bus 116, by way of which the user can interact with one or more of the bilge pumps 12, 102, 108 to manually turn them on or off or by way of which the user can view the status of any of the connected components.

[0042] Although details of the first, second, and third controllers 16, 104, 110 and relays, water-level sensors, and current sensors are not shown in Fig. 5, the relevant hardware shown in Fig. 1 may be included in each of the three bilge pumps 12, 102, 108. For example, the first controller 16 is located on or within a housing 27 of the first bilge pump 12, the second controller 104 is located on or within a second housing 103 of the second bilge pump 102, and the third controller 110 is located on or within a housing 111 of the third bilge pump 108. Each controller 16, 104, 110 includes a storage system, a processor, and a bilge monitor module as described herein above with respect to Fig. 1. Each controller 16, 104, 110 is electrically connected to a float switch near or integral with the respective pump or with non-contact water level sensors as described herein above, which are provided in addition to the water-level sensor 24.

[0043] Because the pump controllers 16, 104, 110 are connected to each other via the serial bus 106, the pump system 100 as a whole is able to control water build-up in the bilge when one of the bilge pumps 12, 102, 108 malfunctions and the respective controller 16, 104, 110 is not able to rectify the malfunction. For example, the first controller 16 may be configured to control the first electric motor 14 in response to a command from the second controller 104. For example, referring to Fig. 7, the second controller 104 is configured to determine if part of the pump system 100 associated with the second bilge pump 102 (e.g., its electric motor 105, its inlet, its outlet, its fuse, etc.) is malfunctioning (step 700). In response to determining that part of the pump system 100 associated with the second bilge pump 102 is malfunctioning (YES at step 700), the second controller 104 is configured to control the second electric motor 105 according to a predetermined routine configured to rectify the malfunction (step 702). The second controller 104 can diagnose and attempt to rectify the malfunction as noted herein above. The second controller 104 is configured meanwhile to command the first controller 16 to start the first bilge pump 12 (step 706) in response to determining that part of the pump system 100 associated with the second bilge pump 102 is malfunctioning (YES at step 700). This way, the first bilge pump 12 can start evacuating water while the second bilge pump 102 self-diagnoses and self-repairs. The controller 16 can run the first bilge pump 12 for only a predetermined period of time after the second controller 104 commands it to start or can run the first bilge pump 12 until the second controller 104 commands it to stop. As noted herein above, depending on the malfunction that is diagnosed, the predetermined routine comprises at least one of the following: (a) stopping the second bilge pump 102 and subsequently restarting the second bilge pump 102; and (b) operating the second bilge pump 102 at a different flow rate than a flow rate at which the second bilge pump 102 was operating when the second controller 104 determined that part of the pump system 100 associated with the second bilge pump 102 was malfunctioning.

[0044] If the second bilge pump 102 is not able to rectify the malfunction (NO at step 704), the second controller 104 can command the first controller 16 to maintain the first bilge pump 12 on, if the first bilge pump 12 was otherwise programmed to turn off after running for a predetermined period of time. On the other hand, if the first controller 16 was programmed to run the first bilge pump 12 until the second controller 104 commanded the first controller 16 to shut the first bilge pump 12 off, no additional signal may be needed. The first bilge pump 12 will shut off once the second controller 104 signals the first controller 16 to do so, such as after a second water-level sensor 112 on the second bilge pump 102 no longer senses water. In another example, the second controller 104 only commands the first controller 16 to turn the first bilge pump 12 on after determining that the malfunction associated with the second bilge pump 102 could not be rectified (i.e., if NO at step 704, proceed to step 706).

[0045] On the other hand, if the malfunction was rectified after running the predetermined routine (YES at step 704), the second controller 104 may resume operation of the second bilge pump 102 according to parameters at which the second bilge pump 102 was operating before the second controller 104 determined that the pump system 100 was malfunctioning (step 708). The second controller 104 may also command the first bilge pump 12 to turn off (step 710), as the second bilge pump 102 is now able to evacuate water from the bilge.

[0046] By way of another example, if the integral water-level sensors 20 and/or 22 for the first bilge pump 12 is/are malfunctioning, the integral water level sensor 112 on the second bilge pump 102 can instead provide the initiating electrical impulse that starts the first bilge pump 12. For example, the pump system 100 includes a water-level sensor 112 connected to (i.e., attached to or within) the second bilge pump 102 and electrically connected (wired or wirelessly) to the second controller 104, and the second controller 104 is configured to command the first controller 16 to start or stop the first electric motor 14 in response to the water-level sensor 112 sensing the presence and/or absence of water.

[0047] Similar to the pump system 10 described above with respect to Fig. 1, the second controller 104 is further configured to communicate details of the malfunction and whether the predetermined routine was able to rectify the malfunction to a display device, such as the user interface 46 on the user device 44 (step 712). For example, as noted above, the malfunction can be one of an airlocked state of a hose in fluid communication with the second bilge pump 102, a stalled state of the second electric motor 105, a blockage in the second bilge pump 102 and/or the hose, and a blown fuse between the battery 32 and the second electric motor 105. Furthermore, at least one of the first, second, and third controllers 16, 104, 110 is configured to determine when a component of at least one of the first, second, and third bilge pumps 12, 102, 108, respectively, is nearing its end of life, and to communicate an alert to a display device in response to same.

