The present invention relates to rotary bits, and more particularly to bits used in the drilling and coring of oil, gas, water, and similar wells.

Rotary diamond bits rely upon circulating fluid for removing the cuttings from the bottom of the hole being produced, and to maintain the working face of the bit cool and clean. In most diamond bits, the diamonds project from the bit matrix or body in which they are embedded, spacing the matrix or body from the bottom of the hole and thereby providing a clearance space through which the circulating medium can flow. However, as the diamonds wear, this clearance space is reduced to the point at which insufficient fluid can flow for the effective removal of the cuttings and for the cooling of the bit face, resulting in a reduced penetration rate of the bit and burning of its working face and diamonds. The same adverse conditions can occur in the absence of diamond wear. If the bit is operating upon a yieldable formation, such as shale, the drilling weight imposed upon the bit depresses or "buries" the diamonds in the formation and reduces the clearance space between the matrix and the hole bottom.

Under conditions in which space is available through which circulating fluid can flow, it has been difficult to obtain positive distribution of the fluid to all portions of the working face of the bit to insure full removal of the cuttings and cleaning and cooling of the entire working face. More particularly, it has been difficult to insure substantially uniform fluid distribution of all parts of the cutting or working face of the bit in a positive manner.

Accordingly, it is an object of the present invention to provide a drill bit in which flow channels are always present for the passage of the circulating fluid over the cutting face of the bit, regardless of wear of the diamonds in the cutting face, or "burying" of the diamonds in a yieldable formation.

Another object of the invention is to insure positive and substantially uniform distribution of the drilling fluid to all portions of the working face of a diamond drill bit.

A further object of the invention is to provide a diamond drill bit in which tracking of sets of diamonds in the cutting face of the bit in the path of other sets is avoided, thereby increasing the drilling rate and life of the bit.

An additional object of the invention is to provide a diamond drill bit that cuts its own waterways in the formation through which the drilling fluid can flow to clean and cool the bit, and maintain the bottom of the hole free of cuttings to insure most effective action of the diamonds or stones in the formation.

Yet, another object of the invention is to provide an improved drill bit in which the circulating fluid is caused to flow in a positive manner, both radially and circumferentially across the entire face of the bit, to flush the cuttings from the bottom of the hole and all regions of the bit itself, so as to maintain the latter in a clean and cool state.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms 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 an isometric projection of a drill bit embodying the invention;

FIG. 2 is a bottom plan view, on an enlarged scale, of the drill bit shown in FIG. 1;

FIG. 3 is a longitudinal section through the drill bit, attached to the lower end of a string of drill pipe;

FIG. 4 is a greatly enlarged plan view of a portion of the drill bit shown in FIG. 2;

FIG. 5 is a vertical section, on an enlarged scale, taken along the line 5-5 on FIG. 4;

FIG. 6 is a bottom plan view, similar to FIGS. 2 and 4, of a portion of a modified form of drill bit;

FIG. 7 is a vertical section, on an enlarged scale, taken along the line 7-7 on FIG. 6;

FIG. 8 is a vertical section through a portion of the bit having the configuration shown in FIGS. 6 and 7.

As disclosed in the drawings, a drill bit A is provided for operation upon the bottom of a bore hole, and to flush the cuttings from the bottom upwardly around the drill bit and a string of drill pipe B to which it is secured, to the top of the hole. The drill bit includes a body or shank 10 having an upper threaded pin 11 for threadedly attaching the bit to the lower threaded box 12 of the string of drill pipe B. Circulating drilling fluid pumped down through the drill pipe B flows into a central or main passage 13 in the body of the tool, from where it will flow through a plurality of circumferentially spaced longitudinal extending ports or openings 14 against the bottom of the hole and also through distributing channels or watercourses 15, 16 and 17, 18 in the cutting surface or face of the bit, as described hereinafter.

The body 10 of the tool has diamonds 17, 18, or similar cuttings elements, secured in its formation contacting face within a matrix (not shown separately) of a suitable type forming a portion of the bit body. As disclosed, the bit A is of the type to drill the entire cross-sectional area of the well bore. However, it is to be understood that the invention is also applicable to other types of bits, such as core bits, in which the central portion of the bottom of the hole is not cut, to produce the desired core. As shown, the central portion 19 of the bit is generally in shape with the sides of the core tapering in an upward and inward direction. Such conical portion merges into a lowermost bottom contacting portion 20, which, in turn, merges into an upwardly diverted conical face 21 terminating at the reaming face 22 of the bit.

