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(54) Side port nozzle in a PDC bit

(57) Using a nozzle having both a main passageway and a side passageway in a fixed head drill bit, especially a PDC bit, provides increased cooling and cleaning power, especially to the outer cutting surfaces. Additionally, causing a smaller side port passageway in a jet nozzle to intersect a larger main passageway in the nozzle in a manner that does not contain a chamfer or taper creates a non-plugging side port. The side port can then be sized down smaller than the size of the expected largest particle present in the mud without causing problems.

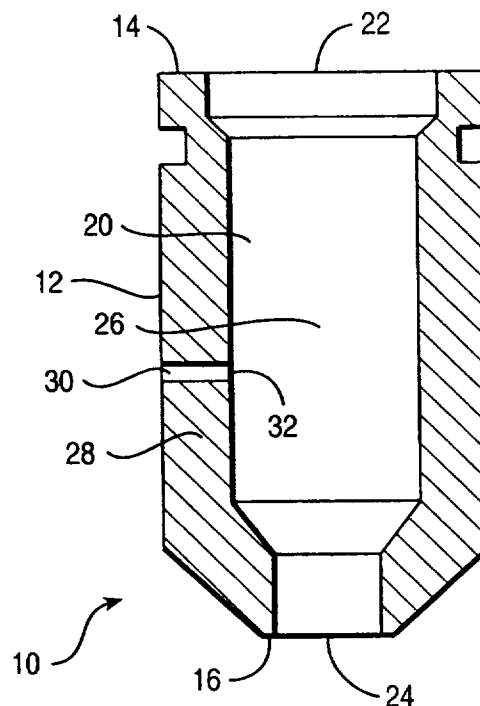


FIG. 1A

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Description

Background and Summary of the Invention

[0001] The present invention relates to down hole equipment. More specifically, but not exclusively, the invention relates to the use of a side-port nozzle in a polycrystalline drill bit and a non-plugging side-port nozzle that has particular usefulness in preventing balling or packing off in drill bits.

Background: Rotary Drilling

[0002] Oil wells and gas wells are drilled by a process of rotary drilling, using a drill rig such as is shown in **Figure 6**. In conventional vertical drilling, a drill bit **110** is mounted on the end of a drill string **112** (drill pipe plus drill collars), which may be several miles long, while at the surface a rotary drive (not shown) turns the drill string, including the bit at the bottom of the hole.

[0003] Two main types of drill bits are in use, one being the roller cone bit, an example of which is seen in **Figure 7**. In this bit a set of cones **116** (two are visible) having teeth or cutting inserts **118** are arranged on rugged bearings such that when rotated about their separate axes, they will effectively cut through various rock formations. The second type of drill bit is a fixed head bit, having no moving parts, seen in **Figure 8**.

[0004] During drilling operations, drilling fluid, commonly referred to as "mud", is pumped down through the drill string and out holes **128** in the drill bit **10**. The flow of the mud is one of the most important factors in the operation of the drill bit, serving at least three purposes: to remove the cuttings which are sheared from rock formations by the drill bit, to cool the drill bit and teeth, and to wash away accumulations of soft material which can clog the bit, generally referred to as "balling" or "packing off." Balling reduces the efficiency of the drilling process; a portion of the cutting energy is consumed when the cutting surfaces act on the impacted mud ball and the mud ball tends to hold weight intended for cutter penetration. Also, the ball can block the flow of fluid to the well bore bottom and impede the removal of cuttings which can often damage the drill bit.

Background: PDC and Other Fixed Head Drill Bits

[0005] Fixed head bits typically use a form of diamond for the hard cutting element, either natural diamonds, synthetic, polycrystalline diamonds, or thermally stable polycrystalline diamond (TSP). Natural and TSP diamonds are cast into the matrix of the cutting surface to act as individual cutters, while polycrystalline diamonds are so small (about 0.001 mm) that they are mixed with a metal and formed into a cylindrical buttons or compacts, which are used alone or bonded to a tungsten carbide post, to do the cutting.

[0006] Although diamonds are the hardest known ma-

terial, they have low impact strength (resistance to shattering from a blow) and low thermal stability (they oxidize at high temperatures, causing them to wear away easily). Additionally, polycrystalline diamond compacts (PDC) are even less stable at high temperatures than other diamond bits. Temperatures high enough to cause deterioration are easily reached in drilling, and thus it is very important to keep the bit cooled. PDC bits use jet nozzles for cooling, as do rotary cone bits, although the nozzles are not interchangeable between the two types of drill bits.

[0007] Examples of PDC bits are seen in Figures 8 and 8A, where the polycrystalline diamond compacts **122** are arranged on the bottom and sides of a generally cylindrical bit. **Figure 8A** is an older style PDC bit, with small ridges on the sides only of the bit for the flow of mud. **Figure 8** shows a newer type PDC bit which normally has from three to more than twenty fixed blades **124** that extend radially from the axis of the PDC bit, with channels between the blades so that cuttings can be washed away.

[0008] Typically, the nozzles on PDC bits are directed at the bottom of the hole or at a slight angle to lubricate, cool, and clean the cutting surfaces. Periodically, however, one or more of the nozzles often becomes plugged and fails to provide the needed drilling fluid to the associated cutting surface. Typically, this happens when the mud circulation is temporarily halted (allowing backflow into the nozzle), then resumed. With one nozzle plugged, the flow is diverted to the other nozzles and cutting blades.

[0009] Additionally, even when the nozzle is not plugged, those areas which do not receive mud flow may experience balling, or packing off. Another problem experienced is the fact that the fixed nature of the PDC bit does not allow the cutters on the circumference, which perform the most work, to periodically be brought into the flow of a jet nozzle, as is true in roller cone bits, so these cutters can be subject to greater heat buildup than cutters which receive more flow. Additionally, any balling which occurs in the grooves of the bit can impede flow around the outer cutters, decreasing the efficiency of the bit and further increasing the chances of overheating the diamond compacts. Whether the problem is a plugged nozzle, balling, or a combination of these or other mud and flow related problems, the efficiency of the drilling and the rate of penetration is reduced.

[0010] Further information of drill bits can be obtained from The Rotary Drilling Series, Unit I, Lesson 2: The Bit (fourth edition), published by the Petroleum Extension Service of The University of Texas at Austin, Austin, Texas, in cooperation with the International Association of Drilling Contractors, Houston, Texas (1995), from which much of this information was taken and which is hereby incorporated by reference.

Background: Jet Nozzles

[0011] Several types of drill bits, such as rotary cone bits and PDC bits, utilize jet nozzles, where velocities of up to 400 feet/second can be obtained. To achieve this velocity, removable flow-restrictors, called nozzles, fit within the aperture where mud leaves the bit. The final inside diameter at the outside end of the nozzle, which therefore determines the final velocity of the mud stream, is measured in increments of 1/32 of an inch, e. g., a size 15 nozzle is 15/32 inches in diameter. An example of a nozzle can be seen in **Figure 9**. In this figure, a nozzle **120** has been inserted into the aperture **128**, where it fits snugly, and can be held in place by any one of several means. At the end of the nozzle which fits into the bit, the inside diameter is approximately that of the opening above it, while at its outside end, the diameter can be whatever is desired to give the final flow characteristics. To adjust the flow, the nozzle can be replaced with another nozzle which has a different internal diameter at the outside end.

