

Aug. 31, 1965

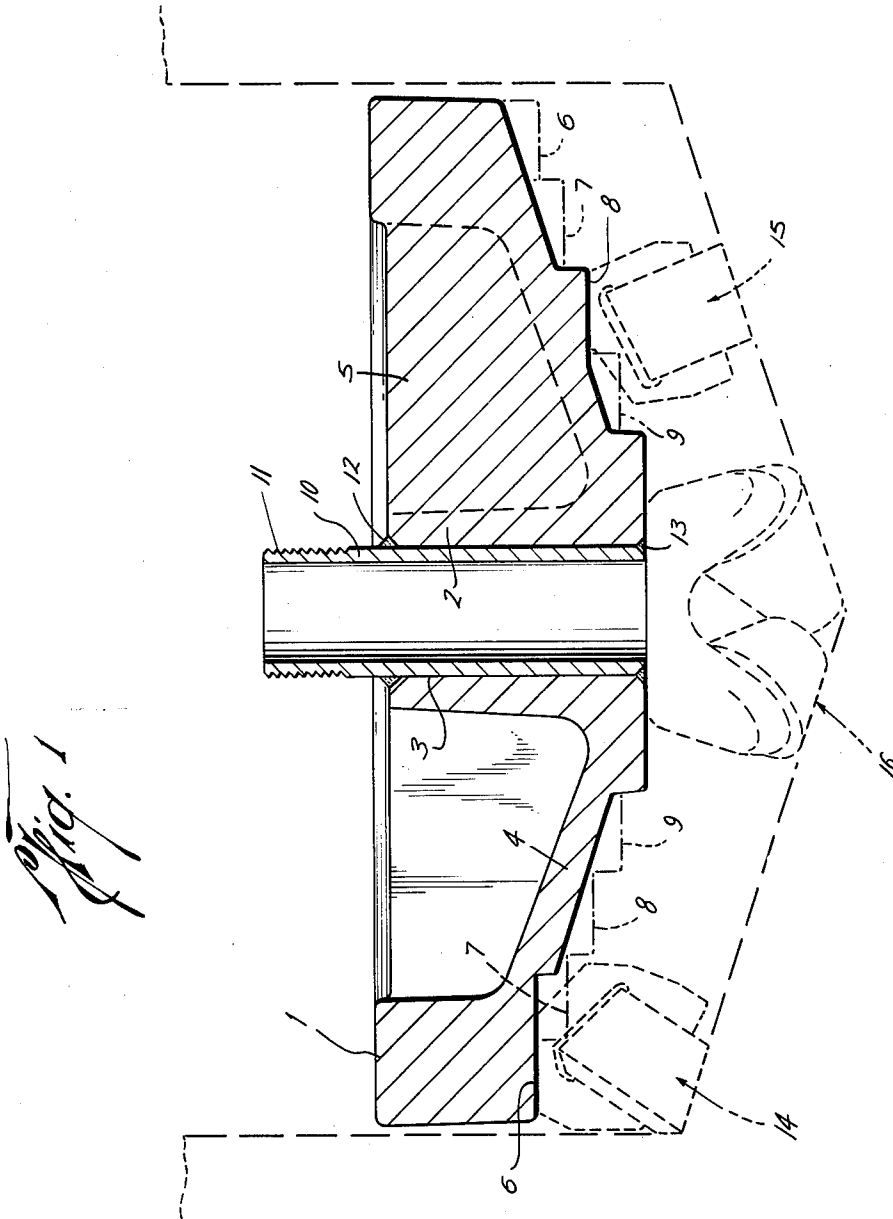
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3,203,492

LARGE HOLE EARTH BORING DRILL BIT

Filed Jan. 14, 1963

6 Sheets-Sheet 1



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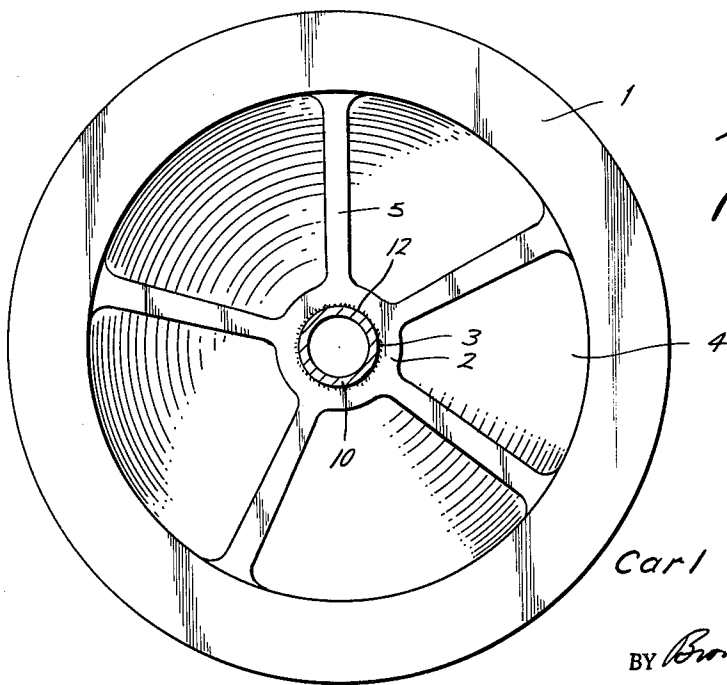
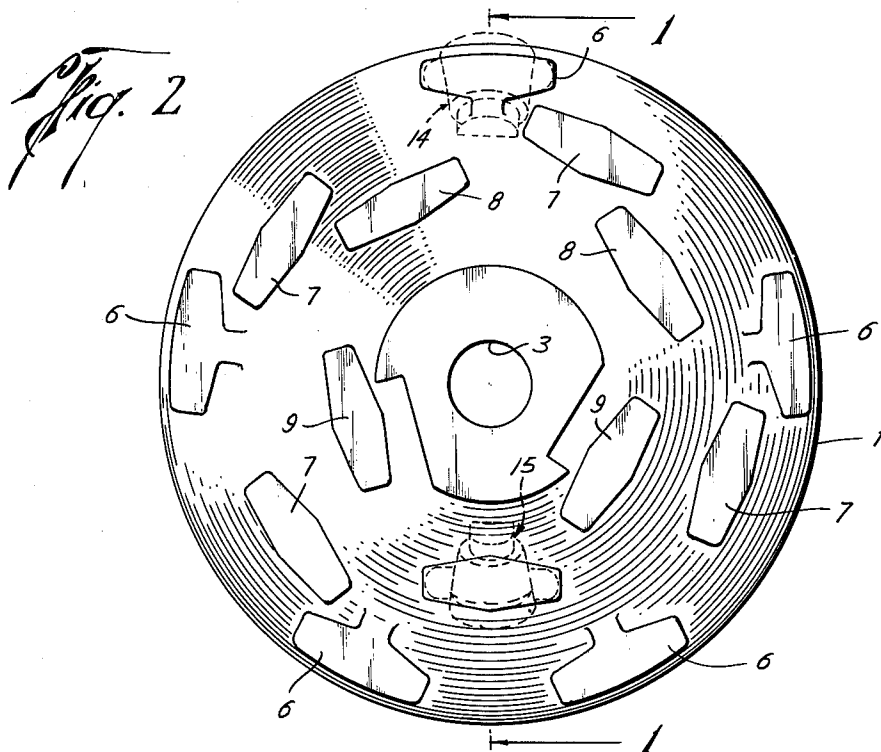
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LARGE HOLE EARTH BORING DRILL BIT

