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(54) MONITORING SYSTEM FOR RECIPROCATING PUMPS

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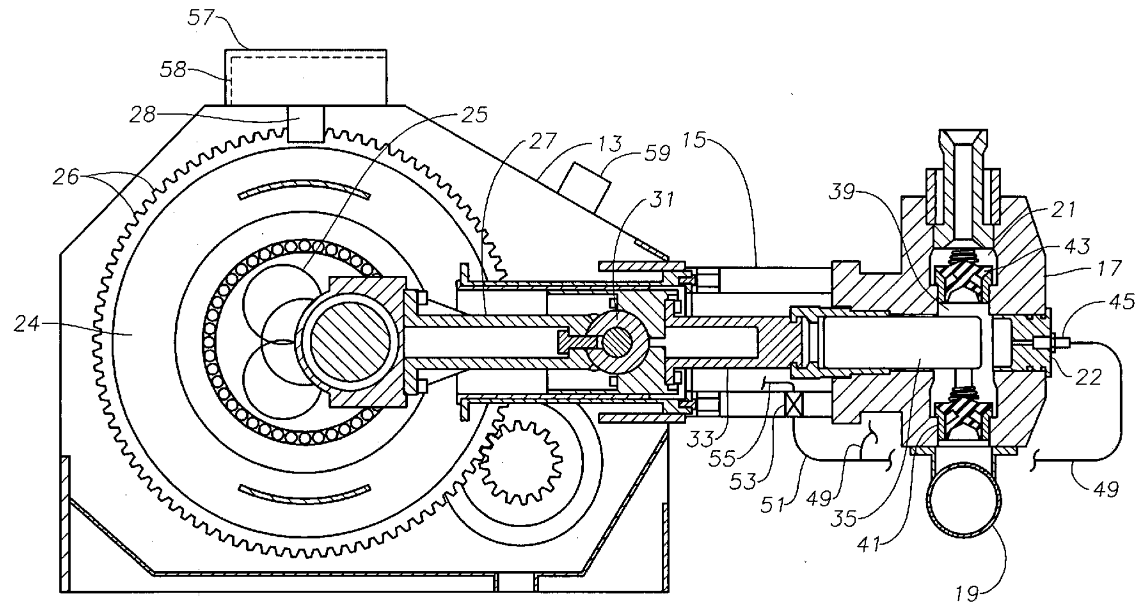
(57) **ABSTRACT**

A reciprocating pump assembly includes a pump housing that houses a crankshaft. Pistons are mechanically connected to the crankshaft for pumping fluid through cylinders. Each cylinder has a fluid inlet and a fluid outlet. The pump also has a monitoring housing connected to the reciprocating pump. Within the monitoring housing is a computer with memory. Pressure sensor assemblies sense a pressure value of a fluid within the pump, and are in electrical communication with the memory. An accelerometer positioned on the pump measures vibrations of the pump and is also in electrical communication with the memory for storage of sensed vibrations or displacements during operations. A proximity sensor in electrical communication with the memory is located within the pump housing to determine the rotational velocity of the crankshaft.



