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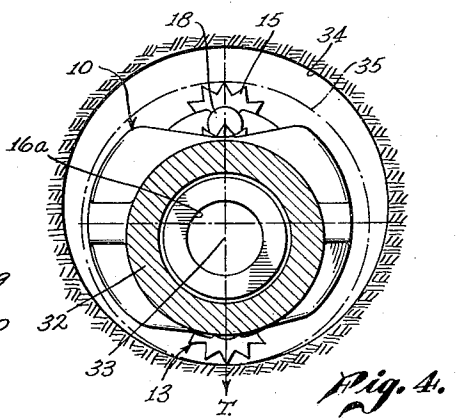
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2,119,618

## OVERSIZE HOLE DRILLING MECHANISM

Filed Aug. 28, 1937

3 Sheets-Sheet 1



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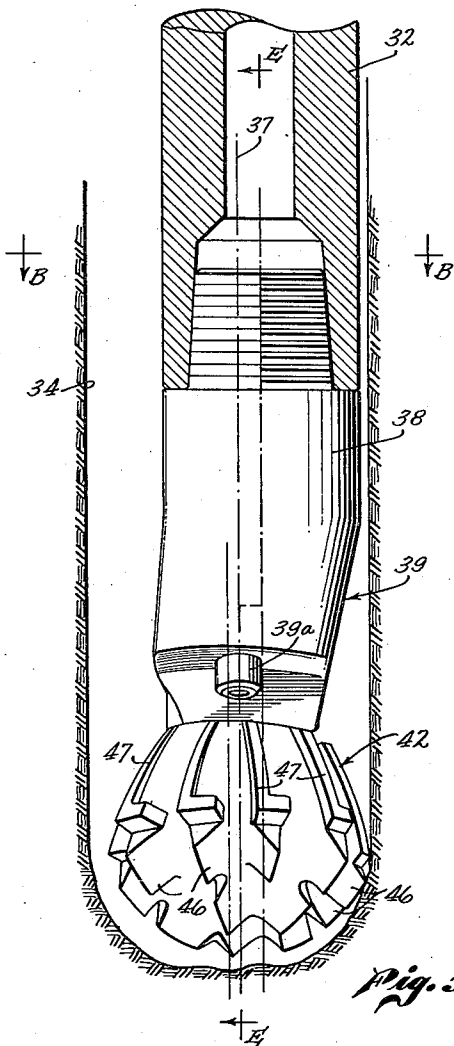


Fig. 5.

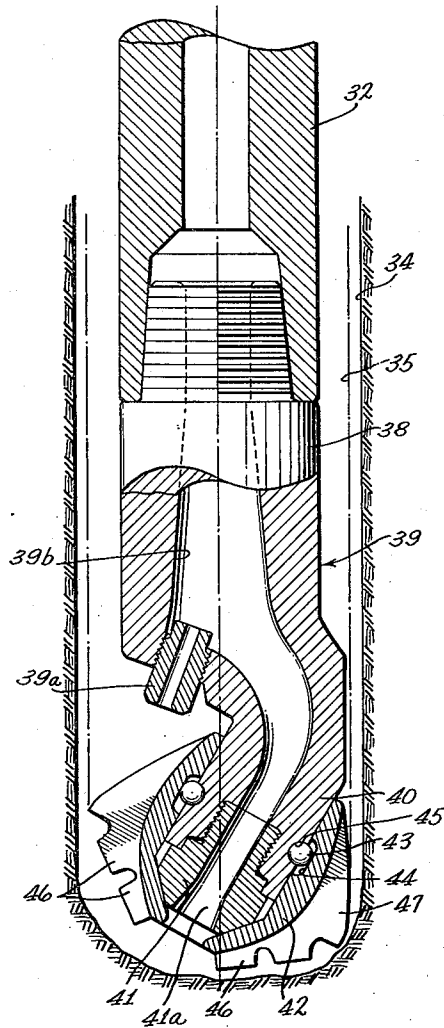


Fig. 7.

