Sept. 20, 1932. F. W. HILD 1,878,141

ROTARY DRILLING APPARATUS

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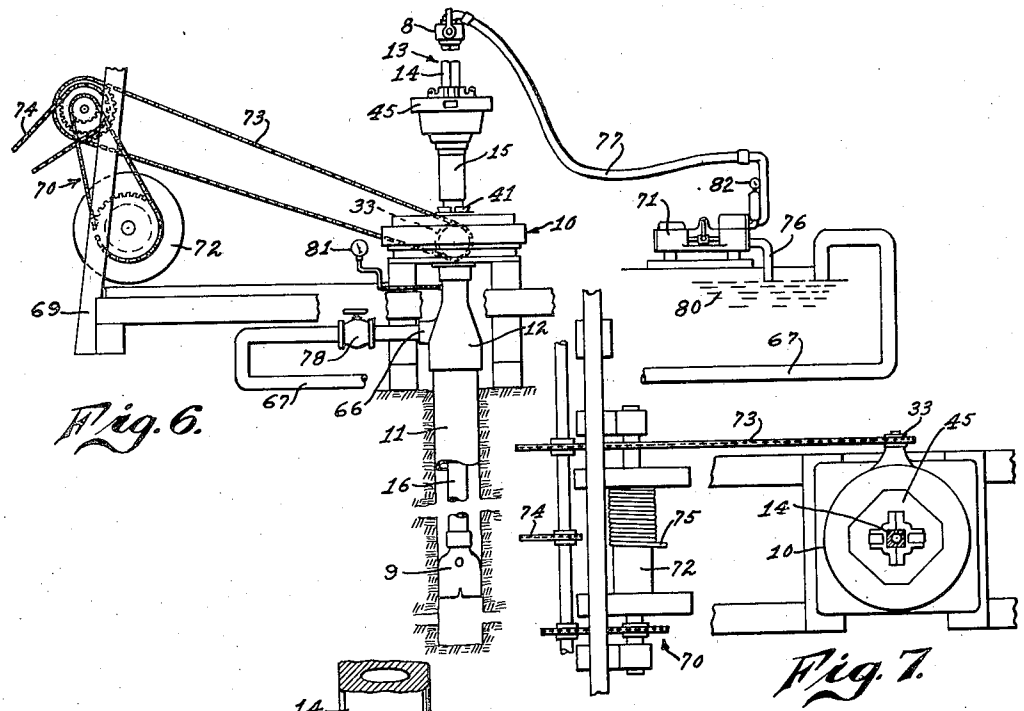


Fig. 6.

Fig. 7.

