

[54] **TURBODRILL**

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[51] Int. Cl. **F01d 15/12**

[58] Field of Search **415/122, 502**

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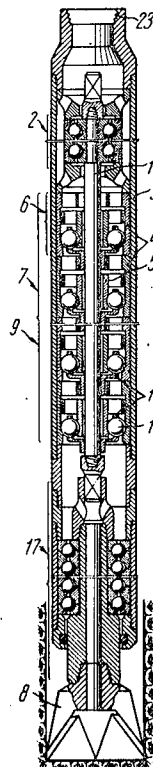
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[57] **ABSTRACT**

A turbodrill for drilling wells, provided with a mechanism for reducing the rotation speed of the bit made in the form of a friction speed reducer wherein the rotors function as the inner wheel while the turbodrill stators function as the outer wheel. The speed reducer carrier accommodates rolling elements between the stators and rotors, said elements rolling during rotor rotation under the effect of the contact forces of friction.

19 Claims, 12 Drawing Figures



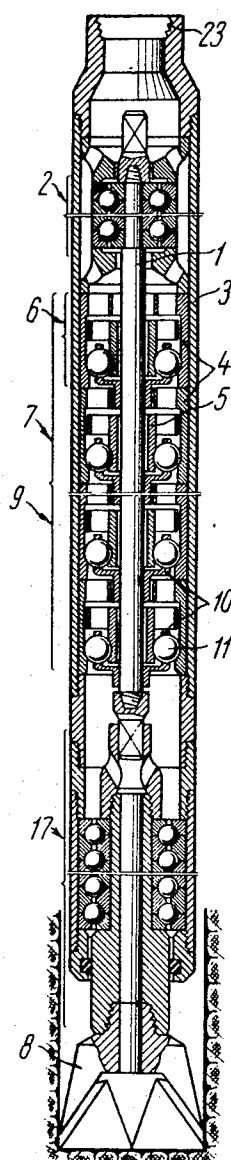


FIG. 1

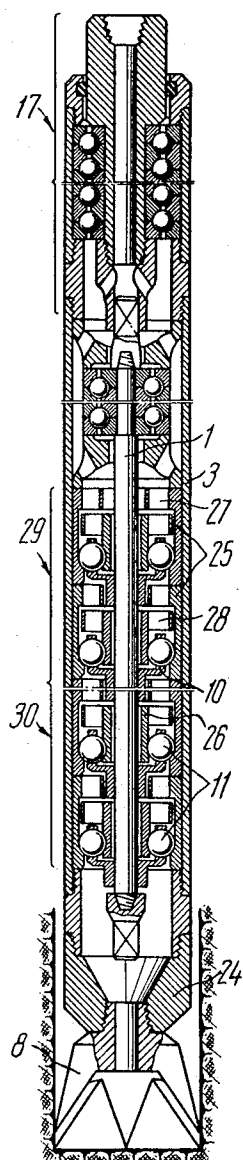


FIG. 5

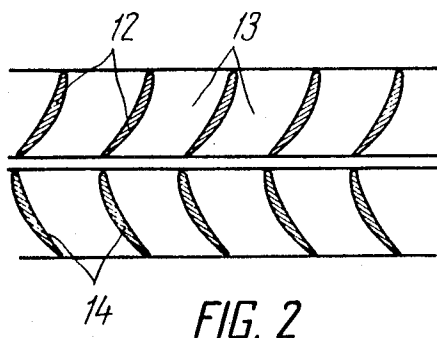


FIG. 2

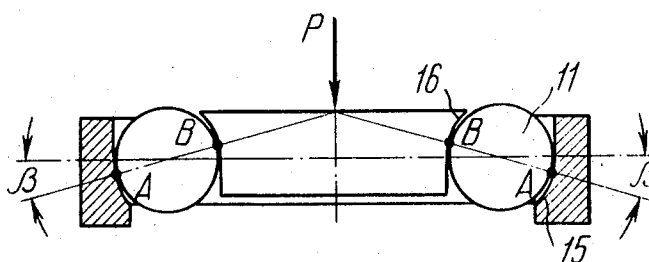


FIG. 4

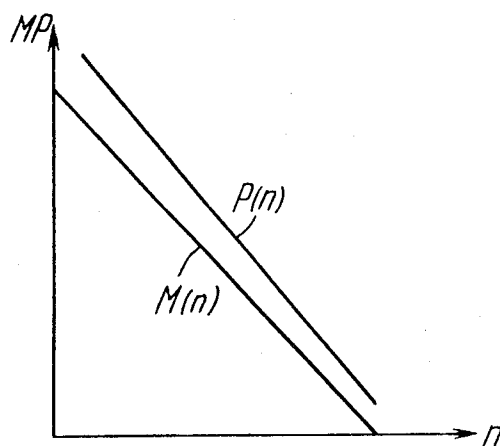


FIG. 12

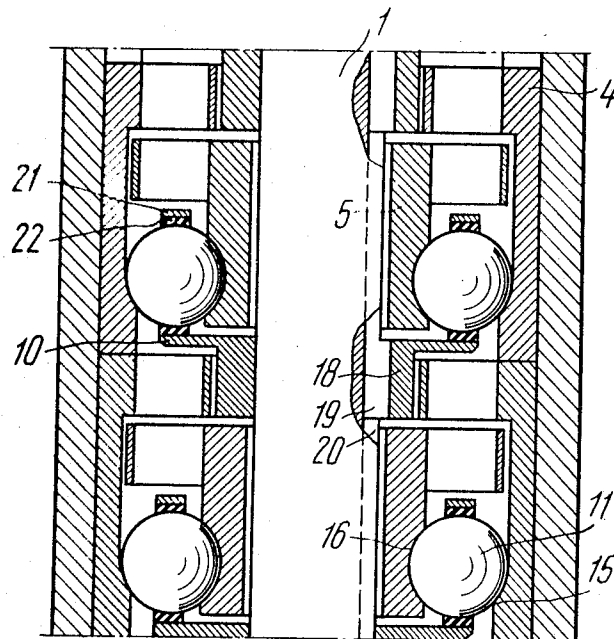


FIG. 3

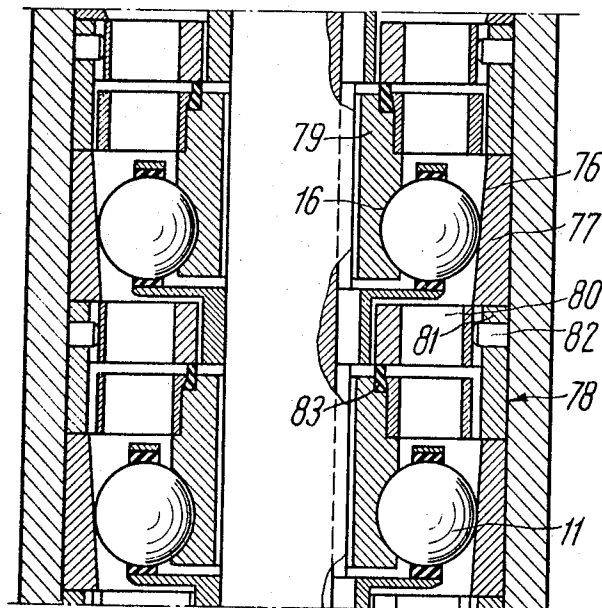


FIG. 11

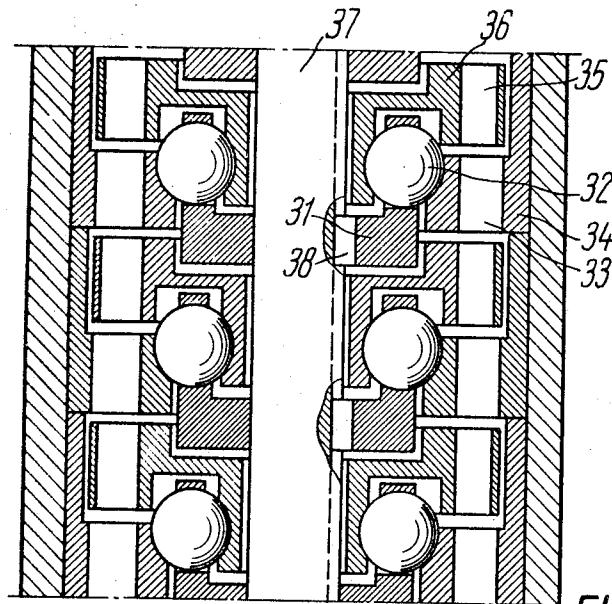


FIG. 6

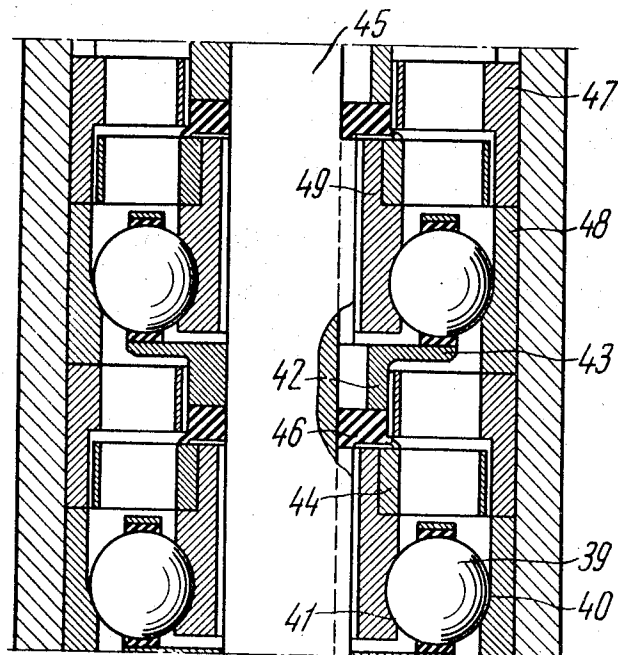


FIG. 7

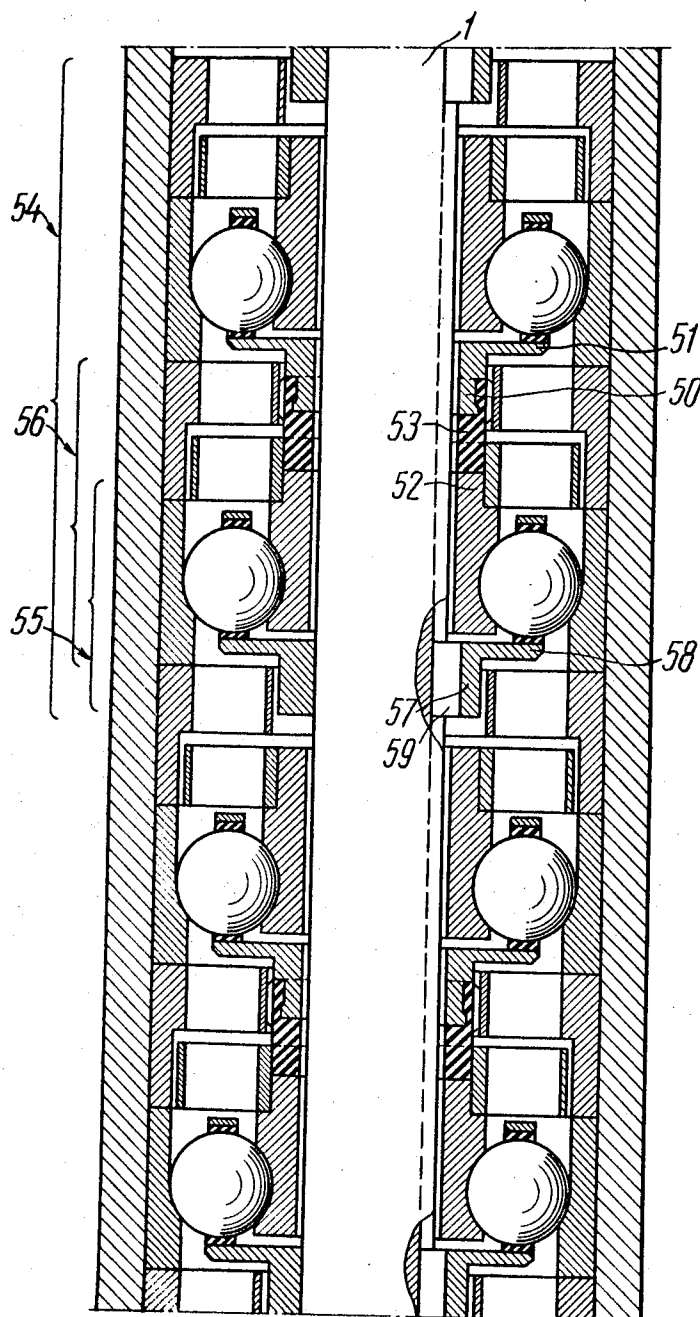


FIG. 8

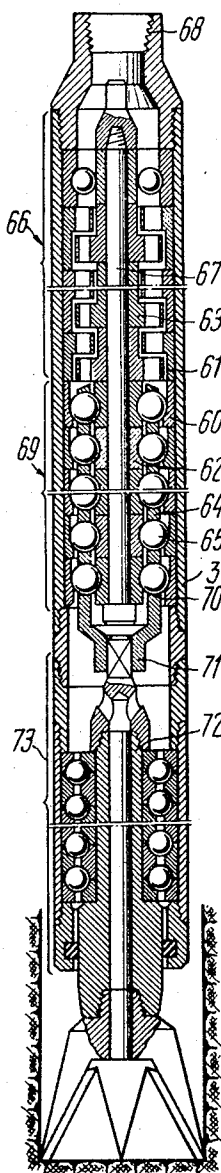


FIG. 9

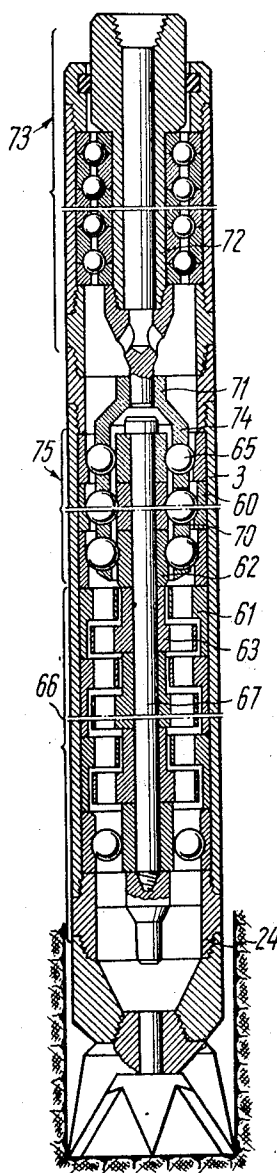


FIG. 10

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TURBODRILL

The present invention relates to hydraulic motors for drilling wells in the prospecting for or production of oil, gas and other mineral resources, and more particularly it relates to turbodrills.

Known in the art is a turbodrill for drilling wells comprising a casing with immovably-mounted stators whose vanes form passages for the flow of the flushing fluid, and rotors whose vanes are directed contrary to the stator vanes so that the rotor which, jointly with the stator, forms a turbine stage, rotates relative to the stator; in addition, the known turbodrill includes a shaft installed on a rolling-contact bearing.

During operation of this turbodrill the shaft rotates at high speeds (400 - 800 rpm), driving a rock-breaking tool, for example, a roller bit.

Operation of roller bits at high speeds reduces penetration per bit; also, taking into account the fact that the lowering and hoisting operations in deep wells take a considerable proportion of the working time, drilling at such speeds becomes impracticable.

Known in the art are designs of turbodrills wherein the bit rotation speed is reduced by a mechanical gear-type speed reducer.

