April 27, 1965 J. M. KELLNER ETAL 3,180,437

FORCE APPLICATOR FOR DRILL BIT

Filed May 22, 1961 4 Sheets-Sheet 1

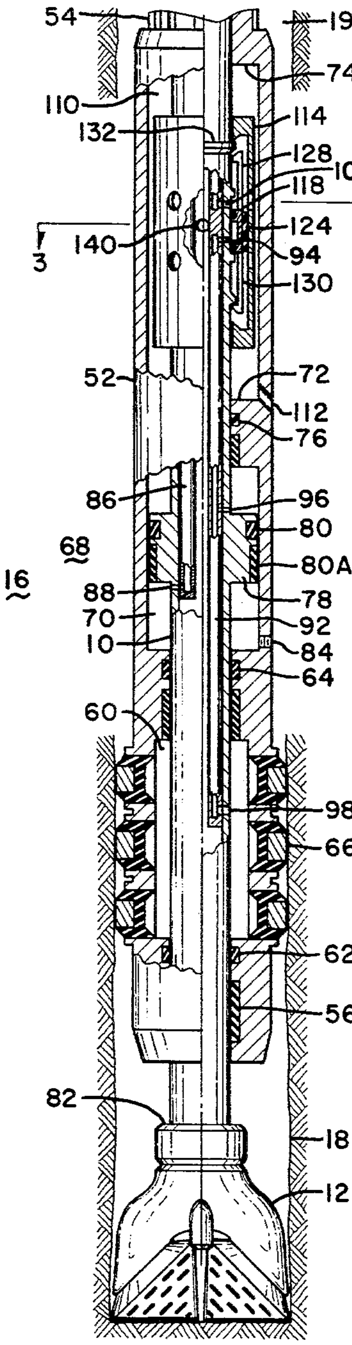

FIG. 1B

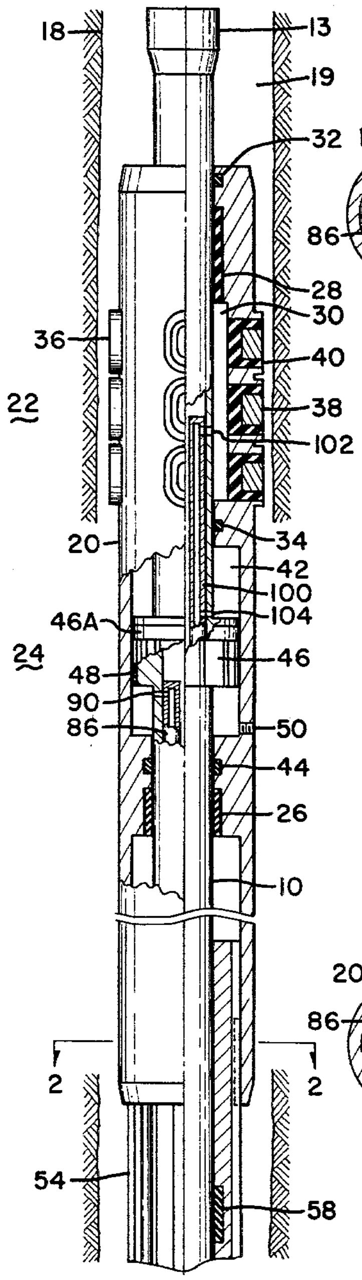

FIG. 1A

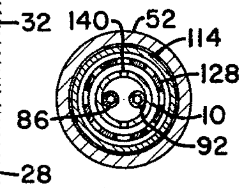

FIG. 3

14

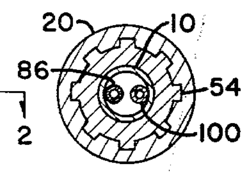

FIG. 2

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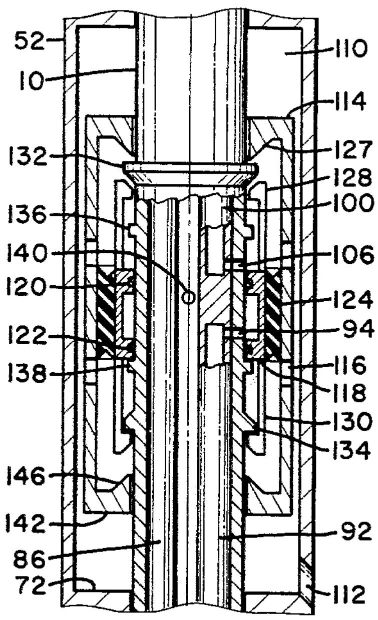

