A drilling rig comprising a derrick, a crown block and a travelling block, a wireline and a drawworks for taking in and playing out the wireline, characterised in that the drawworks comprises a motor (130) having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising a power cable (150) passing through the motor shaft (130), wherein the motor further comprises one channel (139,142) arranged adjacent the power cable (150) for the passage therethrough of a fluid for cooling the power cable.
Abstract: A drilling rig comprising a derrick, a crown block and a travelling block, a wireline and a drawworks for taking in and playing out the wireline, characterised in that the drawworks comprises a motor (130) having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising a power cable (150) passing through the motor shaft (130), wherein the motor further comprises one channel (139, 142) arranged adjacent the power cable (150) for the passage therethrough of a fluid for cooling the power cable.
A DRILLING RIG AND DRAWWORKS THEREFORE

The present invention relates to drawworks, a motor for drawworks, a drilling rig incorporating a drawworks and methods of using a drawworks.

A drawworks is used in connection the raising and lowering of a variety of loads. In wellbore operations, such as drilling a well for oil or gas, a drawworks is used on a rig or with a derrick to hold and to raise and lower tubulars, e.g., but not limited to, a drill string and associated equipment above, into and/or out of a wellbore. A travelling block, having an appropriate hook or other similar assembly typically used for the raising and lowering operations is secured in block-and-tackle fashion to a crown block or other limit fixture located at the top of the rig or derrick. Operation of the travelling block is performed by means of a hoist cable or line, one end of which is secured to the rig floor or ground forming a "dead line", with the other end secured to the drawworks proper and forming a "fast line". Other load bearing assemblies are possible. Herein such load bearing assemblies are referred to as the "travelling block", which can include a hook or other attachment, associated equipment, and/or other load associated therewith as it moves up and down.

In certain aspects, prior drawworks include a rotatable cylindrical drum upon which cable or fast line is wound by means of a prime mover (motor) and power assembly. The drawworks and travelling block assembly are automatically controlled or operated by an operator, e.g. a "driller". In association with the raising of the travelling block, the prime mover (motor) is controlled by the operator e.g. with a foot or hand throttle; or the drawworks is automatically controlled by a suitable
control system. The drawworks is supplied with one or more suitable brakes - for routine operation and for emergencies. The lines or wirelines are usually wire ropes or steel cables, although other materials have also been used.

Drawworks' motors are relatively heavy high-horsepower motors. They provide the power to raise and lower loads that can be many hundred ton loads, some exceeding a thousand tons. Power cables that provide power to these motors can heat up due to the high flow of current through the cables. In the past these cables have been insulated and cooled with air flow or cooled by the media in which a cable is located, e.g. the earth. With certain known cooling methods there is insufficient heat exchange and, regarding certain cooling media, the media must be compatible with cable insulation or with the cable wires.

There is a need, recognized by the present inventors, for effective and efficient drawworks and motors for them. There is a need, recognized by the present inventors, for effective and efficient drawworks motor with power cables maintained at an efficient operating temperature.

According to the present invention, there is provided a drawworks for use in wellbore operations, the drawworks comprising a motor having a rotor, a stator and at least one winding the drawworks further comprising at least one wire passing through at least part of the motor, characterised in that the motor further comprises at least one channel arranged adjacent the at least one wire for the passage therethrough of a heat exchange fluid for the exchange of heat with the at least one wire to cool the at least one wire. The wire is for conducting
carries a high current. The wire may comprise the length of wire carrying the electrical current to the stator and/or rotor and may include at least part of the windings. Drawworks need a high power motor to be able to lift strings of drill pipe or casing, which may be in excess of 500 tonnes. The wire can carry a certain current. Beyond a certain current, the wire may heat up a noticeable amount, which may melt any insulating material that the wire is in and heat up any equipment which is in close proximity to the wire.

