Dec. 19, 1939.

J. A. ZUBLIN

2,184,065

FLUID OPERATED DRILLING BIT

Filed July 15, 1938

2 Sheets-Sheet 1

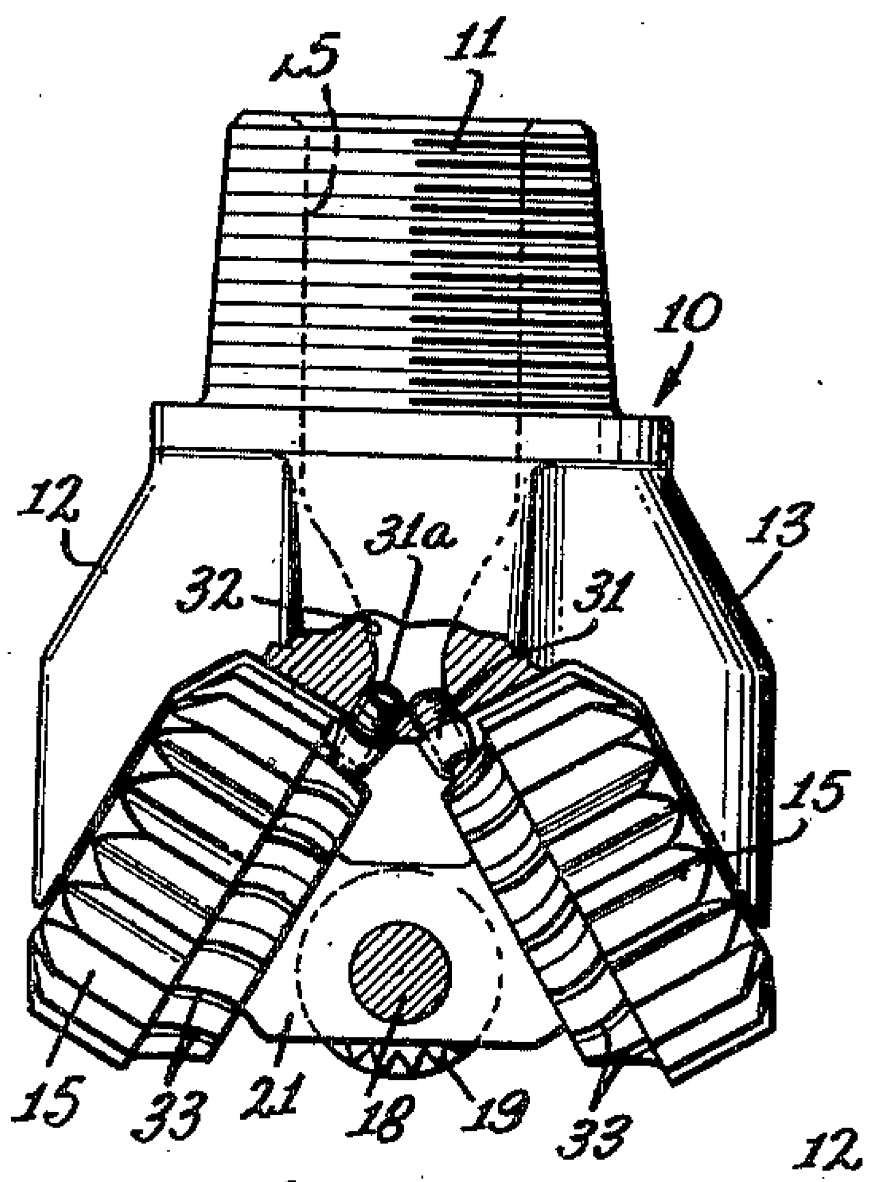

Fig. 8.

Fig. 1.

