

Nov. 27, 1962

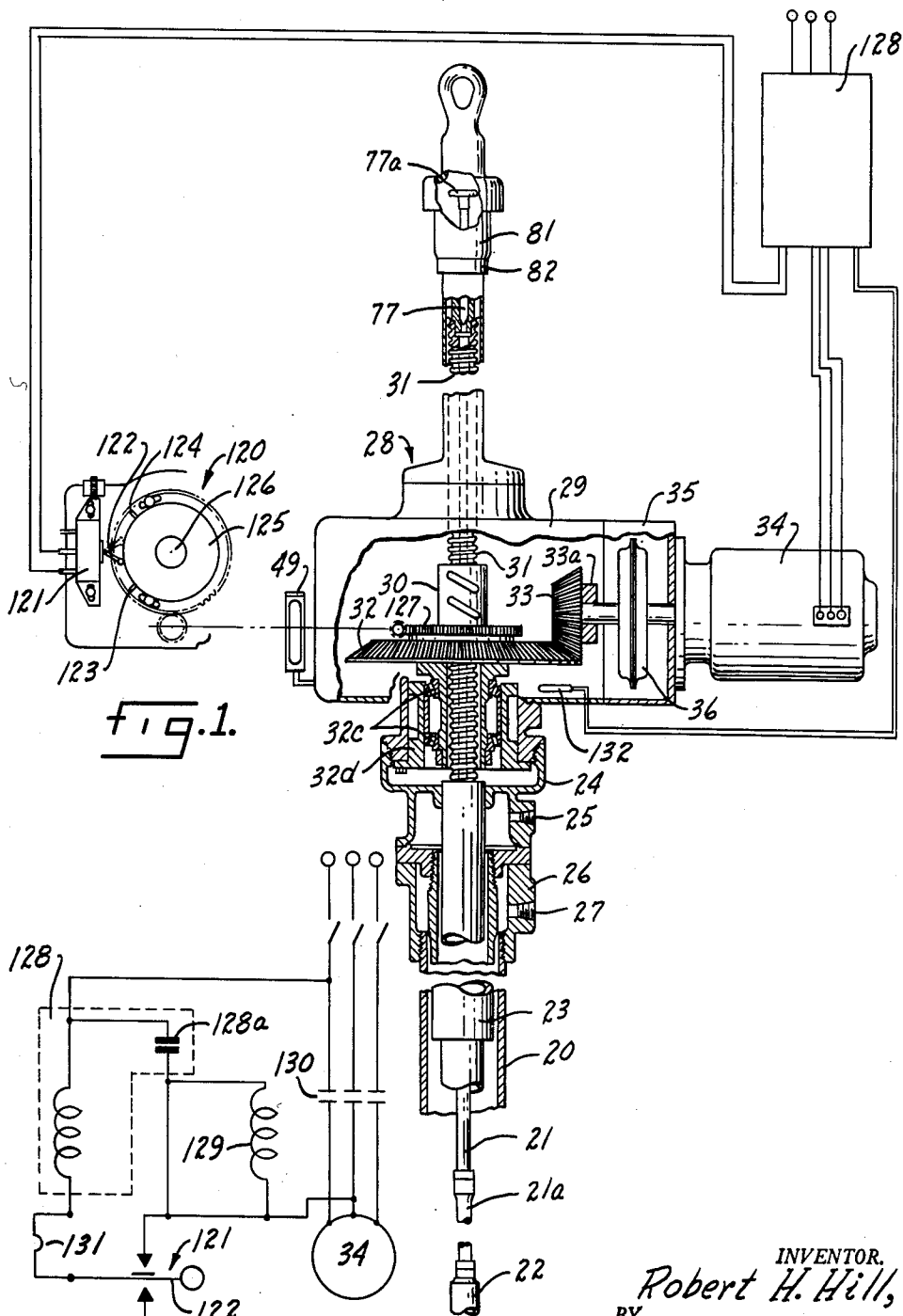
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3,065,704

PUMP ACTUATING SYSTEMS

Filed June 1, 1959

7 Sheets-Sheet 1



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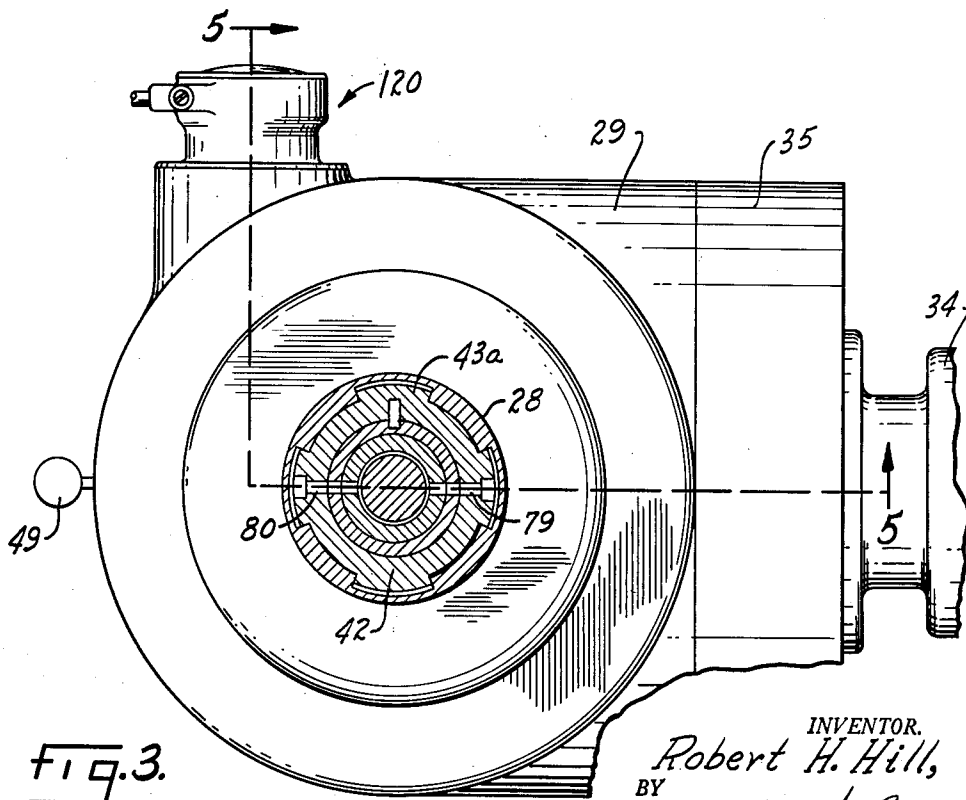
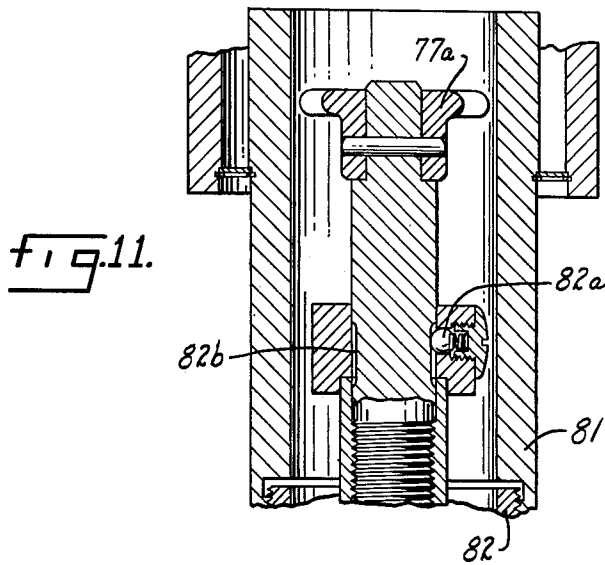
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PUMP ACTUATING SYSTEMS