[0012] Many different nozzles have been created to attempt to increase the efficiency of the mud flow, lubrication, and cleaning of drill bits. Among the prior efforts are nozzles that attempt to produce swirling flows or alter the pressure distribution and turbulence of the flow. Nozzles having various types of side-jetting ports have been introduced in roller cone bits. These side ports are generally directed to the dome of the bit, where balling tends to occur in roller cone bits, or in one case, to the vicinity of the bearing seal. These side port nozzles have apparently never been used in fixed head bits, at least in part because the older styles of bits did not allow room for an extended nozzle, which is necessary for the use of side ports.

[0013] One limitation associated with the design of nozzles used for drilling involved the minimum allowable hole diameters which are limited by the size of the particles in the mud. Drilling mud is filtered before being placed in the formation to remove most of the larger particles. However, because the mud circulated into the formation typically still contains relatively large particles, the passageways and nozzle exits commonly have a minimum diameter of about 10/32 inches. Passageways and nozzle exits smaller than this minimum have a tendency to clog. Plugging of the nozzle prevents the desired flow, reduces the efficiency of the process, and may cause additional damage to the drill bit.

[0014] However, limiting the minimum diameter limits the flexibility of the nozzle design by effectively setting a minimum flow through the hole and limiting the allowable distribution of the nozzle. Accordingly, a non-plugging nozzle that allows the use of smaller holes is desired to improve the efficiency and flexibility of the nozzle.

[0015] Although many of the previous nozzles improve the efficiency of the drilling operation, additional improvements are needed to further increase the effi-

ciency and lower the cost of production. Additionally, getting the flow to where it is most effective is critical, especially in fixed head bits such as the PDC bit.

Background: Jet Nozzles in PDC Bits

[0016] **Figure 5A** shows a bottom view of a typical PDC bit, with four blades and four jet nozzles. Note that with the downward direction of flow from the jet nozzles, only the cutters which are directly in front of the nozzles will be cleaned by the direct flow from the jet nozzle; all other cutters are cleaned only by the turbulence created when the high-velocity mud is ejected into the confined space of the hole. Since the flow loses its velocity quickly after ejection from the nozzle, the outer cutters are cleaned and cooled less effectively. This is particularly true at what is sometimes called the "nose" of the bit, i. e., the outer one fourth of the blade, which is moving the fastest and doing the most work of any of the cutters, but which receives no jet flow.

[0017] It would be desirable to put jet nozzles where they could clean these outer cutters. However, to maintain both the central large flow and additional outer jet nozzles, the outer jets would need to be sized fairly small, such as a 6-8. However, since any nozzle smaller than a 10 tends to plug, small outer jets would not work well consistently.

[0018] Similarly, **Figure 3** shows a side, cross sectional view of an older-style, fixed head drill bit **40** having nozzles **10'** positioned therein, taken from U.S. Patent 4,738,320, which shows one attempt to provide cooling and cleaning to remote areas of the bit. The drill bit has a bit body **42**. The bit body has a first end **44** adapted for connection to a rotary drive member, such as a drill string (not shown). Typically the attachment to the rotary drive member is made using cooperating threaded connections **45**. A second end **46** of the bit body, opposite the first end **44**, has a number of cutting faces **48** and at least one void **50** therein where no cutting faces are positioned.

[0019] The bit **42** defines a fluid communication cavity **54** that is generally axially positioned and extends through the drill bit. The fluid communication cavity communicates with the drill string and provides for communication of the drilling fluid, or mud, through the drill bit. The drilling fluid enters the drill bit through a top of the fluid communication cavity and flows down through the drill bit through fluid passageways **56** defined by the fluid communication cavity. The fluid passageways generally divide and direct the fluid toward desired areas of the bit to provide the needed lubrication, cooling, and removal of cuttings.

Improved PDC Bit Having Side Port Nozzle

[0020] Particular and preferred aspects of the invention are set out in the accompanying independent and dependent claims. Features of the dependent claims

may be combined with those of the independent claims as appropriate and in combinations other than those explicitly set out in the claims.

[0021] One aspect of the present invention discloses a fixed head drill bit, particularly a PDC bit, which uses a nozzle having both a main port and a side port to provide improved cleaning and cooling to the bit, especially to the cutters near the outer circumference of the bit. The main port is directed to the bottom of the hole, as is customary, and has a cross-section which is large enough to pass the largest particles which occur in the drilling fluid, while the side port is directed outward from the center of the bit to clean and cool the cutters on the outer portion of the blades, and has a cross-section which is smaller than that of the main port. The cross-section of the side port can be smaller than the largest particles in the drilling fluid. In the presently preferred embodiment, the nozzle is made non-plugging by having an main passageway and a side passageway which intersects the main passageway in a way that does not include any round, chamfer, taper, bevel or the like, so that the diameter of the side passageway, as measured perpendicular to its axis, does not vary at the intersection of the passageways. The intersection of the side passageway to the central passageway does not create an area where particles within the drilling will tend to become lodged within the relatively smaller side passageway. Additionally, the intersection of the side passageway with the central passageway is placed so that cross-sectional area of the central passageway immediately above the intersection is greater than the combined cross-sectional areas of all ports in the nozzle. This means that the greatest speed of the drilling mud has not been reached, and allows the direction of the fluid to be changed without providing excessive wear on the nozzle. Even if a particle manages to become lodged in the side passageway, the fact that the main passageway is large enough to prevent plugging will allow the abrasive drilling fluid to wear away the particle and restore flow to the side port.

[0022] In some embodiments, the nozzles contain ports which direct the mud flow at an angle from the axis of the bit. For these ports to remain free from plugging, it is preferable that their cross-sections are large enough to allow passage of the largest particle found in the mud. This can be achieved in several applications when the nozzle is a 10 or larger.

[0023] In some embodiments, it is possible to provide one or more of at least the following advantages:

- jet flow can be provided to the outer portions of the PDC bit;
- the side port can be made smaller than the maximum size of particle in the mud without plugging.

[0024] Further aspects of the invention are exemplified by the attached claims.

Brief Description of the Drawing

[0025] For a better understanding of the invention and to show how the same may be carried into effect reference is now made by way of example to the accompanying drawings in which:

[0026] **Figures 1A-C** are side cross-sectional view of respective embodiments of the non-plugging nozzle. **Figures 1C1 and 1C2** respectively show an end-on view of the nozzle of Figure 1C, and a cross-section of a wrench head for insertion and adjustment of this embodiment of the nozzle.

[0027] **Figure 2** shows a nozzle with additional outlets, demonstrating how a small particle can become lodged in the side passageway.

[0028] **Figure 3** is a side cross sectional view of a drilling tool as shown in U.S. Patent 4,738,320.

[0029] **Figure 4** is a side perspective view of a PDC bit incorporating the disclosed nozzle.

[0030] **Figures 5 and 5A** are bottom views of a PDC bit. Figure 5 uses the disclosed nozzle and Figure 5A use an older type nozzle.

