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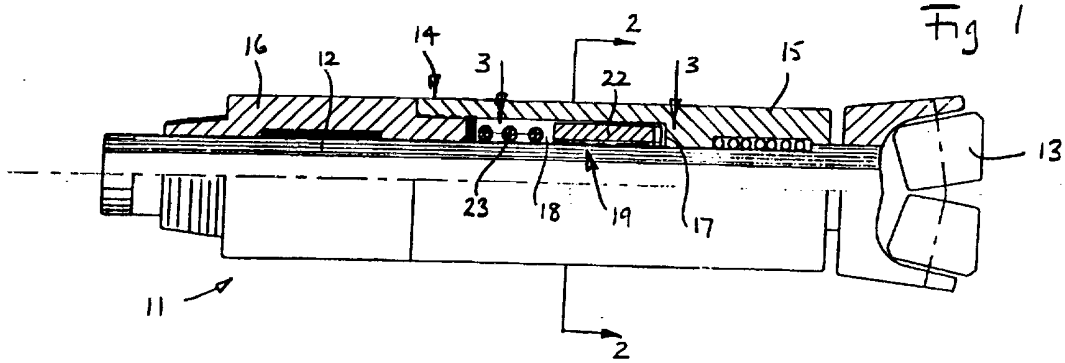
(54) Abstract Title
Downhole motors

(57) A down hole motor assembly 11 comprises a hydraulic drive portion 12, a drill bit 13 operatively connected to the drive portion 12 and a stator 14 connected to the drill string. The drive portion 12 is arranged be rotated relative to the stator by the supply of fluid to a motor which drives the drive portion 12. The assembly 11 also includes a ratchet mechanism 19 operatively connected between the stator 14 and the drive portion 12, the ratchet mechanism being arranged to permit the drive portion 12 to rotate relative to the stator 14 in a normal forward drilling sense and to prevent relative rotation between the drive portion 12 and the stator 14 in the opposite sense.

The assembly also includes a release mechanism arranged to disengage the ratchet mechanism when the resistance to rotation of the drill bit reaches a predetermined level of torque. This release mechanism is provided by the abutment surfaces of the ratchet having an inclination so that when the torque reaches a certain level the abutment surfaces move relatively to each other and release the ratchet.

The application describes two embodiments for the ratchet; one which employs two axially moveable ratchet members with circumferentially arranged teeth (Figs. 2 and 3) and the second which utilises spring loaded arms (Fig. 5).

Fig 1



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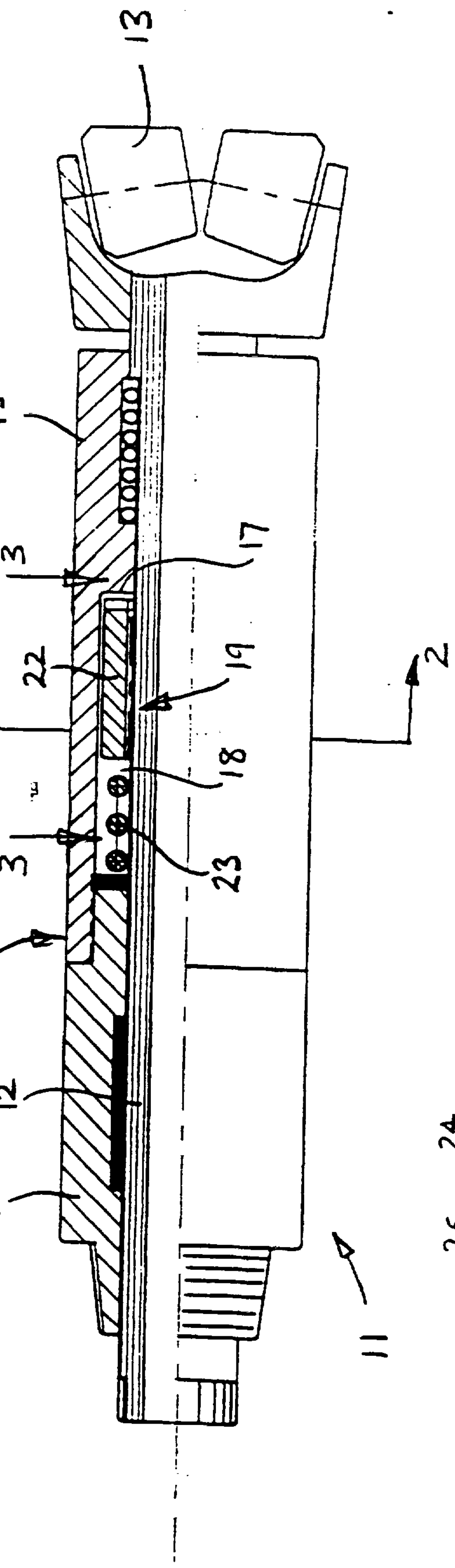


