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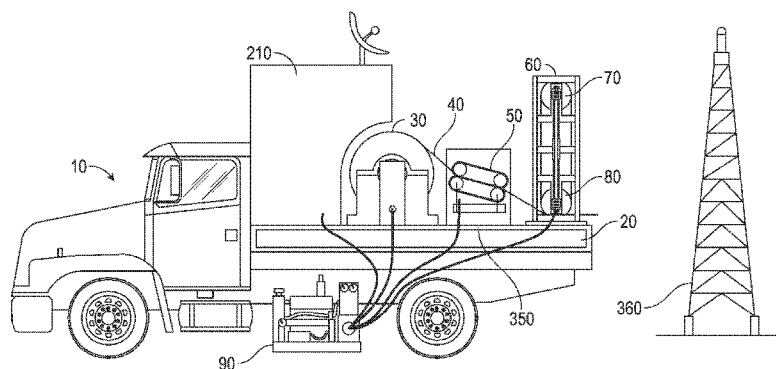
(54) **Title:** SYSTEM AND METHOD FOR POSITIONING EQUIPMENT FOR WELL LOGGING

FIG. 1

(57) **Abstract:** A system and method for positioning equipment on a track system where the equipment may descend a wireline or a cable into a borehole for well logging. The equipment may be a drum unit for storing, deploying and retracting the cable, a winch, a dancer unit and an auxiliary power supply. The equipment may be positioned with the track system for either operations or transport. The cable may be threaded through the equipment to descend into the borehole for well logging purposes.

SYSTEM AND METHOD FOR POSITIONING EQUIPMENT FOR WELL LOGGING

FIELD OF THE INVENTION

[0001] Aspects generally relate to a lightweight portable well logging unit made up of assorted pieces of cable conveyance equipment and a system and a method for using the lightweight portable well logging unit. Further, aspects relate to a system and a method for selecting, placing and for using various pieces of modular equipment.

BACKGROUND INFORMATION

[0002] Well logging, also referred to as wireline or borehole logging, is the practice of creating a detailed record, i.e. a well log of various geologic formations upon penetration into a well or borehole. The well log may be based on visual samples brought to the surface or on physical measurements made by instruments lowered into the well. Well logging can be undertaken during drilling, completing, producing and abandoning the well or at any other time. The well log provides information for various geotechnical studies involving oil, gas, groundwater and minerals.

[0003] The United States onshore oilfield service industry includes two distinct markets: shallow wells with depths up to 8,000 feet and intermediate wells with depths up to 25,000 feet. These markets are traditionally serviced by the same size of wireline logging units. However, using a single size of wireline logging unit for various well depths presents operational problems. For instance, full sized wireline logging units are not well suited for the shallow well market. Thus, shallow well operations are often performed at break even costs or at a loss.

[0004] Many service companies have developed additional logging units designed for the shallow well market. Although shallow well operations may be conducted more efficiently, the addition of another small size well logging unit to

the fleet has led to higher costs associated with maintenance, replacement parts, general operations and personnel. Further, the small size units only address shallow well markets. Additional research and development is required for units used in the intermediate depth well market.

[0005] The design of current wireline units occurred before the development of linear traction winches and advanced hydraulic systems. As a result, the winches used in current wireline logging units and drum type traction winches can only sustain limited loads. Typically, the load handling capability of a drum type winch can only be increased by increasing the size and thus the weight of the winch. More importantly, and unlike a linear traction winch, a drum type traction winch cannot dissipate its load as needed to service deeper wells. Also, higher load weights tax the cables intended to be deployed by the drum type winch.

[0006] Current wireline units cannot meet the demands of modern well logging. For example, the units have reached their maximum weight limits and thus cannot hold even heavier pieces of equipment needed to service deep wells. Further, the weight of the units often exceeds the overall axle weight rating of roads leading to well locations. Thus, the units cannot access remote well locations accessible only by those roads.

[0007] Configuring known wireline units to carry higher weights results in higher operational costs. Naturally, reducing the amount of equipment on each well logging unit may help control operational costs. However, fewer pieces of equipment per vehicle require additional vehicles to transport items to the well site. As a result, the additional vehicles also have associated procurement and maintenance costs and thus increase overall operational costs. Also, additional vehicles increase potential safety hazards associated with job completion.

[0008] Accordingly, a need exists for a well logging unit that can carry only the equipment necessary to service either a shallow well and/or an intermediate well

market. The desired well logging unit limits equipment size and weight to help control associated operational costs. Further, the desired well logging unit does not require supplemental pieces of well logging equipment placed on extra vehicles. Accordingly, the limitation of extraneous pieces of well logging equipment may, in turn, limit the exposure of operational personnel to possible safety hazards.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0009]** FIG. 1 illustrates a view of a well logging unit with a drum unit, a linear traction winch, a dancer and an auxiliary power supply.
- [0010]** FIG. 2A illustrates a front view of the drum unit.
- [0011]** FIG. 2B illustrates a side view of the drum unit.
- [0012]** FIG. 2C illustrates a front view of the drum unit in an extended position showing the hydraulically powered plug and play shaft drive.
- [0013]** FIG. 2D illustrates a side view of the drum unit in an extended position showing the plug and play shaft drive.
- [0014]** FIG. 3A illustrates a side view of the linear traction winch.
- [0015]** FIG. 3B illustrates a front view of the track mounted gripper block.
- [0016]** FIG. 4A illustrates a front view of a cable dancer unit and associated gearing in both the front and side orientations.
- [0017]** FIG. 4B illustrates a side view of a cable dancer unit and associated gearing in both the front and side orientations.
- [0018]** FIG. 5 illustrates a side view of an auxiliary power supply with regenerative circuit.
- [0019]** FIG. 6A illustrates a side view of a standard platform with assorted pieces of equipment in place over rear axle for transport.
- [0020]** FIG. 6B illustrates a front view of a standard platform with the equipment in place over rear axle for transport.
- [0021]** FIG. 7 illustrates a front view of a track mounting on a truck bed with the equipment positioned for transport.
- [0022]** FIG. 8 illustrates a front view of a track mounting on a truck bed with the equipment positioned for operations.

[0023] FIG. 9 illustrates a side view of a modular platform that can be placed on a variety of truck chassis.

[0024] FIG. 10A and FIG. 10B illustrate a side view of the side and a side view of the rear of the logging truck configured for operations.

[0025] FIG. 11 illustrates a side view of an alternative set up where the control cabin is mounted on a separate vehicle that is connected to the equipment for operation.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0026] In the following description, numerous details are set forth to provide an understanding of the present disclosure. However, it will be understood by those of ordinary skill in the art that the aspects may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0027] Referring to FIG. 1, a transport truck **10** carries a modular platform **20** to house a control cabin **210**. The modular platform **20** also houses several separate pieces of equipment capable of being configured to meet individual job requirements. The pieces of equipment may include a lightweight drum unit **30**, a cable or wireline **40**, referred to hereafter as the cable **40** and a linear traction winch **50**. The cable **40** may be encapsulated in a carbon fiber polymer jacket. The carbon fiber polymer jacket has a cable sealing capability that simplifies and reduces the amount of pressure control equipment needed to be transported and handled at the well logging site. The equipment may also include a dancer unit **60** that has an upper driven sheave **70**, a lower driven sheave **80** and an auxiliary power unit **90**. The equipment on the platform **20** may be physically rearranged for operation. During operations, the linear traction winch **50** pulls the cable **40** from the drum unit **30** through the winch **50** and into the dancer unit **60**. The upper driven sheave **70** and the lower driven sheave **80** contract and expand in the vertical direction to control the tension in the cable **40** as the cable **40** descends into the well or borehole. Upon job completion, the equipment may be positioned to accommodate storage and transportation on the platform **20**.

