April 21, 1936. F. L. SCOTT 2,038,387

ROLLER BORING WELL DRILL

Filed Nov. 4, 1935 3 Sheets-Sheet 1

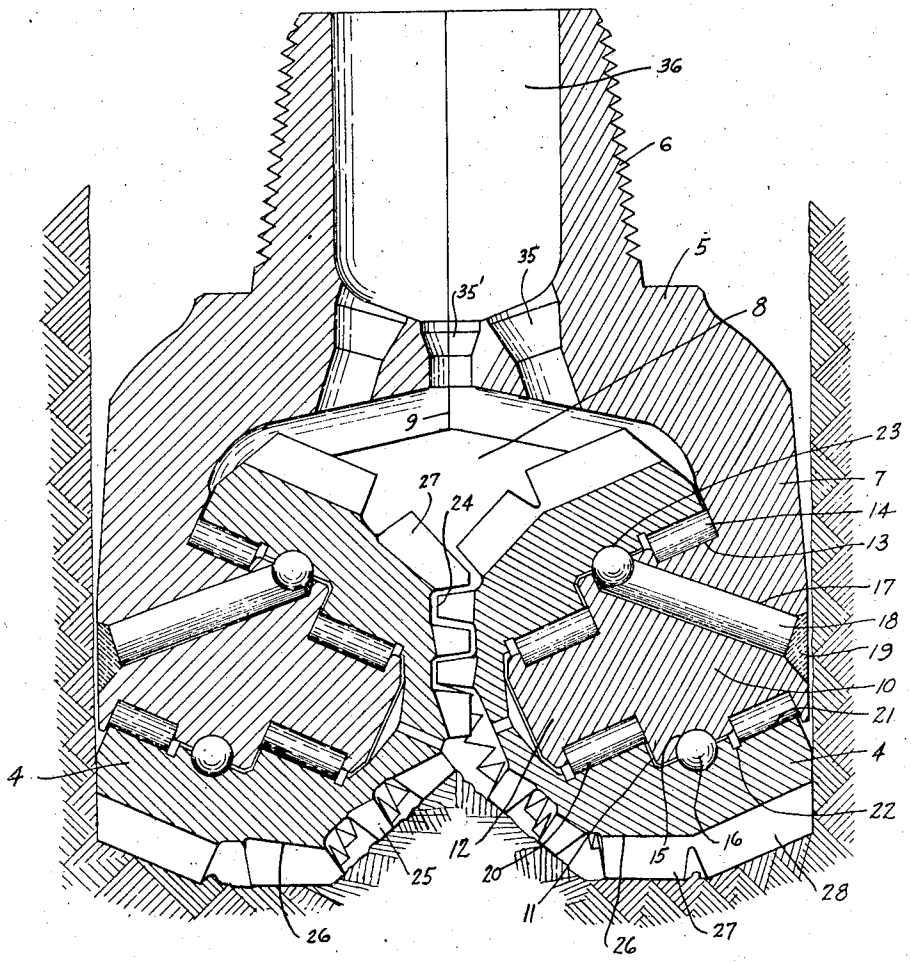


Fig. 1

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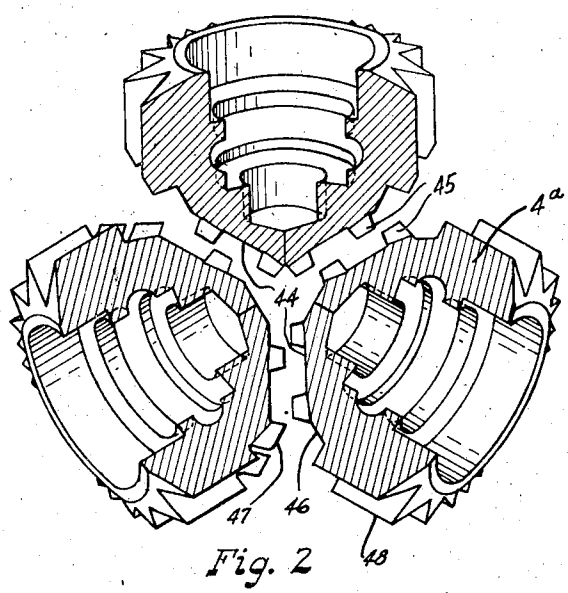


