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J. A. MITCHELL ET AL

2,990,894

TURBODRILL

Filed Oct. 20, 1958

FIG. 1.

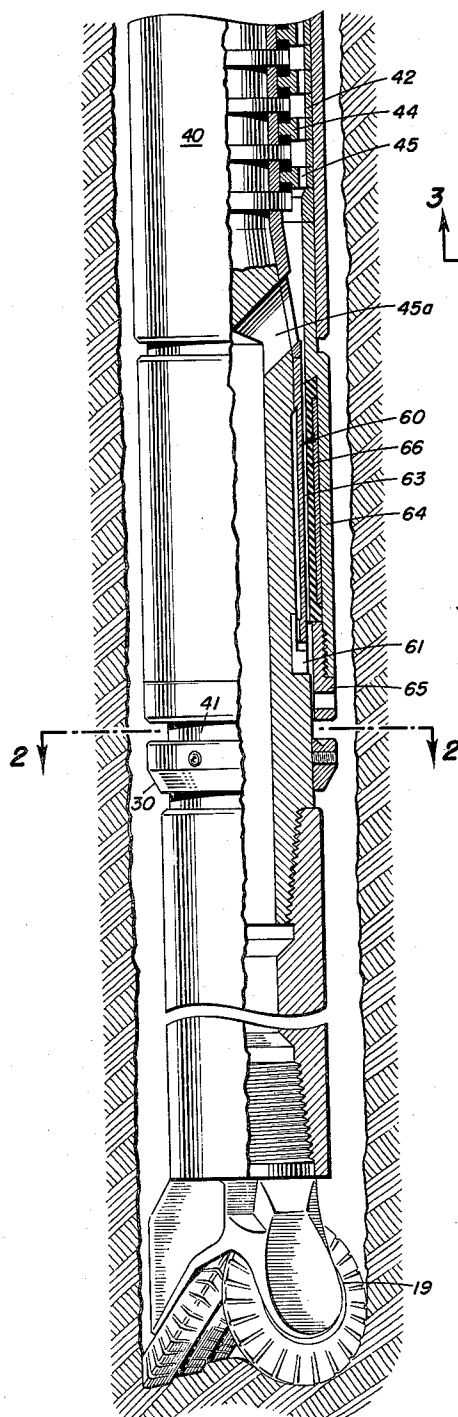


FIG. 2.

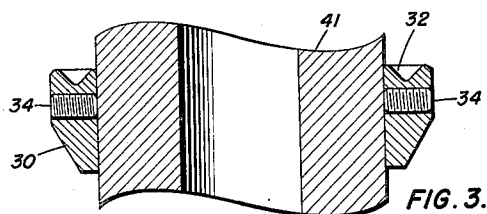
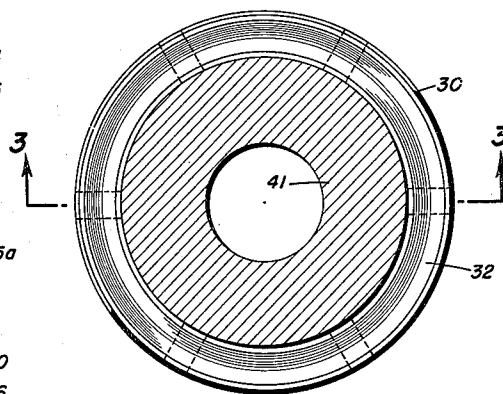


FIG. 3.

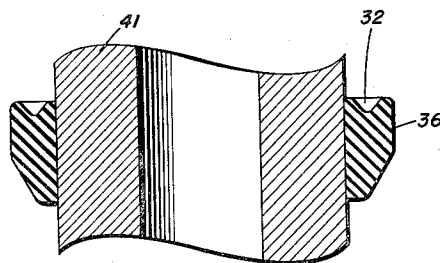


FIG. 4.

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TURBODRILL

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The present invention relates to a turbodrill or fluid driven turbine that is carried on the end of a drill string and, actuated by the downflowing drilling fluid, drives a rotary drill bit for the down-hole drilling of oil wells and the like.

Although the turbodrill has been known for a number of years, as evidenced by Cross Patent No. 142,992 issued in 1873, and Westinghouse Patent No. 307,606 issued in 1884, it is only in very recent years that the basic turbodrill invention has advanced the turbodrill toward a state of commercial usage. There were various technical reasons for the delay, such as the early development of direct rotary drilling which, following its adoption around 1900, became the accepted procedure. Rotary drilling remains the standard procedure in this country and, from the standpoint of cost per foot of hole drilled, it has not as yet been commercially superseded.