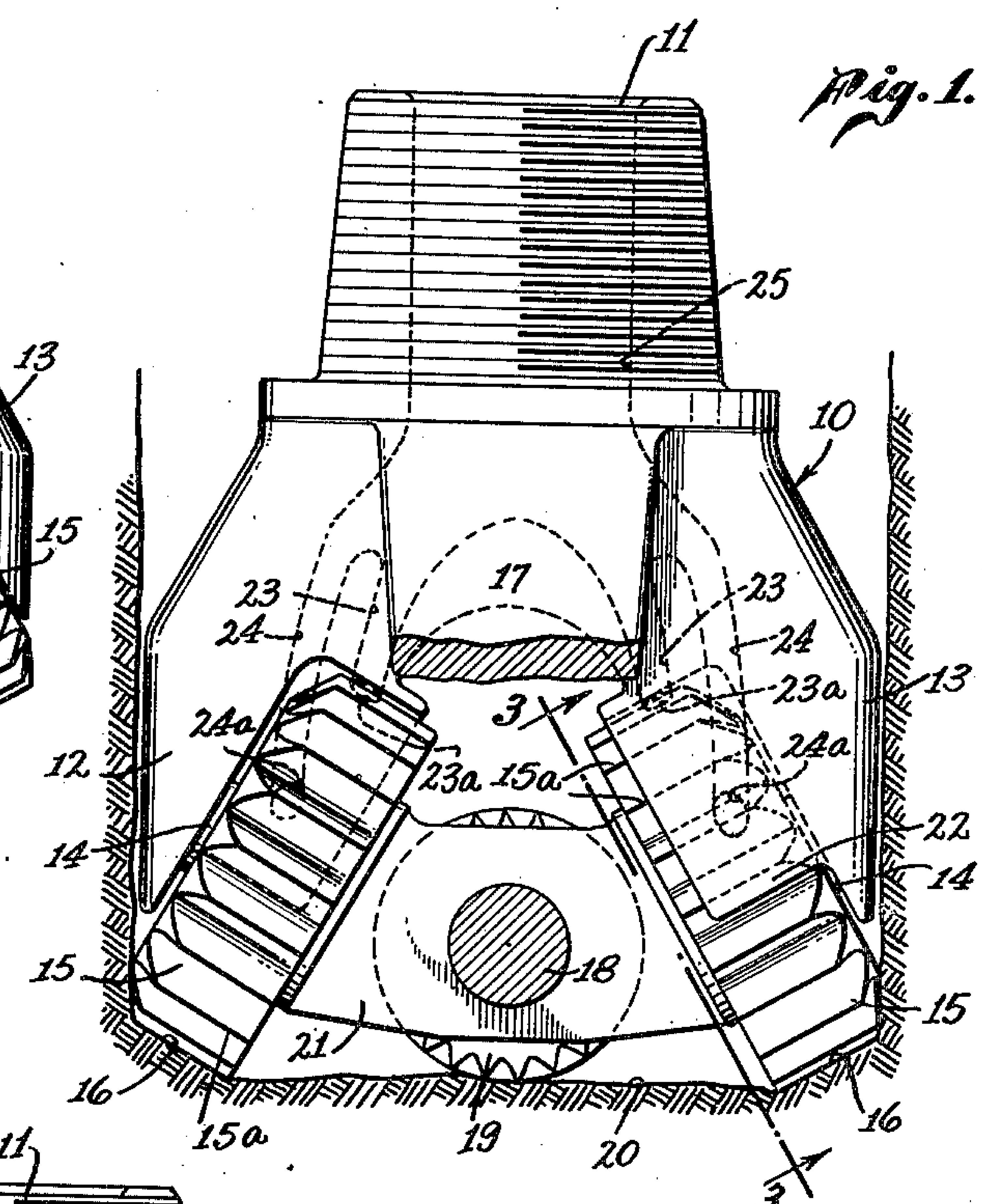

Fig. 2.

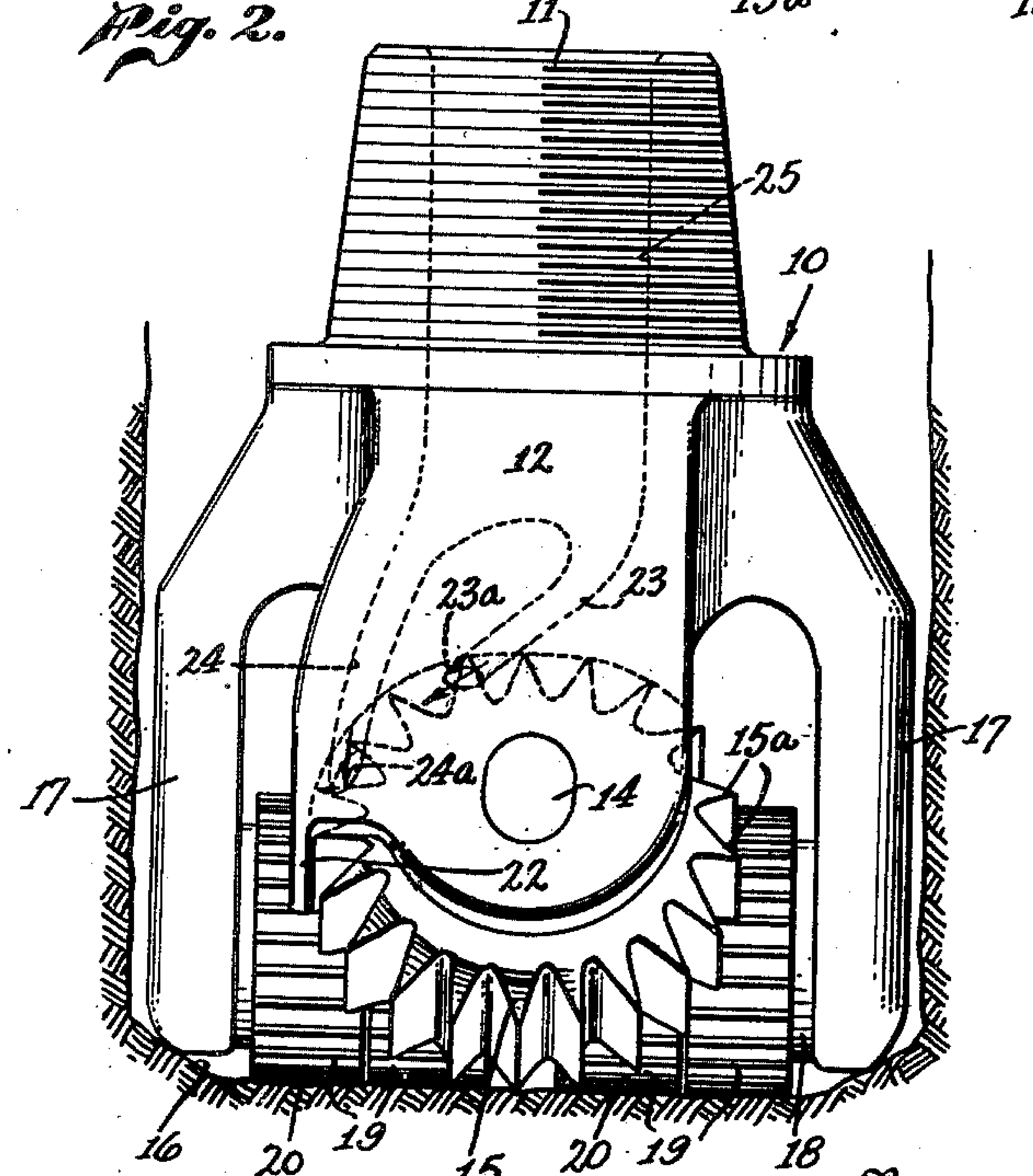

Fig. 3.

