ROTARY DRILL BIT WITH LATERAL CUTTER

Edward B. Williams, Jr., Greenville, Tex., assignor of one-third to Edward B. Williams III, one-third to Joseph W. Williams, and one-third to David B. Williams, all of Greenville, Tex.

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This invention relates to drill bits for drilling bore holes into earth formations, and particularly to those of the type having rotating cutters for drilling through the various formations encountered in the drilling of such bore holes.

The cutters of drill bits of this type are usually of cone shape and provided with teeth arranged for each cutter to roll about the rotational axis of the bit and cut the full gauge of the bore hole. Therefore, the overall outer diameter of the bit substantially conforms to the diameter of the bore hole drilled thereby. Consequently, if it is necessary to case the upper portion of the bore hole, further drilling must be carried on with a smaller sized bit, in order that the bit can be moved through the casing when running the drilling string into and out of the bore hole, as when changing drill bits.

Also, if an upper cutter is to be used after starting a bore hole to continue drilling of the bore hole with a larger diameter bit, and there is not sufficient clearance to run the larger bit through the portion of the bore hole of smaller diameter. Also, in bore holes drilled by conventional bits, the clearance between the bit and wall of the bore hole may be such that the teeth of the cutters may be damaged when running the bit into and out of the bore hole.

It is, therefore, a principal object of the present invention to provide a bit with rotary cutters that may be safely and easily run through a bore hole without damage to the cutters, and which may be run through holes of smaller diameter than the size to be cut by the bit, as when continuing drilling of a larger sized hole to greater depths or when reaming portions of a bore hole at lower depths.

Another object of the invention is to provide a drill bit having frusto-conical cutters of standard arrangement on the body of the bit to drill a pilot hole in conventional manner and to provide the bit body with an upper rotary cutter having teeth offset outwardly of the cone cutters to make a sweeping cut of larger diameter than the pilot hole, and thereby result in a bore hole of the required diameter. With this combination of cutters, the largest overall diameter of the bit is less than the diameter of the bore hole made thereby. Consequently, the bit may be run easily through a cased upper portion of the bore hole, or even a smaller diameter upper portion of the bore hole, without damaging the teeth of the cutters.

In accomplishing these and other objects of the invention as hereinafter pointed out, I have provided improved structure, the preferred forms of which are illustrated in the accompanying drawings, wherein:

FIG. 1 is a vertical section through a bore hole and showing a drilling string equipped with a preferred form of drill bit which embodies the features of the present invention. The lower drill collar of the drilling string and the drill bit are shown in section.

FIG. 2 is a perspective view of the bit body as it appears prior to mounting the frusto-conical cutters, and showing the upper cutter and its mounting spindle in spaced relation with the body of the bit. FIG. 3 is a view of the cutting end of the bit particularly illustrating the arrangement of the cutters which together cover the full gauge of the bore hole when the bit is in use.

FIG. 4 is a sectional view similar to FIG. 1, but showing a modification of the invention as to the mounting of the cutter for making the full gauge of the bore hole.

FIG. 5 is a perspective view of the bit body in the form of invention illustrated in FIG. 4, with the upper cutter and its mounting spindle in disassembled relation with respect to the bit body.

FIG. 6 is a bottom view of the bit to show the cutter arrangement relatively to the diameter of bore hole drilled thereby.

Referring more in detail to the drawings:

1 designates a drill bit constructed in accordance with the first form of the present invention and which is particularly adapted for drilling earth formations. The bit includes a body member 2 having an exteriorly threaded pin 3 and which in the illustrated instance is adapted for coaxial attachment to the lower drill collar of a drill pipe or drill stem 4. The pin 3 is thus concentric with the rotary axis 5 of the drill pipe, and forms, with the body member 2, an annular shoulder 6, as shown in FIG. 1. The portion of the body member 2 immediately below the shoulder 6 has radially outwardly and downwardly depending legs, which in the illustrated instance are three in number and designated 8, 9 and 10, respectively, somewhat similar to the fork portion of a conventional rotary bit. The outer faces 11 of two of the legs, 8 and 9, are formed transversely thereof on equal arcs about the axis of the body member, but the outer face 12 of the third leg extends outwardly from the axis of the body member a greater distance for the purposes of the present invention.

