US 20220082178A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2022/0082178 A1
(43) Pub. Date: Mar. 17, 2022
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(54) **SENSING GATE VALVE POSITION**

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(21) Appl. No.: **17/214,296**

(22) Filed: **Mar. 26, 2021**

Related U.S. Application Data

(63) Continuation-in-part of application No. 17/033,346, filed on Sep. 25, 2020, Continuation-in-part of application No. 17/019,104, filed on Sep. 11, 2020.

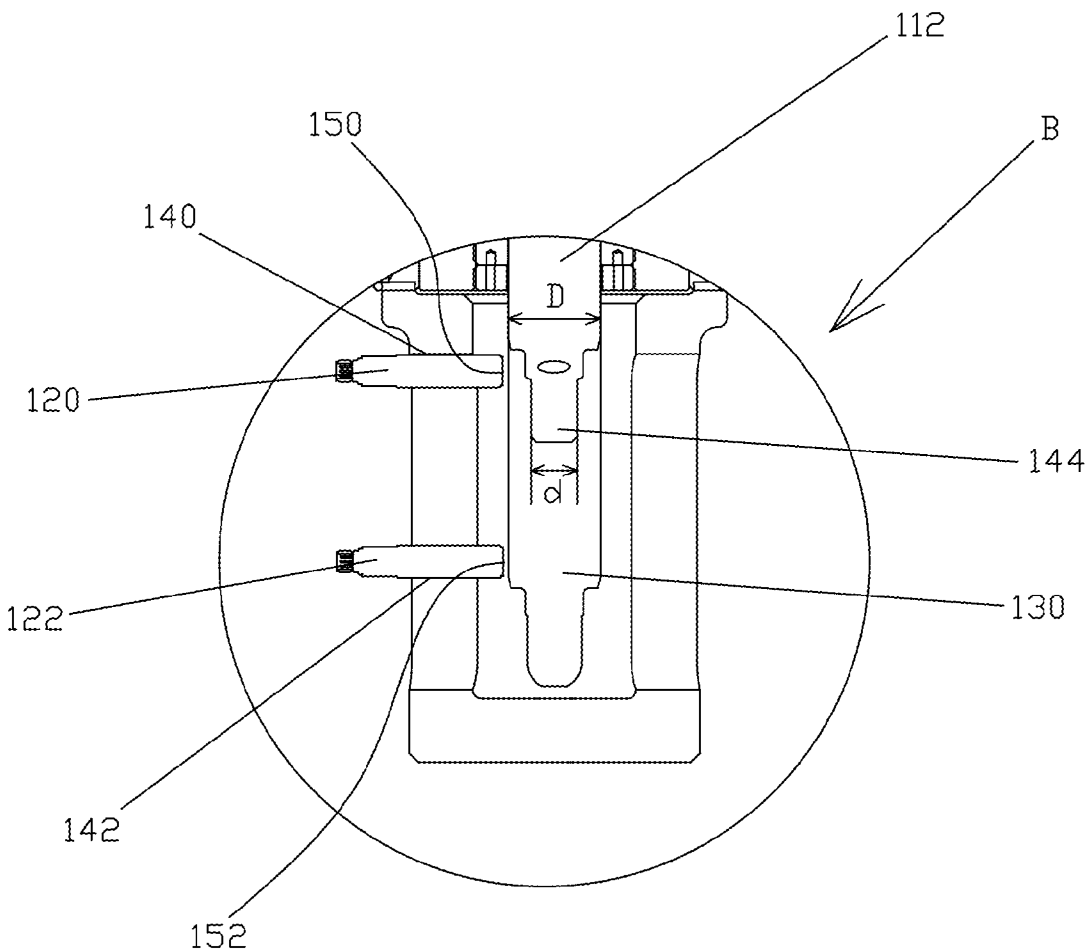
Publication Classification

(51) **Int. Cl.**
F16K 37/00 (2006.01)
E21B 34/16 (2006.01)

(52) **U.S. Cl.**
CPC ***F16K 37/0041*** (2013.01); ***E21B 34/16*** (2013.01)

(57) **ABSTRACT**

A sensor system to indicate whether or not the gate valve is open, closed, or at some position between. In certain instances, two sensors may be used to indicate the position of an attachment to the gate within the gate valve thereby indicating whether or not the gate within the gate valve is fully opened or fully closed. In other instances, a single sensor may be utilized to indicate the position of an attachment to the gate within the gate valve such position being between and including fully opened and fully closed. Generally, a sensor which may include both an emitter and receiver, is affixed externally of the pressurized portion of the gate valve or other type of valves. The sensor system may detect disturbances in a pre-existing field such as a geomagnetic sensor detecting the earth's magnetic field, the sensor may create a field and then detect disturbances within that created field such as a magnetic sensor, or the sensor may send a pulse of energy towards the area to be sensed and then read the reflected energy. Generally, the sensor system includes a logic controller, a memory, a sensor or sensors that may or may not include emitters and receivers, and a display.



