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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 :		(11) International Publication Number: WO 84/ 01186
E21B 10/60, 10/46	A1	(43) International Publication Date: 29 March 1984 (29.03.84)

(21) International Application Number: PCT/GB83/00227

(22) International Filing Date: 16 September 1983 (16.09.83)

(31) Priority Application Number: 8226466

(32) Priority Date: 16 September 1982 (16.09.82)

(33) Priority Country: GB

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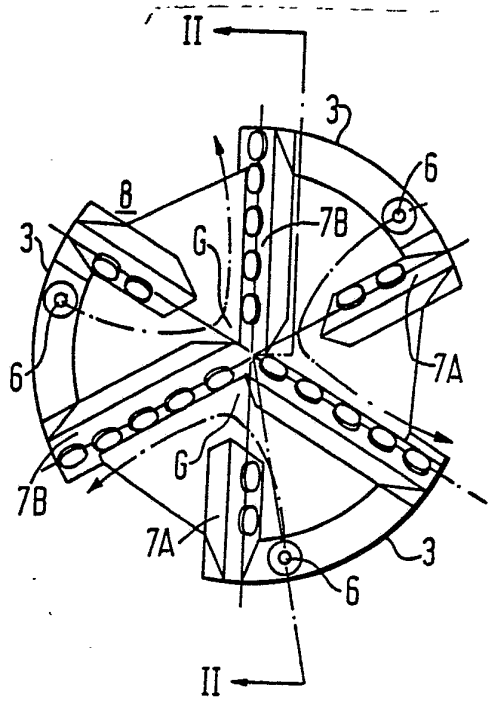
(81) Designated States: AU, BE (European patent), BR, CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, NL (European patent), NO, SE (European patent), US.

Published
With international search report.

(54) Title: ROTARY DRILL BITS



(57) Abstract

A rotary bit for use in subsurface formations comprises a bit body having a central bore (4), the body having a leading face (1) and a trailing gauge region (2), walls (7) on the bit dividing the face into fluid channels, cutting elements C being present on at least some of the walls, and passageways (5) connecting the bore (4) to openings (6) in the fluid channels. At least two wall portions (7) are arranged relative to each openings (6) so that the fluid emerging from the opening is directed to travel first inwardly towards the central axis of the bit before travelling outwardly to the gauge region (2).

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"Rotary Drill Bits"

The invention relates to rotary drill bits and in particular to bits which are used to drill holes in rock or subsurface formations for example to extract oil, gas or water or in mining or in the removal of cores.

A drill bit comprises a bit body with means for connection to a drill string, a leading bit face and a trailing gauge region. The face of the bit carries cutting elements such as polycrystalline diamond compacts which may be arranged in rows at the leading edges of wall portions known as "blades". The face of the bit may also carry so-called fences to control fluid flow and preferably has so-called kickers to centralise the bit in the hole. Fluid such as drill mud is passed down a central bore in the drill string and body and exits via passageways and openings into fluid channels between the blades and/or fences and kickers to flow past the cutting elements and up to junk slots between the kickers in the gauge region, carrying away cuttings and chippings and serving to

cool the formation being drilled.

In known drill bits of this type, the passageways usually lead to openings located in the central region of the bit face, and there are usually many fluid channels which extend away from the centre of the bit. Sufficient fluid channels or waterways are required to ensure that cuttings and heat are removed from the vicinities of all the cutting elements.

Typical designs have the cutting elements arranged in rows in the leading edges of blades, and have a fluid channel in front of each blade. Depending on the design, there may be 3 to 30 blades and the same number of fluid channels.

In certain rock formations, there is a tendency for the channels to become blocked by cuttings of rock formation, and blockage of one channel means that its associated cutting elements are not cooled and cleaned and the entire flow of fluid passes through the remaining channels. Although this will cause some increase in pressure at all the openings, this increase in pressure will not always be sufficient to unblock the blocked channel, so that the cutters associated with that channel will become overheated and/or clogged and so substantially ineffective. The clogging presents a barrier between the bottom of the hole and the cutting elements, preventing penetration or slowing the rate of penetration of the drill bit. This problem is particularly acute when the drill bit is used to drill

certain types of claystone and shale using a water-based drilling fluid.

