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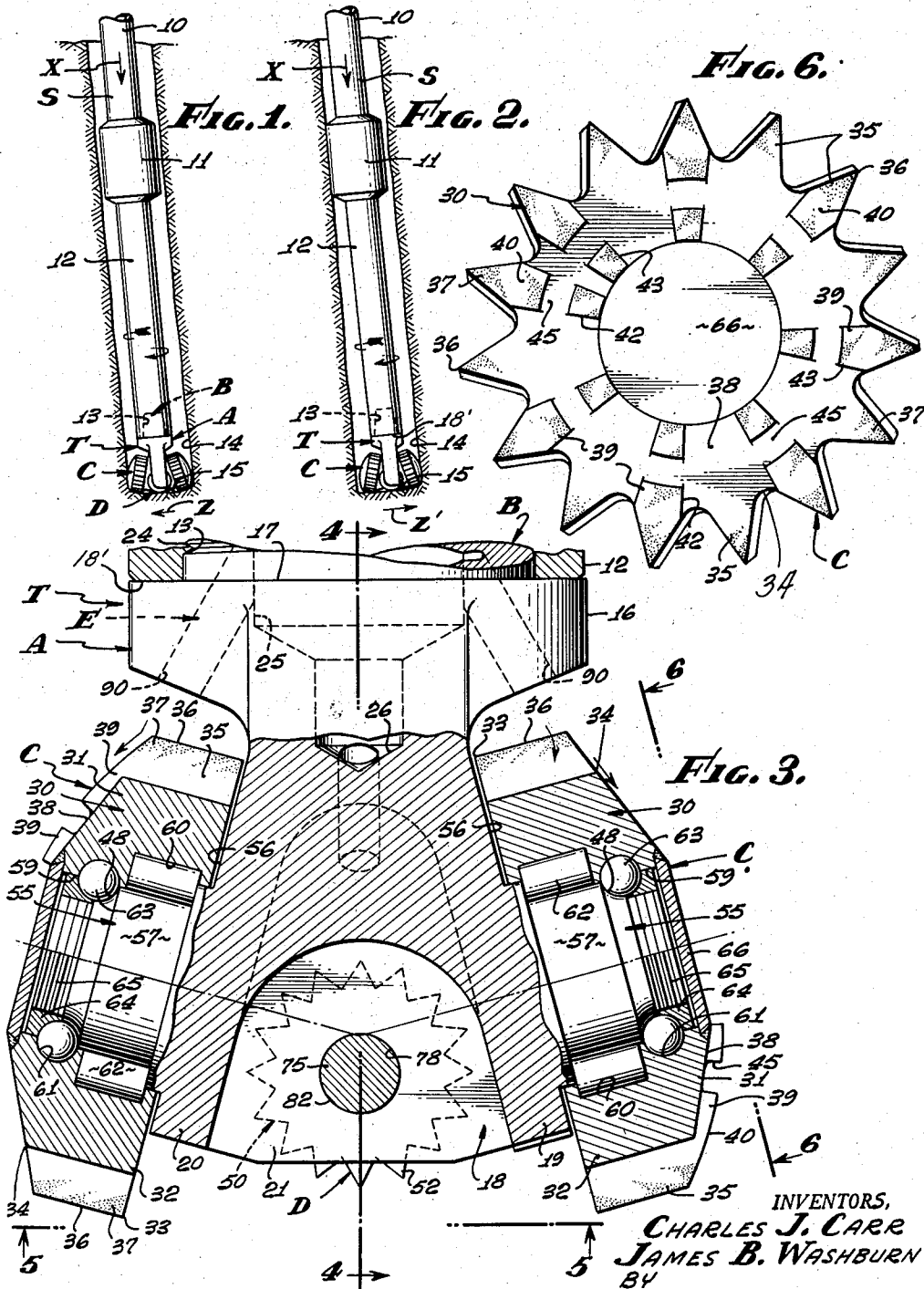
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2,886,293

DIRECTIONAL WELL BORE ROLLER BIT

Filed Jan. 10, 1955

2 Sheets-Sheet 1



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Fig. 4.

