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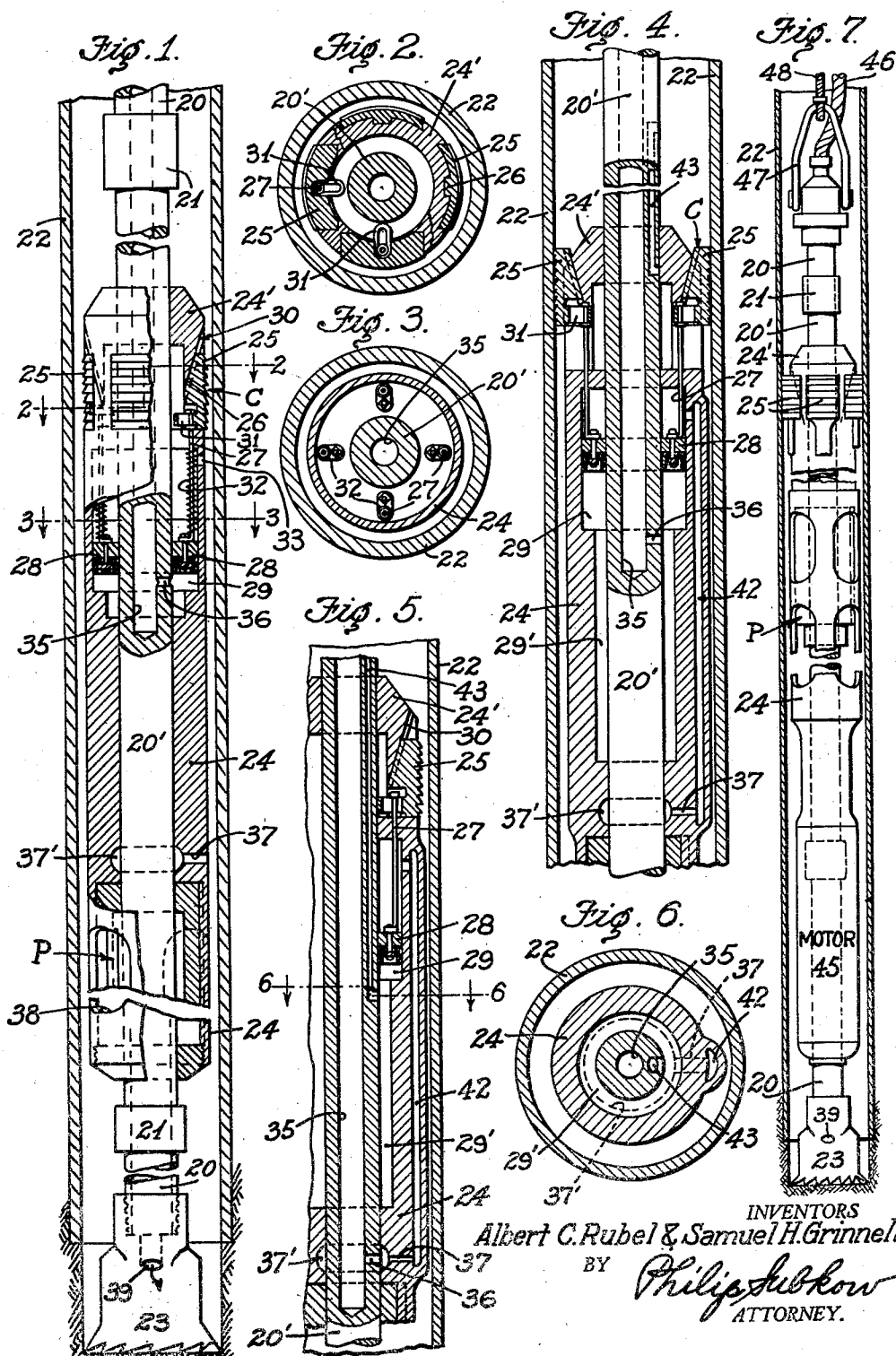
S. H. GRINNELL ET AL

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DRILLING STRUCTURE AND CIRCULATING PUMP

