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(54) Downhole releasable connector

(57) A downhole releasable connector is described for releasably connecting a wireline to a downhole tool. The connector comprises a first portion arranged to be connected to a wireline and a second portion arranged to be connected to a downhole tool. A locking arrangement is arranged to lock the first and second portions together when in a first position and to release the first and second portions from each other when in a second position. A reversible drive mechanism is provided to move the locking arrangement between the first and second portions. As the drive mechanism is reversible, it is able to lock and unlock the locking arrangement and so release and reconnect the first and second portions of the connector so that it can be tested prior to use providing increased confidence in the tool and allowing inspection of critical parts within the release mechanism.

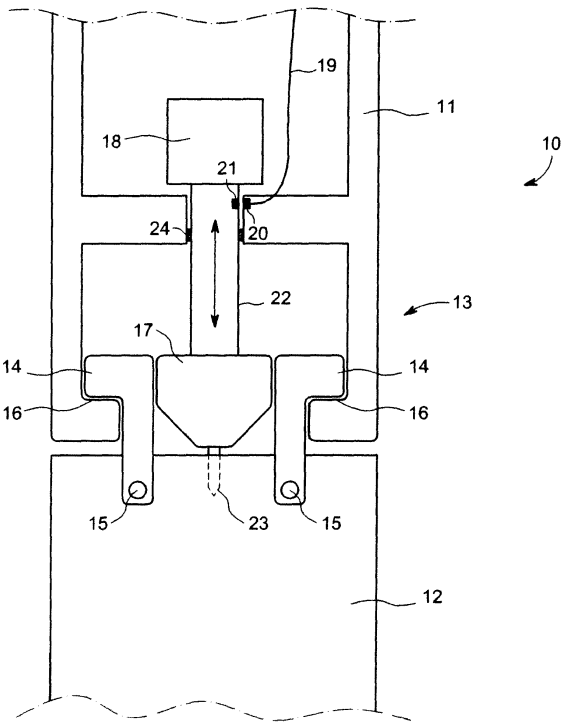

FIG. 2

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Description

FIELD OF INVENTION

[0001] This invention relates to a downhole releasable connector and in particular to a tool string arranged to allow the retrieval of components such as a wireline, cablehead and upper sections of the tool string while lower, stuck, sections are left in the hole.

BACKGROUND OF THE INVENTION

[0002] Sub surface tools such as various measuring, logging and drilling devices are suspended from a wireline, cable or the like, typically threaded together to form a downhole unit which is controlled from the surface. However, the sub surface tools may become stuck downhole and cannot be dislodged by application of a reasonably safe cable tension. If too high a tension is placed on the conductor this may damage the downhole tool or break the cable making the downhole tool difficult to retrieve. Apparatuses for releasing cable suspended well tools have been developed to address the problem of wireline tools becoming stuck downhole to avoid the problem of uncontrolled breaking of the cable.

[0003] US-A-3 327 784 discloses a releasable connector including a rod with a weakened portion which is broken when the cable load reaches a predetermined level and all elements above the weakened portion may then be pulled out.

[0004] US-A-3 517 740 discloses a load-bearing support member adapted to couple a well tool to a suspension cable. The support member has sufficient strength to carry the weight of the tool and withstand normal loads and includes an electrically-responsive explosive means arranged for selectively parting the support member should it be desired to release the cable from the well tool while it is in a well bore.

[0005] US-A-4 275 786 discloses a well bore apparatus for releasably coupling a suspension cable to a well tool. The apparatus comprises upper and lower support members adapted for coupling to a suspension cable and to a well tool. The upper and lower support members are held together by an electrically-disintegratable element such as an exothermic solder which disintegrates allowing the upper and lower members to separate.

[0006] US-A-6 032 733 discloses a wireline release including a shaft having one end releasably connected to the end of the wireline by a connector and being held in the latched position by a fusible material ring. Upon activating heaters in the cable head from the surface via conductors in the wireline, the fusible material ring is melted allowing the shaft, under the tension of the wireline, to shift to an unlatched position whereby the connector releases the wireline from the shaft and cable head.

[0007] US-A-6 431 269 discloses an electrically controlled release device in which a resistive heater melts a solder joint in a metal spring allowing bobbin pieces to separate so that a latch can be released from the cable head and pulled to the surface leaving the remaining assembly in the well bore.

[0008] US-A-7 407 007 discloses a similar device but using a shaped memory alloy that elongates when heated.

[0009] WO 2004/046497 discloses a releasable wireline cable head operated by a solenoid which acts directly on the main release mechanism.

[0010] WO 2008/125108 discloses a downhole system comprising a driving unit for driving an operational tool. Engagement arms may be released to separate a drilling head from the rest of the system.

[0011] US-A-7 588 084 discloses a method for releasing cables from an attached well tool using a cable cutter arranged between the main part of a cable and the well tool. The cable cutter is controlled by an electronic timer.

[0012] However, these releasable connectors suffer from a number of problems. For example, the tools can only be actuated once, for example by actuation of a cutter, an explosive, an electrically-disintegratable element, a fusible material ring or a solenoid and so cannot be pre-tested to ensure that they are working correctly before being provided in a well. Clearly, if it is found that a releasable connector is not working after a tool is stuck downhole, the entire tool may be lost and the hole blocked.