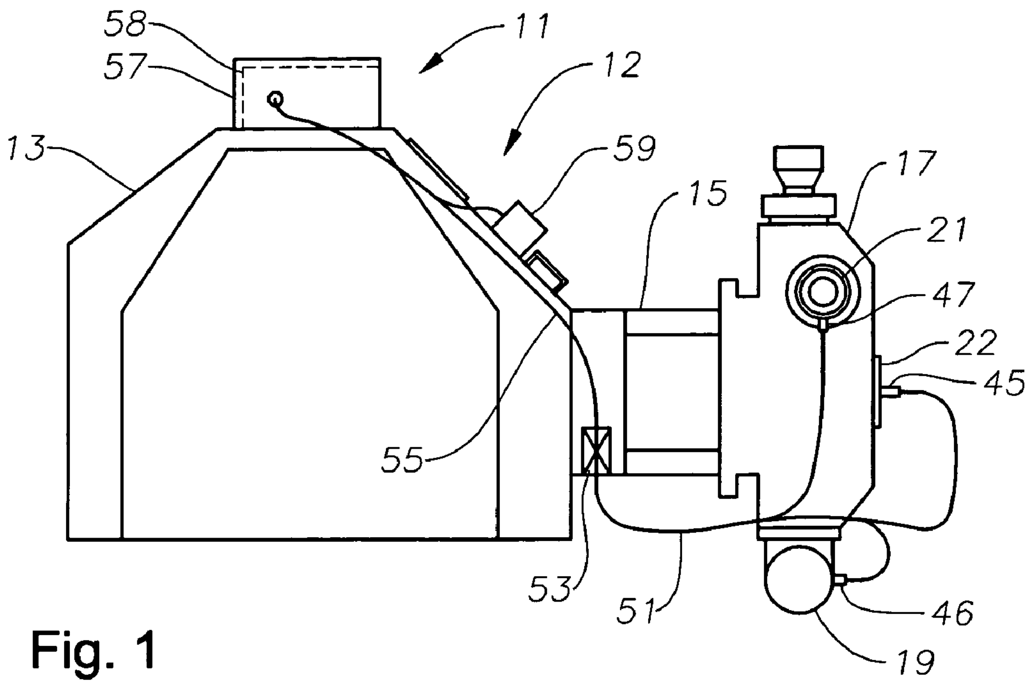

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Fig. 1

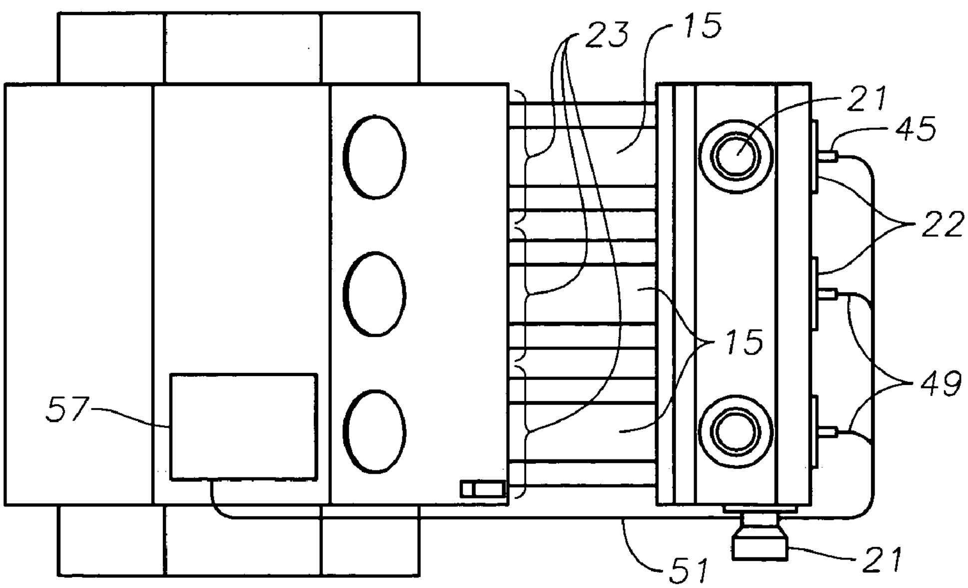
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Fig. 2

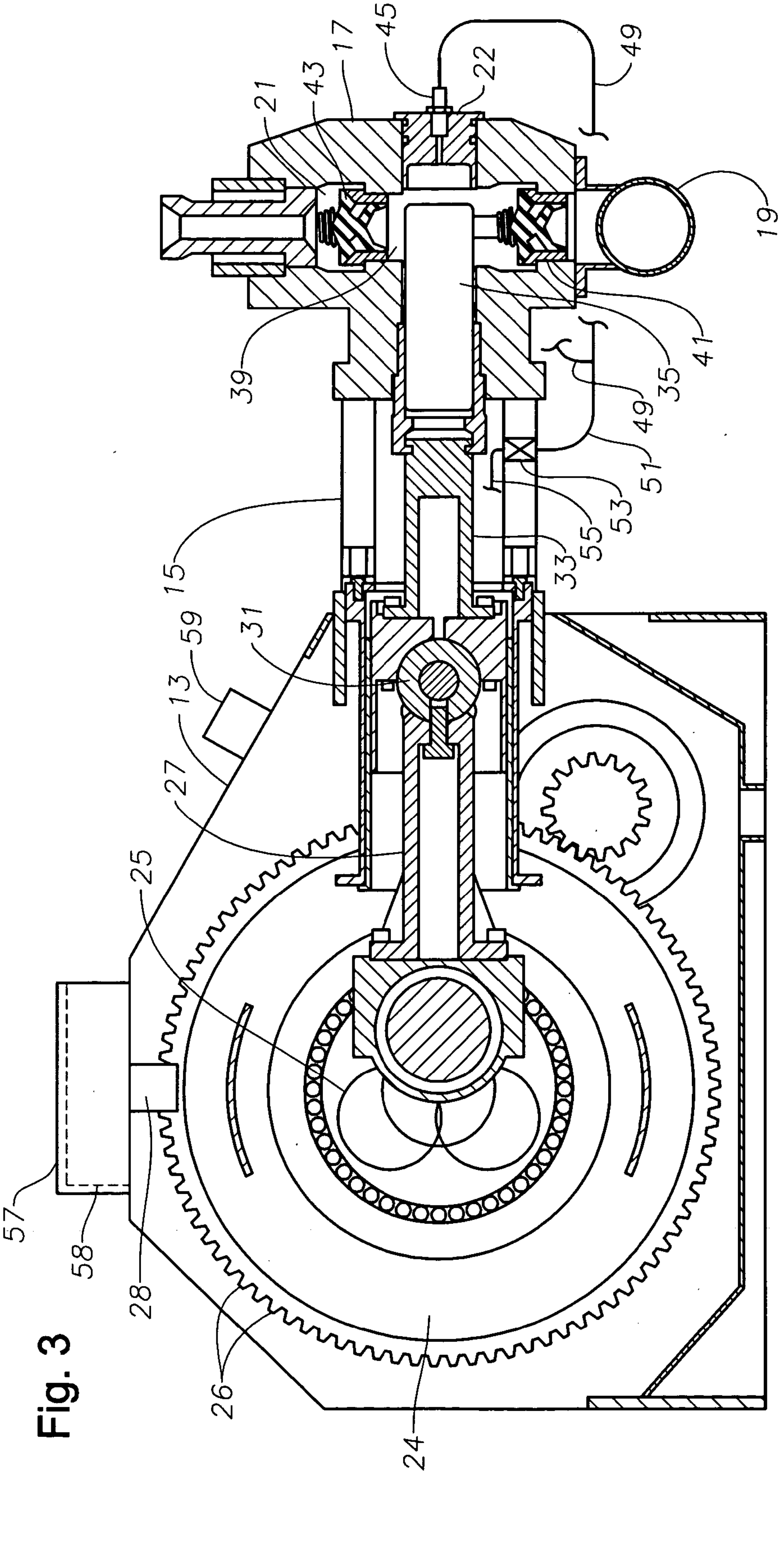
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Fig. 3