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6 Sheets-Sheet 2



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LARGE HOLE EARTH BORING DRILL BIT

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6 Sheets-Sheet 3

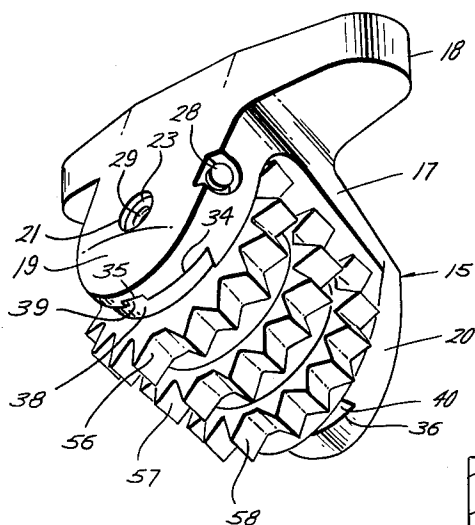


Fig. 4

Fig. 5

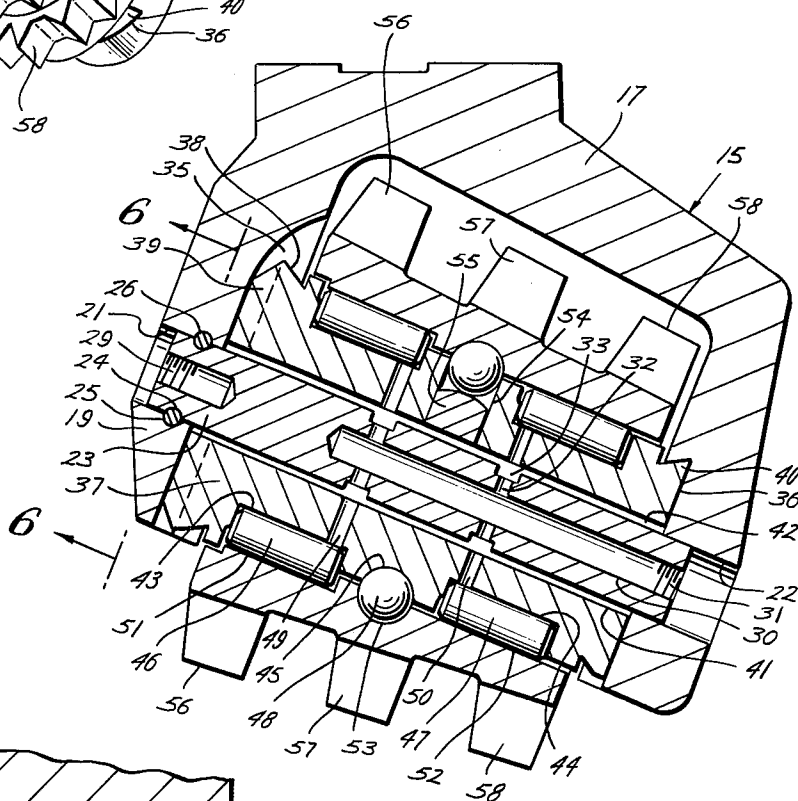
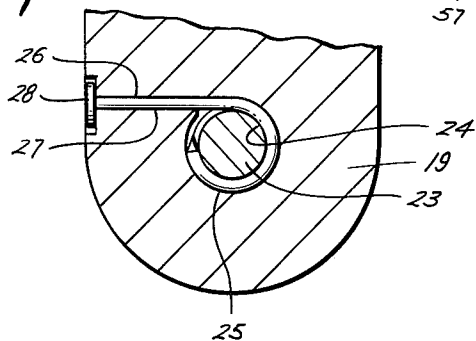


Fig. 6



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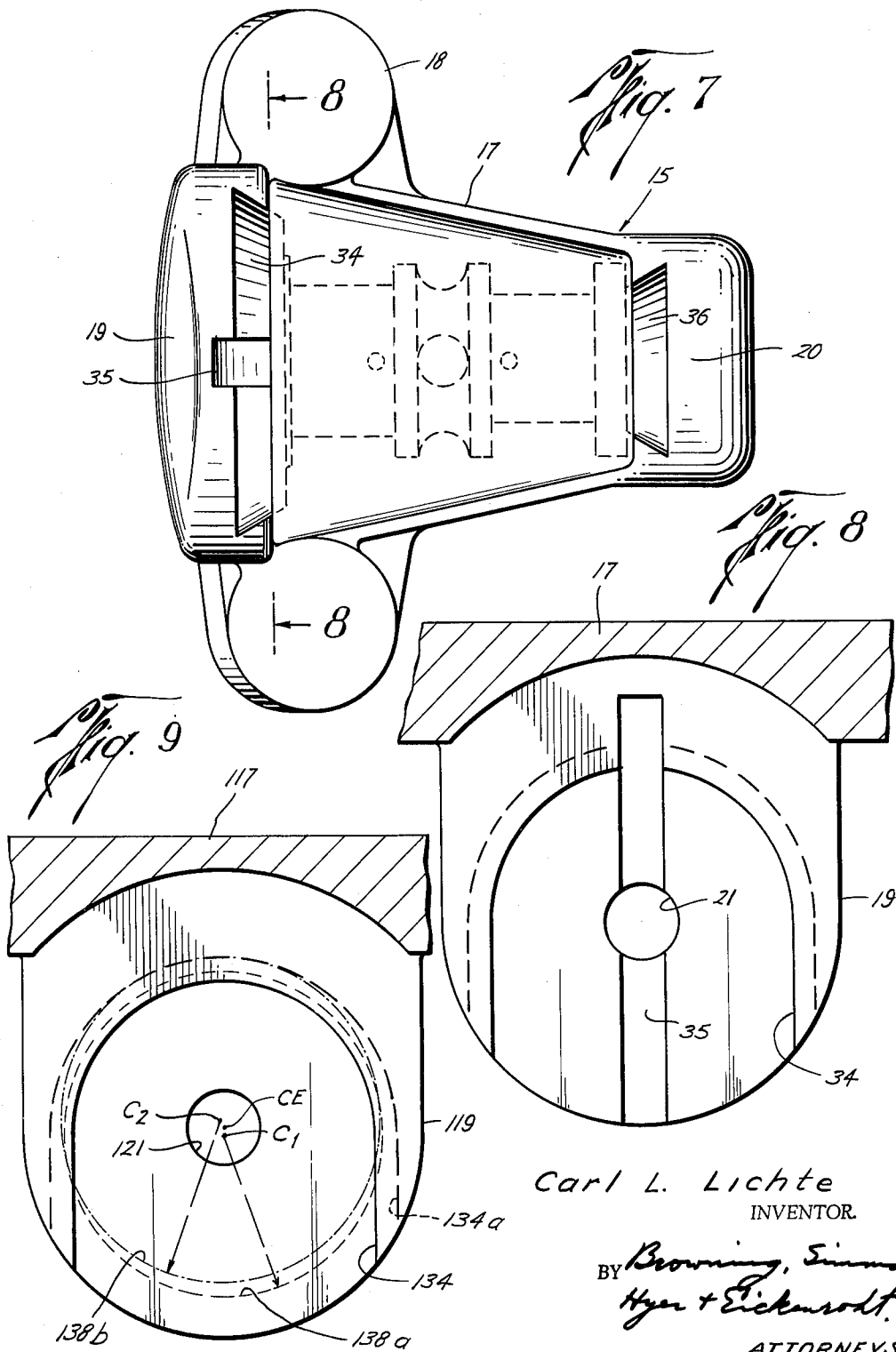
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LARGE HOLE EARTH BORING DRILL BIT

