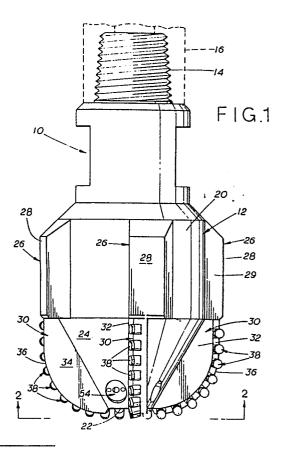
9))	Europäisches Patentamt European Patent Office Office européen des brevets	1 Publication number:	0 295 045 A2
EUROPEAN PATENT APPLICATION			
 Application number: 88305172.4 (5) Int. Cl.4: E21B 10/60 , E21B 10/56 Date of filing: 07.06.88 			
 Priority: 09.06.87 US 59933 Date of publication of application: 14.12.88 Bulletin 88/50 Designated Contracting States: DE FR GB NL 		 Applicant: REED TOOL COMPANY P.O. Box 2119 Houston Texas 77252(US) Inventor: Sabados, Michael F. 7706 Muirfield Circle Houston Texas 77095(US) Inventor: Thompson, Charles M. 5410 Coral Gables Houston Texas 77069(US) Representative: Smith, Norman Ian et al F.J. CLEVELAND & COMPANY 40-43 Chancery Lane London WC2A 1JQ(GB) 	

A Rotary drag bit having scouring nozzles.

A drag type rotary drill bit (10) having a plurality of cutting elements (38) arranged in a plurality of rows extending radially in a generally arcuate path along the adjacent arcuate surface of the drill bit (10). The bore hole is defined by an arcuate concave surface (C) formed by the arcuate rows of the cutting elements (38) upon rotation of the drill bit (10). The centerline (70) of the fluid jet discharged from orifice (66) of scouring nozzle (54) strikes concave surface (C) at a point (P) at an angle between twenty-five (25) degrees and sixty-five (65) degrees with respect to the tangent (T) through point (P) for digging into the concave bottom hole surface (C) in a scouring action and continuing the scouring action after being deflected by the concave surface (C).



EP 0 295 045 A2

Xerox Copy Centre

ROTARY DRAG BIT HAVING SCOURING NOZZLES

5

10

15

20

25

30

35

40

45

50

Background of the Invention

This invention relates generally to drag type rotary drill bits, and more particularly to improvements in the arrangement of cutting elements and fluid discharge nozzles on the drill bit for obtaining a highly effective scouring action against the hole bottom immediately ahead of the associated cutting elements.

1

It has become common practice to dress drag type rotary well drilling bits with cutting elements made of man made polycrystalline diamond compacts or cutters projecting from the bit body. This technology has allowed diamond cutting elements to be formed and shaped into more desirable cutting edges and has further provided higher strength diamonds allowing cutting edges to project a maximum distance from the bit body. One polycrystalline diamond cutting structure in common use has been what is commonly referred to as polycrystalline diamond compact (PDC) which is a small carbide plate with a thin layer of polycrystalline diamond bonded to one face. This has resulted in PDC type diamond drill bits capable of drilling more efficiently in softer formations than was possible with the natural diamonds used in earlier diamond bits.

The use of rotary drag drill bits with diamond cutting elements has also had resultant undesirable increased problems associated with heat degradation and "balling". Balling is a build up of formation chips or cuttings on the bit face or the hole bottom and is caused by sticky formations, such as sticky shales or similar formations having clays therein, adhering to the bottom of the hole and the cutting face of the bit. This balling condition not only deters drilling, but it also causes rapid heat deterioration of the cutting elements due to poor circulation and decreased cutting efficiency.

This balling condition occurs primarily when using water based muds which cause a swelling of the clays. It is highly desirable to provide a bit dressed with polycrystalline diamond cutting elements which has the versatility to not only drill efficiently in soft, sticky formations when using water base muds, but also remains effective and durable when harder formations are encountered.

U. S. Patent No. 4,098,363 dated July 4, 1978 has a plurality of nozzles for each row of cutting elements with the nozzles being arranged in a spiral path extending from the center of the bit to the gage of the bit. The nozzles do not direct streams of drilling fluid immediately ahead of the leading cutting elements, and since a large number of nozzles are provided, relatively small diameter orifices which are subject to clogging are required in order to maintain adequate discharge velocity.

2

U. S. Patent No. 4,499,958 discloses a deep bladed design for a drill bit using polycrystalline diamond cutting elements but this design does not have a desirable cleaning effect for the hole bottom and the edges of the cutting elements. Also, this type bit may be subjected to considerable wear and breakage when harder formations are encountered because of the relatively small number of cutting elements that can be arranged on the blades and the relatively long projection of the cutting elements from the adjacent bit body or blade.

U. S. Patent No. 4,505,342 discloses a drill bit which has a high density of polycrystalline diamond cutting elements, and has fluid nozzles directed at the well bore bottom. After the fluid impinges the well bore bottom a portion of the fluid flows at a relatively low velocity through the fluid channels directing it in front of rows of cutting elements in an attempt to adequately flush all of the cutting elements and clean the hole bottom. The fluid velocity resulting in these channels is too low, however, to prevent balling and to provide adequate cleaning of the hole bottom and the cutting elements when drilling soft sticky formations with water base muds.

In other attempts to solve this severe cleaning problem resulting from soft sticky formations, U. S. Patent Nos. 4,452,324; 4,471,845; 4,303,136; and 4,606,418 have disclosed polycrystalline diamond drill bits with relatively large numbers of nozzle orifices in the bit in an attempt to adequately clean all of the cutting elements on the bit. However, if the velocity and total orifice area are maintained, a large number of nozzle orifices will result in orifices of a small area and this will increase the probability of clogging of some of the nozzle orifices. A reduced velocity will result in the event the total orifice area for the bit is increased and this likewise will increase the probability of clogging of the nozzle orifices.

Summary of the Invention

The present invention discloses a drag type rotary drill bit which shapes the bottom hole in the formation so that a generally arcuate concave outer ring or annular surface is formed along the bottom hole surface. The cutting elements and associated nozzles are arranged so that the nozzles scour the hole bottom along the concave outer surface immeŤ

**

10

15

20

25

30

40

50

55

The cutting elements are arranged in a plurality of rows extending in a generally radial direction along an arcuate path from adjacent the longitudinal centerline of the bit to the gage of the bit which defines the diameter of the borehole. Each row of cutting elements preferably is associated with one nozzle having an outwardly directed relatively large diameter fluid orifice to minimize clogging. The plurality of closely spaced cutting elements in each row are arranged along an arcuate path generally complementary to the adjacent annular concave surface of the bottom hole. The centerline of the outwardly directed stream of drilling fluid being discharged from each nozzle strikes the adjacent concave surface of the bottom hole at an angle of between around twenty-five (25) to sixty-five (65) degrees to the tangent of the adjacent curved concave surface thereby tending to scour or dig into the bottom hole surface for scouring at least a portion of the bottom immediately ahead of the associated cutting elements. The scouring action continues as the discharged drilling fluid is directed along the concave hole bottom surface in a direction generally parallel to the associated row of cutting elements and then flows upwardly along the generally cylindrical side of the hole. By striking the concave surface at an angle between twentyfive (25) to sixty-five (65) degrees the fluid stream is deflected in an upward direction by the concave arcuate surface and continues the scouring action as it flows along the concave surface to assist the upward flow of drilling fluid and entrained cuttings for removal from the hole.

It is an object of this invention to provide a rotary drag type drilling bit utilizing polycrystalline diamond cutters and a minimum number of fluid discharge nozzles for drilling sticky formations with water base muds.

It is a further object of this invention to provide such a rotary drag bit in which the cutting elements are arranged on the bit in a plurality of rows on the outer contour of the bit body extending along a generally arcuate convex path in a generally radially direction from the center of the bit to the gage of the bit.

An additional object of the invention is to provide in combination with the radially extending arcuate rows of cutting elements, at least one nozzle for each row for directing a stream of drilling fluid against the adjacent arcuate concave bottom hole surface immediately in front of the associated row of cutting elements for the flow of fluid in an outward direction generally parallel to the associated row of cutting elements thereby to scour the concave bottom hole surface immediately before it is engaged in cutting contact by the adjacent associated cutting elements.

The terms "diamond", "polycrytalline diamond", or "PDC" cutting elements, as used in the specification and claims herein shall be interpreted as including all diamond or diamond-like cutting elements having a hardness generally similar to the hardness of a natural diamond.

Other objects, features, and advantages of this invention will become more apparent after referring to the following specification and drawings.

Figure 1 is a side elevation view of one embodiment of this invention showing a rotary drag drill bit having a plurality of blades thereon with each blade having a row of cutting elements thereon:

Figure 2 is a bottom plan of the drill bit shown in Figure 1 looking generally along line 2-2 of Figure 1 and illustrating the blades extending in a generally radial direction from the center of the drill bit:

Figure 3 is a section taken generally along line 3-3 of Figure 2 showing a fluid discharge nozzle with a fluid stream being discharged therefrom against the adjacent concave bottom hole surface immediately ahead of the associated row of cutting elements;

Figure 4 is an enlarged fragment of Figure 3 showing the fluid discharge from the discharge nozzle scouring the adjacent concave surface of the bottom hole with the drilling fluid being deflected by the concave surface upwardly after striking the formation;

Figure 5 is a side elevation view of a further embodiment of a drag type drill bit illustrating a 35 generally cylindrical bit body having a lower generally hemispherical outer face for rows of cutting elements mounted on studs extending from the face of the bit body;

Figure 6 is a bottom plan of the rotary drag type drill bit shown in Figure 5; and

Figure 7 is a section taken generally along line 7-7 of Figure 6 showing a discharge nozzle and associated row of cutting elements.

Referring particularly to the embodiment of the 45 invention shown in Figure 1-4, a drag type rotary drill bit is shown generally at 10 having a generally cylindrical bit body 12 with an externally threaded pin 14 at its upper end. Pin 14 is threaded within the lower end of the drill string indicated generally at 16 which is suspended from a drilling rig at the surface for rotating drill bit 10. Drill bit body 12 has a longitudinally extending main fluid passage 18 which is adapted to receive drilling fluid or mud from a drilling rig for the drilling operation and a branch fluid line 19 leads from passage 18.

Bit body 12 has an upper outer peripheral surface 20 forming an outer gage, and a lower

10

15

20

25

30

35

40

45

50

55

<u>ج</u> *

5

outer peripheral face or surface 22 generally indicated which forms a suitable crown and includes a generally frusto-conical outer surface 24 between the lower end of peripheral surfaces 20 and 22. Extensions 26 have an outer arcuate surface 28 and the slots formed between extensions 26 provide a passage for the upward flow of drilling fluid and entrained cuttings. A leading planar surface 29 is formed by each extension 26. It is to be understood that bit body 12 can be formed of various types of crown designs for the face of the bit body depending, for example, on such factors as the type of formation or the mud program proposed for the formation. Bit body 12 may be formed of any suitable material, such as various types of steel or cast tungsten carbide.

Four blades, each indicated by the numeral 30, extend in a generally radial direction from the frusto-conical surface 24 between output peripheral surface 20 and lower generally horizontal surface 22. Blades 30 are spaced circumferentially about frusto-conical surface 24 at ninety (90) degree intervals. Each blade 30 has a generally planar leading surface 32, a generally planar rear surface 34, and an arcuate outer edge surface 36 extending between planar surfaces 32 and 34.

Mounted along adjacent arcuate surface 36 on each blade 30 is a row of closely spaced cutting elements each indicated generally at 38. Each row of cutting elements 38 extends radially in a generally arcuate path along adjacent arcuate surface 36. Each cutting element 38 is identical and comprises a stud 40 formed of a hardened tungsten carbide material. Stud 40 as shown in Figure 4 fits within an opening 42 in blade 30 and is secured therein, for example, by an interference fit or by brazing. Stud 40 has a planar leading surface on which a generally cylindrical disc 44 is secured, such as by brazing. Disc 44 has a base 46 formed of tungsten carbide, an outer planar cutting face 48 defined by an outer diamond layer, and a peripheral cutting edge 50 extending about planar face 48. Cylindrical disc 44 with a diamond face and tungsten carbide base, as well known in the art, is manufactured by the Specialty Material Dept. of the General Electric Company at Worthington, Ohio and sold under the trademark "Stratapax".

It is desirable that cutting face 48 have a negative rake or be inclined with respect to the direction of rotation of drill bit 10. A negative rake angle of around twenty (20) degrees has been found to be satisfactory for most formations although it is believed that a negative rake between around five (5) degrees and around thirty-five (35) degrees will function adequately for a polycrystal-line diamond face or a natural diamond face.

The bore hole as shown particularly in Figure 3 is generally cylindrical and is defined by a cylin-

drical side surface A, a central generally flat bottom surface B, and an arcuate concave annular surface C extending between surfaces A and B. Arcuate concave surface C is formed by the arcuate rows of cutting elements 38 upon rotation of drill bit 10.

As shown in Figure 2, lower face 22 has a pair of relatively small diameter fluid discharge orifices 52 for the discharge of drilling fluid from fluid passage 18 vertically downwardly against the bore hole bottom shown at B. Mounted ahead of each row of cutting elements 38 is a fluid discharge nozzle indicated generally at 54 as shown particularly in Figures 3 and 4. Discharge nozzle 54 is formed of a tungsten carbide material and is externally threaded at 56 for being screwed within an internally threaded opening 58 defining a smooth annular end surface 59. Openings 60 in the face of nozzle 54 adjacent end surface 59 are adapted to receive a suitable tool for securing nozzle 54 within threaded opening 58 for abutting engagement with an abutting end shoulder 62. A resilient 0-ring 64 is provided for sealing between nozzle 54 and bit body 12.

Nozzle 54 defines a relatively large diameter fluid discharge orifice 66 which may circular or oval in shape to provide a laterally divergent stream or jet of fluid illustrated generally by broken lines at 68 on Figure 4. The spray angle of orifice 66 will normally be around five (5) degrees, for example, and a relatively large diameter of over around three-sixteenth (3/16) inch is preferred for orifice 66. The centerline of the jet of fluid being discharged from orifice 66 is shown at 70 and centerline 70 strikes concave surface C at a point P. The divergent fluid stream has a surface area of impingement I against surface C about point P. Centerline 70 with respect to a tangent T through point P is preferably around forty-five (45) degrees but satisfactory results are obtainable at an angle D between around twenty-five (25) degrees and sixtyfive (65) degrees. Upon striking concave surface C at an angle D, the fluid tends to dig into or scour the area of impingement I, such as shown schematically in Figures 2 and 4, and then is deflected in an upward direction while continuing to scour the concave surface C as the fluid flows upward along the concave hole bottom and along the associated row of cutting elements 38. The scouring or scouring action of the fluid stream, which is discharged at a high velocity of over one hundred (100) feet per second, clears or digs into the formation defined by the concave bottom hole surface and continues after striking the impingement areas A with the deflected fluid stream being directed upwardly by the concave bottom surface which continuously changes the direction of fluid flow.

The flow of fluid after striking concave surface C is in a generally radial direction generally parallel

to the row of cutting elements 38 and immediately ahead of the cutting elements. Thus, immediately before cutting elements 38 engage the adjacent bore hole surface, area I is scoured by a high velocity stream of drilling fluid from nozzle 54 and the scouring action continues as the stream flows outwardly along the concave hole bottom thereby improving the cutting effectiveness of a cutting elements 38 while providing drilling fluid for washing the cutting faces of cutting elements 38. Under certain conditions, it may be desirable for at least a portion of the divergent stream of drilling fluid to strike adjacent cutting elements 38 and thereby provide a highly effective washing action including cutting elements 38.

Referring now to Figures 5-7, a separate embodiment of the invention is shown in which the rotary drill bit I0A is shown having an outer peripheral surface 20A and a lower generally hemispherical or bulbous surface 24A forming a smooth continuation of the outer peripheral surface 20A and terminating at a relatively small diameter generally horizontal lower central surface 22A. Junk slots 27A are provided at ninety (90) degree intervals along outer peripheral surface 20A to provide passageways for the upward flow of drilling fluid and entrained cuttings.

Four rows of cutting elements 38A are mounted on the outer surface of drill bit 10A along frusto-conical or hemispherical surface 24A and extend upwardly in an arcuate radial path along outer peripheral surface 20A. Cutting elements 38A are identical to those shown in the embodiment of Figures 1-4 and have studs 40A fitting within openings 42A in body 12A of drill bit IOA. The rows of cutting elements 38A extend in a generally arcuate path radially from the centerline of the drill bit IOA. A fluid discharge nozzle 54A is provided for each row of cutting elements 38A and has an orifice 66A. The centerline of the discharged fluid stream from orifice 66A is illustrated at 70A. Centerline 70A strikes arcuate concave surface C of the bore hole at an angle D1 which is similar to angle D in the embodiment of Figures 1-4. Drilling fluid is received from branch fluid passage 19A and is discharged in a stream or jet having its centerline at 70A for impinging concave surface C at point P with the fluid stream scouring the bore bottom immediately ahead of the associated row of cutting elements 38A and being deflected upwardly by concave surface C for flow out of the bore hole.

Thus, the embodiment shown in Figures 5-7 does not utilize blades for the mounting of cutting elements 38A but instead, mounts cutting elements 38A into openings 42A arranged in drill bit body 12A. The arrangement of nozzles 54A and the fluid flow through orifices 66A is generally identical to that shown in the embodiment of Figures 1-4.

While preferred embodiments of the present invention have been illustrated in detail, it is apparent that modifications and adaptations of the preferred embodiments will occur to those skilled in the art. However, it is to be expressly understood that such modifications and adaptations are within the spirit and scope of the present invention as set forth in the following claims.

10

25

Claims

1. A rotary drag drill bit comprising:

a bit body having a main fluid passage therein adapted to be connected to a drill string for rotation therewith and to receive drilling fluid therefrom, said bit body having a lower face and a plurality of branch fluid passages in fluid communication with the main fluid passage to receive drilling fluid 20, therefrom;

a plurality of generally radially extending rows of closely spaced cutting elements projecting from the lower face of the bit body and extending along a generally arcuate path from adjacent the center of the bit body to the gage of the bit body, the generally radially extending arcuate rows of cutting elements forming an outer concave annular surface on the bore hole bottom; and

at least one relatively large fluid discharge nozzle associated with each row of cutting ele-30 ments and directing a stream of drilling fluid against the outer concave annular surface in a generally outward radial direction extending generally parallel to the associated row of cutting elements, the center of the fluid stream being dis-35 charged from said nozzle striking the outer concave annular surface of the bore hole bottom immediately ahead of the associated row of cutting elements for scouring the bore hole bottom thereat and then being deflected with continued scouring Δn in a generally upward direction by said concave surface for upward flow with entrained cuttings for removal of the cuttings.

2. A rotary drill bit as set forth in claim 1 wherein a plurality of blades extend generally radially along the outer face of the bit body, each blade having a row of cutting elements thereon.

3. A rotary drill bit as set forth in claim 1 wherein said outer face of said drill bit body has a plurality of rows of openings therein;

and studs are secured within said openings and have said cutting elements mounted thereon extending along a generally arcuate path from the center of the bit body to the gage of the bit body.

55

45

50

4. A rotary drill bit as set forth in claim 1 wherein said stream of drilling fluid directed against the outer concave annular surface by the fluid discharge nozzle has its center at an angle of

10

15

20

25

30

35

40

45

50

55

between twenty-five degrees and sixty-five degrees with respect to the tangent of the concave surface of the bore hole bottom at the center of the striking stream, said striking fluid stream being at a sufficient velocity to scour the bore hole bottom immediately ahead of the row of associated cutting elements.

5. A rotary drag drill bit comprising:

a bit body having a main fluid passage therein adapted to be connected to a drill string for rotation therewith and to receive drilling fluid therefrom, said bit body having a lower face and a plurality of branch fluid passages in fluid communication with the main fluid passage to receive drilling fluid therefrom;

a plurality of generally radially extending rows of closely spaced polycrystalline diamond cutting elements projecting from the lower face of the bit body and extending along a generally arcuate path from adjacent the center of the bit body to the gage of the bit body, the generally radially extending arcuate rows of cutting elements forming an outer concave annular surface on the bore hole bottom having a width of at least one-fourth the diameter of the hole;

at least one relatively large fluid discharge nozzle associated with each row of cutting elements and directing a stream of drilling fluid against the outer concave annular surface in a generally outwardly radial direction extending generally parallel to the associated row of cutting elements, the center of the fluid stream being discharged from said nozzle striking the outer concave annular surface of the bore hole bottom immediately ahead of the associated row of cutting elements for scouring the bore hole bottom thereat and then being deflected in a generally upward direction by said concave surface for upward flow with entrained cuttings for removal of the cuttings;

said stream of drilling fluid directed against the outer concave annular surface by the fluid discharge nozzle has its center at an angle of between twenty-five degrees and sixty-five degrees with respect to the tangent of the concave surface of the bore hole bottom at the center of the striking stream, said striking fluid stream being at a sufficient velocity to scour the bore hole bottom immediately ahead of the row of associated cutting elements.

6. A rotary drag drill bit as set forth in claim 5 wherein a plurality of blades extend generally radially along the outer face of the bit body, each blade having a row of cutting elements thereon.

7. A rotary drill bit as set forth in claim 5 wherein said outer face of said drill bit body has a plurality of rows of openings therein;

and studs are secured within said openings

and have said cutting elements mounted thereon extending along a generally arcuate path from the center of the bit body to the gage of the bit body.

8. A rotary drag drill bit comprising:

a bit body having a main fluid passage therein adapted to be connected to a drill string for rotation therewith and to receive drilling fluid therefrom, said bit body having a lower face and a plurality of branch fluid passages in fluid communication with the main fluid passage to receive drilling fluid therefrom;

a plurality of generally radially extending rows of closely spaced cutting elements projecting from the lower face of the bit body and extending along a generally arcuate path from adjacent the center of the bit body to the gage of the bit body;

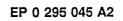
at least one relatively large fluid discharge nozzle associated with each row of cutting elements and directing a stream of drilling fluid against the adjacent bore hole surface in a generally radially outwardly direction extending generally parallel to the associated row of cutting elements, the center of the fluid stream being discharged from said nozzle striking the adjacent bore hole surface immediately ahead of the associated row of cutting elements for scouring the bore hole bottom thereat and continuing scouring the hole bottom after being deflected in a generally upward direction by said bore hole surface for upward flow with entrained cuttings for removal of the cuttings;

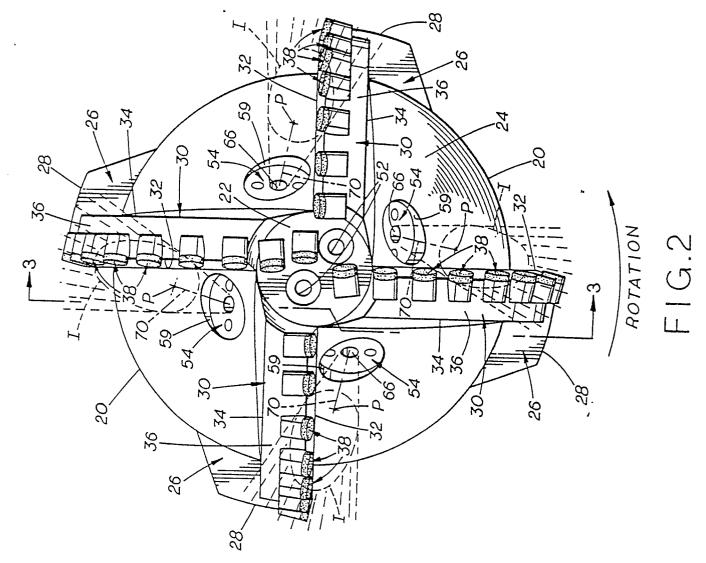
said stream of drilling fluid directed against said bore hole surface by the fluid discharge nozzle has its center striking a point on the bore hole surface at an angle of between twenty-five degrees and sixty-five degrees with respect to a tangent at said striking point, said striking fluid stream being at a sufficient velocity to scour the bore hole bottom in an area immediately ahead of the row of associated cutting elements.

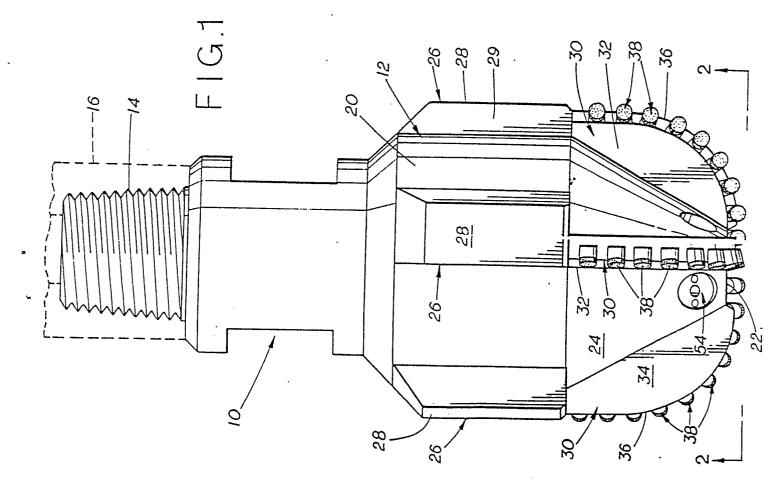
9. A rotary drag drill bit as set forth in claim 8 wherein a plurality of blades extend generally radially along the outer face of the bit body, each blade having a row of cutting elements thereon.

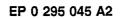
10. A rotary drill bit as set forth in claim 8 wherein said outer face of said drill bit body has a plurality of rows of openings therein;

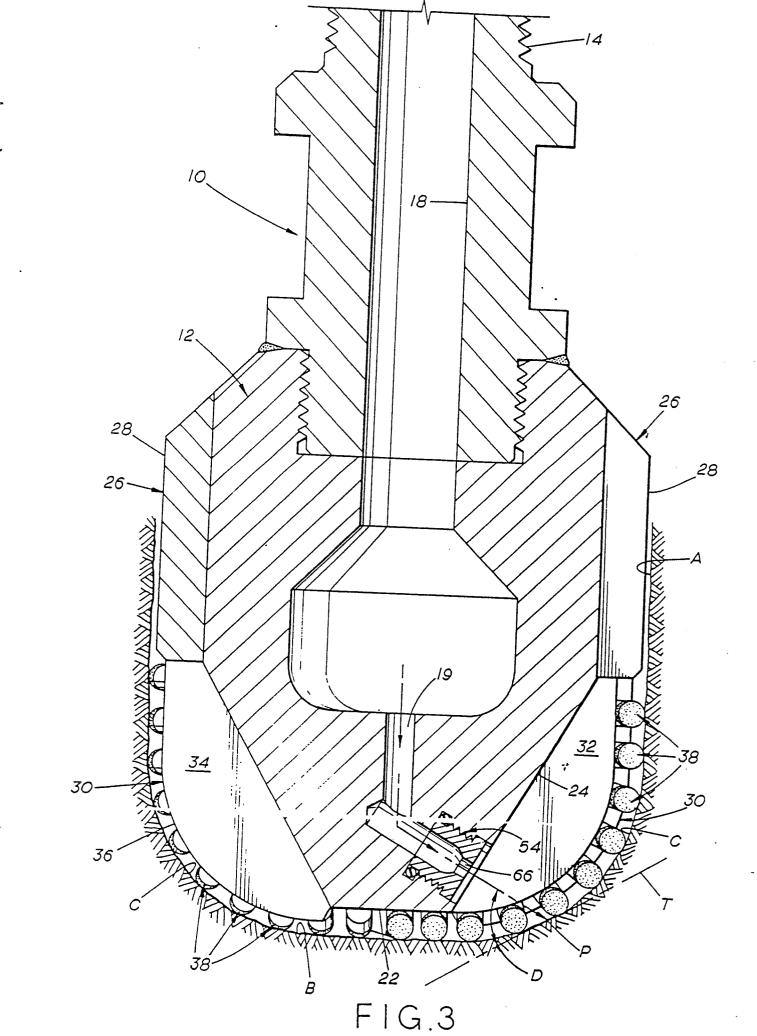
and studs are secured within said openings and have said cutting elements mounted thereon extending along a generally arcuate path from the center of the bit body to the gage of the bit body.

