United States Patent

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[72] Inventor **Jean Mothre**
Le Vesinet, France
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[73] Assignee **Entreprise De Recherches Et D'Activites Petrolieres (ELF)**
Paris, France
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[33] **France**
[31] **69.15506**

[54] **TURBODRILL**
6 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **173/73,** 175/107, 415/502
[51] **Int. Cl.** **E21b 3/12**
[50] **Field of Search** 173/73; 175/107; 415/502, 503

[56] **References Cited**

UNITED STATES PATENTS

3,039,735	6/1962	Tiraspolsky et al.	415/502
3,362,488	1/1968	Ioanesyan et al.	175/107
3,405,912	10/1968	Lari et al.	415/503

Primary Examiner—James A. Leppink
Attorney—Cameron, Kerkam & Sutton

ABSTRACT: A turbodrill in which the hydraulic power unit consists of a rotor which is centered within a cylindrical stator by an axial thrust bearing, the forces exerted on said axial thrust bearing being balanced irrespective of the nature of the formation by virtue of two systems of vanes separated by a baffle for reversing the direction of flow of the driving fluid. Since the entire quantity of fluid passes successively through the two sets of vanes in opposite directions, the axial thrust forces are balanced on the thrust bearing which centers the rotor irrespective of the variations in loss of load on the drilling head.

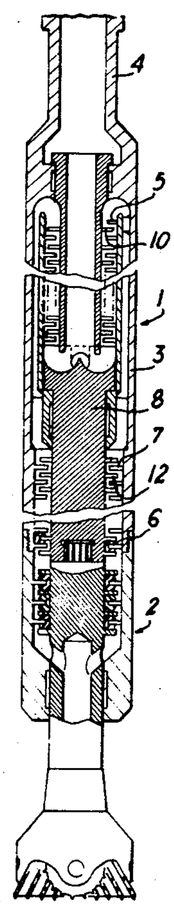


FIG. 1.

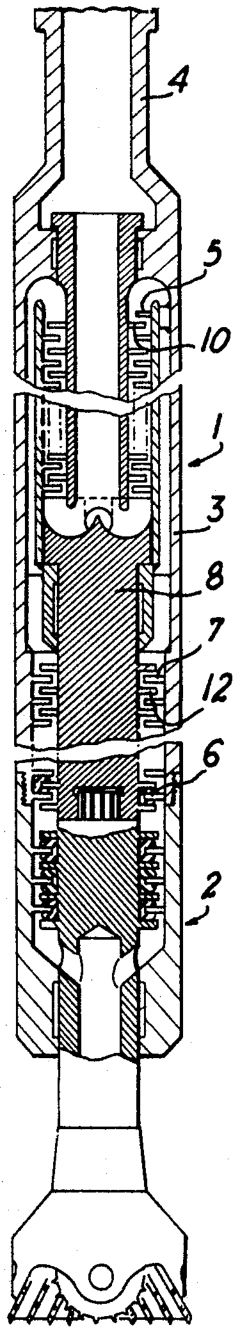
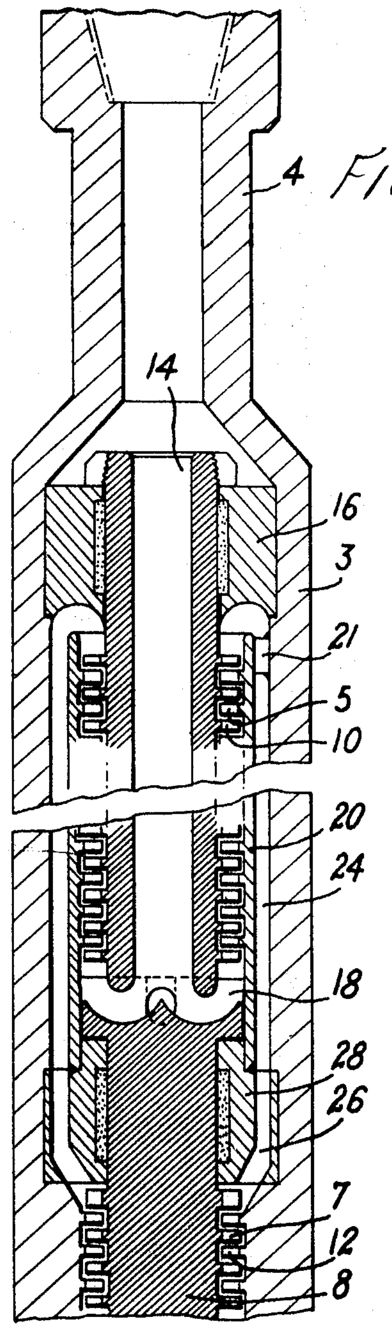


FIG. 2.