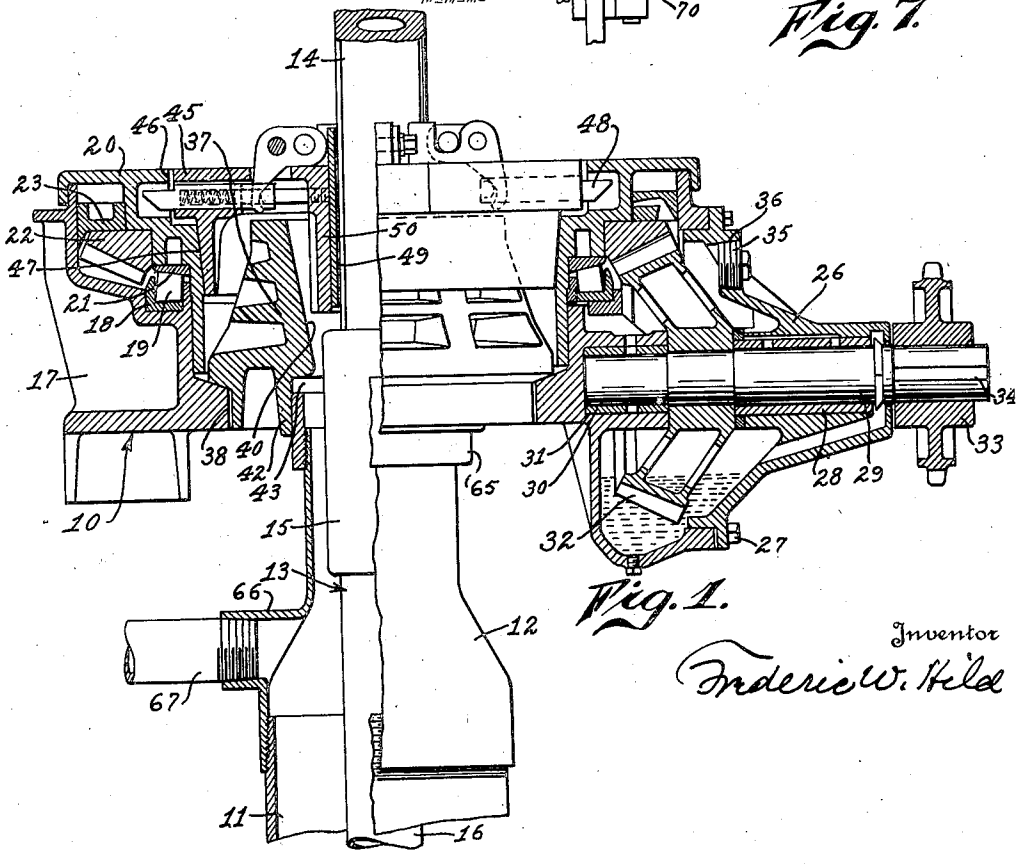


Fig. 1.

Inventor

Frederic W. Hild

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Fig. 3.

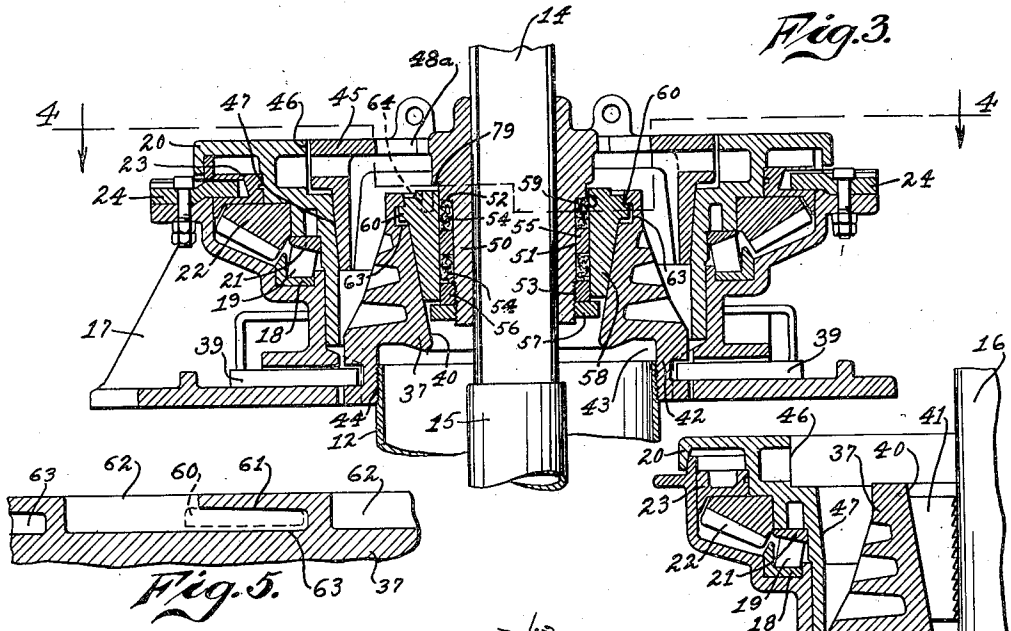


Fig. 5.

Fig. 2.

