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CA 2797565 C 2014/03/18

(11)(21) **2 797 565**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(22) **Date de dépôt/Filing Date:** 2007/03/29
(41) **Mise à la disp. pub./Open to Public Insp.:** 2007/10/11
(45) **Date de délivrance/Issue Date:** 2014/03/18
(62) **Demande originale/Original Application:** 2 646 326
(30) **Priorité/Priority:** 2006/03/31 (US60/787,906)

(51) **Cl.Int./Int.Cl.** *E21B 4/02* (2006.01)
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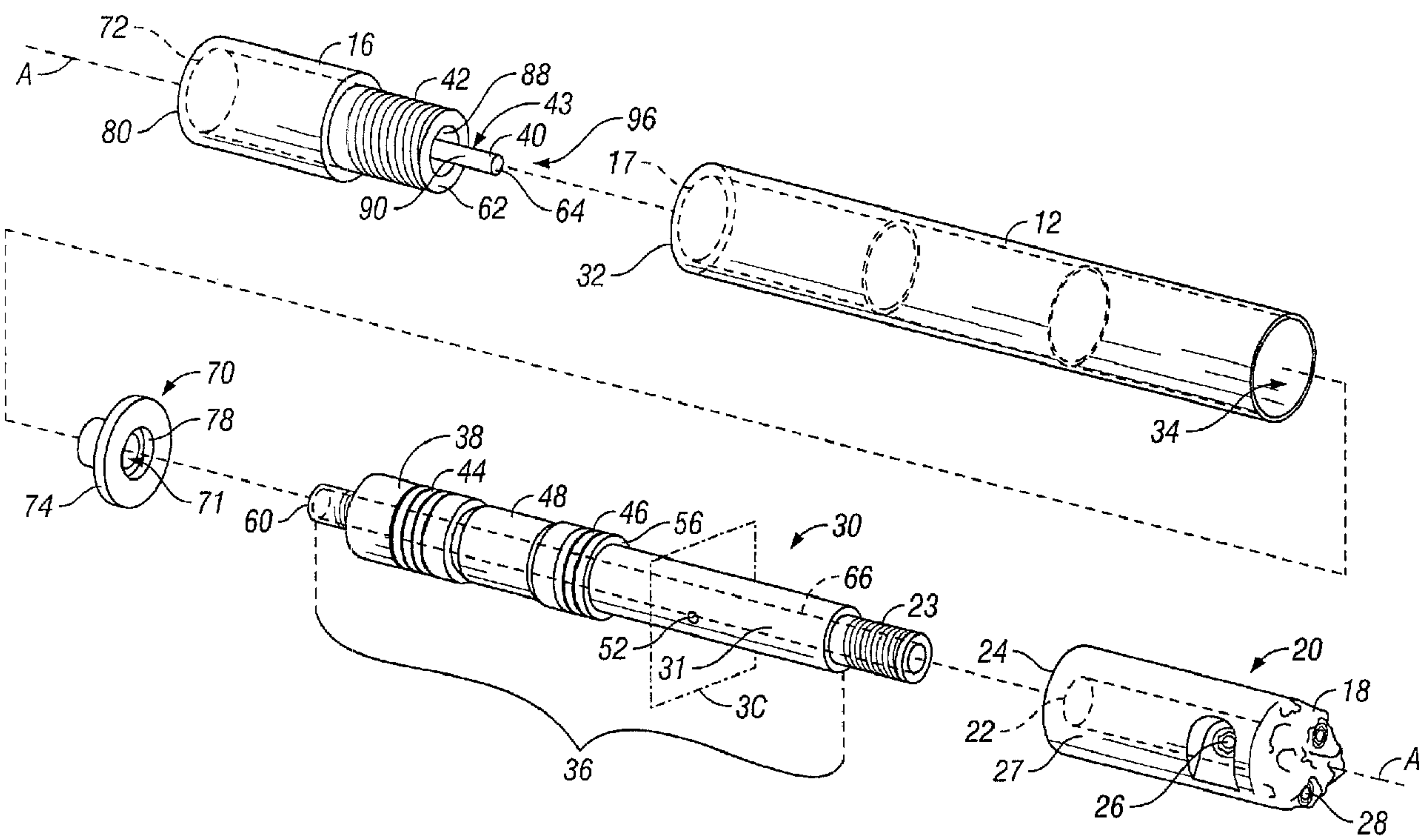
(54) Titre : MOTEUR A REACTION ET PROCEDE ASSURANT LA ROTATION D'UN OUTIL DE FOND DE TROU
(54) Title: JET MOTOR AND METHOD FOR PROVIDING ROTATION IN A DOWNHOLE TOOL



(57) Abrégé/Abstract:
The invention comprises a downhole jet motor that can be utilized to drill or to clean a well bore or tubing. The jet motor comprises a power shaft partially surrounded by a control sleeve defining a blind annular space, closed at the upper end and open at the lower end to allow fluid discharge. At least one opening is provided in the drive shaft wall extending radially within the annulus region. Drilling or cleaning fluid pressure is directed to the at least one opening in the power shaft. The control sleeve provides a reaction structure in relation to fluid discharged from the at least one opening producing rotation of the drive shaft in relation to the control sleeve.

ABSTRACT

The invention comprises a downhole jet motor that can be utilized to drill or to clean a well bore or tubing. The jet motor comprises a power shaft partially surrounded by a control sleeve defining a blind annular space, closed at the upper end and open at the lower end to allow fluid discharge. At least one opening is provided in the drive shaft wall extending radially within the annulus region. Drilling or cleaning fluid pressure is directed to the at least one opening in the power shaft. The control sleeve provides a reaction structure in relation to fluid discharged from the at least one opening producing rotation of the drive shaft in relation to the control sleeve.

JET MOTOR AND METHOD FOR PROVIDING ROTATION IN A DOWNHOLE TOOL

This application is a divisional application of Canadian Patent File No. 2,646,326 filed March 29, 2007.

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.

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 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, 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.

A further aspect of the invention seeks 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 of 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 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.

In a broad aspect, the invention seeks to provide a motor for a downhole tool comprising a cylindrical control sleeve, and a power shaft. The power shaft is at least partially surrounded by the control sleeve, and the power shaft is rotatable in relation to the control sleeve. The power shaft has a power shaft wall and an interior power shaft channel. There is at least one opening provided in the power shaft wall, the at least one opening being in fluid communication with the power shaft channel. The control sleeve has an interior control sleeve surface, and the at least one opening in the shaft wall has an opening axis, the opening axis being oriented toward the control sleeve surface. The power shaft has a power shaft axis and upper and lower ends. The opening axis of the at least one opening in the power shaft wall is acutely oriented in relation to the direction of the upper end of the power shaft, and is obtusely oriented in relation to the lower end thereof. The at least one opening has an interior opening, the opening axis of the at least one opening in the power shaft wall being acutely oriented with respect to a plane passing through the power shaft axis and the power shaft wall at the interior opening. The control sleeve is connected to an upper subassembly, the upper subassembly being connectable to a drill string, and having an interior upper channel. An injection tube provides fluid communication from the interior upper channel to the power shaft channel. The injection tube comprises a tube head and a tube, the tube head being disposed within the upper subassembly. The tube extends into the power shaft channel, and the injection tube has a lower tube end and an opposite upper tube end. The injection tube is connected to the upper subassembly at the upper tube end.