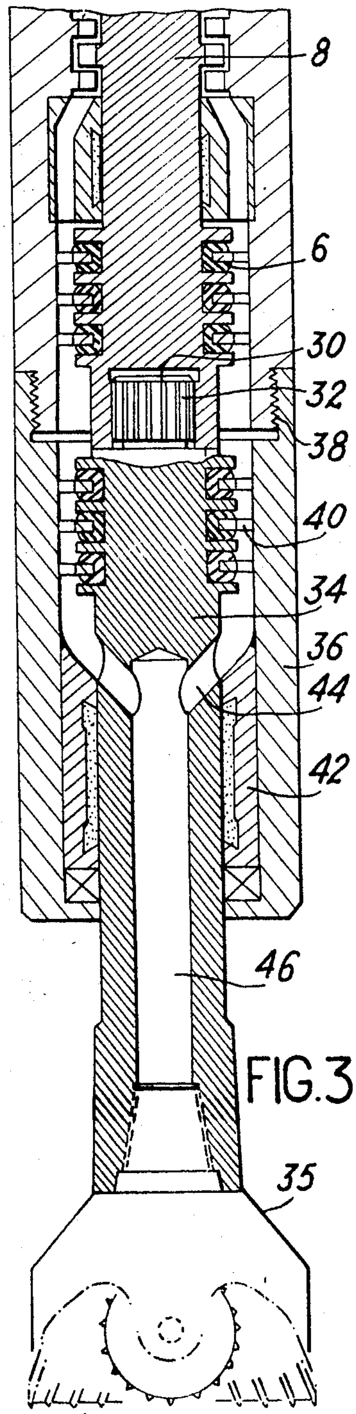
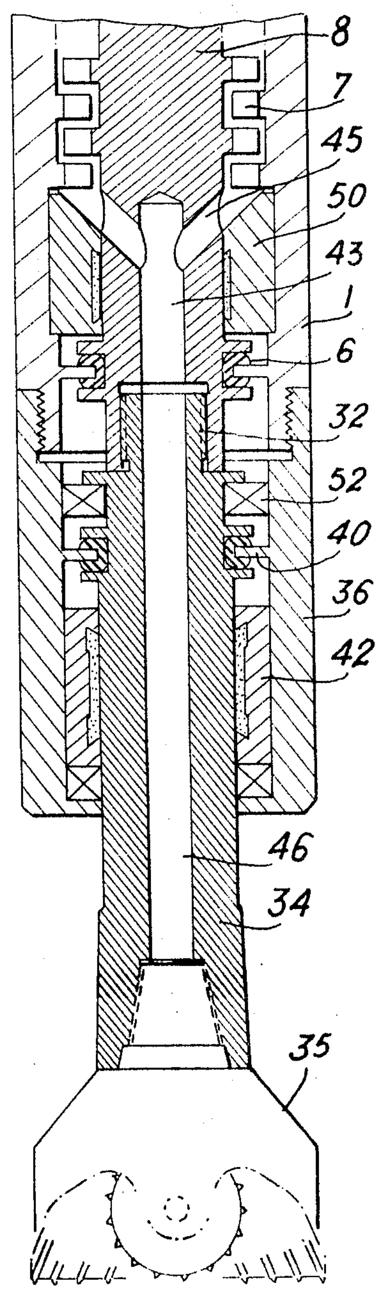


FIG.3

FIG.4



TURBODRILL

It is known that a turbodrill is driven by means of a drilling fluid which is injected into a drill pipe by means of a pump located at the surface of a well bore and that a turbodrill usually carries a rotor which is attached to a cutting tool or roller bit, said rotor being capable of moving inside a cylindrical stator and being maintained within this latter by means of a thrust bearing.