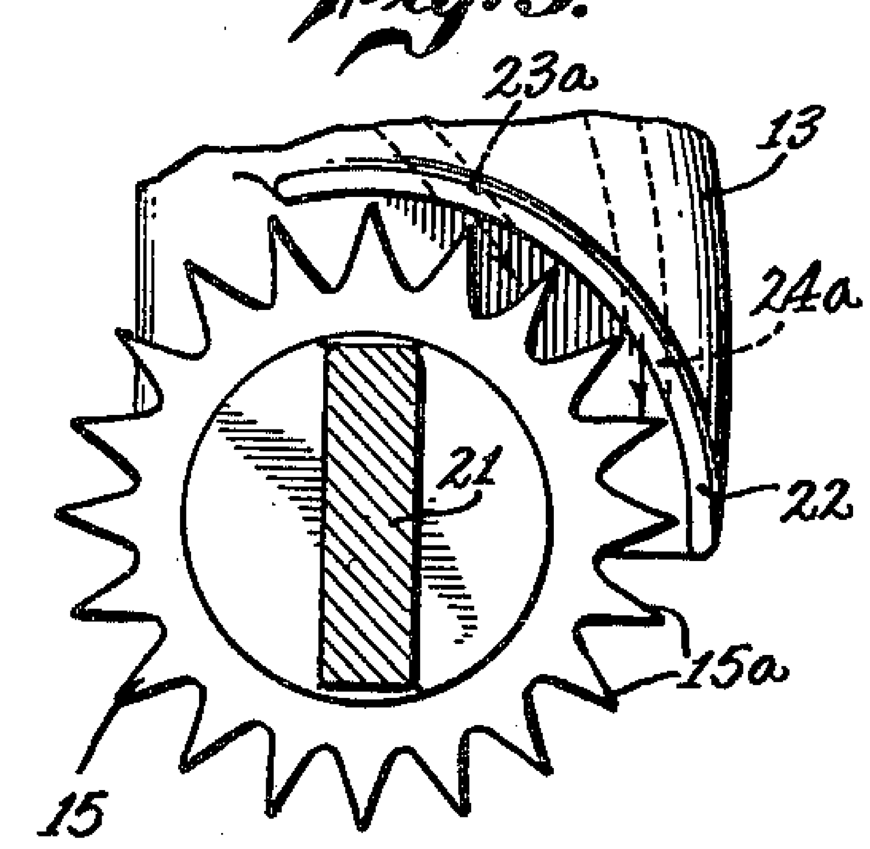

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Fig. 4.

