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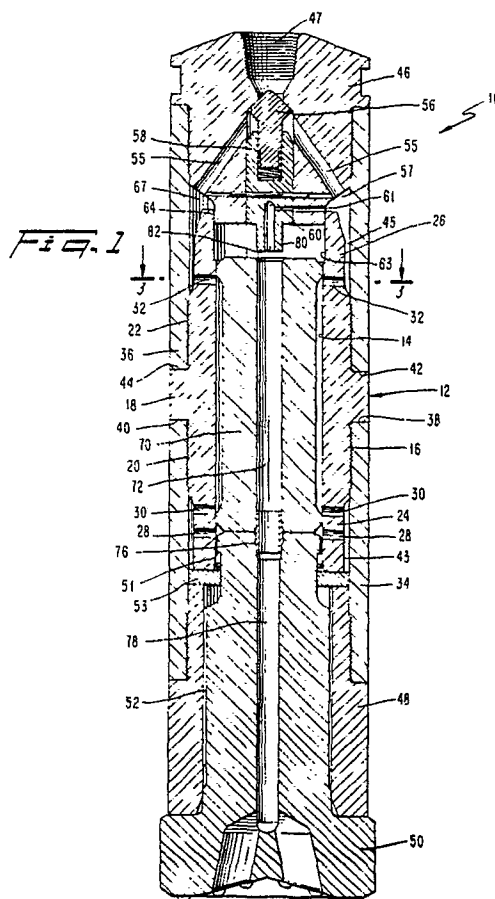
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54 **Percussion drill.**

57 A percussion drill includes a control arbor in which a hammer piston is longitudinally reciprocably disposed. Front and rear casing sections are threadedly coupled to the control arbor in a manner preventing longitudinal movement of the arbor relative to the casing sections. A drill bit is secured to the front casing section, and is repeatedly struck by the piston to effect a percussion drilling operation. A rear sub is secured to the rear casing section, and a front end of the rear sub projects telescopically into a rear end of the control arbor to radially support the latter.



BACKGROUND OF THE INVENTION

The present invention relates to percussive drilling equipment in which a hammer piston is repeatedly impacted against a drill bit.

A conventional percussion drill depicted in FIG. 6 comprises a hollow cylindrical casing 100, a rear sub 102 threadedly attached to a rear end of the casing, and a driver sub 104 threadedly attached to a front end of the casing. A drill bit 106 is mounted in the driver sub 104 and is connected for common rotation therewith by longitudinal splines. Disposed within the casing is an inner cylindrical sleeve 108, a front end of which rests upon a rear edge of the driver sub 104. Seated on a rear end of the inner sleeve is a support body 110 which carries a forwardly extending tube 112. Sandwiched between the support body and the rear sub 102 is a valve guide member 114 in which a check valve 116 is spring-biased toward a closed position. Slidably mounted within the inner sleeve is a hammer piston 118. Pressurized air is conducted downwardly through a passage formed within the rear sub 102, the valve guide member, and the support body, and enters a channel arrangement 117 defined by opposing surfaces of the inner sleeve, the hammer piston, and the casing. The pressurized air is conducted through the channel arrangement and is directed alternately to front and rear ends of the hammer piston for reciprocating the piston forwardly and rearwardly in a manner which is well known in the art. During its forward stroke the piston strikes the drill bit. The rear sub 102 pushes the support body 110 toward the sleeve 108 via a rubber make-up ring 115.

The make-up ring 115 is formed of a resilient material to ensure that the rear sub can be completely screwed onto the casing. However, the ring 115 also makes it possible for the inner sleeve 108 to move longitudinally relative to the casing in response to the percussive vibrations during a drilling operation. That movement of the sleeve can cause galling on the outer circumference of the inner sleeve and the inner circumference of the casing, as well as peening on both ends of the inner sleeves and the components against which they abut. Eventually, a costly and time-consuming replacement of the damaged components is required.