Preferably, the motor further comprises a shaft, the wire passing through the shaft. Advantageously, the at least one channel passes through the shaft. Preferably, the at least one wire is arranged in a bore in the shaft. Preferably, the bore is substantially centrally located in the shaft. Advantageously, the shaft has a first portion and a second portion, the stator between the first portion and the second portion, said at least one channel extending from the first portion, through the stator, and to the second portion, and said heat exchange fluid entering the at least one channel at the first portion and exiting from the second portion. Preferably, the stator is in a fixed relation to the shaft, the shaft substantially non-rotating. Integrally formed with the stator or otherwise fixed thereto. The shaft may be non-rotating to the extent that it will not rotate during normal operation, but may be allowed to rotate during special operations or when being serviced.

Advantageously, the drawworks further comprises a drum for taking in and playing out a wireline. Preferably, the drum is fixed to the rotor. Preferably, the drum has at least one groove for receiving a wireline. Advantageously, the drum is rotatably arranged
about the shaft. Preferably, the drum is rotatable about the shaft on bearings. Preferably, the length of the channel in the motor is at least as long as the at least one wire in the motor.

 Advantageously, the stator and the rotor are arranged within the drum. Preferably, the at least one channel is arranged substantially parallel with the at least one wire, advantageously, at least along the majority of the length of the wire within the motor.

 Preferably, the at least one channel is a plurality of channels. Advantageously, the plurality of channels are arranged substantially parallel with the wire and the plurality of channels arranged about the at least one wire.

 Advantageously, the at least one wire is a plurality of wires in a bundle. Preferably, the at least one wire is isolated with a sheath. Each wire in the plurality of wires in the bundle may be individually isolated with a sheath. Preferably, the at least one wire is potted in a matrix of potting material. The potting material may be an epoxy. The wire may have a sheath and the sheathed wire or plurality of sheathed wires may be potted in a matrix of potting material, such as epoxy, within a bore in a steel shaft of the motor, the steel shaft having a plurality of coolant carrying bore holes surrounding the bore carrying the wires. The steel shaft could be made from any other suitable material, such as aluminium, or other alloy. Advantageously, each of the plurality of wires in the bundle is potted in a matrix of potting material.

 Preferably, the rotor arranged about the stator. Advantageously, the at least one channel is arranged in the stator in close proximity to the windings for
maintaining the temperature of the windings within a predetermined range. Preferably, the pre-determined range is defined by the conductivity of the windings, the windings conductivity characteristics and a safety factor.

Advantageously, the wire is connected to the winding. Preferably, integral with the winding such as a continuation of the wire, a seamless weld or a weld of higher conductivity that the wire. The wire may be a solid metal conductor or made up of a number of strands. The wire may be copper, copper alloy, silver, aluminium or other electrically conducting material.

Preferably, the at least one winding is arranged on the stator. Advantageously, the motor is a DC motor or preferably, an AC motor and may be a three phase AC motor.

Advantageously the heat exchange fluid is a liquid.

The present invention also provides a drilling rig comprising a derrick, a crown block and a travelling block, a wireline and a drawworks of the present invention.

The present invention also provides a motor of the drawworks of the present invention.

The present invention also provides a method for taking in and playing out a wireline on a drilling rig using a drawworks, the drawworks comprising a motor having a rotor, a stator and at least one winding the drawworks further comprising a wire passing through at least part of the motor, characterised in that the motor further comprises at least one channel arranged adjacent the at least one wire, the method comprising the steps of passing a heat exchange fluid through the at least one channel to cool the at least one wire.
The present invention provides a drawworks with may be cooled by heat exchange with cooling flowing adjacent the power cables. In one aspect, the power cables are encased in insulating material to further maintain them at a desired operating temperature. The heat exchange fluid can be any suitable fluid, e.g., but not limited to water, freon, liquid nitrogen, or antifreeze.
For a better understanding of the present invention, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a schematic view of a drilling rig in accordance with the present invention;

Figure 1A is a schematic view of a motor of the drilling rig shown in Figure 1;