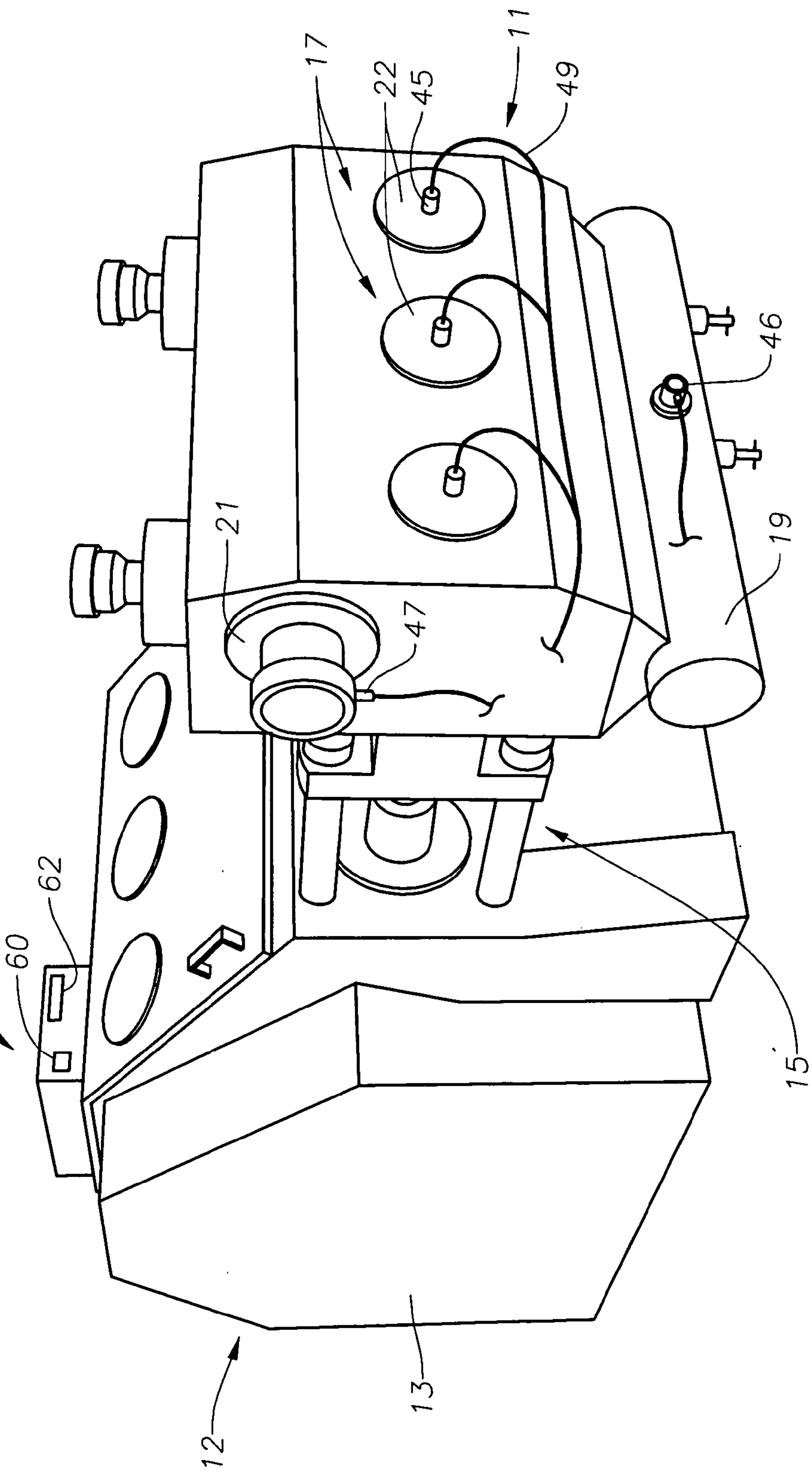
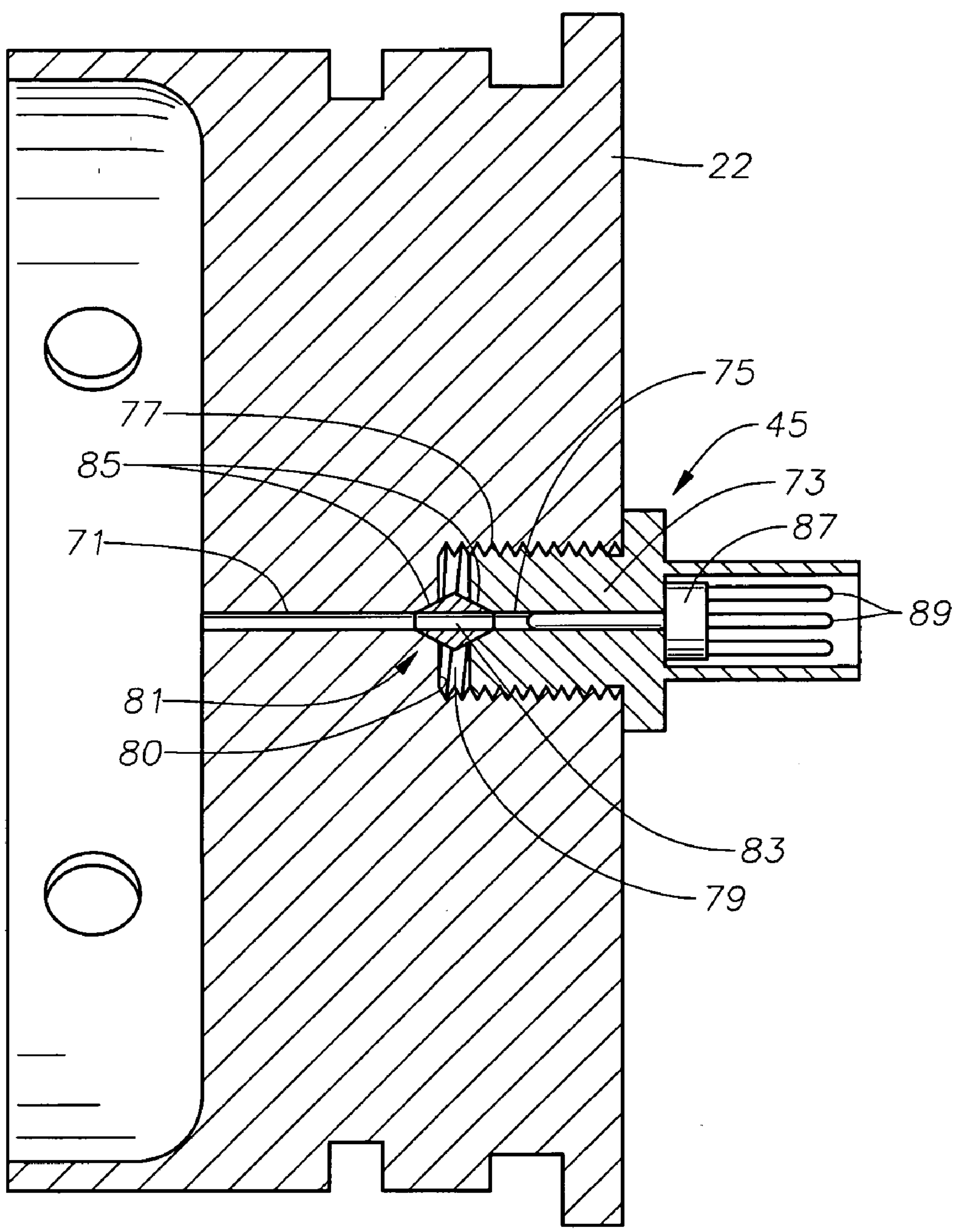


