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(54) **Drag bit with nozzles for drilling plastic formations.**

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Description

The invention relates to a drag bit for drilling a borehole in an earth formation as set forth in the pre-characterizing portion of claim 1.

Drilling in shales or plastic formations with a drag bit has always been difficult. The shale, under pressure and in contact with hydraulics, tends to act like a sticky bubble-gum-like mass, sometimes referred to as gumbo, which balls and clogs the bit. Once the bit balls up, it ceases to cut effectively.

GB-A-2 181 173 shows a bladed drag bit of the type referred to with a plurality of cutters on each blade in combination with a nozzle which creates a vortex flow having a peripheral stream extending across the cutting elements and exiting into a gage region. To enhance the vortex flow a proportion of the drilling fluid is allowed to escape from the central portion of the vortex through a circular exit passage extending azimuthally through the blade of the bit to open into an exit channel in the gage region. However, the cutters are spaced cutters and the nozzle is azimuthally disposed in front of the blade. This does not provide for a directed hydraulic impingement on the chips effectively preventing balling up the bit when drilling in plastic formations.

EP-A-233 737 shows a bladed drag bit of a similar construction including discharge nozzles arranged in front of the blades and directing fluid against the formation in advance of the cutting elements. Such a direction of fluid tends to remove cuttings from the formation prior to the cutting action of the cutting elements, but does not effectively prevent adhesion of chips to the cutting surface.

While many of the prior art attempts have been successful in one degree or another, efficient drilling rates have always been difficult to achieve consistently in all types of plastic formations, with all types of hydraulic formulations and in all types of drilling conditions.

Therefore, what is needed is a bit design for use in shale or plastic formations which is highly efficient in a broad range of conditions and environments.

The invention is a drag bit comprising the features of claim 1. The invention is further a method of preventing bit balling as claimed in claim 14. Further embodiments of the drag bit are characterized in claims 2-13 and of the method in claims 15-18.

As a result, plastic rock formations and other formations tending to ball and clog the bit are efficiently cut in a wide variety of conditions. The fluid flow from a position azimuthally behind the cutting surfaces of the cutters as defined by normal rotation of the bit when drilling tends to peel ad-

heive chips from the cutters or avoid adhesion of the plastic rock formation fragments to the bit by impinging on the azimuthally rear surface of the fragments of the plastic formation as the fragments clear the cutting face. The fluid flow from behind the cutters tends as an additional effect to break the cuttings and to remove the broken fragments from the proximity of the bit by hydraulic transport.

Turn now to the following drawings of the invention wherein like elements are referenced by like numerals.

Figure 1 is a perspective view of a completed drag bit incorporating the invention.

Figure 2 is a diagrammatic plot sketch of the drill bit illustrated in Figure 1.

Figure 3 is a diagrammatic profile of one of the cutting blades of the bit illustrated in Figures 1 and 2.

Figure 4 is a highly diagrammatic partial cross-sectional view in enlarged scale illustrating the cutting and hydraulic action of one blade of the invention.

Figure 5 is a perspective illustration of an alternative embodiment of the bit using half-round diamond cutters in the blade.

Figure 6 is a perspective view in enlarged scale of one of the cutting slugs in the bit of Figure 5 shown in isolation of the bit.

Figure 7 is a side view of the cutter slug of Figure 6.

Figure 8 is a perspective illustration of another embodiment of the invention where the cutting slugs are provided with rectangular diamond faces.

Figure 9 is a partial diagrammatic cross-sectional view of one blade of the bit of Figure 8.

Figure 10 is a perspective illustration of yet another embodiment of the invention wherein triangular diamond faces are combined on the blade of a bit made according to the invention.

Turn now to the following detailed description in which like elements are referenced by like numerals.

An improved bit and method for cutting plastic and sticky formations, which tend to cause bit balling, is provided by a drag bit having a cutting face formed of a plurality of generally radially extending open arched blades. Each arched blade is provided with a cutting face and defines a cavity beneath the arch to the bit body. The cutting elements on the arched blade may include a plurality of synthetic polycrystalline diamonds which are cut, sized and shaped to conformally fit with each other so as to present a substantially diamond-only surface as a cutting surface of the bit. Hydraulic nozzles are defined in the bit body beneath and azimuthally behind the arches formed by each blade. The nozzles direct hydraulic flow across the cavity under the arch and across each portion of

the cutting face on the arch. As a result, when cutting, only a diamond surface is provided for shearing the rock formation or contacting with velocity any portion of the plastic rock formation. Once the rock chip is exuded upwardly across the diamond face of the cutter, it is subjected to a directed hydraulic flow which peels the chip from the diamond face and transports it into the open cavity defined underneath the arched blade. The cavities under the arched blade freely communicate with a plurality of large open waterways and junk slots. Large plastic fragments may then be cut, peeled from the face of the diamond cutters, and flushed through the waterways up the junk slots.

Figure 1 is a perspective illustration of a completed drag bit of the preferred embodiment fabricated through molding according to the invention using conventional metal matrix infiltration methodology. Drag bit 10 is characterized by a threaded portion 12 on the upper end of the shank (inverted in Figure 1 for ease of visualization). Threaded portion 12 is integral with shank 14 and shank 14 is integral with bit body 16. Bit body 16 is comprised of gage 18 and, in the illustrated embodiment, three blades 20. The number of blades is not material to the invention.

As shown in Figures 1 and 3, on each blade 20 is a plurality of synthetic polycrystalline diamond slug cutters 22 formed on the top of the arch comprised by blade 20. Cutters 22 extend from the center of bit 10 to its gage 18. Each blade forms a web characterized by an open cavity 24. Between blades 20 is an open space which forms a large open waterway 26 and face junk slot 28. The demarcation between waterway 26 and face junk slot 28 is somewhat arbitrary, but face junk slot 28 is generally the region adjacent the face 30 of bit body 16 and proximate the lower portion of waterway 26. Face junk slot 28 communicates with upper junk slot 32 which in turn extends to the upper part of the gage (again Figure 1 being inverted for ease of visualization, necessarily has upper junk slot 32 depicted below face junk slot 28 and waterway 26 in the depiction of Figure 1). Gages 18 also includes a plurality of longitudinal broaches 34 and ribs bearing gage diamond kickers 36. Kickers 36 are typically comprised of embedded natural diamonds or fragments of worn synthetic diamonds.