In a number of designs the gear-type speed reducer is accommodated in an oil-filled space provided with an oil-protection system. The drilling motors of this type are difficult to manufacture and unreliable.

In addition there are drilling motors with exposed gear-type speed reducers, i.e. reducers operating in the flushing fluid. These motors are simpler than the oil-filled ones though the exposed gear reducer has a very short service life due to high unit loads and the effect of an abrasive medium, i.e. the flushing fluid.

An object of the present invention resides in eliminating the aforesaid disadvantages.

The main object of the invention is to provide a turbodrill of a simple design which will ensure dependable operation of rock-breaking tools at rotation speeds characteristic of rotary drilling.

There is hereby disclosed a turbodrill for drilling wells, including a casing with stators whose vanes form guide passages for the flushing fluid, and rotors whose vanes are directed contrary to the stator vanes so that the rotor which, together with the stator, forms a turbine stage and rotates relative to the stator; Also, the turbodrill of the present invention includes a shaft installed on a rolling-contact bearing and a mechanism for reducing the rotation speed of the bit. According to the invention, the mechanism for reducing the rotation speed of the bit is made in the form of a friction speed reducer whose inner wheel is constituted by said rotors while the outer wheel is formed by said stators, the rolling elements located between the stators and rotors in the carrier of the speed reducer being rolled during rotation of the rotor by the contact forces of friction. Apart from the rotor, at least one of the two turbodrill elements, i.e., the shaft or the stator, is also rotatable.

Such a solution of the problem gives a simple and compact design of turbodrill with a mechanism for reducing the rotation speed of the bit comprising, apart from the carrier with the rolling elements, the basic parts of the turbodrill, i.e., the rotor, stator and shaft.

Advantageously the turbodrill casing is connected rigidly with a nonrotatable string of drill pipes and the shaft and rotor rotate relative to each other.

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This will allow the turbodrill realized in accordance with the present invention to be used with a conventional layout of drilling tools: drill pipes, a turbodrill, a supporting unit of the turbodrill (spindle) transmitting the weight of the drill pipes on the bit, and a bit.

