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(54) **Rotary drill bit.**

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Description

The present invention relates to a rotary drill bit for cutting in earth formations, comprising a bit body including a cutting face having a peripheral edge and a central recess extending longitudinally inwardly from said peripheral edge, a plurality of fluid discharge nozzles mounted in said cutting face for emitting drilling fluid under pressure, and a plurality of cutter elements, some of which being mounted in said peripheral edge, and others of which being mounted in said recess to fracture an earthen core formed as the drill cuts through the formation, and that the drill bit further comprises a plurality of lateral discharge passages formed in said body, said passages extending radially through said body from said recess and extending longitudinally to said peripheral edge to form circumferential interruptions in said peripheral edge, and a convex protrusion disposed centrally at a longitudinally inner end of said recess and including a convex deflecting surface, said protrusion arranged to contact and fracture the earthen core.

In a typical rotary drilling operation, a rotary drill bit is rotated while being advanced into a soil or rock formation. The soil or rock is cut by cutting elements on the drill bit, and these cuttings are flushed from the borehole by the circulation of drilling fluid toward the top of the borehole. The drilling fluid is delivered to the drill bit downwardly through a passage in the drill stem and is ejected outwardly through nozzles disposed in the cutting face of the drill bit. The ejected drilling fluid is directed outwardly through the nozzles at high speed to aid in cutting, and to flush the cuttings and cool the cutter elements.

A traditional area of concern in the design of rotary drill bits of this type involves the configuration at the center of rotation of the bit cutting face where the linear speed of the cutter elements is relatively slow.

It has been heretofore proposed to provide a drill bit with a concave recess at the center of the cutting face. When cutting through a hard substance, a core of the substance is formed within the recess. The core is gradually broken up by cutter elements disposed within the recess and/or by an inclined surface disposed at an inner end of the recess. A drill bit of that type is known from US—A—4,207,954. However, said drill bit has a relatively difficult cuttings discharge route in that the cuttings must be flushed forwardly toward the leading edge of the drill bit.

From US—A—4,494,618 is previously known a drill bit having a number of cutting elements on its front face. Said drill bit also has a plurality of fluid discharge nozzles mounted in said front face for emitting drill fluid under pressure. However, no lateral discharge passages extending radially from a central recess are present in this drill bit.

From US—A—3,938,599 is previously known a drill bit of the type mentioned above. Said drill bit comprises on its drilling face a number of shoulders arranged to retard the flow of drilling fluid into an associated passage. However, this drill bit has no lateral discharge passages extending radially from a central recess.

Drill bits of the above-described type are subject to certain shortcomings, however, as determined by the present inventor. For example, as the core is engaged and broken up by the inclined surface at the inner end of the recess, an unbalanced force pattern is established on the drill bit. That is, the force generated by the contact between core and the inclined surface includes a radial component which tends to displace the drill bit from its intended travel path. As a result, it becomes difficult to cut in a predetermined straight path.

Furthermore, in cases where the discharge passage in the bit body extends longitudinally all the way to the forward end of the bit, there may be a tendency for drilling fluid to by-pass some of the cutting elements mounted on the bit. That is, such a discharge passage forms a convenient travel path for drilling fluid to travel directly from the nozzle to the annulus without contacting the cutter bits to flush and cool same.

It is, therefore, an object of the present invention to minimize or obviate problems of the above-described sort.

Another object is to provide a drill bit which has utility in hard and soft substances and which promotes drilling in a straight direction.

A further object is to provide such a drill bit which minimizes tendencies for drilling fluid to bypass the cutter elements.

An additional object is to provide a centrally recessed drill bit which fractures a core without generating appreciable unbalanced forces on the bit.

A further object is to provide such a drill with a dam that deflects drilling fluid toward cutter elements which otherwise would be bypassed.

The above and other objects are attained by giving the invention the characterizing features stated in the appending claims.

The invention is described in detail in the following description with reference to the accompanying drawings in which one embodiment is shown by way of example. It is to be understood that this embodiment is only illustrative of the invention and that various modifications thereof may be made within the scope of the claims.

In the drawings, Fig. 1 is a side elevational view, partially in longitudinal section, of a drill bit and drill string according to the present invention.