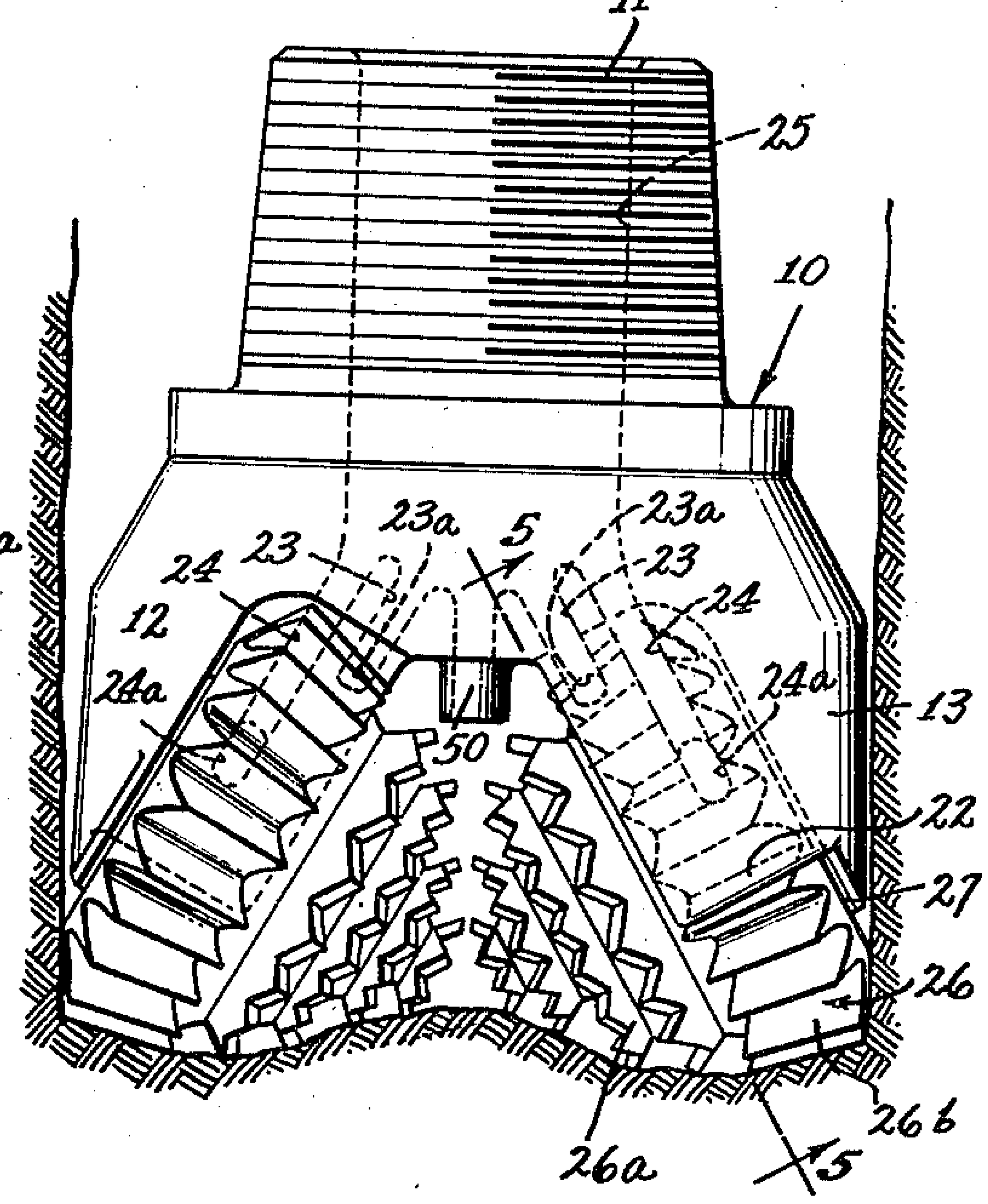


Fig. 5.

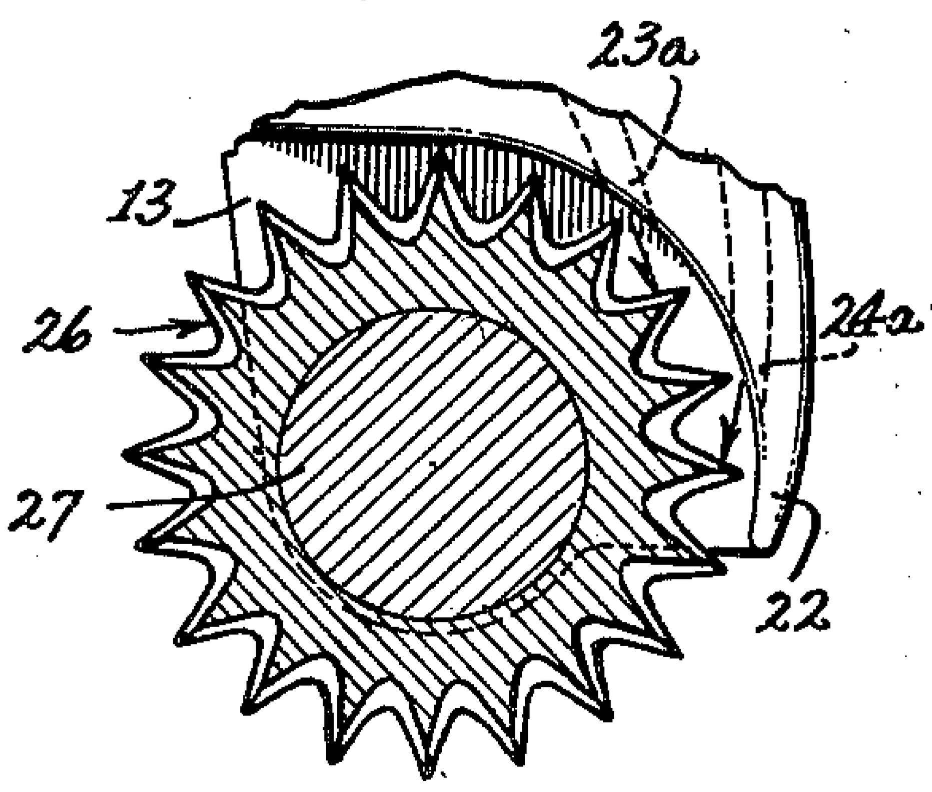


Fig. 6.