It is likewise preferred that the shaft be connected rigidly with the nonrotatable string of pipes and that the stator and rotor should rotate relative to each other.

This will extend the life of the speed reducer and yield a number of technical advantages, viz., an increase in the flywheel moment of the turbodrill, better cleaning of the well bottom of the drilled-out rock by eliminating the leaks of the flushing fluid from the turbodrill in the zone of the bit, and a reduction in the curving of the well while drilling steep seams.

It is preferred that each stage of the turbine comprise a carrier with rolling elements.

This will ensure uniform distribution of the load among the rolling elements and reduce their loading thus improving considerably the efficiency of the speed reducer operating in the flushing fluid.

It is practicable that the carrier with the rolling elements should be located under the rotor vanes of a turbine stage.

This will allow the carrier to accommodate the rolling elements of a maximum possible size, thus increasing the torque transmitted to the bit.

It is preferred that the carrier with the rolling elements should be located between the stator and rotor vanes, and the shaft; this will guarantee a high efficiency and reduce the length of the turbodrill.

For transmitting the torque, it is possible to provide the carrier with a hub and connect the latter with at least one of the two elements — shaft and rotor — of the below-located turbine stage.

For transmitting the torque to the shaft it is preferred that the hub of each carrier be connected to the shaft with a provision for relative axial motion of the hub and shaft; this will ensure independence of the contact forces of friction arising between the rolling elements on the one hand and the stator and rotor on the other, from the axial motions of the shaft.

It is also preferred that at least every other hub of the carrier along the turbodrill length be connected to the rotor of the below-located stage which will increase the speed ratio of the reducer.

It is preferred that the rotor and stator be provided with raceways for the rolling elements and that the raceway of the rotor be located above that of the stator so that the down-ward-directed axial force will press the rolling elements against the raceways thus producing contact forces of friction between the rolling elements and the raceways, said forces ensuring the transmission of torque to the bit this will provide the required force which presses the rolling elements against the raceways for transmitting the torque due to the axial force arising on the rotor due to the pressure differential.