The drilling portions of the bit are divided into a plurality of diamond set sections or lands 23 extending from the inner portion 19 of the bit to its outer reaming face 22. The lands 23 are generally radially arranged and are spaced from each other by lateral inlet or feeder waterways 15 and lateral outlet or collector waterways 16. Each feeder waterway 15 has its inner portion communicating with a longitudinal passage 14 through the bit body. Fluid from such passage can also pass into the inner inlet 24 of a collector waterway 16. The fluid flows in a lateral outward direction from each passage 14 through the Inlet waterway 15 and also the outlet waterway 16.

As disclosed, the central portion 19 of the bit includes upwardly inclined lands 25, 26 circumferentially spaced from one another so as to provide the passages 14 therebetween. Two of the three lands disclosed, namely, lands 25, extend inwardly, but stop short of the central axis 27 of the drill bit. However, one of such lands 26 extends to the axis and preferably across the axis, to insure the cutting of the well bore to the axis of the bit, so that no core is produced tending to retard penetration of the bit into the bottom of the hole.
The upwardly and inwardly inclined inner lands 25, 26 may have diamonds 28 set in their faces for operation upon the central portion of the hole.

It is to be noted that each inlet or feeder waterway 15 has an incline on opposite sides thereof. Accordingly, drilling fluid pumped down through the outlet or collector waterway 16 on the opposite side of such land, and flowing circumferentially or down the inclined inner lands 23 will discharge from a longitudinal passage 14 and flow into this waterway 15 toward the outer or reaming surface 22 of the bit. The drilling fluid spreads in opposite directions from the waterway 15 flowing over the drilling face of one land toward a collector waterway 16 on the opposite side of such land, and flows circumferentially or down this land across the other land and discharging into a collector waterway 16 on the opposite side of such other land, as designated in FIG. 2. To insure the proper distribution of the drilling fluid, the cross-sectional area of each waterway 15 decreases in a direction toward the reaming face 22 of the bit, such gradual reduction in cross-sectional area being provided by tapering or having the sides 29 of the lands converge in a lateral outward direction. In view of such reduction in effective area of a waterway, assurance is had that adequate fluid will be present for flowing across the entire lateral extent to each land. As the reaming face 22 of the bit, the feeder or inlet watercourse merges into a vertical watercourse 30 for the purpose of discharge of the remaining fluid in an upward direction through the reaming face of the bit.

In the specific design illustrated in the drawings, the lands 23 are separated from one another alternately by the inlet or feeder waterway 15 and an outlet or collector waterway 16. Thus, as shown by the arrows in FIG. 2, the drilling fluid will flow in a lateral outward direction through a relatively high pressure inlet or feeder watercourse 15 and then spread in opposite directions to flow circumferentially across a land 23 on one side of the inlet waterway, and in the opposite direction circumferentially or across the land 23 on the opposite side of the same waterway. The fluid from one land will then flow into an adjacent outlet or collector waterway 16, whereas the fluid from the other land will discharge into another outlet or collector waterway 16 adjacent thereto.

It is to be noted that each collector waterway 16 has its sides 31, 32 diverging in an outward direction toward the reaming portion 22 of the bit, to provide a progressively increasing area through which the fluid will flow and pass toward the outer portion 22 of the bit. The fluid will flow to the periphery of the bit where the collector waterway is vertically arranged as a jet slot 33 along the reaming surface of the bit, providing a large area with the wall of the surrounding bore through which the cuttings and the drilling fluid can flow in an upward direction for passage around the body 10 of the bit and the drill pipe B to the top of the hole.

