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(72) Inventors:
• **Hart, Steven James**
Bath, Avon BA1 2TE (GB)
• **Watson, Graham R.**
Gloucestershire GL2 7EY (GB)
• **Daly, Jeffery E.**
Cypress, Texas 77429 (US)

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(71) Applicant: **SCHLUMBERGER HOLDINGS**
LIMITED
Road Town, Tortola (VG)

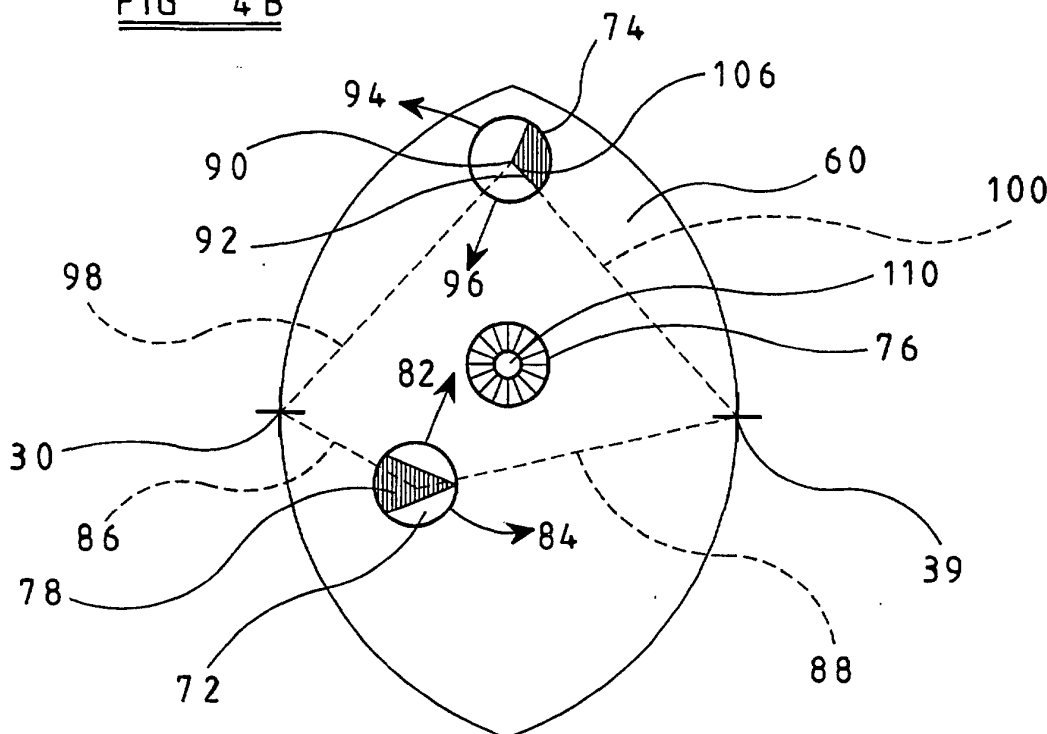
(74) Representative: **Bailey, Richard Alan**
A.R. Davies & Co., 27 Imperial Square
Cheltenham, Gloucestershire GL50 1RQ (GB)

(54) **Multi-directional cutters for bi-center drillout bits**

(57) A drill-out bi-centre bit includes first and second axes (30, 34) of rotation separated by a distance D, a first region (56) of radius D centred on one of the axes of rotation, a second region (58) of radius D centred on the other of the axes of rotation, and a third region (60) defined by the overlap between the first and second regions, wherein the cutters provided within the third re-

gion are designed to withstand cutting in opposing cutting directions. This may be achieved by providing each cutter with two cutting faces, or by providing two groups of cutters, one group arranged to cut in one direction, the other group being designed to cut upon rotation in the other direction, one of the groups protruding from the bit body of the bit to a greater depth than the other group.

FIG 4 B



Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates generally to drill bits, and, more particularly, to a multi-directional cutters for a fixed cutter, drillout bi-center bit.

2. DESCRIPTION OF THE RELATED ART

[0002] In the pursuit of drilling boreholes into the earth for the recovery of minerals, there are instances when it is desirable to drill a borehole with a diameter larger than the bit itself. Drill bits used to form these boreholes are generally known as bi-center type drill bits.

[0003] Bi-center drill bits are well known in the drilling industry. Various types of bi-center drill bits are described in U.S. Patents Nos. 1,587,266, 1,758,773, 2,074,951, 2,953,354, 3,367,430, 4,408,669, 4,440,244, 4,635,738, 5,040,621, 5,052,503, 5,165,494, 5,678,644 and European Patent Application 0,058,061 all herein incorporated by reference.

[0004] Modern bi-center drill bits are typically used in difficult drilling applications where the earth formations are badly fractured, where there is hole swelling, where the borehole has a tendency to become spiraled, or in other situations where an oversize hole is desirable.

[0005] In these difficult drilling applications, the top portion of the well bore is often stabilized by setting and cementing casing. The cement, shoe, float, and related cementing hardware are then typically drilled out of the casing by a drill bit that is run into the casing for this purpose. Once the cement and related hardware are drilled out, the drill-out bit is tripped out of the hole and a bi-center drill bit is run back into the borehole. Drilling then proceeds with the bi-center drill bit, which drills a hole into the formation below the casing with a diameter that is greater than the inside diameter of the casing.

[0006] To reduce drilling expenses, attempts have been made to drill the cement and related hardware out of the casing, and then drill the formation below the casing with a single bi-center drill bit. These attempts often resulted in heavy damage to both the casing and the bi-center drill bit.

[0007] The casing tends to be damaged by the gauge cutting elements mounted on the bi-center drill bit because inside the casing the pilot section of the bit is forced to orbit about its center, causing the gauge cutters to engage the casing. The forced orbiting action of the pilot section can also cause damage to the cutters on the leading face of the bi-center drill bit.

[0008] As is well known in fixed cutter drill bits, the cutting elements have cutting faces which are precisely oriented relative to the direction of travel of the cutter through the formation being drilled. However, cutters located in an area generally between the passthrough

center and the drilling center of the bit face of drillout bi-center bits experience two different directions of travel as they drill. One direction of travel occurs when the bit is drilling out, and the other direction of travel occurs when the bit is drilling the full diameter borehole. The cutters which lie in line between the two centers, in fact, experience exactly opposite directions of travel.

[0009] As previously stated, this has caused severe damage to the cutters in this area in the past. The typical solution to this problem has been to leave this area of the face of the bit devoid of cutters. Unfortunately, in some bi-center bit designs, particularly bi-center bits with large differences between the passthrough diameter and the drilling diameter, leaving this region devoid of cutters may cause the drilling performance of the bit to suffer.

[0010] The present invention is directed to overcoming, or at least reducing the effects of, one or more of the problems set forth above.