In a further aspect, the invention provides a motor for a downhole tool comprising a cylindrical control sleeve, and a power shaft. The power shaft is at least partially surrounded by the control sleeve, the power shaft being rotatable in relation to the control sleeve. The power shaft has a power shaft wall and an interior power shaft channel. At least one nozzle is provided in the power shaft wall, the at least one nozzle being in fluid communication with the power shaft channel. The control sleeve has an interior control sleeve surface, and the at least one nozzle has a nozzle axis. The nozzle axis is oriented toward the control sleeve surface, and the control sleeve is connected to an upper subassembly. The upper subassembly has an interior upper channel, and an injection tube provides fluid communication from the upper channel to the power shaft channel, the power shaft having an interior power shaft surface. The injection tube has a lower tube end and an opposite upper tube end and an exterior tube surface, and is constructed to expand at a predetermined pressure. The exterior tube surface, at the lower tube end, forms a seal against the interior power shaft surface upon application of a predetermined pressure. The control sleeve and the power shaft define an annulus, the annulus having an annulus closed end and an annulus open end. At least one nozzle has a nozzle outlet, the nozzle outlet being intermediate the annulus closed end and the annulus open end, and having a uniform annulus gap between the annulus closed end and the annulus open end.

In a still further aspect, the invention pertains to a motor for a downhole tool comprising a cylindrical control sleeve, and a power shaft. The power shaft is at least partially surrounded by the control sleeve, and is rotatable in relation to the control sleeve. The power shaft has a power shaft wall, and an interior power shaft channel. There is at least one nozzle provided in the power shaft wall, the at least one nozzle being in fluid communication with the power shaft channel. The control sleeve has an interior control sleeve surface, and at least one nozzle has a nozzle axis. The nozzle axis is oriented toward the control sleeve surface, and is connected to an upper subassembly, the upper subassembly having an interior upper channel. There is an injection tube providing fluid communication from the upper channel to the power shaft channel, the power shaft having an interior power shaft surface. The injection tube has a lower tube end and an opposite upper tube end, the injection tube having a flared opening proximate the lower tube end and the lower tube end being received in the power shaft channel proximate the power shaft surface.

A further aspect of the invention is an apparatus that includes a control sleeve and a power shaft. The power shaft is at least partially surrounded by the control sleeve and is rotatable in relation to the control sleeve. The power shaft has a shaft wall with an interior power shaft channel extending therethrough. There is at least one shaft opening provided in the shaft wall that is in fluid communication with the power shaft channel. The at least one shaft opening is configured such that at least some of a fluid flowing through the interior power shaft channel will be directed through the at least one shaft opening and will exit out of the interior power shaft channel through the at least one shaft opening. The at least one shaft opening in the shaft wall has an interior opening with a shaft opening axis. The power shaft also has a central longitudinal shaft axis and an upper end and a lower end. The shaft opening axis of the at least one shaft opening in the shaft wall is acutely oriented with respect to a plane extending through the central longitudinal shaft axis wherein the plane intersects the shaft opening axis at the interior opening. Also included in the apparatus is a drill bit that is operationally connected to the power shaft. The drill bit has a cylinder wall in which at least one drill bit opening is provided. The at least one drill bit opening has a drill bit opening axis that is acutely oriented in relation to the direction of the upper end of the power shaft.

Yet a further aspect of the invention is an apparatus that includes a power shaft that has a shaft wall and an interior power shaft channel with an upper end and an opposite lower end. At least one shaft opening is provided in the shaft wall. There is also a shaft interior opening and a shaft opening axis where the shaft opening axis is acutely oriented in relation to the direction of the upper end of the power shaft. Also included in the apparatus is a drill bit that is operationally connected to the power shaft. The drill bit has a cylinder wall and a drill bit face. The cylinder wall is between the drill bit face and the power shaft. The drill bit has a longitudinal drill bit axis. There is at least one drill bit opening provided in the cylinder wall where the at least one drill bit opening has a drill bit opening axis. The drill bit opening axis is oriented outward from the drill bit axis through the cylinder wall and is also acutely oriented backward in the direction of the upper end of the power shaft. The at least one drill bit opening has a drill bit interior opening and a drill bit opening axis that is acutely oriented with respect to a plane passing through the drill bit axis at the drill bit interior opening.

Still a further aspect of the invention is an apparatus that includes a control sleeve and a power shaft that is at least partially surrounded by the control sleeve. The power shaft is rotatable in relation to the control sleeve. The power shaft has a shaft wall and an interior power shaft channel extending therethrough. At least one shaft opening is provided in the shaft wall that is in fluid communication with the power shaft channel. The at least one shaft opening is configured such that at least some of a fluid flowing through the interior power shaft channel will be directed through the at least one shaft opening and will exit out of the interior power shaft channel through the at least one shaft opening. The at least one shaft opening in the shaft wall has a shaft interior opening and a shaft opening axis as well as a central longitudinal shaft axis and an upper end and a lower end. The shaft opening axis of the at least one shaft opening in the shaft wall is acutely oriented with respect to a plane extending through the central longitudinal shaft axis wherein the plane intersects the shaft opening axis at the shaft interior opening. Also included in the apparatus is a drill bit that is operationally connected to the power shaft. The drill bit has a cylinder wall and a drill bit axis. There is at least one drill bit opening, with a drill bit opening axis, provided in the cylinder wall. The at least one drill bit opening has a drill bit interior opening where the drill bit opening axis is acutely oriented with respect to a plane passing through the drill bit axis at the drill bit interior opening.

Yet still a further aspect of the invention is an apparatus that includes a power shaft that has a shaft wall, an interior power shaft channel, and an upper end and an opposite lower end. At least one shaft opening, with a shaft opening axis, is provided in the shaft wall that also has a shaft interior opening. The shaft opening axis is acutely oriented with respect to a plane extending through the longitudinal shaft axis at the shaft interior opening. Also included in the apparatus is a drill bit that is operationally connected to the power shaft. The drill bit has a cylinder wall and a drill bit face wherein the cylinder wall is between the drill bit face and the power shaft. The drill bit has a longitudinal drill bit axis and there is at least one drill bit opening provided in the cylinder wall. The at least one drill bit opening has a drill bit opening axis that is oriented outward from the drill bit axis through the cylinder wall and that is also acutely oriented backward in the direction of the upper end of the power shaft. The at least one drill bit opening has a drill bit interior opening. The drill bit opening axis is acutely oriented with respect to a plane passing through the drill bit axis at the drill bit interior opening.

Other features and advantages of the invention will be apparent from the 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 drill bit of the jet motor.

Figure 3A is a perspective view of the drill bit of the jet motor.

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

Figure 3C is a cross-sectional view of the power shaft of the jet motor taken along plane 3C in Figure 2.

Figure 4 is a cross-sectional view of the jet motor taken along axis A-A in Figure 1 and through the drive nozzles.

Figure 4A is a cross-sectional view of the drill bit taken along line 4A-4A in Figure 4.

Figure 4B is a cross-sectional view of an alternative embodiment of the drill bit.

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 common central longitudinal 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.