It is to be noted that each outlet or collector waterway 16 has a much greater area than the inlet or feeder waterway 15. Accordingly, the pressure of the fluid in the collector waterway 16 will be comparatively low as compared with the high pressure of the fluid in the feeder waterway 15. Such relative low pressure will be maintained despite the fact that some of the drilling fluid is passing directly from a fluid passage 14 into the inner portion 24 of the collector waterway. Since the collector waterway 16 has a substantially higher pressure than the collector waterway 15, assurance is had that the fluid will flow from each feeder waterway circumferentially in opposite directions toward the collector waterways on opposite sides of the lands 23 being supplied by the feeder waterway.

Each collector waterway 16 has a tapered bottom or side 34 inclined in a direction inwardly of the bit from the trailing edge 31 of a land toward the leading edge 32 of the next land, as regards the right hand direction of rotation of the bit. This tapered side or bottom 34 merges into a trailing face 35 of the collector waterway which is relatively abrupt, being disposed at a relatively steep angle to the cutting face of the drill bit. Because of the relatively abrupt trailing face 35 of each collector waterway 16, it functions as a dam or barrier to minimize or prevent passage of cuttings onto an adjacent land on the trailing side of the drill bit. Instead of the cuttings and fluid discharging from one land into a collector waterway 16, then passing over the next land, they are directed toward the periphery of the drill bit, and will then pass upwardly through the vertical joint slot or groove 33 at the end of each collector waterway, and then upwardly around the body 10 of the bit and the drill pipe B to the top of the hole.

The cutting faces of the bit have diamonds 17, 18 embedded therein. For the purpose of preventing tracking of the diamonds or stones in the formation, they are arranged in arcuate or circumferential rows staggered with respect to one another. As disclosed, each land has concentric ridges 40 formed therein which may be developed about the axis 27 of the drill bit as a center. Each ridge may be substantially triangular in cross-section, including tapered sides 41, 42 that extend toward each other and terminate in an outer crest 43 (FIG. 5). Diamonds 17, 18 may be embedded in each ridge. In one example, an arcuate row of diamonds 17 may be disposed in the crest 42 of a ridge and other rows of diamonds 18 in the sides 41 of a ridge. Preferably, the diamonds in the sides are arranged in staggered relation with the diamonds 17 in the crest, to insure more uniform cutting by the diamonds on the surface of the bit, and its longer effective drilling life. The concentric ridges 40 provide concentric arcuate flow channels 45 therebetween through which drilling fluid from the inlet or feeder waterways 15 can flow toward the collector waterways 16.

To insure the continued flow of fluid from the feeder waterways 15 across the lands 23 to the collector waterways 16, even under conditions in which the diamonds may have worn partially, the concentric ridges 40 in one land are offset with respect to the concentric ridges of another land in the face of the drill bit. As shown in FIGS. 6 and 7, for example, the ridges 40 in one land k are substantially uniformly spaced from one another and are offset from the ridges 40 of an adjacent land p by a distance of about one-half the distance between adjacent ridges, as represented in FIGS. 6, 7, and 8, the distance between adjacent ridges in a land is represented by b. The extent of offset of the ridges of one land k relative to the concentric ridges of an adjacent land p is one-half the distance b, or the distance a. As the result of such offsetting of the ridges of the adjacent lands, one ridge and the diamonds set therein will not track in the corresponding ridge of an adjacent land. As shown in FIG. 8, the ridges of one land will produce generally V-shaped depressions, grooves or flow channels 50 in the bottom of the hole. However, the ridges of an adjacent land, being offset from the ridges of the first land one-half the distance between ridges, will not track in the same channels 50 but will be displaced radially half the distance between such channels, cutting generally V-shaped flow channels 51 in the formation offset from the other generally V-shaped flow channels 50. Flow channels produced by the ridges of one land, such as the ridges 50, will remain between the ridges of the next succeeding land. Despite the fact that the ridges of one land are in intimate contact with the bottom of the hole during its digging action, flow channels, such as channels 50, will still remain between the inner portions of the sides 40 of adjacent ridges, through which the drilling fluid can pass from an inlet waterway 15, across the ridges 40 of the land to the collector waterway 16 at the outlet end of the ridges.

Because of the staggered relationship between the ridges 40 of one land p and the ridges of another land k, the ridges and the stones 17, 18 of one land do not track
in the path produced in the formation by the ridges and the stones of another land. Accordingly, more effective action of the diamonds or stones of another land occurs, the formation material being removed at a more rapid rate, the stones and the matrix material itself having a much greater life.