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7 Sheets-Sheet 2



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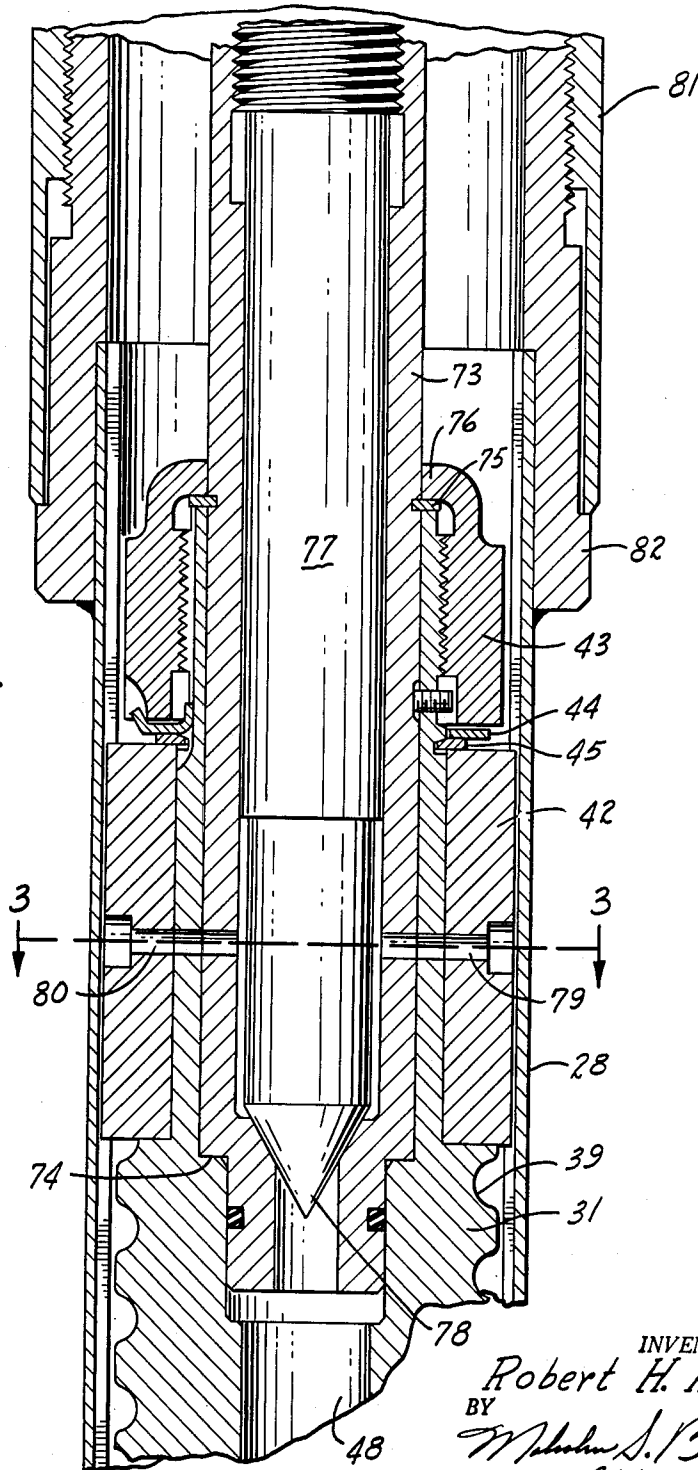
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PUMP ACTUATING SYSTEMS

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7 Sheets-Sheet 3

fig. 4.



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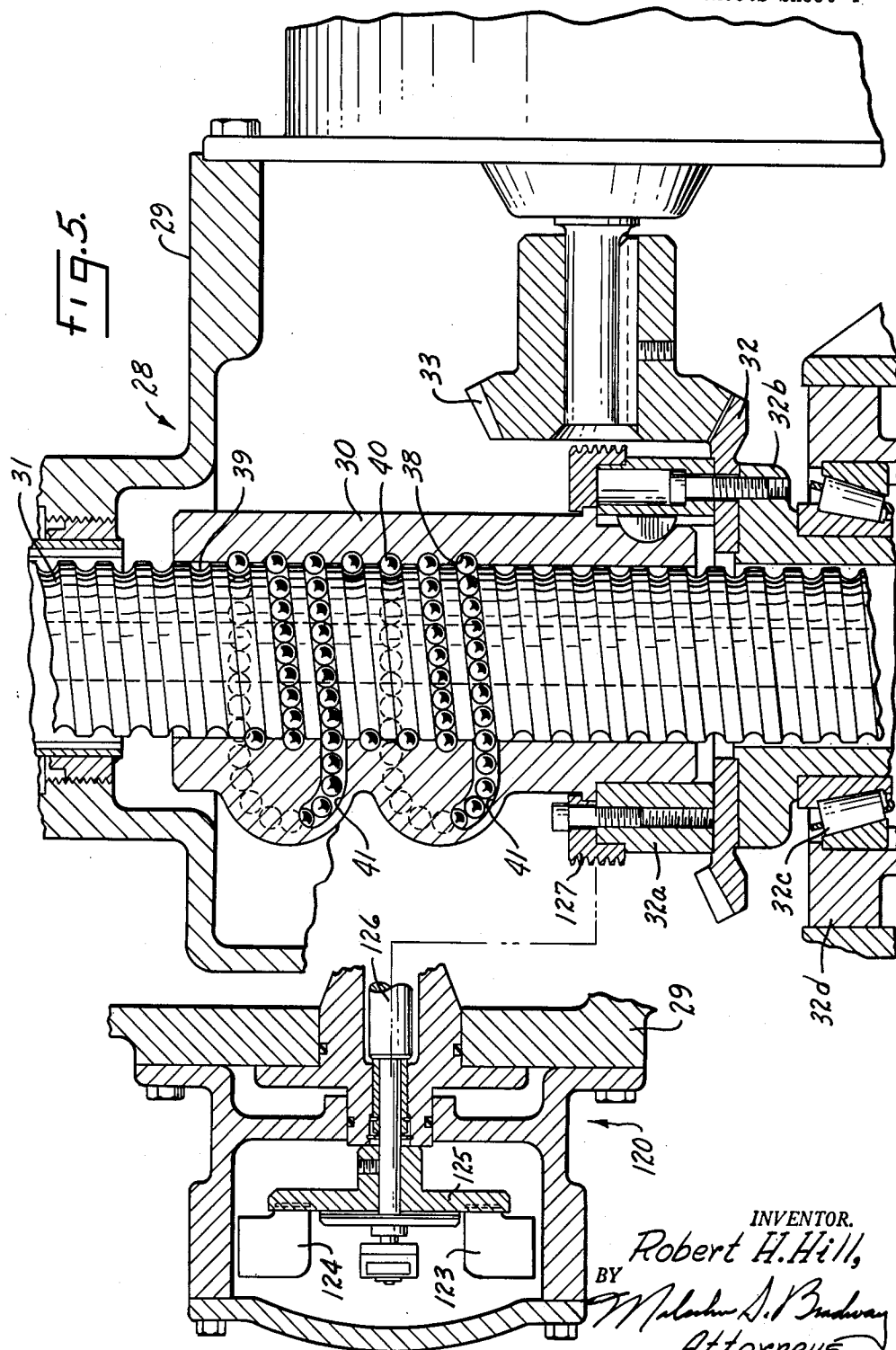
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PUMP ACTUATING SYSTEMS

