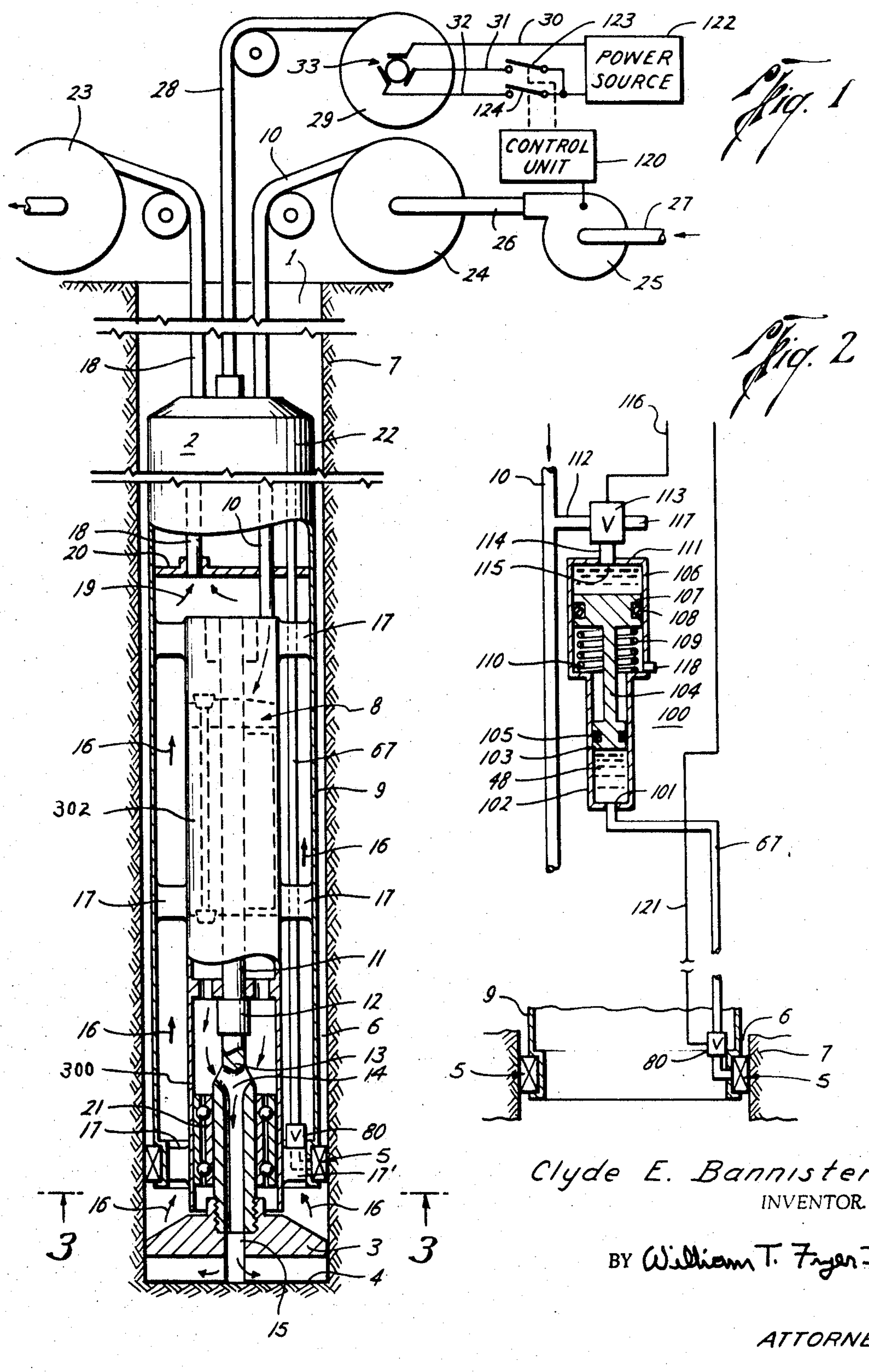
Sept. 30, 1969 C. E. BANNISTER 3,469,499