[0048] Of course, the reference to the pumps as "first" or "second" in the above exemplary routines is arbitrary, and, for example, the first controller 16 can be the one that causes the second pump 102 to start in response to the first water-level sensor 20 sensing water, or to stop in response to water dropping below the water-level sensor 22. Furthermore, any one of the controllers 16, 104, 110 can be configured to control one or both of the other pumps 12, 102, 108, for example perhaps depending on the location of those other pumps, which locations may be stored in the storage system of the controllers 16, 104, 110 and/or in the storage system 42 of the central computing system 38.

[0049] In this way, the pump system 100 can evacuate water from the bilge even if one of the pumps fails or the inlet, outlet, or hose associated with one of the pumps is blocked. In one particular example, if the first bilge pump 12 (which may be located lowest in the bilge) fails, the second and third bilge pumps 102, 108 (which may be higher than the first bilge pump 12) can be turned on in response to a command from the first controller 16, in order to evacuate water while the first bilge pump 12 attempts to self-repair and/or after the first bilge pump 12 is not able to self-repair. In another example, if the separate water-level sensor 24 is placed at a location in the bilge indicating high water (i.e., above the first, second, and third bilge pumps 12, 102, 108), activation of the water-level sensor 24 can result in turning on one or both of the second and third bilge pumps 102, 108. In either case, the second and third bilge pumps 102, 108 can be run for a predetermined period (e.g., ten minutes) or until the water-level sensor on one or both of the second and third pumps no longer detects water. In yet another example, after a higher pump is run to evacuate water, and the water sensor associated with that pump no longer senses water, the controller of the higher pump can command a lower pump (which mayor may not have an integral water sensor) to turn on for a predetermined period of time to empty the remainder of water from the bilge.

EMBODIMENTS

[0050] According to one embodiment of the present disclosure, a pump system 10 comprises a bilge pump 12 powered by an electric motor 14 and a controller 16 controlling the electric motor 14. The controller 16 is configured to determine if the pump system 10 is malfunctioning. In response to determining that the pump system 10 is malfunctioning, the controller 16 is configured to control the electric motor 14 according to a predetermined routine configured to rectify the malfunction.

[0051] In one embodiment, the malfunction is one of an air-locked state of a hose 30 in fluid communication with the bilge pump 12, a stalled state of the electric motor 14, a blockage in the bilge pump 12 and/or the hose 30, and a blown fuse 31.

[0052] In one embodiment, the controller 16 is configured to determine when a component of the pump system 10 is nearing its end of life and to communicate an alert to a display device in response to same.

[0053] In one embodiment, the controller 16 is further configured to communicate details of the malfunction and whether the predetermined routine was able to rectify the malfunction to a display device.

[0054] In one embodiment, the controller 16 is located on or within a housing 27 of the bilge pump 12.

[0055] In one embodiment, the predetermined routine comprises at least one of the following: (a) stopping the bilge pump 12 and subsequently restarting the bilge pump 12; and (b) operating the bilge pump 12 at a different flow rate than a flow rate at which the bilge pump 12 was operating when the controller 16 determined the pump system 10 was malfunctioning.

[0056] In one embodiment, the predetermined routine further comprises: determining if the malfunction has been rectified after performing at least one of (a) and (b); repeating at least one of (a) and (b) in response to determining that the pump system 10 is still malfunctioning; and only after repeating at least one of (a) and (b) a predetermined number of times or for a predetermined period, stopping the bilge pump 12 in response to determining that the pump system 10 is still malfunctioning.

[0057] In one embodiment, the predetermined routine further comprises: determining if the malfunction has been rectified after performing at least one of (a) and (b); and in response to determining that the malfunction has been rectified, resuming operation of the bilge pump 12 according to parameters at which the bilge pump 12 was operating before the controller 16 determined that the pump system 10 was malfunctioning.

[0058] In one embodiment, the pump system 10 further comprises at least one of the following in electrical communication with the controller 16: a current sensor 18 configured to sense a current flowing through the electric motor 14, and a water-level sensor 20, 22, 24 configured to be actuated by a presence and/or absence of water. The controller 16 uses information from the at least one of the current sensor 18 and the water level sensor 20, 22, 24 to determine if the pump system is malfunctioning.

[0059] According to another embodiment, a pump system 100 comprises a first bilge pump 12 including a first electric motor 14 configured to power the first bilge pump 12 and a first controller 16 controlling the first electric motor 14, and a second bilge pump 102 including a second electric motor 105 configured to power the second bilge pump 102 and a second controller 104 controlling the second electric motor 105. The first and second controllers 16, 104 are in signal communication with one another.

[0060] In one embodiment, at least one of the first and second controllers 16, 104 is configured to determine when a component of at least one of the first and second bilge pumps 12, 102, respectively, is nearing its end of life, and to communicate an alert to a display device in response to same.

