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(54) **HYBRID DRILL BIT**

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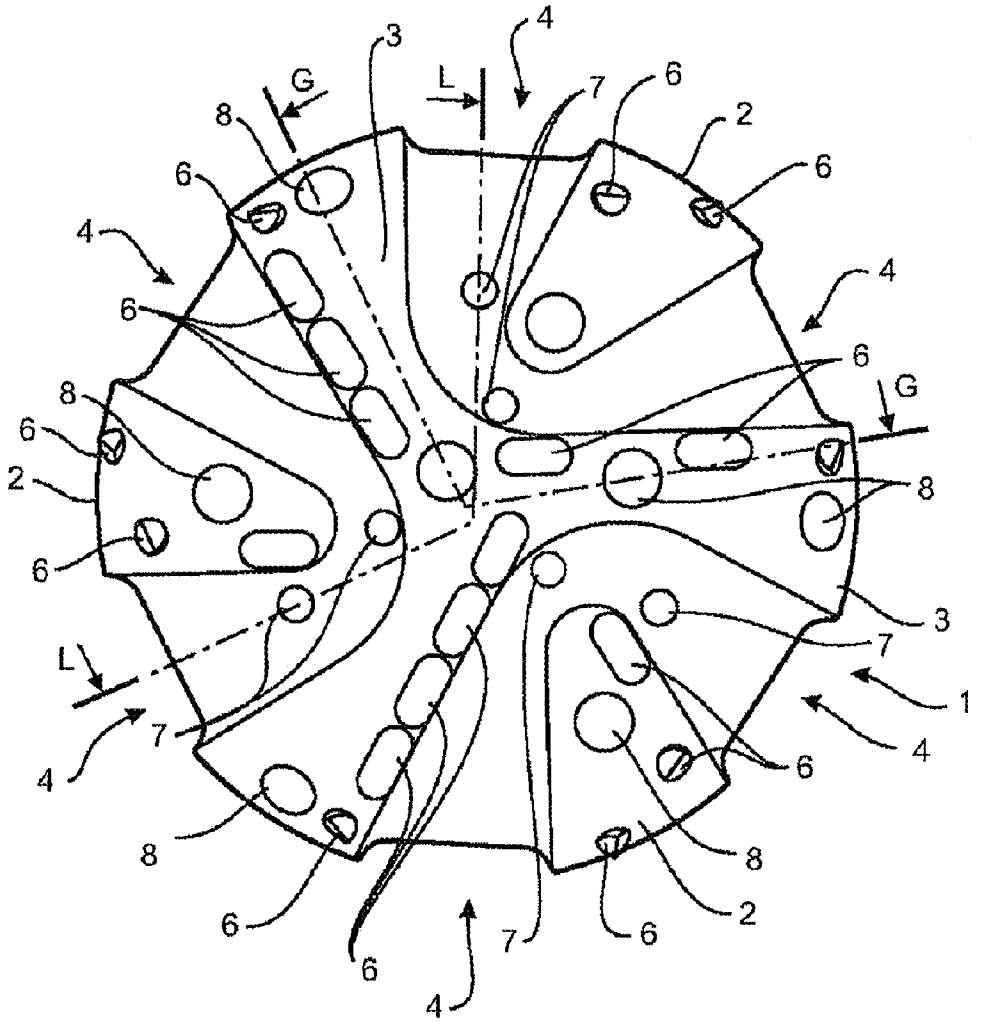
(57) **ABSTRACT**

A boring tool having downhole hammered impact elements that present to the bore face from platforms or plateaux of the work face of the tool, such work face having shear cutters able to benefit over the bore face from disruption caused by the impact elements.