SUMMARY OF THE INVENTION

[0013] According to a first aspect of the present invention there is provided a downhole releasable connector for releasably connecting a wireline to a downhole tool, the connector comprising a first portion arranged to be connected to a wireline and to receive an electrical supply from the surface and arranged to be connected to a second portion connected to and/or including a downhole tool; a locking arrangement arranged to lock the first portion to the second portion when in a first position and to release the first portion from the second portion when in a second position and a reversible drive mechanism to move the locking arrangement between the first and second positions, wherein the first portion is arranged to conduct electricity therethrough from the electrical supply to the second portion via a pair of electrical contacts when in the first locked position and wherein movement of the locking arrangement to the released second position separates the two electrical contacts from each other such that the contact connected to the electrical supply is isolated from the external environment allowing equipment above the electrical contact, in use, to continue to operate in electrically conductive well fluids.

[0014] As the drive mechanism is reversible, it is able to lock and unlock the locking arrangement and so release and reconnect the first and second portions of the connector both physically and electrically so that it can be tested prior to use providing increased confidence in the tool and allowing inspection of critical parts within the

release mechanism. As the first and second portions may be separated non-destructively, electrical integrity may be maintained for tools in use above the release. The reversible drive mechanism may be a reversible linear actuator for example, such as an electric motor.

[0015] The downhole releasable connector may include a mechanically actuatable electrical switch to disconnect supply to the second portion when opened upon release of the first and second portions from each other. A valve may be provided to equalise the internal and external pressure of the connector when actuated upon release of the first and second portions from each other.

[0016] The downhole releasable connector may be, or form part of a downhole tool. A tool string may be provided including one or more downhole releasable connectors. If two or more downhole releasable connectors are provided in a tool string, the lowest connector which still enables the upper sections of the tool string to be recovered is released so that as much of the tool string as possible is recovered.

[0017] According to a second aspect of the present invention there is provided a method of operating a downhole releasable connector for releasably connecting a wireline to a downhole tool, the method comprising operating a drive mechanism in a first direction to move a locking arrangement to lock first and second portions of a tool string together and to close an electrical connection between the two by engaging two electrical contacts, one of which is arranged to receive an electrical supply from the surface, and operating the drive mechanism in the reverse direction to move the locking arrangement to release the first and second portions from each other and to open an electrical connection between the two by separating the two electrical contacts such that the electrical contact arranged to receive an electrical supply from the surface is isolated from the external environment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

[0019] Figure 1 schematically shows a downhole unit suspended form a wireline;

[0020] Figure 2 schematically shows a first example of a downhole releasable connector illustrating the present invention;

[0021] Figures 3 to 5 illustrate a more detailed example of a downhole releasable connector illustrating an example of the present invention in various stages of release of the locking arrangement; and

[0022] Figure 6 is a flow diagram illustrating operation of the releasable connector.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Figure 1 illustrates a downhole unit 10 located in the borehole 26 of a well. The downhole unit 10 is suspended from a wireline 30 fed from a drum 40 via a pulley 50 provided at the surface. As schematically illustrated in figure 1, the downhole unit 10 may become stuck in the borehole.

[0024] Figure 2 illustrates a downhole releasable connector 10 illustrating the present invention and comprising a first portion 11, which in this example is an upper portion forming part of a tool string arranged to be connected to a wireline 30 via various tools (not shown) and a second portion 12, which in this example is a lower portion arranged to be connected to one or more downhole tools such as a well tractor, actuator and/or various sensors for taking measurements of the downhole conditions in the borehole. The first portion 11 and second portion 12 are held together by a locking arrangement 13 which in this example comprises a number of latching elements or dogs 14 which are secured to the second portion 12 in this example at pivoted joints 15 and which contact engagement surfaces 16 on the first portion 11 to lock the first and second portions 11, 12 together when in the first position. In the example of figure 2 the dogs 14 are held in contact with the engagement surfaces 16 by a locking element 17. The first portion 11 is arranged to receive an electrical supply from the surface, in this example by electrical wiring 19. The electrical supply from the surface is conducted through the first portion 11 via a pair of electrical contacts 20,21. In this example, the electrical wiring 19 from the surface is connected to the first contact 20 and the second contact 21 is connectable to the second portion 12 via a conducting portion of the shaft 22 and connector pin 23 shown in dashed lines received in a corresponding socket in the second portion 12.

[0025] When it is desired to release the first and second portions 11,12 from each other, the locking arrangement 13 moves to a second position which in this example comprises retracting the locking member 17 from between the dogs 14 by the action of a reversible drive mechanism 18. Once the locking member 17 is withdrawn from between the dogs 14, this allows them to fall inwards releasing the first and second portions 11,12 from each other. Movement of the locking arrangement 13 to the released second position separates the two electrical contacts 20,21 from each other such that the contact 20 connected to the electrical supply 19 is isolated from the external environment allowing equipment above the electrical contact to continue to operate in electrically conductive well fluids below and around the first portion 11 when the second portion 12 has been released. In this example the contacts 20,21 are within the first portion 11 sealed off from the external environment by the positioning of the locking arrangement 13 within the first portion 11. A seal 24, in this example an O ring, may also be provided around the movable shaft of the locking arrangement 13 to enhance the sealing effect.

[0026] The first upper portion 11 and second lower portion 12 may be locked together again simply by reversing the direction of the drive mechanism 18 to extend the

locking member 17 back between the dogs 14 forcing them into engagement with the surfaces 16 and reconnecting the electrical contacts 20,21 to each other.

