

TITLE OF THE INVENTION

Jet Motor.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application
5 Number 60/787,906 entitled, "Downhole Tool," filed on March 31, 2006, in the
United States Patent and Trademark Office.

STATEMENT REGARDING FEDERALLY SPONSORED
RESEARCH OR DEVELOPMENT

Not Applicable.

10 BACKGROUND OF THE INVENTION

Field of the Invention. The present invention relates in general to a
downhole drilling and cleaning apparatus. More specifically, the invention is
directed to a motor and apparatus for cleaning out production tubing, for drilling
oil and gas wells and like applications.

15 Description of the Related Art. The use of hydraulically driven drill bits is
known in the art as described in the following U.S. Patents.

U.S. Patent No. 1,727,276, issued to Diehl on September 3, 1929, discloses
a drill bit rotating at one speed and a body portion rotating at a second lower
speed. Once the drill bit engages a hard formation the drill bit and the body
20 combine and rotate at the speed of the body portion.

U.S. Patent 1,860,214, issued to Yeaman on May 24, 1932, discloses a
hydraulically rotating drill bit with exhaust passages through the bit body for the
escape of impelling fluid.

U.S. Patent 3,133,603, issued to Lagacherie, et al on May 19, 1964,
25 discloses a fluid driven-bit wherein fluid passes over an internal turbine. The fluid
acts upon the internal turbine in order to rotate the drill bit.

U.S. Patent 3,844,362, issued to Elbert, et al on October 29, 1974, discloses
a device for boring holes comprising a body having a front end and a rear end
wherein forward drive means are provided at the rear end for receiving pressurized

fluid. A boring head is rotatably mounted in the body and projects from the front end of the body. Passages direct fluid from the boring head to impart torque to the boring head.

U.S. Patents 4,440,242 and 4,529,046, issued to Schmidt, et al on April 3, 1984 and July 16, 1985 respectively, disclose a drilling apparatus having nozzles functioning as cutting jets and passages discharging radially to generate torque for rotation.

U.S. Patent 5,101,916, issued to Lesh for on April 7, 1992, discloses a fluid-driven tool wherein pressurized fluid is used to create rotation by force applied to internal helical vanes.

U.S. Patent 5,385,407, issued to De Lucia on January 31, 1995, discloses a tool having three sections wherein lubricant is permitted to flow through orifices to lubricate the bearing assembly.

U.S. Patent 6,520,271, issued to Martini on February 18, 2003, discloses a fluid-driven tool wherein pressurized fluid is used to create rotation by internal vanes.

The prior art does not disclose a downhole motor capable of generating rotational and thrust torque with radially-extending nozzles in cooperation with a control sleeve.

The prior art does not disclose a downhole motor capable of generating significant torque utilizing a fluid comprising either a liquid or a gas.

It is a further object of the present invention to provide a downhole drilling and cleaning tool having a plurality of nozzles providing rotational and forward thrust in cooperation with a control sleeve.

BRIEF SUMMARY OF THE INVENTION

The present invention comprises a jet motor downhole tool that can be utilized to drill or to clean a well bore or tubing associated therewith. The jet motor includes a motor comprising drive nozzles at a power shaft generating rotational torque acting in cooperation with a control sleeve. The jet motor

connects to an upper member that is in fluid communication with the source drilling or cleaning fluid. Drilling or cleaning fluid pressure is directed to nozzles in the power shaft extending generally in a radial direction. The nozzles may be oriented at an axial angle obtusely to provide downward force. The power shaft
5 rotates in relation to a control sleeve spaced from the power shaft, the control sleeve providing a reaction structure in relation to fluid discharged from the nozzles. The control sleeve and the power shaft define a blind annular space, closed at the upper end and open at the lower end to allow fluid discharge.

Other features and advantages of the invention will be apparent from the
10 following description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side view of the jet motor of the present invention fully assembled.

Figure 2 is a partial exploded view of the present invention.

15 Figure 3A is a side view of the drill bit.

Figure 3B is a side view of an alternative embodiment of the drill bit.

Figure 3C is a cross-sectional view of the drill bit.

Figure 4 is a cross-sectional view of the jet motor.

Figure 4A is a cross-sectional view of the power shaft.

20 Figure 5 is a cross-sectional view of an alternative embodiment of the jet motor.

DESCRIPTION OF THE INVENTION

Referring to Fig. 1, the exterior of the present invention 10 generally comprises a drill bit 20, control sleeve 12, and upper subassembly 16 having a
25 common central axis AA.