However, the early concepts of turbodrill operation and subsequent modifications have led the inventively minded in this field to give a great deal of consideration to the realization of the great economies which this form of drilling could afford. These are evident because in rotary drilling there may be as much as 90% energy loss due to the friction of the rotary pipe in the bore hole. Moreover, the effect of the heavy loading on the bit, which now runs as much as 40,000 to 100,000 pounds, not only requires very heavy drill collar sections, but under many circumstances results in angular deviations in drilling that exceed the permissible limits for well bore verticality. With a reduction of load on the bit, there is an attendant reduction in rate of penetration and frequently supplemental equipment such as whipstocks must be used to correct these deviations.

The use of a turbodrill has the distinct advantage over rotary drilling in that the driving torque is close to the bit. It utilizes the drilling fluid which is necessary for removing the cuttings from the well and it can be made of adequate power to permit rapid drilling. The direct drive multiple stage type turbodrill does have a somewhat higher rotational speed as compared to normal rotary operation, but with improved bits the turbodrill can be expected to drill considerably faster and cheaper than is possible with rotary drilling.

A turbodrill is, however, a down-hole engine which operates in a fluid-laden well bore and the atmosphere of highly abrasive fluid stands in the way of any normal lubrication of the wear parts. Its limited diameter, which seldom exceeds twelve inches and is usually in the order of six to eight inches, also limits the internal design beyond that possible with turbines used above ground.

One of the serious problems that has developed in the operation of such turbodrills is a tendency of the high velocity, downwardly moving drilling fluid to leak out through the bearings of the turbodrill and, due to this velocity effect, to erode the rock bit and to interfere with the discharge of cuttings from the bore. Hence, one of the principal objects of this invention is to overcome this grave problem of effectively protecting the rock bit against deterioration and to utilize the forces to assist in clearing the bore. The nature of this problem and the means of its solution will be more fully understood from the following detailed description and a consideration of the accompanying drawings, in which:

FIG. 1 is an enlarged and partially longitudinally sectioned turbodrill showing the lower portion of the turbo-

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drill housing and the depending driving shaft and bit operatively positioned in the bore hole and resting on bottom;

FIG. 2 is a horizontal view of the turbodrill as shown in FIG. 1, taken on line 2-2 thereof and showing the upper face of the mud deflector or bit protector means.

FIG. 3 is a partial vertical section taken on line 3-3 of FIG. 2 and showing the means for securing the protector means in position; and

FIG. 4 is also a partial vertical section of the lower end of the drill string of FIG. 1, illustrating a modification of the protector means shown in FIG. 3.

As is well known in the turbodrill art and as more particularly shown in the copending application of Hammer et al. filed September 30, 1958, Serial No. 764,213, the turbodrill is a down hole mud driven turbine which is supplied with drilling fluid which passes through from the drill string through a series of rotor and stator blades and thence to the drill bit. This drilling fluid then returns through the bore, clearing the cuttings and carrying them to a suitable sump from which the liquid can again be pumped down hole.

In a turbodrill of this type it has been found that for a 6½-inch nominal diameter turbodrill having approximately 100 turbine stages, it is necessary to pump down hole approximately 600 gallons per minute of mud to develop the desired drilling torque equivalent to about 180 H.P. The mud pressure on the surface will range from 1,000 to 3,000 pounds per square inch gauge.

As shown in FIG. 1 the lower portion of the rotating turbodrill shaft 41, which is carried in the housing 40, is provided with suitable thrust bearing discs 42 alternately spaced with stationary bearing members 44 which are carried by the housing to resist axial thrust in either direction. These fixed bearing members have drilling fluid passages 45 whereby the bearings are both cooled and lubricated. Most of the drilling fluid then enters the central part of shaft 40 by port 45a.

In addition to the thrust bearings we also provide a radial bearing assembly, including a hardened sleeve 60 mounted on the shaft 41 and keyed to it by the key 61. This bearing surface is engaged by the adjacent cartridge and sleeve top bearing element 63 which is mounted in the turbodrill housing 64 and is held in place by the retainer ring 65. The outer hardened surface sleeve 66 is customarily provided with fluid passages, which are shown as clearances on the drawing in FIG. 1 and permit some of the drilling fluid to pass between the bearing surface also for the purposes of cooling and lubrication.

It has been found that with the high drilling fluid pressure required to effectively operate the turbine, there is some discharge from the bottom of the housing 64 and the shaft 41. In one instance it was found that the velocity of this discharge was in excess of 1,000 feet per minute and served as a cutting jet which carried all the way to the shirrtail of the rock bit 19, even to the point of cutting upon the back of the forgings and permitting the discharge of the balls from the ball races. It also seriously affects the discharge of the cuttings from the bore causing such turbulence and erosion of the bit as to be critically objectionable.

