Feb. 9, 1937. J. A. ZUBLIN 2,069,799

DRILL BIT WITH ROLLING CUTTERS

Filed Sept. 25, 1936

Fig. 1.

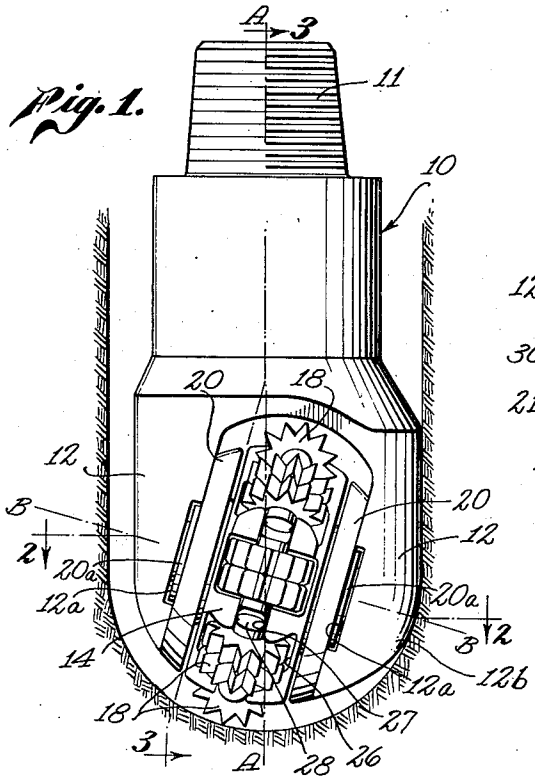


Fig. 2.

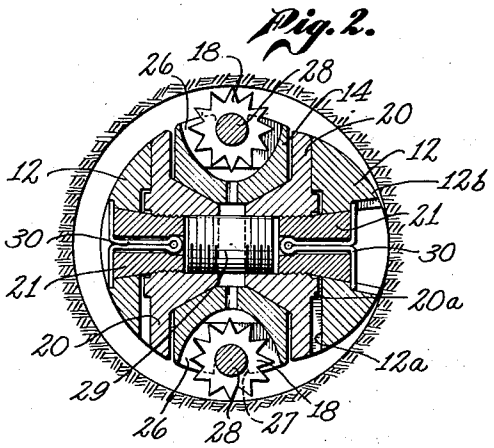


Fig. 3.

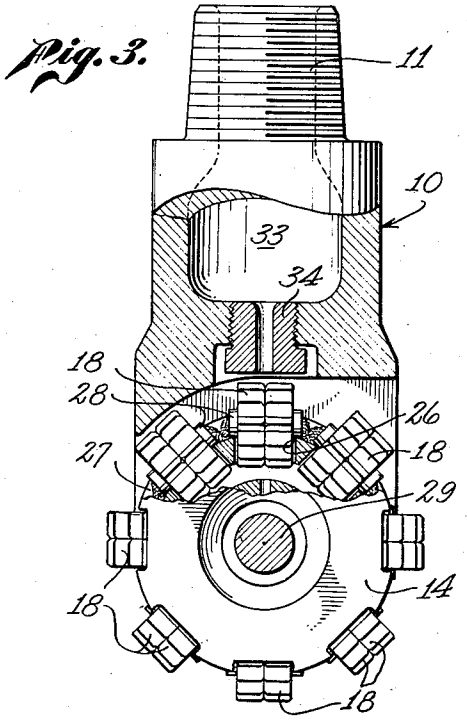
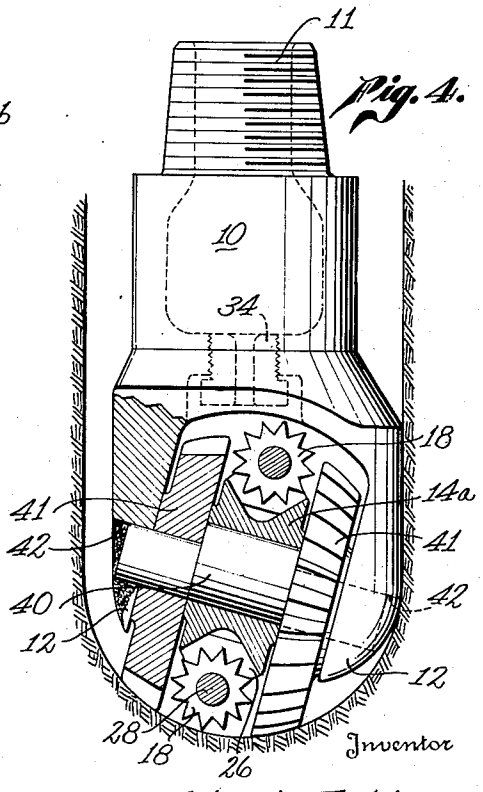


