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2,184,066

FLUID OPERATED DRILLING TOOL

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2 Sheets-Sheet 1

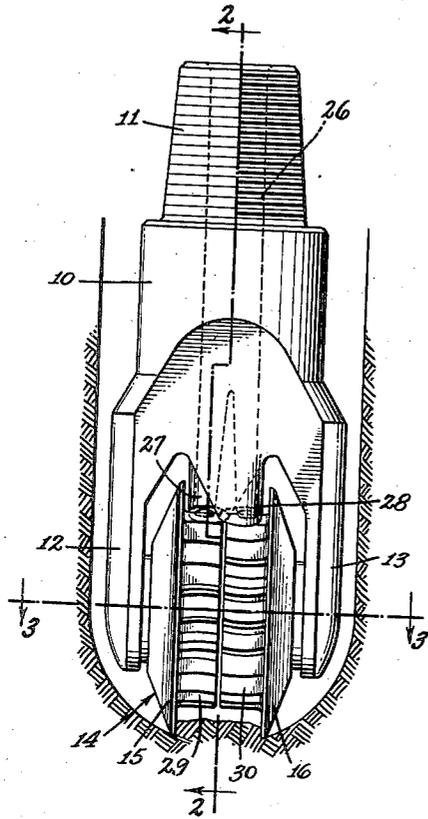


Fig. 1.

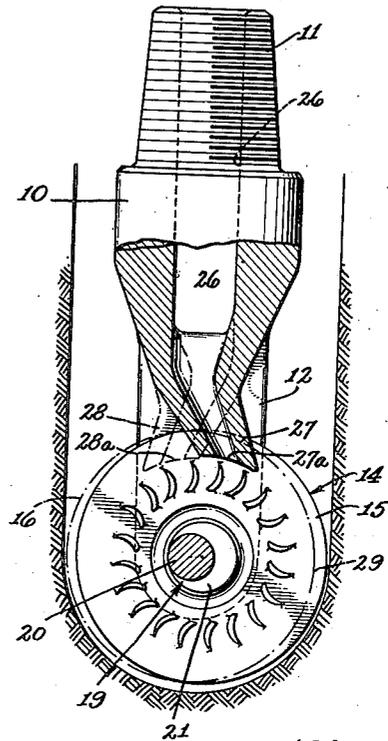


Fig. 2.

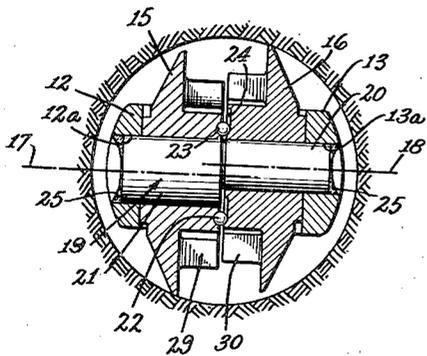


Fig. 3.

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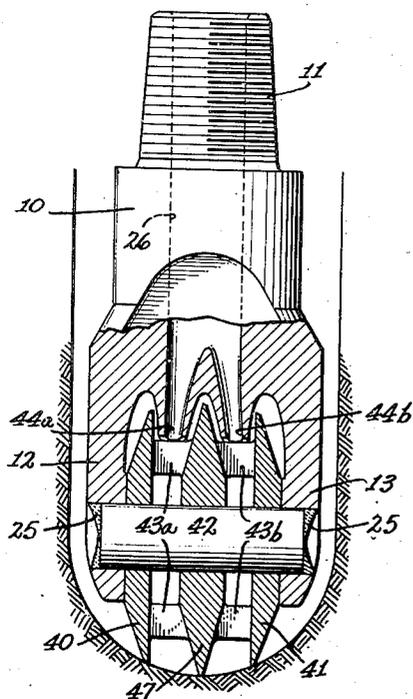
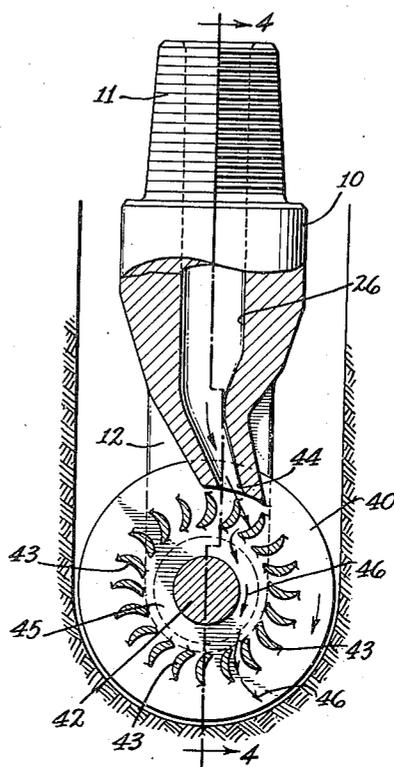
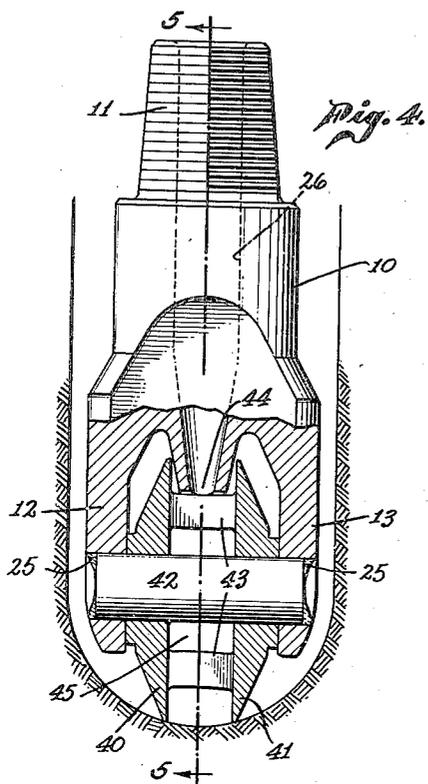
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FLUID OPERATED DRILLING TOOL

