A drill bit comprises a bit body having a plurality of upstanding main blades formed thereon. The main blades have a plurality cutting elements mounted thereon, and they are shaped such that a cutting profile of the bit includes a nose portion, an inner cone region located radially inwards of the nose portion and an outer region located radially outwards of the nose portion. The bit further has at least one additional blade. The additional blade carrying cutting elements located radially inwards of the outer region of the cutting profile, but being substantially free of cutting elements located in the outer region of the cutting profile.
STABLE ROTARY DRILL BIT

BACKGROUND OF THE INVENTION

[0001] This invention relates to a rotary drill bit that is vibrationally stable, and in particular to a rotary drill bit suitable for use in the formation of subterranean well bores.

[0002] The cost of drilling a borehole in the subsurface formations of the Earth is dependent on the length of time taken to drill the borehole to the desired depth. The time spent drilling is in turn determined by the rate of penetration and the number of times the drill bit has to be changed in order to achieve the target depth.

[0003] A known form of drill bit for use in the formation of subterranean well bores comprises a bit body having formed thereon a series of upstanding blades. Each blade is provided with a series of cutting elements. The cutting elements each typically comprise a substrate of, for example, tungsten carbide to which is bonded a table of a superhard material, for example in the form of polycrystalline diamond. Between the blades are formed flow channels to which drilling fluid is supplied in use, the drilling fluid serving to clean and cool the cutting elements and to carry away material removed by the drill bit.

[0004] In use, the drill bit is rotated about its axis while an axially directed load is applied thereto. As a result, material is gouged, scraped or abraded from the formation in which the bore hole is being formed, the material being carried away, as hereinbefore described, by the drilling fluid.

[0005] The cutting elements naturally wear away in use due to the varying abrasive nature of the subsurface rock formations. In practice however, the expected economic life of the known drill bits is often degraded due to the cutters being chipped or broken.

[0006] In these cases, the known drill bits are known to suffer from lateral and torsional vibrations, and these vibrations cause the known drill bit to deviate from its desired smooth path through the formation. This results in the application of large loadings to the cutting elements mounted on the bit which may cause damage thereto, which results in greatly accelerated degradation of the cutting elements. This is particularly apparent when drilling rock formations with bits of relatively large diameter. Obviously this is undesirable and it is an object of the invention to provide a drill bit of improved stability.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will further be described, by way of example, with reference to the accompanying drawings.

[0014] FIG. 1 is a diagrammatic view of a typical known drill rig and a section through a portion of the Earth where a borehole is being drilled.

[0015] FIG. 2 is an end view of a drill bit in accordance with one embodiment of the invention.

[0016] FIG. 3 is a perspective view of the drill bit of FIG. 2.

[0017] FIG. 4 is a side view of the drill bit of FIG. 2.

[0018] FIG. 5 is a diagram illustrating the cutting profile of the bit of FIG. 2.

[0019] FIG. 6 is a view similar to FIG. 2 of an alternative embodiment of a drill bit of the invention.

[0020] FIG. 7 is a sectional view along the line 7-7 of FIG. 6.

DETAILED DESCRIPTION OF THE INVENTION AND THE PREFERRED EMBODIMENT

[0021] Referring first to FIG. 1, a drilling system 1, is shown and comprises a drill rig 2, with a drill string 3, and a drill bit 6, located within borehole 5. The drill bit 6 may be rotated from the surface by rotation of the drill string. Alternatively or additionally the drill bit 6, may be rotated by a downhole motor or turbine 4.

[0022] Referring to FIGS. 2 to 5 there is shown a drill bit comprising a bit body 10 having a front face 12 and a

[0023] Such an arrangement is advantageous in that the number of cutters located in the cone region, relative to the number of cutters on the outer region, can be increased, and
connection region 14 designed to allow the bit to be connected to other downhole components, in use, to allow the bit to be driven for rotation about its centerline 16 and to allow an axially directed load to be applied thereto.

