Oct. 23, 1934. J. H. HOWARD ET AL 1,978,085

CORE DRILL

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Fig 1

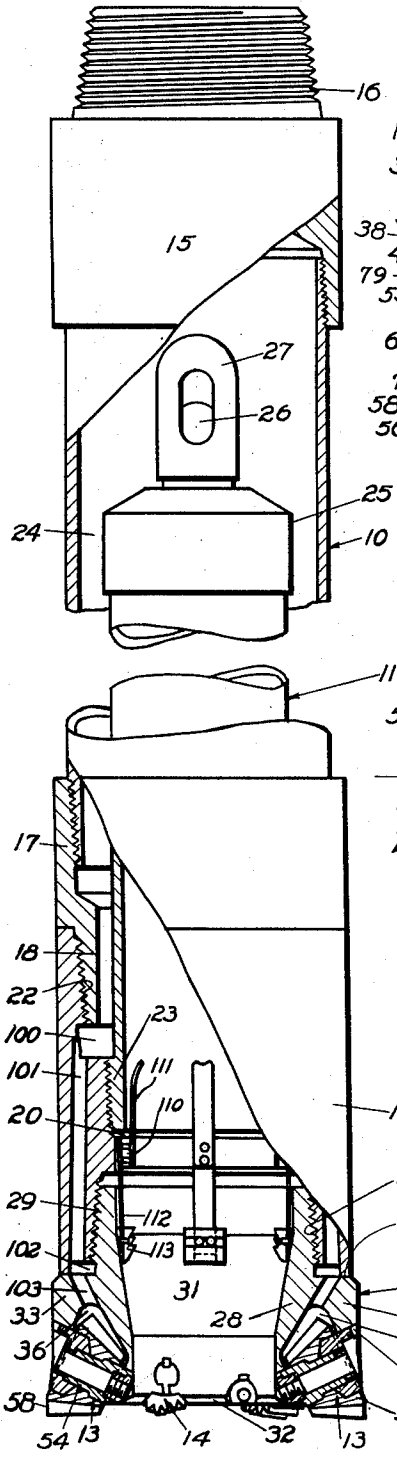


Fig 2

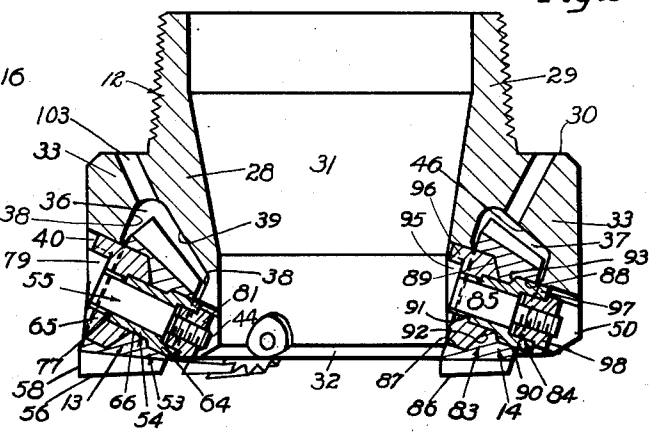
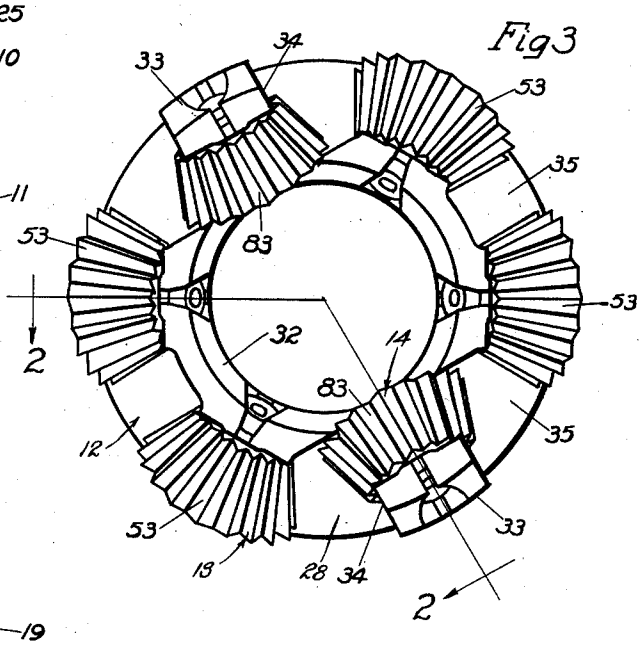


