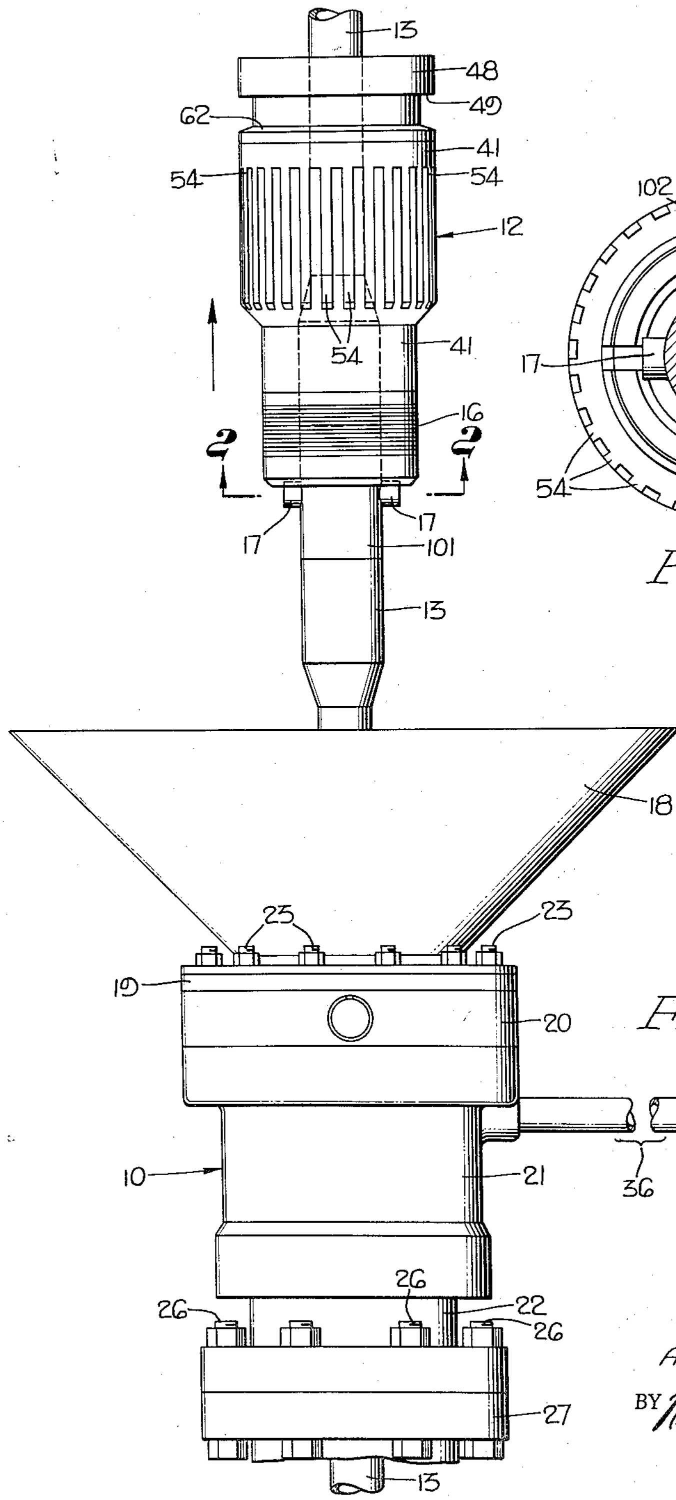
SUBMARINE DRILLING HEAD AND BLOWOUT PREVENTER

Filed June 9, 1959 4 Sheets-Sheet 1



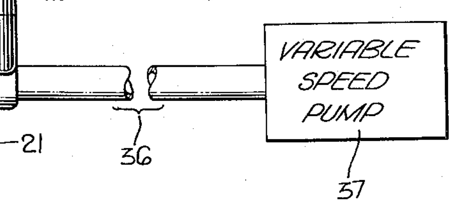


FIG. 1.

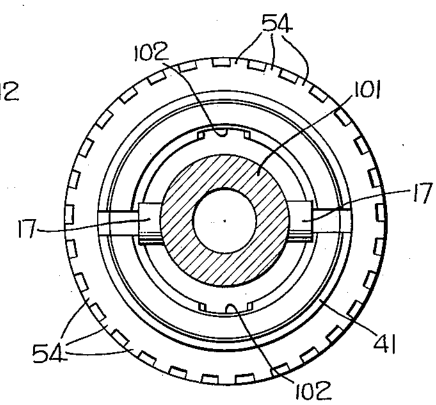


FIG. 2.

