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(71) Applicant : **CAMCO DRILLING GROUP LIMITED**
Hycalog Oldends Lane Industrial Estate
Stonehouse, Gloucestershire GL10 3RQ (GB)

(72) Inventor : **Hollister, Kelly**
13010 Finch Brook Drive
Cypress, Texas 77429 (US)
Inventor : **Newton, Alex**
13711 Cricket Hollow
Houston, Texas 77069 (US)
Inventor : **Griffin, Nigel Dennis**
15 Paynes Meadow
Whitminster, Gloucestershire GL2 7PS (GB)
Inventor : **Taylor, Malcolm Roy**
9 Kenilworth Avenue
Gloucester GL2 0QJ (GB)
Inventor : **Matthias, Terry Richard**
17 Penny Close
Longlevens, Gloucester GL2 0NP (GB)

(74) Representative : **Carter, Gerald et al**
Arthur R. Davies & Co. 27 Imperial Square
Cheltenham, Gloucestershire GL50 1RQ (GB)

(54) **Improvents in or relating to cutting elements for rotary drill bits.**

(57) A preform cutting element for a rotary drill bit includes a cutting table (18) of polycrystalline diamond material having a front cutting face, a peripheral surface, and a rear face bonded to a substrate of cemented tungsten carbide. The cutting table includes an outer peripheral portion (20), defining at least a part of the peripheral surface, which is formed of a first form of diamond, for example of larger grain size, which is of greater impact resistance than a second form of diamond forming other portions (19) of the cutting table. This protects the cutting edge of the cutting element against impact damage in use, particularly before a significant wear flat has formed.

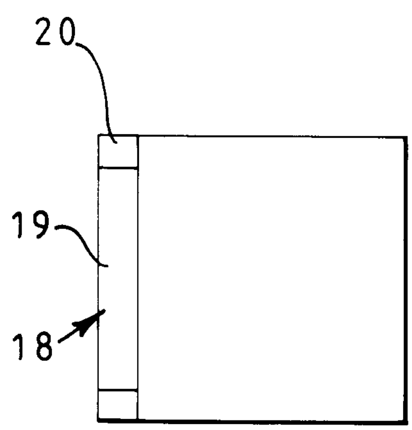

FIG 5

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The invention relates to cutting elements for rotary drill bits for use in drilling or coring holes in subsurface formations. The invention may be applied to a number of different kinds of rotary drill bits, including drag bits, roller cone bits and percussion bits.

By way of example, the invention will be primarily described in relation to cutting elements for use on rotary drag bits of the kind comprising a bit body having a shank for connection to a drill string and an inner passage for supplying drilling fluid to the face of the bit, the bit body carrying a plurality of cutting elements. Each cutting element comprises a preform element, often in the form of a circular tablet, including a cutting table of superhard material having a front cutting face, a peripheral surface, and a rear face, the rear face of the cutting table being bonded to a substrate of material which is less hard than the superhard material.

The cutting table usually comprises polycrystalline diamond, although other superhard materials are available, such as cubic boron nitride. The substrate of less hard material is often formed from cemented tungsten carbide, and the cutting table and substrate are bonded together during formation of the cutting element in a high pressure, high temperature forming press. This forming process is well known and will not be described in detail.

Since the substrate is of less hard material than the cutting table, the two-part arrangement of the cutting element provides a degree of self-sharpening since, in use, the less hard substrate wears away more easily than the harder cutting table.

The preform cutting element may be directly mounted on the bit body or may be bonded to a carrier, for example also of cemented tungsten carbide, the carrier being in turn received in a socket in the bit body. The bit body may be machined from metal, usually steel, or may be formed from an infiltrated tungsten carbide matrix by a powder metallurgy process.

In such cutting elements the cutting table is normally formed from a superhard material having high abrasion resistance since this is necessary for effective operation and long life of the cutting elements under operating conditions. However, the cutting elements may also be subjected to substantial impact loads when the drill is in use down a borehole. For example, such impact loads can result from the impingement of the drill bit on the bottom of the borehole when it is first introduced into the borehole, or may occur when the cutting elements strike hard occlusions in a softer formation. Also, impact can arise due to other unexpected or unpredictable irregularities in the motion of the bit, for example the development of the phenomenon known as "bit whirl".

Such impact loads may result in cracking or chipping of the cutting table or in spalling, that is to say the separation and loss of superhard material over part of the cutting surface of the table. Such damage reduces the cutting efficiency of the element and in severe cases may result in it becoming completely ineffective. Impact damage to cutting elements is particularly liable to occur when a drill bit is new or comparatively new, since at that stage significant wear flats will not have been formed on the cutting edges of the cutting elements, with the result that any impact loads are concentrated on a very small area of each cutting element.

The impact resistance of the cutting table may be increased by appropriate selection of the composition of the superhard material but, generally speaking, an increase in impact resistance will result in a reduction in abrasion resistance. The actual composition selected is usually therefore a compromise between these requirements.

The present invention sets out to provide preform cutting elements which are highly resistant to impact, particularly when the cutting elements are comparatively new, and yet which will still have the required degree of abrasion resistance for normal drilling operations. A further feature of preferred embodiments of the invention is that the cutting elements may also be of enhanced cutting effectiveness.

According to the invention there is provided a preform cutting element including a cutting table of superhard material having a front cutting face, a peripheral surface, and a rear face bonded to a substrate of material which is less hard than the superhard material, the cutting table including an outer peripheral portion, defining at least a part of said peripheral surface, which is formed of a first superhard material which is of greater impact resistance than a second superhard material forming other portions of the cutting table.

Thus, since the material of greater impact resistance is provided at the periphery of the cutting element, the element will be highly resistant to impact damage when new. However, by the time the impact resistant material at the periphery has been worn away so that the more abrasion resistant material is in contact with the formation, the resultant wear flat on the cutting table will have the effect of spreading over a greater area any impact loads which may occur and reducing the risk of damage to the cutting element as a result of such impact loads.

Preferably said outer peripheral portion extends around the entire periphery of the cutting table. Preferably also the outer peripheral portion is disposed around the junction between the front cutting face and the peripheral surface of the cutting table, so as to define at least a part of each of said surfaces.

Said second superhard material may be of greater abrasion resistance than the first superhard material from which the outer peripheral portion is formed.

In one embodiment of the invention there is disposed inwardly of said portion of greater abrasion resistance a further portion of the cutting table which is formed of a superhard material which is of lesser abrasion resistance than said portion of greater abrasion resistance. Said further portion may be of substantially the same composition as the outer peripheral portion.

In another embodiment according to the invention the cutting table may include a layer of said one superhard material in which are embedded a number of bodies of said second superhard material, said bodies being spaced inwardly of the outer periphery of the layer of said one superhard material.

Said bodies of the second superhard material are preferably disposed in an array which is generally symmetrical with respect to the centre of the cutting element, and may include at least one annular ring of said material which is concentric with the cutting element. In another embodiment said bodies of the second superhard material include an array of spaced, generally parallel strips of said material.

Alternatively said bodies of the second superhard material are of a shape selected from circular cylinders, prisms and rectangular blocks.

Preferably the portions of the cutting table comprising said second superhard material extend through substantially the entire thickness of the cutting table.

In the case where the cutting table comprises at least two layers of superhard material, each of said portions of the second superhard material may extend through substantially the entire thickness of at least one of said layers. In such arrangement the layer including said portions of the second superhard material may be overlaid by a layer of superhard material forming the front face of the cutting table.

In any of the above arrangements the cutting table may include a rearward layer of superhard material of lesser abrasion resistance than said portions of the second superhard material, said rearward layer being bonded to the less hard substrate. The superhard material of the rearward layer may be of the same composition as the first superhard material defining said outer peripheral portion of the cutting table. The layer including said outer peripheral portion may be adjacent the rearward layer and the outer peripheral portion may then be substantially integral with said rearward layer.

In any of the arrangements according to the invention the first and second superhard materials may each comprise a mass of bonded particles, said first superhard material of greater impact resistance being of larger maximum particle size than said second superhard material forming at least one other portion of the cutting table.

