April 1, 1952 L. YOST 2,591,488

BALANCED TURBODRILL

Filed Nov. 8, 1946 3 Sheets-Sheet 1

Fig. 1

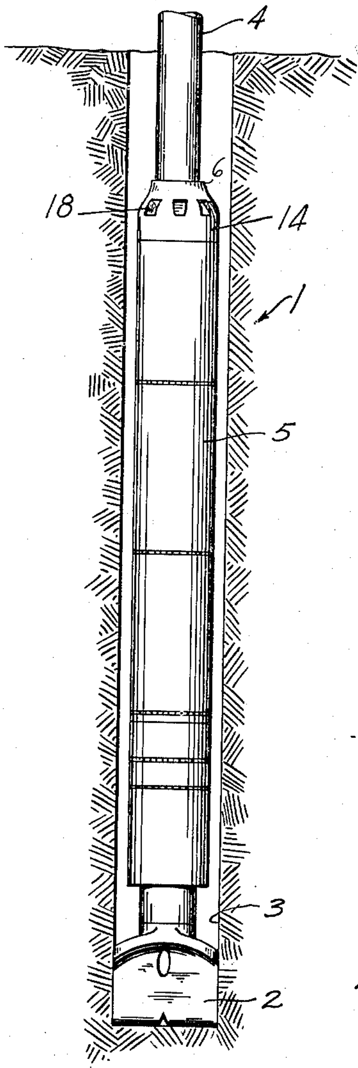

Fig. 2

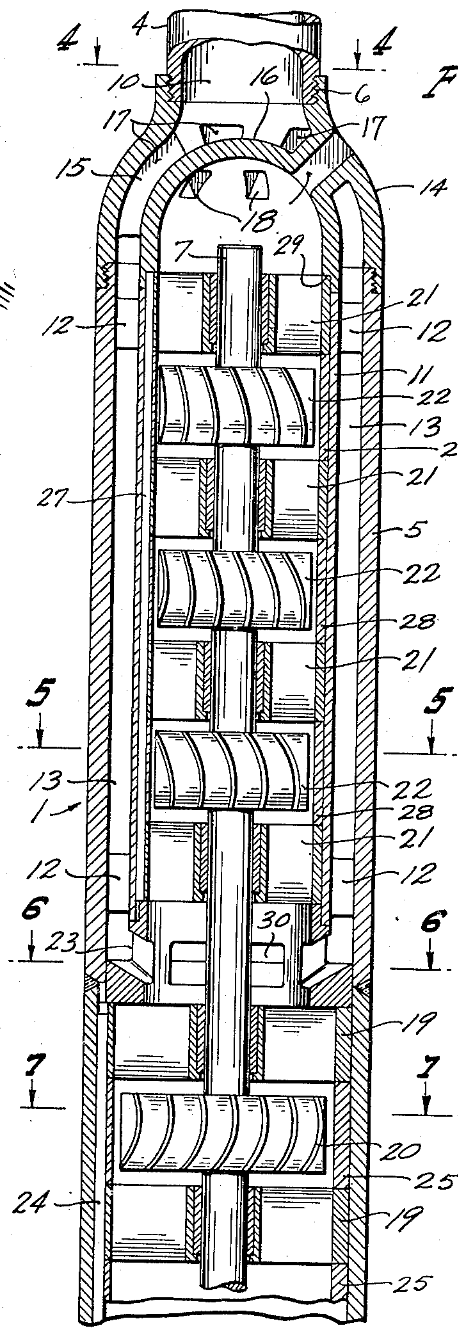

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Fig. 3