[0061] In one embodiment, the pump system 100 further comprises a water-level sensor 24 in electrical communication with both the first and second controllers 16, 104 via a serial bus 106, wherein the first and second controllers 16, 104 are configured to control the first and second bilge pumps 12, 102, respectively, in response to the water-level sensor 24 sensing the presence and/or absence of water.

[0062] In one embodiment, the first controller 16 is located on or within a housing 27 of the first bilge pump 12.

[0063] In one embodiment, the first controller 16 is configured to control the first electric motor 14 in response to a command from the second controller 104.

[0064] In one embodiment, the pump system 100 further comprises a water-level sensor 112 connected to the second bilge pump 102 and electrically connected to the second controller 104, wherein the second controller 104 is configured to command the first controller 16 to start or stop the first electric motor 14 in response to the water-level sensor 112 sensing the presence and/or absence of water.

[0065] In one embodiment, the second controller 104 is configured to determine if part of the pump system 100 associated with the second bilge pump 102 is malfunctioning, and in response to determining that part of the pump system 100 associated with the second bilge pump 102 is malfunctioning, the second controller 104 is configured to control the second electric motor 105 according to a predetermined routine configured to rectify the malfunction.

[0066] In one embodiment, the second controller 104 is configured to command the first controller 16 to start the first bilge pump 12 in response to determining that part of the pump system 100 associated with the second bilge pump 102 is malfunctioning.

[0067] In one embodiment, the predetermined routine comprises at least one of the following: (a) stopping the second bilge pump 102 and subsequently restarting the second bilge pump 102; and (b) operating the second bilge pump 102 at a different flow rate than a flow rate at which the second bilge pump 102 was operating when the second controller 104 determined that part of the pump system 100 associated with the second bilge pump 102 was malfunctioning.

[0068] In one embodiment, the second controller 104 is further configured to communicate details of the malfunction and whether the predetermined routine was able to rectify the malfunction to a display device.

[0069] In one embodiment, the malfunction is one of an air-locked state of a hose in fluid communication with the second bilge pump 102, a stalled state of the second electric motor 105, a blockage in the second bilge pump 102 and/or the hose, and a blown fuse.

[0070] In the present description, certain terms have been used for brevity, clarity, and understanding. No unnecessary limitations are to be implied therefrom beyond the requirement of the prior art because such terms are used for descriptive purposes only and are intended to be broadly construed. The different components and assemblies described herein may be used or sold separately or in combination with other components and assemblies. Various equivalents, alternatives, and modifications are possible within the scope of the appended claims.

Claims

1. A pump system (10) comprising:

a bilge pump (12) powered by an electric motor (14); and
a controller (16) controlling the electric motor (14);
wherein the controller (16) is configured to determine if the pump system (10) is malfunctioning; and
wherein in response to determining that the pump system (10) is malfunctioning, the controller (16) is configured to control the electric motor (14) according to a predetermined routine configured to rectify the malfunction.

2. The pump system (10) of claim 1, wherein the predetermined routine comprises at least one of the following: (a) stopping the bilge pump (12) and subsequently restarting the bilge pump (12); and (b) operating the bilge pump (12) at a different flow rate than a flow rate at which the bilge pump (12) was operating when the controller (16) determined the pump system (10) was malfunctioning.

3. The pump system (10) of claim 2, wherein the predetermined routine further comprises:

determining if the malfunction has been rectified after performing at least one of (a) and (b);
repeating at least one of (a) and (b) in response to determining that the pump system (10) is still malfunctioning; and
only after repeating at least one of (a) and (b) a predetermined number of times or for a predetermined period, stopping the bilge pump (12) in response to determining that the pump system (10) is still malfunctioning.

4. The pump system (10) of claim 2, wherein the predetermined routine further comprises:

determining if the malfunction has been rectified after performing at least one of (a) and (b); and
in response to determining that the malfunction has been rectified, resuming operation of the bilge pump (12) according to parameters at which the bilge pump (12) was operating before the controller (16) determined that the pump system (10) was malfunctioning.

5. The pump system (10) of any one of claim 1 to 4, further comprising at least one of the following in electrical communication with the controller (16):

a current sensor (18) configured to sense a current flowing through the electric motor (14); and
a water-level sensor (20, 22, 24) configured to be actuated by a presence and/or absence of water;
wherein the controller (16) uses information from the at least one of the current sensor (18) and the water level sensor (20, 22, 24) to determine if the pump system (10) is malfunctioning.

6. The pump system (10) of any one of claim 1 to 5, wherein the malfunction is one of an air-locked state of a hose (30) in fluid communication with the bilge pump (12), a stalled state of the electric motor (14), a blockage in the bilge pump (12) and/or the hose (30), and a blown fuse (31).

7. The pump system (10) of any one of claim 1 to 6, wherein the controller (16) is configured to determine when a component of the pump system (10) is nearing its end of life and to communicate an alert to a display device in response to same.

8. The pump system (10) of any one of claim 1 to 7, wherein the controller (16) is further configured to communicate details of the malfunction and whether the predetermined routine was able to rectify the malfunction to a display device.

