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(54) Improvements in or relating to drill bits.

(57) A rotary drill bit for drilling deep holes in subsurface formations comprises a bit body (10) having a shank for connection to a drill string and a plurality of elements (16,22) mounted on the bit body (10) for cutting, abrading or bearing on the formation being drilled. The bit body (10) includes a fixed structure - (11) and a movable structure (17), each carrying elements (16,22) for acting on the formation, the movable structure (17) being capable of reversible movement relatively to the fixed structure (11) between two limiting positions, the relative movement providing at least two configurations in which there are different distributions, between said elements - (16,22), of the loads applied to the bit during its engagement with the formation. Control means, such as hydraulic means (29,30), are provided to control the movement of the movable structure (17), and hence the load distribution between the elements - (16,22), automatically in response to the torque and/or axial loads applied to the bit.

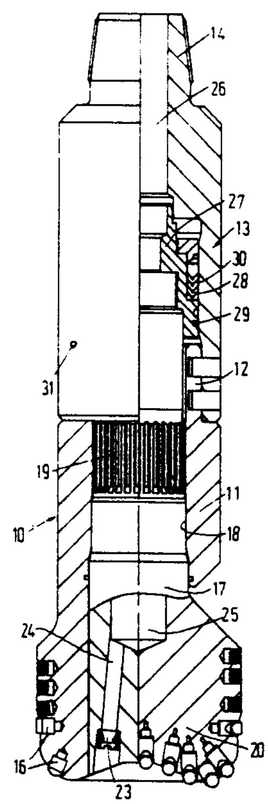

FIG 1

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"Improvements in or relating to Rotary Drill Bits"

The invention relates to rotary drill bits for use in drilling or coring deep holes in subsurface formations.

Rotary drill bits of the kind to which the invention relates comprise a bit body having a shank for connection to a drill string and a plurality of elements mounted on the bit body for acting on the formation being drilled. The elements may comprise cutting elements, abrading elements or wear pads. The invention is particularly, but not exclusively, applicable to drill bits of the kind where the cutting elements are preform elements, each element being in the form of a tablet, usually circular, having a hard cutting face formed of polycrystalline diamond or other superhard material. Typically, abrasion elements may be studs of hard material, such as tungsten carbide, in which diamond particles, for example natural diamond particles, are embedded.

Usually the bit body will incorporate a passage for supplying drilling fluid to the surface of the bit for cleaning and/or cooling of the cutting elements.

In such bits, the cutting elements, particularly if they are of the polycrystalline diamond preform type, are liable to fail or wear excessively when subjected to substantial overheating. Such overheating may arise as a result of excessive weight-on-bit while drilling, i.e. excessive downward force on the cutters, or as a result of excessive drag on the cutters due, for example, to the nature of the formation being cut. It is difficult to prevent such overheating by operator control of the weight-on-bit or torque since it is not possible to determine with any certainty whether overheating is in fact occurring and, in any case, the conditions causing overheating may be encountered only intermittently and for short periods, for example as a result of temporary changes in the nature of the formation through which the drill is passing.

Cutting elements are also liable to fail due to sudden overload, for example due to impact as a result of the bit being dropped into the hole.

The present invention sets out to provide a form of drill bit in which the configuration of the bit is variable to enable it to cope with such overloading, whether it be only momentary or of continuing duration. The change in configuration may be effected automatically in response to the overloading, or may be under operator control.

According to the invention there is provided a drill bit comprising a bit body having a shank for connection to a drill string and, mounted on the bit body, a plurality of elements for cutting, abrading of bearing on the formation being drilled, the bit body including at least two relatively movable structures, each carrying elements for acting on the formation, which structures are capable of reversible movement relatively to one another between two limiting positions, said relative movement providing at least two configurations in which there are different distributions, between said elements, of the loads applied to the bit during its engagement with the formation, means being provided to controls said limited relative movement between said two structures and hence to control the distribution between said elements of the loads applied to the bit.

Said control means may comprise means responsive to loads applied to the bit body during drilling in such manner as to change the configuration of the bit body automatically in accordance with variation in said loads. Alternatively or additionally, said control means may be operator controlled from the surface while the bit is in the hole being drilled. Such operator control may, for example, be effected by a signal, such as an hydraulic signal from the surface to the bit, or may be effected by operation of the bit in such manner that the loads therein effect the required change in configuration.

Preferably the arrangement is such that the change in configuration of the bit body is reversed upon reversal of the variation in the loads applied to the bit body. Such reversal may be subject to a hysteresis effect.

The load responsive means may be responsive to variation in the weight-on-bit, or to the torque applied to the bit, or to both.

In one particular arrangement there may be mounted a number of elements on each of said two relatively movable structures, the elements on one structure being so located that they do not act significantly on the formation in one configuration of the bit body, but act significantly on the formation in another configuration of the bit body.

One structure on the bit body may be fixed in relation to the shank, the other structure being movable relatively to the fixed structure in a direction having at least an axial component, and/or a rotational component, whereby the weight-on-bit load and/or torque tends to move the movable structure relatively to the fixed structure.

Preferably means are provided to oppose relative movement between said relatively movable structures of the bit body from said one configuration to said other configuration, whereby said movement takes places only when the load acting on the bit reaches a value sufficient to overcome the opposing force provided by said means. The means for opposing relative movement between said relatively movable structures preferably applies a force tending to restore said structures to said one configuration upon reduction of the load applied to the bit. Said means may comprise, for example, hydraulic means or spring means.

In one particular embodiment of the invention, the fixed structure is formed with a cylinder in which is slideable a piston member movable with said other structure, said cylinder being in communication with a passage in the bit body for supplying drilling fluid to the surface of the bit, whereby the hydraulic pressure of the drilling fluid urges the movable structure towards one limit of its movement, and opposes movement thereof relatively to the fixed structure.

In an alternative embodiment according to the invention spring means couple the two structures of the bit body together and are such that rotational deformation of the spring means, resulting from applied torque, is accompanied by axial. deformation thereof, whereby a change in the toque applied to said other structure causes relative rotational movement between the structures and rotational deformation of the spring means, and the accompanying axial deformation of the spring means effects relative axial movement between the structures.