One solution to this problem is to isolate the fluid channels from each other and to feed each through one ore more openings or nozzles of restricted area. The area of the nozzles is chosen so that the pressure difference between the common bore and the fluid channels is large enough to clear an accumulation of cuttings in the channel and prevent a blockage. Examples of bits having these features are illustrated in U.S. Patent Specifications Nos. 2,371,489, 2,371,490, and 3,112,803 and in French Patent Specification No. 1,265,943. To provide enough cutting elements in a compact design, many blades may be required. Even if all the required cutting elements can be accommodated on three or four blades, the fluid channels diverge rapidly which means that fluid velocity falls off towards the edge. This can be corrected by the use of fences but dead sectors are formed and they are uncooled in use of the bit. For these reasons, more than three or four blades are preferred. In the simple designs, there is one fluid channel in front of each blade and so the number of nozzles cannot be less than the number of blades. The presence of many openings or nozzles with adequate pressure drop requires each opening or nozzle to be small and there is a risk of some of the openings themselves becoming blocked.

It is one object of this invention to provide

a drill bit body in which the number of openings is kept to the minimum without an undesirable decrease in the number of blades or fences, consistent with ensuring that there is a suitable fluid flow distribution for the purposes of cleaning and cooling.

It is another object to provide a drill bit in which the support structure for the cutters in the centre portion of the bit face need not be interrupted by large openings or nozzles.

The invention is based on the realisation that by suitably locating the openings and the wall portions, at least part of the fluid may be directed to flow in a single path towards the central axis of the bit before exiting via the gauge region.

According to the invention there is provided a rotary bit for use in subsurface formations comprising a bit body having a central bore, the body having a leading face and trailing gauge region, walls on the bit dividing the face into fluid channels, cutting elements being present on at least some of the walls, passageways connecting the bore to openings in the fluid channels, the chennels being arranged to pass most of the fluid from an opening in a single path past the cutting elements to adjacent the gauge region characterised in that at least two wall portions are arranged relative to an opening so that the fluid emerging therefrom is directed to travel towards the central axis of the bit before exiting to the gauge

region.

Preferably,most of the openings are located near the periphery of the bit and the fluid channels lead from these openings first towards the central axis of the bit and from there outwards to the periphery towards a junk slot. Preferably the openings are few enough and small enough to have a pressure drop of between 10 and 200 atmospheres. Thus, if one fluid channel becomes partly blocked, reduction in flow in that fluid channel will cause the pressure drop across the corresponding opening to be reduced and there is a corresponding increase in pressure available to clear the partial blockage. A high pressure drop across the openings not only increases the exit velocity from them but also helps to stabilise the volumetric rate of flow distribution between the fluid channels.

In practice, most of the fluid emerging from a nozzle is directed to flow in the direction specified. In a much preferred feature of the invention the direction is determined by providing blades and for fences in dispositions to direct the flow; for example gaps may be present between blades and blades and/or fences to direct the flow. Auxiliary nozzles may be present to enhance the flow generally or in particular locations. It is an advantage of the invention that some leakage of the fluid flow can be tolerated provided that most of the fluid emerging from a nozzle is caused to travel along the single path.

The cutting elements in the central region of the bit face can be mounted very strongly because in a bit of the invention major arrival openings are not required in that region. Some of the fluid is forced by the geometry of the channels to pass, wash and cool the cutting elements at the central region. Auxiliary openings may be provided in the centre but they can be small, leaving sufficient space to form a strong support for cutting elements.

Because the cutting elements on the bit face may be aligned with their neighbours the fluid flow near each cutting element may be in a direction substantially parallel to the face of the cutting element, thus giving improved washing away of cuttings. This is an advantage over the bit described and claimed in our European Patent Application No. 81.300064.3, Pubilcation No. 0,032,791A.

The openings or nozzles will usually be smaller in diameter than the passageways leading from the central bore in the bit body. The invention however includes bits in which the passageways are themselves of sufficiently small cross-sectional area to control the flow or in which a choke or restrictor is present in the passageway.

The cutting elements may be made of known materials; the use of polycrystalline diamond compacts is preferred. The cutting elements will usually be mounted on a leading edge of the blades. The bit

body may be made of one or more of a wide variety of materials including infiltrated tungsten carbide matrix, steel or steel coated with tungsten carbide.

Two or more inbound fluid channels may joined to feed one common outbound channel and so define a single clear path from each of two or more openings.

One important advantage of this invention is that it permits a reduction in the number of openings in proportion to the number of blades. This enables larger openings to be used, reducing the incidence of blockages in the openings themselves. Another is that nozzles may be interchanged.