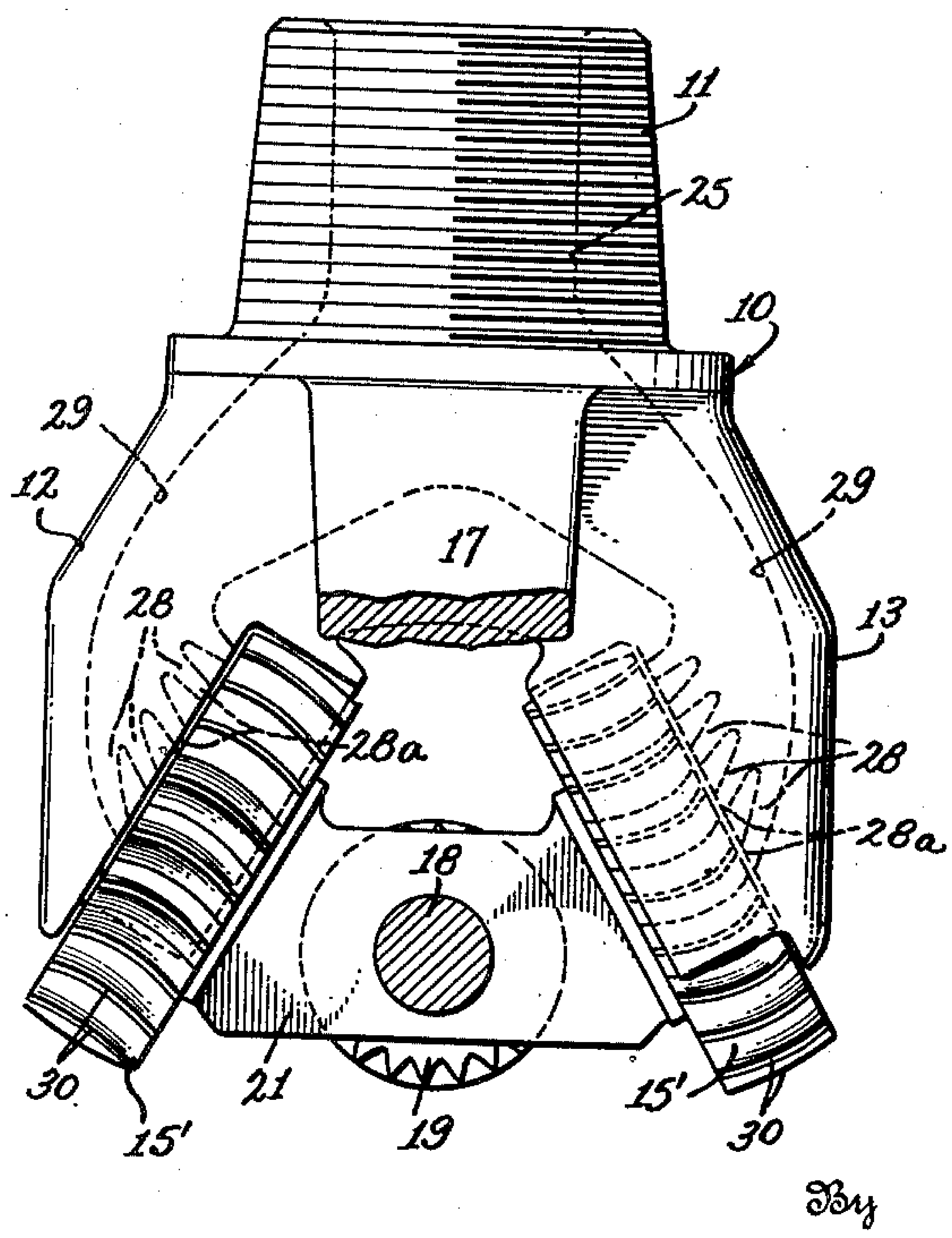
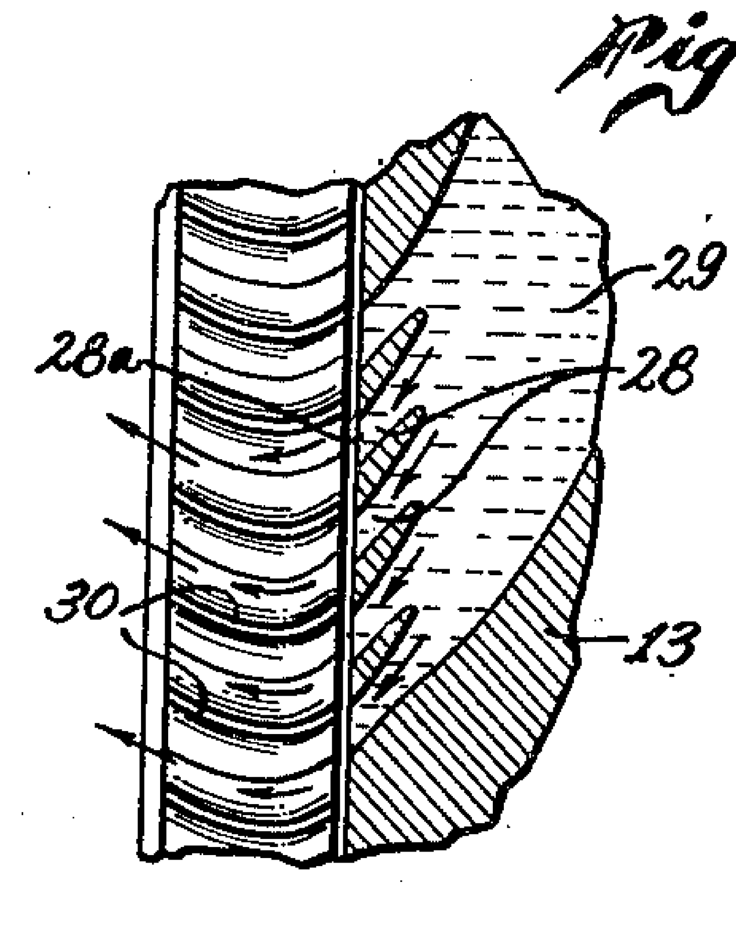


Fig. 7.



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UNITED STATES PATENT OFFICE

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FLUID OPERATED DRILLING BIT

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Application July 15, 1938, Serial No. 219,356

12 Claims. (Cl. 255—71)

This invention relates to drilling tools, and more particularly to tools used in the rotary drilling of bore holes, such as oil wells.

It is an object of this invention to provide a drill bit operable with a decrease in or an elimination of the torque impressed upon the drill pipe by the present rotary drive mechanisms.

It is a further object of this invention to avoid the need for rotating a drill bit primarily through rotation of a string of drill pipe.

Still another object of the invention is to utilize the energy in a fluid under pressure to rotate a drill bit in a hole.

A further object of this invention is to utilize the energy in a fluid under pressure passing through a string of drill pipe to rotate a drill bit in a hole.

Another object of the invention is to incorporate the motive power mechanism for rotating an earth boring tool directly into the tool itself.

A further object of the invention involves the provision of a drilling tool that eliminates the requirement for heavy rotary driving mechanisms at the surface of the bore being produced.

Yet another object of the invention is to utilize the energy in a stream of fluid for rotating an earth boring tool in the hole, while substantially simultaneously cleaning the tool and hole of cuttings.

A further object of the invention is to provide a turbine rotary drilling bit operable against a minimum back pressure.

Another object of the invention is to provide a drilling bit having its cutting elements rotatable by the direct application of drilling fluid acting upon them.

This invention possesses many other advantages and has other objects that will become apparent from a consideratiton of one or more embodiments of the invention. For this purpose, there are shown several forms in the drawings accompanying and forming part of the present specification, which will now be described in detail, illustrating the general principles of the invention. However, it is to be understood that this detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a front elevation of one form of the invention, parts being broken away for purposes of clarity.

Figure 2 is a side elevation as seen from the right of Figure 1.

