**SUMMARY OF THE INVENTION**

According to an aspect or an embodiment of the present invention there is provided a wireline sheave apparatus comprising:

a sheave ~~configured~~ for accommodating a wireline;

a sheave mounting configured for coupling to a wireline stuffing box, the sheave being mounted on the sheave mounting; ~~and~~

a sensor for measuring ~~at least one of~~ wireline tension ~~and deployed wireline length~~ at the sheave; and

a load pin,

wherein the sensor comprises a strain gauge which is arranged to measure strain on the load pin,

wherein the sheave mounting comprises a frame which includes a first frame part and a second frame part, the first and second frame parts being arranged such that tension on the wireline tends to cause the first and second frame parts to pivot relative to one another, and

wherein the load pin is arranged to prevent the first and second frame parts from pivoting relative to one another so that the strain measured by the strain gauge on the load pin is indicative of wireline tension.

The sensor may be configured for measuring deployed wireline length at the sheave.

The sheave mounting may include the sensor.

~~According to another aspect of the present invention there is provided an apparatus comprising: a sheave for accommodating a wireline; and a sheave mounting configured for coupling to a wireline stuffing box and including a sensor for measuring at least one of wireline tension and deployed wireline length.~~

According to an ~~further~~ aspect or an embodiment of the present invention there is provided a wireline work method comprising:

mounting a sheave on a sheave mounting;~~,~~

coupling the sheave mounting to a wireline stuffing box;~~,~~ and

passing wireline around the sheave,

wherein the sheave mounting comprises a frame which includes a first frame part and a second frame part, the first and second frame parts being arranged such that wireline tension tends to cause the first and second frame parts to pivot relative to one another, a load pin is arranged to prevent the first and second frame parts from pivoting relative to one another, and a strain gauge is arranged to measure strain on the load pin so as to indicate wireline tension.

The wireline work method may comprise measuring ~~at least one of wireline tension and~~ deployed wireline length at the sheave.

It should be understood that the steps of mounting a sheave on a sheave mounting, coupling the sheave mounting to a wireline stuffing box and passing wireline around the sheave may be performed in any order. The steps of mounting a sheave

on a sheave mounting, coupling the sheave mounting to a wireline stuffing box and passing wireline around the sheave may be performed sequentially. The steps of mounting a sheave on a sheave mounting, coupling the sheave mounting to a wireline stuffing box and passing wireline around the sheave may at least partially overlap.

The provision of the sensor as part of the wireline sheave apparatus for measuring at least one of wireline tension and deployed wireline length at the sheave may obviate the requirement to provide a separate measuring device at a location different to or remote from that of the wireline sheave apparatus, thus simplifying the wireline set-up, and removing the requirement to feed the wire through the separate measuring device. Alternatively, or in addition, the apparatus may be used to supplement a more conventional measuring arrangement. Also, compared to a conventional two or three wheel wrap-around measuring device, the number of bending cycles the wireline experiences may be substantially reduced, reducing wireline fatigue and extending wireline life.

Wireline may comprise a solid, single strand or a multi-strand wire. Solid, single strand wires are known by various terms, including: slick line; piano wire; solid line; wireline, and measuring line. Multi-strand wire is also referred to by a range of terms, including: braided wire; multi-strand wire (or line); torpedo line, and well-shooter's line. Solid wireline is available in a range of diameters, typically 0.092, 0.108, 0.125, 0.140, 0.150 and 0.160 inches. Multi-strand wire is generally of 3/16, or 7/32 inches in diameter, but is also available in other sizes. Wireline is available in a range of materials, such as mild steel and various alloys, including stainless steels, Monel (trademark) nickel alloys and Inconel (trademark) austenitic nickel-chromium-based superalloys for corrosive environments. Wireline may also be formed of or incorporate composites and signal carrying-elements, such as electrical wiring or optical fibres.

The apparatus may include a transmitter for relaying information gathered by the sensor to an appropriate location, for example a wireline control unit, which may record or display gathered information. The transmitter may operate wirelessly, thus obviating the requirement to provide a physical link between the apparatus and the wireline control unit. An operator may therefore dispense with the conventional requirement to provide and hook up signal cables, and there is then of course no danger of damaging such cables during wireline operations. The provision of wireless transmission, for example using radio frequency transmitters and receivers, also facilitates signal transmission to a variety of different locations, for example a local wireline unit and a more remote control centre.