Fig. 4

Fig. 5



MONITORING SYSTEM FOR RECIPROCATING PUMPS

RELATED APPLICATIONS

[0001] This nonprovisional patent application claims the benefit of co-pending, provisional patent application U.S. Serial No. 60/465,043, filed on Apr. 24, 2003, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to reciprocating pumps, more specifically to an apparatus for monitoring operating conditions of the reciprocating pump.

[0004] 2. Background of the Invention

[0005] In oil field operations, reciprocating pumps are often used for various purposes. Some reciprocating pumps, generally known as "service pumps," are typically used for operations such cementing, acidizing, or fracing the well. Typically, these service pumps run for relatively short periods of time but on a frequent basis. Often they are mounted to a truck or a skid for transport to various well sites. A pump might operate several times a week. Many times, several pumps will be connected in parallel to a flow line. The operator will know the output pressure of the group of pumps due to a pressure gauge on the flow line, but may not know the individual pump output pressure. The operator will often not know the intake pressure, the individual pump speed, or the extent of vibration of a particular pump. A pump might be performing poorly, yet the operator not know.

[0006] To periodically monitor the performance of the pump, an operator typically calls on the services of testing companies that will set up temporary sensors and monitor the performance of the pump during a test period. Generally, the testing service connects pressure gauges to the overall intake and discharge, as well as each individual pressure chamber. The testing service might also monitor the rotational speed and vibration. Then the testing service removes the test equipment and the pump continues operations without monitoring equipment.

[0007] Continuous monitoring of the pump through testing companies is not practical. Moreover, during operations, the pressure of the fluid inside of the pump can become quite high which makes it difficult to obtain readings of pressures within the pump at certain locations without leakage. Operators typically will not often use the testing equipment due to the cost associated with the testing companies. An operator may not have a pump tested unless something appears to be wrong with it. Accordingly, operators are often left in the situation of not knowing what the performance conditions of a pump for long periods of time.

SUMMARY OF THE INVENTION

[0008] In this invention, a reciprocating pump assembly includes a pump housing that houses a crankshaft. A plurality of pistons are mechanically connected to the crankshaft for pumping a fluid through a plurality of cylinders or piston chambers. Each of the cylinders has a fluid inlet and a fluid outlet. The pump also has a monitoring housing connected to the reciprocating pump. Within the monitoring housing is a computer having a memory. The pump also has a plurality of pressure sensor assemblies. Each pressure sensor assembly is in electrical communication with the memory. Each pressure sensor assembly is used to sense a pressure value of a fluid within the pump.

[0009] The invention can optionally also include an accelerometer to measure vibrations by sensing displacement. The accelerometer is typically positioned adjacent the pump housing. The accelerometer is also in electrical communication with the memory of the computer so that the computer can store sensed vibrations or displacements during operations. The invention can also have a proximity sensor located within the pump housing to determine the rotational velocity of the crankshaft. The proximity sensor is in electrical communication with the memory of the computer so that the computer can store sensed proximity values during operations.

[0010] A pressure sensor assembly that can be used in this invention includes a plug member. The plug member is positioned adjacent a sidewall of the pump. The sidewall can be selected from various sidewalls that are in fluid communication with the fluid pumped within the reciprocating pump. A port is located in the sidewall of the pump that is in fluid communication with the fluid within the pump. The plug member has an aperture that registers with the port when the plug member is positioned adjacent the side wall. A seal member is positioned between the plug member and the sidewall. The seal member has a passageway that allows the aperture to register with the port when the seal member and the plug member are in place. A transducer is located within the plug member and is in fluid communication with the aperture. The transducer converts the pressure into electronic signals that can be communicated to the computer.