The stator and rotor are intended to support a number of axial turbine stages which operate under conditions of constant flow. The turbine therefore exerts on the tool an axial thrust which is the sum of the hydraulic pressure of the fluid and of the weight of the rotor.

The stator is attached to a string of drill pipe sections which do not rotate and transmits to the roller bit a thrust which varies as a function of the weight to be applied to said bit. The thrust bearing must accordingly withstand the variations in said thrust. These variations can be of considerable magnitude (of the order of 30 tons). They therefore give rise to rapid wear as a result of friction and are attended by the following disadvantages:

loss of driving torque which causes difficulties in startup and stalling of the turbine;

the need to allow a substantial clearance between stationary and moving vanes in order to compensate for the loss in thickness of the bearing discs as wear increases;

periodic withdrawal of the turbine from service in order to permit replacement of worn parts of the thrust bearing;

considerable difficulty in determining the exact value of the load applied to the drilling bit which is a function of the friction forces acting on said thrust bearing.

In order to limit the degree of wear, consideration has been given to the design of a hydraulic thrust bearing in which the bearing itself compensates for axial movements of the shaft and balances the position of this latter. This type of thrust bearing does in fact limit wear but nevertheless calls for a substantial space between the stationary and moving vanes in order to permit shaft oscillation. The efficiency of the turbine is consequently impaired.

The present invention is intended to avoid such a loss of efficiency by eliminating the axial thrust of the driving portion of the turbine and combining the components which are subject to wear, namely the roller bit and thrust bearing, in a detachable drilling head.

This invention is concerned with a turbodrill which is driven by the drilling fluid itself and comprises a hydraulic power unit constituted by a rotor which is centered in a cylindrical stator by means of an axial thrust bearing. Said turbodrill essentially comprises two sets of stationary vanes carried by the stator and each corresponding to one set of moving vanes carried by the rotor and a baffle for reversing the direction of flow of the fluid between the two sets of vanes. By means of said baffle, the fluid is caused to flow successively and in opposite directions through both sets of vanes prior to arriving at a detachable drilling head which is placed in a removable extension of the stator and coupled for rotation with the rotor only.

The number of vanes of each set is such that the resultant axial thrust of the power unit on the thrust bearing is zero.

In a preferred embodiment of the invention, the turbodrill comprises a first set of vanes fixed between the rotor and a sleeve which is coaxial with the stator and which defines a U-shaped passageway for the flow of fluid between said rotor and said stator.

According to a further property of the invention, the drilling head comprises a rotary shaft having an extension in the form of a splined endpiece disposed in interengaged relation with longitudinal grooves of a recess which is bored in the extremity of the rotor.

By reason of the fact that the fluid therefore flows successively through both sets of vanes of the turbine in opposite directions, the axial thrust forces which act on these two sets of vanes and the weight of the turbine can readily be balanced so as to cancel each other irrespective of the nature of the formation being penetrated and the loss of load on the roller bit. The resultant axial thrust load on the centering thrust bearing within the stator is then zero and the sole purpose of said thrust bearing is to maintain the rotor in a stationary position with respect to the stator. Wear of this thrust bearing is thus reduced to the strict minimum.

On the other hand, the forces exerted on the roller bit are transmitted to the drilling head and consequently to the thrust bearing which serves to maintain the drilling head shaft in position in the line of extension of the stator. This thrust bearing is subject to wear but the complete head assembly is detachable and the thrust bearing can readily be replaced on site without being returned to the factory.

A number of additional advantages and properties of the invention will in any case become apparent from the following description of one embodiment which is given by way of nonlimitative example, reference being had to the accompanying drawings, wherein:

FIG. 1 is a longitudinal sectional view of a turbodrill;

FIG. 2 is an enlarged view of the upper portion of said turbodrill;

FIGS. 3 and 4 are enlarged longitudinal sectional views of two forms of construction of the lower portion of the turbodrill.

The turbodrill according to the invention comprises two basic components as shown in FIG. 1, namely a hydraulic power unit 1 and a drilling head 2.

The hydraulic power unit comprises a cylindrical body 3 having a top extension in the form of an endpiece 4 for attachment to a drill pipe (not shown in the drawings). Said cylindrical body 3 is adapted to carry two stationary sets of vanes 5 and 7 and constitutes a stator in conjunction with said vanes. By means of a thrust bearing 6, said cylindrical body is also adapted to support a shaft 8 fitted with two sets of moving vanes 10 and 12 which constitute a rotor.