A further advantage of the present invention is that the fluid flow can be made to function and cool a rock formation and cutters even when the bit is used in a reaming mode. Bits having cutting elements comprising polycrystalline diamond compacts may be required to ream many tens of metres of hole when following worn or under gauge rock bits and before drilling. Bits designed for drilling (not for reaming) having openings for circulation near their central axis sometimes suffer overheating of their outer cutting elements during this reaming operation because the mud velocities at the gauge are small under these conditions. A bit of this invention does not suffer from this disadvantage since the openings, being located adjacent the outer periphery of the bit, provide high velocity turbulent flow of drilling fluid at the periphery, thus

providing more effective cooling of the outer cutters and of the surrounding formation.

In order that the invention may be well understood, it will now be described by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a front end view of one bit of the invention;

Figure 2 is a longitudinal sectional view of the bit of Figure 1 taken on lines II - II;

Figures 3 to 14 are each a front end view of other bits all within the scope of the invention; and

Figure 15 is a longitudinal sectional view of another bit of the invention, and Figure 16 is a sectional view taken on lines XVI - XVI on Figure 15.

Where possible, the same reference numerals are used to designate the same parts in the different embodiments.

The rotary bit body of Figures 1 and 2 comprises a leading bit end face 1 and a rearward end portion 2 for connection to a drill string, not shown. The intermediate portion comprises a gauge portion having three kickers 3. A bore 4 extends through the connection portion 2 and ends inside the bit. A number of passageways 5 of relatively reduced diameter lead from the bore 4 to the edge or periphery of the bit face where they emerge as outlet nozzles 6: as shown in Figure 2 there are three such nozzles 6 spaced apart

about the circumference of the bit end face. A number of blades 7 is present on the bit end face 1; as shown in Figure 2 there are six such blades 7,i.e. two blades per nozzle. Three of the blades 7A, extend radially from an outlet to towards the centre axis of the bit end face but stop short of reaching the centre point. The other three blades 7B lie between each pair of blades 7A and meet at the centre point. cutting elements C each comprising a polycrystalline diamond compact are mounted in a row on one side of each blade to present a cutting edge. Three junk slots 8 extend from the bit face 1 up past the kickers 3, the slots being located on the opposite side of the blade 7A from the adjacent nozzle 6. Because the blades 7A stop short of meeting the blades 7B at the centre point a gap G is defined. In use, drilling mud is pumped down the bore, and the mud flows along the passageways and out through each nozzle 6. As the bit is rotated the cutting elements C of each blade cut or abrade the formation, producing chippings, not shown. The drilling mud from each nozzle flows in the channels defined by the blades past the cutting elements of the adjacent blade 7A, through the adjacent gap G, and past the cutting elements of the adjacent blade 7B and then up a junk slot 8. This is shown by the arrows. The chippings are removed efficiently and the formation is cooled. The wall portions 7A and 7B are thus arranged relative to the nozzle 6 so that the drilling mud flows towards the centre axis of the bit

before exiting to the gauge region. The mud from each nozzle serves to clean two sets of cutting elements. The mud flows in a single common and unbranched path so, should a blockage occur in the path, there is no escape route for the fluid and as a result pressure builds up in the fluid tending to clear the blockage away.

In the bit of Figure 3, four outlet nozzles 6 are present, and there are a total of eight blades 7. The blades 7B meet at the centre point and are well supported, which of course would not be possible if the bore 4 emerged there and this offers many advantages in terms of bit design, manufacture and strength. The blades 7C are joined to the blades 7B by fences F which separate the channels and add strength.

In the bit of Figure 4, there are three nozzle outlets 6, but a total of twelve wall portions. The blades join the kickers 8 except for blades 7D where there is a gap connecting channels 10 and 11. As a result there is a single path from nozzle 6 to the junk slot 8 through channels 9, 10, 11 and 12. The bit has four blades per nozzle, useful for large diameter bits e.g. above 44 cm.

In the bit of Figure 5, there are four nozzle outlets 6 and six wall portions. As shown by the arrows, the mud is arranged to flow from two outlets 6 into one junk slot 8, so increasing fluid velocity and the cleaning and cooling effect.

In the embodiment of Figure 6, auxiliary nozzles 6A are present to enhance the cleaning action on the second set of cutting elements be releasing auxiliary drilling mud in the gap G.