Figure 2A is a side view in cross-section of a drawworks in accordance with the present invention;

Figure 2B is an enlarged view of part of a motor of the drawworks shown in Figure 2A;

Figure 2C is an end view of part of the motor shown in Figure 2A;

Figure 3A is a perspective view of a shaft of the motor shown in Figure 2A;

Figure 3B is a perspective view of part of the shaft shown in Figure 3A;

Figure 3C is an end view of part of the shaft shown in Figure 3A;

Figure 4A is a perspective view of a shaft in accordance with the present invention for a motor in accordance with the present invention; and

Figure 4B is an end view of the shaft shown in Figure 4A.

Referring to Figure 1 and Figure 1A, a drilling rig R incorporates a drilling apparatus 10 in accordance with the present invention. The drilling rig has a derrick 11. A crown block 15 fixed to a top part of the derrick. Suspended by a rope arrangement 17 from the crown block 15 is a travelling block 20, or load bearing part, for supporting a hook structure 25. Alternatively, the travelling block 20 can be formed as a hook block or other conventional related load bearing parts of a hoist
assembly attached to the rope arrangement 17. As used herein, the term "hook block" refers to the load bearing part 20 of the hoist assembly.

A hoisting line 30 is securely fixed at one end to ground by a dead line 35 and a dead line anchor 40. The other end of the hoisting line 30 forms a fast line 45 attached to a drawworks 50 in accordance with the present invention. The drawworks 50 includes one, two or more electrical motors 55 in accordance with the present invention for rotating a cylindrical rotatable drum 65 for wrapping and unwrapping the fast line 45 as required for operation of the associated crown block 15 and travelling block 20. The rotatable drum 65 is also referred to as a winding drum or a hoisting drum. A brake arrangement 70 connected to the drawworks 50 typically includes a band type primary brake or disk brake, an auxiliary brake, such as an eddy current type brake or a magnetic brake, and an emergency brake. Various sensors 90 and 92 provide information to a drawworks control system 80. Electrical power from a power source 60 (e.g. a typical rig power apparatus) is provided to cables 62 in accordance with the present invention via a junction box 64. Coolant channels 66 adjacent the cables 62 provide for indirect heat exchange cooling of the cables 62. Channels 68, in fluid communication with the channels 66, provide for the exit of fluid pumped through the channels 66 by a pump 72 from a fluid reservoir 74.

Figures 2A to 2C show a drawworks 100 in accordance with the present invention which includes a rotatable drum 110 rotatably secured to mounts 102, 104 on a base 106. A rotor 132 of a motor 130 encompasses a stator 134. The stator 134 has a body 131 with a plurality of
windings 136 and the rotor 132 has a plurality of permanent magnets 138. A shaft 140 projects from either end of the body 131 through the drum 110 and through the respective mounts 102. The motor is interconnected with a gear system 105.

Power cables 150 (or a cable) extend from outside the drum 110 (e.g. from a junction box), through a channel or central bore 142 in the shaft 140, and to connections with the stator windings 136, exiting through a hole 144 in the shaft 140 for connection to the windings 136. The present invention includes within its scope a motor with at least one power cable. The shaft 140 has one or a plurality of fluid channels 146 (multiple channels shown) through which heat exchange fluid is pumped. In communication with these shaft channels 146 are a plurality of corresponding channels 139 in the body 131 of the stator 134. The fluid pumped through the channels 146 is conveyed, via the channels 139 away from the stator 134. Alternatively, certain of the channels 146 are input channels and certain of the channels 146 are output channels, with a pump pumping the heat exchange fluid into the input channels and out the output channels (at the same end of the shaft; the right end as viewed in Figure 2A). Optionally, the power cables may run through any part of the shaft (other than the central bore); and the water channels, shown surrounding the power cables, may optionally, be centrally located or located as desired.

An inner housing 160 with ends 162, 164 contains the stator 134. These ends 162, 164 move on bearings 166, 168 respectively. The shaft 140 is on the bearings 114 in a drum end 116 and on bearings 172 in the mount 102.