Fig 1

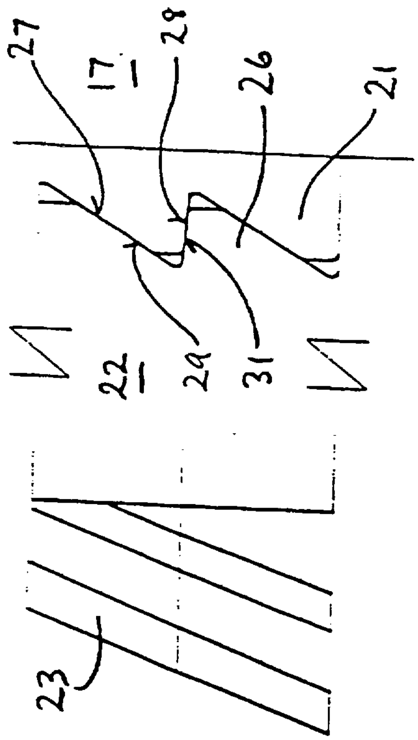


Fig 3

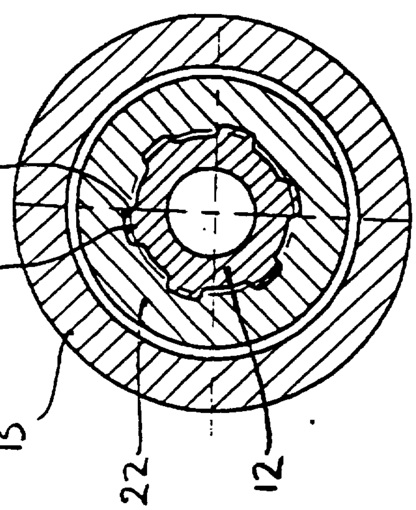
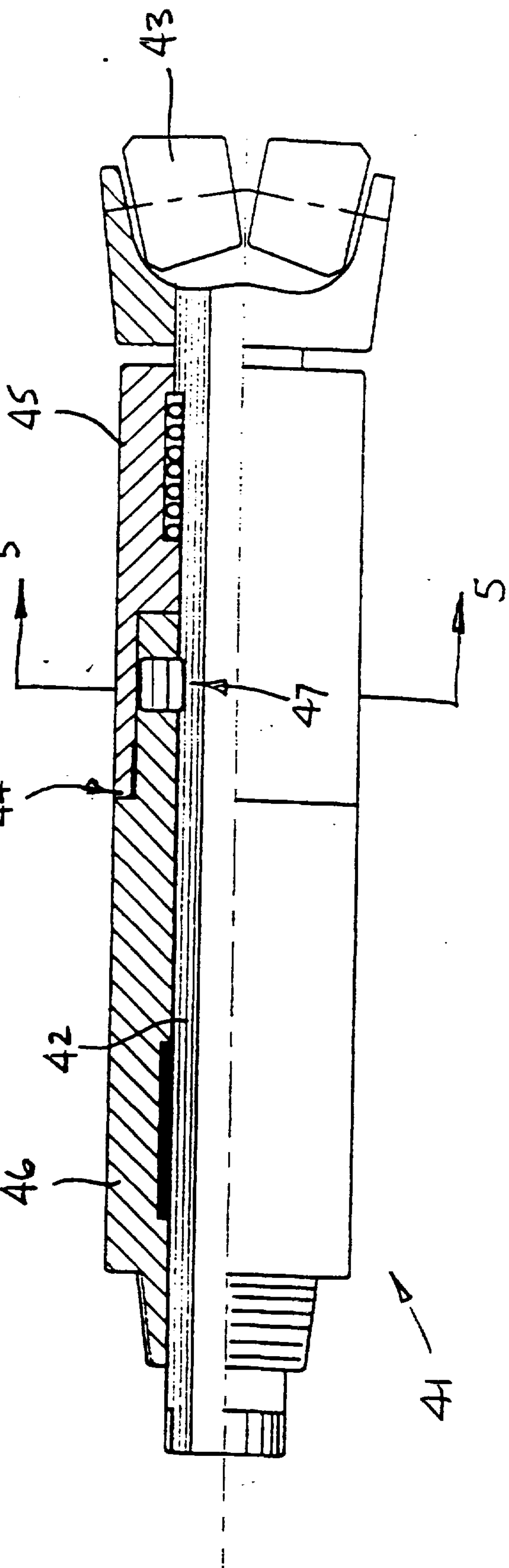