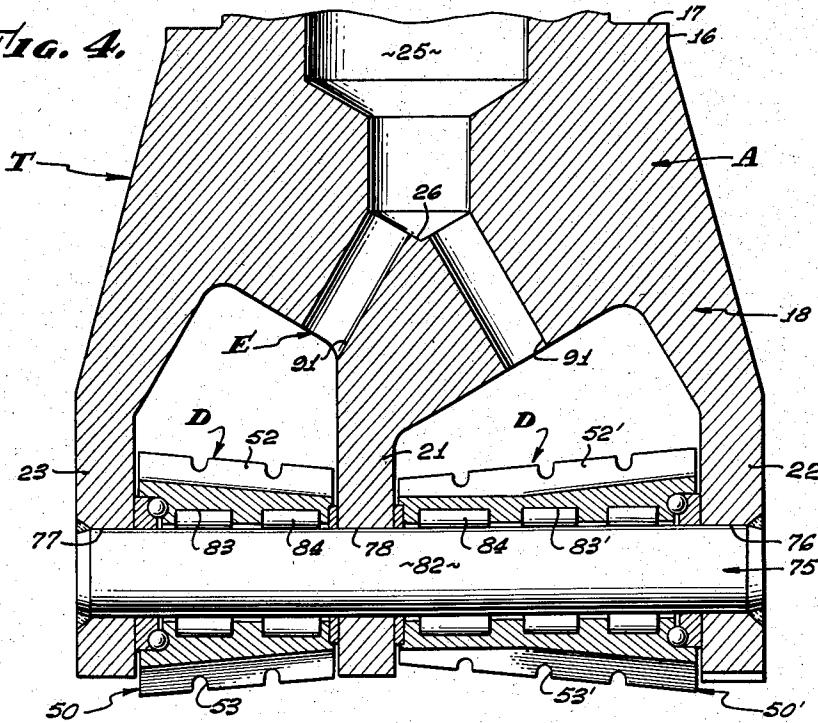
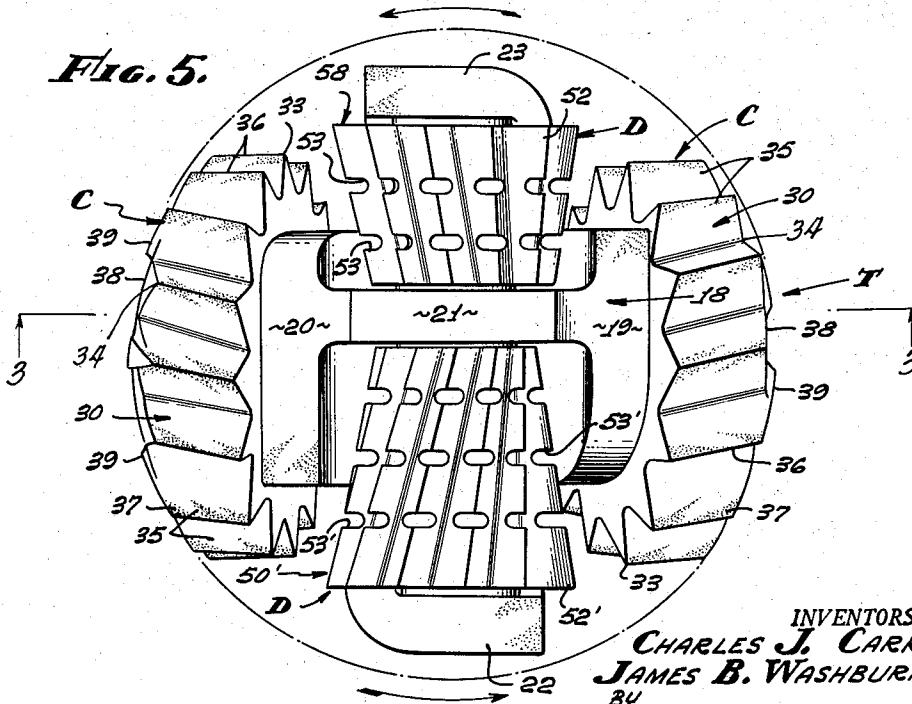


Fig. 5.



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DIRECTIONAL WELL BORE ROLLER BIT

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3 Claims. (Cl. 255—313)

This invention has to do with a well drilling bit and it is a general object of the present invention to provide a well tool construction wherein the active parts or cutters of the tool are particularly adapted for use in directionally cutting a well bore to a specified gauge.

This application is filed as a continuation-in-part of our now abandoned, application Serial No. 428,336 entitled, "Bore Reaming Roller Bit," filed May 7, 1954.

It is a primary object of this invention to provide a well boring roller bit which acts to effectively penetrate the earth formation and which acts to gauge the well bore at the bottom thereof. In the tool of the present invention there are cutters which simultaneously act upon the side wall of the well bore as well as upon the bottom thereof.