[0027] As the drive mechanism 18 is reversible, the locking arrangement 13 may be freely moved between its first locked position and its second released portion so that the downhole releasable connector may be tested before use providing increased confidence in the tool and allowing inspection of critical parts within the release mechanism before use.

[0028] A tool string may be provided including one or more downhole releasable connectors 10. If two or more downhole releasable connectors 10 are provided in a tool string, the lowest connector which still enables the upper sections of the tool string to be recovered is released so that as much of the tool string as possible is recovered. In practice this is done by sequentially releasing the connectors 10 starting with the lowest first.

[0029] Figures 3 to 5 show a more detailed example of the present invention in various stages of release of the locking arrangement.

[0030] In the example shown in figure 3, the reversible drive mechanism 18 is an electrical motor which may include an associated gearbox. Control of the motor may be provided by electronic elements (not shown) which are in turn actuated by signals from the surface via the wireline. The motor 18 is connected to a lead screw 100 which is rotatable along its axis in either direction by the motor. At least a portion of the lead screw 100 is provided with external threads (not shown) which engage with corresponding internal threads on a nut 101. The nut 101 engages with a shaft 102 such that the shaft 102 is arranged to move linearly in the direction of the axis of the first portion 11 by rotation of the lead screw 100 driven by the reversible drive mechanism 18. The shaft 102 includes a locking portion 17 with a cam surface 103 arranged to engage a dog 14 forcing it into locking engagement with surface 16 on the inside surface of the first portion. The cross-sectional view of the downhole unit 10 shown in figure 3 shows only one dog 14 but includes two further dogs spaced 120 degrees apart around the inner circumference of the second portion 12 but not seen in the cross-sectional view of figure 3. However, in practice, any number of dogs 14 may be used as is considered suitable for a particular application. The dogs 14 are secured to the second portion 12 at pivoted joints 15.

[0031] The example shown in figures 3 to 5 includes a number of further advantageous features. The downhole unit 10 has electrical wiring for sensors and the like below the connector to communicate with the surface. However, in prior devices, when the cable is cut, the electrical wiring is also cut which may leave loose live electrical wires which can be dangerous, especially in a downhole well which may contain explosive gases. This problem is overcome in this example of the present invention by the use of a mechanically decouplable electrically isolating switch 200, 201.

[0032] In the example of figure 3, electrical wiring 202 from the surface for communication with devices such as sensors on the downhole unit 10 is connected to one part 200 of the switch. In this example the electrical wiring 202 is connected to an electrically conducting ring 200 fixed in place relative to the body of the first portion 11 of the downhole unit 10. The second part of the switch comprises a second electrically conducting ring 201 which is mounted on to the moveable shaft 102. The second electrically coupling ring 201 is electrically connected to a metal core within the shaft 102 with a connector pin 203 which is releasably received in a connector socket 204 mounted in the second portion 12 of the downhole unit 10.

[0033] In order to equalise the pressure between the first and second portions 11, 12 when they are released form each other, a shuttle valve 300 is provided. The shuttle valve 300 is mounted on the shaft 102 and includes two O ring seals, each mounted around the circumference of the shuttle valve 300 with the two O ring seals 301 spaced axially along the outer surface of the shuttle valve 300. The wall of the first portion 11 includes vent channels 302 passing through the wall of the first portion 11. Whilst the first and second portions 11, 12 are locked together as shown in figure 3, the shuttle value 300 is positioned such that one O ring seal 301 is positioned on each side of the vents 302 preventing any external high pressure fluid from passing the seals 301 into the downhole unit 10.

[0034] A position sensor may be provided to monitor the status of the locking arrangement, for example to determine whether it is locked, released or therebetween. Any suitable sensor may be provided, such as a Hall effect sensor, a potentiometer, a microswitch or other position sensing device to monitor the position of any suitable part of the locking arrangement. In this example a sensor 400 is shown to monitor the position of the actuating shaft 102. Consequently, an operator can check for the current position of the locking mechanism during deployment.

[0035] Figure 4 shows the first and second portions 11, 12 when the locking arrangement has just been released. When it is decided to separate the first and second portions 11,12 an operator from the surface arranges for the motor 18 to rotate a predetermined amount. This rotation of the motor rotates the lead screw 100 which, via engagement of threads on the nut 101 and corresponding threads on an internal cavity 104 at the motor end of the shaft 102 causes the shaft 102 to move axially away from the second portion 12. As the shaft 102 moves away from the second portion 12, the cam surface 103 is pulled out of engagement with a corresponding surface of the dog 14 allowing it to fall inward such that it is no longer in contact with the engagement surface 16. As the cam surface 103 moves, it will of course release its engagement with all of the dogs 14, releasing the first and second portions 11,12 from each other.

[0036] Movement of the shaft 102 also moves the electrically conducting ring 201 of the mechanically actuata-

ble switch out of contact with the electrically conducting ring 200 secured relative to the outer surface of the first portion 11 and so electrically isolating the first and second portions 11,12 from each other. The axial movement of the shaft 102 also retracts at least a portion of the connector pin 203 out of the connector socket 204 on the second portion 12. The electrically conducting ring 200 exposed during the release process is isolated from the lower second portion 12 and from the external environment around the first portion 11 which may include electrically conductive well fluids, allowing the tools above the disconnection to continue to operate after release.