Figure 3 is a section taken along the plane 3—3 of Figure 1.

Figure 4 is a front elevation of a second form of the invention.

Figure 5 is a section taken along the plane 5—5 in Figure 4.

Figure 6 is a front elevation of still another form of invention, parts being broken away for purposes of clarity.

Figure 7 is a developed plane view of the cutter teeth or blades and nozzles used in connection with the bit shown in Figure 6.

Figure 8 is a front elevation of still another form of the invention.

Like reference numerals refer to similar parts in the several forms disclosed.

The various forms of invention contemplate the rotation of the rotary cutting elements and the supporting shank for producing a bore hole without the necessity for rotating the bit about the hole axis through a long drill pipe having motive power imparted to it from the surface of the bore. The drill pipe is used solely as a conductor for fluid under pressure which will be caused to act upon the cutting elements of the bits themselves, or suitable blades, vanes or buckets attached to the tool for the purpose of rotating the cutting elements about their own respective axes in much the same manner as a water wheel or turbine is rotated by impact or reaction of a fluid upon its blades, buckets or vanes. By causing cutters to rotate about their own axes, they will roll along on the formation, and in so doing will carry their supporting shank or bit head with them, causing the cutting parts of the drilling tool to cover all parts of the hole, effecting the formation removal and producing a bore of the requisite dimensions.

A specific embodiment of the invention is disclosed in Figures 1 to 3, inclusive, in which a shank 10 is provided having a tapered threaded pin 11 whereby the bit can be attached to the usual drill pipe (not shown). The shank carries depending leg portions 12, 13 from which extend suitable inclined bearing supporting pins 14, 14 for carrying the side roller cutting elements 15 which will remove the outer portions 16 of the bore and maintain the hole to gauge. Substantially at right angles to the aforementioned legs are positioned two other spaced depending legs 17, 17 carrying between a bearing support 18 on which are rotatably mounted the cross-cutter rollers 19, 19 which serve to remove the central portions 20 of the hole that are not covered by the side cutters. For the purpose of assisting in the support of the bearing members 18 of the cross-cutters, a bridge

21 is provided between the inclined bearings 14 carrying the side cutters, the cross cutter bearing pin 18 extending through this bridge. The specific bearing details for mounting the cutters are not illustrated, since they are not essential to a proper understanding of the invention. Any suitable types of bearings can be used, whether they be roller, ball or plain friction in character. Those skilled in the art can readily choose the proper bearings.

Extending from each of the side cutter supporting legs 12, 13 is a shield or shroud 22 closely embracing the periphery of the side cutters. Each shroud is preferably formed integrally with its leg 12 or 13 and extends upwardly to merge into the main portions of the shank body in order to allow the provision of a plurality of fluid channels 23, 24 communicating with a passageway 25 extending through the threaded pin 11 and into the shank body. Each of these channels terminate at the inner surface of the shield or shroud, being positioned so that its exit opening 23*a* or 24*a* can discharge a jet of fluid against the cutter teeth 15*a* on the side cutters 15.

In the specific illustration shown in Figures 1 to 3, inclusive, the shield 22 and fluid channels 23, 24 and their discharge openings 23*a*, 24*a* are placed so as to direct streams of fluid against the advancing portion of the cutter as regards its rotation. The streams in leaving the respective channels will have their pressure energy changed to velocity energy, the kinetic energy in the stream being imparted to the faces of the cutter teeth 15*a* to tend to rotate each side cutter 15 around its inclined supporting bearing 14. In view of the fact that the cutters are engageable with the formation, they will be caused to walk or roll along the bottom, similarly to the engagement of a pinion with a stationary rack, and in so doing, they will force the shank 10 to rotate with them in the same direction. Since the shank is being rotated, the cross-cutters 19, 19 will also be caused to rotate to remove the major central portion of the formation material at the bottom of the hole.

As will be clearly seen from an inspection of Figure 3, the fluid will discharge from each channel 23, 24 at a proper angle to engage the back faces of each tooth as it passes under the line of action of discharge from the channel. For the purpose of increasing the capacity of the drilling tool, a plurality of channels are shown, being so placed as to direct a discharge against the cutter teeth at the proper angle for best exertion of effort thereagainst. To insure that the cutters will be urged in their proper turning directions the shields and channels for each side cutter are placed on opposite sides of the shank. As seen in Figure 1, the shield and channels for the right hand roller will be positioned up from the plane of the paper, while the shield for the left hand roller is on the other side of the shank, being positioned downwardly with respect to the plane of the paper.

If desired, suitable nozzles (not shown) can be inserted in the channel openings, the nozzles having restricted openings so as to increase the velocity of the jet issuing therefrom, and consequently change the potential energy in the fluid under pressure into kinetic energy. The issuing jet of fluid will exert most of its effort in turning the cutter and drilling tool since its major component lies in the plane of rotation of the cutter. However, an axial component is present which will tend to deflect the stream of fluid along the back faces of the cutter teeth and insure their leaving the ends of the teeth, to prevent interference between the jet leaving the upper channel 23 and the jet leaving the lower channel 24. By placing the shroud or shield 22 in close proximity to the ends of the cutter teeth 15*a*, windage losses will be decreased to a minimum, and eddying will also be diminished since the gap between the exit of the nozzle or channel 23*a* or 24*a* and the ends of the teeth is relatively small.