An object of this invention is to provide a cutter construction for a well drilling tool of the character referred to, which has cutting action on the bottom and the sides of the lower end portion of the well bore so that the operator by controlling the drilling string can determine the angle of drilling. The tool of the present invention is sensitive to weight so that the operator by increasing the weight of the drilling string upon the tool can build up angle in a well bore, or by decreasing the weight of the drilling string can allow the tool to drill downwardly or to drop angle. By employing the tool of the present invention a well bore may be maintained at a given deflection after a whipstocking operation without deviating from side to side.

It is also an object of this invention to provide a bore reaming roller bit having both bottom cutters that dig the bore and side reaming cutters that gauge the bore, and which bit is characterized by the absence of outside leg constructions so that the body of the tool does not come into contact with the well bore.

It is another object of the invention to provide flushing means for the cutters of a bore reaming roller bit of the character referred to, which means acts to clean both the periphery and the outside cutting faces of the roller cutters.

It is still another object of this invention to provide a bore reaming roller bit which acts to open a well bore to full bit diameter and in which the cutters of the bit are of maximum size and are so related to the elements of the structure that maximum chip clearance is provided.

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

Figs. 1 and 2 are cross sectional views taken through a well bore, showing the mode of operation of the roller bit provided by the invention. Fig. 1 shows the bit in operation to maintain a given angle of deflection, while Fig. 2 shows the bit in operation to build angle or to increase the amount of deflection. Fig. 3 is an enlarged detailed sectional view of the bit that we provide and

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taken as indicated by line 3—3 on Fig. 5. Fig. 4 is a view taken as indicated by line 4—4 on Fig. 3, showing the structure in cross section. Fig. 5 is an enlarged lower end view of the roller bit taken as indicated by line 5—5 on Fig. 3 and Fig. 6 is an end view of one of the cutters taken as indicated by line 6—6 on Fig. 3.

The bit T of the present invention is adapted for use at the lower end of a drilling string S which may involve a drill collar 10, a stabilizer 11 and a sub 12. The stabilizer 11 is inserted between the drill collar 10 and sub 12, and the bit T is carried at the lowermost end of the drill string S by the bottom portion of the sub 12 which is internally threaded at 13 to receive the bit T.

The bore reaming roller bit T provided by this invention acts upon the cylindrical side wall 14 of the bore as well as upon the bottom end 15 thereof and involves, generally, a body A, a pin B projecting upwardly from the body, substantially disc-shaped bore gauging cutters C carried at the sides of the body A, roller-type bottom or cross sectional cutters D carried at the bottom of the body A, anti-friction means rotatably carrying the cutters C, anti-friction means rotatably carrying the cutters D, and flushing means E for cleaning the cutters C and D.

The body A is an elongate vertically disposed element having an outer wall 16, a top face 17 and a depending cutter carrying portion 18. The outer wall 16 is preferably of the same diameter as the drill string S and extends downwardly from the lower end of the drill string S. The top face 17 faces upwardly and has seating engagement with a lower end face 18' at the bottom end of the sub 12.

The depending cutter carrying portion 18 of the body A is characterized by and involves a pair of legs 19 and 20 that extend downwardly from opposite sides of the body, a web 21 that extends between and joins the legs, and a pair of arms 22 and 23 that also extend downwardly from opposite sides of the body. The parts of the body A are preferably formed of a single body of material and the legs 19 and 20 project downwardly in substantially diverging planes which are positioned so that the projecting intersecting apex of the planes extend through the vertical axis of the body A while the arms 22 and 23 projecting downwardly in parallel planes spaced radially of the vertical axis of the body and at right angles to the planes in which the legs occur. The web 21 extends between the legs 19 and 20 at or near the vertical axis of the structure thereby tying the legs together to prevent spreading and distortion thereof. The arms 22 and 23 are also spaced and depend from diametrically opposite sides of the body A.

The bore gauging cutters C are substantially disc-shaped members and are on axes which extend transversely of the body A, and are normal to the planes in which the legs occur. The roller type cutters D are on an axis substantially normal to the axes of the cutters C and intersect the axes of the arms 22 and 23 and the vertical axis of the body so that the axes of the cutters C and D are normal to each other in plan view, as illustrated in Fig. 5 of the drawings.