The apparatus may be configured for coupling to an upper end of a stuffing box or lubricator string such that the wireline extending between the sheave and the stuffing box is aligned with the wireline passing through the stuffing box.

Embodiments of the invention may incorporate a stuffing box or a lubricator string. The stuffing box may take any appropriate form, and may include sealing or packing elements to provide a sliding, sealing contact with the wireline. The packing

elements may take any appropriate form and may be hydraulically actuated. The lubricator string may include integrated pressure sensors for providing well pressure and stuffing box hydraulic pressure information during operation.

The sheave may be configured to guide the wireline from a bottom hay pulley into the top of the lubricator and into a well.

The apparatus may be configured such that the sheave contact angle with the wireline is maintained substantially constant, typically at or around 180 degrees, facilitating provision of accurate wireline tension information. This may be assured by provision of guides, such as appropriately positioned rollers.

The sheave may serve as a wireline length measuring wheel and have a calibrated outer diameter. The sheave wheel may have a wear resistant rim. The sheave wheel may have a lightweight material hub to reduce weight and inertia.

The sheave may include a wire retaining arrangement, such as an arrangement of spring-mounted wire retainer rollers, or a wire wrap-around, to ensure that the wireline is maintained in contact with the sheave. This assists in minimizing or preventing wire slippage at low wire tension, thus minimizing measurement error. The retaining force provided by the arrangement may be selected to ensure that axial translation of the wire translates to corresponding rotation of the sheave wheel, even with sudden changes of direction such as experienced during jarring operations. The arrangement may also serve to retain the wire in the sheave groove, and this may be useful during set-up of a wireline-running operation. The arrangement may be configured to press the wire against the sheave regardless of wire size.

The apparatus may include provision for measuring one or more of wireline length, wireline tension and wireline speed. The apparatus may include provision for measuring stuffing box pressure or well pressure, or may be configured to communicate with appropriate pressure sensors in a lubricator assembly or other apparatus.

~~The sheave mounting may comprise a suitable bracket or frame. The frame may provide mounting for one or more sensors. The frame may take any appropriate form and may be in one or more parts. Sensors may be provided between elements of the frame to measure parameters indicative of forces acting on the wireline. A strain gauge may be mounted on the frame and may be utilized to measure wire tension. In one embodiment parts of the frame may be arranged to pivot relative to one another and tension on the wireline may tend to cause the parts to pivot, such that a strain gauge on a load pin preventing the parts from pivoting may be utilized to measure wireline tension.~~ Dual independent strain gauges may be provided, such that back-up is available should one strain gauge fail. Alternatively, or in addition, a hydraulic load cell may be mounted on the frame.

The apparatus may be configured to measure the length of wire passing over the sheave, indicative of the length of wire in the well. The apparatus may include one or more sensors configured to measure one or more of sheave rotation and sheave

rotation direction. Such sensors may include one or more of a mechanical counter, encoder and electromagnetic speed sensor. In one embodiment the mechanical counter and encoder provide a primary output with the electromagnetic speed sensor providing an independent back-up signal.

The apparatus may be configured to permit depth and tension to be displayed and recorded on an electronic display in an associated wireline unit, which may form an element of the invention. The wireline unit may be configured to process signals received from the sensors to provide depth figures which are accurate for the diameter of wireline being used, without requiring replacement of the sheave wheel. This correction may be achieved electronically in a display, using the depth information provided by the encoder and wireline diameter information supplied by the operator or by appropriate sensors.

One or more of depth, tension and well pressure signals may be transmitted wirelessly to a receiver connected to the electronic display or an associated processor. An electronics module for transmitting the signals may be mounted on the sheave mounting. The module may house one or more of sensor amplifiers, power supply, batteries, transmitters and antenna.

The apparatus may include an independent power source. The apparatus may include a power source which is recharged through rotation of the sheave, for example a battery may be charged by a generator in an encoder and an energy harvesting module.

It will be apparent to those of skill in the art that many of the various optional features described above have utility independently of the particular aspects of the present invention to which they refer. Accordingly, these optional features may themselves provide further individual aspects of the invention, some of which are set out below.

~~Another~~ method is described herein comprising~~aspect of the invention relates to~~ running wireline and measuring at least one of wireline tension and length, wherein the wireline experiences less than eleven bending cycles between the wireline winch and the stuffing box.

A ~~further aspect of the present invention relates to a~~ stuffing box sheave assembly is described herein including a sensor and a transmitter for transmitting signals from the sensor to a unit for storing or displaying information gained from said signals.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates typical wireline operation surface equipment;