As more particularly disclosed in FIG. 1 and in FIG. 3, we have found it entirely satisfactory to install a deflector ring generally indicated at 30 on the lower shaft 41 and below the bottom of the housing 64.

In the preferred form, the deflector ring 30 comprises a metallic ring formed with a continuous annular groove 32 on its upper surface, which groove is of V-shape in cross-section and relatively shallow, with each deflecting surface directed away from the other at an angle of the order of 30 degrees from a normal. This ring 30 has

an external diameter that is approximately equal to that of the turbodrill housing 31.

As best shown in FIGS. 2 and 3, the deflector ring 30 may be firmly secured on the drill shaft 41 by a plurality of peripherally spaced set screws 34 countersunk within the ring. While it is ordinarily sufficient to secure the deflector ring 30 in position by means of such set screws, the impact forces thereon may become so great that it is necessary to provide a recessed annular portion on the shaft to receive a key or snap ring retaining means.

Use of the set screw securing means for the deflecting ring as illustrated in FIG. 3 may be eliminated entirely by the substitution for a metal ring a deformable resilient ring 36 of like shape made of rubber or plastic stretched over the lower drill shaft 41. It has been determined that when such a deflector ring 36 having a central bore of two and one-half inch diameter is stretched over a four-inch drill shaft, i.e. (41), it will maintain itself in operative fluid deflecting relation without assistance. Even more positive retention of the resilient deflector ring may be obtained by providing an annular shaft recess partially receiving the inner rim portion thereof.

From the explanation that has been given it will be understood that a jet (usually in the form of an annular curtain) of drilling fluid discharging from the casing will be intercepted and prevented from striking the bit. This of itself would be a valuable protection for the bit and is highly important. In addition, however, the jet or curtain of the mud laden drilling fluid is redirected upwardly where it becomes commingled with the upwardly moving drilling fluid, and positively augments both the lifting force of the returning mud flow to the surface and the discharge of pressure fluid from the turbine.

In this manner indirect but very effective protection has been provided for the drill bit 19 by preventing destructive erosion causing exposure of the bearings of the bit to well fluid scouring.

Similar high velocity leakage from the turbine housing section 31 containing a cartridge type bearing 63 will also be effectively minimized.

Thus it will be appreciated that the successful use of a turbodrill of the character described for practical periods of operation is largely dependent on the effective utilization of the deflecting means in the association described herein.

Having thus described our invention and the best mode of practicing the same, what we claim as novel is:

1. In a mud-driven turbodrill for downhole drilling having a tubular housing, a hydraulic turbine assembly in said housing including a shaft adapted for rotation with respect to the housing by the passage of drilling mud through the housing, a drill bit carried by the shaft, a radial bearing adjacent the end of the housing and between the housing and the shaft, said shaft having a main conduit for carrying mud discharged from the turbine

assembly to the bottom of a hole to return cuttings to the surface of said hole, said bearing having a liquid leakage path from inside the housing to a location below and external of the housing to permit a portion of the drilling mud to pass across the bearing to cool and lubricate said bearing, and deflector means mounted on said shaft beneath said housing and between the end of said housing and said bit, and of a diameter to intercept the mud discharging from said housing through said leakage path to prevent impingement of said mud on said bit, said deflector means having means on the upper surface thereof formed and arranged to redirect said leakage mud upward to aid the mud discharging from the bottom of the shaft in lifting cuttings from the hole.

2. A turbodrill for drilling a well bore, said turbodrill comprising a tubular housing, a hydraulic turbine assembly in said housing and including a driven shaft, a rock bit adapted to be driven by said shaft, a radial bearing between the lower end of said tubular housing and said shaft, said bearing being adapted to provide a downwardly directed liquid leakage path out of said housing and across said bearing, laterally extending deflector means mounted on the shaft in encircling relation and positioned below the housing and above the bit to receive downwardly flowing liquid leakage from said housing and redirect said flowing liquid upwardly between the tubular housing and the well bore so as to avoid scouring and destruction of the bit by the otherwise downwardly directed liquid stream.

3. The combination of claim 1 in which the deflector means is a laterally extending ring detachably affixed to the shaft.

4. The combination of claim 1 in which the deflector means is an annular ring with an upwardly directed V-shaped formation on its upper surface.

5. The combination of claim 1 in which a plurality of circumferentially spaced set screws secure the deflector means to the shaft.

6. The combination of claim 2 in which the deflector means is an annular ring having an upwardly directed continuous groove-shaped formation.

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