Fig 3



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CORE DRILL

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Fig 4

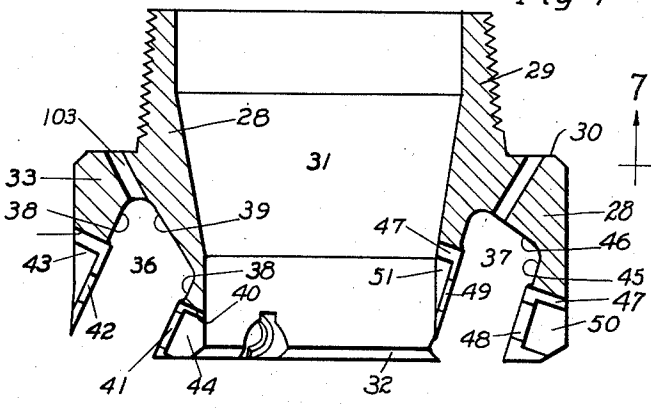
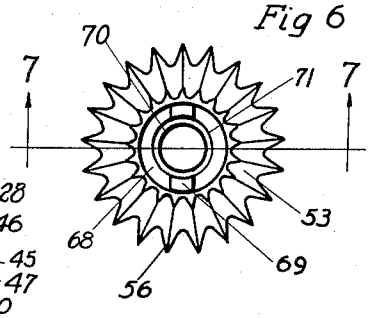


Fig 6



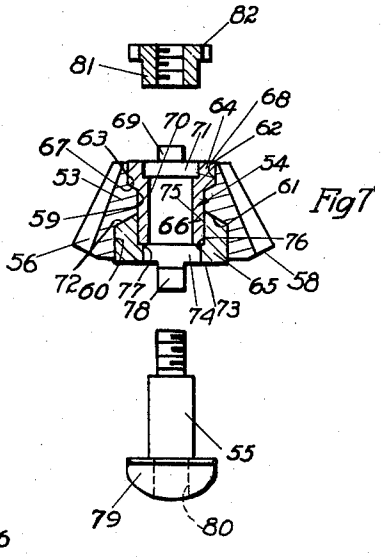


Fig7

Fig5

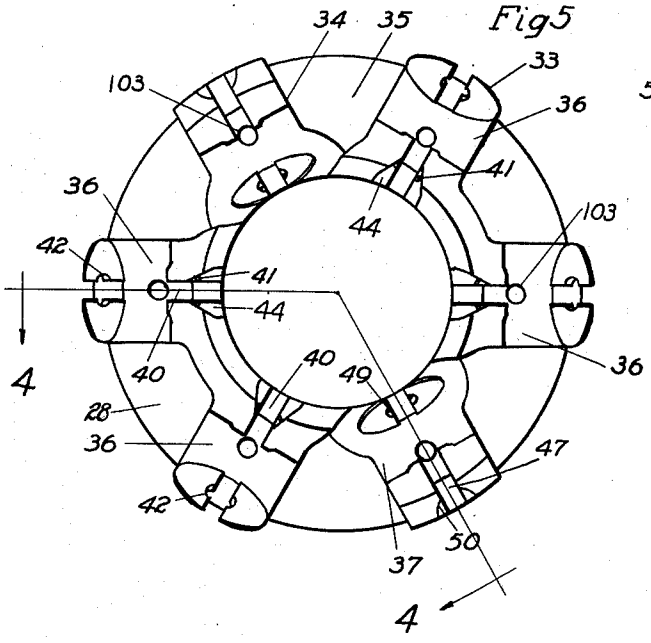
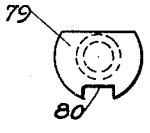


Fig 8



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CORE DRILL

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Fig 9

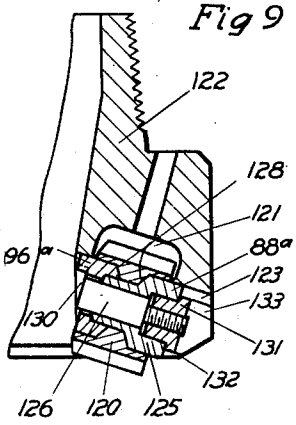


Fig 10

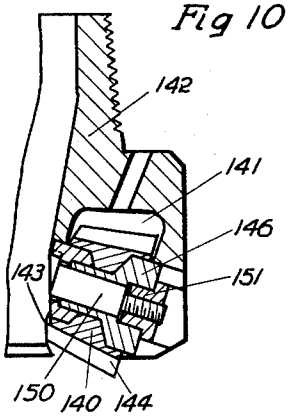


Fig 11

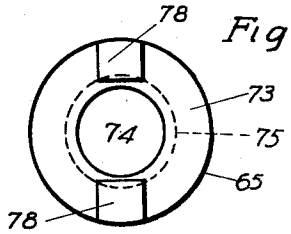


Fig 13

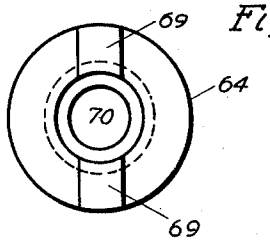


Fig 12

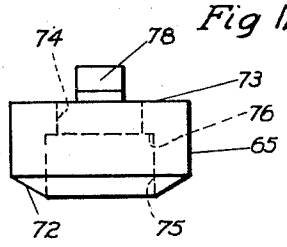
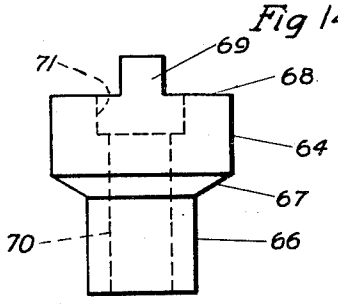


Fig 14



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Patented Oct. 23, 1934

1,978,085

UNITED STATES PATENT OFFICE

1,978,085

CORE DRILL

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Application January 16, 1933, Serial No. 651,984

7 Claims. (Cl. 255—72)

This invention relates to a well tool, and relates more particularly to a core drill. It is a general object of the present invention to provide an improved core drill involving simple, practical and dependable cutter mounting means.