In any of the above arrangements said other structure of the bit body, which is movable relatively to the shank, may have an outer face on which are mounted a plurality of main cutting elements which, under normal drilling loads and in said one configuration of the bit body, perform at least a major part of the cutting and abrading of the formation, and said one structure of the bit body, which is fixed in relation to the shank, may have an outer face on which are mounted a plurality of secondary elements which, under normal drilling loads and in said one configuration of the bit body, are so located in relation to said main cutting elements that they do not act significantly on the formation, relative movement between said structures, under abnormal increased drilling loads, causing the parts to move to said other configuration in which said secondary elements are so located in relation to said main cutting elements that they act on the formation to a significant extent.

The secondary elements may include cutting elements similar to the main cutting elements, abrading elements, wear pads or a roller cone assembly.

The following is a detailed description, by way of example, of embodiments of the invention, reference being made to the accompanying drawings, in which:

Figure 1 is a diagrammatic vertical section through a drill bit in accordance with the invention;

Figure 2 is a diagrammatic end view of the bit shown in Figure 1;

Figures 3 and 4, Figures 5 and 6, and Figures 7 and 8 are similar views to Figures 1 and 2 showing diagrammatically alternative embodiments;

Figures 9 and 10 are a side view and end view respectively of a spring device for coupling the two parts of a drill bit according to the invention;

Figure 11 is a diagrammatic vertical section through an alternative form of drill bit according to the invention;

Figure 12 is an end view of the drill bit shown in Figure 11;

Figure 13 is a section through a further form of drill bit according to the invention;

Figure 14 is an end view of the bit shown Figure 13; and

Figure 15 is a half-section through a drill bit assembly in which the means for controlling the variable configuration of the bit is incorporated in a separate sub-assembly.

Referring to Figures 1 and 2, the main bit body 10 comprises an outer fixed part 11 having at its upper end a reduced diameter portion 12 which is secured within the lower end of a sub-assembly 13, the upper end of which is formed with a threaded shank 14 for connection to the drill string.

At its lower end, the fixed part 11 is formed with two end face portions 15 on which are mounted abrasion elements 16. The abrasion elements 16 may be of any suitable form, for example they may comprise tungsten carbide studs in which are embedded particles of natural diamond. The end face portions, and the abrasion elements thereon, constitute a secondary cutting structure.

A movable central part 17 of the bit is axially slideable within a bore 18 in the part 11, interengaging splines 19 on the part 17 and in the bore 18 being provided for the transmission of torque between the two parts. The lower end of the movable part 17 is formed with a head portion 20 on which are provided blades 21 which carry preform cutting elements 22 in known manner. The head portion 20 and the cutting elements thereon constitute the primary cutting structure of the bit. Nozzles 23 mounted in the end surface of the head portion 20 communicate through passages 24 with a central passage 25 in the movable part 17 of the bit, which passage communicates in turn with a central passage 26 in the subassembly 13. In use of the bit, drilling fluid under pressure is supplied through the passage 26, passage 25, passages 24 and nozzles 23 for cleaning and cooling the cutting elements.

A piston assembly 27, including a heavy duty seal 28 and scraper ring 29, is mounted on the upper end of the movable bit body part 17 and is slideable within a cylinder 30 integrally formed with the sub-assembly 13. The lower end of the cylinder 30 is in communication, through low pressure link passages 31, with the annular space between the sub-assembly 13 and the walls of the bore, - (normally referred to as the annulus).

As previously discussed, the cutting elements 22 mounted on the end face 20 may be susceptible to overheating, and consequent damage or failure, as a result of excessive weight-on-bit and/or excessive torque and the configuration of the bit is such as automatically to compensate for such excessive loads. The configuration also protects the cutters against momentary overloads due to impact, for example as a result of the bit being dropped in the hole.

In normal use of the bit shown in Figures 1 and 2, the hydraulic pressure of the drilling fluid in the passage 26, which is lower than the hydraulic pressure in the annulus and at the face of the bit, urges the piston assembly 27 downwardly in the cylinder 30 so that the movable bit part 17 is in its lowermost position in relation to the fixed bit part 11. In this position the main cutting action at the bottom of the hold being drilled is effected by the primary cutting structure comprising the cutters 22 on the central movable part 17 of the bit. The part 17 may be so positioned normally in relation to the fixed part 11 that when the cutters 22 are in operation under normal weight-on-bit loads the abrasion elements 16 on the face portions 15 are either out of engagement with the formation or perform only a subsidiary cutting effect on the formation.

However, should there be a momentary or continuing overload on the cutters 22, resulting in increased weight-on-bit, the overload will cause the central part 17 to retract upwardly relatively to the outer part 11 against the axial restraint provided by the hydraulic pressure of the drilling fluid. This retraction of the central part 17 will re-distribute the loads on the end face of the bit so that the abrasion elements on the secondary cutting structure carry a higher proportion of the load, thus relieving the overload on the more vulnerable cutters 22.

The particular form of the cutting elements and abrasion elements, and their distribution and mounting over the surface of the bit body do not form a part of the present invention and will not therefore be described in detail. As previously mentioned, however, the invention is particularly applicable to drill bits where the cutting elements are in the form of the preforms, for example comprising a front hard facing layer of polycrystalline diamond or other superhard material bonded to a backing layer of less hard material, such as tungsten carbide. Alternatively, the preforms may comprise a unitary layer of thermally stable polycrystalline diamond material. The preforms may be directly mounted on the bit body or may be bonded to studs, for example of tungsten carbide, which are mounted in sockets in the bit body. The bit body itself may be machined from steel or may be formed of tungsten carbide matrix infiltrated with a binder alloy, or may be a combination of such materials. Again, the precise method of construction of the bit body does not form part of the present invention.

In the alternative arrangement shown diagrammatically in Figures 3 and 4, the drill bit comprises a bit body 110 formed at one end with a threaded shank 111 for connection to the drill string. The operative end face 112 of the bit body is formed with a plurality of cutting elements (not shown).

