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(54) Title: INTELLIGENT WINCH FOR VERTICAL PROFILING AND RELATED SYSTEMS AND METHODS

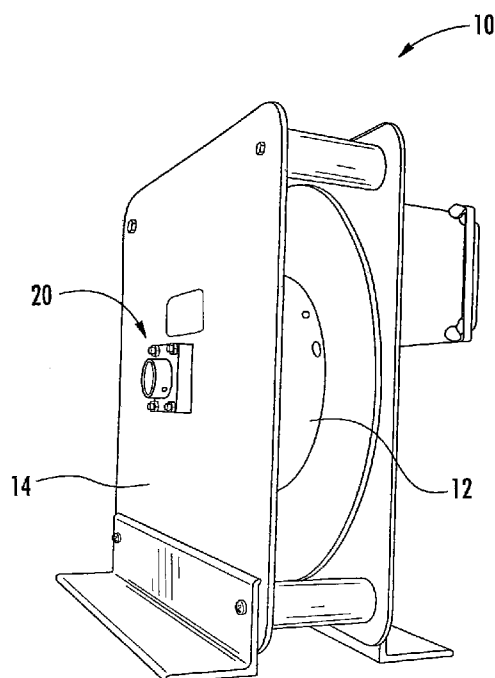


FIG. 1

(57) Abstract: A method includes: (a) providing an intelligent winch including a motor driven winch drum having a cable wrapped there-around and a sensor unit connected to an end of the cable; (b) receiving a position command from a client site at the intelligent winch; (c) rotating the winch drum using the motor to unwind and/or wind the cable to thereby lower and/or raise the sensor unit to a vertical position in a body of water in response to the position command; (d) collecting data associated with one or more water properties at the vertical position using one or more water property sensors of the sensor unit and transmitting the data to the client site using the sensor unit; and (e) repeating steps (b) through (d) a plurality of times to generate a vertical profile of the one or more water properties at a plurality of different vertical positions at the client site.



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Intelligent Winch for Vertical Profiling and Related Systems and Methods

STATEMENT OF GOVERNMENT SUPPORT

[0001] The present invention was made with government support under grant number OCE-0812913 awarded by the National Science Foundation. The government has certain rights in the invention.

BACKGROUND

[0002] Most instruments used for environmental observations in natural settings such as oceans, estuaries, lakes, and reservoirs measure at a single point in space. Commonly used single point sensors measure properties of water such as temperature, salinity, turbidity, pH oxygen and chlorophyll content. Properties such as these often vary strongly over their vertical extent. Consequently it is often important to make measurements at multiple locations vertically. This presents a problem for unattended monitoring. One solution is to purchase multiple instruments and position them at intervals throughout the range of interest. This can be very expensive and still yield inadequate vertical resolution.

SUMMARY

[0003] Some embodiments of the invention are directed to a method including: (a) providing an intelligent winch comprising a motor driven winch drum having a cable wrapped therearound and a sensor unit connected to an end of the cable; (b) receiving a position command from a client site at the intelligent winch; (c) rotating the winch drum using the motor to unwind and/or wind the cable to thereby lower and/or raise the sensor unit to a vertical position in a body of water having a surface in response to the position command; (d) collecting data associated with one or more water properties at the vertical position using the sensor unit and transmitting the data to the client site using the sensor unit; and (e) repeating steps (b) through (d) a plurality of times to generate a vertical profile of the one or more water properties at a plurality of different vertical positions at the client site.

[0004] According to some embodiments, the method includes continuously collecting depth data of the sensor unit below the surface of the body of water using a water depth sensor of the sensor unit, and continuously receiving, at the intelligent winch, position feedback data based on the depth data provided by the sensor unit indicating the vertical position of the sensor unit in the body of water. The rotating step may be carried out using the position feedback data.

[0005] The method may include stopping rotation of the winch drum if the winch drum is rotating or preventing the winch drum from rotating if the winch drum is stopped if the position feedback data is not received for a predetermined period of time.

[0006] The method may include stopping rotation of the winch drum if the position feedback data indicates that the sensor unit is moving in a different direction in the body of water than specified by the position command.

[0007] The method may include stopping rotation of the winch drum if the position feedback data indicates that the sensor unit is not moving in the body of water.

[0008] According to some embodiments, the position command includes a command to move the sensor unit to the vertical position at a specified speed. The method may include limiting the speed of the sensor unit based on the feedback period of the feedback data.

[0009] According to some embodiments, the method includes stopping rotation of the winch drum if the winch drum has reached or exceeded a maximum number of revolutions setting of the intelligent winch. The method may include reversing rotation of the winch drum to rewind the cable if the winch drum has exceeded the maximum number of revolutions setting.

[0010] The rotating step may be carried out by monitoring the number of revolutions of the drum.

[0011] According to some embodiments, the method includes: continuously monitoring a tension of the cable; and stopping rotation of the winch drum if the winch drum is rotating or preventing the winch drum from rotating if the winch drum is stopped if the tension of the cable exceeds a predetermined upper limit and/or falls below a predetermined lower limit.

[0012] The method may include: continuously monitoring a temperature of the motor and/or a motor controller that controls the motor; and stopping the motor if the temperature of the motor and/or the motor controller exceeds a predetermined upper limit. The method may include: continuously monitoring a current draw of the motor and/or a motor controller that controls the motor; and stopping the motor if the current draw of the motor and/or the motor controller exceeds a predetermined upper limit.

[0013] Some other embodiments of the invention are directed to an intelligent winch. The intelligent winch includes a frame, a winch drum on the frame, a cable wrapped around the winch drum, a sensor unit connected to an end of the cable, with the sensor unit including one or more water property sensors, a winch motor on the frame and configured to rotate the winch drum and at least one controller. The controller is configured to: (a) receive a position

command from a client site using a connection associated with the controller; (b) direct the motor to rotate the winch drum to unwind and/or wind the cable to thereby lower and/or raise the sensor unit to a vertical position in the body of water having a surface in response to the position command; and (c) repeat operations (a) and (b) a plurality of times to position the sensor unit at a plurality of different vertical positions. The sensor unit is configured to: (a) collect data associated with one or more water properties at each of the plurality of different vertical positions; and (b) transmit the data associated with the one or more water properties at each of the plurality of different vertical positions to the client site so that a vertical profile of the one or more water properties at the plurality of different vertical positions is generated at the client site.