Another object of the invention is to provide a simple and effective means for detachably mounting rotatable cutters on a well drilling tool.

Another object of the invention is to provide a well tool including cutter assemblies mounted in the bit head of the tool in a manner so that they may be easily and quickly removed or replaced at the well drilling rig.

Another object of the invention is to provide a well tool of the character mentioned in which the detachable cutter assemblies are detachably and securely locked in position on the tool so that they cannot be loosened during the drilling operations, or have any of their parts lost in the well bore.

Another object of the invention is to provide a core drill bit head having recesses for holding the cutters and cutter mounting means that effectively rotatably support the cutters in the recesses and securely connect or tie together the portions of the bit head at the opposite ends of the recesses.

Another object of the invention is to provide a practical and dependable means for detachably mounting rotatable cutters on a well tool that is such that the cutters may be accurately and correctly positioned and mounted on the bit head of the tool without using special tools or equipment.

Another object of the invention is to provide a cutter mounting of the character mentioned including a two-piece bearing, each piece or part of the bearing having portions of different diameters providing shoulders that cooperate with oppositely faced internal shoulders in the rotatable cutter to effectively support the cutter against end thrusts in both directions.

It is another object of the invention to provide a cutter mounting involving a practical and effective bearing for rotatably supporting the cutter that consists of two integrally connected parts.

A further object of the invention is to provide a cutter mounting of the character mentioned that includes a bearing that directly rotatably carries the cutter and that may be treated to be wear resistant, and a pin or bolt that carries the bearing that is not subjected to any wear or friction so that it may be treated for maximum toughness.

A further object of the invention is to provide a core drill having simple and effective means for handling the circulation fluid for flushing the cutters.

A further object of the invention is to provide a simple and inexpensive core drill bit head body or shoe for carrying a plurality of rotatable cutters.

Various objects and features of the invention will be best and fully understood from the following detailed description of typical preferred forms and applications of the invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a side elevation of a core drill involving one form of the invention with certain parts broken away to appear in vertical cross section. Fig. 2 is an enlarged vertical detailed sectional view of the bit head and cutter assemblies of the tool illustrated in Fig. 1, being a view taken as indicated by line 2—2 on Fig. 3. Fig. 3 is a bottom view of the bit head and cutter assemblies. Fig. 4 is an enlarged vertical detailed sectional view of the bit head body or shoe, being a view taken as indicated by line 4—4 on Fig. 5. Fig. 5 is a bottom view of the bit head shoe. Fig. 6 is an enlarged end view of one of the cutter assemblies apart from the other portions of the tool. Fig. 7 is a longitudinal detailed sectional view of the several parts of one of the cutter assemblies. Fig. 8 is an end view of the pin or bolt embodied in the cutter assembly. Fig. 9 is a fragmentary vertical detailed sectional view of the tool embodying a cylindrical cutter carried by the cutter mounting means provided by the invention. Fig. 10 is a fragmentary vertical detailed sectional view of a tool including a frusto-conical inner cutter with its small end innermost and carried by the mounting means of the invention. Fig. 11 is an enlarged end view of one of the parts of a bearing included in the cutter assembly. Fig. 12 is a side elevation of the bearing part illustrated in Fig. 11. Fig. 13 is an end view of another part of the bearing, and Fig. 14 is a side elevation of the bearing part illustrated in Fig. 13.

The bit head structure and the detachable cutter assemblies provided by the present invention may be embodied in coring outfits or core drills of various types. Our co-pending application entitled Rock core drill, Serial No. 727,499, filed May 25, 1934, describes and claims a structure of the same general class as that of the present invention. Throughout the following detailed description, we will disclose typical preferred forms of the invention embodied in a more or less common form of coring outfit or core drill, it being understood that the invention is not to be taken as limited or restricted to the

specific forms or applications about to be described, but is to be taken as including any features or modifications that may fall within the scope of the claims.

The core drill illustrated in Fig. 1 of the drawings includes generally, a body or outer barrel 10, an inner barrel 11 for receiving the core, a bit head 12 on the lower end of the outer barrel 10, and a plurality of replaceable cutter assemblies 13 and 14 on the bit head 12.