Fig. 2

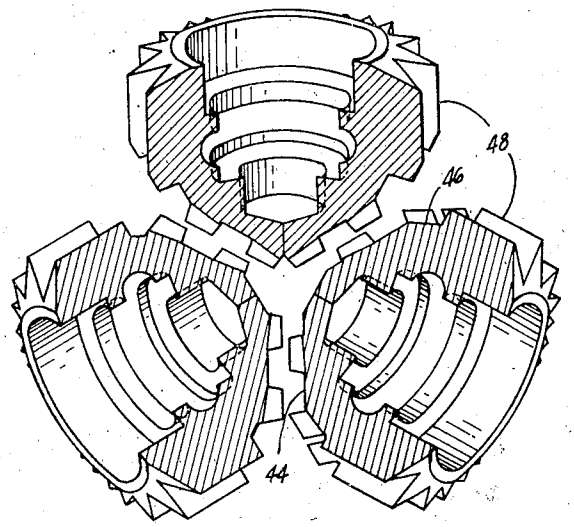


Fig. 3

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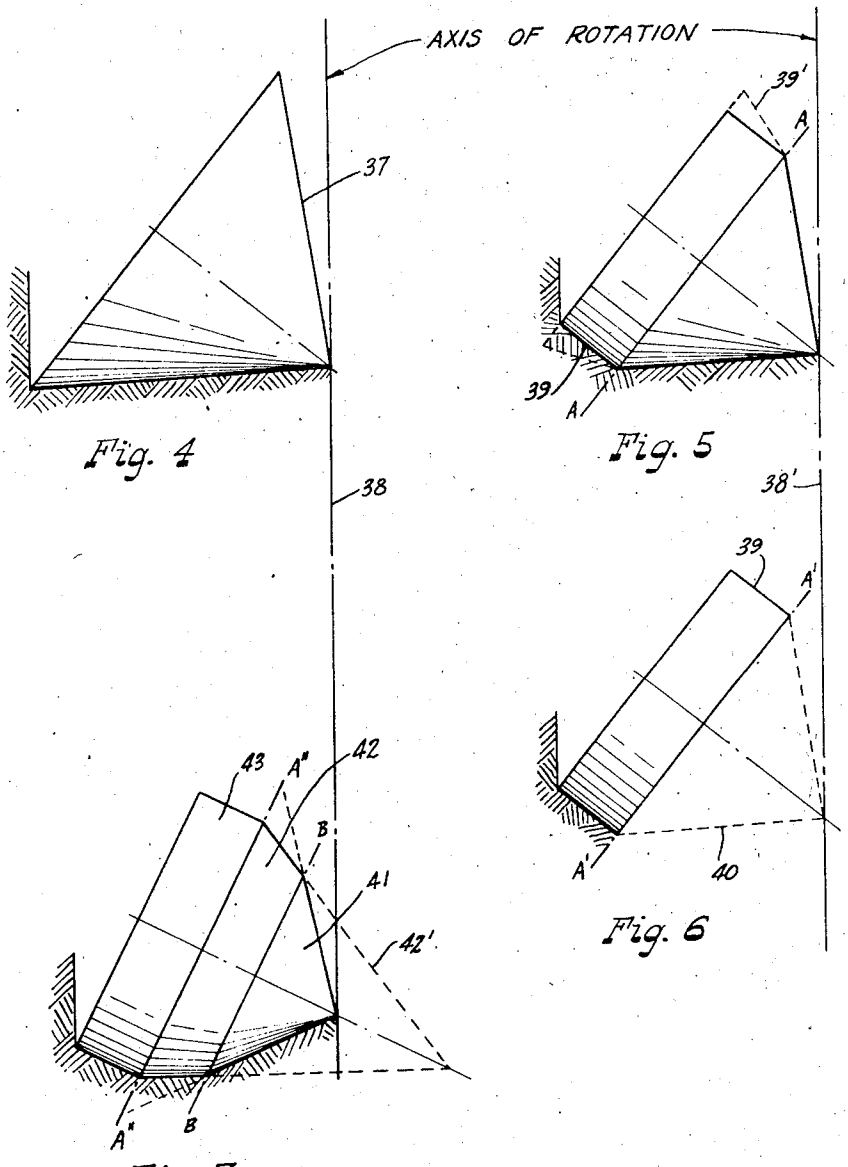


Fig. 4

Fig. 5

Fig. 6

Fig. 7

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2,038,387

ROLLER BORING WELL DRILL

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Application November 4, 1935, Serial No. 48,097

12 Claims. (Cl. 255—71)

My invention relates to cutters on rotary well drills and has particular application to well drills of the type employed in drilling hard formations. Such cutters are designed to surround the inner ends of downwardly inclined shafts and to cover approximately the radius of the hole being drilled. Two or more of such cutters are used on the bit head. Manifestly, however, the invention is not confined to such cutters.