DRILLING SYSTEM

Original Filed Nov. 9, 1964 3 Sheets-Sheet 1



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DRILLING SYSTEM

Original Filed Nov. 9, 1964

3 Sheets-Sheet 2

Fig. 4

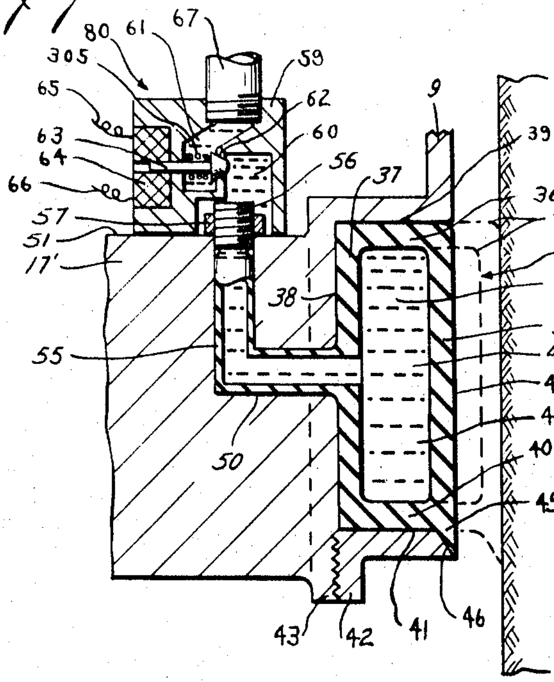

Fig. 3

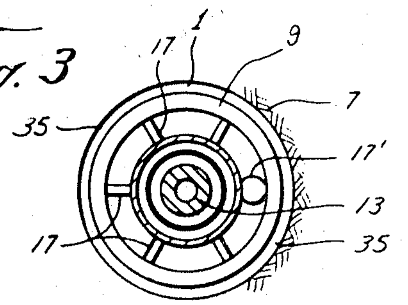

Fig. 5

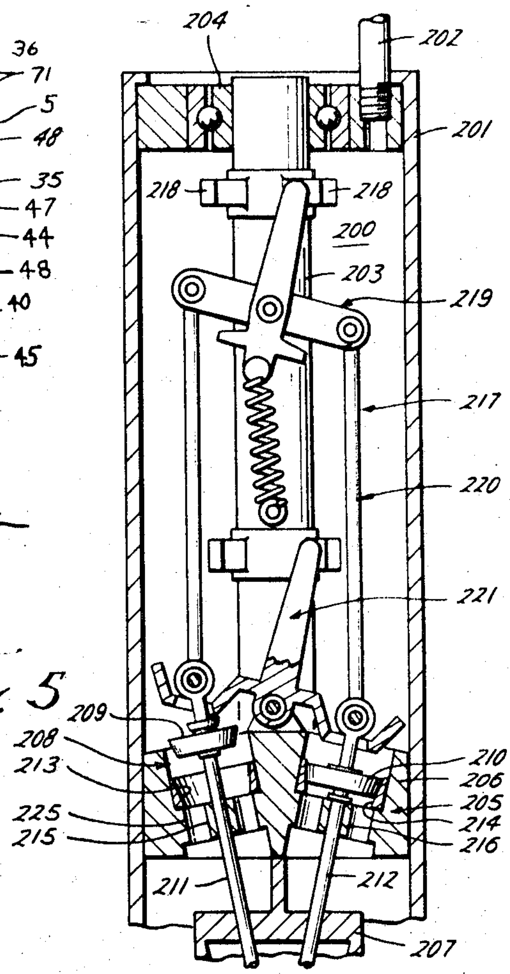

Fig. 6

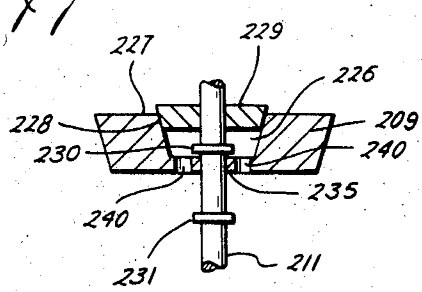

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Fig. 8

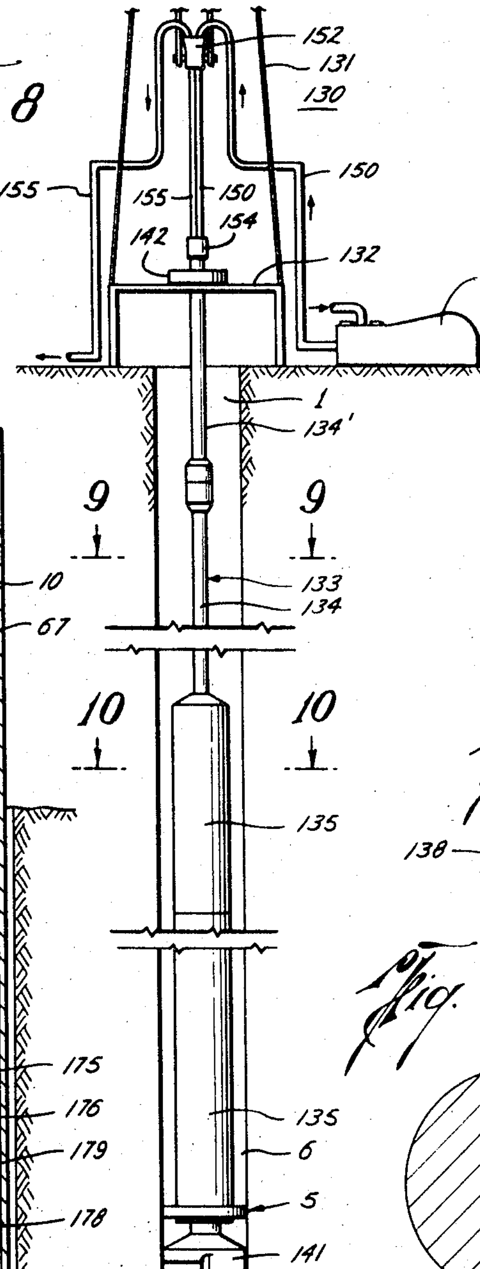


Fig. 7

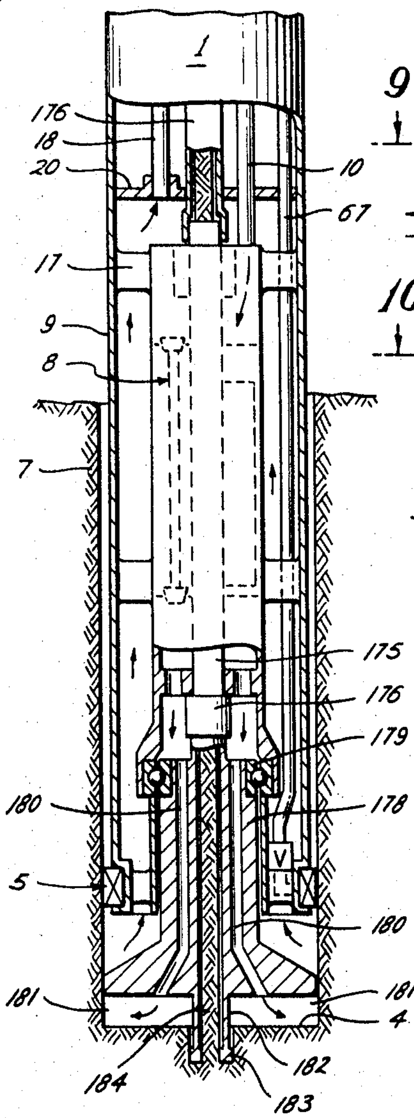


Fig. 9

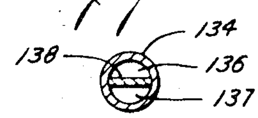
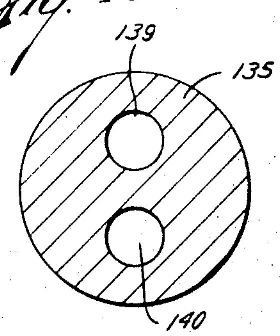