As shown in FIG. 2, six lands 23 are provided in the drilling face of the bit. If the ridges 40 of one land are offset with respect to the ridges 41 of an adjacent land by a distance equal to one-half the distance between adjacent crests 42 of the ridges of a particular land, then alternate lands may have their ridges 40 in circumferential alignment and lands between such alternate lands will also have their ridges in circumferential alignment, but offset with respect to the first-mentioned three lands.

Thus, as shown in FIG. 2, lands k, m, and o will have their concentric ridges lying in the same circles, whereas lands p, l and n will have their ridges concentric of one another, but offset with respect to the ridges of lands k, m and o. Thus, assurance is had that the ridges in one land will not track in the path of the ridges in an adjacent land, there always being the open areas between adjacent ridges and the flow channels 50 produced in the formation by the ridges of a leading land through which circulating fluid can flow from an inlet waterway 15 to the collector or outlet waterway 16.

The staggered relationship between the ridges of the lands as described in FIG. 2, for example, in which six lands are provided in the bit, the ridges in one land may be laterally spaced or offset from the ridge of the next adjacent land by a distance which is the distance between adjacent ridges of one land divided by the number of lands. In the specific example shown in the drawings, since there are six lands, the rides in one land will be offset with respect to the ridges of an adjacent land by one-sixth of the distance between adjacent ridges 40. As represented in FIGS. 4 and 5, the radial offsetting distance a between the ridges of adjacent lands, will be one-sixth of the distance b between adjacent ridges of a land. By referring to FIG. 2, the concentric ridges in land l are offset from the concentric ridges of land k by one-sixth the distance between adjacent ridges, for example, being disposed further radially inwardly one-sixth of such distance. The ridges of land m are offset from the ridges of land l by being disposed radially inwardly one-sixth the distance between adjacent ridges. Similarly, the ridges of lands n, o, p and k are offset inwardly one-sixth the distance between adjacent lands with respect to each other, each land having concentric arcuate ridges extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the ridges of one land being offset radially with respect to the ridges of another land, each ridge including sides exclusively its own, and having the confronting sides of adjacent ridges of one land forming an arcuate recess therebetween, an arcuate row of cutting elements in said crest portion, and an arcuate row of cutting elements in one of said sides in staggered relation to said other row.

In bits designed for drilling in harder formation, the height of each ridge 40 decreases, as well as the size of the stones 17, 18. For the hardest formation, substantially no ridges are provided on the face of the bit. However, the stones in each land still have essentially the same pattern as illustrated in the drawings; that is to say, each land will have concentric rows of stones or diamonds and such stones or diamonds are staggered relative to the concentric rows of stones or diamonds of an adjacent land.

It is, accordingly, apparent that drill bits are provided in which assurance is had that the ridges 40, or stones 17, 18, or both, do not track because of their offset relations. Such offset relationship provides circumferential or arcuate waterways (such as 50) through which the cuttings can be flushed by the drilling fluid in flowing from inlet waterways 15 across the lands 23 to the outlet waterways 16. In this manner, the bottom of the hole is maintained free of cuttings, so that the stones 17, 18 can have most effective action on the underlying formation. The face of the bit and the diamonds or stones therein are maintained in a cool state to prevent burning of the bit and its diamonds, insuring that the penetration rate of the bit is not substantially reduced. Even in yieldable types of formation, in which the diamonds tend to be "buried," the staggered relationship of the ridges or diamonds, or both, insures the presence of arcuate or circumferential waterways or channels across the lands 23 between the inlet and outlet waterways 15, 16 through which fluids and cuttings can always pass.

1. In a rotary bit: a body having a cutting face for drilling a hole; said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having waterways separating said lands from each other, and each land having concentric arcuate ridges extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the ridges of one land being offset radially with respect to the ridges of another land, each ridge including sides exclusively its own, having the confronting sides of adjacent ridges of each land forming an arcuate recess therebetween, an arcuate row of cutting elements in said crest portion, and an arcuate row of cutting elements in one of said sides in staggered relation to said other row.