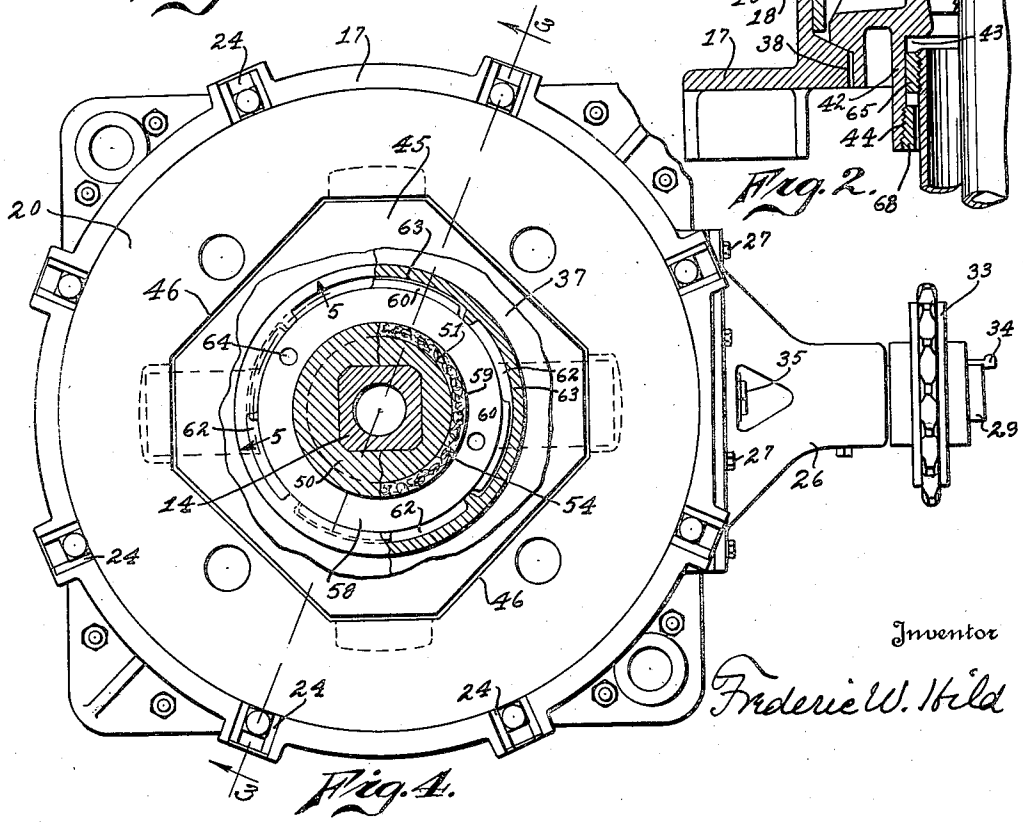


Fig. 4.

Inventor

Frederic W. Hild

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UNITED STATES PATENT OFFICE

FREDERIC W. HILD, OF LOS ANGELES, CALIFORNIA

ROTARY DRILLING APPARATUS

Application filed October 16, 1928. Serial No. 312,887.

My invention relates to the hydraulic rotary drilling system used in the petroleum and mining industries and appertains more particularly to the rotary machine used in that system.

In this system a power driven rotary machine commonly rotates a hollow drill string consisting of a swivel head, a square or fluted drill stem, a drill pipe and a bit, all suitably secured in seriatum. The rotary machine rotatably engages the drill stem which may move longitudinally through the machine. The drill string is usually suspended in a derrick and moved up or down by cables and suitable tackle blocks; or else the drill string is supported by suitable gripping means such as tapered serrated slips in the rotary machine. Both these suspending means are utilized when removing, changing or lengthening the drill string.