The first and second superhard materials preferably both comprise polycrystalline diamond.

The invention also provides a preform cutting element including a cutting table of superhard material having a front cutting face, a peripheral surface, and a rear face bonded to a substrate of material which is less hard than the superhard material, the cutting table including a layer of a first form of superhard material in which are embedded a number of spaced bodies of a second form of superhard material which is of greater abrasion resistance than the first form of superhard material.

The cutting table may include a further layer of superhard material which overlies the layer in which said bodies are embedded, and provides said front cutting face of the cutting table.

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

Figure 1 is a side elevation of a typical drag bit in which wear resistant cutting elements according to the present invention may be used.

Figure 2 is an end elevation of the drill bit shown in Figure 1,

Figure 3 is a diagrammatic section through a typical prior art polycrystalline diamond preform cutting element mounted on a rotary drill bit,

Figure 4 is a diagrammatic front elevation of a similar form of cutting element, in accordance with the present invention,

Figure 5 is a longitudinal section through the cutting element of Figure 2,

Figure 6 is a similar section through an alternative form of cutting element in accordance with the invention,

Figure 7 is a diagrammatic front elevation of a further form of cutting element in accordance with the invention,

Figure 8 is a longitudinal section through the cutting element of Figure 5,

Figures 9, 10 and 11 are similar longitudinal sections through alternative forms of cutting element in accordance with the invention,

Figures 12-53 are, alternately, longitudinal sections and front elevations of further forms of cutting element in accordance with the invention, and

Figure 54 is a perspective view of a typical roller cone bit of a kind in which wear resistant cutting elements according to the present invention may be used.

Figures 1 and 2 show a typical full bore drag bit of a kind to which wear resistant cutting elements according to the present invention are applicable. The bit body 1 is machined from steel and has a shank formed with an externally threaded pin 2 at one end for connection to the drill string. The operative end face 3 of the bit body is formed with a number of blades 4 radiating from the central area of the bit, and the blades carry cutter assemblies 5 spaced apart along the length thereof. The bit has a gauge section including kickers 6 which contact the walls of the borehole to stabilise the bit in the borehole. A central passage (not shown) in the bit body and shank delivers drilling fluid through nozzles 7 in the end face 3 in known manner.

Each cutter assembly 5 comprises a preform cutting element 8 mounted on a carrier 9 in the form of a post which is located in a socket in the bit body. Each preform cutting element is in the form of a circular tablet comprising a thin facing table of polycrystalline diamond, or other superhard material, bonded to a substrate of cemented tungsten carbide. The rear surface of the substrate is bonded, for example by brazing, to a suitably orientated surface on the post 9.

Figure 3 is a section through a form of prior art cutting element which comprises a cutting table 10 of polycrystalline diamond, or other superhard material, having a front cutting face 11, a peripheral surface 12, and a rear face 13 bonded to a substrate 14 of cemented tungsten carbide or other material which is less hard than the superhard material.

In the arrangement shown in Figure 3, the substrate 14 is of sufficient thickness to be directly received and supported within a socket 15 in the bit body 16, the cutting element being brazed into the socket, for example. In other common forms of cutting element where the element is bonded to a post or stud, for example as shown in Figures 1 and 2, the substrate is of substantially smaller thickness than shown in Figure 3.

In Figure 3 the cutting edge of the cutting element 10 is indicated at 17 and comprises the lowermost portion of the junction between the front cutting surface 11 and the peripheral surface 12 of the diamond layer. It is this cutting edge which is primarily subjected to impact forces and abrasion. As previously explained, the cutting edge is particularly susceptible to damage by impact forces when the cutting element is comparatively new and before a significant wear flat has formed on the cutting element.

Figures 4 and 5 show a cutting element of the same basic type as the prior art cutting element shown in Figure 3, but constructed in accordance with the present invention. In this embodiment of the invention the cutting table 18 comprises a central circular portion 19 of high abrasion resistance. For example the composition of the polycrystalline diamond from which the central portion 19 is formed may be of the kind used in conventional prior art cutting elements where abrasion resistance is usually considered to be the prime requirement.

According to the present invention, however, the central portion 19 is surrounded by an annular outer peripheral portion 20 which is of a different composition of polycrystalline diamond selected for high impact resistance. For example, the central portion may be formed from fine grained particles of polycrystalline diamond, and the outer peripheral portion 20 may be formed from coarser grained particles of polycrystalline diamond. It is well established that the relative impact resistance and abrasion resistance of polycrystalline diamond is dependent to a certain extent on the maximum particle size and that, generally speaking, a composition having a greater maximum particle size will be of greater impact resistance than a composition of smaller maximum particle size.

The relative impact resistance and abrasion resistance of the two portions 19 and 20 may also be adjusted by other means, for example by adjusting the relative packing densities of the two compositions or by including an appropriate additive in one composition and not in the other, or by incorporating different proportions of the same additive in the two compositions. For example, the addition of cobalt, or a greater proportion thereof, to the polycrystalline diamond particles has the effect of increasing the impact resistance of the composition.

The cutting element shown in Figures 4 and 5 may be formed in a high pressure, high temperature press in generally similar manner to a conventional cutting element of the kind shown in Figure 3. That is to say a layer of polycrystalline diamond particles is packed into the press in contact with a body of cemented tungsten carbide, usually with the addition of a catalyst such as cobalt. In accordance with the present invention, however, the layer of polycrystalline diamond particles comprises a central circular mass of one composition surrounded by-an annular ring of particles of the other composition.

In the arrangement of Figures 4 and 5 the outer peripheral portion is generally rectangular in cross section. Figure 6 shows an alternative arrangement in which the outer peripheral portion 21 is triangular in cross section. In this arrangement, as the wear flat develops on the cutting edge 22 it may develop more or less parallel to the inner periphery of the annular portion 21, depending on the rake angle of the cutting element when mounted on the drill bit, so that the wear flat breaks into the central abrasion-resistant portion 22 at approximately the same time through the whole thickness of the diamond layer.

Figures 7 and 8 show an alternative arrangement wherein the outer peripheral portion 24 of high impact resistance surrounds an annular intermediate portion 25 of lower impact resistance and higher abrasion resistance which, in turn, surrounds a central portion 26 which is again of high impact resistance and which may be of the same composition as the outer annular portion 24.

Figure 9 shows a modified version of the arrangement of Figure 8 where the outer peripheral portion 27 is triangular in section.

In the arrangements of Figures 4-9, the front cutting table comprises only a single diamond layer and all portions thereof extend through the full thickness of the diamond layer.

Figure 10 shows a modified arrangement in which the cutting table comprises two diamond layers. The front diamond layer, defining the front cutting face 28 of the cutting element, comprises a central portion 29 of high abrasion resistance and low impact resistance and an annular peripheral portion 30 of high impact resistance.

The second layer 31, which is bonded to the substrate 32, is also formed of high impact resistance polycrystalline diamond. The composition of this diamond material may be the same as that of the outer peripheral portion 30 in which case the peripheral portion 30 is essentially integral with the layer 31.

Figure 11 shows a further embodiment of the invention in which the cutting table comprises three layers 33, 34 and 35. Each layer comprises a circular central portion 36, an intermediate annular portion 37, and an outer annular peripheral portion 38.

The various portions of the cutting table are formed from four different compositions of polycrystalline diamond, indicated by A1, A2, B1, B2, of decreasing impact resistance and increasing abrasion resistance, e.g. of decreasing maximum grain size.

It will thus be seen that the front layer 33, defining the cutting face and cutting edge of the cutting element, has an outer peripheral portion 38 of the highest impact resistance (A1), a central portion 36 of lower impact resistance (A2) and an intermediate portion 37 of lower still impact resistance (B1), and hence higher abrasion resistance.

The rearmost layer 35 of the cutting table, however, has both its outer peripheral portion 38 and its inner portion 36 of the maximum impact resistance (A1). The compositions of the intermediate portion 37 of the rearmost layer 35 and of the different portions of the middle layer 34 are selected to provide transitions between the corresponding portions of the front and rear layers.