It is preferred that a sealing ring be installed between the carrier hub and the rotor for increasing the force with which the rolling elements are pressed against the raceways of the rotor and stator.

It is preferred that the rotor and stator be provided with rings which serve as their extensions along the turbodrill axis and have raceways for the rolling elements.

It is also preferred that the rings of the rotor and stator as well as the carrier with the rolling elements be

located under the turbodrill turbine. This will step up the turbodrill efficiency and simplify its design.

It is also preferred that the rings of the stator and rotor with the raceways, and the carrier with the rolling elements be located above the turbodrill turbine. This will also simplify the design and increase the efficiency of the turbodrill.

It is preferred that the raceways of the rotors and stators be of a concave shape; this will prevent the rolling elements from running off the raceways and from falling out of the carrier sockets and will improve the contact between the rolling elements and the raceways.

It is also preferred that the raceways of the stator have a tapered shape; and advantage of such raceways lies in the simplicity of their manufacture and in the constancy of the contact forces of friction between the raceways and the rolling elements when the latter become worn.

It is preferred, for increasing the force with which the rolling elements are pressed against the raceways of the rotor and stator, that the latter be able to move axially relative to the turbodrill shaft.

It is preferred, for producing an optimum force of friction between the rolling elements and the raceways of the stator and rotor that their vanes have a propeller shape; such a shape of the vanes will make it possible to automatically increase the force with which the rolling elements are pressed against said raceways to suit an increase of the torque on the bit.

It is preferred that the carrier have sockets for the rolling elements, said socket being provided with removable bushings coated with an elastic material.

Due to but a slight force of friction between the rolling elements and the elastic material (rubber) in the flushing fluid, the efficiency and life of the friction speed reducers are increased while the provision of replaceable bushing simplifies the reducer repairs.

It is also preferred that the rolling elements have the shape of balls. This will ensure uniform wear of the rolling elements and rule out any troubles in the reducer kinematics in the course of turbodrill operation.

This invention has provided a turbodrill of a simple design, with reliable functioning of the rock-breaking tools at speeds which are characteristic of rotary drilling.

Now the invention will be made more apparent by way of examples and the accompanying drawings in which:

FIG. 1 is a longitudinal schematic section of the turbodrill according to the invention;

FIG. 2 is a section through the stator and rotor vanes of a turbine stage around the circumference, on a plane;

FIG. 3 is a longitudinal section of a turbodrill turbine stage with the carrier and rolling elements arranged under the rotor vanes;

FIG. 4 is a diagram showing the arrangement of the raceways in the stator and rotor rings;

FIG. 5 is a longitudinal schematic section of the turbodrill according to the invention, with a rotatable casing;

FIG. 6 is a longitudinal section of a turbodrill turbine stage wherein the carrier with rolling elements is located between the vanes of the stator and rotor, and the shaft.

FIG. 7 shows the turbine stage with a sealing ring installed between the carrier hub and the rotor;

FIG. 8 is a longitudinal schematic section through a portion of the turbodrill according to the invention, with a two-stage speed reducer;

FIG. 9 is a longitudinal schematic section of the turbodrill with a rotatable shaft wherein the carrier with the rolling elements is located under the turbodrill turbine;

FIG. 10 is a longitudinal schematic section of the turbodrill with a rotatable casing wherein the carrier with the rolling elements is located above the turbodrill turbine;

FIG. 11 is a longitudinal section of the turbodrill turbine stage with a stator capable of axial motion;

FIG. 12 is a chart showing the effect of the rotation speed of a propeller turbine on the values of torque and pressure differential.

Shown in FIG. 1 is one of the versions of the turbodrill realized in accordance with the present invention. The turbodrill comprises a shaft 1 mounted on a rolling-contact bearing 2, a casing 3 with stators 4 secured in it, rotors 5 which, together with the stators 4, form stages 6 of which the turbine 7 is made, a mechanism for reducing the rotation speed of the bit 8 made in the form of a friction speed reducer 9 which includes the stators 4 functioning as the outer wheel of the speed reducer 9, the rotors 5 functioning as the inner driving wheel of the speed reducer and of the carriers 10 located between said wheels and accommodating rolling elements in the form of balls 11.

The stators 4 are provided with vanes 12 (FIG. 2) which are inclined to the plane which is perpendicular to the turbodrill axis, and form guide passages 13 for the flow of the flushing fluid.

The vanes 14 of the rotor 5 are directed contrary to the vanes 12 of the stators 4 due to which the rotors 5 rotate relative to the stators 4 when the fluid is in motion.

The stators 4 and rotors 5 are provided with raceways 15 and 16, respectively, (FIG. 3) of a concave shape. The raceways 15 and 16 are provided for the balls 11 which are rolled by the rotating rotors 5, the raceway 16 of the rotor 5 being located higher than the raceway 15 of the stator 4. The line passing through points A and B (FIG. 4) where the ball 11 contacts the raceways 15 and 16 forms an angle β with the plane perpendicular to the turbodrill axis so that the downward-directed hydraulic axial force P shown by an arrow presses the balls 11 against the raceways 15 and 16 at points A and B which produces the contact forces of friction between the balls and the raceways of the stator and rotor, these forces transmitting the rotor torque to the bit 8 via the friction speed reducer 9.

The bit 8 is connected by means of a screw thread via the supporting unit 17 (FIG. 1) to the shaft 1 with which the carriers 10 of the speed reducer 9 are connected.

To reduce the loading of the balls 11 and to distribute this loading uniformly, the carrier 10 with the balls 11 is provided in each stage 6 of the turbine 7. The carrier 10 with the balls 11 is placed under the rotor 5 which enables the use of balls of a maximum size.

For transmitting the torque to the shaft 1, the carriers 10 of the speed reducer 9 have a hub 18 (FIG. 3). The hub 18 of each carrier 10 of the speed reducer 9 is connected to the shaft 1 by means of a key 19 with a provision for relative axial motion of the hub and the shaft. The key 19 fastened on the hub 18 enters the keyway

20 of the shaft 1. This ensures independence of the contact forces of friction between the balls 11 and the raceways from the axial motions of the shaft 1.

To reduce the intervane leaks of the flushing fluid, the hub 18 of the carrier 10 is located between the stator 4 and the shaft 1 with small radial clearances.

The balls 11 are installed in the sockets 21 of the carrier 10. To reduce the wear of the sockets 21 and balls 11, and to simplify repairs, the sockets 21 are provided with replaceable bushings 22 either coated with rubber or made of solid rubber.

The turbodrill casing 3 has a screw thread 23 on the top (FIG. 1) for connection to the nonrotatable string of drill pipes.