INVENTOR,
ARTHUR E. WILDE
BY Richard L. [signature]
ATTORNEY

Feb. 27, 1962 A. E. WILDE 3,023,012

SUBMARINE DRILLING HEAD AND BLOWOUT PREVENTER

Filed June 9, 1959 4 Sheets-Sheet 2

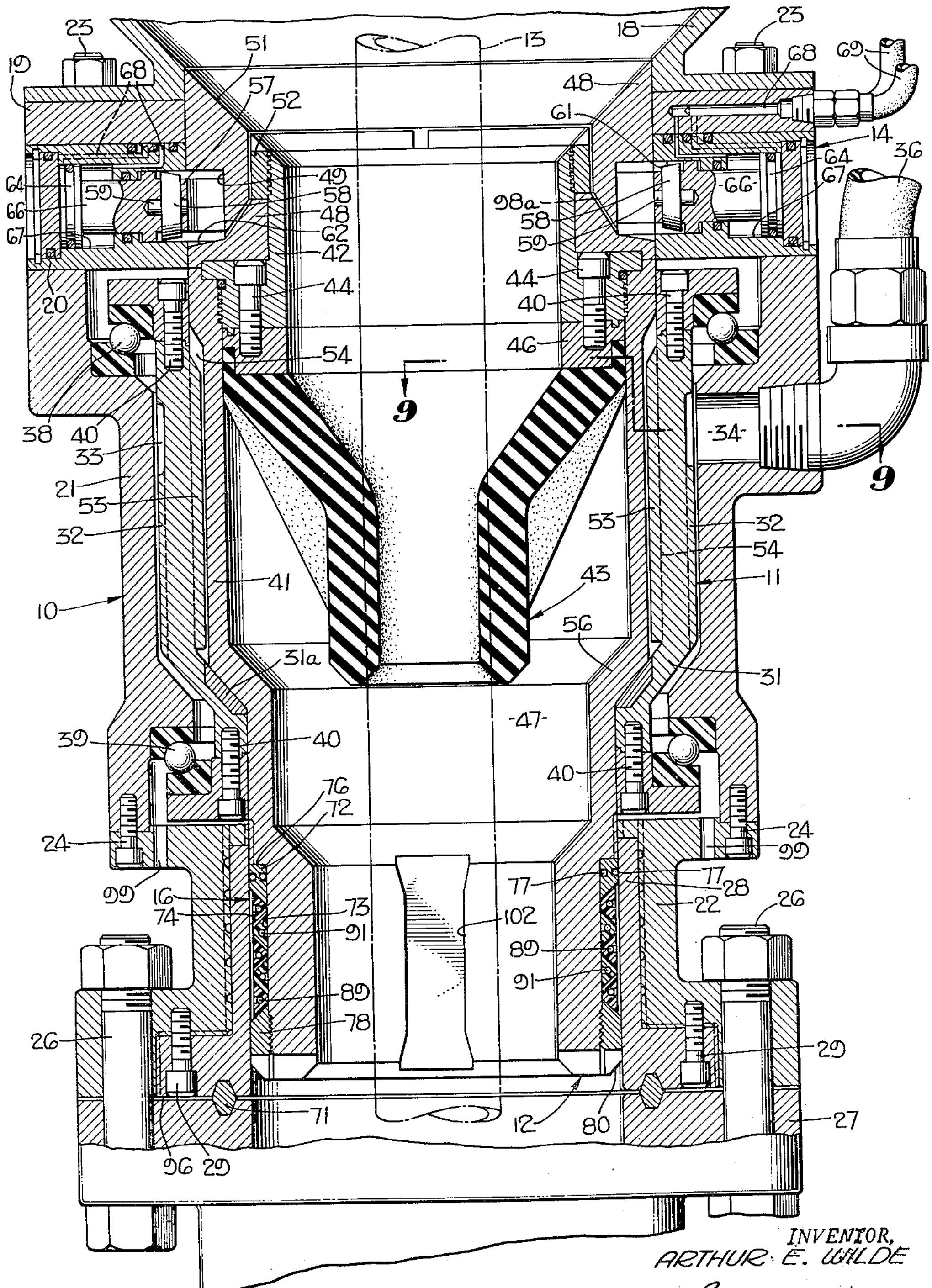


FIG. 3.

INVENTOR,
ARTHUR E. WILDE

BY Richard K. [signature]

ATTORNEY

Feb. 27, 1962 A. E. WILDE 3,023,012

SUBMARINE DRILLING HEAD AND BLOWOUT PREVENTER

Filed June 9, 1959 4 Sheets-Sheet 3

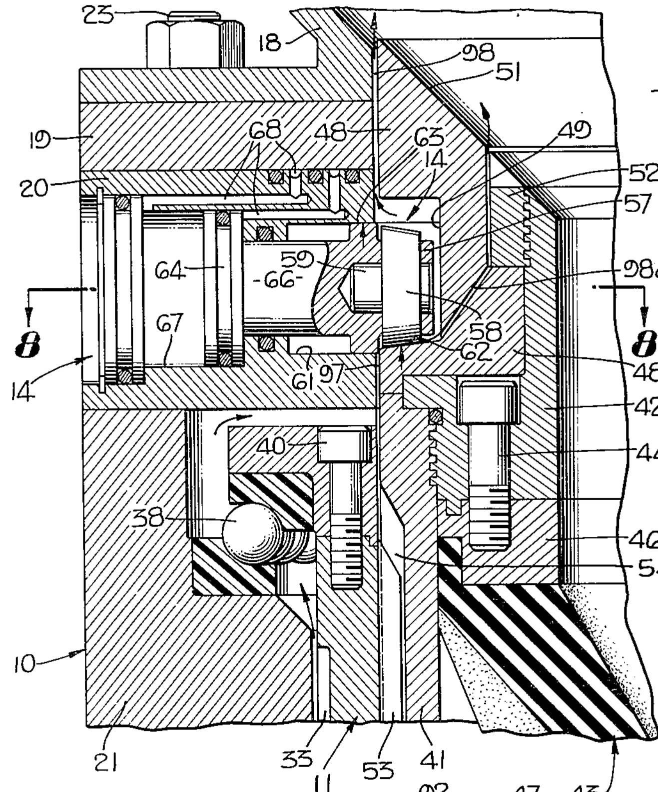


FIG. 4.

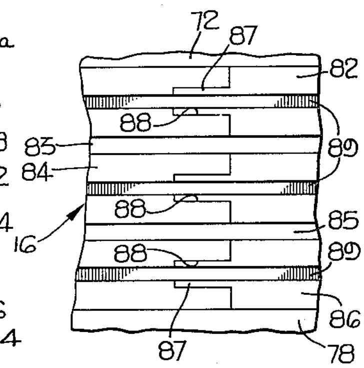


FIG. 7.

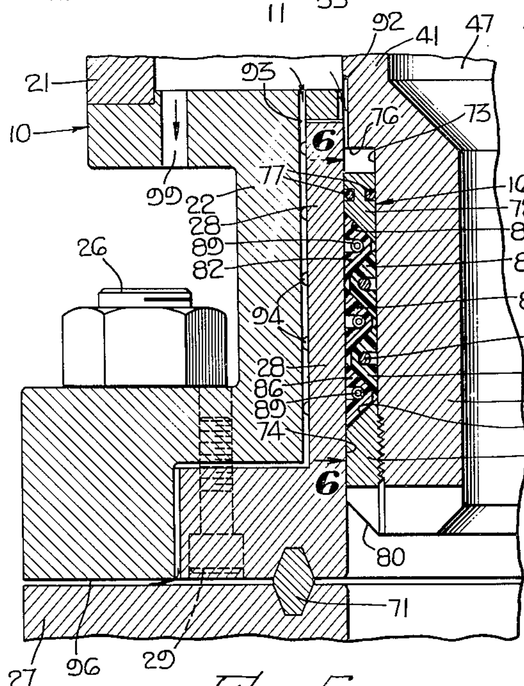
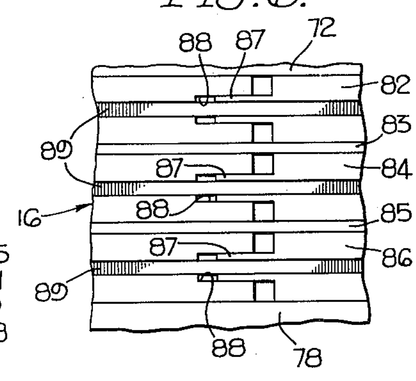


FIG. 5.