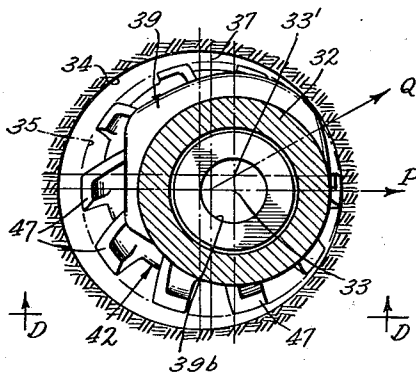


Fig. 6.

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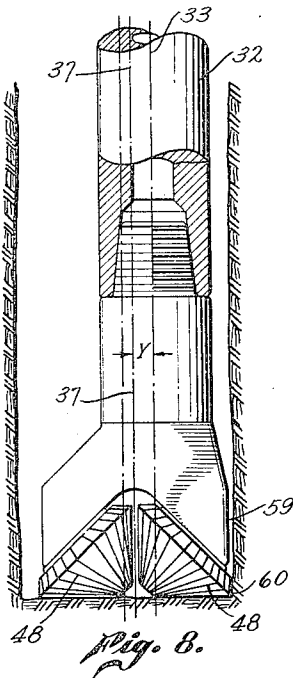
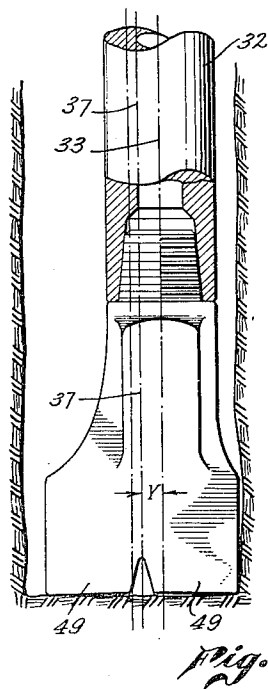
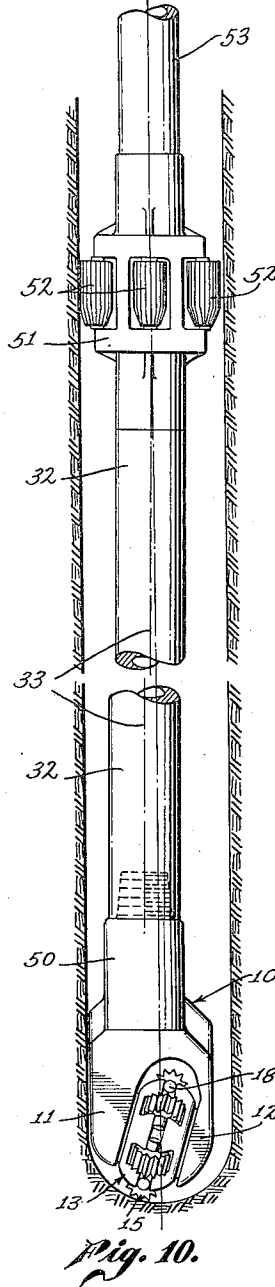
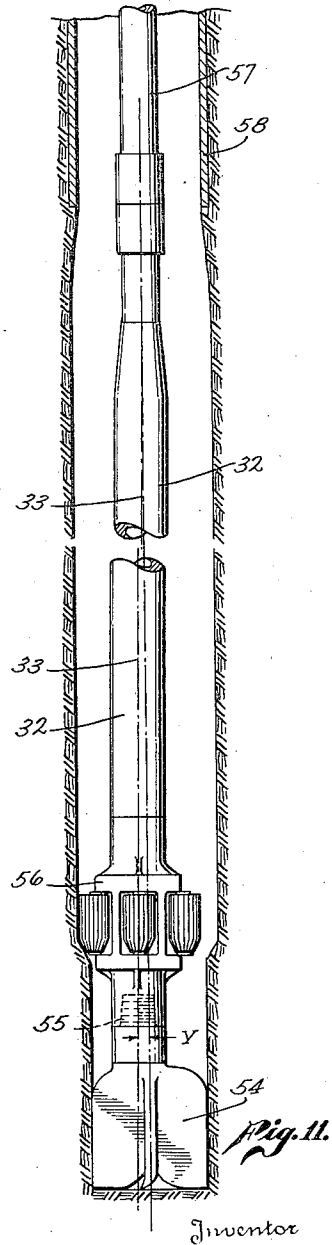
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OVERSIZE HOLE DRILLING MECHANISM

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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,119,618

## OVERSIZE HOLE DRILLING MECHANISM

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Application August 28, 1937, Serial No. 161,483

8 Claims. (Cl. 255—71)

This invention relates to earth boring tools, and particularly to those types which perform drilling operations by the rotation of a drilling string attached to the shank of the tool.

It is an inherent drawback of substantially all drilling tools that they are unable to produce a hole of full gauge throughout the drilling life of their cutting teeth. This result is due to a wearing down or general blunting of the teeth, decreasing the diameter of the tool between the margins of opposite cutting teeth. As this diameter lessens, the bore of the hole produced is of corresponding decreased diameter.

Before drilling can proceed it is essential that the hole be formed to gauge, necessitating the use of reamers after the original cutting tool has been removed. The time lost through round trips and also the cost of the reamers renders it highly desirable that a full gauge hole be produced throughout the useful life of the original drilling bit. Accordingly, it is an object of this invention to provide a drilling mechanism which will maintain the hole to gauge; and this is to be accomplished within reasonable limitations regardless of the wear on the cutting teeth of the tool.

A further object of the invention is to drill a hole having a greater bore than the tool which is used in performing the operation.

It is a further object of this invention to produce an oversize hole by taking advantage of centrifugal force urging the bit outwardly and moving in an orbital path about the axis of the hole. This also contemplates an improved method of enlargening or drilling an oversize hole by varying either one or all of the following factors: weight, eccentricity and R. P. M. of a heavy drill collar attached to the bit.

A further object of this invention is to effect an offsetting of the drilling tool with respect to the hole axis in order to provide a hole of enlarged dimensions when compared with the diameter of the tool itself.

It is still a further object of this invention to offset a heavy drill collar attached to the drill bit in such a direction as to urge the cutting portions of the tool into the formation, which direction is generally the same as that which the tool would normally seek on its own volition.

My invention finds an additional advantage when used in conjunction with the type of drilling bit as described in my U. S. Patents Nos. 2,069,799 and 2,079,142; in which a carrier for rolling cutters is rotatably supported by the shank of the bit, and in which it is necessary in obtaining rotation of the carrier about its own

axis to maintain the bottommost rollers on the carrier to one side of the axis of the hole. Heretofore, as described in the patents referred to, a thickened part has been provided on one of the shank legs which bears against the sides of the hole and prevents the bottommost rollers from coming into coincidence with the hole axis, thus insuring rotation of the carrier by virtue of the reaction of the cutting rollers against the formation.

The thrust on this thickened leg provides a rubbing action against the formation and produces wear on the leg which is extremely detrimental to the life of the shank. Accordingly, it is another object of this invention to eliminate or at least materially decrease the wear on the shank supporting the carrier and rollers by taking advantage of centrifugal force in such manner as to overcome the thrust of the leg against the sides of the hole.

In connection with my patents referred to, it is a further object of this invention to maintain the bottom rollers on the carrier displaced to the axis of the hole by utilizing centrifugal force and by balancing this force against the drilling weight applied to the tool acting in conjunction with a concave or hemispherical bottom surface on the hole, which is characteristically obtained with bits of the nature described in the above patents.

It is a further object of this invention to regulate the ratio between drilling tool revolutions and the carrier revolutions simply by the method of operating the drilling mechanism, namely, by varying the speed of rotation of the tool, or the eccentricity of the drill collar attached to the tool or by altering the drilling weight on the tool, or by using combinations of the factors enumerated. These factors will also determine the bore of the hole in excess of that which would be normally produced.

Still a further object of my invention is to position the cutting portions of drilling bits with respect to the axis of the hole being bored in order to provide for a minimum of sliding of the cutting teeth on the formation with a resultant maximum hole produced per bit.

How these objects and others are obtained can be understood by referring to the attached drawings wherein:

Fig. 1 is a longitudinal designation, partly in section of a bit of the type described in my U. S. Patents Nos. 2,069,799 and 2,079,142.

Fig. 2 is a transverse view partially in section taken along the line A—A of Fig. 1.

Fig. 3 is a transverse section similar to Fig. 2, showing a modified arrangement of the bit shown in Fig. 1.

Fig. 4 is a transverse section similar to Fig. 2, showing a further modification of the bit shown in Fig. 1.

Fig. 5 is an illustration of my invention as applied to a bit of the gyratory type as exemplified in my Patents Nos. 1,758,773; 2,025,260; 2,025,258; etc.; taken along the line D—D of Fig. 6.

Fig. 6 is a transverse section taken generally along the line B—B of Fig. 5.

Fig. 7 is a longitudinal section along the lines E—E of Fig. 5.

Fig. 8 is a representation of my invention as applied to a conical type rock bit.

Fig. 9 is a designation of my invention as applied to a drag bit.

Fig. 10 illustrates the principle of my invention in connection with a reamer, and

Fig. 11 illustrates the general principle of my invention as applied to an underreaming mechanism.

In its general aspects, the improved drilling mechanism depends essential upon centrifugal force urging the drilling tool outwardly against the sides of the formation and in this manner drilling a hole of greater dimensions than the cutting tool would normally produce. To obtain the necessary unbalanced weight which can be acted upon by centrifugal force, I propose to attach a heavy drill collar to the shank of the bit in such a manner that the axis of the drill collar is displaced to one side of the axis of the hole. For the proper functioning of the mechanisms illustrated, it is desirable that the drill collar be rigid and heavy, and be placed in operative connection with the bit in the vicinity of the latter member. The drill collar must be heavy enough so that the centrifugal force developed by its offsetting will be sufficient to penetrate the cutters on the tool into the formation. It is particularly essential that a heavy drill collar be used in view of the fact that the extent of offsetting cannot be very great before the surface of the drill collar will rub against the sides of the formation or casing, with excessive wear being associated with operations under such conditions.

One embodiment of my invention is illustrated in Figs. 1 and 2. The shank of the drilling tool 10 has two depending legs 11, 12; between which is rotatably supported a carrier assembly 13. This assembly includes a cutter carrier 14 that is mounted to rotate about an inclined axis C—C; the reason for the inclination being set out in my above mentioned patents. About the periphery of the cutter carrier is rotatably mounted a plurality of rolling cutters 15 which are successively and intermittently brought into cutting contact with the formation as the carrier is rotated about its axis. Cutters 15 are cleaned of adhering cuttings by a stream of circulating fluid issuing through an inclined nozzle 16 from a fluid passage 16a within the shank.

Cutter carrier 14 comprises a generally circular wheel-like body formed with a plurality of slots 17 extending radially inwardly from the carrier periphery. In each slot is rotatably carried one or more cutters 15 rotatable upon an axle pin 18 which bridges each slot and is welded to the sides thereof.

A bearing structure is provided for rotatably mounting the carrier between the shank legs and comprises a central portion 19 which is internally threaded at one end 20 and has externally a cy-

lindrical surface 21 that forms a journal bearing for the carrier 14. At each end of the cylinder 19 is a flanged member 22, one of which is integral with the central bearing portion and the other of which is screwed into the latter portion. Each flange 22 is inclined upwardly and outwardly from the central member of the bearing structure and has an annular ball receiving groove 23 in this portion so that the diameter of each groove 23 about the bearing axis C—C is greater than the diameter of the cylindrical member 19.

As will be noticed from Fig. 1, the bearing surfaces of the carrier are complementary to the external surfaces of the bearing structure upon which the carrier is mounted. Thus, the carrier has a central cylindrical journal member 24 and on each side of this central portion is an outwardly inclined face in which there is a ball-receiving groove 25. The two grooves in the carrier cooperate with the two grooves in the flanges to form annular channels capable of holding a number of balls to form a bearing at each end of the journal bearing.

Upon assembling the carrier upon the bearing structure, one of the flange members is screwed tightly in the cylindrical portion of the other member so that the endwise pressure of the flanges on the balls holds the carrier supported by the ball bearings.

When thus assembled, the carrier and bearings are ready to be slid sideways as a unit into the space between the shank legs 11, 12. Each flange 22 has on its outside face a raised boss 26 flattened across the top and bottom sides and of a proper dimension to fill a horizontally extended slot 26a recessed in the inner face of each shank leg. The two slots 26a open to the same side of the shank legs so that the assembled bearing may be slid transversely into the slots, and when in position, bosses 26 hold the bearing against rotation within the shank. The described assembly is secured in the shank by a pair of threaded taper pins 27 which are inserted one each through the tapered opening in the side of each shank leg and screwed into an internally threaded bore 28 in the flanges. After the pins 27 are tightened the desired amount, the ends of cotter keys 29, one of which has been previously inserted in each pin, are bent outwardly into notches 30 in the shank leg to hold the taper pins against rotation.

The upper end of the shank is offset with respect to the center line of the shank 31 so that a drill collar 32 threaded thereto will occupy an eccentric position 33 displaced from the hole axis along the line R (Fig. 2). This eccentricity of the drill collar will tend to cause its outward motion in a direction of the line and arrow R under the action of centrifugal force so as to move the lower rollers 15 (as seen in Fig. 2) into the formation and away from the axis of the hole; and eventually will translate the entire bit assembly to a position wherein the rollers 15 are at a greater distance from the hole axis to produce a hole designated by the circle 34 in Fig. 2. Were it not for the action of centrifugal force the hole size produced would be of the nature indicated by the dashed circle 35. Of course, this latter circle would be concentric as regards the hole axis rather than eccentric as indicated on the drawings. However, for the sake of comparison the dashed circle is drawn with the midpoint of the cutting tool as a center and the distance to the extremities of the roller teeth on the cutters 15 as a radius. It is to be under-

stood, that in all of the tool embodiments disclosed on the drawings the dashed circle representation is merely that of a hole size and is not intended to indicate the position of the hole.

With the drill collar displaced as shown from the hole axis, the action of centrifugal force will urge it outwardly until a position is reached wherein the reactive force of the formation on the cutter will counterbalance the effect of the centrifugal force. Such force will determine the extent of outward movement of the drill collar and cutting tool, and consequently the orbital path of motion of the cutter and drill collar about the hole axis; and in this manner the hole size will be fixed.

It has been my observation, that it is the tendency for the drilling tool to dig in more on one side of the hole axis than on the other side. That is, the lowermost rollers 15 (as seen in Fig. 2) appear to have a greater drilling action than the rollers on the other side of the hole axis. It seems to be the tendency of the drilling tool to move in the general radial direction of the lowermost rollers. Additionally, from observations made on the shank legs of the bit, the wear produced by the thrust of the shank against the formation seems to be on the leading edge (assuming a clockwise rotation) of the long leg 12 of the shank. Accordingly, to eliminate this wear and also to take advantage of the tendency of the drill bit to move in the direction of the lowermost rollers 15, I offset the drill collar in a direction of the arrow R. The centrifugal force set up by rotation of the drill collar will tend to move the bit radially outwardly in the direction of this arrow R to assist the lowermost rollers 15 in their inherent tendency to penetrate the formation, and at the same time to move the long leg 12 of the shank away from the walls of the hole being drilled.

Upon moving radially outwardly in the direction of the arrow R, the bottommost roller on the carrier will be moved further away from the axis of the hole to increase the radius of the orbital path traced by the rollers on the hole bottom. The extent of outward motion of the cutter and also of the drill collar can be varied and controlled, if desired, by the speed of rotation of the mechanism, by the extent of offsetting of the drill collar, and by the drilling weight put on the tool. Since the tool forms a concave or hemispherical bottom, the outward motion of centrifugal force requires that the bit ride up the concave surface; necessitating that the outward motion of centrifugal force lift the whole bit and collar. A position will be reached wherein the centrifugal force urging the tool outwardly just counterbalances the drilling weight on the bit. Of course, it should be realized that the entire weight of the drilling string is not on the tool, but that the drilling pipe is maintained in tension with the necessary weight on the tool being supplied by the drill collar alone.

The size of the hole obtainable with this concave or hemispherical bottom drilling tool will be dependent primarily upon the centrifugal force and the drilling weight. If a large hole is desired the speed of rotation of the drill collar need only be increased; and it does not take a very great increase in speed to increase the formation penetration materially, for the centrifugal force varies as the square of the speed. A decrease in the drilling weight would also allow the centrifugal action of the drill collar to move the rollers a greater distance outwardly from the hole center

by decreasing the resistance to upward climbing of the bit on a concave or hemispherical bottom. If the tool is used as an underreamer, or as a reamer, the drilling weight will be zero and the centrifugal force of the offset drill collar can be utilized to fullest advantage.

Thus, through the action of centrifugal force the inclined carrier is maintained to one side of the axis at the bottom of the hole without reliance upon the pressure of the long shank leg 12 against the sides of the wall; thereby eliminating the wear on the shank, with attendant increase in its useful life.

The closer to the hole axis that the center of the carrier is positioned the better is the rolling motion of the cutting rollers over the formation and the less the sliding action. While initially the center line 36 of this carrier 14 is illustrated in Fig. 1 as being offset to the right of the hole axis by the distance X, the action of centrifugal force will move the drill collar and the drilling bit in the direction of arrow R, and in so doing will position the center of the carrier into approximate coincidence with the axis of the hole. This in itself decreases sliding friction along the tooth faces of the rollers so that more effective formation removal is obtained by repeated radial blows of the teeth thereon as the cutters roll over it.

While in Fig. 2 I have shown the drill collar as being offset along the line R, an oversize hole would also be drilled if the axis of the drill collar were displaced along some other line, as along line S, illustrated in Fig. 3. With this modification the drill collar is offset by the distance Y with respect to the center line of the shank. The centrifugal force will tend to move the entire assembly in the direction of arrow S to produce the hole indicated by the circle 34; of materially greater radius than the hole 35 that would have resulted if the action of centrifugal force were not brought into play.

In order to take the fullest advantage of the tendency of the lowermost rollers 15 to move into the formation and also to obtain the largest hole for a given offset of the drill collar, the arrangement illustrated in Fig. 4 can be used. In this embodiment the drill collar is offset along the line T so that the action of centrifugal force will tend to urge the tool in the same direction to produce the larger bore 34, which is of much greater radius than the hole 35 that would have been produced without the assistance of centrifugal force.

The invention is susceptible of broad application. For example, in the arrangement shown in Figs. 5, 6 and 7 the drill collar is attached in offset fashion to a gyratory bit of the type illustrated in my Patents Nos. 1,758,773; 2,025,260; and 2,025,258. The drill collar 32 is offset from the usual center line 37 of the bit in the direction of the arrow P, being threadedly attached to an upper portion 38 of the shank 39, which is offset with respect to the lower part of the shank having an inclined bearing pin 40 to which is attached a threaded conical thrust member 41.

A bowl shaped cutter 42 is rotatably mounted upon the bearing pin and thrust cone; the former part serving to absorb radial loads imposed on the cutter, while the cone absorbs both axial and radial loads on the cutter while maintaining it centered.

Specific details of construction of the bit will not be described here since they are not essential to an understanding of the invention as applied to this type of drilling tool, and may be found

in the patents referred to. It is sufficient to say that the cutter is held in the assembly by the balls 43 engaging in complementary grooves 44, 45 of the cutter and bearing pin, respectively; and that the cutter has digging teeth 46 and reaming teeth 47 thereon. Upon rotation of the shank relatively to the cutter, the cutter will partake of a combined oscillating and rotating motion to remove the formation in a manner characteristic of such bits. The bore will be kept free from cuttings and the cutter kept clean in a usual manner by the issuance of fluid under pressure from the nozzle 41a in the center of the cutter and thrust cone, and the nozzle 39a, directing its stream of drilling mud against the reaming and digging teeth. Both of the orifices receive their fluid from the common passageway 39b.

It is desirable to offset the drill collar in the direction of the arrow P for the reason that the reaming teeth 47 begin to penetrate into the formation at the instantaneous position of that line. Thus, the centrifugal force would urge the reaming tooth illustrated adjacent the line P in Fig. 6 into the formation and continue its urging as the shank moved ahead of that tooth in rotating around the hole. The reaming teeth 47 will be moved downwardly and in so doing will produce the oversize hole 34 of greater dimensions than the hole 35 which would have resulted were it not for the action of centrifugal force. Of course, as the shank of the drill bit rotates, the reaming teeth thereon are progressively urged into the formation by the centrifugal action due to the eccentricity of the drill collar.