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2 Sheets-Sheet 2



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FLUID OPERATED DRILLING TOOL

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9 Claims. (Cl. 255—71)

This invention relates to rotary well drilling equipment and particularly to rotary drilling bits having cutter elements whose cutting portions are in the form of discs.

The prior art disc bits drill bore holes by scraping away the formation in much the same manner as drag bits. Disc bits offer a greater scraping surface for operation upon the formation since the disc cutters thereon can rotate on their supporting shank under the impetus supplied by the shank and the reactive engagement of the cutters with the formation. Despite the fact that the cutters rotate with respect to the shank, the speed of such rotation is relatively small so that the peripheral cutter surfaces effect very little if any, formation removal, which is accomplished predominantly by the side surfaces of the discs.

Reliance upon the formation reaction makes the rotation of the cutters on the shank lacking in positiveness, the disc cutters having a tendency to bind on their bearings and become flat. When this situation develops rotation of the cutters practically ceases, defeating the main object of the prior art disc bits, since they are then unable to present a greater extent of cutting surface to the formation than is obtainable with drag bits. Due to the flattening of the disc cutters it becomes necessary to impose excessive drilling weights on the bit to make progress. Invariably, such excessive weights are productive of crooked holes caused by the tendency of the bit to deviate from the vertical on passing between different types of stratifications.

It therefore becomes an object of this invention to rotate disc cutters positively to avoid and diminish the possibility of their running flat.

It is a further object of the invention to rotate disc cutters on their supporting body at a fast rate of speed in order that the peripheral disc portions can cut many grooves into the formation to effect its removal.

Another object of the invention is to rotate disc cutters positively and at a fast rate of speed to remove the formation primarily by means of the peripheral disc cutter portions, and secondarily by the side cutter portions.

It is desirable to have a prime mover near the disc cutters to avoid the necessity for transmitting power from the surface of the hole through a long flexible string of drill pipe. However, in the prior art arrangements in which a turbine or other prime mover is placed adjacent the drilling bit, twisting strain on the drill pipe is not avoided because of the reactive torque imposed on the turbine stator blades, which are usually

fixed to the drill pipe. About the only advantage that is gained is to avoid the necessity for rotating the drilling pipe, except slowly to eliminate the possibility of its becoming stuck in the hole.

It is therefore a further object of the invention to diminish or eliminate the drilling torque imposed on the drill pipe.

It is a further object of this invention to incorporate a prime mover mechanism directly into a disc type of bit, this prime mover being preferably of the hydraulic type.

A further object of the invention involves a hydraulically operated disc bit in which the energy in a fluid is used to rotate one or more roller cutters through which the fluid passes to keep the cutters and the hole clean.

In the drawings, several embodiments of the invention are disclosed to illustrate how the aforementioned and other objects are accomplished. However, it is to be understood that such exemplifications of the invention are for illustrative purposes only and are not to be construed as limiting the invention, which is best defined in the claims appended hereto.

Figure 1 is a side elevation of a disc bit embodying the present invention.

Figure 2 is a longitudinal section on the plane 2—2 of Figure 1.

Figure 3 is a transverse section on the plane 3—3 of Figure 1.

Figure 4 is a side elevation of a modification of the invention.

Figure 5 is a longitudinal section on the plane 5—5 of Figure 4.

Figure 6 is a side elevation of a further modification of the invention.