Fig 2

Fig 4



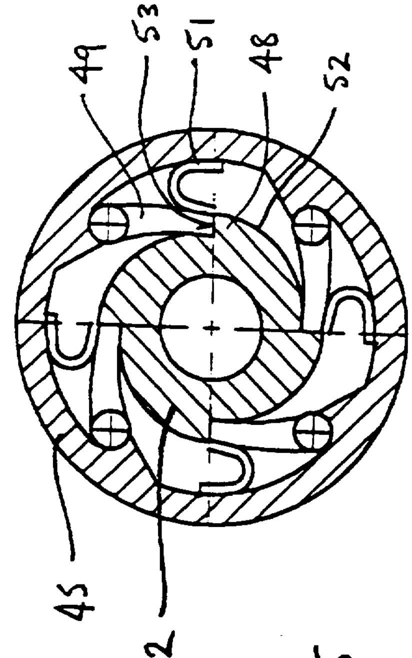


Fig 5

Downhole motors

The present invention is concerned with down hole motors and methods of their operation.

Down hole motors are commonly used in drilling applications, particularly in long reach drilling where the drill string length is considerable. In oil well drilling applications, the drill string length may exceed 10,000m. In general, down hole motors are hydraulically driven by the drilling mud/fluid, though usually the drill string is also rotated in order to increase the rate of penetration.

In a standard down hole motor, the rotor, on which the drill bit is attached, can move freely with respect to the stator (housing). This does not create any problems as long as it is possible/desirable to pump drilling fluid. There are several instances where it may be desirable to rotate the drill string without pumping drilling fluid. These include situations where there is drilling fluid loss to the rock formations, a hole in the drill string (wash-out), pump failure, or a jammed drill bit.

In standard motors, this will result in the rotor of the motor effectively rotating backwards (anti-clockwise) relative to the housing, since the housing will be rotating forwards (clockwise) while the rotor will be stationary. When this occurs, the motor works as a pump and sucks back surrounding drilling fluid which includes drill cuttings. This can ruin the motor.

It is therefore an object of the invention to prevent the motor working as a pump.

When a "wash-out" occurs and the hole is tight, it will be tightest at the bit. Thus, as the string is pulled back, the bit tends to get stuck. It would be easier to withdraw the bit if it could be rotated. It is therefore a further object of the invention to provide a means of rotating the bit forwards without pumping drilling fluid.

According to the present invention, there is provided a down hole motor assembly comprising a hydraulic drive portion, a drill bit operatively connected to the drive portion and a stator arranged to be connected to a drill string, the drive portion being arranged to be rotated relative to the stator by the supply of fluid to a motor to which the drive portion is arranged to be operatively connected, the assembly also including a ratchet mechanism operatively connected between the stator and the drive portion, the ratchet mechanism being arranged to permit the drive portion to rotate relative to the stator in a normal forward drilling sense and to prevent relative rotation between the drive portion and the stator in the opposite sense.