[0011] The computer of the pump assembly can also have a port that allows an operator to download the stored sensed values in the memory. This allows an operator to collect the sensed values of the operating conditions over long periods of operation for analysis and monitoring purposes. Alternatively, the memory of the computer can be a replaceable memory device such as a chip or disk. The computer can include a drive for receiving and ejecting the memory so that the operator can easily retrieve and replace the memory after predetermined periods of operations for analysis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a schematic elevational view of a reciprocating pump assembly constructed in accordance with this invention.

[0013] **FIG. 2** is a top plan schematic view of the reciprocating pump assembly shown in **FIG. 1**.

[0014] **FIG. 3** is a sectional view of a portion of the pump assembly shown in **FIG. 1**.

[0015] **FIG. 4** is a perspective view of the reciprocating pump assembly shown in **FIG. 1**.

[0016] **FIG. 5** is an enlarged sectional view of a monitoring sensor assembly shown in a cover plate of the reciprocating pump assembly shown in **FIG. 1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] Referring to **FIGS. 1 and 3**, reciprocating pump or pump assembly **12** includes a monitoring assembly **11** is shown attached to a reciprocating pump **12**. In the preferred embodiment, reciprocating pump **12** includes a crankshaft housing **13** that comprises a majority of the outer surface of reciprocating pump **12** shown in **FIGS. 1 and 3**. A plunger or piston rod housing **15** attaches to a side of crankshaft housing **13** and extends to a cylinder **17**. Each cylinder **17** preferably includes a fluid inlet **19** and a fluid outlet **21** (**FIG. 2**). As best shown in **FIG. 3**, a cover plate **22** connects to an end of each cylinder **17** opposite from the piston rod housing **15**. While pump **12** is shown in **FIG. 4** as free-standing on the ground, pump **12** can easily be mounted to a trailer that can be towed between operational sites, or to a skid such as for offshore operations. Accordingly a pump assembly is defined as including either a pump **12** mounted directly to the ground or support structure, a skid, or a trailer.

[0018] Referring to **FIG. 2**, piston rod housing **15** is segmented into three portions, each portion comprising a plunger or piston throw **23**. Reciprocating pump **12** as shown in **FIG. 2** has three piston throws **23**, which is commonly know as a triplex, but could also be segmented for five piston throws **23**, which is commonly known as a quintuplex pump. The description focuses on a triplex pump, but as will be readily apparent to those skilled in the art, the features and aspects described are easily applicable for a quintuplex or other type of pump. Each piston throw **23** houses a piston rod **33** (**FIG. 3**) extending to cylinder **17**. As shown in **FIG. 2**, each piston throw **23** extends in the same longitudinal direction from crankshaft housing **13**.

[0019] Referring to **FIG. 3**, a portion of reciprocating pump **12** housed within crankshaft housing **13** is shown. Crankshaft housing **13** houses a crankshaft **25**, which is typically mechanically connected to a motor (not shown). The motor (not shown) rotates crankshaft **25** in order to drive reciprocating pump **12**. In the preferred embodiment, crankshaft **25** is cammed so that fluid is pumped from each piston throw **23** at alternating times. As is readily appreciable by those skilled in the art, alternating the cycles of pumping fluid from each of cylinders **17** helps minimize the primary, secondary, and tertiary (et al.) forces associated with reciprocating pump **12**.

[0020] In the preferred embodiment, a gear **24** is mechanically connected to crankshaft **25**. Gear **24** can be for mechanically connecting crankshaft **25** to the motor (not shown), or for conveying rotational energy to another gear for driving another assembly, such as a lubrication pump for lubricating. Gear **24** typically has teeth **26** spaced around the circumference of gear **24**. In the preferred embodiment, a proximity sensor **28** is positioned adjacent crankshaft **25** for calculating the rotational velocity of crankshaft **25**. One manner proximity sensor **28** can help calculate rotational velocity is by counting teeth **26** as gear **24** rotates. For example, one type of proximity sensor creates a magnetic field within its close proximity. As the each tooth **26** rotates past the proximity sensor **28**, there is a disruption in the magnetic field. These disruptions can be counted and compared to time to help calculate a rotational speed of the gear **24**, which in turn can be used to calculate the rotational speed of crankshaft **25**.

[0021] In the preferred embodiment, a connector rod **27** includes an end that connects to crankshaft **25** and another end that engages a crosshead **29**. Connector rod **27** connects to crosshead **29** through a crosshead pin **31**, which holds connector rod **27** longitudinally relative to crosshead **29**. Connector rod **27** pivots about crosshead pin **31** as crankshaft **25** rotates with the other end of connector rod **27**. A piston rod **33** extends from crosshead **29** in a longitudinally opposite direction from crankshaft **25**. Connector rod **27** and crosshead **29** convert rotational movement of crankshaft **25** into longitudinal movement of piston rod **33**.