Referring to Fig. 2, 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 or power shaft assembly 36.

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. 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 Figs. 4 and 4A, rotation 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 rotational thrust in a desired direction. Specifically, the angle N' of each axis NN with respect to a plane, as depicted by 4A-4A in Fig. 4, passing through axis AA and interior opening 29 of cylinder wall 27 is acute in the preferred direction of rotation.

Referring to Fig. 4B, in an alternative embodiment, axes NN of rotation nozzles 26 are each oriented angularly with respect to axis AA, the angle being acute in the direction of open connection end 24 of drill bit 20 and obtuse with respect to the direction of the drill bit face 18. Accordingly, rotation nozzles 26 may each be oriented rearward from a plane normal to axis AA at the interior opening 29 of each rotation nozzle 26. Such orientation may provide a forward thrust from fluid escaping through rotation nozzles 26.

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 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 provides cutting forces and washes 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.

Referring to Fig. 4, 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 its end 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 bushing 48 intermediate retainer nut 38 and a shoulder 69 on power shaft 30 and shoulder 68 on control sleeve 12, as seen in Figure 4 (upper portion).

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.

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.

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.

Drive nozzles 52 each have an axis DD, as seen in Fig. 3C. Axes DD are each oriented angularly with respect to axis AA, the angle being actue 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.

Referring to Fig. 3C, 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.

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.

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 subassembly 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 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. 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 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 12 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 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. The scope of the claims should not be limited by the preferred embodiments set forth in the examples, but should be given the broadest interpretation consistent with the description as a whole.

What is claimed is:

1. An apparatus comprising:

a 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 extending therethrough;

at least one shaft opening provided in said shaft wall;

said at least one opening in fluid communication with said power shaft channel, wherein said at least one shaft opening is configured such that at least some of a fluid flowing through said interior power shaft channel will be directed through said at least one shaft opening and will exit out of said interior power shaft channel through said at least one shaft opening;

said at least one shaft opening in said shaft wall having an interior opening and an shaft opening axis;

said power shaft having a central longitudinal shaft axis and an upper end and a lower end;

said shaft opening axis of said at least one shaft opening in said shaft wall acutely oriented with respect to a plane extending through said central longitudinal shaft axis wherein said plane intersects said shaft opening axis at said interior opening;

a drill bit operationally connected to said power shaft;

said drill bit having a cylinder wall;

at least one drill bit opening provided in said cylinder wall;

said at least one drill bit opening having a drill bit opening axis; and

said drill bit opening axis acutely oriented in relation to the direction of said upper end of said power shaft.

2. The apparatus of claim **1**, wherein said shaft opening axis is acutely oriented in relation to the direction of said upper end of said power shaft.

3. The apparatus of claim **1**, further comprising:

said control sleeve and said power shaft defining an annulus;

said at least one shaft opening having an opening outlet; and

said at least one opening outlet proximate said annulus.

4. The apparatus of claim **3**, further comprising:

said annulus having an annulus closed end and an annulus open end; and

said at least one opening outlet intermediate said annulus closed end and said annulus open end.

5. The apparatus of claim **1**, further comprising:

an injection tube operationally coupled to said upper end of said power shaft; and

said injection tube capable of forming a seal with at least a portion of the interior of said power shaft wall.

6. The apparatus of claim **5**, further comprising:

said injection tube comprising a tube head and a tube, wherein at least a portion of said tube is intermediate said tube head and said power shaft;

wherein at least a portion of said tube extends within said interior power shaft channel;

wherein at least a portion of said tube is constructed to at least partially expand at a predetermined pressure; and

wherein said injection tube provides fluid communication from a drill string to said interior power shaft channel.

7. The apparatus of claim **6**, wherein said tube has a tube lower end, and wherein said tube lower end has a flared opening.

8. The apparatus of claim **1**, further comprising:

an upper subassembly operationally coupled to said control sleeve;

said upper subassembly having an interior upper channel;

an injection tube at least partially coupled to said upper subassembly, said injection tube allowing fluid communication between said interior upper channel and said interior power shaft channel.

9. An apparatus comprising:

a power shaft;

said power shaft having a shaft wall;

said power shaft having an interior power shaft channel;

said power shaft having an upper end and an opposite lower end;

at least one shaft opening in said shaft wall;

said at least one shaft opening in said shaft wall having a shaft interior opening and a shaft opening axis;

said shaft opening axis acutely oriented in relation to the direction of said upper end of said power shaft;

a drill bit operationally connected to said power shaft;

said drill bit having a cylinder wall and a drill bit face wherein said cylinder wall is intermediate said drill bit face and said power shaft;

said drill bit having a longitudinal drill bit axis;

at least one drill bit opening provided in said cylinder wall;

said at least one drill bit opening having a drill bit opening axis;

said drill bit opening axis oriented outward from said drill bit axis through said cylinder wall and acutely oriented backward in the direction of the said upper end of said power shaft;

said at least one drill bit opening having a drill bit interior opening; and

said drill bit opening axis acutely oriented with respect to a plane passing through said drill bit axis at said drill bit interior opening.

10. The apparatus of claim **9**, further comprising:

a drill bit face disposed distal said power shaft; and

at least one cutting nozzle proximate said drill bit face.

11. The apparatus of claim **9**, further comprising:

a control sleeve, wherein said power shaft is at least partially surrounded by said control sleeve;

said control sleeve and said power shaft defining an annulus;

said at least one shaft opening having an opening outlet; and

said at least one opening outlet proximate said annulus.

12. The apparatus of claim **11**, further comprising:

said annulus having an annulus closed end and an annulus open end; and

said at least one shaft opening outlet intermediate said annulus closed end and said annulus open end.

13. The apparatus of claim **9**, further comprising:

an injection tube operationally coupled to said upper end of said power shaft; and

said injection tube capable of forming a seal with at least a portion of the interior of said power shaft wall.

14. The apparatus of claim **13**, further comprising:

said injection tube comprising a tube head and a tube, wherein at least a portion of said tube is intermediate said tube head and said power shaft;

wherein at least a portion of said tube extends within said interior power shaft channel;

wherein at least a portion of said tube is constructed to at least partially expand at a predetermined pressure; and

wherein said injection tube provides fluid communication from a drill string to said interior power shaft channel.

15. The apparatus of claim **14**, wherein said tube has a tube lower end, and wherein said tube lower end has a flared opening.

16. An apparatus comprising:

a 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 extending therethrough;

at least one shaft opening provided in said shaft wall;

said at least one shaft opening in fluid communication with said power shaft channel, wherein said at least one shaft opening is configured such that at least some of a fluid flowing through said interior power shaft channel will be directed through said at least one shaft opening and will exit out of said interior power shaft channel through said at least one shaft opening;

said at least one shaft opening in said shaft wall having a shaft interior opening and a shaft opening axis;

said power shaft having a central longitudinal shaft axis and an upper end and a lower end;

said shaft opening axis of said at least one shaft opening in said shaft wall acutely oriented with respect to a plane extending through said central longitudinal shaft axis wherein said plane intersects said shaft opening axis at said shaft interior opening;

a drill bit operationally connected to said power shaft;

said drill bit having a cylinder wall;

said drill bit having a drill bit axis;

at least one drill bit opening provided in said cylinder wall;

said at least one drill bit opening having a drill bit opening axis;

said at least one drill bit opening having a drill bit interior opening; and said drill bit opening axis acutely oriented with respect to a plane passing through said drill bit axis at said drill bit interior opening.