Fig. 2 is an end view of the drill bit, depicting the series of holes for receiving cutter elements and nozzles; some of the holes remaining empty in Fig. 2 and the remaining holes being depicted as containing nozzles and cutter elements.

Fig. 3 is a side elevational view of a cutter element employed in the drill bit.

Fig. 4 is a longitudinal sectional view through the drill bit taken along line 4—4 of Fig. 2, with the nozzles and cutter elements being omitted for clarity.

Fig. 5 is a side elevational view of the drill bit taken along line 5—5 of Fig. 2, with the nozzles and cutting elements being omitted for clarity.

Fig. 6 is a cross-sectional view taken along the line 6—6 in Fig. 2 to depict a lateral discharge passage and a dam-forming ridge mounted along a trailing edge of the discharge passage.

Depicted in Figs. 1 and 2 is a rotary drill bit 10 mounted at the end of a drill stem 11. A plurality of small bores 12 (Fig. 2) are formed in the drill bit body 10 which are adapted to receive cutter elements 14 (Fig. 3). The cutter elements 14 may comprise polycrystalline diamond studs in a conventional manner.

A plurality of larger bores 16 are provided in the drill bit for the reception of nozzles 18 for discharging jets of drilling fluid. The drilling fluid is conducted to the nozzles 18 through a passage 20 in the drill stem 11 and drill bit 10 which communicates with passages 22 in the drill bit. The jet streams aid in the cutting of the formation, cooling of the drill bit cutters, and carrying of the cuttings to the top of the borehole.

The cutting face 24 of the drill bit comprises an outer peripheral edge 26 and a central recess 28. The outer edge 26 slopes longitudinally inwardly (upwardly) and radially outwardly. The recess 28 is defined by side walls 30 which are inclined longitudinally and radially inwardly. The cutting elements 14 are positioned in the peripheral edge 26, in the side walls 30, and in a floor 32 of the recess 28. Most of the nozzles 18 are positioned in the floor 32.

The floor 32 of the recess 28 is of concave configuration, the floor preferably comprising a centrally located, generally frusto-conical protuberance 34. If desired, the protuberance 34 could be of other convex shape such as semi-spherical for example. Holes 12A, 12B for cutting elements 14 (Fig. 2) are formed in the protuberance 34, and the aforementioned nozzle 18A is mounted in the protuberance 34.

The drill bit also includes a plurality of lateral discharge passages 36 which communicate with the central recess 28. Those passages 36 include base surfaces 38 (Fig. 4) which constitute continuations of an inclined wedge face 40 of the protuberance 34. The passages 36, preferably three in number, are equidistantly spaced around the longitudinal axis of the drill bit, i.e. at 120 degree intervals.

Each passage extends radially completely through the bit body and extends longitudinally outwardly to the peripheral edge 26 so as to form gaps in the latter.

It will be appreciated that during a cutting operation, the earth formation is cut so as to form a conical earthen core which projects into the central recess 28. The core is fractured by the combined action of the cutting elements 14 and the convex protuberance 34, the former engaging the sides of the core and the apex 41 of the latter engaging the tip of the core. The convex shape of the surface 40 of the protuberance 34 assures that the reaction forces applied against the protuberance will be distributed around the protuberance and thus will tend to be self-balancing in the radial direction. That is, a concentration of forces at one point on the floor of the recess is avoided. As a result, the drill bit will not be caused to deviate from its intended path of travel by unbalanced forces acting on the floor of the recess.

The cuttings are discharged from the recess through the passages 36 by the action of the surface 40 which serves as a wedge, and by flushing fluid from the nozzles 18, 18A.

Disposed on the cutting face of the drill bit along the trailing edge 48 of each lateral discharge passage 36 is a ridge 50 (Fig. 6). The ridge 50 can be formed of a hard or a soft substance, as desired. For example, the ridge 50 can be formed of a hard material such as tungsten carbide or 4140 steel, or formed of a softer substance such as a soft steel (e.g. 1020 steel). The ridge 50 projects outwardly from the cutting face by a distance slightly less than that of the cutter elements 14 and extends longitudinally along the side wall of the recess and radially along the peripheral edge 26.