Thus, when no drilling fluid is pumped to the motor while the drill string is still being rotated, the ratchet mechanism ensures that the drive portion is driven forwards by the stator, as the stator is itself rotated by the drill string. The drill bit can, in this way, be rotated without pumping drilling fluid while at the same time ensuring that the motor does not work in reverse, as a pump, thereby avoiding damage.

Preferably, the assembly also includes a release mechanism arranged to disengage the ratchet mechanism when the resistance to rotation of the drill bit reaches a predetermined level of torque. In this way, when the drill bit is severely jammed, continued rotation of the drive portion will be halted, thereby preventing damage to or destruction of the motor. The predetermined level of torque may be 10,000 to 20,000 Nm, for example, about 15,000 Nm. Preferably, the release mechanism is re settable.

In one embodiment, the ratchet mechanism comprises a first ratchet member connected to and rotationally fixed relative to the drive member and a second ratchet member connected to and rotationally fixed relative to the stator, one of the two ratchet members being axially movable, the assembly further including biassing means arranged to urge the two ratchet members into operative engagement. Preferably, the two ratchet members have mutually engaging, respective, circumferentially arranged teeth, the teeth having correspondingly inclined engaging cam surfaces and respectively abutting radial faces; whereby relative rotation between the drive member and the stator in the normal forward drilling sense causes the respective cam surfaces to slide over one another and the moveable ratchet member to move axially against the force of the biassing means, while relative rotation in the opposite sense is prevented by the respective abutting surfaces coming in to mutual contact.

Preferably the first member is axially moveable. The biassing means may be a spring, preferably a helical compression spring. In this embodiment, the release mechanism may be provided by the abutting radial faces having a slight inclination so that when the torque reaches the predetermined level, the axially movable ratchet member moves axially with the abutting surfaces sliding past each other.

In another embodiment, the ratchet mechanism includes a series of teeth circumferentially arranged on the drive member, a series of arms circumferentially arranged on the stator, the distal ends of the arms being movable radially, and a series of biassing means acting between the stator and the ends of the arms to urge the ends of the arms radially inwards. The teeth preferably have a shallow cam surface and a steep abutment surface. Thus, relative rotation between the drive member and the stator in the normal drilling sense causes the distal ends of the arms to slide over the cam surfaces of the teeth against the force of the biassing means, while relative rotation in the opposite sense is prevented by the distal ends of the arms positively engaging the abutment surfaces of the teeth.

The arms may be held in position by the biassing means. The biassing means are preferably U-shaped springs. In this embodiment, the release mechanism may be provided by the abutment surfaces having a slight inclination so that when the torque reaches the predetermined level, the distal ends of the arms move up the respective abutment surfaces against the force of the respective springs.

The invention also extends to a drill string incorporating a motor as described above and to methods of operating the motor and the drill string. Thus, the invention provides a down hole motor which can rotate the bit without drilling fluid being supplied and which can avoid working as a pump when the drill string is rotated without drilling fluid being supplied.

The present invention may be carried into practice in various ways and some embodiments will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 is an axial section through a down hole motor assembly according to the invention;

Figure 2 is a section on the line 2-2 in Figure 1, to an enlarged scale;

Figure 3 is a projected view on the line 3-3 in figure 3, again to an enlarged scale;

Figure 4 is a view similar to Figure 1, showing a second embodiment; and

Figure 5 is a section on the line 5-5 in Figure 4, to an enlarged scale.

Figure 1 shows a down hole motor assembly 11 including a drive member 12, a drill bit 13 attached to the drive member 12 and a stator housing 14 in two parts, a forward part 15 and a rear part 16. The forward stator part 15 has a stepped portion 17 which defines an annular cavity 18 which houses a ratchet assembly 19.

