July 31, 1962 G. B. WEPSALA, JR 3,047,079

FLOATING SHAFT TURBO-DRILL

Filed Jan. 5, 1959 2 Sheets-Sheet 1

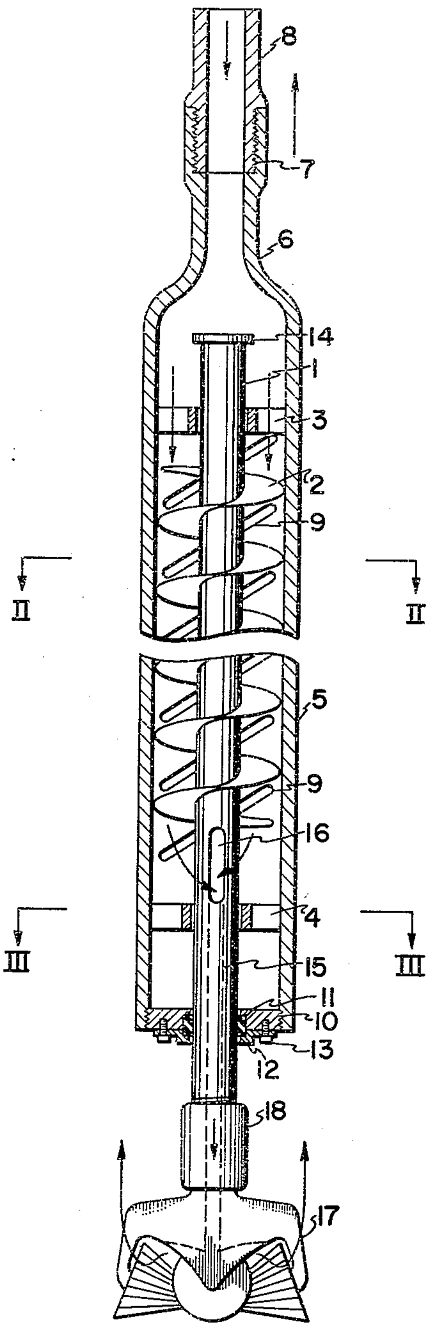

Fig. I

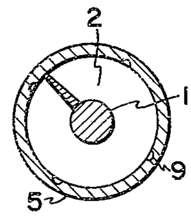

Fig. II

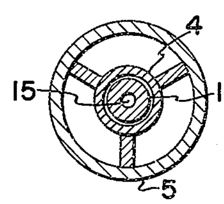

Fig. III

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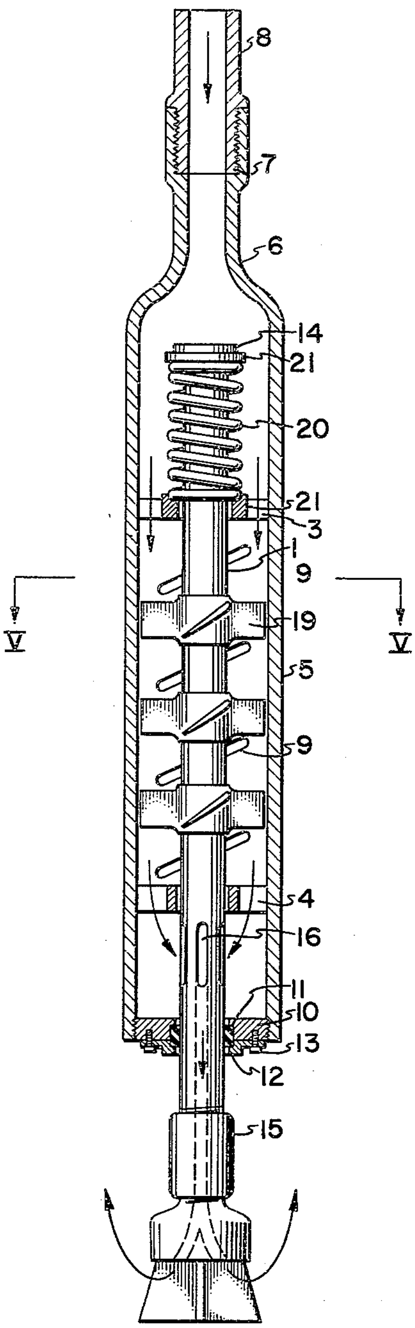

Fig.IV

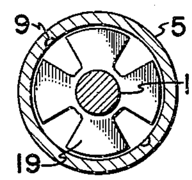

Fig.V

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FLOATING SHAFT TURBO-DRILL

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The present invention relates to apparatus for drilling boreholes in the earth and more particularly relates to an improved turbo-drill adapted to permit more efficient rotary drilling operations than have been possible heretofore.

