June 10, 1958 B. L. AUSTIN 2,838,286

ROTARY DRILL BIT

Filed April 19, 1956 2 Sheets-Sheet 1

Fig. 1.

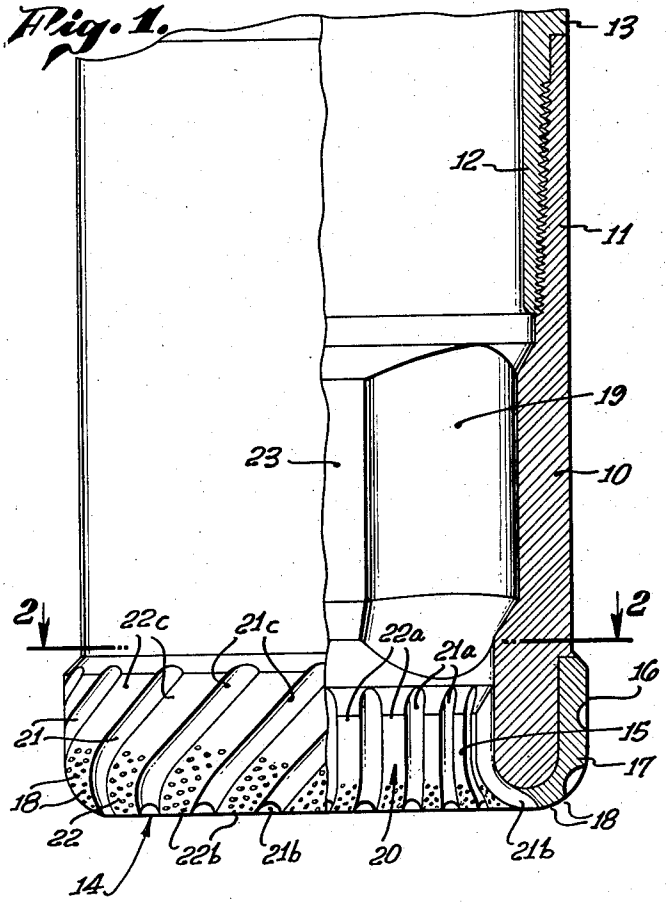
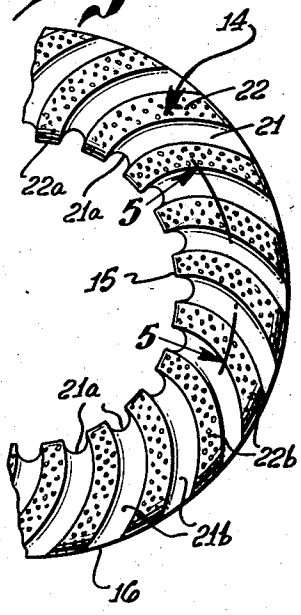


Fig. 3.



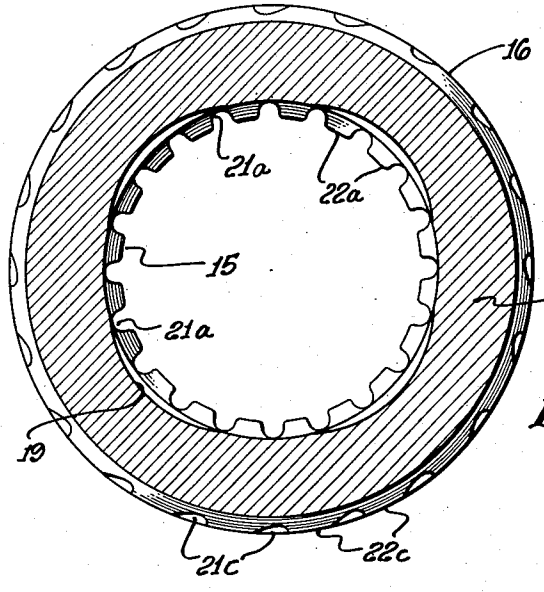


Fig. 2.

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Fig. 4.