Filed Oct. 4, 1932

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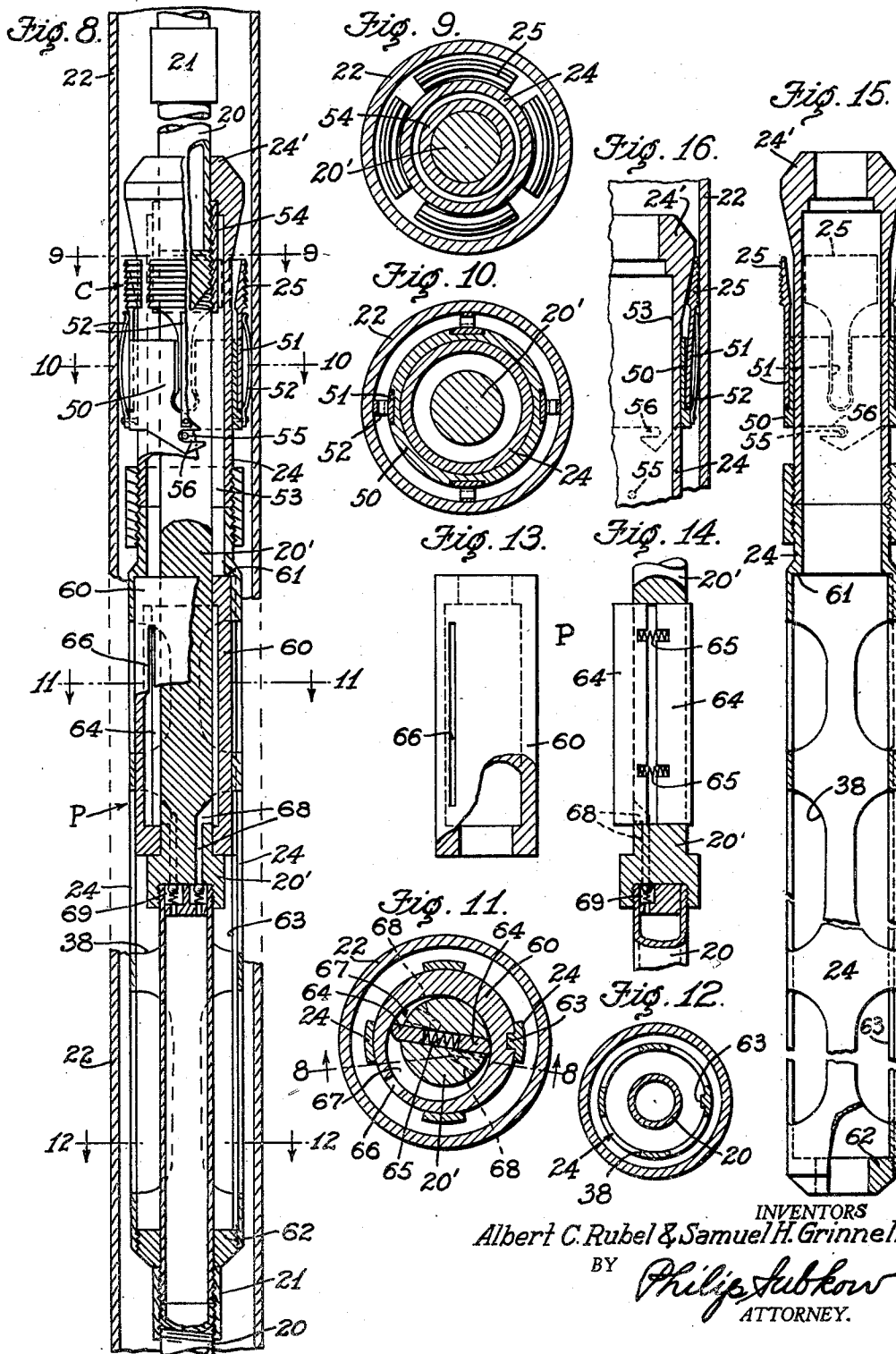
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UNITED STATES PATENT OFFICE

1,983,287

DRILLING STRUCTURE AND CIRCULATING PUMP

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Application October 4, 1932, Serial No. 636,134

11 Claims. (Cl. 255—1)

This invention has to do with apparatus employed in the rotary drilling of deep wells such as oil wells, and is especially related to pumping equipment employed for circulating the usual drilling mud or other drilling fluid in certain instances where only a relatively small head of such drilling fluid is employed in the bottom of the hole being drilled.