However, the inner faces 13 of all the legs diverge outwardly and downwardly substantially at equal distances from the rotational axis of the bit to accommodate the frusto-conical cutters 14, 15 and 16. The inner or facing sides 13 of each leg carries a spindle 17 projecting downwardly therefrom for rotatably mounting the cutters 14, 15 and 16 in any approved manner so that the cutters rotate therewith base faces thereof backed by the face sides 13. Each cutter is of generally frusto-conical shape and has teeth 18 on the conical sides thereof, with the teeth of one cutter having differential spacing and located from the teeth of the other cutters, whereby the teeth on the respective cutters produce an individual cut or chip of the formation when the drill is in use. That is, the teeth of the cutters produce different patterns or cuts, so that the cuts of one cutter are out of registry with the cuts made by the other cutters.

The cutters are also of a size and arrangement wherein they are completely contained within an indicated circle 19 (FIG. 3) extending about the axis of rotation 5 to make a pilot hole 20 (FIG. 1) when the bit is in use as later described.

In order to cut the desired diameter of bore hole 21 which is larger than the diameter of the pilot hole 20, the leg 10 is of special shape and has sufficient metal to accommodate an upwardly and inwardly sloping slot-like recess 22 that is parallel with the inner face side 13.
of the leg 10 to provide an upper secondary leg portion 23, and sufficient metal in the leg 10 below the slot to carry the spindle 17 for the frusto-conical cutter 16. Inserted in the recess 22 is a cutter 24 having peripheral teeth 25 with cutting edges 26 arranged to cut outside the base teeth of the conical cutter 16. The cutter 24 is of generally disk shape and has an axial opening 27 registering with an opening 28 in the secondary leg 23 and a socket 29 in the portion of the leg 10 that carries the spindle 17, to mount a spindle 30 for the cutter 24. If desired, the cutter 24 may be mounted on suitable antifriction bearings 31, as illustrated in FIG. 1. The cutting edges 26 of the teeth 25 are generally parallel with the cutting edges of the cutter 16 and rolling circumferentially of the bottom of the pilot hole 20. The teeth 25 are adapted to chip away the formation as the cutter 24 sweeps about the bore hole 21 when the bit is in use. The body of the bit may be provided with the usual watercourses 32 to discharge drilling fluid from the discharge port 32'. It is apparent that the legs 8, 9 and 10 are spaced radially of the drilling fluid discharge port 32' and at least a portion of the recess or slot 22 extends below the discharge port 32', so that the cutter mounted therein is washed by the drilling fluid discharged from the port while it is moving outwardly between the legs which mount the frusto-conical cutters, whereby all the cutters, including the engaged cutter 24, are washed by the drilling fluid discharged through the port 32'.

The form of the invention illustrated in FIGS. 4 to 6, inclusive, follows the structure of the form illustrated in FIGS. 1 to 3, inclusive, except for the location of the upper cutter 33. In this form of the invention, the body member 34' has three depending legs 34, 35 and 36, all of the same size and shape, to carry the conical cutters 37, 38 and 39 that produce the pilot hole 20. The upper portion of the body member has a threaded pin 40 that is secured by a shoulder 41 to connect the bit with the drill stem 42. The upper cutter 33 is mounted in a lug 44 that extends from the body member 34' intermediate two of the adjacent legs 34 and 35. The cutter 33 is rotatably mounted in a recess or slot 45 of the lug 44 on a spindle 46 that extends through an opening 47 in the lug 44, through an axial opening 48 in the cutter 33 and into a socket 49. The spindle 46 may be suitably welded to the lug at the outer end of the pin, as indicated at 50 in FIG. 4 of the drawings. The cutter 33 may also be carried on an antifriction bearing 51, if desired. The body member 34' may also have a watercourse 52 to supply drilling fluid to the cutters. It is apparent that the recess or slot 45 is located near the discharge port so that the drilling fluid discharged therefrom and moving through the space between the legs 34 and 35 washes the teeth of the gauge cutter 33, so that all of the cutters carried by the bit are directly washed by the drilling fluid discharged from the port 52'.