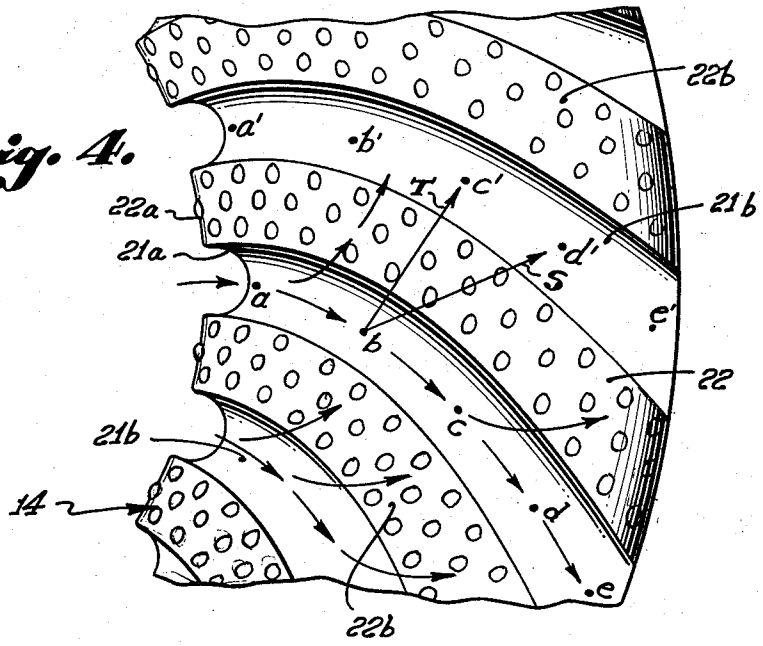
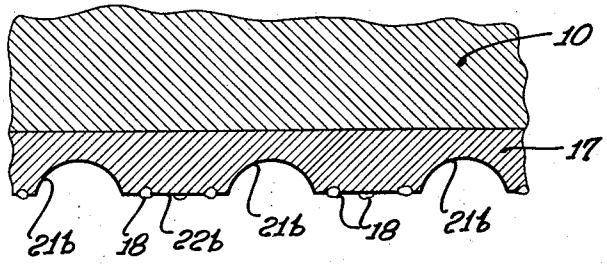


Fig. 5.



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ROTARY DRILL BIT

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Application April 19, 1956, Serial No. 579,299

8 Claims. (Cl. 255—72)

The present invention relates to rotary drill bits, and more particularly to bits having diamonds embedded therein for drilling relatively hard formations.

In rotary drill bits of the diamond type, it is desirable to maintain the diamond studded cutting faces of the bit in a clean and cool state. Circulating fluid, such as drilling mud, is pumped through the bit for discharge into the hole being drilled, for the intended purposes of flushing the cuttings to the top or entrance of the hole, to clean the cutting faces of the bit and the diamonds embedded therein, and to cool such faces and diamonds.

Heretofore, the aforementioned intended purposes have not been accomplished efficiently. The cutting faces and the diamonds embedded therein have not been cleaned properly, reducing the penetration rate of the diamonds in the formation. Reduction of penetration rate is attributable to some extent to the operation of the diamonds upon previously made cuttings remaining between the diamonds and undisturbed formation. It is also caused by the packing of the cuttings between the diamonds, preventing the latter from contacting the bottom of the hole. Instead, the cuttings packed on the bit skid or slide along the hole bottom, generating a large amount of heat which may be sufficient to melt or burn a portion of the matrix material in which the diamonds are held, with consequent dropping out or loss of some diamonds from the bit. Substantial generation of heat will occur, since the inability of the circulation fluid to clean the drill bit also militates against its cooling the bit, for the reason that the packed cuttings prevent the fluid from flowing across the bit faces and the diamonds themselves.

Attempts have been made to clean and cool the bit by providing grooves or watercourses in the cutting faces of the bit, through which circulation fluid will flow. The cutting faces and diamonds adjacent the watercourses have been cleaned and cooled, but those displaced substantially from the watercourses still suffer from insufficient cleaning and cooling, or none at all. This last-mentioned deficiency is most pronounced in the region of the bit adjacent and at its outer reaming portion. If proper concentration of diamonds is placed on the bit, there will be more diamonds around the outer portion of the hole bottom cutting face than around the inner portion of such cutting face. The watercourses, however, have heretofore been much further apart at the outer portion of the cutting face than at its inner portion, resulting in the lack of proper cleaning of the cutting faces and diamonds at the outer portion of the bit, except, possibly, immediately adjacent the watercourses themselves.