[0037] Axial movement of the shaft 102 also axially moves the shuttle valve 300 such that the lower O ring 301 no longer seals against the inside surface of the first portion body 11. In this example, the seal is broken by the lower O ring 301 entering an enlarged cavity associated with a vent 302 such that it is no longer in sealing contact with the inner wall with the first portion 11. Consequently pressure in the cavity of the downhole unit 10 below the shuttle valve 300 is equalised with the pressure outside the downhole unit 10. Typically the pressure at which the downhole tool 10 will operate is very high and pressurised gases and liquids will enter vents 302 allowing the external and internal pressure to be equalised. Once the external and internal pressure is equalised, this removes the hydraulic clamping force on the downhole unit 10 and the first and second portions 11,12 can now be separated, allowing the upper first section 11 and tools above it to be recovered. Figure 5 shows the upper first section 11 separated from the lower section 12.

[0038] If the downhole unit 10 is being tested and inspected prior to use, the second portion 12 may simply be reinserted into the first portion 11 as shown in figure 4 and the reversible drive mechanism 18 operated in the reverse direction from before to move the shaft 102 towards the second portion 12 such that the cam surfaces 103 engage the dogs 14 forcing them into contact with the engagement surface 16 as shown in figure 3 to lock the first and second portions 11,12. Consequently the downhole unit 10 may be operated and reconnected at the surface prior to deployment with no adverse effect on the integrity of the assembled tool. An operator is able to ensure that the tool is fully and correctly assembled prior to use and that the release sequence will happen correctly. As well as or instead of the use of the position sensor 400, the motor 18 used as the reversible drive mechanism may enable feedback to be provided of the current status of the connector.

[0039] Figure 6 is a flow diagram 400 illustrating operation of the releasable connector. The operation may be controlled by a controller, such as a computer or a microprocessor controlled unit at the surface.

[0040] Assuming that the releasable connector is in a locked configuration at step 401, upon actuation the drive mechanism 18 is operated in a first direction. At step 402, as a result of the movement of the drive mechanism in the first direction, the locking arrangement 13 releases the first and second potions 11,12 from each other. As explained above, the movement of the drive mechanism 18 in the first direction may also result in at least one of opening a mechanically actuatable electrical switch 200,201 and opening a pressure equalization valve 300.

[0041] At step 403 the drive mechanism 18 is operated in the reverse direction which results at step 404 in the locking arrangement 13 locking the first and second portions 11,12 together again. The movement of the drive mechanism 18 in the reverse direction may also result in at least one of closing the mechanically actuatable switch 200,201 and closing the pressure equalization valve 300.

[0042] As explained above, the releasable connector may be released and reconnected any member of times by reversing operation of the drive mechanism 18, permitting testing of the device.

[0043] Many modifications and variations may be made to the examples described above while still falling within the scope of the present invention. For example, any suitable locking arrangement may be used to lock the first and section portions 11,12 together. Furthermore any suitable latching member may be used and if dogs are used as in the examples above any number of dogs may be employed.

Claims

1. A downhole releasable connector (10) for releasably connecting a wireline (30) to a downhole tool, the connector comprising
   a first portion (11) arranged to be connected to a wireline (30) and to receive an electrical supply from the surface and arranged to be connected to a second portion (12) connected to and/or including a downhole tool;
   a locking arrangement (13) arranged to lock the first portion (11) to the second portion (12) when in a first position and to release the first portion (11) from the second portion (12) when in a second position and
   a reversible drive mechanism (18) to move the locking arrangement (13) between the first and second positions;
   wherein the first portion (11) is arranged to conduct electricity therethrough from the electrical supply to the second portion (12) via a pair of electrical contacts (20, 21) when in the first locked position and wherein movement of the locking arrangement (13) to the released second position separates the two electrical contacts (20, 21) from each other such that the contact connected to the electrical supply is isolated from the external environment allowing equipment above the electrical contact, in use, to continue to operate in electrically conductive well fluids.

2. A downhole releasable connector according to claim 1, wherein the first and second portions (11, 12) have a common axis and the reversible drive mechanism

(18) is arranged to reversibly move a locking member (17) back and forth in the direction of the common axis.

3. A downhole releasable connector according to claim 1 or claim 2, wherein the locking member (17) is arranged to force one or more latching members (14) attached to one of the first and second portions (11, 12) outwardly into contact with one or more corresponding engagement surfaces (16) on the other of the first and second portions when in a first locked position and to allow the one or more latching members (14) to separate from the one or more corresponding engagement surfaces (16) when in a second released position.

4. A downhole releasable connector in accordance with any one of the preceding claims, wherein the pair of electrical contacts (20, 21) comprise a mechanically actuatable electrical switch for conducting electricity between the first and second portions (11, 12) when closed and for disconnecting supply to the second portion (12) when opened upon release of the first and second portions (11, 12) from each other.

5. A downhole releasable connector according to any one of the preceding claims, wherein one of the contacts (20, 21) is connected to a movable shaft (22) of the locking arrangement (13).

6. A downhole releasable connector according to claim 5, wherein the two electrical contacts (20, 21) are concentric rings, with the internal annular surface of one ring arranged to contact the external annular surface of the other ring when the first and second portions (11, 12) are locked together.

7. A downhole releasable connector according to any one of the preceding claims, further comprising a valve (300) arranged to equalise the internal and external pressure of the connector when the first and second portions (11, 12) are released from each other.

8. A downhole releasable connector according to claim 7, wherein the valve (300) is actuated by the locking arrangement (13), releasing the first and second portions (11, 12) from each other.