According to normal drilling procedure, it is customary to circulate a heavy drilling mud down through the drill stem which carries the drill bit and up outside thereof to the surface so that the circulating mud serves to elevate the cuttings and discharge them from the well. In some cases however such a high head of drilling mud is objectionable for the reason that it tends to seal up the formation being penetrated and cause oil producing zones to be drilled through without knowledge of their penetration. It is therefore desirable in these instances to employ a low head of drilling fluid insufficient to seal the producing formations, and to circulate such drilling fluid locally in the vicinity of the bit. Such local circulation will here be designated as "sub-circulation". In this connection any of several well known expedients may be employed for removal or segregation of the cuttings from the fluid.

A desirable structure for purposes of such sub-circulation includes a rotary pump, and the present invention comprises the combination of a drill bit and a pump with means such as a clutch device adapted for locking a pump-retaining barrel or cage in a non-rotatable position in the lower end of a well casing below which drilling is being accomplished, whereby the pump housing is held against rotation. The invention includes such a combination wherein the non-rotatable pump housing is vertically movable in the cage or barrel so that the pump may advance with the drill bit while the cage is locked upon the well casing. The particular form of pump may be varied; a rotary pump having laterally reciprocating blades and an eccentric housing such as herein disclosed may be satisfactorily employed. The clutch mechanism may be either mechanically or hydraulically actuated, and such actuation may be effected either through the medium of the drill stem or through a hose or line. Similarly the pump may be driven either through the medium of the drill stem or through the medium of a motor submerged with the pump. Thus, in the preferred form the bit and the pump will be driven by a drill stem extending to the surface, the

drill stem itself being employed as a means to release the clutch mechanism and to cause it to engage the inner walls of the casing in which the drill stem works so that said clutch will support a pump-retaining cage in a fixed, non-rotative, suspended position, the drill bit extending downward and protruding in operative position below the lower end of the casing. Or where the drill stem is employed the clutch may be pneumatically operated by air or gas supplied through the drill stem. The invention comprises not only the combination of a drill bit, a rotary pump actuated by the drill stem and means controlled by the drill stem for engaging the casing and positioning the pump as desired, but also other modifications as disclosed herein. The invention also comprises the method of procedure herein disclosed wherein the pump and bit are both driven by the drill stem and the drill stem is actuated to move the pump and its housing down in the well at intervals.

In the accompanying drawings wherein certain embodiments of the invention are disclosed by way of illustration:

Fig. 1 is primarily a vertical sectional elevation showing a combination of a drill stem, a bit, a rotary blade type pump and a pneumatically operated clutch mechanism for positioning and supporting in the well casing a cage or barrel slidably receiving the pump;

Figs. 2 and 3 are cross sections taken respectively on the lines 2—2 and 3—3 of Fig. 1;

Fig. 4 is a vertical sectional detail showing a modified form of pneumatic control for the clutch, the clutch being shown in operative position;

Fig. 5 is a vertical sectional detail showing the clutch mechanism of Fig. 4 in retracted position;

Fig. 6 is a cross section on the line 6—6 of Fig. 5;

Fig. 7 is chiefly an elevational view of a form wherein the pump and bit are driven by a submerged electric motor, the pump cage and motor housing being adapted to be anchored in the well casing by a clutch mechanism pneumatically actuated by air pressure delivered through a hose, the clutch being controlled according to the form of either Fig. 1 or Fig. 4;

Fig. 8 is chiefly a vertical sectional elevation wherein the bit and pump are driven by a drill stem and the clutch is mechanically controlled by movement of the drill stem, the pump being shown in greater detail than in Fig. 1;

Figs. 9, 10, 11 and 12 are cross sections taken

respectively on the lines 9—9, 10—10, 11—11, 12—12 of Fig. 8;

Figs. 13, 14 and 15 are vertical sections taken respectively through the pump housing, the drill stem with its pump blades, and the cage and clutch mechanism of Fig. 8; and

Fig. 16 is a fragmentary vertical section showing the clutch mechanism of Figs. 8, 9 and 15 in operative engagement with the well casing.

Considering the form of Figs. 1 to 3, the usual drill stem 20 comprises various parts connected by couplings 21, this drill stem depending within the usual well casing 22 and carrying on its lower end any suitable drill bit 23. An intermediate section 20' of the drill stem also acts as a drive shaft for a rotary pump generally indicated at P, more fully shown in Figs. 8 to 15 and there described. The intermediate stem section 20' through the agency of the lower coupling 21 also serves to support a cage or barrel 24 which slidably receives pump P in its lower portion and carries at its upper end clutch mechanism generally indicated at C.

