May 30, 1967

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3,322,218

MULTI-PORT DIAMOND BIT

Filed May 4, 1965

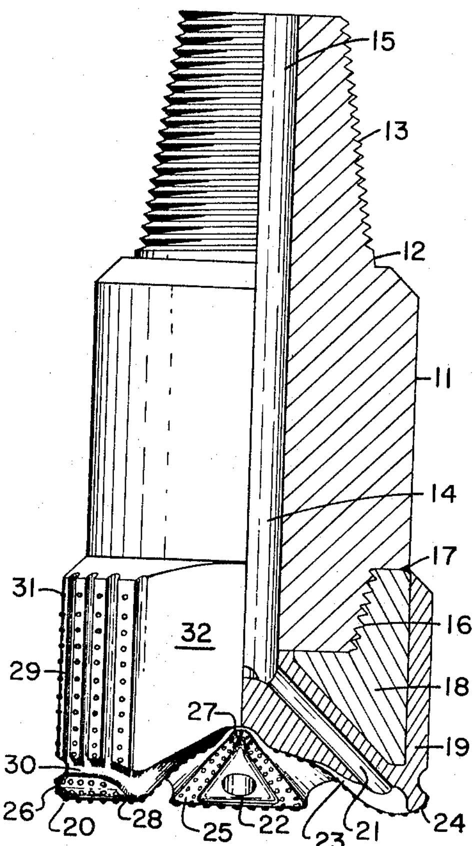

FIG.-1

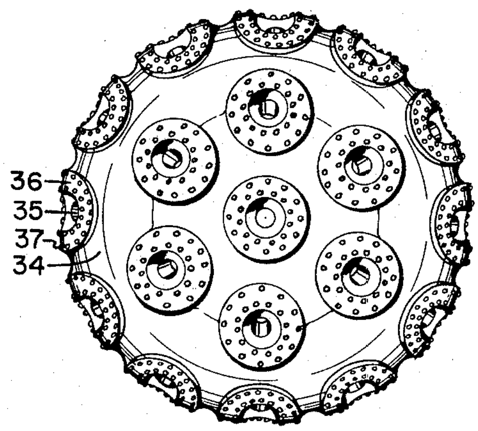

FIG.-3

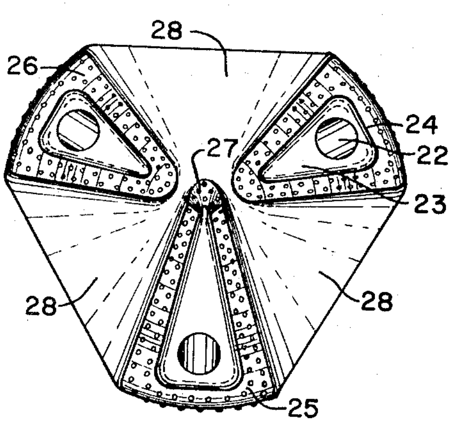

FIG.-2

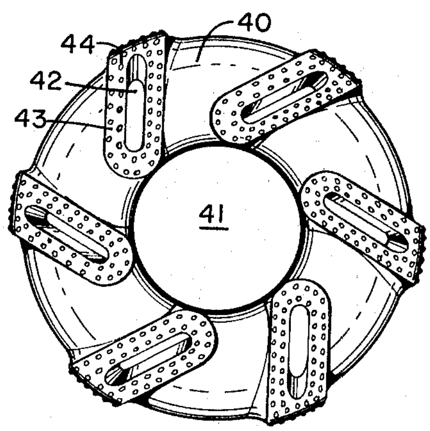

FIG.-4

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United States Patent Office 3,322,218
Patented May 30, 1967

3,322,218
MULTI-PORT DIAMOND BIT

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Filed May 4, 1965, Ser. No. 453,053
9 Claims. (Cl. 175—330)

The present invention relates to rotary drill bits and is particularly concerned with diamond bits for drilling oil wells, gas wells and similar boreholes.