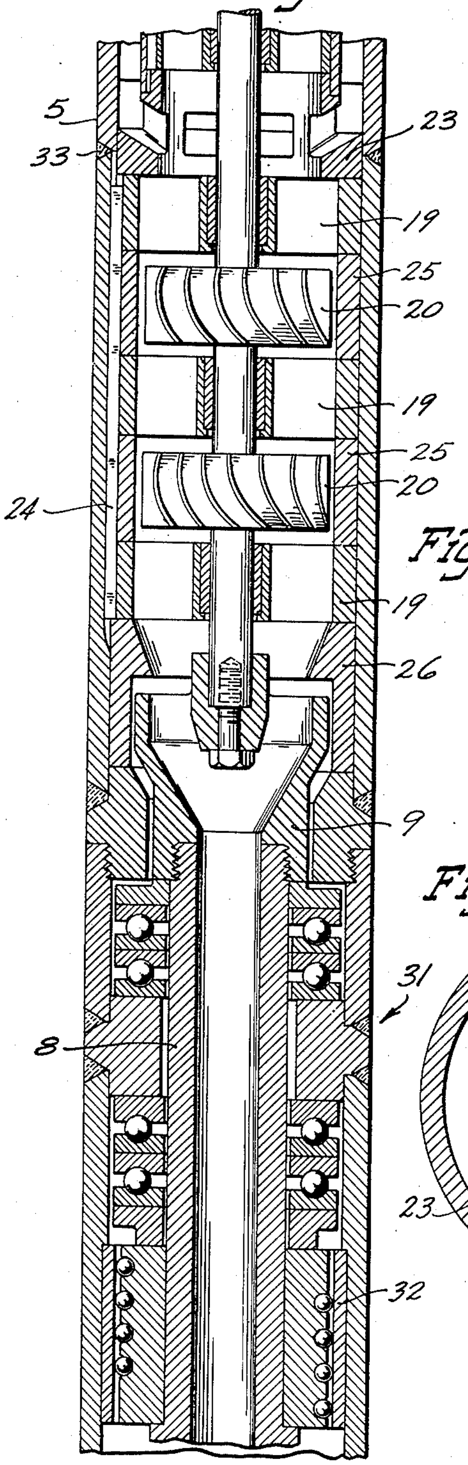

Fig. 4

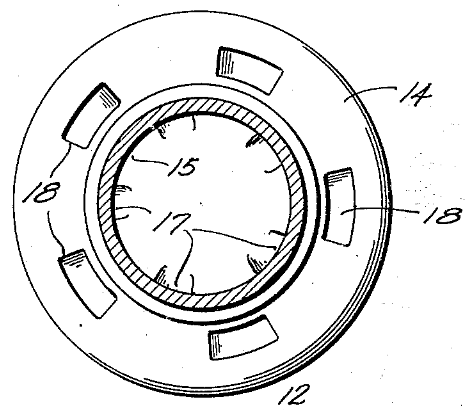

Fig. 5

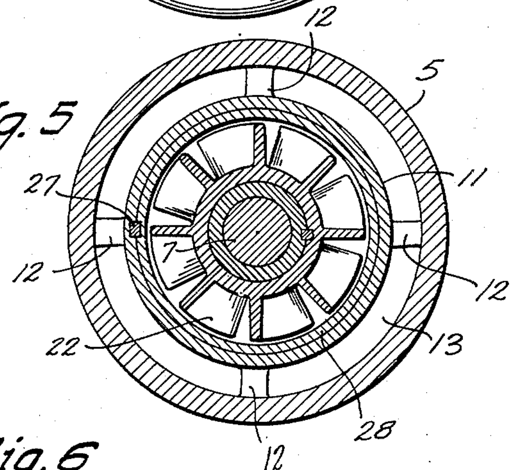

Fig. 6

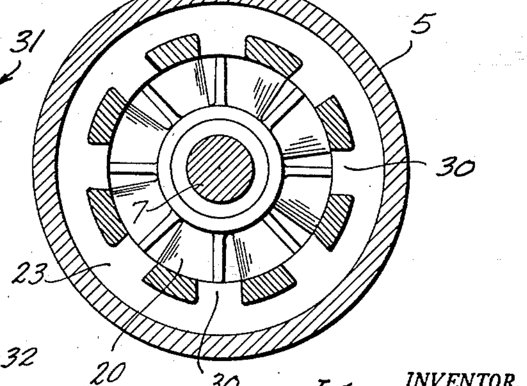