Fig. 10



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United States Patent Office

3,469,499

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3,469,499

DRILLING SYSTEM

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Original application Nov. 9, 1964, Ser. No. 409,735, now Patent No. 3,381,766, dated May 7, 1968. Divided and this application July 31, 1967, Ser. No. 668,979

Int. Cl. F01c 1/00, 9/00

U.S. Cl. 91—58 6 Claims

ABSTRACT OF THE DISCLOSURE

The present invention in one embodiment is arranged to minimize the force required to operate the inlet valves in a fluid motor. A relief hole is provided in each of the inlet valve closure members and a closure means is provided for each relief hole. The closure means is removed by a valve rod prior to unseating the valve closure member. Each valve rod has lengthwise spaced abutments that successively jar and unseat the closure means and then the inlet closure member, to alternately permit fluid to enter the fluid through the inlet valves.

This application is a division of application Ser. No. 409,735, filed Nov. 9, 1964, now Patent No. 3,381,766.

The present invention relates to the field of subsurface exploration and drilling systems utilized therefor, and more particularly to a system especially useful for drilling large holes in the earth.

One of the prior art drilling systems for oil exploration and recovery and the like was the apparatus commonly termed a rotary rig. The rotary rig included a derrick at the surface for suspending a drill string and a motor and mechanism for rotating the drill string to turn a bit attached at its far end. The cuttings were removed by a fluid sent down the drill string and flowing back to the surface through the borehole annulus, the space between the drill string and the borehole wall.

In many applications the fluid force or pressure was not sufficient to remove the cuttings as fast as necessary. The decrease in pressure was most evident when the hole size was increased, whereby the fluid flowed from a drill string having a relatively small opening into the vast expanse of the borehole annulus.

One approach employed with some success for large holes was the reverse circulation technique. As described in the article "72-In. Holes Are Being Drilled," by Robert G. Burke, in the May 4, 1964 issue of The Oil and Gas Journal, pages 71–73, the drillers utilized reverse-air circulation in which air was pushed down the annulus of the borehole, across the bit face, and returned through the drill string. A very high capacity compressor had to be used to develop even a relatively low pressure and there still was circulation loss and inadequate fluid force at times.

Recognizing the limitations of the prior art, I have invented a drilling system which is capable of maintaining a high fluid pressure to remove the cuttings rapidly and which does not require an extremely large fluid pump or compressor. My invention can be used to drill large holes, such as the shafts required by the Atomic Energy Commission for underground nuclear explosions.

My invention is not limited to use with a rotary rig. In fact, I disclose herein an embodiment of drilling apparatus that has the advantages of high fluid pressure and minimum non-drilling time. This embodiment utilizes a bit driven by an oscillating motor to grind up the cuttings into pieces that can be removed easily. The oscillating motor is fluid actuated and I have provided a valve arrangement which is especially advantageous where a high fluid pressure is controlled.

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The above objects and advantages are obtainable with my invention, wherein the borehole annulus is not used as a conduit for the fluid and, instead, means is provided in the drill string, for example, to carry the fluid into and out of the borehole. A seal is established adjacent the bit to prevent the fluid from exiting through the borehole annulus. The cuttings are washed with a high pressure fluid carried down the drill string and the fluid and cuttings are carried up the drill string by the fluid at high pressure to the surface.

In one embodiment of my invention, a drilling system with an oscillating bit can be provided with a seal adjacent the driving motor and flexible hose can carry the fluid down to and out the depths of the borehole. The oscillating bit grinds up the earth into very small pieces and the cuttings require only a small exhaust hose.

In connection with my invention, I have provided control means for the seal means, so that the drilling apparatus can be disposed freely in the borehole, and at a desired depth the seal means can be actuated from the surface to close off the borehole annulus. In one embodiment the fluid in the drilling apparatus actuates the seal means. The seal means in one form can be an expandable means, such as a ring or tube around the drilling apparatus which is inflated by a pressure generator. The pressure generator can be disposed in the drilling apparatus, actuated by the fluid pressure to produce an even greater pressure for inflating the tube. The control means can selectively actuate the seal means to establish or release the seal. The drilling can continue with the seal established and moving forward with the drilling apparatus.

My improved valve for a fluid motor or other devices receiving a high pressure is arranged to minimize the anti-unseating fluid force. A relief hole is provided in the valve closure member and a closure means is provided for the relief hole. The closure means is removed prior to unseating the valve closure member to relieve the fluid pressure. In accordance with my invention, a valve also can be jarred prior to unseating to eliminate sticking. In an embodiment with a valve rod, the valve closure member can be freely mounted thereon and the valve rod can have an engaging means spaced from the valve closure member to move a given distance with the valve rod before striking the valve closure member.

These and other objects of my invention are illustrated by several preferred embodiments to be described with reference to the drawings, wherein

FIG. 1 is an elevation view, partially in section, showing one embodiment of a drilling system in accordance with my invention.

FIG. 2 shows in more detail one form of pneumatic control means for operating the seal means of the drilling system shown in FIG. 1 or of other drilling systems.

FIG. 3 is a horizontal section along the lines 3—3 of FIG. 1.

FIG. 4 is an enlarged view of one form of sealing means for the drilling system of FIG. 1 or other drilling systems.

FIG. 5 is an elevation view in section of a fluid motor equipped with my improved valve.

FIG. 6 is an enlarged elevation view, partially sectioned, of the valve shown in FIG. 5.

FIG. 7 is an elevation view, partially sectioned, of another form of drilling apparatus in accordance with my invention.

FIG. 8 is an elevation view, partially in section, of a rotary rig arranged in accordance with my invention.

FIG. 9 is a horizontal section along the lines 9—9 of FIG. 8, showing the internal arrangement of a drill pipe.

FIG. 10 is a horizontal section along the lines 10—10 of FIG. 8, showing the internal arrangement of a drill collar.

A description of several preferred embodiments of my invention follows next. It will be obvious to one skilled in the art, after reading my description, that other apparatus is equally capable of using my invention and that changes and modifications in the disclosed apparatus embodiments can be made without departing from my invention.