[0031] **Figure 6** shows a drill rig, including a bit which can use the disclosed side-port nozzle.

[0032] **Figure 7** shows an example of a roller cone bit.

[0033] **Figures 8 and 8A** show examples of a fixed head or drag bit, which in these examples are polycrystalline diamond compact (PDC) bits. Figure 8A is an older style bit, while Figure 8 is a newer design, with deeper grooves between the diamond compact cutting surfaces.

[0034] **Figure 9** shows a close-up view of one type of nozzle used in a drill bit.

Detailed Description of the Preferred Embodiments

Fixed Head Bit Having Side Port Nozzle

[0035] To achieve a more effective drill bit, a fixed head bit, such as that shown in Figure 3 can utilize the nozzle embodiments disclosed herein. At least one nozzle, having both a larger main port and a smaller side port, is functionally attached to the bit, preferably at or proximal the second end 46 of the drill bit. The means for functionally attaching the body of the nozzle to the tool body may comprise any one of a number of possible embodiments. Included among the many possible embodiments is a locking, cooperating thread that facilitates positioning of the nozzle and a packing insert as disclosed in U.S. Patent No. 5,579,855 that issued to Dickey on December 3, 1996 and which is hereby incorporated herein by reference.

[0036] The attachment means attaches the nozzle in the tool body with the central cavity of the nozzle in fluid communication with the fluid communication cavity of the drill bit. Preferably, the drill bit includes a plurality of nozzles, each communicating with a separate fluid passageway of the fluid communication cavity. Each nozzle

is positioned so that at least one side passageway of the nozzle is directed at the adjacent void and is, therefore, adapted and positioned to produce a flow of fluid toward the at least one void and create a cross flow therethrough. Creating the cross flow in the void prevents cuttings from accumulating in the void, becoming impacted, and balling. Consequently, including the non-plugging nozzles in the drill bit makes it self-cleaning.

[0037] However, because creating the cross flow through the void typically requires much less flow than the flow required through the exit aperture, the side passageways are typically much smaller than the exit aperture. Thus, the non-plugging nozzle which allows smaller side passageways is particularly useful for this application and allows greater flexibility of drill bit design with a greater downward cleaning flow while still incorporating a self cleaning function.

Polycrystalline Diamond Compact Bits

[0038] In a preferred embodiment, the drill bit 40 is a PDC bit 60. **Figure 4** is a side perspective view of a PDC bit 60 having a non-plugging nozzle 10 therein; **Figure 5** is a bottom view of the PDC bit showing a plurality of non-plugging nozzles positioned therein with the side passageways directed at the voids of the PDC bit 60.

[0039] As in the fixed head drill bits previously described, the PDC bit has a bit body 42 with a first end adapted for attachment to a rotary drive member and a second end delimiting a cutting face. The cutting face is made up of a plurality (generally at least three) of blades 62. Each blade is fixedly attached to the bit body and defines a generally flat forward cutting surface 64. The forward cutting surface includes a plurality of polycrystalline diamond compacts 66 spaced radially along the cutting member. The blades extend in a generally radial direction from the center (axis) of the PDC bit 60 and are relatively evenly spaced from one another. The blades also define a void or groove in front of each of the forward cutting surfaces to allow the compacts to perform their cutting operation.

[0040] The PDC bit 60 includes a plurality of non-plugging nozzles as previously described attached thereto and communicating with the fluid communication cavity of the PDC bit. The main, first flow is directed through the central passageway 20 of the nozzle 10 toward the second end 46 of the drill bit 40 and the bottom of the well bore to provide the needed lubrication, cleaning, and cooling for the cutting operation. At least one side passageways of the nozzles are directed at the adjacent surfaces of the blades to create a cross flow through the grooves that prevents material from accumulating, preventing balling. The non-plugging nozzle allows greater flexibility of PDC bit design by providing more control of the relative flows through the nozzle.

First Nozzle Embodiment

[0041] **Figure 1A** is a side elevational, cross sectional view of one embodiment of the non-plugging nozzle 10. The nozzle has a body 12 with a central passageway 20 extending axially from the top of the body to the bottom of the body. At the top of the body, the central passageway has an inlet aperture 22 and at the bottom of the body, the central passageway has an exit aperture 24. Preferably, the body is axisymmetric and has a circular outer cross sectional shape throughout its length. Similarly, the central passageway also preferably has an axisymmetric shape and a circular cross section throughout its length.

[0042] Although the central passageway preferably changes diameter along its length and includes tapered portions, the nozzle preferably has a cylindrical portion 26 between the top and the bottom of the body. The central passageway of the nozzle shown in **Figure 1A** has a tapered portion proximal the top of the body, a tapered portion proximal the bottom of the central passageway, and cylindrical portion 26 therebetween. The diameter of the central passageway decreases from the top to the bottom so that the diameter of the exit aperture 24 is smaller than the diameter of the inlet aperture 22. However, the size of the exit aperture is sufficiently large that small particles typically found in the application fluid (e. g. filtered drilling fluid) cannot plug the exit aperture.

[0043] The body also contains a side passageway 30 extending through side wall 28 within the cylindrical portion. The side passageway extends through the side wall and is in fluid communication therewith to provide a side jetting nozzle from the central passageway to the periphery of the nozzle. To help prevent plugging of the nozzle, the side inlet orifice 32 does not contain a bevel, taper, or widening of the side passageway at the intersection. Preferably, the diameter of the side passageway is constant, and the passageway itself is substantially straight. The side passageway preferably has an axis that lies in a common plane with the axis of the body, but the axis of the side passageway itself lies at an angle to the axis of the body and of the central passageway.

Alternate Nozzle Embodiment: Direction of Flow

[0044] In alternate embodiments, the side passageway does not have to intersect the main passageway perpendicularly; it can be virtually any angle, but is preferably between about ten and forty-five degrees as a minimum. **Figure 1B** shows the side passageway angled back toward the inlet aperture of the nozzle, so that fluid is directed in an upward direction.

[0045] **Figure 2** illustrates how the present nozzle 10 provides for non-plugging by showing a nozzle not having the features of the present nozzle 10. This figure shows a nozzle 10 having a side passageway 30 communicating with a cylindrical portion 26 of the central passageway 20, but wherein the side inlet orifice 32,

contrary to the presently disclosed nozzle, includes a round, or chamfer. Therefore, as shown in the figure, a small particle 38 traveling through the nozzle 10 may become lodged within the side passageway 30, particularly if the particle 38 has a diameter larger than the diameter of the side passageway 30 but smaller than the largest diameter of the chamfer. The chamfer creates an area within which a particle 38 may settle.