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Fig. 8

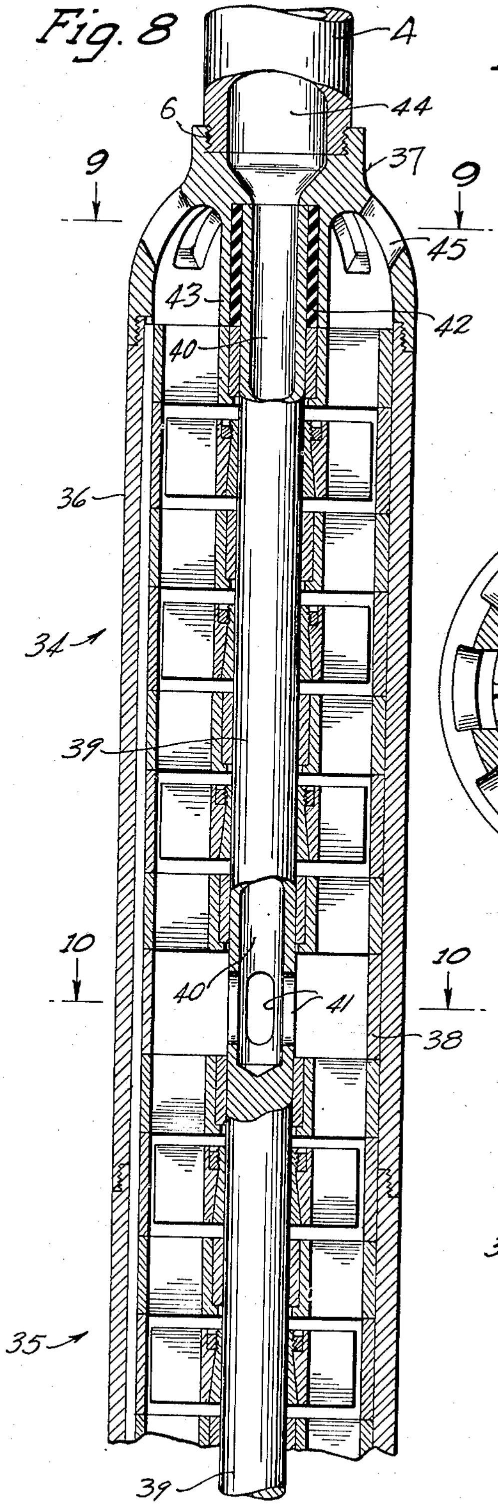


Fig. 7

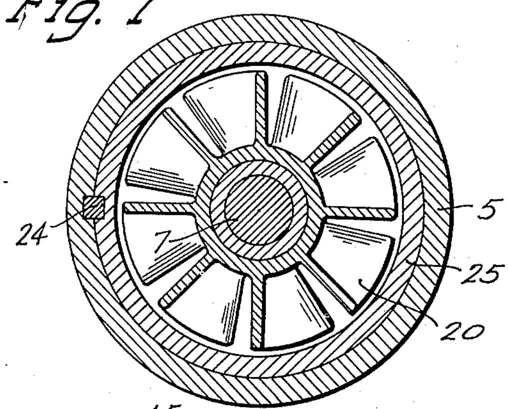


Fig. 9

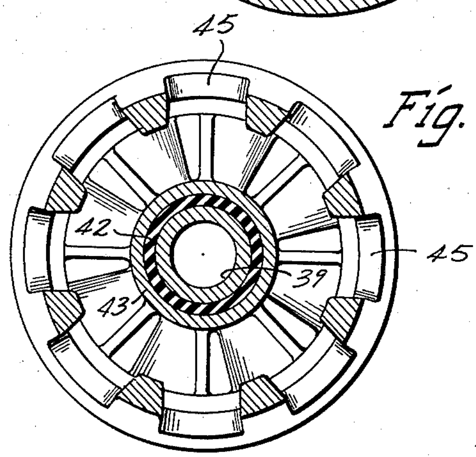
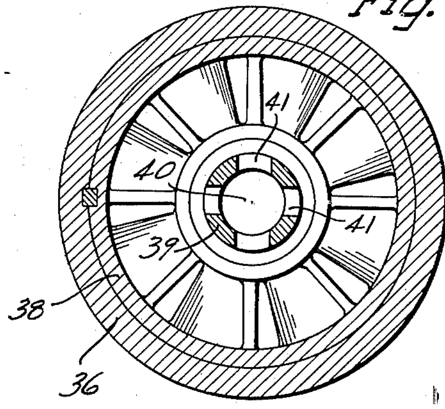


