July 23, 1957 A. M. HATCH ET AL 2,800,296

TURBINE

Filed Oct. 14, 1954 4 Sheets-Sheet 1

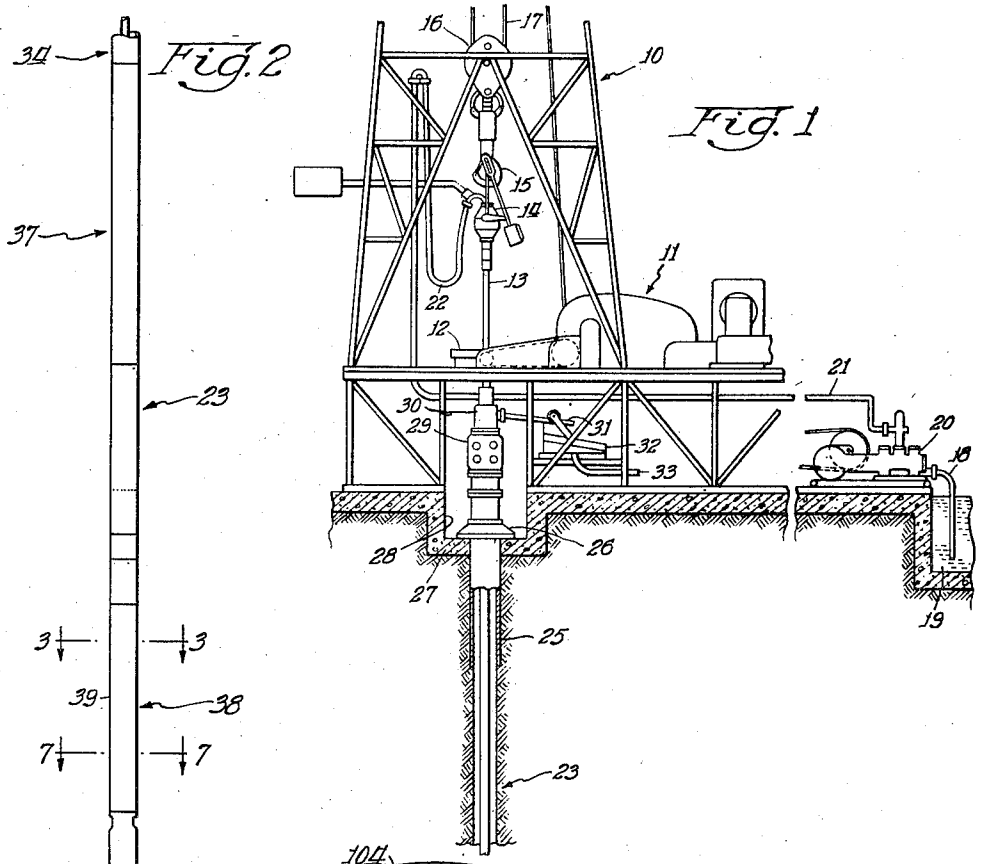


Fig. 1

Fig. 2

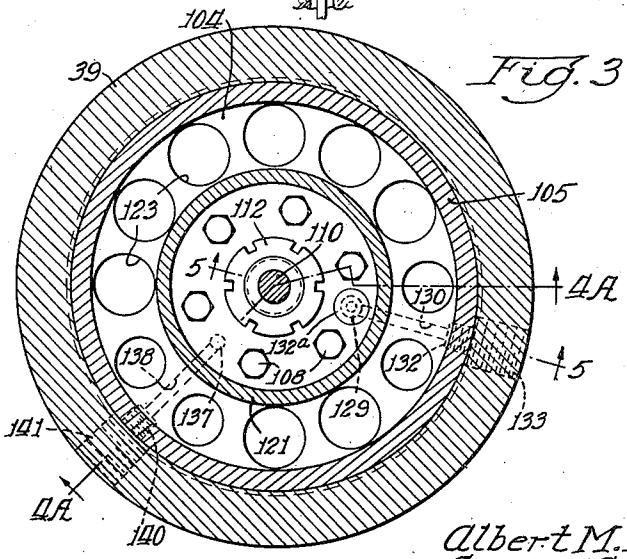


Fig. 3

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TURBINE

Filed Oct. 14, 1954 4 Sheets-Sheet 2

Fig. 4A

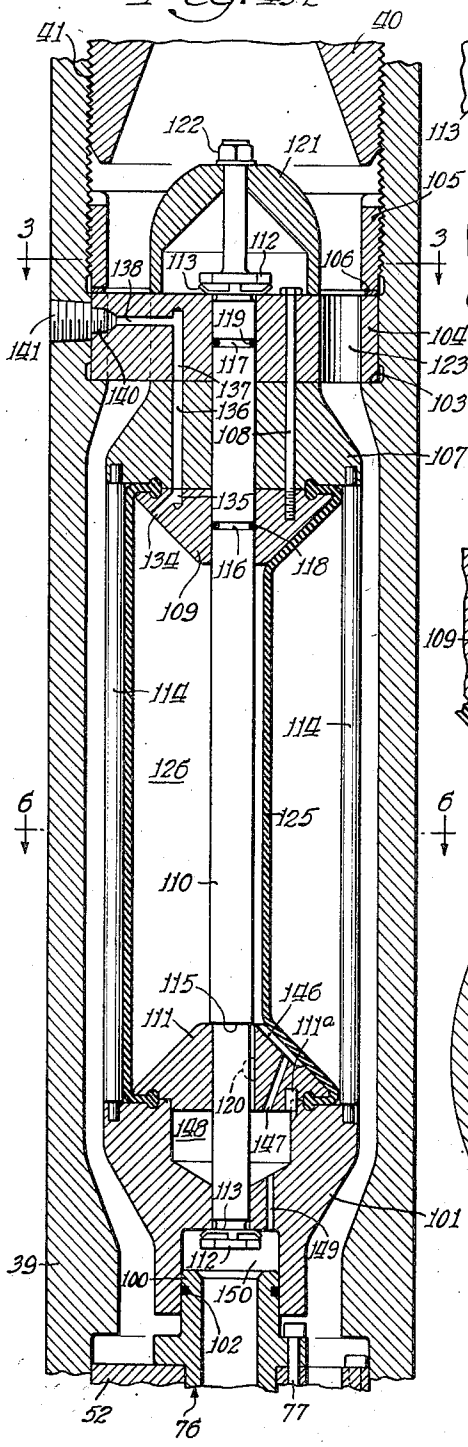


Fig. 5

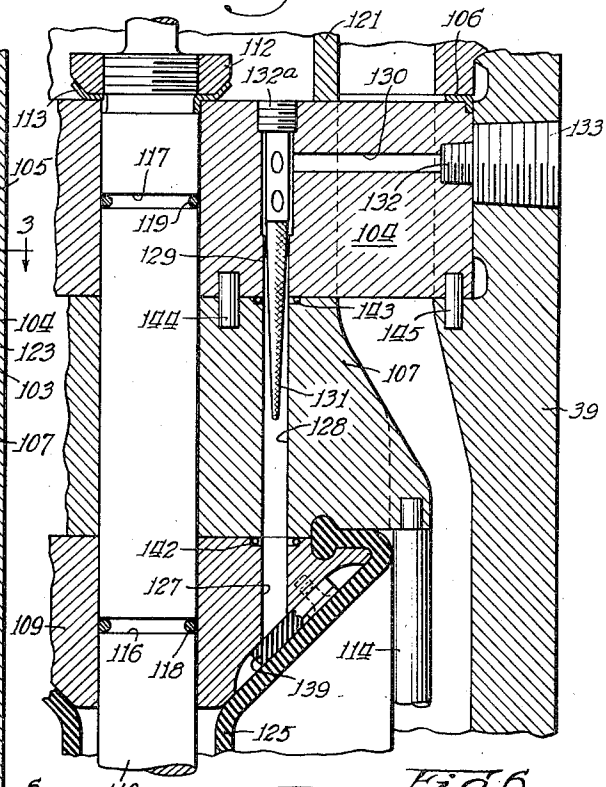