Each cable 150 includes a plurality of wires 154
(e.g. copper or aluminum) running therethrough potted in a potting material 154. For three phase power transmission, these wires are in groups of three.

Figures 4A and 4B illustrate an end 181 of a shaft 180 (like the shaft 140) which is part of or connected to a body (not shown; like the body 131). The shaft 180 has a plurality of fluid channels 186 therethrough (like the channels 146) and a central channel 182 (like the channel 142). A plurality of cables 190 (like the cables 150) run through the shaft 180.

A heat exchange fluid 188 (e.g. water, antifreeze, oil, or mineral oil) is pumped through the channels 186. The cables 190 include a plurality of conducting wires 192 (like the wires 154) are insulated with an insulating jacket 196, e.g. of silicon or high temperature silicones. In one aspect the wires 192 are in group of three bundled together and twisted along their length to minimize inductance heating of metal and objects adjacent the cables. In one aspect each wire has individual insulation. In one aspect each grouping of three wires constitutes a power cable.

The cables are all potted in a matrix 198 of potting material (e.g., but not limited to, e.g. insulating material with a high dielectric constant such as cable jacketing material made from, e.g. insulating resin compounds, thermosetting epoxy material). A junction box used with such cables, e.g. the junction box 64, Figure 1A is, optionally sealed to prevent water leakage.

By using the channels adjacent the power cables to flow heat exchange fluid for cooling the power cables, the overall size of the power cables is reduced as compared to certain prior art power cables, e.g. from 1/3
to 2/3 size reduction, and, in certain cases, a 50% reduction in size. In certain aspects less of the conductor metal (copper or aluminum) is needed to transmit a desired amount of power. For example, in certain aspects with four cables, each conducting 800 amps (total 3600 amps) with basic parameters (geometry, size, material conductivity of cable insulation, number of cables) being equal, a system in accordance with the present invention with water cooling will be about fifty percent smaller in size than a comparable prior art system with air cooling.