SUMMARY OF THE INVENTION

[0011] In one aspect of the present invention, there is provided a drillout bi-center drill bit comprising a bit body with a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends. There is a first drilling center of rotation of the pilot section and a second passthrough center of rotation of the pilot section spaced apart from the first center of rotation by a non-zero distance D . There is also a first region of the pilot section centered about the first center of rotation having a radius D , a second region of the pilot section centered about the second center of rotation having a radius D , and a third region of the pilot section formed by the intersection of the first region and the second region. A cutting element is fixed on the bit body within the third region. The cutting element has a first cutting face generally oriented perpendicular to the direction of travel of the cutting element about first center of rotation of the pilot section and a second cutting face generally oriented perpendicular to the direction of travel of the cutting element about the second center of rotation.

[0012] In another aspect of the present invention, there is provided a drillout bi-center drill bit comprising a bit body with a longitudinal axis and a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends. There is a first drilling center of rotation of the pilot section and a second passthrough center of rotation of the pilot section spaced apart from the first center of rotation by a non-zero distance D . There is a first region of the pilot section centered about the first center of rotation having a radius D , a second region of the pilot section centered about the second center of rotation having a radius D , and a third region of the pilot section formed by the in-

tersection of the first region and the second region. There are a plurality of first cutters in the third region, with superhard cutting faces generally oriented perpendicular to the direction of travel of the cutting element about the first center of rotation, projecting a distance from the bit body. At least one second cutter is fixed on the bit body within the third region and projecting a distance from the bit body greater than the projection of the first cutters, with a cutting face oriented generally perpendicular to the direction of travel of the second cutter about the second center of rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention may be best understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Figure 1 provides a perspective view of a drillout bi-center drill bit in accordance with one embodiment of the present invention;

Figures 2A, 2B and 2C show side views perspectives of the drillout bi-center drill bit of Figure 1;

Figure 3 shows an end view perspective of the drillout bi-center drill bit of Figure 1;

Figure 4A shows an end view perspective of the drillout bi-center drill bit of Figure 1 illustrating the iris shaped third region;

Figure 4B shows a simplified end view of the iris shaped third region of a drillout bi-center drill bit similar to that of Figure 4A;

Figures 5-7 show perspective views of various cutting elements that are mounted in the iris shaped third region on the drillout bi-center drill bit in accordance with the present invention;

Figure 8 is a partial end view of the face of the drillout bi-center drill bit showing an alternate cutter arrangement in accordance with another embodiment of the present invention;

Figure 9 shows a perspective view of a cutting element of the embodiment of the drillout bi-center drill bit of Figure 8;

Figure 10 shows a perspective view of still another cutter arrangement in accordance with another embodiment of the present invention.

[0014] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in

the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0015] Illustrative embodiments of the invention are described below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0016] Turning now to the drawings, and specifically referring to Figures 1, 2A, 2B, and 2C, a drillout bi-center drill bit 10 having multi-directional cutters is shown in accordance with one embodiment of the present invention. The drillout bi-center drill bit 10 has a longitudinal axis 11 upon which the drill bit 10 rotates, and a bit body 12 with a first end 14 adapted to be secured to a drill string (not shown) for driving the drill bit 10. According to one embodiment, threads 16 may be used for coupling the drill bit 10 to the drill string. However, it will be appreciated to those of ordinary skill in the art that various other forms of attachment may be used in lieu of the threads without departing from the spirit and scope of the present invention. At a second, opposite end of the bit body 12 is a pilot section 18 of the drillout bi-center drill bit 10. A reamer section, shown generally by numeral 20, is intermediate the first end 14 and the pilot section 18 of the bi-center drill bit 10.

[0017] While in operation, the bit body 12 is rotated via the drill string by some external means while the drillout bi-center drill bit 10 is forced into the material being drilled. The rotation under load causes cutting elements 24 at the exposed at the cutting face 17 to penetrate into the drilled material and remove the material in a scraping and/or gouging fashion.

[0018] In accordance with one embodiment of the present invention, the bit body 12 includes internal passaging (not shown) that allows pressurized drilling fluid to be supplied from the drilling surface to a plurality of nozzle orifices 22. These nozzle orifices 22 discharge the drilling fluid to clean and cool the cutting elements 24 as they engage the material being drilled. The drilling fluid also functions to transport the drilled material to the

surface for disposal.

[0019] According to one embodiment, the pilot section 18 may have a section with at least one fluid passage 26 provided for return flow of the drilling fluid. There also may be other fluid passages 26 provided in the reamer section 20 of the drillout bi-center drill bit 10 as well.

[0020] Referring specifically to Figures 2B and 2C, side view perspectives of the drillout bi-center drill bit 10 of the present invention are shown. One important characteristic of the drillout bi-center drill bit 10 is its ability to drill a borehole 11 into the earth 13 with a gauge drilling diameter larger than the inside diameter of the casing 15, or pipe or other type of conductor the bit 10 passes through, which is shown in Figure 2C.

[0021] Another important characteristic of the of the drillout bi-center drill bit 10 is its ability to drill out cement 17 (and related hardware, not shown) inside the casing 15 as shown in Figure 2B without causing damage to the casing 15 or the cutting elements 24 of the drill bit 10.

[0022] Turning now to Figure 3, an end view of a drillout bi-center drill bit 10 of the present invention is shown. The gauge drilling diameter, as indicated by the circle 28, is generated by radius R1 from a first center of rotation 30 of the pilot section 18. In this drilling mode, the circular portion of the pilot section 18 will be concentric with the diameter 28. The cutting elements 24 on the portion of the reamer section 20 radially furthest from the first center of rotation 30 actually drill the gauge drilling diameter of the borehole 11, as indicated at numeral 31. The reamer section 20 is formed eccentrically of the pilot section 18, so only a portion of the wall of the borehole 11 is in contact with the cutting elements 24, which cut the final gauge of the borehole 11 at any given time during operation.

[0023] The drillout bi-center drill bit 10 also has a pass through diameter, as indicated by the circle 32, generated by radius R2 from a second center of rotation 34 of the pilot section 18. The shortest linear distance at the face of the bit between the centers of rotation 30, 34 is indicated as D. The second center of rotation 34 is on the centerline of the smallest cylinder that may be fitted about the drillout bi-center drill bit 10. To be effective, the pass through diameter that is indicated by circle 32 must be smaller than the inside diameter of the casing 15 that the drillout bi-center drill bit 10 must pass through.

[0024] For optimal life, the cutting elements 24 must be oriented on the pilot section 18 in a known manner with respect to the direction of scraping through the material being drilled. This is no problem for bi-center drill bits that do not drill the cement and related hardware out of the casing. However, when a drillout bi-center drill bit is drilling the cement and related hardware in the casing, some of the cutting elements 24 may be subjected to reverse scraping while rotating about the second center of rotation 34. Reverse scraping often causes rapid degradation of the cutting elements 24, and must be avoided.