Furthermore, the inner sleeve has holes 120 formed longitudinally along a rear end thereof for conducting pressurized air. Those holes are difficult and expensive to machine, and may crack due to the vibration and peening of the inner sleeve. The holes terminate in radial ports 122 which are also

expensive and difficult to machine and may crack when stressed.

Close tolerances are required between the outer diameter of the inner sleeve and the inner diameter of the casing in order to achieve a proper fit therebetween and to minimize leakage between various air channels defined by those parts. Such close tolerances are expensive to achieve and promote the galling discussed earlier.

SUMMARY OF THE INVENTION

The present invention relates to a percussion drill for drilling in subterranean formations. The drill comprises a cylindrical arbor which includes inner and outer circumferences. The inner circumference defines a front-to-rear extending longitudinal axis. The outer circumference has a forwardly facing first lateral stop shoulder, and a rearwardly facing second lateral stop shoulder disposed rearwardly of the first stop shoulder. A casing arrangement is secured to the arbor and is disposed around the outer circumference thereof. The casing arrangement includes a rearwardly facing lateral stop face and a forwardly facing stop face abutting the first and second stop shoulders, respectively, for constraining the arbor against longitudinal movement relative to the casing arrangement. A drill bit is mounted to a front end of the casing arrangement. A hammer piston is disposed within the inner circumference of the arbor for longitudinal sliding movement relative thereto. A rear sub is mounted to a rear end of the casing arrangement and includes a conduit for conducting a forward flow of pressurized air. The arbor includes a passage arrangement for conducting a pressurized air alternately to opposite ends of the hammer piston for producing rearward and forward longitudinal reciprocation of the hammer piston. The hammer piston applies impacts to a rear end of the drill bit during forward strokes of the hammer piston while the arbor is constrained against longitudinal movement relative to the casing arrangement by stop faces.

Preferably, the casing arrangement comprises separate front and rear casing sections secured to front and rear ends, respectively, of the arbor. The front casing section carries the rearwardly facing stop face, and the rear casing section carries the forwardly facing stop face.

Preferably, the outer circumference of the arbor includes a radially outwardly projecting flange

disposed intermediate front and rear ends of the arbor. That flange carries the first and second stop surfaces.

It is preferred that a front portion of the rear sub is telescopingly received in a rear end of the inner circumference and engages that inner circumference in a manner radially supporting a rear end of the arbor.

The present invention also pertains to a control arbor, per se, which can be employed in a drill of the above-described type.

BRIEF SUMMARY OF THE DRAWINGS

The objects and advantages of the invention will become apparent from the following detailed description of a preferred embodiment thereof in connection with the accompanying drawings, in which like numerals designate like elements, and in which:

FIGURE 1 is a longitudinal sectional view of a percussion drill according to the present invention, with a hammer piston thereof disposed at the forward end of its stroke.

FIGURE 2 is a view similar to FIG. 1 with the hammer piston disposed at the end of a rearward stroke;

FIGURE 3 is a cross-sectional view taken along the line 3-3 in FIG. 1;

FIGURE 4 is a side elevational view of a control arbor of the percussion drill;

FIGURE 5 is a side elevational view of a hammer piston of the percussion drill; and

FIGURE 6 is a longitudinal sectional view taken through a prior art percussion drill.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

A percussion drill 10 according to the present invention comprises a control arbor 12 which includes inner and outer circumferential surfaces 14, 16. The outer surface 16 includes an annular flange 18 projecting radially outwardly at about a longitudinal midpoint of the control arbor, and front and rear externally threaded surface portions 20, 22 disposed on opposite sides of the flange 18. Front and rear ends of the outer surface 16 are defined by portions 24, 26 of reduced diameter, the portion 26 having a chamfer 27.

A circumferential row of radially extending, circumferentially spaced ports 28 is formed in the reduced diameter front portion 24, which ports project completely through the arbor. Another circum-

ferential row of radial ports 30 is formed in the reduced diameter portion 24 longitudinally rearwardly of the first row of ports 28. An additional circumferential row of radial ports 32 is formed in the reduced-diameter rear portion 26.