FIG. 4

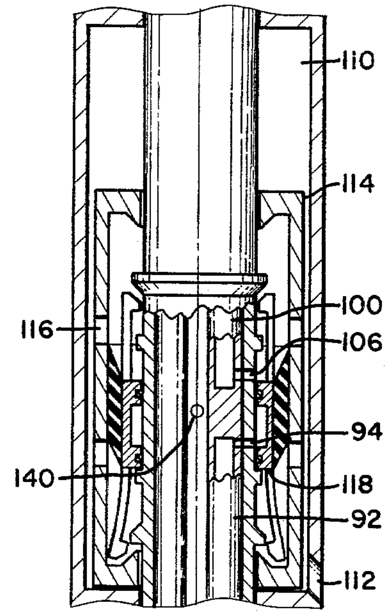

FIG. 5

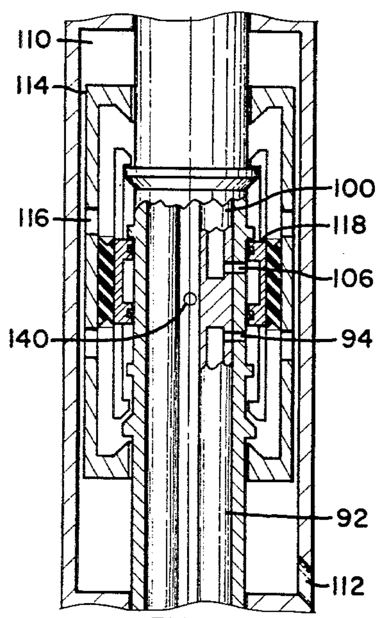

FIG. 6

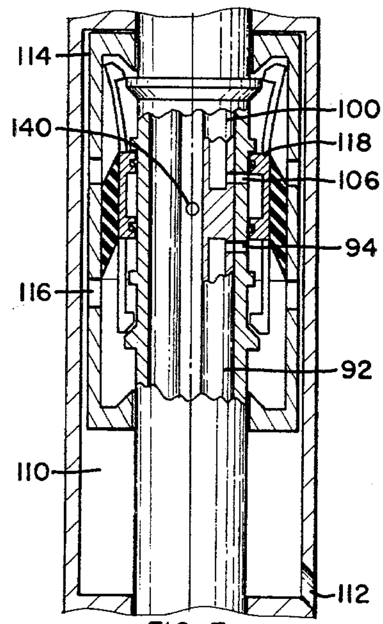

FIG. 7

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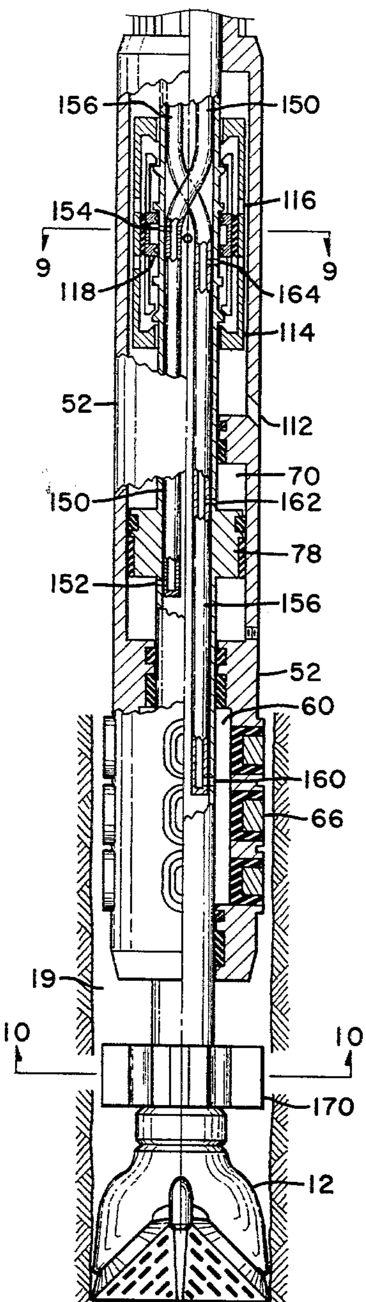