[0028] The control cabin **210** is designed to accommodate three persons and has a control console for the winchman, a work area for the logging engineer and a client workspace. The control cabin **210** may be air conditioned and has an acquisition system which is mounted under the control console to conserve space in the control cabin **210**. A pump driven water fin radiator system, similar to that used in the automotive industry, removes heat from the acquisition system. Further, the control cabin **210** is slightly elevated above the platform **20** to allow a large viewing window and to provide an unobstructed view of a winch deck **350** and a rig **360**.

[0029] Referring to FIG. 2A, an embodiment of the lightweight drum unit **30** is shown. The drum unit **30** has a detachable spool **100** with defined end caps **250** that prevent the cable **40** illustrated in FIG. 1 from slipping off the edge of the drum unit **30** while the pieces of equipment are in operation. The drum unit **30** may be constructed from a bonded metal composite material construction derived from technology commonly available in the aerospace industry. The drum unit **30** is high strength and low weight and can hold up to 30,000 feet of the cable **40**. The drum unit **30** has a footprint that fits into available space on the platform **20**.

[0030] FIG. 2B illustrates the removal of the detachable spool **100**. The detachable spool **100** has a plug and play hydraulically powered shaft **260** with bearings **120** that are mounted on a quick release mounting structure **130** illustrated in FIG. 2C. The hydraulically powered shaft **260** rests on bearings **120** in a quick release mounting structure **130** illustrated in FIG. 2D that allows the spool **100** to be replaced in the field.

[0031] FIG. 2C illustrates a hydraulically powered shaft **260** lifting the spool **100** in the vertical direction away from the bearings **120**. The hydraulically powered shaft **260** mounts on the side of the drum unit **30** to allow the drum unit **30** to have a plug and play design instead of being driven by a heavy chain and sprocket assembly. Standard pillow block mounts **270** are used to secure the

drum unit **30** to the winch frame **50** to allow the drum unit **30** to be replaced in the event that the cable **40** requires replacement.

[0032] For operations, activation of the linear traction winch **50** pulls the cable **40** from the drum unit **30**. Thus, the spool **100** rotates in the direction of movement of the cable **40**. The linear traction winch **50** can at least pull or hold the cable **40** under the tension range generally associated with a shallow well market. Further, the drum unit **30** can hold a high tensile load at its core because of its bonded metal composite material construction.

[0033] FIG. 2D also illustrates the bearings **120** that are mounted on the quick release mounting structure **130**. Similar to FIG. 2C, the hydraulically powered shaft **260** can rest on bearings **120** in the quick release mounting structure **130** that allows the spool **100** to be replaced in the field.

[0034] Referring to FIG. 3A, an illustration of the linear traction winch **50** is shown. The winch **50** departs from traditional logging cable deployment. The winch **50** is designed to pull as much as 20,000 pounds in a footprint no larger than three feet by three feet. Further, the design and operation of the winch **50** is similar to winches used to convey transoceanic cables or oilfield coiled tubing.

[0035] For operations, the winch **50** is configured horizontally and has a gripping mechanism in line with the center of the drum unit **30**. This configuration either simplifies or may eliminate the spooling mechanism otherwise required to store the cable **40** on the drum unit **30**. The winch **50** is mounted on a small super structure **280** designed to absorb the tensile load. This feature eliminates reinforcement of the winch deck **350** which is common on known wireline units. The cable **40** enters the winch **50** and is held against slippage by a series of conformed gripping blocks composed of an upper gripping block **150** and a lower gripping block **160**. As shown in FIG. 3B, both the upper gripping block **150** and the lower gripping block **160** squeeze against the cable **40** to hold the cable **40** in place via an adjustable skate mechanism.

[0036] During operation, tension of the cable **40** is relieved on the output side of the winch **50** before the cable **40** is routed to the drum unit **30**. Upon activation of the winch **50**, the endless high strength belts of the winch **50** rotate to allow the upper gripping block **150** and the lower gripping block **160** to either deploy or retract the cable **40**. Further, the winch **50** can be operated individually or in conjunction with the dancer unit **60**. In the event that the winch **50** becomes disabled and has to be removed from the system, the other components, namely the drum unit **30** and the dancer unit **60**, depending on the cable tension, have the capacity to assume winch system master status and to deploy or to recover the cable **40** from a well.

[0037] Each of the components of the winch **50** has a specific role. Accordingly, the drive system of each component is designed for a specific use to simplify associated hydraulic circuitry. Known winch systems often require stoppage of the winch to change drive speed. In contrast, the winch **50** is designed for a smaller overall range of operation and does not require stoppage to change drive speed. The winch **50** incorporates an automatic type of hydraulic drive system allowing it to be more efficient. The winch **50** replaces a continuously variable hydraulic motor for the dual fixed displacement motor when used with a gearbox. Alternatively, the winch **50** may use a direct drive hydraulic motor that does not require a gearbox. With a direct drive hydraulic motor, the response of the winch **50** operating in a tension limiting mode is greatly enhanced. The elimination of the gearbox allows the winch **50** to respond faster to changes in tension and direction without tension spikes.

[0038] Further, by using flow control valves between the pump **330** of the winch **50** and the motor **140** of the winch **50**, the pump **330** can operate at a higher and more stable displacement without affecting how the motor **140** receives minimal flow for slow winch speeds. With a tailored hydraulic system and the use of a proportional, integral and derivative ("PID") controlled proportional valve, the response of the winch **50** can be optimized as needed for various operational conditions.

[0039] The control cabin **210** also has an electronic control module **310** that has engine data stored on a controller area network bus (“CANbus”) **320**. The CANbus **320** is a specialized internal communications network standard designed for microcontrollers and devices to communicate with each other inside a vehicle without a host computer. Module output data can be captured in a file and stored for performance monitoring of the well logging unit. Performance monitoring can lead to predictive failure of components which can be replaced before lost time occurs on a job. The engine data can also be used to analyze failure in lost time incident to the unit. Also, an Ethernet gateway can be used to pull unit data from the CANbus and send the unit data in real time as needed.

[0040] Referring to FIG. 4A, hydraulic shocks **180** are positioned above a base **190**. The hydraulic shocks **180** compress and expand in the vertical direction to maintain a steady tension in the cable **40** and to absorb shock that may result from a sudden increase in tension in the cable **40** that may occur during operations.

[0041] Referring to FIG. 4B, the dancer unit **60** is a device used in wire and cable manufacturing to control tension on the wire or cable. The dancer unit **60** can operate in at least the range of tensions typically seen in the shallow and intermediate well market. The dancer unit **60** is small and has low power requirements. Further, the dancer unit **60** can be operated individually or in tandem with the linear traction winch **50**. Also, the dancer unit **60** may be removed from the system entirely.