The upper end of cage 24 is in the form of a head 24' which is channelled to slidably receive a plurality of clutch jaws 25 non-rotatably mounted by means of splines 26 as best seen in Fig. 2. Each of the jaws 25 is connected with an actuating rod 27 which extends downward and is connected with an annular piston 28 positioned in an annular chamber 29 formed in the cage 24 and having its inner walls defined by the walls of the drill stem section 20'. The clutch jaws 25 travel on inclined faces on the head 24' as indicated at 30 in Fig. 1. In order to accommodate the corresponding lateral motion any sliding connection between the respective jaw 25 and the rod 27 may be employed such as the apertured inwardly extending arm 31 carried by each jaw. The rods 27 work in vertical passages formed in a transverse wall which determines the upper end of the chamber 29, and for purposes of retraction of these rods and the clutch jaws 25 at certain times expansion springs 32 are mounted about the rods, their upper ends bearing against said upper wall. This chamber 29 may be vented through a lateral port 33.

Actuation of the clutch jaws 25 is therefore to be effected through the medium of the annular piston 28, and this is produced by means of air applied under pressure through a bore 35 extending longitudinally down through the drill stem to an intermediate point in the section 20'. Adjacent this point a port 36 is provided through the side of the section 20' for purposes of communication either with the portion of the chamber 29 below the piston 28 or with a port 37 provided through the cage 24 at a point considerably below the chamber 29 but above the pump P, this port leading from an annular passage 37' which insures communication between ports 36 and 37 regardless of the radial position of port 36.

In the operation of Figs. 1 to 3 the drill stem with its bit 23, cage 24, pump P and clutch mechanism C is lowered into the well casing 22 until the drill 23 reaches the point below the lower end of the well casing at which drilling operations are to proceed. In the lower end of the well there will be a quantity of drilling fluid such as the typical drilling mud, oil or the like, which will extend at least to a point above the pump P and as much higher as desired. In order to drive the pump whose housing is lon-

gitudinally but non-rotatably slidable in the cage 24, it is necessary to lock the cage 24 with respect to the casing 22 to prevent rotation of said cage and pump housing. At this time the cage 24 is resting upon the lower coupling 21, which places the port 36 in communication with that part of chamber 29 below piston 28. Air under pressure is then applied through the bore 35 of the drill stem 20 with the result that the annular piston 28 is forced upward. This action causes the rods 27 to force the clutch members 25 upward and outward along the inclined guide faces 30 to bring the teeth of the clutch members 25 into engagement with the inner walls of the well casing 22, which is the same position as that shown in connection with the slightly modified form of Fig. 4. Drilling may now proceed and as the bit 23 advances the clutch parts 25 bite sufficiently into the walls of the casing 22 to leave the cage 24 and contained parts suspended in the well casing and held therein against rotation. As rotation of the drill stem 20 is continued for purpose of rotating the drill bit 23, the rotary element of the pump P (hereinafter described) is driven and a circulation of the drilling fluid is effected, this fluid being taken into the pump through apertures 38 in the cage 24 and discharged downward through the lower sections of the drill stem 20 to the bit 23 through the outlet port 39 therein as indicated.

Drilling is continued until the port 36 in stem section 20' comes into registry with the annular groove 37' and port 37. This connects the bore 35 in the drill stem with the well hole, thereby discharging the air to the well and resulting in a sharp drop in pressure which will be indicated at the surface of the well and will be employed as a signal that the cage carrying the pump is to be reset at a lower position. The air is then shut off from the drill stem and the stem is lifted to cause the lower coupling 21 thereon to butt against the lower end of said cage 24 and elevate the same sufficiently to cause release of the jaws 25 from their gripping engagement with the well casing. This relative position of the drill stem again brings the port 36 into communication with the lower portion of the chamber 29 below the piston 28 so that pressure in said chamber is released through the bore 35. Having been released, said jaws are returned to their lowermost and retracted position through the medium of the springs 32 which at the same time serve to depress the annular piston 28.

In this relation the cage 24 is now in the original starting position resting upon the lower coupling 21, which enables the drill stem and all the associated structure to be lowered farther into the hole. When the bit reaches the bottom of the previously drilled portion of the hole or when it has been lowered approximately to said bottom, the high pressure air is again applied to the bore 35 of the drill stem, thereby again actuating the piston 28 and causing the jaws 25 to lock upon the well casing 22. Further drilling and local circulation of the mud by the pump P may then proceed.