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Nov. 27, 1962

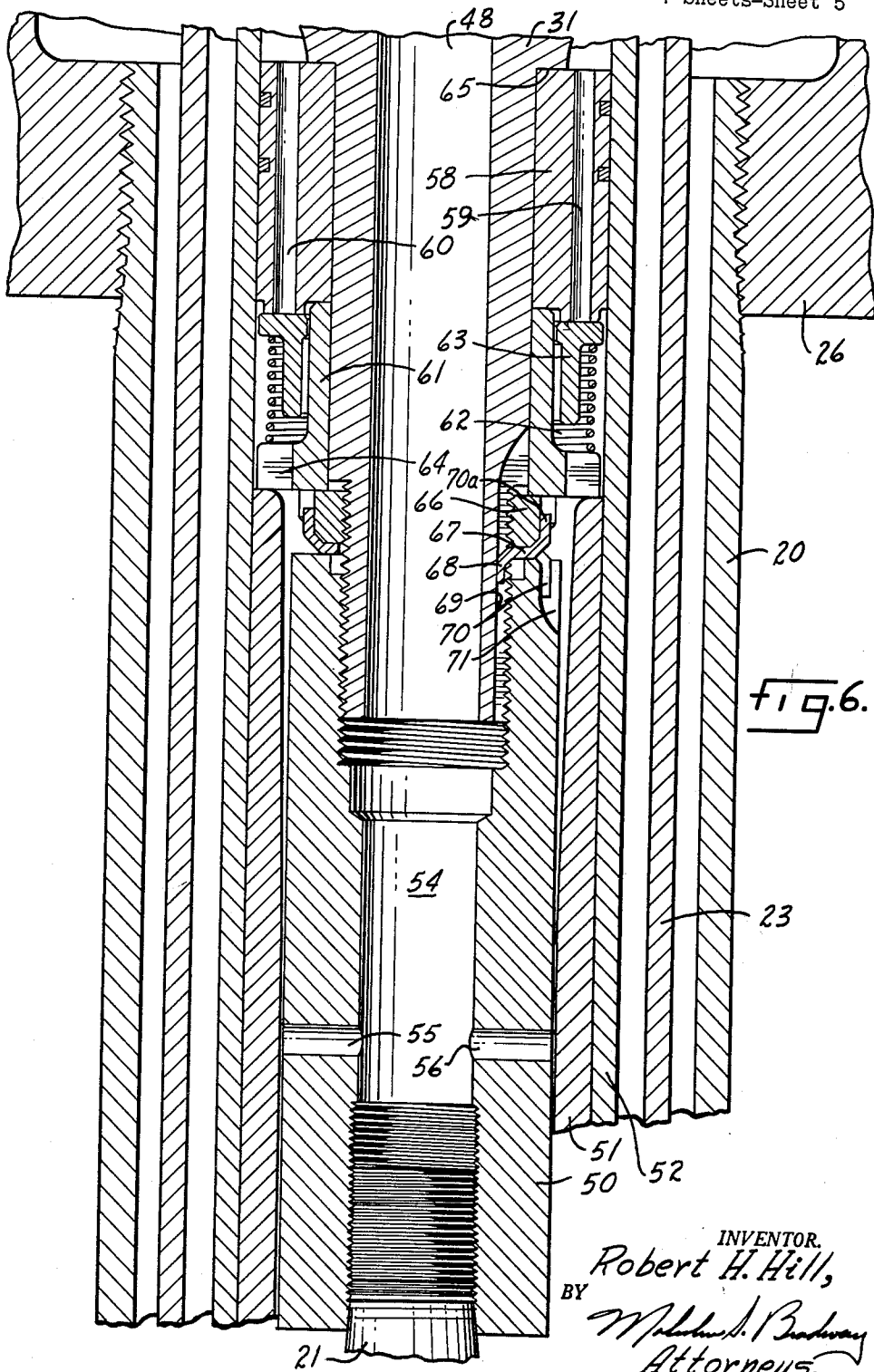
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PUMP ACTUATING SYSTEMS

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7 Sheets-Sheet 5



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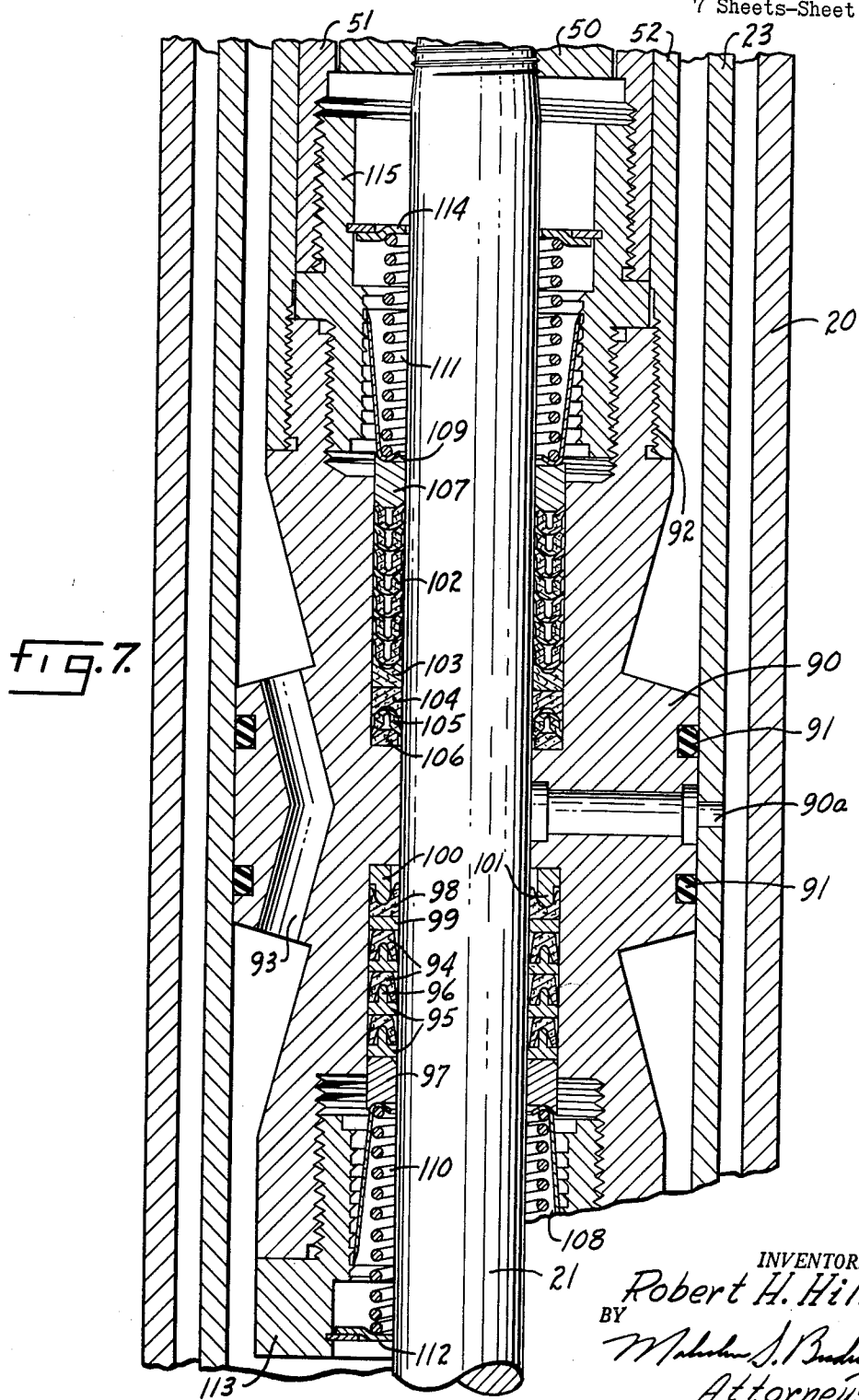
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PUMP ACTUATING SYSTEMS