2. In a rotary bit: a body having a cutting face for drilling a hole; said face comprising a plurality of spaced lands extending laterally from an inner portion of the face to the outer portion of the face, said cutting face having waterways separating said lands from each other, and each land having concentric arcuate ridges extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the ridges of one land being offset radially with respect to the ridges of another land, each ridge including sides exclusively its own and having a plurality of spaced rows of cutting elements concentric of the bit axis, the confronting sides of adjacent ridges of each land forming an arcuate recess therebetween, an arcuate row of cutting elements of one row being in staggered relation to the cutting elements of another row.

3. In a rotary bit adapted to be lowered in a hole on a tubular drill string; a body having a cutting face for drilling the hole and passage means for receiving fluid from the drill string; said face comprising a plurality of lands extending laterally from an inner portion of the
face to the outer portion of the face; said face having laterally extending circumferentially spaced inlet waterways communicating with said passage means, each inlet waterway separating a pair of adjacent lands and adapted to feed drilling fluid to said pair of adjacent lands; said face having laterally extending circumferentially spaced outlet waterways spaced arcuately from said inlet waterways, each outlet waterway separating a pair of adjacent lands and adapted to receive drilling fluid from said pair of adjacent lands, said outlet and inlet waterways being alternately arranged around the circumference of said cutting face and extending from an inner portion of said cutting face to the outer portion of said face; each land having concentric arcuate ridges extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the ridges of one land being offset radially with respect to the ridges of another land; the area of each inlet waterway decreasing in a direction laterally outwardly of the cutting face; the area of each outlet waterway increasing in a direction laterally outwardly of the cutting face.

4. In a rotary bit adapted to be lowered in a hole on a tubular drill string: a body having a cutting face for drilling the hole and passage means for receiving fluid from the drill string; said face comprising a plurality of lands extending laterally from an inner portion of the face to the outer portion of the face; said face having laterally extending circumferentially spaced inlet waterways communicating with said passage means, each inlet waterway separating a pair of adjacent lands and adapted to feed drilling fluid to said pair of adjacent lands; said face having laterally extending circumferentially spaced outlet waterways spaced arcuately from said inlet waterways, each outlet waterway separating a pair of adjacent lands and adapted to receive drilling fluid from said pair of adjacent lands; said face having concentric rows of cutting elements extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the rows of said cutting elements being offset radially with respect to the rows of another land; the area of each inlet waterway decreasing in a direction laterally outwardly of the cutting face; the area of each outlet waterway increasing in a direction laterally outwardly of the cutting face; the trailing sides of said outlet waterways being steeply pitched to the cutting face.

5. In a rotary bit adapted to be lowered in a hole on a tubular drill string: a body having a cutting face for drilling the hole and passage means for receiving fluid from the drill string; said face comprising a plurality of lands extending laterally from an inner portion of the face to the outer portion of the face; said face having laterally extending circumferentially spaced inlet waterways communicating with said passage means, each inlet waterway separating a pair of adjacent lands and adapted to feed drilling fluid to said pair of adjacent lands; said face having laterally extending circumferentially spaced outlet waterways spaced arcuately from said inlet waterways, each outlet waterway separating a pair of adjacent lands and adapted to receive drilling fluid from said pair of adjacent lands; said face having concentric rows of cutting elements extending laterally from the inner to the outer portions of the face and having the bit axis as a center, the rows of said cutting elements being offset radially with respect to the rows of another land; the area of each inlet waterway decreasing in a direction laterally outwardly of the cutting face; the area of each outlet waterway increasing in a direction laterally outwardly of the cutting face; the trailing sides of said outlet waterways being steeply pitched to the cutting face.

References Cited in the file of this patent

UNITED STATES PATENTS

2,032,328  Reedy Feb. 25, 1936
2,264,617  Carpenter et al. Dec. 2, 1941
2,371,490  Williams Feb. 27, 1945
2,495,400  Williams Jan. 24, 1950
2,612,348  Olsen Sept. 30, 1952
2,855,181  Catallo Oct. 7, 1958
2,931,630  Grady Apr. 5, 1960
2,990,897  Short July 4, 1961

FOREIGN PATENTS

625,243  Great Britain June 23, 1949

OTHER REFERENCES