[0042] In normal operating conditions, the winch **50** outputs the cable **40** to the dancer unit **60**. In comparison to other types of oilfield equipment, the dancer unit **60** may be a variable capstan that rotates at variable speeds in the horizontal plane for winding in ropes and cables etc. The dancer unit **60** inputs the cable **40** to relax the tension in the cable **40** to a much lower, i.e. non zero, value. The dancer unit **60** then outputs the cable **40** at a relaxed tension into the borehole.

[0043] The dancer unit **60** employs an upper driven sheave **70** and a lower driven sheave **80**. The cable **40** travels from the winch **50** into either the upper driven sheave **70** or the lower driven sheave **80**, depending on the configuration. Both the upper driven sheave **70** and the lower driven sheave **80** may be adjusted in the vertical direction via compression or expansion of hydraulic shocks **180** illustrated in FIG. 4A to maintain sheave block distance at steady tension and to absorb shock of sudden tension increases. By moving closer together during sudden increases in tension, the upper driven sheave **70** and the lower driven sheave **80** give the winch **50** time to react to mitigate the risk of breakage of the cable **40**. The dancer unit **60** is mounted in a vertical orientation above a base **190** illustrated in FIG. 4A.

[0044] The speed at which the dancer unit **60** responds to tension increases in the cable **40** depends largely on the speed, depth and quantity of the cable **40** on the drum unit **30**. At higher speeds and shallow depths, a shutdown circuit may not react fast enough for the winch **50** to safely shutdown before either a downhole tool is pulled loose from the cable **40** or the cable **40** itself is severed. The dancer unit **60** also deploys an additional amount of the cable **40** as tension in the cable **40** increases to prevent breakage of the cable **40** resulting from the increase in tension. This feature allows faster operating speeds near the surface while maintaining a high level of safety.

[0045] An encoder device to measure cable footage deployed or rewound is incorporated into the downhole output sheave. The downhole output sheave may be either the upper driven sheave **70** or the lower driven sheave **80** depending on configuration. The axle of the downhole output sheave incorporates a strain device for measuring the cable tension.

[0046] The dancer unit **60** is designed to cover an optimal range of cable tensions anticipated for depths of the wells where the dancer unit **60** is used rather than the absolute maximum expected tension. As a result, the dancer unit **60** can have a more compact and lightweight design.

[0047] Referring to FIG. 5, a small 150 horsepower auxiliary power supply **90** provides the hydraulic power and the electrical power requirements of the system. In an embodiment, the auxiliary power supply **90** is powered by diesel **200**. A regenerative hydraulic circuit **290** is used to achieve the low power requirement and to eliminate the need for a large hydraulic power plant. Further, the auxiliary power supply **90** is used to drive a pump driven generator which is used to supply operating power to the control cabin **210**. The auxiliary power supply **90** runs continuously during operations to power the various pieces of equipment. Thus, the equipment can function without receiving power from the engine of the transport truck **10**. This ability saves fuel and reduces associated maintenance costs and emissions to the environment.

[0048] Referring to FIG. 6A, the size of the transport truck **10** used to convey the equipment to the well site can be minimized due to the light weight and small footprint of the equipment. Also, the standard platform **20** on which the pieces of equipment are mounted can be installed on a variety of conventional, commercially available flatbed trucks with a sixteen feet by eight feet bed.

[0049] Referring to FIG. 6B, the platform **20** includes a bolt on winch deck that has a large belly pan **340**. The large belly pan **340** has a track system **300**. The track system **300** may be hydraulically operated. Individual pieces of equipment are then mounted onto the track system **300**. The track system **300** moves to position the equipment to optimally distribute weight over the axle of the transport truck **10** during transport. The bolt on winch deck **350** of the platform **20** can attach to a variety of different types of chassis of the transport truck **10**. Accordingly, the well logging unit is not dependent on a particular chassis and can be selected by availability within the relevant geographical market.

[0050] FIG. 7 illustrates a top view of the track mounted equipment on the standard platform **20** with the equipment positioned for transport. The inset tracks **300** on the standard platform **20** allow the equipment to be moved around the truck bed as needed for optimal weight distribution. Accordingly, the spool

100, the dancer unit **60**, the linear traction winch **50** and the auxiliary power unit **90** are positioned as needed for optimal weight distribution. The control cabin **210** is positioned for optimal weight distribution of the equipment.

[0051] FIG. 8 illustrates a top view of the track mounted equipment on the standard platform **20** with equipment positioned for operations. The inset tracks **300** on the standard platform **20** allow the equipment to be moved around the truck bed as needed for operations with the auxiliary power unit **90** removed from the truck and placed on the ground. The auxiliary power unit **90** can also be removed from the insert tracks **300** and loaded onto the ground during operations.

[0052] FIG. 9 illustrates a side view of the modular platform **20** holding various pieces of equipment. The modular platform **20** is detachable from the transport truck **10** and can be placed on a variety of transport truck chassis.

[0053] During operations of the logging truck **10**, the auxiliary power unit **90** is removed from the platform **20** of the logging truck **10** and positioned onto the ground. FIG. 10A illustrates a side view of the new generation logging truck **10** configured to have the auxiliary power unit **90** loaded onto the ground for operations. The auxiliary power unit **90** can provide the necessary power for the cable **40** to be deployed into the well or borehole.

[0054] FIG. 10B illustrates a rear view of the new generation logging truck **10**. The various pieces of equipment are arranged linearly to allow the cable **40** to be deployed into and retracted from the borehole. Further, the auxiliary power unit **90** is placed on the ground to provide power for the cable **40**.

[0055] FIG. 11 illustrates a side view showing an electronic control module **310** that has engine data stored on a controller area network bus ("CANbus") **320**. The electronic control module **310** is used to operate the well logging unit and may be mounted in a separate vehicle such as a commercial van **240** via a

connection **230** to the control cabin **210**. Mounting the electronic control module **310** in a separate vehicle reduces various requirements for the control cabin **210**. Also, mounting the electronic control module **310** in a separate vehicle creates space on the platform **20** that may now be used for storing tools.

[0056] Equipment necessary for a job may be selected and/or loaded for taking to the job site. Also, the portable well logging unit is based on a standard platform that can be mounted onto a variety of commercially available truck chassis. The well logging unit has a smaller footprint than known well logging units. Further, the well logging unit has equipment that relieves tensile energy as needed to service the range of tension often associated with deep wells.

[0057] In one embodiment a method for positioning equipment on a platform for placement on a vehicle is disclosed, comprising: placing a track system on the platform to move the equipment, mounting the equipment on the track system wherein the equipment enables deployment of the cable and moving the equipment on the track system to a position to descend a cable through a borehole.

[0058] Although exemplary systems and methods are described in language specific to structural features and/or methodological acts, the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as exemplary forms of implementing the claimed systems, methods and structures.