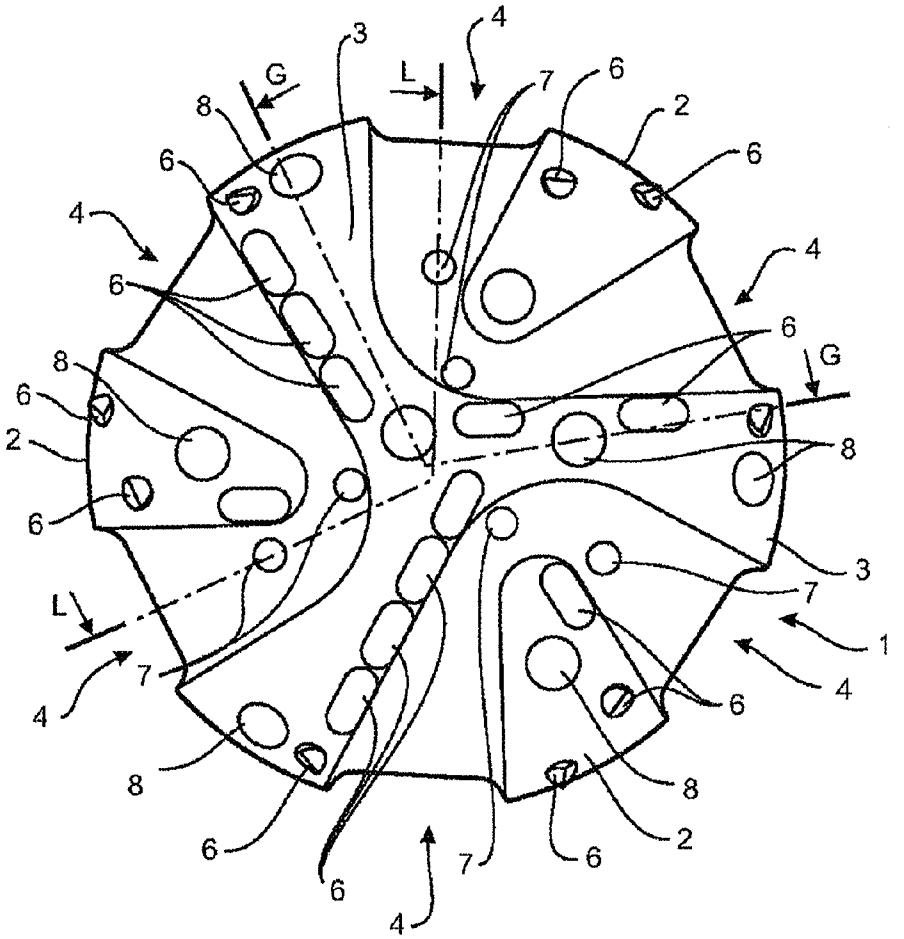


FIGURE 1

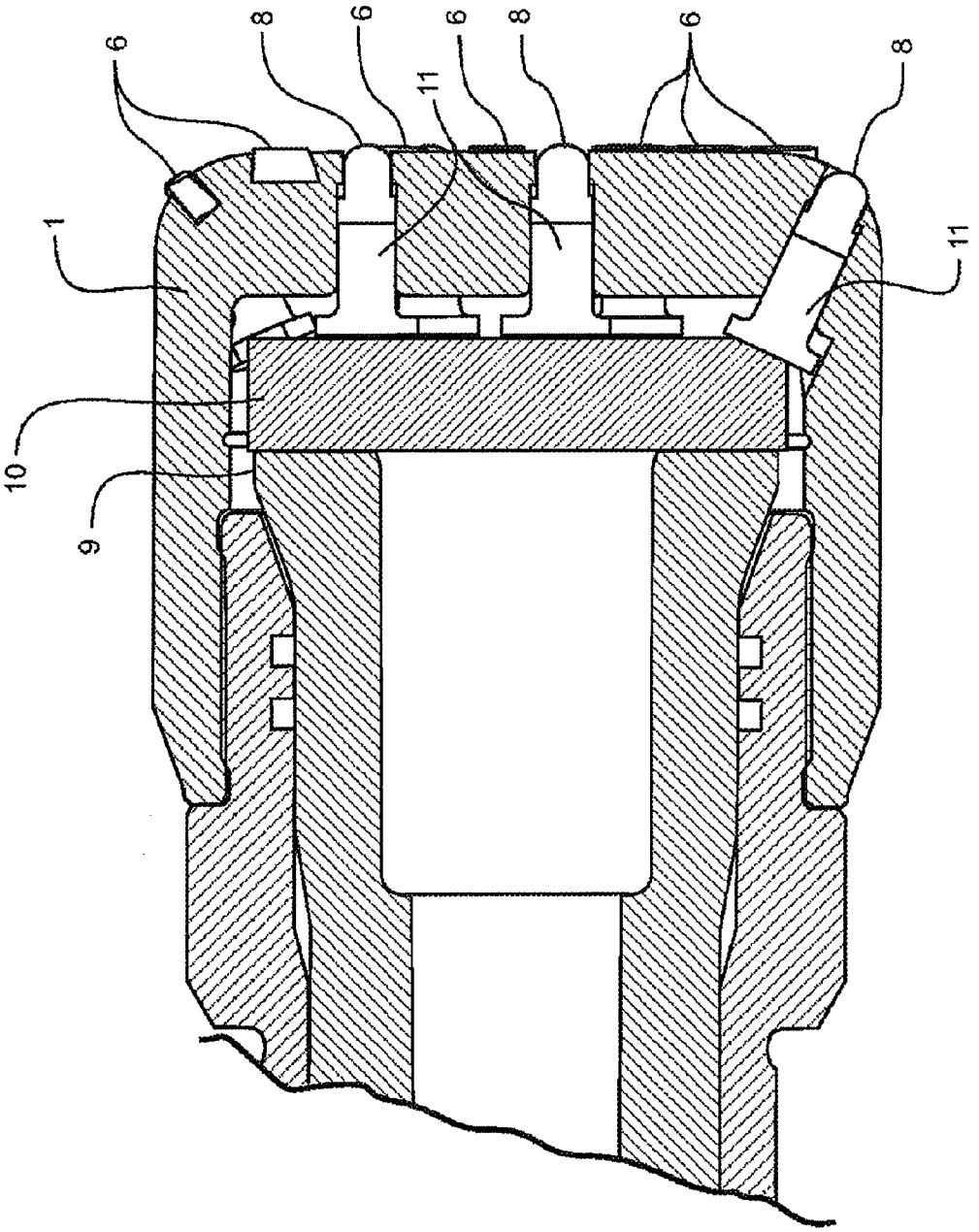


FIGURE 2

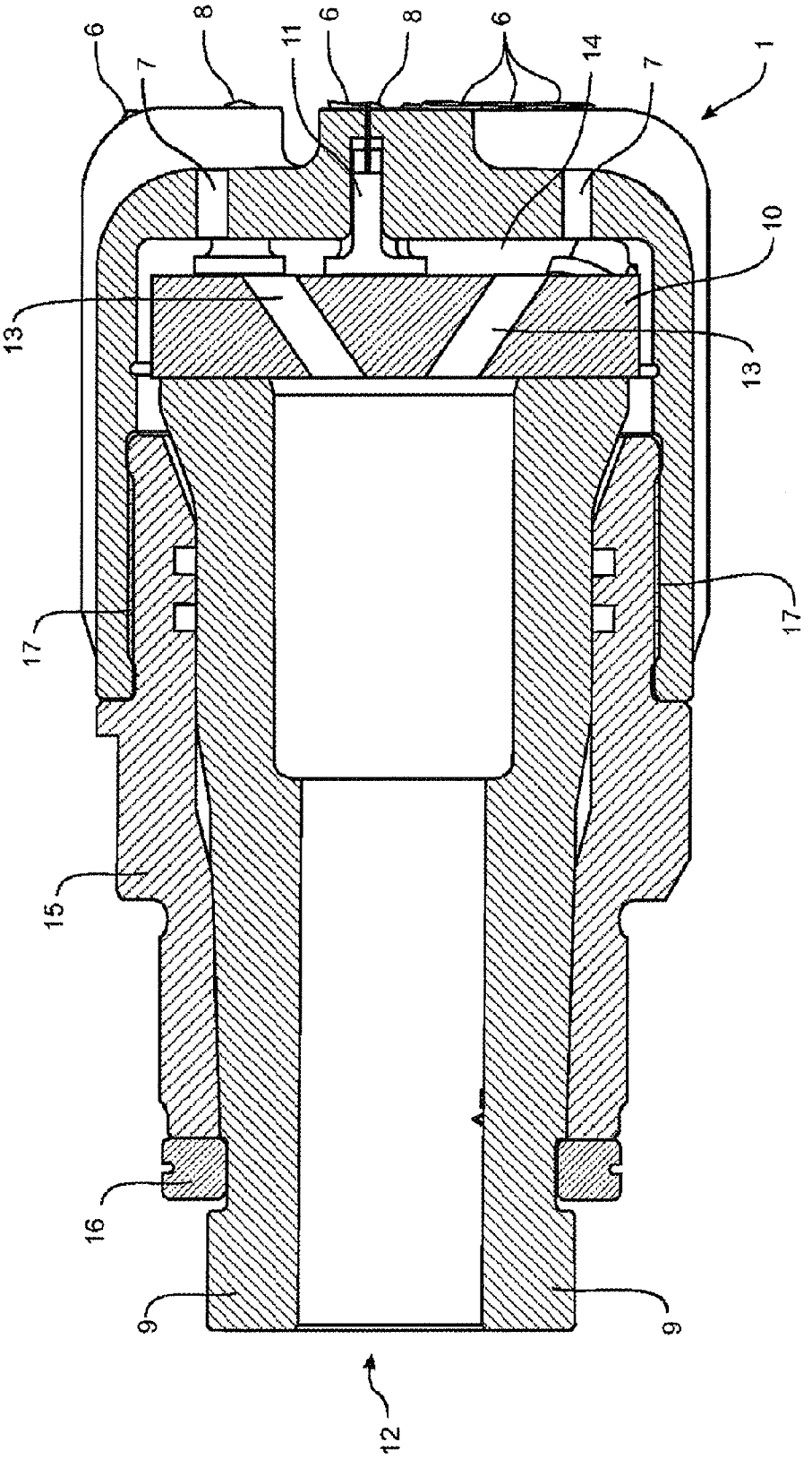


FIGURE 3

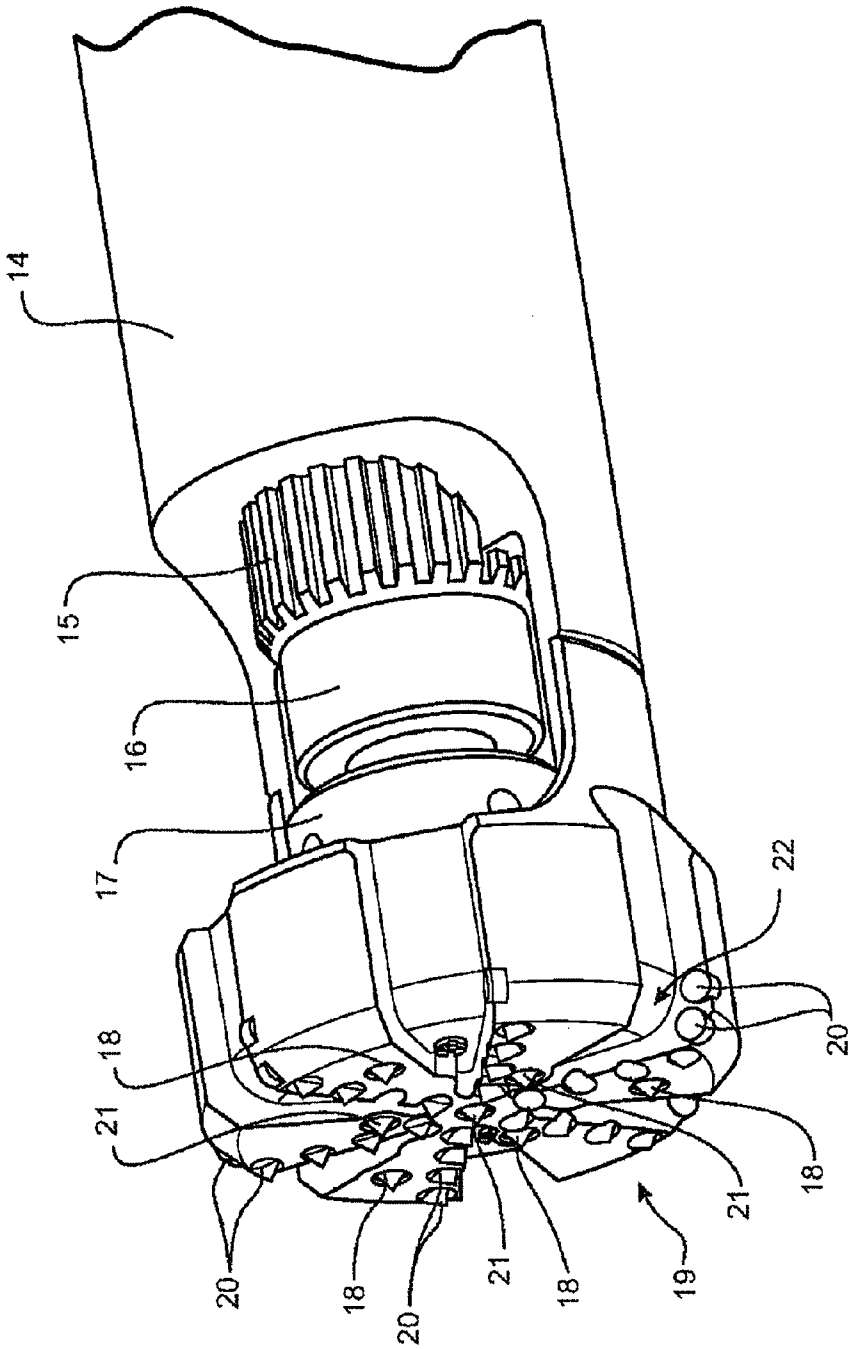


FIGURE 4

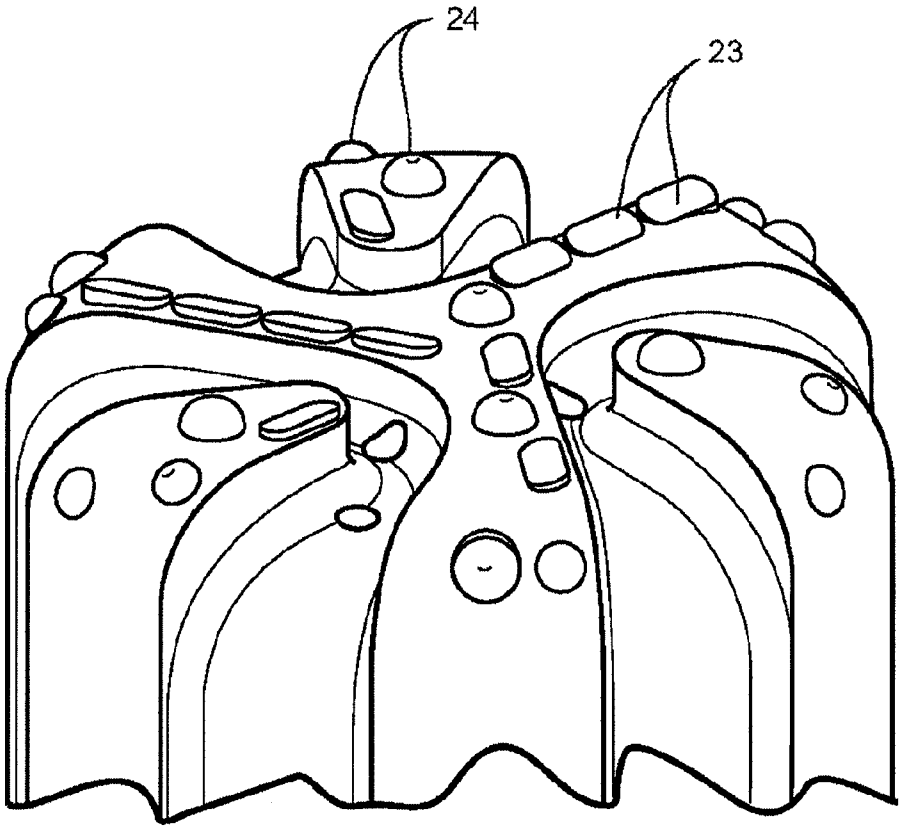


FIGURE 5

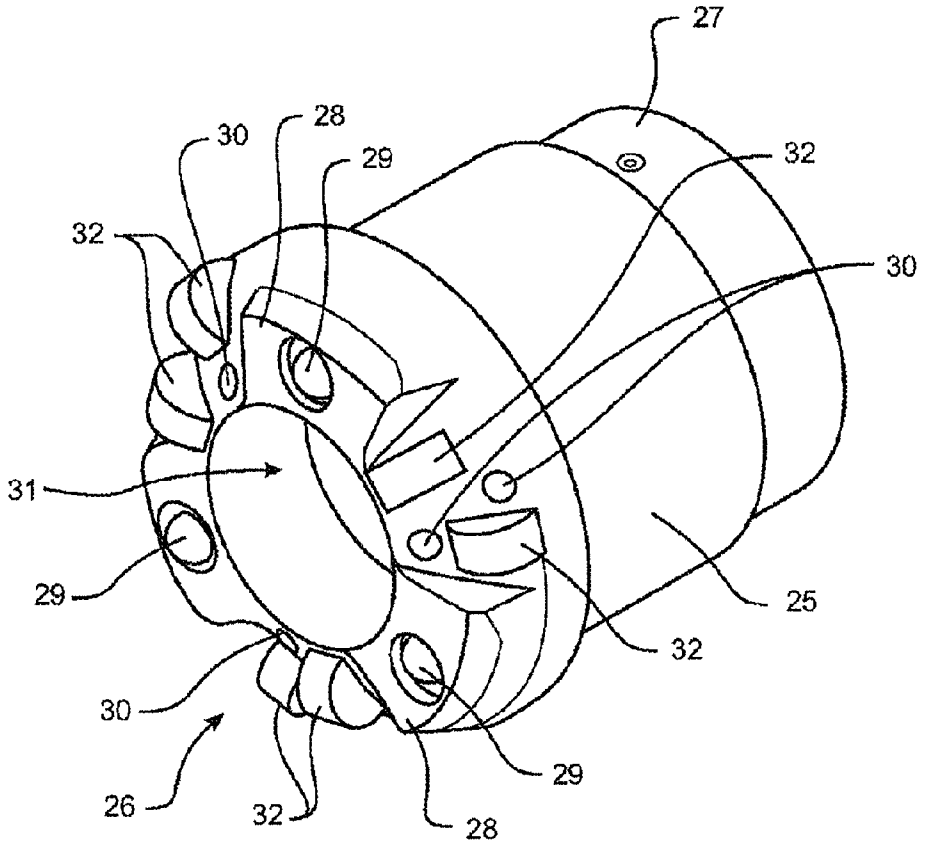


FIGURE 6

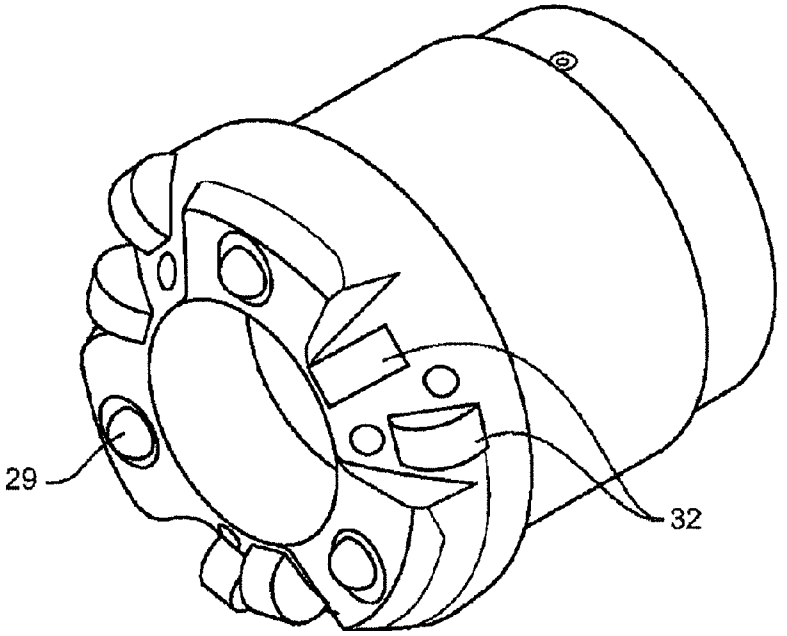


FIGURE 7

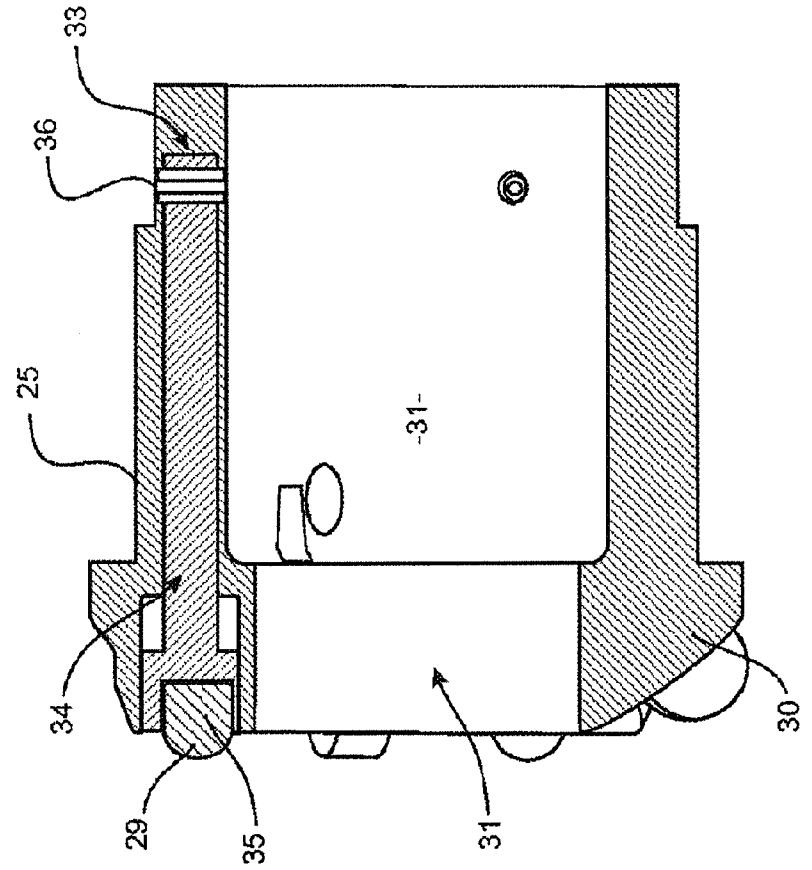


FIGURE 9

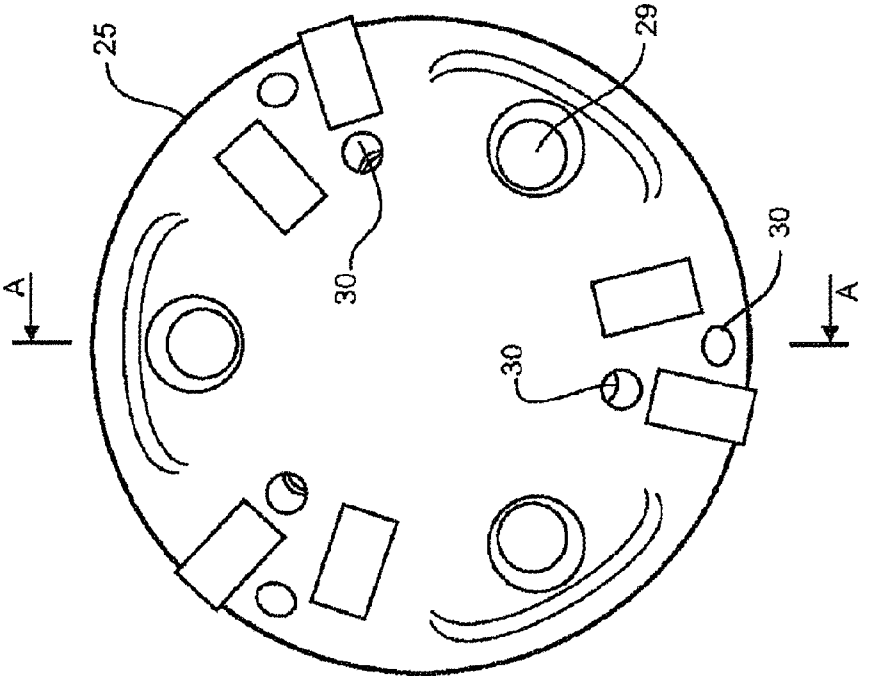


FIGURE 8

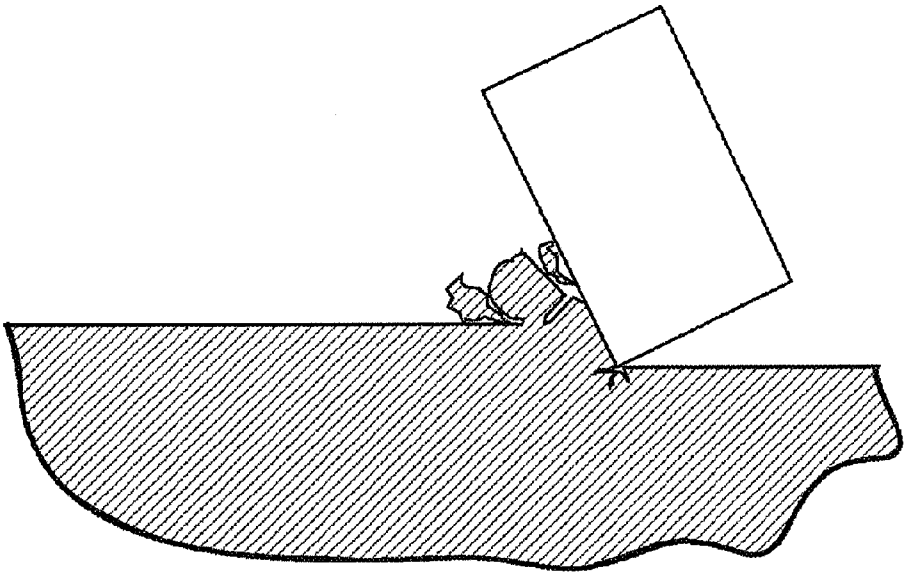


FIGURE 10

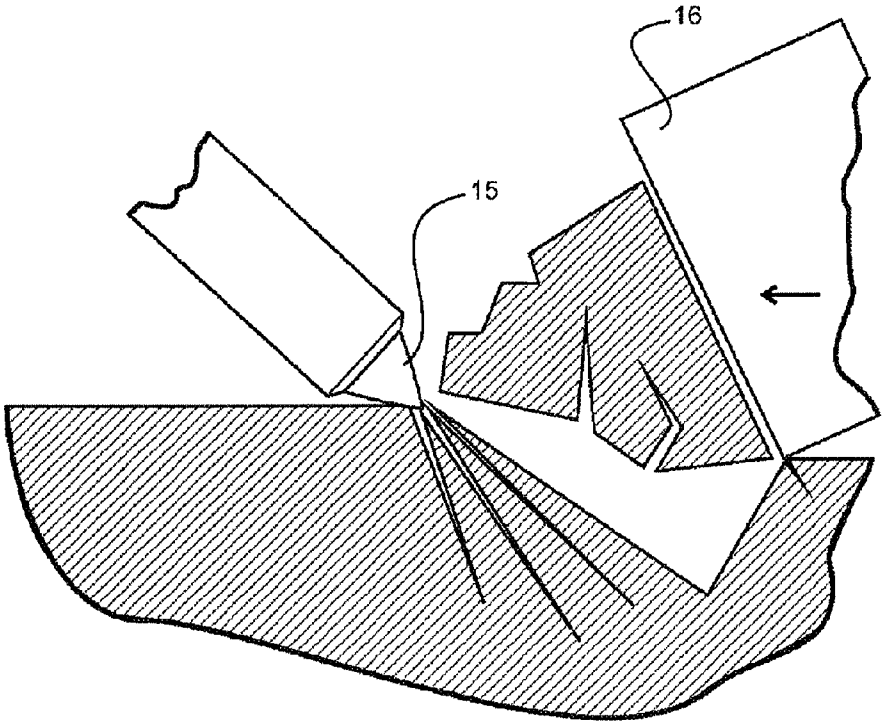


FIGURE 11

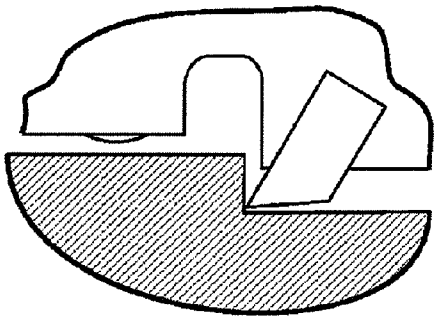


FIGURE 12A

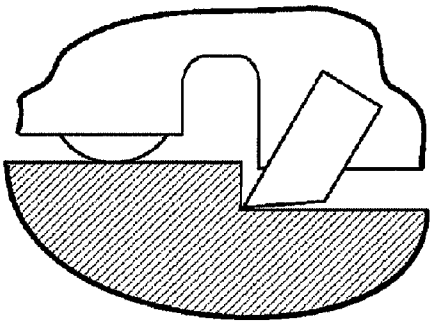


FIGURE 12B

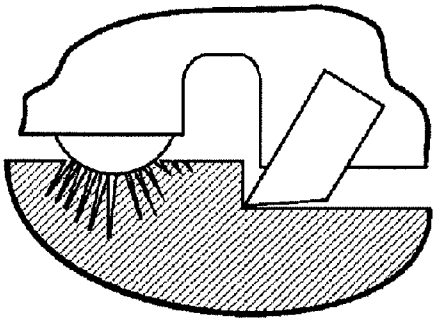


FIGURE 12C

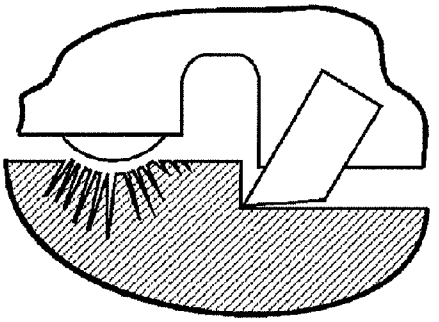


FIGURE 12D

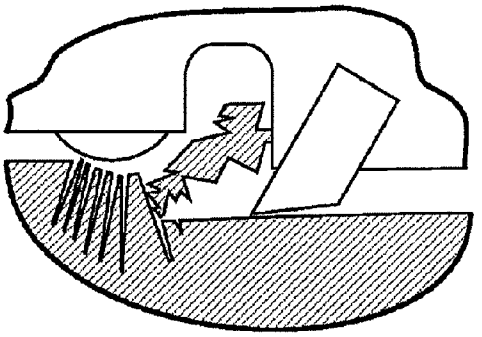


FIGURE 12E

HYBRID DRILL BIT

FIELD OF INVENTION

[0001] The present invention relates to hybrid drill bits.

[0002] More particularly the present invention relates to a drill bit (whether for purely drilling or whether for obtaining a core) where there is a profiled face (e.g. any form able to act as a shear cutting bit) able to act in concert with percussive features better able, than the profiled face, to disturb the integrity, or facilitate the removal of the formation of the bore face.

BACKGROUND

[0003] In deep-high pressure bore holes, the hydrostatic fluid pressure tends to hold down the previously fractured drill chips. This has been partially offset by using "shear cutting" bits (normally poly crystalline diamond "PDC"—or diamond impregnated bits) which scrape away the formation (rather than smashing/crushing the formation as is the case with roller bits or impact hammers).

[0004] However the shear cutters are not suitable for use in very hard rock formations, as these formations easily destroy the cutters.

[0005] In such deep-high pressure bore holes (very much deeper than, say, 1500 metres) downhole hammers acting on a downhole tool should in theory drill rapidly, however at such depths there are high downhole pressures. Testing has shown that once the borehole pressure exceeds 1200 PSI the rate of production when drilling with fluid hammers decreases substantially it is assumed due to chip hold down. While it is believed that the present invention helps overcome the chip hold down phenomenon, this design has also been shown to have advantages in shallow bore hole low pressure drilling applications.

[0006] We propose a hybrid drill bit that combines the impact action associated with down hole hammers—which are effective at fracturing the formation, with shear cutting elements which are very effective at scraping fractured (by the hammer action) rock formations out of the borehole. The hybrid bit is designed in such a way that the shear cutters are somewhat isolated from the hammer action.

[0007] We propose such a hybrid drill bit to have such features rotatable together, yet movable relative to each other axially of the rotational axis, as well as being able to rotate independently (and randomly) of the rotation of the bit body) so that percussive emergent features of high point loading, yet requiring manageable energy inputs to a downhole hammer, can break chips free, or fracture the formation to ultimately provide chips, without hydrostatic chip hold-down owing to their immediately being scraped away and/or cut away into a flushing fluid flow (e.g. mudflow) to take such scraped away chip material(s) away from the formation face.

[0008] U.S. Pat. No. 7,546,888 of Shell Oil Company discloses a percussive drill bit carrying both axial cutters and shear cutters in a mutually fixed interrelationship so that the axial cutters bear on the formation face in advance of the shear cutters.