This type of drill is broadly old and has been very widely used. The cutters on prior bits of this character have been most commonly constructed so that the cutting surface is approximately conical with the apex of the cone lying near the axis of rotation of the drill head, thus giving the cutter a true rolling motion upon the well bottom. The cutting action is, therefore, one of penetration without appreciable creep. The teeth on such cutters press upon the bottom of the hole with a chisel action, giving a direct cutting and crushing stroke. Such cutters are adapted for use where the formation is brittle and will chip easily, but are not well adapted for plastic or semi-plastic formations. A beveled cutting surface formed at the base of the cone such as would result from making this portion cylindrical or only slightly tapered increases the speed or cutting because creep is increased. However, experience shows that even with a beveled base, the conical cutting surface between the apex of the cutter and inner end of the bevel has almost true rolling motion. Thus, the old type cutter is not as effective as it might be in drilling tough non-brittle formations.

It is an object of the present invention to so shape the cutter as to get a combined chisel and twisting or screw-driver stroke of the teeth over its entire operating surface. This new shape has proven to give the desired action.

I desire to provide three different angles of cutting surface in which the area toward the apex converges approximately at the axis of rotation of the drill and the two outer zones of larger diameter, roll in circles which are too small for a true rolling action, thus causing them to have a twisting or scraping action resulting in increased drilling speed. The outer row of teeth is designed to be approximately cylindrical, or only slightly tapered.

I desire to obtain a cutting surface on each cutter which in use tends to move the cutter outwardly away from the center as bearing wear occurs, thus compensating for wear on the gage of the cutters and preventing the bore of the hole from becoming smaller than that desired.

It is a further object to obtain a cutter shape that approaches a beehive contour allowing a strong and heavy cutter bearing even up to the end of the cutter shaft.

I also desire to form the cutters so that the row of teeth toward the apex may or may not interfit with rows on adjacent cutters and which permits the cutter shafts to lie at an angle in the range from 24° to 39° to the well bottom.

I further desire to obtain a more effective direction of the flushing fluid along the large diameter of the cutter where the greatest tendency to clog occurs, due to its greater area of cutting.

In the drawings herewith Fig. 1 is a central longitudinal section through a well drill employing the invention.

Fig. 2 is a sectional plan view partly in perspective, showing the cutters of a three cutter bit lying in drilling position.

Fig. 3 is a similar view of cutters having their teeth cut differently from those on the cutters in Fig. 2.

Figs. 4 to 6 inclusive are diagrammatic views illustrating the cutting action of different shaped cutters relative to the well bottom.

I have shown the invention as applied to drills having either two or three cutters. In Fig. 1 I show two cutters 4 mounted upon a head 5. Said head has an upwardly tapered shank threaded at 6 for attachment to a drill collar or the like.

The lower end of the head is formed with two opposed downwardly extending legs 7 leaving between them a recess 8, the upper wall of which is inclined downwardly away from the center line 9, along which the head is divided longitudinally. At the lower ends of said legs are inwardly and downwardly inclined cutter shafts 10 upon which the rolling cutters 4 are rotatable.

The cutter shafts are approximately cylindrical adjacent the legs and are reduced abruptly in diameter toward their ends thus providing a shoulder 11 beyond which the reduced end 12 forms a side thrust bearing. The larger cylindrical area of the shaft is formed with a countersunk roller raceway 13 to receive the roller bearing members 14. Further inwardly toward the end of the shaft this area has a groove 15 to receive the balls 16 which act not only as anti-friction bearings, but also to lock the cutter upon its shaft. The balls are inserted into the raceway 15, after the cutters are in position upon the shaft, through transverse passageways 17 in the shaft. The said passageways are closed by cylindrical plugs 18 held in place by bonds of welded metal 19. To permit the use of cutters of the desired shape, the cutter

shafts are set at an angle somewhere within the range of 24° to 39° with the horizontal.

The forward reduced end of the shaft has an annular groove to accommodate the roller bearings **20**.

The cutters **4** are of beehive shape. The interior of each cutter is shaped to fit the shaft and bearings thereon. Each cutter has a raceway **21** at the base for the rollers **14**, the inner end of the raceway being recessed at **22** to prevent contact of the rotating cutter with the ends of said rollers **14**. The balls **16** fit in an annular groove **23** in the cutter so that the cutter may be locked upon the shaft by said balls. The ends of the rollers in row **20** are also arranged so that, in rolling, they will not contact with the moving surface of the cutter and hence, also will receive none of the longitudinal thrust of the cutter.