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7 Sheets-Sheet 6



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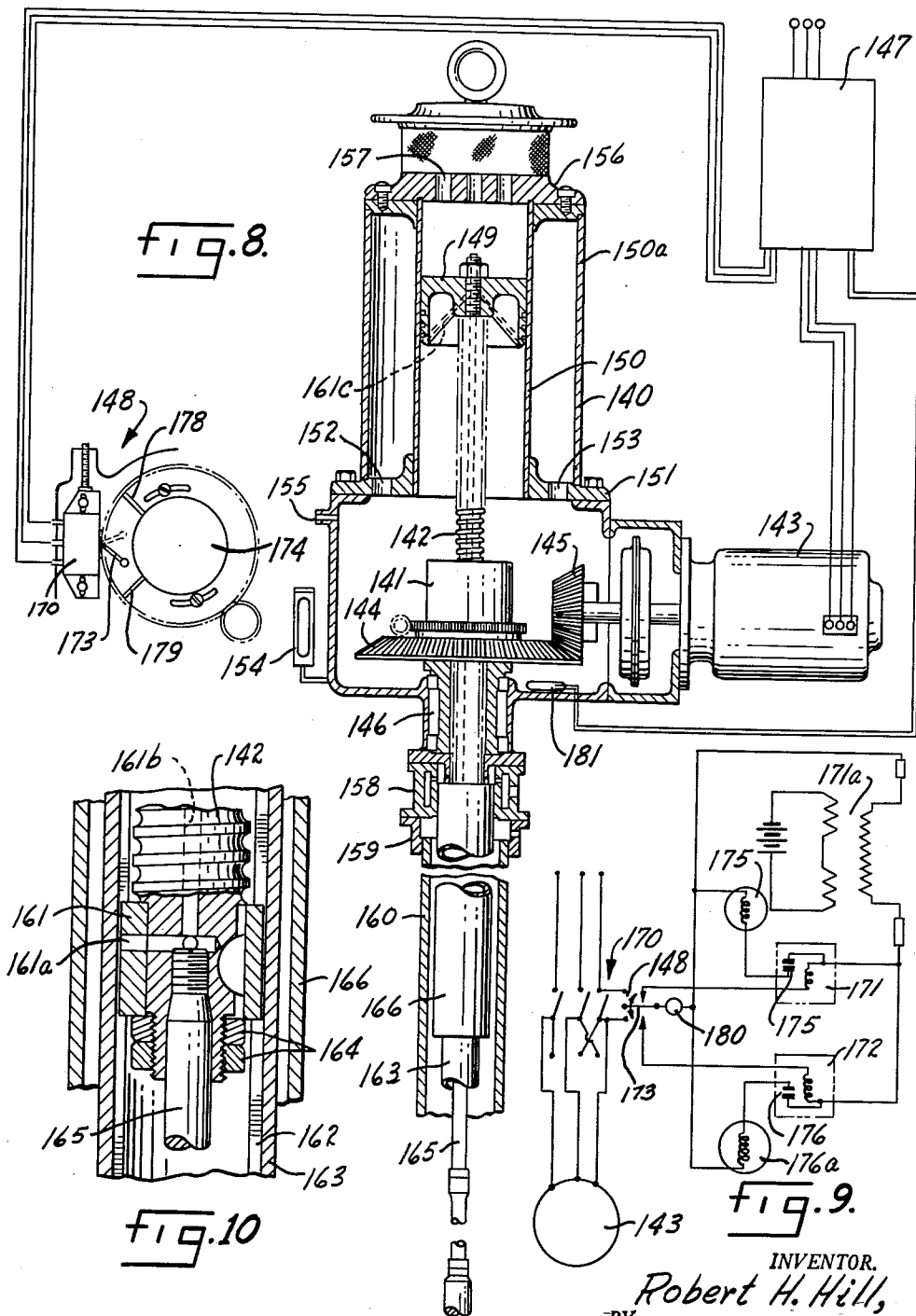
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7 Sheets-Sheet 7



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PUMP ACTUATING SYSTEMS

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7 Claims. (Cl. 103—46)

This invention is directed to improvements in pumping systems and particularly relates to actuators for vertically reciprocating pumps such as are commonly used in oil wells.

In deep well pumps, such as oil well pumps, it is highly desirable to provide an actuating mechanism which provides a long stroke for the pump and at the same time can be used at an economical price. In extremely deep wells, the stretch of the actuating rod for the pump necessitates a long stroke for the proper actuation of the pump. Furthermore a long stroke is desirable from the standpoint of minimizing wear, since a long stroke unit can operate at a slower speed than a short stroke unit for the same production capacity.

Prior actuating systems have oftentimes taken the form of motor driven oscillating beams which are connected to the pump actuating rod for reciprocation thereof. To obtain a long stroke, the beam and other parts of the system must be quite large and cumbersome. Some long stroke pump actuating systems have taken the form of hydraulic cylinders supplied with fluid from an hydraulic pump but these systems are inefficient and require an unduly large amount of power for their operation.

The present invention aims to alleviate these disadvantages by the construction of a relatively inexpensive and efficient reciprocating pump actuating mechanism which is arranged so as to provide an extremely long stroke, if desired, while requiring a minimum amount of operator attention for the operation of the pump.

One object of the invention is to provide a pump actuating system which does not require "plugging" or a reverse flow of current to the motor in order to overcome the inertia of the motor and stop the rotation of the motor, whether the motor is energized or de-energized, as the pump approaches the end of its stroke.

Another purpose of the present invention is the provision of an improved control system for electric motor driven vertically reciprocating pumps, which system allows proper time for the pump to fill at the bottom of the reciprocating stroke and a well filling time interval at the upper portion of the stroke.

Another purpose of the present invention is the provision of novel and practical means for retarding and decelerating the down stroke of a vertically reciprocating pump while at the same time providing circulation of lubricant through an actuating mechanism and providing a cooling system for the lubricant.

Another purpose is to provide a novel balancing system for a vertically reciprocating pump actuated by a double acting reversible motor.

In pumping systems of this general class, packing glands are ordinarily associated with the polish rod which is connected to the sucker rod of the pump and these packing glands must be located below the casing head. If one desires to minimize the above ground height of the unit, the gland must be embedded in the ground, where the problem of tightening the gland, which tends to work and become loosened with the reciprocating motion of the sucker rod, becomes difficult. Packing glands of this class may also function to prevent leakage of lubricating oil for the system along the rod and to prevent the fluid being lifted by the pump from working into the lubricating oil body which would contaminate the lubricant. Accordingly, another purpose of the present invention is to pro-

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vide novel, practical and efficient means for properly packing the polish rod of such a pump to prevent such contamination and leakage, and at the same time provide means for automatically compensating for any wear or loosening of the gland which may occur during the working of the sucker rod.

Other objects and purposes will appear from time to time in the course of the ensuing specification and claims when taken with the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a pump and pumping actuating system embodying the present invention;

FIGURE 2 is a diagrammatic view of a control circuit usable with the system illustrated in FIGURE 1;

FIGURE 3 is a top view of the unit illustrated in FIGURE 1 taken on the lines 3—3 of FIGURE 4;

FIGURE 4 is an enlarged sectional illustration of another portion of the system illustrated in FIGURE 1;

FIGURE 5 is a sectional illustration of FIGURE 3 taken on the section lines 5—5 of FIGURE 3;

FIGURE 6 is an enlarged sectional illustration of another portion of the mechanism illustrated in FIGURE 1;

FIGURE 7 is an enlarged sectional illustration of still another portion of the mechanism illustrated in FIGURE 1 and particularly illustrating packaging means for the polish rod usable with the present invention;

FIGURE 8 is a diagrammatic view of another embodiment of the invention;

FIGURE 9 is a diagrammatic view of a control circuit utilized in the embodiment of FIGURE 8;

FIGURE 10 is an enlarged sectional view of a portion of the system illustrated in FIGURE 8; and

FIGURE 11 is an enlarged sectional view of the upper portion of the actuator housing.

In the drawings and specification, like elements are designated by like characters throughout.

With particular reference now to the drawings and in the first instance to FIGURE 1, 20 designates a well casing that extends vertically into the ground. Mounted within the casing and adapted for reciprocating movement therein is a polish rod diagrammatically represented at 21 which is connected to the sucker rod 21a of the pump. The sucker rod 21a is adapted through vertical reciprocation thereof to actuate a pump diagrammatically indicated at 22 and lift fluid through a tube 23 surrounding the polish rod 21 to and through a manifold 24. The manifold 24 includes a discharge outlet 25 therein. The manifold 24 is mounted upon a head 26 which in turn is mounted upon the casing 20. The head 26 may include a gas outlet 27. It should be understood that the showing of the sucker rod, pump, and casing are intended to be representative of conventional pumping systems as are well known to the art.