Most of the oil and gas wells and similar boreholes produced in recent years have been sunk by rotary drilling methods. In brief, such methods involve the use of a suitable rotary bit positioned at the bottom of the borehole and a string of rigid drill pipe which is connected to the bit and extends to a point above the earth's surface. Drilling is accomplished by clamping the end of the pipe protruding from the borehole in a rotary table and rotating the entire drill string. The rotary motion of the bit, coupled with the weight of the drill string, produces a combination of scraping, grinding and percussion forces which enable the bit to penetrate the formation beneath it relatively rapidly. Cuttings produced from the formation are entrained in a stream of drilling fluid supplied to the bottom of the borehole through the drill string and are withdrawn with the drilling fluid through the annular space between the drill string and the borehole wall. The drilling fluid also serves to cool the bit, to prevent the escape of subterranean liquids and gases encountered during drilling, and, to a limited extent, to reduce friction between the drill string and the borehole wall.

Friction between the drill string and the borehole wall is a serious problem in such rotary drilling operations. Because boreholes drilled to depths of more than a few hundred feet are seldom if ever straight and because long strings of drill pipe have a certain amount of flexibility, contact between the drill string and the borehole wall is unavoidable during conventional rotary drilling. A considerable portion of the total horsepower required in drilling a borehole may be consumed in overcoming the friction produced at the points of contact. In addition, failure of the drill string due to wear resulting from friction is frequent.

In order to avoid the difficulties thus engendered and related difficulties such as that of overcoming the inertia of long strings of drill pipe, it has been suggested that an electric motor or a turbine be positioned at the bottom of the drill string so that the bit alone, rather than the entire drill string, may be rotated. The use of a turbine is particularly attractive for this purpose because the drilling fluid used to remove cuttings can be employed to provide the necessary energy. In attempting to utilize turbines for such service, however, it has been found that severe maintenance problems are encountered because of very frequent failure of the turbine thrust bearings. These bearings are subjected to extreme stresses due to the rapid and erratic vertical motion of the bit.

The present invention provides a new and improved drilling turbine which does not employ thrust bearings and hence permits the use of a stream of drilling fluid as a source of energy for rotary drilling without the bearing maintenance difficulties which have characterized turbo-drilling operations in the past. The necessity for thrust bearings in the apparatus of the invention is eliminated by mounting the turbine blades upon a floating shaft which is retained within the turbine housing by a series of centering guides. During drilling, the upward thrust of the bit and shaft is compensated for by the downward component of force of the moving stream of drilling fluid. A series of flow-reversing recesses or pockets in the housing wall of the turbine serve to straighten fluid flow and obviate the necessity for conventional stators which would restrict vertical movement of the floating shaft and turbine blades. Since in its simplest form the drilling turbine of the invention has but a single moving part, maintenance is relatively simple. The apparatus is much less complex than turbo-drills, mud motors and similar equipment proposed for use in the past; can be easily controlled with respect to the amount of thrust delivered during operation; and has a considerably longer life than equipment of the prior art.

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The exact nature of the apparatus of the invention can be more readily understood by referring to the following detailed description of two embodiments of the invention and to the accompanying drawing, in which:

FIGURE I is an elevation view, partly in section, of a drill turbine constructed in accordance with the invention;

FIGURE II is a sectional view taken along line II—II of FIGURE I;

FIGURE III is a sectional view taken along line III—III of FIGURE I;

FIGURE IV is an elevation view of a further embodiment of the invention in which the floating shaft of the turbine is provided with a thrust control device; and

FIGURE V is a sectional view taken along line V—V of FIGURE IV.

Referring now to FIGURE I of the drawing, it will be seen that the improved drill turbine of the invention consists essentially of a floating cylindrical shaft 1 having a blade 2 affixed thereto which is retained by centering guides 3 and 4 within a generally tubular housing 5. The upper end of housing 5 is tapered to form a necked-down section 6 containing a box thread 7 adapted to receive the threaded lower end of a string of conventional drill pipe 8 extending to the surface of the earth. The inner wall of housing 5 contains a series of recesses or fluid pockets 9, also shown in FIGURE 2, which serve to direct the flow of fluids within the housing. These pockets may be simple vertical indentations in the housing wall but preferably are deep notches cut into the wall at right angles to the turbine blade in order to straighten out the fluid flow and increase the efficiency of the turbine. The lower end of housing 5 is closed by annular plate 10 through which shaft 1 passes. Plate 10 may be provided with a recess to contain packing 11 which prevents the passage of fluids through the annular space between the plate and shaft. A retainer 12 may be secured to the plate surrounding the shaft by bolts 13 or by equivalent means in order to retain the packing in place.

Shaft 1 is surmounted by stop 14 which limits the downward movement of the shaft through centering guide 3 and prevents the lower end of blade 2 from contacting the lower centering guide 4. The lower end of the shaft contains a central conduit 15 which communicates with the interior of housing 5 through one or more ports 16 in the surface of the shaft. A conventional rotary bit 17, which may be of the cone type as shown in FIGURE I, or may be a drag bit or a fishtail bit as shown in FIGURE IV, is connected to the lower end of shaft 1 by coupling 18, thus providing a continuous fluid conduit from port 16 through the bore of the bit into the bottom of the borehole.