Threadedly connected to the front threads 20 of the arbor is the internally threaded rear end of a cylindrical front casing section 34, and threadedly connected to the rear threads 22 of the arbor is the internally threaded front end of a cylindrical rear casing section 36. The casing sections 34, 36 are threaded onto the arbor such that a rear radial end face 38 of the front casing section 34 defines a stop face which abuts a forwardly facing radial stop shoulder 40 of the flange 18, and a front radial end face 42 of the rear casing section 36 defines a stop face which abuts a rearwardly facing radial stop shoulder 44 of the flange 18. Thus, the arbor 12 is securely constrained against longitudinal movement relative to the casing sections 34, 36.

The inner circumferences of the front and rear casing sections 34, 36 define, together with the reduced diameter portions 24, 26 of the outer circumference of the arbor, front and rear annular chambers 43, 45. Those chambers are isolated from one another by the threaded connections between the arbor and casing sections, and by the flange 18.

Threadedly coupled to a rear end of the rear casing section 36 is a rear sub 46, and threadedly coupled to a front end of the front casing section 34 is a driver sub 48. Disposed in a rear end of the rear sub 46 is an internally threaded hole 47 (or optionally an externally threaded post) for connecting the rear sub to a drill string (not shown). Disposed within the driver sub 48 is a drill bit 50 which is connected for common rotation with the driver sub by a conventional splined coupling 52 therebetween. The drill bit 50 is afforded a slight amount of longitudinal movement relative to the driver sub 48, but forward movement of the drill bit terminates when a radial flange 51 of the drill bit engages a bit retainer ring 53.

The rear sub 46 includes diagonal ports 55 for conducting a flow of pressurized air from the hole 47 to an annular chamber 57 disposed between the rear sub 46 and the rear end of the arbor 12. That chamber 57 is contiguous with the earlier described chamber 45. A spring-biased check valve 56 is disposed between the hole 47 and the ports 55 for preventing a back flow of liquid to the hole 47. The check valve 56 is mounted in a check valve guide 58 which can be adjustable in the manner disclosed in US patent Application Serial No. 07/317,865 to align bypass holes 60 of different diameter with a hole 61 in the rear sub 46.

A rear end portion 63 of the inner circumferential surface 14 of the arbor 12 is of slightly en-

larged diameter and snugly telescopingly receives an outer circumferential surface 64 of a front portion of the rear sub 46 so as to be radially supported and stabilized by the rear sub. A longitudinal gap 67 is disposed between the rear end of the arbor 12 and the rear sub 46 to ensure that the rear sub can be fully screwed onto the rear casing section 36.

Slidably disposed within the inner circumferential surface 14 of the arbor is a reciprocable hammer piston 70 which has a central throughbore 72 and a plurality of longitudinally extending, circumferentially spaced ribs 73 (FIG. 5) along its outer circumference. Formed between the ribs 73 are longitudinal channels 74 which terminate short of the piston ends so as to be closed off at their front and rear ends 74F, 74R.

The drill bit 50 carries a rearwardly projecting tube 76 which is receivable in the throughbore 72 of the piston to communicate that throughbore 72 with a throughbore 78 in the drill bit. A forwardly projecting tubular portion 80 of the valve guide 58 is sized to be received in a rear end of the throughbore 72 and contains a passage 82 therein which interconnects the bypass hole 60 with the throughbore 72. In that way, surplus air can be conducted from the chamber 57 and through the holes 61 and 60, the passage 82 and the throughbores 72 and 78 for ejection from a front end of the drill bit for cleaning and cooling the cutting elements and conducting away the cuttings.

The afore-described percussion drill 10 is assembled by threadedly securing the front and rear casing sections 34, 36 to the arbor until the rear and front ends 38, 42 of the casing sections abut the stop shoulders 40, 44 of the flange 18. This ensures that the arbor cannot move longitudinally relative to the casing sections. The rear sub 46 is threadedly secured to the rear end of the rear casing section 36, whereupon the front portion of the rear sub enters the rear portion 63 of the arbor to provide radial support therefor. The hammer piston 70 is slid into the arbor, followed by the attachment of a unit comprised of the drill bit 50, the driver sub 48, and the bit retainer ring 53. That unit is attached by screwing the driver sub 48 to the front casing section 34.

