April 11, 1939. A. C. CATLAND 2,154,032

ROTARY WELL BIT

Filed July 10, 1937 2 Sheets-Sheet 1

Fig. 1.

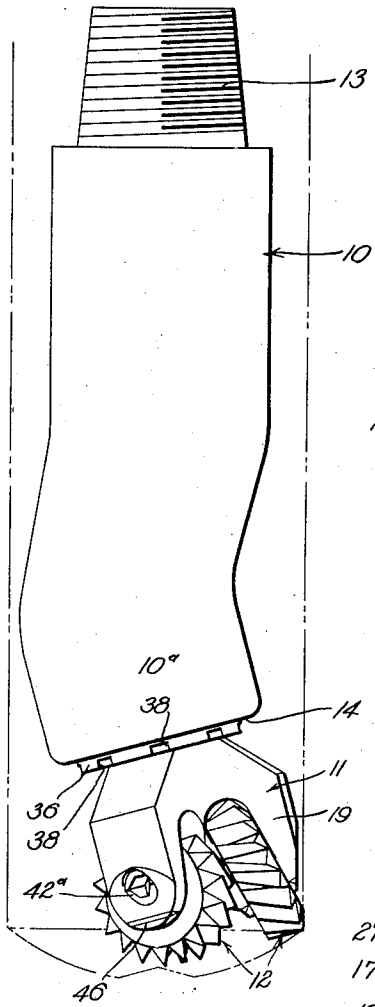


Fig. 2.

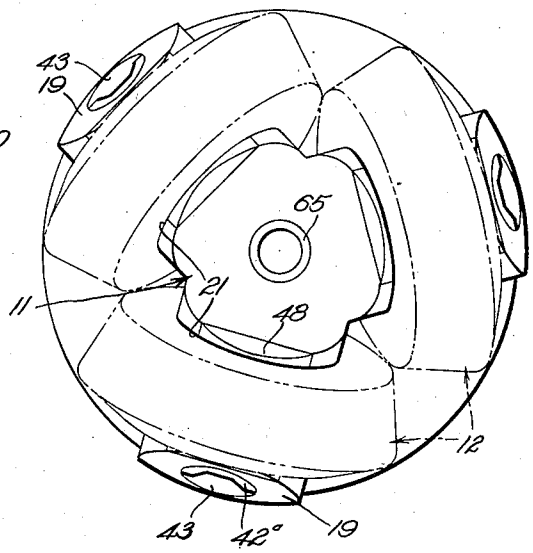
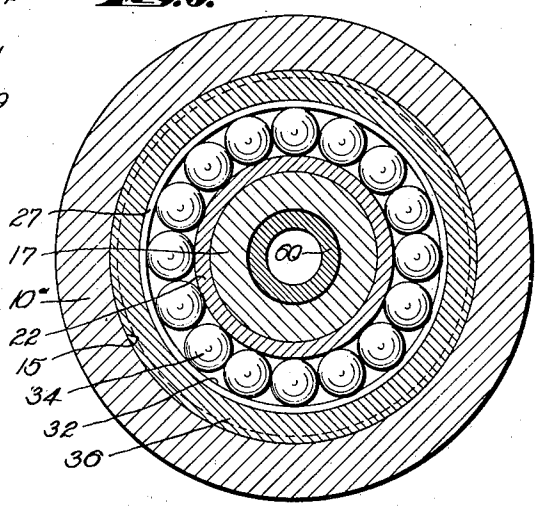


Fig. 3.