[0046] Figure 1B also discloses a particle 38 positioned at the side inlet orifice 32. Note that the particle 38 has a larger diameter than the side inlet orifice 32 (otherwise the particle 38 could freely pass through the side passageway 330). When positioned at the side inlet orifice 32, the particle 38 does not have an area free from the flow within which to lodge as in the nozzle 10 shown in Figure 2A, nor does the nozzle 10 of Figure 1B provide a lip against which the particle 38 may lodge. Therefore, as a small particle 38 contacts the side inlet orifice 32, the particle 38 will simply continue to move past the side inlet orifice 32. Note that in down hole applications, the pressure and velocity of the fluid moving through the nozzle 10 is very high. Therefore, a particle 38 positioned as that shown in Figure 1B will be easily swept through the nozzle 10. Further, the high velocity fluid would wear down any particle 38 that did happen to partially lodge within the side passageway 30 (i.e. such as a non-uniform shaped particle 38). Although the particle 38 shown in Figure 2B would also wear over-time, the lip created by the side passageway 30 provides a greater likelihood of a particle A plugging the side passageway 330.

[0047] By providing a non-plugging nozzle design, the side passageway may have a smaller diameter than is possible with prior nozzles. Thus, a smaller portion of the flow may be directed for side jetting and a larger amount directed downward through the central exit aperture. Also, greater pressures and velocities may be obtained with the non-plugging nozzle and the nozzle may accommodate additional side passageways without sacrificing flow rate through the exit aperture, pressure, or velocity.

Alternate Nozzle Embodiment: Multiple Side Passageways

[0048] In an alternative embodiment, the nozzle includes additional side passageways extending through the side wall at the cylindrical portion of the body. The number of additional side passageways may vary according to the particular needs of the application. Like the first side passageway, each of the additional side passageways intersect the cylindrical portion of the central passageway and define a side inlet orifice at the intersection that does not have a taper or bevel. The additional side passageways generally have the other characteristics of the first side passageway such as constant diameter, direction, and positioning.

[0049] So that the fluid exiting the nozzle has a greater

velocity than the fluid entering the nozzle, the inlet aperture of the body has a greater cross sectional area than the combined cross sectional areas of the exit aperture and side inlet orifice. Likewise, in the case of a nozzle having additional side passageways, the cross sectional area of the inlet orifice has a greater cross sectional area than the combined cross sectional areas of the exit aperture and the side inlet orifices associated with the all side passageways.

[0050] Typically, the amount of fluid needed for side jetting is less than the amount required in the axial direction. Therefore, the diameter of the exit orifice is greater than the diameter of the side inlet orifice. In those nozzles having additional side passageways, the cross sectional area of the exit orifice is greater than the combined cross sectional areas of all the side inlet orifices.

Presently Preferred Nozzle Embodiment

[0051] Figure 1C shows a cross-section of the presently preferred embodiment of the disclosed nozzle. In this embodiment, the side passageway intersects the main passageway in a 45 degree angle, with the side exit aperture pointing more toward the main exit aperture than the inlet aperture. The main exit aperture in this example is 3/8 inch (i.e., this is a size 12 nozzle), while the side aperture is 1/4 inch. Of course, these dimensions are for example only and are not limiting to the scope of this invention.

[0052] In this embodiment, the nozzle is screw threaded so that it can be screwed into place on the bit. Figure 1C2 shows the head of a steel wrench which can be used to insert this nozzle into the bit, while Figure 1C1 shows a view of the exit aperture of the nozzle of Figure 1C, demonstrating how a groove can be formed in the end of the nozzle to facilitate installation/removal.

Alternate Nozzle Embodiment: Internal Diameter not Cylindrical

[0053] Although as discussed herein, the central cavity and the exit aperture are described as having a circular cross sectional shape, the central cavity may have virtually any shape. For example, some nozzles have been developed with non-circular shapes in an effort to create a vortex in the flow or to increase the turbulence of the flow exiting the nozzle. These other nozzle configurations are incorporated herein and considered a part of the scope of the present invention.

Alternate Nozzle Embodiment

[0054] Although generally the diameter of the side passageway is constant and the passageway itself is substantially straight, this is not necessary to the practice of the invention. Some variation in the size of the side passageway or some curvature can be incorporat-

ed for various applications, so long as the relationship at the intersection of the side passageway with the main passageway is maintained.

Alternate Embodiment: Use in Roller Cone Bit

[0055] Although side passageways have been seen in roller cone bits, forming the side passageway so that it intersects the main passageway at a non-tapering portion and does so without the inclusion of a taper or bevel or the like can advantageously provide a non-plugging nozzle for a roller cone bit.

[0056] According to an aspect of the invention, there is provided: A fixed head drill bit, comprising: a body having a first end capable of being attached to a drill string and a second end having cutting elements attached thereto, said body having no moving parts; a passageway through said body, having a first opening at said first end of said body and a second opening at said second end of said body; a nozzle which attaches to said body at said second end and forms a continuation of said passageway; wherein said nozzle comprises a primary exit port and a secondary exit port, said primary exit port having a greater cross-section than said secondary exit port.

[0057] According to another aspect of the invention, there is provided: A drill rig, comprising: a drill string, connected to rotate a fixed head drill bit containing cutting elements; a nozzle attached to said fixed head drill bit proximal to said cutting elements, said nozzle comprising a main passageway which exits said nozzle at a main port and a secondary passageway, said second passageway having a first end which intersects said main passageway and a second end which exits said nozzle at a secondary port which is different from said first port, wherein said main port has a greater cross-section than said secondary port.

[0058] According to a further aspect of the invention, there is provided: A method of operating a drill rig, comprising the steps of: (a.) attaching a fixed head drill bit to a drill string and rotating said drill bit; (b.) pumping drilling fluid through said drill string and said drill bit to a nozzle attached to said drill bit; (c.) pumping drilling fluid out a first port in said nozzle which directs the drilling fluid toward the bottom of a hole being drilled; (d.) pumping drilling fluid out a second port in said nozzle which directs the drilling fluid toward a groove in said drill bit, said second port having a smaller cross-section than said first port.

Modifications and Variations

[0059] As will be recognized by those skilled in the art, the embodiments described in the present application can be modified and varied over a tremendous range of applications, and accordingly the scope of patented subject matter is not limited by any of the specific exemplary teachings given.

[0060] For example, although the body of the nozzle is generally cylindrical, other shapes can be used and can have utility in ensuring proper positioning (e.g. by using flat edges), in facilitating installation (e.g. by using a hex shape adapted to mate with a socket or other wrench), or for other purposes.

[0061] None of the description in the present application should be read as implying that any particular element, step, or function is an essential element which must be included in the claim scope.