[0014] According to some embodiments, the sensor unit includes a water depth sensor. The sensor unit may be configured to continuously collect depth data of the sensor unit below the surface of water and transmit the depth data to the controller. The controller may be configured to continuously receive position feedback data based on the depth data from the sensor unit indicating the vertical position of the sensor unit in the body of water. The controller may be configured carry out operation (b) using the position feedback data.

[0015] The controller may be configured to stop rotation of the winch drum if the winch drum is rotating or prevent the winch drum from rotating if the winch drum is stopped if the position feedback data is not received for a predetermined period of time.

[0016] The controller may be configured to stop rotation of the winch drum if the position feedback data indicates that the sensor unit is moving in a different direction in the body of water than specified by the position command.

[0017] The controller may be configured to stop rotation of the winch drum if the position feedback data indicates that the sensor unit is not moving in the body of water.

[0018] According to some embodiments, the position command includes a command to move the sensor unit to the vertical position at a specified speed. The controller may be configured to limit the speed of the sensor unit based on the feedback period of the feedback data.

[0019] According to some embodiments, the controller is configured to stop rotation of the winch drum if the winch drum has reached or exceeded a maximum number of revolutions setting of the intelligent winch. The controller may be configured to reverse rotation of the winch drum to rewind the cable if the winch drum has exceeded the maximum number of revolutions setting.

[0020] According to some embodiments, the controller is configured to monitor the number of revolutions of the drum to move the sensor unit to the vertical position.

[0021] According to some embodiments, the controller is configured to: continuously monitor a tension of the cable; and stop rotation of the winch drum if the winch drum is rotating or prevent the winch drum from rotating if the winch drum is stopped if the tension of the cable exceeds a predetermined upper limit and/or falls below a predetermined lower limit.

[0022] The controller may be configured to: continuously monitor a temperature of the motor and/or a motor controller that controls the motor; and stop the motor if the temperature of the motor and/or the motor controller exceeds a predetermined upper limit. The controller may be configured to: continuously monitor a current draw of the motor and/or a motor controller that controls the motor; and stop the motor if the current draw of the motor and/or the motor controller exceeds a predetermined upper limit.

[0023] Further features, advantages and details of the present invention will be appreciated by those of ordinary skill in the art from a reading of the figures and the detailed description of the preferred embodiments that follow, such description being merely illustrative of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] **Figure 1** is a side perspective view of an intelligent winch system according to some embodiments of the present invention.

[0025] **Figure 2** is an opposite side perspective view of the intelligent winch system of **Figure 1**.

[0026] **Figures 3 and 4** are block diagrams that schematically illustrate the interrelationship of components of the intelligent winch system of **Figure 1**.

[0027] **Figure 5** is a flowchart illustrating operations according to some embodiments of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0028] The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which illustrative embodiments of the invention are shown. In the drawings, the relative sizes of regions or features may be exaggerated for clarity. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are

provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

[0029] It will be understood that when an element is referred to as being "coupled" or "connected" to another element, it can be directly coupled or connected to the other element or intervening elements may also be present. In contrast, when an element is referred to as being "directly coupled" or "directly connected" to another element, there are no intervening elements present. Like numbers refer to like elements throughout. As used herein the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0030] In addition, spatially relative terms, such as "under", "below", "lower", "over", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0031] Well-known functions or constructions may not be described in detail for brevity and/or clarity.

[0032] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "includes," "comprising," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0033] It is noted that any one or more aspects or features described with respect to one embodiment may be incorporated in a different embodiment although not specifically described relative thereto. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination. Applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to be able to amend any originally filed claim to depend from and/or incorporate any feature of any other

claim although not originally claimed in that manner. These and other objects and/or aspects of the present invention are explained in detail in the specification set forth below.

[0034] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0035] Some embodiments of the present invention are directed to an intelligent winch that can be used to precisely position sensors and to continuously pass along their real-time data stream. Designed to be a component of a complete vertical profiling system, the winch will provide an interface to its internal computer that will accept commands instructing the system to move the instrument to a particular position and at a particular speed. In some embodiments, position can be specified by number of winch drum revolutions from a known home position (in very small increments). In some other embodiments, external position feedback is provided to the system (for example depth in water from an external transducer), and position can be specified in the units of the external feedback. In addition, the system can be protected from malfunction by monitoring the cable tension via additional optional inputs.

[0036] An intelligent winch system **10** according to some embodiments is illustrated in **Figures 1 and 2**. The system **10** includes a winch drum **12** whose diameter, length, and side flange height may be determined by the turning radius and amount of electrical/lifting cable to be spooled. The drum **12** is mounted on a frame **14** via bearings and a hollow axle **16** that can be turned by an electric motor **18** from one side and has a slip ring **20** installed on the other. The motor **18** is sized for the expected load and geared for the desired maximum rotational speed. In some embodiments, the motor **18** has an integral position encoder. In some other embodiments, a position encoder is fixed to another rotating component. A weather-tight box **22** mounted to the frame houses a computer and motor controller, as well as connectors for the cable/slip ring contacts, an Ethernet connector for the internal computer interface and digital I/O ports for the high/low tension limit inputs and manual up/down controls.

[0037] **Figure 3** is a simplified block diagram illustrating the system **10**. The system **10** is configured to operate the drum **12** to wind and unwind cable **30** to thereby lower and raise a sensor unit **32** positioned at or near the end of the cable **30** at a desired speed. Here,

speed may refer to rotational speed of the winch drum **12**. The sensor unit **32** may include one or more sensors configured to sense one or more properties of water such as temperature, salinity, turbidity, pH oxygen and chlorophyll content. In some embodiments, the sensor unit **32** may also include a depth sensor (e.g., a transducer).

[0038] The electrical/lifting cable **30** may be specified considering the expected mechanical load as well as the number and gauge of conductors that will be required to provide power and communications to the attached instrumentation (i.e., the sensor unit **32**).

[0039] In operation, the sensor unit **32** can be lowered or raised via the winch drum **12** to a plurality of incrementally increasing or decreasing depths in a water column. In certain embodiments, at each of the plurality of measurement depths in the water column, the winch drum **12** may pause and the sensor unit **32** may obtain the reading(s), at which point the sensor unit **32** is lowered or raised to the next desired measurement depth. In other embodiments, the property or properties may be continuously or dynamically measured as the sensor unit **32** descends or ascends.

[0040] The movement of the sensor unit **32** may be carried out by commands issued by a primary controller **34** and/or a motor controller **36**. The commands (e.g., lower, raise, speed, pause, and the like) may be programmably set at or prior to installation of the system and/or adjusted during operation. Additionally or alternatively, the position commands may be issued by a remote client site **76** (**Figure 3**) that is described in more detail below.

[0041] Therefore, a software interface provides a relatively simple command set to control winch movement. In the absence of optional position feedback, commands can be for up and down by a number of winch revolutions at a specified speed. As described in more detail below, with external position feedback, additional commands become available to move to a specific position or to move a specific distance. Commands are also available to provide a motor current limit and to stop the system. The system may provide feedback about position, moving speed (or stopped), motor current draw, and fault conditions including over-current, over-temperature, and high and low limit inputs.

[0042] Referring now to **Figure 4**, the primary controller **34** has a connection **38** (e.g., Ethernet connection, serial connection, USB connection, etc.) and is configured to receive and send data through a plurality of ports. An output port **40** provides output data. The output data may be provided as lines of data that are provided continuously by the controller **34** and/or the sensor unit **32**. The output data may include position data which may be based on revolutions of the winch drum **12**. The output data may include velocity data (e.g., with negative values indicating moving up and positive values indicating moving down). The

output data may include the current of the motor **18**. The output data may include an indication of whether the current of the motor **18** has exceeded a current threshold value and/or whether the temperature of the motor **18** has exceeded a temperature threshold value. The controller **34** may direct the motor controller **36** to stop the motor **18** if the motor current and/or temperature exceeds the threshold value.

[0043] The output data may also include measurements by the sensor unit **32**. The measurement data may be communicated from the sensor unit **32** through the cable **30** to the primary controller **34**, for example.

[0044] In some embodiments, the output data includes an indication of whether a no-raise or no-lower digital input has been applied. The no-raise and no-lower digital inputs will be described in more detail below.

[0045] A command port **42** receives and processes commands provided to the system and issues responses to the commands. For example, the command port **42** may receive commands that may be processed and/or forwarded to the primary controller **34** which in turn directs the motor controller **36** to change the direction, position and/or speed of ascent or descent of sensor unit **32**. The command port **42** may also provide readable information such as reason(s) that the motor **18** has stopped. The readable information may be displayed by an on-board display (e.g., a display on the frame **14**, **Figure 1**) or on a display associated with a device that is in communication with the command port **42**.

[0046] Where used, a position feedback port **44** receives position feedback data (e.g., a stream of instrument depth values from the sensor unit **32**) to facilitate additional motor commands. In this regard, movements of the winch can be specified in the units of position rather than in drum revolutions. This may allow for better positioning of the payload because the effective diameter of the drum changes as the cable is unwound or re-wound. This may also allow for better positioning of the payload because water current can cause the payload to hang at an angle other than exactly vertical.

[0047] The system reads from the position feedback port **44**. For example, the system may read from the position feedback port **44** one line at a time and expects one number per line. Commands such as "move to position," "up distance," and "down distance" use the position values on the position feedback port **44** to determine when to stop the movement. To ensure accuracy, the position feedback should be recent. If the age of the feedback exceeds a threshold period of time (e.g., 3 seconds), the movement will not start or if moving the movement will stop.

[0048] Position feedback also allows for additional safety checks to be made regarding the movement of the payload. For example, if the movement specifies that the payload should be moving down (or up) and position values are not increasing (or decreasing) within a threshold period of time (e.g., 3 seconds), the movement will be stopped. This helps to prevent problems such as when the payload is stuck on something or when the cable is winding on the spool in the wrong direction. If the movement is stopped prematurely, a line containing the reason can be sent to the command port 42.

[0049] In some embodiments, the system 10 communicates (e.g., wirelessly communicates) with a remote client site 76. The system 10 may send data from the sensor unit 32 directly to the client site 76 (e.g., without being intercepted by the system) where the data may be processed. If the client wants to provide the system 10 with, for example, the position feedback, the client may return that information to the system 10. In some other embodiments, and as generally described above, the system 10 may intercept the data stream so that the system may use the position feedback for movement of the payload.

[0050] The system may include a user interface device positioned on the frame 14 (Figure 1). Alternatively, the user interface device may be remotely located such as at the client site 76. The user interface device may include manual up and down buttons 50, 52 which, upon actuation, move the winch overriding any other move currently in progress. The release of either button will stop the move. The user interface may also include an emergency stop button 54 to stop the system.

[0051] Where used, no-raise and no-lower inputs 60, 62 are digital inputs that when asserted prevent the system from raising or lowering. These inputs will also immediately stop the motor from moving in the indicated direction. The no-raise and no-lower inputs 60, 62 can be connected to upper and/or lower limit switches and/or a high and low cable tension monitoring device, such as a tension monitoring device 72 illustrated in Figure 3. Monitoring cable tension and limits can prevent costly problems associated with cable damage such as striking a submerged snag or the bottom and allowing the cable to go slack and come partially off of the drum.

[0052] Referring again to Figure 3, the system 10 may include one or more sensors 70 associated with the motor 18. The sensor(s) 70 may be configured to monitor a current draw of the motor 18 and/or monitor a temperature of the motor 18. The system 10 may also include the tension monitoring device 72 configured to monitor the tension of the cable 30. The system 10 may further include memory 74 in communication with the controller 34 and/or the controller 36.

[0053] **Figure 5** is a flowchart that illustrates operations that can be carried out by the intelligent winch according to embodiments of the invention. The intelligent winch may be positioned at or adjacent a body of water (e.g., on land, on a platform, on a boat, etc.). A series of position commands is generated at the intelligent winch (Block 102). The series of position commands may be transmitted to the intelligent winch (e.g., wirelessly from the client site 76) and/or stored in the memory 74. A particular position command may include a number of revolutions of the winch drum 12 (which may be a fractional number) and/or the direction of the winch rotation. Where position feedback is used, a particular position command may include a specific position based on the position feedback or a specific distance up or down (e.g., from the previous position). The position command may also include a speed to move to the desired position.

[0054] In response to the position command, the controllers 34 and/or 36 may direct the motor 18 to rotate the winch drum 12 to unwind and/or wind the cable 30 to thereby lower and/or raise the sensor unit 32 to a vertical position in a body of water (Block 104). According to some embodiments, this is carried out by monitoring the winch drum revolutions (Block 106). According to some other embodiments, this is carried out using the position feedback data (Block 108). For example, the controllers 34 and/or 36 may continuously receive position feedback data provided by a water depth sensor of the sensor unit 32 indicating the vertical position of the sensor unit 32 in the body of water.

[0055] According to some embodiments, the system (e.g., the controller 34 and/or the controller 36) monitors for a fault condition (Block 110). The system may control the winch drum 12 and/or the motor 18 if a fault condition is detected (Block 112).

[0056] For example, the system may expect position feedback within a specified period of time. If the position feedback is not received within a predetermined amount of time, for example, 2.5 times the specified period of time, the system may stop rotation of the winch drum 12 (if the winch drum 12 is rotating) or may prevent the winch drum 12 from rotating (if the winch drum 12 is stopped).

[0057] If the position feedback data indicates that the sensor unit 32 is moving in a different direction in the body of water than specified by the position command, the system may stop rotation of the winch drum 12. Also, if the position feedback data indicates that the sensor unit 32 is not moving in the body of water, the system may stop rotation of the winch drum 12. This may help to prevent problems such as when the payload is stuck on an object or when the cable is winding on the winch drum 12 in the wrong direction.

[0058] As noted above, a particular position command may include a speed at which the payload is to move to the vertical position. According to some embodiments, the system limits the speed for moving the sensor unit **32** based on the feedback period of the feedback data. For example, the speed may be limited by the feedback period so that the winch drum **12** cannot turn more than a quarter turn between feedback position updates.

[0059] The system may include a maximum number of revolutions setting. This may be useful to limit the cable payout to approximately the length of cable available or to limit the payload from exceeding a known depth. Along these lines, the system may prevent or stop the rotation of the winch drum **12** if the winch drum has reached or exceeded a maximum number of revolutions setting of the intelligent winch. According to some embodiments, the system is configured to reverse rotation of the winch drum **12** to rewind the cable if the winch drum has exceeded the maximum number of revolutions setting.

[0060] The system may continuously monitor the tension of the cable (e.g., using the cable tension monitoring device **72**). If the tension of the cable exceeds a predetermined upper limit and/or falls below a predetermined lower limit, the system may stop rotation of the winch drum (if the winch drum is rotating) or prevent the winch drum from rotating (if the winch drum is stopped). Monitoring cable tension and limits can prevent costly problems associated with cable damage such as striking a submerged snag or the bottom and/or allowing the cable to go slack and come partially off the drum.

[0061] The motor **18** may also be monitored for fault conditions. For example, the temperature and/or the current draw of the motor **18** and/or the motor controller **36** may be monitored using the sensor(s) **70**. The motor may be stopped if the temperature and/or the current draw of the motor and/or the motor controller exceeds a predetermined upper limit.

[0062] Referring again to **Figure 5**, data associated with one or more water properties is collected at the vertical position using the one or more water property sensors of the sensor unit **32** (Block **114**). The data is then transmitted to the client site **76** (e.g., using the sensor unit **32**) (Block **116**). It is then determined whether the series of position commands is complete (Decision **118**). If the series of position commands is not complete, the system directs the motor **18** to rotate the winch drum **12** to position the sensor unit **32** at another vertical position in response to the next position command (Block **104**). If the series of position commands is complete, a vertical profile of the water property at the plurality of vertical positions at which the water property was measured may be generated at the client site **76** (Block **120**).

[0063] The intelligent winch described above can be a self-contained, computer-controlled component of a larger automation system. The intelligent winch includes a relatively simple computer interface for payload positioning. The device solves the problem of positioning scientific instrumentation vertically to make measurements in profile. Payload position feedback increases accuracy of vertical positioning which can be inaccurate when moving based on drum revolutions due to changing diameter as the cable is wound on the drum one layer after another, or when moving based on cable payout due to currents which may cause the instruments to hang at an angle from vertical. Although the present invention has been described in relation to profiling with water quality instrumentation, additional applications include use in other fluids (in tanks or wells, in the atmosphere) to move and position a payload as part of an automated system.

[0064] The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of this invention have been described, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the claims. The invention is defined by the following claims, with equivalents of the claims to be included therein.

What is claimed is:

1. A method comprising:
 - (a) providing an intelligent winch comprising a motor driven winch drum having a cable wrapped therearound and a sensor unit connected to an end of the cable;
 - (b) receiving a position command from a client site at the intelligent winch;
 - (c) rotating the winch drum using the motor to unwind and/or wind the cable to thereby lower and/or raise the sensor unit to a vertical position in a body of water having a surface in response to the position command;
 - (d) collecting data associated with one or more water properties at the vertical position using one or more water property sensors of the sensor unit and transmitting the data to the client site using the sensor unit; and
 - (e) repeating steps (b) through (d) a plurality of times to generate a vertical profile of the one or more water properties at a plurality of different vertical positions at the client site.
2. The method of claim 1 further comprising:
 - continuously collecting depth data of the sensor unit below the surface of the body of water using a water depth sensor of the sensor unit; and
 - continuously receiving, at the intelligent winch, position feedback data based on the depth data provided by the sensor unit indicating the vertical position of the sensor unit in the body of water,wherein the rotating step is carried out using the position feedback data.
3. The method of claim 2 further comprising stopping rotation of the winch drum if the winch drum is rotating or preventing the winch drum from rotating if the winch drum is stopped if the position feedback data is not received for a predetermined period of time.
4. The method of claim 2 further comprising stopping rotation of the winch drum if the position feedback data indicates that the sensor unit is moving in a different direction in the body of water than specified by the position command.
5. The method of claim 2 further comprising stopping rotation of the winch drum if the position feedback data indicates that the sensor unit is not moving in the body of water.

6. The method of claim 2 wherein the position command comprises a command to move the sensor unit to the vertical position at a specified speed, the method further comprising limiting the speed of the sensor unit based on the feedback period of the feedback data.

7. The method of claim 1 further comprising stopping rotation of the winch drum if the winch drum has reached or exceeded a maximum number of revolutions setting of the intelligent winch.

8. The method of claim 7 further comprising reversing rotation of the winch drum to rewind the cable if the winch drum has exceeded the maximum number of revolutions setting.

9. The method of claim 1 wherein the rotating step is carried out by monitoring the number of revolutions of the drum.

10. The method of claim 1 further comprising:
continuously monitoring a tension of the cable; and
stopping rotation of the winch drum if the winch drum is rotating or preventing the winch drum from rotating if the winch drum is stopped if the tension of the cable exceeds a predetermined upper limit and/or falls below a predetermined lower limit.

11. The method of claim 1 further comprising:
continuously monitoring a temperature of the motor and/or a motor controller that controls the motor; and
stopping the motor if the temperature of the motor and/or the motor controller exceeds a predetermined upper limit.

12. The method of claim 1 further comprising:
continuously monitoring a current draw of the motor and/or a motor controller that controls the motor; and
stopping the motor if the current draw of the motor and/or the motor controller exceeds a predetermined upper limit.

13. An intelligent winch comprising:
- a frame;
 - a winch drum on the frame;
 - a cable wrapped around the winch drum;
 - a sensor unit connected to an end of the cable, the sensor unit comprising one or more water property sensors;
 - a winch motor on the frame and configured to rotate the winch drum; and
 - at least one controller on the frame and configured to:
 - (a) receive a position command from a client site using a connection associated with the controller;
 - (b) direct the motor to rotate the winch drum to unwind and/or wind the cable to thereby lower and/or raise the sensor unit to a vertical position in a body of water having a surface in response to the position command; and
 - (c) repeat operations (a) and (b) a plurality of times to position the sensor unit at a plurality of different vertical positions;
- wherein the sensor unit is configured to:
- (a) collect data associated with one or more water properties using the one or more water property sensors on the sensor unit at each of the plurality of different vertical positions; and
 - (b) transmit the data associated with the one or more water properties at each of the plurality of different vertical positions to the client site so that a vertical profile of the one or more water properties at the plurality of different vertical positions is generated at the client site.

14. The intelligent winch of claim 13 wherein the sensor unit comprises a water depth sensor, wherein the sensor unit is configured to continuously collect depth data of the sensor unit below the surface of the body of water using the water depth sensor and transmit the depth data to the controller, wherein the controller is configured to continuously receive position feedback data based on the depth data from the sensor unit indicating the vertical position of the sensor unit in the body of water, and wherein the controller is configured carry out operation (b) using the position feedback data.

15. The intelligent winch of claim 14 wherein the controller is configured to stop rotation of the winch drum if the winch drum is rotating or prevent the winch drum from

rotating if the winch drum is stopped if the position feedback data is not received for a predetermined period of time.

16. The intelligent winch of claim 14 wherein the controller is configured to stop rotation of the winch drum if the position feedback data indicates that the sensor unit is moving in a different direction in the body of water than specified by the position command.

17. The intelligent winch of claim 14 wherein the controller is configured to stop rotation of the winch drum if the position feedback data indicates that the sensor unit is not moving in the body of water.

18. The intelligent winch of claim 14 wherein the position command comprises a command to move the sensor unit to the vertical position at a specified speed, and wherein the controller is configured to limit the speed of the sensor unit based on the feedback period of the feedback data.

19. The intelligent winch of claim 13 wherein the controller is configured to stop the rotation of the winch drum if the winch drum has reached or exceeded a maximum number of revolutions setting of the intelligent winch.

20. The intelligent winch of claim 19 wherein the controller is configured to reverse rotation of the winch drum to rewind the cable if the winch drum has exceeded the maximum number of revolutions setting.

21. The intelligent winch of claim 13 wherein the controller is configured to monitor the number of revolutions of the drum to move the sensor unit to the vertical position.

22. The intelligent winch of claim 13 wherein the controller is configured to:
continuously monitor a tension of the cable; and
stop rotation of the winch drum if the winch drum is rotating or prevent the winch drum from rotating if the winch drum is stopped if the tension of the cable exceeds a predetermined upper limit and/or falls below a predetermined lower limit.

23. The intelligent winch of claim 13 wherein the controller is configured to:
continuously monitor a temperature of the motor and/or a motor controller that
controls the motor; and
stop the motor if the temperature of the motor and/or the motor controller exceeds a
predetermined upper limit.

24. The intelligent winch of claim 13 wherein the controller is configured to:
continuously monitor a current draw of the motor and/or a motor controller that
controls the motor; and
stop the motor if the current draw of the motor and/or the motor controller exceeds a
predetermined upper limit.

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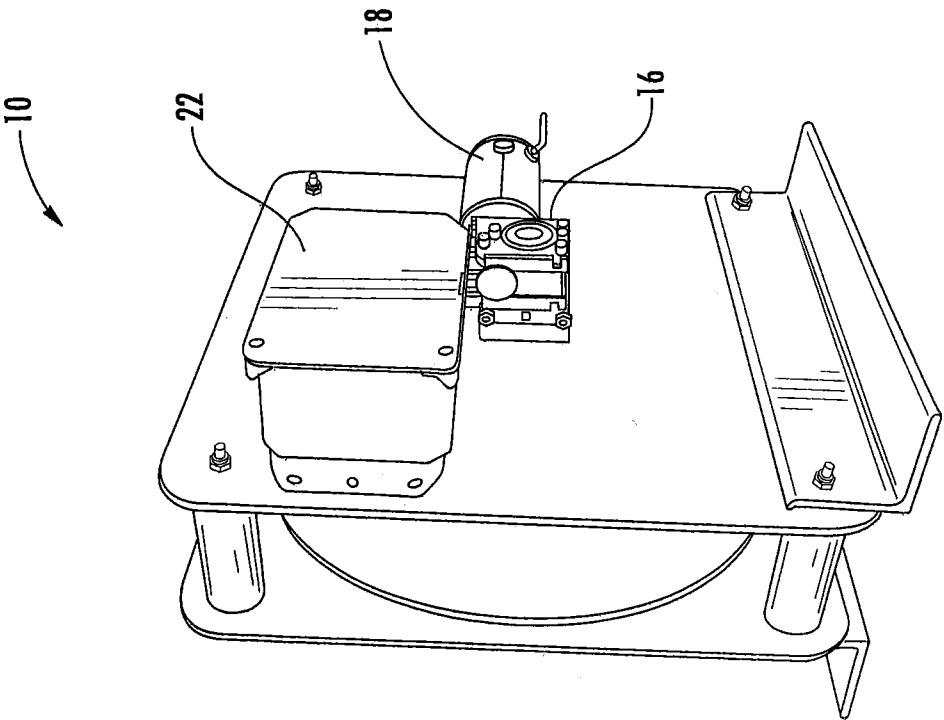


FIG. 2

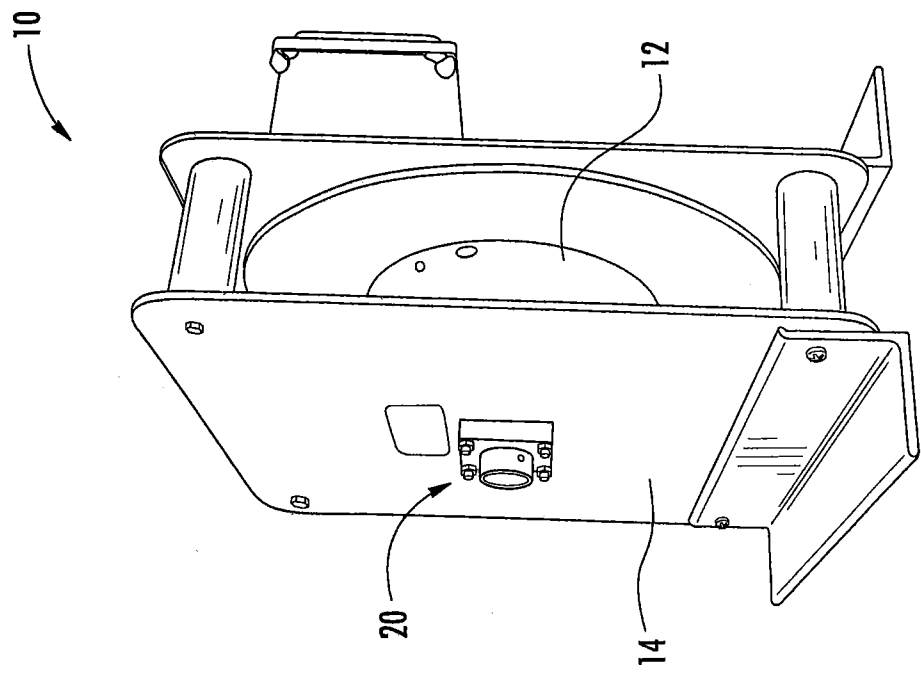


FIG. 1

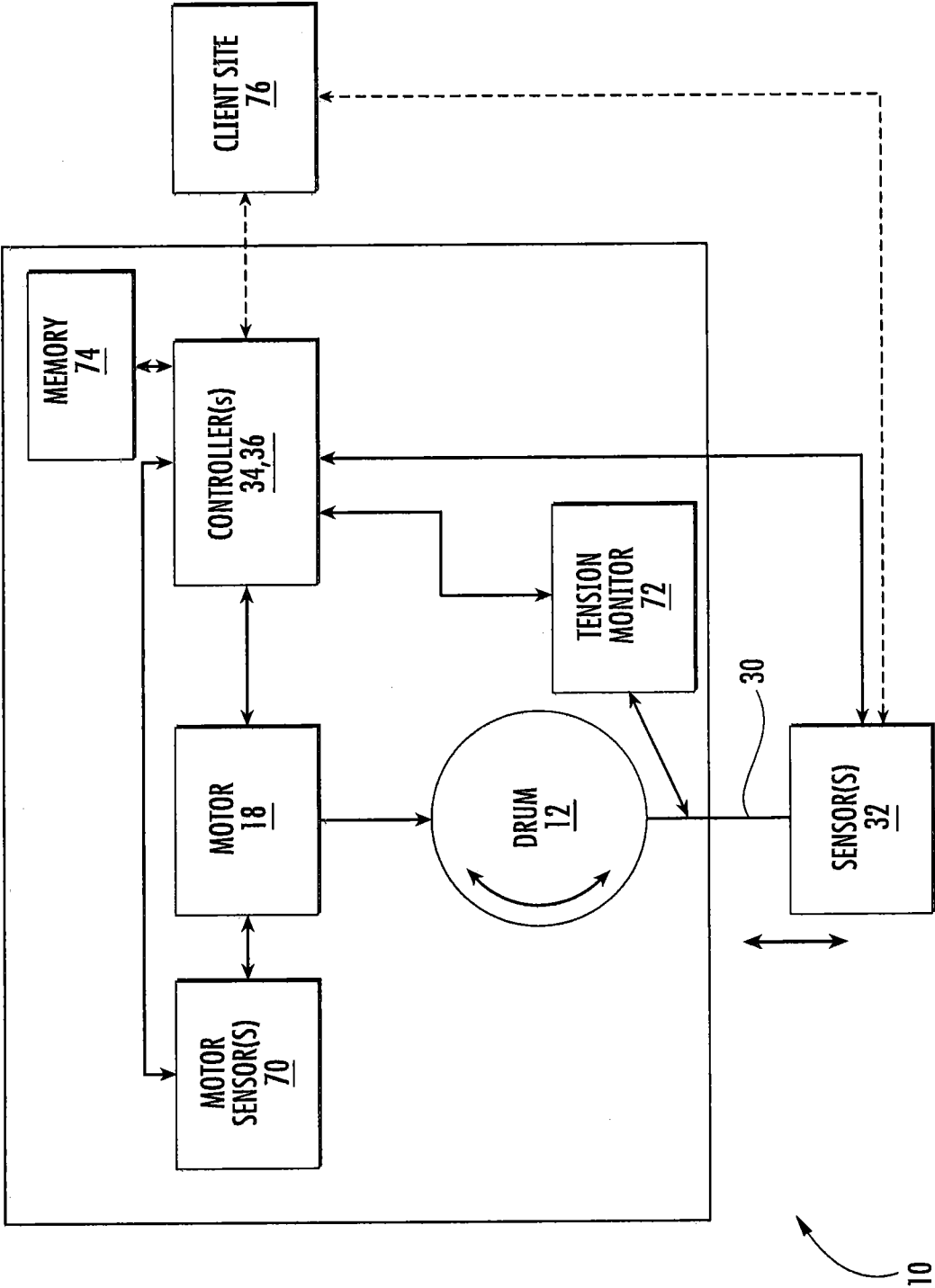


FIG. 3

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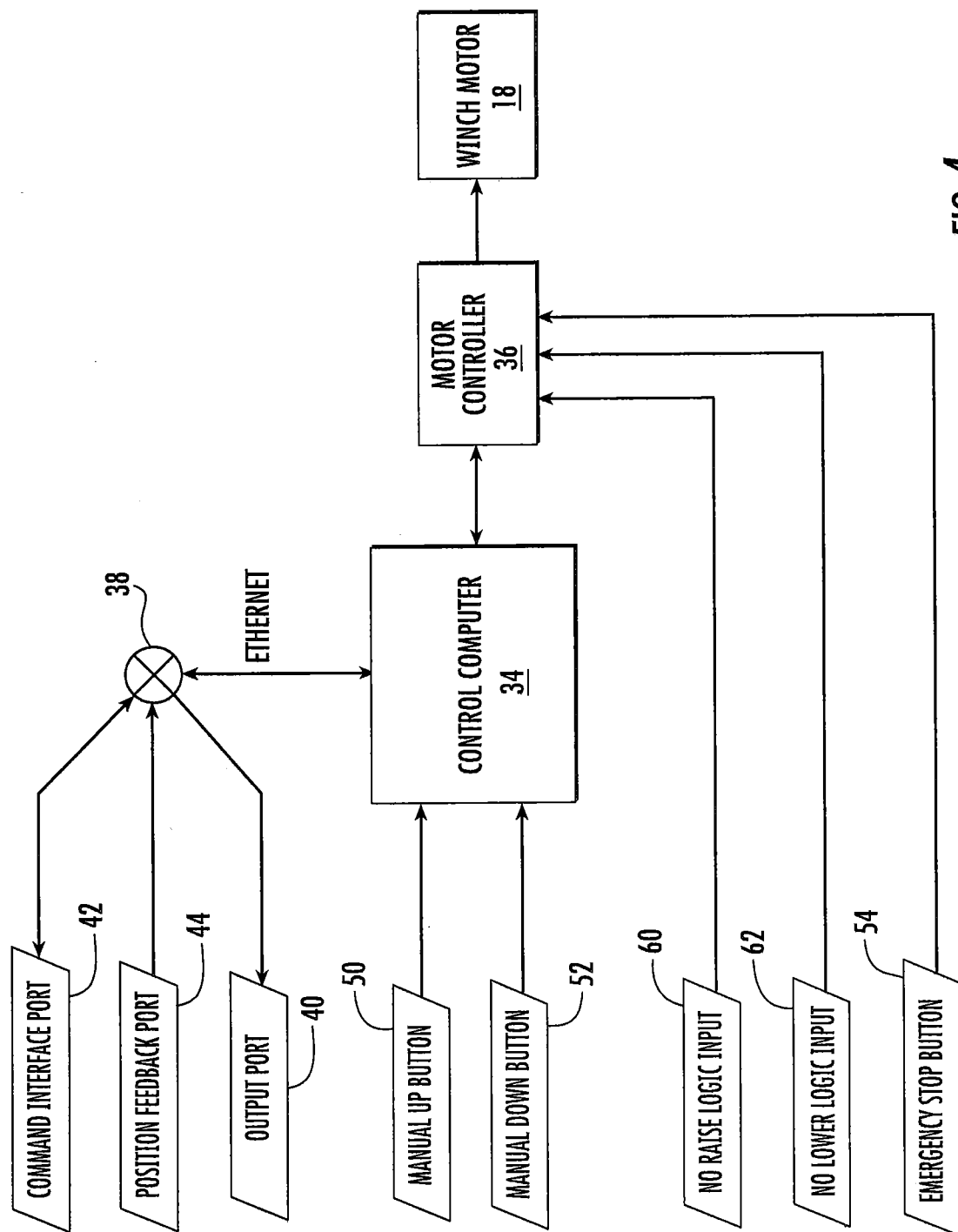