The ratchet assembly 19 comprises a ring of teeth 21 on the stepped portion 17 of the forward stator part 15, a movable ratchet member 22 and a helical compression spring 23, as also shown in figures 2 and 3. The ratchet member 22 is a ring which surrounds the drive member 12 and which is axially slideable relative to it. The ratchet member 22 has internal slots 24 which in engage corresponding ribs 25 on the drive member 12, and has a ring of teeth 26 which engage the teeth 21.

The spring 23 acts between the rear stator part 16 and the ratchet number 22, to urge the two rings of teeth 21, 26 into interengagement. The teeth 21 on the stator have a shallow inclined surface 27 and a steep abutment surface 28. The teeth 26 are similarly formed, having a shallow inclined surface 29 and steep abutment surface 31.

When the motor 11 is in use, hydraulic drilling fluid is pumped along the drill string to the motor (not shown) which rotates the drive member 12 clockwise, which in turn rotates the bit 13. At the same time, the string itself and so the stator 14 might be rotated; this rotation would also be clockwise but at a significantly lower rotational rate. As the drive member 12 rotates, the ratchet member 22 is also rotated due to the engagement of the slots 24 and ribs 25. In this mode, the inclined surfaces 29 of the teeth 26 slide over the inclined surfaces 27 of the teeth 21, moving the ratchet member 22 rearwards against the force of the spring 23. The spring 23 then returns the ratchet member 22 to the forward position with the teeth 21, 26 interengaging once again, but with the ratchet member having advanced one tooth. Thus, the rotation of the drive member 12 is not transmitted to the forward stator part 15.

When the supply of drilling fluid is cut off or otherwise interrupted, the motor ceases to rotate the drive member 12. If the drill string is now rotated clockwise, this will rotate the stator 14 clockwise and with it the ring of teeth 21 on the forward stator part 15. In this mode, the abutment surfaces 28 on the teeth 21 contact the abutment surfaces 31 on the teeth 26. As the teeth 21 rotate clockwise, they take with them the teeth 26, thus rotating the ratchet member 22 clockwise. Rotation of the ratchet member 22 rotates the drive member 12, through the slots 24 and ribs 25, and so the bit 13 is rotated, again clockwise.

If the bit 13 should be completely jammed, the assembly includes a release mechanism. The abutment surfaces 28, 31 on the teeth 21, 26 are slightly inclined. Thus, when a particular level of torque is reached, the teeth 26 will be forced rearwards against the spring 23, with the two sets of abutment surfaces 28, 31 sliding along each other. In this way, damage to the lower drive shaft of the motor and possibly also the drill string can be avoided.

Figures 4 and 5 show a second embodiment. The down hole motor assembly 41 includes a drive member 42, a drill bit 43 is attached to the drive member 42 and a stator housing 44 comprising a forward part 45 and a rear part 46. The assembly 41 also includes a ratchet assembly 47.

The ratchet assembly 47 includes four teeth 48 on the drive member 42, four arms 49 pivotally attached to the forward stator part 45 and four U-shaped compression springs 51. Although four teeth, arms and springs are shown, it will be appreciated that any convenient number can be employed. The teeth 48 consist of a cam surface 52 and an abutment surface 53. The arms 49 are pivoted so that their distal ends move generally radially and the springs 51 act to urge the distal ends of the arms 49 into engagement with the teeth 48.

When the motor is in use, the drilling fluid is pumped along the drill string to the motor (not shown) which rotates the drive member 42 clockwise, which in turn rotates the bit 43. Again, the drill string and stator 44 may be being rotated at the same time but at a slower speed. As the drive member 42 rotates, the teeth 48 move clockwise and the distal ends of the arms 49 slide up over the cam surfaces 52 against the force of the springs 51. As rotation proceeds, the arms 49 snap back down behind the teeth 48 under the action of the springs 51. Thus, the rotation of the drive member 42 is not transmitted to the forwards stator part 45.

When the supply of drilling fluid is cut off or otherwise interrupted, the motor ceases to rotate the drive member 42. If the drill string is now rotated clockwise, this will rotate the stator 44 clockwise. The distal ends of the arms 49 will engage the abutment surfaces 53 and will be maintained in this position by the springs 51. Continued rotation of the stator 44 will therefore rotate the drive member 42 in the same direction, through the arms 49.