The bit has a gauge section including kickers 113 which contact the walls of the bore hole to stabilise the bit in the bore hole. A central passage 114 in the bit body and shank delivers drilling fluid through nozzles in the end face 112 in known manner to clean and/or cool the cutting elements. A socket for one such nozzle is indicated diagrammatically at 117.

The bit body is formed in two parts indicated generally at 115 and 116 in Figures 3. The part 115 is fixed in relation to the shank 111, for example is welded thereto, and comprises a base portion 117 from which three pillars 118 extend downwardly. The pillars 118, as best seen in Figure 4, are equally spaced around the central vertical axis of the drill bit and are of circular cross section.

The second part 116 of the bit body is the main part on which most of the cutting elements are mounted and on which the kickers 113 are provided. The main body part 116 is provided with three cylindrical bores 119 which extend parallel to the central axis and receive the pillars 115 in sliding engagement therein.

The two parts 115 and 116 of the bit body are coupled together by a connector 120 the lower end of which is in screw-threaded engagement with a central threaded blind hold 121 in the bit body part 116. The upper end of the connector 120 passes slideably through a central aperture in the base portion 117 of the body part 15 and is formed at its upper end with a circular flange 122 which is received in a counterbore 123 in the base portion 117.

Surrounding the connector 120 is a resilient coupler comprising concentric spaced tubular elements 124 and 125, between which is bonded an annular layer of elastomeric material 126.

The inner and outer tubular elements 124 and 125 are staggered axially. The outer element is seated in a recess in the base part 117 and the inner element is seated in a similar recess in the body part 116, the arrangement being such that the body part 116 may be displaced vertically with respect to the body part 115 against the resilience of the elastomer 126.

The lower ends of the pillars 118 are formed with elements (not shown) for acting on the formation being drilled. The elements on the lower ends of the pillars may be abrasion elements or wear pads. For example, the abrasion elements may comprise studs of hard material, such as tungsten carbide, in which superhard particles such as natural diamond are embedded.

The elements on the lower ends of the pillars 118 might, alternatively, be cutting elements similar to the cutting elements mounted on the main bit body 116. In this case, however, it is probable that the pillars 118 would be located at a greater radial distance from the axis of rotation of the bit so as to provide a back-up for the cutting elements nearer the gauge region, which are particularly susceptible to overheating and wear.

During normal drilling under design weight-on-bit loads, the cutting of the formation is carried out entirely by the cutting elements and/or abrading elements mounted on the end face 112 of the main bit body part 116. The length of the pillars 118 is such that the elements which they carry at their lower ends project less far than the operative elements on the main body part 116, so that they do not act on the formation. However, as the weight-on-bit increases the main body part 116 moves upwardly relatively to the fixed body part 115, against the action of the elastomer 126. When the weight-on-bit reaches a predetermined level the retraction of the main body part 116 is such that the elements on the lower ends of the pillars 118 come into active engagement with the formation and serve to back up the action of the cutting elements on the end surface 112.

If the elements on the pillar 118 are cutting elements they have the effect of increasing the number of cutting elements over which the weight-on-bit is distributed, thus reducing the downward load on each individual cutting element. Alternatively, the elements on the lower ends of the pillars 118 may comprise simple abrasion elements or wear pads. Such elements are less efficient at cutting than the cutting elements but are much less susceptible to damage by overheating. In this case the engagement of the abrasion elements or wear pads with the formation serves as a temporary back-up for the cutting elements. Such arrangement means less risk of the main cutting elements being damaged due to overheating, but at the cost of a significant reduction in rate of penetration. Such arrangement is particularly suitable for use in formations where there may be layers or inclusions of harder formation to which the cutting elements are subjected only temporarily. The back-up wear pads or abrading elements are thus brought into action for only brief periods to prevent damage to the main cutting elements.

In the alternative arrangement shown in Figures 5 and 6 the resistance to vertical displacement of the main body part 216 relatively to the fixed body part 215 is provided by hydraulic means rather than by an elastomer. In this case the passage 214 for drilling fluid communicates with a chamber 227 between the two parts of the bit body, and the passage 228 leading to each nozzle leads from this chamber. Hydraulic pressure of the drilling fluid within the chamber 227 urges the body part 216 downwardly with respect to the fixed body part and so provides a predetermined resistance to upward displacement of the movable body part as well as returning the movable part to its original position when the weight-on-bit returns to its normal value.

A pin 229 projects radially inwardly from the body part 216 into a recess 230 in the fixed body part 215 so as to limit the relative displacement between the parts.

Figures 7 and 8 shown an arrangement in which the configuration of the bit changes in response to variation in applied torque as well as to variation in weight-on-bit.

As best seen in Figure 7 the arrangement is generally similar to the arrangement of Figure 3 except that the elastomer of the Figure 3 arrangement is replaced by a helical compression spring 331 encircling the connector 320. The bit reacts to variation in weight-on-bit in similar fashion, therefore, to the arrangements of Figures 3 and 5.

However, in this arrangement the bores 319 in the main body part 316 which receive the pillars 318 are elongate in section as shown in Figure 8. This permits rotational displacement of the main body part 316 with respect to the fixed body part 315. The body parts 316 and 315 are mechanically coupled by any suitable means, such as interengaging helical splines, whereby displacement between the parts has both rotational and axial components.

Alternatively, the body parts may be connected by a coupler of the kind shown in Figures 9 and 10. The coupler is generally in the form of a cylindrical steel sleeve 332 the central portion of the sleeve being formed around its periphery with a plurality of equally spaced inclined slots 333. The configuration of the coupler 332 is such that when opposite ends thereof are twisted relatively to one another about its central axis the axial length of the element is reduced.

Consequently, when the main body part 316 of the bit is subjected to sufficient torque to overcome the torsional resistance provided by the coupler 332, the body part 316 is rotationally displaced with respect to the fixed body part 315, such displacement being permitted by the elongate cross-section of the bores 319. The resultant rotational deformation of the coupler 332, which connects the body part 315 and 316 together, causes a reduction in the axial length of the element and this retracts the main body part 316 axially with respect to the fixed part 315. The elements on the lower ends of the pillars are thus brought into effective action on the formation as previously described.