FIG. 8B

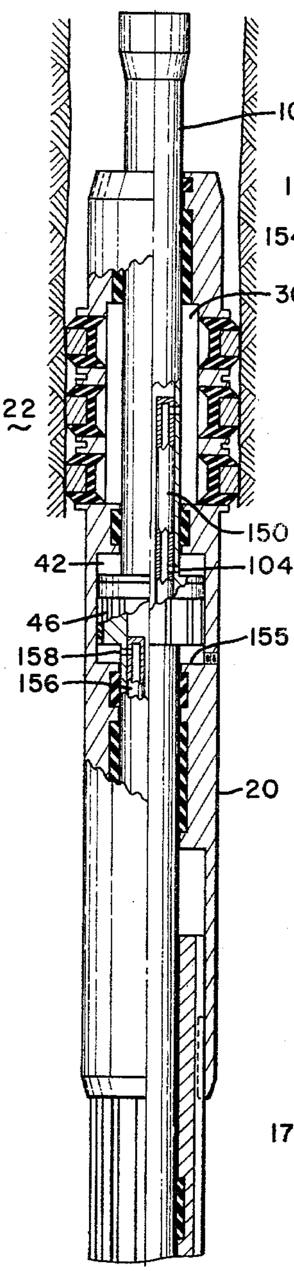

FIG. 8A

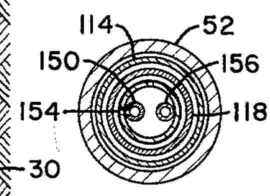

FIG. 9

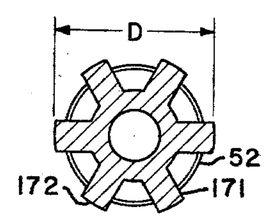

FIG. 10

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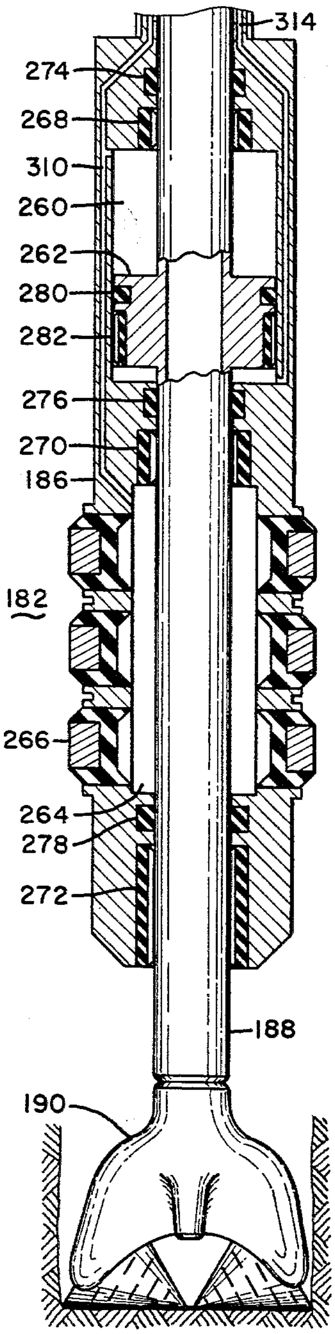