During operation, the rotation speed transmitted by the speed reducer 9 to the bit 8 diminishes and the torque increases by a value equal to the speed ratio of the reducer. This provides for the operation of the bit at optimum speeds, thereby stepping up substantially the efficiency of drilling.

The basic idea of the turbodrill design disclosed above can be used for other versions of the turbodrill with a speed reducer, illustrated in FIGS. 5 through 11.

Shown in FIG. 5 is one of such versions of the turbodrill, here, unlike the turbodrill shown in FIG. 1, the supporting unit 17 is connected rigidly with a nonrotatable string of drill pipes. In this case, the bit 8 is connected through an adapter 24 by means of the screw thread to the lower part of the casing 3. In this version of the turbodrill the shaft 1 and the carriers 10 of the speed reducer 9 connected to it do not rotate while the casing 3 rotates together with the stators 25 mounted on it. The stator 25 and rotor 26 rotate in opposite directions. To obtain regular (R.H.) rotation of the bit 8, the profile of the vanes 27 of the stator 25 is made similar to that of the vanes 14 of the rotor 5 (FIG. 2) while the profile of the vanes 28 of the rotor 26 is made similar to that of the vanes 12 of the stator 4. Other parts and units of the turbodrill illustrated in FIG. 5 are identical with those of the turbodrill shown in FIG. 1.

During operation of this turbodrill, part of the power produced by the turbine 29 of the turbodrill is transmitted to the bit 8 via the casing 3 directly from the stators 25 while the rest of it is transmitted to the bit via the friction speed reducer 30 and casing 3 from the rotating rotors 26.

Inasmuch as the carriers 10 of the speed reducer 30 do not rotate, the speed ratio of the speed reducer will be decreased by a unity. For example, at a speed ratio of 2, the speed reducer will transmit only two thirds of the power produced by the turbodrill turbine. The remaining part of the power, as stated above, will be transmitted to the bit directly from the stators. The total power on the bit, all other conditions being equal, will be the same as in the turbodrill illustrated in FIG. 1. The degree of reduction of the bit rotation speed and the increase in the torque on the bit will also remain unchanged since, due to the opposite direction of rotation of the stator 25, the rotor 26 will rotate with a correspondingly lower speed relative to the stationary shaft while the stator and rotor torques will be added on the casing 3 of the turbodrill. Thus, if the speed ratio of the speed reducer 26 is 2, the rotation speed will decrease and the torque on the bit will increase three times.

Due to a reduction of the relative rotation speed of the rotor, the slipping speed of the ball over the carrier

will also decrease which is quite an important factor for reducing the wear of the carriers and balls.

Apart from extending the life of the speed reducer 30, the turbodrill with a rotating casing has a number of other advantages. Thus, the flywheel moment of the turbodrill is increased, cleaning of the well bottom from the drilled-out rock is improved due to absence of leaks of the flushing fluid, and curving of the well during drilling of steep seams is also reduced. All these factors, taken together, improve the efficiency of the turbodrill with rotatable casing.

In FIG. 6 appears a version of the turbodrill wherein the carrier 31 with balls 32 is located between the vanes 33 of the stator 34, vanes 35 of the rotor 36, and the shaft 37. The carrier 31 is coupled to the shaft 37 by means of a key 38. Such a design of the turbodrill raises the efficiency of its turbine and diminishes its axial length. An increased number of the balls in each carrier 31 extends the life of the speed reducer. This version is most practicable for large-size turbodrills (7½" and over).

In FIG. 7 there is shown a turbodrill for increasing the force with which the balls 39 are pressed against the raceways 40 and 41, the shaft 45 carries a square-sectioned sealing ring 46 of an elastic material, e.g., rubber, installed between the hub 42 of the carrier 43 and the rotor 44. The sealing ring 46 is installed on the shaft with a small interference and its face contacting the rotor has radial channels for lubrication and thus decreasing the force of friction between said ring and the rotor 44. The additional hydraulic axial force transmitted to the rotor 44 is equal to the area of the sealing ring 46 times the sum of the pressure differential in the stator 47, balls 39 and carrier 43, which ensures operation of the friction speed reducer without slipping in case of vibrations originated while drilling hard rocks.

Another distinctive feature of the turbodrill illustrated in FIG. 7 lies in the fact that the raceways 40 and 41 are made in the ring 48 of the stator 47 and ring 49 of the rotor 44, said rings being extensions of said stator and rotor. The ring 48 of the stator 47 is clamped together with the stator in the casing 3 whereas the ring 49 of the rotor 44 is a stationary fit on the rotor. This offers convenience in manufacturing and repairing the turbodrill.

FIG. 8 shows another version of the turbodrill wherein the speed ratio of the speed reducer is increased by connecting the hub 50 of the carrier 51 with the rotor 52 of a lower stage 56 by a coupling 53. In this case the friction speed reducer becomes a two-stage unit wherein the second stage of the reducer 54 is constituted by a speed reducer 55 of the lower turbine stage 56. The hub 57 of the carrier 58 in the lower turbine stage 56 is connected to the shaft 1 by a key 59. The two-stage design of the speed reducer 54 makes it possible to square the speed ratio of the reducer. For example, if the speed ratio of one reducer stage is 3, the speed ratio of the two-stage reducer will be 9. Such a design of the reducer allows the bit to rotate at speeds characteristic of rotary drilling.

Shown in FIGS. 9 and 10 are two versions of the turbodrill wherein the rings 60 of the stators 61 and the rings 62 of the rotors 63 serve as their extensions, and the carrier 64 with the balls 65 are located outside of the turbine 66 of the turbodrill. Such an arrangement raises the turbodrill efficiency by decreasing the inter-

vane leaks and increasing the hydraulic efficiency of the turbine, and simplifies its design.

The turbodrill shown in FIG. 9 has a rotatable shaft 67. In such a case it is more convenient to locate the rings 60 of the stators 61 and the rings 62 of the rotors 63 as well as the carrier 64 with the balls 65 under the turbine 66 of the turbodrill. The stators 61 and the stator rings 60 are secured in the casing 3 connected by a screw thread 68 to the nonrotatable drill pipes. The rotors 63 and the rotor rings 62 are mounted on the shaft 67. The carrier 64 of the speed reducer 69 is made in the form of a pipe with holes 70 for accommodating the balls 65 and with a coupling 71 in the lower narrower part. The coupling 71 serves for connecting the carrier 64 to the shaft 73 of the supporting unit 73 which, in this case, is installed under the turbodrill, and for transmitting the torque to the bit 8.

The turbodrill of this design operates similarly to the turbodrill wherein the rotor and stator rings, and the carriers with the balls are located in each stage of the turbine (FIG. 7).