The ridge 50 performs two important functions. Firstly, the ridge acts to dam-up drilling fluid ejected from the adjacent trailing nozzle 18B (i.e. the nearest nozzle 18B spaced clockwise from the ridge 50 in Fig. 2). That is, in the absence of the ridge, much of the drilling fluid emanating from that nozzle would flow into the adjacent gap in the peripheral edge (i.e., the gap formed by the discharge passage) and then upwardly through the annulus. However, upon encountering the ridge 50, the fluid level is blocked, causing the fluid to rebound and flow to the adjacent cutting elements located behind the ridge, i.e. the cutting elements spaced clockwise from the ridge 50 in Fig. 2.

As noted earlier, the ridges 50 project from the cutting face 24 by a distance less than, e.g. one-half, that of the cutter elements 14. The difference in such projecting distance is about equal to the expected penetration depth of the cutter elements. In this fashion, the ridge will essentially contact the formation, thereby minimizing the travel of fluid between the ridge and the formation.

A second important function of the ridge 50 is to act as a plow to push larger cuttings from the associated discharge passage so that such cuttings do not contact and damage the cutting elements located behind the ridge. In softer substances the ridges 50 may serve as cutter blades as well as plows.

In operation, the drill bit is rotated while simultaneously advanced into an earth formation. As the cutting operation progresses an earthen core is formed which is disposed within the recess 28. The sides of the core are gradually fractured by the cutter elements 14 disposed within the recess, and the tip of the earthen core is fractured by the cutter elements disposed in the floor of the recess, as well as by the convex protuberance 34.

Engagement between the core and the protuberance is such as to establish generally radially balanced forces on the drill bit whereby the drill bit is not diverted from its intended path of travel.

The convex protuberance 34 deflects the cuttings laterally outwardly through the discharge passages 36. Ejection of larger chunks through the discharge passages is aided by the ridges 50 which act as plows to push the chunks along.

The ridges 50 also serve to block the escape of drilling fluid from the nozzles 18. Instead, that fluid rebounds rearwardly and flows across the cutter elements disposed behind the respective ridges in order to flush and cool those cutter elements.

It will be appreciated that the present invention minimizes the likelihood that unbalanced radial forces will be exerted against the drill bit in response to contact between the earthen core and the floor of the recess. Consequently, it is easier to maintain the drill bit in a straight path of travel.

The presence of the ridges 50 aids in pushing larger chunks through the lateral discharge openings and thereby minimizes the likelihood that such chunks could contact and damage the cutter elements.

It is also assured that the cutter elements will be supplied with a substantial amount of cooling and flushing fluid, since it will be difficult for such fluid to bypass the cutter elements by flowing directly into the lateral discharge openings and upwardly through the annulus, due to the presence of the ridges.

Claims

1. The present invention relates to a rotary drill bit for cutting in earth formations, comprising a bit body (10) including a cutting face (24) having a peripheral edge (26) and a central recess (28) extending longitudinally inwardly from said peripheral edge (26), a plurality of fluid discharge nozzles (18) mounted in said cutting face (24) for emitting drilling fluid under pressure, and a plurality of cutter elements (14), some of which being mounted in said peripheral edge (26), and others of which being mounted in said recess (28) to fracture an earthen core formed as the drill cuts through the formation, and that the drill bit further comprises a plurality of lateral discharge passages (36) formed in said body (10), said passages (36) extending radially through said body (10) from said recess (28) and extending longitudinally to said peripheral edge (26) to form circumferential interruptions in said peripheral edge (26), and a convex protrusion (34) disposed centrally at a longitudinally inner end of said recess (28) and including a convex deflecting surface (40), said protrusion (34) arranged to contact and fracture the earthen core, characterized in that the cuttings are deflected to said lateral discharge passages (36) extending longitudinally rearwardly farther than said protrusion (34).

2. A drill bit according to claim 1, including a ridge (50) disposed along a trailing edge of each of said discharge passages (36), each ridge (50) projecting from said cutting face (24) by a distance less than that of said cutter elements (14) and being arranged to retard the flow of drilling fluid into the associated discharge passage (36) from an adjacent one of said nozzles (18), whereby such fluid is caused to flow across cutter elements (14) located behind said ridge (50).