FIG. 6.



INVENTOR,
ARTHUR E. WILDE

BY [signature]

ATTORNEY

SUBMARINE DRILLING HEAD AND BLOWOUT PREVENTER

Filed June 9, 1959 4 Sheets-Sheet 4

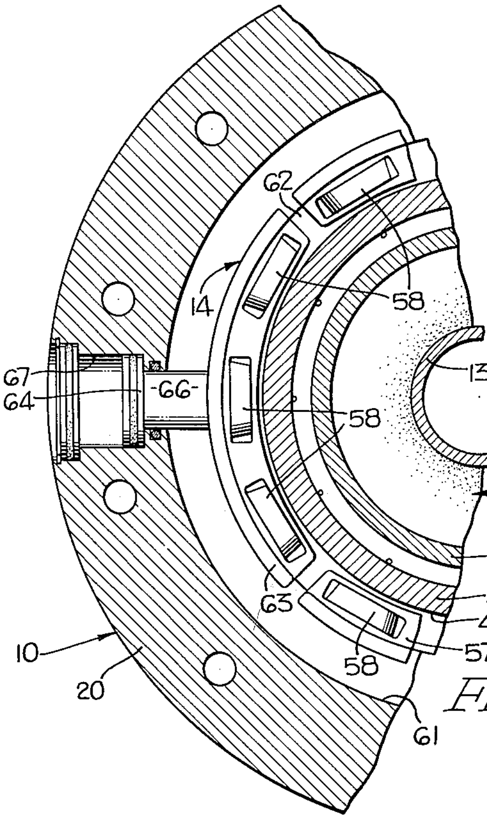


FIG. 8.

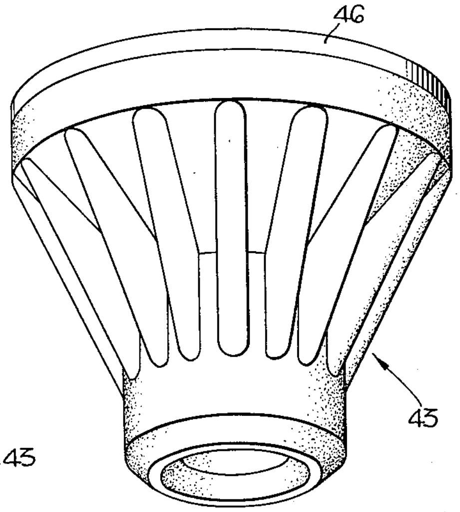


FIG. 11.

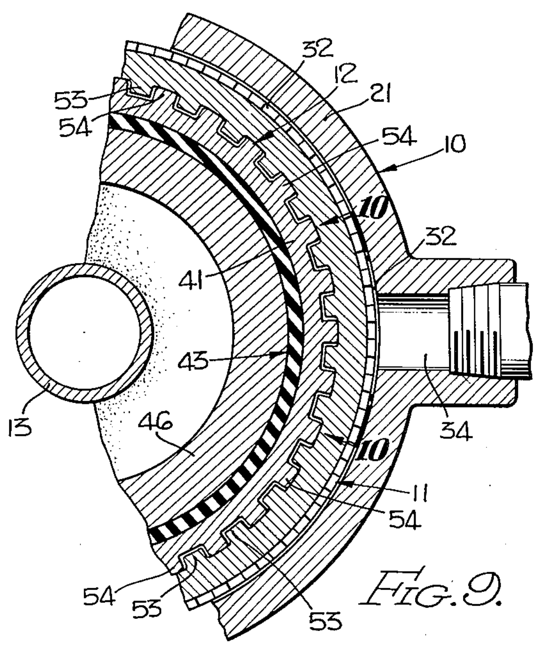


FIG. 9.

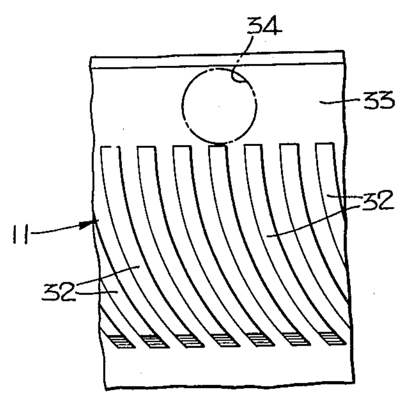


FIG. 10.

INVENTOR,
ARTHUR E. WILDE

BY [signature]

ATTORNEY

United States Patent Office

3,023,012

Patented Feb. 27, 1962

3,023,012

SUBMARINE DRILLING HEAD AND BLOWOUT PREVENTER

Arthur E. Wilde, Santa Ana, Calif., assignor to Shaffer Tool Works, Brea, Calif., a corporation of California

Filed June 9, 1959, Ser. No. 819,083
13 Claims. (Cl. 277—31)

This invention relates to a drilling head and rotating blowout-preventer apparatus particularly adapted to be employed in sub-sea oil well drilling operations. The invention further relates to rotary locking and sealing means incorporated in the drilling head.

Rotating blowout preventers are employed extensively in drilling operations on land, and some of the principles of such blowout preventers are incorporated in certain prior-art submarine drilling heads. However, an important defect of such submarine drilling heads is that there is no effective drive between the drill string and stripper rubber which seals the annulus therearound. Accordingly, it has been found that a large amount of relative rotational movement takes place between the drill string and the stripper rubber to effect rapid wear on the latter.

There exist a number of other defects or problems relative to prior-art submarine drilling heads incorporating rotating blowout preventers. These include the problem of providing a satisfactory rotary seal which may be readily inserted into a stationary housing located on the ocean floor a substantial distance, which may be 400 feet or more, below the drilling barge. Other problems relate to proper cooling of the bearings, which may be of the unlubricated type and exposed to salt water. Additional important problems relate to the provision of satisfactory locking and thrust-bearing means, and to the provision of means for lifting the rotating assembly out of the stationary housing without pulling the entire drill string.

In view of the above and other factors characteristic of submarine drilling heads and problems relating thereto, it is an object of the present invention to provide a simple and practical apparatus for effecting rotation of the stripper rubber at approximately the same speed as the drill string, to thereby reduce relative rotational movement therebetween to a minimum and thus greatly increase the service life of the stripper rubber.