In operation, the drill 10 is rotated by a drill string while the hammer piston 70 is repeatedly reciprocated to strike the drill bit. The hammer piston is guided for movement within the control arbor 12 which is constrained against longitudinal movement relative to the casing sections 34, 36. Furthermore, the rear end of the arbor is radially braced by the front portion of the rear sub 46.

Pressurized air for reciprocating the hammer piston is conducted downwardly through the drill string and into the hole 47 of the rear sub 46. The

air pushes open the check valve 56 and travels through the diagonal ports 55 to the annular chamber 57 and from there to the annular chamber 45. When the hammer piston is positioned at the end of its forward stroke (FIG. 1), the pressurized air travels radially inwardly through the radial ports 32, through the longitudinal channels 74, radially outwardly through the ports 30 and into the front chamber 43. From that chamber 43 the air flows radially inwardly through the ports 28 and acts against the front surface of the hammer piston to displace the latter rearwardly. As the front end of the rearwardly traveling hammer piston travels rearwardly past the radial ports 30, the pressurized air no longer communicates with the front chamber 43. Instead, the pressurized air is able to travel to a location behind the hammer piston 70 once the rear ends of the longitudinal channels 74 of the hammer piston communicate with the enlarged diameter portion 63 of the inner diameter of the arbor (FIG. 2). As this occurs, the hammer piston is displaced forwardly by the air pressure.

It will be appreciated that the arbor is not susceptible to galling or peening since the arbor cannot move longitudinally relative to the casing sections 34, 36. Furthermore, there are no longitudinally drilled holes in the arbor, so the problem of holes cracking under stress is not present. Since no longitudinal holes are disposed in the arbor, there is no need to undertake the difficult and expensive drilling of slots in the inner circumference to communicate such longitudinal holes with the inner circumference. The threaded connections between the arbor and casing sections effectively isolate the front and rear chambers 43, 45 from one another, so there is no need for to establish close tolerances between the outer circumference of the arbor and the inner circumferences of the casing sections 34, 36 to achieve such isolation.

Although the present invention has been described in connection with a preferred embodiment thereof, it will be appreciated by those skilled in the art that additions, modifications, substitutions, and deletions not specifically described may be made without departing from the spirit and scope of the invention as defined in the appended claims.

Claims

1. A percussion drill for drilling in subterranean formations, comprising:
a cylindrical arbor including:
an inner circumference defining a front-to-rear extending longitudinal axis, and
an outer circumference having a forwardly facing first lateral stop shoulder, and a rearwardly facing second lateral stop shoulder disposed rearwardly of

said first stop shoulder, casing means secured to said arbor and disposed around said outer circumference thereof, said casing means including a rearwardly facing lateral stop face and a forwardly facing lateral stop face abutting said first and second stop shoulders, respectively, for constraining said arbor against longitudinal movement relative to said casing means, a drill bit mounted to a front end of said casing means, a hammer piston disposed within said inner circumference of said arbor for longitudinal sliding movement relative thereto, and a rear sub mounted to a rear end of said casing means and including conduit means for conducting a forward flow of pressurized air, said arbor including passage means for conducting the pressurized air alternately to opposite ends of said hammer piston for producing rearward and forward longitudinal reciprocation of said hammer piston, said hammer piston applying impacts to a rear end of said drill bit during forward strokes of said hammer piston while said arbor is constrained against longitudinal movement relative to said casing means by said stop faces.

2. A percussion drill according to claim 1, wherein said casing means comprises separate front and rear casing sections secured to front and rear ends, respectively, of said arbor, said front casing section carrying said rearwardly facing stop face, and said rear casing section carrying said forwardly facing stop face.

