

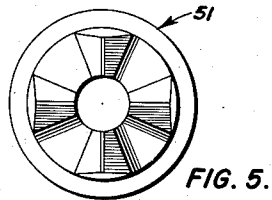
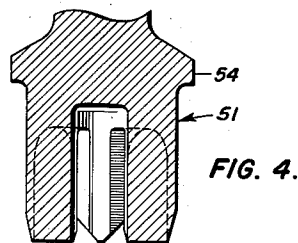
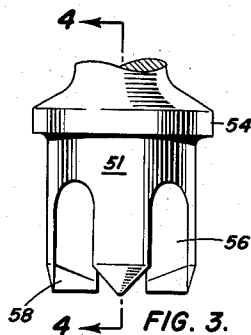
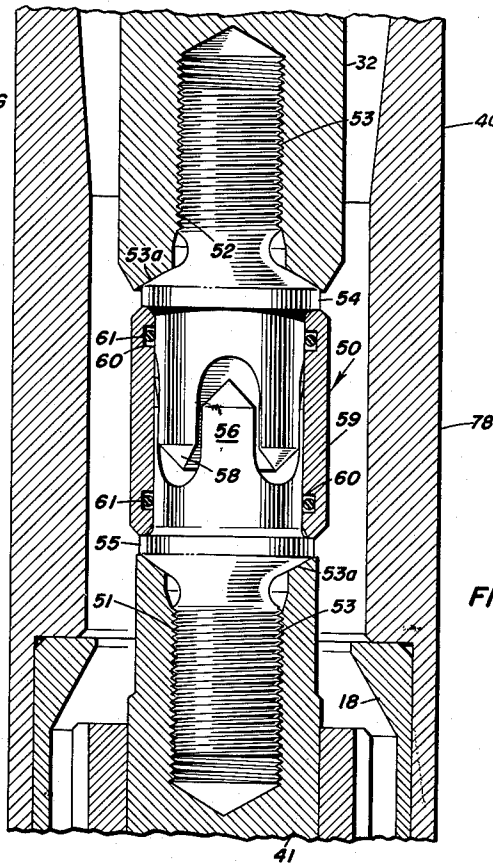
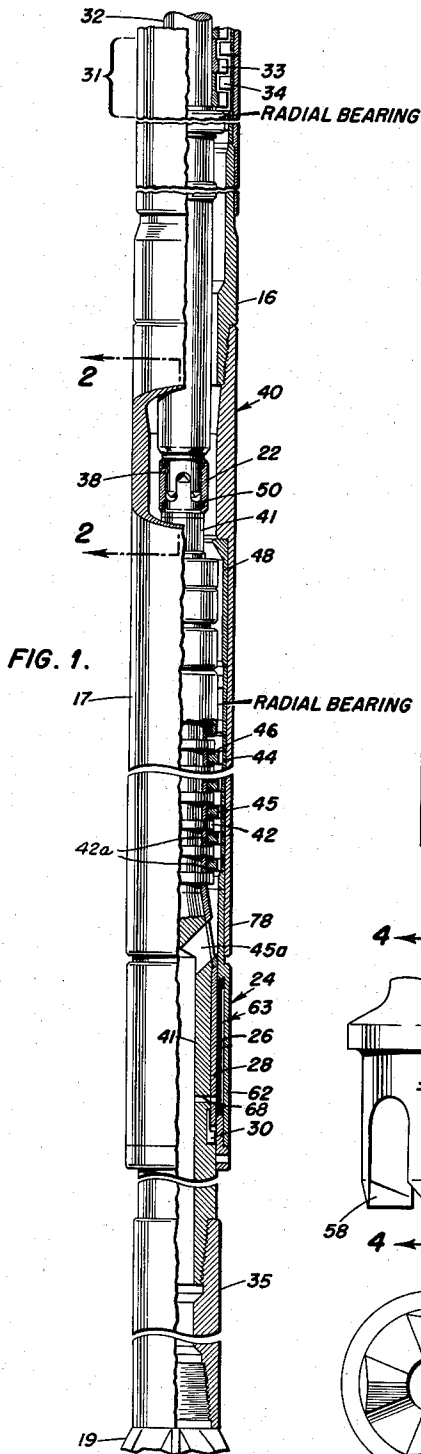
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TURBODRILL

2,990,895

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 6.