Fig. 10



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Patented Apr. 1, 1952

2,591,488

UNITED STATES PATENT OFFICE

2,591,488

BALANCED TURBODRILL

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Application November 8, 1946, Serial No. 708,699

7 Claims. (Cl. 255—4)

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This invention relates to a balanced turbo-drill and has particular reference to the axial flow hydraulic turbine unit thereof which is employed to drive the bit of the turbo-drill at the bottom of oil wells and the like.

A turbo-drill used in well drilling is driven by mud or other fluid pumped through the turbine unit thereof from the top of the well. After passing through the turbine the mud flows up the sides of the drilled hole and flushes out spoil as well as shoring up the walls of the hole. Heretofore in oil well turbo-drills the flow of the mud within the turbine unit has always been in a downward direction.

The present invention proposes to direct the flow of at least a part of the mud through the turbine bladings in an upward direction.

The principal object of the invention is to provide a hydraulically balanced axial flow turbine for turbo-drills.

Another object is to provide a turbine in which hydraulic hammer of mud driving the turbine is substantially decreased.

Another object is to provide approximate balance of the flow of the driving mud against the runners of the turbine.

A further object is to provide a turbine in which downward thrust on the thrust bearings is lessened to increase the life of the bearings.

Another object is to provide a turbo-drill for well drilling in which pressure and abrasive action on the bit is reduced by diverting a portion of the driving mud to the top of the turbine without passing the same through the bit, and by discharging the same into the well for return circulation at a line where the cross-sectional area of the well is greater than the area between the turbine casing and the wall of the well.

Another object is to provide a turbo-drill for well drilling in which scouring action on the walls of the hole being drilled is reduced.

These and other objects of the invention will appear hereinafter in connection with the following description of the invention as shown in the accompanying drawings.

In the drawings:

Figure 1 is a vertical elevational view of a turbo-drill, embodying the invention, disposed in a well;

Fig. 2 is an enlarged longitudinal sectional view of the upper portion of the turbine showing where the downwardly flowing mud splits into an upward and downward flow;

Fig. 3 is an enlarged longitudinal sectional view of the lower portion of the turbine;

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Fig. 4 is a transverse section taken on line 4—4 of Fig. 2;

Fig. 5 is a transverse section taken on line 5—5 of Fig. 2;

Fig. 6 is a transverse section taken on line 6—6 of Fig. 2;

Fig. 7 is a transverse section taken on line 7—7 of Fig. 2;

Fig. 8 is a longitudinal sectional view showing the same application of the invention to another type of turbine;

Fig. 9 is a transverse section taken on line 9—9 of Fig. 8; and

Fig. 10 is a section taken on line 10—10 of Fig. 8.

The balanced turbo-drill of the invention, as illustrated in the drawings, comprises a turbine unit 1 which drives a drill 2 at the bottom of well 3 and is suspended from the top of the well by the drill casing 4. Casing 4 is of substantially lesser diameter than casing 5 of the turbine unit and the casings are joined together such as by the threaded joint 6.

The solid shaft 7 extends centrally longitudinally through turbine unit 1 and is coupled at the lower end to the hollow shaft 8 by the adapter coupling 9 to drive drill 2 on the lower end of shaft 8, when rotated by flow of pumped mud through the turbine, as will be described, from a source above the ground, not shown. The pumped mud enters turbine 1 through the longitudinal passage 10 of drill casing 4 and when discharged from the unit the mud flows up the walls of well 3 and back to the original source for recirculation.

