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

(72) Inventor: **Hollister, Kelly**
13010 Finch Brook Drive
Cypress, Texas 77429(US)
Inventor: **Truax, David**
9711 Cabin Creek Drive
Houston, Texas 77064(US)

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

(54) Rotary drill bit with stabilizing elements.

(57) A rotary drill bit for use in drilling or coring holes in subsurface formations comprises a bit body (10) having a shank for connection to a drill string, a plurality of cutting elements (15) mounted on the bit body, and a passage in the bit body for supplying drilling fluid to the surface thereof for cooling and cleaning the cutting elements. At least some of the cutting elements each comprise a preform cutting element (15) having a polycrystalline front cutting table (17), and respective back-up elements (16) are spaced rearwardly of certain associated cutting elements. Each back-up element (16) projects from the bit body and is formed wholly from a material, such as cemented tungsten carbide, which is less hard than the polycrystalline diamond, and each back-up element (16) has a formation-engaging surface the minimum dimension of which is less than the width of its associated cutting element (15) in a generally radial direction.

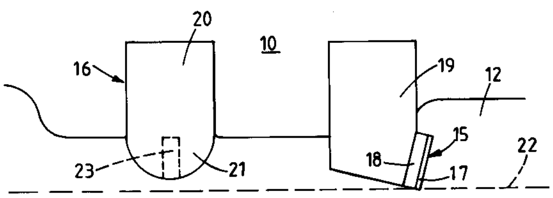

FIG.2.

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The invention relates to rotary drill bits for use in drilling or coring holes in subsurface formations, and of the kind comprising a bit body having a shank for connection to a drill string, a plurality of cutting elements mounted at the surface of the bit body, and a passage in the bit body for supplying drilling fluid to the surface of the bit body for cooling and/or cleaning the cutting elements, at least some of the cutting elements each comprising a preform cutting element having a superhard front cutting face.

The invention is particularly, but not exclusively, applicable to drill bits of this kind in which the cutting elements comprise preforms having a thin cutting table of polycrystalline diamond bonded to a substrate of cemented tungsten carbide. Various methods may be used for mounting such cutting elements on the bit body but such methods, and the general construction of bits of the kind to which the invention relates, are well known and will not therefore be described in detail.

When drilling deep holes in subsurface formations, it often occurs that the drill bit passes through a comparatively soft formation and strikes a significantly harder formation. Also there may be hard occlusions within a generally soft formation. When a bit using preform cutters meets such a hard formation the cutting elements may be subjected to very rapid wear. Preform cutting elements may also be subject to impact damage, for example when a new drill bit is first tripped into an existing borehole, when it may impact on the bottom of the borehole.

In order to overcome such problems, it has been proposed, as described in U.S. Patent Specification No. 4718505, to provide, associated with at least certain of the cutting elements on the bit body, respective abrasion elements which are spaced rearwardly of the cutting element with respect to the normal direction of rotation of the bit. Each abrasion element comprises a plurality of particles of superhard material, such as polycrystalline diamond, embedded in a stud-like carrier element one end of which is received in a socket in the bit body and the other end of which protrudes from the bit body.

Bits incorporating such abrasion elements have been very successful, since the abrasion elements supplement, or take over entirely, the cutting action of a cutting element which has become excessively worn or which has failed through fracture. At the same time, the abrasion elements may share the loads which would otherwise be borne solely by the cutting elements as a result of the weight-on-bit during drilling, or impact of the drill bit with the bottom of the borehole. Furthermore, the abrasion elements may serve as depth stops to limit the depth of cut effected by the primary cutting elements.

However, it is believed that, in certain applications, and when drilling certain types of formation, there may be unexpected advantage in using a different type of back-up element from the diamond-embedded abrasion elements of the kind described in U.S. Patent No. 4718505. For example, if a primary cutting element becomes worn to an extent where its associated abrasion element is abrading the formation, this may significantly increase the resistance to rotation of the drill bit, thus requiring significantly greater input of rotational energy to the drill string. Furthermore, the increased frictional engagement of the abrasion element on the formation is likely to increase the temperature of the drill bit with consequent increased risk of failure of the cutting elements due to thermal degradation.

These problems might theoretically be reduced by so shaping the formation-engaging surface of each abrasion element that the frictional resistance caused by its wear flat varies in a predictable manner and is correlated with the development of the wear flat on the associated cutting element. However, due to the construction of the diamond-embedded abrasion elements, the frictional resistance is liable to vary in an unpredictable manner as the element wears. As the wear flat begins to form, the frictional resistance depends to a great extent on the number and area of the embedded diamond particles which are exposed and are engaging the formation. However, as the wear flat develops, some fresh diamond particles become exposed while others become completely worn away or even become detached from the abrasion element before being completely worn away. Thus the frictional resistance varies, as the wear flat develops, in a manner which depends on the random disposition of the diamond particles in the element, and it cannot therefore be accurately predetermined by the geometrical shape of the formation-engaging surface of the element.

The present invention, therefore, is based on the realisation that, in some circumstances, it may be advantageous to employ, on a rotary drill bit of the kind first referred to, back-up elements which are formed of a material which is less hard and abrasive than the known abrasion elements comprising particles of superhard material embedded in a stud-like element. The invention may have the incidental advantage of such back-up elements being less costly than abrasion elements of the known kind.

U.S. Patent Specification No. 5090492 discloses a rotary drill bit in which there is provided behind each of certain of the cutting elements a stabilising projection integrally formed on the surface of the bit body. Each projection is of peripherally elongated configuration and is circumferentially aligned with an associated cutting element so as to snugly enter and engage the side walls of the formation groove produced by the aligned cutting element. The purpose of the stabilising projections is, by snugly engaging the side walls of the formation groove, to provide substantial resistance against lateral displacement or vibration of the drill bit. However, the peripheral elongation of the projections will necessarily result in the formation of a substantial peripherally elongated wear flat on each projection as drilling proceeds, and such a large wear flat will provide very substantial frictional restraint to rotation of the drill bit, necessitating substantial increase in the rotational energy which must be imparted to the drill string. The present invention overcomes this disadvantage, while at the same time maintaining significant resistance against lateral displacement or vibration of the drill bit.