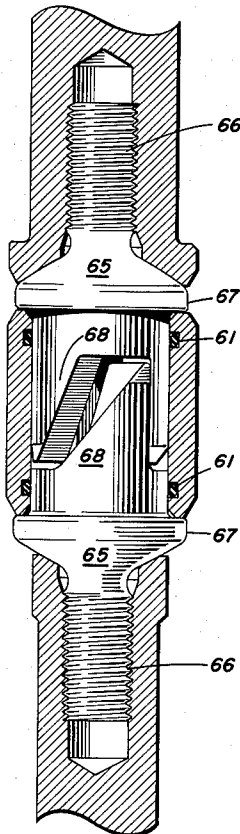


FIG. 8.

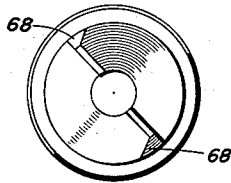


FIG. 12.

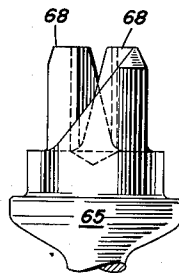
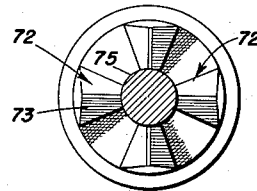


FIG. 7.

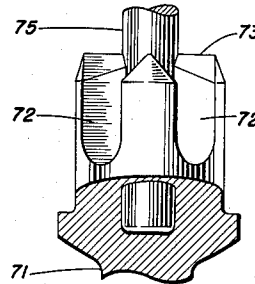


FIG. 11.

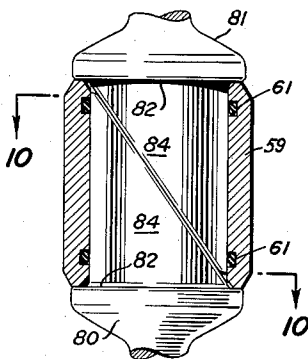


FIG. 9.

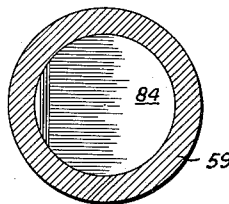


FIG. 10.

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9 Claims. (Cl. 175-107)

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 acceptable procedure. Rotary drilling remains the standard procedure in this country and from the standpoint of cost per foot of hole drilled, it has not 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 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 a 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 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.

Furthermore, a turbodrill is subjected to vertical loading on the thrust bearings which vary from downward thrust due to the pressure of the circulation fluid on the turbine blades, to a very high upward thrust when the drill string weight on the bit exceeds the hydraulic down thrust on the shaft. With the added factor of the remoteness of operation from the ground level, it will be seen that substantial importance is attached to the mechanical details of design of the unit.

The principal object of our invention is to provide an improved turbodrill structure which has the facility of being readily manufactured, easily repaired and maintained at the rig site, and of greater efficiency with respect to the application of available power to the bit as compared to previously available equipment.

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An important object of this invention is to provide a coupling for two or more turbodrill sub-assemblies whereby the relative longitudinal position of both or all sets of rotors and stators is established and maintained against wear and fluctuating loading due to unbalanced hydraulic and other loads.

A specific object of this invention is to provide a significantly improved mechanical arrangement for coupling individual shafts of a multi-section or tandem turbine turbodrills while maintaining the proper spacing between the rotor and stator blades and simultaneously sealing the working surfaces of the coupling against the intrusion of abrasive-laden drilling fluid.

A still further object of this invention is to improve the design of the turbodrill by making it easier to assemble as well as more rugged, whereby it withstands the abuse of field use to a higher degree.

Further objects and advantages of our invention will appear from the following description of preferred forms of embodiment of the invention taken in connection with the attached drawings illustrative thereof, and in which:

FIGURE 1 is a schematic diagram of apparatus in borehole drilling attitude and illustrating a general arrangement of a turbodrill and its associated parts;

FIGURE 2 is an enlarged partial vertical section showing the coupling means between upper and lower driving shafts;

FIGURE 3 is a side elevation of one element of the coupling;

FIGURE 4 is a vertical section of the same element of the coupling means taken on the line 4-4 of FIGURE 3 and showing in partial elevation one of the parts;

FIGURE 5 is a bottom plan view of the coupling of FIGURE 3;

FIGURE 6 is a vertical sectional view showing a modified form of coupling tooth element;

FIGURE 7 is a side elevation of the coupling tooth element shown in FIGURE 6;

FIGURE 8 is a top plan view of the coupling element of FIGURE 7;

FIGURE 9 shows in vertical section a single tooth modified coupling pair; and

FIGURE 10 is a section of the coupling of FIGURE 9 taken on the line 10-10.