Blade 2 affixed to the shaft of the apparatus may take the form of a continuous screw, as shown in FIGURE I, an interrupted screw, or a series of propellers as depicted in FIGURE IV. If a screw-type blade is employed, either a single or a multiple screw may be used. The blade is positioned on the shaft between centering guides

3 and 4, there being sufficient space between the centering guides and ends of the screw to permit vertical movement of the shaft and screw. As shown in FIGURE III, the centering guides offer relatively little resistance to the flow of fluids through the housing.

In drilling with the improved turbo-drill shown in FIGURE I of the drawing, a drill string having the turbine and bit positioned at the lower end thereof is lowered into the borehole. As the turbine is lowered, shaft 1 and blade 2 will drop down in the housing until stop 14 contacts centering guide 3. The apparatus is lowered to the bottom of the borehole in this position. It is generally preferred to start the turbine with the bit disengaged from the formation. In order to do this, the assembly, after having been lowered to the bottom of the borehole, may be raised until the bit no longer contacts the formation. Drilling fluid, a conventional drilling mud comprising a mixture of water and clay for example, is then introduced into the drill string at the surface and passes downwardly through the drill pipe into the upper section of housing 5. As the downflowing mud contacts the surface of blade 2, the hydraulic force exerted causes the blade and shaft 1 to rotate. Flow of the mud through the section of the housing containing the screw is straightened by fluid pockets 9 in the housing wall. Upon reaching the lower section of the housing, the mud enters port 16, passes downwardly through conduit 15 in shaft 1 and enters the bore of rotary bit 17. Emerging from the bore of the bit at the bottom of the borehole, the drilling fluid then passes upwardly around the periphery of the turbine and drill string and is returned to the surface of the earth. After rotation of the bit has been started in this manner, the drill string is lowered until the bit contacts the formation at the bottom of the borehole and stop 14 no longer makes contact with centering guide 3. At this point, the upward thrust against the bit is counterbalanced by weight of the bit, shaft and blade and the downward component of the hydraulic force of the drilling fluid on the turbine blade. The moving parts of the turbine are thus not supported by thrust bearings and hence the difficulties connected with bearing failure are not encountered. Shaft 1, blade 2 of the bit may move downwardly as the borehole is advanced. As drilling progresses the drill string is continually or intermittently lowered so that the weight of the drill string is not placed on the bit under normal drilling conditions.

FIGURE IV of the drawing illustrates a preferred embodiment of the invention in which the shaft of the drill turbine is provided with a thrust control device. As can be seen from the drawing and from FIGURE V, a series of propellers 19 have been employed in lieu of the screw shown in FIGURE I, although the use of such propellers is not mandatory. Similarly, a fishtail type bit is shown in FIGURE IV but it will be understood that any conventional rotary drilling bit may be employed with the apparatus of the invention. The thrust control device of this embodiment of the invention consists essentially of a coil spring 20 which is positioned about the upper end of shaft 1 and rests upon centering guide 3. The centering guide may be provided with a recess 21 in the upper surface thereof in order to accom-

modate the spring if desired. Connected to the upper end of spring 20 is an annular wearplate 21 with which stop 14 makes contact when the shaft assembly is in its lowermost position. The thrust developed at the bottom of the borehole during drilling is controlled by means of this apparatus by regulating the elevation of the turbine housing in the borehole. When the housing is in a position such that wearplate 21 does not contact stop 14, the normal drilling position, the thrust on the drill bit consists of the weight of the shaft and bit assembly plus the downward component of the hydraulic force of the drilling fluid on the blades of propellers 19. This thrust may be decreased as desired by raising the turbine housing until the wearplate contacts stop 14. The thrust on the bit is thereby decreased by the amount of thrust which is taken up by spring 20. This arrangement permits the use of a low thrust when drilling through unconsolidated sands and similar formations. In most cases however the turbine will be operated at the full thrust value.

It will be understood that the invention is not to be limited to the specific embodiments described above and that numerous changes and modifications may be made in the apparatus disclosed without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A down-hole turbine assembly for rotating a drill bit within a borehole in response to the passage of fluid through said assembly which comprises:
   - a tubular housing provided with means for connecting said assembly to a drill string and for admitting fluid from said drill string into said housing, said housing containing discontinuous internal recesses for directing the flow of fluid through said assembly;
   - a rotatable shaft extending axially from within said housing to a point below said housing, said shaft containing a lateral port located within said housing and a passageway extending from said port to an outlet below said housing;
   - a turbine blade mounted on the outer surface of said shaft above said lateral port;
   - means within said housing for retaining said shaft coincident with the longitudinal axis of said assembly, said means permitting axial movement of said shaft with respect to said housing and the passage of drilling fluid downwardly to said turbine blade;
   - and means for limiting axial movement of said shaft to permit retention of the upper portion of said shaft containing said port within said housing.

2. An assembly as defined by claim 1 including means for biasing said shaft and turbine blade in a normally upward position with respect to said housing.

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