In the embodiment of Figure 7, the flow of mud is caused to pass over four sets of cutting elements before exiting via a junk slot 8. The blades 7D do not reach the kickers and are joined at the centre by fences F.

In the embodiment of Figure 8, the nozzle openings 6 are in the central region of the bit face and the fluid is directed to travel away from the central axis and then towards it before exiting in the gauge region.

In the embodiment of Figure 9, there are three junk slots 8. In the case of the nozzle 6B the mud cleans only one set of cutting elements and then goes direct to the facing junk slot 8; in the case of the other outlet nozzles 6 the mud passes two sets of cutting elements. A fence F is present to increase the fluid velocity in front of the blade 7A.

In the embodiment of Figure 10, the fence F1 increases the mud velocity in front of the blade 7A. The fences F join the blades 7A to the blades 7B to separate the path from the nozzle 6A from that of the nozzle 6B.

In the embodiment of Figure 11, a fence F1 is provided adjacent the junk slot 8 to direct the flow of

mud past the cutting elements from outlet nozzles 6 which would otherwise need to be positioned nearer to the central axis.

In the embodiment of Figure 12, the fences F extend from adjacent the outlet to the junk slot better to define the clear flow path. In the embodiment of Figure 13, the blades are curved, permitting cutting elements to be orientated with non-zero side rake angles while still being in mutual alignment with their neighbours.

In the embodiment of Figure 14, there is a small centre non-interchangeable nozzle 6C to clean the central cutters and join the flow from the main nozzle 6. It will be noticed that the fluid emerging from nozzle 6C will tend to divide. The bit includes leakage paths of small cross-sectional area between the blades 7A.

In the embodiment shown in Figures 15 and 16 the bit includes a restrictor 13 on the surface of the bit whose restricted cross-sectional area is bounded partly by part of the bit body and partly by the formation or rock being drilled

CLAIMS

1. A rotary bit for use in subsurface formations comprising a bit body having a central bore, the body having a leading face and a trailing gauge region, walls on the bit dividing the face into fluid channels, cutting elements being present on at least some of the walls, passageways connecting the bore to openings in the fluid channels, the channels being arranged to pass most of the fluid from an opening in a single path past the cutting elements to adjacent the gauge region, characterised in that at least two wall portions are arranged relative to an opening so that the fluid emerging therefrom is directed to travel towards the central axis of the bit before exiting to the gauge region.

2. A rotary bit according to claim 1, wherein most of the openings are located near the periphery of the bit and the fluid channels lead from these openings first towards the central axis of the bit and from there outwards to the periphery towards a junk slot.

3. A rotary bit according to claim 1 or claim 2, wherein the number and size of the openings are such as to provide a pressure drop of between 10 and 200 atmospheres.

4. A rotary bit according to any of claims 1 to 3, wherein said wall portions are provided by blades on which said cutting elements are mounted and/or by fences

spaced from said blades.

5. A rotary bit according to any of claims 1 to 4, wherein auxiliary openings are provided in the fluid channels adjacent the central axis of the bit.

6. A rotary bit according to any of claims 1 to 5, wherein the cutting elements on the bit face are aligned with their neighbours and the fluid flow near each cutting element is in a direction substantially parallel to the face of the cutting element.

7. A rotary bit according to any of claims 1 to 6, wherein each passageway from said central bore to an opening is provided with a choke or restrictor to control the fluid flow.

8. A rotary bit according to any of claims 1 to 7, wherein the cutting elements are polycrystalline diamond compacts.

9. A rotary bit according to any of claims 1 to 8, wherein two or more inbound fluid channels, leading from two or more openings respectively towards the central axis of the bit, feed one common outbound channel leading away from the central axis of the bit towards the gauge region of the bit.

10. A rotary bit for use in subsurface formations, substantially as hereinbefore described with reference to any of Figures 1 to 16 of the accompanying drawings.