A further object is to provide a submarine drilling head incorporating a turbine rotor adapted, in response to fluid flow to the drilling head, to rotate the stripper rubber in the same direction as the drill string and at approximately the same speed.

A further object is to provide a submarine drilling head embodying combination locking and thrust-bearing apparatus which is operable from the surface.

A further object is to provide a rotary seal assembly which automatically increases in diameter subsequent to insertion of the rotating assembly into the stationary housing.

A further object is to provide a submarine drilling head incorporating novel lubricant-free bearings which are cooled by circulating salt water.

A further object is to provide a device operable to lift the rotating assembly to the surface, without pulling the entire drill string, and even though the stripper rubber is worn to such an extent that there is insufficient frictional gripping between it and the drill string to effect lifting of the rotating assembly.

These and other objects and advantages of the invention will be set forth more fully in the following specification and claims, considered in connection with the attached drawings to which they relate.

In the drawings:

FIGURE 1 is a side elevation of the apparatus of the invention, illustrating the rotating assembly being raised out of the stationary body;

FIGURE 2 is a transverse section taken on line 2—2 of FIGURE 1, and looking upwardly as indicated by the arrows;

FIGURE 3 is a longitudinal central sectional view illustrating the condition of the submarine drilling head and blowout preventer immediately after seating of the rotating assembly in the body or housing, prior to locking of the rotating assembly against substantial longitudinal shifting and also prior to application of fluid pressure;

FIGURE 4 is an enlarged fragmentary longitudinal sectional view illustrating the upper left corner of the showing of FIGURE 3, but subsequent to shifting of the combination locking and thrust-bearing means to locking position;

FIGURE 5 is an enlarged fragmentary longitudinal sectional view of the lower left corner portion of the showing of FIGURE 3, but after application of fluid pressure to shift the rotary seal components to sealing positions;

FIGURE 6 is a fragmentary section taken on line 6—6 of FIGURE 5 and illustrating the joints between various ones of the rotary seal components;

FIGURE 7 corresponds to FIGURE 6 but illustrates the conditions of the rotary seal components prior to application of fluid pressure, or after release of fluid pressure;

FIGURE 8 is a fragmentary horizontal sectional view taken on line 8—8 of FIGURE 4;

FIGURE 9 is a fragmentary horizontal sectional view taken on line 9—9 of FIGURE 3, illustrating the spline means and the turbine blades;

FIGURE 10 is a fragmentary section taken on line 10—10 of FIGURE 9 and illustrating the curvature of the turbine blades; and

FIGURE 11 is a perspective view of the stripper rubber.

Referring to the drawings, the apparatus comprises a stationary body or housing 10, a turbine rotor 11 rotatably mounted in the body 10, a rotating assembly 12 mounted around the drill string 13, and means to lock the rotating assembly 12 against rotation relative to turbine rotor 11 while permitting relative longitudinal shifting therebetween. The apparatus further comprises combination thrust-bearing and lock means 14 radially movable between release and locking positions, and a rotary seal assembly 16 to sealingly associate the housing 10 and rotating assembly 12. In addition, means 17 (FIGURE 1) are provided to lift the rotating assembly 12 out of body 10 in the event that the stripper rubber in the rotating assembly becomes worn to the extent that it will not grip the drill string sufficiently tightly to permit frictional withdrawal to the surface.

The phrase "rotating assembly," as employed herein, denotes only those rotating elements which are adapted to be lifted, by the drill string, out of housing 10 and up to the drilling barge. Thus, the "rotating assembly" does not include the turbine rotor 11.

Proceeding first to a detailed description of the stationary body or housing 10, this comprises (starting at the top) a tapered guide or funnel 18, a ring 19 through which fluid passages are provided, a second and thicker ring 20 associated with the thrust-bearing and lock means 14, an upper main housing or body 21, and a lower main housing or body 22. Elements 18–21 are secured together by means of bolts 23, whereas elements 21 and 22 are secured together by means of screws 24. The lower main housing 22 is flanged to receive the bolts 26 which associate the stationary body 10 with a mud cross indicated fragmentarily at 27 in FIGURES 1 and 3. A tubular wear sleeve 28 is inserted upwardly within the lower housing 22 and secured in position by means of screws 29, being associated with the rotary seal assembly 16.

It is to be understood that the submarine drilling head, and also the mud cross 27, form part of a submarine drilling assembly which includes additional elements such as another mud cross, a ram-type blowout preventer, and another tapered guide. Such assembly is mounted at the ocean floor and is adapted to receive the drill string which is initially guided thereto from a drilling barge by means of guide cables or rods, not shown.

The turbine rotor 11 comprises a tubular element which is necked-down at its lower end 31 and is provided with a large number of turbine blades 32 on its outer cylindrical surface. Blades 32 are illustrated in FIGURE 10 as being generally arcuate in shape, having upper portions which extend vertically and lower portions which curve laterally. An annular groove 33 is formed in the rotor 11 immediately above the blades 32 and operates to feed fluid downwardly between the blades so that a rotational action is imparted to the rotor. Such fluid, normally sea water, is pumped to the groove 33 by means of an inlet 34 provided in the upper main housing 21. A feed conduit or hose 36 extends from the inlet upwardly to a variable-speed pump located at the drilling barge. Such pump is adapted to pump sea water at a controlled rate to the turbine rotor and thereby cause the rotor to rotate at a predetermined speed which is selected to be approximately that of drill string 13.

The variable-speed pump, which is illustrated schematically at 37 in FIGURE 1, is preferably located on the drilling barge as previously indicated. It is, however, within the scope of the invention to locate the pump beneath the surface of the water if desired.

It is a feature of the invention that upper and lower water-cooled roller bearings 38 and 39, respectively, are mounted between turbine 11 and housing or body 10 to permit relatively frictionless rotation of the turbine rotor. Each bearing includes two races formed of a material such as nylon, Teflon or fiber, the races being separated by a plurality of corrosion-resistant balls. One race of each bearing is seated in the upper main housing, whereas the other race is locked to a rotor end by means of a retaining ring and screws 40. It is pointed out that the water introduced through inlet 34 may flow freely through both bearings 38 and 39 for discharge into the surrounding ocean as will be described in detail subsequently. This effects continuous cooling of the corrosion-resistant bearings, which are not lubricated.