The outer barrel 10 of the core drill is an elongate tubular structure adapted to be connected with the lower end of an operating string of drill pipe, or the like. In the particular case illustrated in the drawings, a sub 15 having a tapered screw-threaded pin 16 is provided on the upper end of the outer barrel 10 to facilitate connection of the barrel with the operating string. A sub or connecting member 17 is screw-threaded on the lower end of the outer barrel 10 and is provided with a downwardly projecting pin 18. A bit head sub 19 is provided on the lower end of the connecting member 17 to carry the bit head 12. The sub 19 is a tubular member having a central longitudinal opening 20. The sub 19 has comparatively heavy or thick walls, and a screw-threaded socket 21 is provided in its lower end. A threaded socket 22 is provided in the upper end of the bit head sub 19 to receive or cooperate with the pin 18 of the connecting member 17.

The inner barrel 11 is arranged within the outer barrel 10 to receive the core. The core receiving barrel 11 is a tubular structure, and is provided at its lower end with an enlarged portion 23 screw-threaded into the opening 20 of the bit head sub 19. The inner barrel 11 is of considerably less diameter than the outer barrel 10 so that an annular fluid passage 24 is provided between the two barrels. A suitable vent or valve may be provided on the upper end of the core barrel 11 to permit the escape of fluid or air from the inner barrel as the core enters the barrel and to prevent the flow of circulation fluid into the upper end of the inner barrel. In the particular structure illustrated in the drawings, a valve body 25 is provided in the upper end of the inner barrel 11 and has a reduced opening with a valve seat (not shown). The ball 26 is adapted to cooperate with the valve seat of the body 25 to close the upper end of the inner barrel 11 against the entrance of circulation fluid. A cage 27 is provided to hold or maintain the wall valve 26 in its proper position.

The bit head 12 is attached to the lower end of the sub 19 and is provided to carry the removable cutter assemblies 13 and 14. The bit head 12 includes a body or shoe 28. The shoe 28 is an annular or tubular member and as illustrated in the drawings, may be integral. The bit head shoe 28 has a threaded connection with the sub 19. In the specific construction illustrated in the drawings, a pin 29 is provided on the upper end of the bit head shoe 28 to screw-thread into the socket 21. A shoulder 30 may be provided on the shoe 28 at the base of the pin 29 to cooperate with the lower end of the sub 19. The vertical or longitudinal opening 31 in the shoe 28 is in vertical alignment with the opening in the sub 19 and barrel 11, and its lower end is of reduced diameter. A downwardly and outwardly inclined annular face 32 is provided on the lower end of the shoe 28 at the lower end of the opening 31. In accordance with the invention, outwardly projecting enlargements or wings 33 are provided on the shoe 28. The wings 33 are preferably equally spaced apart around the exterior of the shoe 28 and are of equal width or thickness. The sides 34 of the wings 33 may be flat and vertical and the opposite sides of each wing may be substantially parallel. The spaces between the several wings 33 form longitudinal or vertical grooves 35 in the exterior of the shoe 28 to permit the upward flow of circulation fluid from the bottom of the well bore.

Recesses are provided in the shoe 28 of the bit head to receive or carry the cutter assemblies 13 and 14. The recesses are provided in the lower end of the shoe 28 at the outwardly projecting wings 33. The number of wings 33 provided on the bit head and the number and shape of the recesses in the bit head depend upon the respective number of cutter units 13 and 14 embodied in the tool. In the particular form of the invention being described, there are two substantially diametrically opposite pairs of cutter assemblies 13 provided on the bit head, and recesses 36 are provided in the lower end of the shoe 28 at two pairs of adjacent wings 33. The tool also includes two cutter units 14 carried in recesses 37 in the lower end of the shoe 28 at diametrically opposite wings 33.

The cutter assemblies 13 include outer cutters for acting on the formation at the bottom of the well bore and for reaming or cutting the well bore to size, while the cutter assemblies 14 include inner cutters for acting on the formation at the bottom of the bore and for shaping or trimming the core. The recesses 36 for receiving the outer cutter units 13 extend upwardly in the shoe 28 from its lower end and have upwardly and inwardly inclined inner and outer walls 38. The upper walls 39 of the recesses 36 may be inclined downwardly and inwardly. Each recess 36 extends substantially tangentially through the bit head from one side of a wing 33 to the other. Radial slots 40 extend upwardly from the lower end of the shoe 28 and intersect the lower end portions of the recesses 36. The slots 40 have flat parallel side walls at substantially right angles to the inner and outer walls 38 of the recesses 36. The slots 40 are enlarged throughout portions of their lengths by round bores 41 and 42. The axes of the bores 41 and 42 are aligned and are inclined upwardly and outwardly, being at substantially right angles to the inner and outer walls of the recesses 36. As the bores 41 and 42 extend longitudinally or radially through the slots 40, they are in the nature of rounded depressions in the opposite vertical walls of the slots. The bores 41 which are provided in the slots 40 adjacent the inner walls of the recesses 36 are of larger diameter than the bores 42 which are provided in the slots adjacent the outer walls of the recesses 36. Counter bores 43 are provided in the other sides of the wings 33 to join the bores 42. The counter bores 43 are coaxial with the bores 41 and 42 and accordingly have inclined axes. Counter bores 44 are provided in the walls of the shoe opening 31 to join the inner bores 41. The counter bores 44 are coaxial with the bores 41 and 42 and are somewhat smaller in diameter than the outer counter bores 43.

The recesses 37 for carrying the inner cutter assemblies 14 extend upwardly into the lower end of the bit head shoe 28 at diametrically opposite wings 33. The inner and outer side walls 45 of the recesses 37 are inclined downwardly and inwardly relative to the vertical axis of the tool. The upper walls 46 of the recesses 37 may incline downwardly and outwardly as illustrated in Fig.

4 of the drawings. Vertical slots 47 extend upwardly into the lower end of the shoe 28 and intersect the lower end portions of the recesses 37. The slots 47 are radial relative to the longitudinal axis of the shoe and have vertical parallel walls. Bores 48 and 49 are provided in the walls of the slots 47. The bores 48 and 49 extend longitudinally or radially through the slots 49 and have aligned upwardly and inwardly inclined axes. The bores 49 are provided in the walls of the slots 47 at the inner walls of the recesses 37, while the bores 48 communicate with the recesses 37 at their outer walls. The bores 48 are larger in diameter than the bores 49. Counter bores 50 are provided in the outer lower corners of the wings 33 to join the outer ends of the bores 48. Counter bores 51 are provided in the walls of the shoe opening 31 to join the inner bores 49. The counter bores 50 and 51 have upwardly and inwardly inclined axes aligned with the axes of the bores 48 and 49.

The cutter assemblies 13 and 14 are removably locked or mounted in the recesses of the bit head shoe 28 and their cutters are operable to make an annular cut in the earth formation. The outer cutter assemblies 13 each includes a rotatable cutter 53, a bearing 54 for directly rotatably carrying the cutter 53 and a pin or bolt 55 for removably holding the bearing 54 in position. In the form of the invention illustrated in the drawings, the cutters 53 of the outer cutter assemblies are rotatable on inclined axes and are in the nature of frustro-conical cutters. Longitudinally extending peripheral cutting parts or teeth 56 are provided on the cutters 53. The opposite ends of the cutters 53 are preferably flat and normal to the cutters' axes of rotation. When the cutters 53 are rotatably mounted within the recesses 36, they project from the lower ends of the shoe 28 to engage the formation at the bottom of the well bore and their lower cutting edges are substantially horizontal. The outer ends of the cutting teeth 56 may be bevelled as at 58 so that the cutters are effective in acting on the side walls of the well bore. A central longitudinal opening 59 is provided in each cutter 53. In accordance with the invention, enlargements or sockets are provided in opposite ends of the openings 59 to provide oppositely facing annular shoulders in the openings. The sockets 60 in the outer ends of the cutter openings 59 are of round cross section and their bottoms or inner ends form outwardly facing annular shoulders 61. The shoulders 61 may be inclined or tapered inwardly. The sockets 62 in the inner ends of the cutter openings 59 are somewhat smaller in diameter than the sockets 60 and their inner ends form inwardly facing annular shoulders 63 in the cutter openings. The shoulders 63 may be inclined inwardly as illustrated throughout the drawings.

The bearings 54 directly rotatably support the outer cutters 53 and have parts cooperating with the slots which hold them against rotation. It is a feature of the invention that the bearings 54 are operable to transmit end thrusts in either direction directly from the cutters 53 to the shoe 28. In accordance with the invention, each bearing 54 is formed of two parts, an inner part 64 and an outer part 65. The inner parts 64 of the bearings fit the inner end sockets 62 of the cutters 53. The inner bearing parts 64 have outwardly extending continuations or extensions 66 of reduced diameter that project through the cutter openings 59. Annular inclined shoulders 67 are provided at the bases or inner ends of the extensions 66 and are adapted to cooperate with the shoulders 63 in the cutter openings. The outer ends 68 of the bearing parts 64 are flat, and are adapted to seat against or cooperate with the inner walls of the recesses 36. Diametrically opposite lugs 69 are provided on the ends 68 to cooperate with the slots 40 at the inner walls of the recesses 36. The lugs 69 have flat parallel sides to cooperate with the flat walls of the slots 40. A central longitudinal opening 70 extends through each bearing part 64 and is provided at its outer end with a socket or enlargement 71.

The outer parts 65 of the bearings 54 fit or are carried in the sockets 60 in the outer ends of the cutters 53. The outer bearing parts 65 have tapered inner ends 72 for cooperating with the shoulders 61 in the cutter openings. The outer ends 73 of the bearing parts 65 are adapted to engage the outer walls of the recesses 36. Central longitudinal openings 74 are provided in the bearing parts 65 and have enlargements or sockets 75 in their inner ends adapted to receive the end portions of the extensions 66 of the bearing parts 64. The bottoms of the sockets 75 provide shoulders 76 for cooperating with the ends of the extensions 66.