According to the invention there is provided a rotary drill bit for use in drilling or coring holes in subsurface formations comprising a bit body having a shank for connection to a drill string, a plurality of cutting elements mounted on the bit body, and a passage in the bit body for supplying drilling fluid to the surface thereof for cooling and/or cleaning the cutting elements, at least some of the cutting elements each comprising a preform cutting element having a superhard front cutting table, and there being spaced from but associated with at least certain of said cutting elements, with respect to the normal direction of rotation of the bit, respective back-up elements each of which projects from the bit body and is formed wholly from a material which is less hard than the superhard material of the cutting elements, and each back-up element having a formation-engaging surface the minimum dimension of which is less than the width of its associated cutting element in a generally radial direction.

Preferably the back-up elements are spaced inwardly of the cutting profile defined by the cutting elements,

The cutting profile of the cutting elements is defined to mean a generally smooth notional surface which is swept out by the cutting edges of the cutting elements as the bit rotates without axial movement.

Since the material of the back-up elements is less hard than that of the superhard material of the cutting elements, the back-up elements wear away more easily than the cutting elements, should the back-up elements come into engagement with the formation, and thus the frictional restraint to rotation caused by the back-up elements is reduced. The wear flat which forms on each back-up element is also limited in area by the fact that the minimum dimension of the formation-engaging surface of each element is less than the width of its associated cutting element in a generally radial direction. Since the frictional restraint is dependent on the area of the wear flat at any particular time, the frictional restraint, as the wear flat develops, is dependent on the geometry of the back-up element and may thus be predetermined by appropriate design of that geometry.

The maximum dimension of each back-up element in the circumferential direction may be significantly less than the maximum dimension in a radial direction. Thus, the back-up element may then provide substantial restraint against radial displacement or vibration without creating a substantial wear flat and substantially increasing the frictional restraint to rotation.

Each back-up element may be in the form of an elongate stud-like insert having one end received within a socket in the bit body and the other end protruding from the bit body. The insert may, for example, be formed from sintered or cemented tungsten carbide or other refractory material, or from solid infiltrated matrix material, such as particulate tungsten carbide infiltrated with a copper binder.

The bit body may be machined from metal, such as steel, or may be moulded from solid infiltrated matrix material in a powder metallurgy process, of well known kind. In the latter case each back-up element may comprise a projection of matrix material integrally moulded with the bit body.

In the case where the back-up element is in the form of a stud-like insert, at least the end of the insert received within the socket in the bit body is preferably generally cylindrical and of circular cross-section.

In any of the above arrangements, whether the back-up element is an insert or an integrally moulded projection, the projecting end of each back-up element may be domed, for example hemispherically domed. Alternatively, the projecting portion of the back-up element may taper as it extends away from the bit body. In this case it preferably tapers more in a generally radial direction than it does in a generally circumferential direction, so that the projecting portion of the back-up element is generally chisel-shaped.

The outer profile of the projecting portion of each back-up element, as viewed in a circumferential direction, may be substantially the same as the outer profile of the associated cutting element when viewed in the same circumferential direction, the dimension of the formation-engaging surface of the back-up element in the circumferential direction being less than the width of the cutting element.

Each back-up element may be located at substantially the same radial distance from the axis of rotation of the bit as its associated cutting element.

According to another aspect of the invention there is provided a rotary drill bit for use in drilling or coring holes in subsurface formations comprising a bit body having a shank for connection to a drill string, a plurality of cutting elements mounted on the bit body, and a passage in the bit body for supplying drilling fluid to the surface thereof for cooling and/or cleaning the cutting elements, at least some of the cutting elements each comprising a preform cutting element having a superhard front cutting table, and there being spaced from but associated with at least certain of said cutting elements, with respect to the normal direction of rotation of the bit, respective back-up elements each of which projects from the bit body and is formed wholly from a material which is less hard than the superhard material of the cutting elements, and each back-up element being shaped to provide a cross-sectional area which decreases with distance from the cutting profile, whereby the wear flat presented to the formation by the back-up element decreases in area as wear proceeds.

For example, at least the portion of the back-up element which protrudes from the bit body may taper outwardly, in a circumferential direction and/or in a radial direction, as it extends away from the bit body.

In arrangements according to this further aspect of the invention the minimum dimension of the formation-engaging surface of the back-up element is not necessarily less than the width of the associated cutting element, as in the arrangements previously referred to.

The cross-sectional shape of the back-up element may be correlated to the cross-sectional shape of the associated cutting element in such manner that the combined area of the wear flats on the back-up element and the cutting element remains substantially constant, or varies within a predetermined limited range, as wear proceeds.

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

Figure 1 is a front end view of a rotary drill bit according to the invention,

Figure 2 is a diagrammatic section through a cutting element and one form of back-up element,

Figure 3 is a similar view to Figure 2 showing an alternative form of back-up element,

Figure 4 is a diagrammatic front view of the cutting element of Figures 2 and 3,

Figure 5 is a diagrammatic front view of the back-up element of Figure 2,

Figure 6 is a similar view to Figures 2 and 3 showing an alternative chisel-shaped form of back-up element,

Figure 7 is a diagrammatic front view of the back-up element of Figure 6,

Figures 8 and 9 are similar views to Figures 6 and 7, showing a different arrangement of a chisel-shaped back-up element,

Figure 10 is a graph showing variation in the cross-sectional area, with respect to depth from their respective outer extremities, of a typical cutting element and three forms of back-up element,

Figures 11 to 13 are similar graphs to Figure 10, again showing variation in cross-sectional area but in this case with respect to depth from the cutting profile, the graphs representing respectively different values for the depth between the outer extremity of the back-up element and the cutting profile.

Figures 14 and 15 are diagrammatic sections through further forms of back-up element and associated cutting element, and

Figure 16 is a diagrammatic front view of the cutting element of Figure 15.

Referring to Figure 1, the rotary bit body has a leading end face 10 formed with a plurality of blades 11 upstanding from the surface of the bit body so as to define between the blades channels 12 for drilling fluid. The channels 12 lead outwardly from nozzles 13 to which drilling fluid passes through a passage (not shown) within the bit body. Drilling fluid flowing outwardly along the channels 12 passes to junk slots 14 in the gauge portion of the bit.