As used herein, “upper” will refer to the direction of upper end 80 of upper subassembly 16 that connects to a drill string or tubing (not shown). As used herein, “lower” will refer to the direction of the drill face 18 of drill bit 20.

Drill bit 20 is generally a closed cylindrical structure with an open

connection end 24. Channel 22 extends inwardly of bit 20 from connection end 24. In an exemplary embodiment, threading is provided on the interior surface of drill bit 20 proximate connection end 24 for threaded connection to threaded lower connector 23 of power shaft assembly 36.

5 In an exemplary embodiment, drill bit face 18 is textured to model a rock configuration as depicted in Fig. 3A. Alternatively, drill bit face 18 is comprised of a plurality of nodes, as seen in Fig. 3B.

At least one rotation nozzle 26 is disposed in cylinder wall 27 of drill bit 20. In an exemplary embodiment at least two rotation nozzles 26 are provided. 10 Rotation nozzles 26 are in fluid communication with the interior channel 22 of drill bit 20 and allow fluid flow from channel 22 to the exterior of bit 20.

Referring to Fig. 3C, nozzles 26 each have an axis NN. Axes NN are each disposed generally perpendicularly to axis AA. Axes NN of the rotation nozzles 26 are each oriented radially to allow fluid expulsion from nozzles 26 to provide 15 rotational thrust in a desired direction. Specifically, the angle N' of each axis NN with respect to a plane passing through axis AA and interior opening 29 of cylinder wall 27 is acute in the preferred direction of rotation.

In an alternative embodiment, nozzles 26 may each be oriented from a plane normal to axis AA at the interior opening 29 of each nozzle 26 to provide a 20 forward thrust from fluid escaping through nozzles 26.

Referring to Figs. 2, 3 and 4, cutting nozzles 28 are provided in bit face 18. Cutting nozzles 28 are in fluid communication with interior channel 22 of drill bit 20. The axes of cutting nozzles 28 may be oriented parallel with axis AA or at an angle to axis AA. Fluid escaping from nozzles 28 provide cutting forces and wash 25 loose materials away from bit face 18.

Control sleeve 12 is generally composed of an elongated cylindrical barrel body, with a sleeve channel 17 passing therethrough. Sleeve channel 17 is oriented along axis AA.

Control sleeve 12 is provided with threading 19 at its upper end 32 for

threaded connection to threaded lower end 42 of upper subassembly 16. Upper subassembly 16 is provided with threading 82 at upper end 80 of upper subassembly 16 to allow connection to a drill string or tubing (not shown). Such threaded connections are commonly practiced. Accordingly, control sleeve 12, after installation on a drill string or tubing, is in a fixed position in relation to the drill string or tubing.

Referring to Figs. 2 and 4, power shaft assembly 36 is depicted. Power shaft assembly 36 includes power shaft 30, lower radial bearing 46, thrust bushing 48, upper radial bearing 44, retainer 38 and upper thrust bushing 70.

Power shaft 30 comprises a hollow cylinder structure having an internal channel 66 aligned with axis AA. Internal channel 66 allows fluid communication from a drill string or tube (not shown) to channel 22 of drill bit 20.

Power shaft 30 is constructed and sized to rotate within control sleeve 12 with lower radial bearing 46 and upper radial bearing 44 providing radial support. As drill bit 20 is fixedly attached to power shaft 30, drill bit 20 and power shaft 30 rotate together in relation to control sleeve 12.

Thrust bushing 48 extends intermediate lower radial bearing 46 and upper radial bearing 44.

A retainer nut 38 is provided on power shaft 30 intermediate upper radial bearing 44 and upper end 60 of power shaft 30. Retainer nut 38 is provided with an internal threading 39 to attach to corresponding threading 81 provided on power shaft 30 to retain radial bearings 44 and 46 and thrust bearing 48 intermediate retainer 38 and a shoulder 69 on power shaft 30 and shoulder 68 on control sleeve 12.

Power shaft 30, control sleeve 12, shoulder 68 and end 56 of lower radial bearing 46 define a blind annular space 55 intermediate exterior surface 33 of power shaft 30 and inner surface 34 of control sleeve 12, blind annular space 55 having an upper end 45 defined by end 56 of lower radial bearing 46 and shoulder 68 of control sleeve 12.