FIG. 11A

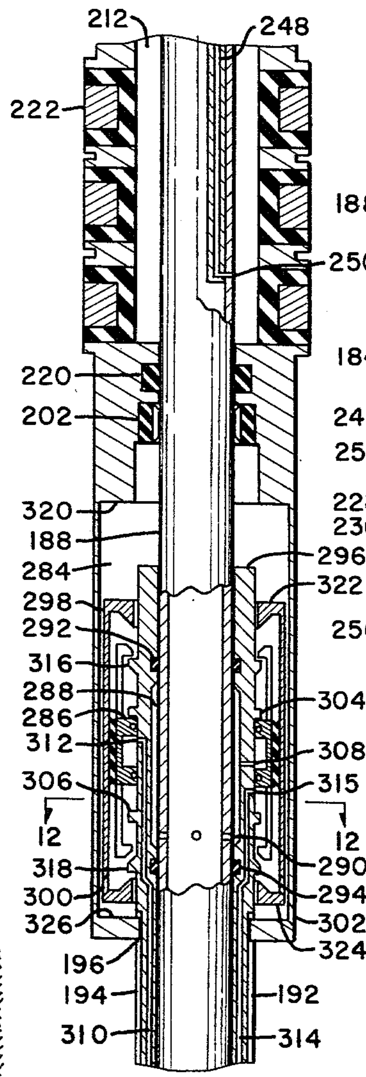

FIG. 11B

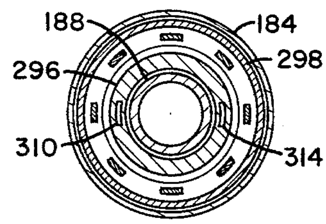

FIG. 12

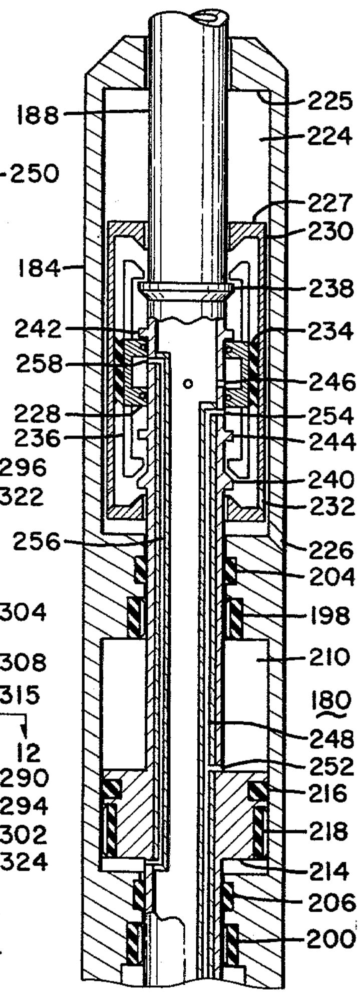

FIG. 11C

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United States Patent Office

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FORCE APPLICATOR FOR DRILL BIT

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Filed May 22, 1961, Ser. No. 114,278
16 Claims. (Cl. 175—230)

This invention relates to apparatus for applying weight to a bit that is used for drilling wells or boreholes into the earth. More particularly it relates to a bottom hole assembly for applying force to a drill bit thereby forcing the bit against the bottom of a borehole. This application is a continuation-in-part of co-pending application Serial No. 77,049, now abandoned, filed December 20, 1960.

In the art of drilling wells for the production of oil and gas the most commonly used method is the so-called rotary drilling method. In the rotary drilling method, a drill bit is suspended at the lower end of a string of drill pipe which is supported from the surface of the earth. A drilling fluid is forced down through the drill string through the drill bit and back up to the surface through the annulus between the drill pipe and the walls of the borehole. The purpose of the drilling fluid includes cooling the bit, carrying cuttings out of the well and also to impose hydrostatic pressure upon high-pressure formations penetrated by the drill bit to prevent the uncontrolled escape of oil, gas or water during drilling operations. Rotary drilling practice has found the rate of penetration of a drilling bit through subterranean formations is increased by increasing the force of a drill bit against the bottom of the well. It has been found further that the drilling of a more nearly straight hole is accomplished by creating a localized force in the area immediately adjacent the drill bit. In the latter instance, the twisting and rotative movement of lengthy strings of relatively flexible drill pipe is straightened immediately adjacent the drill bit by the application of such force.

The usual method that has been tried for increasing the pressure of a bit on the borehole is by the addition of several heavy drill collars between the drill bit and the drill string. Modern drilling practice has indicated that a trend toward even higher bit weight resulted in maximum drilling rates and accordingly minimum footage cost. The use of heavy drill collars has not been completely satisfactory. While the addition of drill collars has aided the penetration rate, this advantage is offset by the need for heavier surface equipment. Also more horsepower and rig time are required in pulling the drill pipe, drill collars and drill bit during normal operations of drilling such as are required when the drill bit becomes worn and needs replacing.

Accordingly it is the object of this invention to provide an apparatus for use in the drilling of wells wherein a drilling fluid is utilized to apply force upon the drill bit thereby eliminating handling of long drill collars.

