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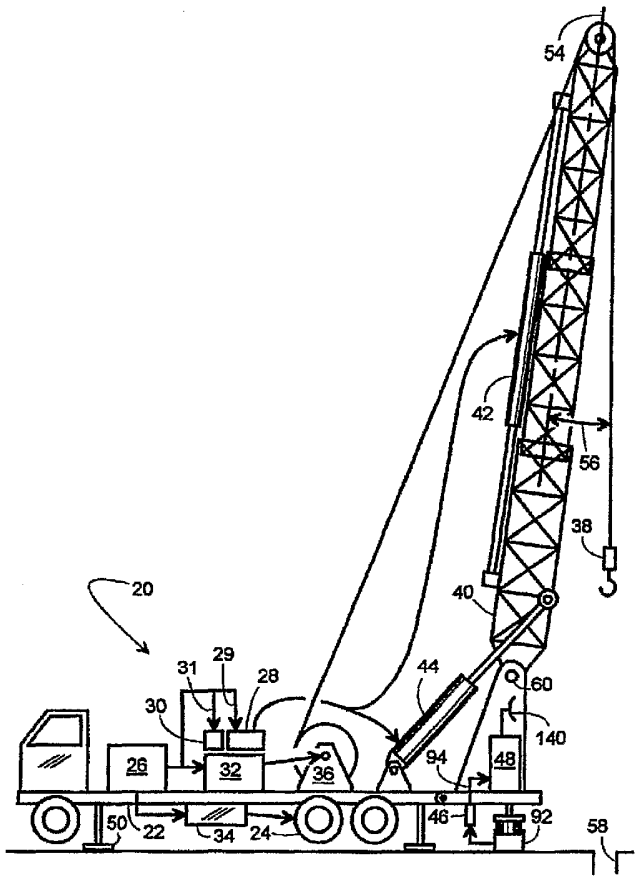
(54) Title: PORTABLE MEMORY DEVICE FOR A MOBILE REPAIR UNIT



(57) Abstract: This invention provides a self-contained mobile repair unit (20) having a universal set of hydraulic and pneumatic tooling for servicing well equipment such as an inner pipe string, a sucker rod, or a pump. One or more transducers sense and collect data indicative of one or more parameters measured by the mobile repair unit (20), such as hook load, engine RPM, or tongue -torque. The data is collected and saved in a non-volatile memory device, which is then physically transferred from the mobile repair unit (20) to a central office location, where the data can be compiled, analyzed, and/or posted on a network such as the Internet.

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PORTABLE MEMORY DEVICE FOR A MOBILE REPAIR UNIT

BACKGROUND OF THE INVENTION

After an oil rig drills a well and installs a well casing, the rig is dismantled and removed from the site. From that point on, a mobile repair unit is typically used to service the well. Servicing includes installing and/or removing inner tubing strings, sucker rods, and pumps, and also requires various other monitoring functions such as detecting dangerous hydrogen sulfide gas. Such work requires a myriad of tools which are provided by the mobile repair unit, and these tools in turn provide a myriad of measured parameters such as torque turn, engine RPM, hook load, hydrogen sulfide concentration, etc. It is important to understand and interpret these measured parameters, as they can be important to assessing the quality, reliability, and safety of the work being accomplished at the mobile repair unit.

The prior art discloses various ways in which these measured parameters can become known to mobile repair unit operators and/or their supervisors. For example, in U.S. Patent 6,079,490, which is hereby incorporated by reference, the mobile repair units are fitted with modems for wirelessly sending the measured parameter data to a centralized data analysis location. While the use of a modem can be useful, it suffers from shortcomings that can hamper its usefulness in the context of a mobile repair unit. For example, wireless or modem transmission techniques are relatively expensive to implement and may be subject to lost or corrupted data during transmission.

SUMMARY OF THE INVENTION

This invention provides a self-contained mobile repair unit having a universal set of hydraulic and pneumatic tooling for servicing well equipment such as an inner pipe string, a sucker rod, or a pump. One or more transducers sense and collect data indicative of one or more parameters measured by the mobile repair unit, such as hook load, engine RPM, or tongue torque. The data is collected and saved in a non-volatile memory device, which is then physically transferred from the mobile repair unit to a central office location, where the data can be compiled, analyzed, and/or posted on a network such as the Internet.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of a mobile repair unit with its derrick extended.

FIG. 2 is a schematic view of a pneumatic slip in a locked position.

FIG. 3 is a schematic view of a pneumatic slip in an open position.

FIG. 4 is a schematic illustration of a set of hydraulic tongs.

FIG. 5 is a side view of a mobile repair unit with its derrick retracted.

FIG. 6 illustrates the raising and lowering of an inner tubing string.

FIG. 7 describes one embodiment of the design of a data acquisition monitor as described herein.

DESCRIPTION OF THE INVENTION

This disclosure first details some of the basic tools present on a mobile repair unit and manner in which various measurements are made by these tools. Thereafter, the disclosure discusses the ways in which these measurements are stored and processed in accordance with embodiments of the invention.