9. The pump system (10) of any one of claim 1 to 8, wherein the controller (16) is located on or within a housing (27) of the bilge pump (12).

10. The pump system (10) of any one of claim 1 to 9, wherein the bilge pump (12) is a first bilge pump (12), the electric motor (14) is a first electric motor (14), and the controller (16) is a first controller (16), and further comprising:

a second bilge pump (102) including a second electric motor (105) configured to power the second bilge pump (102) and a second controller (104) controlling the second electric motor (105);
wherein the first and second controllers (16, 104) are in signal communication with one another.

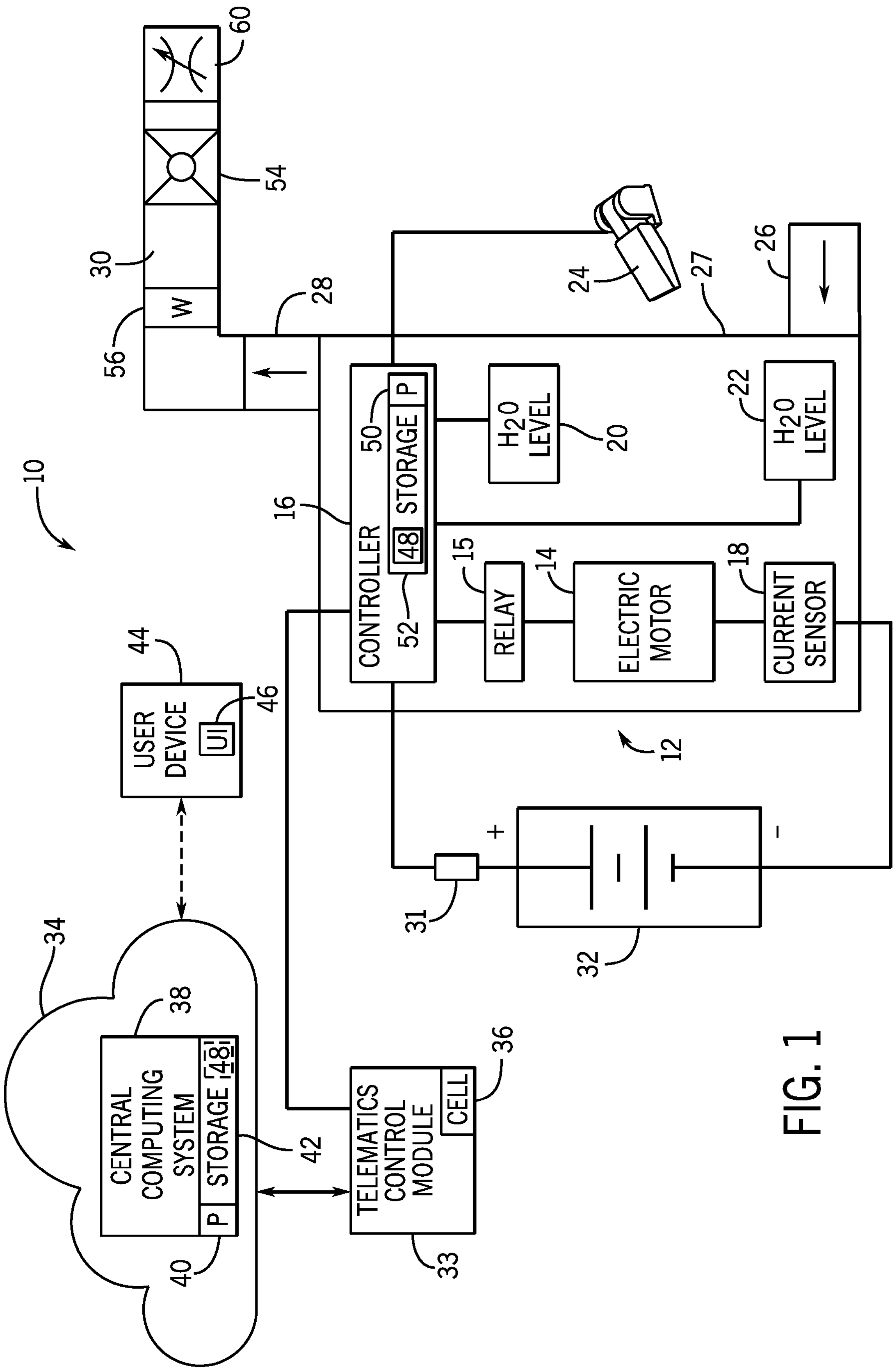
11. The pump system (10) of claim 10, wherein the first controller (16) is configured to control the first electric motor (14) in response to a command from the second controller (104).

12. The pump system (10) of claim 11, further comprising a water-level sensor (112) connected to the second bilge pump (102) and electrically connected to the second controller (104), wherein the second controller (104) is configured to command the first controller (16) to start or stop the first electric motor (14) in response to the water-level sensor (112) sensing the presence and/or absence of water.