3. A percussion drill according to claim 2, wherein said outer circumference of said arbor includes a radially outwardly projecting flange disposed intermediate front and rear ends of said arbor, said flange carrying said first and second stop surfaces.

4. A percussion drill according to claim 3, wherein said rearwardly facing stop face is defined by a rear end of said front casing section, and said forwardly facing stop face is defined by a front end of said rear casing section.

5. A percussion drill according to claim 4, wherein said front and rear casing sections include internal threads coupled to external threads on said outer circumference.

6. A percussion drill according to claim 5, wherein said flange is disposed substantially midway between said front and rear ends of said arbor.

7. A percussion drill according to claim 1, wherein a front portion of said rear sub is telescopingly received in a rear end of said inner circumference and engages said inner circumference in a manner radially supporting a rear end of said arbor.

8. A percussion drill according to claim 1, wherein a rear portion of said outer circumference

is radially spaced from an inner circumference of said casing means for defining therebetween an annular rear chamber which communicates with said conduit means in said rear sub, said passage means in said arbor including first ports extending laterally through said arbor for communicating said rear chamber with a portion of said internal circumference of said arbor located behind said hammer piston.

9. A percussion drill according to claim 8, wherein a portion of said inner circumference of said arbor disposed rearwardly of said first ports is of enlarged diameter.

10. A percussion drill according to claim 9, wherein said rear portion of said outer circumference is of reduced diameter for forming said rear chamber.

11. A percussion drill according to claim 8, wherein a front portion of said outer circumference is radially spaced from said inner circumference of said casing means for defining therebetween an annular front chamber, an outer circumference of said hammer piston including longitudinal channel means, said passage means in said arbor including second lateral ports for communicating said longitudinal channel means with said front chamber and third lateral ports for communicating said front chamber with a portion of said inner circumference located ahead of said hammer piston.

12. A percussion drill according to claim 11, wherein said hammer piston includes a plurality of longitudinally extending, circumferentially spaced ribs defining a plurality of said longitudinal channels.

13. A percussion drill for drilling in subterranean formations, comprising:

a cylindrical arbor including:

an inner circumference defining a front-to-rear extending longitudinal axis, and

an outer circumference including a radially outwardly projecting flange disposed intermediate front and rear ends of said arbor, said flange carrying a forwardly facing first lateral stop shoulder and a rearwardly facing second stop shoulder,

front and rear casing sections secured to said arbor,

said front casing section having internal threads connected to external threads of said outer circumference, and a rear end abutting said first stop shoulder,

said rear casing section having internal threads connected to external threads of said outer circumference, and a front end abutting said second stop shoulder, whereby said arbor is constrained by said front and rear ends of said casing sections against longitudinal movement relative to said casing sections,

a driver sub mounted to a front end of said casing

means,

a drill bit mounted in said driver sub,

a hammer piston disposed within said inner circumference of said arbor for longitudinal sliding movement relative thereto, and

a rear sub mounted to a rear end of said casing means and including:

a front portion telescopically received in a rear end of said inner circumference in engagement with said inner circumference in a manner radially supporting a rear end of said arbor, and

conduit means for conducting pressurized air,

a rear portion of said outer circumference being radially spaced from an inner circumference of said rear casing section for defining therebetween an annular rear chamber which communicates with said conduit means,

said arbor including passage means for conducting pressurized air from said rear chamber alternately to opposite ends of said hammer piston for producing rearward and forward longitudinal reciprocation of said hammer piston, said hammer piston applying impacts to a rear end of said drill bit during forward strokes of said hammer piston while said arbor is constrained against longitudinal movement relative to said casing sections by said stop faces, and said rear end of said arbor is radially supported by said rear sub.

14. A percussion drill according to claim 13, wherein a portion of said inner circumference of said arbor disposed rearwardly of said first ports is of enlarged diameter.

15. A percussion drill according to claim 14, wherein said rear portion of said outer circumference is of reduced diameter for forming said rear chamber.