17. An apparatus comprising:

a power shaft;

said power shaft having a shaft wall;

said power shaft having an interior power shaft channel;

said power shaft having an upper end and an opposite lower end;

at least one shaft opening in said shaft wall;

said at least one shaft opening in said shaft wall having a shaft interior opening and a shaft opening axis;

said shaft opening axis acutely oriented with respect to a plane extending through said longitudinal shaft axis at said shaft interior opening;

a drill bit operationally connected to said power shaft;

said drill bit having a cylinder wall and a drill bit face wherein said cylinder wall is intermediate said drill bit face and said power shaft;

said drill bit having a longitudinal drill bit axis;

at least one drill bit opening provided in said cylinder wall;

said at least one drill bit opening having a drill bit opening axis;

said drill bit opening axis oriented outward from said drill bit axis through said cylinder wall and acutely oriented backward in the direction of said upper end of said power shaft;

said at least one drill bit opening having a drill bit interior opening; and

said drill bit opening axis acutely oriented with respect to a plane passing through said drill bit axis at said drill bit interior opening.

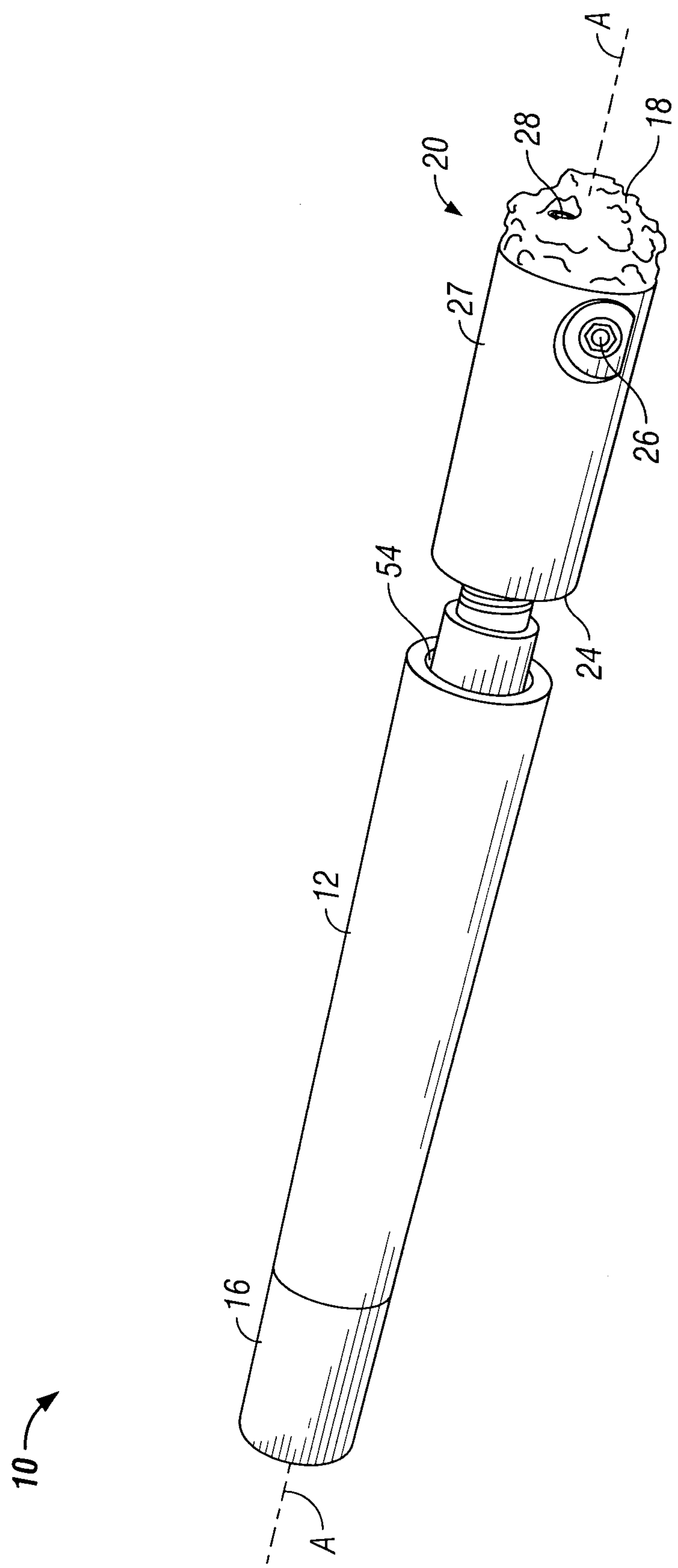


FIG. 1

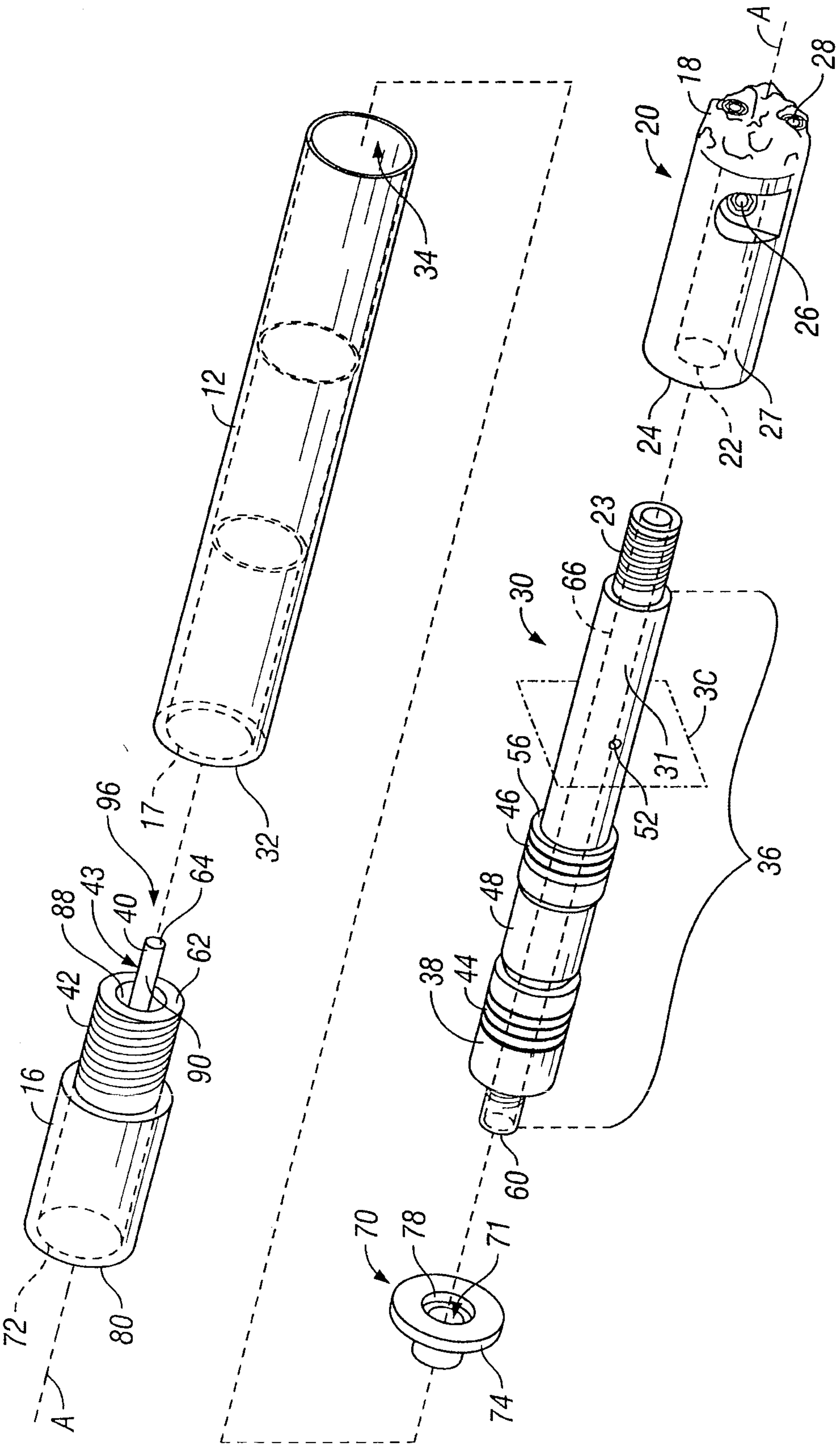

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FIG. 2

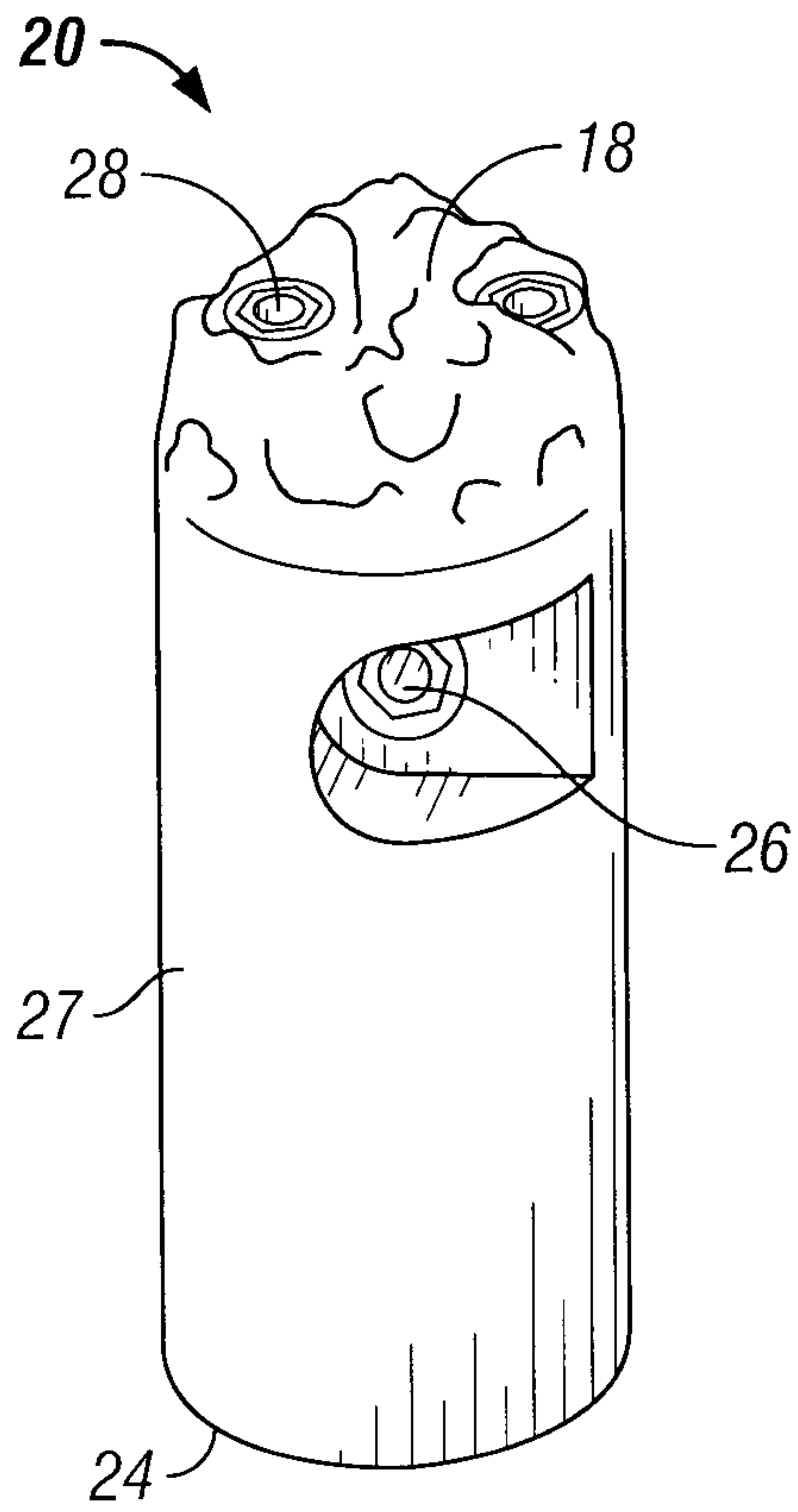

FIG. 3A

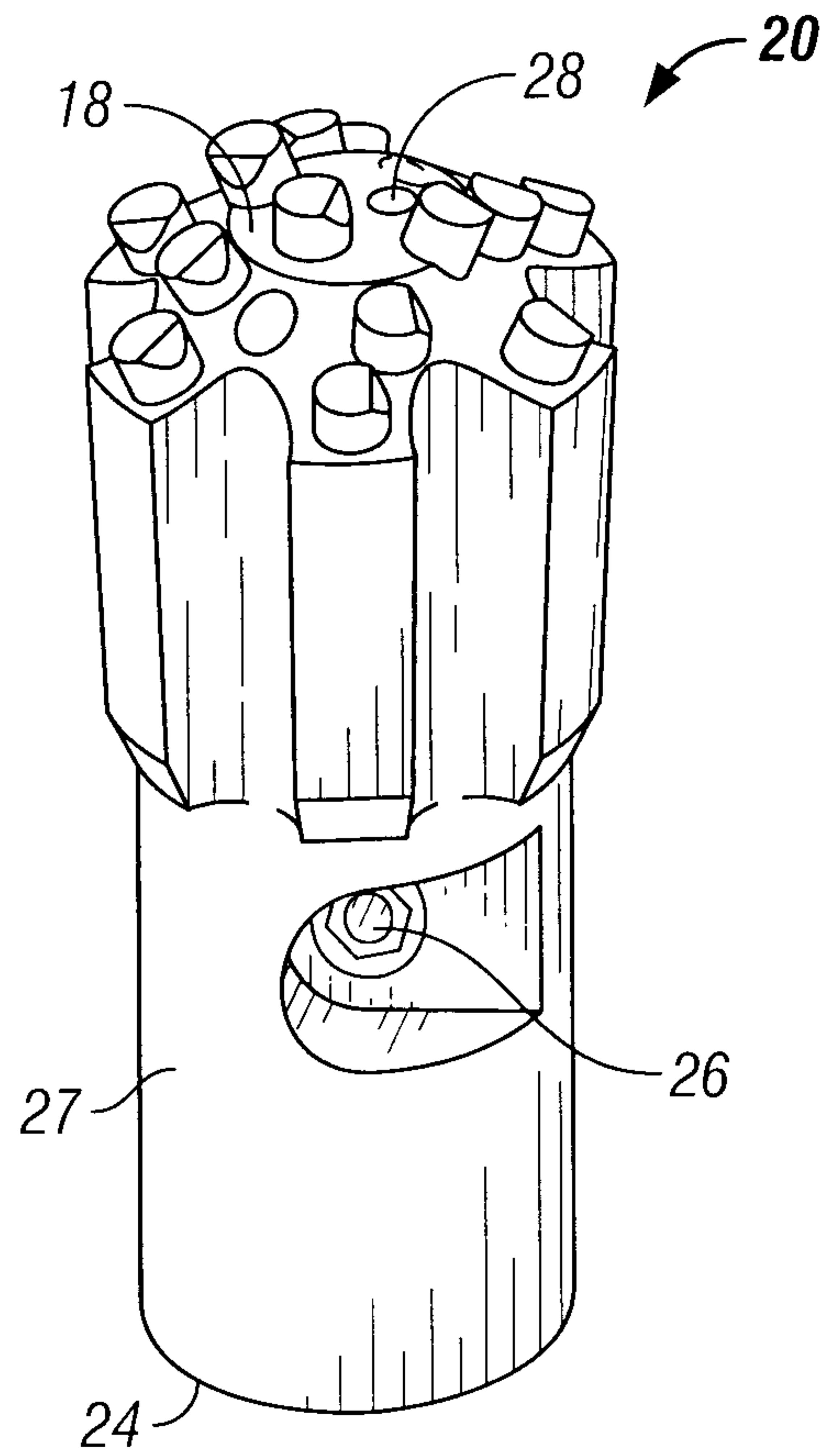

FIG. 3B

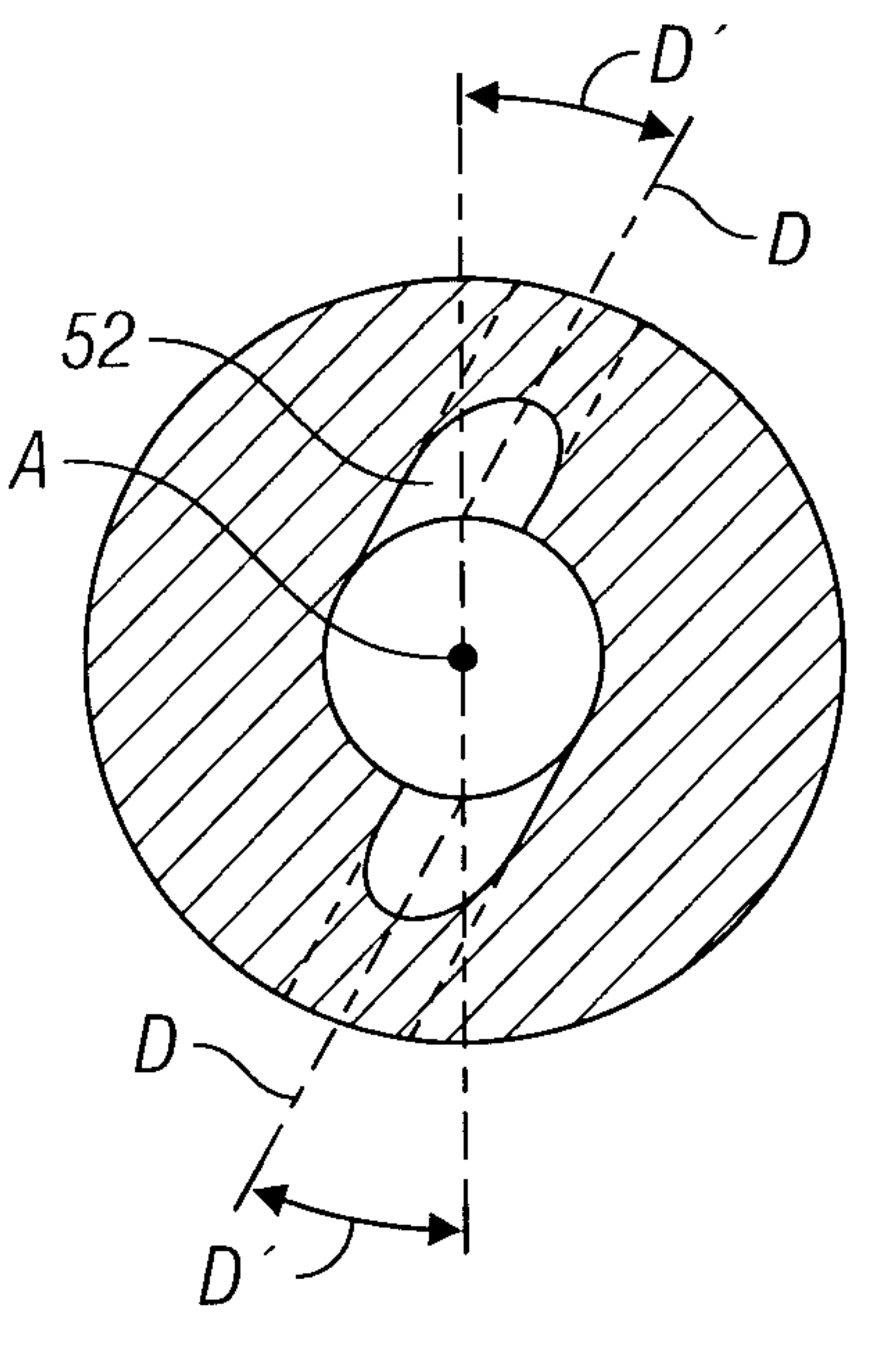

FIG. 3C