In an alternative embodiment, an annular seal (not shown) may be provided at end 56 of lower radial bearing 46 to define the upper end 45 of annular space 55. An annular opening 54 of annular space 55 is defined intermediate control sleeve 12 and power shaft 30.

5 At least one drive nozzle 52 extends through wall 31 of power shaft 30. In an exemplary embodiment, at least two drive nozzles 52 are provided spaced within wall 31 of power shaft 30. Drive nozzles 52 are in fluid communication with the internal channel 66 of power shaft 30.

10 Drive nozzles 52 are located intermediate annular opening 54 of annular space 55 and upper end 45 of lower radial bearing 46. Drive nozzles 52 allow fluid flow from channel 66 to annular space 55.

15 Drive nozzles 52 each have an axis DD. Axes DD are each oriented angularly with respect to axis AA, the angle being acute in the direction of upper end 60 of power shaft 30 and obtuse with respect to the direction of the threaded lower connector 23. Accordingly, drive nozzles 52 are each oriented rearward from a plane normal to axis AA at the interior opening 57 of each nozzle 52. Such orientation provides a forward thrust from fluid escaping through nozzles 52.

20 Referring to Fig. 4A, axes DD of the drive nozzles 52 are each angled radially to allow fluid expulsion from nozzles 52 to provide rotational thrust in a desired direction. Specifically, the angle D' of each axis DD with respect to a plane passing through axis AA and shaft wall 31 at interior opening 57 is acute in relation to the plane.

25 In the exemplary embodiment shown, rotation nozzles 26 and drive nozzles 52 are depicted. In an alternative embodiment, not shown, ports may be provided without nozzles to achieve the results of the invention. The principles taught in this invention apply with ports used in lieu of rotation nozzles 26 or drive nozzles 52.

Inner surface 34 of control sleeve 12 is spaced from exterior surface 33 of power shaft 30. The extent of separation is gap 49. In operation, fluid forced

through internal channel 66 is expelled through drive nozzles 52. Upon impinging inner surface 34, a reactive force is incurred, thereby enhancing the rotation of power shaft 30.

In an exemplary embodiment, gap 49 is in the range of 0.0381 cm to 0.0762 cm (0.015" to 0.030") for a tool having a nominal diameter in the range of 3.175 cm to 4.445 cm (1.25" to 1.75"). In an exemplary embodiment, gap 49 is in the range of 0.508 cm to 0.635 cm (0.20" to 0.25") for a tool having a nominal diameter in the range of 10.4775 cm to 12.065 cm (4.125" to 4.75"). Generally, gap 49 is effective in a range of ratios of gap 49 to nominal diameter of the control sleeve 12 (gap : sleeve diameter) as follows: Ratio of 1:125 to ratio of 1:17. Depending on various application requirements, including the fluid used, nozzle size, pressure and other factors, ratios outside the foregoing range may be preferred.

Referring to Figs.2 and 4, upper subassembly 16 comprises a generally hollow cylindrical body 61 having a connecting threading 82 for connecting to a drill string or tubing (not shown) at its upper end 80 and connecting threading 42 for connecting to control sleeve 12 at control sleeve threading 19. Upper subassembly 16 includes an interior channel 72 aligned with axis AA.

An injection tube 96 is provided in upper subassembly 16. Injection tube 96 includes an elongated tube 40 and tube head 41. Tube head 41 has a larger diameter than tube 40. A tube retaining nut 86 is provided to retain tube head 41 between retaining nut 86 and a shoulder 87 provided in upper subassembly 16. Retaining nut 86, tube head 41 and tube 40 define a continuous tube channel 95 aligned with axis AA. Retaining nut 86 has connecting threading 84 for threaded connection to internal connecting threading 83 provided in upper subassembly 16.

In an exemplary embodiment, injection tube 96 is retained in position by the retaining nut 86 and shoulder 87. Injection tube 96 is free to rotate about axis AA independent of the rotation of power shaft 30 and upper subassembly 16.

Upper subassembly 16 is provided with a cylindrical inset 88 at its lower

end 62. A thrust bushing 70 is provided to provide a bearing surface intermediate upper subassembly 16 and power shaft assembly 36. Thrust bushing 70 additionally encloses and provides radial support for tube 40.