Fig. 4.



Inventor

John A. Zublin

By

Attorney

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DRILL BIT WITH ROLLING CUTTERS

John A. Zublin, Los Angeles, Calif.

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8 Claims. (Cl. 255—71)

The present invention relates generally to rotary well drilling bits as are used to drill oil wells and the like, and more especially to drill bits of the general type described in my prior U. S. Patents 2,050,988 and 2,050,989 issued August 11, 1936. Drill bits of this type are provided with one or more cutter carriers upon which are mounted a number of rotatable cutters. These cutters move over the formation being drilled with a rolling motion that particularly adapts the bit to drilling hard formations. Especially in hard rock, it is of prime importance that the motion of the cutters be as nearly a true rolling motion as possible since any twisting or scraping greatly increases the wear on the bit but does not increase the rate of drilling.

Simplicity and economy in manufacture are best secured by using only one cutter carrier, since the parts are relatively few and are large enough to be easily made; and besides there is the great advantage that, especially in the smaller sizes of bits, all parts are amply strong to carry any load to which they may be subjected. This single carrier is preferably centered on the shank since in this position the carrier can be of the maximum possible diameter, which is of course equal to the diameter of the hole drilled, and can have mounted on it the most cutters, to obvious advantage. A carrier of maximum diameter of course extends across the center of the hole so that the axis of the hole passes through it. For similar reasons, the rotating cutters are preferably so mounted around the carrier periphery that they turn about axes lying in or parallel to the central plane of carrier revolution.

If, however, the cutters are mounted on the carrier as described and the single carrier is mounted on the shank in a perfectly centered position with the carrier axis perpendicular to the shank axis, the carrier is in effect on "dead center" and does not turn since the forces on it are balanced. Consequently, it is desired so to place the carrier that the forces acting on it insure a slow but constant turning.

Thus it is a principal object of my present invention to improve the cutting motion of the rotating cutters and eliminate non-rolling motion from their action as they roll over the formation being drilled.

It is also an object of my invention to provide a simplified form of bit using but a single cutter carrier, thus permitting large economies in manufacture and assuring ample strength of all parts.

An additional object is to provide a form of bit using a single carrier so placed that its cutters effectively dig all parts of the hole and roll both upwardly and downwardly over opposite sides of the hole.

And it is another object to provide a tool, embodying the above objects, which has a positive rotation of the carrier in order to assure the continued intermittent contact of successive cutters with the formation.

These objects have been attained in a bit constructed according to my invention by rotatably mounting a single cutter carrier centrally on the shank and inclining the axis of carrier revolution to the shank axis so that the cutters at the bottom of the hole engage the formation at one side of the vertical axis about which the shank turns. The cutters, although mounted straight across the carrier, i. e., they revolve about axes parallel to the plane of the carrier, are inclined relative to the formation so that they are properly positioned to roll over both upwardly and downwardly inclined spiral paths. Consequently they cut the formation on both sides of the bit without any material amount of non-rolling motion. In addition, positive rotation of the carrier is assured both by the tendency of the cutters to follow an inclined rather than a horizontal path and by the contact of the cutters on the bottom of the hole at a point offset from the shank axis.