The turbodrill illustrated in FIG. 10 has a rotatable casing 3. The carrier 74 with the balls 65, the rings 60 of the stators 61 and the rings 62 of the rotors 63 are located above the turbine 66 of the turbodrill. The rings 60 of the stators 61 and the rings 62 of the rotors 63 are secured, respectively, in the casing 3 and on the shaft 67, together with the stators and rotors. The carrier 74 of the speed reducer 75 is made in the form of a pipe with holes 70 for receiving the balls 65 and with a coupling in the upper narrower part. The coupling 71 is provided for connecting the supporting unit 73 which is installed in this version above the turbodrill, via the shaft 72, to the nonrotatable string of drill pipes. The bit 8 is connected by the adapter 24 to the lower part of the casing 3.

The operating principle of this turbodrill is similar to that of the turbodrill illustrated in FIG. 5.

The uniformity of loading of the balls 65 of the speed reducers 69 and 75 in the turbodrills shown in FIGS. 9 and 10 is achieved by a high manufacturing accuracy of the rings 62 of the rotor 63, of the carriers 64 and 74 and by the subsequent working-in of these parts complete with the balls 65.

The rings 60 of the stator 61, the rings 62 of the rotor 63 and the carrier 64 with the balls 65 can also be accommodated in a separate casing.

Shown in FIG. 11 is still another version of the turbodrill; here, the raceway 76 of the ring 77 of the stator 78 is of a tapered shape which simplifies the manufacture and ensures constant contact friction forces in case of wear of the balls 11, while the raceway 76 of the rotor 79 is made concave.

A reduction in the wear of the balls is achieved in the first place by absence of their slipping over the raceways. The possibility of this slipping is reduced, in particular, by increasing the force with which said balls are pressed against the raceways. One of the methods of increasing this force is the transmission to the rotor of the axial hydraulic force arising on the stator in the course of operation. For this purpose, the stator 78 is of a built-up construction. The vanes 80 of the stator 78 are made separately from the stator hub 81 being connected with the latter by a key 82, and rest on the rotor 79 via a rubber element 83 installed on the face of the rotor 79.

However, the best solution of the problem would be such a design wherein the force applied to the rolling elements would be controlled automatically to suit the changes of torque on the bit; such a solution becomes possible if the vanes of the stator and rotor are given the shape of a propeller.

FIG. 12 is a chart showing the effect of rotation speed "A" vs torque $M(n)$ and pressure differential $P(n)$ of the propeller turbine. It can be seen on the chart that the increase of the torque in the propeller turbine is accompanied by an increased pressure differential in the turbine which will result in the growing force with which the balls are pressed against the raceways. It is obvious, that automatic changes in the ball pressing force conforming to the changes in the bit operating conditions will cut down considerably the wear of the balls and raceways.

Employment of the above-described technical solutions has led to the working out of a simple and compact design of the turbodrill with a mechanism for reducing the rotation speed of the bit the latter, being formed apart from the carriers with the balls by the basic parts of the turbodrill, viz., stator, rotor and shaft, the loads in this mechanism being ideally reduced to a minimum and uniformly distributed.

This ensures a long life and high reliability of the speed reducer functioning in the flushing fluid.

The turbodrills realized in accordance with the present invention in sizes $1\frac{1}{2}$ and $7\frac{1}{2}$ inches are successfully used for industrial drilling under diverse geological conditions.

In all the regions where this invention has been put in practice, the penetration per bit has been increased more than twice while the interrepair intervals have been increased by 50 - 80 percent as compared with conventional turbodrills.

What is claimed is:

1. A turbodrill including a top portion connected with the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion including a member for connection with a bit, comprising:
 - a casing with stators secured therein, said stators including vanes forming guide passages for passing the flushing fluid delivered from the string of drill pipes;
 - rotors in said casing having vanes directed opposite to said vanes of the stator and so arranged that said rotor and stator vanes form turbine stages wherein the progressive motion of the flushing fluid is transformed into the rotary motion of the rotors;
 - a shaft with said rotors located thereon axially installed in the casing on supports for relative rotation with respect to the casing;
 - a supporting unit for transmitting loads from the string of drill pipes to the bit;
 - carriers including bearing means installed therein;
 - means for transmitting torque from said carriers to said supporting unit;
 - said carriers with the bearing means being so arranged between said stators and rotors as to form a friction reducer with the latter whose inner driving wheel is said rotors and the outer wheel is said stators and between which said bearing means roll along during rotation of said rotors under the action of the contact friction force developed between the bearing means, stators and rotors;

the diameter of said inner driving wheel of the reducer being smaller than that of said outer wheel thereof, the speed of rotation of said member to which the bit is attached reduces with respect to the speed of rotation of said rotor; and means for pressing said bearing means to said inner and outer wheels of the friction reducer.

2. A turbodrill including a top portion connected with the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion including a member for connection with a bit, comprising:

a casing with stators secured therein, said stators including vanes forming guide passages for passing the flushing fluid delivered from the string of drill pipes;

rotors in said casing having vanes directed opposite to said vanes of the stator and so arranged that said rotor and stator vanes form turbine stages wherein the progressive motion of the flushing fluid is transformed into the rotary motion of the rotors;

a shaft with said rotors located thereon axially installed in the casing on supports for relative rotation with respect to the casing;

a supporting unit for transmitting loads from the string of drill pipes to the bit;

carriers including bearing means installed therein; means for transmitting torque from said carriers to said supporting unit;

said carriers with the bearing means being so arranged between said stators and rotors as to form a friction reducer with the latter whose inner driving wheel is said rotors, the outer wheel is said stators and between which said bearing means roll along during rotation of said rotors under the action of the contact friction force developed between the bearing means, stators, and rotors;

said rotors and stators having raceways for rolling the bearing means with the rotor raceways in an operating position located above the respective raceways of the stators due to which said bearing means are pressed to said raceways under the action of axial force directed downward and developed on the rotors due to the course of the progressive motion of the flushing fluid through said turbine stages thus resulting in formation of a contact friction force between said bearing means, stator, and rotor raceways which ensure transmission of the torque to the bit, the diameter of the rotor raceways being smaller than that of the stator raceways, the speed of rotation of said member to which the bit is attached reduces with respect to the speed of rotation of said rotors.

3. A turbodrill as claimed in claim 2 wherein the force with which said bearing means are pressed against said raceways of the rotors and stators is increased by providing the latter with a means providing axial displacement relative to said casing for increasing dependability of operation of said friction reducer.