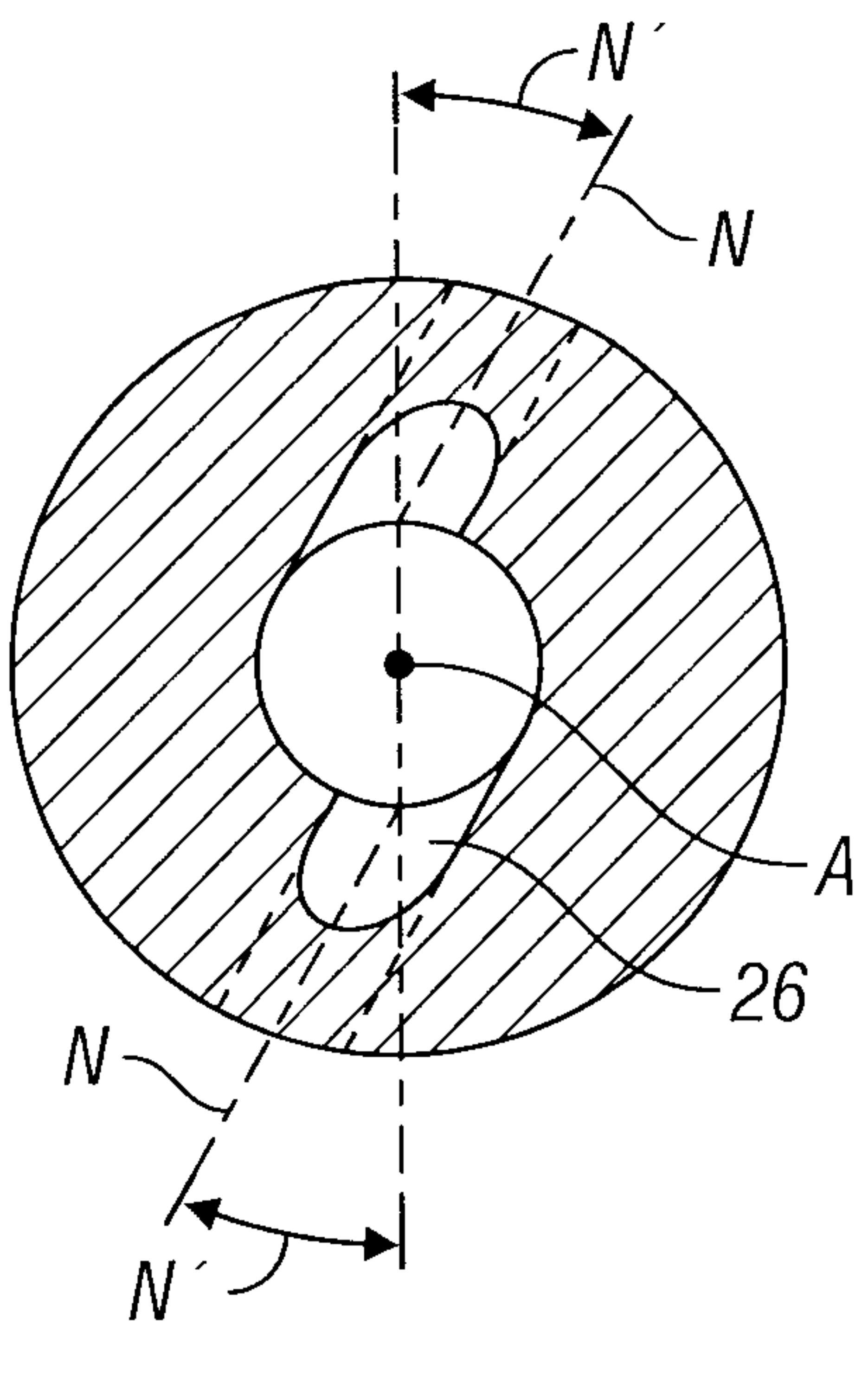

FIG. 4A

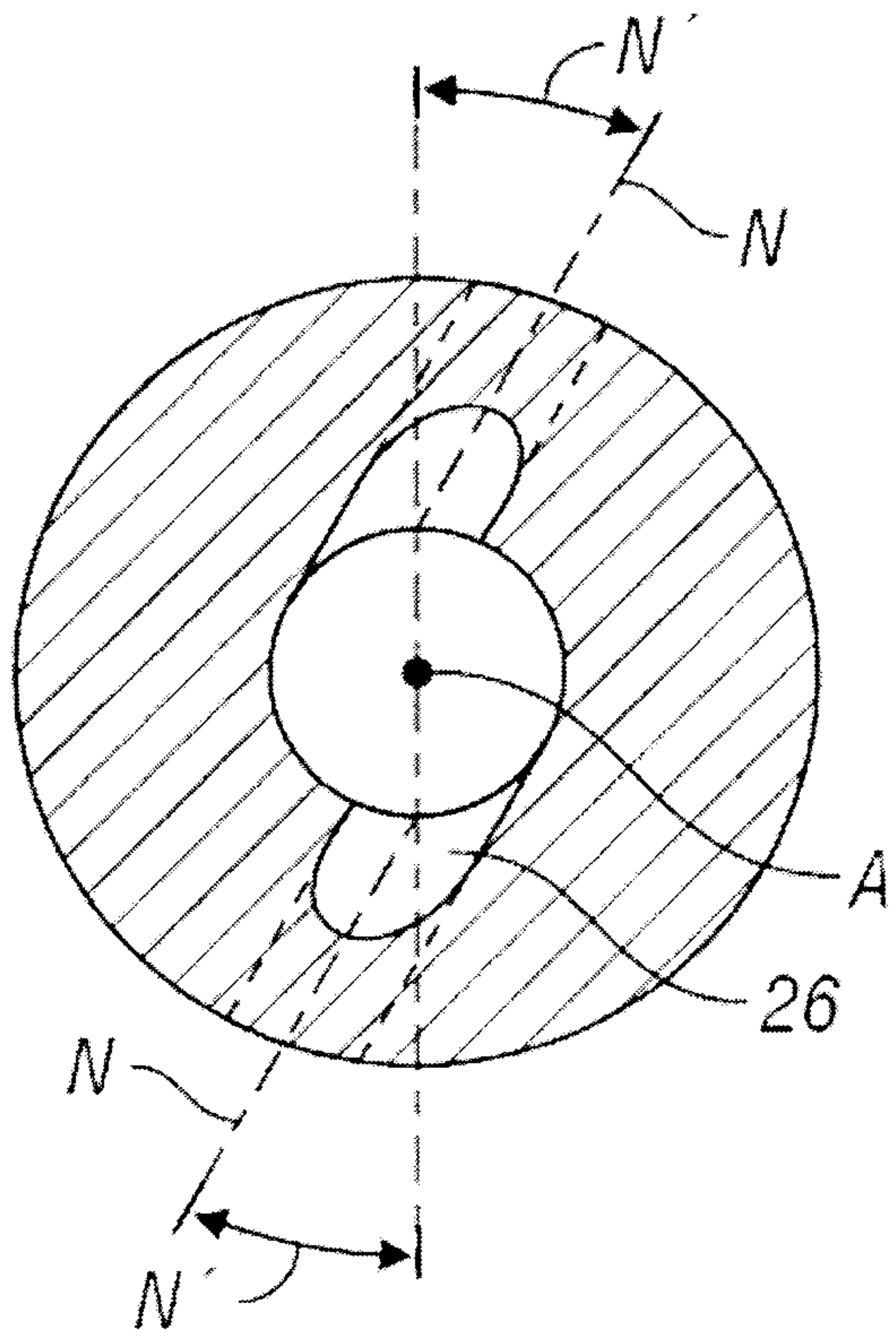

FIG. 4B

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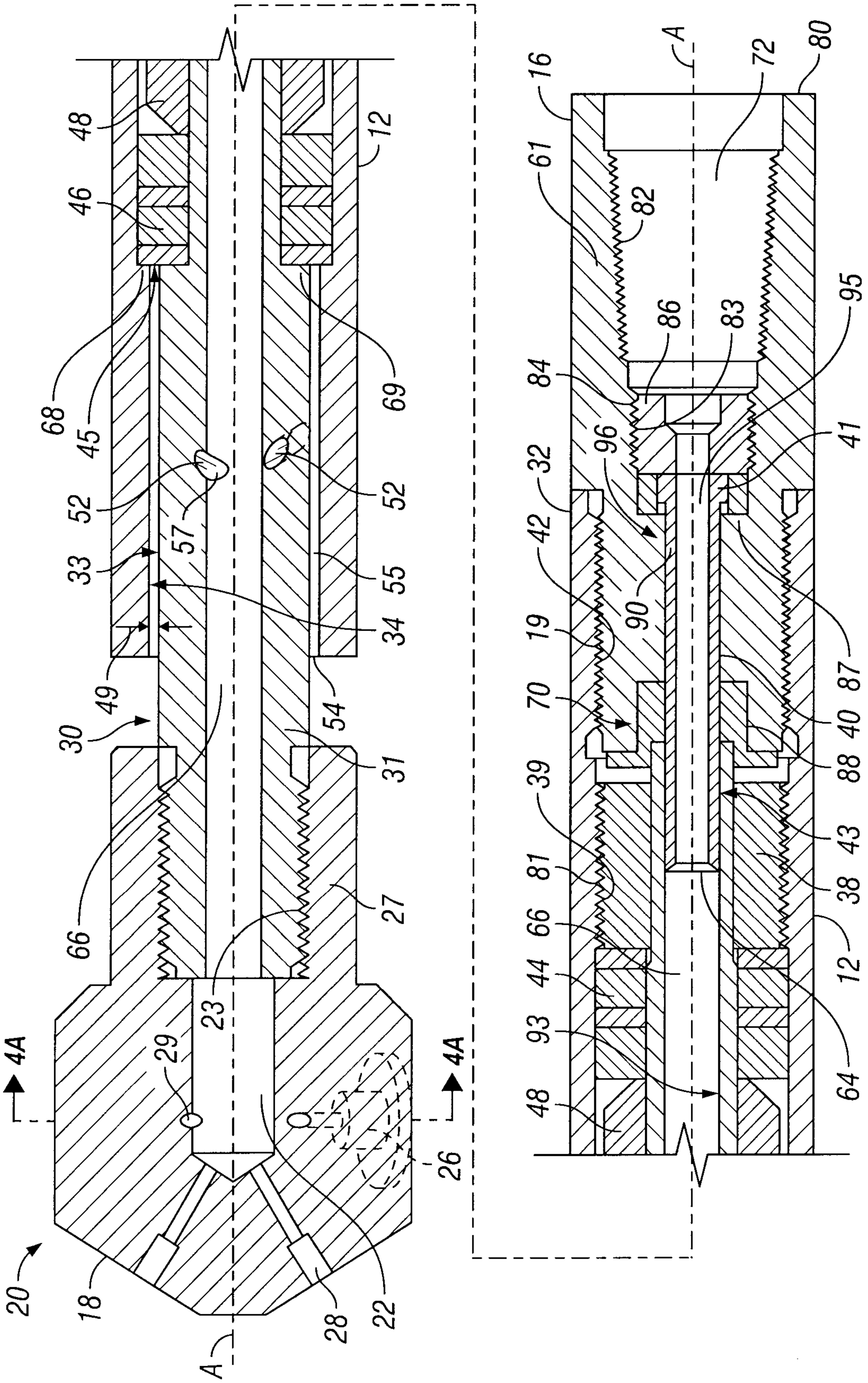
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FIG. 4

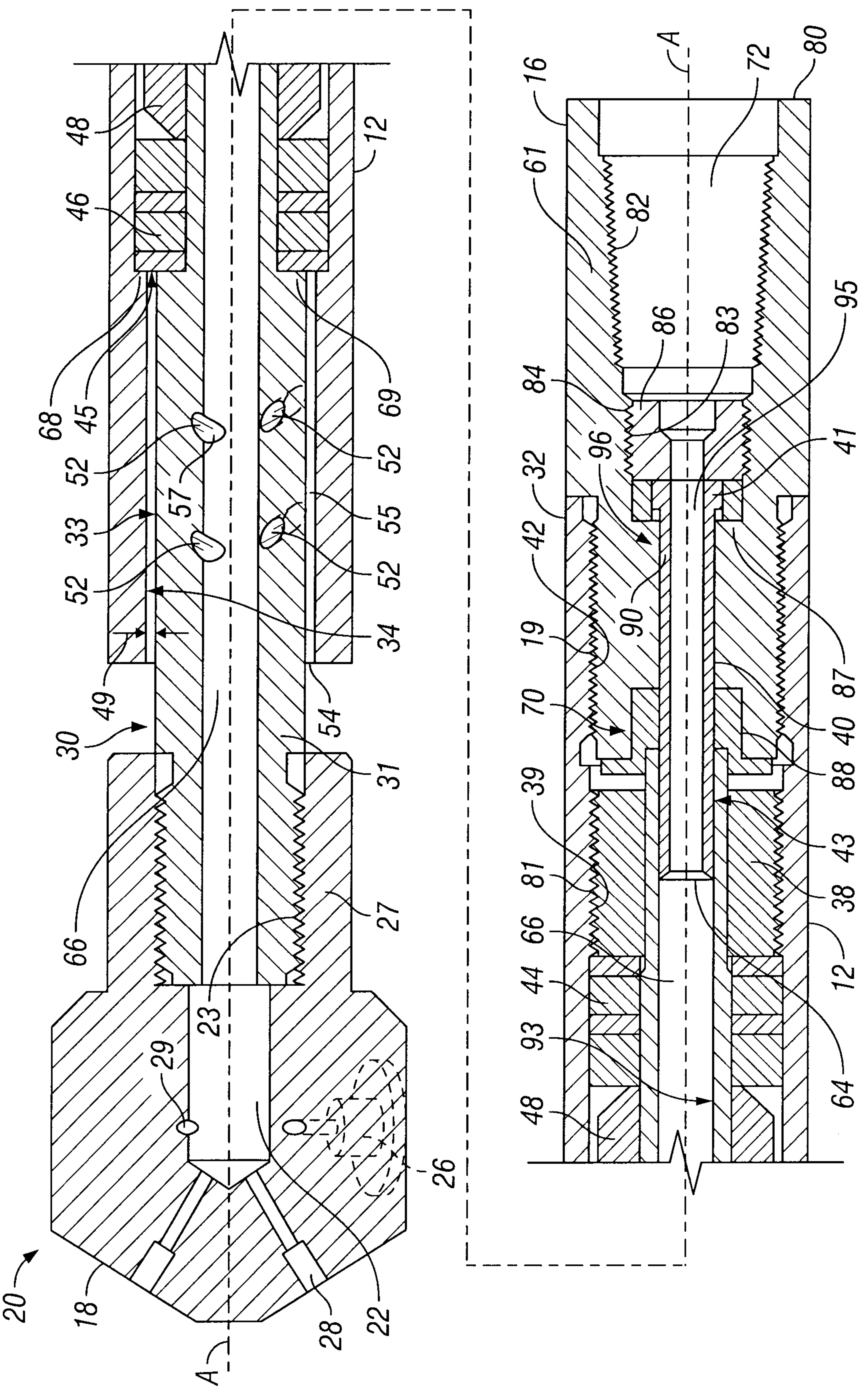

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FIG. 5

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