Filed Jan. 14, 1963

6 Sheets-Sheet 4



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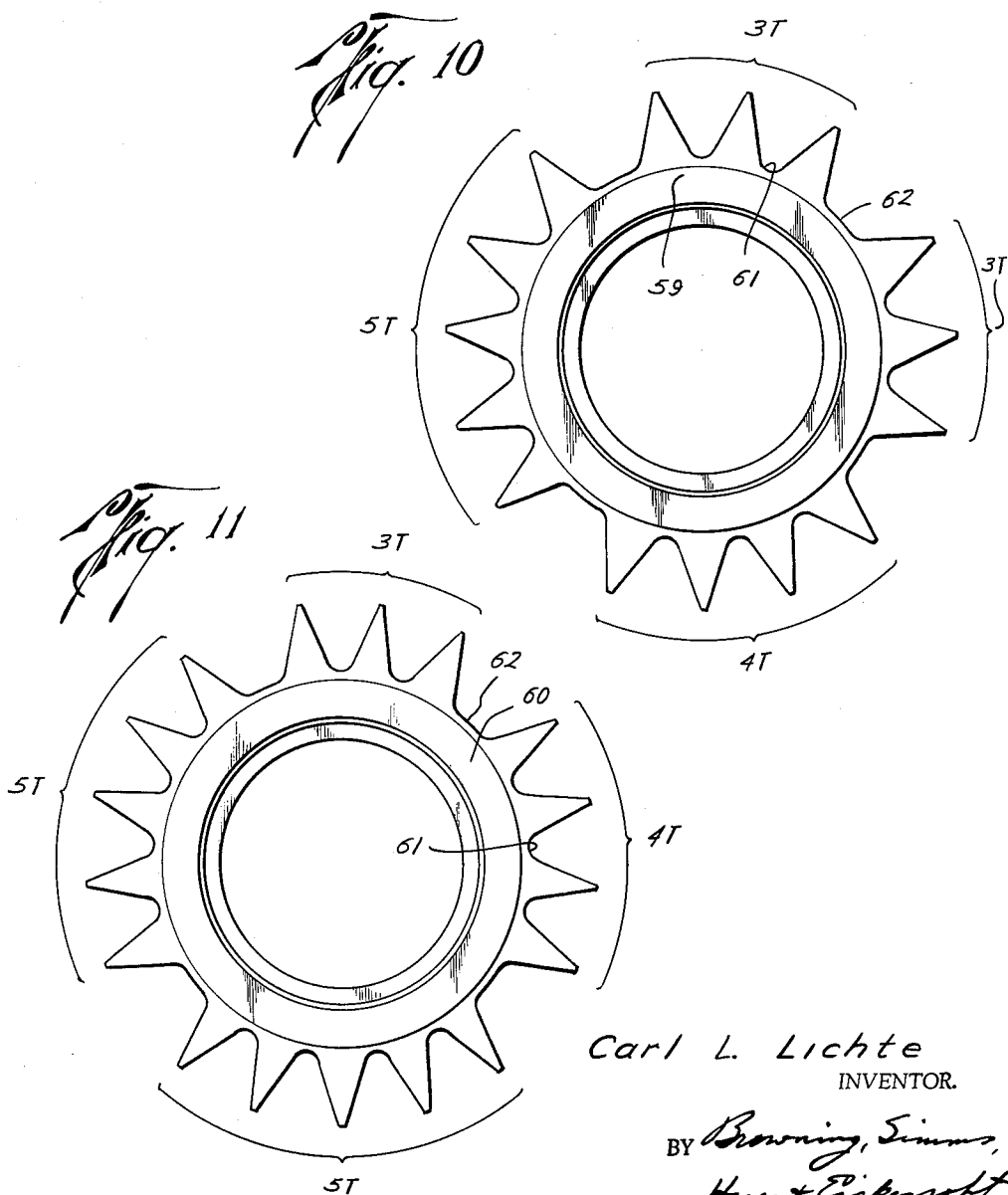
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LARGE HOLE EARTH BORING DRILL BIT