When the two parts 64 and 65 of the bearings are assembled in the cutters, the extensions 66 of the inner parts extend into the sockets 75 and their ends seat against the shoulders 76. In accordance with the invention, the two parts 64 and 65 of each bearing are integrally connected or joined after the two bearing parts 64 and 65 have been assembled in the opening of the cutter, the ends of the extensions 66 being welded to the outer bearing part at the shoulders 76. The openings 74 in the outer bearing parts are sufficiently large in diameter to permit the ends of the extensions 66 to be welded to the outer bearing part as at 77. As the bearings 54 are supported by the pins 55 and are arranged in the recesses 36 so that they are not subjected to any severe pressures or strains, they may be treated so as to have maximum or efficient wear resisting qualities. Projecting lugs 78 are provided on the outer end 73 of each bearing part 65. The lugs 78 are shaped and proportioned to fit the slots 40 in the outer walls of the wings 33. In accordance with the invention, the lugs 78 are flat sided and are sufficiently long to extend into the counter bores 43.

The pins or bolts 55 are provided to detachably lock or secure the assemblies of the cutters 53 and bearings 54 in the recesses 36 of the bit head. The bolts 55 are adapted to be passed inwardly through the outer bores 42, the openings in the bearing 54, and finally into the inner bores 41. The body portions of the bolts 55 are proportioned to slidably fit the openings 70 in the inner bearing parts 64. Heads 79 are provided on the outer ends of the bolts 55 and are adapted to seat in the outer counter bores 43. A notch 80 is provided in each bolt head 79 to receive or cooperate with the lug 78 on the outer end of a bearing. The cooperation of the lugs 78 with the notches 80 holds the bolts 55 against rotation. The outer ends of the bolt heads 79 may be bevelled or cut away to be flush with the outer sides of the wings 33. Nuts 81 are threaded on the reduced inner ends of the bolts 55 and seat or fit in the sockets 71 in the inner ends of the bearings. The nuts 81 seat in the bores 41 and may have enlargements or projecting flanges 82 on their outer ends extending into the inner counter bores 44. After the bolts 55 have been passed through the bores 42 and

bearings 54, the nuts 81 may be threaded onto their inner ends to lock the assembly in position. The extreme inner end portions of the bolts 55 may then be peened to prevent loss or displacement of the nuts 81. If desired or found practical, the heads 79 of the bolts may be shaped and proportioned to fit the counter bores 43 or both the bores 42 and the counter bores 43, and in a like manner the nuts 81 may be shaped to fit the counter bores 44 or both the bores 41 and the counter bores 44. In the simple form of the invention illustrated in the drawings, the bodies of the bolts seat in the bores 42 and the nuts 81 seat in the bores 41 to retain the cutter assembly in position.

It will be apparent how the pins 55 effectively and dependably connect or secure the assemblies of the cutters 53 and the bearings 54 to the shoe 28 in their proper positions in the recesses 36. The cooperation of the bolts 55 with the bores 42 and the cooperation of the reduced cylindrical portions of the nuts 81 with the inner bores 41 hold the assemblies against downward displacement from the bit head. The lugs 69 and 78 in cooperating with the slots 40 positively prevent turning of the bearings 54 and aid in transmitting upward forces from the bearings to the shoe 28. The bolt heads 79 and the nuts 81 cooperate with the ends of the counter-bores 42 and 41 respectively so that the walls of the shoe 28 at the inner and outlet ends of the recesses are rigidly connected together. The cooperation of the oppositely facing shoulders 67 and 72 with the shoulders 61 and 63 of the cutters provide for the transmission of end thrusts from the cutters to the bearings while the engagement of the ends of the bearings with the end walls of the recesses 36 insures the dependable transmission of end thrusts directly from a bearing to the shoe 28. The threadedly connected bolts 55 and nuts 81 act to effectively connect or tie together the portions of the shoe 28 at the inner and outer ends of the recesses 36.

Each of the inner cutter assemblies 14 includes a cutter 83, bearings 84 and bolts 85. The cutters 83 are rotatable about upwardly and inwardly inclined axes and may be frustro-conical, so that the cutting parts at their lower ends are substantially horizontal. When mounted in the recesses 37, the cutters 83 project from the lower ends of the recesses to engage the formation at the bottom of the well bore and project inwardly to trim the core as it passes upwardly into the shoe opening 31. The cutters 83 are provided with central longitudinal openings having inner sockets 87 and outer enlargements or sockets 88. The bottom of each inner socket 87 forms an inwardly facing shoulder 89, while the bottom of each outer socket 88 forms an outwardly facing shoulder 90. The shoulders 89 and 90 may be tapered inwardly or toward one another as illustrated throughout the drawings. The bearings 84 may be similar to the bearings 54 described above, each including two parts integrally connected or joined by welding 91. The bearings 84 thus constitute one-piece members and have oppositely facing shoulders for cooperating with the cutter shoulders 89 and 90. Where the inner cutters 83 are rotatable about upwardly and inwardly inclined axes, their inner shoulders 89 are of comparatively large diameter and are operable to cooperate with complementary shoulders 92 on the bearings 83. The outer internal shoulders 90 of the cutters may be smaller in diameter to cooperate with opposing shoulders 93 on the bearings 84.