The swivel head is flexibly connected to a power driven hydraulic pressure pump, which forces mud fluid downward through the drill string, the mud discharging from the bit and returning upward outside the drill pipe and within the pipe or well casing which is inserted in the bored hole and usually cemented to the sides thereof. Suitable conduit connects the well casing with the mud pool which supplies the pump and the mud fluid is thus circulated. Among its several important functions, the weight of the mud serves to counteract the underground fluid pressures due to gas or other fluids, so that with suitable mechanical means, the mud fluid may be utilized to control the flow and the pressure of the subterranean fluids.

High fluid pressures are frequently encountered at comparatively shallow depths, and there are ample instances of wells during drilling becoming "wild" or out of control causing loss and damage and sometimes death or personal injury to the workers. The increasingly greater depths to which the wells of the petroleum industry must be bored, develop greater hazard and increasingly difficult drilling conditions, not only because of the higher fluid pressures that are encountered, but also the greater length and weight of the drill string requires drilling machinery suitable for the heavier and more exacting duty involved. My invention provides a rotary drilling machine which successfully meets these conditions.

Thus, one object of my invention is to provide a rotary machine which with the drill string, shall control the fluid pressures in the well, so that drilling may safely continue through the higher pressure formations.

Another object of my invention is to provide a rotary machine adapted to apply the weight of the drill string in addition to the column of mud in the well, in opposing the underground fluid pressures. Furthermore, still another object is to utilize with the foregoing, the weight and frictional resistance of the well casing in additional opposition to the upward pressure of the fluids in the well.

Another object of my invention is to provide a rotary machine adapted to be firmly secured to well casing in fluid contact therewith, in order to conduct the well fluid into the machine for controlling upward ejection of the fluid.

In my co-pending application Serial No. 13,049 filed March 5, 1925, I have described an enclosed protected rotary machine in which the gear pinion is mounted on the end of the drive shaft overhanging the shaft bearing within the enclosed machine; and in which the drive sprocket on the said shaft, is supported between the shaft bearings, one of said bearings being outside the enclosed machine; it is an object of my present invention to provide an improved enclosed protected rotary machine, in which the gear pinion shall be mounted on the drive shaft between bearings within the enclosed machine, and the drive sprocket shall be outside the machine—thereby ensuring greater strength and accuracy and more permanency of alignment of the working parts, and better operation of the machine.

In my said co-pending application I have shown a rotary machine employing a rotating drive bushing which is locked against upward displacement by latches which engage the drive bushing with the rotary table. It is an object of my present invention to pro-

vide an improved enclosed rotary machine in which the rotating drive bushing is held against upward displacement by engaging the bushing with a stationary member of the rotary machine and thereby relieve the bearings and gears of the machine from stresses and strains due to upward forces encountered during drilling.

Still another object of my invention is to provide a rotary machine adapted to be joined to the well casing with a flexible connection which is fluid pressure tight.

Other objects and advantages of my invention will be apparent from the following detailed description taken in conjunction with the drawings.

Figure 1 is a vertical section of my improved enclosed protected rotary machine taken through the driving pinion, shaft and sprocket, and shows the machine engaging the drill stem and connected with the well casing. In this view the drive bushing, which is the engaging member for rotating the drill stem,—is shown latched with the rotary table in the same manner as described in my aforesaid co-pending application Serial No. 13,049.

Figure 2 is a part vertical section of the rotary machine showing the drill pipe supported by taper slips in the stationary slip ring member of the machine which is connected with the well casing and in a manner to limit upward displacement of the connected members of the rotary machine.

Figure 3 is a vertical section of the rotary machine taken on the line 3—3 of Figure 4 and shows the machine engaging the drill stem and also connected to the well casing with fluid and pressure tight joints. In this view the rotary table latches are removed from the rotating drive bushing which is shown held against upward displacement by a packing connection with the stationary slip ring member of the machine.

Figure 4 is a plan view of the rotary machine showing a part section taken on the line 4—4 of Figure 3.

Figure 5 is a development of a fragmentary vertical section taken on the arc 5—5 of Figure 4 and illustrates the breech lock connection of the slip ring with the taper packing ring forming part of the aforesaid fluid tight connection.