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6 Sheets-Sheet 5



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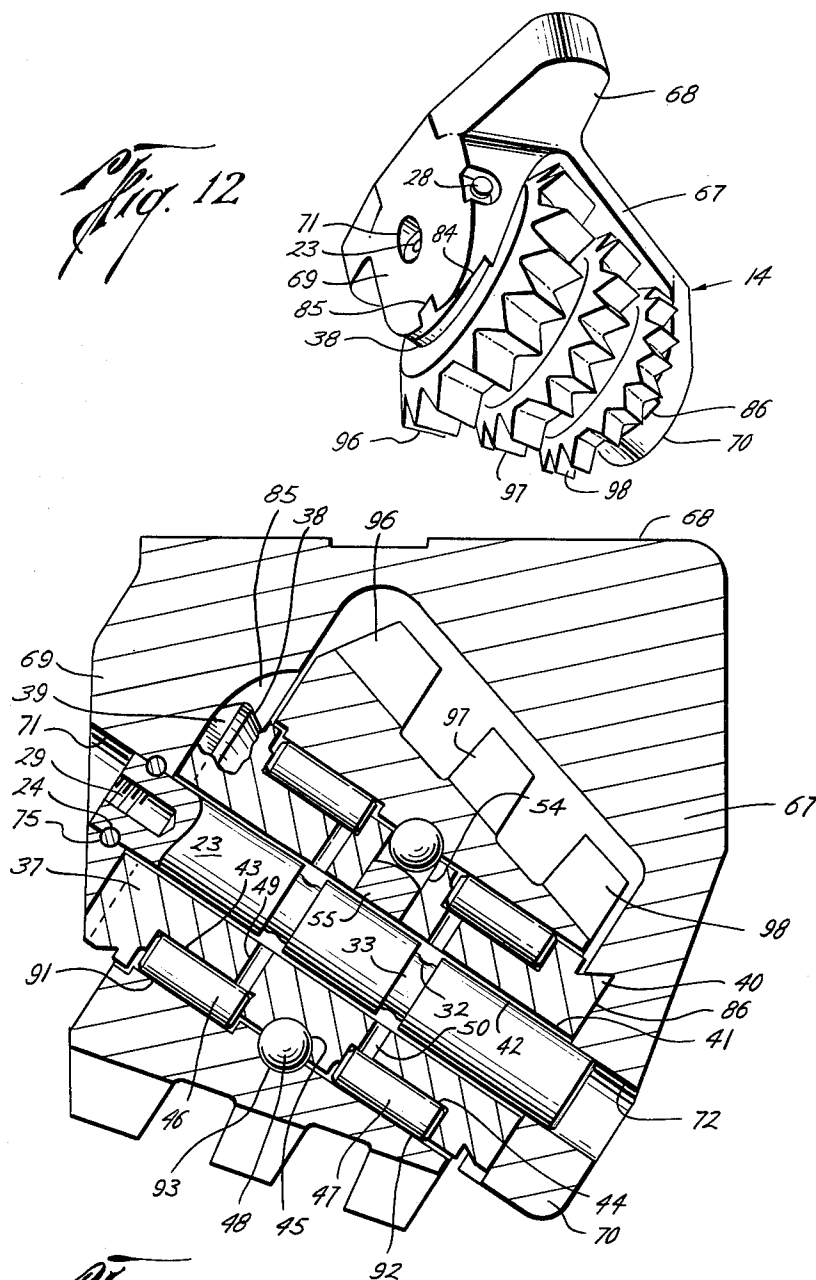
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LARGE HOLE EARTH BORING DRILL BIT

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6 Sheets-Sheet 6



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3,203,492

LARGE HOLE EARTH BORING DRILL BIT
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Filed Jan. 14, 1963, Ser. No. 255,420
13 Claims. (Cl. 175-355)

This invention relates to an earth boring drill bit of the rolling or rotating cutter type adapted for construction in sizes for drilling holes of the order of three feet in diameter upward to a number of times that diameter although the invention is not limited to any specific range of sizes.

In drilling large holes usable as mine shafts, tunnels and the like, as well as large diameter upper end portions of wells intended to be drilled to great depths, it has been found desirable to employ a bit having a considerable number of relatively small rolling or rotatable cutters rotatably mounted on a bit head and exposed endwise and to the outer wall of a hole being drilled. In some instances, the cutters may be directed in the same endwise direction in which the operating stem extends. And this is true in the practice of the present invention also. It is desirable that these be so spaced and located that upon rotation of the bit every portion of the bottom of the hole being drilled will be acted upon by one or more cutters to disintegrate the formation. In bits of this character almost the entire wear of drilling takes place on the rotatable cutters rather than on the bit head, which will serve through the life of many cutters.

However, difficulty has been encountered in providing adequate bearing support for such cutters and the parts on the head for supporting the cutters, so that the parts will not be come distorted under the stresses of drilling. For this reason, even though such parts do not wear, it has been found necessary to provide for them to be more or less readily replaced in order to take advantage of the relatively longer life potential of the remainder of the bit head. Also, the distortion of such parts may so change the disposition of the cutters thereon as to impair or destroy the effectiveness of individual cutters and even of the entire bit. At the same time the danger is present that cutters may be lost in the hole so as to require them to be fished out with much loss of time and at great expense.

It is therefore an object of this invention to provide in a drill bit of the character above mentioned a cutter support means on the head so constructed that it will be adequately supported against distortion under drilling stresses to such an extent as to render exceptional the necessity for replacing it during the life of a bit head on which it is carried.

Another object is to provide such a support in which the application of drilling stresses will result in bracing firmly against one another spaced individual parts of the support subjected to opposite distorting forces, and thereby to greatly reduce the likelihood of distortion of such parts.

Another object is to provide such a bit in which the individual cutters will be carried on bearing members extending completely through each cutter and supported on the body at both of their respective opposite ends to provide maximum bearing support for the cutters.

Another object is to provide a structure of the type last mentioned in which such bearing members will interlock with the bit body parts at opposite ends of the cutters to support such parts against each other to resist both spreading and closing movement relative to one another under drilling stresses.

Another object is to provide such a structure in which such interlocking will become tighter and more rigid under drilling stresses.

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Another object is to provide such a bit in which the individual cutters may be readily removed and replaced while such bit body parts for supporting the cutter opposite ends remain on the body of the bit head.

Another object is to provide a cutter and bearing member which may be fully assembled relative to each other for removal and replacement relative to the bit head, and relative to the parts adapted to receive and support the bearing at opposite ends of the cutter.

Another object is to provide a means for securing such assembly in place so as to positively secure it against becoming lost in a bore hole, yet which securing means will not be subjected to any substantial stresses or likelihood of distortion or breakage due to drilling stresses.

Other objects and advantages of this invention will become apparent from the following description taken in connection with the accompanying drawings in which are set forth by way of illustration certain embodiments of this invention.

In the drawings:

FIG. 1 is a cross section of a bit head constructed in accordance with this invention, taken along a plane through the axis thereof as indicated by the line 1-1 in FIG. 2 and showing in dotted lines exemplary positions of cutters and their mountings which form a part of the completed drill bit.

FIG. 2 is a bottom plan view of the bit head illustrated in FIG. 1, likewise showing in dotted lines the positions which would be occupied by two of the rotating type cutters to make up the completed drill bit.

FIG. 3 is a top plan view of the bit head shown in FIGS. 1 and 2.

FIG. 4 is a perspective view of one of the cutters adapted to cut on the bottom of the hole at a position spaced from the outside wall thereof and known as an inside cutter, together with the supporting arms and body assembled with respect to the cutter.

FIG. 5 is a longitudinal cross section through the cutter illustrated in FIG. 4 and its support and bearing parts.