The bolts 85 are passed through the openings in the bearings 84 and their inner end portions cooperate with the bores 49. Heads 95 are provided on the inner ends of the bolts 85 to seat in the counter bores 51. Lugs 96 are provided on the inner ends of the bolts 85 to seat in the counter bores 51. Lugs 96 are provided on the inner ends of the bearings 84 to cooperate with the slots 47 and with notches in the edges of the bolt head 95. Lugs 97 are provided on the outer ends of the bearings 84 to cooperate with the slots 47 at the outer walls of the recesses 37. Nuts 98 are screw-threaded on to the outer end portions of the bolts 85 and fit the counter sink in the outer ends of the bearings 84. The nuts fit or seat in the bores 48. Enlargements on the nuts 85 seat in the outer counter bores 50. The outer ends of the bolts 85 may be peened to prevent displacement or loosening of the nuts 98. The manner of assembling and mounting the inner cutter assemblies 14 is identical with that of the outer cutter assemblies 13.

The invention provides novel and effective means for flushing or washing the cutters 53 and 83 of the two sets of cutter assemblies. An enlargement or annular recess 100 is provided in the wall of the sub opening 20 at the lower end of the socket 22. Longitudinal fluid passages 101 extend downwardly through the walls of the bit head sub 19 from the recess 100 to the lower end of the sub. An annular recess 102 is provided in the lower end of the sub 19 and is in communication with the ends of the passages 101. The shoulder 30 closes the lower end of the recess 102 so that the recess 102 forms an annular space at the connection between the shoe 29 and the sub 19. Passages 103 are provided in the shoe 28 and extend downwardly from the shoulder 30 where they communicate with the space 102 to the upper ends of the recesses 36 and 27. It will be apparent how the circulation fluid flowing downwardly through the annular space 24 is carried through the fluid passages in the sub 19 and bit head 28 to discharge from the lower ends of the passages 103 and effectively wash and flush the cutters 53 and 83.

The core drill may include a suitable core catching means for holding or retaining the core in the inner barrel 11. It is to be understood that any suitable form of core catcher may be employed in connection with the invention. In Fig. 1 of the drawings we have shown a more or less typical core catcher including a ring 110 slidable longitudinally in the opening 20 of the sub 19. Upwardly projecting spring fingers 111 are provided in the ring 110 to aid in supporting the core in the barrel 11. Spring fingers 112 project downwardly from the ring 110 and carry at their lower ends toothed slips 113. The intermediate portion of the shoe opening 31 is provided with downwardly and inwardly tapering walls and the slips 113 are adapted to cooperate with these walls to be forced inwardly into gripping engagement with the core when the tool is moved upwardly with respect to the core.

Fig. 9 of the drawings illustrates the cutter mounting means provided by the present invention rotatably supporting a cylindrical cutter 120 in a recess 121 in the lower end of a bit head shoe 122. The inner and outer walls of the recess 121 are inclined downwardly and inwardly and vertical radial slots 123 intersect the lower end por-

tions of the recesses. Bores and counter bores are provided at the slots 123 corresponding in arrangement and purpose to the bores 48 and 49 and the counter bores described above. These bores are coaxial, and their axes are inclined upwardly and inwardly. The cutter assembly includes, in addition to the cutter 120, a bearing 125 and a bolt 126. The bearing 125 may be substantially identical with the bearing 84 described above, being formed of two integrally joined parts. The bearing 125 is provided intermediate its ends with spaced oppositely facing shoulders 128 for cooperating with complementary shoulders in the cutter opening. The opposite ends of the bearing 125 seat against the opposite end walls of the recess 121 and lugs 96^a and 88^a are provided on the inner and outer ends of the bearing to cooperate with the slot 123 to hold the bearing against rotation. The bolt 126 extends through the bearing 125 and is provided at its outer end with a head 130 cooperating with a counter bore and engaged by the lug 96^a so that the bolt 126 is held against rotation. A nut 131 is threaded on the inner end of the bolt 126 and is counter sunk in the outer end of the bearing 125. A flange 132 is provided on the nut 121 to extend into a counter bore 133. The projecting end of the bolt 126 may be peened over to prevent loss of the nut 121.

Fig. 10 of the drawings illustrates a frusto-conical cutter 140 rotatably mounted in a recess 141 in a bit head shoe 142. The cutter 140 corresponds generally to one of the cutters 33 described above, however, it is positioned in the downwardly and inwardly sloping recess 141 to have its small or reduced end at the lower end of the core passing opening 143 of the shoe. When the cutter 140 is mounted in this manner, its cutting teeth 144 project from the lower end of the shoe 142 and are inclined upwardly and inwardly where they engage the formation at the bottom of the well bore. The inner ends of the cutting teeth 144 may be bevelled so that they effectively trim or shape the core adjacent the lower end of the shoe. The cutter 140 may be mounted in the same manner as one of the cutters 33 described above. The bearing 146 rotatably supporting the cutter 140 has two oppositely facing shoulders intermediate its ends, the outer of which is of the greatest diameter. Complementary opposite facing shoulders are provided in the opening of the cutter 140 to cooperate with the bearing shoulders. A bolt 150 passes through the bearing and a nut 151 is threaded on the outer end of the bolt. The bolt 150 may be identical with the bolt 55 described above, and operates in the same manner to removably lock the cutter assembly in the recess 141.