Proceeding next to a description of the rotating assembly 12, this comprises an elongated, generally tubular inner drive sleeve 41 which telescopes within turbine rotor 11, the latter also functioning as an outer drive sleeve as will be indicated hereinafter. At its upper end, inner drive sleeve 41 is threadedly and sealingly associated with the mounting ring 42 for a packer member 43 which may be termed the stripper rubber. The mounting ring 42 is associated by means of screws 44 with a steel ring 46, the latter being molded to the upper and relatively wide end of the stripper rubber 43.

As best illustrated in FIGURES 3 and 11, the stripper rubber has a conical upper portion and a generally tubular lower portion, the latter being adapted to fit sealingly around the drill string 13. It is the stripper rubber which it is desired to rotate at approximately the same speed as the drill string, and in the same direction, in order to prevent wear. It is pointed out that an annulus 47 is defined below stripper rubber 43 and around the drill string 13, and that the stripper rubber operates to seal this annulus against a blowout. Furthermore, the stripper rubber acts as a mud return seal and causes the mud to flow through the previously-indicated mud cross 27 instead of upwardly around the upper portion of drill string 13.

Seated above a shoulder portion of the mounting ring 42 is a bearing race ring 48 (FIGURE 4) having an annular peripheral groove or channel 49 adapted to receive portions of the combination thrust-bearing and lock means 14 as will be described subsequently. The upper end of the bearing race ring 48 is tapered, as indicated at 51, at the same angle as the tapered guide 18. Accordingly, these elements cooperate in guiding drill elements into the central passage through the mounting ring 42. A retaining ring 52 is seated over bearing race ring 48 and is threadedly associated with the upper end of mounting ring 42, both of these elements also being tapered at their upper ends. Ring 52 serves the function of maintaining the bearing race ring rigidly in position relative to the remainder of the rotating assembly, and is provided with suitable slots or notches adapted to receive a mounting wrench element.

Spline means are provided to lock the inner drive sleeve 41 against rotation relative to the outer drive sleeve or turbine rotor member 11, while permitting longitudinal shifting therebetween so that the rotating assembly may be lowered into the turbine rotor or drive sleeve 11 and subsequently removed therefrom. Such spline means comprise a plurality of upwardly-extending splines or fingers 53 provided around the interior surface of the upper portion of turbine rotor or outer drive sleeve 11, and a plurality of downwardly-extending splines or fingers 54 provided around the outer-upper portion of inner drive sleeve 41. The ends of such splines or fingers are pointed or tapered, as indicated in FIGURE 1 with relation to splines 54, in order to effect automatic rotation of the outer and inner drive sleeves into locking position as the rotating assembly is lowered. It is pointed out that the rotating assembly is lowered into the outer drive sleeve or turbine rotor until a shoulder portion 56 of inner drive sleeve 41 seats upon the previously-mentioned necked-down portion 31 of the turbine rotor or outer drive sleeve.

The combination thrust-bearing and lock means 14 for rotatably associating the rotating assembly 12 with body or housing 10, and at the same time preventing lifting of the rotating assembly out of the body or housing due to well pressures in annulus 47, comprises a plurality of arcuate shoes 57 adapted to be inserted radially into the annular groove 49 in bearing race ring 48. The shoes are best shown in FIGURES 3, 4 and 8, and each have a plurality of tapered roller members 58 mounted therein for free rotation about axes which extend radially to the axis of drill string 13. Stated more definitely, each roller member 58 is disposed in a slot or recess in an associated shoe 57 and rotates freely on a stub shaft 59 (FIGURE 4) mounted therein.

The shoes 57 and rollers 58 are adapted to be retracted radially outwardly into an outer annular groove 61 which is formed in ring 20 outwardly adjacent the first-mentioned annular groove 49. Groove 61 is sufficiently deep to receive the shoes and rollers, so that the rotating assembly 12 may be freed for shifting into and out of the outer drive sleeve or turbine rotor 11 as previously indicated.

The lower wall 62 of annular channel 49 is generally frustoconical or inclined, in a downwardly-divergent manner, for engagement by the corespondingly tapered rollers 58. Referring to FIGURE 4, and also FIGURE 8, it is pointed out that the outer portions of shoes 57 are raised above the upper surfaces or edges of the various rollers 58 and are adapted to engage the upper wall of outer annular groove 61 as indicated at 63 in FIGURE 4. Thus, the meeting surfaces indicated at 63 absorb the thrust which is created when the well pressure in annulus 47 tends to lift the entire rotating assembly 12 upwardly to the uppermost position permitted by the rollers 58. It is pointed out that FIGURE 3, which illustrates each assembly 14 in retracted condition, shows the rotating assembly 12 in a lower position than does FIGURE 4, the latter illustrating an assembly 14 in operating condition.

Piston means are associated, respectively, with shoes 57 to shift the same radially between retracted (release) positions (FIGURE 3) and operative (lock) positions (FIGURE 4). These comprise pistons 64 connected to piston rods 66 which are integral with the various shoes. The pistons are disposed in cylinders 67 formed in ring 20. Suitable conduit means 68 are formed through ring 20 and the adjacent ring 19, as illustrated in FIGURES 3 and 4, and communicate with hoses 69 which extend to suitable fluid pressure and valve apparatus (not shown) located on the drilling barge. The conduit means 68 and hoses 69 are adapted, when the valve means is operated, to shift the pistons and associated shoes radially to the positions desired.

As previously pointed out, the stripper rubber 43 effects a seal at the upper end of the annulus 47 around the drill string. Furthermore, a seal is provided between the lower end of wear sleeve 28 and the upper surface of mud cross 27, as shown in FIGURE 5, by means of a conventional A.P.I. ring 71. There will next be described the rotary seal means 16 which creates a rotating seal between the interior cylindrical surface of wear sleeve 28 and the outer cylindrical surface at the lower end of inner drive sleeve 41.

Seal assembly or means 16 is best illustrated in FIGURES 5–7, and comprises an upper or "piston" ring 72 having its inner cylindrical surface seated against the outer cylindrical wall 73 of drive sleeve 41 at the lower end thereof, and its outer cylindrical surface seated against the inner cylindrical wall 74 of wear sleeve 28. The wall 73 has a smaller diameter than the remainder of the inner drive sleeve 41, there being a radial shoulder 76 formed on the inner drive sleeve at the upper end of wall 73. Outer and inner sealing rings 77, such as O-rings, are provided on the ring 72 to prevent leakage of water between the above-described meeting cylindrical surfaces.