It will be appreciated that many other multilayer configurations are possible, subject to the basic configuration that the outer peripheral portions of one or more of the layers should be of greater impact resistance than at least some of the other inner portions of the layers.

Since the outer peripheral portions of the cutting table are of greater impact resistance, they are usually also of lower abrasion resistance, as previously explained. In use of the cutting element, therefore, the cutting edge tends to become formed with a small bevel which is constantly refreshed and maintained as the cutting element wears. It is believed that the presence of such bevel on the cutting edge has the effect of inhibiting spalling or flaking of the front face of the cutting table.

Besides providing good impact resistance at the peripheral cutting edge of the cutting element, before the wear flat has formed, arrangements of the kind shown in Figures 7 and 8, Figure 9 and Figure 11 have another advantage. This is due to the fact that the abrasion resistance of the diamond layer varies across the cutting table. Thus in each of these arrangements the cutting table comprises an annular ring of high abrasion resistance surrounded both internally and externally by areas of polycrystalline diamond of lesser abrasion resistance. Consequently, in use of the element as a cutting element in a drill bit, the internally and externally surrounding areas of the diamond layer tend to wear away more rapidly than the annular ring of higher abrasion resistanee. Consequently, in continued use of the cutting, element the more rapid abrasion of the surrounding areas causes the ring of higher abrasion resistance increasingly to stand proud of those surrounding areas. It is believed that the projecting portions may enhance the formation cutting qualities of the cutting element.

Figures 12-53 show a number of alternative designs of cutting element where the increased impact resistance of the peripheral portion of the cutting element, in accordance with the invention, is combined with a configuration such as, with wear, to produce projecting portions in the cutting table, whereby the cutting action of the element may be enhanced.

In each case the cutting table of the element comprises bodies of polycrystalline diamond of high abrasion resistance embedded in a layer of polycrystalline diamond of lower abrasion resistance and higher impact resistance. In the different embodiments the shapes of the embedded portions vary both as viewed in plan and as viewed in section. In each case the cutting element is formed in substantially the conventional manner. That is to say a layer of polycrystalline diamond particulate material of two or more kinds is applied, in the configuration shown, to a substrate (usually a solid disc of cemented tungsten carbide) and subjected to very high pressure and temperature in a press, so that the particles in the diamond layer exhibit diamond-to-diamond bonding, and the different parts of the diamond layer become bonded to one another and to the substrate to form a preform compact.

In each case the outer periphery of the cutting table, or at least a major part thereof, is formed by polycrystalline diamond of lesser abrasion resistance, and higher impact resistance, than portions of the diamond layer inwardly of the peripheral surface.

In the form of cutting element shown in Figures 12 and 13 the front cutting table 40, bonded to a cemented tungsten carbide substrate 41, comprises parallel strips of polycrystalline diamond bonded together side-by-side across the cutting table. The strips are formed from two different types of polycrystalline diamond which alternate across the width of the cutting table 40. The strips indicated at "A" in Figures 12 and 13 are of higher impact resistance and lower abrasion resistance than the alternate strips indicated at "B". It will be seen that the outer strips at each side of the cutting table 14 comprise polycrystalline diamond of higher impact resistance. The differing impact resistance and abrasion resistance of the two types of strip "A" and "B" may be effected by any of the means previously described.

The arrangement shown in Figures 12 and 13 has two important effects. It will be seen from Figure 13 that the strips "A" of polycrystalline diamond make up the major proportion of the outer periphery of the cutting table 40. This renders the cutting element highly impact resistant around its periphery, as previously described. Furthermore, however, since the polycrystalline diamond strips "B" are of greater abrasion resistance than the strips "A", the diamond in the strips "A" will wear away more rapidly as drilling proceeds. Consequently, as drilling proceeds, the strips "B" of higher abrasion resistance will stand proud of the adjacent strips "A" of lower abrasion resistance, particularly in the area where the wear flat is formed. The cutting element will normally be orientated so that the wear flat forms across the ends of the strips "A" and "B", i.e. across the top or bottom of the cutting face in Figure 13. The cutting table will therefore wear away leaving projecting portions which has been found, under certain conditions and with certain types of formation, to have an enhanced cutting effect.

Figures 14 and 15 are views, similar to Figures 12 and 13 respectively, showing a modified version of the cutting element in which the cutting table 42 has an additional disc-like outer layer 43 which overlies the strips "A" and "B" and forms the front cutting surface of the cutting element. The layer 43 may be of a third type of polycrystalline diamond, different from the types making up either of the strips "A" and "B". It may be of higher impact resistance and lower abrasion resistance than even the strips "A", so as to protect the cutting edge formed by the layer 43 from impact damage when the cutting element is comparatively new. Alternatively, the layer 43 may be of substantially the same impact and abrasion resistance as the strips "A", or these properties may be intermediate those of the strips "A" and "B". Again, the cutting element of Figures 14 and 15 will tend to wear in a way to leave projecting portions of diamond.

Figures 16-53 show alternative configurations in accordance with the invention where the cutting table of the cutting element comprises a basic layer of polycrystalline diamond of a type having high impact resistance and low abrasion resistance, in which are embedded one or more elements of a different type of polycrystalline diamond having higher abrasion resistance and lower impact resistance. In each case the basic diamond layer of higher impact resistance and lower abrasion resistance provides at least the major part of the outer periphery of the cutting element and thus provides protection for the cutting edge against impact damage before the wear flat is formed. At the same time, the embedded areas of diamond of higher abrasion resistance will increasingly stand proud of the cutting table, as wear proceeds, in a manner which is believed may enhance the cutting effectiveness of the cutting element.

In all of the arrangements shown in Figures 16-53 the cutting element comprises a polycrystalline diamond layer bonded in a high pressure, high temperature press to a substrate of less hard material, which may be cemented tungsten carbide. In the arrangements of Figures 16-39 the diamond cutting table and substrate comprise circular discs of substantially constant thickness bonded together, so that the front cutting face of the cutting element is flat. In the cutting elements of Figures 40-53, the cutting table is still of substantially constant thickness but the centre of the substrate is elevated so that the cutting face of the cutting element is generally domed or pointed.

In the arrangement of Figures 16 and 17 five generally hemispherical bodies 44 of higher abrasion resistance diamond are embedded in a symmetrical pattern into a diamond layer 45 of lesser abrasion resistance, the cutting table being bonded to a substrate 46. Figure 18-23 show similar arrangements having different numbers of embedded bodies of higher abrasion resistance, arranged in different patterns. In the arrangements of Figures 22 and 23, the bodies of higher abrasion resistance diamond are of two different sizes. In each case the whole periphery of the cutting table is made up of diamond of higher impact resistance.

In the arrangement of Figures 24 and 25 the body of higher abrasion resistance diamond embedded in the layer 47 of lower abrasion resistance diamond is in the form of eight radial "spokes" 48 extending outwardly from a central hemispherical body 49. In this case the spokes 48 extend to the periphery of the cutting element, but the majority of the periphery is made up of the higher impact resistance diamond 47.

In the arrangement of Figures 26 and 27 three rectangular blocks 50 of higher abrasion resistance diamond are embedded in a layer 51 of lower abrasion resistance diamond. In Figures 28 and 29 a single frusto-conical block 52 of higher abrasion resistance diamond is embedded in the centre of a layer 53 of lower abrasion resistance diamond.

Figures 30 and 31 show an asymmetrical arrangement in which five hemispherical bodies 54 of higher abrasion resistance diamond are spaced slightly inwardly from about half -the periphery of the diamond layer 55 of lower abrasion resistance diamond in which they are embedded. In this case the cutting element is orientated, in use, so that the cutting edge is formed by the part of the periphery around which the embedded bodies 54 extend.

Figures 32 and 33 show an arrangement in which the embedded bodies 56 of higher abrasion resistance diamond are in the form of triangular prisms extending through the depth of the layer 57 of lower abrasion resistance diamond.

In the arrangement of Figures 34 and 35 the embedded bodies 58 of higher abrasion resistance diamond are generally chevron-shaped.