Accordingly, it is an object of the present invention to provide an improved rotary drill bit having a diamond studded drilling face, which can be maintained in a clean and cool state by the circulating fluid during the drilling of a hole in the formation, thereby enhancing the penetration rate of the bit and increasing its useful life.

Another object of the invention is to provide a rotary

diamond drill bit having watercourses in its cutting face arranged in such manner as to cause the circulating fluid to flow from one watercourse to another across the diamond studded cutting face, cleaning and cooling all portions of the latter. The outer portions of the cutting face are cleaned and cooled as effectively as its inner portions.

A further object of the invention is to provide a rotary diamond drill bit embodying watercourses that are spaced apart by substantially uniform and relatively short distances across the entire bottom hole contacting face or faces of the bit, to insure circulation of the drilling fluid across all portions of such contacting face or faces and their maintenance in a clean and cool condition.

An additional object of the invention is to provide a rotary diamond drill bit having watercourses in its cutting face or faces arranged in such manner as to result in a substantially uniform concentration of diamonds on its cutting face or faces between the watercourses per unit of projected area, and an effective cleaning and cooling of all areas of such cutting face or faces. The outer portions of the cutting face or faces are cleaned as effectively as the inner portions.

Still a further object of the invention is to provide a rotary diamond drill bit embodying watercourses spaced from one another by relatively short distances to provide relatively narrow spans or lands between watercourses in which the diamonds are held, the watercourses being so arranged that circulating fluid not only travels through the watercourses, but also flows between watercourses and across the lands to clean and cool them.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a combined side elevational and longitudinal section of a rotary core drilling bit embodying the invention;

Fig. 2 is a cross-section taken along the line 2—2 on Fig. 1;

Fig. 3 is a fragmentary bottom plan view of the bit disclosed in Fig. 1;

Fig. 4 is an enlarged view similar to Fig. 3;

Fig. 5 is a section taken along the line 5—5 on Fig. 3.

The invention is illustrated in the drawings as being applied to a core bit, which may form the lower portion of an apparatus for taking a core sample, the core passing upwardly into a core barrel (not shown) in a known manner. It is to be understood, however, that in its broader aspects, the invention is not limited to core bits, but is directed to rotary drill bits generally.

As disclosed in the drawings, the apparatus includes a tubular main bit body or shank 10 having an upper threaded box 11 threadedly secured onto the lower threaded pin 12 of a tubular drill collar or drill pipe 13 forming the lower end of a drill string extending to the top of the bore hole. The main cutting portion of the tool is disposed at its lower hole bottom contacting face 14. Cutting portions may also be provided on the generally cylindrical inner face 15 of the tool as well as on its generally cylindrical outer face 16. The inner face 15 determines the diameter of the core, whereas the outer face 16 determines the diameter of the hole being drilled by the core bit. The lower portion of the bit or shank 10 has a matrix 17 of relatively hard material, of any suitable

type, secured to its outer, bottom, and inner surfaces, in which diamonds **18** of the proper size are secured in a known manner. These diamonds may project from the surface of the matrix **17** to the extent desired, or some of them may be flush with the surface. They are arranged in a desirable pattern on the exposed faces **14**, **15**, **16** of the matrix, to operate upon the bottom and sides of the hole being drilled.

Circulating fluid, such as drilling mud, is pumped down the drill string **13** during the rotation of the apparatus, this drilling fluid passing through relatively shallow longitudinal grooves or recesses **19** in the inner wall of the bit body and around the core barrel (not shown), the drilling fluid discharging through the throat **20** of the bit and onto the bottom of the hole. The drilling fluid will also flow outwardly along the bottom of the hole, to clean the hole of cuttings and carry them around the outside of the bit and the drill string to the top of the hole, all generally in a known manner.