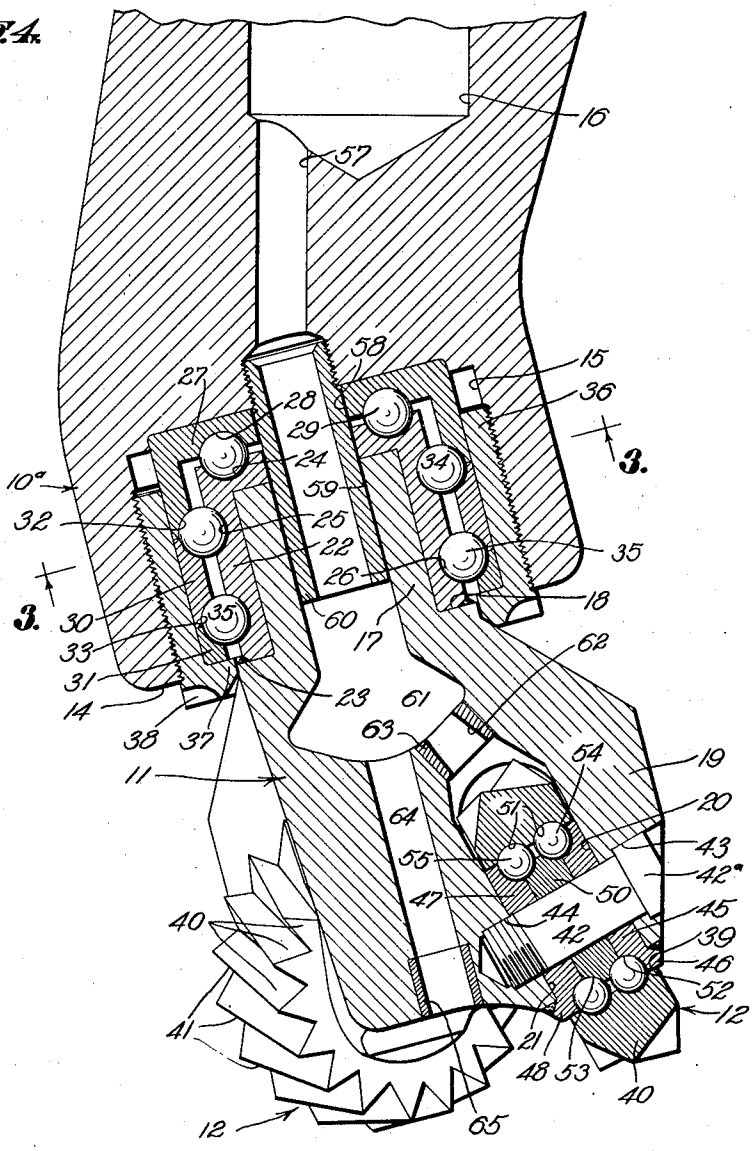
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Filed July 10, 1937 2 Sheets-Sheet 2

FIG. 4.



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ROTARY WELL BIT

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Application July 10, 1937, Serial No. 152,975

10 Claims. (Cl. 255—71)

This invention relates to a drilling tool and relates more particularly to a bit for use in the rotary method of well drilling. A general object of this invention is to provide a gyratory bit that is rapid in its penetration of the earth formation.

Another object of this invention is to provide an improved gyratory well bit embodying roller rock cutters mounted and related to be particularly efficient in operation.

Another object of this invention is to provide a well bit embodying a cutter head supported on the shank for rotation about an inclined axis and a plurality of roller cutters on the head rotatable about axes radiating from and inclined with respect to the axis of rotation of the head.

Another object of this invention is to provide a well bit of the character mentioned in which the cutters have teeth formed and arranged to assure the rotational progression of the cutters and to have a rapid cutting action.

Another object of this invention is to provide a gyratory well bit embodying a novel bearing means for rotatably supporting the cutter head on the shank.

A further object of this invention is to provide a bit of the character mentioned in which the bearing parts and the cutters may be easily and quickly replaced when worn.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred form and application of the invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a side elevation of the bit provided by this invention. Fig. 2 is an enlarged bottom elevation of the cutter head illustrating the cutters in broken lines. Fig. 3 is a transverse detailed sectional view taken as indicated by line 3—3 on Fig. 4 and Fig. 4 is an enlarged vertical detailed sectional view of the head and the adjacent parts of the shank.

The gyratory well bit provided by this invention includes, generally, a body or shank 10 to be connected with the lower end of a rotary well drilling string, a cutter holder or head 11 supported on the lower end of the shank 10 for rotation about an axis inclined with respect to the vertical axis of the shank and a plurality of spaced roller cutters 12 supported on the head 11 for rotation about their individual axes.

The shank 10 may be an elongate, generally cylindrical member provided at its upper end with means for connection with the drilling string. In the case illustrated this means comprises a tapered screw threaded pin 13 projecting from the upper end of the shank. In accordance with the invention the lower portion 10a of the shank 10 is offset and inclined relative to the central vertical axis of the shank 10. The lower end 14 of the shank 10 is inclined being normal to the longitudinal axis of the inclined shank portion 10a. In the preferred construction the longitudinal axis of the shank 10 intersects the axis of the inclined portion 10a adjacent the plane of the lower end 14. A cylindrical socket 15 of substantial depth enters the shank portion 10a from the lower end 14 and is co-axial with the inclined axis of the portion 10a. A central longitudinal fluid passage 16 extends into the shank 10 from its upper end.