16. A percussion drill according to claim 15, wherein a front portion of said outer circumference is radially spaced from said inner circumference of said casing means for defining therebetween an annular front chamber, an outer circumference of said hammer piston including longitudinal channel means, said passage means in said arbor including second lateral ports for communicating said longitudinal channel means with said front chamber and third lateral ports for communicating said front chamber with a portion of said inner circumference located ahead of said hammer piston.

17. A percussion drill according to claim 16, wherein said hammer piston includes a plurality of longitudinally extending, circumferentially spaced ribs defining a plurality of said longitudinal channels.

18. A percussion drill according to claim 16, wherein said flange is disposed substantially midway between said front and rear ends of said arbor.

19. A control arbor adapted to be connected to casing means of a percussion drill for reciprocally

guiding a hammer piston, comprising a cylindrical body having an inner circumference defining a front-to-rear extending axial space adapted to guide a hammer piston for reciprocation, and an outer circumference having a laterally outwardly projecting flange disposed intermediate front and rear ends of said body defining rearwardly and forwardly facing stop shoulders adapted to engage separate casing sections, front and rear external threads disposed on said outer circumference forwardly and rearwardly, respectively, of said flange and adapted to be coupled to internal threads of separate casing sections, a first set of circumferentially spaced fluid ports extending through said body rearwardly of said rear threads, a second set of circumferentially spaced fluid ports extending through said body forwardly of said front threads, and a third set of circumferentially spaced fluid ports extending through said body forwardly of said second set of ports.

20. A control arbor according to claim 19, wherein said first, second, and third sets of ports extend through portions of said outer circumference which are of reduced diameter.