In the arrangements shown in Figures 3 to 10 the pillars are shown as integral with the base portion. It will be appreciated that they might be in the form of separate elements secured to the base portion and, indeed, the shape and location of the fixed body part may be of any other suitable configuration. Two such possible alternative configurations are shown in Figures 11 to 14.

In the alternative arrangement shown in Figures 11 and 12 the main bit body part 416 is provided with preform cutting elements 434 mounted on studs 435 received in the body part. Abrasion elements are mounted on the kickers, one of which elements is indicated at 436, and may comprise tungsten carbide studs in which natural diamonds are embedded.

In this arrangement the fixed part 415 of the bid body is integrally formed with downwardly extending arms 437 on each of which is mounted a roller cone 438 which may be similar to the kind commonly used in rock bits. The roller cone 438 may be of any conventional construction such as is well known in the art and will not be described in detail.

In the arrangement shown, hydraulic means similar to that shown in Figure 5 are provided to resist upward displacement of the body part 416 with respect to the fixed body part 415, but it will be appreciated that any other suitable form of resistance means, such as spring means, may be provided instead.

During normal operation of the drill bit, cutting of the formation is effected by the preforms 434, and the roller cones 438 are held out of effective engagement with the formation. However, upon retraction of the movable body part 416, due to increased weight-on-bit and/or torque due to increased drag forces, the roller cones 438 will be brought into operation and, as is well known, the roller cone type of construction is particularly effective in dealing with hard formations.

While it is known to provide combination bits in which roller cone assemblies are combined with preform cutters, the present invention provides for the different types of cutting action to be brought into use depending on the nature of the formation being cut.

In the alternative embodiment shown in Figures 13 and 14 the downwardly extending arms 537 have at their lower ends surfaces 538 in which are embedded arrays of natural diamonds. Again, as is well known, natural diamonds are more suited to certain types of harder formation than preform cutting elements, and the variable configuration bit according to the present invention ensures that such cutting elements are automatically brought into action if harder formations are encountered which cannot be effectively dealt with by the preform cutters.

It will be appreciated that, in the above described examples, the structure which controls the change in configuration of the bit body may still be operable even when the cutting elements themselves have become so worn as to render the bit unusable for further drilling. There is therefore shown in Figure 15 an embodiment in which the means for controlling the configuration of the bit body forms a separate subassembly to which the bit body is connected. This subassembly is therefore re-usable and only the bit body itself needs to be replaced when worn.

Referring to Figure 15, the main bit body 640 comprises an outer fixed part 641 having at its upper end a threaded shank 642 and at its lower end two end face portions in which natural diamonds or abrasion elements are mounted in similar fashion to the arrangement of Figures 1 and 2. Nozzles are provided for the supply of drilling fluid to these face portions of the bit and communicate with a central passage 647 in the bit body.

A movable central part 648 of the bit is axially slideable within a stepped central bore in the outer part 640 and is formed with a head portion 649 on which are provided blades which carry preform cutting elements 651 is known manner. Such preform cutting elements may be of any of the types previously described. Nozzles mounted in the end surface of the head portion 649 communicate with the central passage 647 in the bit body.

The upper end of the inner part 648, remote from the head portion 649, is connected to a force-transmitting sleeve 654 which is slideable in the central bore in the fixed outer part 640.

The control sub-assembly 643 comprises a fixed outer tube 655 the upper end of which is formed with a threaded shank 656 for connection to the drill string and the lower end of which is formed with an internally threaded socket 657 within which the threaded shank 642 of the main bit body may be engaged. Mounted within the tube 655 is a tubular spring structure 658 which is both longitudinally and rotationally resilient. The upper end 659 of the spring structure is secured to the outer tube 655 and the opposite end carries a coupler 660 which is connected to the end of the force-transmitting sleeve 654 when the main bit body is coupled to the control subassembly.

In normal use of the coupled bit and control sub-assembly, the main cutting action at the bottom of the hole being drilled is effected by the cutters 651 on the central movable part 648 of the bit. The part 648 may be so positioned normally in relation to the outer part 640 that when the cutters 651 are in operation under normal weight-on-bit loads the natural diamonds mounted on the face portions 43 are either out of effective engagement with the formation or perform only a subsidiary cutting effect on the formation. However, should there be a momentary or continuing overload on the cutters 651, resulting in increased torque and/or weight-on-bit, the overload will cause the central part 648 to retract relatively to the outer part 640 against the torsional and longitudinal resilient restraint provided by the structures 658 in the control sub-assembly. This retraction of the central part 648 will redistribute the loads on the end face of the bit so that the natural diamonds or abrasive elements on the outer part 640 carry a higher proportion of the load, thus relieving the overload on the more vulnerable preform cutters 651.

All of the arrangements described above may relieve both continuing overloads, due for example to the bit meeting a harder formation or being subjected to excessive weight-on-bit, or momentary overloads due to impact, for example caused by dropping of the bit in the hole. In the arrangements described above such control of the bit is effected automatically, i.e. variation in the load on the bit causes the change in configuration which enables the bit to cope with such increase in load. However, there may also be incorporated in the bit means whereby the configuration of the bit may be adjusted by command from the surface. For example, the relatively movable parts of the bit may be arranged to be moved to different relative positions in response to codes of hydraulic pulses in the drilling fluid or by coded sequences of movement of the bit. For example, two relatively movable parts of the bit may be arranged to be toggled between two different configurations upon a predetermined type of movement, or sequence of movements, of the bit while it is down the hole.

Claims

1. A drill bit comprising a bit body (10) having a shank for connection to a drill string and, mounted on the bit body (10), a plurality of elements (16, 22) for cutting, abrading or bearing on the formation being drilled, characterised in that the bit body (10) includes at least two relatively movable structures (11,17), each carrying elements (16,22) for acting on the formation, which structures are capable of reversible movement relatively to one another between two limiting positions, said relative movement providing at least two configurations in which there are different distributions, between said elements (16,22), of the loads applied to the bit during its engagement with the formation, means - (29,30) being provided to control said limited relative movement between said two structures and hence to control the distribution between said elements (16,22) of the loads applied to the bit.

2. A drill bit according to Claim 1, characterised in that said control means (29,30) comprise means responsive to loads applied to the bit body - (10) during drilling in such manner as to change the configuration of the bit body (10) automatically in accordance with variation in said loads.