13. The pump system (10) of claim 11 or 12, wherein the second controller (104) is configured to determine if part of the pump system (10) associated with the second bilge pump (102) is malfunctioning, and in response to determining that part of the pump system (10) associated with the second bilge pump (102) is malfunctioning, the second controller (104) is configured to control the second electric motor (105) according to a predetermined routine configured to rectify the malfunction.

14. The pump system (10) of claim 13, wherein the second controller (104) is configured to command the first controller (16) to start the first bilge pump (12) in response to determining that part of the pump system (10) associated with the second bilge pump (102) is malfunctioning.

15. The pump system (10) of claim 13 or 14, wherein the predetermined routine comprises at least one of the following: (a) stopping the second bilge pump (102) and subsequently restarting the second bilge pump (102); and (b) operating the second bilge pump (102) at a different flow rate than a flow rate at which the second bilge pump (102) was operating when the second controller (104) determined that part of the pump system (10) associated with the second bilge pump (102) was malfunctioning.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46
50
52
54
56
60
CENTRAL COMPUTING SYSTEM
STORAGE
48
P
TELEMATICS CONTROL MODULE
CELL
USER DEVICE
UI
CONTROLLER
STORAGE
48
P
RELAY
ELECTRIC MOTOR
CURRENT SENSOR
H_2O LEVEL
H_2O LEVEL
W
+
-

FIG. 1

CURRENT DRAW	PUMP-ON DURATION	ASSUMPTION	DIAGNOSIS
<1 AMP		PUMP IS NOT RUNNING	BLOWN FUSE, FAILED MOTOR, FAILED WIRE HARNESS, POOR GROUND
1-2 AMPS		WATER IS NOT PRESENT	CLOGGED INLET, FAILED W.L. SENSOR
2-4 AMPS	SHORTER THAN NORMAL	WATER IS PRESENT, BUT EMPTYING TOO QUICKLY	FAILED / INTERMITTENT W.L. SENSOR
2-4 AMPS	NORMAL	WORKING CORRECTLY	NORMAL
2-4 AMPS	LONGER THAN NORMAL	WATER IS PRESENT, BUT EMPTYING TOO SLOWLY	CLOGGED OUTLET, HEAVY RAIN, MAJOR LEAK, AIRLOCK
>4 AMPS		DRAWING TOO MUCH CURRENT	STALLED MOTOR, STUCK IMPELLER

FIG. 2

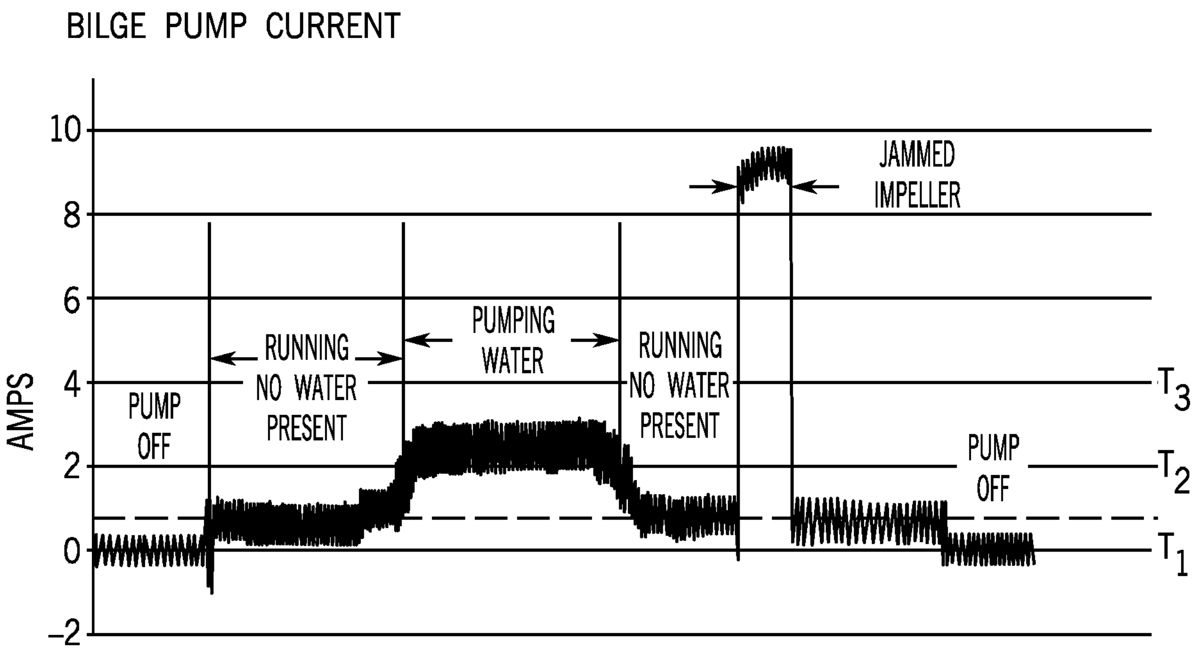
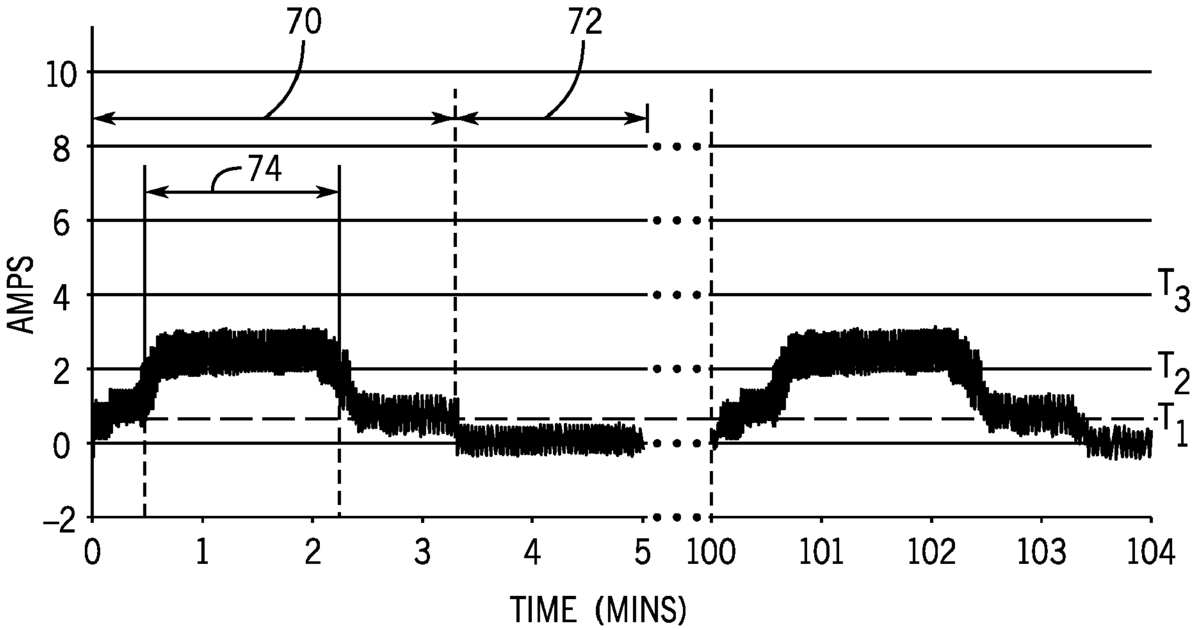