Fig. 1

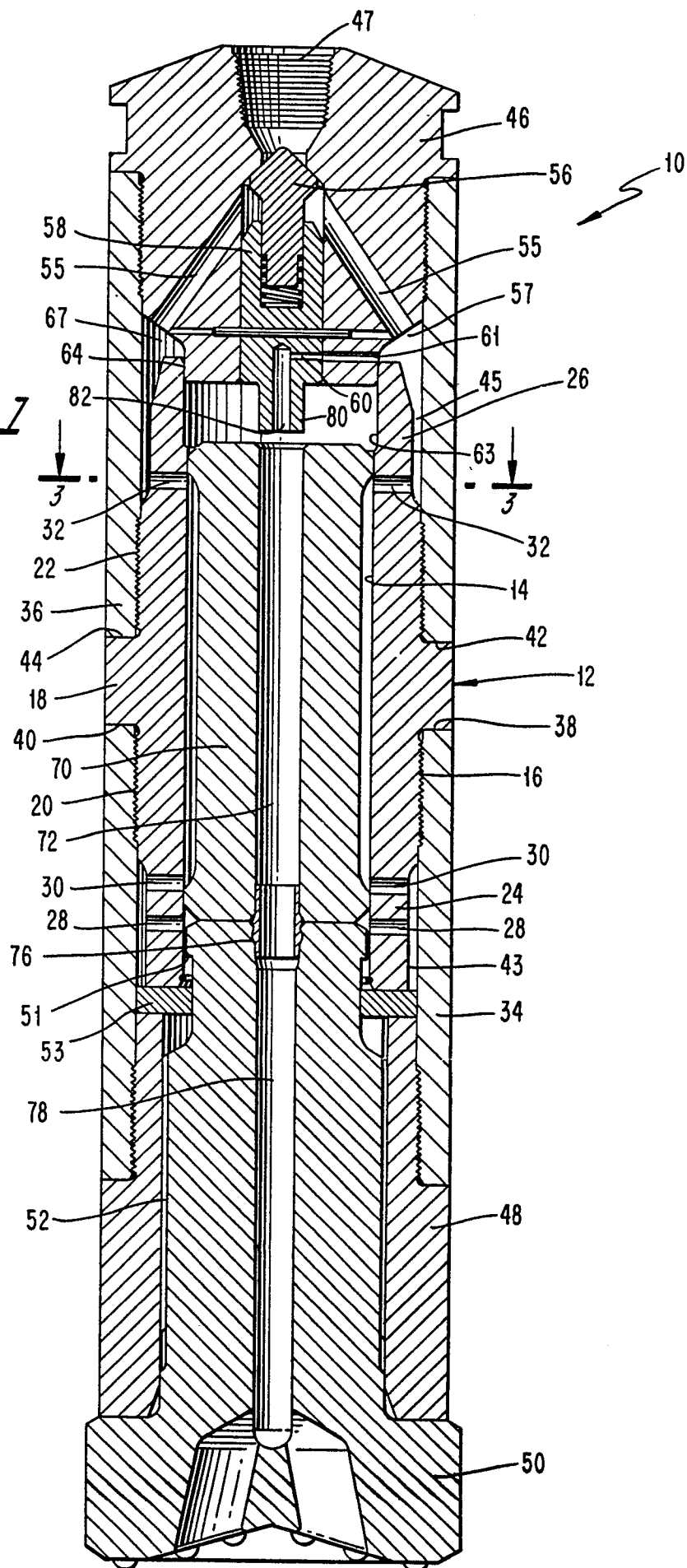


Fig. 2

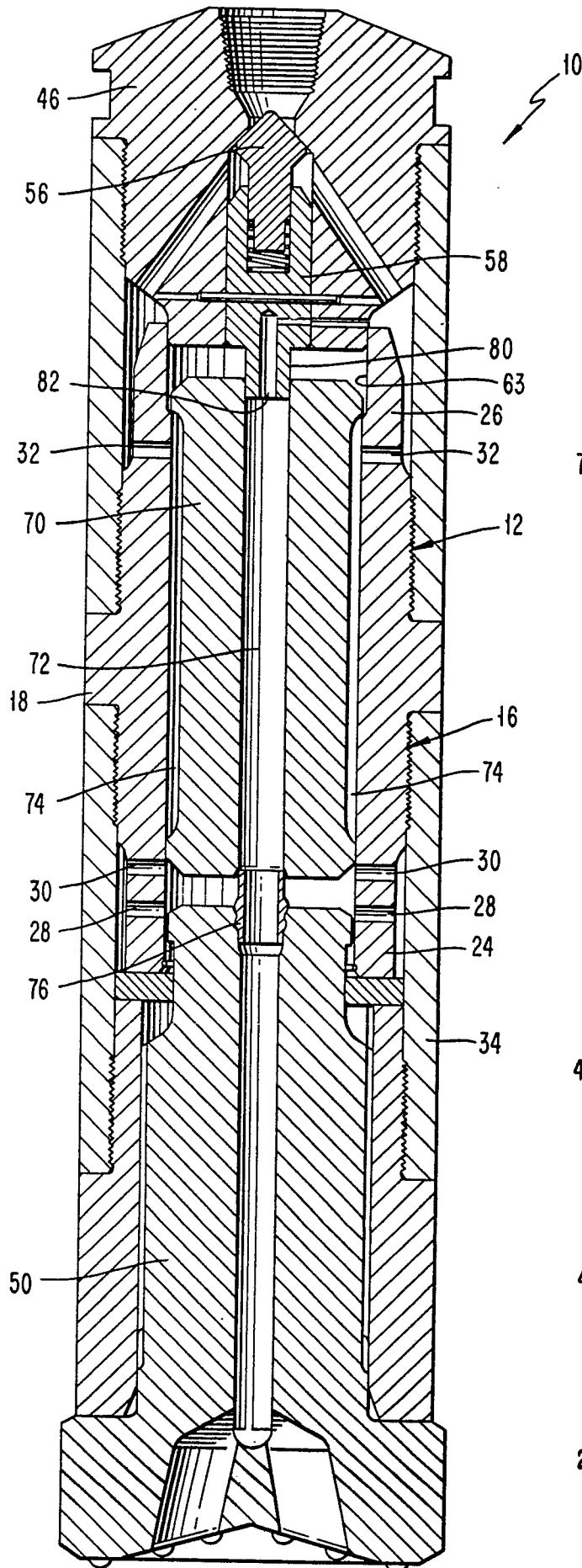


Fig. 3

