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TURBINE FOR DRILLING OIL WELLS AND GAS WELLS

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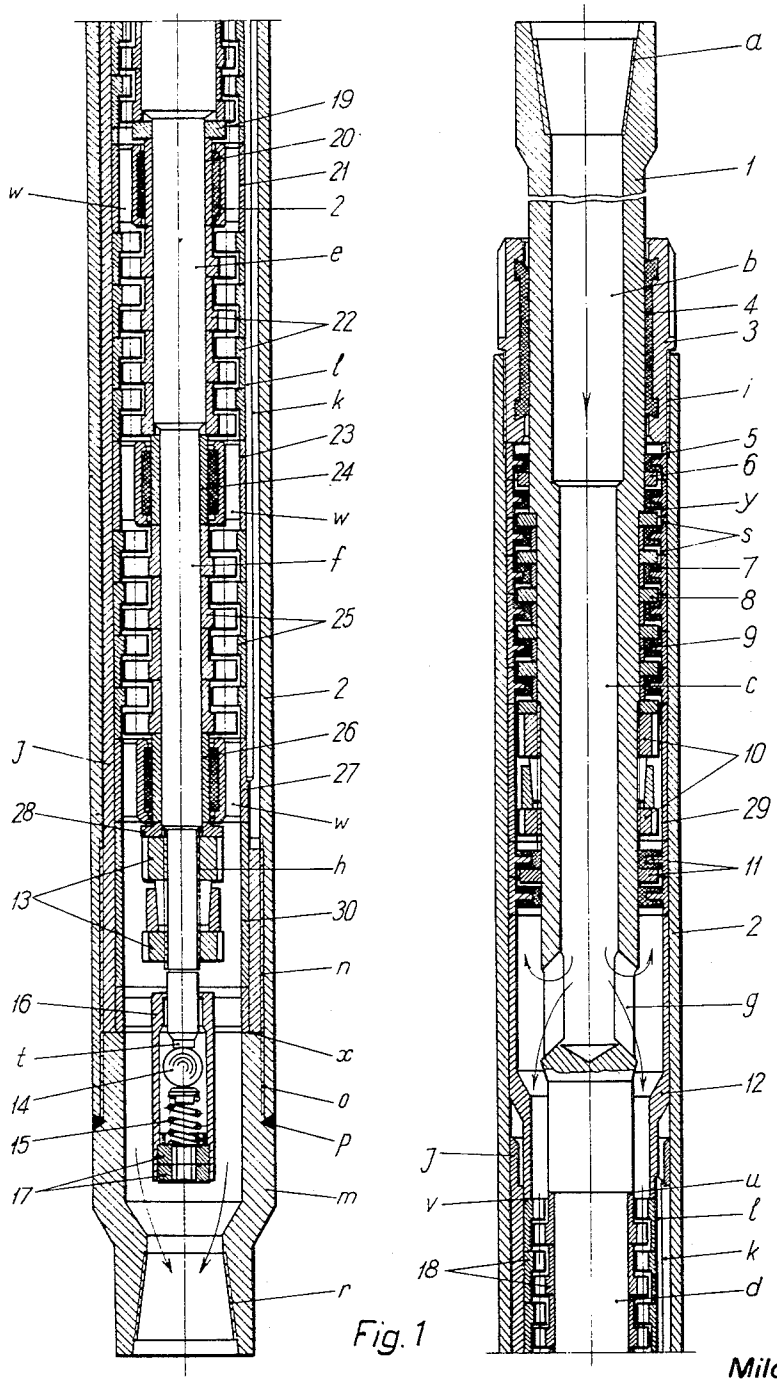


Fig. 1

Ion Lari
Milos Dumitru
Inventors.

By Karl G. Ross
Attorney

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TURBINE FOR DRILLING OIL WELLS AND GAS WELLS

Ion Lari and Dumitru Milos, Cimpina, Rumania, assignors to Ministerul Petrolului, Bucharest, Rumania

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ABSTRACT OF THE DISCLOSURE

A turbine having a reaction-absorbing shank adapted to be attached to a drill string and surrounded by a cylindrical casing of uniform cross section having a central stepped shaft constituting part of the axle and having a large diameter step followed by an intermediate diameter step and a small diameter step forming respective turbine sections with rotor and stator elements respectively engaging the cylindrical casing and the axle shaft respectively, the passage in the axle shaft delivering the drilling fluid to the turbine at a location above the large-diameter turbine but below the thrust bearing.

The invention relates to a drilling turbine wherein an axle shaft forms the reactive element which is attached to the drill string and the body of the turbine forms the rotating element.