BILGE PUMP CURRENT
AMPS
10
8
6
4
2
0
-2
PUMP OFF
RUNNING NO WATER PRESENT
PUMPING WATER
RUNNING NO WATER PRESENT
JAMMED IMPELLER
PUMP OFF
T3
T2
T1

FIG. 3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72
74
AMPS
10
8
6
4
2
0
-2
T3
T2
T1
0
1
2
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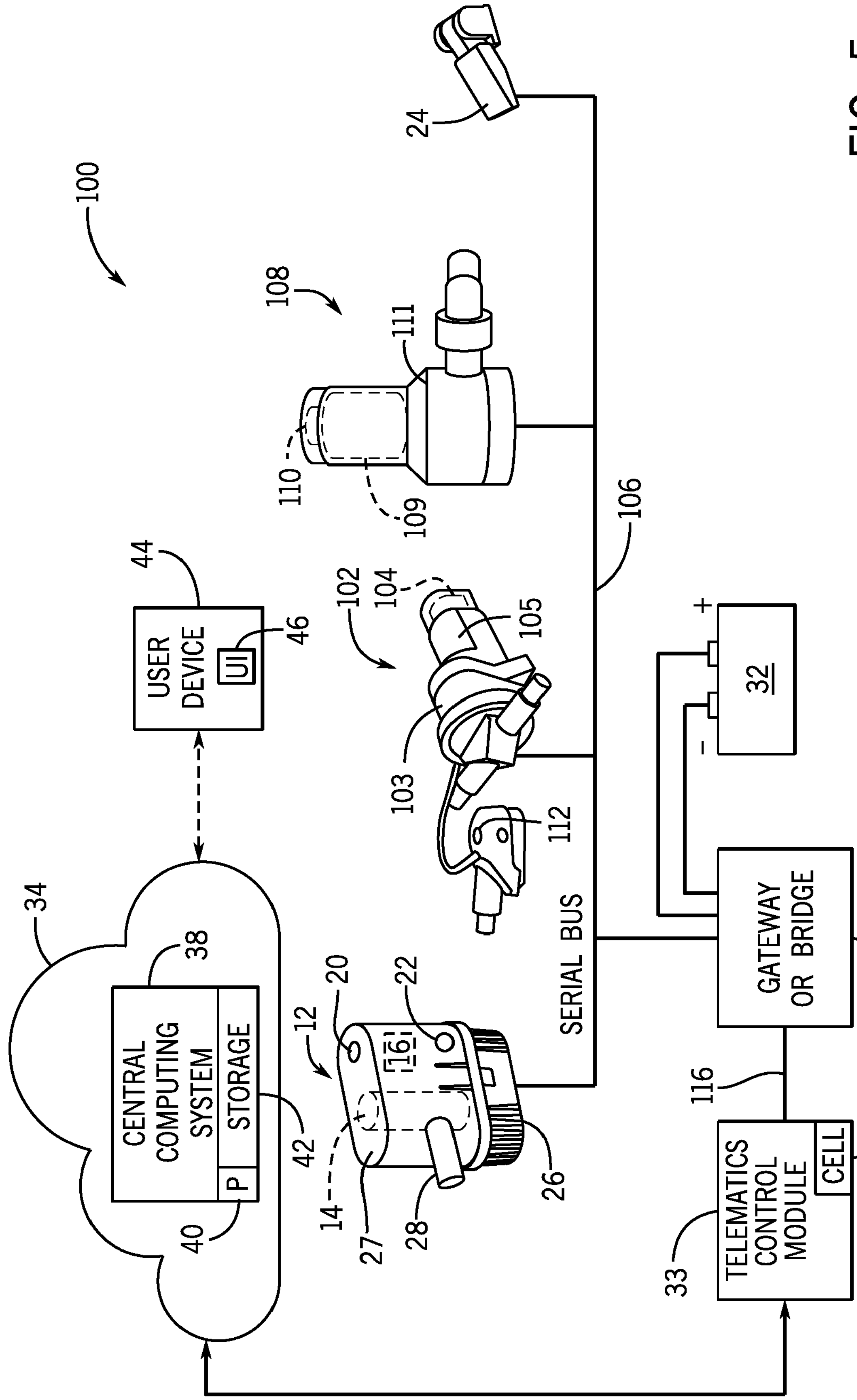
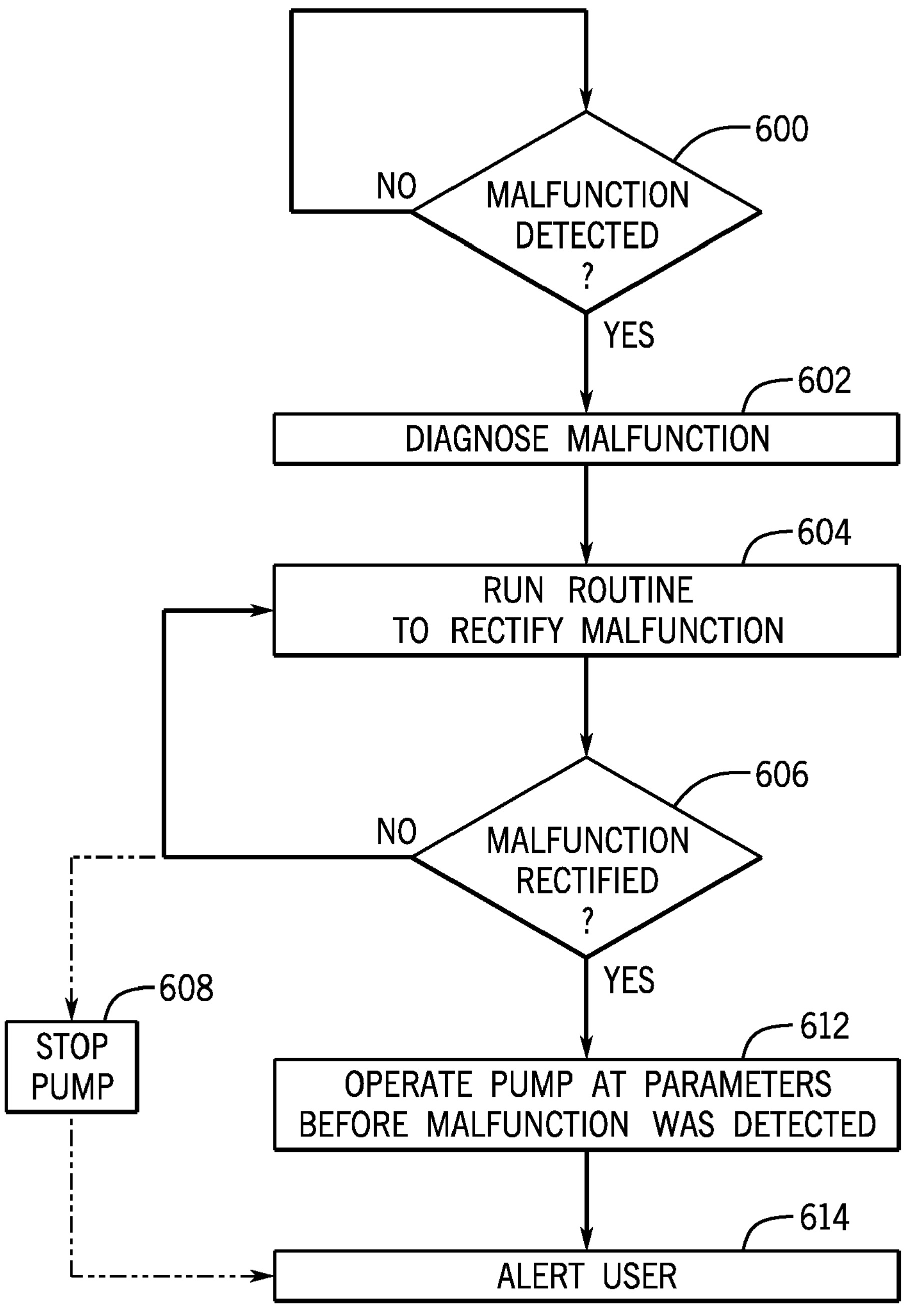
5
100
101
102
103
104
TIME (MINS)