The pin B is in the form of a tapered screw threaded part that projects upwardly from the face 17 of the body A and has a threaded exterior 24 and a central fluid handling bore 25. The exterior 24 is screw threaded into the bottom of the sub 12 at 13, and the bore 25 terminates at a bottom 26 at or within the upper end of the body A.

The bore gauging cutters C are alike and are provided to act upon the cylindrical wall 14 of the well bore as well as upon the peripheral portion of the bottom 15 thereof. Each cutter C is a wheel- or disc-shaped element 30 having a side cutting end portion 31 and a bottom cutting peripheral portion 32. The element 30 has

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inner and outer peripheral corner edges 33 and 34, and as shown throughout the drawings; the cutting end portion 31 has a frusto-conical face that is confined within the outer peripheral edge 34 of the element 30. The portions 31 and 32 of the cutters C are formed concentric with the central axis of the cutters.

The cutters C act upon the outer portion of the well bore and trim or ream the well bore to gauge as the earth formation is penetrated. Each cutter C is carried on an inclined axis that extends upwardly and outwardly from the body portion 18 and the central longitudinal axis of the tool, so that the face of the side cutting end portion of the element 30 lies adjacent to the side 14 of the well bore and so that the bottom cutting peripheral portion 32 of the element 30 lies adjacent to the bottom 15 of the well bore. In the preferred form of the invention the portions 31 and 32 of the element 30 are so related that the frusto-conical cutting face of portion 31 conforms to the circular side 14 of the well bore, while the downwardly disposed tapered portion 32 is substantially parallel to the bottom 15 of the well bore.

An annular series of teeth 35 extend around the circumference of the peripheral portion 32 of the element 30 to project radially outwardly therefrom. The teeth 35 may be V-shaped with cutting edges 36 and are preferably helically formed and extend between the edges 33 and 34 of the element 30. In practice, suitable hard-facing 37 is applied to the cutting edges as is common practice in tools of the type under consideration. The teeth 35 may be equally spaced circumferentially of the cutter or they may be unequally spaced or staggered, as circumstances require.

The side cutting portion 31 of each bore gauging cutter C has a substantially radially disposed, longitudinally outwardly inclined face 33 concentric with the axis of the cutter. The face 38 is coextensive with the outer end of the cutter C, and terminates at the outer peripheral edge 34 thereof. In accordance with the present invention, an annular series of bore gauging teeth 39 project axially outwardly from the face 38 of each cutter C. As clearly illustrated in Figs. 3 and 6 of the drawings, the teeth 39 are in the form of ridges that extend radially from the central portion of the cutter to the outer peripheral portion thereof. In practice, each tooth 39 is in radial alignment with one of the teeth 35 and is extended radially outwardly to overlie the adjacent end of the tooth 35 related thereto.

Since the cutters C are established from a single piece of stock and are formed by a forging and/or machining operation, it will be apparent that the adjacent or related teeth 35 and 39 thereof are in fact integrally joined together.

It is preferred that there be a tooth 39 for every other tooth 35, as shown.

Each ridge-like tooth 39 has an outer land 40 extending longitudinally thereof, which land is spherically formed from a center coincident with the vertical axis of the bit. In the case illustrated, the inner end of the land 40 of each tooth 39 terminates at a point spaced from the central axis of the cutter, while its outer end terminates at the cutting edge 36 of the tooth 35 related thereto.

When the bit of the present invention is operated to penetrate earth formation it is rotated in a clockwise direction as indicated throughout the drawings, in which case the cutter C revolves in a counter-clockwise direction relative to the body A. The teeth 39 are therefore successively brought into cutting engagement with the earth formation. Each tooth 39 has a leading cutting edge 42 and a trailing cutting edge 43 which are coextensive with the tooth at the sides of the land 40 so that the teeth are effective in removing earth formation from the side 14 of the well bore. Suitable hard-facing may be applied to the teeth 39 as circumstances require. Notches 45 are provided in the teeth 39 to allow for

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chip clearance and in effect establish concentric inner and outer annular series of teeth.

The bottom or cross sectional cutters D are substantially alike, and are provided to act upon the bottom of the well bore and are characterized by cylindrically-shaped elements 50 and 50'. The elements 50 and 50' are preferably inwardly tapered and have annular sets or series of teeth 52 and 52' at their exteriors. As shown, the cutters D are carried between the legs 19 and 20 hereinabove referred to, on a common axis which extends horizontally between the arms 22 and 23 and normal to the axes of the cutters C. It is preferred that the elements 50 and 50' be of different lengths, so that the element 50' covers the center of the well bore and overlaps the path of the element 50 as the tool operates. The teeth 52 and 52' are helically pitched in opposite directions and are provided with staggered notches 53 and 53' so that the teeth of one cutter do not track in the path of the teeth of the other cutter.