Turbine-type drives for oil well and gas well drill strings, in which the axle is the reactive element and the surrounding body is the active or rotating element, have been provided heretofore with the turbine elements (i.e. the rotor and the stator) of the same geometrical dimension over the entire length of the turbine. These turbines have the disadvantage that they produce a torque couple proportional to the number of the stages, thereby sharply increasing the rotary speed of the turbine when the drill string is lifted from the bottom of the well and causing excessive wear of the turbine thrust bearing and the ball-bearings of the drill bit.

It is an object of the present invention to provide a turbine construction which avoids these disadvantages and reduces wear of the thrust and drill-bit bearings.

This object has been attained, in accordance with the present invention, by providing a turbine having three distinct sets of cooperating turbine elements with large torque couple and small speed, with a small torque couple and high speed, and with intermediate speed and intermediate torque couple. According to a specific feature of this invention, the rotating and stationary elements are subdivided into three distinct dimensional groups axially spaced along the turbine shaft and together forming a converter turbine. These elements include an upper group of stator elements along the shaft and rotor elements along the wall of the rotatable cylindrical casing, the annular chamber between the casing and the large-diameter step of the turbine in this upper stage having the smallest flow cross section and effective area for the drilling fluid, thereby forming a turbine section with minimum geometrical dimensions and able to produce high speed with a small torque couple; an intermediate couple of stator and rotor elements located along an intermediate step of the shaft and forming a chamber of larger diameter and, consequently, a turbine section with larger geometrical dimensions than the dimensions of the upper turbine section and capable of producing intermediate speeds and force couples with larger values than the force couples of the upper sections; and a lower section formed along a small-diameter step of the shaft with a larger flow cross section and, therefore, larger geometrical dimensions than those of the upper sections to produce a lower turbine section with high torque couples and low speed.

According to another feature of this invention, the axle shaft is surrounded by the casing and is hollow with a passage opening into the upper turbine section below the thrust bearing which is provided between the stator and rotor elements of the turbine section and the upper end of the casing, thereby directing the drilling fluid through the turbine while maintaining the thrust-bearing elements generally out of the path of the drilling-fluid flow.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing, the sole figure of which is a turbine drive for a drill bit in axial section.

In the drawing, we show a turbine whose upper end is represented at the righthand side of FIG. 1 and whose lower side is shown at the lefthand side of this figure. The turbine comprises an axle shaft **1** whose upper end is formed with a female thread *a* into which the drill string can be locked, the axle shaft **1** serving to deliver the reactive force to the drill string. The shaft has an upper tubular portion *b* with a relatively large diameter, a lower tubular portion *c* of smaller outer diameter and a stepped region *d, e, f* as will be described in greater detail hereinafter. The central passage through the shaft **1** terminates in a pair of substantially radial orifices *g* at the base of section *c* to disgorge the drilling fluid, i.e. mud, which is pumped through the drill string in the usual manner. At its lower end *h*, the shaft **1** is formed with a male thread into which the nuts **13** are threaded. The rotating portions of the turbine comprise a cylindrical casing or body **2** which surrounds the shaft **1** with annular clearance and is formed at its upper end with a female thread *c* into which is threaded a nipple **3** forming a radial bearing which simultaneously seals the casing against the large-diameter portion *b* of the shaft **1**. A rubber gasket **4** is fitted into the nipple **3** and engages the shaft **1** to prevent leakage of fluid past the nipple. In the region of the turbine section, the casing **2** is provided with the inner liner *j* having a longitudinal slot *k* into which a wedge *l* is driven to insure a positive connection between the liner *j* and the casing **2**. At its lower end, the casing **2** is formed with an adapter *m* with a female thread *o* into which the male thread of the adapter *m* is fitted, the parts being fixed together by a welding seam *p*. Prior to fitting the adapter *m* into the casing **2**, the slotted liner *j* is introduced and is held in place by its threaded sleeve *n* against the thread *o* of the casing. At its bottom, the adapter *m* is formed with a tapered female thread *r* into which the drill bit may be fitted.

At the upper end of the casing **2** (right-hand side of FIG. 1), we provide an upper sealing device consisting of pair of rotating rubber-coated disks **5** press-fitted to the inner wall of the cylindrical casing **2** which receive between them a metal ring **6** loosely mounted on the axle shaft **1** about the large-diameter portion *b*. With axial pressure, the ring **6** bears against one or the other rubber coated disks **5** to form a frontal-radial seal.

A thrust bearing is formed around section *c* of the shaft by a plurality of rubber-coated rotating disks **7** hugging the inner wall of the casing **2** and bearing against one another with the spacer shoulder *s*. A plurality of metallic rings **8** are affixed (press-fitted) on the axle shaft **1** and are disposed between the rubber-coated disks **7** and are spaced apart by the spacing rings **9** which transmit axial forces from the lower rings **8** to the uppermost ring **8** which is seated against a shoulder *y* between the steps *b* and *c* of the shaft **1**. The members **8** and **9** are held in

place by a pair of lock nuts which are wedged together and bear axially upon the thrust assembly **7–9**.