[0023] Mounted on the bit body 10 are a number of upstanding main blades 18, the main blades 18 upstanding from the front face 12 of the bit body 10. The main blades 18 include a first plurality of blades 18a which extend from the center line 16, of the bit to the gauge region 20 thereof, and a second plurality of blades 18b which stop short of the center line 16, of the bit. These upstanding main blades 18 may be integrally formed on the bit body, or alternately, may be formed separately and later attached to the bit body 10. The gauge regions 20 of the main blades 18 are of substantially uniform gauge length, the gauge regions 20 all being located at the same axial position on the bit.

[0024] As can be seen most clearly in FIGS. 4 and 5, the main blades 18 are shaped to define a bit profile 21 including a nose portion 22 of annular shape located at the axially most remote part of the bit from the connection region. Radially inward of the nose portion 22 is a cone region 24, and radially outward of the nose portion 22 is an outer region 26.

[0025] The main blades 18 each carry a series of cutting elements 28. Each cutting element 28 is in the form of a polycrystalline diamond compact comprising a table of polycrystalline diamond which is bonded to a substrate of less hard material, typically tungsten carbide. The cutting elements 28 are located on parts of the blades 18 in the cone region 24, at the nose portion 22 and in the outer region 26.

[0026] Back-up cutting elements 28a are provided immediately behind, and at the same general radial position as at least some of the cutting elements 28, in a known manner.

[0027] In addition to the main blades 18, the bit body 10 is further provided with a plurality of additional blades 30. As illustrated, each additional blade 30 is located immediately behind an associated one of the main blades 18b, the additional blades 30 being substantially equally spaced apart around the bit body 10. Each additional blade 30 includes a part located in the cone region 24, a part located at the nose portion 22 and a part located in the outer region 26, and includes a gauge region aligned with the gauge regions 20 of the main blades 18.

[0028] Between the main blades 18a, 18b and the additional blades 30 are formed a series of flow channels 32 to which drilling fluid is supplied, in use, through passages (not shown) located internally of the bit and through nozzles 34. The fluid serves to clean and cool the cutting elements, and also serves to carry away from the bit formation material which, in use, is removed by the cutting elements.

[0029] Like the main blades 18, the additional blades 30 are also adapted to carry a series of cutting elements 28. The cutting elements 28 carried by the additional blades 30 are located radially inwards of the outer region 26, being located only in the cone region 24 and the nose portion 22, while the outer region 26 is free of cutting elements 28. The provision of the cutters 28 only in the cone region 24 and nose portion 22 of the additional blades 30 serves to enhance the stability of the bit. This is because, in order to reduce lateral vibrations, it is important for the lateral forces generated by the cutting elements to be balanced. Where the bit is of large diameter, as in the arrangement illustrated, this is usually difficult as the torque generated by the radially outer cutting elements is high compared to the torque generated by the inner cutting elements. The location of the cutting elements on the additional blades 30 only at relatively small radial distances from the axis enables this part of the bit to carry a disproportionately large number of cutting elements, and thereby allows such balancing to be achieved more easily.

[0030] The parts of the additional blades 30 in the outer regions 26 are, as mentioned hereinbefore, devoid of cutters, and will be referred to hereinafter as cutter devoid surfaces 36. In addition to being devoid of cutters, the cutter devoid surfaces are designed to be of larger blade height than the corresponding parts of the main blades 18 with the result that engagement of the cutter devoid surfaces 36 with the formation being drilled, in use, limits the depth of cut achievable by the bit. In use, the bit is located downhole and is driven for rotation about its axis 16. An axially directed load sometimes referred to as weight-on-bit is applied to the bit. The combination of the rotary motion and the weight-on-bit causes the cutters 28 to gouge, scrape or abrade material from the formation, thereby extending the borehole. Changes in the applied weight-on-bit or changes in the formation being drilled can give rise to changes in the depth of cut and this, in turn, can cause torsional vibrations to occur. With the bit described hereinbefore, the maximum depth of cut is limited by the engagement of the cutter devoid surfaces 36 with the formation being drilled. As a result, variations in depth of cut are reduced and the severity of torsional vibrations can be limited, or the initiation of such vibrations can be avoided.