In accordance with the present invention an upstanding actuator housing 28 is adapted to be seated upon and fixed to the upper end of the manifold 24. The housing 28 includes an enlarged transmission portion 29 which houses a rotatable driving member 30 and a vertically reciprocating driven member 31, the driving member and driven member forming a screw and nut type of drive. The driven member 31 is coupled to the polish rod in a manner to be explained in ensuing portions of this specification. The driving member 30 has a bevel gear 32 coupled thereto and is driven from a pinion gear 33 which is supported on bearings 33a and which receives power from the output side of a motor 34. The motor 34 is mounted on the side of an auxiliary housing 35 which may house a fluid coupling 36 for transmitting power from the output shaft of the motor to the pinion gear 33. The driving member 30, as will be seen best in FIGURE 5, may be coupled to the bevel gear 32 through the use of a coupling ring or hub 32a which is keyed to the driving member 30

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and which in turn is bolted to the bevel gear 32 and bolted to a hub 32b for the bevel gear 32. The hub 32b is rotatably supported on tapered roller bearings 32c, the outer races of which are fixed to a bearing support 32d on the inner wall of the housing.

In order to minimize friction, a rolling connection is provided between the driving member 30 and driven member 31. The driving member 30 includes a plurality of passages 38 which are formed on the inner surface of a central, longitudinally extending aperture therethrough and are spirally formed in the manner of a screw thread. The reciprocating driven member 31 includes spirally formed grooves 39 on the exterior surface thereof and through substantially the entire length thereof. The grooves 39 on the driven member 31 are of the same general size and pitch as the grooves on the member 30. Antifriction means in the form of a plurality of spherical members 40 bring about a driving connection between the driving member 30 and the reciprocable driven member 39. The member 30 includes a return passage 41 which spans at least two grooves therein so that the entire space within the passage 41 and the grooves between the ends thereof is filled with the balls 40, such balls being in rolling contact with one another and with the grooves of the driving member and driven member. Thus, during rotation of the member 30, the balls 40 may circulate in the race provided therefor in the member 30 and member 39 and through the passage 41 and during such rolling circulation, the driven member 39 will be reciprocated in vertical directions. Two complete sets of rolling members 40 and return passages 41 may be provided in the assembly, as illustrated in FIGURE 5.

Means are provided for preventing rotation of the member 31 during rotation of the driving member 30. This means takes the form of a splined guide 42 which is coupled to the upper end of the member 31, as seen best in FIGURE 4. The splined member 42 may include quadrilaterally spaced grooves and projections 43a in the surface thereof, as seen best in FIGURE 3. The projections ride in recesses formed in the inner wall of the housing 28, as is seen best in FIGURE 3. The projections on the guide are spaced a small distance from the inner surfaces of the recesses.

The splined member 42 may rest upon a shoulder in the upper end of the driven member 31 and may be held thereon by a locking assembly which may include a locking ring 43 threaded onto the upper end of the member 31 and lock washers 44 and 45 engaged with the ring 43, driven member 31 and the splined member 42.

The invention includes a means for inducing a forced circulation of oil through the housing while at the same time providing a decelerated and cushioning action for the driven member 31 as the driven member approaches the end of its downward stroke. In order to attain this end, the driven member 31 includes a longitudinally extending passage 48 which is formed therein so as to allow circulation of a lubricating fluid from the bottom of this member to the top thereof and then back through the housing. The enlarged portion 29 of the housing may be filled with lubricating fluid to a level somewhat above the level of the bevel gear 32, which level may be indicated from time to time by an oil gauge 49. The fluid may flow downwardly between the driven member 31 and the inner wall of the hub 32b to the general level of the packing gland which appears in FIGURE 7. In this regard it should be noted that the lower end of the driven member 31 is connected to a piston-like member 50 and the polish rod 21 may be threadably connected to the lower end of this piston-like member 50 so that as the driven member 31 is reciprocated, the polish rod and sucker rod will be reciprocated therewith. The piston-like member 50 has a generally cylindrical form and is slidably received in a liner 51 which is fixed to a tube 52, which in turn is spaced from a production tube 23 so as to define therebetween a passage for the upward flow of

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fluid to and through the discharge outlet 25. The tubes 52 and 23 may be supported on the production manifold 24.

The piston-like member 50 includes a longitudinally extending passageway therein so as to allow flow of oil to the passageway 48 through the driven member 31 and includes side passages 55 and 56 that afford communication between the interior of the passage 54 and the space exterior to the piston 50. Thus, as the driven member is moved downwardly, oil displaced thereby may flow through the passages 55 and 56 and upwardly through the passage 54 and the passage 48.

In order to progressively increase the resistance offered by the oil as the piston and driven member move downwardly near the completion of their downward stroke, the inner wall of the liner 51 is tapered upwardly and outwardly so as to cooperate with the passages 55 and 56 in effecting a valving action on the flow of fluid through the passages 55 and 56. The taper to the liner 51 is such that at its lowermost point its diameter corresponds quite closely to the external diameter of the piston-like member 50. When the driven member 31 is near the upper limit of its movement, as when it is just commencing its downward movement, the piston 50 will be disposed above the liner 51 with the passages 55 and 56 similarly disposed above the liner 51. Thus, during the majority of the downward movement of the driven member 31 and piston 50, oil may flow relatively freely through the passages 55 and 56 and will be forced upwardly through the driven member 31 due to the displacement of the oil caused by the downward movement of the piston and as the piston enters the liner 51. As it continues its downward movement the available space between the outer wall of the piston and the wall of the liner 51 is gradually restricted and the piston moves against a heavier resistance offered by the oil beneath the piston. This resistance progressively increases until the piston is at the lower limit of its downward stroke where the restriction on the oil flow is greatest and the result is a final cushioning of the downward stroke of the driven member.

The driven member 31 carries a valving mechanism at a level above the plunger or piston-like member 50 which allows the free flow of oil as the driven member 31 moves upwardly but then, on the down stroke, closes the space through which the member 50 moves to the free communication with the main body of oil in the housing 29. This valving structure includes a piston 58 which is fixed to and moves with the driven member 31 and which includes passages 59 and 60 extending therethrough so as to allow flow of oil from above the piston to the space below. A valve retaining collar 61 is fitted onto the driven member 31 between the member 58 and member 50 and includes a spring 62 surrounding the member 61 and biasing a valve closing member 63 into closing relation to the passages 59 and 60. The valve closing member 63 may take the form of a ring surrounding the collar 61 and having a flange which is adapted to seat against and close the passages 59 and 60 in the member 58. The lower end of the spring 62 may be seated on the upper surface of an outwardly extending flange 64 of the collar 61. The flange 64 may be spider-like in form so as to allow the passage of fluid therethrough.

This valving structure acts as a check valve in allowing free flow of fluid through the passages 58 and 59 and to the space beneath the collar 61 when the driven member 31 is moving upwardly but then as the driven member 31 commences its downward stroke the bias of the spring and the force of the oil exerted in a valve closing direction on the member 63 will close the passages 59 and 60 and thus trap oil beneath the member 58 and beneath the member 50.

The collar 61 and piston 58 may be held in assembled relation on the driven member 31 by means of a shoulder 65 formed on the member 31 and against which the upper surface of the piston 58 abuts and a locking ring 66 which

is threaded onto the driven member 31 to provide a shoulder against which the lower surface of the collar 61 abuts. A lock washer 67 may be positioned between the locking ring 66 and the upper surface of the piston-like member 50. The locking washer 67 may include a projecting portion 68 which seats in a key-way 69 in the driven member, a projecting portion 70 which seats in a keyway 71 in the member 50, and a projection 70a fitting in a key-way in ring 66 so that the locking ring 66 and piston 50 are held unitarily together and against rotation on the driven member 31.

The piston 58 may include rings engaging the inner wall of the tube 52 so as to preclude passage of oil between the piston wall and inner wall of the tube.