A drilling system in accordance with my invention is capable of drilling large holes, such as a hole or boreholes **1** (FIG. 1). Borehole **1** may be as large as six feet in diameter. One possible way of drilling borehole **1** would be to use conventional drilling equipment, such as a rotary rig or oscillating drill system. With a rotary rig, a bit would be supported in borehole **1** by the drill string and rotated in one direction therewith. The cuttings would be removed by fluid flowing down the drill string and out the borehole annulus. But if the fluid must expand into a large volume of the borehole annulus, the fluid pressure drops and the cuttings are not washed away rapidly enough. Reversing the fluid flow route, into the borehole through the borehole annulus and out the drill string, requires a very large capacity pump and the fluid pressure or velocity is not always sufficient to remove large cuttings.

I have shown in FIG. 1 a drilling apparatus **2** capable of operating in large borehole **1** with a high fluid velocity. In general, fluid is carried into borehole **1** by conduit means in drilling apparatus **2** and a bit **3**, disposed at the end of the drill apparatus **2**, is rotated to remove portions or cutting from the borehole bottom **4**. The fluid washes the cuttings out of the borehole through another conduit means in the drilling apparatus **2** at a high pressure. The exhaust conduit means takes the place of the borehole annulus and has the advantage of a constant, relatively small but adequate size, irrespective of the borehole size, to maintain a high fluid pressure.

To prevent the fluid from exiting through the borehole annulus **6**, I provide a seal means **5** adjacent bit **3** which substantially closes off borehole annulus **6**. Seal means **5** is operated selectively by a control means to open or close off annulus **6** at will. Drilling can continue while borehole annulus **6** is closed to penetrate further into the earth **7**.

The particular form of drilling apparatus shown in FIG. 1 utilizes an oscillating, fluid actuated motor **8** mounted in a cylindrical housing **9**. Motor **8** can be of several types, such as the improved motor disclosed in my U.S. Patent 3,183,787 copending application, Ser. No. 265,839. Fluid enters housing **9** through a flexible inlet hose **10** and is coupled to motor **8** to sustain oscillating movement of an impeller blade coupled to drive shaft **11**. The oscillating movement is coupled to bit **3** through clutch **12** and an intermediate shaft **13** threaded at one end to engage bit **3** and mounted for rotational movement in bearing **21**. Fluid leaves motor **8** within the cylindrical skirt **300** of motor casing **302** and passes through a central passage **14** in intermediate shaft **13**, through an opening **15** in bit **3** to wash the borehole bottom **4** and cutting. When an electric oscillating motor is used instead of a fluid motor, inlet hose **10** is coupled directly to bit opening **15** by suitable means.

The washed cuttings are picked up by the fluid and flow around bit **3** into housing **9**, in the direction of arrows **16**. Motor **8** is suspended in housing **9** from arms **17**, resembling a spider (as best shown in FIG. 3), so that the fluid and cuttings can travel between the inside of housing **9** and the outside of motor casing **302** to the entrance of a flexible exhaust hose **18**, in the direction indicated by arrows **19**. Exhaust hose **18** is fastened to a shelf **20** of housing **9**. Shelf **20** prevents the fluid from passing further along housing **9**, forcing the fluid into exhaust hose **18**. Exhaust hose **18** conveys the fluid and cuttings to the surface and the drilling operations continues, supplied by a continuous amount of fluid in inlet hose **10**.

Bit **3** can have a diamond cutting edge and its oscillating motion grinds borehole bottom **4**, so that the cuttings are relatively small and can be carried through a small exhaust hose.

Drilling apparatus **2** is arranged further for continuous drilling by having one or more weighted sections **22**, generally referred to as inertia barrels, to maintain the load on bit **3** necessary for maximum cutting effect. Sections **22** are attached to housing **9**, preferably by a removable coupling, such as tool joint (not shown). Inlet hose **10** and outlet hose **18** pass through sections **22** and are provided with reels **23** and **24**, respectively, for storing sufficient hose length to lower bit **3** to a desired maximum depth. The fluid entering inlet hose **10** is at a high pressure, because a pump **25** is connected intermediate fluid couplings **26** and **27**. Fluid enters coupling **27** from a reservoir (not shown) at a low pressure and the pressure is increased in the pump output to coupling **26** which is connected to inlet hose **10**. The elongated structure of housing **9** and sections **22** is suspended in borehole **1** by a cable **28** attached at one end to the end section **22** and at the other end to a reel **29**. Cable **28** takes the load off inlet hose **10** and exhaust hose **18** and the cable reel **29** is attached to a drive mechanism (not shown) to raise and lower bit **3** at will.

Cable **28** is provided with insulated electric conductors (not shown) that are used for a purpose to be described and these conductors are connected to electric lines **30**, **31** and **32**, respectively, through a commutator assembly **33** on reel **29**.

The seal means can take several forms to carry out its function of substantially sealing off the borehole annulus **6**. The sealing mechanism can be an extendable member inserted between the borehole wall and the drilling apparatus that circumfeerntially engages the borehole wall and drilling apparatus, or knifes into the borehole wall to seal off borehole annulus **6**. Another arrangement is to have the seal means formed by pivotally mounted sections of an annular plate that is forced into engagement with the borehole wall and the drilling apparatus. These embodiments do not normally have freedom of axial movement in borehole **1**, which is desirable, although not essential, and the seal means has to be retracted to move drilling apparatus **2** any appreciable distance. For this reason I have illustrated an embodiment that substantially seals off the borehole annulus **6** and allows for at least some axial movement in borehole **1** to have continuous drilling without adjusting the seal means. It is apparent that other forms of seal means can perform these functions.

Seal means **5** is supported at the end of housing **9** adjacent bit **3**. The fluid and cuttings can enter housing **9** but they cannot go very far into the borehole annulus **6**, because seal means **5**, when closed, presents a substantially complete fluid lock between housing **9** and the borehole wall. The seal or fluid lock is formed by an inflatable tube **35** (FIG. 4), constructed of rubber or other elastic, fluid containing material, that rings or circumferentially surrounds and fits in a recess of housing **9**.