3. A drill bit according to claim 1, wherein said protrusion (34) is of frusto-conical shape.

4. A drill bit according to claim 3, wherein the base surface (38) of each passage (36) constitutes a continuation of an inclined wedge face (40) of the protrusion (34).

5. A drill bit according to any of the preceding claims, wherein all of said cutter elements (14) are disposed in said recess (26) and on said peripheral edge (28), and said protrusion (34) being disposed longitudinally rearwardly of all cutter elements on said peripheral edge (28).

6. A drill bit according to any of the preceding claims, wherein some of said nozzles (18) are mounted in a side wall (30) of said recess (28) and one (18A) of said nozzles is mounted in said protrusion (34).

7. A drill bit according to any of the preceding claims, wherein at least one of said cutter elements (14) is mounted in said protrusion (34).

8. A drill bit according to any of the preceding claims, wherein there are three of said discharge passages (36), said passages disposed equidistantly around the circumference of said bit.

9. A drill bit according to any of claims 2—8, wherein said cutter elements (14) project farther from said cutting face (24) than said ridges (50) by a distance equal to the expected penetration depth of said cutter elements (14).

10. A drill bit according to any of claims 2—8, wherein said ridges (50) project from said cutting face by a distance equal to about one-half the distance which said cutter elements (14) project from said cutting face (24).

Patentansprüche

1. Die vorliegende Erfindung betrifft eine Drehbohrerspitze für das Schneiden in Bodenformationen mit einem Bohrerspitzenkörper (10) mit einer Schneidfläche (24) mit einer Umfangskante (26) und einer mittigen Vertiefung (28), die sich in Längsrichtung von der Unfangskante (26) aus nach innen erstreckt, mehreren Fließmittelabgabedüsen (18), die in der Schneidfläche (24) zur Abgabe von Bohrfließmittel unter Druck angeordnet sind, und mehreren Schneidelementen (14), von denen einige in der Umfangskante (26) und andere in der Vertiefung (28) angeordnet sind, um einen Erdkern zu brechen, der gebildet wird, wenn der Bohrer durch die Formation schneidet, und wobei die Bohrerspitze außerdem mehrere seitliche Abgabedurchgänge (36), die in dem Körper (10) ausgebildet sind, wobei diese Durchgänge (36) sich radial durch den Körper (10) von der Vertiefung (28) aus und in Längsrichtung

zu der Umfangskante (26) erstrecken, um ringsumlaufende Unterbrechungen in der Umfangskante (26) zu bilden, und einen konvexen Vorsprung (34), der mittig an einen in Längsrichtung inneren Ende der Vertiefung (28) angeordnet ist und eine konvexe Ablenkfläche (40) aufweist, wobei dieser Vorsprung (34) so angeordnet ist, daß er den Erdkern berurt und bricht, aufweist, dadurch gekennzeichnet, daß der Verschnitt zu den seitlichen Abgabedurchgängen (36) hin abgelenkt wird, die sich in Längsrichtung nach hinten weiter als der Vorsprung (34) erstrecken.

2. Bohrerspitze nach Anspruch 1 mit einer Rippe (50), die entlang einer Hinterkante jedes der Abgabedurchgänge (36) angeordnet ist, wobei jede Rippe (50) von der Schneidfläche (24) über einen geringeren Abstand als jenen der Schneidelemente (24) vorspringt und so angeordnet ist, daß sie den Fluß von Bohrfließmittel in den verbundenen Abgabedurchgang (36) von einer benachbarten der Düsen (18) verzögert, wodurch ein solches Fließmittel dazu gebracht wird, quer über di Schneidelement (14), die hinter der Rippe (50) liegen, zu fließen.

3. Bohrerspitze nach Anspruch 1, bei der der Vorsprung (34) von Kegelstumpfform ist.

4. Bohrerspitze nach Anspruch 3, bei der die Basisfläche (38) jedes Durchgangs (36) eine Fortsetzung einer geneigten Keilfläche (40) des Vorsprunges (34) darstellt.