[0025] The cutting elements 24 are typically polycrystalline diamond compact cutters or PDC. A PDC is typically comprised of a facing table of diamond or other superhard substance bonded to a less hard substrate material, typically formed of but not limited to, tungsten carbide. The PDC is then often attached by a method known as long substrate bonding to a post or cylinder for insertion into the bit body 12. This PDC type of cutting element 24 is particularly sensitive to reverse scraping because loading from reverse scraping can easily destroy both the diamond table bonding and the long substrate bonding.

[0026] In prior art drill bits, the cutting elements are typically configured with a single cutting surface, where the cutting surface is properly oriented to cut through material being drilled when the drill bit rotates around a first center of rotation, such as center of rotation 30, for example. However, when the drillout bi-center drill bit 10 rotates around a second center of rotation, such as center of rotation 34, for example, the cutting surface of the cutting element is not properly oriented to optimally cut through the drilled material. That is, when the cutting element is configured with this single cutting surface, the drill bit is optimally utilized while drilling around the first center of rotation, but is not optimally positioned to cut material when the drill bit rotates around a second center of rotation. With this particular prior art configuration, the cutting element will undesirably wear at a faster rate when the drill bit is rotating around the center of rotation where the single cutting surface of the cutting element is not optimally positioned to cut material. As a result of the cutting elements wearing at a faster rate, the life of the drill bit is undesirably shortened.

[0027] As previously stated, the distance D is the shortest linear distance between center of rotation 30 and center of rotation 34. As shown in Figure 4A, a first region 56 of the pilot section 18, centered about the first center of rotation 30, has a radius D. A second region 58 of the pilot section 18 centered about the second center of rotation 34, and also has a radius D. A third region 60 of the pilot section 18 is formed by the intersection of the first region 56 and the second region 58. This iris shaped third region 60 is the critical area where reverse cutter scraping is possible.

[0028] Turning now to Figure 4B, a diagrammatic view of the positions of some of the cutting elements of a drillout bi-center drill bit similar to that of Figure 4A is shown. Three cutting elements 72, 74, 76 (Figures 5-7) of the present invention are shown in the iris shaped third region 60 between the drilling center of rotation 30 and the passthrough center of rotation 34.

[0029] Cutter 72 has two cutting faces 78, 80. When the drillout bi-center drill bit 10 is rotating about the drilling center of rotation 30, cutting face 80 of cutter 72 is properly oriented for cutting along the path indicated by arrow 82. Cutting face 80 is generally oriented perpendicular to the direction of travel of the cutter 72 in this operating mode which is parallel to dashed line 86 pass-

ing through about the drilling center of rotation 30.

[0030] In a similar manner, when the drillout bi-center drill bit 10 is rotating about the passthrough center of rotation 34, cutting face 78 of cutter 72 is properly oriented for cutting along the path indicated by arrow 84. Cutting face 78 is generally oriented perpendicular to the direction of travel of the cutter 72 in this operating mode which is parallel to dashed line 88 passing through about the passthrough center of rotation 34

[0031] Cutter 72 may be formed of any material suitable for drilling earth formations. Since the wear rate of cutting elements near the center of the bit is generally low, cemented tungsten carbide may be suitable. It is understood that during drillout operation, only a small amount of wear is likely to occur on cutting face 78 of cutter 72. It would be expected that much more wear would occur on face 80 when the bit is drilling into the earth. If the wear rates are unacceptably high, the cutter 72 may be formed of an infiltrated material comprising metallic powders such as tungsten carbide mixed with diamond particles and a binder.

[0032] Cutter 74 operates in a manner similar to cutter 72, although as described later, cutter 74 is intended for much more abrasive drilling than cutter 72. Cutter 74 has two cutting faces 90, 92. When the drillout bi-center drill bit 10 is rotating about the drilling center of rotation 30, cutting face 90 of cutter 74 is properly oriented for cutting along the path indicated by arrow 94. Cutting face 90 is generally oriented perpendicular to the direction of travel of the cutter 74 in this operating mode which is parallel to dashed line 98 passing through about the drilling center of rotation 30.

[0033] In a similar manner, when the drillout bi-center drill bit 10 is rotating about the passthrough center of rotation 34, cutting face 92 of cutter 74 is properly oriented for cutting along the path indicated by arrow 96. Cutting face 92 is generally oriented perpendicular to the direction of travel of the cutter 74 in this operating mode which is parallel to dashed line 100 passing through about the passthrough center of rotation 34.

[0034] In order to survive severe, abrasive drilling conditions the cutting face 92 of cutter 74 is quite different from that of cutter 72. A PDC cutting element 102 is mounted on cutting face 92 a small distance 104 from the end 106 of cutter 74 exposed at the cutting face 17 of the drill out bi-center drill bit 10. During the drillout phase, a small amount of wear will occur on end 106. After drillout, the bit will then start drilling a full diameter hole in the earth. However, in abrasive drilling conditions, even cutters near the center will wear rapidly. Therefore, the end 106 of cutter 74 will wear rapidly, exposing the PDC element 102. Once this happens, the cutter will wear at a rate comparable to other PDC cutters near the center.

[0035] In this embodiment, the PDC is attached to the cutter 76 by a method known as long substrate bonding. The cutter 76 is then inserted into the bit body 12, which gives the PDCs an alternative orientation with respect

to the center of rotation about which the drill bit 10 rotates.

[0036] It should be apparent that cutters 72 and 74 will generally have different orientations of cutting faces 78, 80, 90, 92 depending where they are located within the iris shaped third region 60 between the drilling center of rotation 30 and the passthrough center of rotation 34. Although some mis-match of cutting faces 78, 80, 90, 92 would be tolerated, allowing some commonality of cutting face orientations, many different configurations of cutters 72 and 74 would still be necessary for most drillout bi-center drill bits 10.

[0037] One alternate, a cone shaped cutter 76 suitable for very non-abrasive drilling condition, is shown in Figure 7. In cutter 76, the side 108 is generally conic and terminates in a flat top 110 that is also exposed at the cutting face 17. Since these cutters 76 are symmetrical, they may be placed anywhere within the iris shaped third region 60 between the drilling center of rotation 30 and the passthrough center of rotation 34. In this cutter 76, the cutting edge 112 is the intersection of the side 108 and the flat top 110. Although not particularly 'sharp', cutter 76 is suitable for non-abrasive drilling conditions.

[0038] Shown in Figure 8 is a particular bit configuration where the cutting functions for drillout and full diameter drilling are embodied in separate cutters. Two cutting face sections 17 are shown on bit body 12. A plurality of conventional cutters 24 is shown with arrows 114 indicating their rotation path about the drilling center of rotation 30. A plurality of cutters 116 (shown in Figure 9) have cutting faces 118 oriented for drilling out, with arrows 119 indicating their rotation path about the passthrough center of rotation 34.