Claims

1. A fixed head drill bit, comprising:
 - a body having a first end capable of being attached to a drill string and a second end having cutting elements attached thereto;
 - a passageway through said body, having a first opening at said first end of said body and a second opening at said second end of said body;
 - a nozzle which attaches to said body at said second end and forms a continuation of said passageway;
 - wherein said nozzle comprises a primary exit port and a secondary exit port, said primary exit port having a greater cross-section than said secondary exit port.
2. The fixed head drill bit of claim 1, wherein said drill bit is a polycrystalline diamond compact (PDC) bit.
3. The fixed head drill bit of claim 1 or 2, wherein said secondary exit port is positioned on a portion of said nozzle away from the center of said body.
4. The fixed head drill bit of claim 1, 2 or 3, wherein said cutting elements are arranged on blades which are separated by grooves and said secondary exit port of said nozzle is positioned to direct drilling fluid across the face of one of said blades.
5. The fixed head drill bit of any preceding claim, wherein said primary exit port has a diameter of 10/32 inches or greater and said secondary exit port has a diameter of 8/32 inches or less.
6. The fixed head drill bit of any preceding claim, wherein the passageway to said secondary exit port intersects a cylindrical portion of the passageway to said primary exit port.
7. The fixed head drill bit of any preceding claim, wherein said body has no moving parts.
8. A drill rig, comprising:

a drill string, connected to rotate a fixed head drill bit containing cutting elements;

a nozzle attached to said fixed head drill bit proximal to said cutting elements, said nozzle comprising a main passageway which exits said nozzle at a main port and a secondary passageway, said secondary passageway having a first end which intersects said main passageway and a second end which exits said nozzle at a secondary port which is different from said first port, wherein said main port has a greater cross-section than said secondary port.

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9. The fixed head drill bit of claim 8, wherein said drill bit is a polycrystalline diamond compact (PDC) bit.

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10. The fixed head drill bit of claim 8 or 9, wherein said cutting elements are arranged on blades which are separated by grooves and said secondary port of said nozzle is positioned to direct drilling fluid across the face of one of said blades.

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11. The fixed head drill bit of claim 8, 9 or 10, wherein said main port has a diameter of 10/32 inches or greater and said secondary port has a diameter of 8/32 inches or less.

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12. The fixed head drill bit of claim 8, 9, 10 or 11, wherein the passageway to said secondary port intersects a cylindrical portion of the passageway to said main port.

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13. A method of operating a drill rig, comprising the steps of:

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(a) attaching a fixed head drill bit to a drill string and rotating said drill bit;

(b) pumping drilling fluid through said drill string and said drill bit to a nozzle attached to said drill bit;

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(c) pumping drilling fluid out a first port in said nozzle which directs the drilling fluid toward the bottom of a hole being drilled;

(d) pumping drilling fluid out a second port in said nozzle which directs the drilling fluid toward a groove in said drill bit, said second port having a smaller cross-section than said first port.

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14. The method of claim 13, wherein a polycrystalline diamond compact (PDC) bit is attached to said drill string.

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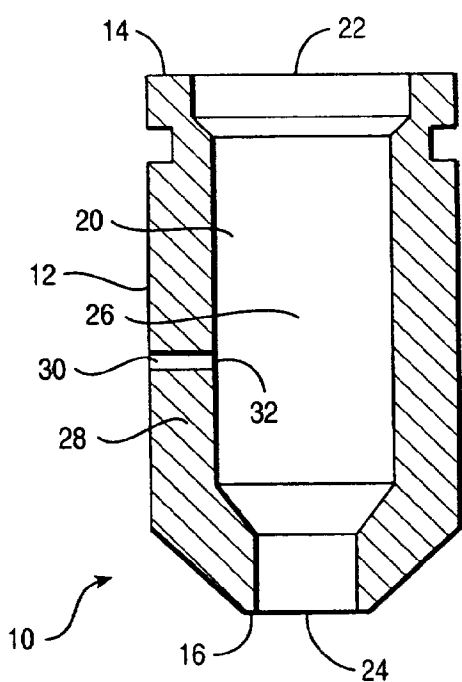