Turbine casing 5 is of sufficient diameter to accommodate the inner casing 11 of turbine unit 1 which compares in diameter to the drill casing 4. Casing 11 is concentrically spaced from turbine casing 5 by the webs 12 which are located adjacent the lower and upper ends thereof and define the annular passage 13 between the casings. Casing 11 extends for a substantial distance within the upper portion of casing 5.

Drill casing 4 and turbine unit 1 are joined together by the coupling ring 14 which is threaded at the upper end to drill casing 4 at joint 6 and at the lower end to the turbine casing 5 and abuts end to end with inner casing 11 of the turbine unit. Coupling 14 is formed to conform with the differences in cross-section between drill casing 4 and turbine casing 5. The inner and outer walls of coupling 14 are separated by a plurality of webs 15 and the inner wall 16 of the coupling closes off flow of mud from passage

10 of drill casing 4 into turbine 1. The passages 17 extend between the circumferentially spaced webs 15 and connect passage 10 of drill casing 4 with annular passage 13 extending longitudinally between turbine casings 5 and 11. A passage 18 is directed diagonally upwardly through each of webs 15 and connects the inside of turbine 1 with well 3.

Turbine unit 1 is multiple stage and comprises a lower blading section having the guides 19 and the runners 20 thereof located in alternate positions and an upper blading section with the guides 21 and runners 22 thereof similarly alternated. The guides 21 and runners 22 of the upper blading section may be of lesser diameter than guides 19 and runners 20 and are so shown in the drawings. The lower blading section comprising guides 19 and runners 20 is assembled within casing 5 while the upper blading section comprising guides 21 and runners 22 is disposed within the inner casing 11 as will be described hereinafter.

The respective blading sections are separated by the spacer ring 23 which abuts against the lowermost guide 21 of the upper blading section and the uppermost guide 19 of the lower blading section. The ring 23 extends within the lower end of casing 11 and is keyed thereto to prevent rotation. Shaft 7 freely rotates within ring 23.

The guides 19 of the lower blading section are assembled around solid shaft 7 by any suitable bearing means to permit rotation of the shaft therein and are secured to casing 5 by key 24 to prevent rotation thereof. The guides are spaced apart by the spacer sleeves 25. The lowest guide 19 rests on annular ring 26 which is supported within turbine casing 5 upon a suitable abutment ring.

The runners 20 are located between guides 19 and are suitably secured to shaft 7 to rotate the same. The blades of runners 20 are of a size to leave a slight clearance between the tip of each blade and the spacer sleeve 25 surrounding the same to permit free rotation of the runners.

The guides 21 of the upper blading section are assembled around shaft 7 by any suitable bearing means to permit rotation of the shaft therein and are secured to inner casing 11 such as by key 27. The guides are spaced apart by the spacer sleeves 28. The uppermost guide 21 abuts against annular ledge 29 provided in coupling 14. The lowermost guide 21 is supported on the sleeve 23 and spaced thereby from the uppermost guide 19 of the lower blading section.

The runners 22 are located between guides 21 and are suitably secured to shaft 7 to rotate the same. The blades of runners 22 are of a size to leave a slight clearance between the tip of each blade and spacer sleeve 28 surrounding the same to permit free rotation of the runners.

Normally a greater number of runners and guides will be provided in the upper blading section than in the lower section of the turbine to obtain hydraulic balance in the turbine unit.

The ring 23 disposed between the blading sections has a plurality of radial openings 30 therethrough to provide passages from annular passage 13 between casings 5 and 11 into the upper and lower blading sections of turbine 1.

The driving mud flows from passage 13 through openings 30 and then splits with a portion flowing upwardly through the upper blading section of turbine 1 and another portion of substantially equal amount flowing downwardly through the lower blading section of turbine 1. The blades in each blading section are directed to provide the same directional rotational force to the drill shaft.