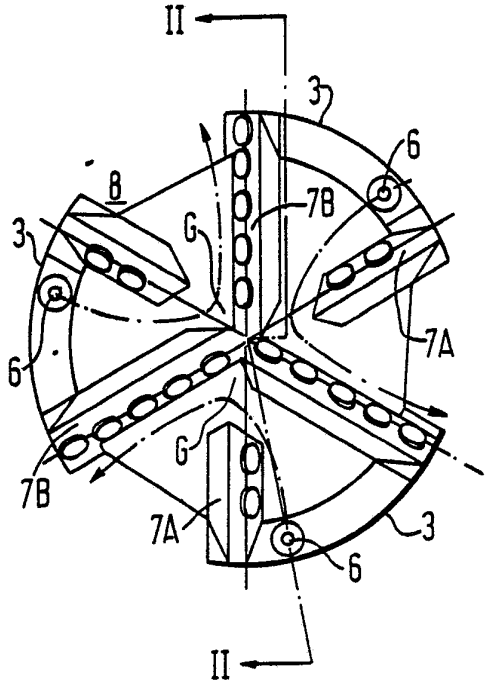

FIG.1

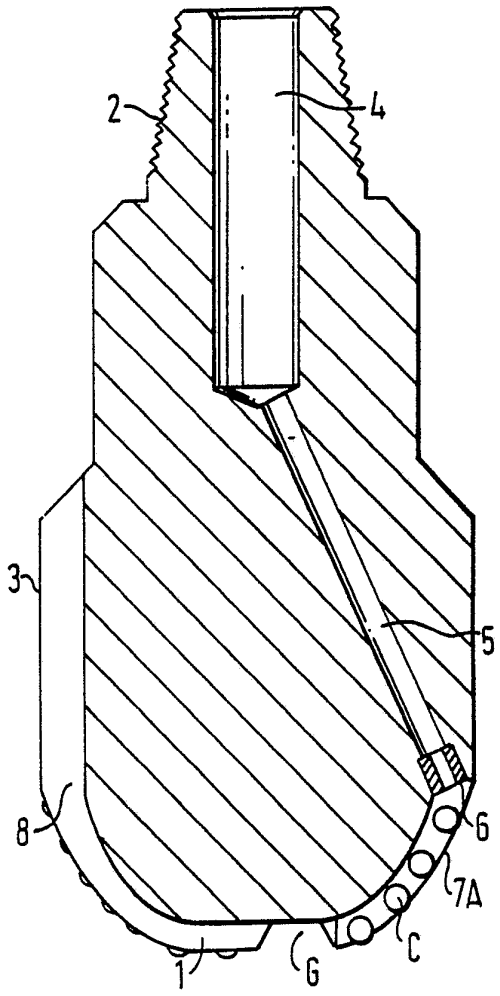

FIG.2

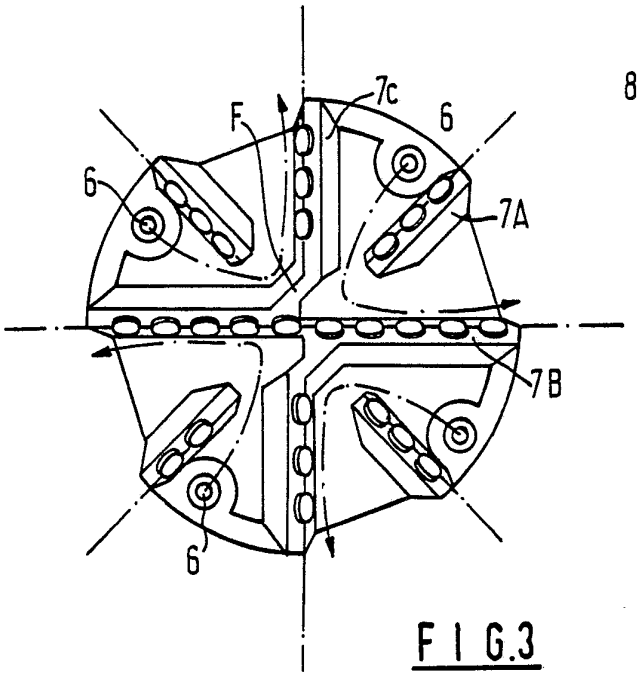

FIG.3

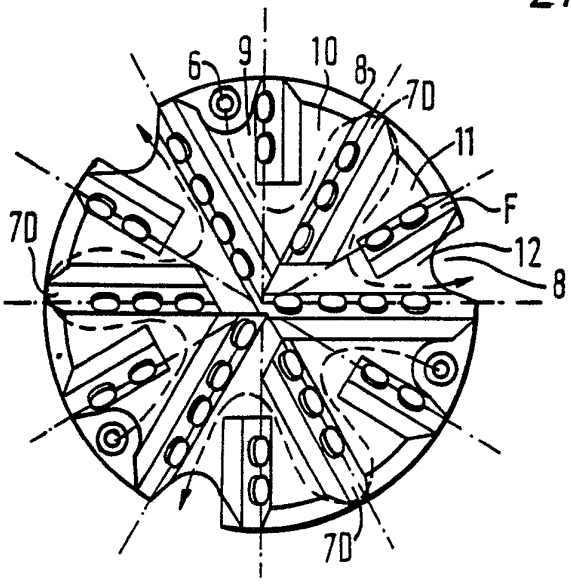

FIG.4

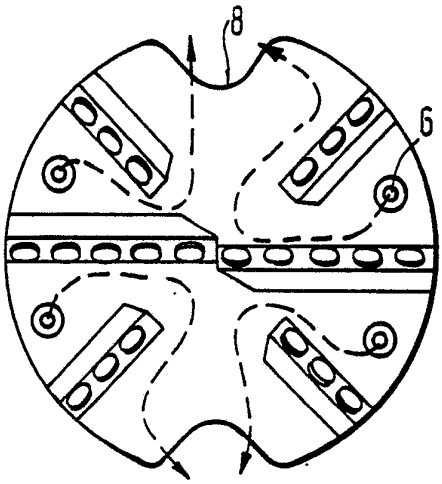

FIG.5

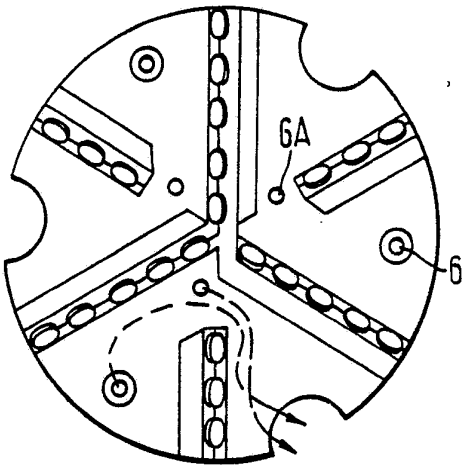

FIG.6

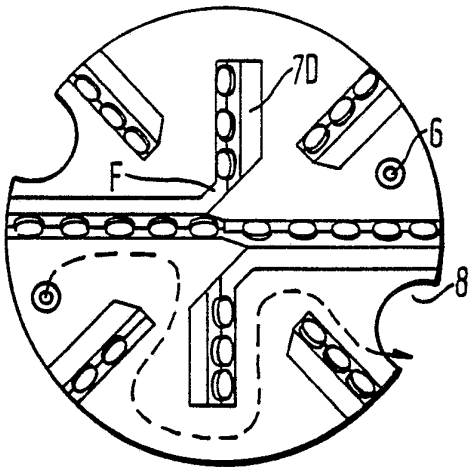

FIG.7

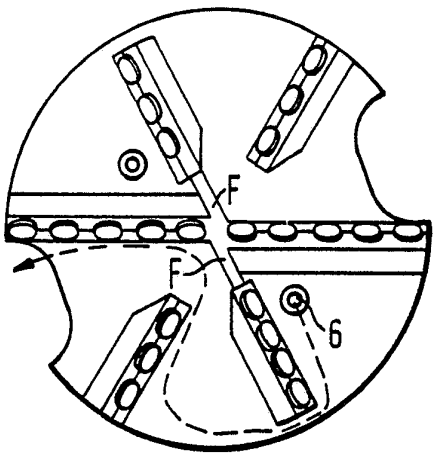

FIG.8

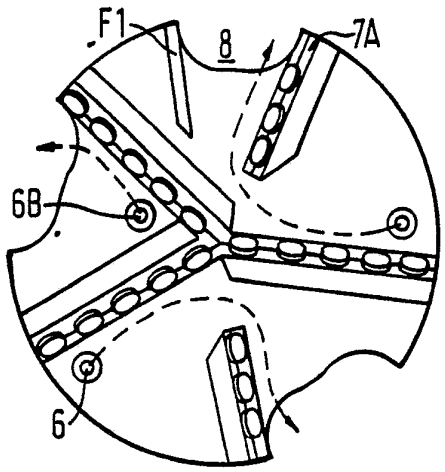

FIG.9

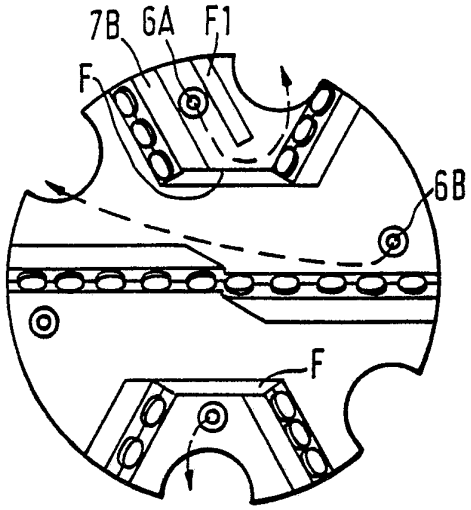

FIG.10

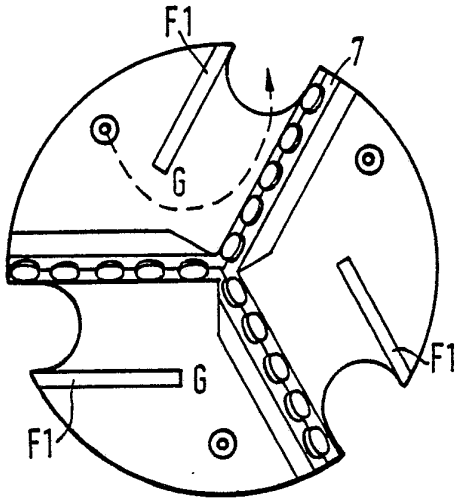

FIG.11

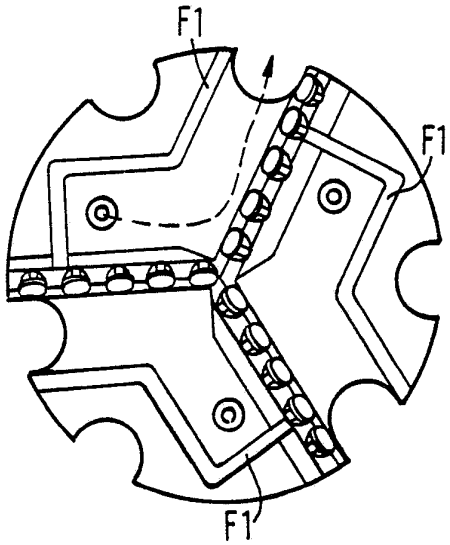

FIG.12

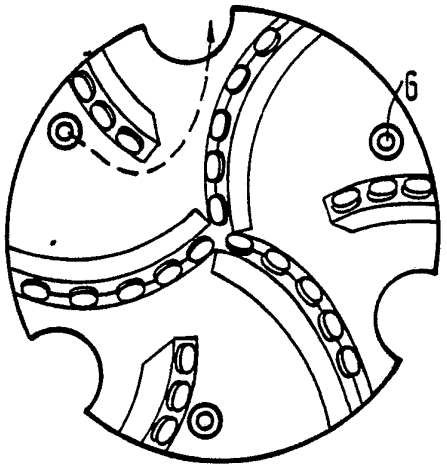

FIG.13

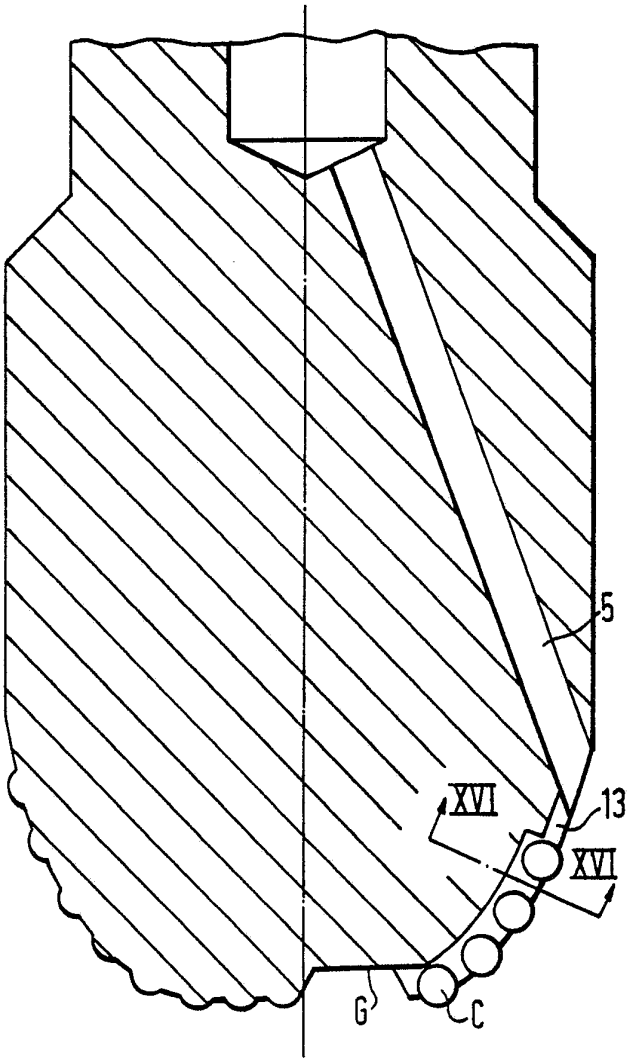

FIG.15

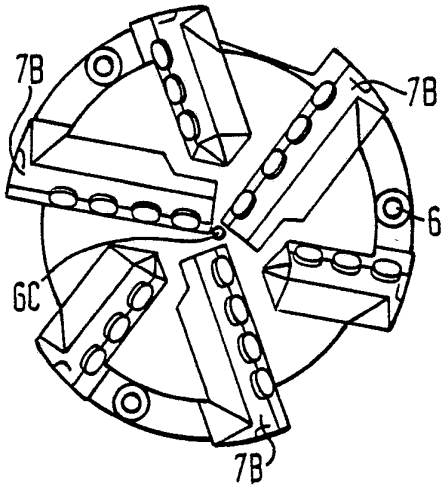

FIG.14