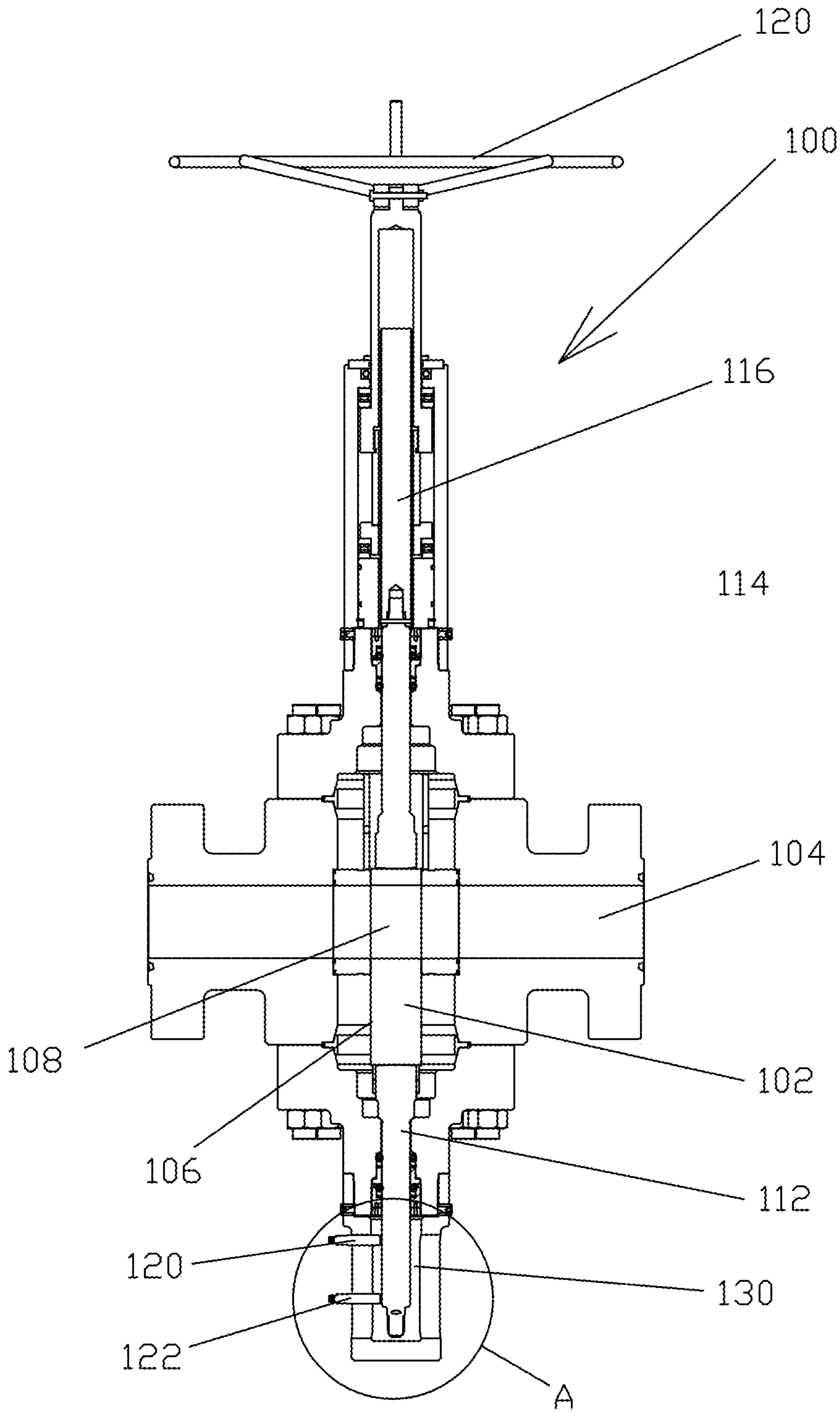


Figure 1

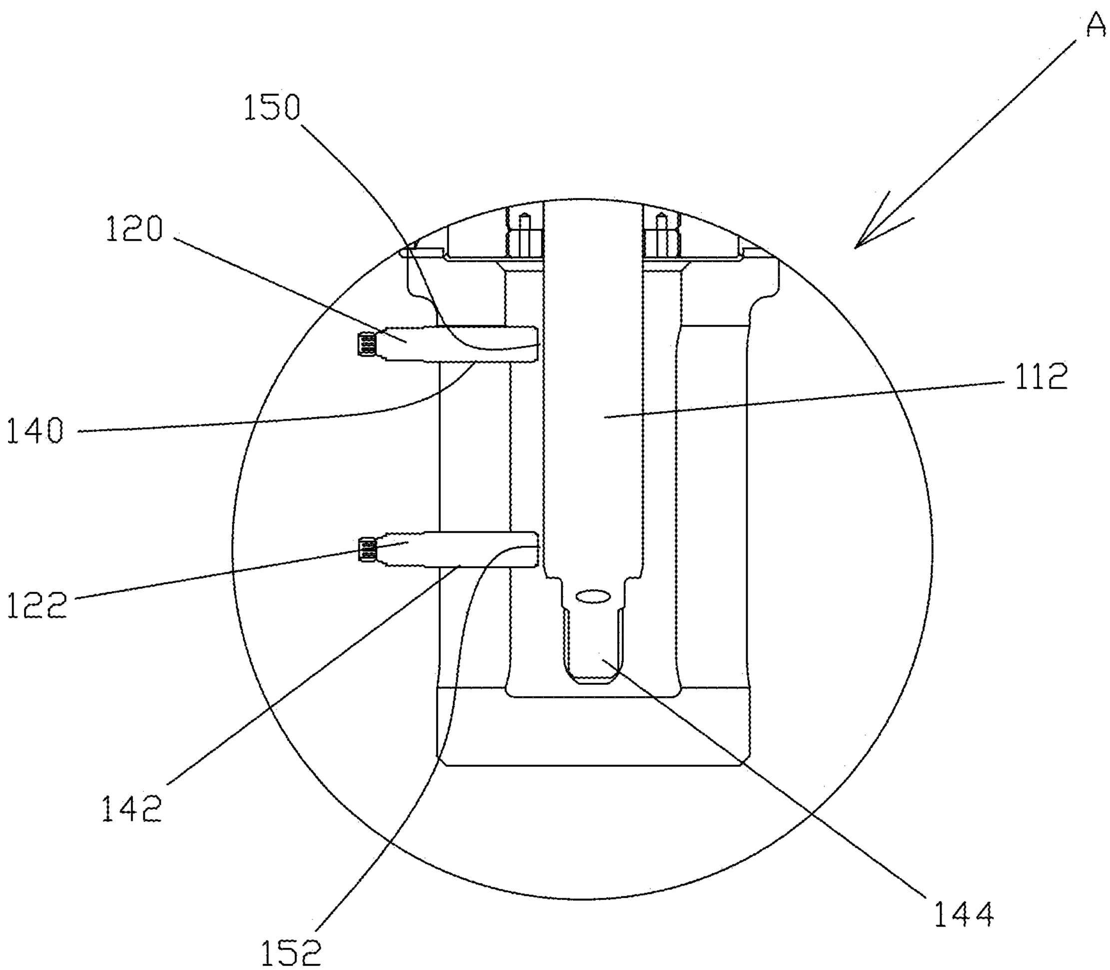


Figure 2

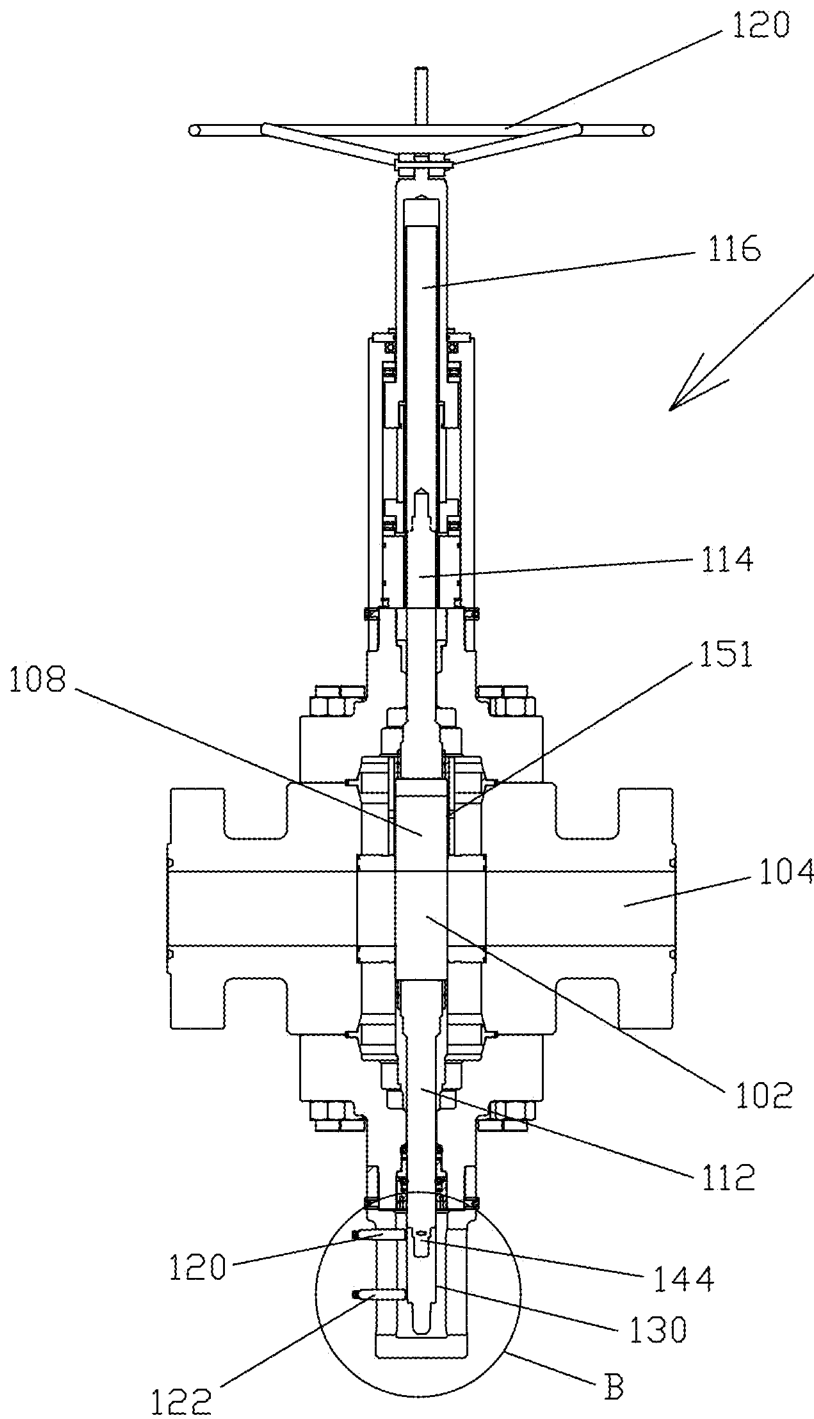


Figure 3

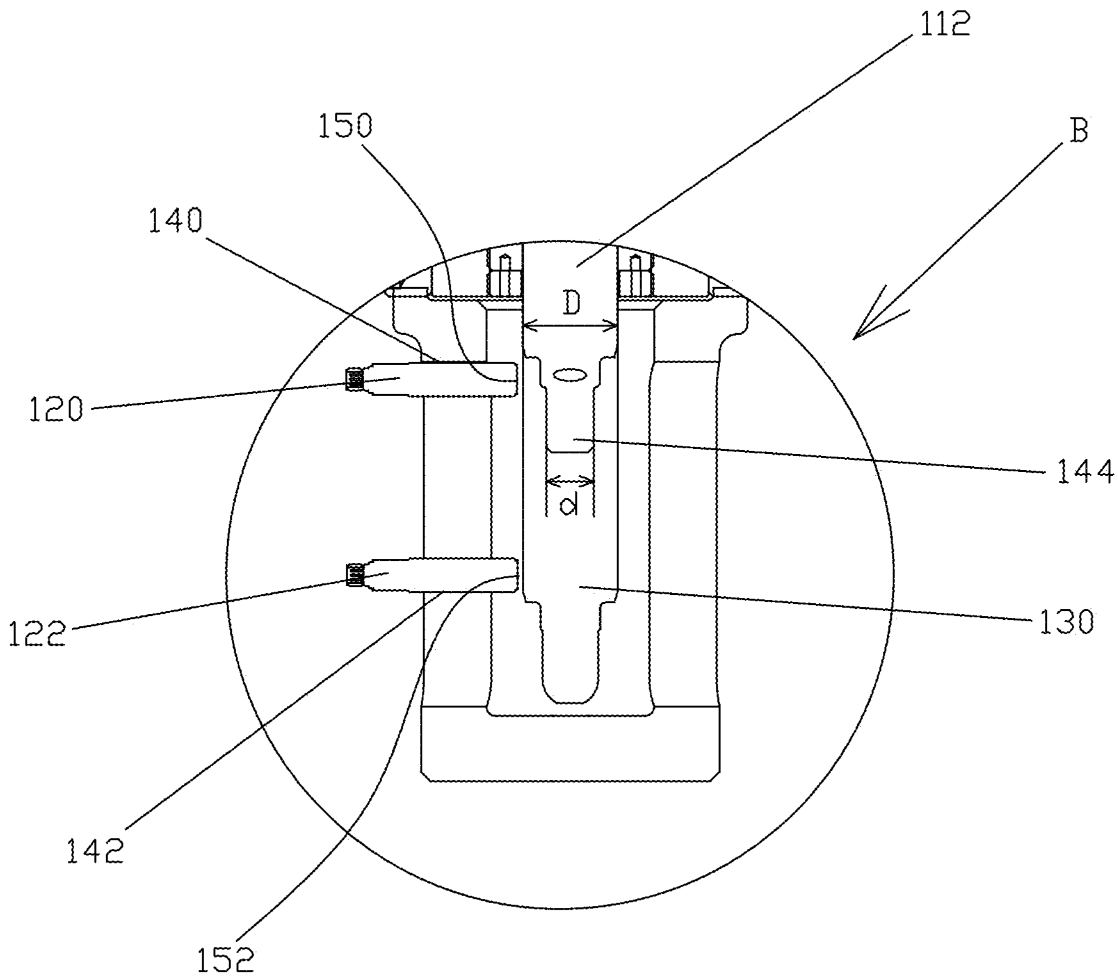