FIG. 4



100
24
108
111
110
109
106
44
USER DEVICE
UI
46
102
104
105
103
112
+
32
−
34
38
CENTRAL COMPUTING SYSTEM
STORAGE
P
40
42
12
20
22
16
14
27
28
26
SERIAL BUS
GATEWAY OR BRIDGE
114
116
TELEMATICS CONTROL MODULE
CELL
33
36

FIG. 5



600
NO
MALFUNCTION DETECTED ?
YES
602
DIAGNOSE MALFUNCTION
604
RUN ROUTINE TO RECTIFY MALFUNCTION
606
NO
MALFUNCTION RECTIFIED ?
YES
608
STOP PUMP
612
OPERATE PUMP AT PARAMETERS BEFORE MALFUNCTION WAS DETECTED
614
ALERT USER

FIG. 6

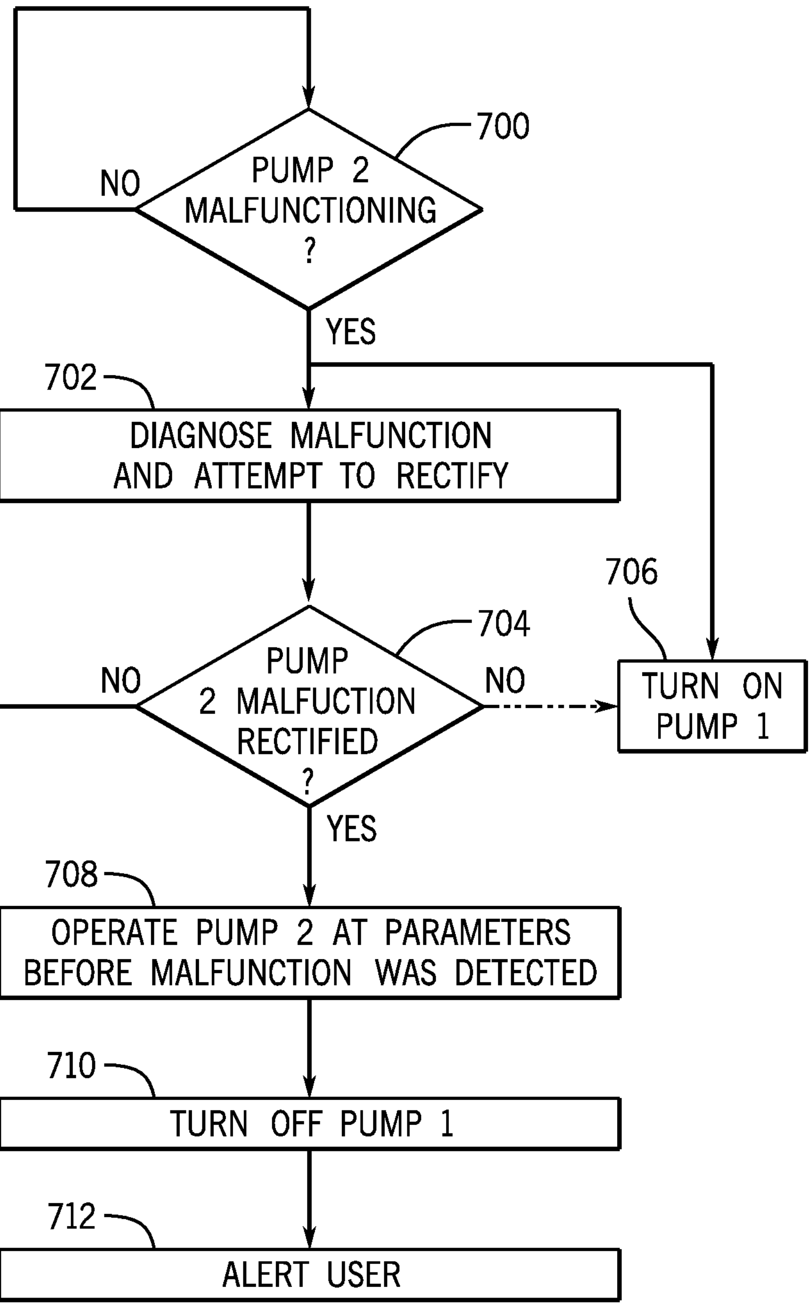

PUMP 2 MALFUNCTIONING ?
700
NO
YES
DIAGNOSE MALFUNCTION AND ATTEMPT TO RECTIFY
702
PUMP 2 MALFUCTION RECTIFIED ?
704
NO
NO
YES
TURN ON PUMP 1
706
OPERATE PUMP 2 AT PARAMETERS BEFORE MALFUNCTION WAS DETECTED
708
TURN OFF PUMP 1
710
ALERT USER
712

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 5997

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1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 February 2022	Oliveira, Damien

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