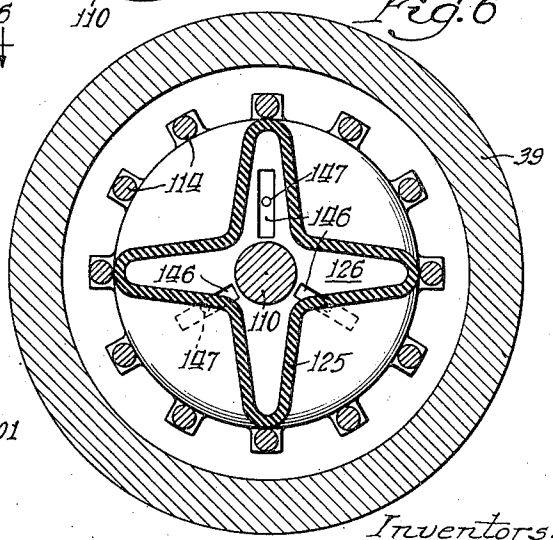


Fig. 6



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July 23, 1957 A. M. HATCH ET AL 2,800,296

TURBINE

Filed Oct. 14, 1954 4 Sheets-Sheet 3

Fig. 4B

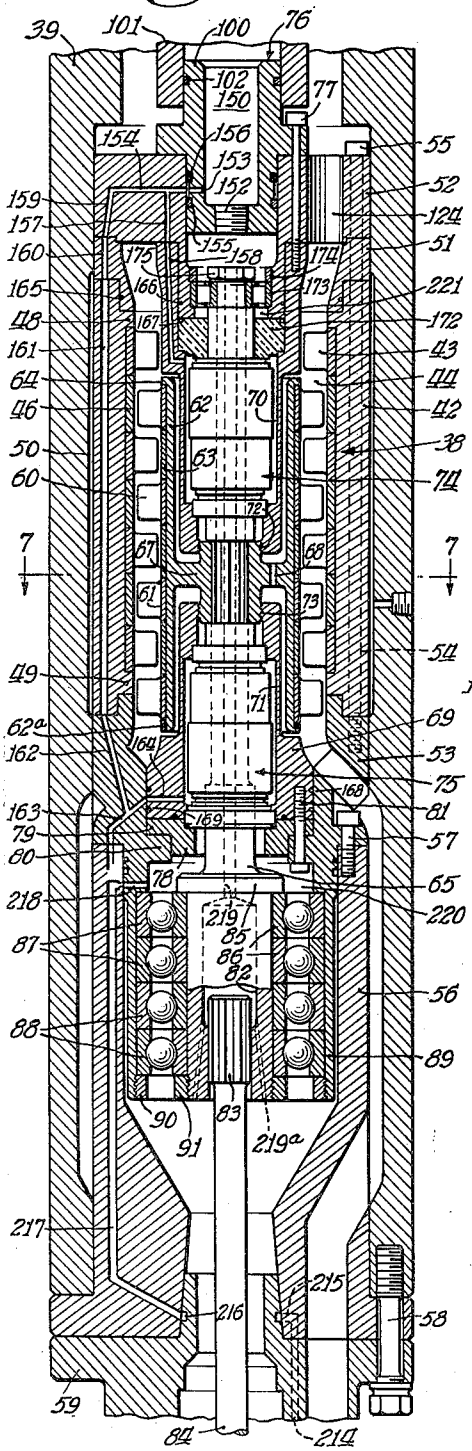
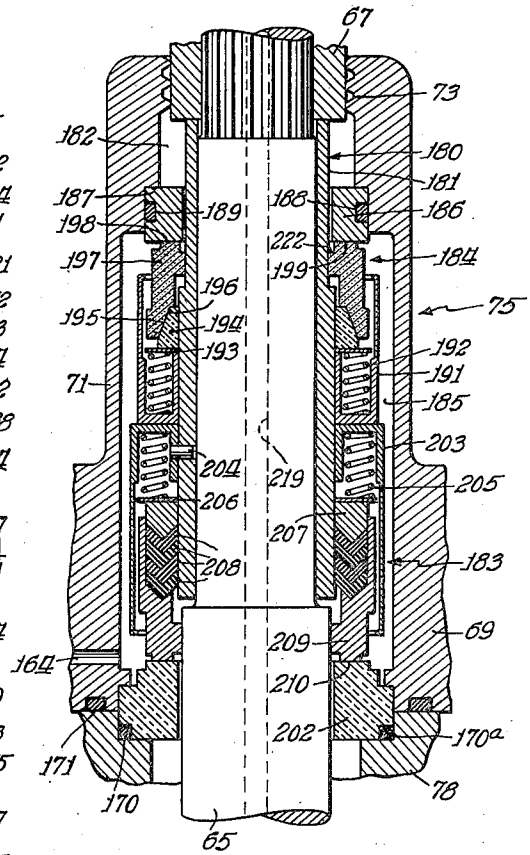


Fig. 10



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July 23, 1957 A. M. HATCH ET AL 2,800,296