Figure 6 shows in vertical elevation the rotary machine in a derrick and connected to the draw works and the well casing; also the drill string and the hydraulic mud pump.

Figure 7 shows a plain view of the rotary machine connected to the draw works.

Referring to Figures 1 and 2 the rotary machine 10 connects with the casing 11, of the casing top 12. The machine engages the drill string 13 which consists of the swivel head 8 (shown in Figure 6), the drill stem 14, the tool joints 15, the drill pipe 16 at the lower end of which is drill bit 9 (shown in Figure 6).

The machine 10 comprises the stationary base 17 which contains the race 18 and cone rollers 19 for radial and thrust bearing support of the rotary table 20. The table 20 contains the race 21 for bearing on the cone rollers 19. The ring gear 22 is shrunk tight onto the table 20 and serves as thrust bearing seat for the hold down ring 23 which is in segments for convenience of assembly, removal and adjustment. The hold down ring 23 is adjustably held in stationary relationship by the clamps 24 (shown in Figs. 3 and 4), which are bolted to the base 17. Thus the cone rollers 19 and the hold down ring 23 which are separated axially a substantial distance, provide ample radial and thrust bearing support for the rotary table 20 and prevent its lateral and axial displacement with respect to the base 17.

A bored opening in the side of base 17 receives a tight fitting one piece housing 26 which is further secured to the base by the bolts 27. This housing contains sleeve bearing 28 for radial and thrust bearing support of one end of shaft 29. Another sleeve bearing 30 is inserted in hole 31 which is bored in the base 17 below the race 18 in line with the axis of housing 26 and bearing 28; the other end of shaft 29 is supported in bearing 30. Between both said bearings, the pinion gear 32 is mounted on the shaft 29 and meshes with the ring gear 22. The outer end of shaft 29 projects beyond the housing 26 for the purpose of receiving the sprocket 33 which is firmly secured to the shaft by the feather key 34. A threaded opening 36 is bored in the housing 26 above the shaft, so as to afford inspection of the gears where they mesh and for pouring lubricant into the enclosed chamber formed by the base 17, the table 20 and the housing 26. A plug 35 is screwed into the opening 36 for totally closing the chamber.

The axis of rotation of table 20 constitutes the common axis of the drill string 13, the casing 11 and also the slip ring 37 and the drive bushing 45. The slip ring 37 is seated in base 17 in the circular opening 38 of base and is held against rotation by latches 39 (shown in Fig. 3) which fit loosely in holes or slots in the slip ring registering with holes in the base. A tapered hole 40, centering in the common axis, extends through the slip ring 37 for the purpose of receiving and seating the customary tapered serrated slips 41, when it is desired to grip and hold the drill pipe in the machine against downward displacement. Projecting downward from the main body of the slip ring is a hollow cylindrical portion 42 which forms the socket 43, the lower inner face of which may be threaded at 44 as shown in Figures 2 and 3.

The drive bushing 45 is seated in the rotary table 20 in the octagonal recess 46 and

the cylindrical center opening 47 of the table. The shape and contour of the outer sides of the drive bushing 45, correspond with the said recess and opening so that the table 20 limits the downward displacement of the drive bushing and drives it during rotation. Upward displacement is prevented by the latches 48 which lock the drive bushing to the rotary table.

The center portion 50 of the drive bushing 45 projects downward into the tapered opening 40 of the slip ring 37 but does not contact the slip ring. A square opening 49 through this center portion receives the drill stem 14 for rotating it and permits the drill stem to slide vertically through the drive bushing 45.

Referring to Figures 3, 4 and 5, the slip ring 37 and drive bushing 45 are connected together by a packing ring 58 with suitable glands. The latches 48 are removed from the drive bushings.