[0022] A piston **35** connects to piston rod **33** for pumping the fluid passing through reciprocating pump **12**. Cylinder **17** connects to the end of piston rod housing **15** extending away from crankshaft housing **13** (**FIG. 1**). Cylinder **17** typically includes a cylinder chamber **39**, which is where the fluid being pumped by reciprocating pump **12** is compressed by piston **35**. Cylinder **17** preferably includes an inlet valve **41** and an outlet valve **43**. Valves **41** and **43** are preferably spring-loaded valves, which are actuated by a predetermined differential pressure. Inlet valve **41** actuates to control fluid flow through fluid inlet **19** into cylinder chamber **39**, and outlet valve **43** actuates to control fluid flow through fluid outlet **21** from cylinder chamber **39**. Piston **35** reciprocates, or moves longitudinally toward and away from cylinder **17**, as crankshaft **25** rotates. As piston **35** moves longitudinally away from cylinder chamber **39**, the pressure of the fluid inside chamber **39** decreases creating a differential pressure across inlet valve **41**, which actuates valve **41** and allows the fluid to enter cylinder chamber **39** from fluid inlet **19**. The fluid being pumped enters cylinder chamber **39** as piston **35** continues to move longitudinally away from cylinder **17** until the pressure difference between the fluid inside chamber **39** and the fluid in fluid inlet **19** is small enough for inlet valve **41** to actuate to its closed position. As piston **35** begins to move longitudinally towards cylinder **17**, the pressure on the fluid inside of cylinder chamber **39** begins to increase. Fluid pressure inside cylinder chamber **39** continues to increase as piston **35** approaches cylinder **17** until the differential pressure across outlet valve **43** is large enough to actuate valve **43** and allow the fluid to exit cylinder **17** through fluid outlet **21**. In the preferred embodiment, fluid is only pumped across one side of piston **35**, therefore reciprocating pump **12** is a single-acting reciprocating pump. If fluid were also being pumped on the side of piston **35** that connects to piston rod **33**, this would be a double acting pump.

[0023] In the preferred embodiment, a pressure sensor assembly monitors the pressure of fluid being pumped by reciprocating pump **12**. Preferably there are a plurality of pressure sensor assemblies advantageously positioned adjacent various sidewalls of pump **12** to sense fluid pressure values at various locations throughout pump **12**. For example, as best shown in **FIG. 4**, there is a pressure sensor assembly **45** mounted to each cover plate **22**, which allows for sensing the output fluid pressure individually within each cylinder **17**. In the embodiment shown in **FIG. 4**, there is also preferably a pressure sensor assembly **46** mounted to fluid inlet **19**, which feeds into each of cylinders **17**, to sense the overall suction fluid pressure of the fluid entering pump **12**. Additionally, there is also preferably a pressure sensor assembly **47** mounted to each discharge flange or well fluid outlet **21** to sense the individual fluid pressure of the fluid exiting each cylinder **17**. In the preferred embodiment, wires

49 are in electrical communication with pressure sensors **45**, **46**, and **47**. In the preferred embodiment, each pressure sensor assembly **45** includes a plurality of wires **49** extending therefrom. A preferred structure of each pressure sensor assembly is provided in more detail below.

[**0024**] As best illustrated in **FIGS. 2-4**, wires **49** extending from each pressure sensor assembly **45** combine to form a single bundle or wire harness **51**. Wire harness **51** preferably extends below cylinders **17** toward crankshaft housing **13**. Referring back to **FIG. 2**, the end of wire harness **51** extending toward crankshaft housing **13** connects to a wire harness disconnect **53** located on crankshaft housing **13**. Wire harness disconnect **53** preferably allows an operator to selectively disengage wire harness **51** while replacing or repairing cylinders **17**. A second bundle or wire harness **55** extends from wire harness disconnect **53** toward an upper portion of crankshaft housing **13**.

[**0025**] In the preferred embodiment, a monitoring housing or data collector **57** is located on an upper portion of crankshaft housing **13**. Data collector **57** preferably comprises a computer **58** (**FIG. 1**) that receives and stores data about the operating conditions of pump **12**. In a manner known in the art, computer **58** includes memory. As shown in **FIG. 4**, computer **58** can include a port **60** for downloading data from the memory to another computer. Additionally, computer **58** can optionally include portable memory that is removable and insertable through a drive **62**. Such replaceable memory allows an operator to store operating conditions on the memory of computer **58** for a predetermined length of time, and then retrieve the memory with the stored data for analysis and replace the previous memory with a replacement memory for storing data for another predetermined length of time.

[**0026**] The end of wire harness **55** extending from wire harness disconnect **53** connects to data collector **57**. Data collector **57** receives and records the inlet and outlet pressures for each of cylinders **17** associated with reciprocating pump **12** as pistons **35** stroke. As will be appreciated by those skilled in the art, the inlet and outlet pressures from each cylinder **17** can then be transmitted from data collector **57** to a centrally located facility or the measurements can be digitally stored until retrieved by an operator. Additionally, proximity sensor **28** (**FIG. 3**) is also preferably in electrical communication with the memory of computer **58** so that proximity sensor can transmit the sensed proximities of teeth **26** for storage in the memory of computer **58**. Computer **58** computes speed of rotation based on the rate that proximity sensor **28** senses teeth **26**. In the preferred embodiment, data collector **57** includes memory that receives and stores the information. Monitoring inlet and outlet pressures within cylinder chambers **39** allows operators to monitor the efficiency of reciprocating pump **12** as well as the differential pressures associated with inlet and outlet valves **41**, **43**. By monitoring inlet and outlet pressures within cylinder chamber **39**, operators can more effectively determine the appropriate time for replacing inlet and outlet valves **41**, **43**.