TURBINE

Filed Oct. 14, 1954 4 Sheets-Sheet 4

Fig. 7

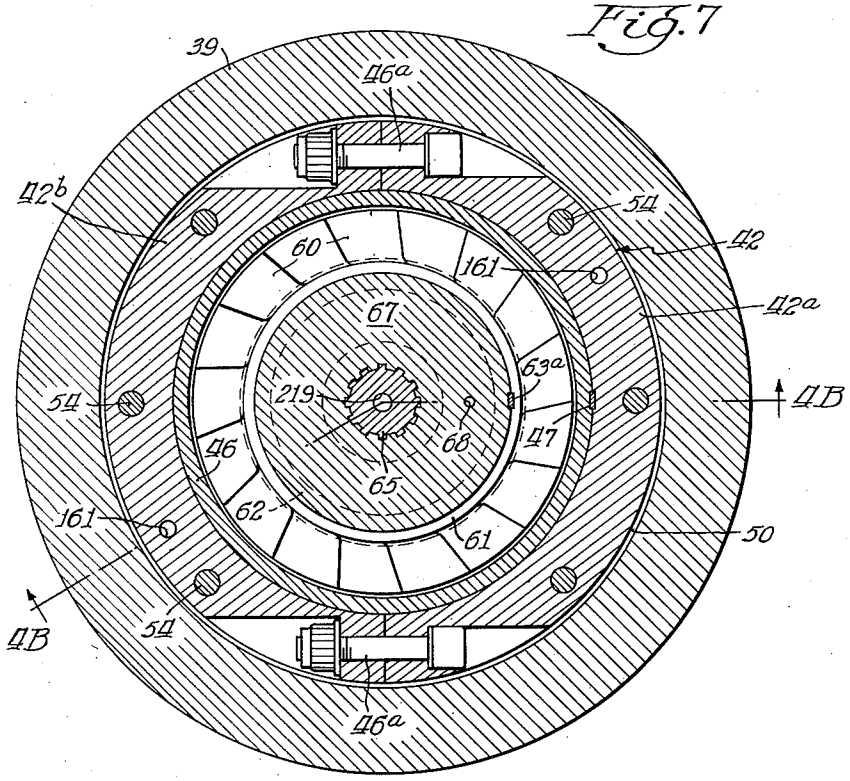


Fig. 8

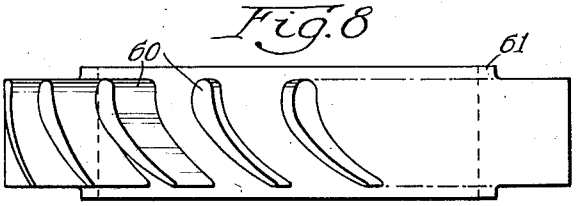
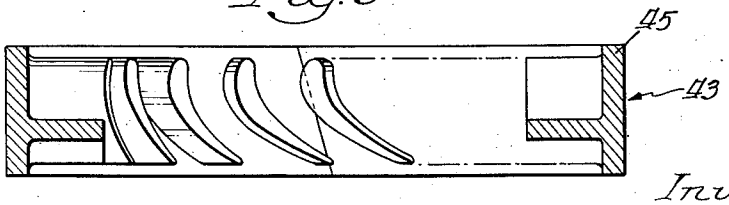


Fig. 9



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United States Patent Office 2,800,296 Patented July 23, 1957

2,800,296

TURBINE

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Application October 14, 1954, Serial No. 462,158

8 Claims. (Cl. 253—32)

The present invention relates to turbines and is more particularly concerned with turbines adapted to be used in an oil well drill string for actuating a vibratory drill rod of the type disclosed in Bodine Patent No. 2,554,005, wherein the power for actuating the turbine is derived from mud fluid pumped down through the oil well drill pipe string.

It is therefore a principal object of the present invention to provide an improved turbine capable of being driven by an abrasive fluid such as the mud fluid which is used in conventional oil well drilling operations.

A more specific object of the present invention is to provide a mud fluid actuated turbine of the above-mentioned general type which includes means for by-passing a portion of the mud fluid around the turbine elements so as to facilitate cooling of the elements of the turbine and thereby dissipate heat generated by friction between different turbine elements.

A further object of the present invention is to provide a suitable sealing device for a mud fluid actuated turbine of the foregoing general type which sealing means is capable of sealing out the abrasive mud fluid from the turbine driven shaft and the associated mechanism driven thereby. In this connection, it is contemplated that a suitable fluid lubricant will be disposed within a chamber located upstream from the turbine in such a manner that the pressure of the fluid lubricant will be maintained at the pressure of the mud fluid at the point of its entry into the turbine. Communication between the mud fluid and the driven turbine shaft only occurs at a point below at least one stage of turbine blades and inasmuch as there is a pressure drop across each stage of turbine blades, the relatively higher pressure of the fluid lubricant is capable of insuring that any leakage across the sealing means around the shaft occurs in the direction of the mud fluid so that the mud fluid is kept away from the turbine driven shaft and out of the chamber within which the shaft is enclosed.

It is also necessary that the aforementioned sealing means for keeping the mud fluid out of the turbine driven shaft chamber be effective to maintain a very low pressure within the chamber (the pressure of the mud fluid being of the order of several thousand p. s. i. and the pressure in the turbine chamber being of the order of one or two atmospheres) and in this connection, the high pressure fluid lubricant is disposed on one side of the sealing means whereas the very low pressure is on the other side of the sealing means so that if there is any leakage it is in the direction from the lubricant into the low pressure chamber. The slight leakage of fluid lubricant into the low pressure chamber is not undesirable as the exact pressure within this chamber as well as the occurrence of lubricant therein is not critical.

Inasmuch as the aforementioned sealing means comprises relatively movable parts, there is considerable heat generated by friction between the relatively moving seal parts and by turbulence of the fluid lubricant in the seal spaces. The aforementioned means for by-passing a portion of the mud fluid around the turbine elements is effective to dissipate this heat.