[0009] U.S. Pat. No. 7,104,344 also of Shell Oil Company discloses a method of drilling into geological formations where there is a use downhole of both percussive elements and shear or drilling cutters. There is a percussive movement of a predominant and central percussive part (with plural percussive elements extending to the perimeter) relative to the more outwardly arrayed banks of drilling cutters. The drilling cutters have the function of a scraping away of the cracked parts of the formation.

[0010] The embodiments of U.S. Pat. No. 7,104,344 have, as its percussive element, a structure carrying multiple percussive cutters about which are deployed gangs of drilling cutters. The numbers of percussive cutters greatly outnumber the numbers of drilling cutters.

[0011] The arrangements of U.S. Pat. No. 7,104,344, by having the large number of percussive axial cutters and by having the gangs of drilling cutters in constant contact with the rock face, has a high energy requirement to render the percussive axial cutters effective owing to a resultant low point loading. Also the multiple percussive cutter structure denies the option of the drilling cutters extending as arrays, radial or otherwise, to regions close to the axis of rotation.

[0012] The arrangements of FIGS. 2 and 4 of U.S. Pat. No. 7,140,344 with ratios of percussive cutters: drilling cutters of 38:16 and 21:16 respectively also have flushing fluid parts confined well away from the central zone thereby reducing entrainment efficiency from that zone.

[0013] Eddison U.S. Pat. No. 7,461,706B2 describes several embodiments, one of which uses emergent impact features in conjunction with either rolling elements—of shear cutters. With this device it is not possible to have the impact projectiles strategically covering the entire diameter of the drill face.

[0014] In a second embodiment of U.S. Pat. No. 7,461,706B2 a core sampling device is described—however with this device, once the central hammer with (impacting profiles) is withdrawn—the core drilling falls solely on the shear cutters, which will not survive in hard rock formations—or relies on rolling elements, which can drill hard rock—but require a high level of thrust (weight on bit) to advance into the formation. This extra thrust will require extra torque to rotate the bit, this can then have the negative consequence of causing a stick/slip reaction which can prematurely destroy drill bits.

[0015] A hybrid drill bit of the present invention (whether for hole drilling, core sampling or otherwise) is likely to overcome this problem in several ways;

[0016] by using an impact hammer action (through dedicated percussive features emergent through the shear cutter carrying face) (e.g. of Carbide or Diamond) that percussively fractures the hard rock formations—significantly weakening the rock structure.

[0017] the percussive features are strategically located across the face of the drill bit, from the centre, to the outer periphery, this greatly assists in bit design as when used with hammers of even modest impact force, the impact force can be applied across a relatively small number of strategically placed percussive features—thereby still giving significant point loading—or rock destruction, while allowing ample space to affix the shear cutting members, which can then remove the fractured formation.

[0018] A second embodiment will describe a core sampling hybrid bit. Again the ability to strategically place the percussive features as required—allows a core drilling bit to be designed whereby the ring of rock surrounding the core sample is able to be destroyed by impact and removed in conjunction with shear cutters, this is particularly important in hard rock mineral sampling as the shear cutters by themselves would likely not survive in