Mounted on each blade 11 is a row of cutting elements 15. The cutting elements project into the adjacent channels 12 so as to be cooled and cleaned by drilling fluid flowing outwardly along the channels from the nozzles 13 to the junk slots 14. Spaced rearwardly of the three or four outermost cutting elements on each blade are back-up elements 16. In the arrangement shown each back-up element lies at substantially the same radial distance from the axis of rotation of the bit as it associated cutting element, although other configurations are possible.

Referring to Figures 3 and 4, it will be seen that each cutting element 15 is a circular preform tablet comprising a front thin hard facing cutting table 17 of polycrystalline diamond bonded to a thicker substrate 18 of less hard material, such as cemented tungsten carbide. The cutting element 15 is bonded, in known manner, to an inclined surface on a generally cylindrical stud 19 which is received in a socket in the bit body 10. The stud 19 may be formed from cemented tungsten carbide and the bit body 10 may be formed from steel or from solid infiltrated matrix material.

Each back-up element 16 comprises a generally cylindrical insert having a portion 20 which is received in a socket in the bit body 10 spaced rearwardly of the stud 19. In accordance with the invention, the back-up element 16 is formed wholly from material which is less hard than the polycrystalline diamond, or other superhard material, of the cutting element. Suitable materials are cemented tungsten carbide or solid infiltrated matrix material of the kind used for moulded bit bodies.

The back-up element has a hemispherically domed projecting portion 21 which projects beyond the surface of the bit body 10. The outer extremity of the projecting portion 21 of the back-up element is spaced inwardly of the cutting profile defined by the cutting elements 15, such profile being indicated by the chain line 22. Thus, during drilling, before any significant wear of the cutting element has occurred, only the cutting element 15 engages the formation. The projecting portion 21 of the back-up element will only engage the formation when the cutting element has worn beyond a certain level, or has failed through fracture. The back-up element will then serve to share the load on the cutting element and thus reduce the risk of further damage to the cutting element.

At all times, the back-up elements 16 will serve to limit the depth of cut which may be effected by the cutting elements 15 and will also serve to a certain extent to limit impact damage to the cutting elements.

The engagement of the back-up elements 16 with the formation may serve to reduce radial vibration of the drill bit, but at the same time the configuration of each back-up element 16 is such that only a comparatively small wear flat is formed. Since the projecting portion 21 of the back-up element is hemispherically domed the formation-engaging surface of the back-up element will initially comprise, at most, only a narrow strip of the domed surface, indicated in dotted lines at 23 in Figure 2, which extends for 180° or less around the projecting portion 21 in a radial direction and which is narrow in the circumferential direction (with respect to the drill bit). As a wear flat develops on the back-up element the width of the surface portion 23 will increase in the circumferential direction but its dimension in this direction will always be less than the width of the cutting element 15 in the radial direction, in accordance with the present invention.

As previously mentioned, in the absence of embedded diamond or other superhard material in the back-up element, the frictional restraint to rotation caused by the back-element depends only on the area of the wear flat (for a given set of operating parameters) and is not subject to variations in the composition of the wear flat. The geometry of the back-up element may thus be selected to give a predictable pattern of frictional restraint as wear proceeds. The effect of the back-up element may therefore be accurately controlled with respect to the requirements of the associated cutting element. This control of the frictional restraint resulting from the back-up elements also enables control of the heat generated.

Figure 3 shows an alternative arrangement in which the bit body is moulded from solid infiltrated matrix material, such as powdered tungsten carbide infiltrated with a copper binder. In this case the back-up element 24 comprises a generally hemispherically domed projection integrally moulded with the surface of the bit body. The geometrical arrangement of the projection 24 with respect to the cutting element is similar to that of the projecting portion 21 of the insert 20 in the arrangement of Figure 2 and the shape of its formation-engaging surface will be similar.

Figure 4 is a diagrammatic front elevation of the cutting element 15 and stud 19 in the arrangement of Figure 2, and Figure 5 is a front elevation of the domed insert 21. The outer peripheral shape of the insert 20 is generally of the same width as the cutting element 15 and the radius of the domed extremity is similar to the radius of the cutting element 15 also.

Figure 6 is a similar view to Figures 2 and 3 showing a different form of back-up insert 25. In this case the projecting portion 26 of the insert is tapered both in the circumferential direction, as shown in Figure 6, and in the radial direction, as shown in Figure 7. It will be seen however, that the insert tapers more in the radial direction than it does in the circumferential direction, with respect to the drill bit, so that the projecting portion 26 of the insert is generally chisel-shaped. This, again, ensures that the formation-engaging surface of the projecting portion 26 of the element has a minimum dimension which is less than the width of the associated cutting element 15 in a generally radial direction, in accordance with the invention. Such arrangement means that the wear flat, as the insert is worn down by engagement with the formation, remains comparatively small in area while the insert still remains effective for protecting the cutting element and for providing radial stability to the drill bit.

Figures 8 and 9 show a modified version of the arrangement of Figures 6 and 7, in which the insert 25 has been rotated through 90°, so that the wider aspect of the chisel-shaped projecting portion extends generally radially, instead of circumferentially.

It is possible, for a given geometry of back-up, for a graph to be drawn of the area of the wear flat against the depth of wear towards the bit body, and a similar graph can be drawn for the cutting assembly. The geometry of the projecting portion of the back-up element may be so selected that the size of the wear flat on the back-up element, as wear proceeds, is at all times correlated to the size of the wear flat on the associated cutting assembly.

One such set of graphs is shown in Figure 10 where the cross-sectional area of the cutting element or back-up element (in square millimetres) parallel to the formation is plotted against the distance from the tip or outermost extremity of the element (in millimetres). Figure 10 assumes that the tip of the back-up element lies on the cutting profile, and is thus at the same level as the cutting edge of the cutting element.