In the arrangement of Figures 36 and 37 the embedded bodies of higher abrasion resistance diamond comprise a central generally cubic block 59 surrounded by eight circumferential blocks 60 of frusto-conical shape which are spaced equally apart around the periphery of the cutting table and extend only part way through the layer 61 of lower abrasion resistance diamond.

Figures 38 and 39 show an arrangement in which hemispherical bodies 62 of higher abrasion resistance diamond are arranged in a symmetrical pattern in the cutting face of the layer 63 of lower abrasion resistance. In this case, however, further hemispherical bodies 64 of higher abrasion resistance diamond are embedded around the peripheral surface of the layer 65 of lower abrasion resistance material, as best seen in Figure 38. However, the bodies 62 and 64 are all spaced from the junction between the cutting face and peripheral surface of the cutting table so that this junction, which forms the initial cutting edge of the cutting element, is provided by the diamond of lower abrasion resistance and higher impact resistance.

All of the cutting elements described by way of example in relation to Figures 4-39 are generally in the form of flat circular tablets and are therefore primarily intended for use in drag-type rotary drill bits, for example of the kind shown in Figures 1 and 2. Figures 40-53 show cutting elements where the cutting surface is generally domed or pointed, and while such cutting elements may also be used in drag-type drill bits, the same or similar cutting elements may also be suitable for use as cutting elements in roller-cone drill bits and percussion bits.

In the arrangement of Figures 40 and 41 the substrate 66 is in the form of a square having a conical front portion 67. Bonded to the surface of the conical front portion 67 of the substrate is a polycrystalline diamond layer 68 of lower abrasion resistance in which are embedded two rings 69 of polycrystalline diamond of higher abrasion resistance. A circular body of diamond of higher abrasion resistance 70 is also embedded in the layer 68 at the apex of the cone.

In the arrangement of Figures 42 and 43 the substrate 71 is circular and has a domed front portion 72 to which is bonded a layer 73 of diamond of lower abrasion resistance. Embedded in this layer, in a cross-like pattern, is an array of generally cylindrical bodies 74 of higher abrasion resistance diamond.

In Figures 44 and 45 the substrate 75 has a frusto-conical front portion 76 to which is bonded a layer 77 of diamond of lower abrasion resistance. Embedded in the layer 77, in a cross-like array, are bodies 78 of higher abrasion resistance diamond surrounded by a peripheral ring 79 also of higher abrasion resistance diamond. However, as will be seen from Figure 44, an annular portion 80 of the layer 77 of lower abrasion resistance and higher impact resistance diamond extends around the cutting table outwardly of the ring 79 to provide impact resistance to the outer periphery of the cutting table.

Figures 46 and 47 show an arrangement somewhat similar to the arrangement of Figures 40 and 41, but in this case the substrate 81 is circular.

In the embodiment of Figures 48 and 49 the substrate 82 has a conical front portion 83 to which is bonded a layer 84 of lower abrasion resistance diamond. Embedded in the layer 84, in a cross-like array, are generally cylindrical bodies 85 of higher abrasion resistance diamond.

In the embodiment of Figures 50 and 51 the substrate 86 is basically circular but has a front portion 87 having a flat outer surface 88 and inclined side surfaces 89 extending across the circular substrate 86 parallel to a diameter thereof. A layer 90 of lower abrasion resistance diamond is bonded to the surfaces 88 and 89 and embedded in this layer are spaced strips 91 of higher abrasion resistance diamond. The strips extend parallel to the surfaces 88 and 89 and to a diameter of the substrate 86.

Figures 52 and 53 show an arrangement somewhat similar to that of Figures 44 and 45, but in this case the apex of the projecting front portion 92 of the substrate 93 is in the form of a square flat surface and the embedded bodies 94 of higher abrasion resistance diamond are generally square.

As previously mentioned, cutting elements in accordance with the invention, such as some of the embodiments described above, may be used as cutting elements in roller-cone and percussion drill bits. Figure 54 is a diagrammatic perspective view of one form of typical roller-cone drill bit of a kind to which cutting elements according to the invention may be applied.

As is well known, the roller-cone bit comprises a bit body 95 having a threaded pin 96 for connection to a drill string and three equally spaced depending legs 97 which carry inwardly inclined journals (not shown) on which are rotatably mounted respective roller cones 98.

Each roller cone 98 carries a number of peripheral rows of cutting elements 99 secured, for example by brazing, within sockets in the surface of the cones 98. Nozzles 100 in the bit body deliver jets of drilling fluid on to the roller cones and the bottom of the borehole to clean and cool the cutting elements and also to carry away to the surface the cuttings from the bottom of the borehole.

As the roller cones 98 rotate, the cutting elements 99 tend to break up the formation at the bottom of the hole with a crushing action. The cutting elements therefore project away from the surface of the roller cone bodies. For this reason the cutting elements according to the invention which will be particularly suitable for roller-cone bits are those where the front cutting surface of the cutting element is domed or pointed.

Claims

1. A preform cutting element including a cutting table of superhard material having a front cutting face, a peripheral surface, and a rear face bonded to a substrate of material which is less hard than the superhard material, the cutting table including an outer peripheral portion, defining at least a part of said peripheral surface, which is formed of a first superhard material which is of greater impact resistance than a second superhard material forming other portions of the cutting table.

2. A cutting element according to Claim 1, wherein said outer peripheral portion extends around a major part of the periphery of the cutting table.

3. A cutting element according to Claim 1, wherein said outer peripheral portion extends around the entire periphery of the cutting table.

4. A cutting element according to any of claims 1 to 3, wherein the outer peripheral portion is disposed around the junction between the front cutting face and the peripheral surface of the cutting table, so as to define at least a part of each of said surfaces.

5. A cutting element according to any of Claims 1 to 4, wherein said second superhard material is of greater abrasion resistance than the first superhard material from which the outer peripheral portion is formed.

6. A cutting element according to Claim 5, wherein there is disposed inwardly of said portion of greater abrasion resistance a further portion of the cutting table which is formed of a superhard material which is of lesser abrasion resistance than said portion of greater abrasion resistance.

7. A cutting element according to Claim 6, wherein said further portion is of substantially the same composition as the outer peripheral portion.

8. A cutting element according to any of Claims 1 to 7, wherein the cutting table includes a layer of said one superhard material in which are embedded a number of bodies of said second superhard material, said bodies being spaced inwardly of the outer periphery of the layer of said one superhard material.

9. A cutting element according to Claim 8, wherein said bodies of the second superhard material are disposed in an array which is generally symmetrical with respect to the centre of the cutting element.

10. A cutting element according to Claim 9, wherein said bodies of the second superhard material include at least one annular ring of said material which is concentric with the cutting element.

11. A cutting element according to Claim 9, wherein said bodies of the second superhard material include an array of spaced, generally parallel strips of said material.

12. A cutting element according to Claim 8 or Claim 9, wherein said bodies of the second superhard material are of a shape selected from circular cylinders, prisms and rectangular blocks.

13. A cutting element according to any of Claims 1 to 12, wherein the portions of the cutting table comprising said second superhard material extend through substantially the entire thickness of the cutting table.

14. A cutting element according to any of Claims 1 to 12, wherein the cutting table comprises at least two layers of superhard material, each of said portions of the second superhard material extending through substantially the entire thickness of at least one of said layers.

15. A cutting element according to Claim 14, wherein the layer including said portions of the second superhard material is overlaid by a layer of superhard material forming the front face of the cutting table.

16. A cutting element according to any of Claims 1 to 15, wherein the cutting table includes a rearward layer of superhard material of lesser abrasion resistance than said portions of the second superhard material, said rearward layer being bonded to the less hard substrate.

17. A cutting element according to Claim 16, wherein the superhard material of the rearward layer is of the same composition as the first superhard material defining said outer peripheral portion of the cutting table.

18. A cutting element according to Claim 17, wherein the layer including said outer peripheral portion is adjacent the rearward layer and the outer peripheral portion is substantially integral with said rearward layer.