Tube **35** has a rectangular vertical cross-section when deflated, one of its longer sides **37** lying against a flat annular face **38** of housing **9** and one of its smaller sides **36** lying against another flat annular face **39** of housing **9**. The other smaller side **40** lies against a flat annular face **41** of a ring **42** having an internal thread that engages a threaded end **43** of housing **9**. Ring **42** can be unscrewed to remove tube **35**. The other longer side of tube **35**, generally termed the shoe, has its outer face **44** substantially even with the outer face of housing **9** when tube **35** is deflated. Adjacent ring **42**, the corner of tube **35**, where the fluid first hits, has a projection **45** that is beveled towards the borehole wall so that the fluid will tend to increase the pressure of shoe face **44** against the borehole wall. When tube **35** is deflated, as shown in FIG. 4, projection **35** rests against a matching beveled face **46** of ring **49**. Tube **35** has an annular central cavity **47**.

One of the support arms **17'** for motor **9** (FIG. 3) is larger than the other support arm **17** to allow space for a passage **50** extending between housing face **38** and a surface **51** of support arm **17'**. Tube **35** has inlet extension **55** constructed of the same material as tube **35** that lies in passage **50** and has a metal, externally threaded, open end piece **56** projecting above support arm surface **51**. End piece **56** has a nut **57** firmly securing tube inlet extension **55** in support arm **17'**. Secured to support arm **17'** in fluid tight relation by fasteners or welding (not shown) is a valve **80** having a housing **59** with a chamber **60** in which tube end piece **56** extends and a second chamber **61** communicating with chamber **60** by a passage **62**. Passage **62** has a poppet valve closure member **63** that seats with the fluid, biased closed by coil spring **305**, and is opened by an electromagnet **64** when energized by a current through electromagnet coil having terminal leads **65** and **66**. Chamber **61** has an internally threaded aperture that is coupled to an externally threaded end of pipe **67**.

The operation of seal means **5**, without reference at this point to anything more than the simplest control means, can be pictured by first assuming that tube **35** is deflated, as shown in FIG. 4, with a captive, imcompressible fluid **48** in the tube cavity **47**, tube inlet extension **55**, and chambers **60** and **61**. Valve **80** is opened by energizing electromagnet **64**, withdrawing poppet valve closure member **63**. If there is no pressure in pipe **67** nothing will happen. As pressure is built up in line **67**, tube **35** expands because of the increased pressure in tube cavity **47**. The only way tube **35** can expand is at the shoe face **44** and as pressure increases further shoe face **44** engages the borehole wall completely around housing **9** and over a substantial face area. The new shape of tube **35** is represented by dotted lines **71**. The fluid and cuttings are deflected by tube side **40** and projection **45** and the borehole annulus **6** is substantially sealed off. Once tube **35** is expanded, electromagnet **64** can be de-energized, closing valve **80**, and tube **35** will remain inflated.

The pressure in pipe **67** that inflates tube **35** can come from many sources disposed at a number of locations. For example, the pressure can be controlled by a pressure generator at the surface coupled to pipe **65**. The pressure in pipe **67** can be decreased after poppet valve **80** is closed to allow tube **35** to deflate a predetermined amount whenever valve **80** is opened, as may be desirable momentarily to move bit **3** in or out of borehole **1**. Normally, housing **9** and sections **22** move further into borehole **1** with tube **35** inflated and maintaining a substantial fluid lock as the drilling continues.

The pressure in pipe **67** that inflates tube **35** is preferably provided by a pressure source mounted on drilling apparatus **2**. The pressure source thereby need not transmit the high fluid pressure required to inflate tube **35** over a long distance. In my preferred embodiment, a pressure transmitter **100** (FIG. 2) is mounted in housing **9** on the other side of shelf **20** from where the fluid and cuttings flow. Pipe **67** passes through shelf **20** in a fluid tight seal (not shown), in the same manner as inlet hose **10**, and is connected to a high pressure port **101** in a transmitter housing. One end of the transmitter housing is a cylinder **102** that receives a slidable piston having a head **103** and connecting rod **104** to form a pressure generator. Piston head **103** has means for providing a slidable fluid seal against the wall of cylinder **102**, such as O-ring **105**. The volume in front of piston head **103** and pipe **67** contains captive, incompressible fluid **48**, that is placed under pressure as piston head **103** moves towards housing port **101**.

Connecting rod **104** can be manipulated by any suitable means to control the pressure in pipe **67**. For example, an electromagnet or reversible motor can be used. I have illustrated a more sophisticated mechanism which does not require an electric power source, except to energize two valves, and can be operated without any electrical connection, if desired.

In my embodiment, pressure transmitter **100** includes a pressure operated actuator formed by a cylinder **106**, at the opposite housing end from cylinder **102**, and a piston head **107** having O-ring **108**. Piston head **107** is attached to connecting rod **104** to move piston **103** and is biased in the opposite direction from piston **103** by a coil spring **109** surrounding connecting rod **104** and enaging a housing ledge **110** and the inner face of piston **107**. In this arrangement, piston **107** normally is held against housing end **111** and is motivated in the opposite direction only by a force created by permitting fluid from inlet hose **10** to pass through coupling **112**, valve **113**, and coupling **114** to a port **115** in housing end **111**. Valve **113** has two positions, electrically selected by a current over electric line **116** (the two wires of a conventional electrically controlled valve are shown as one electric line for convenience). One position, called position A, when valve **113** is energized, connects coupling **114** to coupling **112** and the other position, called position B, connects coupling **114** to a vented coupling **117**, open at its unconnected end to the air in housing **9** above shelf **20**. The volume on the opposite side of piston **107** from port **115** is continuously vented to the air in housing **9** above shelf **20** by a coupling **118** connected adjacent housing ledge **110**.