The typical diamond bit employed in the petroleum industry includes a generally cylindrical body and a crown which extends below the body and contains lands in which the diamond cutting elements are embedded. The drilling fluid circulated to such a bit flows downwardly through an axial passageway in the body and upper part of the crown, is discharged from a port in the lower crown surface, and passes outwardly to the gage surface through radial or spiral waterways extending between the lands. This fluid has several important functions, including cooling of the diamonds and the removal of cuttings and mud solids from beneath the bit. It has been shown that inadequate distribution of the fluid is a major cause of diamond bit failure. Solid particles which accumulate beneath the bit due to improper fluid distribution absorb bit weight and rotary power, limit penetration of the diamonds, and prevent adequate cooling and lubrication of the diamonds. Efforts to avoid these and related difficulties caused by poor fluid distribution have not been wholly successful. Distribution of the fluid is generally poor regardless of the arrangement of the lands and waterways on the underside of the bit and hence adequate cleaning of the diamonds and adjacent surfaces is seldom obtained.

It is therefore an object of the present invention to provide improved diamond bits for drilling oil wells, gas wells and similar boreholes in the earth. Another object is to provide diamond bits which permit better distribution of the drilling fluid and more effective cleaning of the diamonds and adjacent surfaces than can generally be obtained with conventional tools available in the past. A further object is to provide diamond drill bits on which the lands and waterways are positioned so that the drilling fluid circulates about each diamond and carries away any solids that otherwise might tend to accumulate. Still other objects will become apparent as the invention is described in greater detail hereafter.

The improved diamond bits of this invention are characterized by a plurality of discharge ports in the lower crown surface. Each of these ports is surrounded by a relatively narrow land which extends a short distance below the adjacent surface and supports the diamonds. The lands are spaced on the lower surface of the tool so that the entire formation beneath the bit is cut away as the tool rotates. Fluid emerging from each of the discharge ports must flow beneath the surrounding land and past the diamonds embedded therein before it can escape from beneath the bit. The relatively short paths of the fluid across the lands and the relatively high velocities adjacent the diamonds permit significantly better cleaning of the stones and adjacent surfaces than can generally be obtained with bits having radial or spiral waterways of conventional design. The improved cleaning results in longer life and better bit performance.

The nature and objects of the invention can best be understood by referring to the following detailed description of several bit embodiments and to the accompanying drawing in which:

FIGURE 1 is a vertical elevation, partially in section, of a diamond drilling bit constructed in accordance with the invention;

FIGURE 2 is a bottom view of the bit shown in FIGURE 1;

FIGURE 3 is a bottom view of a drilling bit similar to that of FIGURES 1 and 2 showing an alternate arrangement of the discharge ports and lands; and,

FIGURE 4 is a bottom view of a core bit constructed in accordance with the invention.

The diamond bit depicted in FIGURE 1 of the drawing includes a tubular body **11** of steel or similar material having an upper shank **12** provided with external threads **13**. If the bit is to be used in the petroleum industry, the dimensions of the shank and the thread size are preferably selected in accordance with the specifications for an API tool joint pin. Similar standards are available for tool joints on bits intended for use in the mining industry. In lieu of a pin as shown, the bit may be provided with an API tool joint box or other connecting means. The body **11** includes an axial passageway **14** which extends therethrough from an opening **15** at the upper end of the body. Threads **16** are provided on the lower end of the body to facilitate its attachment to the crown. The crown is normally manufactured separately and later connected to the body and welded in place. The welded joint is designated in FIGURE 1 by reference numeral **17**. As an alternate method of construction, the body and crown may in some cases be fabricated as a single unit.

The crown on the bit shown in FIGURE 1 includes an annular steel blank **18** surfaced with a metallic matrix **19** in which the diamond cutting elements or similar hard, abrasion-resistant particles **20** are embedded. The crown blank will generally be attached to the body by threading the two together and then running a weld along the joint. The matrix **19** is normally composed of a copper-nickel alloy or similar bonding metal containing powdered tungsten carbide or an equivalent refractory hardmetal in quantities sufficient to convey the required strength and erosion resistance. The bonding metal employed in the matrix will generally have a melting point within the range between about 1500° and about 2500° and in the molten state should have the ability to wet the tungsten carbide or other refractory hardmetal powder utilized. The crown may be fabricated by placing the diamonds or similar cutting elements in shallow depressions in the inner wall of a refractory mold of the desired shape, positioning the crown blank **18** in the mold, filling the spaces between the blank and mold wall with the hardmetal powder, and thereafter heating the mold and its contents to a preselected infiltration temperature between about 1600° and about 2600° F. After the infiltration temperature is reached, a molten binder metal is allowed to flow into the interstices between the mold wall, the hardmetal granules, and the surface of the blank. The mold is then allowed to cool to room temperature. As the molten binder metal solidifies, it forms a metallurgical bond with the steel and hardmetal particles surrounding the protruding diamonds. The finished crown can then be removed from the mold, sandblasted to remove surface irregularities, and connected in place at the lower end of the body. In lieu of this procedure, a liquid phase sintering technique carried out at high pressure and elevated temperature may be employed. Other matrix compositions and methods for the fabrication of diamond bits are described in the "Diamond Drill Handbook," by J. D. Cumming, 1956 edition, published by J. K. Smit & Sons of Canada, Limited, Toronto, Canada.