19. A cutting element according to any of Claims 1 to 18, wherein the first and second superhard materials each comprise a mass of bonded particles, said first superhard material of greater impact resistance being of larger maximum particle size than said second superhard material forming at least one other portion of the cutting table.

20. A cutting element according to any of Claims 1 to 19, wherein the first and second superhard materials both comprise polycrystalline diamond.

21. A preform cutting element including a cutting table of superhard material having a front cutting face, a peripheral surface, and a rear face bonded to a substrate of material which is less hard than the superhard material, the cutting table including a layer of a first form of superhard material in which are embedded a number of spaced bodies of a second form of superhard material which is of greater abrasion resistance than the first form of superhard material.

22. A preform cutting element according to Claim 21, wherein the cutting table includes a further layer of superhard material which overlies the layer in which said bodies are embedded, and provides said front cutting face of the cutting table.

FIG 1

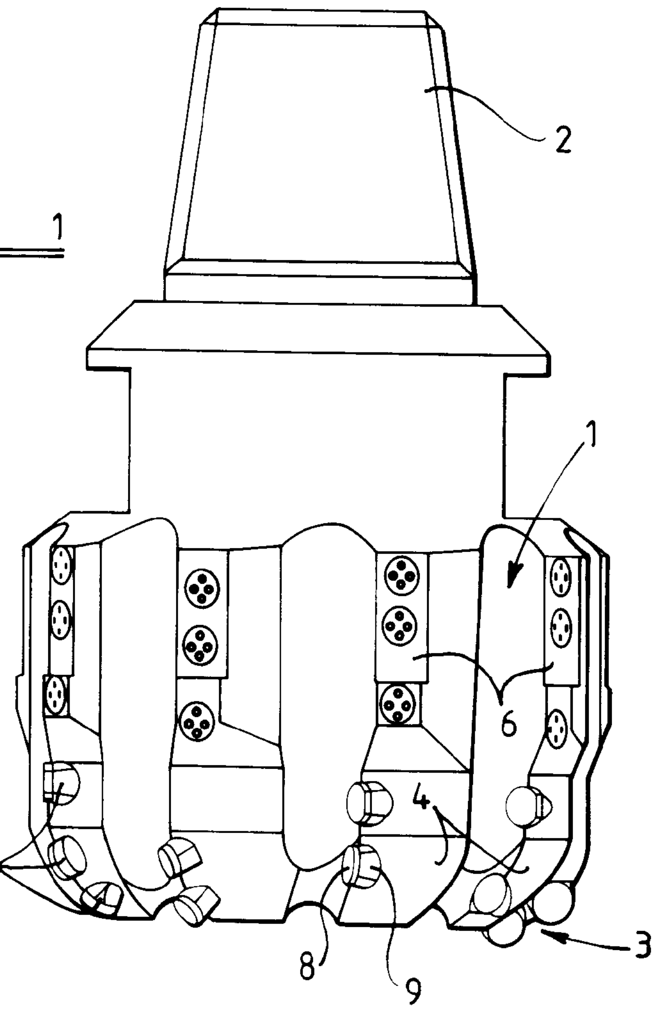
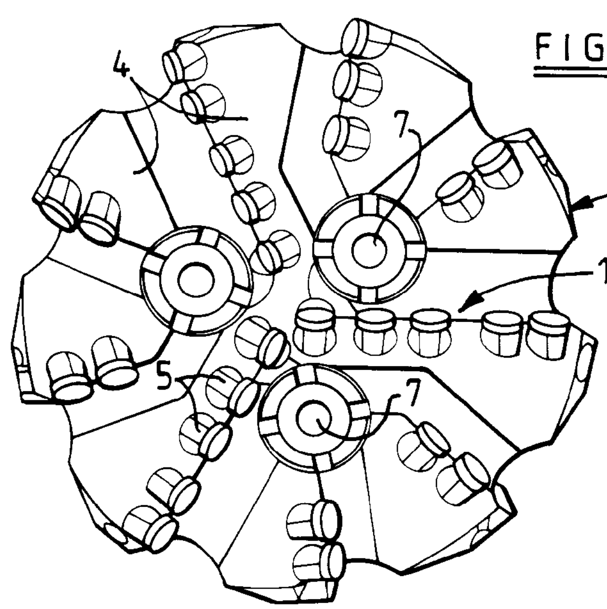


FIG 2



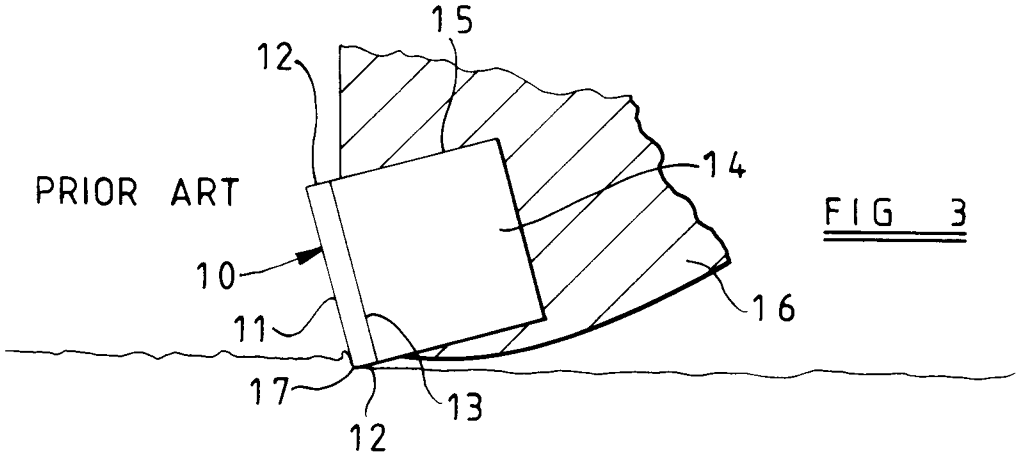
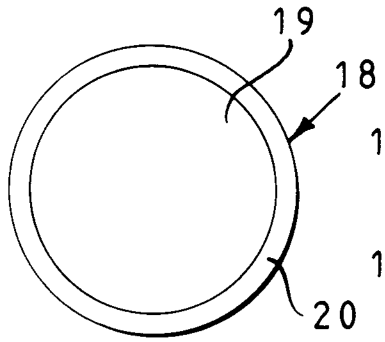


FIG 3



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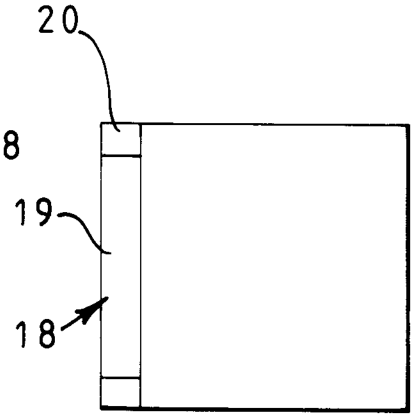