The foregoing and numerous other objects and advantages of the present invention will become apparent from the following description when read in conjunction with the accompany drawings, wherein:

Fig. 1 is a view showing an example of conventional oil well drilling apparatus adapted to maintain a drill pipe string suspended within an earth bore hole;

Fig. 2 is a view of a section of drill pipe string having an earth boring bit attached thereto and adapted to be suspended in an earth bore hole by the apparatus disclosed in Fig. 1;

Fig. 3 is a sectional view taken substantially along the line 3—3 in Fig. 2 and showing certain of the detailed components of the fluid lubricant chamber used in connection with the turbine disclosed herein;

Figs. 4A and 4B comprise sectional views taken substantially along the line 4A in Fig. 3 and disclose the principal features of the present invention;

Fig. 5 comprises an enlarged fragmentary sectional view showing a portion of the fluid lubricant chamber;

Fig. 6 comprises a sectional view of the fluid lubricant chamber taken substantailly along the line 6—6 in Fig. 4A;

Fig. 7 comprises a sectional view taken substantially along the line 7—7 in Fig. 4B or Fig. 2;

Fig. 8 is a detailed view of the one stage of the turbine rotor blades;

Fig. 9 is a detailed view, partly in section, showing one stage of the turbine stator blades; and

Fig. 10 is an enlarged fragmentary view illustrating the principal features of the sealing devices utilized in the present invention for sealing out the mud fluid from the turbine driven shaft and chamber for housing the elements associated with said turbine driven shaft.

In earth bore drilling apparatus of the type disclosed in the aforementioned Bodine Patent No. 2,554,005, it is necessary that the driving turbine be capable of withstanding extreme shock loads and excessive vibrations impressed thereon by the massive vibratory drill rod which is utilized for actuating the drilling bit. It has been found that a turbine constructed in accordance with the principles disclosed herein meets the requirements for a turbine utilized for actuating a drill rod of the type shown in said Bodine patent.

Referring specifically to the drawings, wherein like reference numerals in the different views identify identical parts, the turbine is disclosed in conjunction with a massive drill rod such as is disclosed in the Bodine patent, which drill rod is adapted to be suspended at the lower end of a drill pipe string positioned in an earth bore hole and supported by mechanism similar to that disclosed in Fig. 1 of the drawings. This supporting mechanism is conventional in oil well drill operations and includes a derrick 10, draw works 11, driving rotary table 12, kelly 13 extending through table 12, swivel 14 coupled to the upper end of a fluid passage through kelly 13 and hook 15 supporting the bail of swivel 14. The hook 15 is suspended through a travelling block 16 and cable 17 from the top of the derrick 10 and the cable 17 is wound on the usual hoisting drum of the draw works 11. Mud fluid, such as is conventionally employed in oil well drilling operations, is pumped from a supply tank or sump 19 and is delivered under pressure by pumps 20 through a pipe 21 and hose 22 to the gooseneck of swivel 14, and from this point the mud fluid flows down through the kelly 13 and into and through a drill pipe string 23 coupled to the lower end of the kelly 13.

The kelly 13 and drill pipe string 23 extend into a bore

hole 24 which extends downwardly into the earth. The bore hole 24 is lined or cased for a suitable distance down from the ground surface by surface casing 25 which is supported by a landing flange 26 resting on a concrete footing 27 in the bottom of a pit 28. A blow-out preventer 29 is mounted at the head of the casing 25 and a riser 30 above the blow-out preventer 29 is provided with a mud flow line or delivery pipe 31. The mud flow line 31 is shown as discharging onto a conventional vibratory mud screen 32, and the mud is led from the latter back to the sump 19 by means of a pipe line 33.

The drill pipe string 23 coupled at the lower end of kelly 13 comprises a conventional drill pipe string made up of a number of drill pipe lengths 34 which may be coupled together by the usual tool joints. A longitudinally vibratory drill rod 35, as disclosed in the aforesaid Bodine patent, is disposed at the lower end of the drill pipe string 23 and has a bit 36 fastened at the bottom thereof for penetrating the earth formation at the bottom of the earth bore 24. The drill rod 35 is connected to the lower end of the suspending drill pipe string 23 and is isolated theerfrom by means of suitable isolating apparatus, such as is disclosed in the copending patent application of H. V. D. Stewart et al., Ser. No. 417,117, filed March 18, 1954. This isolating device is identified herein by reference numeral 37 and will not be described in further detail in the present application.

In order to provide the motivating force for vibrating the drill rod 35, a suitable oscillator mechanism of the general type disclosed in the aforementioned Bodine patent is adapted to be actuated by means of a turbine represented generally by reference numeral 38 in Fig. 2 of the drawings. This turbine comprises the subject matter of the present invention and will now be described in detail.

The turbine 38 is housed within an enclosing section of the drill pipe string 39 which is suitably cut away for facilitating the passage of mud fluid therethrough and for mounting the turbine 38 therein. The drill pipe section or sub 39 is connected with a sub or drill pipe section 40 immediately above the sub 39 by means of a suitable threaded joint 41.

The drill pipe section 39 comprises an outer sleeve for housing the turbine 38 and is provided with an inner turbine stator mounting sleeve 42 for mounting a plurality of stages of turbine stator blades 43 within a suitable turbine chamber 44. Each stage of turbine stator blades 43 comprises a plurality of blades (see Fig. 9) formed on an annular collar 45 which is adapted to fit snugly within the inner periphery of the sleeve 42. Disposed between each adjacent pair of annular collars 45 is a spacer collar 46 for providing the proper spacing between the successive stages of stator blades 43 within the sleeve 42. The sleeve 42 is formed in two sections 42*a* and 42*b* (see Fig. 8), each of these sections being secured together by means of a plurality of bolts 46*a*. Each of the stages of stator blades 43 and the spacer rings or collars 46 are suitably keyed within the sleeve 42 by means of a key 47 which serves to lock the stator blades in a fixed position within the sleeve 42. It will be noted that each of the sleeve sections 42*a* and 42*b* is provided with an upper and a lower flange respectively designated by reference numerals 48 and 49 for rigidly securing the stages of stator blades 43 within the sleeve 42 against longitudinal movement.

In order to facilitate assembly of the sleeve 42 within the outer sleeve 39, the outer sleeve is cut away on its inner periphery as indicated at 50 and this space is filled with a heavy grease which serves to lubricate the various parts of the turbine as they are being inserted into the sleeve 39.

Disposed immediately above the sleeve 42 is an annular member 51 with a second annular member 52 being disposed immediately above the member 51. Immediately beneath the sleeve 42 is a third annular member 53. The three annular members 51, 52 and 53, together with the sleeve 42, are suitably drilled longitudinally in order to receive a plurality of connecting rods 54. The connecting rods 54, it will be noted, are threaded at their lower ends and are adapted to be received by suitable mating threaded areas in the openings formed in the annular member 53. When the rods are turned tightly to bring their heads 55 against the upper surface of the annular member 52, the three annular members 51, 52 and 53 and the sleeve 42 are held together as a unit.