The form of invention disclosed in Figures 1 to 3 includes a shank or supporting body 10 having a tapered threaded pin 11 at its upper end and depending legs 12, 13 at its lower portion, between which is carried the disc cutter assembly 14. A plurality of discs 15, 16 is disclosed, and these can be carried by the shank to rotate thereon about coincident axes. However, for the purpose of decreasing the extent of cutter contact with the formation in order that they will penetrate with lesser drilling weight, the respective axes 17, 18 of the disc cutters 15, 16 are mutually offset.

To obtain the offset relationship between the discs, they are mounted to rotate upon a stepped bearing supporting shaft 19, with one disc 16 mounted on the smaller bearing section 20 and the other disc 15 mounted on the larger bearing

section 21. The ends of the shaft are mounted in the shank legs with the smaller end 20 fitting into a bore 13a in one of the legs 13, the larger end 21 being receivable in a bore 12a in the other leg 12.

Radial loads or thrusts upon the discs 15, 16 will be absorbed by the cylindrical bearing portions 20, 21 on the shaft. Axial or end thrusts imposed upon the cutters by the formation are transmittable directly to the legs, or a suitable thrust bearing (not shown) can be placed between the end face of each disc and its adjacent leg. Endthrusts are transmitted between the discs 15, 16 through the use of the bearing balls 22 which can roll in a toroidal raceway 23 in one of the discs 15 and in a second raceway 24 in the other disc 16, which raceway is elongated in a radial direction in order to permit proper rolling action of the balls 22 therein as the discs rotate with respect to one another.

The discs can be mounted on the shank by laying one of them 15 in a substantially horizontal position and placing the balls 22 in the raceway 23, after which the other disc 16 can be placed on these balls with its raceway 24 in contact therewith. The two discs thus assembled are then inserted between the legs 12, 13 and the stepped bearing shaft 19 inserted through the leg 12 and the disc cutters until its small end 20 is seating properly within the bore 13a in its cooperative leg. Rotation of this shaft and its endwise displacement will be prevented by welding in material 25 between the sides of the leg bores 12a, 13a and the ends of the shaft. Removal of the bearing 19 and the cutter elements 15, 16 can be had by cutting away the welding material 25 either through the use of a drill or a cutting torch, and then by disassembling the bearing and cutters by reversing the above noted procedure.

Positive rotation of the discs on their respective bearing supports is insured by making use of the energy in a fluid, such as drilling fluid, passing through a string of drill pipe (not shown), through the fluid passageway 26 in the shank and then through the nozzles 27, 28 whose outlet openings 27a, 28a are placed in close proximity to blades, buckets or vanes 29 or 30 fixed to each disc 15 or 16, as by forming them integrally therewith. The blades are shaped to simulate those of an impulse type of water wheel or turbine, although it is to be understood that blades of the reaction type, or of a combined impulse and reaction type, can be used. The angle of discharge from each nozzle is preferably such as to direct fluid generally tangentially of the blades, imparting its energy thereto and rotating its associated disc cutter on its bearing support.

The nozzles 27, 28 for each set of legs 12, 13 and disc cutters 15, 16 are inclined in opposite directions so that the energy in the fluid stream will cause the cutters to rotate in opposite directions. These nozzles and the blades 29, 30 can be so arranged as to assist the rotation of the discs with respect to the shank under the influence of the shank rotation in the hole and their reaction with the formation, or the nozzles and blades can be arranged to rotate the discs in an opposite sense to that induced by the shank and the formation. Regardless of which direction of rotation is used, assurance will be had that the discs will be positively rotated to avoid flat spots, any rotation induced by the shank and the formation being only of secondary moment.

In addition to the feature of insuring positive rotation of the disc cutters, the nozzles and blades can be designed and arranged so that the fluid discharge upon the blades possesses sufficient energy to rotate the discs at a high rate of speed to cause their peripheral portions to cut grooves into the formation in a manner similar to the action of a thin grinding wheel or a milling cutter. Simultaneous rotation of the spring of drill pipe and the shank attached thereto will cause the discs to assume an infinite number of positions of rotation and produce a similar number of grooves, all of them combining to produce a bore hole of the required diameter. However, it is contemplated that the main cutting effort be induced by the fluid stream, the string of drill pipe being turned to insure that all parts of the hole are covered by the cutters and to prevent the pipe from binding in the bore.

The fluid nozzle arrangement imposes very little reactive torque on the drill pipe since the line of action of the nozzles is longitudinally of the hole axis, the transverse or horizontal component of the fluid discharge being small and correspondingly keeping the reactive torque to a minimum.