How the above and other objects and advantages of my invention are secured will be better understood by reference to the following description and the annexed drawing in which:

Fig. 1 is a side elevation of a drill bit made according to my invention;

Fig. 2 is a section in plan on line 2—2 of Fig. 1;

Fig. 3 is a section on line 3—3 of Fig. 1, showing the carrier in elevation except for a portion thereof broken away; and

Fig. 4 is a side view partially in section and partially in elevation of a variational form of bit.

There is shown in Fig. 1 a drill bit provided with a shank generally indicated at 10, having on its upper end threaded pin 11, by means of which the shank is attached to a drill stem for rotation about its longitudinal axis A—A, which is normally vertical or generally so. As will be seen later, the shank axis is generally coincident with the hole axis or substantially so, and in the latter case the two axes are parallel. The lower portion of the shank is formed with two depending legs 12 which carry between them a cutter carrier 14. About the periphery of this carrier is rotatably mounted a plurality of rolling cutters 18.

The means provided for rotatably mounting the carrier between the shank legs comprises a pair of bearing members 20, each of which is held in position on one of legs 12 by a tapered pin 21 screwed into the bearing. Bearing member 20 is held against rotation relative to the shank by means of raised boss 20^a on the outside face of the bearing. Boss 20^a is flattened across the top and bottom sides, and is of proper dimensions to fill horizontally extending slot 12^a recessed in the inner face of shank leg 12.

Slot 12ª opens to one side of the shank leg so that boss 20ª may be slid horizontally into the slot and when in position, as in Fig. 2, holds bearing member 20 against rotation. The two bearing members 20 have central conical portions which together provide a bearing upon which cutter carrier 14 rotates, and these bearings, because of their conical shape, take lateral thrust and keep the carrier at the center of the bearing.

Cutter carrier 14 comprises a generally circular, wheel-like body formed with a plurality of slots 26 extending radially inward from the carrier periphery. At each side of slots 26 are formed smaller notches 27. In each of slots 26 there is mounted a pair of cutters 18 upon an axle pin 28, which is seated at each end in a notch 27 and then secured in place by any suitable means, as by welding. Axle pins 28 are mounted tangentially of the carrier so that the axes of cutters 18 are perpendicular to the carrier axis. Pins 28 are preferably centered on the carrier so that the cutter axes lie in the central plane of revolution of the cutter carrier, but they may be slightly offset so that the cutter axes lie parallel thereto. Although cutters 18 may be of any suitable size or shape, they are here shown as substantially cylindrical rollers with cutting teeth about their peripheries.

In order to assemble the bit, one end of threaded pin 29 is screwed into the central opening of a bearing member 20. The bearing member then is laid horizontal and cutter carrier 14 is placed over the conical portion of the bearing. Next the second bearing member 20 is put in place by screwing it onto the other end of central pin 29. The proper fit for the bearings is obtained by screwing up the two bearing members 20 on pin 29 to the proper distance.

Cutter carrier 14 and its bearing members thus form a complete assembly which is slid sideways into the space between shank legs 12, bosses 20ª being received in slots 12ª as described. A pin 21, with a cotter key 30 already inserted in the pin, is then inserted in the tapered opening in each shank leg and screwed into the central opening in the adjacent bearing member 20. The two pins 21 are tightened up and locked in place by bending outwardly the ends of cotter keys 30, as shown in Fig. 2, which fit in notches in the shank leg to hold the tapered pins against rotation.

The upper end of shank 10 is formed with an internal fluid passage 33 which receives circulation fluid from the drill stem. Fluid discharges from passage 33 through nozzle 34 on to rollers 18 as they pass beneath the nozzle 34, the discharging stream cleansing the rollers of adhering particles.