Referring to FIG. 1, a retractable, self-contained mobile repair unit 20 is shown to include a truck frame 22 supported on wheels 24, an engine 26, a hydraulic pump 28, an air compressor 30, a first transmission 32, a second transmission 34, a variable speed hoist 36, a block 38, an extendible derrick 40, a first hydraulic cylinder 42, a second hydraulic cylinder 44, a first transducer 46, a monitor 48, and retractable feet 50. Monitor 48, of special importance to the disclosed invention, receives amongst other things various parameters measured during the mobile repair unit's operation.

Engine 26 selectively couples to wheels 24 and hoist 36 by way of transmissions 34 and 32, respectively. Engine 26 also drives hydraulic pump 28 via line 29 and air compressor 30 via line 31. Compressor 30 powers a pneumatic slip 84 (FIGS. 2 and 3), and pump 28 powers a set of hydraulic tongs 66 (FIG. 4). Pump 28 also powers cylinders 42 and 44 that respectively extend and pivot derrick 40 to selectively place derrick 40 in a working position (FIG. 1) and in a retracted position (FIG. 5). In the working position, derrick 40 is pointed upward, but its longitudinal centerline 54 is angularly offset from vertical as indicated by angle 56. This angular offset 56 provides block 38 access to a well bore 58 without interference from the derrick

framework and allows for rapid installation and removal of inner pipe segments (i.e., inner pipe strings 62) and sucker rods (FIG. 6).

Individual pipe segments (of string 62) and sucker rods 64 are screwed together using hydraulic tongs 66 (FIG. 4). Hydraulic tongs are known in the art, and refer to any hydraulic tool that can screw together two pipes or sucker rods, such as those provided by B.J. Hughes company of Houston, Tex. In operation, pump 28 drives a hydraulic motor 68 in either forward or reverse directions by way of valve 70. Motor 68 drives pinions 72 that turn a wrench element 74 relative to clamp 76. Wrench element 74 and clamp 76 engage flats 81 on mating couplings 78 of a sucker rod or inner pipe string. However, rotational jaws or grippers that hydraulically clamp on to a round pipe (i.e., with no flats) can also be used in place of the disclosed wrench element 74. The rotational direction of motor 68 determines whether the couplings 78 are assembled or disassembled.

The transducer 80 of FIG. 4 detects by feedback the amount of torque that is used to assemble or disassemble the string 62 or sucker rods 64, and provides an analog signal 82 (e.g., from 0-5 Volts DC) indicative of that torque value. This signal 82 is provided to monitor 48 and is stored in a manner to be described shortly.

Referring to FIGS. 2 and 3, when installing inner pipe string segments 62, pneumatic slip 84 is used to hold the pipe string 62 while the next segment 62' is screwed on using tongs 66 as just described. Compressor 30 provides pressurized air through valve 86 to rapidly clamp and release slip 84, as shown in FIGS. 2 and 3 respectively. A tank 88 helps maintain constant air pressure. Pressure switch 90, a type of transducer, provides monitor 48 with a signal that indirectly indicates that repair unit 20 is in operation.

Referring back to FIG. 1, weight applied to block 38 is sensed by way of a hydraulic pad 92 that supports the weight of derrick 40. Hydraulic pad 92 is basically a piston within a cylinder such as those provided M. D. Totco company of Cedar Park, Tex, but can alternatively constitute a diaphragm. Hydraulic pressure in pad 92 increases with increasing weight on block 38, and this pressure can accordingly be monitored to assess the weight of the block. Thus, pad 92 constitutes another type of transducer, and it too transmits a signal (not shown) to the monitor 48.

In short, and as is well known, the mobile repair unit contains numerous tools for performing various repair tasks, and most of these tools contain some sort of transducer for providing an indication of the work being performed. (As used herein, "transducer" should be understood as any sort of detector, sensor, or measuring device for providing a signal indicative of the work being performed by a particular tool). Using such transducers, important parameters can be measured or monitored, such as hook load, tong torque, engine RPM, hydrogen sulfide concentration.

As noted, of the signals provide by the various transducers associates with the tools are sent to data acquisition monitor 48. The primary objective of monitor 48 is to gather well maintenance data and save it so that it can be transferred and subsequently monitored at a site other than the location of the mobile repair unit, such as a central office site. Monitor 48 is generally installed in an openly accessible location on the mobile repair unit. For example, on a mobile repair unit, monitor 48 is installed somewhere outside the cab for easy access by human operators who may walk up to the mobile repair unit to interface with the system and collect data. In addition to storing the measured data from the tools, the monitor 48 may also include a screen display for displaying the data.

In one embodiment, monitor 48 contains specialized circuits that are programmed to process the measured signals and store that data, either in raw or processed form, on a removable storage media containing nonvolatile semiconductor memory chips. A human operator physically interfaces with the system on site and removes the storage media from its plug in port on the monitor 48 and then physically transports the storage media from the mobile repair unit to a predetermined, central location, such as a central office site, for processing and analysis.