The external contour of the cutters forms a valuable feature of my invention and in order that the significance of the shape of the cutter may be understood, reference is had to Figs. 4 to 6 inclusive. By calculation and by virture of many hundreds of experiments in the laboratory and in the field, it has been found that a true rolling action of a cone cutter upon the well bottom is not of value in many formations where the formation is not brittle. It is desirable to obtain a scraping or twisting action over the whole of the cutting area.

In Fig. 4, a true rolling cutter shape is shown. The cutter surface **37** tapers to an apex lying at the center of the hole, at the axis of rotation of the drill. The vertical lines **38** and **38'** show the axis about which the cutters roll. Where the cutter of Fig. 4 is moved about the axis **38**, the cutting teeth would have a downward penetration without twisting.

In Fig. 5 the cutter shape indicated in full lines illustrates a conical forward end **40** with a cylindrical zone **39** adjacent the base. I find in such a cutter shape there is true rolling action from the apex up to and including the line A—A. Twisting action, in rolling, is obtained on the cylindrical area **39** only. Where the base area is made of the shape shown in dotted lines at **39'**, there is still a twisting action of cutting teeth on this area due to the fact that the teeth are constrained to move in a circle of smaller diameter than they normally would. A faster cutting action is thereby obtained.

In Fig. 6 a cylindrical cutter is shown set at approximately the same angle as is the area **39** in Fig. 5. I find that when this cutter is moved about a center indicated by the axis **38'** the inner margin A'—A' will have a true rolling action approximately as it would if there were a true rolling portion **40** thereon, indicated by the dotted lines. In other words the margin A'—A' behaves as if it were integral with a conical portion **40** there present. Outwardly away from this inner edge the cutter has a twisting and scraping action. There is a powerful force existing tending to keep the inner edge rolling like a thin disc without apparent slip.

In Fig. 7 is a type of cutter employing the principles illustrated in Fig. 4 to 6 inclusive. So as to obtain a most efficient cutting action on all areas of the cutting surface, I divide the cutting area longitudinally into three zones. The forward area **41** adjacent the apex tapers so that the cutting area converges near the axis **38**. The next adjacent area **42** is tapered in such a manner that if extended, as shown by dotted lines **42'**, it would converge beyond the axis of rotation. This area could not from its taper have a true rolling action. The third or outer area **43** is shown as cylindrical. It is to be understood, of course, that this outer area may be somewhat tapered, if desired, but preferably an approximately cylindrical area is used. In this form of cutter the cutting surface will have a true rolling action at no point except along the line A''—A''. The areas **42** and **43** are large compared with the area **41** adjacent the apex and exert an influence on the said area **41**, causing it to slip or creep upon the well bottom and giving it a twisting and scraping action. There is thus a scraping action upon each zone of cutting area and speed of cutting is greatly increased.

Referring back again to the drill shown in Fig. 1, it will be seen that the construction shown in Fig. 7 has been employed.

The cutters have three cutting zones on their outer surfaces. There is a forward cutting zone **24** which tapers to an apex near the axis of the hole. The teeth **25** on this area are in circumferential rows offset relative to similar rows on adjacent cutters and hence are adapted to interfit and allow the cutters to be of larger size. The crests of the teeth **25** pass the center line of the hole along the axis of rotation of the drill. There is hence room for the ends of the bearing shafts to approach closely together.

The next cutting zone **26** is tapered to come to an apex beyond the center of the hole. The teeth **27** thereon cut the formation with a combined penetrating and screw-driver action which increases their cutting efficiency. These teeth on adjacent cutters do not interfit except at their inner ends.

The outer row of teeth **28** are on a zone which is approximately cylindrical. They have a sort of twisting or screw-driver action upon the well bottom, and hence cut rapidly.

The cutters are cleaned of material tending to adhere thereto by the action of the flushing fluid which is directed toward the largest diameter of the cone by passages **35** inclined in the direction of the cutter from the inner fluid passage **36** in the cutter head. The central passage **35'** flushes the apices of the cutters and the intermediate cutting zones.

The advantages of this construction of bit are many. By the general shape and contour of the cutters, and the manner in which they are mounted, I am able to provide large cutter shafts which are of comparatively large diameter even at the smaller end. Thus the wear of the bearings at the end of the shaft in use can be fairly marked without endangering or breaking the bearing pin or the rollers.