Figure 4

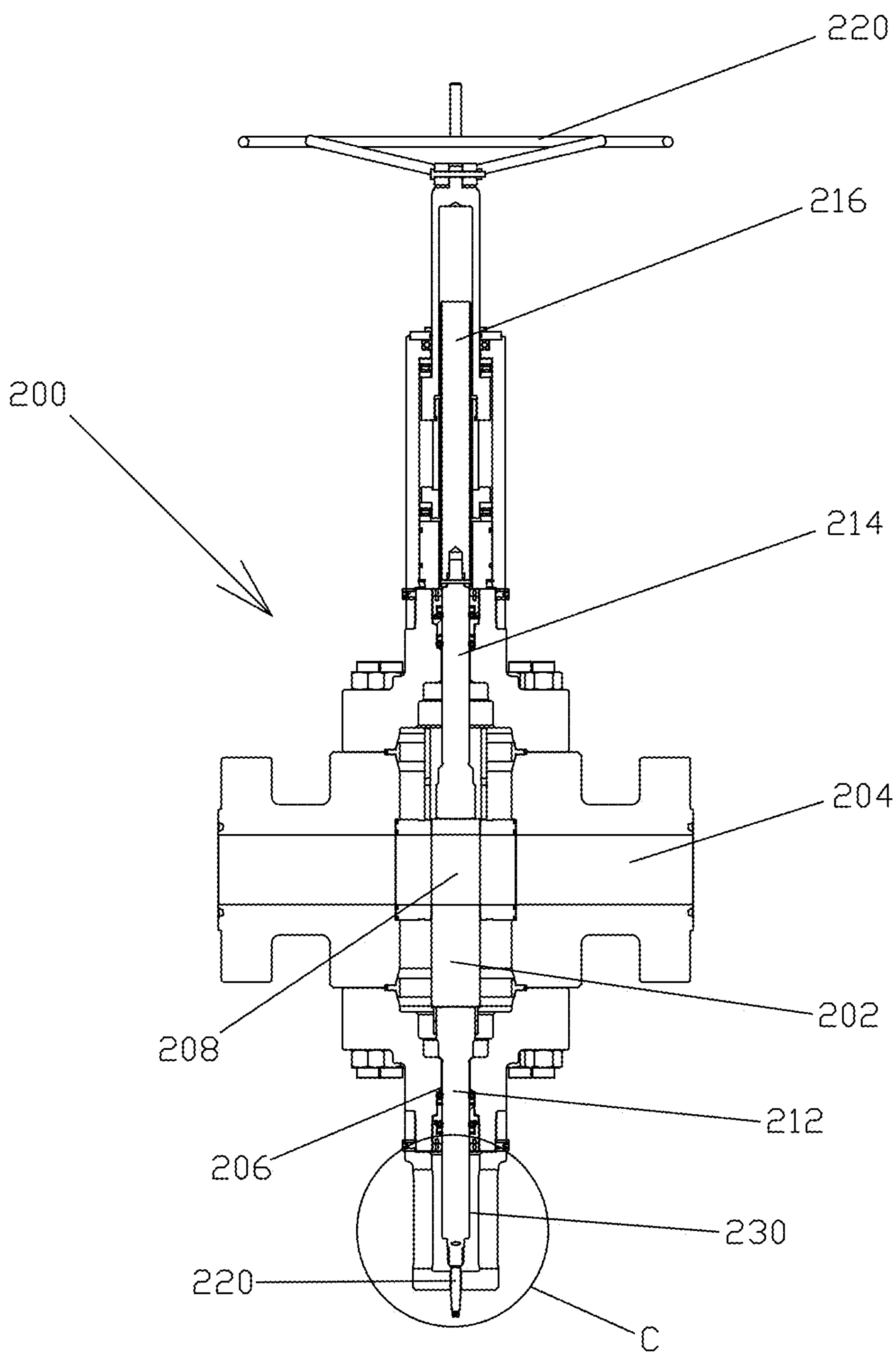


Figure 5

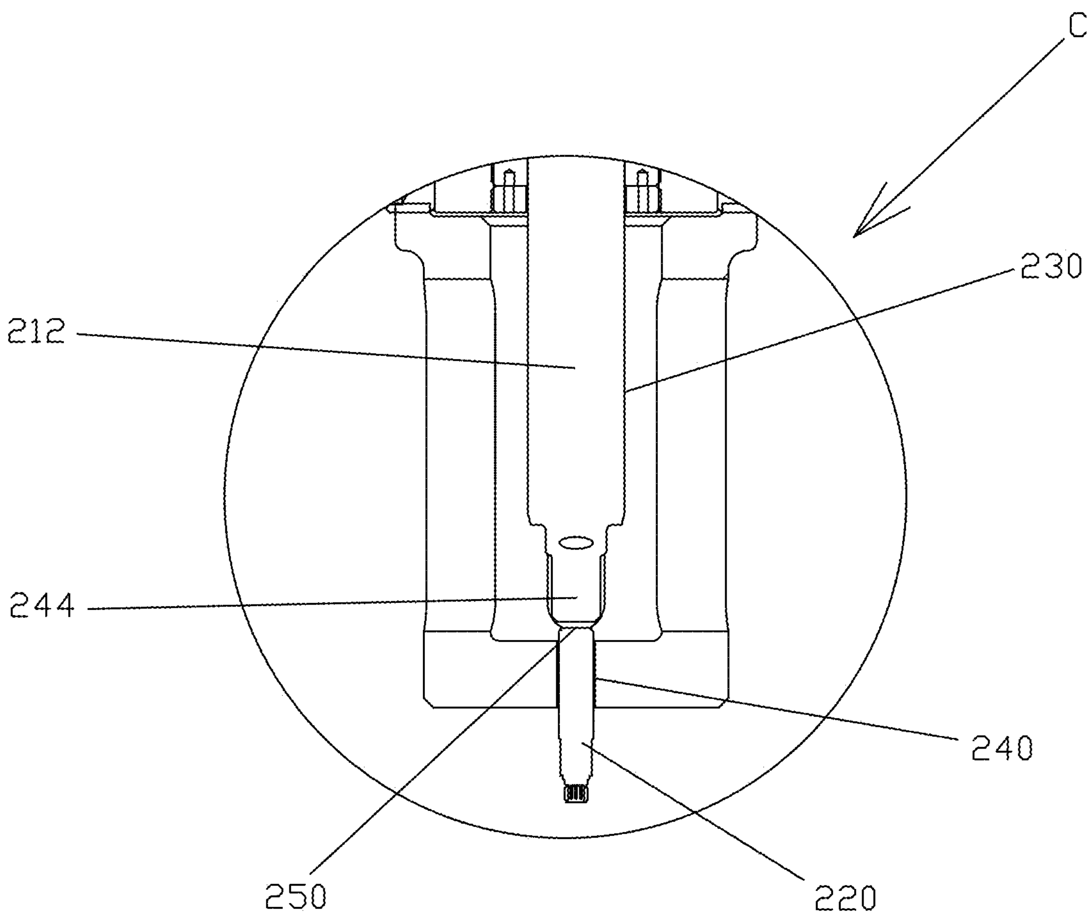


Figure 6

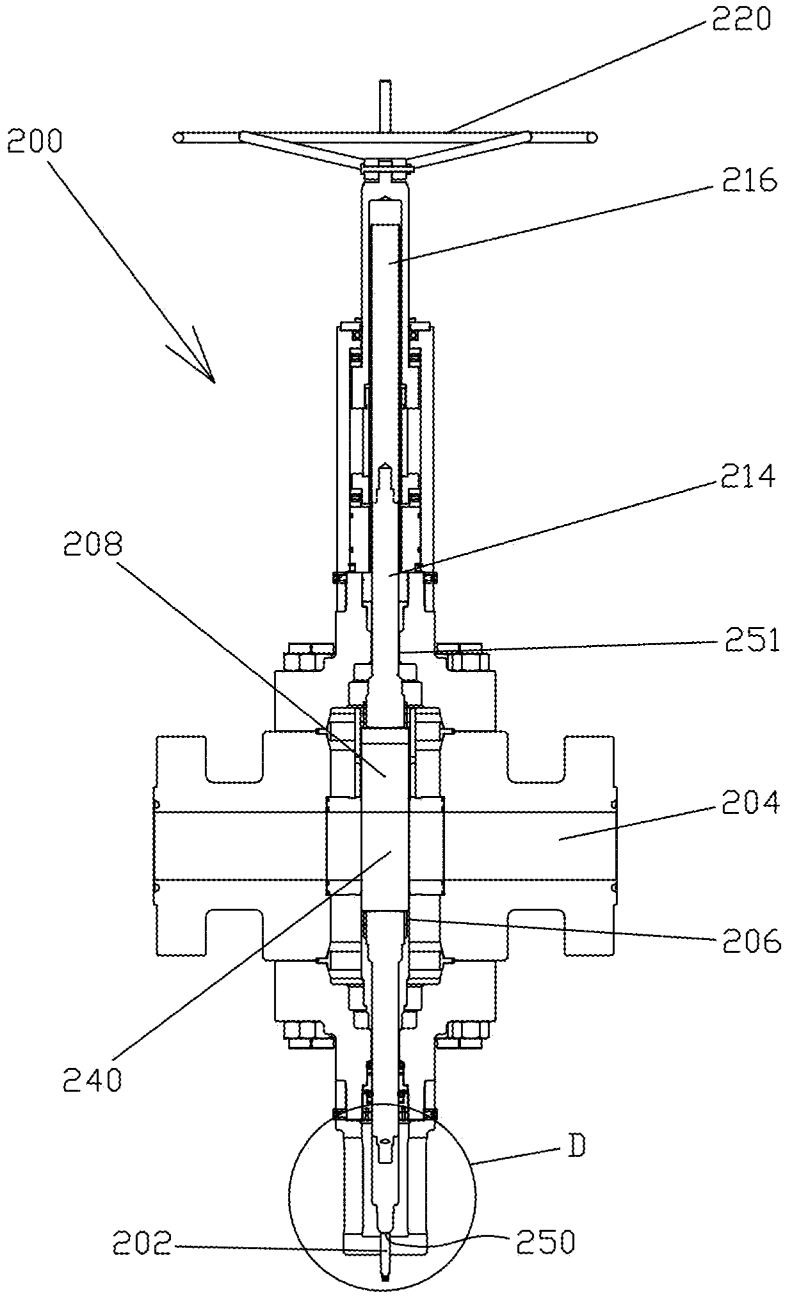


Figure 7

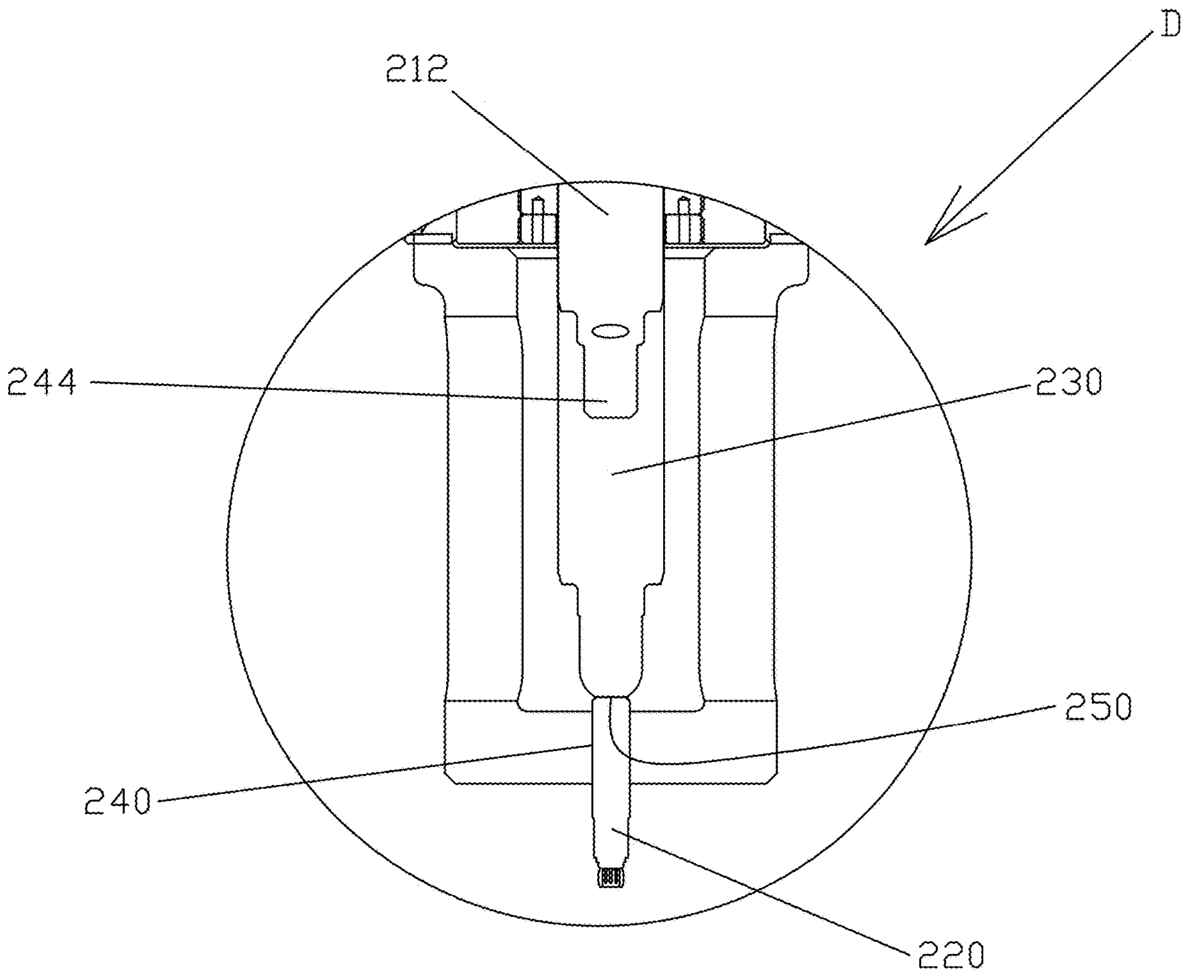