As shown in FIG. 2, the shaft 8 is pierced at the top and in central alignment with the endpiece 4 by an axial passageway 14 for guiding the drilling fluid which is admitted through said endpiece 4 and is placed at this point within a bearing 16 which seals off the space formed between said shaft and the cylindrical body 3.

The passageway 14 opens via curved ducts 18 into a space which is defined around the shaft 8 by a sleeve 20, said sleeve being coaxial with the cylindrical body 3 and attached to this latter by means of spacer members 21 so as to form an annular space 24 between said sleeve and said cylindrical body. Said sleeve 20 is adapted to carry the stationary vanes 5 internally thereof while the shaft 8 is adapted to carry the moving vanes 10 externally thereof, said vanes 5 and 10 being interengaged so as to form at least one axial turbine stage. A communication is established between said turbine 5—10 and the space 24 at the top of the sleeve 20 so that the fluid which has entered through the endpiece 4 should thus flow through a double U-shaped loop. Ducts 26 form an extension of the space 24 through a bearing 28 in which the shaft 8 is rotatably mounted and to which the sleeve 20 is rigidly fixed. Said ducts open into the top portion of a second turbine which is formed by the stationary vanes 7 and moving vanes 12 which are carried respectively by the cylindrical body 3 and the shaft 8.

The fluid which has entered the top portion of the turbine via the endpiece 4 flows through the passageway 14 within the shaft 8, then upwards within the turbine 5—10, returns in the opposite direction within the spacer 24 and the ducts 26, then passes downwards through the turbine 7—12. The fluid therefore produces an upwardly directed axial thrust within one of said turbines and a downwardly directed thrust within the other turbine.

The number of vanes of each set is chosen so that the upwardly directed axial thrust produced by the flow of fluid within the upper set of vanes counterbalances the downwardly directed axial thrust exerted by the fluid which circulates within the second set of vanes as well as the specific weight of the rotor in the drilling fluid. The resultant thrust load on the thrust-bearing **6** is thus practically zero. The essential design function of said thrust bearing is to center the rotor within the cylindrical body **3**.

The drilling head **2** is coupled to the hydraulic power unit which is formed by the combined assembly of both turbines through which fluid circulates in opposite directions. Accordingly, an axial recess **30** is formed in the extremity of the rotor **8** and provided with longitudinal grooves in which is engaged a splined endpiece **32**, said endpiece being rigidly fixed to a shaft **34** which carries the roller bit **35**.

Said shaft **34** is supported within a cylinder **36** which forms an extension of the cylinder **3** and is screwed on this latter at **38**, the top end of said shaft **34** being maintained by a thrust bearing **40** which is similar to the thrust bearing **6** and the bottom end of said shaft being maintained by a bearing **42**.

In a preferred embodiment which is illustrated in FIG. 3, the shaft **34** is pierced beneath said thrust bearing **40** so as to form inclined ducts **44** which are extended by an axial passageway **46** and this latter opens into the endpiece to which the roller bit **35** is attached, the fluid which passes out of the lower turbine **7—12** being thus discharged towards said bit by means of said inclined ducts.

The bearing **42** serves to guide the shaft **34** within the extension **36** and also to ensure leaktight closure of the fluid circuit beneath the ducts **44**.

The weight which is applied to the thrust bearing **40** by means of the cylindrical body **3** and its extension **36** and which is reduced by the hydrostatic pressure applied by the driving fluid to that section of the shaft which is located at the level of the bottom bearing **42** is transmitted to the drilling bit **35** by said thrust bearing but this latter is not subjected to any axial force produced by the power unit, only the driving torque being transmitted to the shaft **34**. However, the thrust bearing is subjected to the variations in the load applied to the drilling bit and to the friction forces arising from such variations, thus resulting in a tendency to wear, which is not the case with the thrust bearing **6**. This wear, that is to say the loss of thickness of the bearing discs, can cause axial displacement of the shaft **34**, that is to say sliding of the splined endpiece **32** within the grooved recess **30**, but does not result in any displacement of the rotor **8**. The load on the thrust bearing **6** therefore remains unchanged.