5 Tube 40 extends past the lower end 62 of upper subassembly 16 into the channel 66 of power shaft 30.

The interior surface 71 of thrust bushing 70 is sized and constructed to encircle the exterior surface 43 of tube 40 but to allow rotation between the surfaces. Thrust bushing 70 further contains a flange 74 extending radially outward. Flange 74 is received between the lower end 62 of upper bearing
10 assembly 16 and upper end 60 of power shaft 30. Thrust bushing 70 includes a cylindrical inset 78 to receive a segment of power shaft 30 at the upper end 60 of power shaft 30. Cylindrical inset 78 is sized and constructed to slidably receive end 60 of power shaft 30.

The diameter of outer surface 43 of injection tube 30 is preferably only
15 slightly smaller than the diameter of channel 66 allowing injection tube 30 to be slidably received in channel 66.

In an exemplary embodiment of the present invention, the injection tube 96 with a tube wall 90 having a width such that the wall will expand slightly when an appropriate operating pressure is applied internal of wall 90 in tube channel 95.
20 Such slight expansion creates a seal between the exterior surface 43 of tube wall 90 and the interior surface 93 of power shaft 30 that defines channel 66.

In an exemplary embodiment, the tube wall 90 is provided with a slight flare proximate its lower end 64 to enhance sealing of tube wall 90 and the interior surface 93. A preferred flare angle is up to five degrees outwardly from the tube
25 wall segment that is not flared.

In summary, the power shaft assembly 36 is fixedly attached to the drill bit
20. Power shaft assembly 36 is rotatable within control sleeve 12. A blind annular space 55 is defined between power shaft 30 and control sleeve 12.

In operation, jet motor 10 of the present invention is attached to a drill

string or tube (not shown). A fluid (drilling fluid or gas) is introduced into the drill string or tube at determined pressures. Pressure is applied to the fluid forcing the fluid through aligned channels 72, 95, 66 and 22. The fluid is forced through drive nozzles 52, rotation nozzles 26 and cutting nozzles 28. The pressure from the fluid in channels 66 and 22 is greater than the ambient downhole pressure. Differential pressure at rotation nozzles 26 and drive nozzles 52 create rotational torque on the drill bit 20 and power shaft 30.

Importantly, the proximity of inner surface 34 of control sleeve provides a surface that is stationary relative to power shaft 30. The expansive force of the fluid escaping drive nozzles 52 impinging surface 34 enhance the rotational torque on power shaft 30.

Gap 49 may be determined to provide desired reactive force of fluid expelled through drive nozzles 52 at inner surface 34. In addition, the force of the drilling fluid may be manipulated in order to control the thrust of the drilling fluid against the sleeve inner surface 34 through the drive nozzle 52 thereby controlling the rotation of the power shaft 30 and the drill bit 20.

As the drive nozzles 52 are located intermediate opening 54 of annular space 55 and upper end 45, fluid forced out of drive nozzles 52 is forced out of opening 54, thereby continually washing annular space 55 and preventing accumulation of debris in annular space 55.

Fig. 5 depicts an alternative exemplary embodiment wherein four drive nozzles 52 are located on power shaft 30 in order to increase the amount of fluid expelled through the drive nozzles 52. Drive nozzles 52 are depicted as symmetrically situated opposing pairs with respect to each other. Drive nozzles 52 may also be situated asymmetrically or in any combination of the two.

In an exemplary embodiment, an appropriate gas, such as nitrogen, may be utilized as the fluid medium. The construction of the present invention, particularly the construction of injection tube wall 90 with expansion capability upon application of appropriate fluid pressure in tube channel 95 together with fit

of exterior surface 43 of tube wall 90 and the interior surface 93 of power shaft 30 allows the creation of an effective seal even though the fluid is a gas.

The exemplary embodiment providing a flared lower end 64 of tube wall 90 provides an effective seal at interior surface 93 as internal fluid pressure is applied
5 at the open end lower end 64.

The foregoing description of the invention illustrates a preferred embodiment thereof. Various changes may be made in the details of the illustrated construction within the scope of the appended claims without departing from the true spirit of the invention. The present invention should only be limited by the
10 claims and their equivalents.