[0039] The tops 120 of cutters 116 are orientated relatively farther from the bit body 12 than the remainder of cutters 24 on the cutting face section 17 of the drillout bi-center bit 10. Therefore the cutting faces 118 of cutters 116 will engage the drillout material and prevent damage to cutters 24 during drillout. Once drillout is complete, the cutters 116 will rapidly wear, allowing the cutters 24 to drill normally. The operation is therefore effectively the same as cutter 74. Cutter 116 may be formed of any material suitable for drilling earth formations. However, similar to cutter 74, a cemented tungsten carbide material or an infiltrated material comprising metallic powders such as tungsten carbide mixed with diamond particles and a binder is suitable. In this embodiment and similar to cutters 72, 74 and 76 the cutter 116 is oriented as necessary then fixed into the bit body 12,

[0040] An alternate embodiment for the arrangement of the drillout cutters shown in Figure 8 is possible when the bit body 12 is an infiltrated powdered metal matrix material. When this is the case, the cutter 122 is formed as a bump in the matrix of the bit body 12. The cutting face 118, and top 120, of cutter 122 function identically to cutter 116. However, because matrix bits are made in

a moulding process, orienting and fixing the cutters 122 into the bit body 12 is not necessary. Cutter 122 is integral with the bit body. This method of construction of matrix drill bits is well known in the art. Accordingly, the specific details of such will not be disclosed herein to avoid unnecessarily obscuring the present invention.

[0041] The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention.

Claims

1. A drill-out bi-centre drill bit comprising a bit body with a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends, the pilot section having a first drilling centre of rotation and a second passthrough centre of rotation spaced apart from the first centre of rotation by a non-zero distance D, the pilot section further having a first region centred about the first centre of rotation and having a radius D, a second region centred about the second centre of rotation and having a radius D, and a third region formed by the intersection of the first region and the second region, a cutting element being fixed on the bit body within the third region, the cutting element having a first cutting face generally oriented perpendicular to the direction of travel of the cutting element about first centre of rotation of the pilot section and a second cutting face generally oriented perpendicular to the direction of travel of the cutting element about the second centre of rotation.
2. A bit according to Claim 1, wherein the cutting element is of cemented tungsten carbide form.
3. A bit according to Claim 1, wherein the cutting element is formed of an infiltrated material comprising metallic powders mixed with diamond particles and a binder.
4. A bit according to Claim 1, wherein a polycrystalline diamond compact cutter is mounted on one of the cutting faces of the cutting element.
5. A bit according to Claim 1, wherein the cutting element is of generally conical form, the first and second cutting faces being defined by different parts of a generally conical surface of the cutting element.
6. A drill-out bi-centre drill bit comprising a bit body with a longitudinal axis and a first end adapted to be detachably secured to a drill string, a pilot section on a second, opposite end of the bit body and a reamer section intermediate the first and second ends, the pilot section having a first drilling centre of rotation and a second passthrough centre of rotation spaced apart from the first centre of rotation by a non-zero distance D, the pilot section further having a first region centred about the first centre of rotation having a radius D, a second region centred about the second centre of rotation having a radius D, and a third region formed by the intersection of the first region and the second region, a plurality of first cutters being positioned in the third region, with superhard cutting faces generally oriented perpendicular to the direction of travel of the cutting element about the first centre of rotation, projecting a distance from the bit body, and at least one second cutter on the bit body within the third region and projecting a distance from the bit body greater than the projection of the first cutters, with a cutting face orientated generally perpendicular to the direction of travel of the second cutter about the second centre of rotation.
7. A bit as claimed in Claim 6, wherein the or each second cutter is of cemented tungsten carbide form.
8. A bit as claimed in Claim 6, wherein the or each second cutter is of an infiltrated material comprising a mixture of metallic powders, diamond particles and a binder.
9. A bit as claimed in Claim 6, wherein the bit body is of infiltrated powdered metal matrix form and is shaped to define the or each second cutter.