A similar form of arrangement is disclosed in the embodiment shown in Figures 4 and 5. In this bit form, a conical type of cutter 26 is shown, each cutter being rotatably mounted upon a bearing supporting member 27 extending from the depending legs 12, 13 of a shank 10, which shank carries the usual tapered threaded pin 11 for attaching to the drill pipe (not shown). In this bit form, the shields 22 and channels 23, 24 are arranged in a similar manner to that described in connection with Figures 1 to 3. However, the channels are arranged so that substantially the entire energy in the fluid is expended in rotating the cutters, inasmuch as the resultant component of discharge is entirely in the plane of the outer set 26*b* of cutting teeth 26*a*. While interference between the channels can be avoided in the Figure 1 construction by the partial flowing of the fluid along the faces of the teeth 15*a*, it is preferred to eliminate any possible interference in the Figure 4 construction by positioning the channels 23, 24 operating on each cutter in different planes. Thus, the channel 24 having its exit opening 24*a* in the lower part of the shield 22 will operate on approximately the outer half of the teeth 26*b*, while the upper channel 23 will operate on approximately the inner half of the teeth 26*b*. By this device, the turning effort applied to each cutter is multiplied and the drilling capacity of the bit increased.

In effect, the construction disclosed in Figures 4 and 5 is similar to a tangential flow water wheel or turbine, while the construction disclosed in Figures 1 to 3 is a combination of a tangential flow turbine and an axial flow turbine.

The form of invention shown in Figures 6 and 7 is similar to the Figure 1 to 3 construction insofar as the general features of the shank 10, side cutters 15, cross cutters 19, and their rotatable bearing mountings 14, 18 are concerned. However, the fluid for each side cutter 15′ is caused to issue through a series of nozzles 28, each of which is arranged in substantially the same plane as the cutter tooth adjacent it. In other words, the turbine bit described is of the axial flow type with the streams entering the space between adjacent teeth endwise of the cutter. As clearly represented in Figure 7, the flow channel 29 communicating with the passageway 25 in the shank can conduct the fluid to a plurality of discharge openings or nozzles 28 having restricted exit openings 28*a*, so as to produce an increase in the fluid velocity, and the exiting fluid will impinge against the cutter teeth 30, which are of modified form, to simulate turbine blades, primarily of the impulse type. The fluid jets will strike against the concave faces of the blades or buckets 30 and impart their kinetic energy thereto, producing rotation of the cutter about its own axis and also rotation of the shank, as described above. The fluid will leave the blades against the back pressure present at the bottom of the hole.

The Figures 6 and 7 construction possesses the advantage that a greater number of discharge nozzles or openings 28, 28*a* can be provided in the shank for each cutter, giving rise to a greater horsepower of bit. Although the nozzles have been described as being of restricted area at their exit opening to give rise to an impulse effect upon the turbine or cutter blades, if desired, the cutter teeth can be so shaped as to provide a reaction type of turbine effect by making the exit area between the blades smaller than the entrance area, causing the fluid to expand through the blades and by virtue of its reactive effort urging rotation of the cutters in the proper direction. One versed in turbine or water wheel design can readily determine the specific shapes of teeth or blades necessary.

Three types of nozzles and cutters have been disclosed; namely, a tangential flow type, an axial flow type, and a modification of the two consisting of both an axial and tangential flow. In Figure 1 and in Figure 6 only the side cutters have been illustrated as being acted upon by fluid under pressure. It is to be understood, however, that the cross cutters 19 could also be acted upon by fluid pressure by suitable direction of the fluid under pressure against their cutting teeth. It is also to be understood that although the fluid is shown as acting directly on the teeth, the invention also contemplates the action of the fluid jets upon suitable vanes, blades or buckets affixed to the cutters, which elements would not necessarily contact with the formation, such contact and formation removal being effected by the presently used cutter teeth. An embodiment of this aspect of the invention is shown in Figure 8.

The form disclosed in Figure 8 is similar to the Figure 1 construction so far as the shank, cutter and bearing support constructions are concerned. Instead of the fluid acting tangentially directly upon the cutting teeth in order to cause rotation of the cutters and the shank, the nozzles 31, 31*a* communicating with the channels 32 are so arranged as to direct a jet of fluid substantially tangentially against a series of blades, buckets or vanes 33 formed integrally with or suitably attached to the side cutters 15. Although they could contact with the formation, it is preferred that the diameter of the vane portions 33 of each side cutter be smaller than the cutter teeth 15*a* to eliminate their formation contact, and consequently prevent blunting of their outer ends. Thus, the fluid streams will strike against the blades to rotate the cutters 15 and the shank 10, the cutting action of the side cutters being left entirely to the circumferential teeth thereon.

It will be noted that the blades or vanes 33 are curved. Such curvature will produce a thrust component parallel to the axis of the side cutter, tending to move it outwardly. This action will tend to maintain the hole size to the proper gauge, since the wear on the cutter and reaming teeth 15*a* will be compensated for by the axial motion of the side cutters on their bearings.

It is to be understood that the nozzle arrangements 31, 31*a* regarding tangential and axial flow are similar to the Figure 1 construction in that the line of discharge from the right hand nozzle 31 (as seen in Figure 8) is up from the paper, whereas the line of discharge of the left hand nozzle 31*a* is downwardly from the paper, or away from the observer. The blades, vanes or buckets on each cutter 15 are reversely curved, as shown in the drawings, to provide proper cooperation between the fluid streams issuing from the nozzles 31, 31*a* and the vanes.

The use of the fluid jets for rotating the cutters will perform the additional function of keeping them clean and free of all adhering matter, and also remove the cuttings from the bottom of the hole. In the Figures 4 and 5 construction, an additional cleaning nozzle 50 has been disclosed positioned substantially centrally of the bit to direct a stream of cleaning fluid onto the hole bottom to assist in the cleaning action. This nozzle or opening has communication with the passageway 25 or fluid reservoir in the shank body 10.