At the extreme lower end of inner drive sleeve 41 is mounted, in threaded relationship, a retaining ring 78 having beveled or frustoconical upper and lower surfaces 79 and 80, respectively. The lower surface 81 of the upper (piston) ring 72 is likewise beveled or frustoconical, being downwardly convergent whereas surface 79 is upwardly convergent. Lower surface 80 of the retaining ring is adapted to aid in guiding the rotating assembly through the tapered guide 18 and into seated position during lowering as previously described.

The beveled surfaces 79 and 81 are adapted to cooperate with a plurality of stacked sealing rings 82–86 and effect a fluid-tight seal between the previously-described cylindrical walls 73 and 74. Each of the rings 82–86 is generally triangular or trapezoidal in cross section, with corresponding rings being disposed in alternation. The respective tapered or frustoconical surfaces of the rings 82–86 are in engagement with each other and with the tapered or frustoconical surfaces 79 and 81. The radial dimension of each ring 82–86 is less than that of shoulder 76 and retaining ring 78. However, the radial dimension of the upper or piston ring 72 is approximately equal to the radial dimension of shoulder 76.

Each of the sealing rings 82–86 is formed of graphite or a suitable friction-reducing plastic such as nylon. Furthermore, each sealing ring 82–86 is not continuous but instead is formed in arcuate sections the ends of which meet, as shown in FIGURES 6 and 7, in tongues 87 adapted to fit in grooves 88. This permits expansion and contraction of the sealing rings 82–86 by means of the springs next to be described. The springs may comprise a plurality of helical springs 89 which are annular in shape and are seated in suitable grooves around the outer portions of the alternate rings 82, 84 and 86. The helical springs 89 are so constructed that they tend to reduce the diameters of their associated rings 82, 84 and 86. Expansion rings or springs 91, which may be solid in cross section and of the split variety, are mounted in suitable interior grooves in the remaining alternate sealing rings 83 and 85. Springs 91 tend to increase the diameters of such rings 83 and 85.

The result of the above construction is that the springs 89 and 91, and the cooperating frustoconical surfaces, normally force the seal assembly 16 to the extended position shown in FIGURE 3, with the upper radial wall of ring 72 seated against shoulder 76. The outer surfaces of the sealing rings 82–86 are then of smaller diameter than the outer surface of retaining ring 78, which protects the sealing rings from injury during lowering of the rotating assembly into seated position. Upon application of water pressure to the inlet 34, in order to drive the turbine rotor 11 and thus the rotating assembly 12, pressure is applied to the upper surface of ring 72 to force such ring downwardly. This effects increased nesting of the rings 82–86, and expansion of the rings 82, 84 and 86 until the inner surface 74 of wear sleeve 28 is closely and sealingly engaged. Furthermore, the engaged frustoconical surfaces of the respective rings 72, 78 and 82–86 are closely and sealingly engaged with each other due to the action of the springs 89 and also 91. The result is an effective rotary seal between the inner drive sleeve 41 and the wear sleeve portion 28 of the main housing.

As soon as the water pressure is released, the springs 89 and 91 again shift the rings to the positions shown in FIGURE 3, following which the rotating assembly may be readily lifted out of the housing. It is pointed out that FIGURE 7 corresponds to FIGURE 1 and shows the outer sealing rings 82, 84 and 86 in their smaller diameter conditions, whereas FIGURE 6 corresponds to FIGURE 5 and shows the rings 82, 84 and 86 in expanded conditions.

There will next be described the passages by which water under pressure is fed from inlet 34 to the piston ring 72 and also to various cooling and outlet passages. The water after entering through inlet 34 from conduit 36 passes through the annular groove 33 and then downwardly between the blades 32 of the turbine rotor. It then flows downwardly between the races of the lower bearing 39 to effect cooling of such bearing, after which it flows downwardly through passages 92 (FIGURE 5) into the space above the piston ring 72.

Water may discharge downwardly through passages 93, and annular grooves 94, which are provided in the lower main housing 22 radially outwardly of the wear sleeve 28. The water flowing continuously through such passages 93 and annular grooves 94 effects continuous cooling of the wear sleeve 28, thereby removing heat generated during the rotary sealing action. From the lower ends of passages 93, the water may discharge between the wear sleeve and housing elements as indicated at 96. The described cooling of the wear sleeve 28 increases the life thereof and the effectiveness of the seal means. Should the wear sleeve become excessively worn, it may be readily replaced by merely removing the bolts or screws 29 and inserting a new sleeve.

A portion of the water entering through inlet 34 and annular groove 33 flows upwardly through the upper bearing 38 to effect cooling thereof, as best shown in FIGURE 4, following which it flows through passages 97 to the annular groove 49 in which the rollers 58 are disposed. Such water therefore effects cooling of the thrust-bearing and locking means. The water then discharges upwardly through the annulus 98 between bearing race ring 48 and elements 18 and 19. Additional discharge paths, for various portions of the water, include passages 98*a* (FIGURE 4) in ring 48, and ports 99 (FIGURE 5) in element 22.

The combined minimum cross-sectional areas of all of the above-mentioned discharge paths, through which water is discharged into the surrounding ocean or other body of water, should be smaller than the cross-sectional area of inlet 34. The water in the interior of the apparatus will then be at a pressure sufficient to effect the above-described downward shifting of piston ring **72** of rotary seal **16**, and to create a forced flow through the various cooling passages. A pressure drop occurs in the apparatus, it being understood that the apparatus operates as a turbine to drive the turbine rotor **11**, and thus the rotating assembly including stripper rubber **43**, instead of being driven by the drill string **13** through the stripper rubber **43**.

There will next be described the key means **17** (FIGURES 1 and 2) for lifting the rotating assembly **12** to the surface of the ocean or other body of water in the event that the stripper rubber **43** becomes worn to the extent that the drill string **13** slides therethrough when pulled. Such wear on the stripper rubber **43** is effected primarily due to longitudinal shifting of the drill string **13** therethrough as it is lowered into the hole, it being understood that, with the present invention, there is little or no wear on the stripper rubber due to relative rotation between it and the drill string.

The means **17** comprises two keys or ears formed on an insert **101** which is provided in a joint in the drill string **13**. Keys **17** are adapted to be lowered through grooves **102** which are formed, as shown in FIGURES 2 and 3, through the inner or smallest diameter portion of inner drive sleeve **41**, at the lower end thereof. Guide grooves **102** have tapered ends to facilitate insertion of the keys **17** therein when the desired rotated position of the insert **101** relative to drive sleeve **41** is approximately achieved.