9. A downhole releasable connector according to any one of the preceding claims, including a position sensor (400) to determine the status of the locking arrangement (13).

10. A downhole releasable connector according to claim 9, wherein the position sensor (400) determines whether the locking arrangement (13) is in a first locked position, a second released position or therebetween.

11. A tool string including one or more releasable connectors according to any one of the preceding claims

12. A method of operating a downhole releasable connector (10) for releasably connecting a wireline (30) to a downhole tool, the method comprising
operating a drive mechanism (18) in a first direction to move a locking arrangement (13) to lock first and second portions (11, 12) of a tool string together and to close an electrical connection between the two by engaging two electrical contacts (20, 21), one of which is arranged to receive an electrical supply from the surface, and
operating the drive mechanism (18) in the reverse direction to move the locking arrangement (13) to release the first and second portions (11, 12) from each other and to open an electrical connection between the two by separating the two electrical contacts (20, 21) such that the electrical contact arranged to receive an electrical supply from the surface is isolated from the external environment.

13. A method of operating a downhole releasable connector according to claim 12, wherein operating the drive mechanism (18) in the reverse direction opens a mechanically actuatable electrical switch preventing the conduction of electricity between the first and second portions (11, 12).

14. A method of operating a downhole releasable connector according to claim 12 or claim 13, wherein operating the drive mechanism (18) in the reverse direction actuates a valve (300) equalising the internal and external pressure of the connector.