The center portion 50 of the drive bushing has a smoothly finished cylindrical outer surface 51 extending from the shoulder 52 to the thread 53 at the lower end of portion 50. The packing glands 54 and the follower ring 55 are fitted to the surface 51, and are adjusted to the proper fit by the packing nut 56 and the jam nut 57 which are on the thread 53.

The packing ring 58 has smooth inner bore 59 which fits over the follower ring 55 and packing nut 56, so that the glands 54 bear against the bore 59, and the packing ring and the drive bushing 45 may have rotative motion relative to each other. The jam nut 57 is larger in outside diameter than the bore 59 of the packing ring 58, whence the jam nut and the shoulder 79 on the central portion 50 of the drive bushing, limit relative axial movement.

The smooth conical outer surface of the packing ring fits tightly in the taper bore 40 of slip ring 37 when downward pressure is exerted on the packing ring. Such pressure is applied by the breech lock connection of the two members.

The packing ring 58 has tongues 60 projecting radially from its upper conical surface; the tongues 60 have upper faces 61 at a comparatively small angle with the plane of rotation. When lowering the combined drive bushing 45 and packing ring 58 into the slip ring 37, the tongues 60 are first inserted in the slots 62 at the top of the slip ring, and then the packing ring is rotated a few degrees, thereby moving the tongues into the grooves 63 which are extensions of slots 62. The under faces of the grooves 63 have the same angular relationship as the faces 61 of tongues 60, so that as the packing ring is rotated as above stated it also is forced downward, thereby seating the packing ring 58 firmly and tightly in the taper bore 40 of the slip ring 37. The latch opening 48*a* in the drive bushing 45 permits inserting a bar or rod into hole 64 of the packing ring 58 and thus utilizing the rotary table 20 and the drive bushing to impart the desired rotative movement to the packing ring for the purpose of locking it to the slip ring. The hole 64 may be threaded to receive a bolt for obstructing reverse movement of the packing ring if desired. Thus upon proper adjustment of the glands 54 by means of the nuts 56 and 57, it is evident that the drive bushing 45, the packing ring 58, and the slip ring 37 are firmly secured together in a fluid pressure tight joint which permits the drive bushing to rotate, and moreover to have adjustable axial movement with respect to the other members of the rotary machine.

Figures 1, 2 and 3 show the slip ring connected to the well casing.

In Figure 1, the casing collar 65 is threaded onto the upper end of casing top 12, and has a slideable fit with the socket 43 of slip ring 37. The casing top 12 is threaded onto well casing 11, and has a lateral projection 66 into which is threaded the pipe 67 for conveying the mud fluid from the well casing to the mud supply pool.

In Figure 2, the socket collar 68 has a sliding fit on the casing top 12 below the collar 65, and is screwed into the slip ring on the thread 44 of socket 43.

In both Figures 1 and 2, the casing top and the slip ring may have a limited axial movement with respect to each other. If as shown in Figure 2, the heavy drill pipe is supported in the slip ring by the taper slip 41, the great weight thus imposed may cause the rotary machine 10 to settle appreciably downward, depending upon the supporting provision for the rotary machine, such as the floor timbers of the derrick. The casing however would be immovable. But the space between the end of casing collar 65 and the horizontal face of the socket 43 of the slip ring will permit the required settling movement of the rotary machine.

In Figure 3 the slip ring 37 is screwed directly onto the casing top 12 at the thread 44. With a solid foundation such as concrete, there will be relatively little axial settling movement of the rotary machine. The slip ring having slight permissive movement in all directions except downward, may readily adjust and align its position, thereby providing the required flexibility in the connection, of the rotary machine with the casing.

Referring now to Figures 6 and 7, the rotary machine 10 is mounted on suitable supports in derrick 69 in which are placed the draw works 70, the mud pump 71, and the hoisting tackle (not shown) which hoists and lowers the drill string 13 or its constituent parts.

The sprocket 33 of the rotary machine is connected by chain 73 with a sprocket of the draw works. A motor (not shown) supplies power which is transmitted by the chain 74 to another sprocket of the draw works 70 for driving the rotary machine 10 and the hoist drum 72.