FIG 5

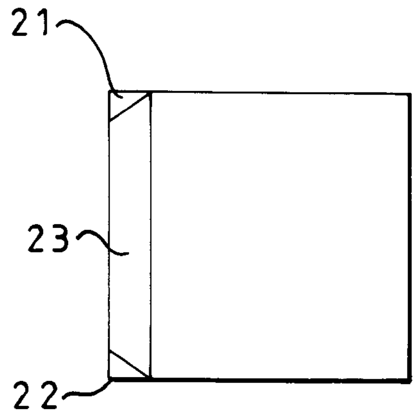


FIG 6

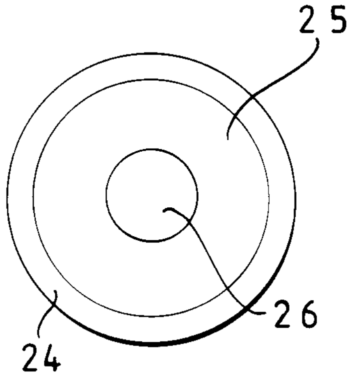


FIG 7

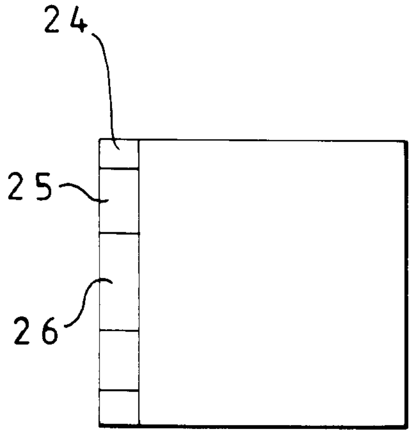


FIG 8

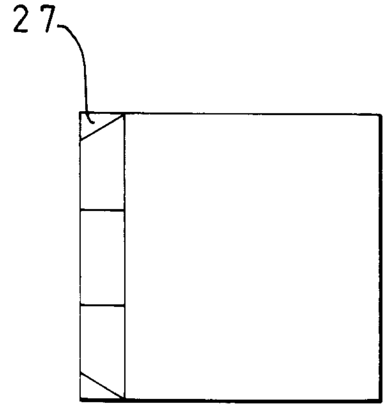


FIG 9

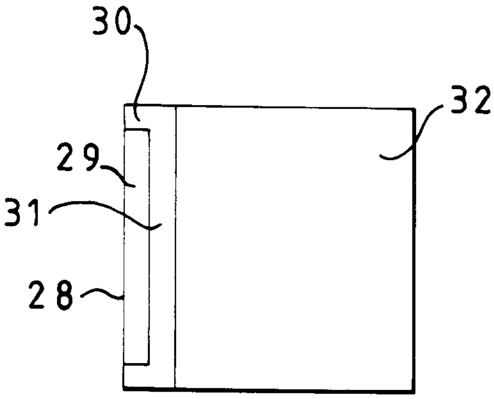


FIG 10

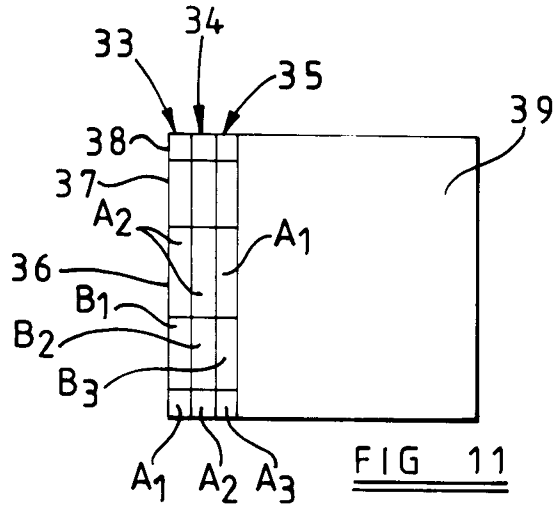


FIG 11

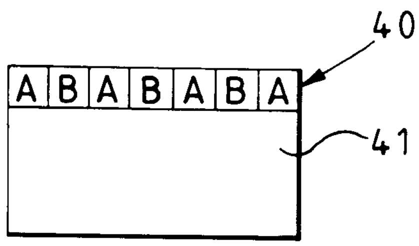


FIG 12

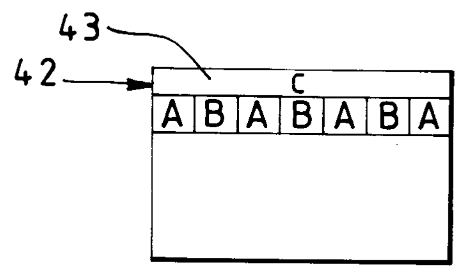


FIG 14

FIG 13

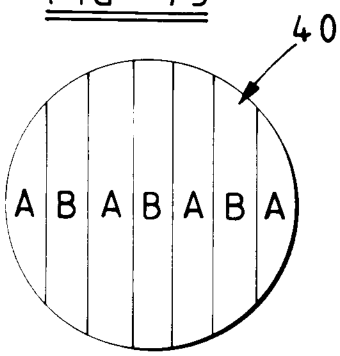
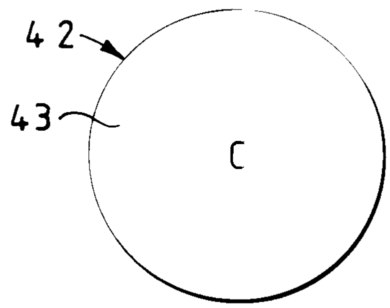


FIG 15



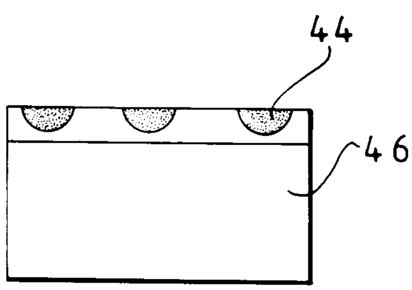


FIG 16

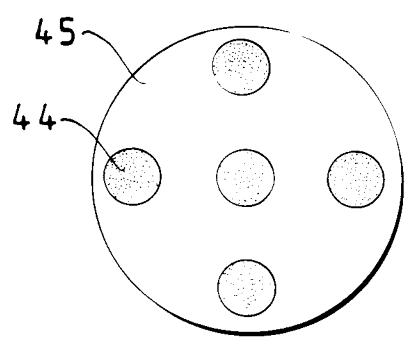


FIG 17

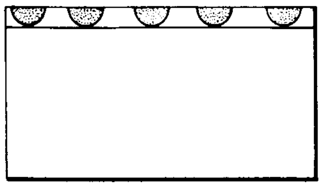


FIG 18

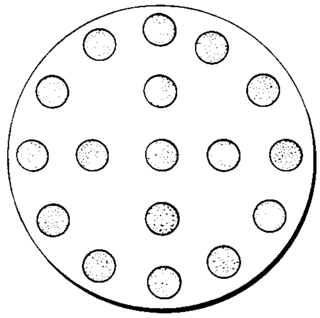


FIG 19

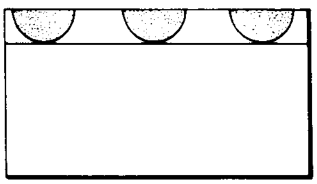
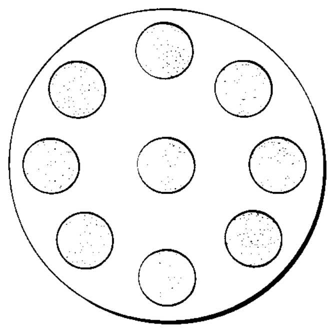


FIG 20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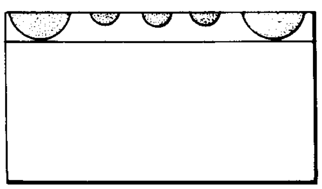
FIG 22