3. A drill bit according to Claim 2, characterised in that the arrangement is such that the change in configuration of the bit body (10) is reversed upon reversal of the variation in the loads applied to the bit body.

4. A drill bit according to Claim 2 or Claim 3, characterised in that the load responsive means - (29,30) are responsive to variation in the weight-on-bit.

5. A drill bit according to any of Claims 2 to 4, characterised in that the load responsive means - (332, Figs. 9 & 10) are responsive to variation in the torque applied to the bit.

6. A drill bit according to any of Claims 1 to 5, characterised in that there are provided two relatively movable structures (11,17), each having a number of said elements (16,22) mounted thereon, the elements (16) on one structure (11) being so located that they do not act significantly on the formation in one configuration of the bit body (10), but act significantly on the formation in another configuration of the bit body.

7. A drill bit according to Claim 6, characterised in that one (11) of said structures on the bit body (10) is fixed in relation to the shank (14), the other structure (17) being movable relatively to the fixed structure (11) in a direction having at least one axial component, whereby the weight-on-bit load tends to move the movable structure (17) relatively to the fixed structure (11).

8. A drill bit according to Claim 6, characterised in that one (315, Fig. 7) of said structures on the bit body is fixed in relation to the shank - (311), the other structure (316) being movable relatively to the fixed structure in a direction having at least a rotational component, whereby the torque load tends to move the movable structure (316) relatively to the fixed structure (315).

9. A drill bit according to any of Claims 6 to 8, characterised in that means (29,30) are provided to oppose relative movement between said relatively movable structure (17)s of the bit body (10) from said one configuration to said other configuration, whereby said movement takes place only when the load acting on the bit reaches a value sufficient to overcome the opposing force provided by said means (29,30).

10. A drill bit according to Claim 9, characterised in that said means (29,30) for opposing relative movement between said relatively movable structures (11,17) applies a force tending to restore said structures to said one configuration upon reduction of the load applied to the bit.

11. A drill bit according to Claim 10, characterised in that hydraulic means (29,30) are provided for opposing relative movement between said relatively movable structures (11,17).

12. A drill bit according to Claim 11, characterised in that said fixed structure (11) is formed with a cylinder (30) in which is slideable a piston member (29) movable with said other structure - (17), said cylinder being in communication with a passage (26) in the bit body (10) for supplying drilling fluid to the surface of the bit, whereby the hydraulic pressure of the drilling fluid urges the movable structure (17) towards one limit of its movement, and opposes movement thereof relatively to the fixed structure (11).

13. A drill bit according to Claim 10, characterised in that spring means (331, Fig. 7; 332, Fig. 9) are provided for opposing movement between said relatively movable structures (315,316).

14. A drill bit according to Claim 13, characterised in that said spring means (332, Fig.9) couple the two structures (315,316) of the bit body together and are such that rotational deformation of the spring means, resulting from applied torque, is accompanied by axial deformation thereof, whereby a change in the torque applied to said other structure causes relative rotational movement between the structures and rotational deformation of the spring means (332), and the accompanying axial deformation of the spring means effects relative axial movement between the structures.

15. A drill bit according to any of Claims 7 to 14, characterised in that said movable structure - (17) has an outer face on which are mounted a plurality of main cutting elements (22) which, under normal drilling loads and in said one configuration of the bit body (10), perform at least a major part of the cutting and abrading of the formation, and said fixed structure (11) has an outer face on which are mounted a plurality of secondary elements (16) which, under normal drilling loads and in said one configuration of the bit body (10), are so located in relation to said main cutting elements (22) that they do not act significantly on the formation, relative movement between said structures, under abnormal increased drilling loads, causing the parts to move to said other configuration in which said secondary elements (16) are so located in relation to said main cutting elements (22) that they act on the formation to a significant extent.

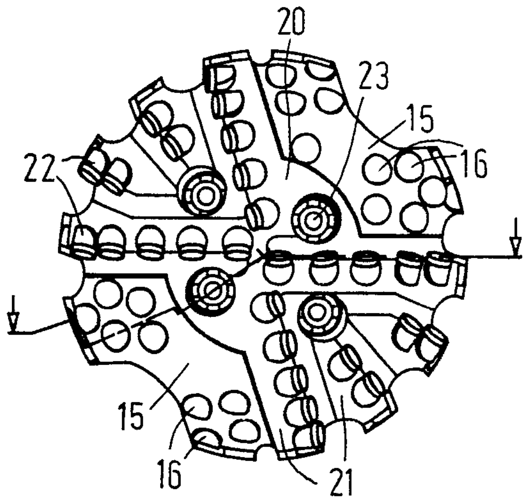
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FIG.2

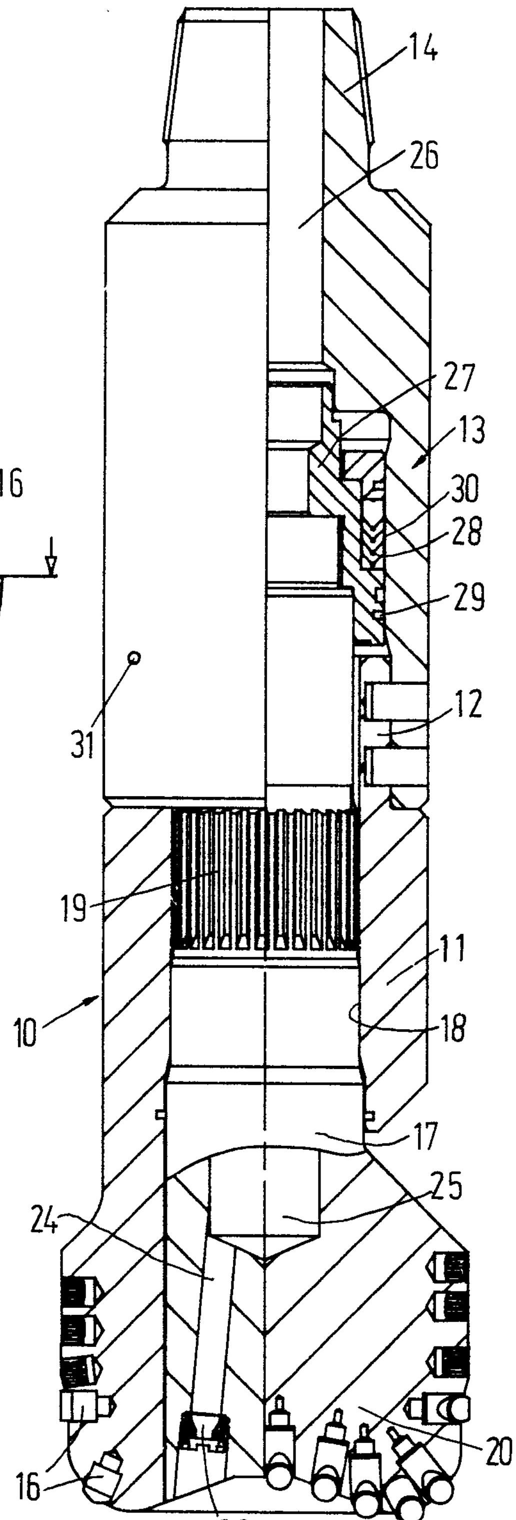
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FIG.1