In the bottom of each cavity 24 are one or more nozzles 38 which direct hydraulic fluid from behind and upwardly across the face of cutters 22. The position of nozzles 38, cutters 22, blades 20 and waterways 26 can be better understood and visualized by now turning to the plot sketch of Figure 2. The plot sketch is a diagrammatic plan view of bit 10 of Figure 1. In the illustrated embodiment, cutters 22 are compax cutters which typically

are comprised of a polycrystalline synthetic diamond table 40, mounted, bonded or otherwise fixed to a metallic backing slug 42 which in turn is set within a cutter body 44 manufactured as part of the infiltration molding process. It is to be expressly understood that many other types of cutting elements or diamond cutters, e.g. natural diamond thermally stable polycrystalline diamond or bonded stud cutters, could be substituted without departing from the spirit and scope of the invention. In the illustrated embodiment, each diamond table 40 is in the shape of a generally circular disc approximately one inch or more in diameter. It is also contemplated that fractions of a circular cutter may be used, such as half circular cutting elements. As will be described below, many other types, shapes and sizes of cutters may be employed according to the invention without departing from its scope.

As graphically depicted in Figure 2, each of the primary cutters 22 overlaps with at least one adjacent cutter. A series of cutters 22 forms a three-dimensional arch as depicted in Figure 1, and as more simply and graphically depicted in the profile sketch of one of blades 20 in Figure 3. A first cutter, denoted by reference numeral 22a as shown in Figure 3, is disposed near the apex portion of blade 20. It is a full circle. However, the next adjacent cutter 22b has been moon-cut so that it fits cutter 22a in a complementary manner and so that diamond tables 40 of cutters 22a and 22b are seen and act as a single diamond-only face. It should be noted that little or no matrix metal of bit 10 is presented to the rock formation in the proximity of the cutting blade. The next two adjacent cutters, also denoted by reference numeral 22b, have the same complementary fit as cutter 22b which is adjacent to cutter 22a. Cutters 22c are also moon-cut to provide a complimentary fit.

Returning to Figure 3, it can be seen that there are four cutters 22c which complete the diamond arch on web 20. The radial outermost cutter 22c extends radially from the longitudinal center of bit 10 to the gage diameter. Further gage definition is provided by a smaller diamond slug cutter 54 placed above the radial outermost cutter 22c which depicted below cutter 22c in Figure 3. As better seen in the plot sketch of Figure 2, gage cutter 54 is rotated azimuthally outward or side raked. Additional gage definition and protection are provided by similar small slug cutters 56 which are azimuthally displaced behind the arch of primary cutters 22a-22c again as best depicted in Figure 2. Figure 3 shows that such supplementary cutters 56 longitudinally overlap the radial outermost cutter 22c and its corresponding gage cutter 54.

The cutter placement as just described is repeated three times in the bit, once for each blade 20, thereby providing a triple redundancy of cutters

and cutting action. The degree of redundancy could of course be increased or decreased according to the number of blades used.

Blade 20 is particularly characterized as depicted in Figure 3 as forming an open web characterized by a cavity 24 which underlies the arch of primary cutters 22a-22c. As shown in Figure 1, cavity 24 is completely open allowing free communication through each blade. However, disposed in the bottom of each blade is one or more nozzles 38 which are best depicted in Figure 2. Nozzles 38 are placed in the base portion 58 of the web best seen in Figure 3 which defines cavity 24 and behind the arch formed by cutters 22a-22c. In the illustrated embodiment, two sets of nozzles are provided for each blade 20. Nozzle 38a, for example, provides a directed flow as symbolically denoted by arrow 60 which fans out from behind, down and then across the diamond tables 40 of cutters 22b-22c from approximately the midpoint to the gage end of the arch of cutters. Nozzle 38b similarly provides a directed flow, as symbolically denoted by arrow 62, across cutters 22a-22b from the midpoint to the apex of the arch of cutters. The hydraulic flow and its coaction with chip removal is best depicted in connection with Figure 4.

Figure 4 is a diagrammatic cross-sectional view taken through cavity 24 of one of blades 20 as the bit is cutting into a formation 64. The primary cone of hydraulic flow is symbolically depicted as cone 66. The flow is ejected by nozzle 38 through cavity 24 downwardly and from behind cutters 22a. Chips being gouged from formation 64 are extruded upwardly across the face of diamond table 40 of cutter 22 and caught at their upper edge by the hydraulic flow contained within and adjacent to cone 66. The hydraulic flow peels chip 68 away from the face of diamond table 40. Ultimately chip 68 becomes of such a size that it separates from formation 64 and is transported by the hydraulic flow into waterways 26, face junk slots 38 and junk slots 32. The chips are entrained in the hydraulic flow up the borehole and carried to the well surface. According to the invention, chip 68 only contacts the cutting faces of diamond tables 40 and no other portion of the bit is presented for impact or diving contact with chips 68. Furthermore, chips 68 are exposed and impacted by hydraulic flow 66 from behind cutters 22. Cavities 24 are believed to act as chip breakers and to allow large chips 68 to be broken into smaller, more manageable pieces at the bit crown. The open design of bit 10 also allows a great deal of chip dynamics and turbulence to be created at the bit crown at the expense of a very limited amount of hydraulic volume. Therefore, bit 10 is able to operate at lower hydraulic volumes and pressures and to tolerate a degree of plasticity in formations that would not otherwise

be possible with cutter designs allowed or permitted greater impact between chips 68 and noncutting surfaces of bit 10. Chips 68, almost regardless of their plasticity or stickiness, have very little opportunity to contact or adhere to any surface of the bit before being broken up, pressure relieved, hydrated and carried away.

The overall geometry and operation of bit 10 of the invention now having been described, consider the methodology wherein a bit according to the illustrated embodiment is manufactured. As first stated, bit 10 is manufactured using conventional metal matrix infiltration techniques. A metal blank body serves as the core of the bit, to which the blades are attached and around which the metal matrix is infiltrated. As known in the art the blank has a generally cylindrical form comprised of a base portion which is machined at its lower end.

The bit blank, once assembled, is inserted into a conventional graphite mold (not shown) together with a number of additional carbon and sand pieces which will define cavity 24, waterways 26, face junk slot 28 and junk slot 32 among other details of the bit face. Cutters 22 will be milled or defined into the bottom of the graphite mold, and the bit blank, as described with its various carbon pieces, is aligned within the bit mold relative to the cutter blanks and other bit face features set up within the mold.