The cutter holder or cutter head 11 is supported at the lower end of the shank 10 for rotation about an inclined axis with respect to the shank. The head 11 is provided at its upper end with a reduced stem 17 which is rotatably supported in the socket 15 by the bearing means to be hereinafter described. An upwardly facing annular shoulder 18 is provided on the head 11 at the base of the stem 17. The lower portion or major portion of the head 11 is formed to receive and support the cutters 12. The head 11 has a plurality of spaced downwardly and outwardly projecting legs 19. In the preferred construction there are three equally circumferentially spaced legs 19. The inner surfaces 20 of the legs 19 are flat and inclined downwardly and outwardly relative to the longitudinal axis of the head 11. The body of the head 11 is provided with flat surfaces 21 opposing and substantially parallel with the surfaces 20 of the legs 19. The spaces between the opposing surfaces 20 and 21 form pockets for receiving the cutters 12. The lower outer corners of the legs 19 are preferably bevelled off.

The means for rotatably supporting the head 11 on the shank 10 is preferably an anti-friction bearing means. The bearing means includes a sleeve or thimble 22 of inverted cup shape arranged on the stem 17. The thimble 22 bears on the upper end of the stem 17 and its lower end bears on the shoulder 18. The thimble 22 is secured to the head 11 so that it may be removed for replacement when worn. In the particular structure illustrated in the drawings the thimble 22 is welded to the shoulder 18 at 23 in such a manner that it may be easily removed for replacement. The thimble 22 is provided with a plurality of ball races. The upper end of the thimble 22 has an annular groove or ball race 24.

The race 24 is co-axial with the stem 17 and faces upwardly. Two axially or longitudinally spaced ball races 25 and 26 are provided in the side or periphery of the thimble 22.

The bearing means further includes a sectional ball retainer or bearing cage enclosing the thimble 22. The cage includes an upper section 27 which has the shape of an inverted cup. The upper end of the cage section 27 is recessed in the upper wall of the socket 15 to be maintained centralized relative to the socket and the stem 17. The internal upper wall of the section 27 has an annular ball race 28 opposing the race 24. A series of balls 29 cooperates with the opposing races 24 and 28 for the transmission of vertical thrusts or axial thrusts between the thimble 22 and the cage section 27. The bearing cage further includes a tubular section 30 having its upper end bearing on the lower end of the section 27 and a second tubular section 31 whose upper end bears on the lower end of the section 30. Grooves are cut in the adjacent inner corners of the sections 27 and 30 and register to form an annular ball race 32 that opposes the race 25 of the thimble 22. Similar grooves are cut in the adjacent inner corners of the cage sections 30 and 31 to form a ball race 33 which opposes the race 26 of the thimble 22. A series of balls 34 is provided in the opposing races 25 and 32 and a series of balls 35 is provided in the opposing races 26 and 33. The balls 34 and 35 transmit the radial loads or forces between the thimble 22 and the bearing cage. The balls 34 and 35 may also take some of the axial loads and serve to prevent downward separation of the head 11 from the bearing cage and the shank 10.

Means is provided to retain the above described bearing cage in the socket 15 and thus retain the rotatable head 11 on the shank 10. This means comprises a tubular nut or sleeve 36 threaded in the socket 15 from its lower end. The internal surface of the sleeve 36 engages or cooperates with the external surfaces of the cage sections 27, 30 and 31 whereby the sleeve 36 centralizes the cage sections and transmits the lateral or radial loads from the cage sections to the shank 10. The sleeve 36 is provided at its lower end with an inwardly projecting flange 37 which cooperates with the lower end of the cage section 31 to retain the several cage sections in the socket 15 and thus hold the head 11 and the associated parts against downward separation from the shank 10. Notches 38 may be provided in the lower end of the sleeve 36 to facilitate its turning or unthreading. It will be observed that the head 11 is supported on the lower end of the shank 10 for rotation, with a minimum of friction, about an axis inclined with respect to the axis of the shank. The wearing parts of the bearing means supporting the head 11 on the shank 10 are all readily removable for replacement.

The cutters 12 are carried by the pitched and rotatable head 11 for rotation about their individual axes. There is a cutter 12 supported between each pair of opposing surfaces 20 and 21 for rotation about an inclined but generally transverse axis. It is a feature of the invention that the cutters 12 are in the form of toothed roller cutters mounted and designed to have particularly effective cutting engagement with the earth formation. The cutters 12 may be alike in size and shape. The cutters 12 are provided with flat opposite ends and central longitudinal openings 39. In the particular form of the invention illustrated the cutters 12 are frusto-conical having pitched or tapered peripheral outlines as best illustrated in Fig. 2 of the drawings. Cutting teeth 40 are provided on the peripheries of the roller cutters 12. The teeth 40 are preferably comparatively large and deep. In accordance with the invention the cutter teeth 40 are sharply pitched or have a steep angle. The teeth 40 formed or arranged in this manner have their principal cutting edges 41 extending circumferentially as well as axially of the cutters 12.