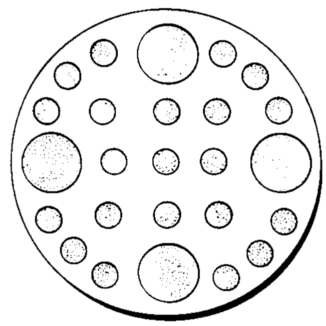
FIG 23

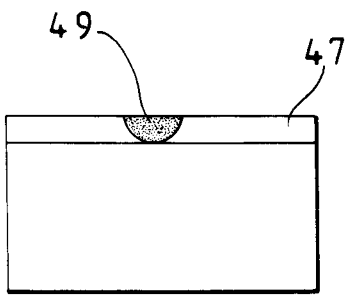

FIG 24

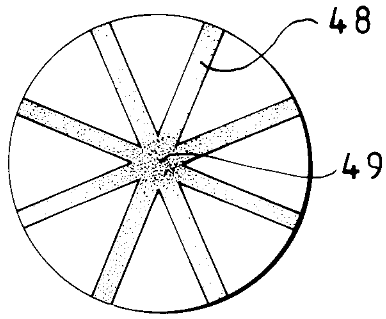

FIG 25

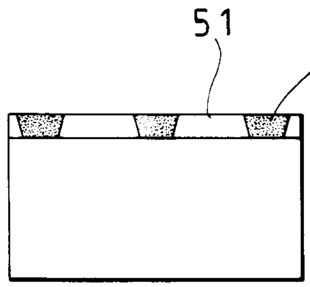

FIG 26

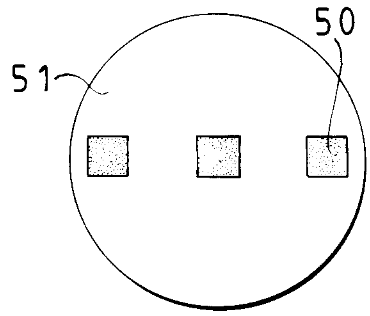

FIG 27

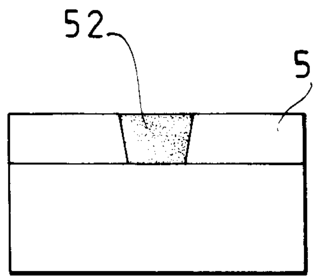

FIG 28

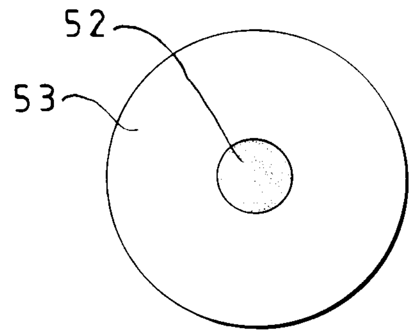

FIG 29

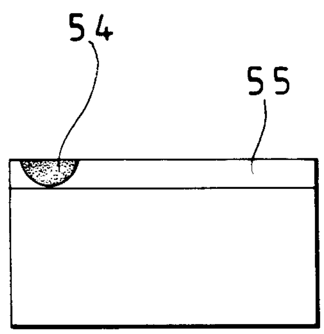

FIG 30

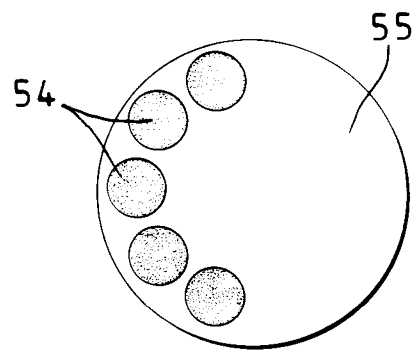

FIG 31

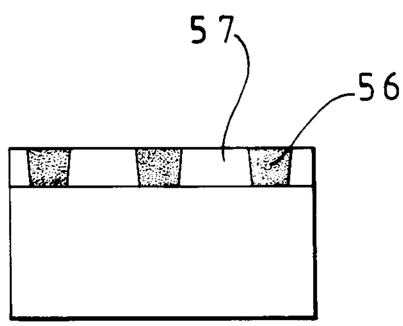

FIG 32

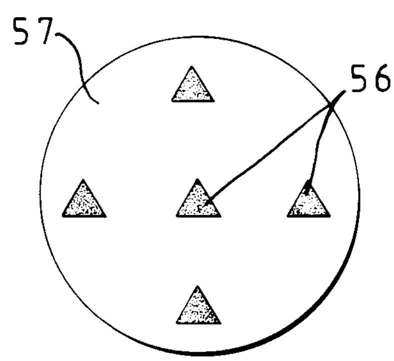

FIG 33

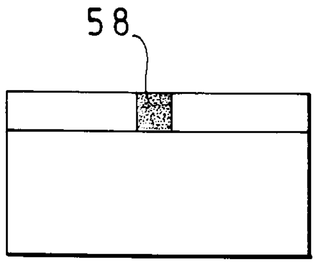

FIG 34

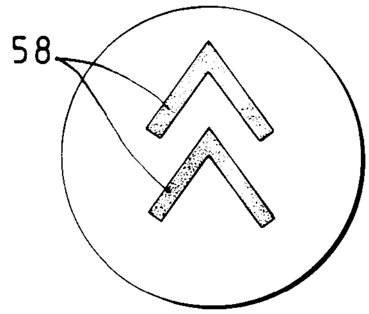

FIG 35

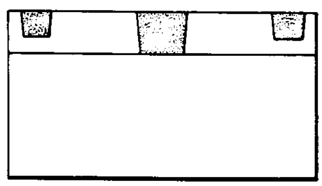

FIG 36

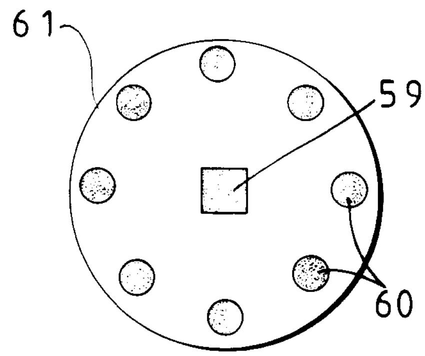

FIG 37

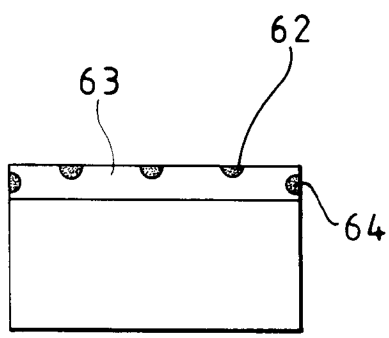

FIG 38

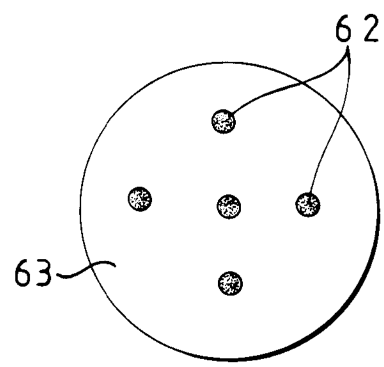

FIG 39

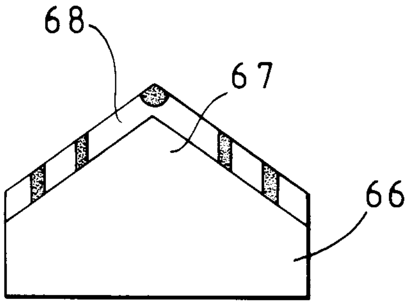

FIG 40

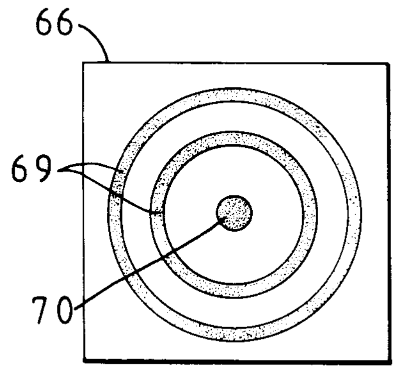

FIG 41

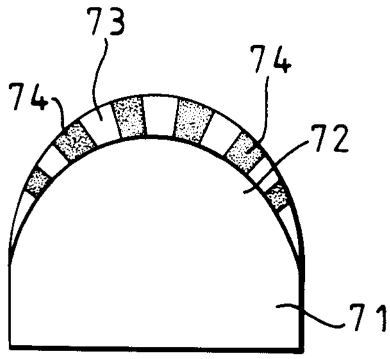

FIG 42

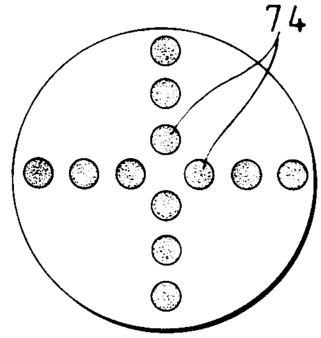

FIG 43

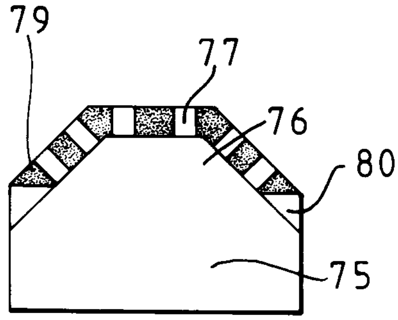

FIG 44

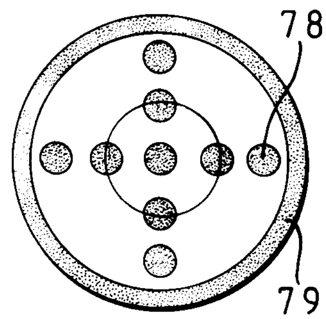

FIG 45

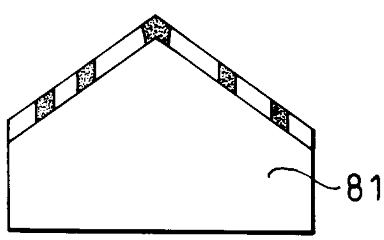

FIG 46

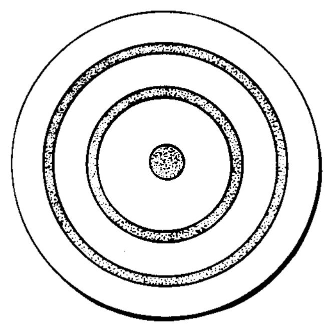

FIG 47

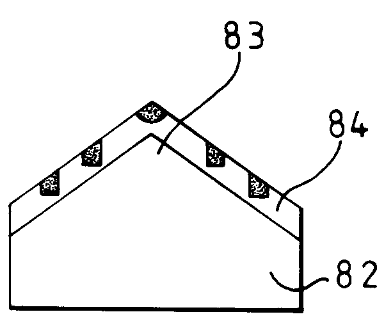

FIG 48