As specifically disclosed, the drill bit is provided with a convex bottom portion **14** merging into an inner surface **15** and also an outer surface **16**. Since the bit specifically illustrated is a core bit, the inner surface **15** is substantially cylindrical, which is also true of the outer surface **16** which constitutes the reaming portion of the bit. To enable the bit to drill hard formations, the matrix **17** has the diamonds **18** embedded in the inner, lower and outer faces **15**, **14**, **16**, these diamonds being arranged in any desired pattern.

For the purpose of cleaning and cooling the cutting surfaces of the bit, a plurality of grooves **21** is formed in such faces in a particular manner, providing watercourses through which the circulating fluid can flow readily from the interior of the bit to the bottom of the hole, and thence outwardly along the bottom of the hole, from where the fluid will flow in an upward direction past the reaming face **16**. The grooves **21** are relatively shallow, and are substantially equally spaced from each other around the cutting faces of the bit to provide spans or lands **22** between the grooves in which the diamonds **18** are embedded. The grooves **21** extend along the inner face **15**, around the convex lower face **14**, and upwardly along the outer reaming face **16** of the bit. The grooves are separated from one another by relatively short distances to provide relatively short or narrow lands **22** therebetween in which the diamonds are embedded and from which they may project. As shown, the groove portions **21***a* are substantially parallel to the axis of the bit along the inner cylindrical face **15** of the matrix, the upper ends of these watercourse portions **21***a* opening into the bore **23** of the bit body or shank, to receive drilling fluid therefrom. The groove portions **21***b* are arranged in spiral fashion along the convex lower face **14** of the bit, the inner ends of these spiral groove portions merging into the lower ends of the groove portions **21***a* and their outer ends into inclined groove portions **21***c* generally parallel to one another and arranged along the gauge or reaming face **16** of the bit. Each groove **21** is continuous beginning at the upper end of the inner cylindrical face **15**, where it communicates with the main fluid passage **23** in the bit body, and then continuing down along the inner cylindrical face **15** and into the convex face **14**, where the groove portion **21***b* is arranged in a spiral manner (at an increasingly greater angle with respect to a radial line drawn from the axis of the bit to the commencement of the spiral) outwardly toward the reaming face **16** of the bit, the groove then continuing as the inclined portion **21***c*, as disclosed most clearly in Fig. 1, to the upper end of the reaming face **16**, where the groove portion has an outlet into the well bore around the bit body **10**. The inclined groove portion **21***c* makes a substantial angle to a plane radial of the bit axis.

The grooves **21** are separated from one another by the relatively short lands or spans **22**, and are also generally equidistant from one another, the lands each including an inner cylindrical portion **22***a*, merging into a lower spiral portion **22***b* (which is also directed at an ever increasing angle to a radius drawn through the beginning of the spiral portion), the spiral portion of the land running into an inclined land portion **22***c* between the inclined watercourse portions **21***c* extending along the outside diameter or reaming face **16** of the bit.

In the use of the apparatus, it is lowered in the well bore to the bottom of the hole, the proper drilling weight being then imposed thereon while the bit is rotating at the proper speed. During the drilling action, circulating fluid, such as drilling mud, is pumped down the string of drill pipe **13**, and will pass through the main or central passage **23** in the bit body and the recesses **19** into the watercourses or waterways **21**. The fluid passes through the watercourse or groove portions **21***a* in the interior of the bit and thence through the spiral portions **21***b* along the bottom contacting face **14** of the bit, then passing upwardly through the inclined watercourse portions **21***c* in the outer face **16** of the bit into the well bore annulus around the bit body or shank **10**. The circulating fluid is pumped through the tool and the watercourses **21** at a proper rate, and will flush the cuttings from the drilling region in an outward direction and up around the bit and the drill string **13** to the top of the well bore.