The lower end of shaft 7 rests on the adapter coupling 9 which is in turn supported on the thrust bearing assembly 31. The hollow drill shaft 8 with the drill bit 2 on the lower end thereof is secured to coupling 9 and rotates within radial bearings 32. The coupling is of conical shape to direct the mud flowing through the lower turbine section of turbine 1 into hollow shaft 8.

Reference to Patent No. 2,248,047 of the present inventor issued May 2, 1944 may be had for a more detailed description of the runners and guides of turbine 1 and the lower portion of the turbo-drill. The method of assembly of the present invention is also similar as there described insofar as shaft 8, bearings 31 and 32, coupling 9 and the runners and guides of the lower blading section of turbine 1 are concerned.

After the lower part of the turbo-drill and uppermost guide 19 of the lower blading section is assembled on shaft 7 within the lower section of turbine casing 5, the spacer ring 23 is lowered on shaft 7 until it rests on uppermost guide 19.

A guide 21 of the upper blading section is then lowered over shaft 7 until it rests on ring 23 and a runner 22 is thereafter dropped over shaft 7 and anchored to the shaft above guide 21. The spacer sleeve 28 is then lowered around runner 22 onto the assembled guide 21. The guides and runners are built up alternately in this manner until the uppermost guide 21 is assembled on shaft 7.

Casings 11 and 5 are next assembled around the runners and guides on shaft 7 with the assembly being accomplished so that guides 21 are joined to casing 11 by key 27. The two sections of casing 5 are then joined together by the circumferential weld 33 at approximately the location of ring 23.

The coupling 14 is next threaded onto the upper end of turbine casing 5 and against upper guide 21.

The assembly is completed by assembling the drill casing 4 with coupling 14 such as by threading these members together at joint 6. The drill casing 4 may be assembled with coupling 14 before the turbine unit 1 is assembled with the coupling, if desired.

The operation of the turbo-drill of the invention is as follows: The mud that operates the turbine is pumped into passage 10 of drill casing 4 from a sump above the ground, not shown. The mud flows from passage 10 through inlet passages 17 into the longitudinal annular passage 13 between turbine casing 5 and casing 11.

The mud then flows through passage 13 to radial openings 30 in spacer ring 23 where the mud divides into two directions of flow.

A portion of the mud continues downwardly through guides 19 and runners 20, thence into coupling 9 and hollow drill shaft 8 and out into the bottom of well 3 through suitable openings in drill bit 2. This mud then flows upwardly along the wall of the well to a sump at the surface, not shown.

The guides and runners of the lower portion of turbine 1 are shaped to receive the mud and pass the same downwardly from radial openings 30. As the mud flows through the runners the latter are rotated thereby and drive drill 2 through shaft 7, coupling 9 and shaft 8.

The remainder of the mud flows upwardly

within inner casing 11 through guides 21 and runners 22. The upwardly flowing mud then flows through outlet passages 18 and is discharged into well 3 where it converges with the mud flowing upwardly from drill bit 2.

As with the lower runners and guides the upper runners 22 and guides 21 are shaped to receive the mud and pass the same upwardly and to give the same directional rotational force to shafts 7 and 8 as does the lower blading section for rotation of drill bit 2.

The turbine illustrated in Figs. 8, 9 and 10 of the drawing differs mainly from the previous turbine in the entry and exit of the mud from the turbine.

In this embodiment the turbine comprises an upper blading section 34 and a lower blading section 35 assembled within the turbine casing 36 which is joined to the drill casing 4 by the coupling ring 37. The respective blading sections are separated by a sleeve 38.

The central shaft 39 around which the runners and guides of blading sections 34 and 35 are assembled is solid throughout the lower blading section 35 and is provided with the longitudinal passage 40 therethrough throughout the portion around which the upper blading section 34 is disposed.

Passage 40 leads to the runners and guides of the respective blading sections 34 and 35 through radial openings 41 provided in the hollow portion of shaft 39 between the sections 34 and 35.

The upper end of shaft 39 is surrounded by a packing sleeve 42 and the latter is enclosed by the axially projecting sleeve 43 of coupling ring 37. Sleeve 43 abuts against the uppermost guide of blading section 34 and holds the guides of the turbine against axial movement as well as confining the upper end portion of shaft 39.