FIGURE 11 is a partially sectioned side elevation view of one member of a multitoothed coupling element provided with spacing means; and

FIGURE 12 is a top plan view of the coupling element of FIGURE 11.

With reference to FIGURE 1 of the drawings, the turbodrill as generally shown at 17 includes one or more turbine units 31, each provided with an upper shaft 32 having rotor blades 33 which are alternately spaced with stator blades 34 mounted in the turbodrill housing 16. The combination of the rotor and stator blades provides a multiple stage turbine unit which is actuated by the drilling fluid, and for typical operations has approximately one hundred pairs of blades or stages that develop from about one hundred fifty to three hundred horsepower. This, of course, will depend upon the drilling fluid circulation rate and is merely intended to reflect the approximate horsepower capacity.

Mounted below the turbine units 31 there is provided a separate bearing sub-assembly or "sub" generally indicated at 40. This includes a lower shaft 41 which has rotating thrust bearing disks 42, which are alternately spaced with stationary bearing members 44. The construction is such that there is both support for and resistance to vertical movement of the lower shaft 41, as well as free passage for the drilling fluid in the passages 45, whereby the drilling fluid after it drives the turbine enters port 45a with a portion passing down over the bearings and through

the port 68 into the lower shaft 41 and then to and through the drill bit 18.

The stationary bearing members 44 are mounted within the sub-assembly 40 and are provided with rubber bearing surfaces 46 adjacent to the rotating disks 42 which are mounted on the shaft 41 with suitable spacer rings 42a, the entire assembly being held against the distance bushing 48 by the threaded engagement of the bearing housing 24 in the lower portion 78 of the bearing sub-assembly 40. The bearing housing 24 carries the resilient sleeve bearing 26 which engages against a bearing sleeve 28 which is keyed to the shaft 41 by the key 30.

The extent of the load on the bearings will be appreciated when it is understood that with one form of turbodrill there is from six hundred to one thousand pounds per square inch pressure drop through the turbine which results in a downward hydraulic thrust of from eighteen to twenty thousand pounds.

If the bit is now moved into drilling position and a loading of eighteen thousand to twenty thousand pounds is placed on the turbodrill casing, the bearing surfaces 46 on the stationary bearing members 44 in the bearing sub-assembly will float in a balanced condition. If, however, extra weight of the drill string on the bit is found desirable, the bearing surfaces become reversely loaded to the extent of the difference between the total drill string load and the hydraulic thrust. The stationary members of the bearings are normally covered with some flexible material such as rubber for this reason.

In order to support the turbine by the lower shaft 41 with the necessary spacing between the rotor and stator blades 33 and 34, the upper shaft 32 is coupled to the lower shaft 41 through a clutch type coupling generally shown at 50 in FIGURE 2. It includes two stud members 51 and 52, each of which has a shank portion 53 appropriately threaded into an adjacent threaded bore of the respective shafts 32 and 41, such shank portions 53 ending in a collar or shoulder sections 54 and 55, respectively. The surfaces 53a of the shank portion 53 adjacent the end of the respective shafts 32 and 41 are preferably dome shaped to thereby provide a greater contact area between each of said surfaces and its respective bearing area on the shafts 32 and 41.

Conveniently the stud members 51 and 52 are provided with one or more clutch jaws or teeth 56 of which, in one preferred form of embodiment, four are shown in FIGURES 2, 3, 4 and 5. These teeth 56 on the upper and lower coupling studs interengage for a substantial distance, but do not abut at either ends. Preferably, they are formed with wedge-shaped faces as indicated at 58, and thereby interengagement can be obtained during assembly by blind stabbing.

In order accurately to space the ends of the respective shaft sections 32 and 41 and to take thrust loads as well as to seal the bearing surfaces of the wedge-shaped teeth 56, it is preferred to use a sealing collar and spacer ring 59. This is so shaped as to be of extremely accurate length so as to precisely space the shoulders 54 and 55 of the clutch members 51 and 52 at such a distance one from the other that with the turbodrill completely assembled the rotors 33 and the stators 34 of the turbine section 31 will be held in their desired position by means of the bearing sub-assembly 40.