The means provided for rotatably carrying the cutters C involve a trunnion 55 for each element 30. The trunnions 55 project upwardly and outwardly from the outer sides 56 of the divergent legs 19 and 20, respectively, and each trunnion has a radial bearing surface 57 and an annular race 48 at the outer terminal end thereof. Each cutter element 30 has a bore 59 that is adapted to receive a trunnion 55 and which has an inner bearing surface 60 and an annular race 61 at the outer end thereof. An annular row or series of anti-friction rollers 62, or the like, is provided between the bearing surfaces 57 and 60, and the rollers are retained by axially spaced shoulders in the member 30.

The cutters C are retained on the trunnions 55 by means of an annular series of balls 63 operating in the races 48 and 61. As shown, the race 61 is formed in the bore 59 to open radially inwardly while the race 48 is formed in the trunnion 55 to open longitudinally and radially outwardly. In practice, a retainer 64 is threadedly secured to the end portion of the trunnion 55 at 65 and, as shown, forms the outer half of the race 48. A suitable lock pin, or the like, may be provided to secure the retainer in position. It will be apparent how the balls 63 are inserted between the races and retained therein to take axial thrust thereby rotatably securing the cutter on the trunnion. As shown in Fig. 3 of the drawings, a cover plate 66 is provided and closes the outer end of the bore 59 covering the bearing rollers 62 and balls 63 and the retainer 64. Welding, or the like, is used to fasten the plate 66 in place.

The means for rotatably carrying the cutters D involves a pin 75 and bearing supports for the pin. The pin 75 is a simple elongate part that extends transversely of the bottom of the body A between the arms 22 and 23. Bearing openings 76 and 77 are provided in the arms at the sides of the body A and a bearing opening 78 is provided in the web 21 between the elements 50 and 50'. As shown, in Fig. 4 of the drawings, the web 21 is off-set relative to the central axis of the body A, and the bearing openings 76, 77 and 78 are aligned in the arms 22 and 23 and web 21 for receiving and carrying the pin 75. The pin 75 has an outer bearing surface 82, while the elements 50 and 50' have inner bearing surfaces 83 and 83'. An annular row of rollers 84 is provided between the bearing surfaces of each cutter and the pin, so that the cutters are free to rotate on the pin. The pin 75 may be suitably secured in the bearing openings in the arms and web of the body A by means of welding, or the like.

The flushing means provided by the present invention provides for cleaning of both sets of rollers. That is, the flushing means acts to flush or clean the bore gauging cutters C as well as the bottom or cross sectional cutter D. As clearly illustrated in Figs. 3 and 4 of the drawings, jets 90 are provided which direct the flow of mud from the drilling string to the edge 34 of each

cutter element 30. It will be noted that the streams of mud delivered by the jets 90 are split by the edges 34, so that a portion of the mud cleans the end faces 38 of the cutters while a portion of the mud cleans the periphery thereof. Jets 91 carry mud to the lower cross sectional cutters D as shown in Fig. 4 of the drawings.

In operation of the bit, the shank or pin is connected with the lower end of the drilling string and the bit is operated on the lower end of the string in the usual manner. As the bit is fed downwardly the cross section cutters D act on and cut away the formation in the central portion of the bottom 15 of the bore while the bore gauging cutters C act on and cut away the formation at the outer portion of the bottom 15 and cut the wall 14 of the bore to gauge. The cutters are positioned so that they have direct active cutting engagement with the entire bottom of the well bore, as the tool or bit revolves, there being no outer legs or supports as employed in usual bit constructions. The circulation fluid or mud is pumped downwardly through the drilling string and discharges through the jets 90 and 91 to clear the chips from the cutters and from the bottom and sides of the well bore.

In order to build angle in a deflected well bore as clearly illustrated in Fig. 2 of the drawings, a substantial amount of weight is applied to the bit through the drill string as indicated by the arrow X. The drill string is then rotated whereupon the cutters C act to cut upon the high side of the well bore as indicated by the arrow Z', there being no outer legs or supports to prevent such action as is the case with ordinary bit constructions.