It will be noted that carrier 14 is so mounted on the shank that it revolves about an axis B—B inclined to the horizontal, and consequently inclined also to the axes of the shank and the hole being drilled. The axis of revolution of the carrier is typically inclined to the horizontal by an angle of approximately 15°, though a greater or smaller angle may be used as this angle is a matter of choice. The central plane of revolution of the carrier, which is perpendicular to the carrier axis, is inclined from the shank axis by an equal angle. An angle of about 15° is preferred since it makes the carrier rotate once for each five to fifteen turns of the shank, depending on drilling conditions, and so the vertical movement of the cutters over the formation is held within proper ranges. The shank axis passes through the carrier assembly and preferably intersects the plane of carrier revolution substantially at the center of the carrier, as shown in Fig. 1, and the axis of the carrier preferably also passes through this point of intersection, although the bit may be so constructed that the carrier axis is offset horizontally to one side of said intersection.

The drill bit is normally rotated to the right, or clockwise as viewed in Fig. 2, and consequently the cutters on the near side of the carrier in Fig. 1 are moving upwardly while the cutters on the back side are moving downwardly, since the cutter carrier is moving in a counter-clockwise direction when viewed as in Fig. 3. Cutters 18 first contact the formation at a point approximately horizontally opposite the center of the carrier and roll over the formation in a downwardly inclined spiral path to a point on the bottom of the hole underneath the bit, when they start to roll over the formation in an upwardly spiral path to a point at the same level as their point of engagement, when they then disengage the formation. When viewed as in Fig. 1, it will be noticed that the cutters at engagement and disengagement of the formation are at diametrically opposite points on the bit, and as the cutters move from one point to the other they do not pass through the shank axis, but the cutters pass to one side of the shank axis and at or near the bottom of the hole contact the formation at a point offset from or to one side of the shank axis. As a result of the carrier rotation, each of the cutters intermittently contact the formation, and all cutters successively move over similar paths.

Positive rotation of the carrier is assured because of two sets of forces operating on the carrier, as described in greater detail in my above mentioned prior patents. The first of these forces is the tendency of the cutters to follow an inclined path over the formation, so that the vertical component of the cutter motion turns the carrier in the direction described. It will be noted that when the carrier rotates about an inclined axis as shown, a cutter at one side of the bit is properly positioned to move with a true rolling motion over a downwardly inclined path, and then as carrier rotation moves that cutter to the other side of the bit the cutter inclination is again correct for the cutter to move with a rolling motion over an upwardly inclined path so that the vertical components of the cutter movements on both sides of the carrier aid the carrier rotation. The second force turning the carrier is that resulting primarily from contact of the cutters on the bottom at a point offset from the shank axis. It will be clear that as the shank rotates about its axis, the off-center engagement of the cutters with the formation causes the carrier to rotate about its own axis with the forward side of the carrier moving downwardly in the same manner as a vehicle wheel when the vehicle is pushed over a surface, and that the speed of carrier rotation will be approximately proportional to the distance between the shank axis and the point of engagement of the cutters with the formation.

As the bit is rotated in the hole, the bottom of the hole assumes a hemispherical shape, and there is a natural tendency for the cutters to roll down to the lowest point in the hole. If the shank body is small enough that there is clearance on all sides between it and the walls of the hole, the bit will move to the right in Fig. 1, so that bottom cutters 18 are at or near the center of the hole. To prevent this occurrence by stabilizing the movement

of the cutters at the bottom of the hole, the shank has a built up portion 12b on one of the shank legs, this built up portion being positioned in line with axis B—B and on the side of the shank axis opposite to that at which cutters 18 contact the formation. The built up portion 12b extends from the shank axis a distance substantially equal to the radius of the hole being drilled in order to bear against the walls of the hole, and so keeps the shank axis substantially coincident with the center of the hole and maintains cutting contact of the bottom cutters at the proper distance to one side of the vertical axis. Built up section 12b has no edges that cut the formation, but may be hard surfaced if desired to resist abrasion encountered as it rubs the hole walls.

Fig. 4 shows a variational form of bit in which cutter carrier 14a is rotatably mounted upon the enlarged central portion of bearing shaft 40. Also rotatably mounted upon bearing shaft 40 at each side of carrier 14a is a rotating cutter 41 having a number of teeth about its periphery. The assembly comprising shaft 40, the cutter carrier, and the two side cutters, is moved upwardly into the space between the shank legs and the ends of shaft 40 seated in vertically extending slots 42, one in each leg 12. The open ends of slots 42 are then closed by welding to hold the shaft in place. The position and operation of the cutter carrier is the same as previously described, except that the bit has the additional cutting action obtained from the two rolling side cutters.