At the lower end of the upper portion of the axle shaft **1**, there is provided a lower seal **11** having essentially the same construction as the upper seal **5, 6**, i.e. a pair of rubber-coated disks which are tightly held in the casing **2** but have rubber portions engaging the periphery of step *c* of the shaft while a rotatable ring is received between these disks.

At the upper part of the turbine section (right-hand side of FIG. 1), we provide a spacing sleeve **12** whose upper, large diameter end, is sealingly fitted into the casing **2** and acts to retain the rubber-coated rings of the seal **11** in place. Member **12** surrounds the passages *g* mentioned earlier and is formed with a reduced-diameter lower portion which extends into the turbine portion of the casing in all around clearance with the latter. Thus the diameter of the body **12** changes just below the orifices *g* but above the slotted liner *j*. At its bottom end, the axle shaft **1** is provided with a system of nuts and lock nuts **13**, which are threaded onto the portion *h*, to hold the stator elements in place. The extremity *t* of the axle shaft is supported by a ball **14** loaded thereagainst by a spring **15** mounted in a cage **16** rigidly connected with the cylindrical body of the casing **2**. The assembly constituted by cage **16**, spring **15** and the ball **14** forms a damper restricting longitudinal oscillation of the shaft **1** and has a pair of adjusting nuts **17** enabling the regulation of the force of spring **15**.

As noted earlier, the openings *g* lie just above the upper turbine section but below the thrust-bearing assembly and seal (**5–11**) so that the drilling mud flows through the turbine section without coming into contact with the thrust-bearing structure. The upper end of the turbine section surrounds the large-diameter step *d* of the axle shaft **1** and has a plurality of alternating stator and rotor rings of minimum geometrical dimensions, in interfitting relationship and with the stator ring engageable with the wall of the shaft and a plurality of rotor rings in engagement with the inner wall of the casing **2**. The throughflow cross section of the upper turbine **18** is relatively small and the areas of the stator and rotor vanes (as well as their effective lengths) are minimal so that the turbine **18** is designed to drive the casing **2** at high rates but with relatively low torque.

Below the upper, high-speed turbine section **18**, we provide an intermediate turbine section **22** whose stator elements engage the intermediate-diameter portion of the shaft **1** while the rotor elements engage the liner *l*. Thus while the stator elements of the upper turbine section **18** are seated against a shoulder *u* above the larger-diameter step *d*, the rotor elements bear axially upon a shoulder *v* formed by the spacing sleeve **12**. Spacers **19** and **20** separate the stator elements of turbine section **18** from turbine section **22** and cooperate with a radial bearing **21** of the liner *l* and the cylindrical casing **2**. The radial bearing has an armature *z* lined with rubber and is formed with axially extending channels *w* through which the drilling mud passes. The stator and rotor elements **22** of the intermediate section have larger areas than the corresponding elements of the upper turbine **18** and are disposed in a turbine chamber of larger flow cross section; thus the turbine, by comparison with the turbine section **18**, produces a larger force couple and a lower rotating speed.

Another radial bearing **23** is provided between the intermediate turbine secton **22** and the lower turbine section **25**, a spacer **24** being disposed between the stator elements of the two sections at the upper part of the small-diameter step *f*. The radial bearing and spacer assembly **23, 24**, *w* are substantially identical to the corresponding parts of assembly **20, 21** and *w*, but have internal diameters and dimensions corresponding to the reduced diameter of the axle-shaft section *f*. Beneath the radial bearing **23**, the rotor and stator elements of turbine section **25** have larger effective areas and dimensions than the stator

and rotor elements of the turbines **18** and **22** and are received in an annular turbine compartment of larger cross section. Thus the turbine section **25** has a larger force couple and generates a smaller rotating speed than the turbine sections **15** and **22**. A further spacer **26** and radial bearing **27** is provided below the turbine section **25** and corresponds in dimension and shape to the spacer **24** and the radial bearing **23** described earlier. A further spacer ring **28** locks the stator elements ultimately against the shoulder *u* with a force generated by an upper nut of locking assembly **13** which is threaded onto the extension *h* of the axle shaft **1**. The lower nut of this assembly wedges the assembly tight. The nut assembly **10**, similarly, serves to clamp the axial bearings by axial forces transmitted through the spacers **9** and the ring **8** to the shoulder *y* of the shaft **1**.