Briefly, a preferred embodiment of this invention concerns upper and lower hydraulic bit loading units. An inner mandrel or arbor extends through each loading unit and fluidly connects the interior of a drill string with the bit. A lower case or section of an elongated housing surrounds the lower part of the mandrel immediately above the drill bit and a second or upper case or section of a housing surrounds the mandrel and is just above the lower case. The upper case and the lower case each contain

thrust or pushdown means positioned between the mandrel and the case for exerting force on the mandrel longitudinally thereof in the direction of the bit, and anchor means attached to each case operable upon actuation to transfer reaction thrust of the pushdown means to the borehole wall. Thus an upper and a lower bit loading units are provided. Control means are provided such that when the anchor means and pushdown means of one unit is being reset deeper down the hole, the other bit loading unit is operative. Differential pressure of drilling fluid which exists across a drill bit attached to the mandrel is utilized (1) to anchor the case of the unit (being operative) to the borehole wall, and (2) to apply force to the drill bit. A snap-acting valve arrangement operable by movement of the inner mandrel with respect to one of the cases controls the sequences of actuation of the upper and lower bit loading units. While one bit loading unit is being reset, the other is operative thus permitting force to be applied to the drill bit at substantially all times.

Other objects and a better understanding of the invention will become more apparent from the following description taken in conjunction with the drawing in which:

FIG. 1A is an upper and FIG. 1B is a lower elevational view partially in section which when taken together illustrates one embodiment of this invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1A;

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 1B;

FIGS. 4, 5, 6 and 7 are enlarged fragmentary sectional views of the valve mechanism representing various operational positions of the valve used in this invention;

FIGS. 8A and 8B are elevation views partially in section which when taken together illustrates another and preferred embodiment of the invention;

FIG. 9 is a sectional view taken along the line 9—9 of FIG. 8B;

FIG. 10 is a sectional view taken along the line 10—10 of FIG. 8B;

FIG. 11A is a lower, FIG. 11B is an intermediate, and FIG. 11C is an upper elevational view, in section, which when taken together illustrate another embodiment of this invention; and,

FIG. 12 is a sectional view taken along the line 12—12 of FIG. 11B.

In the drawing in FIGS. 1A and 1B in particular, mandrel 10 is a hollow cylindrical member or arbor which is supported from and connected to a conventional tubular drill pipe, not shown, through drill tool joint 13. The lower end of mandrel 10 is connected to a bit 12. Thus, as shown in the drawing, mandrel 10 provides a rigid connection between drill bit 12 and the drill string. The particular advantage of such a connection will be discussed in greater detail hereinafter. Mounted about the upper portion of mandrel 10 is upper bit loading unit 14 and about the lower portion of mandrel 10 is a lower bit loading unit 16. The apparatus is shown suspended in borehole 18.

Upper bit loading unit 14 includes case or housing 20 having an anchor section 22 and a thrust or pushdown section 24. Upper case 20 is supported from mandrel 10 by lower bearing 26 and upper bearing 28. These bearings may be of the fluted rubber type. An anchor pressure chamber 30 is formed between the upper case 20 and the exterior of mandrel 10. Seals for pressure chamber 30 are provided by sealing means 34 at the lower end of the pressure chamber and seal 32 at the upper end of the case preferably above bearing 28. Mounting details of the various seals and bearings illustrated in the drawing will not be shown, as means for mounting such seals and bearings are known. Mounted in ports in the wall of case 20 adjacent pressure chamber 30 are a plurality of anchor shoes 36 which preferably is a metal element 38 mounted in rubber 40 which seals it with the periphery of the port. Shoes 36 thus are a type which expands outwardly against the borehole wall when pressure is applied in pressure chamber 30 and retracts to the position shown when pressure is released.

Below anchor section 22 is cylinder 42 defined between the outer surface of mandrel 10 and the inner surface of upper housing 20. Seal 34 is at the upper end of cylinder 42 between mandrel 10 and housing 20 and seal 44 is similarly at the lower end of cylinder 42. Mounted within cylinder 42 is piston 46 which can be made an integral part of mandrel 10 or can be otherwise secured thereto. Mounted around the lower part of piston 46 is a fluted rubber bearing 48 which prevents excessive lateral movement to piston seal 46*a* within cylinder 42. Mounted in the wall of cylinder 42 at its lower end is plug 50 which as will be seen hereinafter is used to charge the portion of cylinder 42 below piston 46.