We claim:

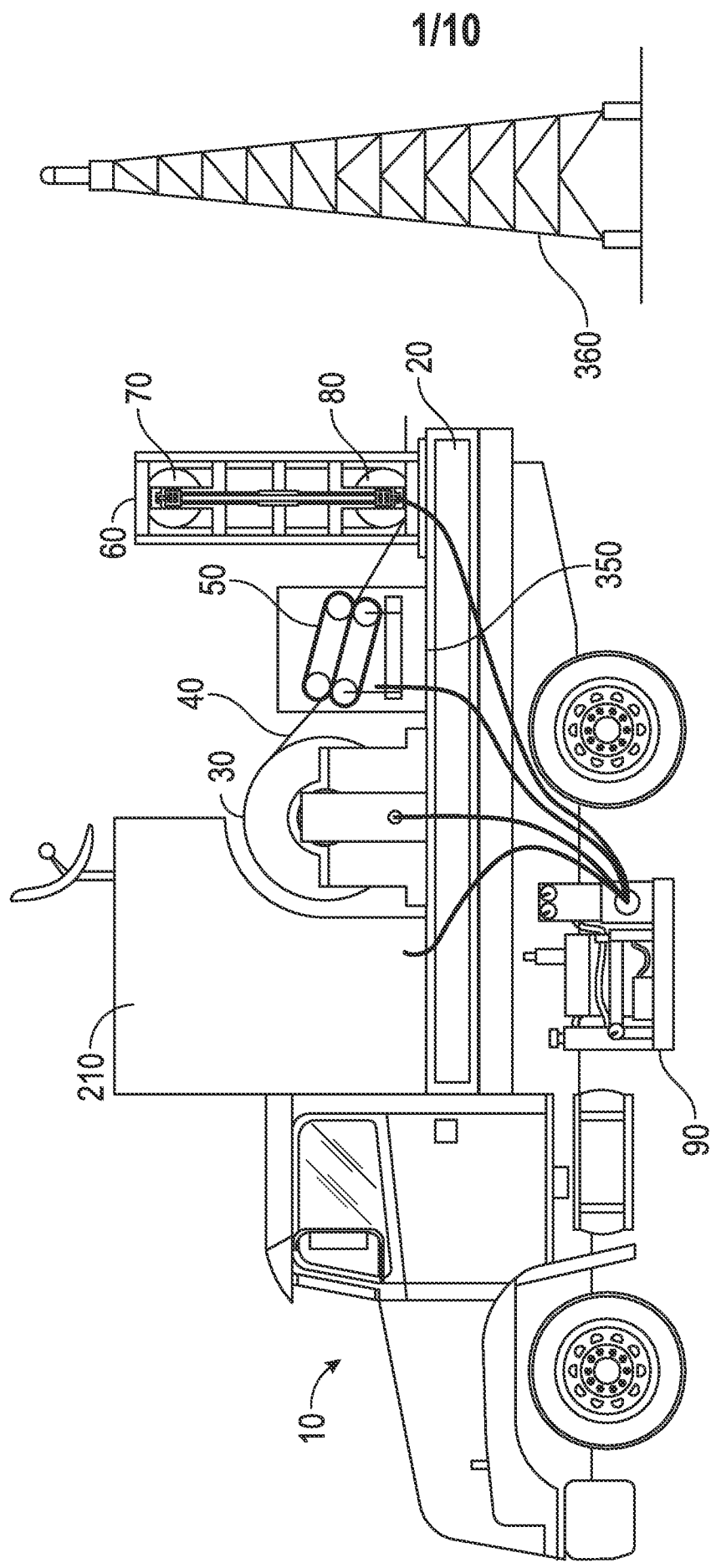
1. A method for positioning equipment on a platform for placement on a vehicle, comprising:
 - placing a track system on the platform to move the equipment;
 - mounting the equipment on the track system wherein the equipment enables deployment of the cable; and
 - moving the equipment on the track system to a position to descend a cable through a borehole.
2. The method of claim 1, comprising:
 - securing a drum unit on a winch frame.
3. The method of claim 1, comprising:
 - adhering a gripping block onto a winch to abut against the cable.
4. The method of claim 1, comprising:
 - deploying the cable through a dancer unit to control a tension in the cable.
5. The method of claim 1, comprising:
 - powering the track system with a hydraulic power supply.
6. The method of claim 1, comprising:
 - controlling the equipment from an electronic control module.
7. A method for deploying a cable into a borehole, comprising:
 - situating equipment on the track system to deploy the cable into the borehole;
 - threading the cable through the equipment;
 - sending a signal from an electronic control module to control the equipment; and
 - descending the cable wherein the cable travels through the equipment into the borehole to obtain well logging data.
8. The method of claim 7, comprising:
 - reducing an increase in a tension in the cable through a compression of a shock absorber on a dancer unit.

9. The method of claim 7, comprising:
preventing slippage of the cable by mounting a gripping block on a winch to abut against the cable.
10. The method of claim 7, comprising:
deploying the cable from a dancer unit in response to an increase in tension in the cable.
11. The method of claim 7, comprising:
maneuvering the cable through a driven sheave in a dancer unit.
12. The method of claim 7, comprising:
measuring footage of the cable.
13. The method of claim 7, comprising:
measuring tension in the cable on a driven sheave.
14. The method of claim 7, comprising:
monitoring equipment performance during cable deployment.
15. A system for positioning equipment on a track system mounted on a platform, comprising:
a drum unit;
a winch;
a dancer unit that deploys cable to control an increase in a tension in the cable;
a cable threaded through the drum unit, the winch, and the dancer unit to descend into a borehole; and
a power supply that provides power to the equipment.
16. The system of claim 15, wherein the cable being encapsulated by a carbon fiber polymer jacket.
17. The system of claim 15, wherein the drum unit maneuvers the cable.
18. The system of claim 15, wherein the winch rotates to pull the cable from the drum unit.
19. The system of claim 15, comprising:
a shock absorber on the dancer unit that compresses to reduce tension in

the cable.

20. The system of claim 15, comprising:

an electronic control module that sends a signal to control the drum unit, the winch and the dancer unit.