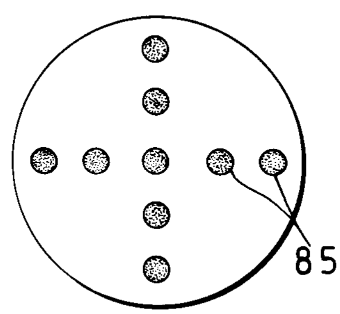

FIG 49

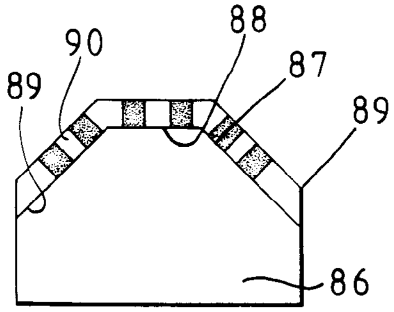

FIG 50

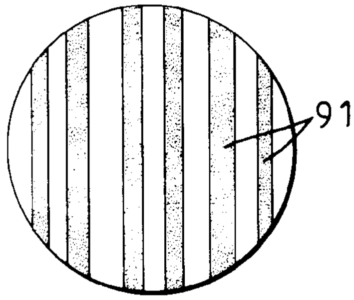

FIG 51

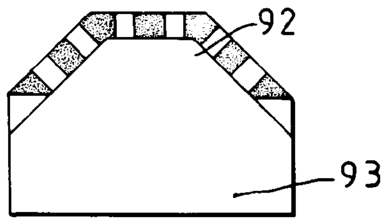

FIG 52

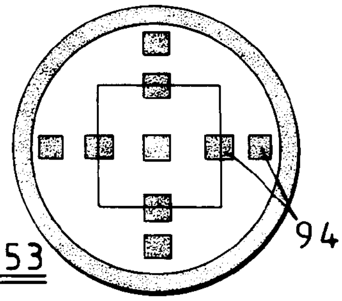

FIG 53

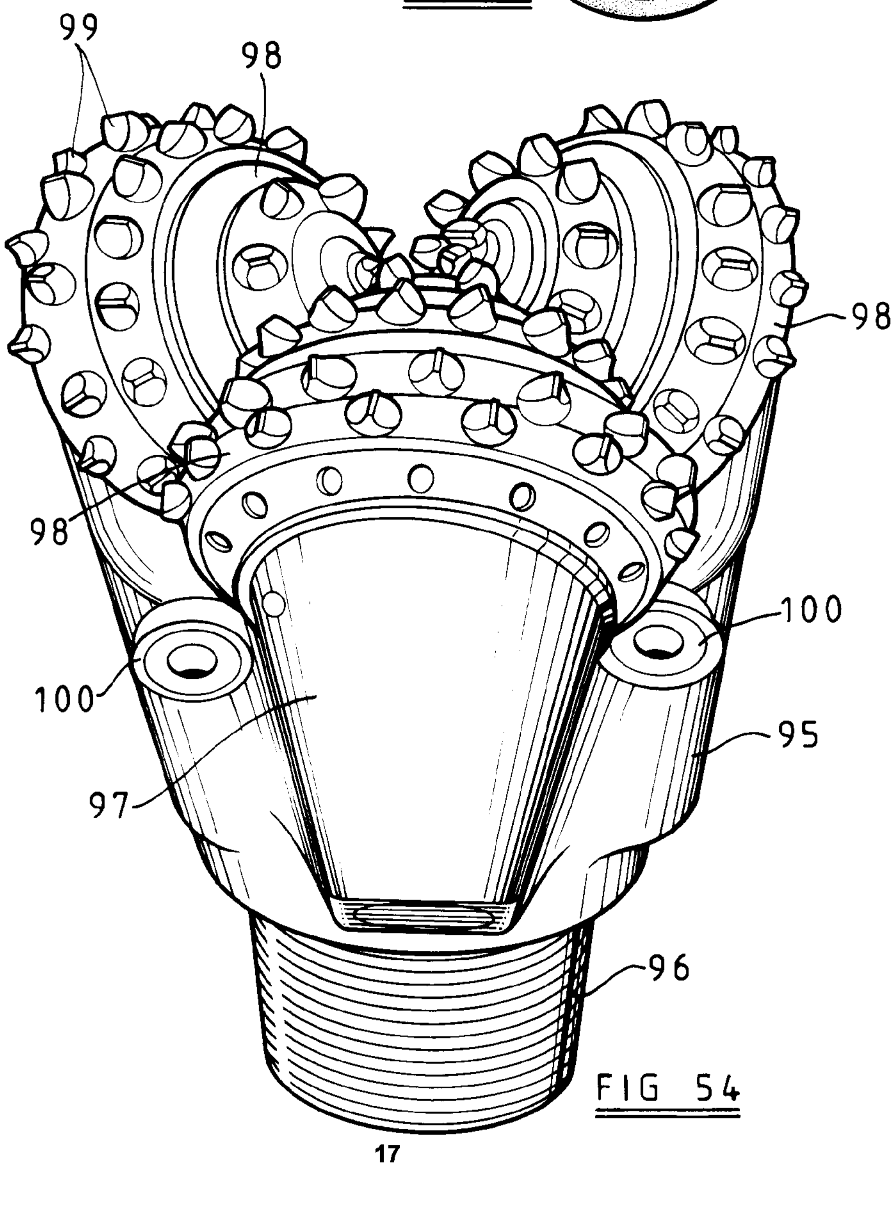

FIG 54

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 31 0836

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.5)
X	EP-A-0 453 426 (SANDVIK AKTIEBOLAG) * page 3, line 11 - page 5, line 15; figures 5-14 *	1,2,4, 8-18,21	E21B10/56
X,P	EP-A-0 462 091 (SANDVIK AKTIEBOLAG) * page 3, line 20 - page 4, line 37; figures 7-14 *	1-19, 21-22	
A	EP-A-0 312 281 (DE BEERS INDUSTRIAL DIAMOND DIVISION (PROPRIETARY) LIMITED) * the whole document *	1,5,8, 20-22	
A	US-A-4 854 405 (DONALD S. STROUD) * the whole document *	1-6	
A	GB-A-2 168 404 (GERD ELFGEN) * page 1, line 95 - page 2, line 109; figures 3,4 *	1-18	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	05 FEBRUARY 1993	CUNY J.

CATEGORY OF CITED DOCUMENTS

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Y : particularly relevant if combined with another document of the same category
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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

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