It can be appreciated that the drill collar could be offset along different lines than the one indicated by the arrow P. For example, the displacement of the drill collar along the line Q (Fig. 6) so that its axis would be at the position 33' would provide a maximum urging of the ream-blades into the formation after the blades had penetrated to some extent.

In Fig. 8, a type of rock bit is illustrated in which the cones 48 are rotatably mounted upon the shank of the tool in a well known manner. Here again the axis of the drill collar 33 is offset with respect to the center line of the tool 37 by the distance Y by attaching the drill collar 32 to an upper offset portion of the shank, so as to urge the cutting tool against the sides of the formation to produce an oversize hole by the centrifugal force exerted on the drill collar and bit.

Similar action is true of the drag bit, such as is illustrated in Fig. 9. The drill collar 32 is attached to an offset upper shank part so as to be displaced with respect to the center line of the tool 37 by distance Y to produce an oversize hole by the action of the centrifugal force urging one of its legs 49 into the formation.

Fig. 10 illustrates the application of the invention to a reamer combined with a drilling tool such as is disclosed in Fig. 1. This modification of the lower drilling tool is designed the same as the tool described in connection with Fig. 1 with the drill collar 32 attached to an offset portion 50 of the shank so that the action of centrifugal force can be availed of. The upper part of the drill collar is attached to one end of the reamer 51 having rolling cutters 52 thereon. The upper end of the reamer is attached to the drill pipe 53. This latter point of attachment is practically coincident with the hole axis, but the lower part of the reamer will be slightly offset

because of the inclination of the drill collar 32. Upon rotation, the centrifugal force acting on the heavy drill collar will urge the reamer into the sides of the hole to remove more formation than would have ordinarily occurred and thereby produce an enlarged bore.

Fig. 11 illustrates the invention as applied to an underreamer. A drag bit 54 has its screw threaded pin 55 offset by distance Y with respect to the center line of the cutting portions of the drag bit. A reamer 56 is screwed on to this threaded pin, with the upper end of the reamer, in turn, being screwed to the heavy drill collar 32 which is threaded to the drill pipe 57 at its upper end. The drag bit 54 serves as a pilot for the reamer and also provides the initial offset of the drill collar with respect to the drill pipe and hole axis. The pilot, drag bit and the reamer are of such dimensions as to be capable of passing down through the casing 58. Upon rotation of the mechanism the action of centrifugal force thereon, and particularly that developed by the heavy drill collar will move the reamer and pilot bit radially outwardly to produce formation penetration by the rolling cutters on the reamer and also by the blades on the drag bit to enlarge the well bore below the casing.

This latter arrangement is also adapted for general underreaming operations such as are encountered when it is necessary to follow with casing closely behind the drilling tool when drilling in caving formations.

With all of the embodiments shown the centrifugal force will tend to increase the eccentricity of the drill collar. The extent of outward motion in all cases will be determined by the reactive force of the formation on the bits; and this will also determine the resultant hole size.

The centrifugal action of the drill collar will be particularly effective in connection with the embodiments illustrated in Figs. 1 to 7, inclusive; for from the very nature of the construction of those cutting tools each tooth will be urged into the formation by the action of centrifugal force at some time during a complete cycle of operation. In Figs. 1 to 4, all of the roller cutters 15 spaced around the circumference of the bit will at some time be in the position presently held by the lowermost roller (Fig. 2); that is, they will progressively move from a vertical position to a substantially horizontal position illustrated in Fig. 2. In Fig. 4, each reaming tooth 47 will progressively partake of a combined rotary and longitudinal motion to ream away the formation while the drill collar will simultaneously be progressively positioned adjacent each reaming tooth to urge it to a greater extent into the formation than would normally occur. On the other hand, in drilling tools of the type illustrated in Figs. 8 and 9, and this is also true of disc bits, regardless of the offset position of the drill collar, the only effective portions urged against the formation will be the side 59 of the shank and the bottom back cone portion 60 of only one of the cones 48. The other cone will not have any effect in producing an oversize hole. Similarly, the drag bit of Fig. 8 will have only one of its cutting blades 49 urged into the sides of the hole to produce an oversize bore. The remaining cones and cutting blades will be ineffective insofar as oversize hole production is concerned.