It will be noted that the crown of the bit shown in FIGURE 1 includes internal passageways **21** which communicate with axial passageway **14** in the body. Discharge ports **22** in the lower surface of the crown permit the escape of fluid from the passageways into the space between the lower surface of the tool **23** and the underlying formation. The bit shown, as indicated more clearly in FIGURE 2, contains three discharge ports which are located in the outer part of the lower crown surface and are spaced at intervals of about 120°. Narrow lands 24, 25 and 26 extend across the lower surface to points adjacent the crown periphery. Each land projects downwardly a short distance below the adjacent surfaces and completely surrounds one of the discharge ports. On the bit shown, the lands are of generally triangular configuration, each including a base extending along the periphery of the tool and an apex located near the longitudinal axis of the bit. Land 25 extends through the longitudinal axis so that the formation beneath the center of the tool can be drilled. A shallow generally conical depression or concavity 27 is located at the axis. This serves to center the bit in the borehole and improves the cutting efficiency of the diamonds near the axis. The diamonds or other particulate cutting elements 20 employed for drilling purposes are embedded in the lower surfaces of lands 24, 25 and 26. These diamonds are arranged in one or more rows on each land and are preferably staggered to avoid the tracking of one diamond by another. Large waterways 28 extend between the adjacent lands to permit escape of the fluid and entrained solids from beneath the tool.

The bit shown in FIGURES 1 and 2 is provided with gage surfaces 29 which extend upwardly above the lands on the outer surface of the crown and are separated therefrom by transverse waterways 30 on the gage surface of the tool. Gage diamonds or inserts of tungsten carbide or a similar hardmetal 31 on the gage surfaces aid in maintaining the required borehole diameter and help stabilize the bit. These diamonds or inserts may be arranged in any of variety of different patterns. Intervening faces 32 extend between the gage surfaces so that fluid and entrained solids from waterways 28 can pass upwardly above the crown.

The tool depicted in FIGURES 1 and 2 of the drawing is utilized by first connecting the bit to the lower end of a rotary drill string and lowering it into place in a borehole. Drilling mud or similar fluid is circulated downwardly through the drill string and withdrawn from the borehole annulus as the string is rotated. The mud passes downwardly through axial passageway 14 and internal passageway 21 and is discharged through discharge ports 22 in the lower surface of the tool. From here the mud flows beneath the lands 24, 25 and 26, entraining cuttings produced as the diamonds attach the underlying formation. The lands are of substantially uniform width at all points about their peripheries and hence the pressure drop is substantially the same in all directions. This permits considerably more uniform distribution of the drilling fluid to the diamonds than can generally be obtained where conventional radial or spiral waterways are employed. Since each port is surrounded by a comparatively narrow land, the fluid flows past the diamonds at relatively high velocities. This effectively reduces the accumulation of cuttings and mud solids between the diamonds and alleviates difficulties frequently encountered due to the clogging of conventional bits. Better cooling and lubrication of the diamonds are obtained. Drilling rates are generally somewhat better than what can be obtained with conventional tools because less regrinding of the cuttings takes place and because the more efficient removal of solids reduces the pressure drop across chips in the formation. The mud emerging beneath the lands flows outwardly to the crown periphery and passes upwardly through the borehole annulus.

It will be understood that the bits of the invention are not restricted to three fluid discharge ports as shown in FIGURES 1 and 2 of the drawing. Two or more ports may be provided. FIGURE 3 of the drawing is a bottom view of a bit having a crown 34 containing more than three discharge ports. Each of the circular ports 35 on the lower surface of the bit is surrounded by a narrow, substantially circular land 36 containing one or more rows

of diamonds 37. The ports may all be of the same size or may be of different sizes so that more fluid is discharged from certain ports than from others. The diamond wear is generally more severe near the bit axis than near the crown periphery and hence the inclusion of somewhat larger ports near the axis is often advantageous. The size of the ports and the number provided will depend in part upon the desired pressure drop across the tool and the available pressure at the surface. The lands should be spaced so that the diamonds engage the entire formation beneath the bit as the tool rotates. A variety of different patterns in addition to that shown in FIGURE 3 of the drawing will readily suggest themselves to those skilled in the art.