Means are provided for adjustable restricting the upward flow of oil through the driven member so that the downward speed of the driven member may be selected and adjusted in accordance with the desires of the user. This means takes the form of a needle valve assembly in the upper portion of the driven member 31 and which regulates the flow of oil therethrough and out to and through the splined guide therefor. As will be seen best in FIGURE 4, the upper end of the driven member 31 has a needle valve housing 73 mounted thereon. The needle valve housing 73 may have a lower shouldered surface seating on the shoulder 74 of a recess in the member 31 and may be held fixed to the member 31 as by means of a retaining ring 75. This ring 75 is fixed to the housing 73 at a point overlying the upper end of the member 31 and in a manner such that the ring is confined between an inwardly directed flange 76 of the locking collar 43 and the upper end of the member 31. The needle valve housing 73 includes a passage extending therethrough and generally aligned with the passage 43 through the member 31. A needle valve 77 is threaded into the needle valve housing 73 and includes a needle 78 in adjustably restricted relation to the lower end of the passage therethrough. Aligned apertures are formed in the needle valve housing 73, member 31 and splined guide 42 as appear at 79 and 80 in FIGURE 4 so that oil may pass from the passage in the needle valve housing through these passages 79 and 80 and down into the spaces between the splined member 42 and housing 23. The upper portion of the needle valve above the passages 79 and 80 is in fluid-tight relation to the housing 73. Thus, as the driven member 31 moves downwardly, oil may move upwardly through the central passage 43, past the needle valve and through the passages 79 and 80 where it may then flow downwardly through the spaces between the splined member 42 and the housing for a return to the main body of the lubricant in the enlarged portion of the housing.

By suitably adjusting the needle valve 78, the rate of oil flow through the driven member is adjusted and hence the restricting or retarding effect offered by the oil to the driven member during its entire downward movement may be adjusted. In addition to the retarding action the system insures a circulatory flow of the lubricating fluid which not only provides adequate lubrication for the splined fitting and the transmission in the enlarged portion of the housing, but at the same time provides cooling for the lubricant and hence cooling for the transmission.

The upper end of the housing 23 may include a cap 81 which is threaded onto a cylindrical member 82 fixed to housing 23. The upper end of the needle valve 77 may include a handle 77a, as is seen in FIGURE 1, for suitably adjusting the needle valve to provide the desired restricting and speed regulating effect. The needle valve assembly may be locked in position by means of a spring biased detent 82a which is selectively engageable with circumferentially spaced grooves 82b thereby preventing turning of the valve due to vibration.

In some cases, a check valve may be provided in the passage 54 or 48 and arranged to allow the flow of lubricant upwardly through these passages on the downstroke

of member 31 while preventing flow of lubricant and air through these passages on the upstroke of member 31.

The invention contemplates a self-tightening packing gland which, if desired, may be positioned beneath the ground and remaining effective without requiring operator attention. In FIGURE 7 a packing gland housing 90 is fitted in the tube 23 with the central portion thereof in engagement with the tube 23. The central portion may be sealed with the tube 23 as by O-rings 91. The upper end of the housing is fixed to the inner tube 52 as by threads 92. The central portion of the housing has a passage or passages 93 therethrough so as to allow the fluid lifted by the pump to flow upwardly between the tubes 52 and 23 for consequent discharge through the production manifold.

In packing glands of this type, the gland must effectively seal the space above the gland from the space below the gland. In a structure of the type illustrated, the pressure in the space above the gland may reach several thousand pounds per square inch as the actuating rod reaches the lower extremity of its stroke. The pressure in the space below the gland may be much lower so that the gland is subjected to a high differential pressure which tends to force lubricating fluid downwardly along the rod. Furthermore, in a gland of this type, the production fluid, which has a pressure exceeding the dash pot pressure of near zero when the actuation member is near the top of its stroke and which is lifted in the space surrounding the polish rod, must be kept from working along the rod and into the lubricating fluid with consequent contamination thereof.

In order to minimize these problems, the packing of the invention uses upper and lower glands each of which is tightened against the housing and rod independently of the other. The upper gland packs the rod primarily against the downward flow of lubricating fluid and the lower gland packs the rod primarily against the upward flow of the production fluid, while each gland is effective against both upward and downward flow in the event one or the other of the glands fails and allows leakage.

The packing system also includes a vent 90a intermediate the two glands which allows bleed-off of the lubricating fluid if the upper gland fails and bleed-off of the production fluid in the event that the lower gland fails, thus allowing the system to continue operation with failure of one gland.

Each end of the housing has an enlarged recess therein so as to accommodate packing rings between the walls of the recesses and the surface of the rod 21 which passes through the housing. The packing rings are an expansible type and upon compression thereof, are adapted to tighten the seal between the housing and rod.

The rings 94 on the lower side of the housing for the low pressure gland may be of a type known as U-shaped and may be stacked with spacer rings 95 therebetween. The spacers 95 each have a circular projection 96 which is adapted to fit between the legs of the U-shaped rings 94 and prevent collapse thereof. A pressure ring 97 bears against the lower surface of the lowermost ring 95.

An additional U-shaped ring 98 may be positioned between the rings 94 and the inner end of the packing space. The ring 98 may be upwardly open and disposed between a spacer ring 99 which is in contact with the uppermost ring 94 and a spacer 100. The spacer 100 may have a downwardly extending circular projection 101 which prevents collapse of the legs of the ring 98.

The rings 102 which comprise the high pressure gland at the upper end of the housing may be of a V-shaped type and stacked in contact with one another so that compression of the series of rings causes the legs thereof to expand outwardly into sealing relation to the housing and rod. The lowermost ring 102 bears against a spacer ring 103 which is in contact with a spacer ring 104 which bears against an inverted V-shaped ring 105. The legs of the ring 105 are held against collapse by a ring 106

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which bears against the shoulder defining the inner end of the upper recess.

A pressure transmitting ring 107 bears against the uppermost ring 102.

Packing glands of the type defined by the rings 94 or rings 102 may become loose and tend to work longitudinally with respect to the housing due to the reciprocation of the rod 21. The movement of the rod causes a frictional wearing of the packing and when the packing becomes worn and tends to work back and forth with the rod, the sealing efficiency of the packing is seriously impaired.

In order to prevent such "working" of the packing the invention includes a means which automatically compresses the rings to a fixed degree and maintains a firm sealing engagement of the rings with the housing and rod whenever wear on the rings impairs the seal. The means include spring biased latching members 108 and 109 which bear against the rings 97 and 107 respectively. Coiled springs 110 and 111 surround the rod 21 and exert pressure on the members 108 and 109 in packing tightening directions. The spring 110 may be seated on a washer assembly 112 carried by a fixed latching member 113 while the upper end of spring 111 bears against a washer assembly 114 carried by a fixed latching member 115.

The latching members 108 and 109 are preferably of cup shape with a plurality of resilient arms diverging from the base thereof and the axis of the rod and members. The outer ends of the arms are adapted for engagement with a series of vertically spaced ratchet-like teeth or notches formed in the inner walls of the members 113 and 115. The ends of the arms may ride over the teeth in an inward or packing tightening direction but cannot move outwardly.

The arrangement is such that the latching members 108 and 109 may move inwardly under the bias of their associated springs but are prevented from return or outward movement. The springs 110 and 111 are of such strength that they provide an initial compression of the packing rings. Further compression is provided by the pressure of the fluid which bears against the packing. Whenever the rings become worn or loose, the pressure of the fluid will compress the rings and the springs 110 or 111 as the case may be, will move their associated latching members 108 or 109 into firm back up relation to the packing. The compression of the packing may be enhanced by the movement of the rod 21, since on the upstroke the friction between rod 21 and rings 94 and 98 tends to move these rings into a more highly compressed state, while on the downstroke of the rod 21, the frictional engagement tends to move the rings 102 and 105 into a more highly compressed state. The effect is an automatic take-up or tightening of the packing followed by a positive locking of the packing in that position.

The packing gland at each end of the housing is thus confined between a fixed stop on the housing and a movable stop comprised of the pressure ring and latching mechanism, the movable stop being effective to automatically "take up the slack" and further expand the rings for effective sealing action thereof when such is required.