For example, in the case where nonthermally stable diamond is used on diamond tables 40 of cutters 22, dummy blanks will be placed within the mold in place of the cutting slugs and the diamond tables. After the bit is fabricated, the dummy slugs will be removed and the diamond compax slugs may then be brazed or otherwise secured to the bit at a lower temperature than the infiltration temperature, which lower temperature will not degrade the diamond.

In the case where thermally stable diamond is used in cutter 22, that is, where diamond which is thermally stable in excess of temperature of 1200 degrees C., the diamond cutters may be directly furnished into the bit as the metal matrix is infiltrated around the bit blank.

Gross and detailed structure of the bit depicted in Figure 1 is formed within the filled mold by use of variously sized graphite or sand pieces and clay according to conventional infiltration molding techniques. The metal matrix is then packed into the mold according and furnished to produce an integral and solid mass in which the blanks are embedded and otherwise hidden from view.

Many modifications and alterations may be made by those having ordinary skill in the art without departing from the spirit and scope of the invention.

For example, although the illustrated embodiment has been described in terms of moon-cut discs many other types of cutters or cutter shapes may be employed. For example, in Figure 5 a bit, generally denoted by reference numeral 200, is depicted wherein a plurality of semicircular diamond tables 210, which are comprised of slug cutters 202 which are made from cutters of the first embodiment which have been cut in half, are used to form the cutting elements in the blade arch. This allows relative inversion of the cutters along the gage of bit 200, as exemplified by cutter 204 as compared to cutters 210 to enhance gage definition. As best depicted in Figures 6 and 7 cutter 202 could be formed on tungsten carbide slugs 206 carrying a tungsten carbide backing 208 behind diamond table 210. A side view of slug 206 is depicted in Figure 7 and a perspective view is shown in Figure 6.

Yet another embodiment is shown in Figures 8 and 9 wherein rectangular diamond tables are laser cut from large cylindrical discs to provide a diamond cutting bar 302 of bit 300. Not only is an integral and diamond-only blade presented to the rock formation as shown in the perspective view of Figure 8, but portions of the blade behind the primary surface can also be covered with diamond plates 304 in a mosaic or tile pattern as best depicted in the cross-sectional view shown in Figure 9 of one of the blades depicted in Figure 8.

Yet another embodiment may be devised as shown in the perspective view of figure 10 wherein the diamond tables of the slug cutters are formed or cut into a triangular shape to comprise cutters 402 of bit 400. Again, the only surface of the blade which is substantially exposed as a cutting surface is a diamond-only surface and no opportunity is provided to the plastic chips to adhere to any other surface of the bit.

Many other types of cutters in addition to diamond or diamond-related cutters, now known or later devised, could similarly be substituted for those specifically described without departing from the spirit and scope of the invention. Moreover, different sized and shaped cavities which provide the same effect as the open toroidal cavity of the preferred embodiments may be employed. Finally, the nozzles may be placed to direct hydraulic flow across the cutting face from the side, front or other orientation.

Claims

1. A drag bit (10) for drilling a borehole in an earth formation (64) comprising a bit body (16) having a fluid passage therethrough, at least one generally radially extending blade (20) having a first, leading side and a second, trail-

ing side relative to the direction of intended rotation of the bit (10) when drilling, said at least one blade (20) extending longitudinally from said bit body (16) and secured thereto, a cutting surface (40, 210, 302) on said first side of said at least one blade (20) proximate an azimuthally extending cavity (24) associated with said blade (20), and at least one nozzle (38) associated with said at least one blade (20) and communicating with said fluid passage of said bit body (16),

characterized in that said at least one nozzle (38) is disposed and oriented so as to direct a flow of fluid adjacent said cutting surface (40, 210, 302) from behind said cutting surface (40, 210, 302) and generally in the direction of bit rotation.

2. The drag bit of claim 1, wherein said cavity (24) extends generally radially between said bit body (16) and said cutting surface (40, 210, 302).

3. The drag bit of claim 2, wherein said at least one nozzle (38) is disposed at least partially within said cavity (24).

4. The drag bit of claims 1 to 3, wherein said at least one nozzle (38) is oriented in the general direction of bit rotation.

5. The drag bit of claims 1 to 4, wherein said at least one nozzle (38) comprises at least two nozzles (38), each nozzle (38) being oriented to direct a flow of fluid from said fluid passage proximate a different lateral portion of said cutting surface (40, 210, 302).

6. The drag bit of claim 1, wherein said at least one blade (20) extends radially to define the gage of said borehole.

7. The drag bit of claim 1, wherein said cutting surface (40, 210, 302) is substantially continuous.

8. The drag bit of claim 7, wherein said cutting surface (40, 210, 302) comprises a plurality of cutters (22, 202), selected cutters (22, 202) of said plurality of cutters (22, 202) being conformably cut to laterally engage and abut adjacent cutters (22, 202).

9. The drag bit of claim 1, wherein said cutting surface (40, 210, 302) comprises a substantially diamond-only cutting surface (40, 210, 302).

10. The drag bit of claim 1, wherein said at least one blade (20) comprises a plurality of generally radially extending blades (20).
11. The drag bit of claim 10, wherein said plurality of blades (20) each have a first, radially outer end and a second, radially inner end, each blade (20) having its first end independently secured to said bit body (16) and its second end commonly secured with the second ends of the remaining blades (20) to said bit body (16).
12. The drag bit of claim 10, wherein each of said blades (20) includes a cavity (24) therein extending between said first and second blade sides thereof to form a continuous toroidal space between said bit body (16) and said cutting surface (40, 210, 302).
13. The drag bit of claim 4 and 10, wherein said at least one nozzle (38) is disposed behind said second blade side and is oriented in the general direction of bit rotation so as to direct a flow of fluid adjacent said cutting surface (40, 210, 302) through said cavity (24).
14. A method of preventing bit balling in the cutting of a plastic rock formation (64) with a drag bit (10), comprising the steps of providing a drag bit (10) having a bit body (16) and a cutting surface (40, 210, 302), rotating said drag bit (10); presenting substantially only said cutting surface (40, 210, 302) to said plastic rock formation (64), cutting said plastic rock formation (64) with said cutting surface (40, 210, 302) and removing rock cuttings (68) cut by said cutting surface (40, 210, 302) by directed hydraulic flow, characterized by directing hydraulic flow from behind said cutting surface (40, 210, 302) and generally toward the direction of bit rotation.
15. The method of claim 14, wherein said flow is directed primarily to the portion of said cutting surface (40, 210, 302) most removed from said plastic formation (64).
16. The method of claim 14, wherein said step of removing rock cuttings (68) includes impinging said hydraulic flow on said cuttings (68) as said cuttings (68) clear said cutting surface (40, 210, 302) and extend thereabove.
17. The method of claim 14, wherein said drag bit (10) includes a cavity (24) between said bit body (16) and said cutting surface (40, 210, 302), and said hydraulic flow emanates from

within said cavity (24).