The curve indicated at 27 relates to a polycrystalline diamond cutter of a typical form used in drag type drill bits. Curve 28 relates to a prior art back-up element of the kind comprising a cemented tungsten carbide post having a 118° conical projecting portion impregnated with particles of natural diamond or other superhard material. Curves 29 and 30 relate to generally chisel-shaped inserts of cemented tungsten carbide, for example inserts of the kind shown in Figures 6-9, which may be standard tungsten carbide inserts of a kind used as the primary cutting elements in roller cone bits.

As can be seen from Figure 10, the prior art back-up element, represented by curve 28, will produce a much larger wear flat for a given depth of wear than either of the chisel-shaped inserts indicated by curves 29 and 30. The smaller wear flat generated by the latter inserts may create less resistance to rotation of the drill bit than that created by the prior art back-up element. In addition to this, the if frictional engagement is lower it will generate less heat.

Figures 11-13 are graphs generally similar to Figure 10, but showing the situation where the outer extremity of the back-up element is spaced inwardly from the cutting profile by a predetermined amount. In each case, therefore, a certain amount of wear of the cutting element occurs, and a wear flat develops, before the back-up element engages the formation and formation of a wear flat on the back-up element begins.

In Figure 11 the back-up element is spaced 1.5 mm inwardly from the cutting profile, in Figure 12 it is spaced 1 mm from the profile, and in Figure 13 it is spaced 0.5 mm inwardly from the cutting profile.

It will be seen that at the greatest difference in depth between the back-up element and cutting element (Figure 11) the area of the wear flat on the back-up elements according to the present invention always remains significantly less than the area of wear flat on the cutting elements, whereas with a conventional diamond impregnated back-up element the area of the wear flat is always greater than the area of the wear flats on back-up elements according to the invention, and once the cutting element has worn to a depth of about 3.5 mm, the area of the wear flat on the back-up element exceeds the area of the wear flat on the cutting element.

As previously mentioned, where the back-up element is formed wholly from material which is less hard than the superhard material, i.e. does not include any superhard particles or inserts, the frictional restraint to rotation depends only on the area of the wear flat and not on the composition of the wear flat at any instant, since the composition of the material of the wear flat is uniform. Consequently, it is possible to control the frictional resistance to rotation, and the generation of heat, solely by controlling the geometry of the back-up elements.

Figure 14 illustrates another form of back-up element in accordance with the invention. In this case the back-up element comprises a post 31 of cemented tungsten carbide, solid infiltrated matrix or other non-superhard material. The post is generally cylindrical and circular in cross-section and has a portion 32 which projects from the surface of the bit body 10. The projecting portion 32 comprises a main part-spherically domed portion 33 at the centre of which is an additional part-spherical projecting portion 34 of smaller radius.

The size of the central portion 34 may be so selected that normally only this central portion is worn away during the normal life of the cutting element 15. During the life of the back-up element, therefore, it presents only a comparatively small surface wear flat to the formation and, in accordance with the present invention, the minimum dimension of the formation-engaging surface of the back-up element will always be significantly less than the width of the cutting element 15 in the radial direction.

However, by providing the smaller portion 34 on a larger stud 31, it is ensured that the comparatively small surface-engaging portion 34 has the necessary strength to prevent failure of the element in use, due for example to impact forces in the downhole environment.

It is normally accepted that, during the life of a drill bit the area of the wear flat on both the cutting element and the back-up elements will increase as wear proceeds with a consequent continuous increase in frictional restraint against rotation of the bit and generation of heat.

In the arrangement shown in Figures 15 and 16, the back-up element 35 shown in side view in Figure 15 and front view in Figure 16 is so shaped that it tapers outwardly as it extends away from the bit body 10, with the result that the cross-sectional area of the back-up element decreases with distance from the outer extremity of the element. As a consequence of this geometry, the area of the wear flat presented by the element 35 to the formation will decrease as wear proceeds. Since the area of the wear flat presented by the cutting element 15 increases as wear proceeds, it will be appreciated that, by suitable selection of the geometric shape of the back-up element 35, it is possible to correlate the development of the two wear flats so that the combined area of the two wear flats remains substantially constant, or varies only over a predetermined limited range, as wear proceeds.

As previously mentioned, in all of the above described arrangements according to the invention, the back-up element, or at least the portion thereof which engages the formation during the normal life of the bit, is formed wholly from a material which is less hard than the superhard material of the associated cutting element. Although the back-up elements described above will normally be made of cemented tungsten carbide or solid infiltrated matrix material, the invention does not exclude the use of other materials which are non-superhard, and any other suitable materials may be employed provided, of course, that they have the other well known characteristics required for elements which must be mounted in a drill bit and must survive in the harsh downhole environment.

Claims

1. A rotary drill bit for use in drilling or coring holes in subsurface formations comprising a bit body (10) having a shank for connection to a drill string, a plurality of cutting elements (15) mounted on the bit body, and a passage in the bit body for supplying drilling fluid to the surface thereof for cooling and/or cleaning the cutting elements, at least some of the cutting elements (15) each comprising a preform cutting element having a superhard front cutting table (17), and there being spaced from but associated with at least certain of said cutting elements, with respect to the normal direction of rotation of the bit, respective back-up elements (16) each of which projects from the bit body (10), characterised in that each said back-up element (16) is formed wholly from a material which is less hard than the superhard material of the cutting elements (15), and has a formation-engaging surface the minimum dimension of which is less than the width of its associated cutting element in a generally radial direction.

2. A rotary drill bit according to Claim 1, characterised in that said back-up elements (16) are spaced inwardly of the cutting profile (22) defined by the cutting elements (15).

3. A rotary drill bit according to Claim 1 or Claim 2, characterised in that the maximum dimension of each back-up element (16) in the circumferential direction is significantly less than the maximum dimension in a radial direction.

4. A rotary drill bit according to any of Claims 1 to 3, characterised in that each back-up element (16) is in the form of an elongate stud-like insert having one end (20) received within a socket in the bit body and the other end (21) protruding from the bit body.

5. A rotary drill bit according to Claim 4, characterised in that each insert (16) is formed from a refractory material.

6. A rotary drill bit according to Claim 5, characterised in that said refractory material is selected from sintered tungsten carbide and cemented tungsten carbide.

7. A rotary drill bit according to Claim 4, characterised in that each insert (16) is formed from solid infiltrated matrix material.