In the form of Figs. 4, 5 and 6 provision is made for the automatic release and resetting of the jaws 25 of the clutch C, so as to cause the cage 24 to follow the drill down in an automatic fashion. Here the annular chamber 29 is provided with a reduced lower extension 29' which extends downward into the vicinity of the port

37, and a channel 42 provided along the outer side of the cage 24 connects said port 37 with port 33 in the upper portion of chamber 29 above piston 28. The springs about the rods 27 may be eliminated. With this form the jaws 25 will be set as before and drilling will proceed until the port 36 registers with port 37 whereupon the high pressure air in the bore 35 will be transmitted through channel 42 to the upper side of the piston 28, such full applied air pressure tending to return piston 28 to its lower position and to retract the jaws 25 through the medium of the rods 27. In order to vent the lower portion of the chamber so that the pressure applied above piston 28 may function to return the latter, a venting by-pass 43 is provided in an upper portion of the drill stem section 20' in such relation that, when port 36 registers with port 37, the lower end of said by-pass 43 will communicate with the lower portion of the chamber 29 and cause the pressure to be vented into the well at a point above the head 24' of the cage. This relation of parts is illustrated in Fig. 5. With sufficiently high air pressure the bite of the jaws 25 will be broken, and the cage 24 will automatically drop until it rests again upon the lower coupling 21. As the cage 24 drops, port 36 will come into communication with the lower portion of the extension 29' of the annular chamber 29 tending to build up pressure therein to again elevate the piston 28, and during the same early portion of the movement the by-pass 43 will in part vent the portion of the chamber 29 above the piston 28. But as movement continues, by-pass 43 will move upward beyond said chamber portion so that the air trapped therein will serve to cushion and retard upward motion of piston 28. This retarding effect is assisted by reason of the fact that the capacity of the lower chamber portion 29' is of sufficient magnitude to require an appreciable interval for pressure to be built up therein sufficient to move the piston 28 far enough to bring the jaws 25 into casing-engaging position. Leakage past the rods 27 of the air trapped above piston 28 is slow enough to permit the cage 24 to have dropped until it reaches collar 21 before the jaws 25 are reset. When the piston 28 finally rises sufficiently, the jaws 25 will be reset so that drilling may continue and the operation of the pump to circulate the drilling fluid may function in conjunction therewith. In cases where the cage is sufficiently light so that its dropping upon the coupling 21 offers no objection, this structure is satisfactorily employed.

Instead of driving the bit and pump from the drill stem 20 as in the forms of Figs. 1 to 6, these parts may be driven by an electric motor 45 as indicated in Fig. 7 whose housing is rigidly connected with the cage 24. In this case the actuation of the jaws 25 by the piston 28 is effected through the application of air to the drill stem section 20' by way of a hose 46, the whole equipment being handled through the medium of a bail 47 supported by cable 48 running to the surface. Thus the locking of the clutch jaws 25 upon the casing 22 serves to lock both the cage 24 and the motor housing 45 against rotation, so that the rotor of the motor effects rotation of both the bit 23 and the pump P.

Figs. 8 to 15 disclose a form wherein the jaws of the clutch are mechanically controlled, and these figures also show the details of the rotary pump P which has been used with all forms. Here

the cage 24 carries pump P and the clutch as in the other form, but the clutch jaws 25 instead of being mounted in the head 24' are mounted upon a carrier sleeve 50, slidable upon the outer wall of the cage 24. The jaws 25 have downwardly extending arms 51 which may be loosely mounted as indicated and which are retained in their mounting by means of curved leaf springs 52 which perform the double function of retaining the arms of the jaws and of frictionally engaging the inner walls of the casing 22 when the device is lowered into the well. Movement of the clutch sleeve 50 and the clutch jaws 25 into operative position is here effected by rotation of the drill stem 20. The drill stem extends into the head 24' and is connected with the intermediate solid section 20' by means of a coupling 54 which is adapted to reciprocate within an annular space 53 in the cage 24 above the pump P. The cage 24 carries a pin 55 which engages in a slot 56 formed by a tongue on the lower end of the sleeve 50. By elevating the drill stem to bring the coupling 54 up into the upper end of the space 53 in the head 24' said coupling 54 may be made to act in conjunction with head 24' so as to serve as a clutch to rotate the cage 24. By then rotating the drill stem to the left the pin 55 is withdrawn from said slot 56, the sleeve 50 being held against rotation by reason of the frictional engagement of the bowed springs 52 against the inner walls of casing 22. The drill stem 20 will then be lowered and will carry the cage 24 downward with it, but the frictional engagement of the springs 52 will cause the sleeve 50 to be retained substantially in the original position until the tapered walls 30' of the head 24' engage the inner corresponding walls of the clutch jaws 25, whereupon said jaws 25 are forced outward into engagement with the casing and caused to bite thereinto with sufficient force to suspend the entire cage upon the inner walls of the well casing 22. This movement places the pin 55 below the sleeve 50 as indicated in Fig. 16. Drilling may now proceed by rotation of the drill stem, the cage 24 being held against rotation by jaws 25.