4. A turbodrill including a top portion connected with the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion for connection with a bit, comprising:

a casing including means for connection at an upper end with the string of drill pipes;

a shaft in said casing on supports for relative rotation to the casing;

a supporting unit for transmitting loads from said string of drill pipes to the bit, said unit being located in said casing and accommodating said shaft and connecting said shaft to the bit; stators secured in said casing, said stator including vanes forming guide passages for receiving the flushing fluid delivered from said string of drill pipes;

rotors in said casing having vanes directed opposite to said vanes of the stators and so arranged that said rotor and stator vanes form turbine stages wherein the progressive motion of the flushing fluid is transformed into the rotary motion of the rotors; said rotors being axially installed on said shaft to be rotatable relative to said rotating shaft;

said rotors and stators being provided with raceways, the raceways of the rotors in the operating position being disposed above the respective raceways of the stators;

carriers with bearing means installed therein arranged in each stage of the turbine between the raceways of said stators and rotors so that said rotors thrust through said bearing means upon said stators and form with the latter and said carriers a planetary friction-reducer whose inner driving wheel is said rotors, whose outer stationary wheel is said stators, the planetary friction-reducer wheels including pinions comprising the bearing means, and the driven element of said reducer being said carriers, said carriers transmitting torque generated being provided with hubs connected to said shaft and being axially displaceable relative to the shaft, the diameter of said raceways of the rotors being smaller than that of said raceways of the stators, the speed of rotation of said carriers and the shaft connect to the bit being reduced with respect to the speed of rotation of said rotors.

5. A turbodrill as claimed in claim 4 in which said bearing means are of maximum possible diameter, said carriers with the bearing means being arranged under the vanes of the rotors of said turbine stages.

6. A turbodrill as claimed in claim 4 in which said carriers and bearing means are arranged between the vanes of said stators and rotors and said shaft for increasing efficiency and keeping the turbodrill at reduced length.

7. A turbodrill as claimed in claim 4 wherein said rotors and stators include rings which extend along the turbodrill axis, said rings being provided with raceways for said bearing means.

8. A turbodrill as claimed in claim 7 wherein said raceways of the rotors and stators have a concave shape for improving contact of said bearing means and alignment of said rotors.

9. A turbodrill as claimed in claim 7 wherein said raceways of the rotor are of concave shape, and the raceways of the stator are tapered for insuring permanent action of the contact friction force during wear of said bearing means.

10. A turbodrill as claimed in claim 7 wherein sealing rings are located between said carriers and below said rotors with rings being an extension of the rotors, said sealing rings increasing the pressure on said bearing means in said raceways.

11. A turbodrill including a top portion is connected with the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion connected to a bit, comprising:

a casing including means adapted for connection at its upper end with the string of drill pipes;
 a shaft accommodated in said casing on supports for rotation relative to the casing;
 a supporting unit for transmitting loads from said string of drill pipes to the bit;
 said unit being located under said casing and accommodating said shaft and connecting the casing with the bit;
 stators secured in said casing having vanes forming guide passages for passing the flushing fluid delivered through said string of drill pipes;
 rotors in said casing having vanes directed opposite to said vanes of the stators and so arranged that said rotor and stator vanes form turbine stages wherein progressive motion of the flushing fluid is transformed into the rotary motion of the rotors, said rotors being axially installed on said shaft for rotation rotatable relative to said rotating shaft;
 said rotors and stators including rings having an extension along the turbodrill axis and having raceways;
 carriers with bearing means installed therein and arranged in each stage of the turbine between the raceways of said rings of said stators and rotors so that said rotors thrust through said bearing means upon said stators with rings and form with the latter and said carriers a planetary friction-reducer whose inner driving wheel is said rotors with rings, the outer stationary wheel is said stators with rings, the planetary wheel pinions comprise the bearing means, and the driven element of said reducer is said carriers;
 said carriers comprising means for transmitting the torque including hubs; one part of said hubs being connected to said shaft and being axially displaced relative to the latter and the other part of said hubs to increase the transmission ratio of the reducer, at least each second hub along the length of said turbodrill being connected with the rotors of said turbine stages located therebelow, and friction reducer being multi-stage, and the majority of the hubs being connected with the next lower rotors for increasing the transmission ratio of said reducer.

12. A turbodrill including a top portion connected to the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion connected to a bit, comprising: a casing including means for connection of its lower end with the bit;
 a shaft accommodated in said casing on supports with means for permitting the casing to be rotatable relative to the shaft; a supporting unit in said casing for transmitting loads from said string of drill pipes to the bit,
 said unit being located above said casing accommodating said shaft and connecting the latter with the string of drill pipes; stators secured in said casing having vanes forming guide passages for passing the flushing fluid delivered from said string of drill pipes; rotors in the casing having vanes directed opposite to said vanes of the stators so arranged that said rotor and stator vanes form turbine stages in the casing wherein progressive motion of the flushing fluid is transformed into the rotary motion of the rotors and stators,

said rotors being axially installed on said shaft to be rotatable relative to said shaft, said shaft being fixed against rotation, said rotors and stators including rings comprising extensions along the turbodrill axis and having raceways, the raceways of the rotors being located in an operating position above the respective raceways of the stators;
 carriers with bearing means installed therein, said carriers being located in each stage of the turbine, under the vanes of the rotors and between said raceways of the rings of the rotors and stators so that said rotors, with rings thrust through said bearing means upon said stators with rings and form therewith and said carriers a friction reducer in which an inner driving wheel is said rotors with rings, the outer driven wheel is said stators with rings, the intermediate wheels are said bearing means, and the stationary element of the reducer is said carriers having hubs connected with said fixed shaft, said hubs being axially displaceable with respect to said shaft the diameter of said raceways of the rotor rings being smaller than that of the raceways of the stator rings whereby the speed of rotation of the casing coupled with the bit is reduced with respect to the speed of rotation of said rotors;
 sealing rings installed between said hubs of the carriers and said rotors and located therebelow to increase the pressure of said bearing means onto said raceways of the stators and rotors.