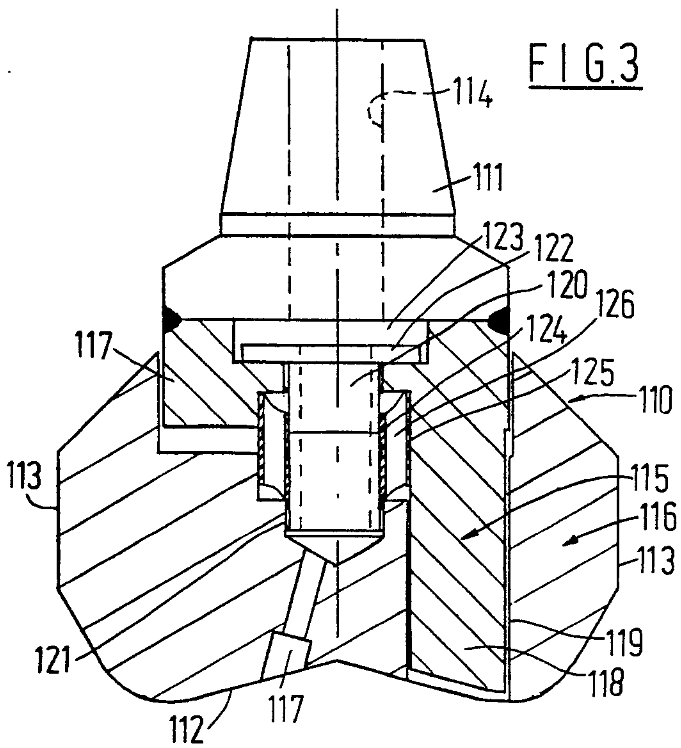


FIG.3

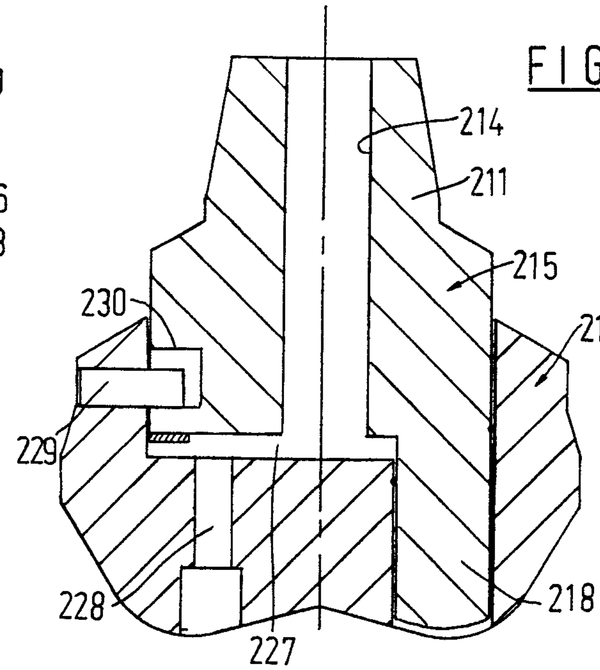


FIG.5

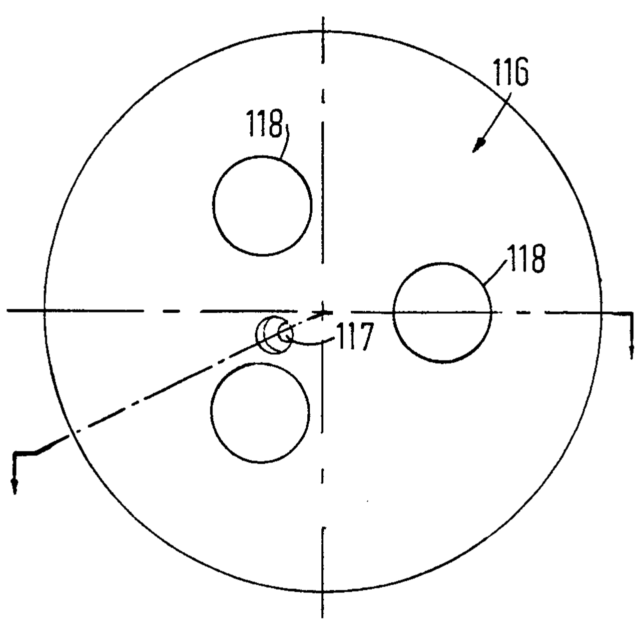


FIG.4

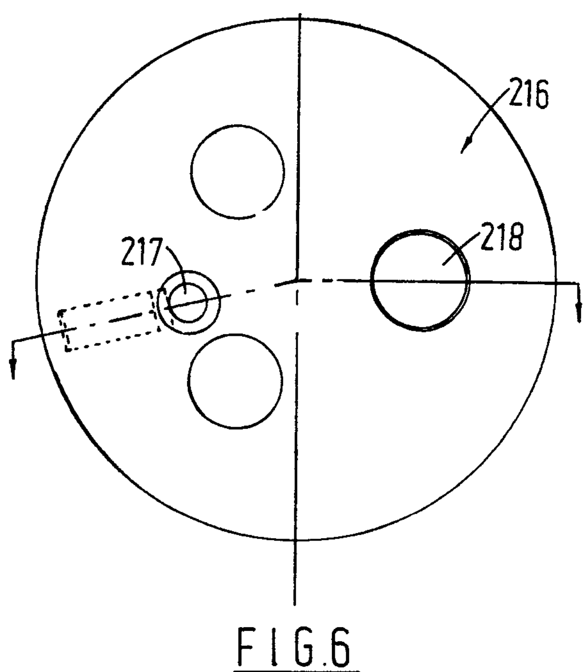


FIG.6

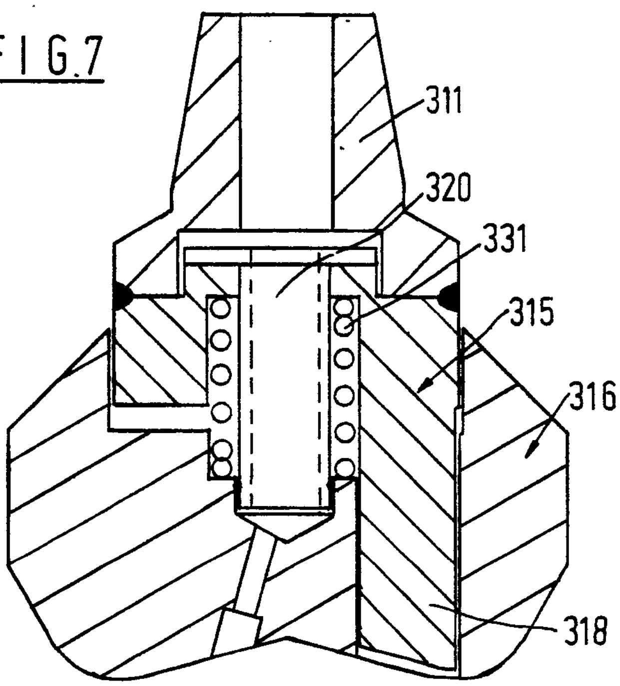


FIG.7

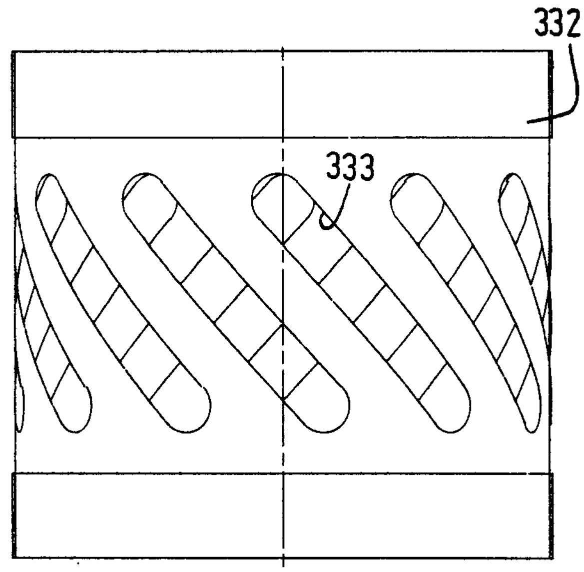


FIG.9

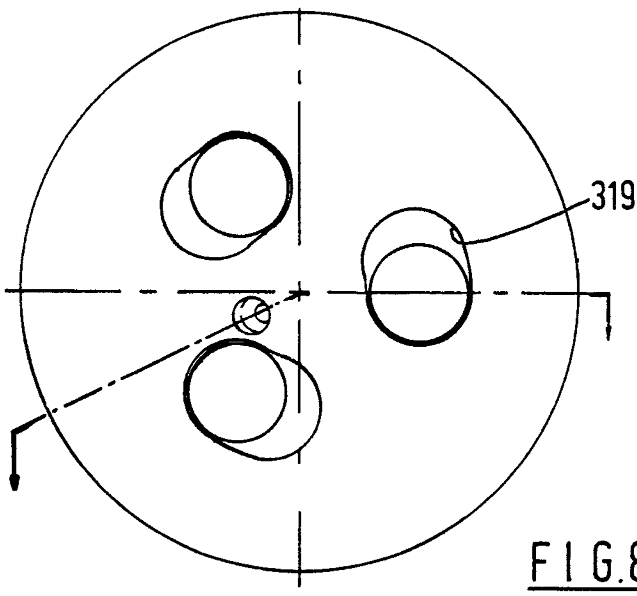


FIG.8

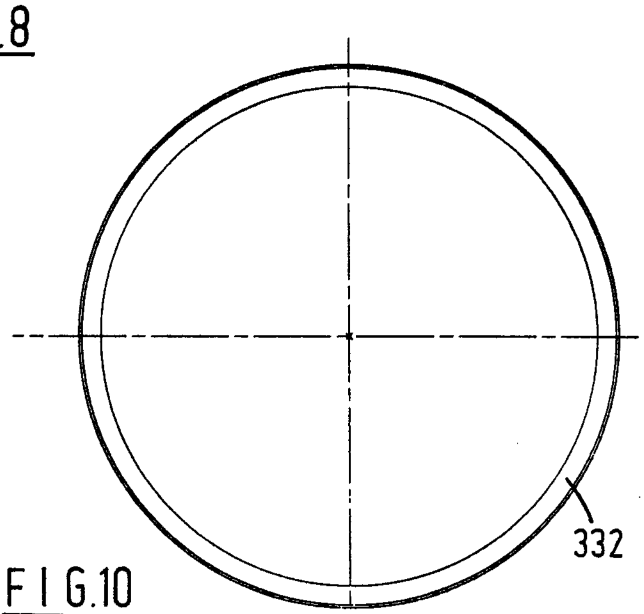
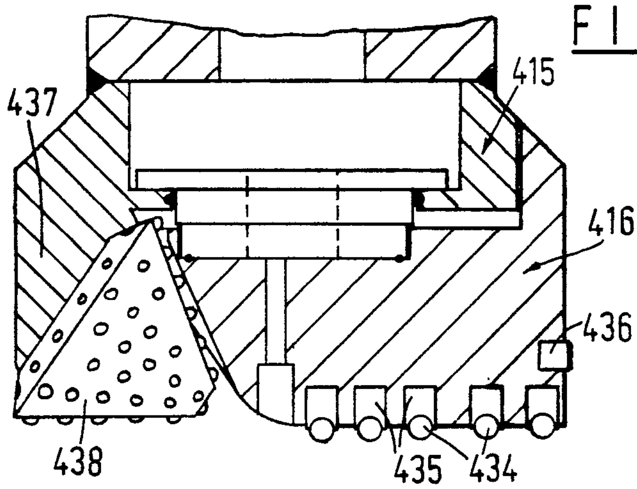