Anti-friction bearing means are provided for rotatably supporting the cutters 12. Cutter supporting pins 42 are passed inwardly through openings 43 in the legs 19 and are threaded into sockets 44 in the head 11. The pins 42 have heads 42^a received in the openings 43 and the heads may be welded or peened into openings 43 to lock the pins 42 against unthreading. The openings 43 and the sockets 44 lie in planes that are radial relative to the axis of rotation of the head 11 and the longitudinal axes of the openings 43 and the sockets 44 are inclined downwardly and inwardly relative to the axis of the head.

The pins 42 pass through the openings 39 of the cutters 12 and bearing parts are provided on the pins to rotatably support the cutters. Thrust washers or bearing washers 45 are provided on the pins 42 and bear on the surfaces 20 of the legs 19. Lugs 46 are provided on the lower edges of the washers 45 and are welded to the lower ends of the legs 19 to prevent rotation of the washers. Thrust washers 47 are provided on the pins 42 and bear against the surfaces 21 of the head 11. The washers 47 have lugs 48 at their lower ends welded to the head 11 to prevent turning of the washers. The washers 45 and 47 are received in the end portions of the cutter openings 39. A bearing sleeve or bushing 50 is provided on each pin 42 between the spaced washers 45 and 47. The bushings 50 may be somewhat smaller in diameter than the washers 45 and 47. The wall of each cutter opening 39 is provided with axially or longitudinally spaced ball races 51. The adjacent ends of the washers 45 and the bushings 50 are provided with grooves which register to form ball races 52. The adjacent ends of the washers 47 and the bushings 50 have registering grooves which form ball races 53. The races 52 and 53 each directly oppose a race 51 of the surrounding cutter 12. Series of balls 54 are arranged in the opposing races 51 and 52 and series of balls 55 are provided in the opposing races 51 and 53. The balls 54 and 55 rotatably support the cutters 12 for free rotation with a minimum of friction. The balls 54 and 55 transmit radial thrusts as well as end thrusts in both directions, the races 51, 52 and 53 being of such depth that the balls may transmit all of the thrusts imposed on the cutters. The cutters 12 mounted as just described project downwardly beyond the inclined lower end of the tilted head 11 and project laterally beyond the sides of the legs 19 to act on the earth formation at the bottom of the well bore. The cutters 12 are supported for independent rotation about axes inclined downwardly and inwardly relative to the axis of rotation of the tilted head 11.

The invention provides effective means flushing the cutters 12 and for discharging a stream of fluid from the lower end of the head 11 to assist in cutting or eroding the formation at the bottom of the bore. A port 57 of reduced diameter communicates with the lower end of the fluid

passage 16 and extends downwardly through the inclined portion 10a of the shank 10 to the socket 15. A central opening 58 extends through the assembled cage section 27 and thimble 22 and a central longitudinal opening 59 extends through the stem 17 into the head 11. A wash pipe 60 is threaded in the lower end of the port 57 and extends downwardly through the opening 58 and into the opening 59. The pipe 60 extends through a substantial portion of the opening 59 and cooperates with its wall to prevent the leakage of fluid through the bearing means of the rotatable head 11. A distributing chamber 61 is provided in the head 11 at the lower end of the opening 59. Ports 62 extend from the chamber 61 to the spaces between the legs 19 and the head 11 and beans or nozzles 63 are set in the ports 62. The nozzles 63 discharge streams of circulation fluid under pressure downwardly against the adjacent cutters 12. A port 64 of reduced diameter extends downwardly through the head 11 from the chamber 61 to the lower end of the head. A nozzle 65 may be provided in the lower end of the port 64 to discharge a stream of circulation fluid downwardly from the lower end of the head.

In operation the shank 10 of the internal bit is secured to the lower end of the well drilling string and the bit is rotated in the well in the usual manner. The cutters 12 act on or engage the formation at the bottom of the well bore and their engagement with the formation effects the turning of the cutters about their individual axes and offers resistance to turning of the head 11. The engagement of the cutters 12 with the earth formation causes turning of the head 11 on its own axis at a slower rate of rotation than the shank 10. The head 11 being supported for rotation about an axis inclined with respect to the axis of rotation of the shank 10 wobbles or gyrates in the well bore. The head 11 is supported on the shank 10 through an effective antifriction bearing means and is free to rotate with a minimum of friction. The cutters 12 projecting from the tilted lower end of the gyrating head 10 are alternately brought into rolling and cutting engagement with the formation at the bottom of the well bore raising and plunging as the head wobbles.