Not only does the fluid flow through the watercourses or grooves **21** themselves, but it also flows transversely from the waterways across the diamond-studded lands **22** to other waterways in a substantial quantity, removing the cuttings between the diamonds **18** on the lands and cooling the lands. The fluid effectively prevents cuttings from packing between the diamonds **18**, which would minimize the extent of penetration of the diamonds into the formation. The effective cleaning and cooling action of the fluid passing across the lands **22** from one waterway to the next waterway is due to the fact that the fluid flowing downwardly through the throat **20** of the bit and its inner waterway portions **21***a* tends to follow a straight line path and resists attempts to confine it for lateral outward flow along a curved path, such as through the spiral waterway portions **21***b*. Some of the fluid, therefore, moves out of one waterway **21**, and flows across a land **22** to the next adjacent waterway on the opposite side of the land. In flowing across the land, it cleans and cools the face of the land and the diamonds projecting therefrom.

The tendency for the fluid to flow along a straight line path, which, in the present instance is generally radially of the bit in an outward direction is enhanced by the fact that a pressure differential exists between different points of adjacent curved or spiral watercourse portions **21***b*. Each watercourse or groove portion **21***b* may be considered as a conduit through which fluid is flowing, since the formation substantially closes its open side. Inasmuch as the watercourse is relatively shallow, and particularly since the circulating fluid is usually a comparatively heavy drilling mud, there will be a progressive pressure drop in each watercourse commencing from its inlet and running to its outlet portion. As shown diagrammatically in Fig. 4, the pressure in a watercourse portion **21***b* at the point *a* will be greater than the pressure at the point *b*, which will be greater than at a point *c* further along the watercourse. In other words, the pressure will progressively decrease along the length of each watercourse. Since the fluid tends to flow along a straight line path, or in a generally radial direction, it will tend to cross a land, travelling from different points in one watercourse portion **21***b* to the next watercourse portion **21***b*, reaching the next watercourse portion at greater distances from its inlet a^1 than its points of exit from the first-mentioned watercourse portion.

The following example is given of the foregoing statement, reference being had to Fig. 4. The pressure in a watercourse drops progressively along its length, decreasing progressively at the points *a*, *b*, *c*, *d*, *e*. The corre-

sponding points in the next watercourse are designated a^1, b^1, c^1, d^1, e^1. Since the drilling fluid tends to resist following a curving flow path, fluid in one watercourse at point *b* tends to continue movement in a straight line path S across a land **22** to the next watercourse, entering the latter at the point d^1. This point d^1 is at a much greater distance from the entry point a^1 of the watercourse than is the point *b* from the entry *a* of its watercourse. Accordingly, in view of the progressive pressure drop along each watercourse, the pressure at point *b* will be substantially higher than at point d^1, producing a pressure differential, which induces the fluid to leave one watercourse and flow across the land to the next watercourse. In so flowing across the land, it cleans it of detritus and cools it as well. The fluid from point *b* not only follows the straight line path S, but also flows more directly across the land, in view of the lesser pressures at other points of the next watercourse. Thus, the pressure at point c^1 is less than at point *b*, some fluid at the point *b* flowing along the path T to the point c^1. It is evident that the pressure differentials between the watercourses will produce a general transverse flow across the lands **22** from one watercourse to the other, and such transverse flow coupled with flow of fluid through the watercourses themselves, will thoroughly clean the bottom of the hole of the cuttings, completely flushing such cuttings from each land and insuring its maintenance in a clean and a cool condition.

It is to be noted that the distance between watercourse portions **21***b* is very little greater at the outer region of the bit bottom than at its inner region. The lands **22***b* themselves are of substantially uniform width, possibly being only slightly wider at their outer regions than at their inner regions. The spiral arrangement of watercourses or grooves **21***b* results in such substantial uniformity of widths of lands **22***b* and of watercourses **21***b* across the bottom face of the bit. It also results in the ability to concentrate diamonds across the bottom face of the bit in such manner that they are uniformly disposed per unit or square inch of projected area, the substantially uniform disposition and concentration of diamonds being maintained from the inside diameter of the bit to the outside diameter or reaming face **16** of the bit. Such substantially uniform concentration of diamonds per unit of projected area equalizes the work which is done by each diamond or stone on the face of the bit, inasmuch as there are obviously more diamonds available for cutting action at the outer portion of the bottom cutting face 14 than at the inner portion. The general uniformity of disposition of the stones 18 on the face of the bit per unit of projected area insures a more uniform rate of wear of the diamond stones, and results in a greatly increased life of the drill bit.