[**0027**] Accelerometer **59** is supported on pump housing **13** and monitors the vibrations of reciprocating pump **12** as crankshaft **25** drives each piston **35** with piston rods **33**. Typically, accelerometer **59** transmits various voltages responsive to vibrations to data collector **57** for computer **58** to calculate vibrations. Monitoring vibrations associated with reciprocating pump **12** allows operators to detect any abnormal operating conditions of reciprocating pump **12**. In the preferred embodiment, the chip (not shown) in data collector **57** also receives and stores the information from accelerometer **59**. In the preferred embodiment, monitoring assembly **11** includes the combined assembly of data collector **57**, accelerometer **59**, proximity sensor **28**, wires and wire harnesses **49**, **51**, **55**, wire harness disconnect **53**, and pressure sensor assemblies **45**, **46** and **47**.

[**0028**] **FIG. 5** shows an example of the preferred embodiment of the pressure sensor assembly **45**. In the example shown in **FIG. 5**, pressure sensor assembly **45** is connected to one of cover plates **22** to sense discharge pressure. As will be readily appreciated by those skilled in the art, this arrangement is easily suitable for the positioning of pressure sensor assemblies **45**, **46**, **47** on the other various selected sidewalls of pump **12**, like at pump inlet and outlets **19**, **21**.

[**0029**] Pressure sensor assembly **45** is positioned on the outer surface of cover plate **22**. A port **71** extends from an interior surface of cover plate **22** toward the outer surface of cover plate **22**. Port **71** is in fluid communication with the fluid pumped by one of the pistons **35**. A plug member **73** preferably extends into a portion of cover plate **22**. An aperture **75** extending through a portion of plug member **73** registers with port **71**. In the preferred embodiment, a thread **77** formed on a portion of the outer circumference of plug member **73** that engages a counter-bored thread **79** formed in cover plate **22** for securing plug member **73** to cover plate **22**. The counter-bore portion of port **71** defines an outward facing shoulder **80**.

[**0030**] A metal seal member **81** is sealingly positioned and compressed between an end of plug member **73** and shoulder **80**. A passageway **83** extends longitudinally through seal member **81** so that aperture **75** can register with port **71**. In the preferred embodiment, seal member **81** has a pair of frusto-conical surfaces **85** formed at each longitudinal end for engaging plug member **73** and shoulder **80**. The pair of frusto-conical ends **85** form a metal to metal seal with seal member **81** between plug member **73** and shoulder **80** when plug member is installed. A transducer **87** is located within plug member in fluid communication with aperture **75**. A set of electrical prongs **89** extend from transducer **87** for connection to a plug on each wire **49**. Wires **49** (**FIGS. 1-4**) communicate sensed pressure values electronically to the memory of computer **58**.

[**0031**] In operation, pressure assemblies **45**, **46**, **47** are fixedly positioned adjacent various selected sidewalls of pump **12**. Seal member **81** of each pressure sensor assembly **45** provides a seal against leakage of the fluid pumped by pump **12** from exiting through pressure sensor assemblies **45**. Wires **49** are connected to pressure sensor assemblies **45** so that wires **49** are in electrical communication with prongs **89** extending from each transducer **87**. During operation of pump **12**, the fluid communicates with transducer **87** through port **71**, passageway **83**, and aperture **75**. Transducer converts the sensed pressure to an electrical signal and communicates the signal to the memory in computer **58** via wires **49**. In the preferred embodiment, accelerometer **59** and proximity sensor **28** are also communicating their sensed displacement and proximity readings to the memory in computer **58**.

[**0032**] Computer **58** stores the sensed values from pressure sensor assemblies **45**, **46**, **47**, accelerometer **59**, and proximity sensor **28** in the computer memory. The operator can download the sensed values from the memory via a port **60**. In the preferred embodiment, the operator can alternatively remove the memory with the stored values from computer **58** via drive **62**, and insert a replacement memory for receiving and storing continued sensed operating conditions. This allows continuous monitoring of sensed pressure values of fluid at various positions, and at high pressures within reciprocating pump **12** during long periods of operation rather than only during short test runs.

[**0033**] While the invention has been shown in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention. For example, wires **49** can extend through various sides or ends of cylinders **17** to connect with pressure transducers **45**, **46**, **47**. Furthermore, in situations where the pump assembly is mounted to a skid or a trailer, it will be readily appreciated by those skilled in the art that equipment that is mounted to a pump or crankshaft housing (e.g. data collector **57**) can easily be mounted to the skid or trailer instead of the crankshaft housing with a minimal changes and a little extra length of wiring. As a further example, while all the figures illustrate service pumps that are typically used for cementing, acidizing, or fracing, the monitoring assembly **11** could also easily be used on mud pumps for drilling operations.

That claimed is:

1. In a reciprocating pump assembly having a pump housing that houses a crankshaft, a plurality of pistons mechanically connected to the crankshaft for pumping a fluid through a plurality of cylinders, each of the cylinders having a fluid inlet and a fluid outlet, the reciprocating pump, comprises:

a monitoring housing mounted to the reciprocating pump assembly;

a computer located within the monitoring housing, the computer having a memory; and

a plurality of pressure sensor assemblies mounted to the pump and in electrical communication with the memory to sense a pressure value of a fluid within the pump.

2. The pump assembly according to claim 1, further comprising a proximity sensor assembly in electrical communication with the memory and positioned adjacent the crankshaft to calculate a rotational velocity of the crankshaft.

3. The pump assembly according to claim 2, wherein the crankshaft is mechanically connected to a gear assembly having a plurality of teeth, and the proximity sensor counts teeth on gear assembly to calculate the rotational velocity of the crankshaft.

4. The pump assembly according to claim 1, further comprising an accelerometer in electrical communication with the memory and positioned on the pump housing to sense vibrations of the pump.