Further, the particular angles at which the cutting zones upon the cutters are presented to the well bottom enables the teeth to cut effectively and the speed of cutting is increased. It is to be noted also that the angle of the shaft is such that considerable more wear in an upward direction can take place on the bearings before the cones start running together, thus preventing locking of the cutters with each other as is the case with the old type of cone bit. The intermediate cutting zone on each cutter, being conical with its apex on opposite sides of the bit axis, has a powerful urge to move the cone outwardly toward the wall because of its geometrical relation, which constrains it to move in a smaller circle than it normally would. This urge outwardly tends to compensate for wear on the gage

of the cutters thus preventing the bore of the hole from becoming smaller than desired.

Where the cutting area of the cutter is tapered to converge at the apex and is approximately cylindrical at the base, with an intermediate zone having a different angle of inclination, a fast cutting cutter has been obtained.

In Figs. 2 and 3 I have illustrated more clearly the relations of adjacent cutters where the invention is employed on a three cutter drill. The cutters here shown have approximately the same shape as is seen in Fig. 1. In Fig. 2 the cutters 4a are shown in section and it is to be understood that a sector of the total circumference of each cutter has been removed, and the cutters placed in cutting position with their adjacent sides as they would appear in operation if mounted upon the drill head. The forward zone 44 on each cutter is formed and positioned to remove the center portion of the hole. The sides of this zone are parallel, or approximately so, with the corresponding sides of adjacent cutters. The teeth 45 on this area are in rows offset relative to each other longitudinally of the cutters but they are shown as not interfitting normally in use.

The next outer adjacent area 46 has a taper corresponding to that at 42 in Fig. 7. The teeth 47 on this area tend strongly to twist as they roll in a circle too small for true rolling action. The outer area 48 is cylindrical. These cutters cut rapidly and all the teeth skid or slip on the well bottom and have a twisting or screw-driver action as has been previously explained.

In Fig. 3 the cutters are arranged as shown in Fig. 2 but the rows of teeth on adjacent cutters are shortened so as not to contact with those on adjacent cutters. The rows of teeth are not arranged so that they can interfit with the teeth on adjacent cutters. As the shape of the cutter is the same as that of the cutters in Fig. 2 the action of the cutters upon the well bottom is approximately the same. The forward zone 44 would have a true rolling action were it not for the control exerted thereon by the two outer zones which prevents this action.

A valuable feature of this type of cone is its ability to cut rapidly. On both the two cone and the three cone bits it is found that the cutters make progress in cutting the well bottom at a speed in excess of that of any other cutter of this general character. It will make hole long after the teeth have become dulled. The scraping action of the teeth on the different zones acts to disintegrate the material where a crushing and chipping action alone would not be effective. The shape of the cutter and the position of the shaft upon which it is mounted makes it possible to employ a heavy and substantial bearing shaft, thus also tending to make a stronger and more substantial tool.

It is desirable in drilling to rest as little weight upon the drill as possible, thus assuring a straight hole. With this improved form of drill, fast drilling is obtained even where the load is light, and hence a straight hole is more accurately obtained.

What I claim as new is:

1. A roller boring drill including a head, a plurality of downwardly diverging legs thereon, shafts on said legs the axes of which are positioned at an angle in the range of 24° to 39° with the horizontal, cutters surrounding said shafts and enclosing the forward ends thereof, a forward cutting zone on each cutter tapered to an apex at approximately the central axis of the hole and having rows of cutting teeth positioned to interfit between teeth on adjacent cutters, a second toothed cutting zone outside the forward zone, tapered to come to an apex on the opposite side of the axis of the drill, and an outer toothed cutting zone which is approximately cylindrical.

2. A roller boring drill including a head, legs on said head, downwardly and inwardly converging shafts on said legs, the inner ends of said shafts being of substantial thickness and spaced apart a short distance, roller bearings on said inner ends, toothed cutters of approximately beehive shape mounted on said shafts, the teeth on said cutters being arranged in rows, the outer row being formed on a substantially cylindrical surface.

3. A roller boring drill including a head, inwardly and downwardly inclined shafts thereon, cutters mounted on said shafts, teeth on said cutters arranged in three zones, the outer zone at the base of the cutter being an approximately cylindrical one, a zone adjacent the small end of the cutter which is tapered to converge near the axis of rotation of the drill and an intermediate zone tapering to an apex beyond the axis of rotation of the drill, the teeth on the small end zone being adapted to interfit with the corresponding teeth on an adjacent cutter.