8. A rotary drill bit according to Claim 7, characterised in that the solid infiltrated matrix material comprises particulate tungsten carbide infiltrated with a copper binder.

9. A rotary drill bit according to any of Claims 4 to 7, characterised in that at least the end (20) of the insert (16) received within the socket in the bit body is generally cylindrical and of circular cross-section.

10. A rotary drill bit according to any of Claims 1 to 3, characterised in that the bit body (10) is moulded from solid infiltrated matrix material in a powder metallurgy process and each back-up element comprises a projection (24) of matrix material integrally moulded with the bit body.

11. A rotary drill bit according to any of Claims 1 to 10, characterised in that the projecting end (21) of each back-up element (16) is domed.

12. A rotary drill bit according to Claim 11, characterised in that the projecting end (21) of each back-up element (16) is hemispherically domed.

13. A rotary drill bit according to any of Claims 1 to 10, characterised in that the projecting portion (26) of each back-up element (25) tapers as it extends away from the bit body (10).

14. A rotary drill bit according to Claim 13, characterised in that the projecting portion (26) of the back-up element (25) tapers more in a generally radial direction than it does in a generally circumferential direction, so that the projecting portion (26) of the back-up element is generally chisel-shaped.

15. A rotary drill bit according to any of Claims 1 to 14, characterised in that the outer profile of the projecting portion (21) of each back-up element (16), as viewed in a circumferential direction, is substantially the same as the outer profile of the associated cutting element (15) when viewed in the same circumferential direction, the dimension of the formation-engaging surface (23) of the back-up element in the circumferential direction being less than the width of the cutting element (15).

16. A rotary drill bit according to any of Claims 1 to 15, characterised in that each back-up element (16) is located at substantially the same radial distance from the axis of rotation of the bit as its associated cutting element (15).

17. A rotary drill bit for use in drilling or coring holes in subsurface formations comprising a bit body (10) having a shank for connection to a drill string, a plurality of cutting elements (15) mounted on the bit body, and a passage in the bit body for supplying drilling fluid to the surface thereof for cooling and/or cleaning the cutting elements, at least some of the cutting elements (15) each comprising a preform cutting element having a superhard front cutting table (17), and there being spaced from but associated with at least certain of said cutting elements, with respect to the normal direction of rotation of the bit, respective back-up elements (35) each of which projects from the bit body (10), characterised in that each said back-up element (35) is formed wholly from a material which is less hard than the superhard material of the cutting elements, and is shaped to provide a cross-sectional area which decreases with distance from the cutting profile, whereby the wear flat presented to the formation by the back-up element decreases in area as wear proceeds.

18. A rotary drill bit according to Claim 17, characterised in that at least the portion of the back-up element (35) which protrudes from the bit body tapers outwardly, in a circumferential direction and/or in a radial direction, as it extends away from the bit body.

19. A rotary drill bit according to any of Claims 1 to 18, characterised in that the cross-sectional shape of the back-up element (35) is correlated to the cross-sectional shape of the associated cutting element in such manner that the combined area of the wear flats on the back-up element and the cutting element remains substantially constant, as wear proceeds.

20. A rotary drill bit according to any of Claims 1 to 18, characterised in that the cross-sectional shape of the back-up element is correlated to the cross-sectional shape of the associated cutting element in such manner that the combined area of the wear flats on the back-up element and the cutting element varies within a predetermined limited range, as wear proceeds.

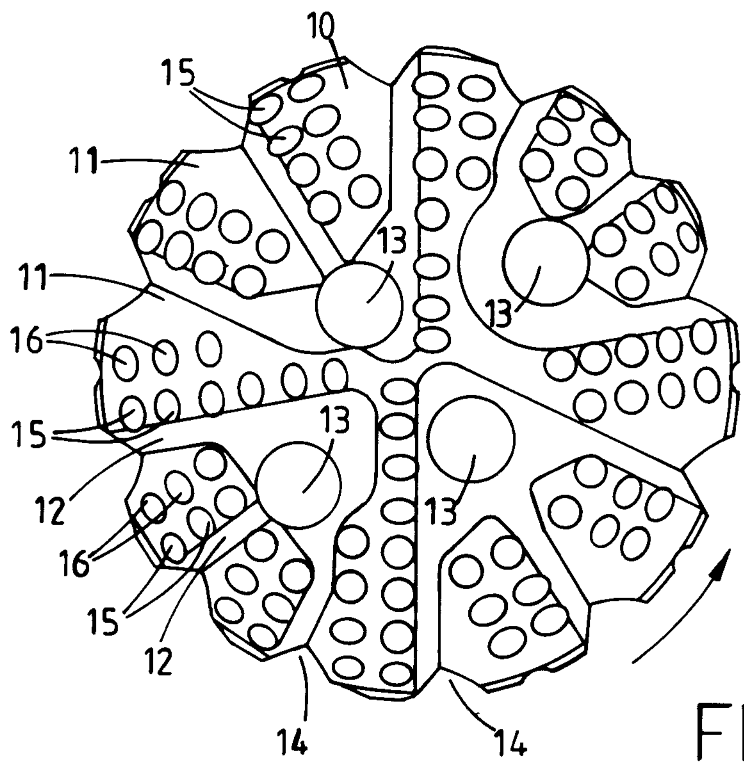

FIG.1.

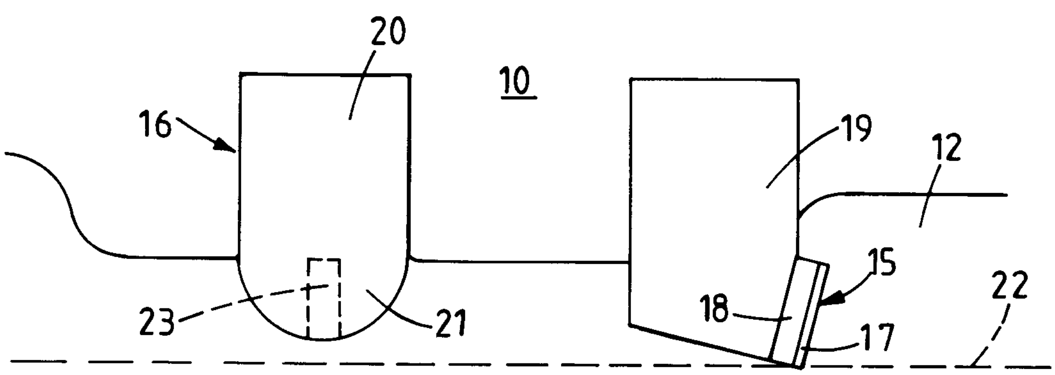

FIG.2.