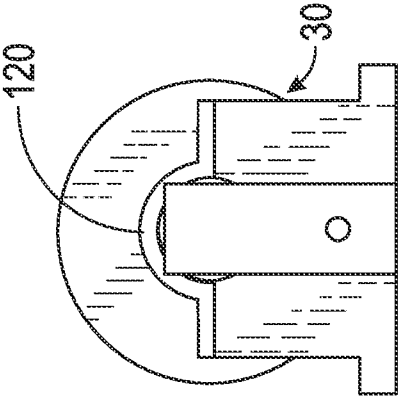


FIG. 2B

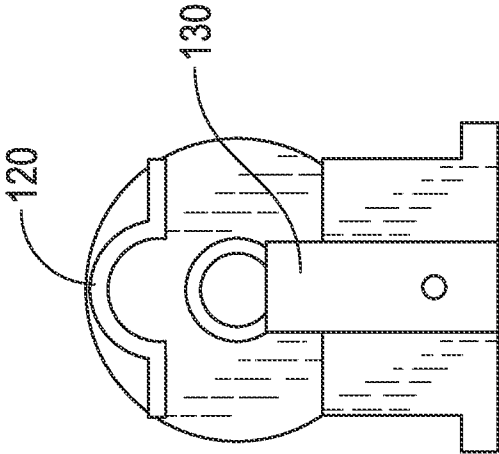


FIG. 2D

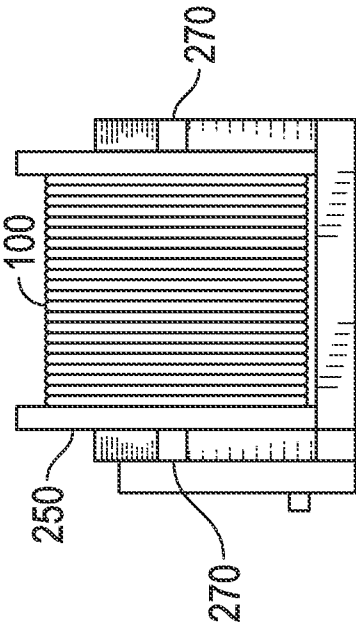


FIG. 2A

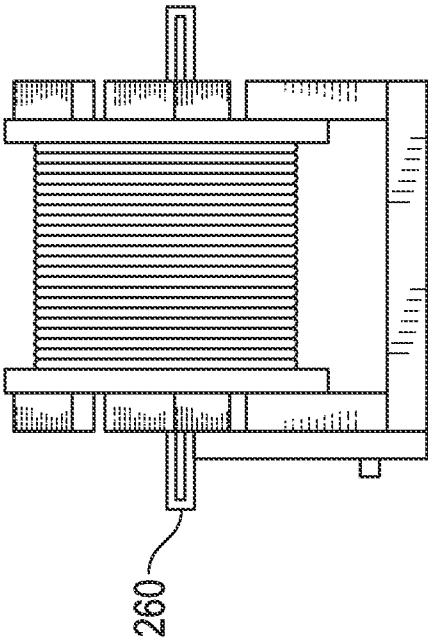


FIG. 2C

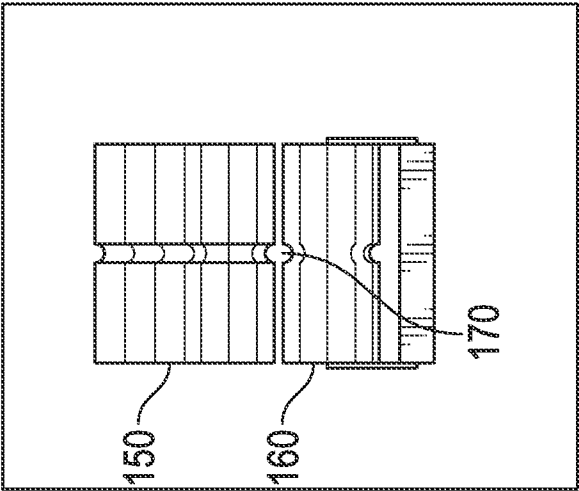


FIG. 3B

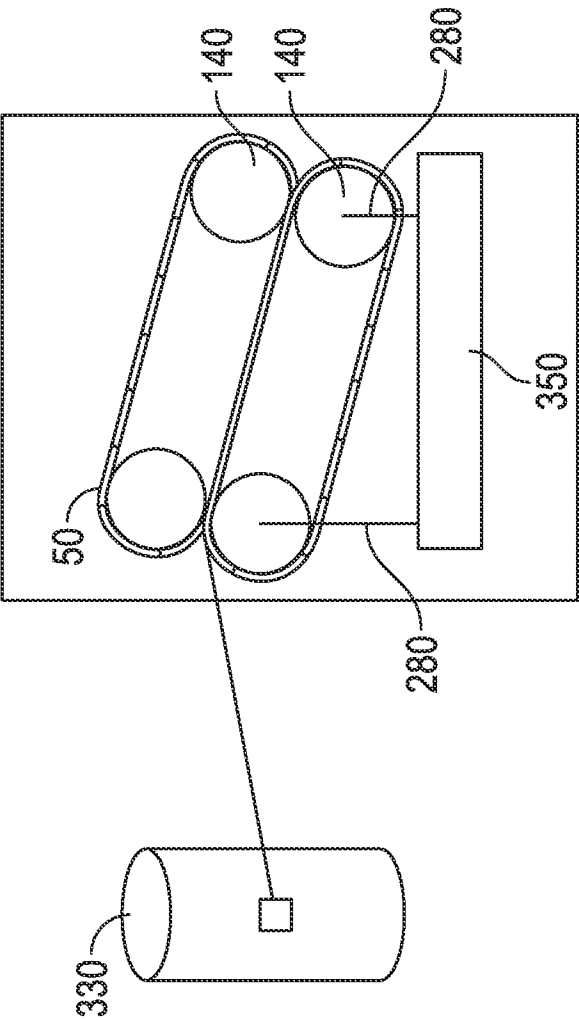


FIG. 3A

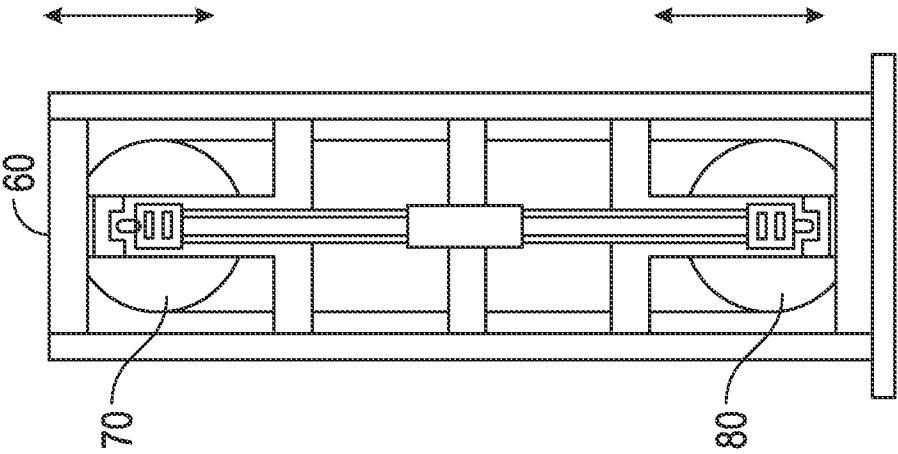


FIG. 4B

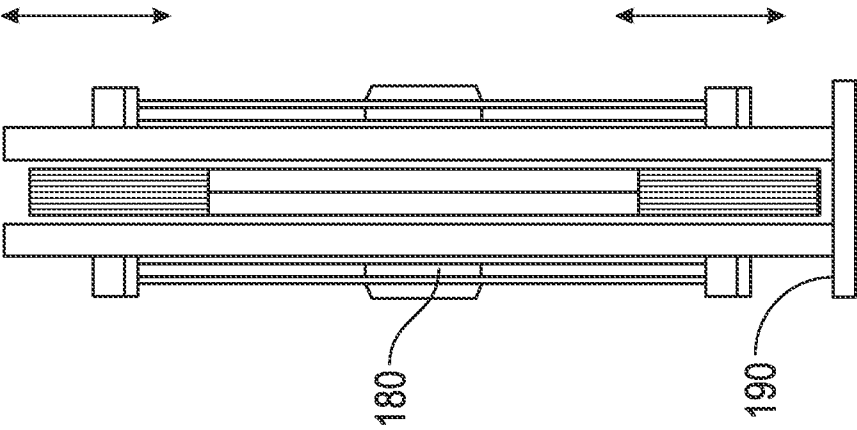


FIG. 4A

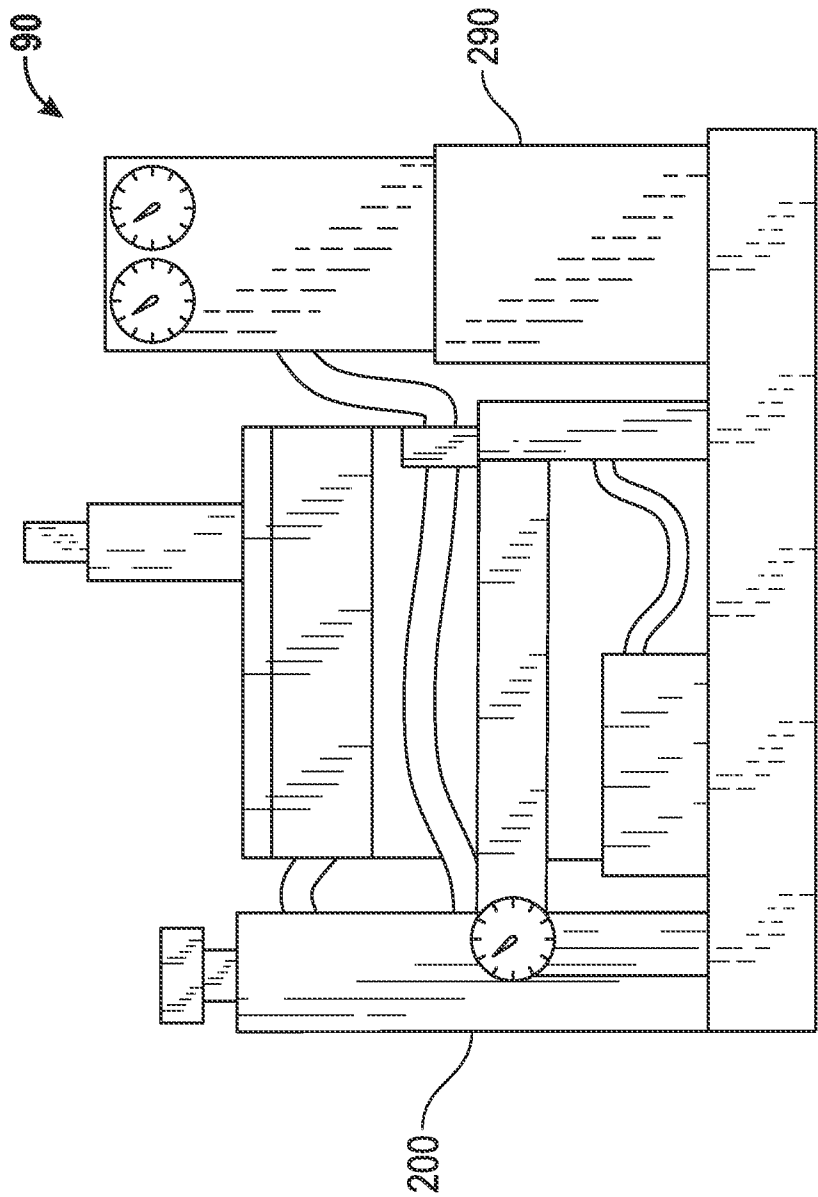


FIG. 5

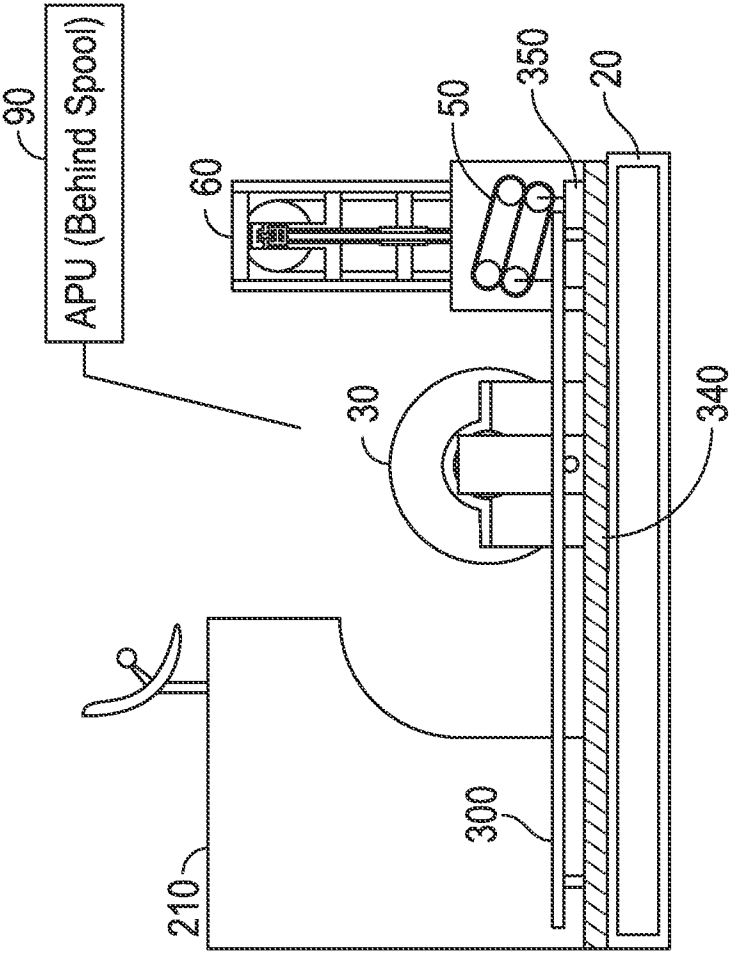


FIG. 6A

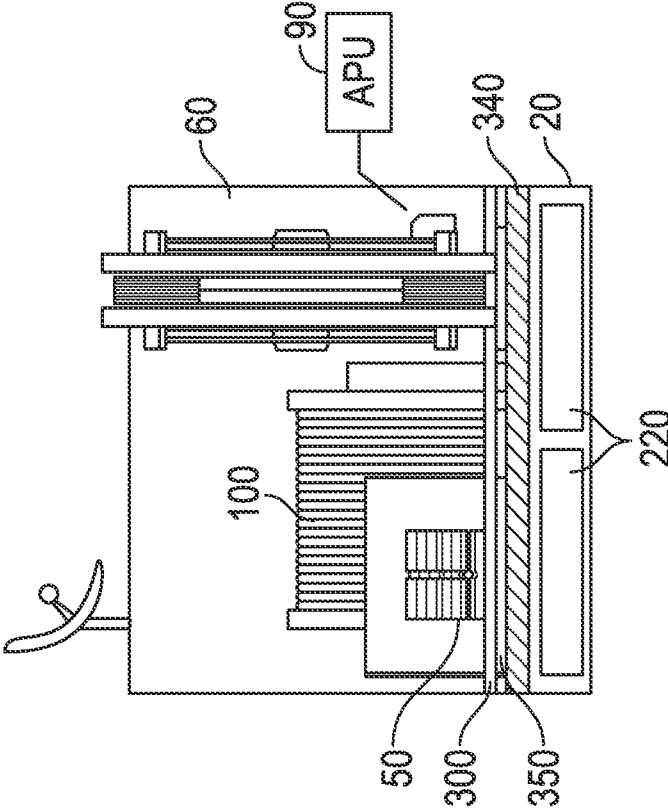


FIG. 6B