In a preferred embodiment, the removable storage media constitutes a memory stick, as will be disclosed in further detail herein. Alternatively, the storage media may constitute another device containing nonvolatile memory chips, such as a hand-held computing device, for example, a Palm Pilot™, a Pocket PC, or a laptop computer. The hand-held computing device may be connected to monitor 48 via a wire connection using an available Ethernet port or an RS-232 port on the monitor 48. Alternatively, the hand-held computing device can connect with monitor 48 using radio frequency (RF), infrared, or some other type of wireless means for the transferring the data to the hand-held computing device. As with the memory stick, the hand-

held computing device can be physically transported from the mobile repair unit in the field to the central office site for processing and analysis.

Once the processed data has been physically transported to the central location, it will be coupled to a computing station having a port similar to the port on the monitor for reading the data out of the storage media. In a preferred embodiment, the computing station will comprise or include computers or web servers capable of storing and if necessary processing the data into a format more readily useful to those at the central location who are responsible for monitoring the operation of the various mobile repair units deployed in the field. In a preferred embodiment, the computing station is connected to web servers so that oil well owners or others can access the mobile repair unit operation data using standard web browsers from any computer in the world via the Internet.

FIG. 7 illustrates one embodiment of monitor 48. Monitor 48 consists of sensor and interface module 210, data acquisition module 220, communication module 230, user console 240, and data storage module 250. Generally, sensor and interface module 210 receives analog and digital signals from various transducers present on the mobile repair unit. For example, the hook load, tong torque, pressure, and temperature transducers might provide analog data to module 210, while the engine RPM, block position, rotary RPM, and pump strokes transducers might provide digital data. In any event, sensor and interface module 210 is equipped to handle one or more analog input signals 212 and one or more digital input signals 214. Module 210 is also capable of producing one or more analog output signals 216 and one or more digital output signals 218. One skilled in the art will recognize that module 210 includes other electrical circuitry, such as amplifiers, multiplexers, and analog-digital converters, which are used to condition the input signals and if necessary to convert them to digital signals to facilitate further processing.

Sensor and interface module 210 sends the digitized signals to data acquisition module 220. Applications programs in Data Acquisition Module 220 process the signals and send processed data to Communication Module 230. Data Acquisition Module 220 comprises CPU 222, firmware 224, clock 226 and memory 228. Firmware 224 contains application programs that are designed to process the input signals received from sensor and interface module 210. Clock 226 (like clock 236 present in the communication module 230) is preferably a real-time

clock with battery back up and allows the data to be time stamped. Memory 228 is preferably a non-volatile one-megabyte flash ROM storage device, but can be any type of suitable memory device. Memory 228 is used to store calibration parameters and other user parameters. The address space of memory 228 is distinct and separate from the memory address space in CPU 222 and CPU 232. The application programs in firmware 224 are executed in CPU 222 to process the mobile repair unit sensor measurement signals received from sensor and interface module 210. For example, the CPU 222 might process the hydrogen sulfide transducer data to determine the concentration of hydrogen sulfide, or process the hook load and tong torque data to provide a measurement indicative of the completeness of the connection of two sucker rods.

The processed data results are then transferred from the data acquisition module 220 to the communication module 230 to facilitate storage of the data and communication to the operators. Bus 229 is preferably an 8-wire parallel data bus, and preferably connects to an 8-bit parallel slave port on CPU 232 in module 230. Firmware 234 contains application programs executable by the CPU 232 that are designed to: enable presentation of the processed data results (graphical and text) on a user console 240; enable storage of the processed data results in data storage module 250; and/or enable communication with a hand-held computing device such as those disclosed earlier and in the manners disclosed earlier. As noted earlier, user console 240 is integrated into monitor 48 via a direct-wired connection 242 through the Ethernet port in interfaces 238 of communication module 230. A human operator preferably interacts with monitor 48 via user console's 240 touch-screen interface or keyboard, which allows the operator to run application programs in module 230 and to view graphical or textual representations of the processed data results. The operator may also use the interface to enter data into monitor 48 (such as job ticket information) or to manipulate calibration parameters stored in memory 228 of module 220.

Communication module 230 also stores the processed data results in data storage module 250. In one embodiment, data storage module 250 consists of a fixed memory device 252 and the removable storage media device 254 alluded to earlier (e.g., the memory stick). On one embodiment, fixed memory device 252 comprises a flash ROM memory device or a magnetic disk drive. The removable storage media device 254 can comprise any number of portable non-volatile means for storing data, such as a floppy disc, a CD (compact disk), or a magnetic tape,

but preferably constitutes a memory stick as will be disclosed in further detail herein. In any event, both memory devices interface with communication module 230 by any suitable means, such as by direct wire connections via separate 2-wire serial data buses 256 and 258 respectively. When module 230 receives the processed data from module 220, one complete copy of the data results is stored in the fixed memory device 252 and a separate but identical complete copy of the data results is stored in the removable storage media device 254. When a human operator uses console 240 to view processed data results, the application programs in firmware 234 of module 230 access the data stored in fixed flash ROM 252.

As previously explained, a copy of the processed data results that are stored in the fixed memory device 252 must be physically transported to the central office site. To accomplish this result, the operator has two options: the removable storage media option or the hand-held computing device option.

Pursuant to the first option, the removable storage media device 254 is accessible to an operator from the outside of monitor 48. Preferably, removable storage device 254 comprises a small, weatherproof cylinder containing a non-volatile memory chip (such as a Flash EEPROM) or memory module containing numerous such chips. The cylinder of device 254 is preferably filled with a suitable epoxy to stabilize the chip(s) and to protect them from moisture and mechanical shock. Pins connected to the chip(s) project from the epoxy along one end of the device and are insertable into the port on the monitor 48. Care should be taken when choosing an epoxy to ensure that the chips will not overheat when they are operating. A human operator manually removes the removable storage media device 254 by physically removing the storage media from the data storage module 250 of the monitor 48 after it has been written with data. The operator then physically transports the removable storage media device 254 to the central office site. The operator then transfers the data to computers or web servers at the central office site by placing the removable storage media 254 into a memory reader that is connected to the web servers (e.g., via a local area network or a wide area network).

Pursuant to the second option for transporting the data, the operator can connect a hand-held computing device 260 such as those disclosed herein to a port on monitor 48. As mentioned earlier and as FIG. 7 contemplates, this can be accomplished via a physical wired connection using an available Ethernet port or RS 232 port, or can be accomplished via a wireless

connection such as a RF or infrared connection. Computer application programs residing in the hand-held device 260 and firmware 234 work together to transfer a copy of the processed data results from fixed memory device 252 to the memory storage space of the hand-held computing device 260. Once a copy of the processed data results has been stored in the hand-held device 260, the operator then disconnects the hand-held device 260 from the port (if any) on the monitor 48 and physically transports the hand-held device from the remote mobile repair unit in the field to the central office site. Once the hand-held device 260 has been physically transported to the central office site, the operator transfers the data to web servers by connecting the hand-held device 260 to a computer at the central office site which is itself connected to central office site web servers (e.g.. via a local area network or a wide area network).

Once the processed data is transferred to web servers using either one of the two foregoing options, oil well owners and customers may access the processed operations data using standard web browsers from any computer in the world via the Internet or other more limited network, such as a intranet. Preferably, this is accomplished using secure UNIX-based web servers that require customers to enter a username and password at a login prompt before they are granted access to the processed data results. In this manner, mobile repair unit operations data may remotely assessed.

Although the invention is described with respect to a preferred embodiment, modifications thereto will be apparent to those skilled in the art. Therefore, the scope of the invention is to be determined by reference to the claims that follow.

CLAIMS:

1. A system for monitoring operations at a well, comprising:

a mobile vehicle containing a data acquisition monitor and at least one tool for monitoring an operation of the well;

at least one transducer associated with each tool for providing a parameter indicative of the operation of the well, wherein each transducer provides an electronic signal to the data acquisition monitor;

a hand-held non-volatile memory device coupled to the data acquisition monitor, wherein the memory device is physically removable from the data acquisition monitor for relocation to a predetermined location.

2. The system of claim 1, wherein the mobile vehicle further comprising a truck frame supported on a plurality of wheels.

3. The system of claim 2, further comprising an engine selectively coupled the wheels.

4. The system of claim 3, wherein the engine is selectively coupled to a hoist.

5. The system of claim 3, wherein the engine drives a hydraulic pump.

6. The system of claim 5, wherein the hydraulic pump powers a set of hydraulic tongs for use in the instillation and removal of pipe segments within the well.

7. The system of claim 5, wherein the hydraulic pump powers a plurality of hydraulic cylinders for moving a derrick attached to the mobile repair unit.

8. The system of claim 1, wherein the parameter is selected from the group consisting of a hydrogen sulfide gas concentration, hook load, engine RPM, and tong torque.

9. The system of claim 1, wherein the electric signal is selected from the group consisting of analog and digital signals.

FIG. 1

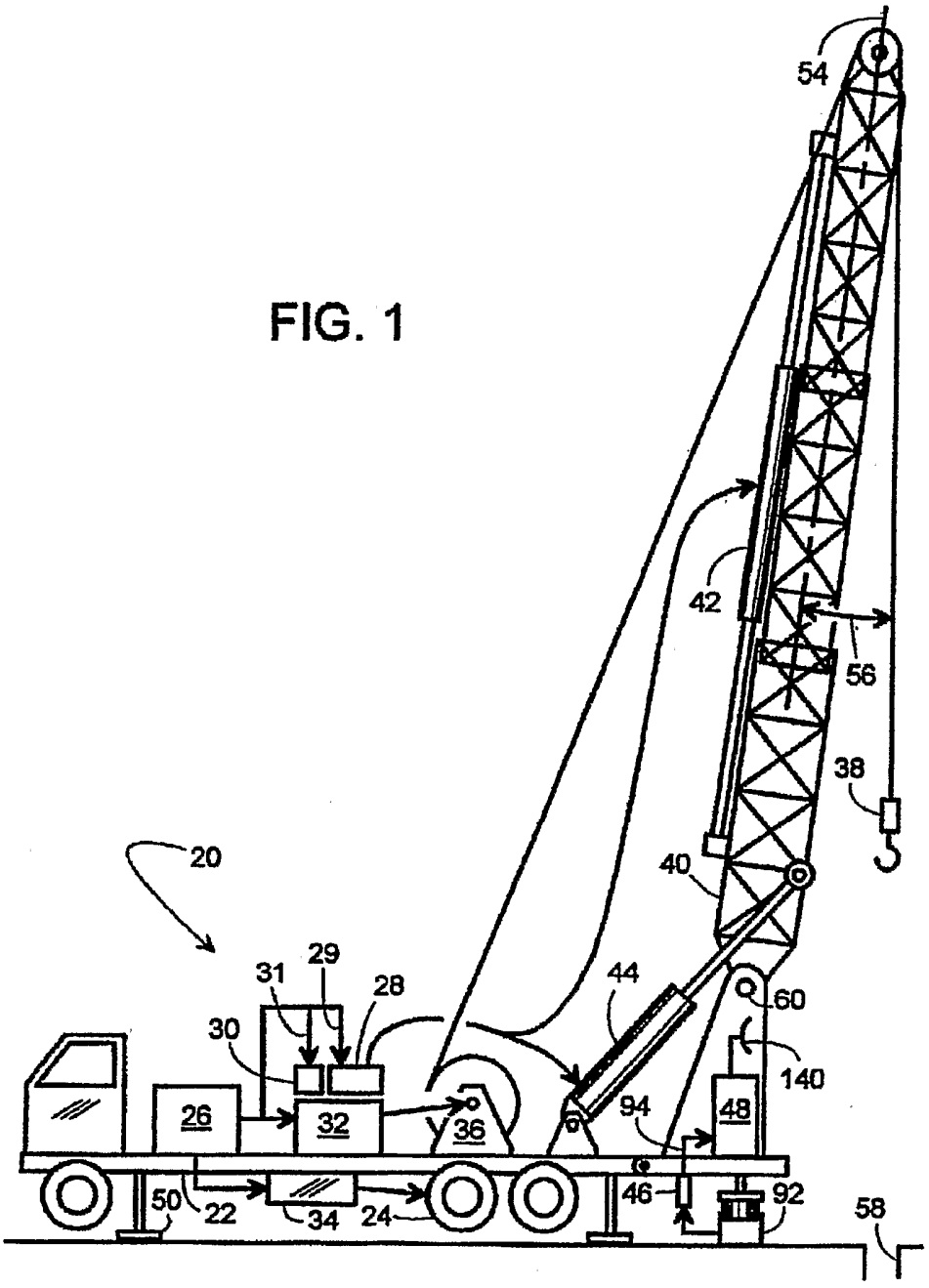
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FIG. 2