The annular member 53 is suitably fastened to an annular member 56 disposed immediately beneath the member 53 by means of a plurality of screws 57 and, as is clear from Fig. 4B, the member 56 is fixed to the sleeve 39 by means of a plurality of bolts 58 which also connect a sub 59, disposed immediately beneath sub 39, to the sub 39. It will thus be seen that the turbine sleeve 42 is rigidly secured to the outer sleeve 39 at a point below the turbine 38.

The turbine 38 also includes a plurality of stages of rotor blades 60 which are respectively secured to suitable collars 61 mounted concentrically around a supporting rotor sleeve 62. Disposed between adjacent collars 61 are suitable spacer collars or rings 63 which serve to maintain the different stages of rotor blades 60 in the proper longitudinal position. A key 63*a* seated within suitable grooves formed on the outer periphery of the sleeve 62 and on the inner peripheries of the collars 61 and 63 secures the rotor blades 60 to the sleeve 62 against relative rotary movement. It will be noted that the spacers 63 and the spacers 46 respectively maintain the proper longitudinal positioning of the rotor blades 60 and stator blades 43 so that within the turbine chamber 44 the successive stages of stator blades and rotor blades are alternately arranged. The supporting rotor sleeve 62 is provided with a radially outwardly projecting flange 64 at its upper end against which the upper collar 61 abuts, and at the lower end of the sleeve 62 a nut 62*a* is threaded thereon for holding all of the stages of rotor blades 60 and the different spacers 63 fixed longitudinally within the sleeve 62.

The rotor supporting sleeve 62 is suitably mounted on a turbine driven shaft 65 by means of a collar 67 integrally formed on the sleeve 62 and splined on the shaft 65 as is clearly shown in Fig. 8. The collar 67 is provided with a single aperture 68 for permitting a portion of the mud fluid to be by-passed around the turbine 38 so as to cool the turbine parts and thus dissipate heat generated in the turbine parts due to friction between the relatively movable turbine parts.

In order to form the inner periphery of the turbine chamber 44, the annular member 51 and an annular member 69 are respectively provided with longitudinally extending annular flanges 70 and 71.

The annular flanges 70 and 71 are provided with internal serrations 72 and 73 adapted to fit loosely around the mounting collar 67 for the turbine rotor sleeve 62 and these flanges serve to hold a quantity of grease within the flanges which tends to prevent mud fluid from entering the space within the flanges during assembly of the turbine and initial operation thereof. The space within the longitudinally extending flanges 70 and 71 serves to receive suitable sealing devices 74 and 75. Only the sealing device 75 is shown in detail in Fig. 10, the sealing device 74 being a mirror image of the sealing device 75 and therefore it not being deemed necessary to describe the sealing device 74 in detail.

In order to rigidly mount the annular member 51 together with its projecting flange 70, with respect to the other elements of the turbine, a plurality of suitable aligned apertures are formed in the annular member 51, annular member 52 and in an annular member 76 for receiving a plurality of connecting bolts 77. A locking ring 78 fits concentrically within member 53 and is provided with a shoulder 79 adapted to rest on an inwardly

projecting shoulder 80 formed on member 53. A plurality of suitably aligned apertures are formed in the shoulders 80 and 79, in members 53 and 78 respectively, and in member 69, and a plurality of bolts 81 extend through these apertures for connecting the members together. It is thus apparent that the longitudinally extending flanges 70 and 71 which form the inner periphery of the turbine chamber 44 are also rigidly connected with the other stationary elements of the turbine 38.

The turbine driven shaft 65 is enlarged at its lower end and hollowed out, as indicated at 82. The inner periphery of the hollowed portion 82 of the shaft 65 is splined for receiving complementary external splines 83 formed on the upper end of a shaft 84 which leads to the oscillator mechanism mentioned briefly heretofore. The shaft 65 is provided with a radially outwardly projecting flange or shoulder 85 adapted to rest on the upper end of the inner race 86 of the upper one of a plurality of thrust bearings 87. The outer race 88 of each of the thrust bearings 87 is mounted within a longitudinally extending flange 89 formed at the lower end of the annular member 53 and an internal nut 90 is provided for holding the external races 88 of the thrust bearings 87 rigid with respect to the annular member 53. The hollowed portion 82 of the shaft 65 is threaded at its lower end on the external periphery for receiving an external nut 91 which serves to fix the internal races 86 of the thrust bearings 87 to the hollowed portion 82 of the shaft 65.

The means for maintaining a high pressure fluid lubricant for effecting a seal between the mud fluid and the chamber for housing the thrust bearings 87 and the mechanism associated with the driven turbine elements will now be described.

The annular member 76 is provided with an upper longitudinally extending annular flange 100 around which an annular member 101 is mounted. A suitable peripheral groove is formed around the flange 100 for receiving an O-ring 102 so as to seal the flange 100 with respect to the member 101. The sleeve 39 is formed at its upper end with an internal shoulder 103 and a ring or disc 104 is seated on the shoulder 103. In order to hold the disc 104 in place, an internal nut 105 is provided for cooperating with suitable internal threads formed at the upper end of sleeve 39 and when the nut 105 is turned down against a sealing ring 106 the disc 104 is rigidly secured to the sleeve 39. Mounted immediately beneath the disc 104 is an annular member 107 which is fastened to the disc 104 by means of a plurality of connecting bolts 108 which extend through suitable apertures in the disc 104 and member 107 and are threaded into an annular cone-shaped member 109. Thus the connecting bolts 108 serve to hold the disc 104, annular member 107 and cone-shaped member 109 together as a unit. A connecting rod 110 extends through a central opening formed in the disc 104 and in each of the annular members 107 and 109 as well as through a central opening in a cone-shaped member 111 and through a central opening formed in the member 101. A plurality of compression rods 114 are disposed around the peripheries of the members 107 and 101. The connecting rod 110 is threaded at each end and when external nuts 112 are turned down against sealing rings 113 the annular members 101 and 107 are forced toward each other so that the compression rods 114 form a cage. It will be noted that the connecting rod 110 is provided with a downward facing shoulder 115 which abuts the upper face of the member 111 so as to hold the member 111 against the member 101. The connecting rod 110 is also provided with annular grooves 116 and 117 for receiving O-rings 118 and 119 respectively so as to seal the rod with respect to the members 109 and 104. A suitable key 120 is provided for keying the member 111 to the rod 110. The upper end of the rod 110 is provided with an extension which extends through a central opening formed in a dome-shaped member 121 disposed on the top face of the disc 104. A suitable nut 122 is adapted to be threaded on the upper end of the connecting rod 110 in order to hold the dome-shaped member 121 in place.

Each of the sections of drill pipe string are hollow so as to permit the passage of mud fluid therethrough when pumped down the drill pipe string by means of the mud pumps 20. In order to permit the mud fluid to pass through the turbine, the disc 104 is provided with a plurality of openings 123 and the annular member 52 is provided with a plurality of openings 124 which permit the mud fluid to pass downwardly through the turbine 38.

A flexible generally annular membrane 125 is secured at its ends respectively between members 109 and 107 and members 111 and 101 so as to define a chamber or cavity 126 for enclosing a supply of fluid lubricant at a pressure substantially equal to the pressure of the mud fluid outside of the chamber 126 and within sleeve 39. The flexible membrane is pre-formed so that it will tend to assume the shape disclosed in Fig. 6 when the mud fluid pressure collapses the membrane. In order to fill the chamber 126 with fluid lubricant, the members 109, 107 and 104 are drilled as indicated respectively at 127, 128, 129 and 130. A lubricant strainer 131 is adapted to be disposed in the lubricant line leading into the chamber 126 and comprises a screen effective to screen out large abrasive particles which might accidentally get into the lubricant. Suitable plugs 132 and 133 are adapted to be screwed into threaded openings formed in member 104 and sleeve 109 respectively in order to close the entrance to the lubricant cavity 126. A plug 132*a* is provided for facilitating inserting the strainer 131 into passage 128 and is normally closed. The annular members 109, 107 and 104 are also drilled as indicated at 134, 135, 136, 137 and 138 so as to provide a suitable passage for permitting air to escape from the cavity 126 when the cavity is being filled with fluid lubricant.

During a cavity filling operation, fluid lubricant is forced through the passages 130, 129, 128 and 127 and passes into the cavity 126 by opening a flap valve 139. The flap valve 139 is a one-way valve which is adapted to close as soon as the supply of fluid lubricant being forced into the cavity 126 is cut off. When the lubricant commences to pass out of the cavity through openings 134, 135, 136, 137 and 138 this indicates that the cavity 126 is full and at that time suitable threaded plugs 140 and 141 are threaded in place in order to close the cavity.

In order to provide a seal so as to prevent the escape of the lubricant between the members 109 and 107 and 107 and 104, suitable O-rings 142 and 143 are disposed in grooves respectively formed in members 109 and 107 around openings 127 and 128. In order to properly align the members 104, 39 and 107 during assembly of the turbine, positioning pins 144 and 145 are provided. Likewise a positioning pin 111*a* is provided for aligning the member 111 with the member 101 prior to assembly.

Fluid lubricant passages leading from the cavity 126 down to the turbine mechanism will now be described. The conical member 111 is provided with three grooves 146 on its upper surface, each of which is connected with a passage 147 which leads to an opening 148 formed at the upper end of member 101. The opening 148 connects with a central opening 150 defined by members 101 and 76 by means of one or more conduits 149. The O-ring 102 prevents leakage of the fluid between the members 101 and 76. The cavity 150 is closed at the bottom by means of a suitable plug 152 threaded into the bottom end of this cavity. The high pressure fluid lubricant from the cavity 126 is extended to the sealing devices 74 and 75 through a conduit 153 formed in the side of member 76 and this conduit 153 communicates with an opening 154 formed in the member 52. Suitable O-rings 155 and 156 seal the members 52 and 76

with respect to each other and line 154 in member 52 communicates with sealing device 74 through conduits 157 formed in member 52 and 158 formed in member 51. The conduit 154 communicates with the sealing device 75 through opening 159 formed in member 52, opening 160 formed in member 51, opening 161 formed in sleeve 42, openings 162 and 163 formed in member 53 and opening 164 formed in member 69. In order to provide the necessary seals for these high pressure lubricant lines, suitable O-rings 165, 166, 167, 168, 169, 170 and 171 are provided.

In order to hold the sealing device 74 in the proper position within the flange 70, an annular ring 172 is positioned within member 51 and held in place by annular member 52.

A suitable centralizing bearing 173 is provided at the upper end of shaft 65. The outer race of the bearing 173 is held fixed with respect to annular member 52 by means of an internal nut 174 and the inner race of the bearing 173 is held fixed to the shaft 65 by means of an external nut 175.

The sealing devices 74 and 75 will now be described. As stated heretofore, these two sealing devices are substantially mirror images of one another and it is considered necessary, for a thorough understanding of the invention, to only describe the one sealing device 75. The sealing device 75 comprises a sleeve 180 secured around the shaft 65 and adapted to fit snugly thereon. The sleeve 180 is turned down on its outer periphery, as indicated at 181, and between the sleeve 180 and the flange 71 is a cavity 182 adapted to be filled with a heavy grease. The outer periphery of the sleeve 180 is turned smooth so that sealing devices 183 and 184 are capable of providing an effective seal therewith. The sealing device 184 is effective to seal off mud fluid which may enter the chamber 182 from high pressure fluid lubricant in a chamber 185 supplied with high pressure fluid lubricant through the conduit 164. The sealing device 184 comprises an annular sealing ring 186 which fits snugly within the inner periphery of flange 71 in abutment with a shoulder 187 formed on the flange 71. The external periphery of the ring 186 is provided with an outwardly opening groove 188 adapted to receive an O-ring 189 which functions to provide a substantially fluid tight seal between the ring 186 and the flange 71.

An annular member 191, substantially U-shaped in cross section, is concentrically disposed around the sleeve 180 and encloses a plurality of compression springs 192. In abutment with the upper end of the compression springs 192 is an annular disc 193. Disposed above the disc 193 is a piston 194 having an internal periphery adapted to fit snugly against the external periphery of sleeve 180. The piston member 194 has an angular or cone shaped face 195 cooperable with a complementary face 196 on a second piston member 197. The force from the springs 192 forces the piston faces 195 and 196 so as to bring an upper face 198 on piston 197 against a lower face 199 on sealing ring 186. The faces 198 and 199 are what is known as "optical flats" and even though they rotate relatively to one another they are capable of providing an effective seal.

The sealing device 183 is similar to the sealing device 184 and comprises a sealing ring 202 provided with a peripheral groove 170*a* for receiving the O-ring 170. An annular member 203 having a substantially U-shaped cross section is pinned to the sleeve 180 by means of a pin 204 and encloses a plurality of compression springs 205 which are capable of urging a pressure disc 206 downwardly. A piston 207 abuts the pressure disc 206 and a plurality of chevron-shaped annular sealing rings 208 are disposed between the piston 207 and a sealing member 209. The sealing member 209 is provided on its bottom end with an optically flat surface 210 adapted to cooperate with a complementary optically flat surface formed on the upper end of member 202.

Suitable fluid pressure supply means are provided in the oscillator mechanism located immediately beneath the turbine mechanism and the fluid under pressure from such fluid pressure supply means is forced through conduits 214 formed in member 59, 215 formed in member 56, peripheral groove 216 formed in member 59, conduit 217 formed in member 56 and conduit 218 formed in member 53. The fluid supplied through this supply line is maintained under a rather low pressure and serves to lubricate thrust bearings 87, by merely dripping out of conduit 218 and running down around the bearings 87. Suitable means are also provided for supplying this same low pressure fluid for the centralizing bearing 173 and any excess of this low pressure fluid may pass back to the oscillator through a suitable opening 219 formed in the shaft 65. This fluid may escape from the hollowed portion 82 of the shaft 65 through suitable grooves 219*a*.

It will be apparent that high pressure mud fluid will be in the cavity 182 and low pressure oil will be in the cavity 220 below sealing ring 202 and in cavity 221 below centralizing bearing 173. Thus optical flats 198 and 199 must isolate high pressure fluid lubricant from mud fluid maintained at slightly lower pressure than the high pressure fluid lubricant and optical flats 210 and 211 must isolate high pressure fluid lubricant from very low pressure. As will be apparent from Fig. 10, the high pressure fluid lubricant is capable of acting against the lower ends of pistons 194 and 197 to thus force the optical flats 199 and 198 together. Mud fluid pressure is capable of acting on surface 222 of piston 197 in opposition to the high pressure fluid lubricant. Spring pressure from compression springs 192 also tends to urge the piston 197 toward the sealing ring 186 and thus there is a greater force urging the optical flats together than urging them apart. This is effective to maintain a seal between the mud fluid and the high pressure fluid lubricant.

High pressure fluid lubricant also acts on the upper ends of piston 207 and sealing member 209 to add to the force of compression springs 205 in urging optical flat 210 against optical flat 211 and thus there is a substantial force urging these two optical flats together so as to effect a seal between the high pressure fluid lubricant in cavity 185 from low pressure fluid lubricant in cavity 220.

It will be apparent that the pressure differential across each of the sealing devices decreases away from the high pressure fluid lubricant and as a result any leakage is of the high pressure fluid lubricant across the seal rather than of the mud fluid or low pressure across a seal.

In the operation of the turbine disclosed herein mud fluid is pumped down the drill pipe string by means of the mud pumps 20 and upon reaching the fluid lubricant cavity 126 the mud fluid acts on membrane 125 so as to place the fluid lubricant in the cavity 126 under a pressure substantially equal to the pressure of the mud fluid as it first enters the turbine 38. The mud fluid then enters the turbine, being directed in the proper direction by the different stages of stator blades 43 so that it acts on the turbine blades 60 causing them to turn. The rotating turbine blades 60 in turn drive the shaft 65 which in turn drives the shaft 84 to supply rotative power for the oscillator mechanism disposed beneath the turbine 38.

Due to the rather considerable force acting in a manner so as to urge the relatively rotatable optical flat sealing surfaces together there is substantial friction between these surfaces during relative rotation thereof and this friction generates considerable heat. Further, there is substantial turbulence in the fluid lubricant used to urge the sealing surfaces together and this also generates heat. Since it is essential to dissipate this friction generated heat and the heat generated by turbulence of the lubricant a desirable feature of the present invention resides in the small mud fluid aperture 68 in the turbine collar 67 which by-passes a small, but nevertheless sufficient amount of mud fluid around the turbine so as to carry off this heat.

Another desirable feature of the present invention re-

sides in the unique manner of providing the high pressure fluid lubricant for effecting the different sealing operations necessary. Due to the fact that mud fluid communicates with the seals only after it has passed the first stage of stator blades, the pressure of the high pressure fluid lubricant is always greater than the pressure of the mud fluid which acts on the seals. This is due, of course, to the fact that there is a definite pressure drop in the mud fluid as it passes each stage of blades.

It is contemplated that numerous changes and modifications may be made in the present invention without departing from the spirit or scope thereof.

What is claimed is:

1. A turbine for driving a rotatable shaft disposed concentrically within a cylindrical housing adapted to have a fluid flow therethrough, said turbine comprising stator and rotor elements, said stator element consisting of a plurality of sets of blades fixed to said cylindrical housing, said rotor element including a plurality of sets of blades disposed on a sleeve element mounted concentrically around said rotatable shaft, said sleeve element and said shaft together defining a cylindrical cavity having a fluid inlet and a fluid outlet for admitting a portion of the fluid inside said sleeve element, said cylindrical cavity having disposed therein an annular web interconnecting said sleeve element and said rotatable shaft, and said web including means defining a fluid passage therethrough, the fluid flowing through said cylindrical housing being effective on the blades of said rotary element for driving the latter and in turn driving the rotatable shaft, and said web passage being effective to by-pass the portion of the fluid admitted inside of said sleeve for dissipating heat generated in the rotary turbine element by friction between the fluid and the blades of said rotor element.

2. A turbine comprising, in combination, a cylindrical housing adapted to have fluid flow therethrough, said housing including an outer shell portion and including means radially spaced from said outer shell portion, and together with said outer shell portion forming an annular cavity, a plurality of spaced sets of stator blades fixed to said outer shell and disposed within said cavity, a driven shaft concentrically disposed within said cylindrical housing, a turbine shell disposed within said cavity and having a plurality of spaced sets of turbine blades alternately spaced between said spaced sets of stator blades, said turbine shell being spaced from said driven shaft to thereby define a cavity having a fluid inlet and a fluid outlet for admitting a portion of said fluid inside of said turbine shell and said turbine shell being fixed to said driven shaft by an annular web, and said web including fluid passage means extending therethrough, the fluid flowing through said housing being effective on said turbine blades for driving the latter and in turn driving said driven shaft, and said passage means being effective to by-pass the portion of the fluid admitted inside of said turbine shell for dissipating heat generated in the turbine shell by friction between the fluid and the turbine blades.

3. A turbine comprising, in combination, a cylindrical housing adapted to have fluid flow therethrough, said housing including an outer shell and including means defining an inner shell portion radially spaced from said outer shell and together forming an annular turbine cavity, a plurality of spaced sets of stator blades fixed to said outer shell and disposed within said cavity, a driven shaft concentrically mounted within said outer and inner shell portions, a turbine shell disposed within said annular turbine cavity and spaced from said inner shell portion to thereby define a fluid inlet and a fluid outlet for admitting a portion of the fluid between said turbine shell and said inner shell, said turbine shell being fixed to said driven shaft by an annular web and having a plurality of spaced sets of turbine blades alternately arranged with said stator blades, and said annular web including means defining a passage therethrough, the fluid flowing through said cylindrical housing being effective on said turbine blades for driving them and in turn driving said driven shaft, and said web passage being effective to by-pass the portion of the fluid admitted inside of said turbine shell for dissipating heat generated in the turbine shell by friction between the fluid and the turbine blades.

4. A turbine comprising, in combination, a cylindrical housing for conveying an abrasive fluid therethrough, said housing including means defining a generally annular turbine cavity therein, a plurality of stator blades fixed to said housing and disposed within said annular cavity for controlling the direction of flow of said abrasive fluid through said cavity, a rotatable shaft disposed within said housing and having a turbine shell secured thereto, said turbine shell being disposed in said annular turbine cavity and having a plurality of turbine blades adapted to be driven by the flowing abrasive fluid, bearing devices operably disposed between said shaft and housing on opposite sides of said turbine shell for rotatably mounting said shaft within said housing, and sealing means operably disposed between said housing and said shaft and located respectively between said turbine shell and said bearing devices, said sealing means each comprising a pair of relatively rotatable substantially optically flat annular surfaces respectively carried by said shaft and said housing and effective to isolate said abrasive fluid from said bearing devices.

5. A turbine comprising, in combination, a cylindrical housing for conveying an abrasive fluid therethrough, said housing including means defining a generally annular turbine cavity therein, a plurality of stator blades fixed to said housing and disposed within said annular cavity for controlling the direction of flow of said abrasive fluid through said cavity, a rotatable shaft disposed within said housing and having a turbine shell secured thereto, said turbine shell being disposed in said annular turbine cavity and having a plurality of turbine blades adapted to be driven by the flowing abrasive fluid, means providing a source of fluid lubricant at a pressure substantially equal to the pressure of said abrasive fluid, bearing devices operably disposed between said shaft and said housing on opposite sides of said turbine shell for rotatably mounting said shaft within said housing, sealing means operably disposed between said housing and said shaft and located respectively between said turbine shell and said bearing devices, said sealing means each comprising a pair of relatively rotatable substantially optically flat annular surfaces respectively carried by said shaft and said housing and a piston element movable to urge said optically flat annular surfaces toward engagement with each other, and means for conveying said fluid lubricant to said piston element of said sealing means whereby the fluid lubricant acts on the piston element which, in turn, applies a force against said optically flat annular surfaces tending to urge them toward sealing engagement with each other for thereby isolating said abrasive fluid from said bearing devices.

6. A turbine comprising, in combination, a cylindrical housing for conveying an abrasive fluid therethrough, said housing including means defining a generally annular turbine cavity therein, a plurality of stator blades fixed to said housing and disposed within said annular cavity for controlling the direction of flow of said abrasive fluid through said cavity, a rotatable shaft disposed within said housing and having a turbine shell secured thereto, said turbine shell being disposed in said annular turbine cavity and having a plurality of turbine blades adapted to be driven by the flowing abrasive fluid, means providing a source of fluid lubricant at a pressure substantially equal to the pressure of said abrasive fluid, bearing devices operably disposed between said shaft and said housing on opposite sides of said turbine shell for rotatably mounting said shaft within said housing, sealing means operably disposed between said housing and said shaft and located respectively between said turbine shell and said bearing devices, said sealing means each com-

prising a pair of relatively rotatable substantially optically flat annular surfaces respectively carried by said shaft and said housing and a relatively movable piston element, said optically flat surfaces carried by said housing being substantially fixed with respect thereto and said optically flat surfaces carried by said shaft being formed on said piston element and movable with the piston element and with respect to the shaft, and means for conveying said fluid lubricant to said piston elements whereby the fluid lubricant applies a force on the piston elements so as to tend to urge the opticaly flat surfaces toward sealing engagement with each other for thereby isolating said abrasive fluid from said bearing devices.

7. Power generating means for driving an earth boring drill of the type adapted to have mud fluid pumped into the earth bore through the drill for the purpose of washing out chips of earth formation cut away at the bottom of the bore by the drill and comprising, in combination, a substantially cylindrical housing adapted to convey the mud fluid therethrough, said housing including means forming an annular cavity therein, a rotatable shaft disposed within said housing, turbine means fixed to said shaft and disposed within said annular cavity, said turbine means being adapted to be acted upon by the mud fluid flowing through said housing for driving said shaft, bearing means disposed in spaced relation to said turbine means for maintaining concentric alignment of said shaft within said cylindrical housing, a compressible fluid lubricant chamber disposed in communication with the mud fluid within said housing for providing a source of fluid lubricant at a pressure substantially equal to the pressure of the mud fluid, a pair of seals each comprising a piston element and a pair of cooperable substantially optically flat annular surfaces respectively carried by said housing and shaft and located between said bearing and turbine means, the piston element of each seal having one of the optically flat surfaces formed thereon, and means for conveying fluid lubricant from said chamber to the respective piston elements whereby the fluid lubricant acts on said piston elements in a manner tending to urge the cooperable optically flat surfaces together for effectively isolating said mud fluid from said bearing means.

8. Power generating means for driving an earth boring drill of the type adapted to have mud fluid pumped into the earth bore through the drill for the purpose of washing out chips of earth formation cut away at the bottom of the bore by the drill and comprising, in combination, a substantally cylindrical housing adapted to convey the mud fluid therethrough, said housing including means forming an annular cavity therein, a rotatable shaft disposed within said housing, turbine means fixed to said shaft and disposed within said annular cavity, said turbine means being adapted to be acted upon by the mud fluid flowing through said housing for driving said shaft, bearing means disposed in spaced relation to said turbine means for maintaining concentric alignment of said shaft within said cylindrical housing, a compressible fluid lubricant chamber disposed in communication with the mud fluid within said housing for providing a source of fluid lubricant at a pressure substantially equal to the pressure of the mud fluid, a pair of sealing devices each comprising a first annular member having a substantially optically flat annular surface and sealed with respect to said housing and a second annular member having a substantially optically flat annular surface cooperable with the optically flat surface on the first member, said second annular member being sealed with respect to said shaft and having limited sliding movement with respect thereto, said sealing devices being located respectively between said turbine and bearing means, and means for conveying fluid lubricant from said source to said sealing devices whereby the fluid lubricant acts on each of said second annular members in a manner tending to urge the cooperable optically flat annular surfaces together for isolating said mud fluid from said bearing means.

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