13. A turbodrill including a top portion connected to the lower end of a string of drill pipes for receiving a flushing fluid and a bottom portion for connection with a bit, comprising:
 a casing including means for connection at its lower end with the bit;
 a shaft accommodated in said casing on supports including means permitting the casing to be rotatable relative to the shaft; a supporting unit transmitting loads from said string of drill pipes to the bit,
 said unit being located above said casing and accommodating said shaft and connecting the latter with the string of drill pipes;
 stators secured in said casings having vanes forming guide passages for passing the flushing fluid delivered through said string of drill pipes;
 rotors in the casing having vanes directed opposite to said vanes of the stators so arranged that said rotor and stator vanes form turbine stages wherein progressive motion of the flushing fluid is transformed into the rotary motion of the rotors and stators, said rotors being axially installed on said shaft and rotatable relative to said shaft, said shaft being fixed relative to said casing,
 said rotors and stators having raceways of which the raceways of the rotors are located in an operative position above the respective raceways of the stators; carriers with bearing means installed therein, said carriers being located in each stage of the turbine between said vanes of the rotors and stators and said shaft in such a manner so that said rotors apply thrust through said bearing means onto said stators and form with them and said carriers a friction reducer having an inner driving wheel comprising said rotors, an outer driven wheel comprising said stators, intermediate wheels comprising said bearing means, and a stationary element of the

reducer comprising said carriers having hubs connected with said rotatable shaft and being axially displaceable with respect to said shaft;

the diameter of said raceways of the rotors being smaller than that of the raceways of the stator and the speed of rotation of the casing, coupled with the bit, reduces with respect to the speed of rotation of said rotors.

14. A turbodrill including a top portion connected to the lower end of the string of drill pipes for receiving a flushing fluid and bottom portion connected to a bit, comprising:

a casing including means for connection at its lower end with the bit;

a shaft accommodated in said casing on supports including means for permitting said casing to be rotatable relative to said shaft;

a supporting unit transmitting loads from said string of drill pipes to the bit,

said unit including means above said casing and accommodating said shaft and connecting the latter with the string of drill pipes;

stators secured in said casing having vanes forming guide passages for passing the flushing fluid from said string of drill pipes;

rotors in the casing having vanes directed opposite to said vanes of the stators and so arranged that said rotor and stator vanes form turbine stages wherein progressive motion of the flushing fluid is transformed into the rotary motion of the rotors and stators, said rotors being axially installed on said shaft to be rotatable relative to said shaft;

said rotors and stators including rings comprising an extension along the turbodrill axis and have raceways, the raceways of the rotors being located in an operating position above the respective raceways of the stators;

carriers with bearing means installed therein, said carriers with said bearing means being located in each stage of the turbine under said vanes of the rotors and between said raceways of the rings of the rotors and stators so that said rotors with rings apply thrust through said bearing means onto said stators with rings and form with them and said carriers a friction in which an inner driving wheel is said rotors with rings, an outer driven wheel is said stators with rings, intermediate wheels are said bearing means, and a stationary element of the reducer is said carriers, said carriers are provided with hubs for transmitting torque, one part of said hubs being connected to said shaft and being axially displaceable relative to the latter and the other part of said hubs to increase the transmission ratio of the reducer, at least each second hub along the length of said turbodrill being connected with the rotors of said turbine stages located below, and forming, as a result, a friction reducer which is multi-stage, and the majority of the hubs are connected with the next lower rotors for increasing the transmission ratio of said reducer.

15. A turbodrill including a top portion connected to the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion for connection with a bit, comprising:

a casing including means for connection at its upper end with the string of drill pipes;

a shaft accommodated in said casing on supports for relative rotation to the casing;

a supporting unit for transmitting loads from said string of drill pipes to the bit,

said unit being located under said casing, accommodating said shaft and including means for connection to the bit;

stators secured in said casing having vanes forming guide passages for passing the flushing fluid delivered through said string of drill pipes;

rotors in said casing having vanes directed opposite to said vanes of the stators and so arranged that said rotor and stator vanes form turbine stages wherein the progressive motion of the flushing fluid is transformed into the rotary motion of the rotors, said rotors and stators including rings having extension along the turbodrill axis and having raceways, said rotors and rings

extending axially and secured on said shaft; carriers with bearing means arranged between said raceways of the rings of said rotors and stators so that said rotors and its rings apply thrust through said bearings means upon said stators and its rings and form therewith and with said carriers a planetary friction-reducer whose inner driving wheel comprises said rotors with rings, outer stationary wheel comprises said stators with rings, planetary wheels (pinions) comprise the bearing means, and the driven element of said reducer comprises said carriers, said rings with raceways of the rotors and stators and said carrier with the bearing means being located under said stages of the turbine,

said carrier having in the lower portion thereof a coupling for connection to said supporting unit and transmitting torque to the bit.

16. A turbodrill having a top portion connected to the lower end of the string of drill pipes for receiving a flushing fluid and a bottom portion connected with the bit, comprising:

a casing including means for connection at its lower end with the bit;

a shaft accommodated in said casing on supports including means permitting said casing to be rotatable relative to said shaft; a supporting unit transmitting loads from said string of drill pipes to the bit,

said unit including a portion located above said casing accommodating said shaft and being connected with the lower end of the string of drill pipes;

stators secured in said casing having vanes forming guide passages for passing the flushing fluid through said string of drill pipes;

rotors in said casing having vanes directed opposite to said vanes of said stators and so arranged that said rotor and stator vanes form turbine stages wherein the progressive motion of the flushing fluid is transformed into the rotary motion of the rotors and stators,

said rotors and stators being provided with rings which are extensions along the turbodrill axis and have raceways in which the raceways of the rotor are located above the respective raceways of the stators,

said rotors with their rings being axially installed in said casing and are secured on said shaft;

carriers with bearing means installed therein arranged between said raceways of the rings of said

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rotors and stators so that said rotors with rings
apply thrust through said bearing means upon said
stators with ring and form therewith and said carri-
ers a friction-reducer in which the inner driving
wheel comprises said rotors with rings, the outer
driven wheel comprises said stators with rings in-
termediate wheels comprise said bearing means,
and a stationary element of the reducer comprises
said carriers,
said rings with raceways of the rotors and stators and
said carriers with the bearing means being located
above said stages of the turbine,
said carrier having in the upper portion thereof a
coupling for connection to the lower portion of
said supporting unit for transmission of reactive
torque to the string of drill pipes.

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17. A turbodrill as claimed in claim 1 wherein said
vanes of the rotor and stator of the turbine stage have
a propeller shape which ensures an optimum force of
friction between said bearing means and the raceways
of the stator and rotor for increasing turbodrill operat-
ing dependability.
18. A turbodrill as claimed in claim 1 wherein said
carrier has sockets with replaceable bushings coated
with an elastic material for receiving said bearing
means to reduce the wear of said bushings and bearing
means and facilitate maintenance.
19. A turbodrill as claimed in claim 1 wherein said
bearing means comprise balls to increase dependability
of the turbodrill operation.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,754,835 Dated August 28, 1973

Inventor(s) Evgeny Illarionovich Ivanov et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

It is certified that error appears in the above-identified patent and said letters patent is hereby corrected as shown below:

Column 11, line 8, cancel "casing" insert -- latter --.

Column 12, line 2, insert -- non- -- before "rotatable".

Signed and sealed this 12th day of March 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents