Oct. 27, 1936. C. E. REED 2,058,626

COMBINED DISK AND ROLLER BIT

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Fig. 2.

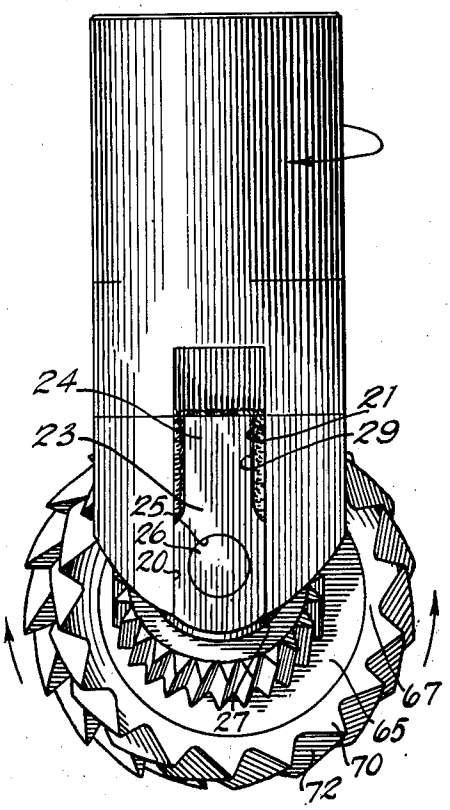
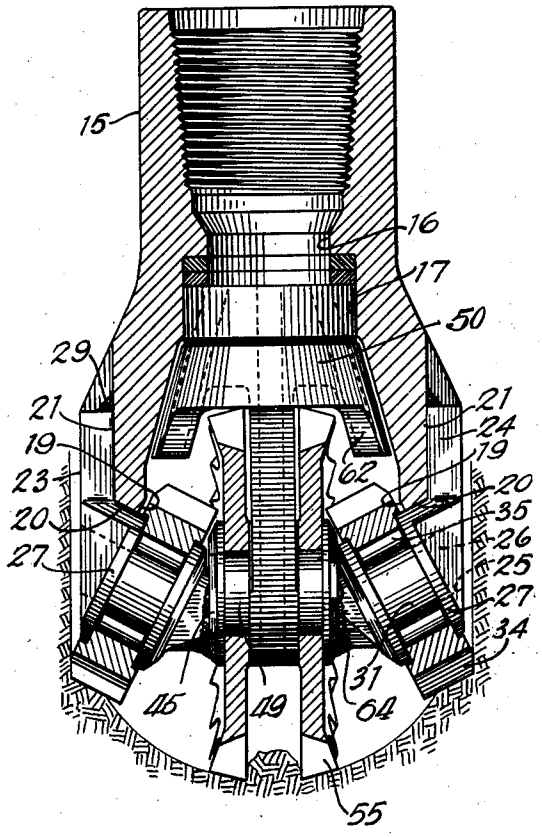


Fig. 1.



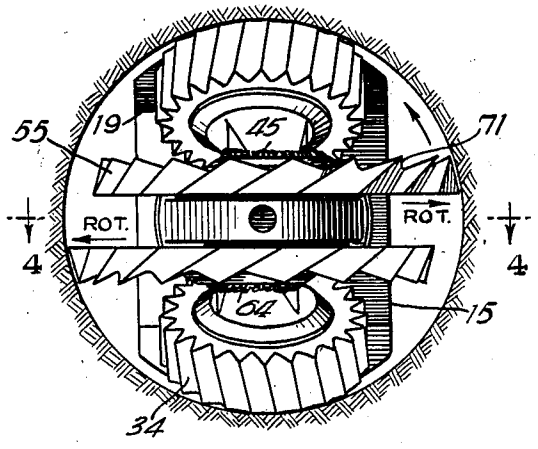


Fig. 3.

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COMBINED DISK AND ROLLER BIT

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Fig. 4.

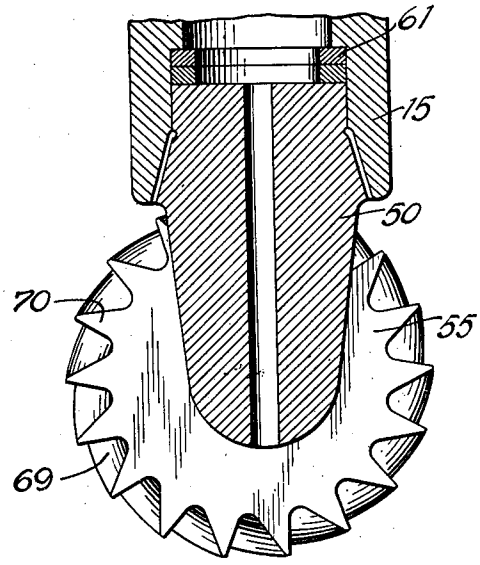


Fig. 5.