FIG. 1A

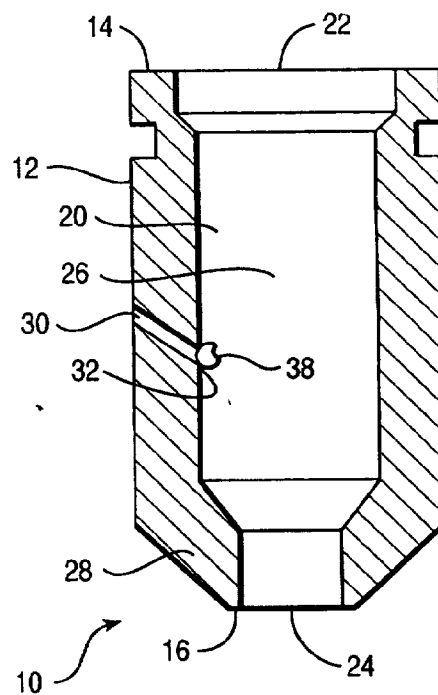


FIG. 1B

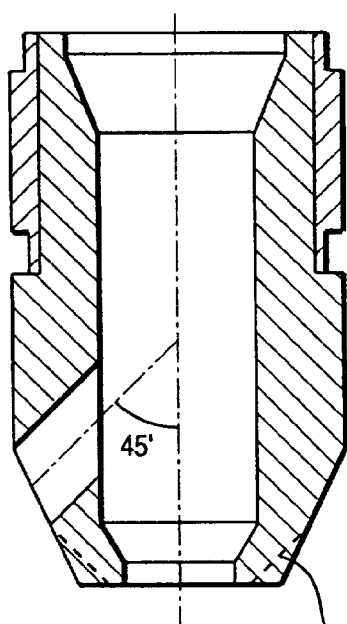


FIG. 1C

WRENCH
GROOVES

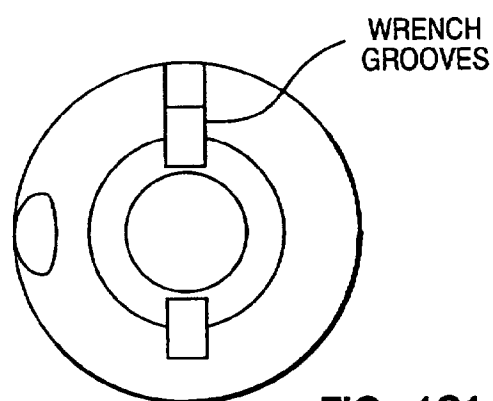


FIG. 1C1

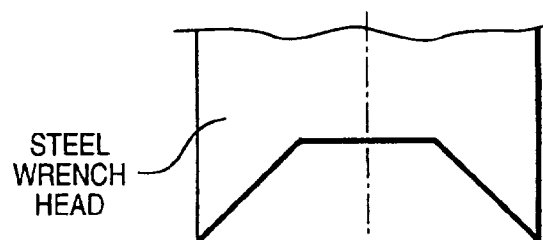


FIG. 1C2

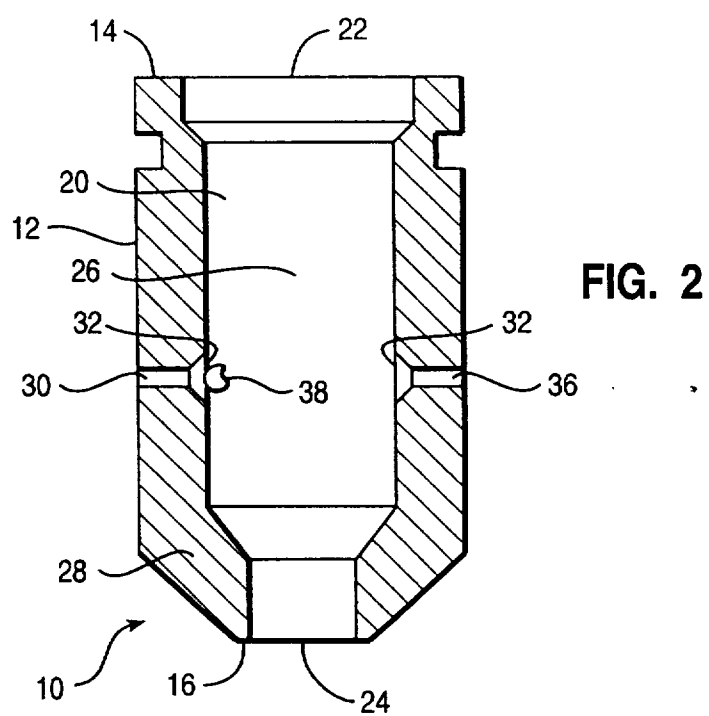
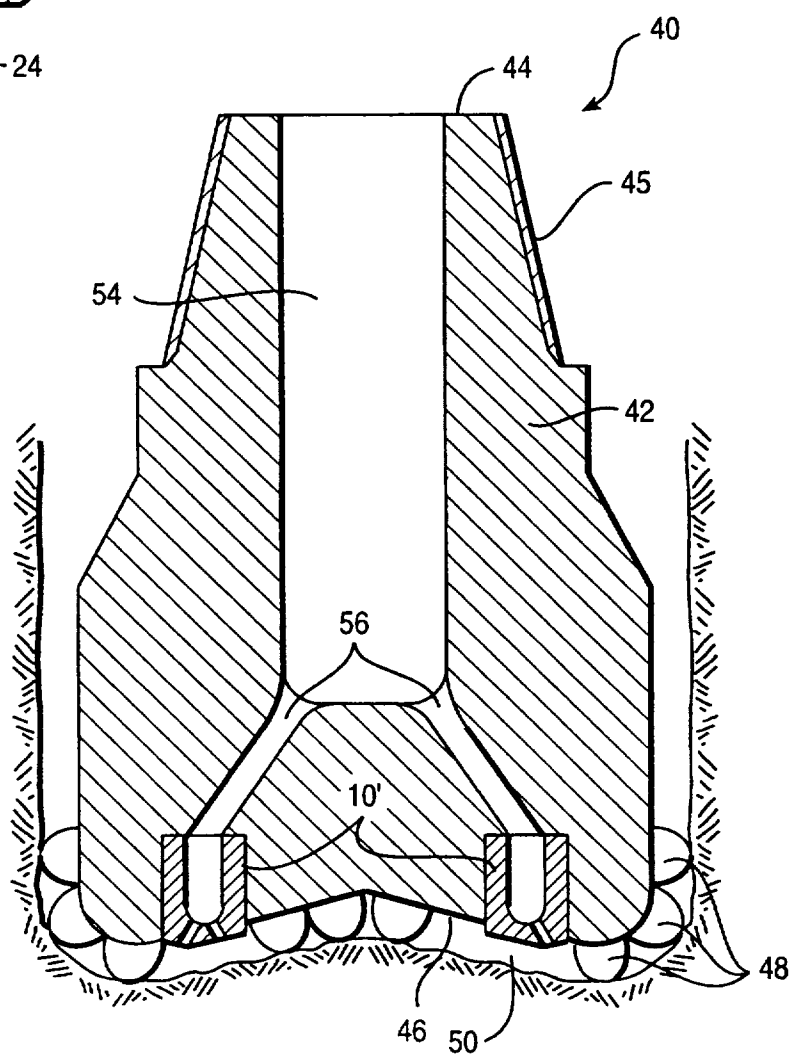