At the same time the pump P is caused to function to circulate the mud standing in the well hole and to force it down through the lower portion of the drill stem and past or out of the bit to clear cuttings away from the bit.

The pump P is shown in assembled relation in Figs. 8, 11 and 12 and in exposed form in Figs. 13, 14 and 15. The pump proper comprises a housing 60 (Fig. 13) through which the drill stem section 20' passes. This housing is vertically reciprocable in the cage 24 between the shoulders 61 as an upper limit and the lower head 62 which closes the lower end of the cage (Fig. 8). Rotation of the housing 60 in the cage 24 is prevented by reason of the spline connection indicated at 63, this spline extending continuously down one of the longitudinal ribs positioned between the openings 38 in said cage 24. The pump housing 60 is eccentrically bored as best shown in Fig. 11 for cooperation with a pair of blades 64 mounted in a transverse slot extending longitudinally in the stem section 20'. These blades are urged into engagement with the inner walls of the housing 60 by reason of springs 65 which insure the necessary contact, the position of the blades changing as the stem 20' rotates, such change in position resulting in a transverse reciprocation of blades through the

slot in the stem. At one side the housing 60 is provided with an intake slot 66 which extends vertically and serves to supply to the housing the drilling fluid which enters from the well through the openings 38 in the cage. As the drill stem rotates the fluid which is trapped by the blades 64 as they pass the intake slot 66 is forced by reason of the contraction of the pump chamber 67 through discharge ports 68 formed in the stem section 20' adjacent the lower end of the blade 64, which ports extend downward to the end of said section 20' and there communicate with the upper end of the hollow drill stem sections 20 which lead by way of the lower coupling 21 to the drill bit 23 as in Fig. 1. Ball check valves and retainers indicated at 69 may be employed to prevent return through the ports 68. The mud continues down to the discharge port 39 and is discharged therefrom to clear the cuttings away from the drill teeth. This rotary pump thus operates eccentrically after the fashion of the usual rotary type blade pump in which the blades reciprocate laterally through a drive element.

In operation of this pump, as the drill bit advances and the cage 24 is left suspended in the casing 22, the pump housing 60 slides downward on the spline 63 and the drilling is continued approximately until said pump housing 60 reaches the head 62 closing the lower end of said cage 24. At this time it is necessary to reset the cage and pump for future drilling of a further distance. To accomplish this end the drill stem and bit are lifted into their original position with respect to the cage 24, that is, until the lower coupling 21 strikes the under side of the head 62. The continued elevation of the drill stem then causes the head 24' of the cage to be lifted from the clutch jaws 25 and the pin 55 to engage the under edge of the sleeve 50. This movement in conjunction with the springs 52 causes retraction of the jaws 25 from their casing-engaging position of Fig. 16 so that they assume again the position of Fig. 8. In order that the sleeve 50 and the jaws 25 may be forced farther down into the casing against the friction of the springs 52, the drill stem must be rotated to the right until the pin 55 enters the slot 56. Thereafter, upon lowering the drill stem 20 the pressing of the pin 55 upon the tongue forming the slot 56 forces the sleeve 50 and the jaws 25 down along with the stem and the cage 24. Resetting of the cage in the jaws 25 is accomplished by repetition of the steps of releasing the pin 55 and further lowering of the drill stem and the cage as above described. A further amount of drilling represented by the amount of travel of the pump housing 60 in the cage 24 may then be allowed without a further resetting of the clutch C.

Of course where the casing 22 in any of these forms is being lowered approximately along with the descent of the drill bit, a resetting of the cage and the clutch is not required except at such times as it is necessary to withdraw the parts from the hole as for the purpose of renewing the drill bit 23, or for bailing out cuttings which accumulate in the drilling fluid. When desired the bailing of the drilling fluid to remove cuttings may be avoided by employment of any known or preferred trapping means for gradual accumulation of the cuttings during drilling.