18. The method of claim 17, wherein said step of removing rock cuttings (68) includes transporting said rock cuttings (68) into said cavity (24) and thereafter into an annulus between said drag bit (10) and the wall of a borehole being drilled by said drag bit (10).

Patentansprüche

- Fräsmeißel (10) zum Bohren eines Bohrloches in einer Erdformation (64), mit einem Meißelkörper (16) mit einem Flüssigkeitsdurchlaß durch diesen, zumindest einem sich im wesentlichen radial erstreckenden Flügel (20), der eine erste vorauslaufende Seite und eine zweite nachlaufende Seite in bezug auf die Richtung der vorgesehenen Drehung des Meißels (10) beim Bohren aufweist, wobei sich der zumindest eine Flügel (20) in Längsrichtung zum Meißelkörper (16) erstreckt und mit diesem verbunden ist, mit einer Schneidfläche (40,210,302) an der ersten Seite des zumindest einen Flügels (20), die nahe einer sich azimuthal erstreckenden, dem Flügel zugeordneten Ausnehmung (24) angeordnet ist, und mit zumindest einer Düse (38), die dem zumindest einen Flügel zugeordnet ist und mit dem Flüssigkeitsdurchlaß im Meißelkörper (16) in Verbindung steht, **dadurch gekennzeichnet**, daß die zumindest eine Düse (38) so angeordnet und orientiert ist, daß sie eine Flüssigkeitsströmung angrenzend an die Schneidfläche (40,210,302) von der Rückseite der Schneidfläche her und im wesentlichen in Richtung der Meißeldrehung richtet.
- Fräsmeißel nach Anspruch 1, bei dem sich die Ausnehmung (24) im wesentlichen radial zwischen dem Meißelkörper (16) und der Schneidfläche (40,210,302) erstreckt.
- Fräsmeißel nach Anspruch 2, bei dem die zumindest eine Düse (38) zumindest teilweise innerhalb der Ausnehmung (24) angeordnet ist.
- Fräsmeißel nach den Ansprüchen 1 bis 3, bei dem die zumindest eine Düse (38) in die Grundrichtung der Meißeldrehung gerichtet ist.
- Fräsmeißel nach den Ansprüchen 1 bis 4, bei dem die zumindest eine Düse (38) zumindest von zwei Düsen (38) gebildet ist, von denen jede Düse durch ihre Ausrichtung eine Flüssigkeitsströmung aus dem Flüssigkeitsdurchgang auf einen unterschiedlichen Seitenbereich der Schneidfläche (40,210,302) lenkt.

6. Fräßmeißel nach Anspruch 1, bei dem sich der zumindest eine Flügel (20) radial erstreckt und das Kaliber des Bohrlochs definiert.
7. Fräßmeißel nach Anspruch 1, bei dem die Schneidfläche (40,210,302) im wesentlichen zusammenhängend ausgebildet ist. 5
8. Fräßmeißel nach Anspruch 7, bei dem die Schneidfläche (40,210,302) eine Mehrzahl von Schneidkörpern (22,202) aufweist, wobei aus der Mehrzahl von Schneidkörpern (22,202) ausgewählte Schneidkörper (22, 202) für einen seitlichen Eingriff und seitliches Angrenzen an benachbarte Schneidkörper (22,202) übereinstimmend geschnitten sind. 10 15
9. Fräßmeißel nach Anspruch 1, bei dem die Schneidfläche (40,210,302) eine im wesentlichen diamantene Schneidfläche (40,210,302) bildet. 20
10. Fräßmeißel nach Anspruch 1, bei dem der zumindest eine Flügel (20) aus einer Mehrzahl von sich allgemein radial erstreckenden Flügeln (20) gebildet ist. 25
11. Fräßmeißel nach Anspruch 10, bei dem die Mehrzahl von Flügeln (20) jeweils ein erstes, radial äußeres Ende und ein zweites, radial inneres Ende aufweisen, wobei jeder Flügel an seinem ersten Ende unabhängig am Meißelkörper (16) befestigt ist und an seinem zweiten Ende mit den zweiten Enden der übrigen Flügel gemeinsam mit dem Meißelkörper verbunden ist. 30 35
12. Fräßmeißel nach Anspruch 10, bei dem jeder Flügel eine Ausnehmung aufweist, die sich zwischen der ersten und zweiten Flügelseite erstreckt und einen durchgehenden toroidalen Raum zwischen dem Meißelkörper (16) und der Schneidfläche (40,210,302) bildet. 40
13. Fräßmeißel nach Anspruch 4 und 10, bei dem die zumindest eine Düse (38) hinter der zweiten Flügelseite angeordnet und in die Grundrichtung der Meißeldrehung gerichtet ist, um einen Flüssigkeitsstrom durch die Ausnehmung (24) auf einen der Schneidfläche (40,210,302) benachbarten Bereich zu richten. 45 50
14. Verfahren zur Vermeidung eines Verschmieren eines Meißels beim Schneiden einer plastischen Erdformation (64) mittels eines Fräßmeißels (10), bei dem ein Fräßmeißel mit einem Meißelkörper (16) und einer Schneidfläche (40,210,302) verwendet und der Fräßmeißel (10) in Drehung versetzt wird, im wesentlichen nur die Schneidfläche (40,210,302) der plastischen Erdformation (64) ausgesetzt wird, die plastische Erdformation (64) mit der Schneidfläche (40,210,302) geschnitten und Bohrklein (68), das von der Schneidfläche (40,210,302) geschnitten wurde, durch Richten eines Flüssigkeitsstromes entfernt wird, **dadurch gekennzeichnet**, daß der Flüssigkeitsstrom von der Rückseite der Schneidfläche (40,210,302) her und allgemein in Richtung der Meißeldrehung gerichtet wird.
15. Verfahren nach Anspruch 14, bei dem die Flüssigkeitsströmung hauptsächlich auf einen Bereich der Schneidfläche (40,202,302) gerichtet wird, der von der plastischen Erdformation weitestmöglich entfernt gelegen ist.
16. Verfahren nach Anspruch 14, bei dem die Entfernung des Schneidkleins der Erdformation (68) das Auftreffen der Flüssigkeitsströmung auf dem Schneidklein (68) umfaßt, sobald das Schneidklein von der Schneidfläche (40,210,302) frei kommt und sich über diese hinauserstreckt.
17. Verfahren nach Anspruch 14, bei dem der Fräßmeißel (10) eine Ausnehmung (24) zwischen dem Meißelkörper (16) und der Schneidfläche (40,210,302) aufweist und die Flüssigkeitsströmung ihren Ausgang von einer Stelle innerhalb der Ausnehmung (24) nimmt.
18. Verfahren nach Anspruch 17, bei dem die Entfernung des Schneidkleins der Erdformation (68) das Vorbewegen des Schneidkleins der Erdformation (68) in die Ausnehmung (24) und danach in einen Ringraum zwischen dem Fräßmeißel (10) und der Wandung des Bohrloches, das mit dem Fräßmeißel (10) gebohrt wurde, umfaßt.