The roller cutters 12 are effective in grinding or cutting away the earth formation when in active contact with the earth formation. The teeth 40 of the cutters 12 extending circumferentially as well as axially of the cutters offer substantial resistance to movement along lines substantially radial with respect to the center of the well bore during such bodily movement of the cutters with the head 11 and thereby effect turning of the cutters 12 about their individual axes. Accordingly, the teeth 40 are effective in producing the rotational progression of the cutters whereby the cutters are particularly effective in their cutting action and the teeth are successively brought into their cutting positions. The cutters 12 mounted as described above have a generally downwardly directed action on the earth formation although their cutting teeth 40 may act on the side wall of the bore adjacent its bottom when the cutters are in their outermost positions with respect to the center of the bore. Circulation fluid is pumped downwardly through the drilling string to discharge from the nozzles 63 and 65. The fluid discharging from the nozzles 63 effectively flushes the cutters 12 clear of mud and cuttings and the fluid discharging from the nozzle 65 assists in maintaining an effective agitation of the fluid at the bottom of the bore and may erode the formation at the bottom of the well.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of toothed roller cutters, and means supporting the cutters on the head for rotation about axes that lie in planes substantially radial with respect to the axis of rotation of the head.

2. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of toothed roller cutters, and means supporting the cutters on the head for rotation about axes that lie in planes substantially radial with respect to the axis of rotation of the head and that are inclined with respect to the axis of rotation of the head.

3. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of toothed roller cutters, and means supporting the cutters on the head to project downwardly therefrom and to rotate about axes inclined downwardly and inwardly and in planes substantially radial with respect to the axis of rotation of the head.

4. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of toothed roller cutters, and means supporting the cutters on the head for rotation about axes inclined downwardly and inwardly relative to the axis of rotation of the head and that lie in planes substantially radial with respect to the axis of rotation of the head.

5. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of roller cutters, helically pitched teeth on the peripheries of the cutters, and means supporting the cutters for rotation about inclined axes lying in planes substantially radial relative to the axis of rotation of the head where the cutters project beyond the lower end of the head.

6. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, a plurality of frusto-conical roller cutters, cutting teeth on the cutters, and means supporting the cutters on the head for rotation about axes inclined downwardly and inwardly relative to the axis of rotation of the head and that lie in planes substantially

radial relative to the axis of rotation of the head to project downwardly from the head and to have their lower teeth substantially transverse of the axis of rotation of the head so that they have a rolling crushing action on the bottom of the well.

7. A rotary well bit comprising a shank having a socket in its lower end, the longitudinal axis of the socket being inclined relative to the longitudinal axis of the shank, a head having a stem extending into the socket, means supporting the head for rotation about an axis inclined relative to the axis of the shank including balls transmitting end thrusts between the end of the stem and the upper wall of the socket, and balls transmitting radial thrusts between the stem and the side wall of the socket, and cutters rotatably supported by the head.

8. A rotary well bit comprising a shank having a socket in its lower end, the longitudinal axis of the socket being inclined relative to the longitudinal axis of the shank, a head having a stem extending into the socket, means supporting the head for rotation about an axis inclined relative to the axis of the shank including a bearing cage in the socket, balls bearing between the upper end of the stem and the cage for transmitting end thrusts in one direction between the stem and the cage, and balls bearing between the cage and the side of the stem transmitting radial thrusts and end thrusts in the other direction between the stem and the cage, and cutters rotatably carried by the head.

9. A rotary well bit comprising a shank having a socket in its lower end, the longitudinal axis of the socket being inclined relative to the longitudinal axis of the shank, a head having a stem extending into the socket, means supporting the head for rotation about an axis inclined relative to the axis of the shank including a bearing cage in the socket, balls bearing between the upper end of the stem and the cage for transmitting end thrusts in one direction between the stem and the cage, and balls bearing between the cage and the side of the stem transmitting radial thrusts and end thrusts in the other direction between the stem and the cage, spaced roller cutters carried by the head for rotation about their axes and to project from the lower end of the head, and means for conducting fluid through the shank, stem and head and for discharging separate streams of fluid against the cutters.

10. A rotary well drilling bit comprising a shank, a cutter head at the lower end of the shank, means mounting the head on the shank for rotation about an axis inclined with respect to the longitudinal axis of the shank, the head having a downwardly projecting central part and circumferentially spaced downwardly projecting legs spaced outwardly from the central part, pins extending between the legs and the central part, and cutters on the pins between the legs and central part rotatable about axes inclined with respect to the axis of rotation of the head and projecting downwardly beyond the central part and legs to act on the earth formation.

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