From the foregoing it will be apparent that the provision of a clutching device such as here

disclosed upon any barrel or cage or other means which reciprocably but non-rotatably carries the pump housing, renders it convenient to employ a sub-circulating pump on the lower end of the drill stem in the vicinity of the bit for circulation of drilling fluid in all cases where a low head of drilling fluid is employed. This is particularly true in such cases as here disclosed wherein a pump, such as the rotary type blade pump hereof, is driven through the agency of the drill stem. It will be understood that in all cases the head of fluid in the well will rise at least to the intake slot 66 provided in the pump housing 60. This insures a continuous circulation of mud or other drilling fluid which enters the structure through the openings 38 in the sides of the cage 24 and passes through the slot 66 and pump housing 60 to be trapped by the blades 64 of the rotary pump and forced by them from the pump chamber 67 downward through the discharge passages 68 past the check valve 69 into the lower drill stem sections 20 and thence into the vicinity of the teeth of the drill bit by way of the discharge port 39 (Figs. 1, 8, 11 and 14). In these instances the clutch actuating means may be mechanical, pneumatic, or hydraulic.

It is to be understood that the disclosures here made are merely illustrative of the generic invention and that they are not to be considered as limiting upon applicant's claim.

We claim:

1. In combination a well casing, a drill stem depending therein, a bit carried by the lower end of said stem, a pump carried by the stem above the bit, said pump including a housing, a cage positioned about said stem and pump, said housing being non-rotatably and axially slidable in said cage, and means carried by the cage and adapted to engage said well casing for anchoring the cage and pump housing against rotation therein.

2. A structure according to claim 1 wherein the pump comprises a rotary part working within said housing, said part being connected in driving relation with said stem.

3. In combination a well casing, a drill stem depending within said casing, a drill bit on the lower end of said stem, a pump carried by the lower end of said stem, said pump including a housing and a movable member within the housing, and said movable member being reciprocable within the housing, and means connected with said housing adapted to anchor the latter within the well casing.

4. A well drilling structure comprising a drill stem, a drill bit carried by the lower end of said stem, a rotary pump connected with said stem, said pump comprising a rotary member mounted on the stem for rotation thereby, a pump housing in which said rotary member operates, a barrel in which said pump housing is splined, and a clutch mounted on said barrel and adapted to engage a well casing in which the structure is suspended to anchor said barrel.

5. A structure according to claim 4 wherein the drill stem below the pump has a passage therethrough communicating with the bit and wherein the pump housing and the barrel have ports therein communicating with the exterior of the barrel for the circulation of fluid past the bit and wherein the clutch is adapted to engage any portion of the well casing to suspend the structure in any position therein.

6. A structure according to claim 4 wherein

the clutch comprises a plurality of jaws, a sleeve carrying said jaws, means carried by the sleeve adapted to engage the well casing tending to resist motion of the sleeve and a dis-engageable driving connection between the barrel and the sleeve permitting the barrel to move the sleeve when in one position and to expand said jaws when the barrel is in another position with respect to the sleeve.

7. A structure according to claim 4 wherein the clutch includes casing-gripping means movable on the barrel, means on the barrel to actuate said gripping means when the barrel is in one position with respect to said gripping means, and a pin and slot connection between said barrel and gripping means for bodily movement of the gripping means when the pin and slot are in engaging position.

8. A structure according to claim 4 wherein the clutch is a fluid actuated clutch.

9. A structure according to claim 4 wherein the clutch comprises jaws adapted to grip the casing, a piston connected with said jaws, said drill stem containing a fluid passage adapted for

the application of fluid under pressure to actuate the piston and jaws.

10. A structure according to claim 4 wherein the clutch comprises means for gripping the casing, a piston connected with said gripping means, said barrel having a cylinder in which said piston moves, a passage in said drill stem for applying an actuating fluid to said piston at one side to move the gripping means into casing engagement position when the drill stem is in one relative position, and a passage for applying fluid pressure to the other side of the piston for automatic release of said jaws when the drill stem is in another position relative to said barrel.

11. In combination a drill stem, a bit carried at the lower end thereof, a cage slidably mounted on the drill stem, a clutch carried by the cage and adapted to engage and anchor on a well casing, and relatively slidable pump parts carried by the cage and the drill stem and actuable by the latter.

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