The operation of pressure transmitter **100** is controlled from the surface where the fluid pressure in inlet **10** is generated and can be turned on or off by control unit **120** energizing or stopping pump **25**, respectively. The electric wires running to the electromagnet terminals **65** and **66** of valve **80** have been represented as a single electric line **121** in FIG. 2, for convenience, but in actual arrangement a two wire cable is used. One wire from each of lines **116** and **121** can be tied together and connected to one of the electric wires in cable **28**, mentioned above, and ultimately connected through commutator assembly **33** to line **30**. The other two wires, one from valve **113** and one for valve **80** are individually connected to separate wires in cable **28** and ultimately connected to lines **31** and **32**, respectively. Line **30**, being the common lead, is directly connected to one side of a power source **112**, usually a DC supply, and lines **31** and **32** are selectively coupled to the other side of the DC supply by separate switches **123** and **124** actuated at will, either individually or together, by a control unit **120**, the sequence depending on the desired operation.

As the drilling apparatus **2** is lowered into borehole **1**, pump **25** is denergized and no fluid flows in inlet hose **10**. Valves **80** and **113** are deenergized (valve **113** is in position B, venting cylinder **106**), and tube **35** is deflated as shown in FIG. 4. Piston **107** of pressure transmitter **100** is held against housing end **111** by spring **109**. Once the drilling position is reached, control unit **120** energizes valves **113** and **80** by closing switches **123** and **124**, and pump **25** is energized to send a high pressure fluid down inlet hose **10**. A part of the fluid flows into cylinder **106** and acts against the face of piston **107** which is substantially larger than the face of piston **103**, preferably at least four times larger.

The fluid pressure in inlet hose **10** and entering cylinder **107** is not high enough to adequately inflate tube **35** and there is the further problem of bleeding the fluid lines. Pressure transmitter **100** serves to increase the pressure and provides a uniform control with several further advantages. Piston **107** is displaced by the fluid pressure against the force of spring **109** and, because of the common connecting rod **104**, piston **105** is also displaced to increase the pressure of captive fluid **48** in cylinder **102**, pipe **67**, and cavity **47**. The increase in pressure within tube **35** causes shoe face **44** to extend and force against wall of borehole **1** to substantially seal off the borehole annulus **6**. The smaller face area of piston **103** produces a much greater force or pressure than the pressure acting on piston **107**. It is apparent that tube **35** will not be inflated until there is sufficient pressure in inlet **10** to displace piston **107**. In other words, there is a predetermined pressure below which piston **107** will not be displaced and there is a predetermined pressure—the normal pressure in inlet **10**—which will displace it completely. The drilling system, including pressure transmitter **100**, is designed so that the normal fluid pressure in inlet **10** is adequate to expand tube **35** to the maximum expected borehole annulus spacing and tube **35** expands laterally if the spacing is less than the maximum expected.

Once tube **35** is inflated to seal off borehole annulus **6**, control unit **120** is operated to de-energize valve **80**, retaining the high pressure in cavity **47**. Valve **113** can be deenergized also, venting cylinder **106** adjacent piston **107** to the air. Spring **109** forces out all the fluid in cylinder **106** and pistons **107** and **103** return to their biased positions. The withdrawal of piston **103** reduces the pressure in pipe **67** to normal. Then valve **80** can be energized and tube **35** will deflate, opening the seal. The energization of valves **80** and **113** can be timed to permit a total or partial deflation of tube **35**. The partial deflation can be used to free tube **35** should it happened to become stuck against a projecting part of the borehole wall and it is not desired to completely release the seal.

The actuation of tube **35** need not require the use of valves or any electrical connection to the drilling apparatus **2**. For example, control of the fluid pressure in inlet **10** is sufficient to actuate selectively tube **35**. Assuming that valves **80** and **113** are not in the system, i.e. the connections are as if each valve is energized, with fluid from inlet **10** entering cylinder **106** and fluid from pipe **67** entering tube **35**. When the fluid pressure is below a predetermined level, piston **107** will not be displaced. As the pressure is increased, piston displacement occurs and tube **35** is inflated at the normal pressure in inlet **10**. To deflate tube **35**, the fluid pressure in inlet **10** is decreased, by turning pump **25** off, for example, and piston **107** returns to its biased position after expelling the fluid from cylinder **106**.

Other forms of pressure transmitters can be employed to build up the pressure for inflating tube **35**, and these pressure transmitters can be controlled in several ways to close or open the seal.

As mentioned above, my invention can be applied to a rotary rig, such as rotary rig **130** shown in FIGS. 8–10 with a few modifications of existing equipment. The conventional derrick **131** (only partially shown) is located above borehole **1** and includes platform **132**. The drill string **133** is composed of modified drill pipes **134** and modified drill collars **135**.

Drill pipe **134** (FIG. 9), including kelly joint **134'**, has two conduits **136** and **137**, for the inlet fluid and outlet fluid, respectively, formed by the tubular body wall and an axially extending partition **138** secured therein. Partition **138** extends into the tool joints on each drill pipe and kelly joint **134'**, and, when drill pipes **134** and kelly joint **134'** are coupled tightly, two essentially continuous conduits are formed. Each drill collar **135** (FIG. 10) has two longitudinally extending and laterally spaced holes **139** and **140** therethrough that line up, when drill collars **135** are coupled together to provide two continuous conduits. The tool joint between the end drill collar **135** and the end drill pipe **134** provides a separate passage (not shown) connecting one of the conduits in the drill collar **135** to a conduit in the drill pipe **134**, and another passage (not shown) connecting the other of the conduits in the drill collar **135** to the other conduit in the drill pipe **134**. The end drill collar **135** is coupled to bit **141**. The inlet fluid conduit in end drill collar **135** is coupled to a central aperture in bit **141** and the exhaust conduit opens at the lower face adjacent bit **141**. Fluid passes from the inlet conduit in end drill collar **135**, through bit **141** and forces the cuttings into the exhaust conduit in end drill collar **135**.