Figure 8

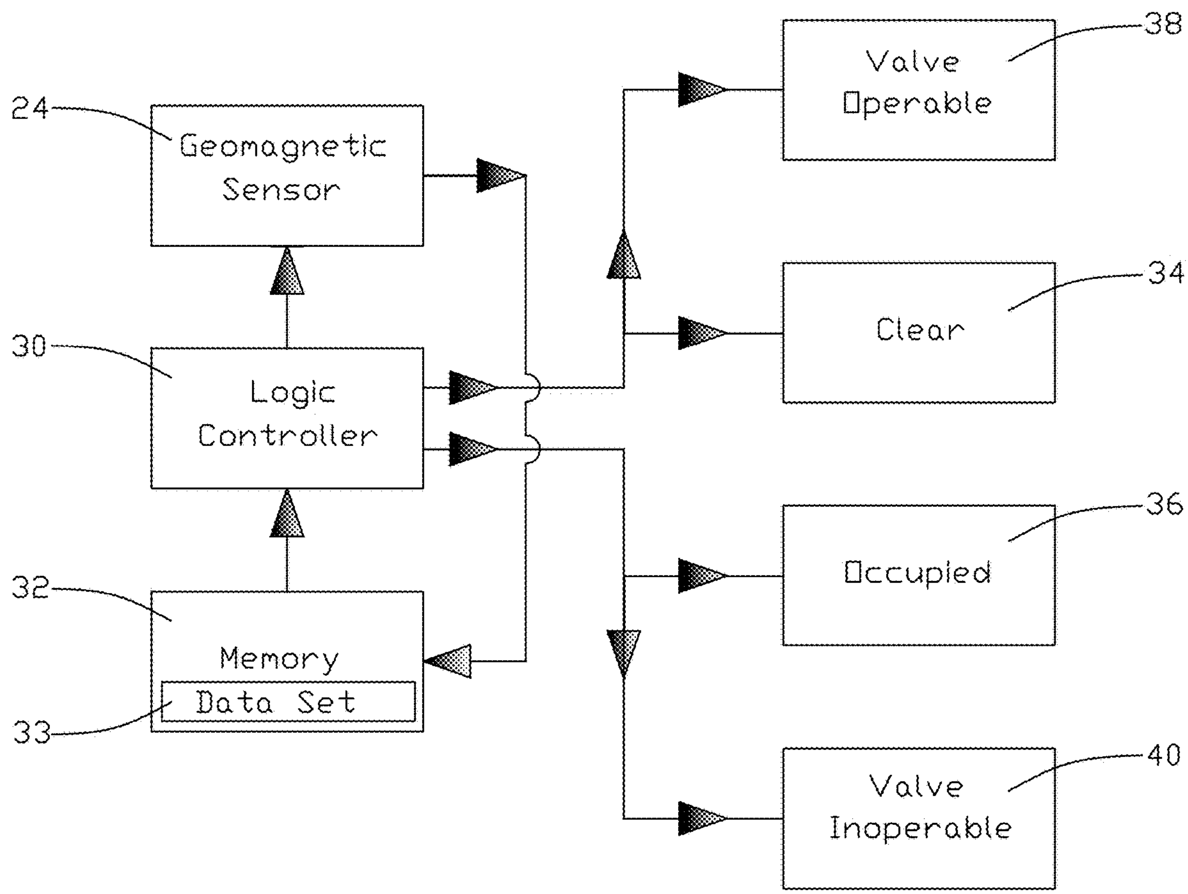

Geomagnetic Sensor
Logic Controller
Memory
Data Set
Valve Operable
Clear
Occupied
Valve Inoperable
24
30
32
33
38
34
36
40

Figure 9