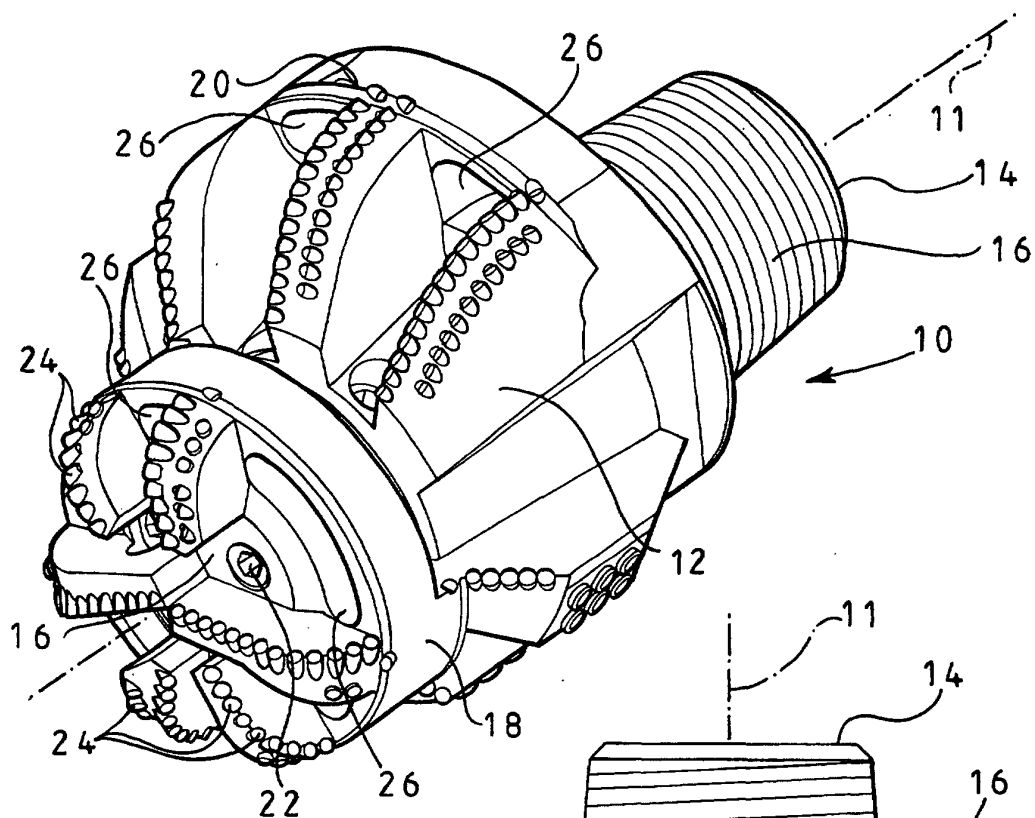


FIG 1

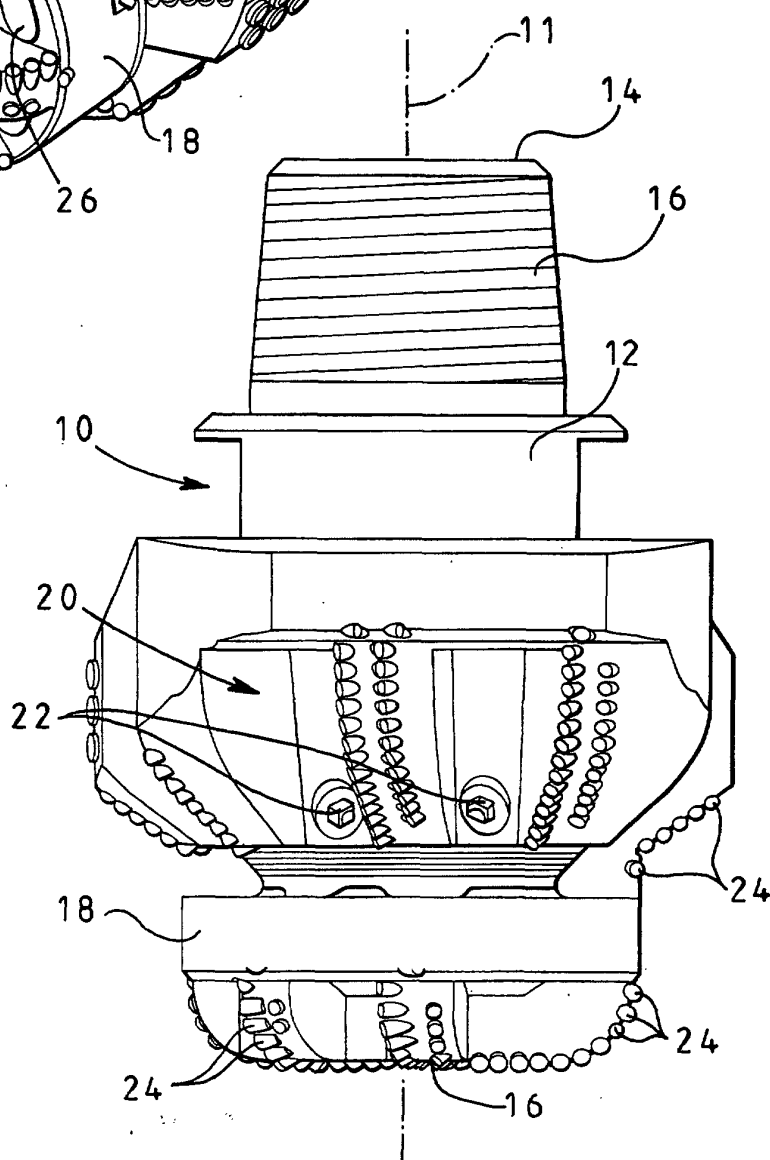
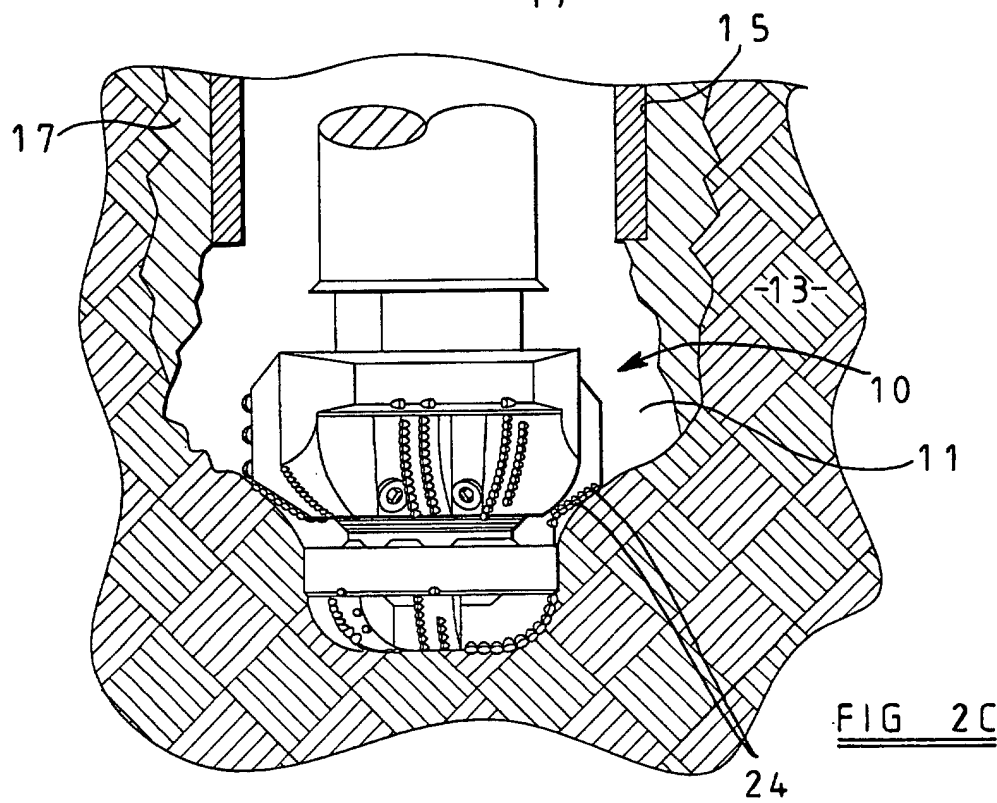
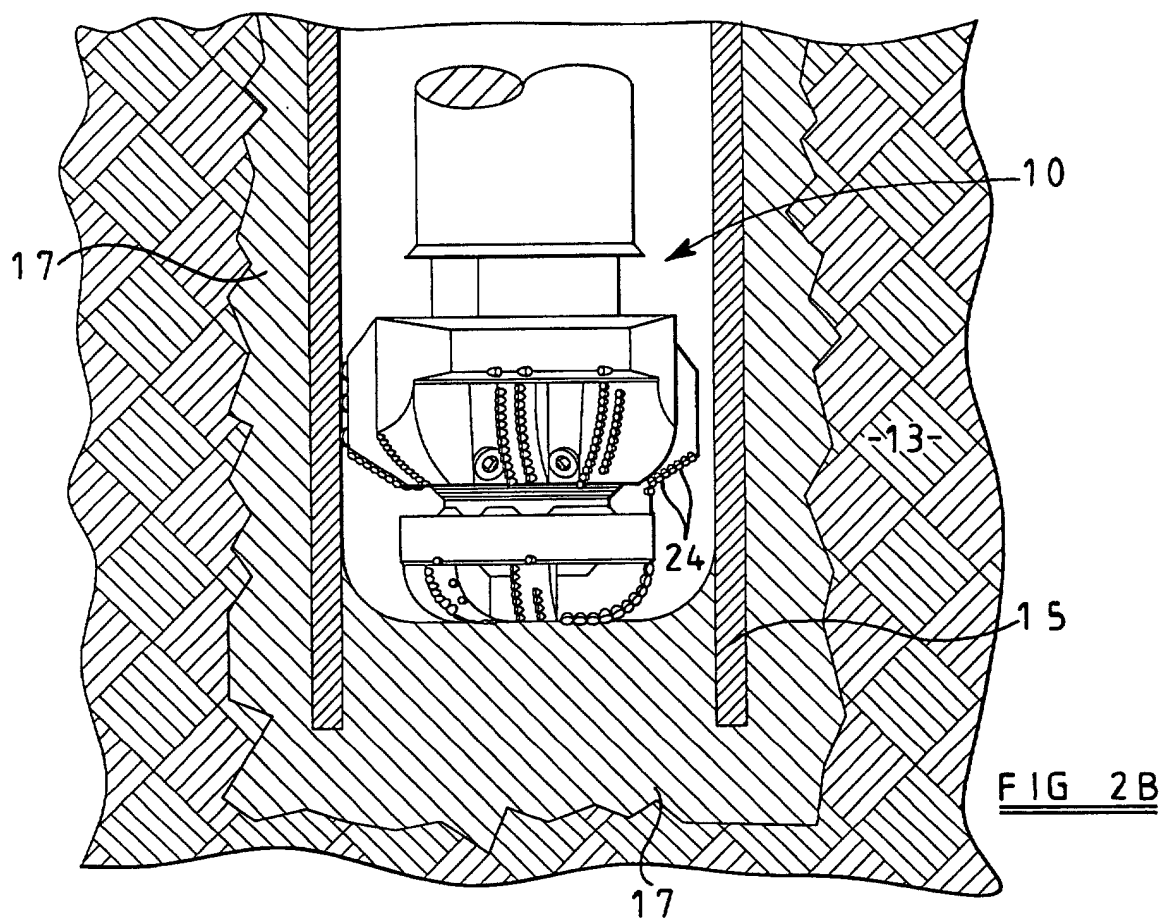