Drill string **133** is rotated by a kelly **142** and its associated engine (not shown). The fluid coupling **154** to the kelly joint **134'** has a lower portion that rotates with drill string **133** and an upper portion that is stationary. The rotatable joint, which can be similar to the coupling shown in my U.S. Patent 2,345,465, or other types, is connected through conduits to the respective inlet and outlet conduits of kelly joint **134'**. Coupling **154** connects the inlet conduit of kelly joint **134'** to inlet hose **150** carried by a swiveled pay-out block **152** suspended by derrick **131**. Hose **150** is connected to the fluid pump **153**. The exhaust conduit in kelly joint **134'** is connected by fluid coupling **154** to exhaust hose **155** also carried by pay-out block **152** and connected to a fluid reservoir (not shown).

The drilling operation for rotary rig **130** follows the conventional procedures, except for the use of seal means **5** supported adjacent bit **141** on end drill collar **135**. The mechanical details for seal means **5** can be the same as described above. End drill collar **135** is arranged to mount tube **35** outside and pressure transmitter **100** inside which is coupled to the inlet conduit. Valves **80** and **113** need not be employed and pressure transmitter **100** can be operated by controlling the fluid pressure in the inlet conduit, as described above. Alternately, when valves **80** and **113** are incorporated, an electric cable can be layed in one of the conduits and a commutator assembly used adjacent coupling **154** to connect a control means **120** and power supply **122** in the manner described above.

Seal means **5** functions in the same manner on rotary rig **130** to provide a substantial fluid lock across the borehole annulus **6**. Drill string **133** moves further into borehole **1** as the drilling continues and seal **5** permits this movement while still retaining the substantial fluid lock.

The drilling apparatus shown in FIG. 1 can be modified as shown in FIG. 7 to include the added feature of retrieving a borehole core as the drilling continues. The surface equipment is the same and the only major change is in the motor **9** and bit **3**. Motor **9** is modified to the extent that the solid drive shaft **11** is replaced by a hollow drive shaft **175** and a tube **176** extends over one end of drive shaft **175** and is mounted in axial alignment in housing **9**. The other end of drive shaft **175** is coupled through a coupling **176** having a central opening that connects drive shaft **175** and the shaft end of a bit **178**. Bit **178** has the conventional cutting teeth **181**, preferably diamond edge, and is mounted for rotational movement in bearing **179**. The inlet fluid passes from motor **9** through several passages **180** in bit **178**, out the lower face of bit **178** to wash the cuttings into the exhaust fluid path through housing **9**.

Bit **178** further includes a rigid, axially aligned tube **182** projecting outward from the cutting teeth **181** into borehole bottom **4**. The far end of tube **182** has a cutting edge **183**, preferably diamond studded, for cutting into the earth. In this manner the center of the borehole bottom **4** is cored and not drilled. The center of the borehole **1** is the slowest section drilled due to the slow movement of bit **178**, so that no appreciable delay in drilling is produced. Tube **182** receives core **184**. Core **184** passes through an axial opening in bit **178**, into coupling **176**, drill shaft **175** and into tube **176**. Drive shaft **175** rotates freely within the end of tube **176**, tube **176** being stationary and constituting a core storage facility that can extend a substantial distance.

In drilling a large hole, the fluid motor for drilling apparatus **2** (FIG. 1) must be of substantial size. One of the chief problems in enlarging a fluid motor which has valve closure members that seat with the fluid, is unseating the valve closure members. A fluid motor like the one described in my above referenced U.S. Patent 3,183,787 can be modified to facilitate valve unseating. The modification improves the motor operation with a high pressure, continuously flowing fluid, decreasing the chance of a stuck valve closure member. In general, I have provided a means for relieving the pressure against the valve closure member so that the valve closure member can be opened more easily while not inhibiting the closing function. In another respect, I have provided actuator means that moves a distance before engaging the valve closure member with a jar to dislodge a stuck valve closure member.

A preferred embodiment of a fluid motor **200** having these improvements, is shown in FIG. 5. Motor **200** is arranged in most respects like the motor described in my above referenced U.S. Patent 3,183,787 including motor casing **201**, fluid inlet pipe **202**, drive shaft **203** mounted in bearing **204**, motor housing **205** with only the intake block **206** and part of the valve rod block **207** shown. The impeller blade (not shown) is driven by the fluid entering the motor housing by manipulation of the valve means **208** in the intake block and exhaust block (not shown), as is described in my referenced U.S. Patent 3,183,787.

The valve means **208** includes intake poppet valve closure members **209** and **210** and the exhaust poppet valves (not shown), each arranged in the same unique fashion of my invention on their respective valve rods **211** and **212** for seating with the fluid pressure in matching valve seats **213** and **214**, respectively. Valve rods **211** and **212** are supported and pass freely through spiders **215** and **216**, respectively, in intake block **206** to prevent lateral movement.

Valve means **208** is manipulated by an actuator means **217** including projection means **218** on drive shaft **203** for oscillation therewith. Projections **218** operate a lost-motion spring-loaded actuator means **219** that, in turn, shifts the linkage means **220** to open an intake valve on one side of the impellar blade (not shown) and the exhaust valve on the other side of the impellar blade, then opening the other intake and exhaust valves, and alternating this sequence with the oscillation of drive shaft **203**. Linkage means **220** is also actuated by an auxiliary valve unseating means **221**. All these mechanisms operate as described in my above referenced U.S. Patent 3,183,789.

The modification in the valve means **208** that reduces sticking and facilitates opening the valve closure member is best shown in FIG. 6 for poppet valve closure member **209** and valve rod **211**. Poppet valve closure member **209** closes fluid passage **225** (FIG. 5), seating with the fluid when valve rod **211** is in one position. A heavy pressure continues to keep valve closure member **209** closed and when valve rod **211** is lifted by the linkage means **217** a very large force is required to counter the fluid pressure.

I have provided in valve closure member **209** a central passage **226** that, when open, carries fluid from the face **227** of valve closure member **209** into the motor housing through spider **215**. When passage **226** is opened, pressure is relieved on valve closure member **209** and linkage means **217** can unseat valve closure member **209** more easily. Passage **226** has a poppet valve seat **228** that receives a poppet valve closure member **229** that slides freely on valve rod **211**, has a smaller surface area face than face **228** and seats with the fluid pressure. When valve rod **211** is in the position for valve closure member **209** to close, as shown in FIG. 6, valve closure member **229** is seated also.