As shown e.g. in Figure 2A the rotor and stator are housed within a drum or housing. It is within the scope of the present invention to provide a motor in accordance with the present invention which is outside such a drum or housing. It is within the scope of the present invention to provide cooling of power cables in accordance with the present invention, cooled power cables in accordance with the present invention, and a motor with such cables in accordance with the present invention, in one aspect with the motor outside a drum or housing for a drawworks or other apparatus.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a system for use in wellbore operations, the system including: a rig; a derrick on the rig; a drawworks; a motor for powering the drawworks, the motor including a motor shaft, a plurality of power cables for providing electrical power to the motor, a portion of each of the plurality of power cables passing through the shaft and a plurality of channels passing through the shaft adjacent the power cables and spaced-apart therefrom, the channels for the passage therethrough of a heat exchange fluid for
the exchange of heat with the power cables to cool the power cables. Such an apparatus may have one or some, in any possible combination, of the following: a drum on the drawworks for taking in and playing out a line, and the motor disposed within and connected to the drum; the power cables including at least one wire through which electric current flows, the wires insulated with insulating material; each power cable comprises a plurality of conducting wires, each conducting wire is insulated, and all the power cables are potted in a matrix of potting material; the power cables extend within the motor shaft along a first length, the channels for the passage therethrough of a heat exchange fluid extend within the motor shaft along a second length, and the second length at least as long as the first length; the motor shaft having a center bore, the power cables extend through the center bore of the motor shaft, and the channels are around the center bore; and/or the motor shaft having a first portion, a second portion, and a stator between the first portion and the second portion, the channels extending from the first portion, through the stator, and to the second portion, and the heat exchange fluid entering the channels at the first portion and exiting from the second portion.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a system for use in wellbore operations, the system including: a rig; a derrick on the rig; a drawworks; a motor for powering the drawworks, the motor including a motor shaft, a plurality of power cables for providing electrical power to the motor, a portion of each of the plurality of power cables passing through the shaft, a plurality of channels passing through the shaft adjacent
the power cables and spaced-apart therefrom, the channels for the passage therethrough of a heat exchange fluid for the exchange of heat with the power cables to cool the power cables, a drum on the drawworks for taking in and playing out a line, the motor disposed within and connected to the drum, and wherein motor shaft has a center bore, the power cables extend through the center bore of the motor shaft, and the channels are around the center bore.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a system for use in wellbore operations, the system including: a rig; a derrick on the rig; a drawworks; a motor for powering the drawworks, the motor including a motor shaft, a plurality of power cables for providing electrical power to the motor, a portion of each of the plurality of power cables passing through the shaft, a plurality of channels passing through the shaft adjacent the power cables and spaced-apart therefrom, the channels for the passage therethrough of a heat exchange fluid for the exchange of heat with the power cables to cool the power cables, a drum on the drawworks for taking in and playing out a line, the motor disposed within and connected to the drum, and wherein motor shaft has a center bore, the power cables extend through the center bore of the motor shaft, and the channels are around the center bore.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a motor including: a motor shaft; a plurality of power cables for providing electrical power to the motor; a portion of each of the plurality of power cables passing through the shaft; and a plurality of channels passing
through the shaft adjacent the power cables and spaced-apart therefrom, the channels for the passage therethrough of a heat exchange fluid for the exchange of heat with the power cables to cool the power cables. Such an apparatus may have one or some, in any possible combination, of the following: a drum for taking in and playing out a line, and the motor disposed within and connected to the drum; the power cables including at least one wire through which electric current flows, the wires insulated with insulating material; each power cable is a plurality of conducting wires, each conducting wire is insulated, and all the power cables are potted in a matrix of potting material; the power cables extending within the motor shaft along a first length, the channels for the passage therethrough of a heat exchange fluid extend within the motor shaft along a second length, and the second length at least as long as the first length; the motor shaft having a center bore, the power cables extending through the center bore of the motor shaft, and the channels are around the center bore; and/or the motor shaft having a first portion, a second portion, and a stator between the first portion and the second portion, the channels extending from the first portion, through the stator, and to the second portion, and the heat exchange fluid entering the channels at the first portion and exiting from the second portion.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a method for moving an item in a rig system, the rig system for use in wellbore operations, the rig system being any rig disclosed herein, the method including: raising or lowering the item by running a rig motor, and cooling a power cable or power cables of the rig motor by passing
heat exchange fluid through a plurality of channels adjacent the cable or cables. Such an apparatus may have one or some, in any possible combination, of the following: the power cable or cables extend within a motor shaft along a first length, the channels for the passage therethrough of a heat exchange fluid extend within the motor shaft along a second length, and the second length at least as long as the first length; and/or the motor shaft has a center bore, the power cables extend through the center bore of the motor shaft, and the channels are around the center bore.