5. Bohrerspitze nach einem der vorausgehenden Ansprüche, bei der alle Schneidelemente (14) in der Vertiefung (26) und auf der Umfangskante (28) angeordnet sind und der Vorsprung (34) in Längsrichtung hinter allen Schneidelementen auf der Umfangskante (28) angeordnet ist.

6. Bohrerspitze nach einem der vorausgehenden Ansprüche, bei der einige der Düsen (18) in einer Seitenwand (30) der Vertiefung (28) angeordnet sind und eine (18A) der Düsen in dem Vorsprung (34) angeordnet ist.

7. Bohrerspitze nach einem der vorausgehenden Ansprüche, bei der wenigstens eines der Schneidelemente (14) in dem Vorsprung (34) angeordnet ist.

8. Bohrerspitze nach einem der vorausgehenden Ansprüche, bei der es drei der Abgabedurchgänge (36) gibt, wobei diese Durchgänge in gleichem Abstand um den Umfang der Bohrerspitze angeordnet sind.

9. Bohrerspitze nach einem der Ansprüche 2 bis 8, bei der die Schneidelemente (14) weiter von der Schneidfläche (24) aus als die Rippen (50) über einen Abstand vorspringen, der der erweiterten Eindringungstiefe der Schneidelemente (14) gleich ist.

10. Bohrerspitze nach einem der Ansprüche 2 bis 8, bei der die Rippen (50) von der Schneidfläche aus um einen Abstand vorspringen, der etwa der Hälfte des Abstandes gleich ist, über welchen die Schneidelemente (14) von der Schneidfläche (24) aus vorspringen.

Revendications

1. La présente invention concerne un trépan rotatif pour forer des formations de sol, comportant un corps de trépan (10) comprenant une face de coupe (24) présentant un bord périphérique (26) et une cavité centrale (28) s'étendant longitudinalement vers l'intérieur à partir dudit bord périphérique (26), une pluralité d'ajutages (18) de sortie de fluide montés dans ladite face de coupe (24) pour déliverer sous pression du fluide de forage, et une pluralité d'éléments de coupe (14) dont certains sont montés dans ledit bord périphérique (26), les autres, étant montés dans ladite cavité (28) pour fracturer un noyau de sol formé lors du forage de la formation par le trépan, le trépan comportant en outre une pluralité de passages latéraux (36) de sortie ménagés dans ledit corps (10), lesdits passages (36) s'étendant radialement à travers ledit corps (10) à partir de ladite cavité (28) et s'étendant longitudinalement jusqu'audit bord périphérique (26) pour constituer des interruptions circonférencielles sur ledit bord périphérique (26), et une saillie convexe (34) située centralement à une extrémité longitudinalement intérieure de ladite cavité (28) et présentant une surface convexe (40) de déviation, ladite saillie (34) étant agencée pour venir en contact et fracturer le noyau de sol, caractérisé en ce que les débris de forage sont déviés vers lesdits passages latéraux (36) de sortie qui s'étendent longitudinalement vers l'arrière au-delà de ladite saillie (34).

2. Un trépan selon la revendication 1, comportant une nervure (50) disposée le long d'un bord avant de chacun desdits passages de sortie (36), chaque nervure (50) faisant saillie de ladite face de coupe (24) sur une distance inférieure à celle desdits éléments de coupe (14) et étant agencée pour retarder l'écoulement du fluide de forage dans le passage associé (36) de sortie à partir d'un adjutage adjacent (18), de sorte que ce fluide est amené à circuler à travers les éléments de coupe (14) situés derrière ladite nervure (50).

3. Un trépan selon la revendication 1, dans lequel ladite saillie (34) est de forme tronconique.

4. Un trépan selon la revendication 3, dans lequel la surface de base (38) de chaque passage (36) constitue un prolongement d'une face inclinée (40) en forme de coin de la saillie (34).

5. Un trépan selon l'une quelconque des revendications précédentes, dans lequel l'ensemble desdits éléments de coupe (14) sont disposés dans ladite cavité (28) et sur ledit bord périphérique (26), et ladite saillie (34) étant disposée longitudinalement en arrière par rapport à tous les éléments de coupe sur ledit bord périphérique (26).