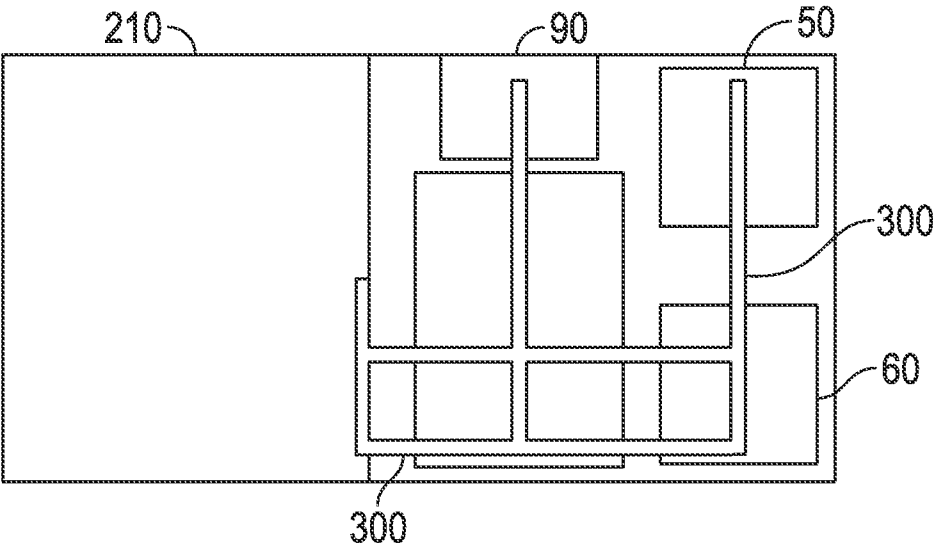


FIG. 7

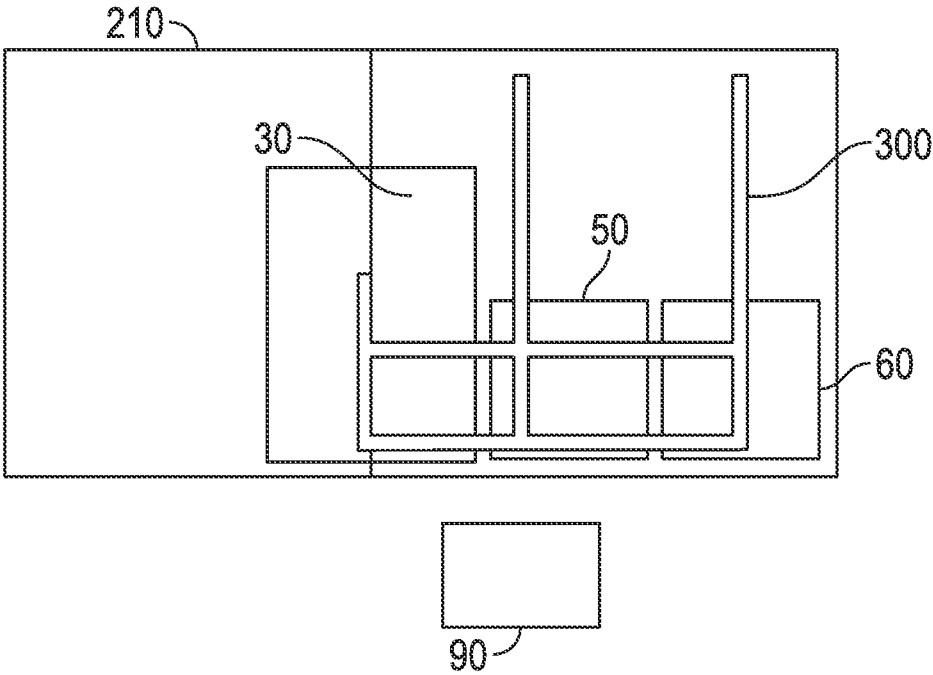


FIG. 8

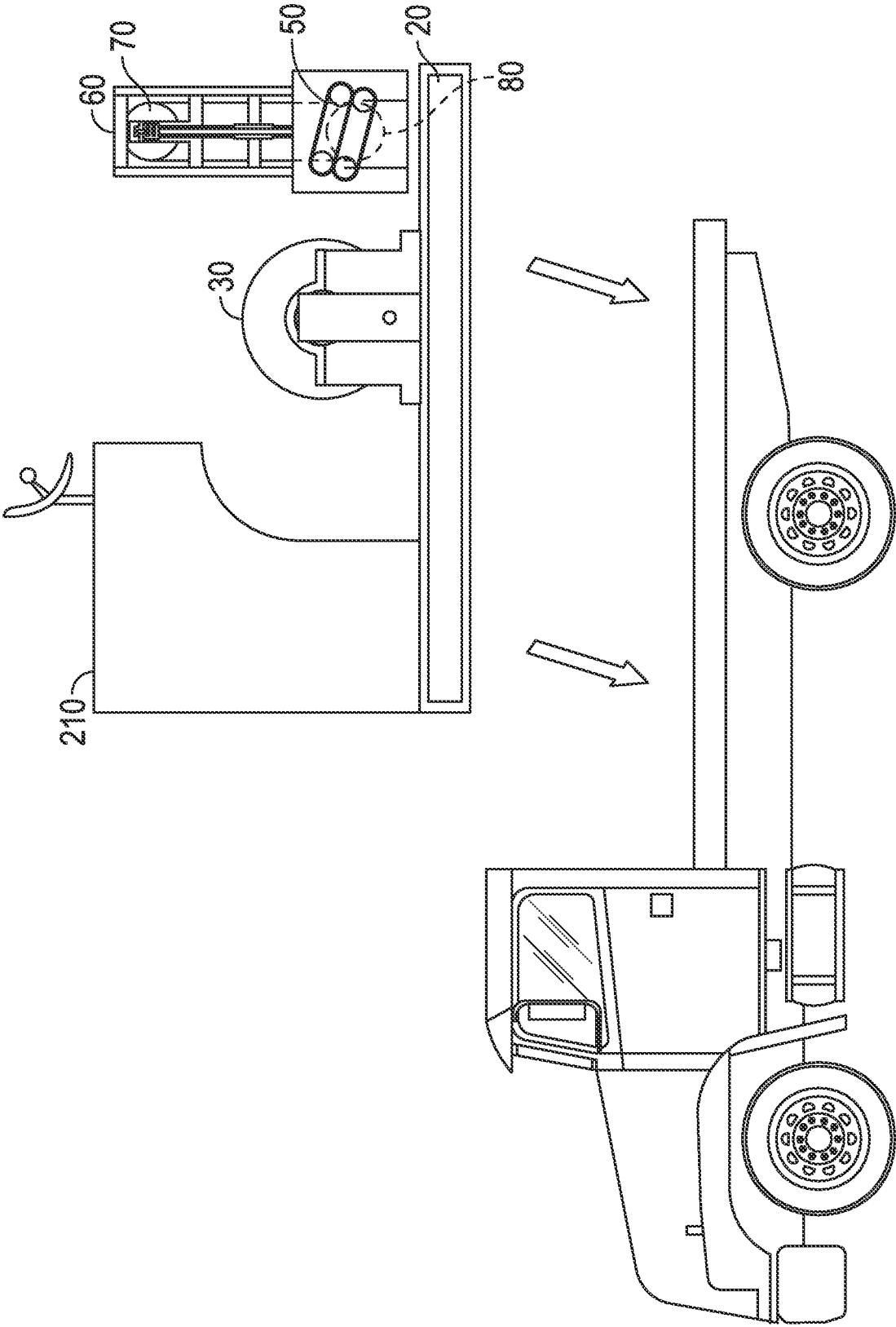


FIG. 9

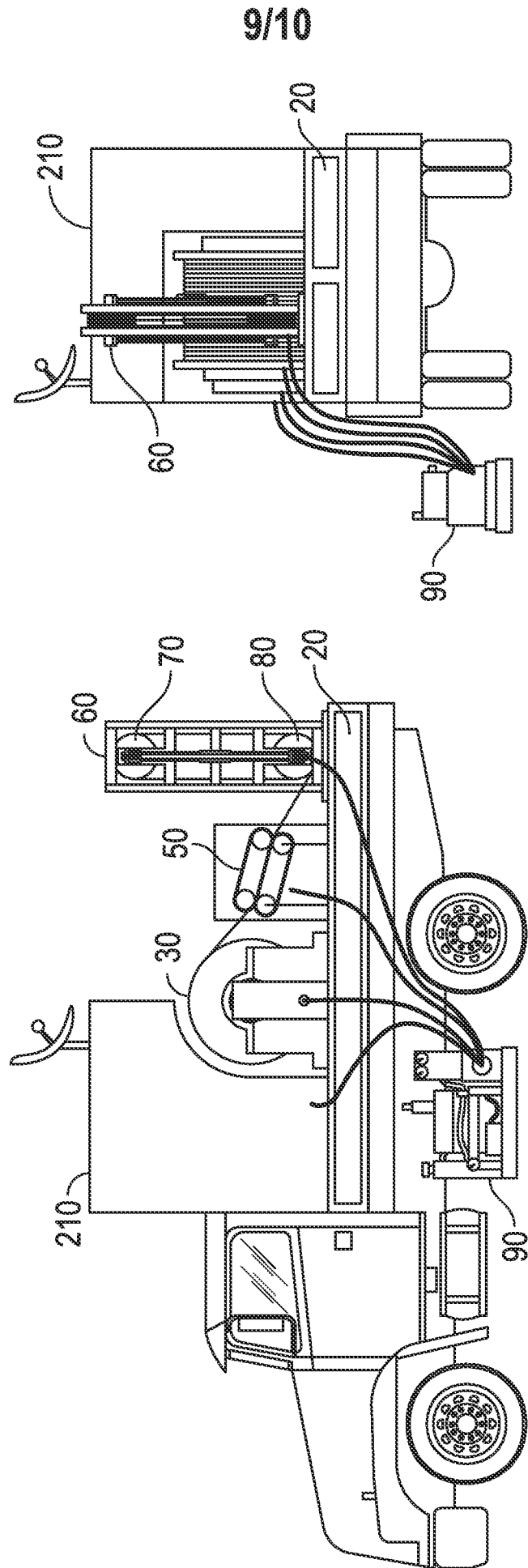
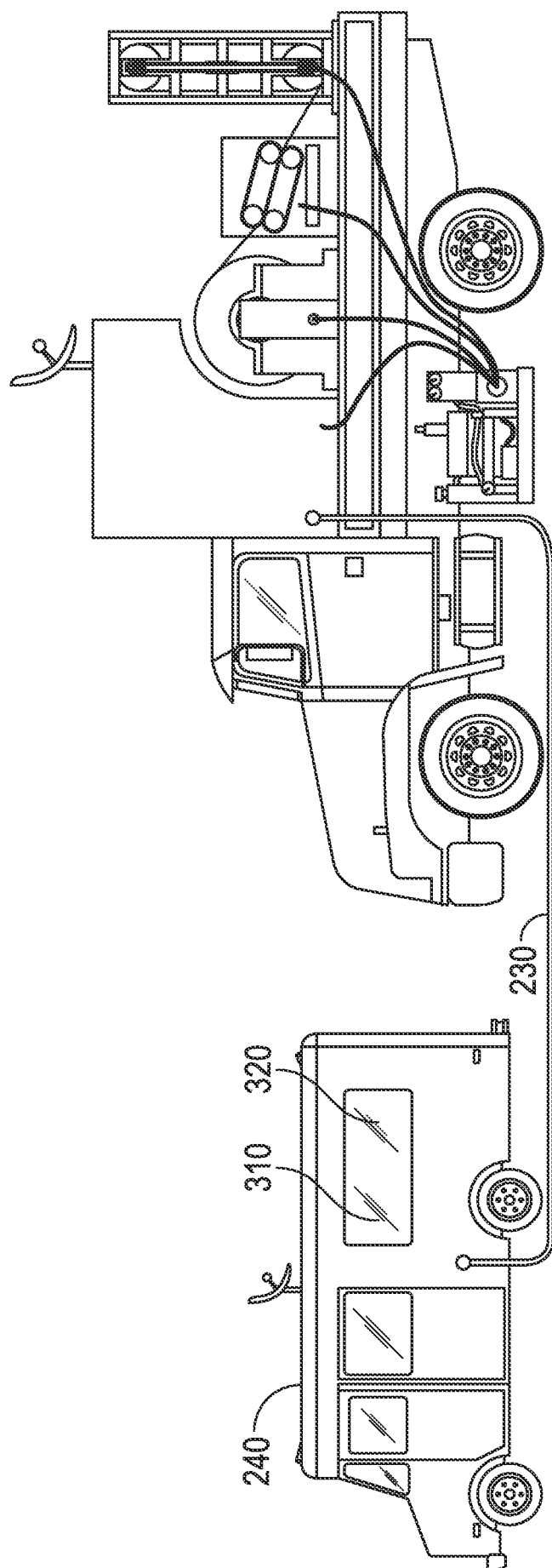


FIG. 10B

FIG. 10A

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/071407**A. CLASSIFICATION OF SUBJECT MATTER****E21B 23/14(2006.01)i, E21B 7/02(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)

E21B 23/14; B32B 1/08; E21B 47/01; E21B 19/08; G01V 1/40; B62D 21/00; E21B 19/02; E21B 17/00; E21B 19/084; E21B 7/02

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: well logging unit, track, cable, drum unit, winch, dancer unit, power supply, and electronic control module

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4765435 A (REICHERT, VOLKER L.) 23 August 1988 See column 4, line 33 - column 5, line 25, column 6, lines 14-32, column 7, line 47 - column 8, line 60 and figures 1, 5-6.	1,5-7
Y		2-4,8-20
Y	US 2009-0020294 A1 (VARKEY, JOSEPH et al.) 22 January 2009 See paragraphs [0020], [0024]-[0025], [0032]-[0034], [0044] and figures 1-2B, 5.	2-4,8-20
Y	US 2009-0242194 A1 (VARKEY, JOSEPH et al.) 01 October 2009 See paragraphs [0021], [0026] and figures 1-2.	16
A	US 2009-0260804 A1 (MYDUR, RAVICHARAN et al.) 22 October 2009 See paragraphs [0015]-[0018] and figures 1-2.	1-20
A	US 6148925 A (MOORE, BOYD B.) 21 November 2000 See column 4, lines 49-66, column 9, lines 56-67 and figures 1, 10.	1-20

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search

05 March 2014 (05.03.2014)

Date of mailing of the international search report

06 March 2014 (06.03.2014)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/071407

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