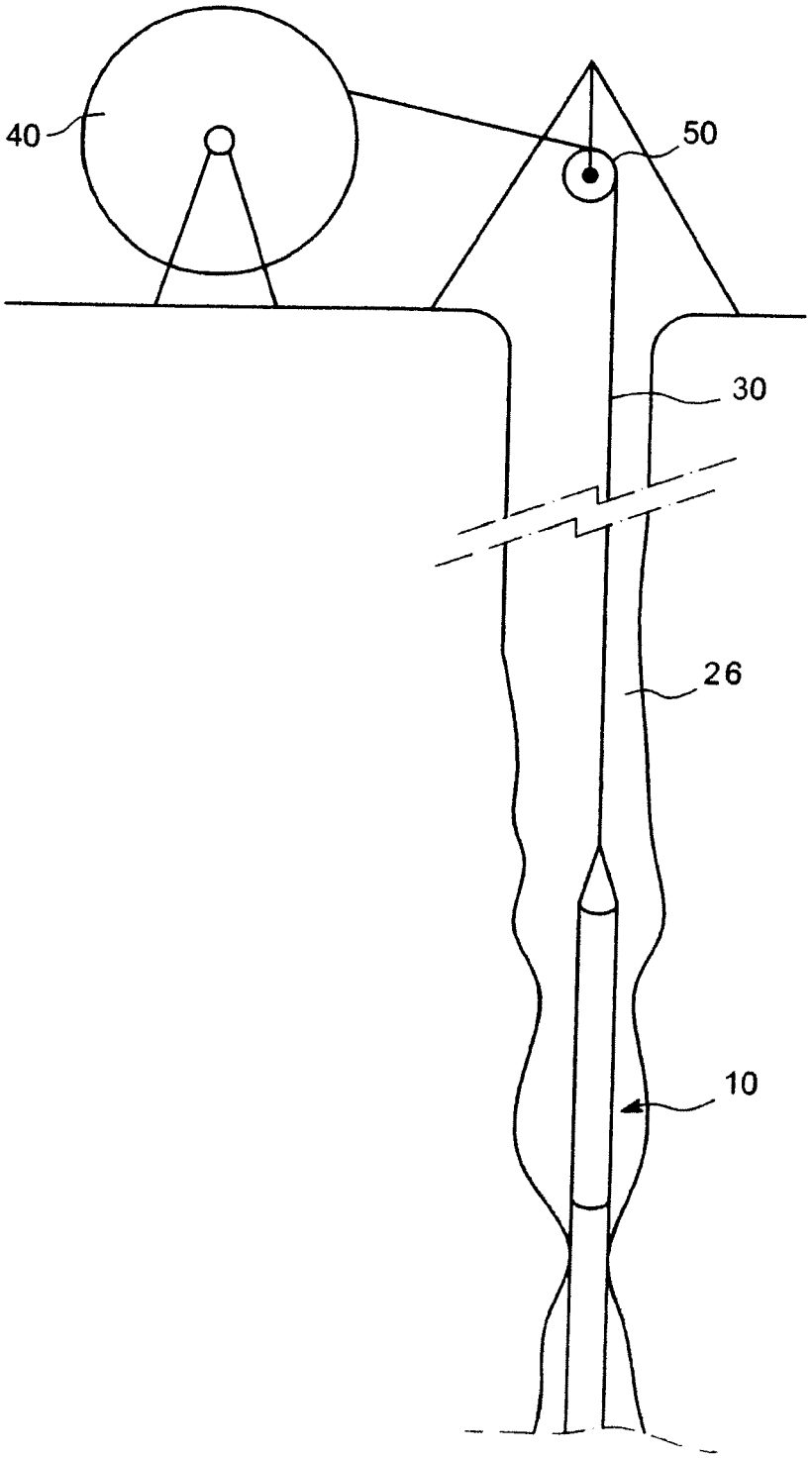

FIG. 1

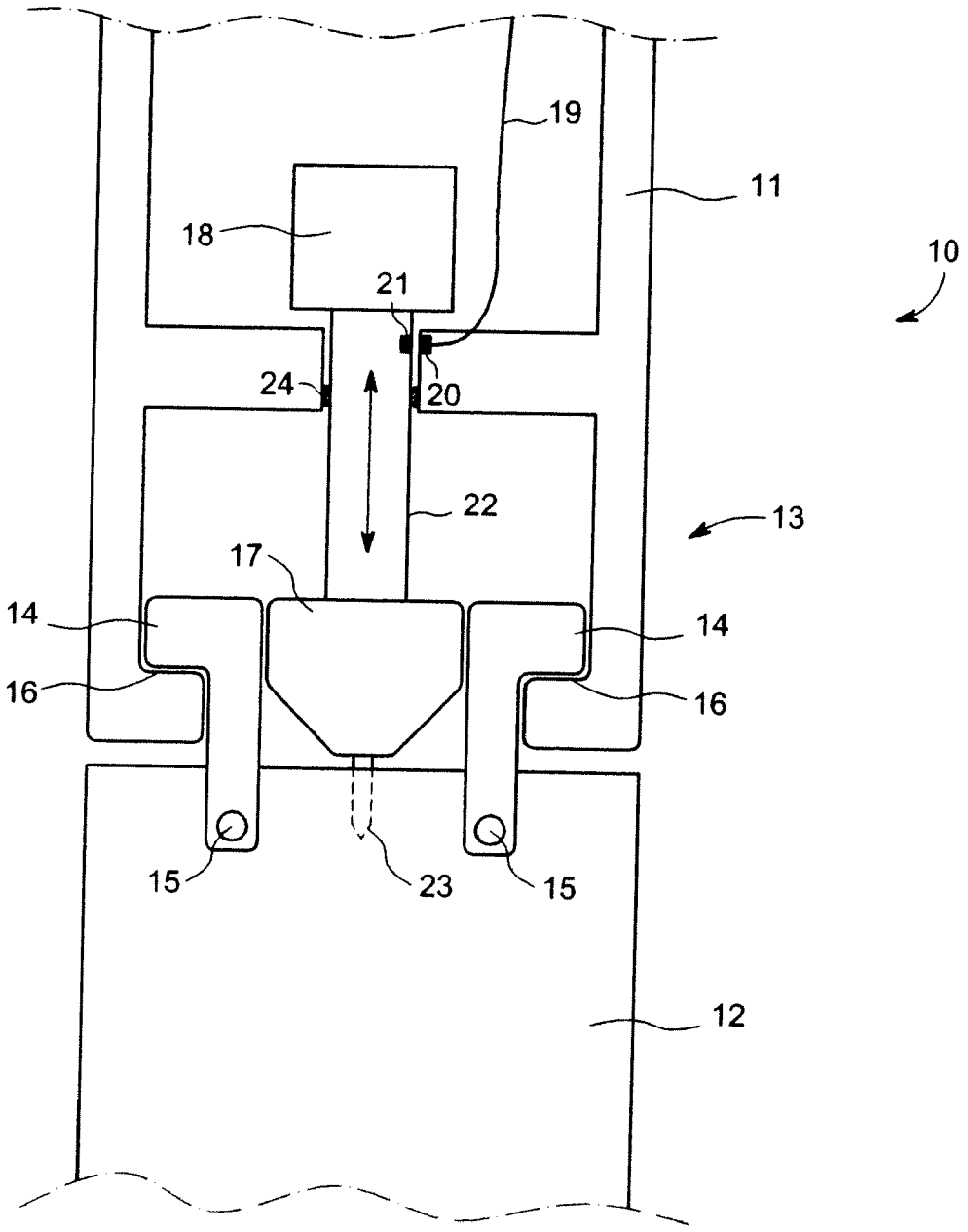

FIG. 2

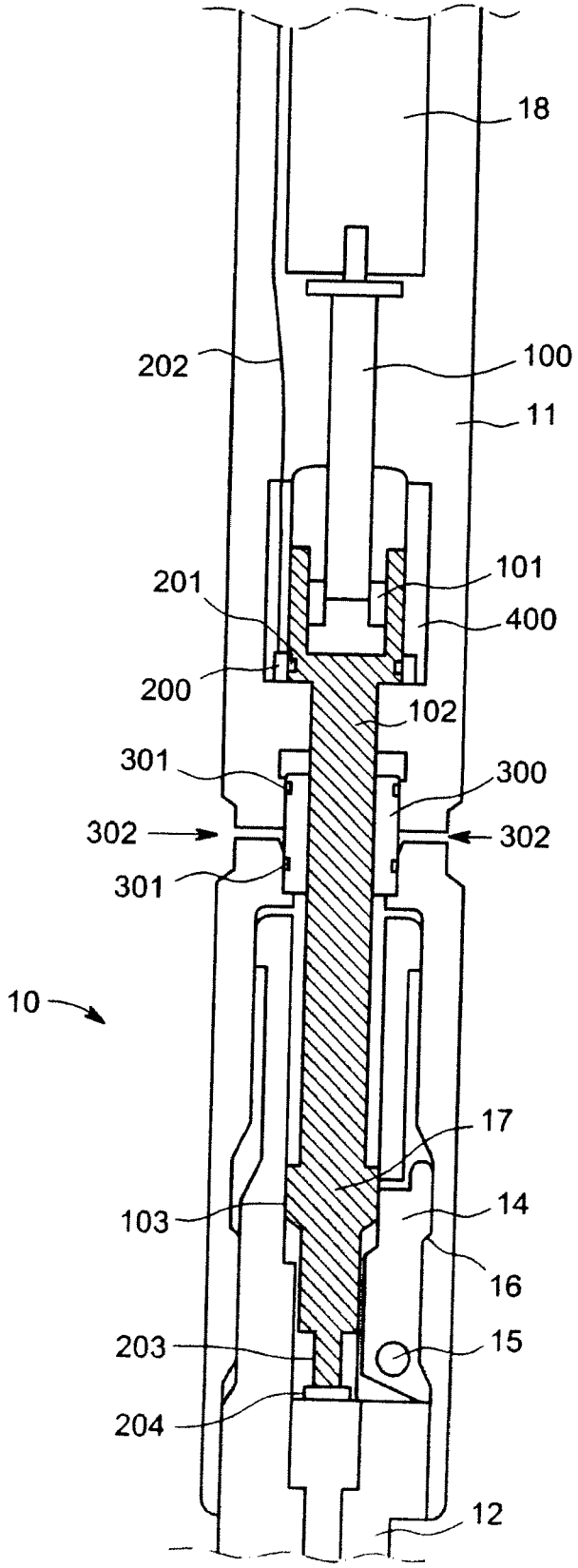
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FIG. 3