5. The pump assembly according to claim 1, further comprising a port extending through a sidewall of the reciprocating pump;

wherein each pressure sensor assembly further comprises a plug member having an aperture that registers with the port; and

a seal member positioned between the sidewall of the reciprocating pump and the plug member.

6. The pump assembly according to claim 5, wherein the seal member further comprises a passageway extending longitudinally therethrough, so that the aperture registers with the port.

7. The pump assembly according to claim 1, wherein at least one of said plurality of sensor assemblies is positioned adjacent the fluid outlet of each of the cylinders to sense the fluid pressure of the fluid exiting the pump.

8. The pump assembly according to claim 7, wherein the fluid outlet further comprises a discharge flange for receiving fluid from one of the plurality of cylinders, with at least one of said plurality of sensor assemblies being positioned on the discharge flange.

9. The pump assembly according to claim 1, wherein at least one of said plurality of sensor assemblies is positioned adjacent the fluid inlet of the cylinder to sense the fluid pressure of the fluid entering the pump.

10. The pump assembly according to claim 1, further comprising a cover plate connected to each of the cylinders on a side of each cylinder opposite from the crankshaft; and

wherein one of said sensor assemblies is mounted to each of the cover plates to sense a discharge fluid pressure within each of the cylinders.

11. A reciprocating pump assembly, comprising:

a pump housing that houses a crankshaft for the reciprocating pump;

a plurality of piston rods extending from the pump housing, each being mechanically connected to and driven by the crankshaft, each of the piston rods having a piston portion on the end extending away from the crankshaft;

a plurality of piston chambers in fluid communication with the piston portion of each of the piston rods, each of the piston chambers receiving fluid to be pumped by the piston portion of each of the piston rods, each of the piston chambers having a fluid inlet and a fluid outlet;

a plurality of ports extending through a selected plurality of sidewalls of the reciprocating pump, each of the ports having a threaded counter-bore, defining an outward facing shoulder;

a monitoring housing mounted to the reciprocating pump;

a computer located within the monitoring housing, the computer having a memory; and

a plurality of pressure sensor assemblies in electrical communication with the memory to sense a pressure value of a fluid within the pump, each pressure sensor assembly comprising:

a threaded plug member that secures to one of the ports, the plug member having an aperture therethrough that registers with the port;

a metal annular seal member compressed between an inward facing end of the plug member and the outward facing shoulder; and

a transducer mounted to the plug and in fluid communication with the aperture.

12. The pump assembly according to claim 11, wherein the transducer is mounted on an outer end of the plug member.

13. The pump assembly according to claim 11, further comprising an accelerometer in electrical communication with the memory and positioned on the pump housing to sense vibrations of the pump.

14. The pump assembly according to claim 11, further comprising a proximity sensor assembly in electrical communication with the memory and positioned adjacent the crankshaft to calculate a rotational velocity of the crankshaft.

15. The pump assembly according to claim 11, wherein the seal member has a pair frusto-conical surfaces on opposite ends of the seal member and through which a passageway extends and wherein the pump assembly further comprises:

a first conical counter-bore formed in the plug member adjacent an inner end of the aperture, the first conical counter-bore engaging one of the frusto-conical surfaces of the seal member; and

a second conical counter-bore formed in the outward facing shoulder, the second conical counter-bore engaging the other of the frusto-conical surfaces of the seal member.

16. The monitoring assembly according to claim 11, wherein at least one of said pressure sensor assemblies is positioned adjacent a fluid outlet of the piston chambers to sense an overall fluid pressure of the fluid exiting the pump.

17. The monitoring assembly according to claim 11, wherein at least one of said pressure sensor assemblies is positioned adjacent a fluid inlet of the piston chambers to sense an overall fluid pressure of the fluid entering the pump.

18. The monitoring assembly according to claim 11, further comprising a cover plate enclosing a side of each of the piston chambers opposite from the crankshaft; and

wherein at least one of said sensor assemblies is mounted to each of the cover plates to sense an individual fluid pressure of the fluid within each of the piston chambers.

19. The monitoring assembly according to claim 11, further comprising a memory housing, and wherein the memory is a portable module that adapted to be removed to have information retrieved from the memory at another location and replaced with another portable module to receive data from the sensors.

20. A method of monitoring the operating conditions of a reciprocating pump assembly having a pump housing that houses a crankshaft, a plurality of pistons mechanically connected to the crankshaft for pumping a fluid through a plurality of cylinders, each of the cylinders having a fluid inlet and a fluid outlet, the method comprising:

providing a computer with a memory, mounting the computer in a monitoring housing, and mounting the monitoring housing to the reciprocating pump;

positioning a plurality of pressure sensor assemblies in fluid communication with ports formed in a selected location and electrically connecting the sensor assemblies to the computer of the reciprocating pump, operating the pump, sensing fluid pressure with the sensor assemblies; and

communicating pressure values from each of the sensor assemblies to the memory.

21. A method of claim 20, further comprising:

mounting an accelerometer to the pump housing and electrically connecting the accelerometer to the computer;

operating the pump and sensing vibrations with the accelerometer; and

communicating a sensed vibration value from the accelerometer to the memory.

22. A method of claim 20, further comprising:

positioning a proximity sensor adjacent the crankshaft to calculate a rotational velocity of the crankshaft;

communicating a counted value of sensed proximity values from the proximity sensor to the memory.

23. A method of claim 20, further comprising downloading the sensed values from the memory to a remote computer via an access terminal.

24. A method of claim 20, further comprising removing the memory after a predetermined length of time through a memory drive located within the monitoring housing and inserting a replacement memory for the computer through the memory drive.

* * * * *