When it is desired to lift the rotating assembly **12** to the surface for repair or other purposes, water pump **37** is stopped, the lock means is retracted, and the drill string **13** is pulled for a distance equal to the depth of the body of water. If there is relatively little wear on the stripper rubber **43**, the friction between it and the drill string will effect lifting of the rotating assembly to the surface along with the adjacent portion of the drill string. However, if the wear is so great that the drill string slides through the stripper rubber **43**, the insert **101** with its keys **17** is inserted in a joint in the drill string, following which the drill string is lowered for a distance equal to the depth of the body of water. This will cause the keys **17** to pass through the worn stripper rubber **43** and through the guide grooves **102**, the latter being accomplished by merely rotating the drill string until the keys drop. After the keys have dropped through grooves **102**, the drill string is rotated through approximately 90°. Thereafter, the drill string is raised to cause the keys **17** to engage the lower ends of retaining ring **78** and inner drive sleeve **41**, preferably in retaining recesses therein.

Continued lifting of the drill string causes the entire rotating assembly **12** to be lifted as indicated in FIGURE 1, it being pointed out that FIGURE 1 illustrates the retrieving operation and not the initial lowering of the rotating assembly **12** since the keys **17** are not normally employed during the lowering of a rotating assembly with a fresh stripper rubber. Were it not for the presence of keys **17**, it would be necessary, in order to retrieve rotating assembly **12**, to pull the entire drill string **13** and cause the drill bit to engage the lower ends of retaining ring **78** and inner drive sleeve **41**.

Operation

To summarize briefly the operation of the submarine drilling head and blowout preventer, it is to be understood that prior to drilling of the well the stationary body or housing **10** is suitably mounted on the ocean floor by a procedure which forms no part of the present invention. The body **10** contains the rotatable turbine rotor element **11**, which may also be termed the outer drive sleeve.

The rotating assembly **12**, which is disposed on the drilling barge, is next positioned around the drill string by attaching a conical dummy sub, or starting mandrel, at the lower end of the drill string and then forcing such dummy sub downwardly through the stripper rubber **43**.

The dummy sub is then removed, and the drill bit is mounted in its place. The assembly comprising the drill bit, drill string **13** and rotating assembly **12** is then lowered down to the housing **10** by means of guide rods or cables, not shown. The drill bit is guided into the housing **10** by means of the tapered guide **18**, and the lower end of the rotating assembly **12** is likewise guided into the housing. As the rotating assembly drops into the housing and into the outer drive sleeve or turbine rotor **11**, the splines **53** and **54** come into locking engagement with each other, and the rotating assembly seats on the neck portion **31** previously described.

During the lowering operation, the control means for pistons **64** and their associated shoes **57** are so positioned that the shoes **57** are in retracted positions in outer groove **61**. As soon as the rotating assembly **12** is seated in the turbine rotor of outer drive sleeve **11**, the controls for pistons **64** are operated to shift the shoes **57** and rollers **58** from the retracted positions shown in FIGURE 3 to the locking positions shown in FIGURE 4. The head is then ready for commencement of drilling.

The variable-speed pump **37** (FIGURE 1) is then started to force sea water through conduit **36**, inlet **34** and feed groove **33** to the blades **32** of the turbine rotor or outer drive sleeve. This effects rotation of the turbine rotor and thus, because of the splines **53** and **54**, of the rotating assembly including stripper rubber **43**. The operation of pump **37** is caused to be such that the rotating assembly will rotate at approximately the same speed as the drill string **13**, and in the same direction, so that relative movement between the drill string and stripper rubber is minimized for reduction of wear. It is to be understood that the apparatus is suitably calibrated, prior to use at the bottom of the body of water, so that it is known what pump speed will effect rotation of the turbine rotor **11** at approximately the same speed as the drill string **13**.

The flow of water through the apparatus additionally effects, as above described, cooling of the bearings **38** and **39** for the turbine rotor or outer drive sleeve **11**, and also cooling of the thrust-bearing rollers **58**. Furthermore, and very importantly, the water flows through passages **92** (FIGURE 5) to force the slidable upper ring **72** of seal assembly **16** downwardly until the sealing rings **82–86** are in sealing positions. This provides, as described above in detail, one seal for the annulus **47**.

As drilling progresses, the drill string **13** is forced downwardly through the stripper rubber **43**. The stripper rubber **43** (and the rotary seal **16** as well as seal **71**) act as the seals for the mud which is circulated through the mud cross **27** during drilling. When the hole has become sufficiently deep that there is substantial well pressure in annulus **47**, the stripper rubber and the entire rotating assembly **12** are lifted by the annulus pressure to bring the tapered surface **62** (FIGURE 4) into pressure engagement with rollers **58**. This thrust is absorbed, as previously described, at the meeting surfaces **63** shown in FIGURE 4.

When it is desired to lift the rotating assembly back to the surface for repair, or replacement of parts such as the stripper rubber, the pump **37** is stopped, and the hydraulic controls are operated to retract the shoes **57** into outer groove **61**. The drill string **13** is then lifted, which operates through friction between the stripper rubber **43** and drill string to lift the rotating assembly to the surface without pulling the entire drill string. Should such friction between the stripper rubber and the drill string be insufficient for this purpose, the key means **17** (FIGURES 1 and 2) is inserted into the drill string and employed as described above in detail.

A bumper ring **31*a*** (FIGURE 3) may be seated in a corresponding annular groove in neck portion **31** of the turbine rotor **11**, and may be considered as forming part of such portion **31**. Ring **31*a*** is adapted to be engaged by the lower end of rotating assembly **12**, during seating of the rotating assembly, and thus receives a considerable amount of wear. After such wear occurs, ring **31a** may be easily replaced by a new ring.

Various embodiments of the present invention, in addition to what has been illustrated and described in detail, may be employed without departing from the scope of the accompanying claims.

I claim:

1. A submarine drilling head and blowout preventer, comprising a housing adapted to be fixedly mounted at the floor of an ocean or other body of water, a turbine rotor disposed in said housing, bearing means to mount said turbine rotor in said housing for rotation about a generally vertical axis, a rotating assembly disposed coaxially in said rotor and including a packer member adapted to be sealingly mounted around a drill string and to permit longitudinal shifting of said drill string therethrough, means to prevent relative rotation between said turbine rotor and rotating assembly while permitting longitudinal shifting therebetween whereby said rotating assembly may be lifted out of said turbine rotor and said housing, means to lock said rotating assembly against excessive axial shifting in said turbine rotor while permitting rotation of said rotating assembly, rotary seal means to effect a rotary seal between said rotating assembly and said housing, and passage means to introduce fluid into said housing and to said turbine rotor to effect rotation of said turbine rotor and thus of said rotating assembly.