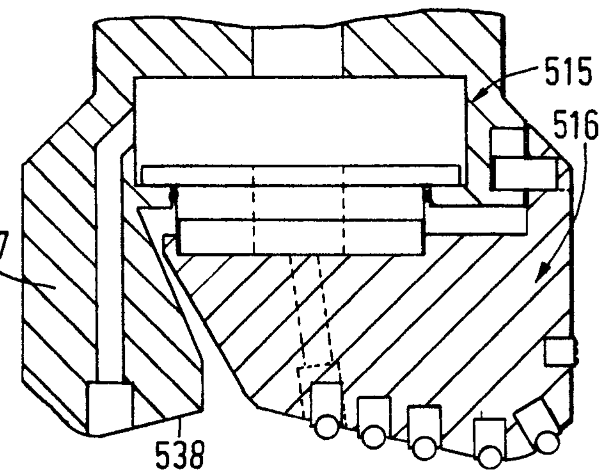


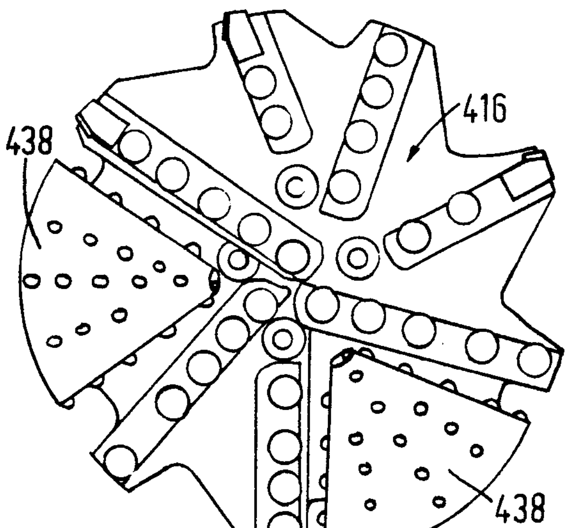
FIG.10



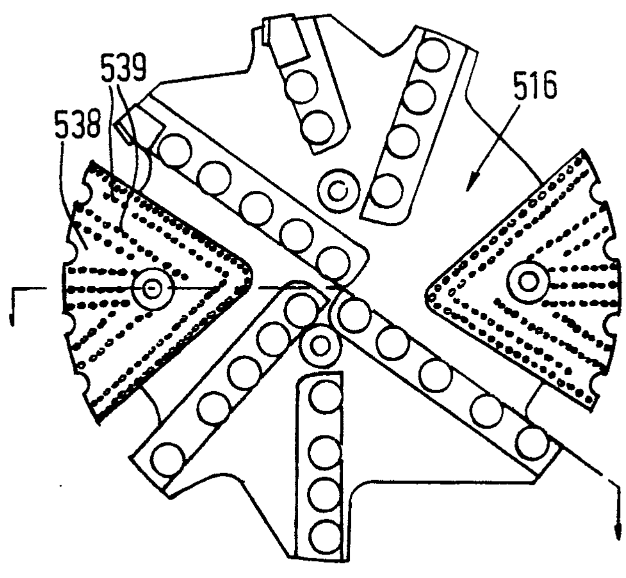
F I G.11



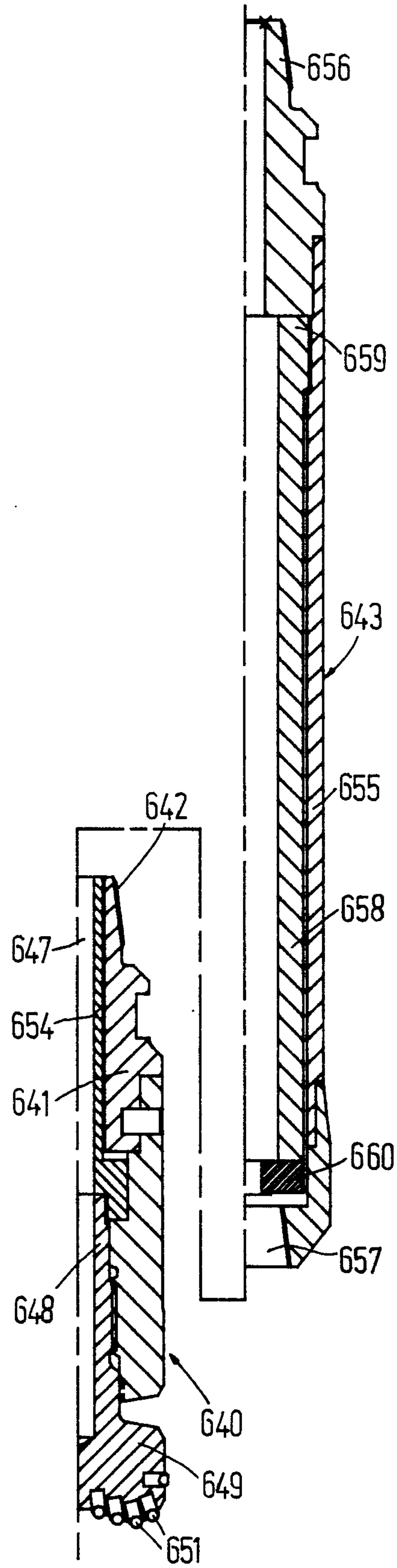
F I G.13



F I G.12



F I G.14



F I G.15