It is evident that the spiral fluid course pattern, which produces the spiral lands **22** containing the diamonds, provides a substantially uniform concentration of diamonds from the inside of the bit to its outside diameter without substantially widening the lands adjacent the outside diameter of the bit, which would have the drawback of the watercourses **21** being widely separated, diminishing the flushing action of the circulating fluid across the lands or spans **22** between watercourses at the outer portion of the bit.

It is, accordingly, apparent that a rotary diamond drill bit has been provided, in which the bit is maintained in a clean and cool condition by the circulating fluid, assurance being had that all cutting faces of the bit will be thoroughly flushed by the drilling fluid. The fluid does not only flow through the watercourses, but also transversely from one watercourse across a land to an adjacent watercourse throughout the length of the land, and, in so doing, insures the maintenance of all surfaces of the land face in a clean and cool condition. Accordingly, there is no localized burning of land areas, particularly in regions that are not immediately adjacent the watercourses themselves. A proper concentration of diamonds is secured across the cutting faces of the bit, there being more diamonds around the cutting faces adjacent the outside or reaming portions of the bit than on the inside, which, of course, is desirable since the circumference traversed by the outer portions of the bit during each revolution is much greater than the circumference covered by the inner portion of the bit, the outer portion being required to remove more formation than the inner portion and being subjected to a greater total amount of work.

The inclination of the watercourse portions **21***c* along the reaming face **16** of the bit also results in a proper cleaning and cooling of such reaming face, since the fluid will not all remain in the inclined watercourses, but will tend to move in a direction generally parallel to the axis of the bit, flowing from one waterway, across the inclined reaming lands **22***c*, and into the next waterway. In so flowing across the land **22***c*, it cleans and cools the latter.

The inventor claims:

1. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of the hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced generally spiral watercourses to provide substantially uniformly spaced generally spiral lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said spiral watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees.

2. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of the hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of spaced generally spiral watercourses to provide spaced generally spiral lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said spiral watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees.

3. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of the hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced generally spiral watercourses to provide substantially uniformly spaced generally spiral lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said spiral watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees, each watercourse having a substantially

uinform width throughout its length, each land having a substantially uniform width throughout its length.

4. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of the hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of spaced generally spiral watercourses to provide spaced generally spiral lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said spiral watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse and land around the drilling face being substantially less than 360 degrees, each watercourse having a substantially uniform width throughout its length, each land having a substantially uniform width throughout its length.

5. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced smoothly curved watercourses to provide substantially uniformly spaced smoothly curved lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees.

6. In a rotary drill bit: a body having a drilling face adapted to engage the bottom of a hole in which the bit is operating and a fluid passage extending longitudinally therethrough and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced smoothly curved watercourses to provide substantially uniformly spaced smoothly curved lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said watercourses commencing at said fluid passage and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees, each watercourse having a substantially uniform width throughout its length, each land having a substantially uniform width throughout its length.

7. In a rotary drill bit: a body having a convex drilling face adapted to engage the bottom of a hole in which the bit is operating and fluid passage means extending longitudinally through and opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced generally spiral watercourses to provide substantially uniformly spaced generally spiral lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said spiral watercourses commencing at said fluid passage means and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees.

8. In a rotary drill bit: a body having a convex drilling face adapted to engage the bottom of a hole in which the bit is operating and fluid passage means extending longitudinally through an opening into said drilling face, said drilling face containing a plurality of substantially uniformly spaced smoothly curved watercourses to provide substantially uniformly spaced smoothly curved lands between said watercourses, each land being engageable with the bottom of the hole across substantially the full width of the land, cutting elements secured to said lands for operation upon the bottom of the hole, each of said watercourses commencing at said fluid passage means and extending laterally outwardly therefrom to the outer portion of said body at an increasing angle to a radial line from the body axis to the commencement of said watercourse, the arcuate extent of each watercourse and land around the drilling face being substantially less than 360 degrees.

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