the hard rock environment without the pre crushing that the strategically placed percussive features provide. It also means that unlike the Eddison U.S. Pat. No. 7,461,706B2—high thrust loads and the resultant negative stick/slip are not required/encountered when core drilling In either of the embodiments our design offers the ability for the percussive features to be housed in such a way that as the drill bit body is rotated (—generally from a surface drive) the percussive features are free to randomly rotate within their respective housings. Some of the drilling fluid is allowed to flow around the percussive features shaft and the bit body housing—this assists in lubricating/cooling the axially moving and rotating percussive features.

[0019] This independent and random rotation of the percussive features has the significant advantage of helping to avoid flat spot wear on the impact faces (which leads to premature dulling of the drill bits). Given that the drill bits can often be many thousands of meters below ground, the benefits of minimizing premature bit wear can save considerable time.

[0020] by using, in concert with such impact hammer action through the emergent percussive features, a profiled main drill face with shear cutters (of any shape, or material, or positioned with positive, negative, or neutral angles of rake, or mixtures thereof) that can be located in any suitable array, including to regions close to the axis of rotation, to scrape away or shear cut the fractured rock more efficiently

[0021] by using preferably drill fluid jetted preferably through the profiled main drill face as a flushing fluid (albeit serving other uses if desired) to the rock formation to assist in removing the fractured rock from the whole of the rock face.

[0022] The present invention is directed to hybrid drill bits (whether for drilling a bore or for core drilling or otherwise) which incorporates some of these features or which provides an advantage or at least provides a useful choice in the tool choice for rock or downhole formation drillers.

BRIEF DESCRIPTION OF THE INVENTION

[0023] In an aspect the invention is a boring tool for use downhole for hole boring or core taking when connected so as to depend and rotate with a drill string about an axis of rotation aligned to that of the drill string, the tool comprising or including

[0024] a body member or assembly ("body"), the body to depend from the drill string and defining a profiled work face to be presented against the bore face and to accord substantially to the area and shape of the bore face, such bore face to be bounded by a circle if the tool is for hole boring and such bore face to be annular if the tool is for core taking,

[0025] shear cutters carried by the profiled work face, and

[0026] impact elements, whether of a common component or not, supported by the body so as to be movable through the work face of the body and able to be hammered directly or indirectly from behind the work face of the body to provide, or be, localised impact emergences beyond localities of the profiled work face;

[0027] wherein said profiled work face defines recessed or non-protuberant regions amongst non-recessed or protuberant regions;

[0028] and wherein the localised impact emergences are each from a non-recessed or protuberant region of the profiled work face of the body

[0029] and wherein the localised impact emergences and bit features of the profiled bit will act in concert across the bore face.