The assembly which consists of the drilling head **2** can readily be removed by unscrewing the extension **36** and withdrawing the splined endpiece **32** by sliding as soon as the wear of the thrust bearing **40** is found to be excessive. The thrust bearing can then be replaced.

In some cases, it can prove preferable to ensure that only the thrust bearing **40** is subjected to the influence of the load applied to the tool, the action of the hydrostatic pressure of the driving fluid at the level of the bottom bearing being transferred to the thrust bearing **6** or, more precisely, being counteracted by means of the arrangement of the turbines in opposite directions. Since the rate of flow is constant, this can readily be ensured.

The passageway **44** which passes axially through the shaft **34** of the drilling head is in this case extended to the lower extremity of said head as shown in FIG. 4 and passes through the splined endpiece **32**. Said passageway even extends into the rotor **8** by way of a passageway **43** which communicates with the lower set of vanes **7—12** by way of inclined ducts **45**.

The lower portion of the cylindrical body **3** is provided in this case above the thrust bearing **6** with a bearing **50** for the leaktight closure of the fluid circuit. Moreover, the shaft **34** is guided within the interior of the extension **36** both by the thrust bearing **40** and the bearing **42** and by a ball bearing **52** which is disposed at the top end of said shaft.

In this form of construction as in the previous embodiment, the bearings can be either of the rubber type or of the baffle type and the thrust bearing can consist of rubber discs, balls, rollers or can be of any other type.

The entire quality of the fluid passes through both sets of vanes and the drilling head and produces action on the roller bit. No reduction in the flow rate of fluid or in the effort exerted on the roller bit is therefore liable to impair the efficiency of this latter. On the other hand, only the thrust bearing **40** is subjected to the axial movements which are transmitted to the roller bit or which result from vibrations of this latter and consequently to the friction forces which arise from these displacements. In consequence, wear on this thrust bearing alone takes place progressively as the drilling operation proceeds. Since the complete drilling head assembly can readily be removed by unscrewing the extension **36** and then withdrawing the splined endpiece **32** by sliding within the recess **30**, said drilling head can readily be withdrawn and replaced by another head of the same type without thereby entailing the need to return the turbodrill to the factory.

Since the hydraulic power unit does not have any component which is subject to veritable wear and operates independently of the drilling parameter, namely the weight applied to the bit, said power unit can be employed over an extremely long period of time irrespective of the nature of the operation which is being performed.

Moreover, the stationary and moving sets of vanes can be moved towards each other in order to obtain enhanced efficiency. At equal power, this turbine can have a lesser number of vanes and consequently be shorter in length than a conventional turbine. Losses of driving torque arising from friction forces are also eliminated and startup operations are made easy.

It will be clearly understood that a number of modifications could be made in the form of construction which has just been described by way of example without thereby departing either from the scope or the spirit of the invention.

What I claim is:

1. A turbodrill driven by the drilling fluid itself and comprising a cylindrical stator, a rotor within the interior of said stator, an axial thrust bearing for centering said rotor within the stator, two sets of stationary vanes carried by the stator, two sets of moving vanes carried by the rotor and each engaged within one of the sets of vanes of the stator, a baffle for reversing the direction of flow of the fluid between the two sets of vanes and for guiding the flow of the total quantity of fluid successively through the two sets of vanes and a removable drilling head rotatably coupled only to the rotor and traversed by the fluid which has already passed through said two sets of vanes.

2. A turbodrill according to claim **1**, wherein the number of vanes of each set is such that the resultant axial thrust of the power unit on the axial thrust bearing is zero.

3. A turbodrill according to claim **1** wherein the first set of vanes is fixed between the rotor and a sleeve which is coaxial with the stator and which defines a U-shaped passageway for the flow of fluid between said rotor and said stator.

4. A turbodrill according to claim **3**, wherein the rotor is pierced by an axial duct for the admission of the fluid and by lateral outlets which are curved in the direction of the first set of vanes or specifically of the U-shaped passageway.

5. A turbodrill according to claim **1**, wherein the space between the sleeve and the stator is adapted to communicate with the second set of vanes.

6. A turbodrill according to claim **1**, wherein the drilling head comprises a rotary shaft having an extension in the form of a splined endpiece disposed in interengaged relation with longitudinal grooves of a recess which is bored in the extremity of the rotor.