It will be noted that the diameter of the blades 29, 30 is preferably smaller than the diameter of the discs 15, 16 so that the blades are free from contact with the formation. It is only upon extreme wear occurring on the discs that the blades will engage the formation, and upon this condition presenting itself, the blades can function as cutter elements in addition to their normal turbine or water wheel function.

In the embodiment illustrated by Figures 4 and 5, a double disc 40, 41 operating as a single integral member is carried by the shank 10 between the two legs 12, 13 on a suitable bearing supporting pin 42. It will be noted that the disc cutters 40, 41 are spaced apart, being connected for simultaneous rotation by the ribs 43 which are in the form of blades, buckets or vanes. A drilling fluid will have its velocity increased in passing through a nozzle 44 in the shank and will impinge upon the buckets 43 to cause rotation of the discs 40, 41 with respect to the shank 10. The interior 45 of the disc and turbine wheel construction is hollow to form a chamber permitting the fluid to exhaust from the blades 43 and pass transversely within the cutter assembly to its other side, the fluid making a second passage through the blades before exiting, as shown by the arrows 46.

In its general aspects this type of turbine disc bit is similar to a radial flow impulse turbine. The fluid exiting by reason of its discharge through the blade assembly avoids interference between it and the inlet fluid from the nozzle 44. This same exiting fluid will clean the blades 43 and also the cutting edges of the discs 40, 41 and will pass to the bottom of the hole to remove the cuttings therefrom.

In the modification disclosed in Figure 6 the construction is similar to Figures 4 and 5 with the exception that an additional disc 47 and two sets of nozzles 44a, 44b and turbine blades 43a, 43b are used. The horsepower of the bit is increased by this construction since a greater quantity of fluid at a given pressure can be used to rotate the discs on their axis. Of course, the nozzles 44a, 44b and blades 43a, 43b will face in the same direction so that the entire combined effect of the fluid streams can be realized.

I claim:

1. A drill bit including a supporting body, a plurality of individual disc cutters supported by said body for rotation with respect thereto, a plurality of vanes fixed to each cutter, and fluid nozzles on said supporting body with their respective outlets closely adjacent said vanes, said nozzles being inclined with respect to each other and arranged to direct their respective discharges substantially tangentially against the vanes to rotate the cutters relatively to the body.

2. A drill bit including a supporting body, a plurality of disc cutters supported by said body for rotation with respect thereto, a plurality of vanes fixed to said cutters whereby they are rotatable together as a unit, and fluid discharge means arranged on said supporting body to direct its discharge against said vanes to rotate the cutters relatively to the body.

3. A drill bit including a supporting body, a plurality of disc cutters supported by said body for rotation with respect thereto, a plurality of vanes extending between and fixed to said cutters whereby they are rotatable together as a unit, and a nozzle arranged on said supporting body to direct its discharge against said vanes to rotate the cutters relatively to the body.

4. A drill bit including a supporting body, a plurality of cutters supported by said body for rotation with respect thereto, a plurality of vanes extending between and fixed to said cutters to form a chamber therewithin, and a nozzle arranged on said supporting body to direct its discharge against said vanes to rotate the cutters relatively to the body.

5. A drill bit including a supporting body, a cutter supported by said body for rotation with respect thereto, a plurality of vanes fixed to said cutter to provide fluid entrance and exit portions generally radially of said cutter, and a

nozzle arranged on said supporting body to direct its discharge against the entrance of said vanes to rotate the cutter relatively to the body.

6. A drill bit including a supporting body, a cutter supported by said body for rotation with respect thereto, a plurality of vanes fixed to said cutter to provide fluid entrance and exit portions generally radially of said cutter, and a nozzle arranged on said supporting body externally of said cutter to direct its discharge inwardly against the entrance of said vanes to rotate the cutter relatively to the body.

7. A drill bit including a supporting body, a plurality of individual disc cutters supported by said body for rotation with respect thereto about mutually offset axes, a plurality of vanes fixed to each cutter, and fluid nozzles on said supporting body with their outlets closely adjacent said vanes to direct their discharges thereagainst and rotate the cutters relatively to the body while said cutters are in formation contact.

8. A drill bit including a supporting body, a pair of cutters supported by said body for rotation with respect thereto, a plurality of vanes extending circumferentially between said cutters and fixed thereto to form a chamber therewithin, and a fluid nozzle arranged on the body to direct its discharge against said vanes from where it will pass to said chamber.

9. A drill bit including a supporting body, a pair of end cutters and an intermediate cutter supported by said body for rotation with respect thereto, circumferentially arranged vanes fixed to said intermediate cutter and one end cutter, circumferentially arranged vanes fixed to said intermediate cutter and said other end cutter, and a pair of nozzles on said body respectively cooperable with each group of vanes to direct their discharges thereagainst.

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