[0030] Preferably said impact elements are emergent of non-recessed or protuberant regions of the profiled work face and said shear cutters are on the non-recessed or protuberant regions, the recessed or non-protuberant regions, or both

[0031] Preferably each said impact element can rotate about a reciprocation axis at least substantially parallel to said axis of rotation.

[0032] Preferably the body includes porting to allow a fluid egress.

[0033] Preferably the impact emergences are spread about the work face of the impact elements and the spread involves localities of different radii from said axis of rotation.

[0034] Preferably shear cutters are on said non-recessed or protuberant regions.

[0035] In one option the tool is for core taking and said impact elements are on an at least substantially common radius from said axis of rotation and said sheer cutters act inwardly and outwardly of the locus of that at least substantially common radius.

[0036] Preferably, for that option, said shear cutters are in recessed or non-protuberant regions of the profiled work face of the body.

[0037] In another aspect the invention is a boring tool having downhole hammered impact elements that present to the bore face from platforms or plateaux of the work face of the tool, such work face having shear cutters able to benefit over the bore face from disruption caused by the impact elements.

[0038] In another aspect the invention is a hybrid drill bit suitable for use downhole, for hole boring, the hybrid drill bit comprising or including an assembly which when associated with a drill string defines, or will define,

[0039] a profiled bit or bit assembly ("bit") able to be rotated about an axis of rotation to have an effect on a bore face over its diameter of operation, the profiled bit having bit features able to effect, in use, a shear cutting affect, a chip sweeping affect or a scraping affect, or any combination of the affects, and

[0040] impact elements, whether of a common component or not, able to be hammered directly or indirectly to provide, or be, localised impact emergences beyond localities of the profiled bit;

[0041] wherein the localised impact emergences, upon rotation of the profiled bit, and thus the hybrid drill bit, have

[0042] (a) plural radiused loci of rotation, or

[0043] (b) plural radiused loci of rotation and a location at the axis of rotation;

[0044] and wherein the localised impact emergences and the bit features of the profiled bit act in concert across said diameter of operation of the profiled bit.

[0045] Preferably said profiled bit is profiled in part by shear cutters or wear resistant members ["shear cutters"] as inserts presenting from a bit body.

[0046] Preferably said bit body itself is profiled to present both

[0047] (i) protuberant regions and

[0048] (ii) less protuberant or recessed regions.

[0049] Preferably each said impact elements presents, when hammered directly or indirectly, from a said protuberant region.

[0050] Preferably said shear cutters present from said protuberant regions.

[0051] Preferably fluid outlets are disposed in said bit body in said less protuberant or recessed regions.

[0052] Preferably the profiled bit is splined to a captive hammering assembly.

[0053] Preferably said hammering assembly comprises or includes an annular hammer able to duct fluid.

[0054] Preferably a ported member to receive fluid via said annular hammer receives and conveys the impacts of the hammer to the impact elements and receive fluid to said outlets.

[0055] Preferably said impact elements are individually rotatable relative to said profiled bit.

[0056] Preferably each impact element is of a profiled bit captive wear resistant material held by or impactable upon by a captive guided hammerable member.

[0057] In another aspect the invention is a downhole tool comprising or including

[0058] a bit profiled by at least multiple shear cutting inserts or shear cutters ("shear cutters") able to be presented to a bore face as the bit is rotated, and

[0059] multiple impact elements rotatable with the bit yet hammerable directly or indirectly so as to emerge or further emerge from the bit to act in concert with the shear cutters;

[0060] wherein the shear cutters are arrayed so as, in use as the tool is rotated and the impacted elements are hammered directly or indirectly, to at least substantially fully sweep/shear cut on loci of rotation about the rotational axis of the bit that will follow disruption of the or a bore face caused by the hammered emergence, or further emergence, of said impact elements that rotate on loci of rotation about the rotational axis of the bit to be intermittently disruptive over at least all of the area of the or said bore face.

[0061] Preferably the bit has a bit body with a profiled face presentable to a bore face in use, said profiled face having more protuberant regions and less protuberant or recessed regions, the impact elements being emergent each from an opening through a protuberant region.

[0062] Preferably shear cutters as insets are carried by some or all of said protuberant regions.

[0063] Preferably ports for fluid emergence are provided through some or all of said less protuberant or recessed regions.

[0064] In another aspect the invention is apparatus (i.e. hybrid drill bit or downhole tool) as aforesaid positioned downhole to rotate with a drill string and provided with a hammering mechanism actuable to directly or indirectly hammer the impact elements.

[0065] In another aspect the invention is a hybrid downhole tool able to bore into a bore face whilst presenting a spread of captive localised percussive elements or cutters to the bore face and clearing dislodged and/or ruptured material(s) of the bore face reliant upon a profiled array of shear cutters;

[0066] wherein the captive percussive elements or cutters despite being emergent from hammered directly or indirectly to provide, as the tool is rotated, both a radial spread of loci of intermittent percussive action across substantially the whole diameter of the effect of the tool.

[0067] In still another aspect the invention is a hybrid coring tool suitable for use downhole for core taking, the tool comprising or including an assembly which when associated with a drill string defines, or will define, a profiled bit or bit assembly ("bit") having an annular profile able to be rotated about an axis of rotation to have an annular affect on a bore face over its annular field of operation, the profiled bit having bit features able to effect, in use, a shear cutting affect, a chip sweeping affect, or a scraping affect, or any combination of the affects, and

[0068] impact elements, whether of a common component or not, able to be hammered directly or indirectly to provide, or be, localised impact emergencies beyond localities of the annular field of action of the profiled bit.

[0069] Preferably the localised impact emergences, upon rotation of the profiled bit, and thus the hybrid coring tool, have

[0070] a single radius loci of rotation or plural radiused loci of rotation, yet having inwardly and outwardly of the locus of rotation, or said loci of rotation, shear cutters.

[0071] In another aspect the invention is the use of a downhole rotatable tool to have an effect on a bore face on a delimited area being:

[0072] (A) an area delimited by a radial distance from the tool's axis of rotation, or

[0073] (B) an annular area delimited between different radial distances from the tool's axis of rotation;

[0074] wherein the tool is characterised in having a body presenting a profiled face towards the bore face over the delimited area;

[0075] and wherein protuberances of the profiled face carry wear resisting shear cutters;

[0076] and wherein emergent from passageways opening from said protuberances are impact elements able directly or indirectly to be hammered to provide a percussive disruption into said delimited area from whence any ruptured or dislodged material can be cleared from the delimited area by said shear cutters and/or the profiled face.

[0077] Preferably the use is together with fluid released via and/or to the profiled face.

[0078] In another aspect the invention is a method of removing material from a subterranean face which comprises or includes the steps of rotating against such face a downhole rotatable tool which has an effect on a bore face on a delimited area, the delimited area being

[0079] (A) an area delimited by a radial distance from the tool's axis of rotation, or

[0080] (B) an annular area delimited between different radial distances from the tool's axis of rotation:

[0081] characterised in that whilst rotating the tool a profile faced body or assembly ("tool body") of the tool which has protuberances as plateau regions, both

[0082] (i) carries wear resisting shear cutters and

[0083] (ii) allows the emergences from each dedicated passageway of passageways opening from such plateau regions impact elements that are hammered, said method comprising ensuring such impact elements are directly or indirectly downhole hammered whilst rotating in unison with the tool body to the affect that the impact elements provide a percussive disruption into said delimited area of the bore face from whence any ruptured or dislodged material(s) can be cleared from the delimited area by said shear cutters and/or the profile of the tool body.

[0084] In another aspect the invention is a hybrid drill bit (whether for hole drilling, core sampling or otherwise) com-

prising or including an assembly, or at least an assembly when associated in use with a drill string, having

[0085] a first component (unitary, fabricated or assembled) providing a profiled face, and

[0086] a second component (unitary, fabricated or assembled) to provide or providing emergent features through and from a dedicated passageway for each emergent feature from the profiled face of the first component;

[0087] wherein relative movement can occur or can be caused (e.g. by a hammering system) between the first and second components such that emergent features emerge, if not always emerged, and/or emergent features are further emerged from an already emerged condition;

[0088] and wherein the emergent features can have a percussive effect responsive to an appropriate input to the second component (e.g. by such a hammering system);

[0089] Preferably a hammering system can cause said relative movement (whether actively or inwardly or outwardly, or both).

[0090] Preferably a said profiled face is, or includes elements to provide, a shear cutting- or scraping face.

[0091] Preferably such shear cutting face or element can be made of any suitable formation shearing and or cutting compound (e.g. diamond, synthetic diamond, tungsten carbide etc). The rake angle of such shear cutting or scraping face can be positive, negative or neutral, or some mixture of those.

[0092] In another aspect the invention is a hybrid drill bit (whether for hole drilling, core sampling or otherwise) comprising or including an assembly, or at least an assembly when associated in use with a drill string, having

[0093] a first component (unitary, fabricated or assembled) providing a profiled face carrying multiple shear cutting elements and having at least one outlet for a flushing fluid, and

[0094] a second component (unitary, fabricated or assembled) to provide or providing emergent percussive features through (and not simply alongside) the profiled face of the first component, the number of percussive features being fewer than the number of shear cutting elements;

[0095] wherein relative movement can occur or can be caused (e.g. by a hammering system) between the first and second components such that emergent percussive features emerge, if not always emerged, and/or emergent features are further emerged from an already emerged condition;

[0096] and wherein the emergent features can have a percussive effect responsive to an appropriate input to the second component (e.g. by such a hammering system) relative to the first component. Preferably the hybrid drill bit is associated for activation with a magnetic hammering assembly having interacting magnetic arrays providing a hammering affect responsive to a rotational relative movement able to be caused between the magnetic arrays.

[0097] In respect of either of the preceding two aspects:

[0098] Preferably said profiled face is a shear cutting face.

[0099] Preferably the profiled face may include shoulders, edges, relief features and/or the like of a hard material (e.g. carbides, PDC, etc) able to effect scraping and/or cutting and/or sweeping for chip removal purposes (commonly referred to as "shear cutters").

[0100] Optionally a PDC or a diamond impregnated material forms part, if not all, of said profiled face.