It will be understood that changes may be made in the construction and arrangement of parts without departing from the intent and scope of my invention, and consequently, that the foregoing description is to be considered illustrative of rather than restrictive upon the claims attached hereto.

I claim as my invention:

1. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem; a cutter carrier placed centrally of the shank with said shank axis passing through the carrier, said carrier being rotatably mounted to turn about an inclined axis; a plurality of cutters rotatably mounted on the carrier for successive intermittent contact with the formation at the bottom of the hole at one side of said shank axis upon rotation of the carrier; and means to maintain the cutting contact at said one side of the shank axis.

2. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem; a cutter carrier placed centrally of the shank with said shank axis passing through the carrier, said carrier being rotatably mounted to turn about an inclined axis; a plurality of cutters rotatably mounted on the carrrier for successive intermittent contact with the formation at the bottom of the hole at one side of said shank axis upon rotation of the carrier; and a built-up section on the shank adapted to bear against the walls of the hole being drilled and maintain the cutting contact of the cutters at said one side of the shank axis.

3. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem; a cutter carrier rotatably mounted on the shank to turn about an axis inclined to the shank axis, the carrier being disposed centrally of the shank; a plurality of cutters rotatably mounted on the carrier for successive intermittent contact with the formation upon rotation of the carrier; and a rotatable cutter with teeth around its periphery mounted beside said cutter carrier.

4. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem, a single cutter carrier rotatably mounted on the shank about an axis intersecting the vertical axis of the hole and inclined to the axis of the shank, a plurality of roller cutters rotatably mounted on the cutter carrier for successive intermittent contact with the formation whereby the contacting rollers close to the bottom of the hole are held off center with respect to the axis of the hole by means guided by the wall of the hole.

5. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem, a single cutter carrier rotatably mounted on the shank about an axis inclined to the axis of the shank, a plurality of roller cutters rotatably mounted on the cutter carrier for successive intermittent contact with the formation whereby the contacting rollers close to the bottom of the hole are off center with respect to the axis of the hole, said roller cutters being mounted to rotate respectively in planes at right angles to the plane of the cutter carrier and in inclined planes respective to the axis of the shank.

6. In a rotary well drilling bit, the combination of a shank enlarged on one side to contact continuously the walls of a hole and adapted to be rotated about a generally vertical axis by a drill stem, a single cutter carrier rotatably mounted on the shank about an axis intersecting the axis of the hole and inclined to the axis of the shank, and a plurality of roller cutters rotatably mounted on the cutter carrier for successive intermittent contact with the formation whereby the contacting rollers on opposite sides and at the bottom of the bit contact the formation simultaneously and the contacting rollers close to the bottom of the hole are kept off center of the hole by the enlargement on the shank.

7. In a rotary well drilling bit, the combination of a shank adapted to be rotated about a generally vertical axis by a drill stem, a single cutter carrier rotatably mounted on the shank, a plurality of roller cutters rotatably mounted on the carrier for successive intermittent contact with the formation, and means guided by the wall of the hole to continuously push the carrier substantially at right angles to its plane and causing the lower part of the carrier with its bottom contacting cutters to move about a circle concentric with the axis of the hole.

8. In a rotary well drilling bit, the combination of a shank enlarged on one side to contact continuously the walls of a hole and adapted to be rotated about a generally vertical axis by a drill stem, a single cutter carrier rotatably mounted on the shank, a plurality of roller cutters rotatably mounted on the carrier for successive intermittent contact with the formation, said enlargement on the shank being guided by the wall of the hole to continuously push the carrier substantially at right angles to its plane and causing the lower part of the carrier with its bottom contacting cutters to move about a circle concentric with the axis of the hole.

JOHN A. ZUBLIN.