FIG. 6 is a fragmentary cross section taken along the line 6-6 of FIG. 5.

FIG. 7 is a view of the cutter support structure illustrated in FIGS. 4 and 5 for supporting an inside cutter, with the hollow cutter bearing shaft shown in phantom therein.

FIG. 8 is a transverse cross section through the structure illustrated in FIG. 7, taken along the line 8-8 of FIG. 7 and showing the bearing support part on the radially outermost arm of such structure.

FIG. 9 is a view similar to FIG. 8 but showing a modification.

FIG. 10 is an end view of one type of cutter tooth arrangement employed on both inside and outer cutters.

FIG. 11 is an end view of the cutter tooth arrangement employed on certain other of the inside and outer cutters.

FIG. 12 is a view similar to FIG. 4 but showing one of the outer cutters and its support parts assembled with respect to one another.

FIG. 13 is a view similar to FIG. 5 but showing the structure set forth in FIG. 12.

Referring more specifically to the drawings, there is illustrated in FIGS. 1, 2 and 3 a bit head 1 in the form of a generally disc shaped body having an elongated sleeve-like central portion 2 forming a hub with an opening 3 therethrough, the center of this opening being the central axis about which the bit head and the bit as a whole are intended to rotate in the course of drilling a well. The central hub 2 is joined to the outermost rim portion of the bit head 1 by means of a web 4 which is slightly conical in its over-all configuration. Additionally, radially extending webs 5 are provided at circumferen-

tially spaced positions to lend stiffness and strength to the structure of the bit head.

On the convex or lower face of the bit head it will be seen on reference to FIG. 2 that there are provided a plurality of bosses providing for the mounting of individual cutter supports. These bosses are arranged in groups in which they are spaced circumferentially from the other bosses in the same group and the groups are of different distances from the central axis of the bit head. Thus, the bosses 6 are spaced circumferentially from each other adjacent the outer margin of the bit head and are intended for the mounting of the outside supports illustrated in more detail in FIGS. 12 and 13. The group of bosses 7 are located likewise in circumferentially spaced relationship to one another but are all of similar distance from the central axis of the bit head. The same is true of the bosses 8 and the bosses 9. All of the bosses 7, 8 and 9 are intended for the mounting of supports for inside cutters which are illustrated more in detail in FIGS. 4 to 8, inclusive.

The central opening 3 through the bit head is adapted to receive a length of pipe 10 having a suitable connection 11 on a projecting end thereof for receiving a rotary operating stem whereby the drill bit will be rotated in use. This section of pipe 10 may be secured in place within the bit head in any suitable fashion as by the welding 12 and 13 at the upper and lower extremities of the bit head.

At 14 is indicated in dotted lines in FIGS. 1 and 2, the mounting of an outside cutter support with its outside cutter therein and at 15 is indicated the mounting of an inside cutter support with a cutter therein. Both of these are in dotted lines in FIGS. 1 and 2 and are for the purpose of illustrating the manner in which the bosses 6, 7, 8 and 9 serve as positioning means for mounting the cutter supports for the outside and inside cutters respectively. It will be understood that these bosses 6, 7, 8 and 9 are so positioned that they will locate the respective cutters in a manner to balance the completed drill bit when it has all of the cutters mounted thereon. It will further be understood that while the bosses 6, 7, 8 and 9 are shown as having plane surfaces located in radial planes with respect to the central axis of the bit head, they are not necessarily of such configuration or disposition so long as they are appropriately shaped to receive the mating portions of the cutter supports. In FIG. 1, there are shown in broken lines the radial positions of certain of these bosses, rotated from the position they would actually occupy into the plane of the section. There is also shown in dotted lines, a conventional small hole bit 16, which may be used to cut the center portion of the bore hole. It is also to be understood that although the cutter supports are shown as being formed of bodies separate from the main portion of the bit head and adapted to be secured thereto as by welding, they could be formed integrally or secured to the bit head in some other fashion than by welding. In special circumstances under which it might be anticipated that these cutter support parts would be damaged in use, it might be desirable that they be formed separately and removably secured by any well known means, but in the absence of such circumstances it is preferred that they be either integrally secured or otherwise made integral with the main portion of the bit head.

Referring now to FIGS. 4-8, there is illustrated a support member 15 for supporting an inside cutter. This support member has an elongated intermediate connecting portion 17 adjacent one end of which is an enlarged base or pad 18 adapted to be welded or otherwise secured to one of the bosses, 7, 8 and 9 on the bit head, whereupon it would become a part of the bit head. This support would be mounted on the bit head in such fashion that the base or pad 18 would be at the radially outermost extremity thereof and the remainder of the support would extend radially inwardly therefrom.

At the outermost extremity of the support 17 is a cutter support arm or part 19 and at the radially inner extremity is another cutter support arm or part 20.

The cutter support arm 19 is provided with an opening 21 therethrough and the cutter support arm 20 is provided with an opening 22 therethrough, the openings 21 and 22 being in axial alignment with one another and being of a size to receive a retainer pin 23 extending therethrough. This retainer pin is illustrated as merely being supported within the opening 22 but as being locked in place within the opening 21. This locking of the pin 23 in place within one of the openings 21 and 22 so that it will be secured within both openings is accomplished in the illustration shown by semi-circular circumferential groove 24 in that portion of the pin lying within the opening 21, and by complementary groove 25 in the interior of the opening 21 so that when these two grooves are aligned with one another they will provide a circular passageway around the pin 23 partly in the pin and partly in the material of the arm 19 surrounding the opening 21. In order to lock these parts together there is illustrated a nail-like member 26, preferably of relatively soft material, forced into place in this groove through a passageway 27 leading from the exterior of the arm 19 until it encircles a major portion of the pin 23 as shown in FIG. 6. The outer end of this nail-like member 26 is shown as having a head 28 by which if and when desired it may be extracted to allow the pin 23 to be removed from the arms 19 and 20.

In order to facilitate the removal of the pin 23 in the event it should become corroded or otherwise stuck in its position within the openings 21 and 22, there is provided in one end of the pin a tapped opening 29 into which a suitable threaded pulling member might be inserted so as to pull the pin out. It is contemplated by this invention that the retaining pin 23 might also serve the purpose of assisting in the lubrication of the bearing for the cutter to be supported in surrounding relation to this pin in a manner which will presently be described. In order to serve this purpose a lubricant passageway 30 is illustrated as being formed from that end of the pin opposite the tapped opening 29 for a substantial portion of the length of the pin. The outer end of this pin may be threaded as shown at 31 so as to provide a connection through which lubricant may be forced into the passageway 30. Likewise, radial openings 32 are illustrated connecting this central passageway 30 in the pin 23 with circumferential grooves 33 on the exterior surface of this pin so that lubricant could pass out through the radial openings 32 and then flow circumferentially around the pin through the grooves 33.

On the inner face of the cutter support arm 19 and opposed to the cutter support arm 20 is a bearing support part 34 which in the illustration takes the form of a dove-tail mortice or groove. Formed in the bottom of this groove and extending transversely of the axis of the opening 21 is a deeper groove or keyway 35. Preferably this keyway extends the full length of the groove 34 and slightly therebeyond so that it would be free to receive a spline or key of the full extent of the mortice or groove 34.

Similarly on the inner face of the arm 20 which faces the arm and is opposed to the arm 19, there is formed a bearing support part 36 likewise in the form of a groove or mortice of dove-tail shape.

These two bearing support parts being opposed to each other and aligned with each other are adapted to receive and support the cutter support bearing shaft 37 which has at its one end a tenon 38 adapted to fit snugly within the groove or mortice 34. At the same end it also has a transversely extending spline or key 39 adapted to fit within the keyway 35 and providing a non-circular part on the bearing shaft 37 by which it may be prevented from rotating when in place between support arms 19 and 20.

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At its opposite end the bearing shaft 37 has a second tenon 40 likewise shaped to fit snugly within the mortice or groove 36. This bearing shaft 37 is shown as being hollow and providing a passageway 41 therethrough somewhat larger than the exterior dimension of the pin 23 so as to provide a very loose embracing of this pin which will permit the bearing shaft 37 to move a substantial distance radially of the pin without being restricted thereby.

It will be seen that the arrangement just described permits the load on the bearing shaft to force the tenons 38 and 40 tightly against the ends of the grooves 34 and 36, respectively. These grooves being dove-tail in cross section and having their ends likewise provided with an undercut of the same nature as the sides of the grooves, when the tenons 38 and 40 are forced to the bottom or ends of the grooves they will provide a snug rigid connection between the bearing shaft 37 and the arms 19 and 20, respectively. This will very rigidly connect these two arms and serve to brace and support them one against the other. When drilling stress is placed on the cutters surrounding such bearing shafts 37, the same will tend to force these bearing shafts in a direction to tighten the tenons in the grooves and provide this interconnection and bracing of the arms 19 and 20 against one another. Whereas normally such drilling forces exerted upon a cutter mounted between two such arms tends strongly to move the arms apart and deform them, this tendency in the present structure will be overcome by the interlocking engagement just described.

Preferably the portions of the mortices or grooves which form the closed ends thereof against which the tenons 38 and 40 will be forced in use, are made of circular cross section and the tenons themselves may be formed by circular grooves about the end portions of the shaft so that they likewise will be circular in cross section to fit the grooves. However, the mortice and tenon may be of any shape desired so long as they provide a taper or wedge fit which will tend to bind under the stresses imposed on the cutter and bearing shaft during drilling, specifically in the form just described under movement of the bearing shaft more deeply into the space between the arms 19 and 20.

On the other hand, other types of movement, preferably those which would take place or tend to take place under the stresses encountered in drilling, could be employed for tightening these joints as well as the rectilinear movement in the form just described. For example, in FIG. 9, there is illustrated a modification in which the bearing shaft opening would be the same size as the pin 23 so as to closely embrace the same yet permit the bearing shaft 37 to rotate about the pin. In this form there would be no element corresponding to the key 39 or the keyway 35. Instead, however, the tenon on the end of the bearing shaft would be made slightly eccentric to the hole through the bearing shaft and the position of the pin as determined by the hole 121 through the arm 119 would be slightly eccentric with respect to the undercut shoulder forming the circular end of the groove or mortice 134. In this figure the point CE would represent the center of the hole 121 and of the pin 23 which would be mounted therein. The point C1 would represent the center of the rounded end portion of the undercut shoulder forming the edge of the groove or mortice, and would also represent the center of the tenon on the end of the bearing shaft in its initial position as indicated by the dotted lines 138a. Inasmuch as the outer edge of the tenon represented by the dotted line 138a is eccentric with respect to the shaft as determined by the opening 121, then when the bearing shaft rotates about the center of the opening 121, the center of the tenon C1 would rotate about the center CE until it arrived at some second position such as C2. During such rotation the position of the tenon would also change from the dotted circle 138a to the dotted circle 138b in which posi-

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tion it would come into tangency with the inside of the mortice near the upper portion of its curve and seat tightly preventing further rotation of the bearing shaft about the center CE and wedging the bearing shaft tightly in the mortice to rigidly join the bearing shaft to the arm 119. Thus in this form the wedge surfaces would tend to be tightened by rotation of the bearing shaft which would be induced in turn by the rotation of the cutter in the course of the drilling operation. As before, the stresses imposed by the action of the drilling operation would tend to tighten the wedge surfaces and hence the joint between the arm 119 and the shaft on which the cutter rotates. A similar mounting for the shaft will be provided at its opposite end on an arm corresponding to the arm 20.

In both of the forms described it will be seen that the major force transmitted to the bearing shaft by the cutter will be transmitted by the bearing shaft directly through the mortice and tenon joint to the bit head and that in the first form described no such force will be transmitted through the pin 23 while in the second form described very little if any such force will be so transmitted through the pin 23.

With reference to the actual cutter bearing, it will be seen that the cutter bearing shaft 37 has on its outer surface a pair of spaced radial bearing races 43 and 44 and an intermediate ball thrust bearing race 45 which are respectively adapted to receive rolling radial bearing members 46 and 47 and ball thrust bearing members 48. Radial openings 49 and 50 extend through the cutter bearing shaft 37 from its inner bore 41 to the radial bearing races 43 and 44, respectively, to lubricate such radial bearings. If desired, similar means may be provided for lubricating the thrust ball bearings.

Surrounding the bearings 46, 47 and 48 is a cutter having a bearing bore therethrough open at both ends so as to permit a bearing support on both ends of the cutter. The interior of this cutter body is provided with radial bearing races 51 and 52 which, when the cutter is in place on the bearing shaft 37, will be directly opposed to the radial bearing races 43 and 44 on the shaft and the radial bearing elements 46 and 47 between such races. Likewise, there is a thrust bearing race within the cutter as shown at 53 which cooperates with the thrust bearing race 45 on the shaft to receive the thrust balls 48. These balls may be put in place before the bearing shaft 37 is inserted between the arms 19 and 20 by inserting the balls through the hollow interior of the shaft 37 and through a lateral bore 54 provided for the purpose. Thereafter this lateral bore is closed by any suitable method such as by a plug 55 pressed into place therein. In this manner the cutter is provided with adequate bearing on the shaft 37 and is locked in place thereon.

On the exterior of the cutter it is provided with a number of circumferential rows of cutter teeth illustrated as being three in number in this case and designated by the numerals 56, 57 and 58, respectively. These rows of cutter teeth are separated in the usual fashion by spaces, it being the intention that passage of successive cutters over substantially the same area will cause the disintegration of the formation left between the rows of teeth of one such cutter. For this purpose the cutter supports of a particular circumferential aligned group of cutters may be at slightly different distances from the central axis of the bit head.

In FIGS. 10 and 11 are illustrated two different forms of tooth arrangement which may be employed on a cutter. Preferably all of the inside cutters will be identical except that in any given circumferential group at least one of each type of tooth arrangement shown in FIGS. 10 and 11 will be employed. Likewise, preferably all of the outside cutters will be identical except that at least one cutter of each of two types of tooth arrangement will be employed. It will be understood, however, that this invention is not dependent upon having all of

the inside cutters identical nor on having all of the outside cutters identical, this being preferable only from the standpoint of economy and ease of interchange. It will also be understood that the tooth arrangements illustrated are not necessarily the ones to be employed, the important thing being that two different tooth arrangements as a minimum be employed in any circumferential group of cutters.

With reference more specifically to FIGS. 10 and 11, cutters with the two different tooth arrangements are illustrated at 59 and 60 in these two figures, respectively. In each of these figures it will be seen that some of the cutter teeth have narrow spaces 61 therebetween whereas less frequently adjacent teeth are separated by a wider space 62. Thus the cutter teeth on a given cutter are divided into groups by the wider spacing between certain teeth. In the cutter 59 shown in FIG. 10 there are two groups of three teeth each and one group of four teeth and one of five teeth, whereas in the cutter 60 shown in FIG. 11 there is one group of three teeth, one group of four teeth and two of five teeth each.

The purpose of having two different sets of tooth arrangement on different cutters within the same circumferential group is that if only one tooth arrangement were employed on all the cutters, then the teeth of each cutter might exactly track the teeth of the previous cutter with the result that each tooth on each cutter would be contacting a place already chipped away on the bottom of the hole and the cutting would be at a much slower pace than if the teeth engaged portions of the hole not already chipped. By having cutter teeth of different tooth arrangements as illustrated the teeth on succeeding cutters will not track one another and at least some of the teeth on the cutter following will strike at places not previously chipped by the preceding cutter teeth, resulting in an increased rate of drilling. More than two different tooth arrangements may be employed on cutters of the same circumferential group if desired, but it is felt that the use of two different tooth arrangements on different cutters in the same circumferential group will prevent tracking to a sufficient degree to make it unnecessary to employ more different arrangements.

Turning now to FIGS. 12 and 13, much the same arrangement is shown for mounting the outside cutters as was previously described in connection with FIGS. 4 and 5 for mounting the inside cutters.

Because it is desirable if the outer end of the outside cutters is to cut outwardly beyond the outer confines of the bit head that the outside cutters be mounted on a steeper angle with respect to the central axis of the bit than the angle on which the inside cutters are mounted, it is necessary that a different mounting be employed. This increased angle is also desirable for the purpose of balancing the thrust due to the cutting of the cutter against the outside wall of the hole against the thrust in an axial direction due to the impact on the bottom of the hole. An angle has been selected which substantially balances these forces and eliminates a major portion of the thrust which otherwise might be present tending to move the outside cutters axially one way or another upon their bearing shafts.

Thus in FIGS. 12 and 13 there is shown a cutter support member 14 which is quite similar to but on a different angle from the cutter support member 15 previously described. Many of the parts are interchangeable in the bearings and retaining means employed with this cutter support and have been numbered accordingly with numbers corresponding to those utilized in FIGS. 4 and 5. Since this support is specifically different, however, it will be briefly described and the differences and similarities discussed.

The support member 14, like the support member 15, has an elongated intermediate connecting portion 67, but unlike the connecting portion 17, it is not made relatively thin but fairly thick and provides a portion

of the base or pad 68 which is adapted to be welded or otherwise secured to one of the bosses 6 on the bit head. Thereupon this support becomes a part of the bit head. The difference in shape of the support member is due to the difference in direction and nature of stresses upon this support and upon the side cutters as compared with the inside cutters.

At the outermost extremity of the support 67 is a cutter support arm 69 and at the radially inner extremity is a cutter support arm 70 corresponding, except for their angles and length, to the cutter support arms 19 and 20 of the support member 17.

The cutter support arm 69 is provided with an opening 71 therethrough and the cutter support arm 70 is provided with an opening 72 therethrough corresponding in position and function to the openings 20 and 21 in the arms of the support member 17. They are in axial alignment with one another and of a size to receive a retainer pin which may be the same retainer pin 23 as used in connection with the support member 17. Inasmuch as this retainer pin may be identical with the retainer pin 23, it will not be again described. It is locked in place in a manner similar to that of the pin 23 within the arm 19, the arm 69 having a groove 75 therein complementary to the groove 24 in the pin 23 and for the same purpose. The same type of fastening employing a nail with a head 28 may be inserted in the same fashion as in the previous description and pin 23 thereby locked in position within the arms 69 and 70.

On the inner face of the cutter support arm 69 opposed to the cutter support 70 is a bearing support part 84 in the form of a dove-tail mortice or groove. In the bottom of this groove and extending transversely of the axis of the opening 71 is a deeper groove or keyway 85. As in the case of the groove 35, the keyway 85 extends the full length of the groove 84.

Similarly, on the inner face of the arm 70 which faces and is opposed to the arm 69 there is formed a bearing support part 86, likewise in the form of a groove or mortice of dove-tail shape. These two bearing support parts 84 and 86 are adapted to receive and support the cutter support bearing shaft 37 which may be identical with the shaft of the same number heretofore described.

The interrelation between the bearing support member 67 and the pin 23 and bearing shaft 37 are identical with the relation between the bearing support 17 and the pin 23 and bearing shaft 37 and need not be again described.

The outside cutter shown in FIGS. 12 and 13 has inner radial bearing races 91 and 92 and an inner thrust bearing race 93 similar in all respects to the races 51, 52 and 53 of the inside cutter. Likewise, the outside cutter has rows of cutting teeth on its exterior, these being designated as 96, 97, and 98, respectively, in similar fashion to the rows of cutting teeth 56, 57 and 58 on the exterior of the inside cutter. It will be understood that in neither case is the number of rows of teeth of great significance as any number of rows of teeth desired may be employed, but it is felt desirable to provide all of the cutters on a bit of this type as nearly of the same characteristics as possible except for the necessary differences between inside and outside cutters as above described and the necessary contrasting of cutter tooth arrangements on cutter teeth cutting along the same path.