Mounted about the lower portion of mandrel 10 is lower housing 52. The upper end of lower housing 52 is reduced in diameter from the remaining portion of the housing and into a splined section 54. Section 54 is insertable into the lower end of upper housing 20 which is splined internally to match the outer splines. This is shown clearly in FIG. 2. The splined connection between upper housing 20 and lower housing 52 results in the upper housing and the lower housing being connected in a non-rotatable but longitudinally slidable relationship with each other.

Lower housing 52 is supported from mandrel 10 by lower bearing 56 and upper bearing 58 which may be fluted rubber bearings. A seal 62 is above fluted bearing 56 and seals the exterior of mandrel 10 with the interior of lower housing 52.

An anchor section is provided in the lower part of lower bit loading unit 16. This includes a pressure chamber 60 defined between the exterior wall of mandrel 10 and the interior wall of lower housing 52. Pressure chamber 60 has a lower seal 62 and an upper seal 64 which forms a seal between mandrel 10 and the interior part of lower housing 52. Mounted in the wall of lower housing 52 opposite pressure chamber 60 are a plurality of anchor shoes 66 which are similar to anchor shoes 36.

Mounted above the anchor section in the lower housing is a pushdown or thrust section 68 which is similar to thrust section 24 of the upper bit loading unit. A cylinder 70 is defined between the exterior wall of mandrel 10 and the internal wall of lower housing 52. In the lower part of cylinder 70 is charging plug 84. Cylinder 70 is of slightly greater length in its longitudinal dimension than is chamber 110. A piston 78 is attached to or made part of mandrel 10. The upper face of piston 78 is preferably the same size in area as the upper face of piston 46 so as to have the same downward thrust from each loading unit. The ends of the effective stroke of piston 78 permitted in the cylinder 70 is limited by shoulder 72 and lower shoulder 74 in chamber 110 which actuates the alternating valve mechanism. Cylinder 70 is sealed at its upper end by seal 76 and at its lower end by seal 64. Supported on mandrel 10 within cylinder 70 is piston 78 which can be made an integral part with mandrel 10 as shown. A seal 80 is provided between piston 78 and the interior of cylinder 70. Bearing 80*a* prevents excessive lateral deformation of seal 80. The lower end of mandrel 10 is provided with a pickup shoulder

82 upon which lower housing 52 can rest when in its lowermost position.

Mounted within mandrel 10 is a resetting fluid conduit 86 which through ports 88 in the wall of mandrel 10 below piston 78 and through port 90 in mandrel 10 below piston 46 fluidly connects cylinder 42 below piston 46 with cylinder 70 below piston 78.

A lower power conduit 92 is provided within the lower part of mandrel 10. At the upper end of lower power conduit 92 is port 94 in the wall of mandrel 10. Intermediate the ends of conduit 92 is a throttle port 96 in the wall of mandrel 10 which establishes fluid communication between the interior of conduit 92 and the interior of cylinder 70 above piston 78. Positioned at the lower end of power conduit 92 is inflation port 98 in the wall of mandrel 10 which establishes fluid communication between the interior of power conduit 92 and the interior of pressure chamber 60.

An upper power supply conduit 100 for supplying power to upper bit loading unit 14 is provided in mandrel 10 and extends from just above lower power conduit 92 to adjacent anchor section 22. At the upper end of upper supply conduit 100 in the wall of conduit 10 is supply port 102 which fluidly connects the interior of pressure chamber 30 with the interior of supply conduit 100. A throttle port 104 in mandrel 10 provides communication between the cylinder 42 above piston 46 and the interior of upper supply conduit 100. A lower port 106 is in the wall of mandrel 10 and communicates with the interior of upper supply conduit 100. Ports 106 and 94 are spaced sufficiently close together to permit convenient operation of D-slide valve or valve ring 118 which surrounds mandrel 10.