The power driven mud pump 71 receives mud fluid through the inlet pipe 76 from the mud pool 80 and forces the mud fluid through the flexible hose 77 which is connected with the swivel head 8 of the drill string 13. The mud fluid discharges from openings in bit 9 of the drill string and flows upward within the casing 11 to the lateral outlet 66 of the casing top 12, thence through pipe 67 to the mud supply pool 80. A valve 78 in pipe 67 regulates the discharge of the mud fluid from the well casing. A gauge 81 connected to the casing top 12 shows the fluid pressure exerted against the rotary machine members. A gauge 82 at the pump 71 shows the mud fluid pressure to the drill string.

The cable 75 which is wound on the hoist drum 72, loops through the tackle blocks (not shown) to which the swivel head 8 of the drill string 13 is secured. The drill string is shown as having been raised by the hoisting equipment, so that the bit 9 is "off bottom" of the bored hole and the drive bushing 45 is lifted from its seat in the rotary machine and is resting upon the tool joint 15 which is attached to the drill stem 14. The drill pipe 16 is gripped by the taper slips 41, which as illustrated in Figure 2, are wedged in the taper bore 40 of slip ring 37. Thus the drill string 13 is supported by the rotary machine 10.

Figures 6 and 7 illustrate several possible operations during drilling. Thus for the several arrangements disclosed in the drawings,—the drill stem may be removed preparatory to lengthening the drill pipe or changing the bit, or the change may have been made and the drill string is about to be lowered by the hoisting equipment upon removal of the slips 41.

Or considering Figures 1 and 2, the bit may have entered a high gas pressure horizon which the mud column in the well cannot hold. Then upon supporting the drill string in the rotary machine as shown in Figures 2 and 6, the upward pressure of the fluid in the well is opposed by the combined weight of the drive bushing 45, the slip ring 37 and the entire drill string 13, in addition to the weight of the column of mud in the well. The closure at the rotary machine will compel discharge of the fluid through the pipe 67, so that by means of valve 78 and pump 71, the driller can regulate and control the well pressures. Meanwhile, by increasing the specific gravity of the mud fluid, the column of mud in the well can be made heavier to meet the requirements.

In the event that high gas or hydrostatic pressure be encountered underground, sufficient to threaten blowing out the drill pipe as well as the mud fluid, then in Figure 2, upward movement of the slip ring 37 would be checked by the socket collar 68 on the slip ring intercepting the casing collar 65, whereupon the great weight and frictional resistance of the well casing would prevent further movement. However, should the upward pressure be sufficiently great to force the slips 41 and the drill pipe from their seat in the slip ring 37, then the arrangement disclosed in Figure 3 fulfills the requirements, without lifting the drive bushing from the rotary table.

Underground fluid pressure upwardly exerted would encounter the closed, fluid tight connection of the well casing and the rotary machine. Should the pressure be sufficient to raise the drill string, the upward movement of the latter would stop when the tool joint 15 attached to the drill stem 14, encounters the drive bushing 45. In Figure 3, the upward force of the fluid pressure in the well casing would be opposed by the combined weight of the drive bushing, the packing ring, the slip ring, the drill string and the well casing and also by the enormous frictional resistance of the well casing due to its anchorage in the earth.

With the drive bushing 45 and the slip ring 37 connected together as disclosed in Figure 3, and the casing top 12 connected to the slip ring as disclosed in either Figure 2 or 3, and with the drill string 13 rotatably engaged at the drill stem 14 by the rotary machine, the driller by means of the pump 71 and the valve 78 can regulate and control the well pressures, without interferring with the rotation of the drill string. Thus, with the pump 71, the driller can force heavier mud from supply pool 80 into the well and thereby counteract and diminish the upward pressure of the subterranean fluids; and by varying the opening of valve 78 he can regulate the fluid discharge from the well. The gauges 82 and 81 by showing him respectively the pump pressure and the discharge pressure at the casing top will guide him in this operation.