It is to be understood that in its broad aspects the invention is adapted for use in many other types of drilling tools than have been illustrated,

and those appearing in the drawings are designed for illustrative purposes rather than as being restrictive upon the scope of the invention. Accordingly, the invention is to be limited only as defined in the following claims.

I claim:

1. An earth boring mechanism comprising a shank; a carrier rotatably supported by said shank; cutters rotatably mounted on said carrier, said cutters when in their bottommost position being contactable with the formation at one side of the axis of the bore; and a heavy drill collar connected with said shank, the axis of said drill collar being offset with respect to the center of rotation of the cutter carrier and in the direction of the bottommost cutters, said collar being also offset with respect to the bore axis on the same side thereof as said bottom contactable cutters, whereby centrifugal force developed by revolution of said drill collar will maintain the cutter contact to said one side of the bore axis.
2. An earth boring tool comprising a shank; a carrier rotatably supported by said shank, cutters rotatably mounted on said carrier, said cutters when in their bottommost position being contactable with the formation at one side of the axis of the bore; and a threaded connector at one end of the shank, the axis of the connector being offset with respect to the center of rotation of the cutter carrier and in the direction of the bottommost contactable rollers.
3. An earth boring mechanism comprising a shank having a pair of depending legs; a carrier rotatably carried by said legs; cutters rotatably mounted on said carrier, said cutters when in their bottommost position being contactable with the formation at one side of the axis of the bore; one of said legs being positioned on the other side of said axis and by its contact with the walls of the bore preventing said bottommost rollers from coming into coincidence with said axis; and a heavy drill collar connected with said shank, the axis of said drill collar being offset with respect to the center of rotation of the cutter carrier and in the direction of the bottommost rollers, said collar being also offset with respect to the bore axis on the same side thereof as said bottommost contactable rollers; whereby centrifugal force developed by revolution of said drill collar will maintain the cutter contact to said one side of the bore axis and tend to move said one leg from contact with the walls of the bore.

4. An earth boring tool comprising a shank having a pair of depending legs; a carrier rotatably carried by said legs; cutters rotatably mounted on said carrier, said cutters when in their bottommost position being contactable with the formation at one side of the axis of the bore; one of said legs being positioned on the other side of said axis and by its contact with the walls of the bore preventing said bottommost rollers from coming into coincidence with said axis; and a threaded connector on one end of the shank, the axis of the connector being offset with respect to the center of rotation of the cutter carrier and in the direction of the bottommost contactable rollers.

5. An earth boring mechanism comprising a shank, an inclined bearing pin on said shank, a cutter rotatably mounted on said pin, and a heavy drill collar connected to said shank, the axis of said drill collar being offset with respect to a longitudinal plane including the inclined bearing pin.

6. An earth boring tool comprising a shank, an inclined bearing pin on the shank, a cutter rotatably mounted on said pin, and a threaded connector on one end of the shank, the axis of said connector being offset with respect to a longitudinal plane including the inclined bearing pin.

7. An earth boring mechanism comprising a shank, inclined bearing means on said shank, cutter means rotatably carried by said inclined bearing means, and a heavy drill collar connected to said shank, the axis of the drill collar being offset immediately rearwardly relative to the direction of rotation of the shank with respect to a longitudinal plane including the axis of said bearing means to outwardly advance the cutter means transversely into the formation under the action of centrifugal force produced by revolution of said drill collar.

8. An earth boring tool comprising a shank, inclined bearing means on said shank, cutter means rotatably carried by said inclined bearing means, said cutter means being contactable with the formation on one side of a longitudinal plane including the axis of said bearing means, and a threaded connector on one end of said shank, the axis of said connector being offset with respect to said longitudinal plane on the same side thereof as said contactable cutter means.

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