With this form of packing, the upper V-shaped rings effectively pack the polish rod and prevent the high pressure lubricant from moving downwardly along the rod while the U-shaped packing prevents the production fluid from contaminating the lubricant. If the upper rings for any reason leak lubricant under the high pressure of the dash pot, such lubricant may run off through the vent 90a and down to the pump, thus minimizing a pressure build-up on the upper side of the lower rings. If the lower rings fail and allow leakage of the production fluid upwardly along the rod, such fluid may run off through vent 90a for return to the pump.

The assembly uses a control system which is particu-

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larly effective in allowing the use of relatively small motors, while providing adequate driving power for the pumping unit. Energization and de-energization of the power input to the motor 34 is under control of a switch assembly generally designated at 120. The switch assembly 120 is preferably mounted on the housing portion 29 as will be seen with reference to FIGURES 1 and 3. In FIGURE 5, the switch assembly 120 is illustrated in rotated relation to the remainder of the assembly illustrated in FIGURE 5, the showing of the switch assembly being removed from the rear portion of the housing portion 29 in FIGURE 5 so as to enable an understanding of the principles thereof. The switch assembly includes a toggle switch 121 having an actuating member 122 which is movable between the two extremes indicated in dotted outline in FIGURE 1. The actuating member 122 is contacted intermittently during the operation of the system by switch actuating arms 123 and 124 which are adjustably mounted in angular directions on a member 125. The member 125 is rotated by a shaft 126 which carries a gear meshing with a gear 127 which is rotatable with the driving member 30. The gear arrangement is such that the shaft 126 and member 125 are rotated through a partial revolution during the rotation of the driving member 30 necessary to reciprocate the driven member 31 through the desired length of stroke. Thus, as the driving member 30 rotates in one direction during the lifting of the driven member 31, one member, such as the member 123, will move through that partial revolution necessary to engage the switch actuating member 122 near the end of the lifting stroke of the member 31. When the member 30 moves in the opposite direction, the member 125 is revolved in the opposite direction, so that near the end of the descending stroke of the member 31, the member 124 will contact the actuating member 122 and reverse the switch.

By adjusting the angular positions of the members 123 and 124, the time or point in the stroke of member 31 at which the switch 121 is actuated may be adjusted in accordance with the desires of the user.

The system illustrated in FIGURE 1 is adapted to energize the motor 34 after a time interval immediately following the time when the member 31 reaches the bottom of its stroke and thereafter hold the motor in the energized condition until the driven member 31 reaches the top of its stroke; whereupon the motor 34 is de-energized to allow a gravitational descent of the driven member 31. The controlling circuit is diagrammatically illustrated in FIGURE 2. The system includes a time delay mechanism 128 which becomes operative when the switch actuating member 122 closes the circuit thereto. The time delay mechanism may include clock work or any suitable well known mechanism adapted to close a switch 128a after a selected time interval. After closing of the switch 121 has been completed and after the selected time interval, the time delay mechanism switch 128a completes a circuit to a relay 129 to close the on-off motor switch 130 and energize the motor 34. When the motor 34 is energized it rotates the driving member 30 in such a direction as to cause elevation of the driven member 31. When the driven member 31 reaches the top of its stroke, the switch actuating member 122 is contacted by one of the members, as for example the member 124, to open this switch and thus break the circuit to the relay 129 which holds the switch 130 in a closed position. When the motor 34 is de-energized, the weight of the driven member 31 and pumping unit attached thereto is sufficient to cause the descent of the member 31, thereby causing opposite rotation of the member 30 and motor 34. This descent of the member 31 continues until its final downward movement is retarded and checked by the dash pot assembly illustrated in FIGURE 6. At this point the other actuating member 123 reverses the switch 121 so as to again energize

the time delay mechanism to set up the motor controlling circuit for the elevation of the driven member 31.

The time delay may be an interval such that the pump has adequate time to fill near the bottom of the stroke while allowing time for the motor to come to a complete stop before it is energized for the opposite direction of rotation.

In order to prevent overheating of the driving assembly, a thermostatic switch or fuse 131 is in the circuit between switch 121 and time delay mechanism 127. The thermostatic element 131 may have a heat sensing element 132 located in the lubricant reservoir so as to cause opening of the circuit whenever the temperature is above a predetermined maximum. Thus, if oil should leak from the reservoir with the result that the space within the housing heats up unduly, the element 131 will stop operation of the actuator, thus allowing the system to fail safely. Furthermore, it should be noted that if the packing glands become unduly heated, the heat thereof will be transmitted to the lubricant with the result that lubricant may heat to a temperature causing opening of the circuit. Thus the element 131 protects both the transmission and packing gland against overheating.

FIGURE 8 illustrates a further embodiment of the invention. In this embodiment, the housing is shown at 140 and houses a driving member 141 and driven member 142 of the same character as the driving and driven members 30 and 31 of FIGURE 1. A motor 143 is mounted on an enlarged intermediate portion of the housing and supplies power to the drive member 141 through bevel gears 144 and 145. The driving member 141 and gear 144 may be supported by bearings 146 in a manner similar to the support of the similar elements in FIGURES 1 and 5. In this embodiment of the invention the motor 144 is controlled through a time delay system 147 which, includes a reversing switch mechanism generally designated at 148. The switch mechanism 148 is similar to the switch assembly 120 of FIGURE 1 and is actuated in response to rotation of the driving member 141.

In the system of FIGURE 8, the upper end of the driven member 142 carries a piston 149 which is slidably mounted in a cylinder 150. The cylinder 150 is positioned within the upper portion 150a of the housing. A supporting plate 151 may be mounted on the portion of the housing surrounding the transmission to provide support for the lower end of the cylinder 150 and upper housing wall. The plate 151 includes apertures 152 and 153 leading into an air jacket surrounding the cylinder 150. Oil may be maintained in the central portion of the housing to a level generally corresponding to a level slightly above the level of the gear 144 as may be indicated from time to time by the oil level gauge 154. In this embodiment, the portion of the housing space above the level of oil is filled with air under pressure as through an air inlet 155. As the driven member 142 and piston 149 move downwardly, the air within the housing is further compressed, thus retarding the downward movement of the driven member 142 and pump. The pressure may be maintained at a level such that the total load imposed on the motor 144 during the down stroke of the member 142 is generally equal to the load on the motor during the upward stroke.

The upper wall 156 of the housing includes apertures 157 which permit the ready escape of air from the space above the piston 149 as the piston and driven member 142 move upwardly.

The actuator housing 140 is adapted to be fixed to a production manifold 158 which is similar to the production manifold 24 of FIGURE 1. The production manifold 158 is seated upon and bolted to a casing head 159 which is fixed to the casing 160 of the well.

In the system of FIGURE 8 a splined guide is provided for the driven member 142 at a position within

the casing 160. As will be seen best in FIGURE 10, the lower end of the driven member 142 carries a splined guide block 161 which has grooves therein which receive splined ribs 162 on the tubing 163. The guide block 161 may be keyed to the lower end of the driven member 142 and held thereon as by means of nuts 164. The polish rod 165 for the pump may be threaded into the lower end of the driven member 142.

In order to lubricate the cylinder 150, the spline block 161 has transverse passages 161a therein which feed lubricant from the exterior of the block to a longitudinally extending passage 161b in the driven member 142 so that during descent of the spline block 161, lubricant is forced upwardly through the screw for discharge through feed passages 161c in the piston 149.

A production passage is provided between the tubing 163 and a second tube 166, which tube 166 is spaced inwardly from the casing 160 to define a gas passage therebetween.

It should be understood that a packing means, which may take the form of the packing illustrated in FIGURE 7, may be fixed with respect to the tube 163 at a level beneath the lowermost point of travel of the splined guide.