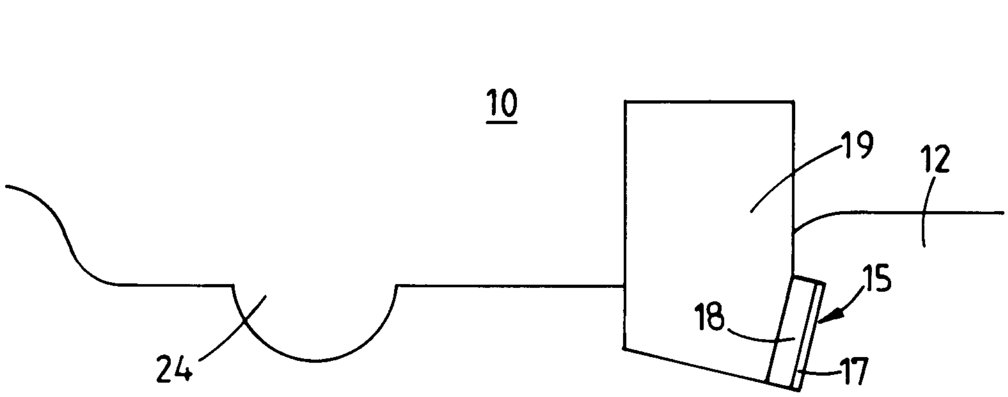

FIG.3.

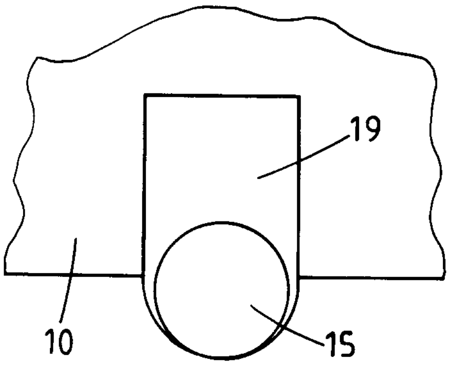

FIG.4.

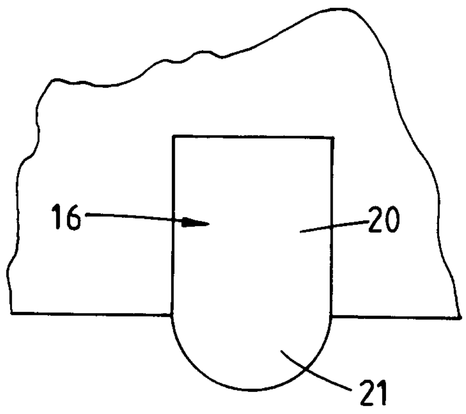

FIG.5.

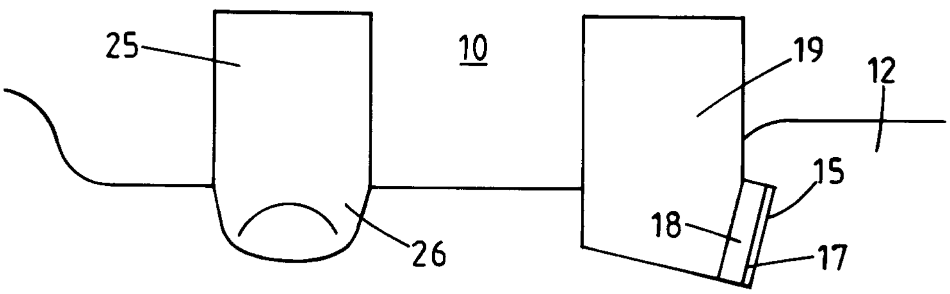

FIG.6.

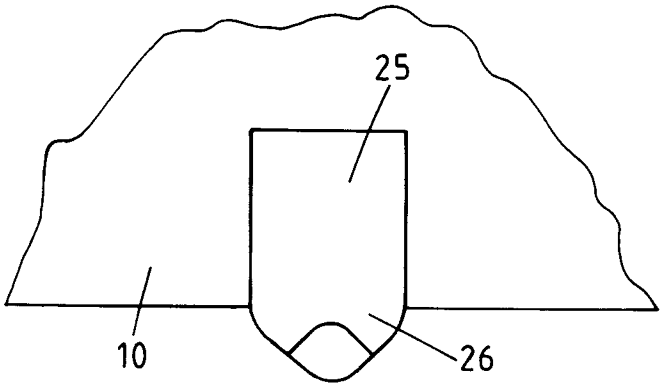

FIG.7.

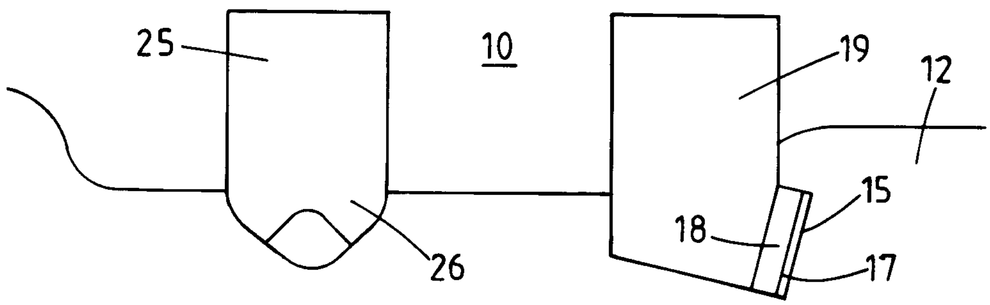

FIG.8.