Preferably, the sealing collar and spacer ring 59 is provided with suitable channel recesses on the inner wall as indicated at 60, and is adapted to receive gaskets as for example, resilient O-rings 61, whereby the device becomes pressure tight against the introduction of any abrasive fluid particles. This is especially important in deep well drilling where the drilling fluid is heavily laden with abrasive particles.

As the coupling 50 is adapted to resist compressive stresses only, it is normally placed below the turbine unit 31 and above the bearing sub-assembly. However, it can also be used between tandem turbine units.

Under normal circumstances, before the bit 19 hits bottom, with the turbine running, there is from six hundred to one thousand pounds per square inch pressure drop through the turbine, which is the standard size tools of 6½" and up will result in a downward hydraulic component of from eighteen thousand to twenty thousand pounds or higher on the shaft. This component, in the absence of other bearings, is taken through the coupling 50 and by the bearing sub-assembly.

If the bit is now moved into drilling position and the customary loading of eighteen thousand to twenty thousand pounds is placed on the turbodrill casing, the bearing faces in the bearing sub-assembly will float in a balanced condition. If, however, extra weight of the drill string on the bit is found desirable, the bearing faces become reversely loaded to the extent of the difference between the total drill string load and the hydraulic thrust. The bearings are normally made of some flexible material such as rubber for this reason.

In accordance with our invention, it now becomes entirely practical to place the thrust bearing in a self contained bearing sub-assembly which is readily detachable from the turbine unit without in any manner requiring disassembly of that unit. It is thus possible quickly to substitute a new bearing sub-assembly for a worn one by merely uncoupling the bearing sub and pulling the shafts apart. Thereafter, by blind stabbing, the new bearing shaft 41 may be engaged with the turbine shaft 32 and with the spacer collar 50 in place, there is again accurate positioning of the rotor and stator blades in the turbine with the bearings 42 and 44 carrying the thrust loads.

It is, of course, to be understood that reference has been made only to axial thrust and that other bearings are provided at appropriate places on the turbodrill shaft or shafts to counteract lateral thrust. As shown for example, there is provided in the lower bearing housing 62 a side thrust bearing member 63 of the cartridge and sleeve type.

A modified form of tooth coupling and stud is shown in FIGURES 6, 7 and 8 in which each stud unit 65 having a threaded shank 66 and shoulder portion 67 is provided with a suitably and oppositely inclined pair of clutch jaws or teeth 68 of wedge type. These two pairs of teeth coact complementally as illustrated in FIGURE 6. Normally, it is preferable to have two or more teeth in view of the torque on the shaft, but it is entirely possible to design and build a single tooth coupling, as shown in FIGURES 9 and 10.

The single tooth arrangement depicted in FIGURES 9 and 10 comprises a pair of tooth coupling stud members wherein each stud 80 has a shoulder portion 82 from which extends a single wedge type tooth 84. The teeth complementally coact with each other as shown in FIGURE 9 and are surrounded by the usual sealing collar and spacer rings 59 having suitable gaskets such as resilient O rings 61.

Another modified form of construction of coupling is shown in FIGURES 11 and 12, in which case the stud member 70 is provided with a shank which may be suitably threaded as is shank 65 and has teeth 72 of which four are shown, such teeth having wedge-shaped faces 73 similar to those shown in FIGURES 3, 4 and 5. It will be understood that a coupling includes two cooperating stud members as generally shown in FIGURE 2.

In this construction, a central pin 75 is shown, which is in the nature of a dowel and extends into the respective sockets in the studs and being of fixed length, which is accurately established, it provides the necessary spacing of the separate coupling elements. It will be appreciated in this construction that by using pins or dowels of different length it is possible to quickly substitute one dowel for another, and thereby taking up for wear as necessary.

This form of construction is also provided with a cylindrical sleeve and seals as indicated in FIGURE 2 for

the principal purpose of maintaining the coupling parts free of external mud.

While in the foregoing description reference has been made to a coupling between an upper shaft and a lower shaft, and in such case, particular reference has been made to the upper shaft as a turbine unit and the lower shaft as being a thrust bearing, it is also entirely possible to use the same type of coupling for coupling two turbine sections together.

While we have shown and described preferred forms of embodiment of our invention and the best mode of practicing the same, we are aware that modifications may be made thereto within the scope and spirit of such disclosure without departing from the principles thereof and the scope of the appended claims.