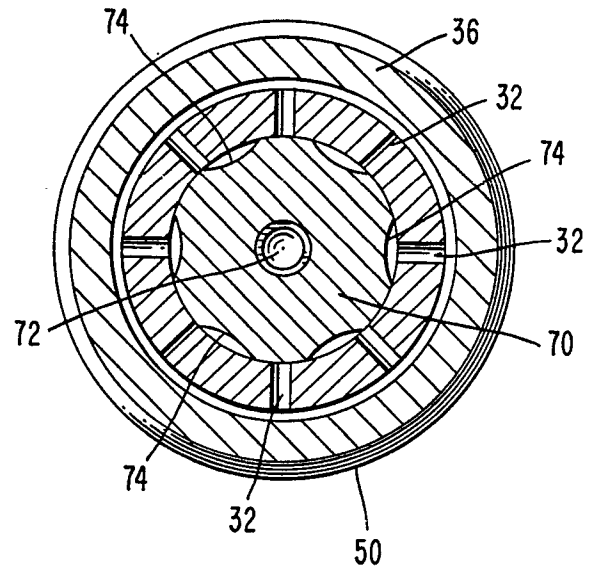
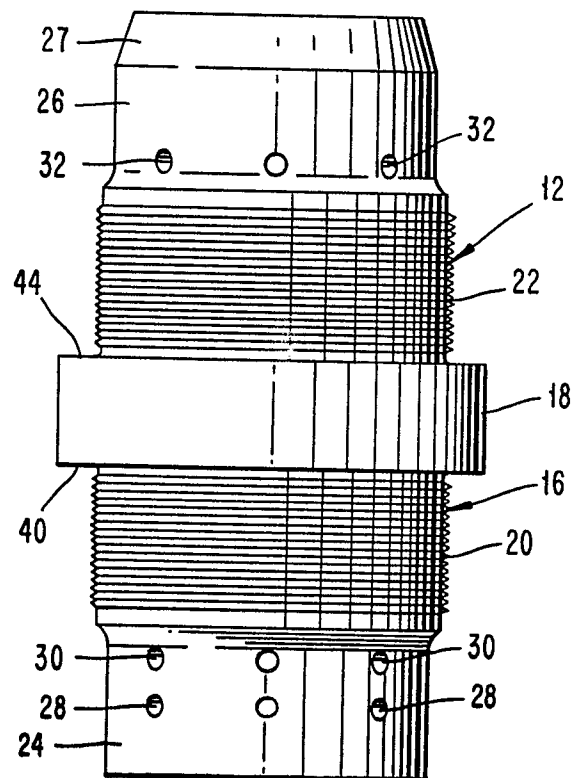


Fig. 4



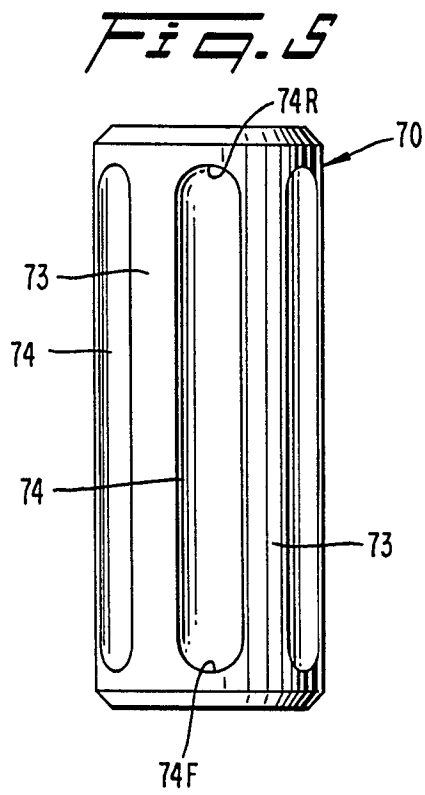


Fig. 6