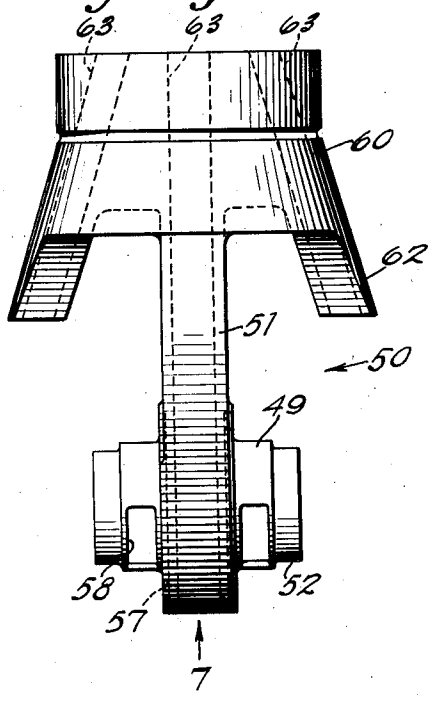


Fig. 6.

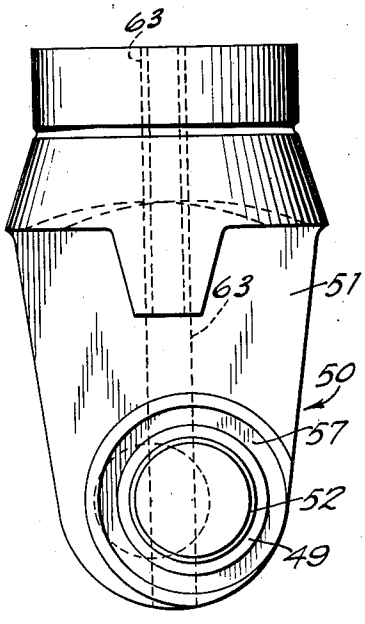
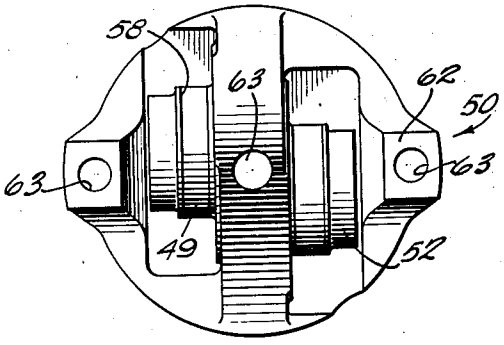


Fig. 7.



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Fig. 8.

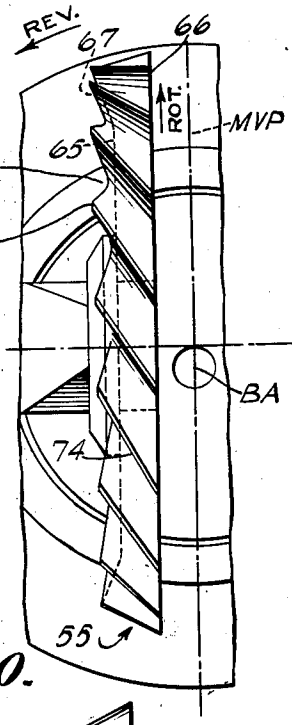


Fig. 9.

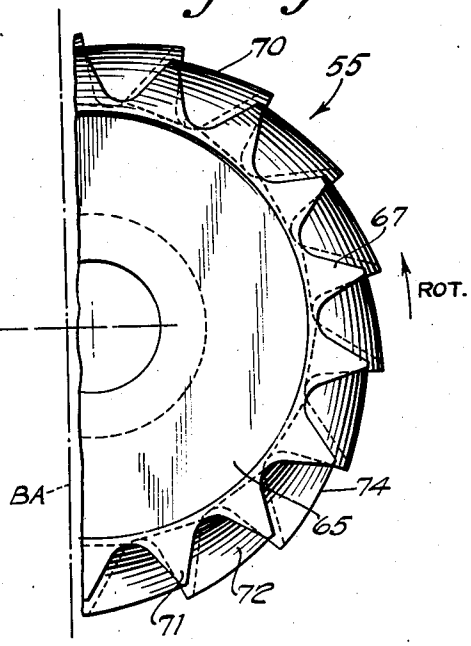


Fig. 13.

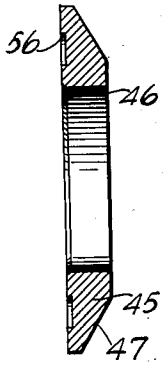


Fig. 10.

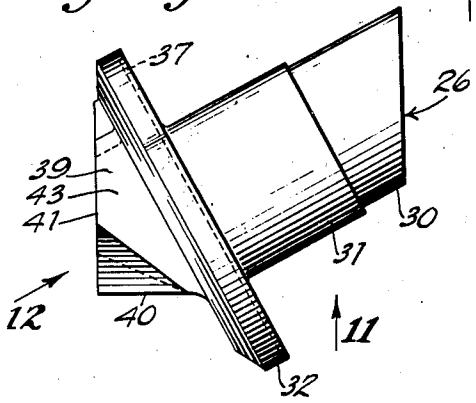
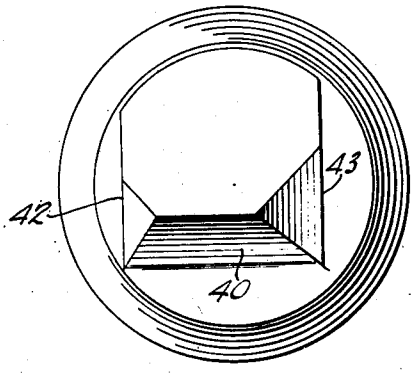


Fig. 12.



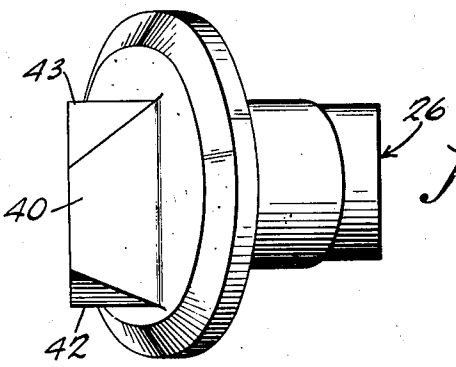


Fig. 11.

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COMBINED DISK AND ROLLER BIT

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Fig. 14.

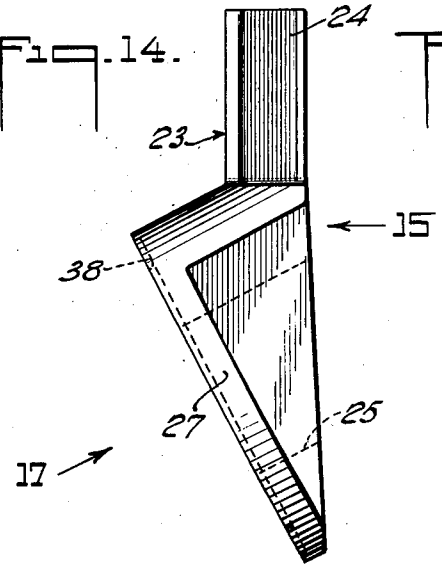


Fig. 15.

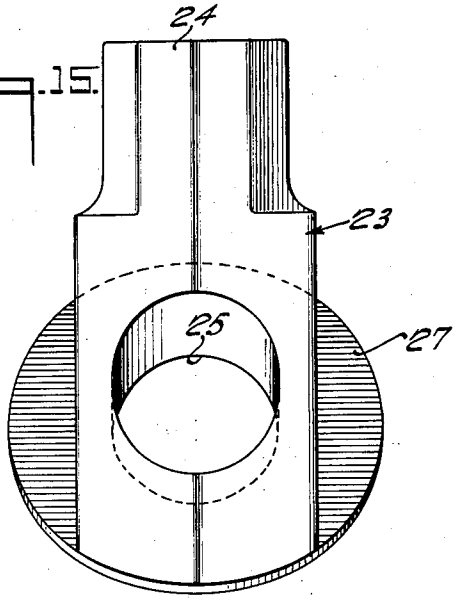


Fig. 16.

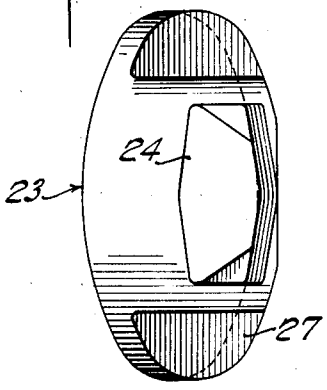


Fig. 17.

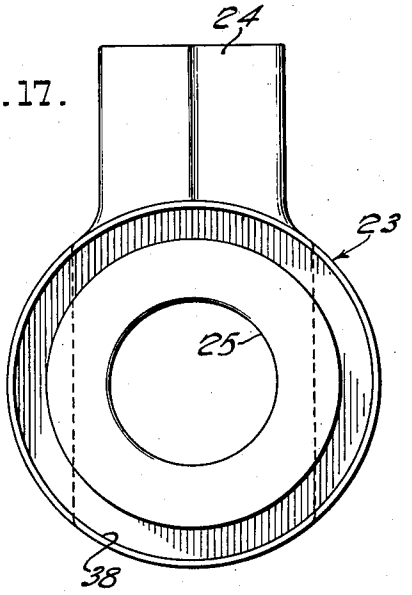
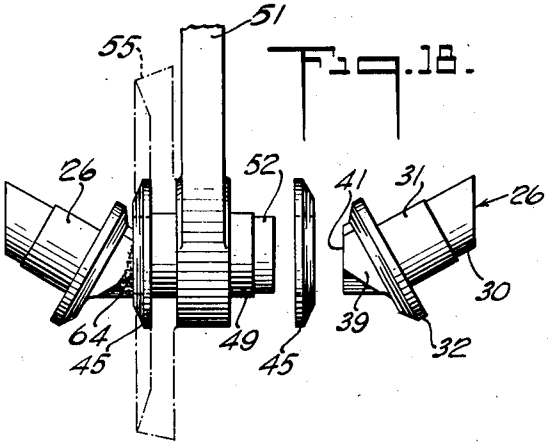


Fig. 18.



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Patented Oct. 27, 1936

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UNITED STATES PATENT OFFICE

2,058,626

COMBINED DISK AND ROLLER BIT

Clarence E. Reed, Wichita, Kans., assignor to Chicago Pneumatic Tool Company, New York, N. Y., a corporation of New Jersey

Application January 17, 1934, Serial No. 706,989

14 Claims. (Cl. 255—71)

This invention relates to rotary earth boring apparatus and more particularly to a drill bit having disk cutters and/or roller cutters rotatively mounted thereon and revoluble with the bit. The invention is concerned with the construction and shape of the disks, the position of the disks with respect to the bit head and with respect to the roller cutters, and the means for supporting all of the cutters on the bit head.

Among the general results which the present invention has for its objects to attain are the following: increased speed of penetration or footage; a smooth cut surface; expeditious removal of the cuttings from the bottom of the hole, thereby preventing packing; maintenance of the gauge of the hole by reducing wear on the disks and eliminating the effect of such wear on the clearance between the drill bit and the wall of the hole; improved traction of the disks assisted by the reaction produced by the earth formation; increased strength and simplicity of manufacture.

In the preferred embodiment of the invention, two disk cutters are arranged in parallel planes on opposite sides of and equidistant from a central vertical plane passing thru the bit axis. The axes of the disks are offset, one to the left and the other to the right, with respect to the axis of the bit, looking in the same direction. The offsetting of the disk axes is preferably opposite to the arrangement in the conventional disk bit whereby, as the disk revolves about the bit axis, the scraping segment of the disk precedes said central vertical plane instead of trailing the central plane as heretofore. Stated differently, the front radial face of the cutting segment, which face does the scraping and is subject to wear, is further from the bit axis than the rear face, whereas the standard practice is to arrange the front face nearer the axis, it being understood that the direction of revolution in both instances is clockwise, looking downwardly. Among the effects of applicant's rearrangement of the disks is to throw the loosened earth formation or shavings upwardly from the bottom of the hole to the side, from whence they may be removed by the flushing fluid. This lifting action is induced by the traction of the cutting disk or rotation of the disk about its own axis, the direction of which is dependent upon the position of the disk on the bit. In the usual disk bit, traction of the disk is such that the front face of the cutting segment of the disk moves downwardly as it plows, thereby tending to pack the formation at the bottom of the hole.

It would not be feasible to obtain the above-described advantage by merely repositioning the axes and inverting the disks in a conventional bit. In the first place, such transposition would ordinarily move the arcuate cutting edge and radial cutting face further from the bit axis by a distance approximately equal to the thickness of the disk, thereby increasing the problem of removing the core surrounding said axis. Secondly, this rearrangement reduces the angle between the front or cutting face of the disk and the tangent to the bore hole from an obtuse to an acute angle, making it difficult for the usual cutting edge to penetrate. Applicant's invention involves the solution of these and other problems to make an upwardly plowing disk bit practical.

In accordance with this invention, each disk is provided with a peripheral edge of substantial thickness and having teeth thereon extending from the front to the rear face of the disk. The teeth are so inclined as to augment rotation or traction of the disk. The inclination of the peripheral teeth furthermore is effective to produce a combined scraping, slicing and plowing action as will be described more fully hereinafter. These teeth are so arranged and proportioned that usually the path cut by one tooth partially overlaps the path cut by the preceding and by the following tooth, thereby cutting a surface which is smooth and devoid of grooves or furrows. The cutting action is produced throughout the thickness of the disk thereby reducing the size of the uncut core.

The front face of the disk is inwardly bevelled or dished which produces the following results: it makes the cutting ends of the peripheral teeth pyramid shape or pointed; it decreases the cutting angle with respect to the earth formation; and it urges the shavings inwardly to the flat surface of the disk which carries them upwardly.

Side roller cutters maintain the gauge of the hole and relieve wear on the disks. The side cutters reduce the area of the active cutting segments of the disks. On the other hand, the disks provide a greater speed of penetration than obtainable with the roller cutters alone since the disks cut the central portion and if the disks are arranged to plow upwardly, they prevent cuttings from the roller cutters from dropping to the extreme bottom of the hole.

In addition to the above improvements in the cutters, the invention comprises novel means for supporting the cutters in the bit head. The supporting means include a set of spindles for the disk and roller cutters, arranged in the form of

an inverted arch, the outer ends of the roller cutter spindles being received within suitable supporting members. A feature of the invention resides in the means for mounting these supporting members in the bit head whereby when the members are welded in place the heat is applied at a point remote from the spindles.

Other objects and features of this invention will appear more clearly from the following description taken in connection with the accompanying drawings and appended claims.

In said drawings:

Fig. 1 is a central sectional view of a bit embodying the present invention, certain parts being shown in elevation;

Fig. 2 is a side elevation;

Fig. 3 is a bottom view;

Fig. 4 is a fragmentary central section at right angles to the section of Fig. 1;

Fig. 5 is a front elevation of the central casting which comprises spindles, a strut therefor, and a wash plate;

Figs. 6 and 7 are side and bottom views resepctively of said casting;

Fig. 8 is a fragmentary bottom view of the bit showing one of the disk cutters;

Fig. 9 is a side elevation of a fragment of a disk cutter;

Fig. 10 is a front elevation of the spindle member for a roller cutter;

Fig. 11 is a bottom view of the spindle member;

Fig. 12 is an end view of the spindle member as indicated by the arrow 12 in Fig. 10;

Fig. 13 is a section of a thrust plate for disposal adjacent the outer face of a disk;

Fig. 14 is a side view of one of the bearing members for a roller cutter supporting spindle;

Fig. 15 is a view looking in the direction of the arrow 15 in Fig. 14;

Fig. 16 is a top view of the bearing member shown in Fig. 14;

Fig. 17 is a view looking in the direction of the arrow 17 in Fig. 14; and

Fig. 18 is a front view showing certain parts of the bit in assembled relation and certain other parts separated.

The illustrative embodiment of the invention comprises a bit head 15 (Figs. 1 to 4) having an internally threaded upper end for attachment to a drill pipe. It has a central bore 16 for the downward passage of flushing fluid, below which is a counterbore 17. The upper portion of the counterbore is cylindrical and the lower portion flaring. At its lowermost end the inside surface of the bit head terminates in inclined walls 19. The depending walls 19 have downwardly open notches or bearing seats 20. The notches 20 are in line with each other or, in other words, their centers lie in a vertical plane which includes the axis of the bit. Above each of the notches 20 the side of the bit head is recessed or notched as indicated at 21.

In order to support the roller cutter spindles near the extreme lower end of the bit head, the invention provides a pair of similar bearing members 23 each seated within the notches 20 and having an upward extension 24 received by the groove 21. The lower or body portion of the bearing member 23 is apertured at 25 to receive the roller cutter spindle 26, and is provided with a thrust-sustaining flange 27 for a purpose hereinafter described. The upper portion 24, which is of considerable length, is welded at 29 to the bit head. Although the welded area is large it is sufficiently remote from the bearing 25 that the heat applied during the welding operation will not affect the temper of the bearing or of its associated spindle.

Referring particularly to Figs. 10, 11, and 12, the roller cutter spindle members 26 which may be identical in construction, each comprise a reduced end 30 adapted to fit the bearing 25, a body portion 31, and a flange 32. A roller cutter 34, mounted on roller bearings 35, surrounds the body portion 31 and is held against axial movemen by the flange 32 on the spindle member and the flange 27 on the bearing respectively. The surface of the flange 32 in contact with the roller cutter is provided with an annular groove 37 for the reception of suitable hardening material such as stellite. The flange 27 may be provided with a similar groove 38. The opposite side of the flange 32 is integrally connected to an eccentric abutment member 39, whose center of gravity is offset oppositely to the direction of revolution about the bit axis. Viewed from the side the abutment is generally in the shape of a right triangle whose hypotenuse is connected to the flange 32 and whose legs lie in the horizontal bottom face 40 and vertical face 41 respectively. Lateral faces 42 and 43, unequally spaced from the axis of the roller cutter spindle 26, are also in vertical planes at right angles to the eccentrically positioned face 41.

Referring to Fig. 18, an annular thrust plate 45 is placed in face-to-face contact with surface 41 and then the plate is rigidly secured to the spindle member 26 by welding. As seen in Fig. 13, the thrust plate has a circular aperture 46 offset in the same direction as the eccentric face 41, when connected to the latter. To facilitate welding, the face of the thrust plate engaging the eccentric abutment may be bevelled at 47, while the corners of the abutment may be truncated as shown in Figs. 10, 11, and 12.

The apertures 46 in the two thrust plates 45 provide offset bearings for receiving and supporting the spindle portions 49 at the lower end of a one-piece casting 50 shown best in Figs. 5 and 7. This casting comprises a depending strut portion 51, from the lower end of which project the two spindles 49, the outer ends 52 of which are reduced to fit the apertures 46 of the thrust plates 45. The larger diameter portion of the spindle 49 supports the disk cutter 55 for rotation thereon. The construction of the disk cutter will be described presently. In order to reduce wear caused by the disk, hardening material, such as stellite, is inserted in annular grooves 56 and 57 formed in the thrust plate and strut respectively and in a crescent shaped groove 58 on the bottom of spindle 49.

The casting 50 comprises a flaring hood 60 from which the strut 51 depends, the hood being shaped to fit the recess 17 in the bit head 15, the upper portion of the hood being cylindrical. Pressure of the earth formation tending to force the casting upwardly is resisted by one or more compressible gaskets 61 overlying the top of the hood. Two downwardly diverging spouts 62 project toward the side roller cutters 34. A series of passages 63 lead from the opening 16 in the bit head thru the spouts 62 for flushing the side cutters and thru the strut 51 for permitting flushing fluid to impinge on the bottom of the hole between the disks.

In assembling the parts of the drill bit hereinbefore described, the first step, preferably, is to join the thrust plates 45 to the respective spindle members 26. This may be accomplished by

placing the thrust plate in face-to-face contact with the eccentric vertical face 41 on the associated spindle member and then butt welding the plate to the member, the weld being indicated as 64 in Figs. 1, 3, and 18. The unitary structure formed by joining the thrust plate to the spindle member, provides a bearing surface 46 adapted to receive the end 52 of the spindle 49 projecting from the casting 50. Before the thrust plates are placed on the reduced ends 52, the disk cutters 55 are first mounted on the offset spindles 49. With the casting 50 and disks loosely connected to each other and to the united thrust plate and spindle structures, the next step is to mount the roller bearings 35 and roller cutters 34 on the spindles 31. The reduced ends 30 of the spindle members which project beyond the roller cutters 34, are fitted into the openings 25 in the bearing members 23 shown best in Figs. 14 to 17 inclusive. The parts thus far assembled constitute a structure resembling an inverted arch and adapted to be inserted as a unit into the bit head 15, the extensions 24 on the bearing members 23 being slidable upwardly in the associated bit head grooves 21 until the bearing members 23 rest against bearing seats 20. At the same time the upper end of the central casting 50 is forced against the gaskets 61 shown in Fig. 4.

The unit comprising the casting, cutters, spindles, and bearing members may be held against accidental removal from the bit head by means of the weld 29. This weld may be broken, however, to permit the exchange of cutter units.

The construction and operation of the disk cutters will be understood most clearly by reference to Figs. 8 and 9, in which the reference character BA designates the bit axis and MVP the median vertical plane separating the disks and including the axis BA. The arrows ROT. and REV. indicate, respectively, the direction of rotation of the disk about its own axis, and the direction of revolution of the disks, spindles and associated parts as a whole about the bit axis BA. The two disks are identical in construction. The locus of each point on the periphery of a disk is the composite result of the direction and speed of rotation and of revolution, and of the speed of penetration or descent of the bit in the well. According to the present invention, the cutting surfaces on the disks are so arranged and proportioned with reference to the locus of a point on the disk under average conditions, that a cutting tooth moves at an acute angle to the cutting edge, thereby slicing a deep groove in the earth formation. The cutting segment of the disk, which is the part that is offset away from the bit axis BA (the upper part in Fig. 8) revolves in advance of the median vertical plane MVP, thereby departing from standard practice. Hence, the advancing face 65 of this disk segment is further from the axis than the trailing face 66. As a result, the advancing face rotates from the extreme bottom to the side of the hole (see Fig. 9 in which the direction of revolution is such that the teeth approach the observer) throwing up the loosened earth formation or cuttings which are then removed by the flushing fluid. The face 66 of the disk is provided with a bevelled edge 67 which aids in confining the cuttings in contact with the advancing face of the disk while the cuttings are being lifted.

The peripheral surface of the disk has the general shape of a frustum of a cone, the trailing face 66 being of larger radius than the advancing face of the cutting segment so that the disk penetrates as it moves sidewise. This surface is interrupted by a series of inclined deep grooves 69 forming long teeth 70 of V-shaped cross-section. Due to the bevelled surface 67 on the front face, the forward end of the tooth has approximately the shape of a triangular pyramid whose apex 71 is adapted to pierce the earth formation like the point of a plow. The peripheral edge of the tooth is inclined with respect to the flat faces of the disk and is at an acute angle with respect to the direction of movement of the tooth. The direction of inclination is such that the side 72 of the tooth which contacts with the earth formation is caused to ride upwardly over the latter (moving towards the observer in Figs. 2 and 9) and the camming action of the rock or other earth formation assists the disk in rotating about its own axis.

In operation the advancing point or apex 71 of each tooth 70 moves through a series of spirals, successively receding from and then advancing towards the bit axis BA. Just before it reaches the lowermost point on the disk, it digs into the earth formation under the weight of the drill stem forming a sharp groove and advancing spirally towards the outside of the hole. The apex 71 is immediately followed by the surface 72 which deepens and widens the groove, the peripheral edge 74 scraping the entire path passed over by the tooth to produce a smooth surface over a wide area. The periphery of the disk is constructed with considerable thickness so that for the same angle of tooth a wider area can be cut than with a thin disk.

It will appear from a study of Fig. 8 that the entire body of the tooth 70 does not trail the advancing point 71 in a perfect circle around the bit axis but has a sidewise movement resulting in a combined wedging and scraping action on the formation, which sidewise wedging action is further accentuated by the rotation of the cutter about its own axis. The area cut by a plurality of teeth resembles a plurality of corresponding zones of considerable width extending spirally and arranged adjacent to each other. The result is a relatively smooth surface as compared with the corrugated bottom produced, for example, by true rolling cone cutters.

The length of the teeth in a radial sense makes it possible for the teeth to plow deeply into the earth formation, while the use of side roller cutters relieves these teeth of a considerable portion of the load which would otherwise wear them down.

The sides 72 and the bevelled front faces 67 of the teeth may be hardened to resist wear on the disk.

Due to the thickness of the disks and to the arrangement of teeth adapted to cut throughout the full thickness thereof, the uncut core at the center of the hole between the disks is not of great diameter, and can be disintegrated by the action of water discharged through the central passage 63. The loosened formation is picked up by the front face 65 of the disk which throws it upwardly to the side edges of the hole. This upwardly rotating face on the cutting segment of the disk, furthermore, prevents the descent of loose formation cut by the side roller cutters 34.

There is no tendency for the hole to taper as the disks become worn inasmuch as the side roller cutters 34 maintain the guage of the hole. The latter, moreover, relieve the disks from cutting at the outermost zone of the hole where the work done in cutting is greatest per revolution.

In arranging the parts constituting the illustrative embodiment of the invention, attention was given to the problem of providing adequate strength of the spindles and supports in the limited space available at the bottom of the bit head. The side roller cutters **34** tend to cause crowding since they are inclined in planes converging in the bit head and are therefore close to each other at the upper end. Separation of these cutters is effected by lowering them with respect to the inclined walls **24** of the bit head, which is made possible by the bearing members **23** whose flanges **27** take the thrust from the roller cutters at the extreme bottom of the bit head. The peripheral portions of the disks may be made of desired thickness, by virtue of the bevelled edge **67** which enables the central portions to clear the roller cutters.

While the invention contains several features contributing to the success of the bit, it is apparent that some of them could be used independently of the others, if desired. Furthermore, modifications of the illustrative embodiment may be made within the spirit of the invention and the scope of the appended claims.

The construction and arrangement of the bearing member 23, which has a stem portion **24** seated in a recess 21 at the side of the bit head, a thrust sustaining flange 27, and means for supporting a roller cutter, is claimed in applicant's copending application Serial No. 716,879 filed March 22, 1934.

What is claimed is:

1. A disk bit comprising a bit head having depending projections integral therewith, a plurality of disks supported in parallel vertical planes on opposite sides of the bit axis, horizontal spindles for the disks, means including said depending projections for supporting the outer ends of the spindles, a strut member connected to the inner ends of the spindles and adapted to resist upward thrusts thereon, said strut member being detachable from the bit head, said disks and strut member being positioned in a recess in the bit head between said depending projections.

2. A roller and disk bit comprising a plurality of spindles arranged in the shape of an inverted arch, the outside spindles converging downwardly and having roller cutters mounted thereon, the outermost ends of said spindles being supported in the bit head, disk cutters mounted upon intermediate spindles, and means positioned between said disk cutters for supporting the inner ends of the last-named spindles against upward thrusts.

3. A roller and disk bit according to the preceding claim in which the cutters and spindles are detachable from the bit head as a unit.

4. In a roller bit, a bit head having a bore therein, a centrally positioned strut having at each side a cutter spindle offset laterally from the bit axis, the strut having flushing fluid passage therethrough, the upper portion of the strut enlarged to form a closure for the bore in the bit, said enlargement having flushing fluid passages.

5. In a roller bit, a bit head, a strut supported thereby and positioned substantially centrally thereon, a spindle projecting from the side of the strut, the axis of said spindle being offset or spaced from the bit axis, a disk cutter rotatably mounted on said spindle, the disk cutter being of relatively large diameter and adapted to scrape the area on the bottom of the bore hole, the outer or free end of the spindle having a portion of reduced diameter, and means removably mounted on the reduced portion engageable with the disk cutter and adapted to take end thrusts of the cutter.

6. In a roller boring drill, a bit head having a recess opening exteriorly of the head and having an inner wall inclined downwardly and outwardly with respect to the drill axis, a side roller cutter inclined to, and cutting clearance for, the side of said head, means for mounting said cutter in the head, said means comprising a member having a shank received within said recess, said member having a flange seated on said inner wall, a spindle portion projecting downwardly and inwardly from said flange, end thrust receiving means positioned at the lower end of the spindle, and rolling bearings between the cutter and the spindle, and means supported by the bit head and connected to the inner end of the spindle for supporting the latter against upward thrusts.

7. A carrier member for attachment to the lower part of a bit head comprising an upper portion to fit a recess within a bit head, a depending strut portion, bosses projecting from the lower part of the strut portion to mount roller cutters, the axes of said bosses lying in a plane transverse to the bit head axis and lying on opposite sides of the bit head axis and being parallel, and spindle portions extending outwardly and upwardly from the bosses, and having associated therewith flange surfaces sustaining end thrusts of roller bearings and a roller cutter.

8. In an earth boring apparatus, a bit head having a recess in its under side, a carrier fitting at its upper part into said recess, a strut depending from the carrier member and having a laterally projecting boss, a bearing member attached to the exterior of the bit head, a spindle projecting from the bearing member into proximity with said boss, means connecting said spindle and boss together at their proximate ends to receive support from each other, and roller cutters carried by said spindle and said boss.

9. An earth boring tool according to claim 8 in which said spindle inclines downwardly toward the bit axis, and said connecting means is triangular in vertical cross-section, the side faces of said connecting means providing end thrust surfaces for the cutters.

10. In an earth boring drill, a bit head having an exterior face which is provided with a recess, and having an inner wall inclined downwardly and outwardly with respect to the drill axis, a bearing member having a stem seated in said recess, said stem having a lateral enlargement at its lower portion, said enlargement having parallel side walls connected at the upper end by a curved bearing surface, said side walls and bearing surface being shaped to fit the lower end of the recess, said enlargement having a flange seated against the inner wall of the bit head and inclined at an acute angle with respect to the same, said enlargement having a bore, and a spindle received within said bore and adapted to support a roller cutter.

11. In an earth boring drill, a bit head having an outer face provided with an exteriorly open recess and having an inner wall, a bearing member for supporting a spindle, said bearing member having parallel sides connected by a curved bearing surface, said parallel sides and bearing surface being shaped to fit the recess, said member having an extension seated in the recess and adapted to be welded to the bit head in a locality remote from the bearing surface, a spindle re-

ceived within a bore in the bearing member, rolling bearings and a roller cutter mounted on said spindle, said bearing member having a flange, one side of which bears on the inner wall of the bit head and the other side of which receives end thrusts from the rolling bearings and cutter.

12. In combination in a roller boring drill, a bit head, a roller cutter which cuts a path outwardly beyond the side wall of and cutting clearance for the head, said bit head having a recess for receiving said cutter and having an auxiliary recess opening outwardly of the side of the head, and communicating with the cutter recess, a roller cutter hanger having a portion received in the auxiliary recess for attachment to the head, said hanger having a spindle portion upon which said cutter is mounted, rolling bearings between the spindle portion and cutter, said hanger having flanges sustaining end thrusts of the rolling bearings and spindle cutter, and means connected to the inner end of the spindle and supported by the bit head independently of the hanger and supporting said inner end against upward thrusts.

13. A roller bit comprising a bit head having a depending wall, the outer face of which has a recess opening exteriorly of the bit head, said recess being open at its lower end, a side cutter support having a shank seated in said recess and attachable to the bit head by upward movement of the shank in a direction parallel to the bit axis, an inclined spindle carried by said support at its outer end and inclining therefrom downwardly and inwardly toward the vertical axis of the bit, a strut positioned substantially in line with the bit axis and supported at its upper end by said bit head, a second spindle supported by and projecting from one side of the strut and having an axis offset laterally with respect to the bit axis, means connecting the outer end of the second spindle with the inner end of the inclined spindle, a side cutter rotatably mounted on the inclined spindle, said side cutter projecting beyond the side of the bit head and cutting clearance therefor, a scraping disk cutter rotatably mounted on said second spindle, said disk cutter being of larger diameter than the side cutter and having a body portion and a periphery of greater width than the body portion, said cutters, spindles, strut and support being adapted to be handled as a unit and as such attached to and removed from the bit head.

14. A roller bit according to claim 13 in which the means connecting the spindles comprises members adapted to be welded to each other after the cutters have been placed on the respective spindles, one member having means sustaining end thrusts of the disk cutter and another member having means sustaining end thrusts of the side cutter.

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