From the foregoing it will be apparent that an apparatus has been described which fully accomplishes all of the objects and advantages sought by this invention. Specifically, it provides a sturdy and readily usable and durable bit head especially adapted for the mounting of the necessary cutters in specified positions on specially provided bosses designed to receive the same. It further provides cutter support members at the positions desired and bearing means for supporting the cutters in the cutter support members in such fashion as to retain the cutter support members against distortion and utilize the stresses

resulting from drilling to support and brace rather than to distort the cutter support arms. Furthermore, it provides a means whereby cutters may be readily replaced without special tools and with out special knowledge of any kind and provides for interchangeability of as many parts as possible so as to minimize the necessary stock to be carried on hand. At the same time, it provides for utilizing to the maximum life the bit head and the cutter support members carried thereby. It further provides for the utilization of a cutter and bearing assembly which if desired can be previously made up in a factory and lubricated before being sent out to be mounted on a bit head, thereby minimizing the number of operations necessary to be carried out by relatively unskilled workmen in the field, avoiding exposure to dirt and other deleterious matter of highly machined and polished bearing parts.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described what is claimed is:

1. An earth boring drill bit head comprising a body of generally disc shape about a central axis and having means on one face for securing a rotary driving stem thereto concentrically with said axis, and a series of cutter supporting mounting bosses on the opposite face spaced from one another about said axis and circumferentially aligned in groups, said bosses each having a cutter support engaging surface in a plane approximately normal to said axis, the groups being at different distances from said axis and the cutter support engaging surfaces of the respective groups being in different planes.

2. An earth boring drill bit comprising a head of generally disc shape about a central axis and having means on one face for securing a rotary driving stem to the head concentrically with said axis, a series of pairs of cutter support arms extending from the opposite face, the pairs being spaced from one another about said axis and circumferentially aligned in groups, the groups being at different distances from said axis, the arms of each pair being at different radial distances from said axis and having opposed, aligned bearing support parts for receiving and supporting the opposite ends of a cutter bearing, a cutter bearing shaft having spaced portions interlocked with the bearing support parts of the respective arms of each pair, said interlocked bearing support parts and spaced shaft portions comprising tightly interfitting projections and recesses on said parts and shafts extending in a direction transverse to and spaced from said shaft axes to brace the arms of each pair through said shafts and prevent movement of said arms toward and from one another, and projections and recesses on said shafts and one arm of each pair having radially extending interengaging surfaces to prevent rotation of said shafts relative to said arms, and a rotating type cutter rotatably mounted about each such shaft between the arms with which the shaft is interlocked.

3. An earth boring drill bit as set forth in claim 2 in which said bearing shafts have openings therein from end to end, in combination with means carried by said arms and extending through each of said shafts to retain said cutters and shafts against accidental dislodgement from between said arms.

4. An earth boring drill bit as set forth in claim 3 in which said retaining means is free of bearing engage-

ment with said bearing shaft whereby bearing forces will be transmitted directly from said bearing shaft to said arms.

5. An earth boring drill bit as set forth in claim 4 in which said first mentioned projections and recesses are so disposed as to be tightened upon movement of said bearing shafts toward the face of said head and said second mentioned projections and recesses are interengaged guide and slide means on said shafts and arms respectively for restraining said shafts to a desired path in such movement toward the face of said head and against rotation of the shafts with respect to the arms.

6. A cutter mounting for a rotatable type cutter for a drill bit comprising a body having a pair of generally parallel cutter bearing support arms projecting therefrom, said arms having opposed seats thereon and a cutter bearing shaft having its ends removably seated in said seats respectively, said seats and shaft ends having interengaging grooves and tenons with opposed tapered engaging parts adapted to wedge into tighter interlocking engagement upon relative movement in one direction, and means for retaining said seats and shaft ends in engagement with each other.

7. A cutter mounting for a rotatable cutter of a drill bit as set forth in claim 6 in which said grooves are in the arms and said tenons on the shaft ends, said grooves terminating at their parts most remote from the ends of said arms in tapered undercut shoulders and said tenons having side portions of mating shape engaging such shoulders when said tenons are fully engaged with said grooves whereby when said shaft ends are moved into said seats and said tenons are forced against said shoulders said arms will be rigidly secured together and braced against one another by said shaft.

8. A cutter mounting for a rotatable type cutter of a drill bit as set forth in claim 6 in which said grooves are in the arms and said tenons on the shaft ends and said grooves are open toward the ends of said arms and are closed at their opposite ends with circular arc shaped tapered undercut shoulders and said tenons have circular mating side portions engaging such shoulders when said tenons are fully engaged with said grooves, whereby when said shaft ends are moved from the ends of said arms into said seats and said tenons are forced against said shoulders said arms will be rigidly secured together and braced against one another by said shaft.

9. A cutter mounting for a rotatable type cutter of a drill bit as set forth in claim 6 in which said shaft is hollow and said means for retaining is a pin extending freely through said shaft and removably secured in engagement with said arms.

10. A replaceable bearing shaft and cutter assembly for a drill bit comprising a rotating type cutter open at both ends and a bearing shaft extending therethrough and projecting from both ends of the cutter, and radial and thrust bearings between said cutter and shaft, the projecting ends of said shaft being dove-tail tenons.

11. A replaceable bearing shaft and cutter assembly for a drill bit as set forth in claim 10 in which said shaft has a hollow interior and lubricant passages from its hollow interior to said bearings.

12. A replaceable bearing shaft and cutter assembly for a drill bit comprising a rotating type cutter open at both ends and a bearing shaft extending therethrough and projecting from both ends of the cutter, and radial and thrust bearings between said cutter and shaft, the projecting ends of said shaft having V-shaped encircling grooves adjacent their extremities forming said ends into dove-tail tenons of circular cross section, and one of said ends having a part of non-circular cross section by which said shaft may be held against turning.

13. An earth boring drill bit comprising a head of generally disc shape about a central axis and having means on one face for securing a rotary driving stem to the head concentrically with said axis, a series of pairs of cutter

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support arms extending from the opposite face, the pairs being spaced from one another about said axis and circumferentially aligned in groups, the groups being at different distances from said axis, the arms of each pair being at different radial distances from said axis and having opposed, aligned bearing support parts for receiving and supporting the opposite ends of a cutter bearing, a cutter bearing shaft for each pair having spaced end portions, means rotatably supporting said shaft on said arms for rotation on an axis fixed relative to said shaft and arms, interlocking means on the said bearing support parts of the respective arms of each pair and on said shaft end portions, comprising interfitting grooves on said arms extending at least between said shaft axis and disc and projections on said shaft eccentrically of said shaft axis, whereby rotation of such shaft on its axis and relative to said means for supporting said shaft will cause said

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grooves and projections to interengage and tighten against one another and brace the arms of such pair through said shaft to prevent movement of said arms toward and from one another, and a rotating type cutter rotatably mounted about each such shaft between the arms with which the shaft is interlocked.

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