Revendications

1. Trépan à lames (10) pour le forage d'un trou dans un sol (64) comprenant un corps de trépan (16) traversé de part en part par un passage de fluide, au moins une lame (20) s'étendant dans l'ensemble radialement et présentant un premier côté d'attaque et un second côté de fuite par rapport au sens de rotation prévu pour le trépan (10), lors du forage, ladite au moins une lame (20) s'étendant longitudinalement à partir du corps de trépan (16) et étant fixée à celui-ci, une surface de coupe (40, 210, 302) sur le premier côté de ladite au moins une lame (20), à proximité

- d'une cavité à extension azimutale (24) associée à la lame (20) et au moins un ajutage (38) associé à ladite au moins une lame (20) et communiquant avec le passage de fluide du corps de trépan (16), caractérisé en ce que ledit au moins un ajutage (38) est disposé et orienté de manière à diriger un flux de fluide à proximité de la surface de coupe (40, 210, 302) depuis l'arrière de la surface de coupe (40, 210, 302) et généralement dans le sens de rotation du trépan.
2. Trépan à lames suivant la revendication 1, dans lequel la cavité (24) s'étend dans l'ensemble radialement entre le corps de trépan (16) et la surface de coupe (40, 210, 302).
 3. Trépan à lames suivant la revendication 2, dans lequel ledit au moins un ajutage (38) est disposé au moins partiellement à l'intérieur de la cavité (24).
 4. Trépan à lames suivant les revendications 1, à 3, dans lequel ledit au moins un ajutage (38) est orienté dans le sens général de rotation du trépan.
 5. Trépan à lames suivant l'une quelconque des revendications 1 à 4, dans lequel ledit au moins un ajutage (38) comprend au moins deux ajutages (38), chaque ajutage (38) étant orienté de manière à diriger un flux de fluide à partir du passage de fluide à proximité d'une partie latérale différente de la surface de coupe (40, 210, 302).
 6. Trépan à lames suivant la revendication 1, dans lequel ladite au moins une lame (20) s'étend radialement de manière à définir le calibre du trou foré.
 7. Trépan à lames suivant la revendication 1, dans lequel la surface de coupe (40, 210, 302) est sensiblement continue.
 8. Trépan à lames suivant la revendication 7, dans lequel la surface de coupe (40, 210, 302) comprend une pluralité d'éléments de coupe (22, 202), des éléments de coupe sélectionnés (22, 202) de la pluralité d'éléments de coupe (22, 202) étant taillés de manière conforme afin d'engager latéralement et d'aboutir des éléments de coupe adjacents (22, 202).
 9. Trépan à lames suivant la revendication 1, dans lequel la surface de coupe (40, 210, 302) comprend une surface de coupe en substance exclusivement en diamant (40, 210, 302).
 10. Trépan à lames suivant la revendication 1, dans lequel ladite au moins une lame (20) comprend une pluralité de lames (20) qui s'étendent dans l'ensemble radialement.
 11. Trépan à lames suivant la revendication 10, dans lequel les lames (20) de la pluralité présentent chacune une première extrémité radialement externe et une seconde extrémité radialement interne, la première extrémité de chaque lame (20) étant fixée de manière indépendante au corps de trépan (16) et sa seconde extrémité étant fixée en commun avec les secondes extrémités des autres lames (20) au corps de trépan (16).
 12. Trépan à lames suivant la revendication 10, dans lequel chacune des lames (20) contient une cavité (24) qui s'étend entre le premier et le second côté de la lame pour former un espace toroïdal continu entre le corps de trépan (16) et la surface de coupe (40, 210, 302).
 13. Trépan à lames suivant les revendications 4 et 10, dans lequel ledit au moins un ajutage (38) est disposé derrière le second côté de la lame et est orienté dans le sens général de rotation du trépan de manière à diriger un flux de fluide à proximité de la surface de coupe (40, 210, 302) à travers la cavité (24).
 14. Procédé pour empêcher le bourrage du trépan lors de la taille d'une formation rocheuse plastique (64) à l'aide d'un trépan à lames (10), comprenant les étapes consistant à fournir un trépan à lames (10) comportant un corps de trépan (16) et une surface de coupe (40, 210, 302), à faire tourner le trépan à lames (10), à ne présenter en substance que la surface de coupe (40, 210, 302) à la formation rocheuse plastique (64), à tailler la formation rocheuse plastique (64), à l'aide de la surface de coupe (40, 210, 302) et à évacuer les débris de roche (68) taillés par la surface de coupe (40, 210, 302) par un flux hydraulique dirigé, caractérisé en ce qu'on dirige le flux hydraulique depuis l'arrière de la surface de coupe (40, 210, 302) et d'une manière générale dans le sens de rotation du trépan.
 15. Procédé suivant la revendication 14, dans lequel le flux est dirigé principalement vers la partie de la surface de coupe (40, 210, 302) la plus éloignée de la formation plastique (64).
 16. Procédé suivant la revendication 14, dans lequel l'étape consistant à évacuer les débris de roche (68) consiste à projeter le flux hydraulique

que sur les débris (68) lorsque ces débris (68) se détachent de la surface de coupe (40, 210, 302) et s'étendent au-dessus de celle-ci.