FIG 2A



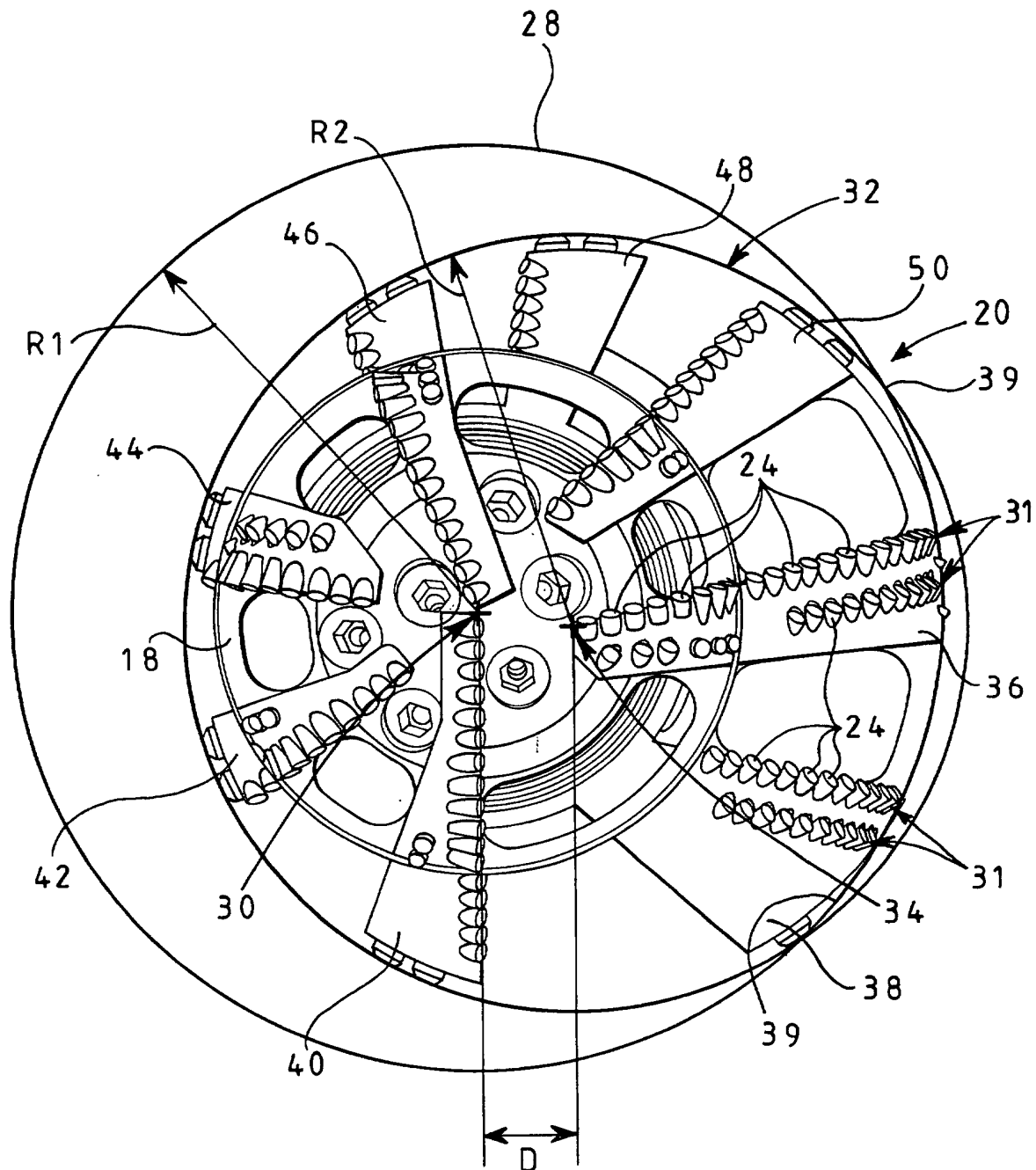


FIG 3

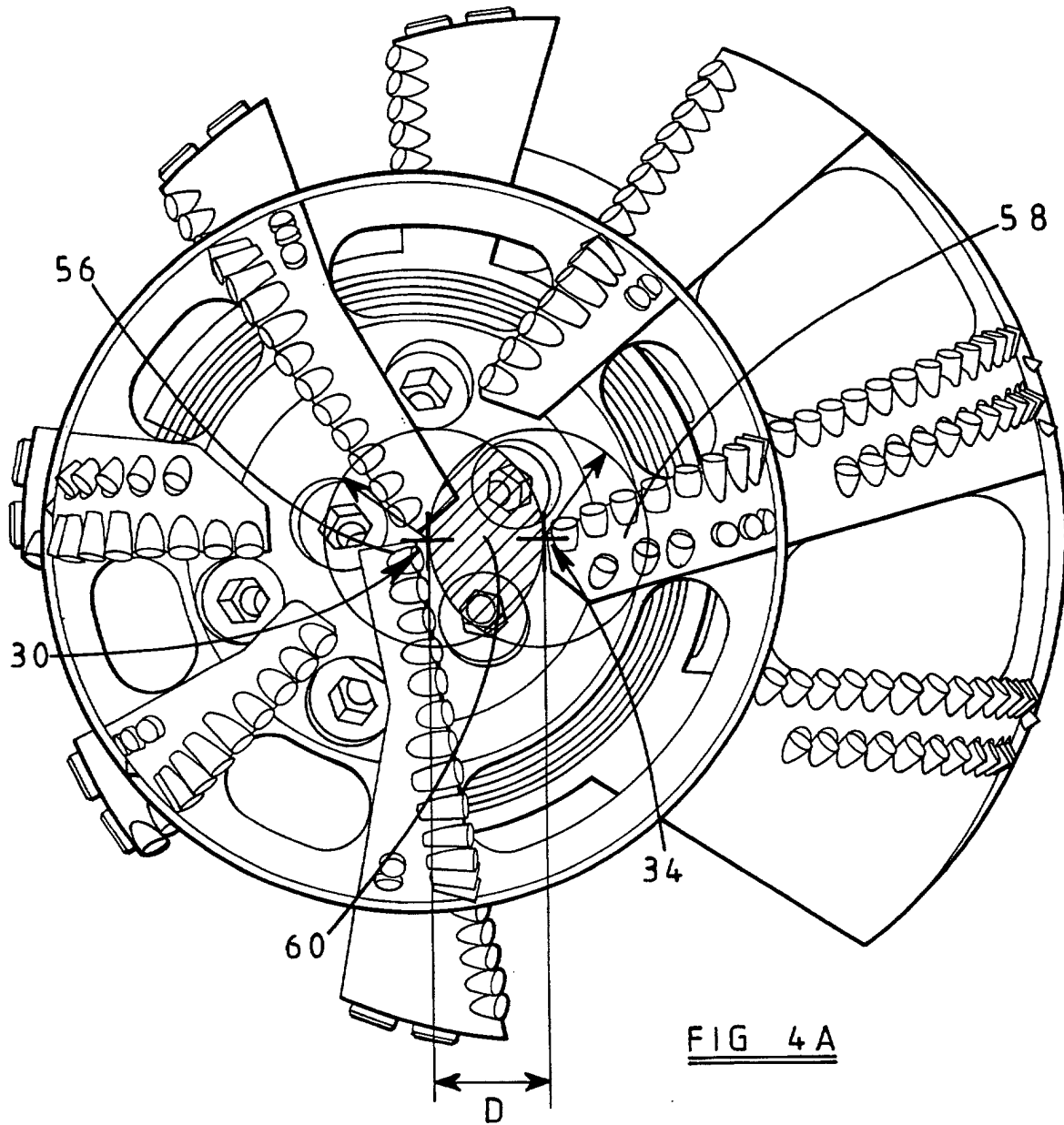
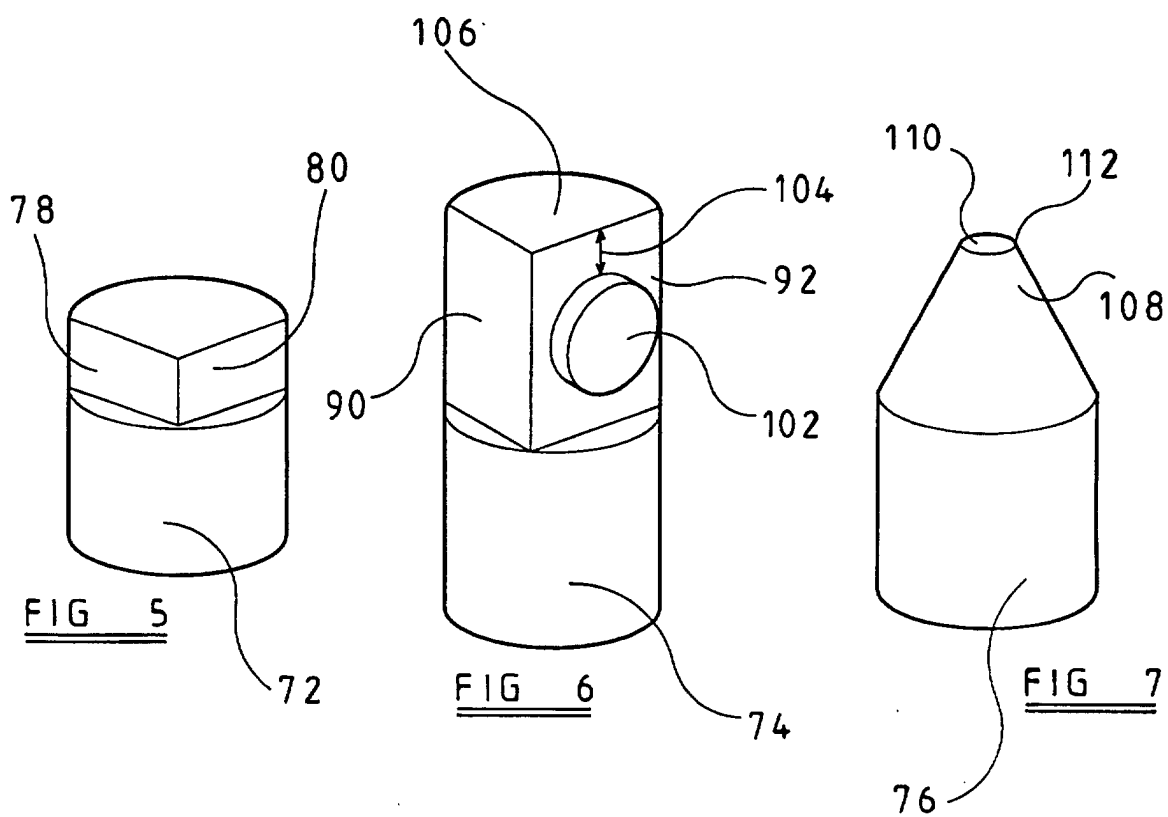
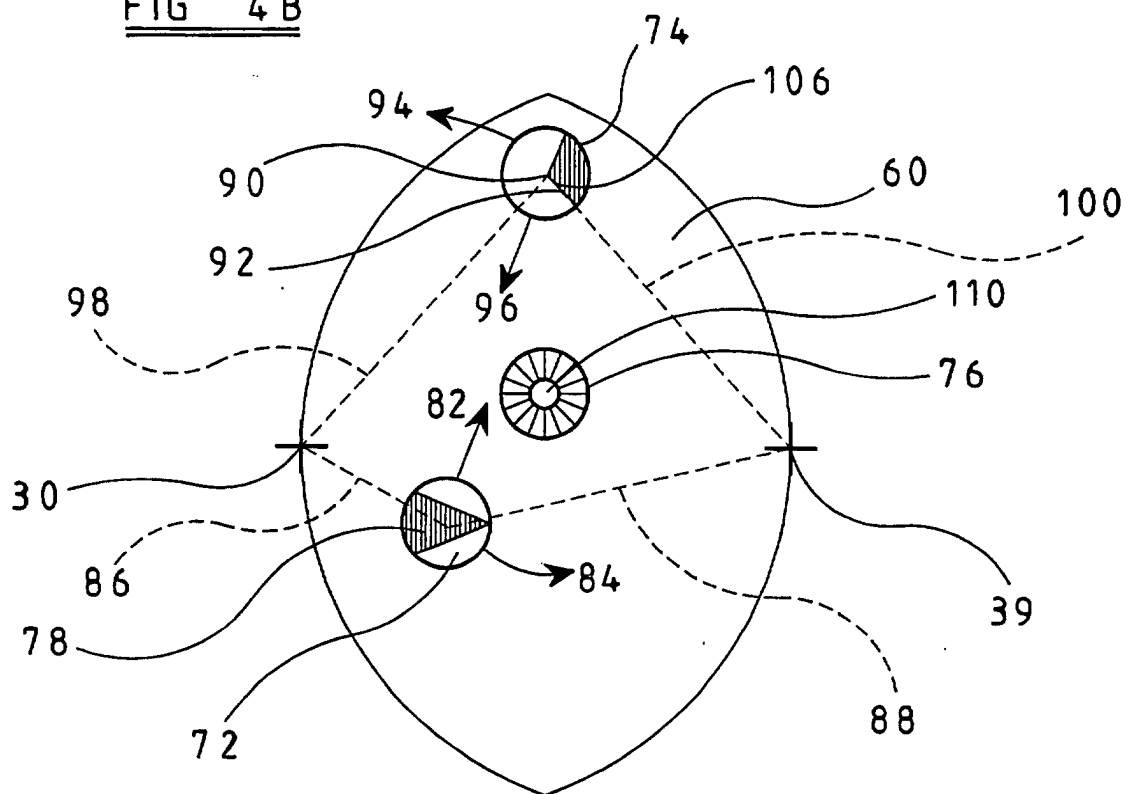
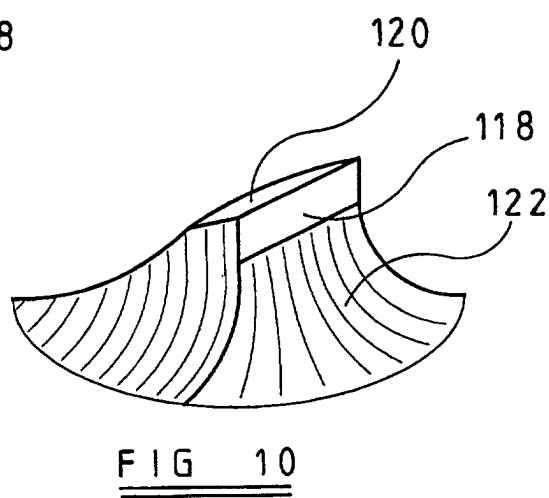