What is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. In a well turbine drilling assembly adapted for attachment to a drill pipe string and adapted to have a drilling bit on its lower end and through which drilling fluid is passed from the pipe string for return circulation upwardly through the annular space afforded by the well bore formation surrounding the pipe string, the combination comprising: a housing, a first shaft mounted for rotation within said housing, cooperating stator and rotor blades mounted respectively on said housing and on said shaft, said stator and rotor blades forming a fluid turbine engageable by the drilling fluid to drive said shaft with respect to said housing, a second shaft mounted for rotation in the housing in alignment with the first shaft, thrust bearing means cooperatively mounted on said second shaft and said housing whereby longitudinal thrust on said second shaft is transmitted to said housing, and a longitudinally separable shaft coupling between said first shaft and said second shaft, said coupling having axial thrust bearing surfaces compression resisting spacer means engaging said surfaces whereby said second shaft will take any longitudinal thrust of the first shaft, said coupling including interacting clutch jaws for transmitting torque from the first shaft to the second shaft.

2. A well turbine drilling assembly as claimed in claim 1 in which the torque transmitting members include at least one interengaging tooth projecting from the adjacent ends of the respective shafts, at least one of said teeth being provided with a tapered surface for stabbing coupling engagement with the other tooth.

3. A well turbine drilling assembly as claimed in claim 2 in which the compression resisting spacer means is a cylindrical sleeve, and gasket means between said sleeve and said torque transmitting members to resist the entrance of environmental drilling mud.

4. A well turbine drilling assembly as claimed in claim 2 in which the compression resisting spacer means is a central dowel pin.

5. In an oil well turbine drilling assembly adapted for attachment to a drill pipe string and adapted to have a drilling bit on its lower end and through which drilling fluid is passed from the pipe string for return circulation upwardly through the annular space afforded by the bore formation surrounding the pipe string, the assembly comprising: a housing, a first shaft mounted for rotation within the housing, a fluid turbine having cooperating stator and rotor blades mounted respectively in cooperating re-

lation on the inside of the housing and the outside of the shaft, a second shaft mounted for rotation within the housing in alignment with said first shaft, said second shaft being supported by a radial bearing assembly and a thrust bearing assembly, and longitudinally separable shaft coupling elements secured in opposition on the adjacent ends of said first and second shafts, each coupling element being provided with a bearing shoulder on its opposing end and being formed with a plurality of equally spaced elongated projecting teeth interengaging with the teeth of the opposing element, said teeth being formed with tapered surfaces for stabbing coupling interengagement, and an annular spacer ring fitting closely over the interengaged teeth of said coupling elements and abutting the bearing shoulders of the coupling elements.

6. An oil well drilling assembly as claimed in claim 5 in which the teeth have an inwardly tapered cross section and a wedge-shaped tooth end to aid the stabbing coupling interengagement.

7. A shaft coupling assembly for turbodrills comprising a longitudinally aligned pair of spaced shafts, a pair of longitudinally separable shaft coupling elements secured in cooperable relation with each other on the respective ends of said pair of shafts, said coupling elements having axial thrust bearing and surfaces and a plurality of equally spaced elongated teeth extending beyond each bearing surface, said teeth lying within the lateral limits thereof and being wedge shaped and arranged for stabbing interengageable driving relation with each other, and a spacer ring closely fitted over the interengaging teeth of said coupling elements and abutting said bearing surfaces to provide an enclosure for said coupling elements in their coupled relation.

8. A shaft coupling assembly for turbodrills comprising a longitudinally aligned pair of spaced shafts, a pair of longitudinally separable shaft coupling elements secured in cooperable relation with each other on the respective ends of said pair of shafts, each of said coupling elements having an axial thrust bearing surface and at least one elongated tooth extending beyond each bearing surface, said teeth lying within the lateral limits of the coupling elements and being complementally wedge shaped and arranged for stabbing interengageable driving relation with each other, and a spacer ring closely fitted over the interengaging teeth of said coupling elements and abutting said bearing surfaces to provide an enclosure for said coupling elements in their coupled relation.

9. A well turbine drilling assembly as claimed in claim 2 and wherein separate studs carry the torque transmitting members, said studs having threaded engagement with the respective adjacent shaft ends, the surface of said studs adjacent the shaft ends being dome-shaped to thereby provide greater contact area between each of said surfaces and their respective area on the shaft ends.

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