17. Procédé suivant la revendication 14, dans lequel le trépan de forage (10) comprend une cavité (24) entre le corps de trépan (16) et la surface de coupe (40, 210, 302) et le flux hydraulique provient de l'intérieur de la cavité (24). 5 10

18. Procédé suivant la revendication 17, dans lequel l'étape consistant à évacuer les débris de roche (68) implique le transport des débris de roche (68) dans la cavité (24), puis dans un passage annulaire formé entre le trépan à lames (10) et la paroi d'un trou en cours de forage par le trépan à lames (10). 15 20

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Fig. 1

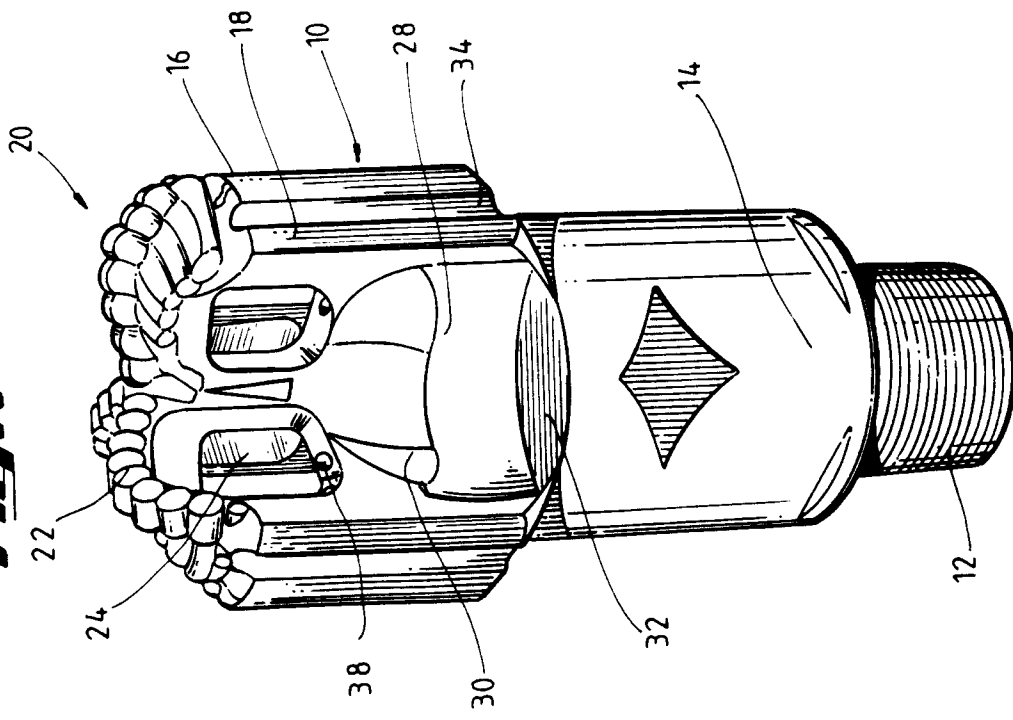


Fig. 2

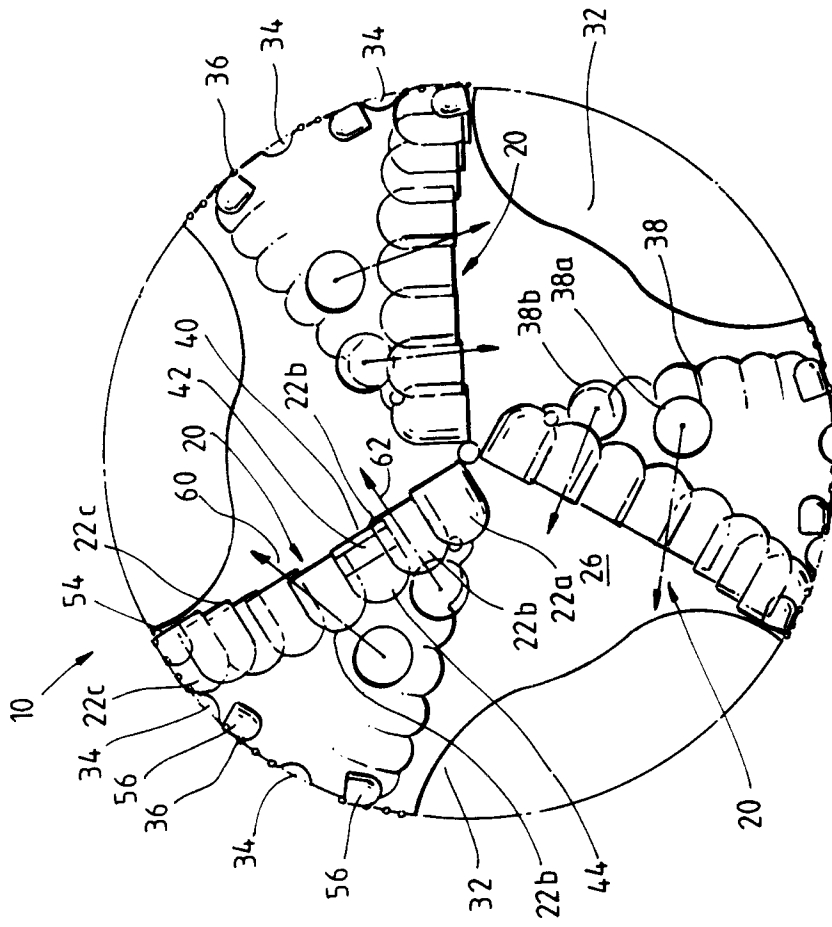


Fig. 3