This embodiment may possibly also include a release mechanism although this is not shown. In this case, if the abutment surfaces 53 are slightly inclined, when a particular level of torque is reached, the distal ends of the arms 49 will ride up the abutment surfaces against the springs 51. In this way, the risk of damage to the lower drive shaft of the motor and possibly also the drill string can be minimised.

Claims

1. A down hole motor assembly comprising a hydraulic drive portion, a drill bit operatively connected to the drive portion and a stator arranged to be connected to a drill string, the drive portion being arranged to be rotated relative to the stator by the supply of fluid to a motor to which the drive portion is arranged to be operatively connected, the assembly also including a ratchet mechanism operatively connected between the stator and the drive portion, the ratchet mechanism being arranged to permit the drive portion to rotate relative to the stator in a normal forward drilling sense and to prevent relative rotation between the drive portion and the stator in the opposite sense.

2. An assembly as claimed in Claim 1, further including a release mechanism arranged to disengage the ratchet mechanism when the resistance to rotation of the drill bit reaches a predetermined level of torque.

3. An assembly as claimed in Claim 1 or Claim 2, in which the ratchet mechanism comprises a first ratchet member connected to and rotationally fixed relative to the drive member and a second ratchet member connected to and rotationally fixed relative to the stator, one of the two ratchet members being axially movable, the assembly further including biassing means arranged to urge the two ratchet members into operative engagement.

4. An assembly as claimed in Claim 3, in which the two ratchet members have mutually engaging, respective, circumferentially arranged teeth, the teeth having correspondingly inclined engaging cam surfaces and respectively abutting radial faces; whereby relative

rotation between the drive member and the stator in the normal forward drilling sense causes the respective cam surfaces to slide over one another and the moveable ratchet member to move axially against the force of the biassing means, while relative rotation in the opposite sense is prevented by the respective abutting surfaces coming in to mutual contact.

5. An assembly as claimed in Claim 4, in which the release mechanism is provided by the abutting radial faces having an inclination so that when the torque reaches the predetermined level, the axially movable ratchet member moves axially with the abutting surfaces sliding past each other.

6. An assembly as claimed in any of Claims 3 to 5, in which the first ratchet member is axially moveable.

7. An assembly as claimed in any of Claims 3 to 6, in which the biassing means is a helical compression spring.

8. An assembly as claimed in Claim 1 or Claim 2, in which the ratchet mechanism includes a series of teeth circumferentially arranged on the drive member, a series of arms circumferentially arranged on the stator, and biassing means acting between the stator and the arms to urge the arms into engagement with the teeth.

9. An assembly as claimed in Claim 8, in which the arms are pivotally mounted on the stator so that their respective distal ends are movable in a generally radial sense.

10. An assembly as claimed in Claim 9, in which the teeth have a relatively shallow cam surface and a

relatively steep abutment surface whereby relative rotation between the drive member and the stator in the normal drilling sense causes the distal ends of the arms to slide over the cam surfaces of the teeth against the force of the biassing means, while relative rotation in the opposite sense is prevented by the distal ends of the arms positively engaging the abutment surfaces of the teeth.

11. An assembly as claimed in any of Claims 8 to 10, in which the biassing means comprises a series of springs acting between the stator and the distal ends of the arms.

12. An assembly as claimed in Claim 11, in which the release mechanism is provided by the abutment surfaces having an inclination so that when the torque reaches the predetermined level, the distal ends of the arms move up the respective abutment surfaces against the force of the respective springs.

13. A drill string incorporating a down hole motor assembly as claimed in any preceding Claim.

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Application No: GB 9916077.2
Claims searched: 1 - 13

Examiner: David Hotchkiss
Date of search: 8 December 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): E1F (FEE, FEF)

Int Cl (Ed.6): E21B

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2055927 A	(Engineering Enterprises Inc.) Whole document	1 & 8 - 11
X	US 5350242	(William Wenzel) Whole document	1 & 8 - 11

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