The drillers, their work and the well drilling operations are further benefited by my rotary machine, in which the gears and all of the bearings are protectively enclosed so as to exclude mud and other foreign materials while all of the bearings and gear are automatically lubricated by a common distributing system. Although I have illustrated sleeve bearings the novel arrangement may use roller bearings of the spherical, cylindrical or conical type. The novel method of supporting the drive shaft with the pinion between the bearings ensures the maximum of strength, of accuracy and per-

manence of alignment,—with the minimum of friction.

Although I have described several specific embodiments of my invention, it will be obvious to those skilled in the art, that various modifications may be made in the details of construction, the general arrangement, the association of the several co-operating parts and the application of my invention without departing from the spirit thereof or the principles herein set forth.

I claim as my invention:

1. In combination: well casing, and a rotary drilling machine having means for securing the machine in a fluid tight connection to the casing in a manner to prevent separation of the machine from said casing.

2. A control head for well casing, said control head consisting of: a casing outlet member, and a rotary drilling machine secured in a fluid tight connection to said member in a manner to prevent separation of said machine from said member.

3. A rotary drilling machine containing a stationary member adapted for fluid conducting connection with well casing, a bushing and means for locking the bushing to the stationary member in fluid tight, rotatable connection.

4. In a rotary drilling machine having a member adapted to receive tapered slips, the combination of: said member, a bushing rotatable in said member, and means including packing for uniting said member and said bushing.

5. In combination with a stationary well casing and a drill string, a rotary drilling machine secured to the casing by a fluid tight connection having means for limiting axial movement between the casing and the rotary machine beyond a set limit.

6. In combination with a stationary well casing and a drill string, a rotary drilling machine secured to the casing and forming therewith a fluid tight chamber for the reception of a fluid, said rotary machine being secured to the well casing by a fluid tight connection having means for limiting axial movement between the casing and the rotary machine.

7. In combination: a drill string having an angular faced drill stem, casing for conducting fluid from a well, a rotary drilling machine secured to said casing and engaging the angular faces of the drill stem, said machine containing means for preventing ejection of said drill stem.

8. A rotary drilling machine having a rotary table, a drive bushing locked to said table, a stationary member adapted to be secured to a well casing, and packing means between said stationary member and the drive bushing.

9. A rotary drilling machine having a rotary table locked therein against axial upward movement, a drive bushing locked to said table, a stationary member adapted to be secured to a well casing, and packing means between said stationary member and the drive bushing.

10. A rotary drilling machine having a rotary table locked therein against axial upward movement, a drive bushing locked to said table, a stationary member adapted to be threaded to a well casing, and packing means between said stationary member and the drive bushing.

11. A rotary drilling machine having a rotary table, a drive bushing in said table, said drive bushing having a depending sleeve adapted to embrace a kelly stem, a stationary member spaced from and concentric with said sleeve, said stationary member being adapted to be threaded to a well casing, and packing means between the stationary member and the depending sleeve.

12. A rotary drilling machine having a rotary table, a drive bushing locked to said table, said drive bushing having a depending sleeve adapted to embrace a kelly stem, a stationary slip ring extending into the machine in spaced concentric relation with said sleeve to define therewith an annular space, said stationary member being adapted to be threaded to a well casing, and packing means in said annular space.

13. In combination: well casing, a rotary drilling machine, and means concentrically disposed within said machine for connecting said rotary machine with said casing, said machine including a rotatable drive bushing in fluid tight relation with said casing and said means.

14. In combination: well casing, a rotary drilling machine, and means comprising a slip ring for connecting said rotary machine with said casing, said machine including a rotatable drive bushing in fluid tight relation with said casing and said means.

In testimony whereof, I have hereunto set my hand at Los Angeles, California, this 4th day of October, 1928.

FREDERIC W. HILD.