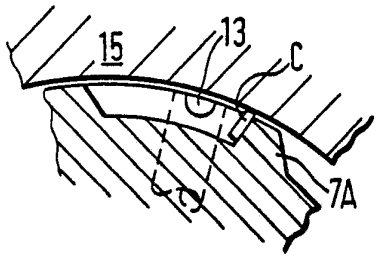

FIG.16

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 83/00227

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[3]: E 21 B 10/60; E 21 B 10/46

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC[3]	E 21 B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 3215215 (KELLNER) 2 November 1965 see figure 9; column 6, line 69 - column 7, line 12; column 7, lines 24-33; column 4, lines 18-20	1-3,6,7,10
A	US, A, 4098363 (ROHDE) 4 July 1978 see figures 1-4,6,9; column 3, lines 10-18; column 4, lines 5-36; column 5, lines 1-15	1,4-8,10
A	US, A, 3308896 (HENDERSON) 14 March 1967 see figures 11 and 14; column 6, lines 7-18; column 3, lines 50-55	1-6,10
A	DE, B, 1199209 (BUTTCHEREIT) 26 August 1965 see column 2, lines 14-17	3
A	DE, B, 2814165 (GUSE) 16 August 1979 see column 2, line 57 - column 3,	3 ./.

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [3]	Date of Mailing of this International Search Report [3]
18th November 1983	02 JAN. 1984
International Searching Authority [1]	**Signature of Authorized Officer [20]**
EUROPEAN PATENT OFFICE	G.L.M. Kruyderberg

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, 16 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No 18
	line 31	
	--	
A	GB, A, 2085945 (JÜRGENS) 6 May 1982 see the entire document	1,4-8,10
	--	
A	EP, A, 0032791 (FULLER) 29 July 1981 see the entire document cited in the application	1,4,8,10

ANNEX TO The INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/GB 83/00227 (SA 5754)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 01/12/83

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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 3215215		None		
US-A- 4098363	04/07/78	BE-A-	866300	24/10/78
		FR-A,B	2388982	24/11/78
		DE-A,C	2817986	02/11/78
		GB-A-	1596609	26/08/81
US-A- 3308896		None		
DE-B- 1199209		None		
DE-B- 2814165	16/08/79	GB-A-	2017533	10/10/79
		FR-A,B.	2420996	26/10/79
		AU-A-	4501279	18/10/79
		US-A-	4244521	13/01/81
		CA-A-	1112255	10/11/81
GB-A- 2085945	06/05/82	BE-A-	890802	15/02/82
		FR-A-	2492451	23/04/82
		DE-A,C	3039633	06/05/82
		JP-A-	57100287	22/06/82
		AU-A-	7636981	29/04/82
EP-A- 0032791	29/07/81	JP-A-	56125593	01/10/81