CLAIMS

I claim:

1. A motor for a downhole tool comprising:
 - a cylindrical control sleeve;
 - a power shaft;
 - said power shaft at least partially surrounded by said control sleeve;
 - said power shaft rotatable in relation to said control sleeve;
 - said power shaft having a shaft wall;
 - said power shaft having an interior power shaft channel;
 - at least one opening provided in said shaft wall;
 - said at least one opening in fluid communication with said shaft channel;
 - said control sleeve having an interior sleeve surface;
 - said at least one opening having an opening axis;
 - said opening axis oriented toward said control sleeve surface.
2. The motor of claim 1 further comprising:
 - said control sleeve and said power shaft defining an annulus;
 - said at least one opening having an opening outlet; and
 - said opening outlet proximate said annulus.
3. The motor of claim 2 further comprising:
 - said annulus having an annulus closed end and an annulus open end; and
 - said opening outlet intermediate said annulus closed end and said annulus open end.
4. The motor of claim 1 further comprising:
 - said power shaft having a shaft axis; and
 - said opening axis acutely oriented in relation to a plane through said shaft axis.
5. The motor of claim 1 further comprising:
 - said control sleeve connected to an upper subassembly;
 - said upper subassembly connectable to a drill string;

said upper subassembly having an interior upper channel;
an injection tube providing fluid communication from said upper channel to said shaft channel.

6. The motor of claim 5 further comprising:
said injection tube comprising a tube head and a tube;
said tube head in said upper subassembly; and
said tube extending into said shaft channel.
7. The motor of claim 6 further comprising:
said shaft channel having an interior shaft surface;
said tube having an exterior tube surface; and
said tube slidably received in said shaft surface.
8. The motor of claim 7 further comprising:
said tube constructed to expand at a predetermined pressure;
wherein said tube surface forming a seal against said shaft surface upon application of a predetermined pressure.
9. The motor of claim 8 further comprising:
said tube having a flared opening proximate a lower tube end; and
said lower tube end received in said shaft channel proximate said shaft surface.
10. The motor of claim 1 wherein said at least one opening provided in said shaft wall comprising a nozzle.
11. A motor for a downhole tool comprising:
a cylindrical control sleeve;
a power shaft;
said power shaft at least partially surrounded by said control sleeve;
said power shaft rotatable in relation to said control sleeve;
said power shaft having a shaft wall;
said power shaft having an interior power shaft channel;
at least one nozzle provided in said shaft wall;

- said at least one nozzle in fluid communication with said shaft channel;
said control sleeve having an interior sleeve surface;
said at least one nozzle having a nozzle axis;
said nozzle axis oriented toward said control sleeve surface.
12. The motor of claim 11 further comprising:
said control sleeve and said power shaft defining an annulus;
said at least one nozzle having a nozzle outlet;
said nozzle outlet proximate said annulus;
said annulus having an annulus closed end and an annulus open end; and
said nozzle outlet intermediate said annulus closed end and said annulus open end.
13. The motor of claim 12 further comprising:
said power shaft having a shaft axis; and
said nozzle axis acutely oriented in relation to a plane through said shaft axis.
14. The motor of claim 11 further comprising:
said control sleeve connected to an upper subassembly;
said upper subassembly connectable to a drill string;
said upper subassembly having an interior upper channel;
an injection tube providing fluid communication from said upper channel to said shaft channel.
15. The motor of claim 14 further comprising:
said injection tube comprising a tube head and a tube;
said tube head in said upper subassembly;
said tube extending into said shaft channel;
said shaft channel having an interior shaft surface;
said tube having an exterior tube surface;
said tube slidably received in said shaft surface;
16. The motor of claim 15 further comprising:

- said injection tube rotatable in relation to said upper subassembly; and
said injection tube rotatable in relation to said power shaft.
17. The motor of claim 16 further comprising:
said tube constructed to expand at a predetermined pressure;
wherein said tube surface forming a seal against said shaft surface upon
application of a predetermined pressure.
18. The motor of claim 16 further comprising:
said tube having a flared opening proximate a lower tube end; and
said lower tube end received in said shaft channel proximate said shaft
surface.
19. A method for providing rotation in a downhole tool comprising:
attaching a control sleeve to a drill string,
attaching a rotatable power shaft having at least one opening to the drill
string such that the power shaft is at least partially within the control sleeve to
define an annulus intermediate the power shaft and the control sleeve; and
providing a fluid under pressure to the rotatable power shaft such that the
fluid is forced through said at least one opening into said annulus to impact said
control sleeve.
20. The method of claim 19 wherein:
said fluid comprising nitrogen.
21. The method of claim 19 wherein:
said fluid comprising a conventional drilling fluid.