[0031] As the cutter devoid surfaces 36 will in use, bear against the formation being drilled, at least for some of the time, the surfaces 36 may be subject to wear. In order to limit such wear, a wear resistant coating may be applied thereto. Alternatively, a series of wear resistant inserts, for example in the form of suitably shaped polycrystalline diamond compacts, may be mounted upon the surfaces 36.

[0032] FIGS. 6 and 7 illustrate an alternative embodiment, which, in many respects, is the same as that illustrated in FIGS. 2 to 5. The biggest difference between the two embodiments is in the number of blades provided, the FIG. 6 embodiment includes four main blades 18a, four main blades 18b and four additional blades 30. FIG. 7 illustrates the profile of the additional blades 30, the profile of the corresponding parts of the main blades 18 being represented by the dotted line 38, thereby illustrating the difference in blade heights of the blades 18, 30. Specifically, the cutter devoid surfaces 36 of the additional blades 30 are at a greater blade height than the corresponding parts of the main blades 18.

[0034] It will be appreciated that a range of modifications and alterations may be made to the arrangements described hereinbefore without departing from the scope of the invention. For example, rather than using polycrystalline diamond compacts as the cutting elements, it may be possible to use diamond crystals or polycrystalline diamond mounted upon or embedded in the blades 18, 30. Further, alternative means may be used to render the cutter devoid surfaces of good wear resistance. A further possibility may be to shape the cutter devoid surfaces so as to match the actual shape of the bottom hole surface created by the cutting elements 28, at the
desired rate of penetration. As a result, the full surface area of each cutter devoid surface can be arranged to engage the formation being drilled.

[0035] Whereas the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications apart from those shown or suggested herein, may be made within the scope and spirit of the present invention.

What is claimed is:

1. A drill bit comprising a bit body having a plurality of upstanding main blades formed thereon, the main blades having a plurality cutting elements mounted thereon, the main blades being shaped such that a cutting profile of the bit includes a nose portion, an inner cone region located radially inwards of the nose portion and an outer region located radially outwards of the nose portion, the bit further comprising at least one additional blade, the additional blade carrying cutting elements located radially inwards of the outer region of the cutting profile, but being substantially free of cutting elements located in the outer region of the cutting profile, wherein the cutting elements provided on the main blades and on the additional blades are located such that the lateral forces generated by the cutting elements, in use, are substantially balanced.

2. A drill bit according to claim 1, wherein a part of the additional blade located in the outer region of the cutting profile is of increased blade height as compared to parts of the main blades located in the outer region of the cutting profile.

3. A drill bit according to claim 1, wherein the bit has a diameter falling within the range of about 12¼" to 26".

4. A drill bit according to claim 1, wherein the cutting elements comprise polycrystalline diamond compact cutters.

5. A drill bit according to claim 1, wherein the cutting elements comprise diamond crystals mounted upon or embedded in the main and additional blades.

6. A drill bit according to claim 1, wherein the cutting elements comprise polycrystalline diamond crystals mounted upon or embedded in the main and additional blades.

7. A drill bit according to claim 1, wherein an outer surface of a part of the additional blade located in the outer region of the cutting profile is rendered of improved resistance to wear.

8. A drill bit according to claim 7, wherein the said part of the additional blade located in the outer region is rendered of improved resistance to wear by having suitably shaped and positioned, non-cutting, polycrystalline diamond elements mounted thereon.

9. A drill bit according to claim 7, wherein the said part of the additional blade located in the outer region is rendered of improved resistance to wear by having a hard facing material coating applied thereto.

10. A drill bit according to claim 1, wherein the plurality of main blades comprise a first plurality of blades which extend inwardly to a centerline of the bit body, and a second plurality of blades which stop short of the centerline of the bit body.

11. A drill bit according to claim 1, wherein a plurality of the additional blades are provided, the additional blades being substantially equally spaced around the bit body.

12. A drill bit according to claim 1, wherein the main blades and the additional blades each have a gauge region, the gauge regions being of substantially uniform length and being aligned with one another.

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