FIG. 3



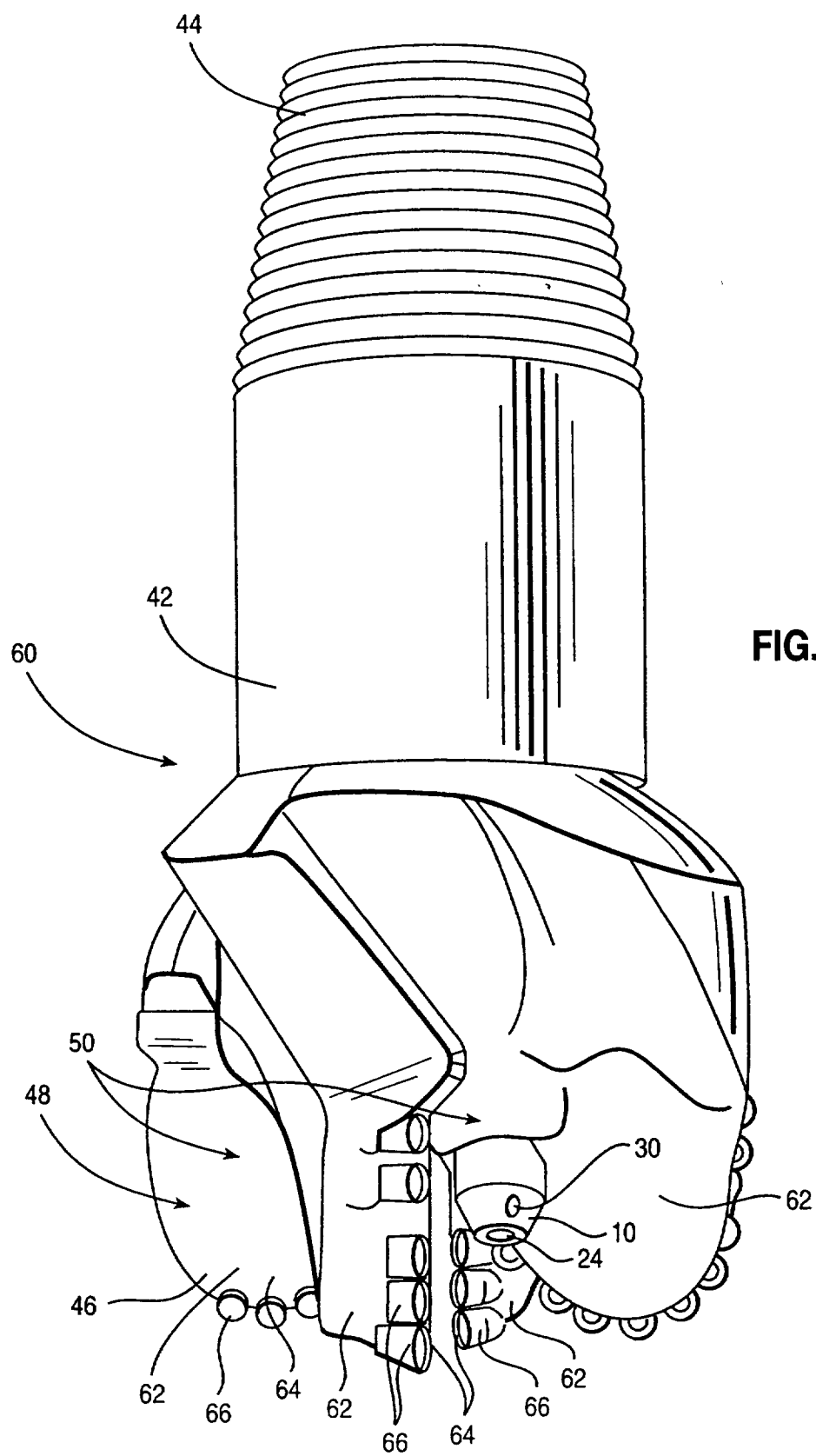


FIG. 4

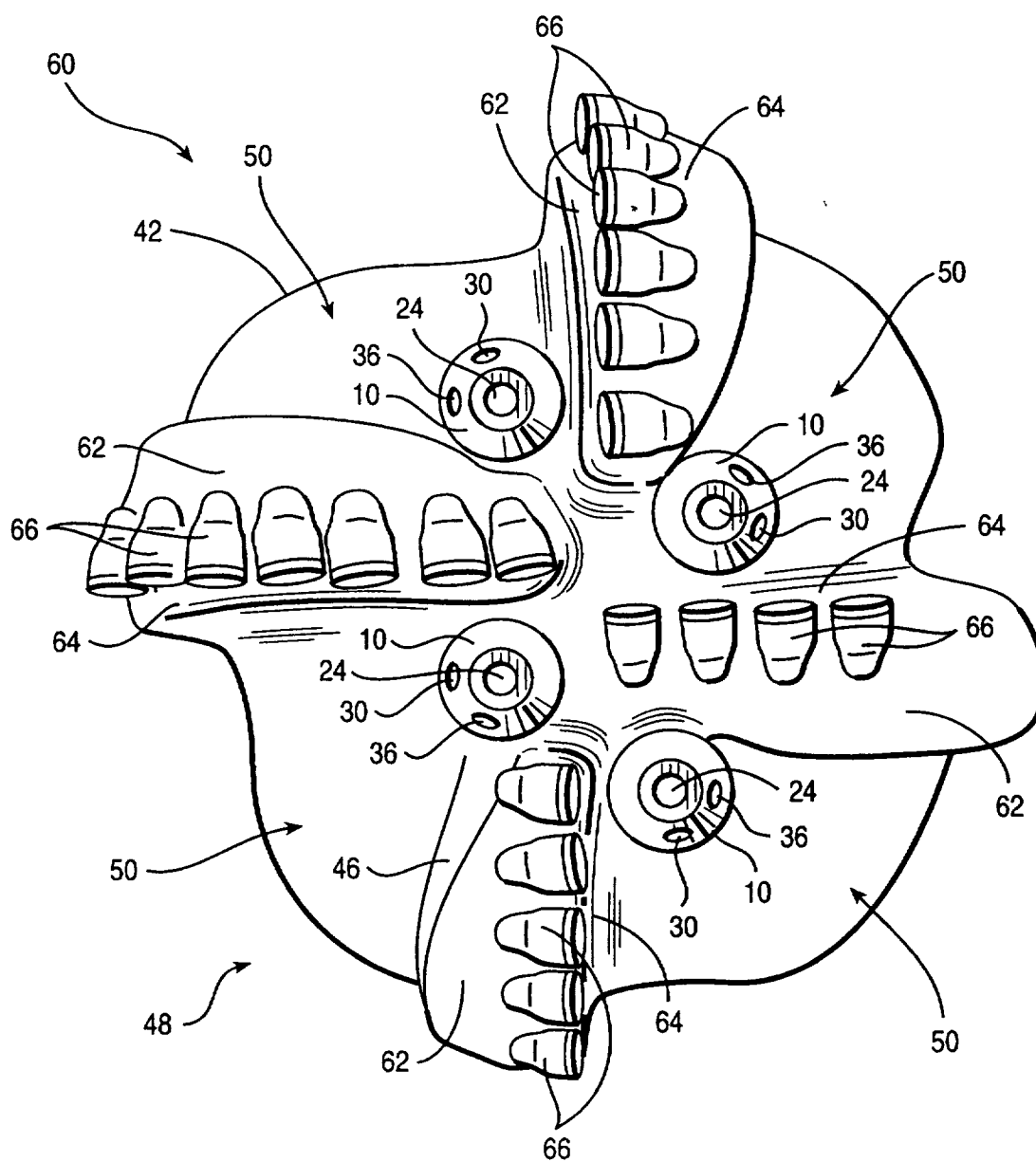


FIG. 5

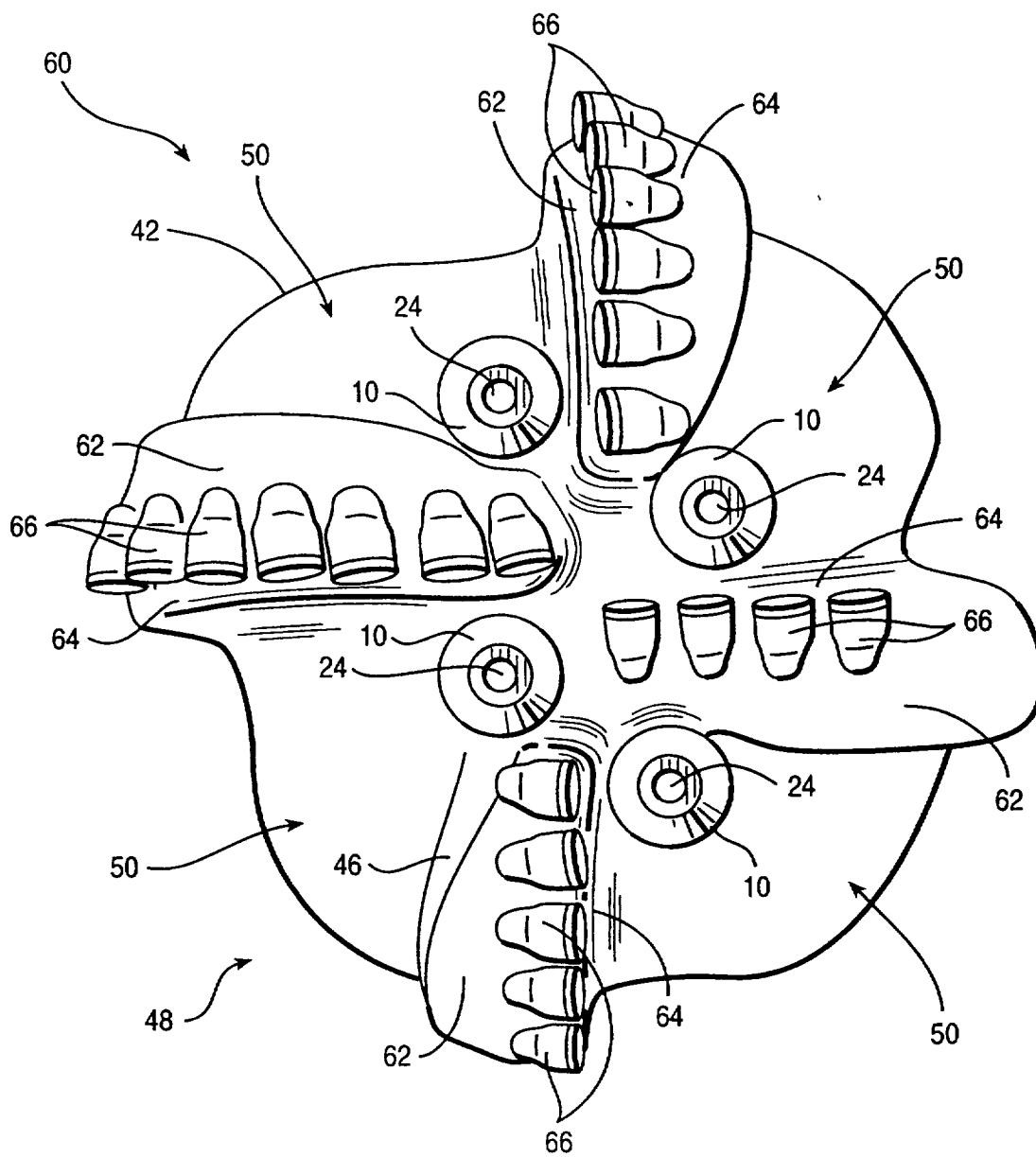


FIG. 5A

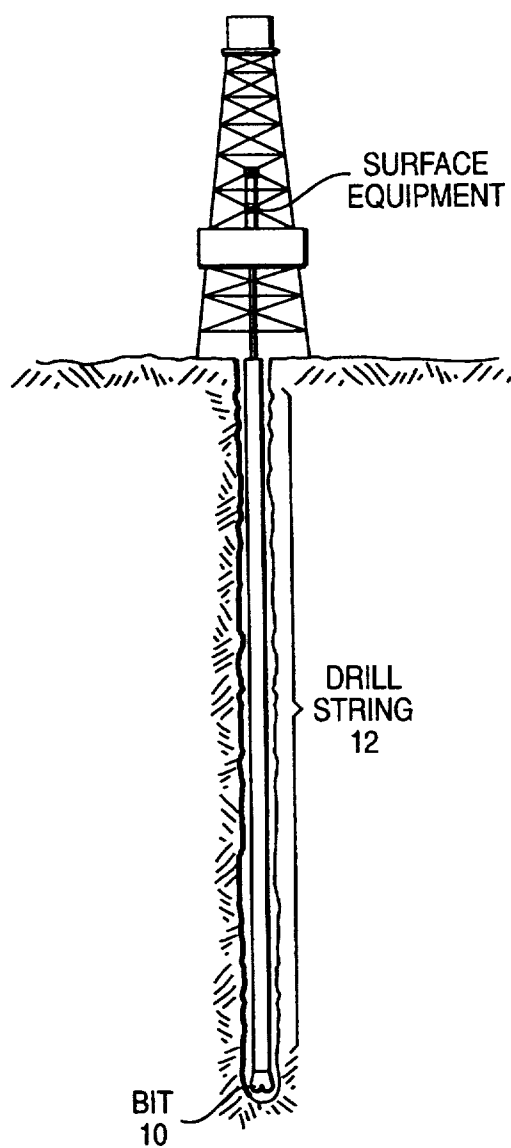