The present invention, therefore, provides, in at least certain but not necessarily all embodiments, a motor including: a motor shaft; at least one power cable for providing electrical power to the motor; a portion of the at least one power cable passing through the shaft; and at least one channel passing through the shaft adjacent the at least one power cable and spaced-apart therefrom, the at least one channel for the passage therethrough of a heat exchange fluid for the exchange of heat with the at least one power cable to cool the at least one power cable.
CLAIMS:
1. A drawworks for use in wellbore operations, the drawworks comprising a motor (130) having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising at least one wire (150) passing through at least part of said motor (130), characterised in that the motor further comprises at least one channel (139,142) arranged adjacent said at least one wire (150) for the passage therethrough of a heat exchange fluid for the exchange of heat with the at least one wire to cool the at least one wire.
2. A drawworks as claimed in Claim 1, wherein the motor further comprises a shaft (140), the wire passing through the shaft (140).
3. A drawworks as claimed in Claim 2, wherein the at least one channel passes through the shaft.
4. A drawworks as claimed in Claim 3, wherein said at least one wire (150) is arranged in a bore in the shaft (140).
5. A drawworks as claimed in any one of Claims 2 to 4, wherein said shaft (140) has a first portion and a second portion, said stator (134) between the first portion and the second portion, said at least one channel (139,142) extending from the first portion, through the stator (134), and to the second portion, and said heat exchange fluid entering said at least one channel at the first portion and exiting from the second portion.
6. A drawworks as claimed in any one of Claims 2 to 5, wherein the stator (134) is in a fixed relation to the shaft (140), the shaft (140) substantially non-rotating.
7. A drawworks as claimed in any preceding claim, further comprising a drum (110) for taking in and playing out a wireline.
8. A drawworks as claimed in Claim 7, wherein said drum (110) is fixed to said rotor (132).
9. A drawworks as claimed in Claim 7 or 8, wherein said drum (110) is rotatably arranged about said shaft (140).
10. A drawworks as claimed in any one of Claims 7 to 9, wherein said stator (134) and said rotor (136) are arranged within said drum (110).
11. A drawworks as claimed in any preceding claim, wherein said at least one channel (139,142) is arranged substantially parallel with said at least one wire (150).
12. A drawworks as claimed in any preceding claim, wherein said at least one channel is a plurality of channels.
13. A drawworks as claimed in Claim 12, wherein said plurality of channels (139,142) are arranged substantially parallel with the wire (150) and the plurality of channels arranged about said at least one wire.
14. A drawworks as claimed in any preceding claim, wherein said at least one wire (150) is a plurality of wires in a bunble.
15. A drawworks as claimed in any preceding claim, wherein said at least one wire (192) is isolated with a sheath.
16. A drawworks as claimed in any preceding claim, wherein said rotor arranged about the stator.
17. A drawworks as claimed in any preceding claim, wherein the at least one channel (139,142) is arranged in the stator in close proximity to the windings for maintaining the temperature of the windings within a predetermined range.
18. A drawworks as claimed in any preceding claim, wherein said wire (150) is connected to the winding.
19. A drawworks as claimed in any preceding claim, wherein said wire (150) is integral with said winding (136).

20. A drawworks as claimed in any preceding claim, wherein said winding (136) is arranged on said stator (134).

21. A drawworks as claimed in any preceding claim, wherein said motor is a DC motor.

22. A drawworks as claimed in any preceding claim, wherein said motor is an AC motor.

23. A drawworks as claimed in Claim 22, wherein said motor is a three-phase AC motor, the motor comprising three sets of windings (136) and three sets of wires (150) feeding said three sets of windings.

24. A drawworks as claimed in any preceding claim, wherein said at least one wire is potted in a matrix of potting material.

25. A drawworks as claimed in any preceding claim, wherein said heat exchange fluid is a liquid.

26. A drilling rig comprising a derrick (11), a crown block (15) and a travelling block (20), a wireline (45) and a drawworks for taking in and playing out said wireline, characterised in that the drawworks comprises a motor (130) having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising a wire (150) passing through at least part of said motor (130), characterised in that the motor further comprises at least one channel (139,142) arranged adjacent said at least one wire (150) for the passage therethrough of a heat exchange fluid for the exchange of heat with the at least one wire to cool the at least one wire.

27. A method for taking in and playing out a wireline on a drilling rig using a drawworks, the drawworks
comprising a motor (130) having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising a wire (150) passing through at least part of said motor (130), characterised in that the motor (130) further comprises at least one channel (139,142) arranged adjacent said at least one wire (150), the method comprising the steps of passing a heat exchange fluid through the at least one channel (139,142) to cool the at least one wire.

28. A motor having a rotor (132), a stator (134) and at least one winding (136) the drawworks further comprising at least one wire (150) passing through at least part of said motor, characterised in that the motor further comprises at least one channel (139,142) arranged adjacent said at least one wire (150) for the passage there through of a heat exchange fluid for the exchange of heat with the at least one wire to cool the at least one wire.