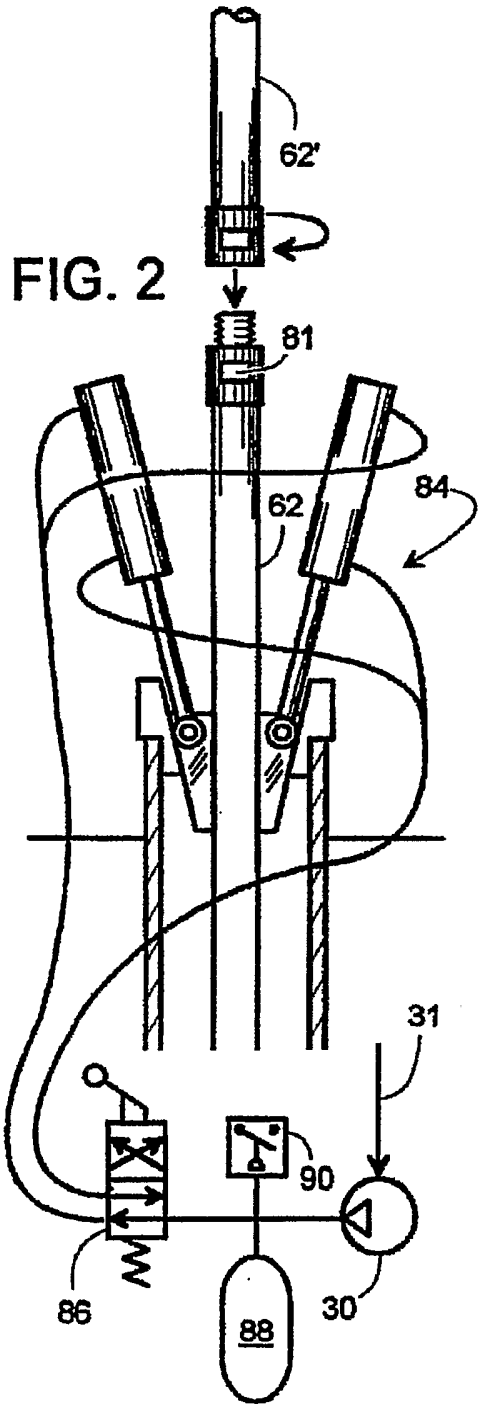


FIG. 3

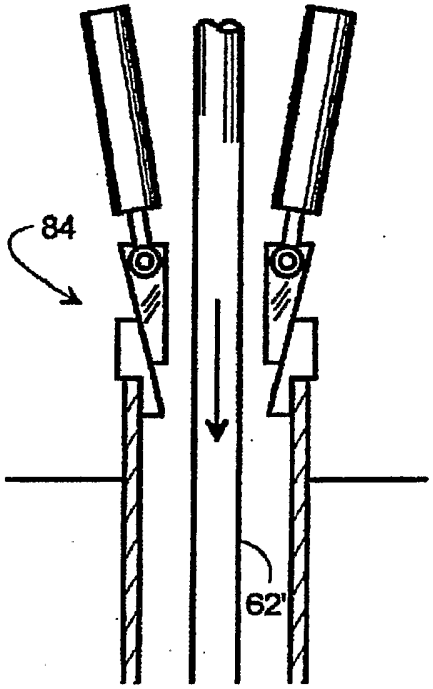


FIG. 4