2. The invention as claimed in claim 1, in which means responsive to fluid pressure within said housing are provided to effect said rotary seal when substantial fluid pressure is present in said housing and to release or remove said rotary seal when there is less fluid pressure in said housing.

3. The invention as claimed in claim 1, in which means are provided to effect fluid cooling of said bearing means by fluid introduced through said passage means.

4. The invention as claimed in claim 1, in which said lock means includes thrust rollers mounted upon radially movable elements for radial movement between locking positions in engagement with said rotating assembly and release positions disposed radially outwardly of said rotating assembly, and in which means are provided to shift said rollers between said locking and release positions.

5. The invention as claimed in claim 1, in which means are provided for association with said drill string to effect lifting of said rotating assembly out of said turbine rotor upon release of said lock means and despite the absence of sufficient friction between said packer member and said drill string to prevent relative longitudinal shifting therebetween.

6. A submarine drilling head and blowout preventer, which comprises a stationary housing adapted to be fixedly mounted at the floor of an ocean or other body of water, an outer drive sleeve disposed in said housing, upper and lower roller bearings seated between said housing and said outer drive sleeve to permit rotation of said outer drive sleeve about a generally vertical axis, a rotating assembly including a generally funnel-shaped stripper rubber adapted to fit sealingly around a drill string, said rotating assembly also including an inner drive sleeve having a portion adapted to seat upon a seat portion of said outer drive sleeve, generally vertical spline means provided on said outer drive sleeve and said inner drive sleeve to prevent relative rotation therebetween while permitting relative longitudinal shifting therebetween, means to effect a rotary seal between said inner drive sleeve and said housing to thereby cooperate with said stripper rubber in sealing off the annulus around said drill string, combination lock and thrust-bearing means mounted in said housing and including a plurality of roller members adapted to seat on a bearing surface of said rotating assembly, means to shift said rollers radially from a locking position adjacent said bearing surface to a release position disposed radially outwardly therefrom, turbine blade means provided on said outer drive sleeve to effect rotation thereof and thus of said rotating assembly upon introduction of fluid under pressure between said housing and said outer drive sleeve, and inlet means to introduce fluid under pressure into the space between said housing and said outer drive sleeve for impingement against said turbine blade means.

7. The invention as claimed in claim 6, in which pump means are provided for mounting on a drilling barge and are connected through hose means to said inlet means, said pump means being adapted to operate at a speed which is predetermined to effect rotation of said stripper rubber in the same direction as said drill string and at substantially the same speed.

8. In a rotating blowout preventer adapted to be employed at the floor of an ocean or other body of water, a housing, a rotating assembly including seal means to fit sealingly around a drill string, turbine rotor means connected to said rotating assembly to effect rotation of said seal means with said drill string, a rotary seal assembly to effect a seal between the peripheral part of said rotating assembly and said housing, said seal assembly being adapted to be fluid-pressure actuated into sealing condition subsequent to insertion of said rotating assembly into said housing, and fluid-pressure means to effect both rotation of said turbine rotor means and actuation of said rotary seal assembly to said sealing condition, in which said rotary seal assembly includes a plurality of sealing rings having tapered faces in engagement with each other, spring means to urge at least one of said rings to relatively small-diameter inoperative condition facilitating insertion of said rotating assembly into said housing, and piston-ring means responsive to fluid pressure within said housing to expand at least one of said sealing rings into operative condition against the bias of said spring means.

9. In a rotating blowout preventer, a housing, a rotating assembly including a packer member for a drill string, said rotating assembly being adapted to move longitudinally relative to said housing, and combination thrust-bearing and lock means to effect locking of said rotating assembly against excessive longitudinal shifting, said last-named means including a plurality of thrust-bearing rollers adapted to be shifted radially of said drill string against a bearing surface of said rotating assembly, and means to shift said rollers radially between said positions in engagement with said bearing surface and retracted positions disposed radially outwardly from said bearing surface to permit longitudinal shifting of said rotating assembly in said housing.

10. In a drilling head apparatus, a housing, a rotating element rotatably mounted in said housing and adapted to be shifted longitudinally into said housing and subsequently removed therefrom, a combination thrust-bearing and lock means to lock said rotating assembly against substantial longitudinal shifting in said housing while facilitating rotation thereof despite longitudinal thrust imposed thereon, said last-named means comprising a plurality of arcuate shoes disposed in a plane which is generally perpendicular to the longitudinal axis of said rotating assembly, generally radial bearing surface means provided on said rotating assembly, roller means provided on said shoes and rotatable about axes generally radial to said longitudinal axis, and means to shift said shoes and roller means radially between release positions disposed radially outwardly from said rotating assembly and locking and bearing positions at which said rollers are engaged with said bearing surface means.

11. The invention as claimed in claim 10, in which said bearing surface means of said rotating assembly forms a wall of an annular groove therein, in which said housing has an annular groove disposed radially outwardly from said annular groove in said rotating assembly, in which said shoes are adapted to be shifted radially between said annular grooves, and in which

thrust-surface means are provided on said shoes for bearing engagement with a radial wall of said annular groove in said housing during rolling engagement of said roller means with said bearing surface means of said rotating assembly.

12. In combination with a submarine drilling head including a housing and a rotating assembly adapted to rotate in said housing and to be shifted longitudinally into and out of said housing, said rotating assembly including a stripper rubber adapted to be in frictional and slidable engagement with a drill string disposed therein, key means adapted to be mounted in said drill string for lowering to said rotating assembly, and slot means provided in said rotating assembly for reception of said key means when said key means and said rotating assembly are at a first predetermined relative rotated position, whereby said key means may not be lifted out of said rotating assembly when said drill string and said rotating assembly are at a second predetermined relative rotated position.

13. The invention as claimed in claim 12, in which said key means comprises radial ear means on an insert adapted to be threaded into a joint of said drill string.

References Cited in the file of this patent

UNITED STATES PATENTS

369,869	Medrick	Sept. 13, 1887
661,664	Lane	Nov. 13, 1900
1,560,763	Collins	Nov. 10, 1925
2,333,847	Deely	Nov. 9, 1943
2,506,538	Bennett	May 2, 1950
2,628,852	Voytech	Feb. 17, 1953
2,886,350	Horne	May 12, 1959