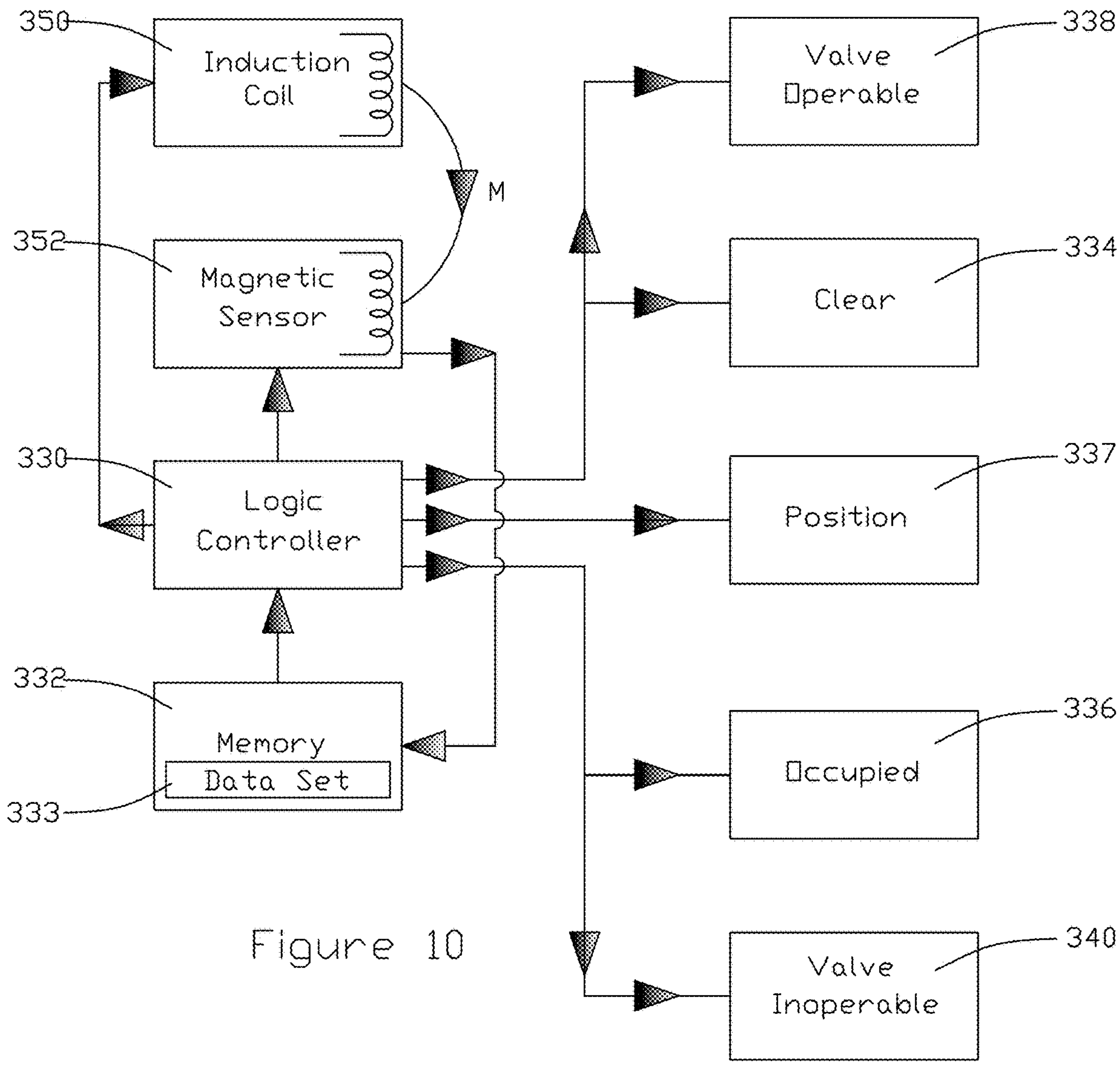

350
Induction Coil
352
Magnetic Sensor
M
330
Logic Controller
332
Memory
Data Set
333
Valve Operable
338
Clear
334
Position
337
Occupied
336
Valve Inoperable
340

Figure 10

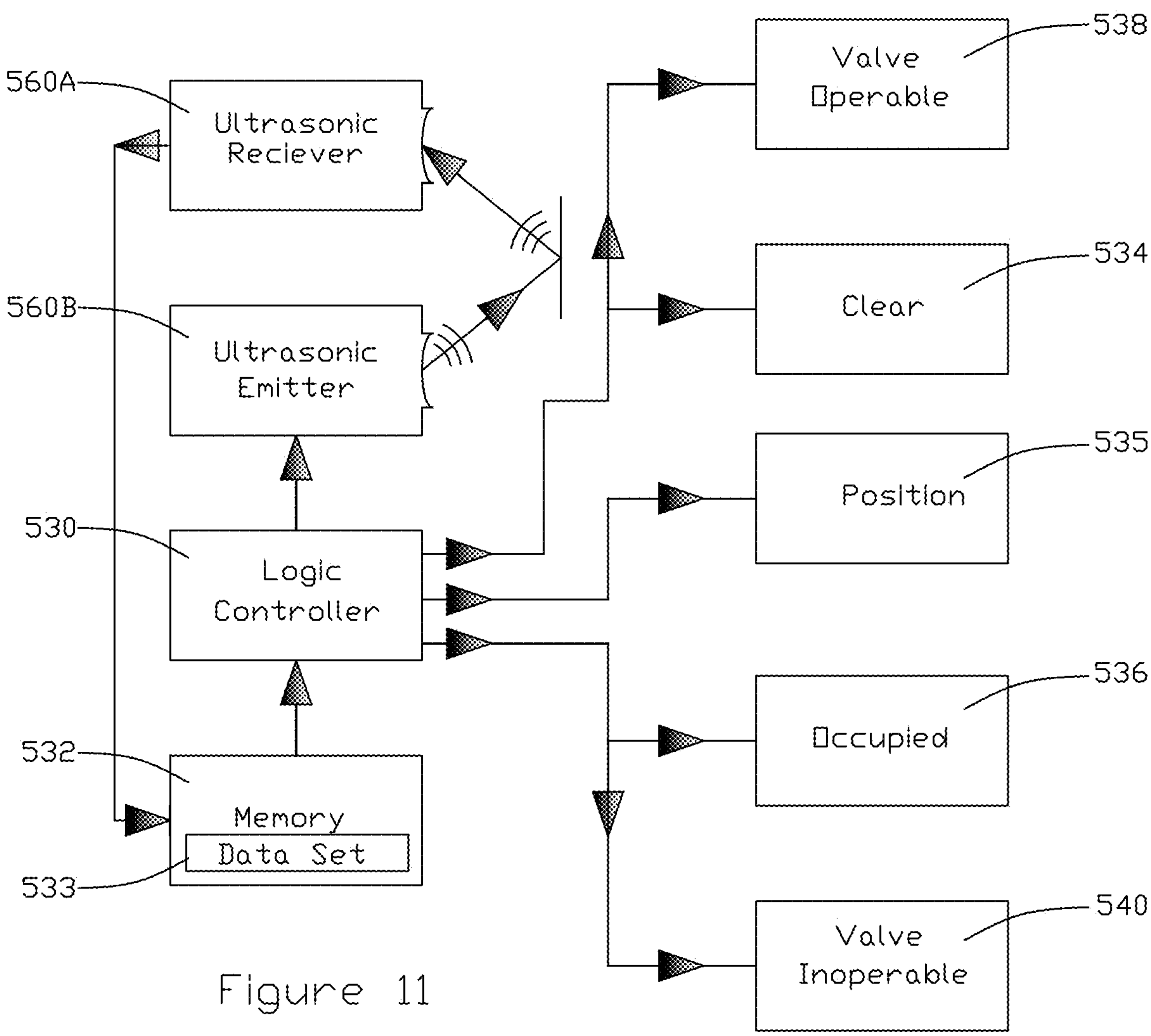

560A
Ultrasonic Reciever
560B
Ultrasonic Emitter
530
Logic Controller
532
Memory
Data Set
533
538
Valve Operable
534
Clear
535
Position
536
Occupied
540
Valve Inoperable

Figure 11

SENSING GATE VALVE POSITION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. patent application Ser. No. 17/033,346 that was filed on Sep. 25, 2020 and U.S. patent application Ser. No. 17/019,104 that was filed on Sep. 11, 2020.

BACKGROUND

[0002] When drilling and completing an oil and gas well one or more downhole formations containing high pressure gas and liquid may be penetrated by the drilling operation. Generally, a blowout preventer or other large bore valves are attached at the surface to the uppermost tubular or casing that is cemented within the wellbore.

[0003] Generally, these valves are gate valves. Each gate valve has a gate between a pair of seats. When the gate transits between an open and closed position a gate stem is utilized to push the gate into or out of position. When a gate is closed, pressurized fluid will push against the gate causing the gate to land on the seat on the opposite side of the pressurized fluid. On the side of the gate towards the fluid there is a gap between the seat and the gate. This gap allows pressurized fluid to flow into the clearance space provided to allow the gate to move between its open and closed positions. The pressurized fluid is generally proppant laden therefore the proppant or other debris moves with the fluid into the clearance space behind the gate. When enough proppant or debris moves into the clearance space behind the gate, the gate is no longer able to move between its open and closed positions as the clearance space provided to allow the gate to move between its open and closed positions is clogged with proppant, well debris, or other solids.

[0004] As the clearance space becomes clogged the gate may initially be able to move partially into the clearance space allowing the gate to move some amount thereby opening or closing the gate valve to some position between fully open or fully closed. While there may be some instances in which an operator desires to only partially open or close a gate valve generally a gate valve that is partially open is problematic. A gate valve that is partially open when the operator expects the valve to be fully open allows the gate to extend into the proppant stream where the abrasive particles erode the gate. An eroded gate may then be placed in the closed position while remaining partially open due to a portion part of the gate being eroded away. A gate valve that is partially open when the operator expects the valve to be fully closed may allow well pressure past the gate valve creating dangerous conditions for anyone approaching the well or near lines that may be subject to the uncontrolled wellbore pressure.

SUMMARY

[0005] In an embodiment of the present invention one or more proximity sensors are placed adjacent to the gate valve to detect the presence or lack of the stem which directly correlates to a position of the gate. Generally, two sensors are utilized to detect the presence of the stem one sensor detects the presence of the stem at certain positions that correlate to the fully open position and while another sensor detects the absence of the stem which correlates to the fully closed position. In certain circumstances multiple sensors may be utilized to detect partial open positions for example as when the valve is 25 percent or 50 percent open. The sensors may be inductive, magnetic, geomagnetic, or ultrasound when no penetrations through the valve case are desired. If a penetration of the valve case is allowed then other sensors may also be used such as a light/infrared based sensor.

[0006] In another embodiment a position sensor or sensors may determine the relatively precise location of the stem and thus the gate within the gate valve. A sensor may be placed at the end of the stem so that the stem moves towards or away from the sensor as the gate moves between its open or closed position. A sensor placed in a position to directly observe the end of the stem is able to provide information as to whether the gate is fully open, fully closed, or any position between and is able to do so in real time. With a sensor able to provide the position of the stem, in this case by measuring the distance from the sensor to a known position on the stem the sensor is then able to provide where the gate is within the gate valves and to determine whether the gate is 0 percent open, 10, percent open, 90 percent open, fully open or other positions. An operator may utilize the position of the gate to determine whether or not the gate is worn beyond safe tolerances such as when the sensor indicates that the gate is closed but there is pressure leakage beyond the gate. Or when the valve is open to limits but the sensor may indicate that the gate is only partially open, for example 77 percent, the clearance space may be packing off with debris preventing the gate from fully opening. A flush may then be performed, preferably prior to the valve failing, to allow the gate to fully retract into the clearance space thereby preventing or minimizing further erosion of the gate by the proppant.

[0007] A position sensor may include a light/laser sensor to measure the distance from the sensor to a position on the stem. Sensors may also include mechanical sensors such as a rod sensor. The sensors may be electrical resistance, capacitance, or induction sensors. The sensor may utilize ultrasound to determine the position of the stem. Magnetic field sensors whether the magnetic field is artificial or geomagnetic or otherwise natural may also be used to determine the location of the stem.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a side cutaway view of a gate valve, with side sensors, in the open position.

[0009] FIG. **2** is a side cutaway view of a portion of the gate valve, with side sensors, in the open position.

[0010] FIG. **3** is a side cutaway view of a gate valve, with side sensors, in the closed position.

[0011] FIG. **4** is a side cutaway view of a portion of the gate valve, with side sensors, in the closed position.

[0012] FIG. **5** is a side cutaway view of a gate valve, with an end sensor, in the open position.

[0013] FIG. **6** is a side cutaway view of a portion of the gate valve, with an end sensor, in the open position.

[0014] FIG. **7** is a side cutaway view of a gate valve, with an end sensor, in the closed position.

[0015] FIG. **8** is a side cutaway view of a portion of the gate valve, with an end sensor, in the closed position.

[0016] FIG. **9** is a block diagram depicting the operation of the geomagnetic sensor, logic controller, memory, and display.

[0017] FIG. **10** is a block diagram depicting the operation of the induction coil, magnetic sensor, logic controller, memory, and display.

[0018] FIG. **11** is a block diagram depicting the operation of an ultrasonic transducer, a logic controller, a memory, and a display.

DETAILED DESCRIPTION

[0019] The description that follows includes exemplary apparatus, methods, techniques, or instruction sequences that embody techniques of the inventive subject matter. However, it is understood that the described embodiments may be practiced without these specific details. When referring to the top of the device or component top is towards the surface of the well. Side is radially offset from a component but minimally longitudinally offset.

[0020] FIG. **1** is a side cutaway view of a gate valve **100**. The gate valve **100** includes gate **102** and central bore **104**. As depicted, the gate **102** is retracted into space **106** within gate valve **100** so that the attached gate throughbore **108** is open, providing fluid access from one side to the other of central bore **104**. A 1^{st} gate stem **112** is affixed to gate **102** while a 2^{nd} gate stem **114** is attached to gate throughbore **108**. Gate stem **114** is attached to rod **116**. Rod **116** is driven radially inward towards central bore **104** by handle **120**. In some instances handle **120** may be replaced by a powered actuating mechanism to drive gate **102** radially inward into or out of the central throughbore **104**. When gate **102** is driven into central throughbore **104** fluid flow from one side to the other of central bore **104** is prevented.

[0021] With the gate **102** in the open position, as indicated, stem **112** is in its lowest position so that sensor **120** is able to detect the stem **112** within the stem bore **130** and sensor **122** is also able to detect stem **112** within the stem bore **130**. When both sensors **120** and **122** detect the stem **112** within the stem bore **130** an indication is sent to the operator that gate throughbore **108** is in the fully open position within central bore **104**.

[0022] FIG. **2** is a close-up of section A from FIG. **1**. The 1^{st} sensor **120** is placed within a bore **140** so that a sensor end **150** is within sensing distance of stem **112**. A 2^{nd} sensor **122** is placed within a bore **142** so that a sensor end **152** is within sensing distance of stem **112**. Stem **112** has a lower end **144**. Sensors **122** and **120** may both detect stem **112**. Each of the 1^{st} or 2^{nd} sensors **120** or **122** may be acoustic, inductive, magnetic, geomagnetic, contact, or light based.

[0023] FIG. **3** depicts gate valve **100** in the closed position. Handle **120** has been actuated to move rod **116**. In turn rod **116** moves 2^{nd} gate stem **114**. Gate stem **114** moves gate throughbore **108** from its open position where fluid is allowed to move past gate throughbore **108** within the central bore **104** to its closed position wherein gate throughbore **108** is moved into space **151** while gate **102** is moved from space **106** into central bore **104** preventing fluid from moving past gate **102** within the central bore **104**. As gate **102** moves into central bore **104** first stem **112** moves with gate **102**. Stem **112** lower end **144** moves within bore **130** as the stem **112** moves within bore **130** sensor **122** no longer detects stem **112** within sensor **122**'s sensing distance. As the stem **112** continues to rise within bore **130** as gate **100** to moves fully into its closed position sensor **120** may, at some point, no longer detect stem **112** within sensor **120**'s sensing distance.

[0024] FIG. **4** is a close-up of section B from FIG. **3**. The 2^{nd} sensor **122** has been adjusted such that the sensitivity of sensor **122** is no longer able to detect the stem **112** within bore **130**. Sensor **120** is generally adjusted such that the sensitivity of sensor **120** is not able to detect stem **112** within bore **130**. However, in some instances the sensitivity of sensor **120** may be adjusted to allow sensor **122** detect the smaller diameter d of the lower end **144** of stem **112** as compared to the larger diameter D of stem **112**. Detecting the various values of diameter of the stem **112** within bore **130** may allow the operator to determine a position of the gate **102** somewhere between fully open and fully closed. Simply detecting the presence or absence of the stem within bore **130** at the locations of bore **140** and bore **142** allows the operator to turn to determine whether or not the gate **102** is fully within central bore **104** or fully retracted within bore **130**.

[0025] FIG. **5** is a side cutaway view of a gate valve **200**. The gate valve **200** includes gate **202** and central bore **204**. As depicted, the gate **202** is retracted into space **206** within gate valve **200** so that the gate throughbore **208**, is in its open position, providing fluid access from one side to the other of central bore **204**. A first gate stem **212** is affixed to gate **202** while a second gate stem **214** is attached to gate throughbore **208**. Gate stem **214** is attached to rod **216**. Rod **216** is driven radially inward towards central bore **204** by handle **220**. In some instances handle **220** may be replaced by a powered actuating mechanism to drive gate **202** radially inward into or out of the central throughbore **204**. When gate **202** is driven into central throughbore **204** fluid flow from one side to the other of central bore **204** is prevented.

[0026] With the gate **202** in the open position, as indicated, stem **212** is in its lowest position so that sensor **220** is able to detect the stem **212** within the stem bore **230**. With sensors **220** detecting the stem **212** within the stem bore **230** an indication is sent to the operator that gate throughbore **208** is in the fully open position within central bore **204**.

[0027] FIG. **6** is a close-up of section C from FIG. **5**. The sensor **220** is placed within a bore **240** so that a sensor end **250** is within sensing distance of stem **212**. Stem **212** has a lower end **244**. Sensor **220** may detect stem **212**. The sensor **220** may be acoustic, inductive, magnetic, geomagnetic, contact, or light based.

[0028] FIG. **7** depicts gate valve **200** in the closed position. Handle **220** has been actuated to move rod **216**. In turn rod **216** moves second gate stem **214**. Gate stem **214** moves gate throughbore **208** from its open position where fluid is allowed to move past gate throughbore **208** within the central bore **204** to its closed position wherein gate throughbore **208** is moved into space **251** while gate **202** is moved from space **206** into central bore **204** preventing fluid from moving past gate **202** within the central bore **204**. As gate **202** moves into central bore **204** first stem **212** moves with gate **202**. Stem **212** lower end **244** moves within bore **230**. As the stem **212** moves within bore **230** sensor **220** detects a diminishing signal return indicating stem **212** has moved away from sensor **220**. Sensor **220** may be calibrated to indicate the stem **221**'s position within bore **230**. The distance of the stem **212** from the sensor **220** may be utilized as an indicator of the gate **102** and the gate throughbore **208**'s position between and including fully open and fully closed.

[0029] FIG. **8** is a close-up of section D from FIG. **7**. The sensor **220** has been adjusted such that the sensitivity of sensor **220** is able to detect the stem **212** within bore **230** from stem **212**'s lowest position within bore **230**, indicating that gate throughbore **208** is in position within gate bore **208** thereby placing the gate valve in the open condition. The sensitivity of sensor **220** is adjusted such that sensor **220** may also detect the stem **212** within bore **230** at stem **212**'s highest position within bore **230**, indicating that gate **202** is in position within gate bore **208** thereby placing the gate valve in the closed condition. Detecting the various values of sensor sensitivity of sensor **220** may allow the operator to determine a position of the gate **202** including and somewhere between fully open and fully closed.

[0030] FIG. **9** is a block diagram depicting the operation of a geomagnetic sensor, logic controller, memory, and display. The geomagnetic sensor **24** may have a memory, a logic controller, and a display. When initiated the logic controller **30** sends a command to the geomagnetic sensor **24** to take an initial geomagnetic field reading. The geomagnetic sensor then takes the initial geomagnetic field reading and sends it to memory **32**. The logic controller **30** will continue, at predetermined intervals, to command the geomagnetic sensor **24** to take secondary geomagnetic field readings and send each secondary geomagnetic field reading to memory **32**. The logic controller **30** will then access from memory **32** the initial geomagnetic field reading and the secondary geomagnetic field reading. If the secondary geomagnetic field reading and the initial geomagnetic field reading are similar or within predetermined bounds then the logic controller will send a 1^{st} message **34** indicating that the gate is open. However, if the secondary geomagnetic field reading and the initial geomagnetic field readings differ or are outside of predetermined bounds then the logic controller **30** will send a 2^{nd} message **36** that the gate is closed or at some position between clear and occupied or open or closed. In certain instances, the memory may contain a data set **33**. The logic controller may then compare the first reading, as well as any additional readings to the data set **33** within the memory to determine whether the gate valve is fully open, fully closed, or in between. Additionally, in some instances the logic controller may also send a signal, such as valves operable **38**, to any powered gate valve actuator allowing the gate valve to be closed or opened. The valve actuator may include the gate, the stem, or any appurtenance that moves in relation to the gate position. Or the logic controller may send a signal, such as valves inoperable **40**. In certain instances, the geomagnetic sensor, the logic controller, the memory, and the display may be a single unit in a single housing and the display may simply be a light on or off, a colored light, a raised flag, or other signal. In other instances, the geomagnetic sensor may be connected by wire or radio to a separate logic controller and memory such as an app on a smart phone, smart pad, or computer. The radio connection is a wireless connection that includes bluetooth, wi-fi, cellular or other radio types. The display may be directly wired to the logic controller or may be connected by radio to the logic controller and may simply be a screen where an icon or other notification may be displayed.

[0031] FIG. **10** is a block diagram depicting the operation of the induction coil, magnetic sensor, logic controller, memory, and display. The induction coil **350** may provide a continuous magnetic field, an intermittent magnetic field, or an on command magnetic field. The magnetic sensor **352** may include a memory **332**, a logic controller **330**, and a display. When initiated the logic controller **330** sends a command, if needed, to the induction coil **350** to create a magnetic field. The logic controller **330** also commands the magnetic sensor **352** to take an initial magnetic field reading. The magnetic sensor **352** takes the initial magnetic field reading and sends it to memory **332**. The logic controller **330** will continue, at predetermined intervals, to command the induction coil **350** to create a magnetic field if necessary and also command the magnetic sensor **352** to take secondary magnetic field readings sending each secondary magnetic field reading to memory **332**. The logic controller **330** will then access from memory **332** the initial magnetic field reading and the secondary magnetic field reading. If the secondary magnetic field reading and the initial magnetic field reading are similar or within predetermined bounds then the logic controller will send a 1^{st} message **334** indicating that the gate is open. However, if the secondary magnetic field reading and the initial magnetic field readings differ or are outside of predetermined bounds then the logic controller **330** may provide a message **336** that the gate is closed and at which position the gate is located **337** up to and including that the gate is fully closed. Additionally, in some instances the logic controller **330** may also send a signal, such as valves operable **338**, that allows the gate valve to be actuated. In certain instances, the magnetic sensor **352**, the logic controller **330**, the memory **332**, and the display may be a single unit. In certain instances, the memory may contain a data set **333**. The logic controller may then compare the first reading, as well as any additional readings to the data set **333** within the memory to determine whether the gate valve is fully open, fully closed, or in between. The display may simply be a light on or off, a colored light, a raised flag, or other signal. In other instances, the geomagnetic sensor may be connected by wire or wireless to a separate logic controller and memory such as an app on a smart phone, smart pad, or computer. The display may simply be a screen where an icon or other notification may be displayed.

[0032] FIG. **11** is a block diagram depicting the operation of either ultrasonic transducer **560** or **570**, a logic controller **530**, a memory **532**, and a display. The ultrasonic transducers **560** or **570** generally have an ultrasonic emitter **560**B and an ultrasonic receiver **560**A in the same housing however in some instances the ultrasonic receiver **560**A may be in a different housing than the ultrasonic emitter **560**B. In some instances the entire each sensor or unit including memory, logic controller, and display may be housed in the same unit. In any event, upon initiation or start the logic controller **530** sends a command, if needed, to the ultrasonic emitter **560**B to send an initial ultrasonic pulse. The ultrasonic receiver **560**A receives the initial ultrasonic pulse reflection or reflections and sends them to memory **532** to be recorded. The logic controller **530** will continue, at predetermined intervals, to command the ultrasonic emitter **560**B to send secondary ultrasonic pulses. The secondary reflections of the secondary ultrasonic pulses are then recorded by ultrasonic receiver **560**A and sent to memory **532**. The logic controller **530** will then access from memory **532** the initial ultrasonic pulse reflection and the secondary ultrasonic pulse reflection. The logic controller will then determine the position **535** of the gate within the throughbore based upon the initial and secondary reflections. In certain instances, the memory may contain a data set **533**. The logic controller may then compare the first reading, as well as any additional readings to the data set **533** within the memory to determine whether the gate valve is fully open, fully closed, or in between

[0033] In certain instances, the magnetic sensor **552**, the logic controller **530**, the memory **532**, and the display may be a single unit. The display may simply be a light on or off, a colored light, a raised flag, or other signal. In other instances, the ultrasonic transducer **560** or **570** may be connected by wire or wireless to a separate logic controller and memory such as an app on a smart phone, smart pad, or computer. The display may simply be a screen where an icon or other notification may be displayed.

[0034] An initial reading of the geomagnetic field, magnetic field, or the ultrasonic pulse may each be taken when the gate is fully open. In certain instances, the initial reading may be taken with the gate fully closed with the second and tertiary readings compared to the gate closed readings. The logic controller will then adjust the display accordingly to show a closed gate when the gate is closed and to show an open gate when the gate is open.

[0035] The nomenclature of leading, trailing, forward, rear, clockwise, counterclockwise, right hand, left hand, upwards, and downwards are meant only to help describe aspects of the tool that interact with other portions of the tool.

[0036] Plural instances may be provided for components, operations or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.

What is claimed is:

1. A gate valve positioning system comprising;

a tubular having a throughbore affixed to a well,

a valve actuator within the tubular;

a sensor, a logic controller, and a memory;

wherein the logic controller commands the sensor to take a first reading of the valve actuator and the first reading is sent to the memory,

wherein the logic controller commands the sensor to take a second reading of the valve actuator and the second reading is sent to the memory,

further wherein the logic controller compares the first reading to the second reading.

2. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor, the logic controller, and the memory are housed in a single housing.

3. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor sends and receives information between the logic controller and memory by wires.

4. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor sends and receives information between the logic controller and memory by radio.

5. The gate valve positioning system of claim **1** wherein, the logic controller is connected to a display.

6. The gate valve positioning system of claim **1** wherein, the logic controller is connected to a display via radio.

7. A gate valve positioning system comprising;

a tubular having a throughbore affixed to a well,

a valve actuator within the tubular;

a sensor, a logic controller, a memory, and a data set within memory;

wherein the logic controller commands the sensor to take a first reading of the valve actuator and the first reading is sent to the memory,

further wherein the logic controller compares the first reading to the data set.

8. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor, the logic controller, and the memory are housed in a single housing.

9. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor sends and receives information between the logic controller and memory by wires.

10. The gate valve positioning system of claim **1** wherein, the geomagnetic sensor sends and receives information between the logic controller and memory by radio.

11. The gate valve positioning system of claim **1** wherein, the logic controller is connected to a display.

The gate valve positioning system of claim **1** wherein, the logic controller is connected to a display via radio.

* * * * *