The longitudinal inlet passage 44 through drill casing 4 is aligned with longitudinal passage 40 in the shaft 39.

The circumferentially spaced upwardly directed outlet openings 45 are provided in coupling ring 37 at the upper end portion thereof and lead from upper blading section 34 into well 3.

The unit is assembled much in the same manner as in the previous embodiment and need not be described in detail.

In the described embodiment the driving mud flows from inlet passage 44 into passage 40 of hollow shaft 39. When the mud reaches radial openings 41 in shaft 39, the mud splits in two directions of flow.

A portion of the mud continues downwardly through the runners and guides of lower blading section 35 to drive the runners thereof and rotate a drill bit, such as bit 2 of the previously described turbine unit through the shaft 39. After passing through the bit this mud flows upwardly within well 3 and back to the source of supply.

The remainder of the mud turns upwardly from radial openings 41 and flows through the runners and guides of upper blading section 34 and out into well 3 through the discharge passages 45 to converge with the mud flowing upwardly from the bottom of the well. The runners of section 34 are rotated by the mud and drive shaft 39 in the same direction as the runners of the lower blading section 35 to rotate the drill bit, not shown, connected to the lower end of the turbo-drill.

The mud passing through the bit shown in the embodiments of the invention is sufficient to flush the bit and carry off spoil. By splitting the flow of drilling mud so that only a part of it goes down through the bit, the remainder of the mud is discharged into the well for return circulation at a place where the circumferential space between the drill casing and the well wall is greater than that adjacent the bit and the well wall. Only that portion of the mud discharged through the bit need flow through the restricted space between the turbine casing and well wall.

Abrasion of the parts of the bits is decreased and hydraulic resistance and friction due to the smaller area at the bottom of the well and along the turbine shell or casing is reduced.

By splitting the mud into two directions of flow within the turbine the driving power of the mud is retained with decrease of thrust on bearings 31, since the working thrust of the mud is substantially equalized in an upward and downward direction and hydraulic balance of the mud against the runners in the upper and lower blading sections is obtained.

A smaller hole may be employed in the bit under the present construction. This is desirable since with a large hole and greater flow of mud the wall of the well may be pitted and washed away, but a large hole may be necessary in those constructions where all the driving mud flows through the bit. Under previous construction where a smaller hole was employed the driving power of the mud was decreased. In the present construction there is no such restriction as a portion of the mud flows freely through the upper blading sections and out into the well.

Where the runners of the lower blading section of the turbine are provided of greater diameter than the upper set of runners, the turbine is almost perfectly balanced, since there is a greater drop in presure through the upper set of runners than through the lower set. The drop in pressure across the upper set of runners takes place almost entirely through the runners and guides themselves, while the drop across the lower set is only a part of the total drop in the line of flow of the portion of fluid flowing therethrough. A considerable drop occurs by reason of hydraulic friction through the bit itself, in the turbulence around the bit and in hydraulic friction between the casing of the turbo and the well, as the fluid stream rises from the bit.

Various embodiments of the invention may be employed within the scope of the accompanying claims.

I claim:

1. In a balanced turbo-drill for oil well drilling and the like having a drill bit rotated by a turbine unit driven by mud pumped therethrough, said turbine unit comprising an upper blading section and a lower blading section including a common bit-drilling shaft and formed with a plurality of alternated guides and runners disposed to flow the mud upwardly and downwardly, respectively, a casing surrounding the upper blading section and spaced from the outer casing of the turbo-drill to provide a longitudinal annular inlet passage therebetween for flow of mud, a spacer member disposed between the upper and lower blading sections to space the same axially and having radial passages therethrough for flow of mud from the annular inlet passage into the upper and lower blading sections in substantially equal and opposite lines of flow to hydraulically balance the turbine, and means providing for exit of the

mud flowing through said upper and lower blading sections into the well being drilled above and below said sections, respectively.