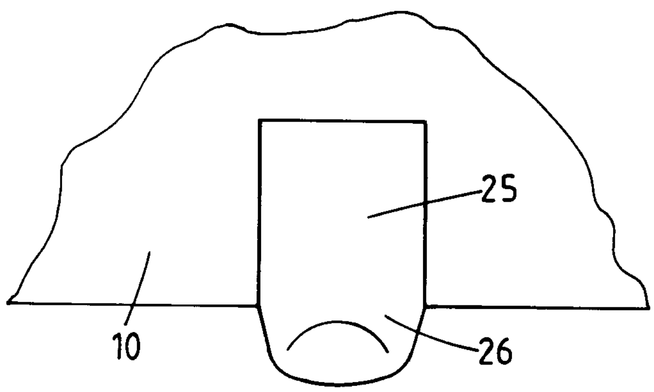

FIG.9.

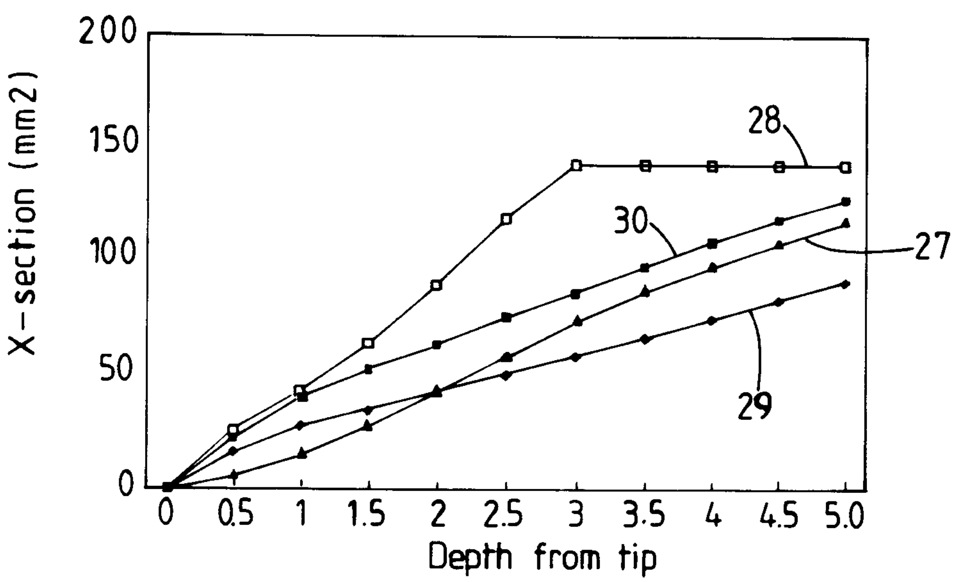

FIG.10.

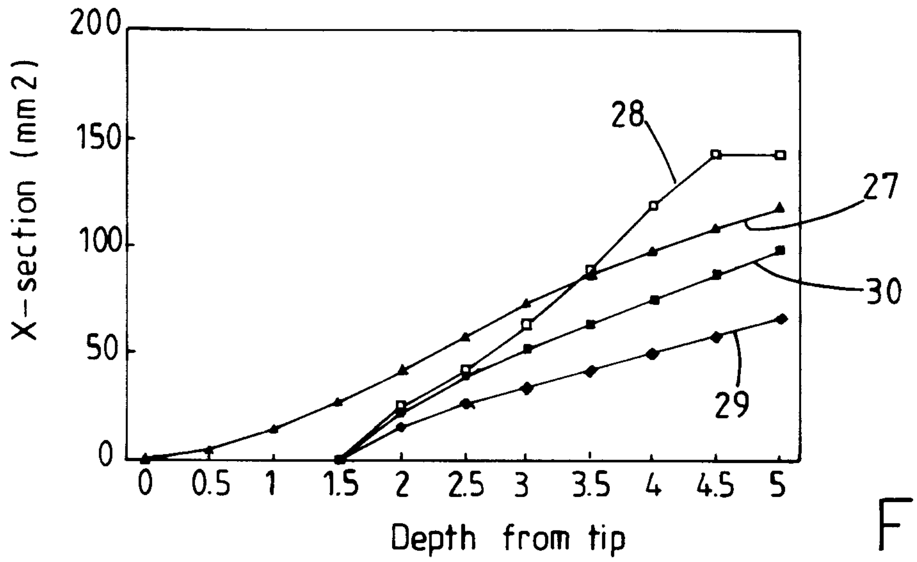

FIG.11.

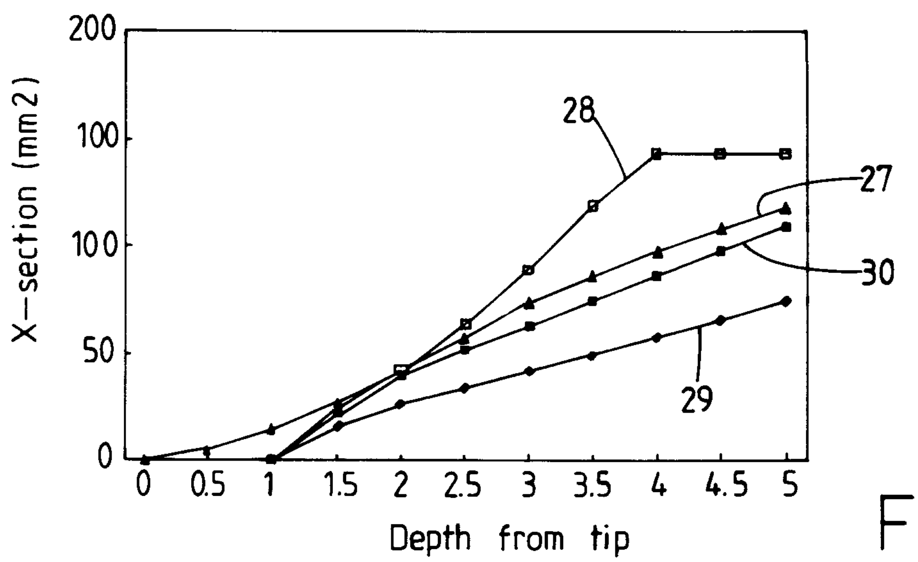

FIG.12.