FIG. 4

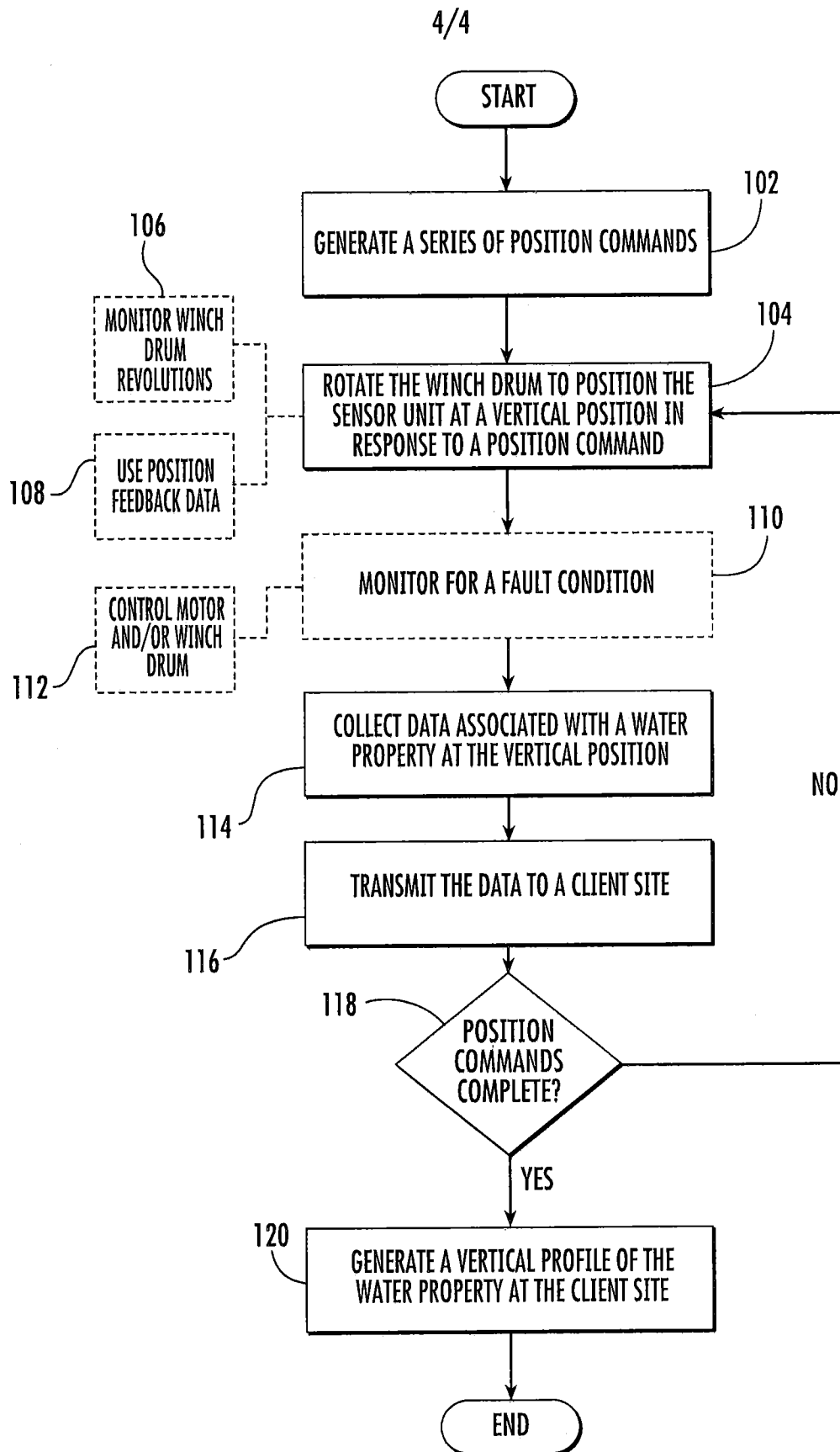


FIG. 5

A. CLASSIFICATION OF SUBJECT MATTER**G01N 33/18(2006.01)i, B66D 1/40(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01N 33/18; E21B 7/00; G01V 1/38; B63B 21/66; G06F 19/00; G01S 19/47; E21B 19/20; G01N 33/487; B66D 1/40

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: intelligent winch system, method, vertical, profile, feedback, motor, controller, sensor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003-0037602 A1 (GLASGOW JR., HOWARD et al.) 27 February 2003 See paragraphs [0014], [0017], [0055], [0062], [0068], [0071], [0075]-[0076]; claims 1, 7-8, 61, 77; and figures 1A, 3-4, 10-11.	1-24
A	US 2012-0050095 A1 (SCHERZINGER, BRUNO et al.) 01 March 2012 See abstract; paragraph [0019]; and claims 2-3.	1-24
A	US 2006-0074525 A1 (CLOSE, ERIC et al.) 06 April 2006 See paragraph [0064]; and claims 3-4, 11, 18, 22.	1-24
A	WO 2013-077905 A2 (CAMERON RIG SOLUTIONS, INC.) 30 May 2013 See claims 1, 3, 13.	1-24
A	US 2014-0104985 A1 (ION GEOPHYSICAL CORPORATION) 17 April 2014 See paragraphs [0081], [0205]; and claims 1, 11, 16, 19.	1-24



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

16 May 2016 (16.05.2016)

Date of mailing of the international search report

16 May 2016 (16.05.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

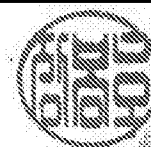
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/019858

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