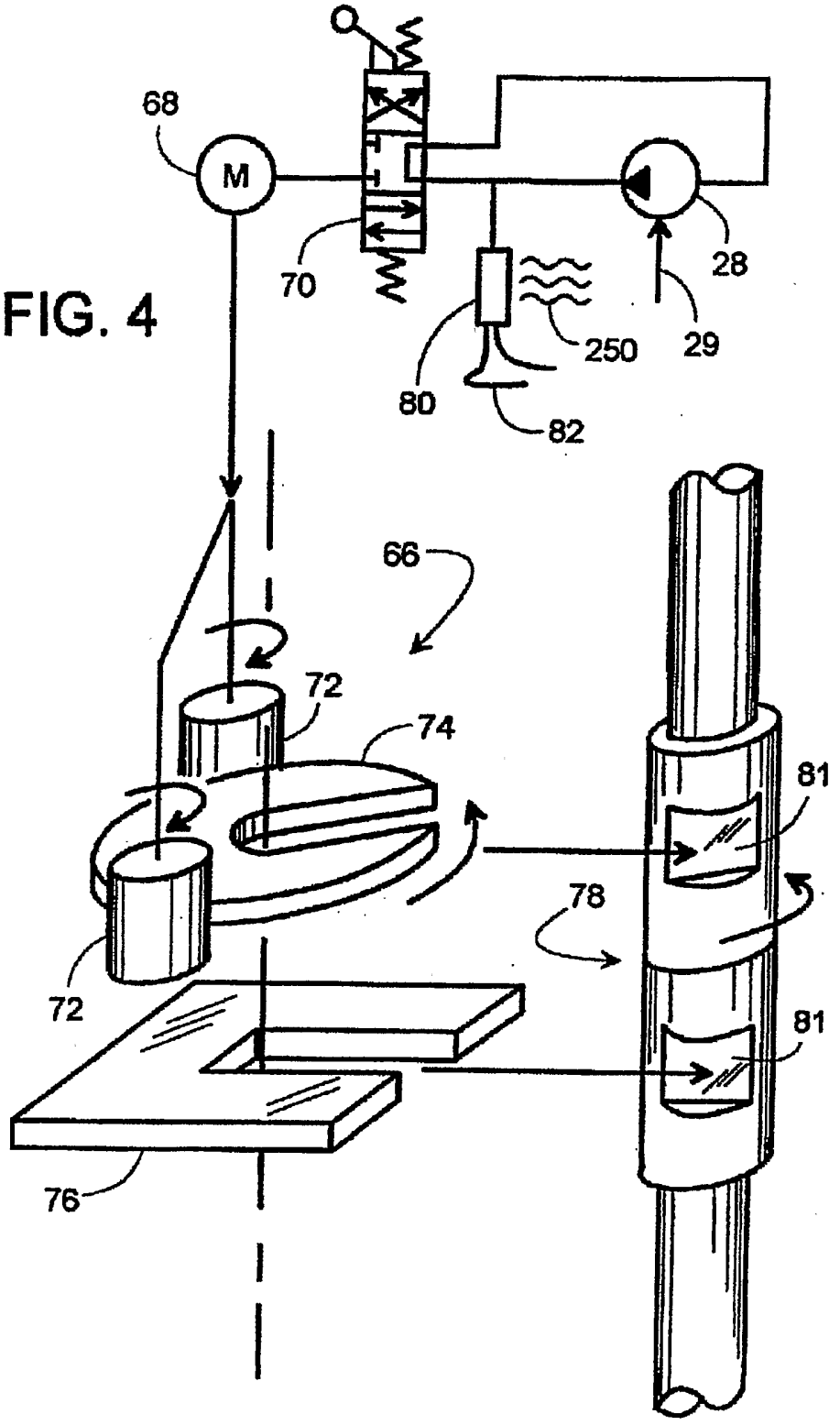


FIG. 5

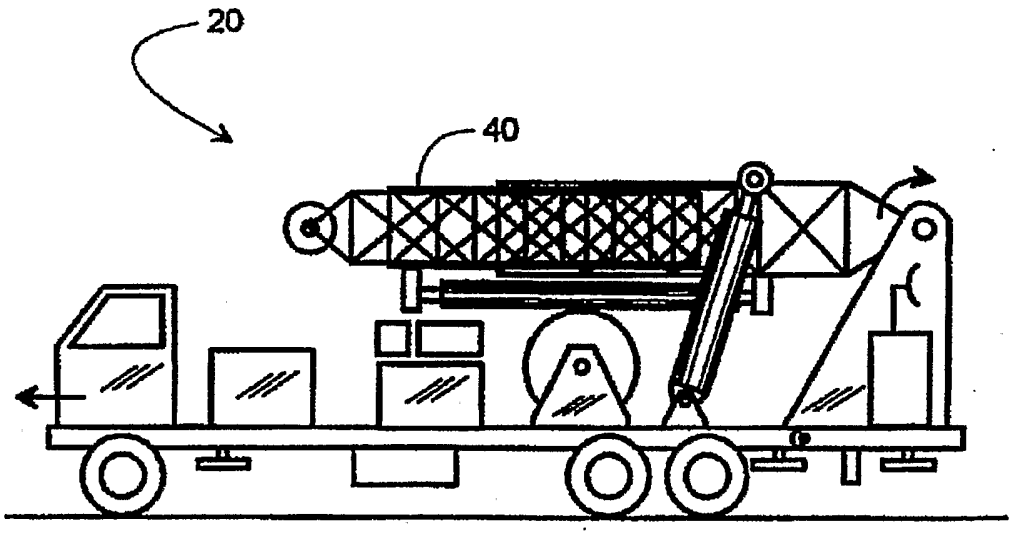
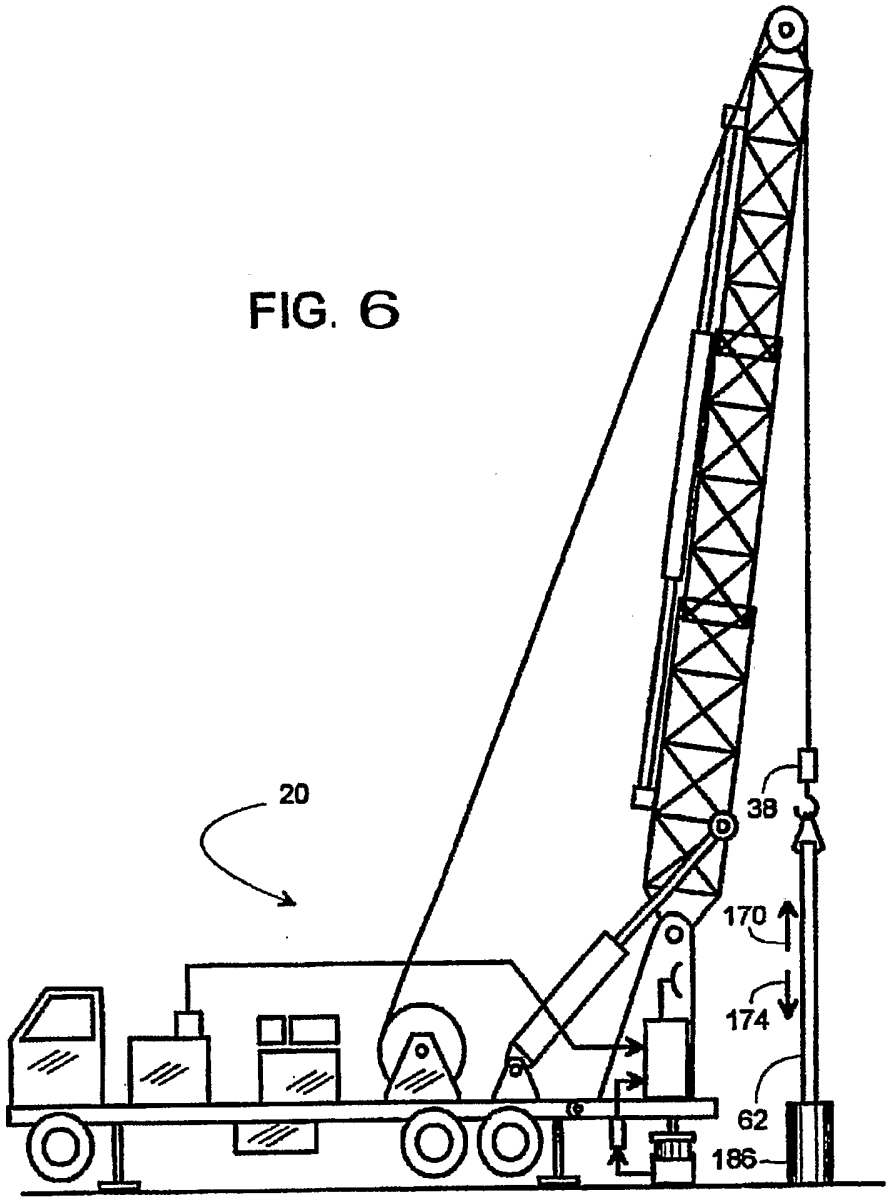