In order to drop angle or to return a well bore to vertical, as clearly illustrated in Fig. 1 of the drawings, it is merely necessary to use less weight of the drilling string in the direction indicated by the arrow X and to rotate the string so that the cutters C act upon the lower side of the well bore as indicated by the arrow Z, there being no interference from body parts such as legs or supports.

Having described only typical preferred forms and applications of our invention, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art and fall within the scope of the following claims:

Having described our invention, we claim:

1. A well boring bit of the character referred to including, an elongate vertically disposed cylindrical body, a pair of downwardly divergent legs depending from diametrically opposite sides of the body, a pair of arms depending from diametrically opposing sides of the body and spaced 90° from the legs, a pair of axially aligned elongate, horizontally disposed roller cutters of different longitudinal extent extending between and rotatably carried by the arms to occur between the lower end portions of the legs and engage the bottom of a well bore, a substantially disc-shaped cutter with a substantially radially outwardly facing frusto-conical end rotatably carried by each leg to project outwardly therefrom on an axis disposed radially outwardly and upwardly relative to the central vertical axis of the body, each disc-shaped cutter having circumferentially spaced axially disposed cutting teeth about its outer periphery to engage the bottom of the well bore and having outwardly projecting radially disposed bore engaging teeth on said frusto-conical end to engage the bore, said bore engaging teeth being in radial alignment with and joining the bottom engaging teeth related thereto, said bore engaging teeth being spherically curved about a common point occurring on the central vertical axis of the bit and flushing means for each disc-shaped cutter including a fluid handling bore in the body and a jet opening in the body related to each of said cutters and adapted to direct circulating fluid on the cutters between the axially and radially disposed teeth thereon.

2. A well boring bit of the character referred to including, an elongate vertically disposed body, a pair of downwardly divergent legs depending from diametrically opposite sides of the body, a pair of arms depending from diametrically opposite sides of the body and spaced 90° from the legs, a web extending between the legs and offset from the vertical axis of the body, an elongate horizontally disposed shaft extending between and carried by the arms to intersect the vertical axis of the body, project through the web and occur between the lower end portions of the legs, an elongate roller cutter rotatably carried by the shaft between the web and each arm and adapted to engage the bottom of a well bore, a substantially disc-shaped cutter with a radially outwardly facing frusto-conical end rotatably carried by each leg to project radially outwardly therefrom on a radially outwardly and upwardly inclined axis and having circumferentially spaced axially disposed cutting teeth about its periphery to engage the bottom of the well bore and having outwardly projecting, radially disposed bore engaging teeth on said frusto-conical end to engage the wall of the bore, said bore engaging teeth being arranged in radial alignment with the axially disposed teeth and extending radially outwardly from said edge of the cutter to join with the adjacent ends of the axially disposed teeth related thereto, said radially disposed teeth being spherically curved about a common point occurring on the central vertical axis of the bit, and flushing means for each cutter including a fluid handling bore in the body and jet openings in the lower end of the body related to each cutter.

3. A well boring bit of the character referred to including, an elongate vertically disposed body, a pair of downwardly divergent legs depending from diametrically opposite sides of the body, a pair of arms depending from diametrically opposite sides of the body and spaced 90° from the lower end portion of the legs, a web extending between the legs and offset from the vertical axis of the body, an elongate horizontally disposed shaft extending between and carried by the arms to intersect the vertical axis of the body, project through the web and occur between the lower end portions of the legs, an elongate roller cutter rotatably carried by the shaft between the web and each arm and adapted to engage the bottom of a well bore, a substantially disc-shaped cutter with a radially outwardly facing frusto-conical end rotatably carried by each leg to project radially outwardly therefrom on a radially outwardly and upwardly inclined axis and having axially disposed cutting teeth about its periphery to engage the bottom of the well bore and having outwardly projecting, radially disposed bore engaging teeth on said frusto-conical end to engage the wall of the bore, said bore engaging teeth being arranged in radial alignment with the axially disposed teeth and extending radially outwardly from said edge of the cutter to join with the adjacent ends of the axially disposed teeth related thereto, said radially disposed teeth being spherically curved about a common point occurring on the central vertical axis of the bit, and flushing means for each cutter including a fluid handling bore in the body and jet openings in the lower end of the body related to each cutter, said jet openings related to the roller cutter being directed towards the top of each roller cutter at a point intermediate its ends, said jet opening related to each disc-shaped cutter being directed at the top of each disc-shaped cutter at a point where said frusto-conical end joins the outer periphery of the cutter.

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