The system of FIGURES 8, 9 and 10 utilizes a time delay in the motor control system at each limit of movement of the driven member 142. The control unit 147 includes a reversing switch 170 for the motor. The circuit for the system, which is diagrammatically illustrated in FIGURE 9, includes a pair of time delay mechanisms in parallel with one another and diagrammatically indicated at 171 and 172. The time delay mechanisms receive power from a transformer 171a which alternately supplies power to one or the other of the mechanisms as switch 148 is moved from one position to the other. One time delay mechanism 171 is actuated when the driven member 142 nears the end of its upper limit of movement and causes actuation of the switch member 173 in one direction, as by means of the rotatable switch actuating member 174 which is driven from the driving member 141 in a manner similar to the driving of the switch member 125 in FIGURE 1. Conversely, when the driven member nears the end of its lower limit of movement, the switch actuating member 173 is snapped to the opposite position.

The arrangement is such that near the upper limit, the switch 173 opens the motor circuit and energizes the time delay mechanism 171, which closes a switch 175 to energize a relay 173a after a predetermined interval of time, to thereby reverse the switch 170 and thus reverse movement of the motor 144 to cause descent of the driven member 142. When the driven member 142 approaches the bottom limit of movement, the switch member 173 is moved to the opposite position, thus opening the motor circuit and energizing the time delay mechanism 172 which, after a predetermined interval of time, closes a switch 176 to energize a relay coil 176a to reverse the switch 170 for rotation of the motor 144 in the opposite direction and to cause elevating movement of the driven member 142.

Thus when the driven member 142 approaches either limit of movement, the motor current is discontinued to allow the motor 144 to coast to a complete stop without need of any "plugging" of the motor 144. Actuation of the switch 173 breaks the circuit to the motor and sets up the motor control circuit for the reverse movement.

A heat sensitive member 180 is responsive to the heat of the lubricating reservoir as by a sensing element 181 for breaking the circuit from switch 148 when the heat in the region of the transmission reaches an excessive amount thus providing safety as in the system of FIGURE 1.

It should be understood that the switch actuating blades 178 and 179 are so angularly related to the center of rotation of the member 174 that the circuit to the

motor is broken at a point before the limit of movement desired so that the motor, in effect, may coast to the final limit.

Where as the drawings illustrate motors coupled to the driving members through the use of fluid couplings, it should be understood that other coupling arrangements could be used. Furthermore, it should be understood that the pinion gears illustrated in FIGURES 1 and 8 can be driven by means of a motor away from the housing and interconnected with the pinion 145 through the use of suitable belt or chain transmissions or the like.

The actuators herein illustrated and described are easily fitted to the casing head of existing wells as by coupling the actuator housing to the casing head.

The actuators are particularly well suited for situations requiring long operating strokes. The actuators may be used with quite a variety of different lengths of pumping strokes, the reciprocating driven member and housing being made sufficiently large to accommodate the maximum stroke desired in any particular situation. The actuators are particularly efficient in the transmission of power from the prime mover to the sucker rod. In this regard the bevel gear and particular screw and nut transmission utilized are highly efficient in that power losses due to friction in the transmission are held to a minimum. In transmitting the power from the prime mover to the reciprocating rod in any installation, the length of stroke is easily adjusted in accordance with the desires of the user by simply adjusting the angular position of the actuating member of the toggle switch assemblies to thus adjust the upper limit of travel of the driven member.

In each form of the invention described, namely the embodiment of FIGURE 1 and the embodiment of FIGURE 8, the down stroke of the reciprocating driven member is retarded near the end of its stroke so as to slow down the downward movement of the sucker rod and allow the motor and transmission to coast to a stop against the cushion of fluid in the dash pot of FIGURE 1 or the air cylinder of FIGURE 8.

The switch actuating members are preferably so adjusted that they actuate their associated switches prior to the time that the end of the reciprocating stroke is reached. In the case of the embodiment of FIGURE 1, for example, the switch may be actuated sometime after the piston enters the tapered dash pot cylinder. Actuation of the switch energizes the time delay mechanism and the time interval between actuation of the switch and energization of the motor may be such that when the motor finally comes to rest, the driven member may stay at this lower position for a short period of time sufficient to enable the pump cylinder to fill before the motor is energized to commence the upward stroke. During upward movement the toggle switch is again actuated to shut off the current to the motor prior to the time that the driven member reaches the upper limit of travel so that the motor will spin to a stop against the weight of the sucker rod and driven member. When the upper limit is reached, the weight of the sucker rod and driven member are sufficient to cause them to descend and in the course of such descent the driving member and motor will be rotated in the opposite direction.

In the embodiment illustrated in FIGURES 8 and 9, the toggle switch 170 is actuated to break the current to the motor prior to the time that the driven member reaches either its lower limit of travel or its upper limit of travel. Actuation of the toggle switch at either limit of travel breaks the circuit to the motor and the motor gradually coasts to a stop. The toggle switch at the same time energizes the time delay mechanism so that after a predetermined interval of time following actuation of the toggle switch, the reversing switch is reversed and the motor is again energized for the stroke in the opposite direction.

In the system of FIGURE 8, the time interval between de-energization of the motor and consequent reversing

thereof at the upper end of the stroke may be such that it is only slightly greater than the time necessary to allow the motor to come to a complete stop.

It should be noted that the system of FIGURE 1 allows the motor to coast to a stop after actuation of the limit switch which occurs prior to the time that the actuator reaches the upper limit of travel. When the motor comes to a stop at the end of this stroke, the driven member 31 will start to descend slowly. Thus the time interval occurring after the motor is de-energized and during the final coasting of the motor and during the slow initial portion of the descent of member 31 will be such as to provide a well filling time interval, or time for the production fluid to flow into the well.

In the system of FIGURE 8 the time interval at the top of the stroke may be varied to suit individual installations, as by suitable adjustment of the time delay mechanism in the circuit of FIGURE 9.

The controlling circuits for the actuators are highly adaptable to fully automatic operation as by means of program control systems or the like to turn the actuators on and off for predetermined periods of operation.

Whereas, I have shown and described an operative form of my invention, I wish it to be understood that this showing is to be taken in an illustrative or diagrammatic sense only. There are many modifications to the invention which will be apparent to those skilled in the art and which will fall within the scope and spirit of the invention. The scope of the invention should be limited only by the scope of the hereinafter appended claims.

I claim:

1. A reciprocating pump actuating system including a reciprocating pump actuating member adapted at one end of its stroke to allow filling of a pump actuated thereby, a prime mover in driving relation to said actuating member, means retarding movement of said actuating member as it approaches said end of its stroke, control means for causing operation of said prime mover for reverse travel of said actuating member at said end of its stroke, time delay means delaying operation of said control means when said member is at said end of its stroke so as to provide a pump filling time interval, and means terminating operation of said prime mover prior to the time that said member reaches the other end of its stroke to thereby allow said member and prime mover to coast to a stop at said other end of the member's stroke.

2. The system of claim 1 wherein said member reciprocates vertically and descends to said pump filling end of stroke by gravity, the prime mover being driven by said member in a de-energized state during said descent.

3. The system of claim 1 wherein said member reciprocates vertically and said prime mover drives said member in each stroke direction of said member, said control means including means for reversing said prime mover for reverse operation of said member at each end of the stroke of said member.

4. The system of claim 1 wherein said retarding means includes a hydraulic dash pot associated with said member.

5. The system of claim 1 wherein said retarding means includes an air counterbalance associated with said member and adapted to compress air as said member reaches said end of its stroke.

6. In a reciprocating pump actuating mechanism, a reciprocable driven member and a rotatable driving member in engagement therewith and adapted during rotation thereof to reciprocate said driven member, motor means for rotating said driving member, switch means for energizing and de-energizing said motor means, switch actuating means driven by said driving member for actuating said switch at predetermined points in the reciprocating travel of said driven member, said switch means being adapted to energize said motor means for reverse move-

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ment thereof, and time delay means delaying operation of said motor for a predetermined interval of time after actuation of said switch means, said time delay means being effective to delay energization of said motor and reciprocation of said driven member at each limit of travel of said driven member.

7. The system of claim 6 characterized by and including heat responsive means for de-energizing said motor upon the occurrence of a predetermined elevated temperature in the region of said driven member and said driving member.

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