[0101] Preferably said hybrid drill bit has provision for the passage of a fluid (e.g. drill fluids) to the bore face and/or from the profiled face.

[0102] Preferably said emergent features are substantially emergent to the same extent simultaneously under an action that causes sufficient relative movement to have them standing proud of each adjacent part of said profiled face.

[0103] Preferably said emergent features are protuberances that [when not retracted and/or forced back] bear on the formation (at least when fully emergent) in preference to parts of the profiled face. Optionally the emergent features can be connected to the reciprocating hammer shuttle so they are actively driven into and pulled away from the formation face.

[0104] For example, preferably shear cutting or the like features of the profiled face preferably follow where it is, or a zone where it is, an emergent member will likely first have encountered the intact rock face and had a sufficient percussive effect to fracture the rock, resulting in less wear on the profiled face relief feature following that emergent feature, and allow the profiled face (shear cutters) to survive in hard formations where they may otherwise be damaged.

[0105] In a further aspect the invention consist in a hybrid drill bit having reliance on features rotatable together yet movable relative to each other axially of the rotation axis, as a result of energy inputs, of

[0106] (i) intermittently percussively striking the formation with first wear resisting protuberant features, and

[0107] (ii) shear cutting, scraping, sweeping and/or the like the weakened formation and any chips generated by the percussive action (i.e. of (i)) with second wear resisting features;

[0108] wherein the first wear resisting protuberant features can rotate about their own axes yet are emergent of a body or component carrying the second wear resisting features.

[0109] Preferably the percussive features (i) are features carried so as to emerge, or emerge more proudly, through a profiled face having the other features (ii).

[0110] In a further aspect the invention consist in a hybrid drill bit having reliance on features rotatable together yet movable relative to each other axially of the rotation axis, as a result of energy inputs, of

[0111] (iii) intermittently percussively striking the formation with first wear resisting protuberant features, and

[0112] (iv) shear cutting, scraping, sweeping and/or the like the weakened formation and any chips generated by the percussive action (i.e. of (i)) with second wear resisting features; the second wear resisting features being greater in number than the first wear resisting features.

[0113] Preferably the percussive features (i) are features carried so as to emerge, or emerge more proudly, through a profiled face having the other features (ii).

[0114] In core drilling variants the number of second wear resisting features need not be greater. See hereinafter where they are shown as about the same as an option.

[0115] In a further aspect the invention consist in a hybrid drill bit having reliance on features rotatable together, yet movable relative to each other axially of the rotation axis, as a result of energy inputs, of

[0116] (i) intermittently percussively striking the formation with first wear resisting protuberant features; and

[0117] (ii) shear cutting, scraping, sweeping and/or the like any chips generated by the percussive action (i.e. of (i)) with second wear resisting features;

[0118] wherein the percussive features (i) are features carried so as to emerge, or emerge more proudly, through a profiled face having the other features (ii);

[0119] and wherein the percussive features (i) are fewer in number than the features (ii).

[0120] Preferably the hybrid drill bit is associated for activation with a magnetic hammering assembly having interacting magnetic arrays providing a hammering affect responsive to a rotational relative movement able to be caused between the magnetic arrays. In respect of either of the preceding two aspects:

[0121] Preferably any suitable form of assembly is contemplated. The examples hereinafter described with or without reference to the accompanying drawings are mere examples.

[0122] Hereinafter described with reference to some of the drawings is a core sampling form of such a hybrid drill bit. Such a core sampling form of hybrid drill bit could be incorporated in apparatus for core sampling.

[0123] In other forms the hybrid drill bit is for drilling into a hole against a bore face (e.g. whether steered (directional) or unsteered and whether upward, horizontal or vertically downward for any suitable purpose. Preferably it is to be used through rock or formations that may include rock.

[0124] Preferably there is provision for a drilling fluid or other fluid to pass through at least part of the hybrid drill bit.

[0125] Preferably that fluid passage provision is via the profiled face which has a plurality of ports appropriately positioned to provide an efficient outcome.

[0126] In another aspect the invention is a hybrid drill bit (whether for hole drilling, core sampling or otherwise) comprising or including an assembly, or at least an assembly when associated in use with a drill string, having

[0127] a first component (unitary, fabricated or assembled) with a profile with plateaux carrying shear cutters thereby providing a shear cutting face, and

[0128] plural impact elements extending through the first component and actuable to provide a percussive effect or a pounding functionality;

[0129] wherein the first component can sweep and/or shear cut away material(s) disrupted by the plural impact elements thereby to clear the bore face (circular and extending from the rotational axis of the first component or annular about that rotational axis if a core taking drill bit).

[0130] In another aspect the invention is a hybrid drill bit (whether for hole drilling, core sampling or otherwise) comprising or including an assembly, or at least an assembly when associated in use with a drill string, having

[0131] a first component or assembly (unitary, fabricated or assembled) providing a shear cutting functionality which arises from a profiled face carrying multiple shear cutting elements and having at least one outlet for a flushing fluid, and

[0132] an array of impact elements (unitary, fabricated or assembled) to provide or providing plural impacts the bore face area, each impact element area extending through a spread array of passageways of the first component or assembly, each for a said impact element, and actuable to provide a percussive effect or a pounding functionality. Preferably the hybrid drill bit is associated for activation with a magnetic hammering assembly having interacting magnetic arrays providing a hammering affect responsive to a rotational relative movement able to be caused between the magnetic arrays.

[0133] Preferably the shear cutting elements outnumber the impact elements.

[0134] In respect of either of the preceding aspects:

[0135] Preferably the relative movement of the impact elements relative to the first component can occur or can be caused by a hammering system. However the impact elements can be energised by any suitable means to have the percussive effect or pounding functionality.

[0136] Preferably the shear cutting face may include shoulders, edges, relief features and/or the like of a hard material able to effect scraping and/or cutting and/or sweeping for chip removal purposes.

[0137] Optionally a PDC or a diamond impregnated material forms part, if not all, of said shear cutting face.

[0138] Preferably said hybrid drill bit has provision for the passage of a fluid (e.g. air, gas, liquids) to the bore face and/or from the shear cutting face.

[0139] Preferably said impact elements are emergent features, i.e. having sufficient relative movement to have them standing sufficiently proud of each adjacent part of said profiled face to have said percussive effect or pounding functionality.

[0140] Preferably said impact elements when not retracted and/or forced back bear on solid rock in preference to parts of the profiled face.

[0141] For example, preferably shear cutting features follow where it is, or a zone where it is, an impact element will likely first have encountered the intact rock face and had a sufficient percussive effect or pounding functionality to create stress fractures within the formation and allow less wear or stress on the shear cutting relief feature following that impact element.

[0142] In another aspect the invention consist in the reliance downhole of the formation-face destructive protuberances of a shear cutting drill bit, the protuberances being repeatedly moved to a proud, or more proud, and percussive effect condition on the formation-face under the action of a downhole hammer.

[0143] In another aspect the invention consist in the reliance downhole of the formation-face destructive protuberances of a shear cutting drill bit, the protuberances being repeatedly moved to a proud, or more proud, and percussive effect condition on the formation-face under the action of a downhole hammer.

[0144] wherein each protuberance can freely rotate about its own axis and/or the protuberances, as an array, when rotated about the axis of a carrier of the shear cutters, has such percussion affect sufficient for the whole field of action of the shear cutters.

[0145] In yet a further aspect the invention is a hybrid drill bit for core sampling comprising or including

[0146] a body defining an annular or near annular face or end ("face") about a passage to receive the core;

[0147] a plurality of shear cutters carried by the body and projecting from the face; and

[0148] a percussively driveable bank of percussive elements able to be percussively emergent or more emergent from the face of the body.

[0149] In yet a further aspect the invention is a hybrid drill bit for core sampling comprising or including

[0150] a body to be rotated downhole about its axis, the defining an annular or near annular face or end ("face") about its axis and about a passage to receive the core;

[0151] a plurality of shear cutters carried by the body and projecting from the face; and

[0152] a percussively driveable bank of percussive elements able to be percussively emergent or more emergent from the face of the body;

[0153] wherein any one or more of the preferments or options herein described applies.

[0154] In another aspect the invention is any hybrid drill bit satisfying the earlier mentioned criteria where a downhole hammer (air, fluid, magnetic, etc) can repeatedly thrust out, to percussive effect, multiple protuberances. Preferably the protuberances as a gang move simultaneously. These hammerable protuberances may or may not be mechanically driven into and out of the drill bit housing.

[0155] Preferably the protuberances are an array disposed in conjunction with shear cutting features not repeatedly thrust out.

[0156] In a further aspect the invention consists in, as an assembly, a hammering arrangement for use downhole as part of a drill string or within part of a drill string, and a hybrid drill bit of any of the kinds herein described. In yet a further aspect the invention consists in a method of drilling and/or core taking which involves the operative use of a hybrid drill bit in accordance with the present invention and/or any of the other assemblies of the present invention. This concept has many advantages over conventional bits (either shear cutter bits or impact bits) the advantages are:

[0157] The shear cutters do not suffer from impact from the hammer action

[0158] Cause the formation to fail in compression, tension and shear.

[0159] The impact forces from the hammer can be spread over relatively few impact teeth—the result is deep and broad fracturing of the formation

[0160] A low energy requiring magnetic hammering arrangement is all that is required for effective percussive action.

[0161] The scraping action of the shear cutters is not confined to a small annulus set out from the rotational axis.

[0162] The elimination of the "stick/slip" phenomenon associated with aggressive shear cutters

[0163] The shear cutters become effective in very hard rock

[0164] Low up hole shock levels

[0165] Propensity to drill straighter bores due to slow drill string/bit rotation speeds of typically less than 100 rpm—this is especially true when used in core drilling applications when compared to diamond core drilling which often requires 1000+RPM

[0166] Extends bit life

[0167] The advantages when used in a core drilling or sampling application are:

[0168] Fast accurate core sampling through a broad variety of formations

[0169] The impact hammer pre crushes an outer ring of the formation

[0170] The shear cutters scrape out the damaged rock and/or debris from the formation

[0171] The shear cutters do not suffer from impact stresses (which they are vulnerable to)

[0172] Allows shear cutters to survive in hard rock or other formations

[0173] Drill fluid is jetted to the formation in the normal way, to assist in removing the fractured debris

[0174] Propensity to drill straighter bores

[0175] Extends bit life

[0176] As used herein "drill", "drilling", etc relate to a rotary action of whole or part of apparatus able to remove material from a rock surface and/or bore face.

[0177] As used herein the term "profile face" in no way refers to its method of formation. It refers to there being sufficient relief features (whether outstanding and/or inset from a radial plane or otherwise of the hybrid drill) presentable to the bore face.

[0178] As used herein "emergent", "proud", etc includes any sufficient emergence further emergence, proudness, or further proudness to achieve an advantageous percussive or pounding affect on the formation.