It is believed that the utility and practicability of the well tool provided by the present invention will be readily apparent from the foregoing description. It is to be understood that the shoe 28 of the bit head is a simple integral member that is inexpensive of manufacture and of sturdy construction. The provision of the recess 102 in the lower end of the bit head sub 19 insures the proper delivery of circulation fluid to the discharge passages 103. The removable or detachable cutter assemblies provided by the present invention are such that they may be easily and quickly replaced at the well drilling rig. The one-piece bearing rotatably carrying the cutter may be easily passed upwardly into the recess in the lower end of the shoe 28. The locking lugs on the opposite ends of the bearing properly locks or positions the bore and acts to positively prevent rotation of the bearing. The bolt cooperates with the bore at the outer end of the cutter carrying recess and the nut on the bolt cooperates with the other counter bore to prevent displacement of the cutter assembly from the lower end of the bit head. The cooperation of the lug with the notch in the bolt head effectively holds the bolt against turning. The opposite ends of the bearing may seat against the opposite end walls of the recess in the bit head, so that the bearing has no tendency for longitudinal movement. In a like manner, the oppositely facing shoulders on the interior of the cutter cooperate with the two shoulders on the bearing to positively prevent longitudinal movement of the cutter on the bearing. The cooperation of the shoulders on the bearing and cutter insures the transmission of all the end thrusts directly from the cutter to the bearing and prevents engagement of the cutter with the walls of the recess in the shoe. The slots, bores and counter bores in the shoe insure the proper positioning of the cutter assembly in the recess of the bit head. The nut may be easily removed from the bolt so that the bolt may be disengaged from the bit head and the bearing and the assembly of the cutter and bearing removed from the recess. The cutter assembly or means for detachably mounting the cutter on the bit head is simple and inexpensive of manufacture, and is positive and dependable in operation, as the parts cannot become loosened or displaced.

Having described only typical preferred forms of our invention, we do not wish to limit ourselves to the specific details set forth, but wish to reserve to ourselves any changes or variations that may appear to those skilled in the art or fall within the scope of the following claims.

Having described our invention, we claim:

1. In a well tool, a body having a recess in its lower end, there being a slot in the lower end of the body intersecting the recess, and a bore in the walls of the slot intersecting the recess, a bearing extending through the recess, parts projecting from opposite ends of the bearing engaging the slot to hold the bearing against rotation, and a removable bolt extending through the bore and carrying the bearing, one of said parts engaging the bolt to hold it against rotation.

2. A cutter assembly for a well tool including a cutter having an opening, and a bearing for rotatably carrying the cutter comprising two integrally joined parts, one part extending into each end of the cutter opening, each of said parts having portions of different diameters joined by an inwardly facing shoulder, there being oppositely facing shoulders on the walls of the cutter opening for cooperating with the shoulders of the bearing.

3. A cutter assembly for a well tool including, a cutter having an opening enlarged at its ends to form outwardly facing inclined shoulders, and a bearing for rotatably carrying the cutter comprising, two parts having aligned openings to receive a mounting member, one part extending into each end of the opening in the cutter, the said bearing parts having integrally joined telescoping portions and each having an inclined shoulder for engaging a shoulder in the opening in the cutter.

4. In a well tool, a body having a recess, a bearing extending through the recess and comprising two sections one having a tubular part and the other having an opening through it receiving the

tubular part, the inner end portion of said tubular part being integrally secured in the opening in said other part, shoulders on the sections facing one another, a cutter rotatable on the bearing and having shoulders cooperating with the shoulders on the bearing, means holding the bearing against rotation, and a bolt carrying the bearing and tying together the portions of the body at the opposite ends of the recess.

5. In a well drill a cutter bearing including two sections, one having an opening through it to receive a mounting pin and having a large bearing part at one end and a reduced bearing part projecting therefrom, the other section having a bore receiving the projecting end portion of the reduced part of the first mentioned section, said end portion of the said reduced part being integrally connected with said other section, the sections having opposed inclined cutter retaining shoulders.

6. In a well drill a cutter bearing including two sections, one having an opening through it to receive a mounting pin and having a large bearing part at one end and a reduced bearing part projecting therefrom, the other section having a bearing part substantially larger in diameter than any bearing part of the first mentioned section and having a bore receiving the projecting end portion of the reduced part of the first mentioned section, said end portion of the said reduced part being integrally connected with said other section, the sections having opposed cutter retaining shoulders.

7. In a well tool, a body having a recess in its lower end, there being a slot in the lower end of the body intersecting the recess, and a bore in the walls of the slot intersecting the recess, a bearing extending through the recess, a part on the bearing engaging the slot to hold the bearing against rotation, a removable bolt extending through the bore and carrying the bearing, and a lug and notch connection between the said part and bolt to hold the bolt against rotation.

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