Valve rod **211** passes freely through a ring **235** supported in passage **226** from valve closure member **209**, by spaced arms **240** that permits fluid flow therearound. As linkage means **220** moves valve rod **211** to a second position, opening valve closure member **209**, valve rod **211** has engaging means, such as collar **230** fixed thereto and spaced between and from valve closure member **229** and ring **235** that jars and unseats valve closure member **229** to permit fluid to enter passage **209** and **225**. The pressure on valve closure member **209** being relieved, valve closure member **209** is jarred and unseated by an engaging means, such as a collar **231** fixed to valve rod **211** and spaced from ring **235** on the opposite side from collar **230**. The spacing is sufficient to develop a forceful jar. As long as valve rod **211** is in the second position, valve closure member **209** remains unseated.

The arrangement of engaging means and valve rod can take other forms to unseat a relief valve closure member first. Other arrangements of a valve rod and valve closure member can be used to provide a jar at a central location to prevent valve sticking. These features, either together or individually, can be utilized in other devices where valves are employed and for many types of valves.

While I have disclosed several preferred embodiments of my invention, other embodiments could be illustrated and are obvious to one skilled in the art.

I claim:

1. A fluid control valve, comprising,
valve seat means defining a first passage,
first valve closure means seating with the fluid pressure into the valve for closing said first passage,
said first valve closure means having a second passage to permit the fluid coming into said valve to flow into said first passage with said first valve closure means seated,
second valve closure means for closing said second passage,
means for successively jarring and unseating said second valve closure means from said second passage and unseating said first valve closure means from said first passage to facilitate opening of the valve even when fluid is flowing into said valve.

2. Apparatus, as described in claim **1**, wherein,
said first valve closure means is a removable first member that engages a valve seat to close off said first passage,
said second passage being a hole in said member,
said second closure means is a removable second member for closing off said member hole and seating with the fluid flowing into the valve,
said second member having a hole extending in line with the direction of movement of said second member, said removing means including a valve rod extending freely through said second member hole and said first member hole and having a first engaging means arranged, when said first and second members are seated and upon movement of said valve rod, to unseat successively said second member and said first member to release pressure on said first member.

3. Apparatus, as described in claim **2**, wherein,
said engaging means includes spaced first and second abutments,
said first abutment being closest to said second member and, upon movement of said valve rod in the opposite direction from fluid flow, jarring and carrying said second member in said opposite direction to open said second member hole and permit a portion of the fluid to enter said first passage and thereafter said second abutment jarring and carrying said first member in said direction to fully open said first passage to said fluid.

4. In combination with a fluid actuated motor having at least first and second inlet passages and first and second valve closure members for said respective first and second inlet passages that each seat with the fluid pressure, separate from a respective seat by movement of respective valve rods, and open and close to permit said fluid to flow alternately into said fluid motor through said first and second passages, the improvement comprising,
each of said valve rods extending through a hole in said respective valve closure member for free movement in the direction of unseating and having means on the opposite side of said respective valve closure member from the side said respective valve closure member unseats for engaging said valve closure member said means being arranged to engage said respective valve closure member after a given distance of free movement of said respective valve rod, to jar said respective valve closure member prior to unseating and unseat said respective valve closure member as said respective valve rod moves further in the direction of unseating,

each of said valve closure members comprising a removable first member that closes off said respective inlet passage,

said first removable member having a hole,

a removable second member for closing off said first member hole and seating with said fluid flowing into said motor, said second removable member having a hole extending in line with the direction of movement of said removable second member,

said respective valve rod extending freely through said second member hole and said first member hole,

said engaging means comprising on each of said valve rods first and second abutments spaced apart along the length of said respective valve rod, said first abutment being closest to said second member and, upon movement of said respective valve rod in the opposite direction from said fluid flow, jarring and carrying said second removable member, in said opposite direction to open said second removable member hole and permit a portion of the fluid to enter said respective inlet passage, and thereafter said second abutment jarring and carrying said first removable member in said opposite direction to fully said respective inlet passage to said fluid.

5. A fluid control valve, comprising,

valve seat means defining a first passage,

first valve closure means seating with the fluid pressure into said valve for closing said first passage, said first valve closure means comprising a removable first member that engages a valve seat to close off said first passage, said first valve closure means having a second passage to permit the fluid coming into said valve to flow into said first passage with said first valve closure means seated, said second passage comprising a hole in said member,

second valve closure means for closing said second passage,

said second valve closure means comprising a removable second member for closing off said second passage hole and seating with the fluid flowing into said valve, said removable second member having a hole extending in line with the direction of movement of said second member,

means for successively unseating said second valve closure means from said second passage and said first valve closure means from said second passage, said unseating means including a valve rod extending freely through said removable second member and having a first abutment closest to said second removable member, and a second abutment spaced from said first abutment on the opposite side of

said first abutment from said second member, and upon movement of said valve rod in the opposite direction from said fluid flow, jarring and carrying said second member in said opposite direction to open said second member hole and permit a portion of said fluid to enter said valve and thereafter further movement of said valve rod in said opposite direction, said second abutment jarring and carrying said first member in said opposite direction to open fully said first passage to said fluid.

6. In combination with a fluid activated motor having at least one valve closure member that seats with the fluid pressure and is separated from the seat by movement of a valve rod, the improvement comprising,

said valve rod extending through a hole in said valve closure member for free movement in the direction of unseating and having means on the opposite side of the valve closure member from the side said valve closure member unseats for engaging said valve closure member, said means being arranged to engage said valve closure member after a given distance of free movement of said valve rod, to jar said valve closure member prior to unseating and unseat said valve closure member as said valve rod moves further in the direction of unseating,

said valve rod being supported for free movement through a spider disposed between said engaging means and a second engaging means on said valve rod,

said spider being part of a second valve closure member that seats with said fluid,

said second engaging means being arranged to unseat said second valve closure member after said one valve closure member is jarred and unseated.

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