[0179] As used herein "formation" or "rock formation" refers to any formation that requires fracturing whether it's rock like or not.

[0180] As used herein reference to "across the diameter" or equivalent words (whether in respect of the whole distance or just those parts to accord to an annulus) does not mean aligned on the same diameter. It includes any spread of the impact elements or any spread of the shear cutters where, collectively, when one considers the loci of action of each, generates a sufficient sequence of concentric circular loci equivalent to that which would also occur were the spread aligned on a common diameter passing through the axis of rotation of the whole or annular (or equivalent) profiled work face.

[0181] Reference herein to a "profiled work face" or other reference to the "profile" of the body to carry the shear cutters and to allow a reciprocal emergence (or other emergence) of the impact elements or features may include

[0182] (A) recesses, valleys or "junk slot" like features whether single ended, or as shown in the drawings, doubled ended and whether, as shown, or not, with a dog leg form.

[0183] (B) non-recesses, platforms, plateaux or protuberances of any layout and whether or not of single or more types, the figures in some instances showing as options, in no way limiting, where some are discrete lands and others meander somewhat. Preferably the layout is such that over a rotation of the tool, all areas from the centre, or near the centre, and out to near the maximum circumference of action by the shear cutters and/or impact elements/features will be covered by such non-recesses, platforms, plateaux or protuberances.

[0184] It matters not whether the surfaces of the general region of each such forms (i.e. (A) or (B), or both) are flat, arcuate, undulate, textured, or other. Preferments include the surface forms shown in the figures but are not to be limited thereby.

[0185] As used herein the term "(s)" following a noun means one or both of the singular or plural forms.

[0186] As used herein the term "and/or" means "and" or "or". In some circumstances it can mean both.

A BRIEF DESCRIPTION OF THE DRAWINGS

[0187] A preferred form of the present invention will now be described with reference to the accompany drawings in which

[0188] FIG. **1** is one embodiment of hybrid bit assembly (the bit rotates counter clockwise when viewed from the boreface) in accordance with the present invention, such a

hybrid bit assembly comprising recesses and protuberances (plateaux) adapted to allow the reciprocal hammered emergence from the protuberances and bore face returned retreat of impact elements, such a profile bit preferably being rendered more functional not only by the inherent profile of the body, but also by the insetting of the wear resistance shear cutters to be described hereafter, and by fluid porting,

[0189] FIG. **2** is a section at 120° on GG with respect to FIG. **1**, such a sectional view being through three of the impact elements shown to number (this is in no way critical) seven in the view shown in FIG. **1**, FIG. **2** showing the hammer assembly splined and retained to a main body member of the profile bit,

[0190] FIG. **3** is a similar section to that of FIG. **2**, but this time of the 120° section at LL which is in the recesses, but does cross a plateau, such a section LL passing through two of the six fluid outlet ports shown,

[0191] FIG. **4** shows an isometric view, with some cutaway to show a spline, of another version of hybrid drill bit (i.e. different in profile of the bit body) but still having a mixture of inset fitted shear cutters on plateau regions and having impact elements able to be hammered to an emergent/more emergent condition (preferably from the plateaux or protuberant parts of the profiled bit) and having ports for fluid outlet, FIG. **4** showing some cutaway to reveal a spline, (required when hybrid bit is used in conjunction with a magnetic hammer-preferred form)

[0192] FIG. **5** shows still a further embodiment of a hybrid drill bit, this one having greater similarity to the inset provided profiled bit of FIGS. **1** to **3**, but not exactly the same, FIG. **5** showing protuberant impact elements, liquid ports and plural shear cutters of different types,

[0193] FIG. **6** is an isometric view of a preferred form of a core taking tool in accordance with the present invention, this one showing a mixture of shear cutters of a profiled annulus or providing and/or part providing part of the profile of such an annulus, there being shown three, but it could be any number, impact elements able to hammered so as to be emergent from the condition shown in FIG. **6**,

[0194] FIG. **7** is the core taking apparatus of FIG. **6**, but with the impact elements emerged fully or more fully or more emergent than as in FIG. **6**,

[0195] FIG. **8** is a front elevational view (e.g. as if from the bore face from which a core is to be taken) of the core taking apparatus of FIGS. **6** and **7**,

[0196] FIG. **9** is a sectional view A-A with respect to FIG. **8** (i.e. of the apparatus of FIGS. **6** to **8**) showing an emergent impact or percussive element,

[0197] FIG. **10** shows a shear cutter acting alone,

[0198] FIG. **11** shows an impact element (angling optional) acting in concert with a shear cutter, and

[0199] FIGS. **12**A to **12**E show how an element as a shear cutting face or scraping face (e.g. of diamond, synthetic diamond, tungsten carbide, or the like) can be provided obliquely to provide a positive rake angle better able to uplift material shown as being fractured prior to uplift in the drawing sequence.

DETAILED DESCRIPTION OF THE INVENTION

[0200] In its preferred forms of the present invention any suitable form of hammer can be used.

[0201] Reference previously to "hammers" or "hammering" or "hammering systems" is not restricted to hammering systems of a magnetic interaction type reliant upon our creating a shuttling relativity between interactive magnetic arrays. Indeed any form of suitable hammering apparatus can be used e.g. eccentric, hydraulic, downhole and/or uphole provided it has a downhole affect. Particularly advantageous types of hammering apparatus are those of typified by our magnetic hammering systems of PCT/NZ2008/000217 (WO 2009/028964) and PCT/NZ2005/000329 (WO2006/65155). Or indeed even our PCT Application No. PCT/NZ2011/000123 (WO2012/002827).

[0202] Other suitable downhole forms of hammer can also be used, preferably those that are pneumatically or fluid driven.

[0203] The embodiment of the FIGS. **1** to **3**, but with some reference to other drawings will now be described.

[0204] FIG. **1** is an example of a full face hybrid bit, the geometry is generic in nature—but would typically include plateaux (or platforms) (**2**,**3**) for shear cutters (**6**), whether of an identical or varied type, that are strategically positioned as profile features across the diameter of the bit. It would also include areas for fluid jets (**7**), and valleys or recesses (**4**)—commonly known in the industry as junk slots that assist with the removal of the rock cuttings. In addition, the impact elements (**8**) are also strategically placed across the full diameter of the bit to crush/fracture the formation—allowing the shear cutters correspondingly to scrape away the damaged material.

[0205] As shown in FIGS. **1**, **2** and **3** the moulded, machined, or otherwise formed component or body **1** has a profiled face as a profiled work face which itself is further profiled by the fixing or insetting of the shear cutters **6** (i.e. wear resistant cutting/sweeping/scraping components).

[0206] The fluid outlets **7** provide an outlet for fluid (e.g. drilling mud) directed to the rock face to help remove fractured rock via junk slots **4**, Whether magnetic hammer systems or non magnetic hammering systems are used [e.g. eccentric, hydraulic, pneumatic or other,] in each case, preferably there is a hammering component **9** (FIG. **2**) able to act upon an impact plate **10** (in some embodiments it may be advantageous to have the hammer **9** impact directly to the reciprocatable members **11** & **8**) so that the hammering impact, conveyed by hammer **9** into the impact plate **9**, affects reciprocatable members **11** able to act upon cutters **8** of the impact elements, (**8**&**11** may be a common component e.g. carbide). Such cutters **8** despite being captive in the body **1**, are free to move both axially and rotationally. Preferably **8** and **11** may be interconnected or not. If connected or unconnected freedom to rotate is desirable. Such rotation is caused by the rotation of the bit body **1**—normally rotated from a surface drive causing **8**/**11** to rotate randomly as a consequence of the action of the rock face on the individual cutters during the course of use

[0207] Shown through the hammer region **9** (FIG. **3**) is a fluid passageway **12** that feeds via passageways **13** in the impact plate **10** through a communication chamber **14** to the fluid outlet ports **7**.

[0208] As can be seen, a sleeve member **15** (as part of the drill string and/or its casing sequence) can be located on the hammer **9** by a ring member **16** and be adapted to keep captive to itself, on an interacting spline **17**, the bit body **1**.

[0209] The components **19**, **10**, **11**, **15** and **16** can be any suitable material e.g. a suitable steel. The impact parts **8** can be of a shock resistant, wear resistant material e.g. a hardened steel, but can, in some circumstances, be of hardened steel, tungsten carbide, diamond etc.

[0210] Persons skilled in the art will appreciate how the function of the members **8** as impact or percussive elements or cutters is to create stress waves of a rock destructive kind in the formation of the bore face. It is not their function to hold the elements **6** from the bore face.

[0211] FIG. **4** shows a slightly different embodiment (when used with a magnetic hammer) to that of FIGS. **1** to **3**. Nonetheless there is a casing **14** to form a part of a drill string and to spline onto a spline **15** of a hammer **16**. The hammer **16** is to act via an impact member **17** onto each of the protuberant components **18** of the plateau regions **19** and to act in concert with shear cutters **20**. These cutters in effect cover all of the area, or at least substantially all of the area, to be disrupted. Other impact elements **21** can be strategically placed as required across the full diameter of the drill bit.

[0212] Any suitable spread and interrelationship of numbers of impact elements **18**/**21** to non impacting shear cutting, sweeping, etc components **20** can be utilised provided that, in preferred forms, there is a sufficient disruption of a face as a result of the repeated impacts over several radial loci about the axis of rotation of the tool and a sufficient shear cutting and sweeping of the released or ruptured materials across most, if not all, of the effective face of the profile drill head with its impact elements to achieve full clearance.

[0213] It is to be noted that the shear cutters extend preferably around the edge of the actual bore face to provide some gauge cutting affect about the face being achieved with the majority of the shear cutters.

[0214] Shown also are potential outlets (junk slots) to allow the cuttings to be removed from the drill face (e.g. provided in recesses **22**)

[0215] FIG. **5** shows a bit to rotate anticlockwise (viewed from the top down) so as to present shear cutting elements **23** (e.g. of diamond, synthetic diamond, tungsten carbide, or other suitable material) at a positive rake angle (owing to its facial and leading edge presentation whether arising from its shape or its oblique mounting, or some mixture of both). The profile features of the bit of FIG. **5** are to operate so that the shear cutting elements **23** act as in FIGS. **12**A to **12**E after an impact element **24** weakens the formation.

[0216] The disadvantage of having a negative angle of rake on the shear cutters or scrapers is that in deep hole high pressure applications, having a negative angle on the shear cutters may tend to push the cuttings back down and/or against the formation. In such situations, it is an advantage to provide the shear cutters or scrapers with a positive angle of rake that can aid (as shown in FIGS. **12**A to **12**E) in lifting and/or moving the cuttings in a more upwards direction thereby increasing drilling efficiency. FIGS. **6** to **9** show a preferred form of core taking in accordance with the present invention. For that purpose it is a bit to provide an annular cut so that a central opening within the annulus can be used for the uptake of the core in any suitable known manner.