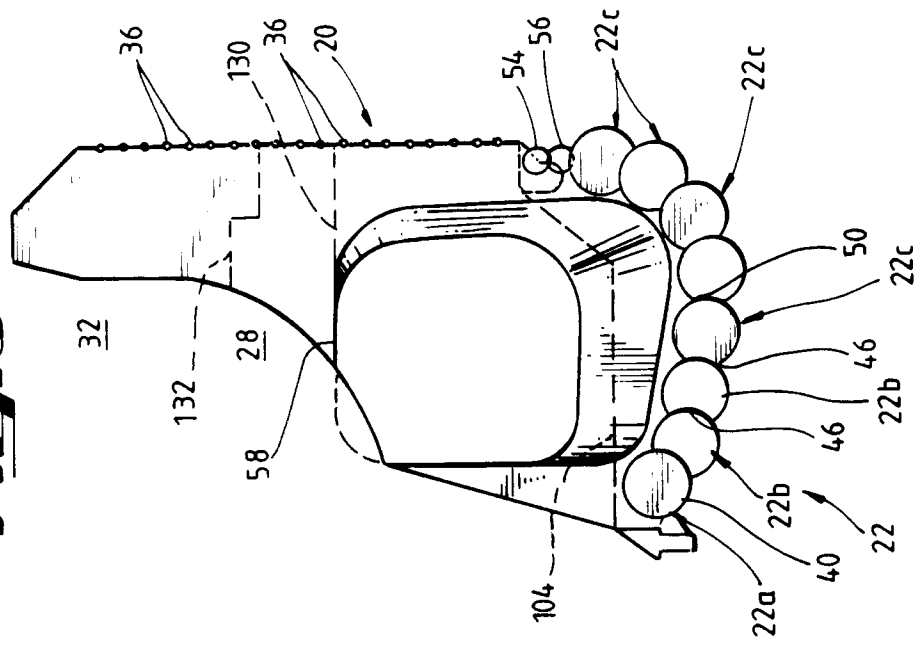


Fig. 4

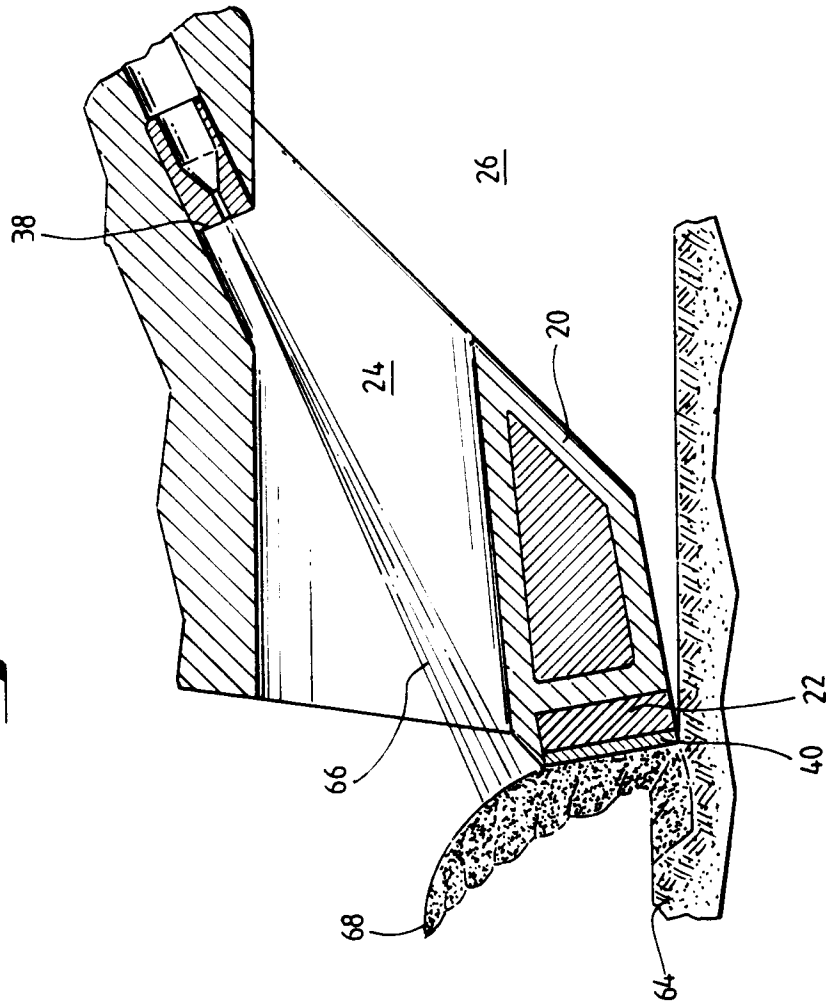


Fig. 5

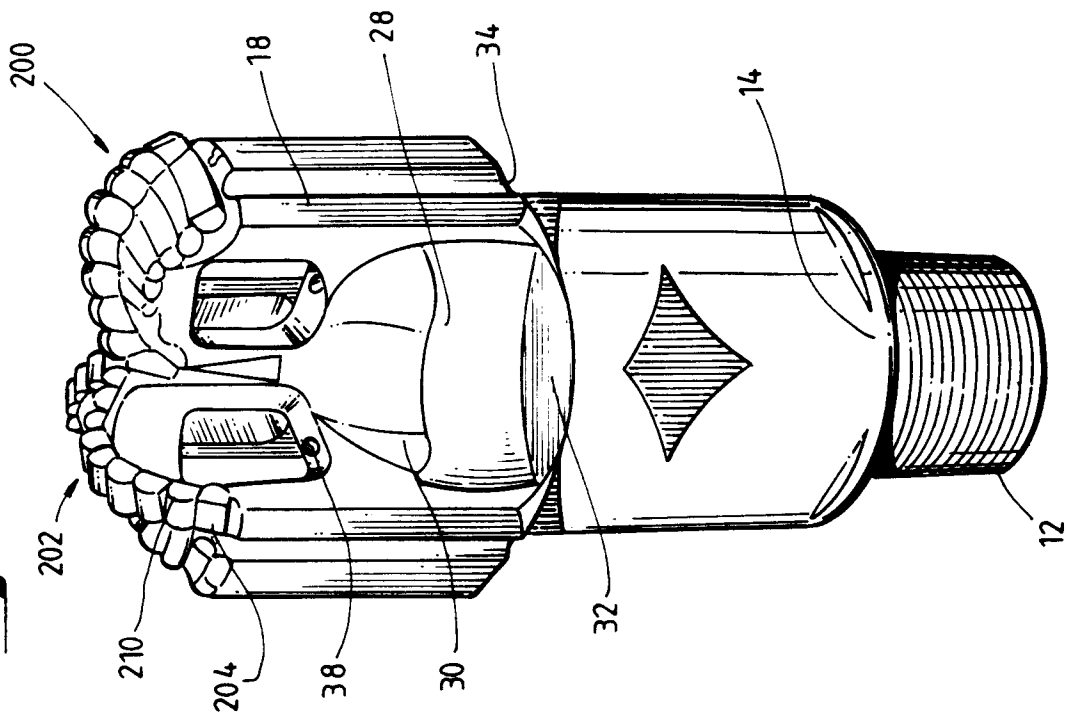


Fig. 6

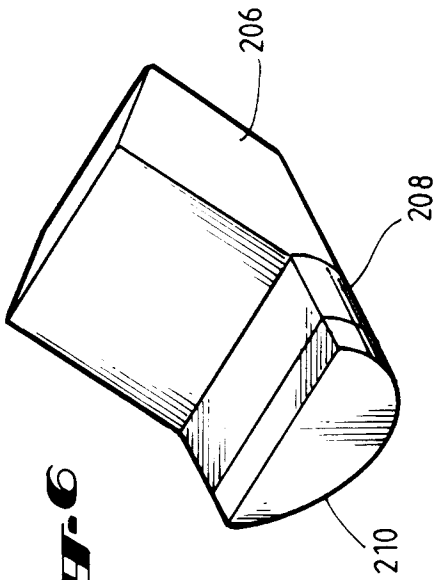


Fig. 7

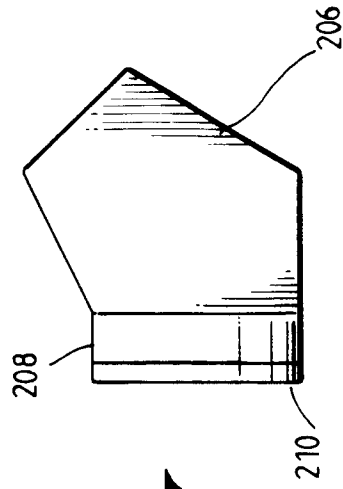


Fig. 8

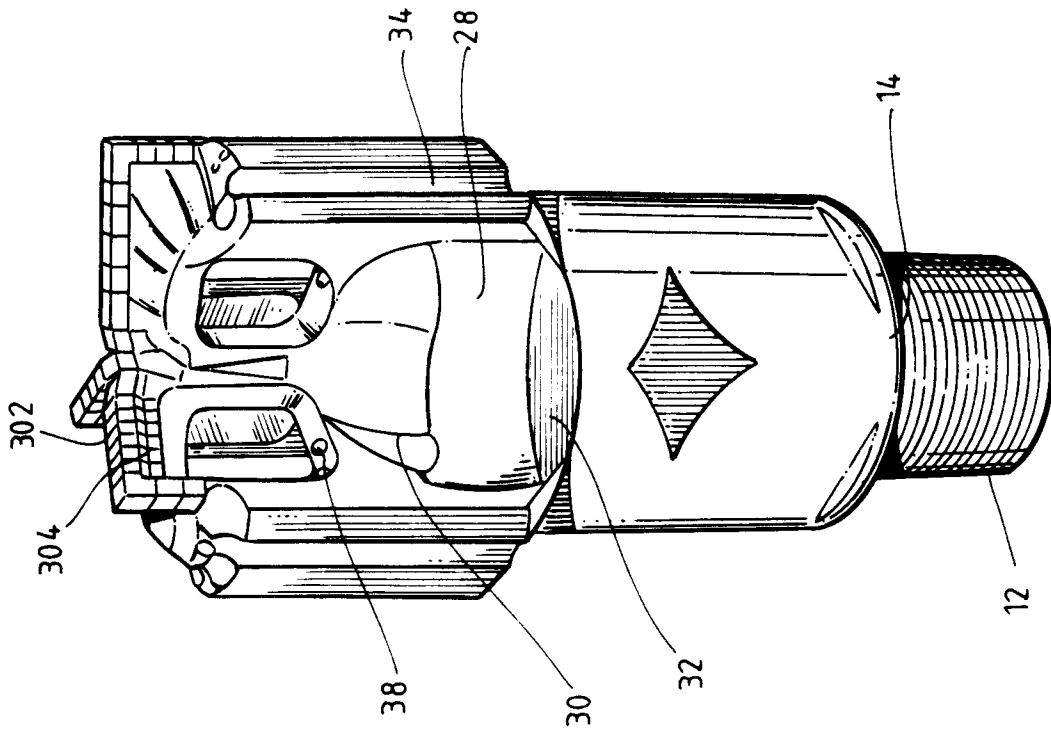


Fig. 9

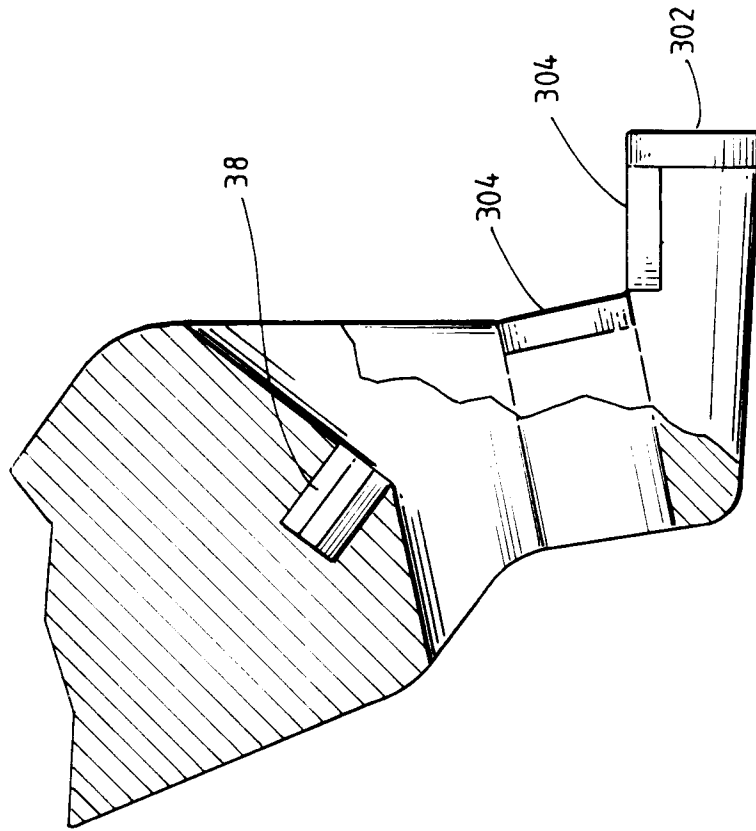


Fig.10