The drilling bits disclosed can be rotated in the hole to remove the formation solely through the effort exerted upon the cutters by the fluid under pressure. There is no necessity for rotating the drill pipe from the surface of the bore for the purpose of effecting forced rotation of the shank and consequent rotation of the cutters by virtue of their reaction with the formation. The drill pipe following the rotating shank serves merely as a conduit or conductor for the fluid under pressure that is operable on the cutter teeth. As a result, rotary driving mechanism at the surface of the bore is needed only to the extent of preventing back torque and unscrewing of the drill pipe, the usual pumps for supplying drilling fluid being sufficient for creating an adequate pressure and volume for operation of the fluid upon the cutter teeth or blades. The elimination of the need for transmitting the entire torque necessary to turn the bit through the drill pipe and threaded joints, permits the entire drill pipe to be made of thinner section since they are no longer required to withstand twisting stresses imposed upon them. This is of particular value in deep well drilling of the nature of 9,000, 12,000 or 15,000 feet, since the heavy sections heretofore required by the need for withstanding a high torque transmission adds to the tension in the drill pipe and strains it almost to the yield point.

It has been proposed heretofore to utilize the energy in a stream of fluid for rotating a drilling bit by placing a long, multi-stage turbine near the lower end of the drilling string, the driven end of the turbine being coupled to the shank of the usual bit for rotating it at a rapid speed. Such arrangements possess the disadvantage that the turbines are susceptible to extreme wear caused by the heavy drilling fluid, and they must also operate against a very high back pressure, produced by the necessity for keeping the bit and the hole clean through fluid issuing through the usual nozzles presently incorporated in rotary drilling bits. Manifestly, the use of such high back pressures decreases the efficiency of the turbine unit. Moreover, there is substantially no advantage in the use of such turbine combinations insofar as the drill pipe and joints are concerned. The drill pipe must still support its own weight in tension; and still has the entire drilling torque imposed upon it since the reactive torque upon the stator of the turbine unit will be transmitted to the drill pipe to which it is connected. Consequently, the drill pipe and joints must be made of as heavy sections as are required if the drill pipe is used as a power transmitter between the rotary table at the surface of the hole and the drilling bit.

As distinguished from the prior art combination of mechanisms, the various embodiments described in connection with my invention incorporate the turbine directly into the drilling bit, there being no need for operating against high back pressures, since the fluid exhausting from the cutting teeth also performs all cleaning functions. Nor is there any reactive torque imposed upon the drill pipe. It will be noted that the channel or nozzle outlet portions are positioned to rotate the various cutters about axes making a substantial angle with the axis of the drill pipe. As a consequence, there is very little, if any, reactive torque on the drill pipe, since the reaction is primarily in a direction longitudinally of the pipe. This non-transmittal of torque permits the use of lighter drill pipe, and decreases the tension therein.

I claim:

1. In an earth boring apparatus, a supporting body, a cutter having teeth supported by said body for rotation with respect thereto, and fluid discharge means cooperable with said body having its discharge opening closely adjacent said cutter teeth, the line of action of said fluid means intersecting the teeth faces and being directed generally lengthwise of the cutter axis.

2. An earth boring tool including a shank, a plurality of roller cutters rotatably supported by said shank, fluid discharge means carried by the shank on one side thereof having its discharge opening adjacent one of said cutters in contact with the formation being operated upon, and fluid discharge means carried by the shank on the other side thereof having its discharge opening adjacent one other cutter in contact with the formation, whereby substantially the full force of fluid discharge upon the cutters will be adapted to cause their rotation, and by virtue of their engagement with the formation produce rotation of the shank.

3. An earth boring tool including a shank, a plurality of roller cutters having teeth rotatably supported by said shank, fluid discharge means opening through the shank on one part thereof, and fluid discharge means opening through the shank on another part thereof, said openings being closely adjacent respective cutter teeth, whereby substantially the full force of fluid discharge upon the cutter teeth will be adapted to cause rotation of said cutters, and by virue of their engagement with the formation produce rotation of the shank.

4. An earth boring tool including a shank, side roller cutters rotatably supported by said shank, cross roller cutters rotatably supported by said shank, and fluid discharge means arranged on said shank to direct substantially the full force of discharge against said side roller cutters to rotate them with respect to the shank, and by virtue of their engagement with the formation produce rotation of said shank in the hole.

5. An earth boring tool as defined in claim 4, the lines of action of said discharge means being substantially tangential of said side cutters.

6. An earth boring tool as defined in claim 4, the lines of action of said discharge means being lengthwise of said side cutter axes.

7. An earth boring tool as defined in claim 4, the lines of action of said discharge means intersecting formation engaging teeth on said cutters.

8. An earth boring tool as defined in claim 4, the lines of action of said discharge means intersecting turbine blades on said cutters which are free from formation contact.

9. An earth boring tool including a shank, a plurality of conical cutters having teeth rotatably supported by said shank, and fluid discharge means arranged on said shank to direct substantially the full force of discharge against said teeth to rotate the cutters with respect to the shank.

10. An earth boring tool including a shank, a cutter rotatably supported by said shank, a shield adjacent said cutter embracing a portion of the periphery thereof, and fluid discharge means arranged on the shank to effect its discharge directly against said cutter to cause its rotation, said shield confining said fluid in its action upon said cutter.

11. An earth boring tool including a shank, a cutter rotatably supported by said shank, a shield adjacent said cutter embracing a portion of the periphery thereof, and fluid discharge means extending through said shield arranged to effect discharge against said cutter to rotate it with respect to said shank.

12. An earth boring tool including a shank, a cutter rotatably supported by said shank, and a plurality of fluid discharge means arranged on said shank externally of said cutter to effect their discharges in substantially parallel planes against said cutter to rotate it with respect to said shank.

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