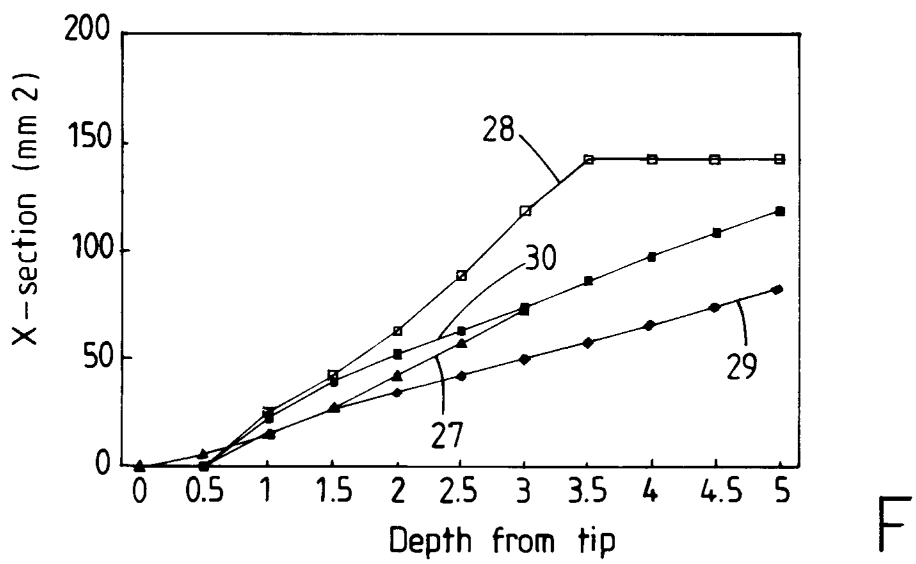

FIG.13.

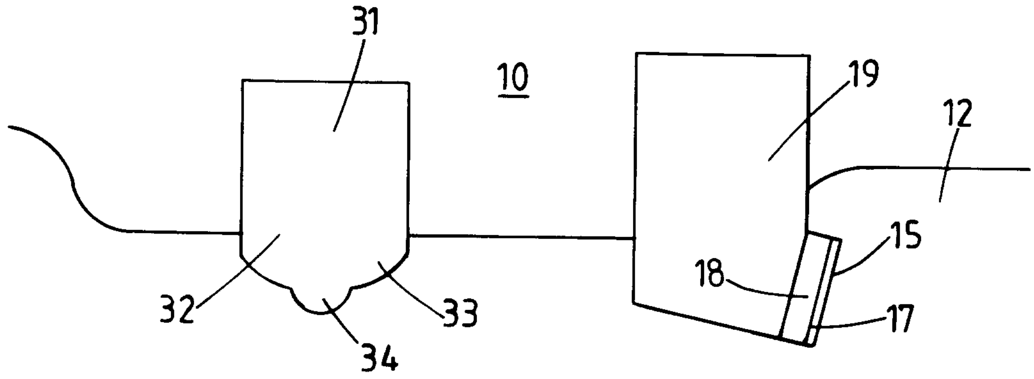

FIG.14.

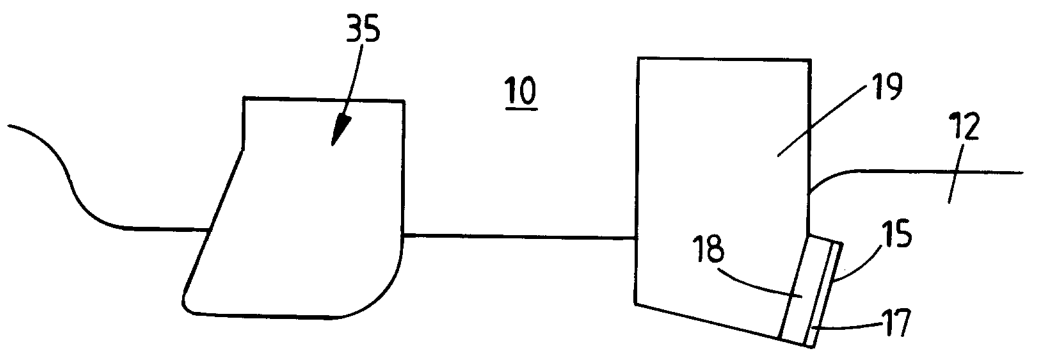

FIG.15.

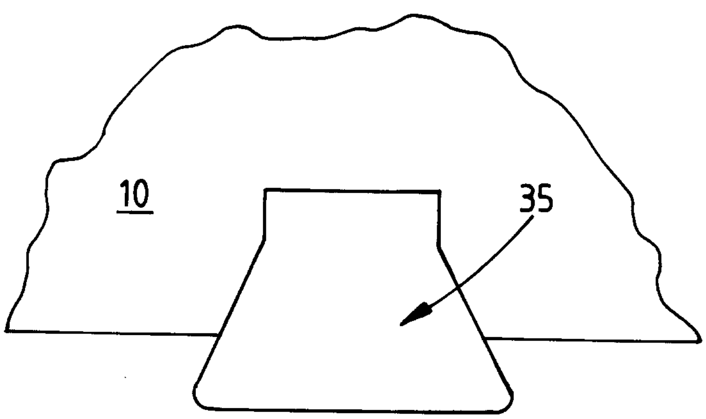

FIG.16.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 31 0193

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)
A,D	US-A-4 718 505 (FULLER) * column 3, line 43 - column 5, line 37; figures *	1,2,4-6, 9,11,17	E21B10/52
A	EP-A-0 370 717 (SMITH INTERNATIONAL) * column 4, line 10 - line 45 * * column 8, line 37 - column 9, line 5; figures *	1,2,4-6, 9,11,17	
A	EP-A-0 291 314 (REED TOOL COMPANY) * column 5, line 6 - line 54; figures 7,9 *	1,2,4-6, 9,17	
A,D	US-A-5 090 492 (KEITH) * column 2, line 62 - column 3, line 68; figures *	1,2,4-6, 17	

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
THE HAGUE	20 April 1994	Lingua, D

CATEGORY OF CITED DOCUMENTS

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