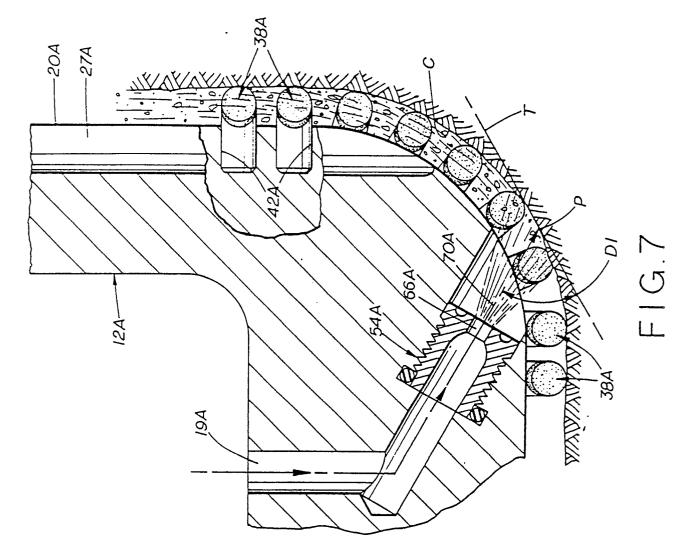




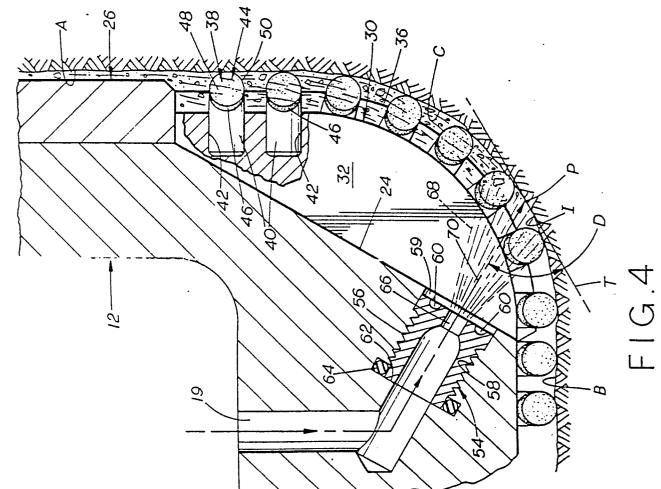


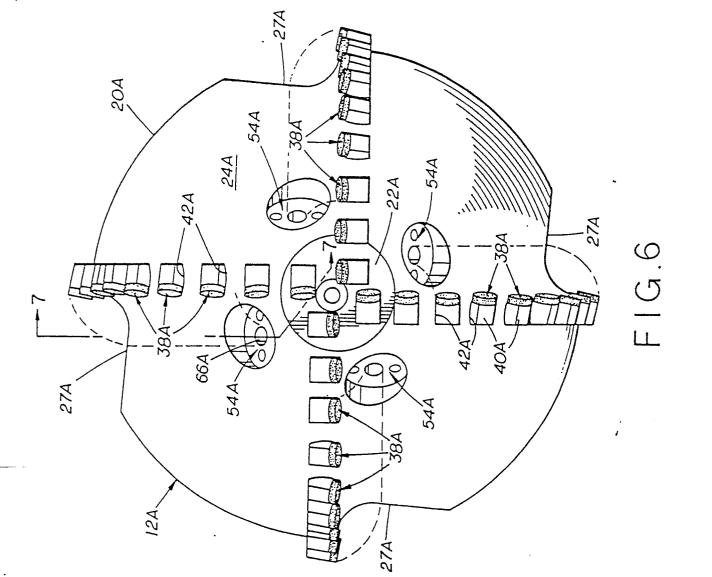


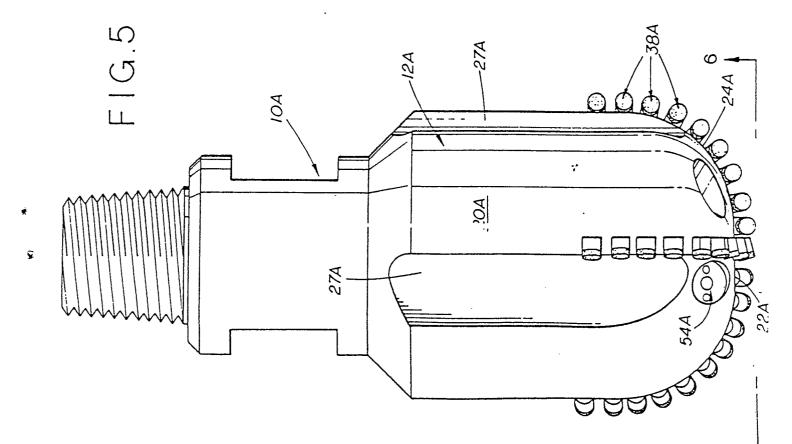




٣.,







9-