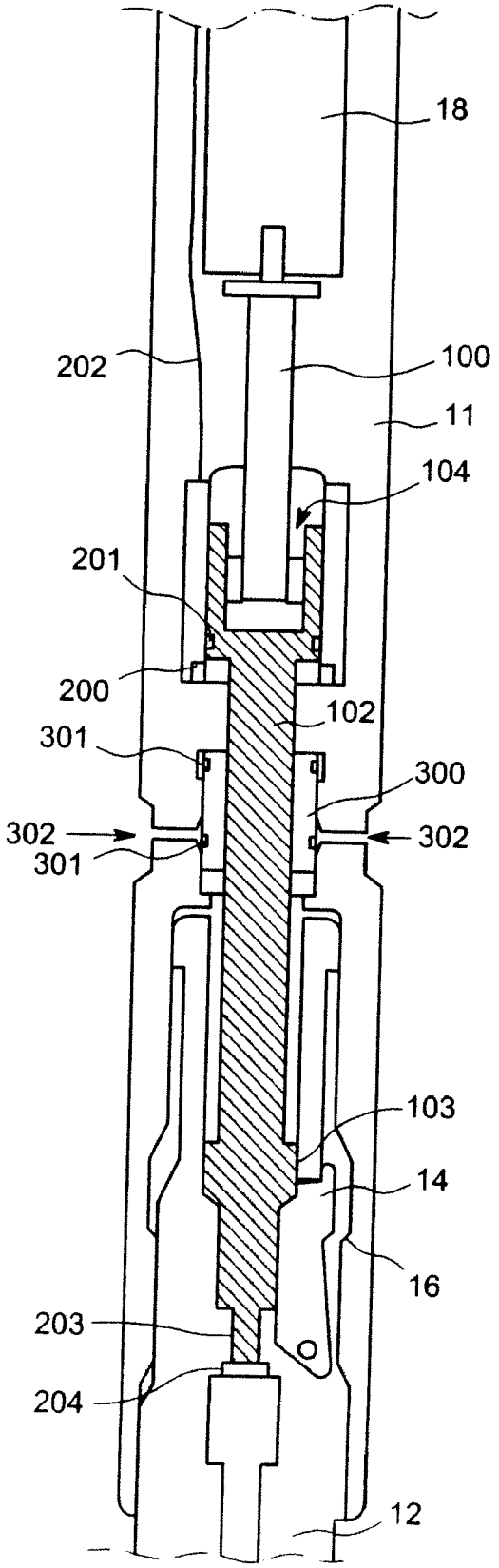
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FIG. 4