6. Un trépan selon l'une quelconque des revendications précédentes, dans lequel certains desdits ajutages (18) sont montés dans une paroi latérale (30) de ladite cavité (28) et l'un (18A) desdits ajutages est monté dans ladite saillie (34).

7. Un trépan selon l'une quelconque des reven-

dications précédentes, dans lequel au moins l'un desdits éléments de coupe (14) est monté dans ladite saillie (34).

8. Un trépan selon l'une quelconque des revendications précédentes, dans lequel lesdits passages de sortie (36) sont au nombre de trois, lesdits passages étant disposés de manière équidistante sur la périphérie dudit trépan.

9. Un trépan selon l'une quelconque des revendications 2 à 8, dans lequel lesdits éléments de coupe (14) font saillie, par rapport à ladite face de coupe (24), au-delà desdites nervures (50) sur une distance égale à la profondeur de pénétration prévue desdits éléments de coupe (14).

10. Un trépan selon l'une quelconque des revendications 2 à 8, dans lequel lesdites nervures (50) font saillie par rapport à ladite face de coupe d'une distance égale à environ la moitié de la distance dont lesdits éléments de coupe (14) font saillie par rapport à ladite surface de coupe (24).

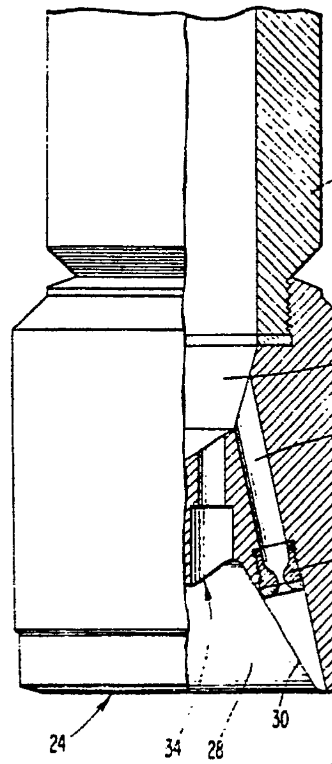


Fig.1

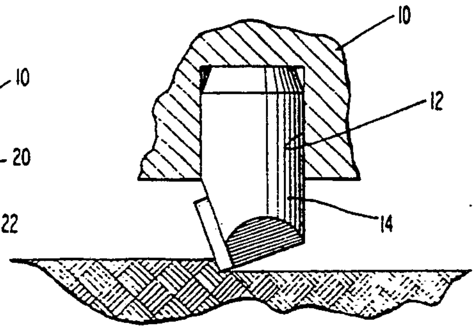


Fig.3

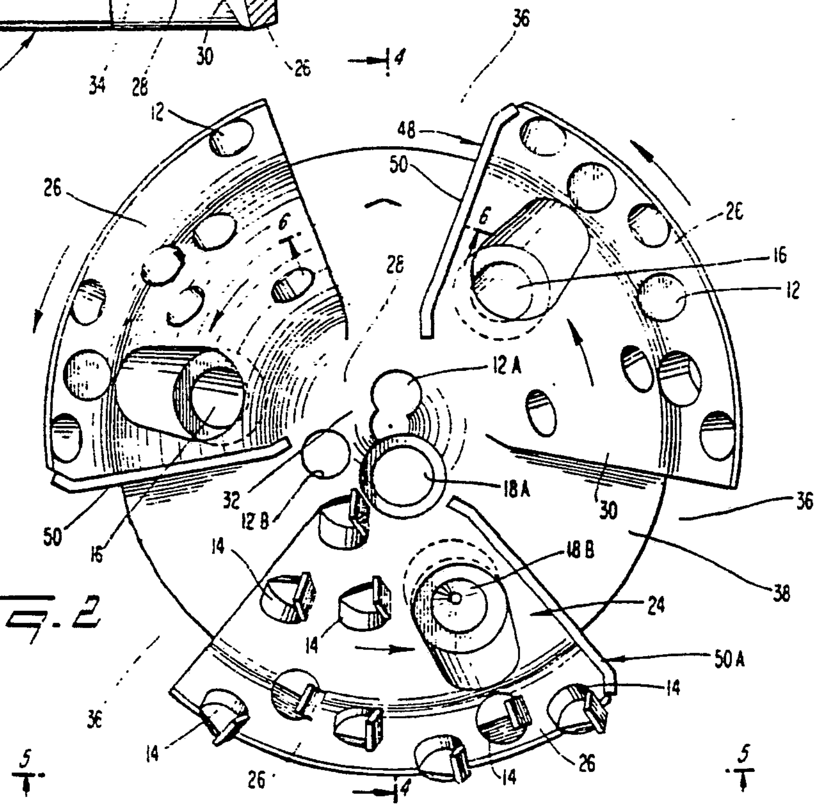
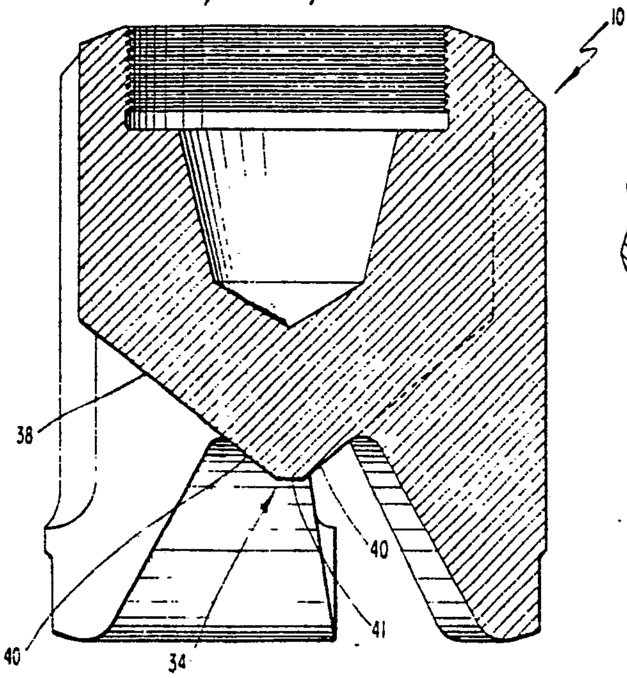


Fig.2

Fig. 4



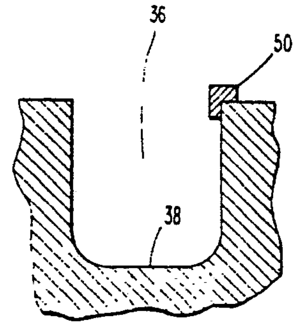


Fig. 6

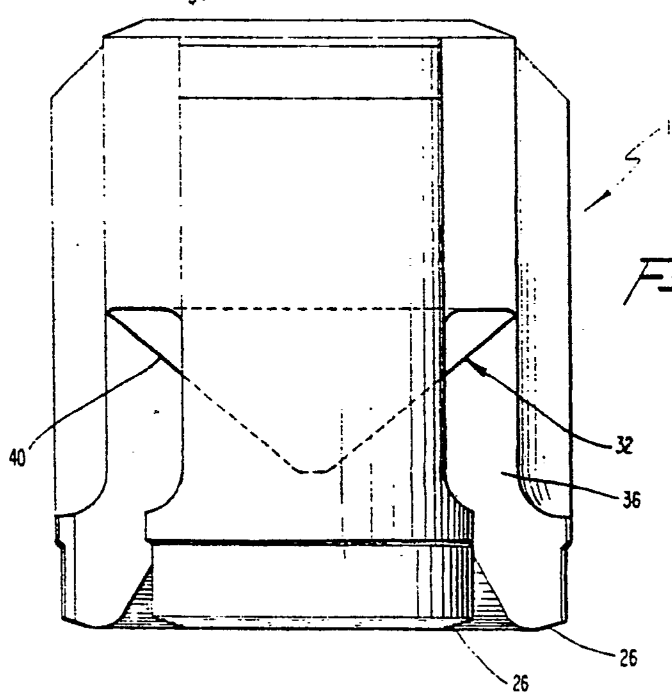


Fig. 5