FIG. 6

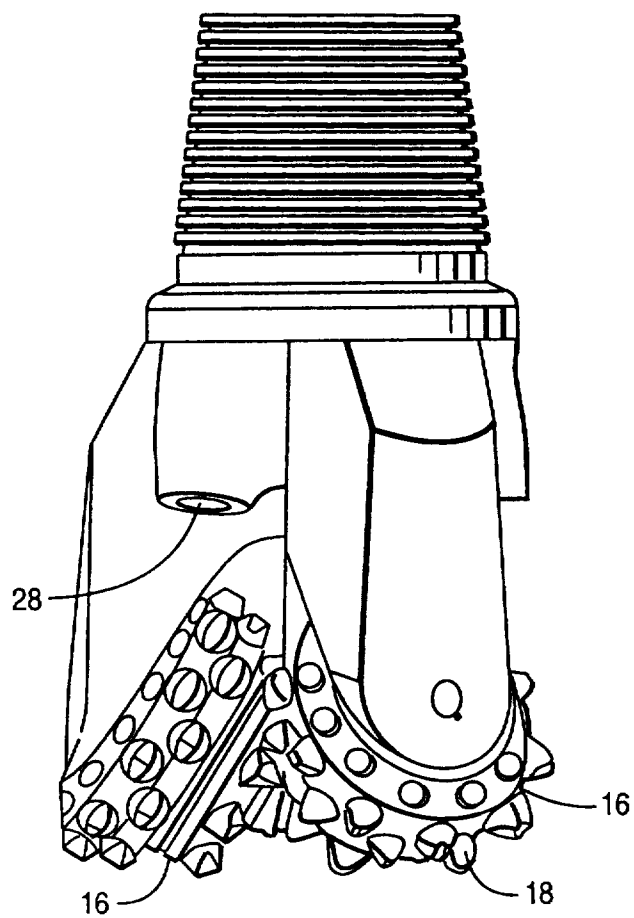


FIG. 7

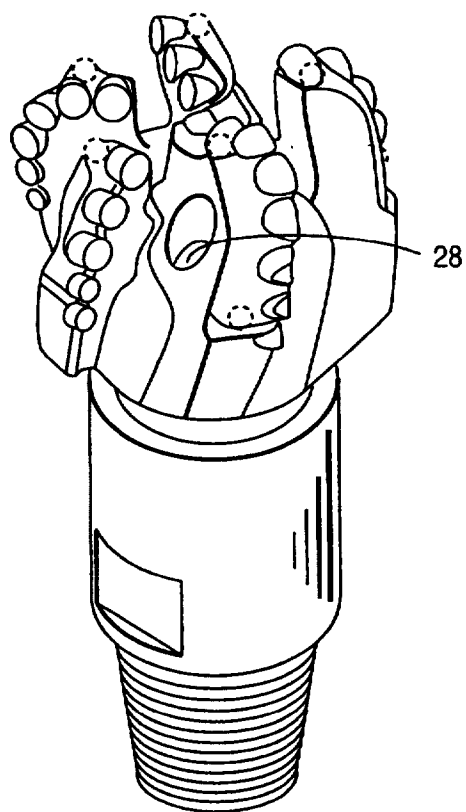


FIG. 8

FIG. 8A

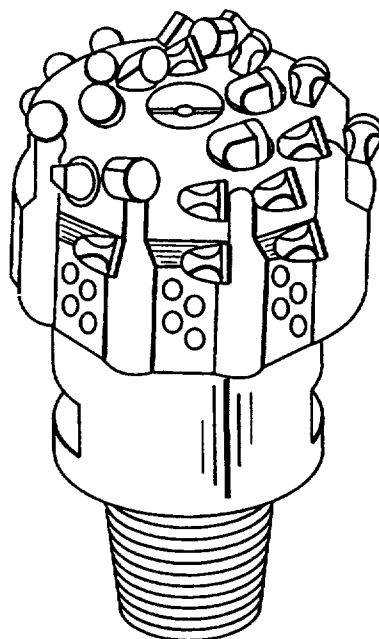


FIG. 9