As indicated earlier, the nipple **3** is threaded into the cylindrical casing **2** to apply the necessary axial force through the contact surfaces of the rotor disks **5**, the disks **7** at the shoulders *s*, the spacer **29**, the spacer **12**, the rotor elements of turbine sections **18, 22** and **25**, etc. to the shoulder *x* of the adapter *m*. The wedge *l* is driven into the wedge slot lying between a generatrix of the rotor elements of the turbine **18, 22** and **25**, thereby transmitting rotary movement to the slotted liner *j* and to the casing **2**.

The drilling mud is forced under pressure from the drill string to the upper tubular sections *b* and *c* of the stationary axle shaft **1** and is passed through the orifices *g* directly into the rotor/stator assembly of the upper high speed turbine section **18**, the intermediate speed turbine section **22** and the low speed turbine section **25**, in succession. Thereafter, the fluid passes through the orifices *w* of the radial bearing **27** to the orifices of the drill bit.

When there are high axial pressures on the drill bit, the turbine operates in the stability zone of the lower turbine section **25** at low speed, but with a considerable force couple. When the pressure is less however the speed lies in the stability zone of the intermediate turbine **22** and, when the bit is raised from the bottom of the well, the turbine rotates at the highest speed of the stability range of the upper turbine section **18**, the speed of the latter being retarded by the other turbine sections **22** and **25** to create a converter of conventional turbine constructions. When higher pressures are used, turbines **18** and **22** cooperate, although inefficiently, with the turbine **25** to drive the bit.

The converter turbine of the present invention has some important advantages by comparison with earlier systems. Firstly, it eliminates problems arising from the sealing of the turbine chambers by removing the thrust bearing and seal from the flow path of the drilling fluid. Secondly, the turbine assembly does not tend to bear against the wall of the shaft and tends to produce vertical holes.

The invention described and illustrated is believed to admit of many modifications within the ability of persons skilled in the art, all such modifications being considered within the spirit and scope of the appended claims.

We claim:

1. A turbine drive for a drill bit comprising:

an axially extending stator shaft connectable at an upper end to a drill string for delivering reaction force thereto upon operation of the drive, said shaft having a generally tubular upper portion and a lower portion and being formed with at least one orifice for discharging a motive fluid;

a rotor casing surrounding said shaft and journaled thereon while having means for connecting said casing to a drill bit;

sealing means surrounding said upper portion of said shaft at a location spaced above said orifice and connected to said casing for preventing upward escape of said fluid from said casing;

thrust-bearing means in said casing between said orifice and said location and including at least one rotatable

thrust element carried by said casing and bearing axially upon said upper portion of said shaft for transmitting axial force between said casing and said shaft; and

turbine means below said orifice for driving said rotor casing relatively to said shaft and including a plurality of turbine sections of different force-couple and rotary-speed stability ranges.

2. A turbine drive as defined in claim 1 wherein:

said shaft is provided at said lower portion with at least three axially extending steps of progressively decreasing diameter including a large-diameter step, an intermediate-diameter step and a small-diameter step;

said turbine means include a first set of stator rings mounted upon said large-diameter step and bearing axially against one another and against said shaft, and a first set of rotor rings alternating with said stator rings and bearing axially against one another and in axial force-transmitting relationship with said thrust-bearing means while engaging said casing for forming a first of said turbine sections having relatively small effective dimensions and a relatively high stable speed range with relatively low torque couple, a second set of stator rings surrounding said intermediate-diameter step of said shaft and in axial force-transmitting relationship with one another and a second set of rotor rings in axial force-transmitting relationship with one another and with said first set of rings while engaging said casing, said second sets of rings alternating with one another and defining a second of said turbine sections with an intermediate-speed stability range and an intermediate force-couple output, and a third set of stator rings surrounding said small-diameter step and in axial force-transmitting relationship with one another and a third set of rotor rings alternating with the stator

rings of said third set and in avial force-transmitting relationship with the rotor rings of said second set while being rotatably engaged with said casing, said third sets of rings defining a third of said turbine sections with a relatively low-speed stability range but high force-couple output; and

said casing is formed with a shoulder remote from said thrust bearing means and retaining said rotor rings axially against said thrust bearing means.

3. A turbine drive as defined in claim 2, further comprising:

a respective radial bearing rotatably supporting said casing on said shaft and disposed intermediate said first and said second sets of rotor rings and between said second and said third sets of rotor rings, respectively; and

thrust means at a lower end of said shaft including a cage carried by said casing and at least partly surrounding said lower end of said shaft, spring means in said cage adapted to exert an axial force, and a ball bearing upon said lower end of said shaft under the force of said spring means; and wherein said thrust-bearing means includes a plurality of thrust rings received in said casing and in axial force-transmitting relationship with one another while having inwardly extending annular rubber-coated portions in axially spaced relationship, and a plurality of thrust elements received between said rubber-coated portions and engaging said upper portion of said shaft.

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