[0217] In typical core sampling drilling (as required to gather information about sub surface formations) a hollow centred drill bit (core bit) normally covered with shear cutting elements such as diamond (synthetic or natural) is rotated at very high speed (normally from a surface drive) and gently advanced into the formation. The resulting core sample is pushed into a core barrel (a hollow tube) normally several metres long. Once the core barrel is full. The core sample and core barrel are normally pulled to surface via a wire cable—through the centre of the hollow drill rods—while leaving the drill rods in the ground (which form a temporary casing and stop the drill hole from collapsing) the core sample is removed at surface and the core barrel is lowered back down through the hollow drill rods by a wire line to continue the sampling operation

[0218] This approach works well, except in very hard formations—where the diamond core bits suffer excessive wear—or progress is very slow. This problem is exacerbated in mixed formations where the rapidly spinning diamond bit can easily be destroyed if an unexpected hard formation is encountered.

[0219] What we propose is a core bit to be used in conjunction with a hammer (of any type) that has impact profiles strategically placed around the partial face of the core bit, which under the influence of the hammer crush and fracture the ring of rock to be removed—allowing the shear cutters to remove the fractured rock efficiently, while being (somewhat) isolated from the hammer impact.

[0220] This approach allows diamond shear bits etc to survive in hard rock environments and drill rapidly—even with relatively slow drill string rotation (which also helps minimise wear on rill rods etc)

[0221] FIGS. **6** to **9** show a main body a name body **25** presenting a profiled annulus **26** towards what will be the bore face. A person skilled in the art would appreciate how the body **25** (whether with splining or not) can associate with a hammer yet be rotatable with the drill string to be connected, for example, over or under region **27**.

[0222] The profiled annular face **26** as shown shows plateaux **28** as part of the profile of the member **25** or a fabricated member connected thereto. Emergent from these are the impact elements **29** of which three (example) are showing, each more or less on a common radius about the central radius of the annular structure.

[0223] Disposed in less protuberant regions are ports **30** to allow the egress of a fluid (e.g. drilling mud or the like). Alternatively, or additionally, there can be some release of fluid internally of the core taking cavity **31**.

[0224] Shown to co-act with each protuberant emergence **29** (each shown emerged in FIGS. **7** and **9**) are shear cutting wear resistance members **32**. The shear cutters can be of any geometry and any suitable material and these are staggered on different radii to the common or similar radii of each impact element **29**.

[0225] In alternative forms, there can be some radial variation of location of the passageways in which each member **29** locates so that they do not describe intermittent impact hits on the same rotational axis as their common locus.

[0226] Flanking internally and externally of this common locus are the loci of action of the more numerous share cutting wear resistant elements **32**. These can be a suitable material of any of the kinds previously described.

[0227] Any suitable arrangement can be provided for the hammering of the end region **33** of the carrying pins or rods or other form of members **34** which carry an impact resistant material **35** as the or part of each impact element **29**.

[0228] Preferably each impact element **29** has the material **35** fixed to member **34** and member **34** is held captive, for example by a restriction profile **36**, to the component **25**. Its end to the right in FIG. **9** (the end **33**) is to be available for action directly or indirectly by the hammer. A suitable hammer mechanism again is an annular hammer. For example of the type previously described able to act through an annular interposed member.

[0229] Any suitable porting arrangement for fluid to outlet **30** can be provided including from within the cavity **31**.

[0230] A variation will be noted between the embodiments of a tool that is to clear a full circular region about the axis of rotation when compared to that that is to clear an annulus only.

[0231] For the annulus clearing required for a core taking apparatus preferably the shear cutters are on loci to flank internally and externally the impact element locus of action, but nevertheless have an effect on material fracture, ruptured, dislodged, etc, by the impact elements.

[0232] For the non annular arrangements of FIGS. **1** to **4**, preferably there is a staggering of the impact elements at different radial distances with respect to the axis of rotation of the overall bit assembly yet, nevertheless, a preferably more numerous provision of shear cutters such that there is a sufficient number of shear cutters (e.g. of type **6**) to clear the direct face as well as additional shear cutters **6'** to assist further in expanding and clearing material.

[0233] What is highly preferable is that all impact elements whether of the embodiments of FIGS. **1** to **3**, **4**, **5** or **6** to **9** have the impact elements **8/11**, **18**, **21**, **29**, **35**, **35/34** rotatable about their own axis preferably aligned to the rotational axis of the overall apparatus. This prevents localised wear on the impact face. This is easily achieved by having each impact element captive yet rotable on its own longitudinal axis in its guide but able to be struck directly or indirectly by the hammer (e.g. through a common struck member i.e. hammerable member).

[0234] The embodiments shown enable high point loading of the gang or array of percussive elements, choice of how they are arrayed through the shear cutting assembly, choice of array of the shear cutting elements (including into at least near the centre), a profiling of the face to allow flushing fluid porting from at least one recess, selectivity of mode of operation when coupled to a (preferably magnetic) hammering system able to be active/deactivated despite its preferred downhole disposition, etc.

[0235] Persons skilled in the art will appreciate that the embodiments described are just some of many different ways to achieve the in concert functionality between an impact element and a shear cutting feature.

1. A boring tool for use downhole for hole boring or core taking when connected so as to depend and rotate with a drill string about an axis of rotation aligned to that of the drill string, the tool comprising or including

a body member or assembly ("body"), the body to depend from the drill string and defining a profiled work face to be presented against the bore face and to accord substantially to the area and shape of the bore face, such bore face to be bounded by a circle if the tool is for hole boring and such bore face to be annular if the tool is for core taking,

shear cutters carried by the profiled work face, and

impact elements, whether of a common component or not, supported by the body so as to be movable through the profiled work face of the body and able to be hammered directly or indirectly from behind the profiled work face of the body to provide, or be, localised impact emergences beyond localities of the profiled work face;

wherein said profiled work face defines recessed or non-protuberant regions amongst non-recessed or protuberant regions;

and wherein the localised impact emergences are each from a non-recessed or protuberant region of the profiled work face of the body

and wherein the localised impact emergences and bit features of the profiled bit will act in concert across the bore face.

2. The tool of claim **1** wherein said impact elements are emergent of non-recessed or protuberant regions of the profiled work face and said shear cutters are on the non-recessed or protuberant regions, the recessed or non-protuberant regions, or both.

3. The tool of claim **1** or wherein each said impact element can rotate about their own reciprocation axis.

4. The tool as claimed in claim **3** wherein said reciprocation axis is at least substantially parallel to said axis of rotation of said tool.

5. The tool of claim **1** wherein the body includes porting to allow a fluid egress.

6. The tool of claim **1** wherein the impact emergences are spread about the work face of the impact elements and the spread involves localities of different radii from said axis of rotation.

7. The tool of claim **1** wherein shear cutters are on said non-recessed or protuberant regions.

8. The tool of claim **1** wherein the tool is for core taking and said impact elements are on an at least substantially common radius from said axis of rotation and said sheer cutters act inwardly and outwardly of the locus of that at least substantially common radius.

9. The tool of claim **1** wherein said impact elements are rotatable through the profiled work face of the body.

10. A hybrid drill bit suitable for use downhole, for hole boring, the hybrid drill bit comprising or including an assembly which when associated with a drill string defines, or will define,

a profiled bit or bit assembly ("bit") able to be rotated about an axis of rotation to have an effect on a bore face over its diameter of operation, the profiled bit having bit features able to effect, in use, a shear cutting affect, a chip sweeping affect or a scraping affect, or any combination of the affects, and

impact elements, whether of a common component or not, able to be hammered directly or indirectly to provide, or be, localised impact emergences beyond localities of the profiled bit;

wherein the localised impact emergences, upon rotation of the profiled bit, and thus the hybrid drill bit, have

(a) plural radiused loci of rotation, or

(b) plural radiused loci of rotation and a location at the axis of rotation;

and wherein the localised impact emergences and the bit features of the profiled bit act in concert across said diameter of operation of the profiled bit.

11. The hybrid drill bit of claim **9** wherein said profiled bit is profiled at least in part by shear cutters or wear resistant members ["shear cutters"] as inserts presenting from a bit body.

12. The hybrid drill bit of claim **10** wherein said bit body itself is profiled to present both

(i) protuberant regions and

(ii) less protuberant or recessed regions.

13. The hybrid drill bit of claim **9** wherein fluid outlets are disposed in said bit body in said less protuberant or recessed regions.

14. The hybrid drill bit of claim **9** wherein the profiled bit is splined to a captive hammering assembly.

15. The hybrid drill bit of claim **13** wherein said hammering assembly comprises or includes an annular hammer able to duct fluid.

16. The hybrid drill bit of claim **14** wherein a ported member to receive fluid via said annular hammer receives and conveys the impacts of the hammer to the impact elements and conveys received fluid to outlets of the bit body.

17. The hybrid drill bit of claim **9** wherein said impact elements are individually rotatable relative to said profiled bit.

18. The hybrid drill bit of claim **9** wherein each impact element is of a profiled bit captive wear resistant material held by or impactable upon by a captive guided hammerable member.

19. A downhole tool comprising or including

a bit profiled by at least multiple shear cutting inserts or shear cutters ("shear cutters") able to be presented to a bore face as the bit is rotated, and

multiple impact elements rotatable with the bit yet hammerable directly or indirectly so as to emerge or further emerge from the bit to act in concert with the shear cutters;

wherein the shear cutters are arrayed so as, in use as the tool is rotated and the impacted elements are hammered directly or indirectly, to at least substantially fully sweep/shear cut on loci of rotation about the rotational axis of the bit that will follow disruption of the or a bore face caused by the hammered emergence, or further emergence, of said impact elements that rotate on loci of rotation about the rotational axis of the bit to be intermittently disruptive over at least all of the area of the or said bore face.

20. The tool of claim **18** wherein the bit has a bit body with a profiled face presentable to a bore face in use, said profiled face having more protuberant regions and less protuberant or recessed regions, the impact elements being emergent each from an opening through a protuberant region.

21. The tool of claim **19** wherein shear cutters as insets are carried by some or all of said protuberant regions.

22. The tool of claim **19** wherein ports for fluid emergence are provided through some or all of said less protuberant or recessed regions.

23. The apparatus of claim **9** positioned downhole to rotate with a drill string and provided with a hammering mechanism actuable to directly or indirectly hammer the impact elements.

24. The apparatus of claim **22** positioned downhole to rotate with a drill string and provided with a hammering mechanism actuable to directly or indirectly hammer the impact elements.

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