In using the bit, the bit will be connected to the bottom drill collar of the drill stem and lowered into the bore hole with the axis of the bit offset laterally of the bore hole, so that sufficient clearance is provided around the entire circumference of the bit. In this way, the bit may be freely run into a small bore hole or a casing smaller than the gauge of the hole. When the bit reaches the bottom of the hole 21, the usual rotating mechanism is connected with the drill stem. Upon starting rotation of the drill stem, the cutters 14, 15 and 16 automatically seat concentrically with the center of the bottom of the bore hole. The drilling operation will proceed with the bit rotating about the axis 6 with the cutters 14, 15 and 16 rolling upon the bottom of the bore hole to produce the pilot hole 20. During rotation of the bit, the teeth 25 of the gauge cutter 24 will roll in a circular path on the side of the cutters 14, 15 and 16 in a plane parallel with the bottom of the hole and upon the annular shoulder 53 (FIG. 1). The teeth 25 will chip away the shoulder as the gauge cutter rolls thereon progressively with deepening of the pilot hole, to maintain the desired gauge of the bore hole.

When it becomes necessary to pull the drilling string from the bore hole, the drill bit will draw freely through the bore hole and pass through the smaller or cased portion of the bore hole.

The form of the invention illustrated in FIGS. 4 to 6, inclusive, will be used in the same manner as the form of the invention illustrated in FIGS. 1 to 3, since the only difference is in the mounting of the gauge cutter.

What I claim and desire to secure by Letters Patent is:

1. A drill bit for drilling bore holes in earth formations, said drill bit including a rotary body member having a drill stem connection coaxial with said body member and said body member having radially outwardly and downwardly directed legs spaced radially of a drilling fluid discharge port in said body and with said legs having outwardly and downwardly sloping inner faces, spindles projecting from said inner faces, frusto-conical cutters rotatably carried on the spindles with base faces thereof in contact with said inner faces of the legs and having teeth extending outwardly between the legs which mount the frusto-conical cutters thereof and provided with cutting edges rolling in circular paths concentric with the axis of rotation of the drill stem connection and to be washed by the drilling fluid discharged from said port and moving outwardly between said legs for cutting a pilot hole when the drill bit is in use, means within the zone of the discharge port for providing on said body member an upwardly and inwardly sloping slot with a portion thereof substantially at the level of the discharge port, a gauge cutter for establishing gauge of the bore hole and having a disk shaped body rotatable in said slot and having teeth extending from the disk shaped body and provided with cutting edges extending in corresponding parallel relation with the cutting edges of the teeth of the frusto-conical cutters and in direct contact with outwardly moving drilling fluid under flow between said legs whereby the gauge cutter is directly washed by the drilling fluid discharged from said port, and a pin carried by said body member and extending across said slot for providing a spindle to support said gauge cutter with the cutting edges of the teeth rolling circumferentially of the pilot hole for cutting an annular shoulder substantially parallel with the bottom of the pilot hole.

2. A drill bit as described in claim 1, in which the means that provides the upwardly and inwardly sloping slot consists of spaced apart upper and lower leg portions projecting from said body member at a point intermediate two of said downwardly directed legs and diametrically opposite a third leg to provide the upwardly and inwardly projecting slot.

3. A drill bit for drilling bore holes in earth formations, said drill bit including a rotary body member having the entire end of the drill stem connected coaxial with said body member and said body member having radially outwardly and downwardly directed legs spaced radially of a fluid discharge port in said body and with said legs having outwardly and downwardly sloping inner faces, spindles projecting from said faces, frusto-conical cutters rotatably carried on the spindle and having teeth extending between the legs which mount the frusto-conical cutters thereof and provided with cutting edges rolling in circular paths concentric with the axis of rotation of the drill stem connection and to be washed by the drilling fluid discharged from said port and moving outwardly between said legs for cutting a pilot hole when the drill bit is in use, one of said legs having a slot therein sloping upwardly...
and inwardly from below said port for dividing said leg into upper and lower leg portions, said leg portions having a downwardly and inwardly extending bore therein in upwardly offset relation to the spindle carried by the said one leg, a gauge cutter having a disk shaped body rotatable in said slot and having teeth extending angularly from the inner face of the disk to rotate in overlapping relation with the lower leg portion and provided with cutting edges extending to rotate in a path generally parallel with the path of the frusto-conical cutter that is mounted upon the spindle of said one leg and in direct flow of the drilling fluid moving between said legs whereby all of the cutters are directly washed by the drilling fluid discharged from said port, and

a pin in said bore of the leg portions and extending through the disk shaped body of the gauge cutter for providing a spindle on which said gauge cutter turns to rotate the teeth thereof circumferentially of the pilot hole for cutting an annular shoulder substantially parallel with the bottom of the pilot hole.

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