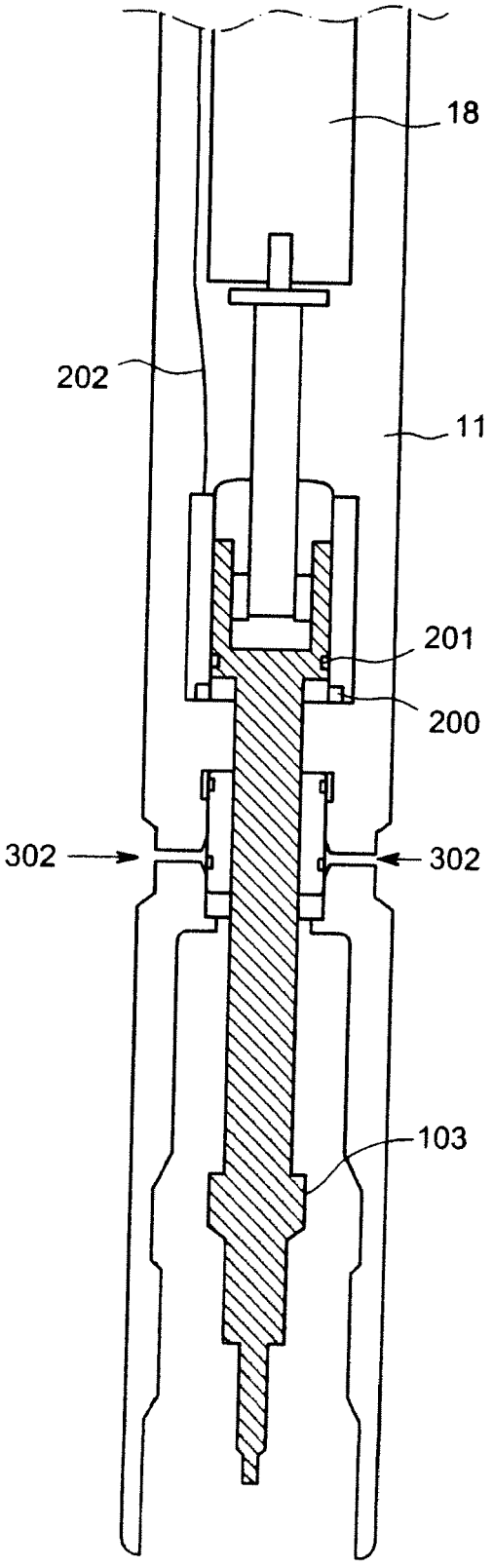

FIG. 5

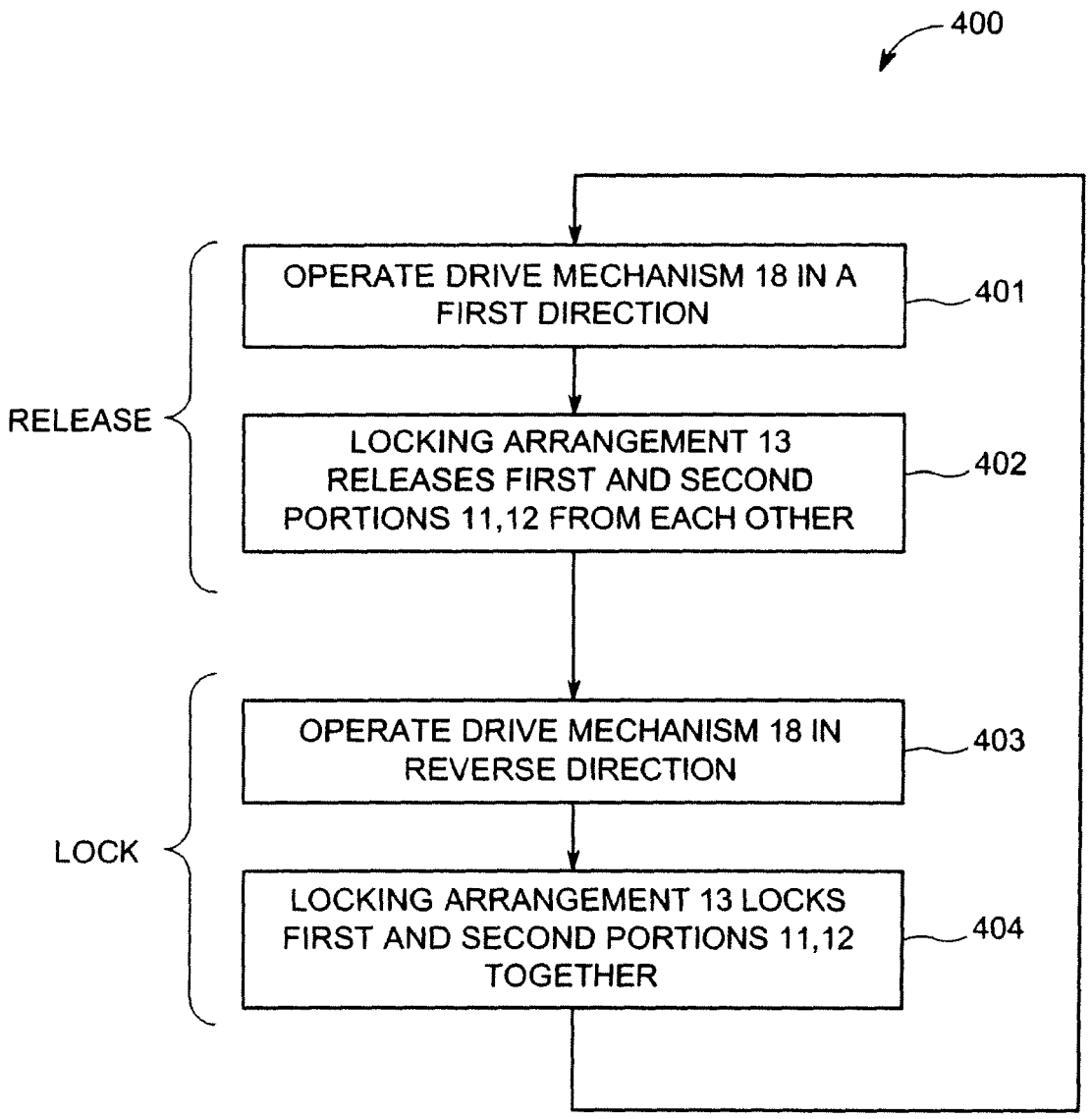
400
OPERATE DRIVE MECHANISM 18 IN A FIRST DIRECTION
401
RELEASE
LOCKING ARRANGEMENT 13 RELEASES FIRST AND SECOND PORTIONS 11,12 FROM EACH OTHER
402
OPERATE DRIVE MECHANISM 18 IN REVERSE DIRECTION
403
LOCK
LOCKING ARRANGEMENT 13 LOCKS FIRST AND SECOND PORTIONS 11,12 TOGETHER
404

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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