FIG. 6



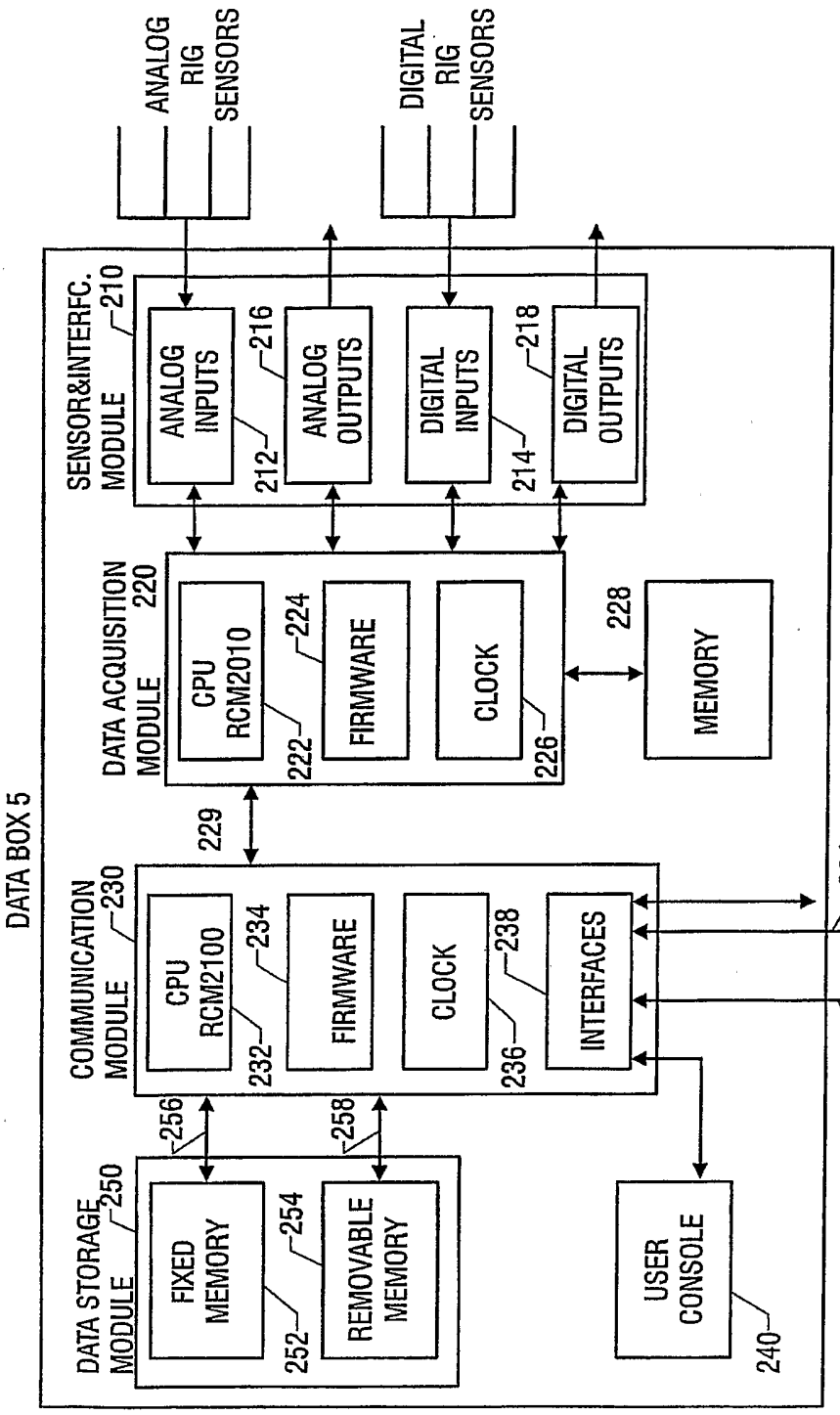

ANALOG RIG SENSORS
DIGITAL RIG SENSORS
DATA BOX 5
SENSOR&INTERFC. MODULE 210
ANALOG INPUTS 212
ANALOG OUTPUTS 216
DIGITAL INPUTS 214
DIGITAL OUTPUTS 218
DATA ACQUISITION MODULE 220
CPU RCM2010 222
FIRMWARE 224
CLOCK 226
MEMORY 228
229
COMMUNICATION MODULE 230
CPU RCM2100 232
FIRMWARE 234
CLOCK 236
INTERFACES 238
256
258
DATA STORAGE MODULE 250
FIXED MEMORY 252
REMOVABLE MEMORY 254
USER CONSOLE 240
264
262
260
HAND-HELD COMPUTING DEVICE
-PALM PILOT
-POCKET PC
-LAPTOP

FIG. 7

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/014715

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B7/02 E21B47/00

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)
IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 6 276 449 B1 (NEWMAN FREDERIC M) 21 August 2001 (2001-08-21) the whole document	1-9
X	US 2003/042020 A1 (NEWMAN FREDERIC M) 6 March 2003 (2003-03-06) paragraphs '0031! - '0034!; figure 1	1-3,5,8, 9
X	US 6 377 189 B1 (NEWMAN FREDERIC M) 23 April 2002 (2002-04-23) column 2, line 38 - column 3, line 61; figure 1	1-3,5,8, 9

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2004	18/10/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Stroemmen, H.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US2004/014715

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 432 709 A (VOLLWEILER ARTHUR R ET AL) 11 July 1995 (1995-07-11) the whole document	1,9
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INTERNATIONAL SEARCH REPORT

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