4. A roller boring drill including a head, inwardly and downwardly inclined shafts thereon, cutters mounted on said shafts, teeth on said cutters arranged in three zones, the outer zone at the base of the cutter being an approximately cylindrical one, a zone adjacent the small end of the cutter which is tapered to converge near the axis of rotation of the drill and an intermediate zone tapering to an apex beyond the axis of rotation of the drill, said cutter shafts being inclined so that the intermediate row of teeth contacts continuously with the bottom of the hole in an approximately horizontal position.

5. A roller boring drill including a head, inwardly and downwardly inclined shafts thereon, cutters mounted on said shafts to enclose the ends thereof, teeth on said cutters arranged in three zones, the outer zone at the base of the cutter being an approximately cylindrical one, a zone adjacent the small end of the cutter which is tapered to converge near the axis of rotation of the drill and an intermediate zone tapering to an apex beyond the axis of rotation of the drill, the teeth on the small end zone being adapted to interfit with the corresponding teeth on an adjacent cutter, and water courses through said head inclined to discharge the flushing fluid upon the outer cylindrical area of each cutter.

6. A roller boring drill including a head, inwardly and downwardly inclined shafts thereon, cutters mounted to roll on said shafts and enclose the ends thereof, said cutters having a plurality of cutting zones to form a cutting surface approximately beehive in shape, and teeth arranged in circumferential rows on said cutters to cut the bottom of the hole, the forward cutting areas being approximately parallel with those on adjacent cutters.

7. A roller boring drill including a head, downwardly and inwardly converging shafts on said head, the ends of said shafts being spaced a comparatively short distance apart, cutters enclosing the ends of said shafts and adapted to roll thereon, the outer cutting areas of said cutters having a larger zone which is approximately cylindrical, the forward end of the cutter being rounded to be approximately hemispherical, circumferential rows of cutting teeth on said cutters,

those at the smaller end being offset from similar rows on adjacent cutters.

8. A roller boring drill including a head, downwardly and inwardly converging shafts on said head the ends of said shafts being spaced a comparatively short distance apart, cutters enclosing the ends of said shafts and adapted to roll thereon, the outer cutting areas of said cutters having a larger zone which is approximately cylindrical, the forward end of the cutter being rounded to be approximately hemispherical, circumferential rows of cutting teeth on said cutters, and a row of teeth at the larger end of each cutter to cut the well bottom and contact with the well bottom in an upwardly inclined position.

9. A roller boring drill including a head, a plurality of downwardly diverging legs thereon, cutter shafts on said legs extending inwardly, cutters rotatably mounted on said shafts, a forward cutting zone on each cutter lying approximately parallel with similar areas on adjacent cutters, a second cutting zone outside the forward zone tapered to come to an apex on the opposite side of the axis of the drill, an outer zone on said cutter which is approximately cylindrical, and cutting teeth on each of said zones.

10. A roller boring drill including a head, a plurality of downwardly diverging legs thereon, cutter shafts on said legs extending inwardly, cutters rotatably mounted on said shafts, a forward cutting zone on each cutter lying approximately parallel with similar areas on adjacent cutters, two cutting zones outwardly from the forward cutting zones, said outward zones diverging to an increasing angle from similar zones on adjacent cutters, and circumferential rows of teeth on said cutters.

11. A roller boring drill including a head, a plurality of inwardly and downwardly extending cutter shafts thereon, toothed cutters mounted on said shafts and rotatable thereon, a forward conical cutting area on each cutter the sides of which are approximately parallel with similar areas on adjacent cutters, an outer cutting area on each cutter which is approximately cylindrical and an intermediate cutting area diverging from similar areas on adjacent cutters, said cutting areas being so positioned and inclined as to produce a slipping and twisting action on all said areas when in contact with the well bottom.

12. A roller boring drill including a head, a plurality of downwardly and inwardly inclined shafts on said head positioned at an angle in the range of 24° to 39° with the horizontal, cutters rotatably mounted on said shafts, a forward cutting zone on each cutter to remove the center portion of the hole and having circumferential rows of teeth thereon offset from corresponding rows of adjacent cutters, a second toothed cutting zone outside the forward zone, tapered to come to an apex on the opposite side of the axis of rotation of the drill, and an outer toothed cutting zone which is approximately cylindrical.

FLOYD L. SCOTT.