2. In a balanced turbo-drill for oil well drilling and the like having a drill bit rotated by a turbine unit driven by mud pumped therethrough, said turbine unit comprising a drive shaft provided with a hollow portion and a solid portion and having an upper blading section assembled with the hollow shaft portion and a lower blading section assembled with the solid shaft portion, means to axially space said blading sections, outlet openings provided in the hollow portion of the shaft between said blading sections to split mud pumped through the hollow shaft into two directions of flow with a portion thereof flowing upwardly through the upper blading section and a portion thereof flowing downwardly through the lower blading section to substantially balance the working thrust of the mud as it flows through said sections, and means providing for exit of the mud flowing through said upper and lower blading sections into the well being drilled above and below said sections, respectively.

3. In a balanced turbo-drill for oil well drilling and the like having a drill bit rotated by a turbine unit driven by mud pumped therethrough, said turbine unit comprising an upper blading section and a lower blading section spaced aixally from each other on a common bit-driving shaft and provided with an inlet therebetween for passage of driving mud into each section in substantially equal and opposite flow, a casing enclosing the upper blading section and spaced from the outer casing or the turbo-drill to provide an annular passage therebetween for flow of mud to said inlet, and a coupling member provided in said casing above the upper blading section with circumferentially spaced inlet passage therethrough for flow of mud into the annular passage between said casings and circumferentially spaced outlet passages for flow of a portion of the driving mud out of the upper blading section and into the well being drilled without passing through the drill bit.

4. In a balanced turbo-drill for oil well drilling and the like having a drill bit rotated by a turbine unit driven by mud pumped therethrough and an outer casing surrounding the same, said turbine unit comprising an upper blading section and a lower blading section spaced axially from each other on a common bit-driving shaft and provided with an inlet therebetween for passage of driving mud into each section in substantially equal and opposite flow, the upper blading portion of said shaft being hollow for flow of the pumped mud therethrough to said inlet, and circumferentially spaced outlet openings provided through said outer casing at the upper end of the upper blading section for flow of a portion of the driving mud into the well being drilled after passage through said upper blading section and without flowing through said drill bit.

5. In a turbo-drill for well drilling and the like and having a long multi-stage hydraulic turbine assembly with the lower end of the rotary turbine shaft carrying a drill bit of a diameter greater than the turbine assembly and with the upper end of the substantially non-rotary turbine casing carried by the end of a drill pipe which supplies a substantially incompressible power mud to drive the turbine and to raise the spoil in the well, a turbine assembly comprising a cylindrical casing secured to the drill pipe axially thereof, a turbine shaft disposed axially of the casing to rotate in bearings supporting the same, spaced upper and lower axial-flow turbine blade sections including runner sections carried by the turbine shaft and intermediate guide sections carried by the turbine casing, the power mud inlet for said turbine being disposed between said upper and lower blade sections, a passage from the drill pipe to said inlet for the power mud to operate the turbine, a discharge passage through the turbine shaft and drill bit for the power mud passing through the lower blade section, and a series of upward discharge openings at the top of said casing and surrounding the drill pipe for the power mud passing through the upper blade section, the quantity of power mud required to operate said turbine and the diameter of the turbine relative to that of the drill bit and consequent diameter of the well being such that full discharge of all of the power mud at the drill bit would tend to damage the well by reason of an insufficient radial space for its passage upward between the turbine and the walls of the well, and the by-pass discharge of a portion of the power mud upwardly at the top of the casing serving to assist in giving impetus to the upward moving mixture of power mud and spoil from the bit.

6. The structure defined in claim 5 in which that portion of the casing surrounding the upper blade section is double-walled with the space between the inner and outer walls constituting the passage for power mud from the drill pipe to the inlet for the turbine, and in which the upward discharge passages extend through both walls of the casing and are separated from the space therebetween by tubular members joining the casing walls.

7. The structure defined in claim 5 in which the passage between the drill pipe and the turbine inlet is formed by an axial bore in the turbine shaft extending from the upper end thereof to the middle of the turbine and is provided with radial ports at said turbine inlet.

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