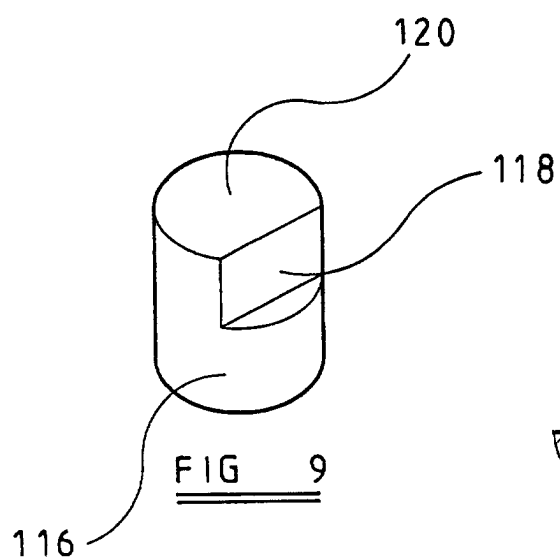
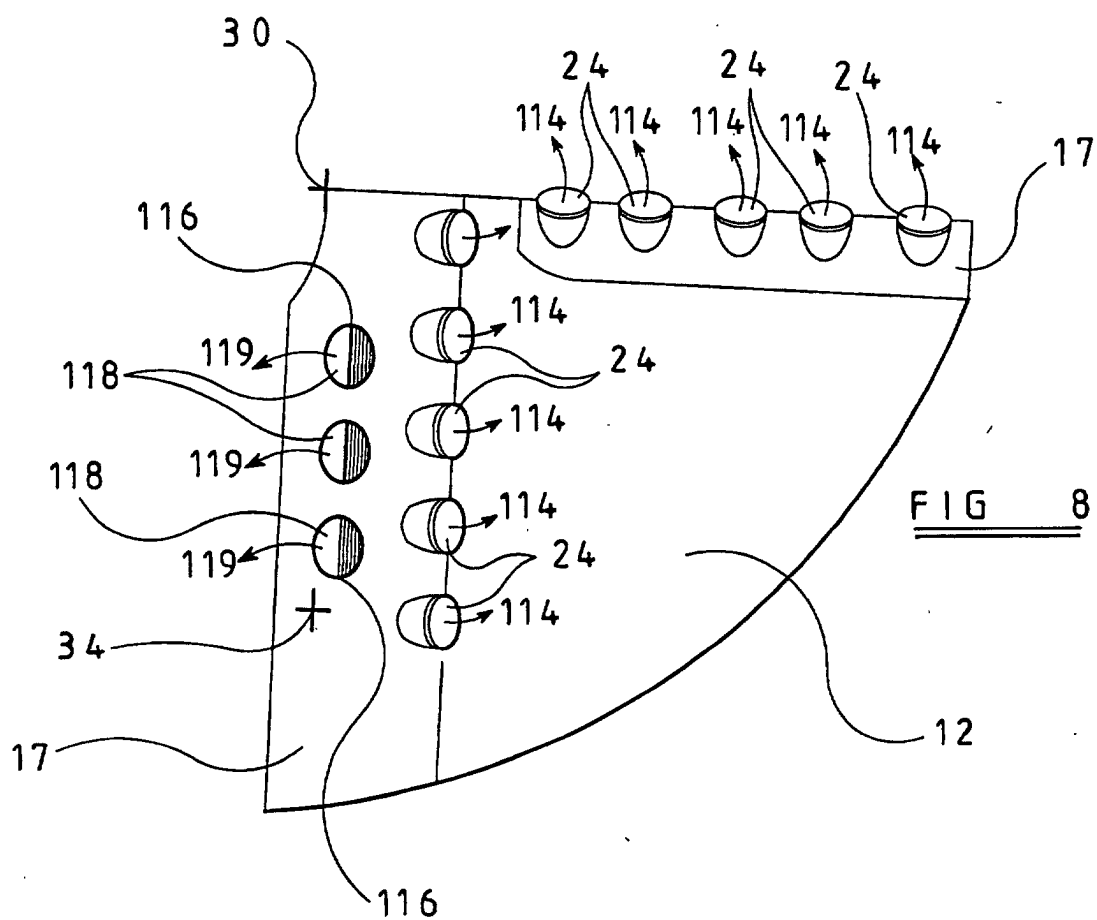


FIG 4 B







European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 5833

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 7 December 2001	Examiner Dantinne, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 30 5833

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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07-12-2001

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