FIGURE 4 in the drawing is a bottom view of a core bit constructed in accordance with the invention. The bit shown in FIGURE 4 includes a crown 40 containing a large axial opening 41 of circular cross-section into which the core extends as the surrounding formation is cut away by the tool. Elongated ports 42 are provided in the lower crown surface surrounding the core opening to permit the discharge of drilling fluid beneath the tool. The ports are preferably slanted with respect to the radii of the tool to permit the use of openings of greater length than would otherwise be feasible. One end of each port is located near the core opening and the other end is positioned near the bit periphery. Each elongated port is surrounded by a narrow land 43 across which the discharged fluid must pass before it escapes from beneath the bit. The lands extend a short distance below the adjacent crown surfaces. Diamonds 44 are embedded in each land and arranged in one or more rows extending around the port. The internal structure of the tool of FIGURE 4 may be similar to that of a conventional core bit and has therefore not been illustrated.

The operation of the tools of FIGURES 3 and 4 is similar to that of the bit described earlier. In each case the use of narrow lands which surround the fluid discharge ports and contain only a relatively few diamonds permits better fluid distribution and more effective cleaning than can generally be obtained with bits of conventional design. It will be apparent that still other configurations in addition to those described and specifically illustrated can be devised without departing from the concept of the invention.

What is claimed is:

1. A rotary drill bit comprising:

(a) a body member containing a longitudinal passageway for transmitting drilling fluid through said member;

(b) a crown affixed to the lower end of said body member, said crown including (i) a lower surface containing a plurality of fluid discharge ports communicating with said passageway in said body member; (ii) a plurality of lands extending downwardly below the adjacent lower crown surface, said lands extending around and enclosing said ports whereby fluid discharged from the ports must pass beneath the lands to reach the borehole annulus; and (iii) gage surfaces extending upwardly above said lower surface; and

(c) a plurality of particulate cutting elements embedded in said lands for engaging the underlying formation.

2. A bit as defined by claim 1 wherein said lands are of generally triangular configuration, each including a base extending along the crown periphery and an apex located near the longitudinal axis of the tool.

3. A bit as defined by claim 1 wherein said lands are of substantially circular configuration, each land surrounding a substantially circular discharge port.

4. A bit as defined by claim 1 wherein said lands have elongated configurations, one end of each land being located near the crown periphery and the other end being located inwardly toward the longitudinal axis of the tool.

5. A diamond drilling bit comprising:

(a) a body member containing a longitudinal passageway for transmitting drilling fluid through said member;

(b) a crown connected to the lower end of said body member, said crown including (i) a lower surface containing a plurality of discharge ports communicating with said passageway in said body member; (ii) a plurality of lands extending downwardly below the adjacent lower crown surface, each of said lands surrounding a discharge port whereby fluid flowing from said port must pass beneath said land to reach the borehole annulus and each land being of substantially uniform width; and (iii) gage surfaces extending upwardly on the crown periphery, said gage surfaces being spaced at intervals on the periphery to permit the passage of drilling fluid and entrained cuttings between adjacent gage surfaces; and

(c) a plurality of diamonds embedded in the lower faces of said lands.

6. A bit as defined by claim 5 including transverse waterways on the crown periphery between said lands and said gage surfaces.

7. A bit as defined by claim 5 wherein each of said lands extends inwardly from a point near the crown periphery to a point near the bit axis.

8. A diamond core bit comprising:

(a) a body member containing longitudinal passageways for receiving a core and transmitting drilling fluid through said member;

(b) an annular crown connected to the lower end of said body member, said crown including (i) a lower surface containing an axial core opening and a plurality of discharge ports communicating with said passageways in said body member; (ii) a plurality of lands extending downwardly below the adjacent crown surface around said discharge ports, each of said lands enclosing a discharge port whereby fluid discharged from said port must pass beneath said land to reach the borehole annulus and each land being of substantially uniform width at all points about the port enclosed therein; and (iii) gage surfaces extending upwardly on the crown periphery; and

(c) a plurality of diamonds embedded in the lower faces of said lands.

9. A bit as defined by claim 8 wherein each of said lands has an elongated configuration, one end being located near the crown periphery and the other end being located near said core opening.

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