Preferably in lower housing 52 above section 68 is valve operating chamber 110 (shown in enlarged views in FIGS. 4, 5, 6 and 7) which is vented at 112 to the relatively lower differential pressure existing during drilling conditions within annulus 19 between the apparatus and the borehole wall. The valve itself operatively surrounds inner mandrel 10 and includes annular valve release cage or tube 114 which has vertical movement about mandrel 10 within chamber 110. Release tube 114 has a multiplicity of ports 116 formed in its wall. D-type slide valve 118 is longitudinally sealed in a slidable relationship with inner mandrel 10 using upper and lower shaft seals such as O-rings 120 and 122. Slide valve 118 is connected to valve release tube 114 by a resilient spring means 124, typically a resilient elastomer material bonded to the valve 118 and release tube 114. Attached to slide valve 118 are a multiplicity of spring loaded latch fingers 128 and 130 which are adapted to be latched or unlatched to or from respective upper shoulder 132 and lower shoulder 134 attached to or made integral with inner mandrel 10. Positive stops 136 or 138 on mandrel 10 limits the vertical travel of valve 118 with respect to mandrel 10.

Slide valve 118 is operable to alternately connect the upper and lower supply conduits with the pressure fluid supply port 140 which is midway between shoulders 132 and shoulder 134 and extends through the wall of mandrel 10. When in the position shown in FIG. 1B, the interior of mandrel 10 is fluidly in communicaiton with lower power conduit 92 which in turn is in fluid communication with cylinder 70 above piston 78 and the pressure chamber 60 of the anchor section of the lower bit loading unit. Inflation port 98 of pressure chamber 60 is made larger than throttle port 96 above piston 78. In operation, this permits anchor shoes 66 to be expanded against the borehole wall before the reaction thrust in cylinder 70 can cause substantial upward movement of housing 52. When in the position shown in FIGS. 1A and 1B, upper supply conduit 100 is in fluid communication with annulus 19 through port 106 and mandrel 10, port 116 in valve release tube 114 and vent 112. When valve 118 is in its alternate position, it fluidly connects the interior of mandrel 10 with upper power supply conduit 100, which supplies power for anchor section 22 and pushdown or thrust section 24. When valve 118 is in its upper position against stop 136, port 94 is uncovered and thus the interior of lower power conduit 92 is in fluid communication with annulus 19 through ports 116 and release tube 114 and vent 112.

The operation of the apparatus shown in FIGS. 1A and 1B will now be described, with attention also being directed to the views of FIGS. 4, 5, 6 and 7 which illustrate in greater detail the valve operating mechanism while taken in combination with the views of FIGS. 1A and 1B.

Before the device is lowered into the well bore resetting fluid, which may be a lightweight oil, for example, is injected through either plug 84 or plug 50 to fill cylinder 70 below piston 78, the interior of resetting fluid conduit 86 and that portion of cylinder 42 below piston 46. To obtain optimum operation, the stroke of piston 78 in the lower unit is approximately equal to the stroke of piston 46 in the upper bit loading unit. The stroke of valve release tube 114 within valve operating chamber 110 is preferably slightly less than the stroke of piston 78 to prevent bumping of the pistons 78 against the shoulders of cylinder 70 and also prevents the bumping of piston 46 against the shoulders of cylinder 42. A rotary drill pipe, not shown, is attached through coupling 13 to inner mandrel 10 and bit 12. Drilling fluid is pumped down through the interior of the rotary drill pipe and the interior of inner mandrel 10 to the bit where it passes through the bit and is circulated to the surface through the annulus 19. The pressure drop through the bit then results in a relatively high pressure within the interior of mandrel 10 in a relative lower pressure in annular space 19. Assume that in the initial operation the inner mandrel and valve mechanism is in the position shown in FIGS. 1A and 1B and FIG. 4. A small portion of the drilling fluid passes through supply ports 140 into the confined portion of slide valve 118 and thence through port 94 into lower power conduit 92. Substantially instantaneously this pressure is transferred into pressure chamber 60 forcing anchor shoes 66 into anchor contact with the borehole wall. Since throttling port 96 is smaller than inflation port 98, thrust force is delayed until the anchor shoes have been positioned. Thereafter full pressure is applied to the upper part of power piston 78 tending to force it downwardly with respect to lower housing 52.

Rotary drilling imparted to mandrel 10 to bit 12 continues with slide valve 118 traveling therewith as drilling progresses until such time as the lower part or face 142 of valve release tube 114 engages the lowermost position of upward face 72 of valve operating chamber 110. Rotary drilling continues under the applied pressure force of lower bit loading unit 16 until the lower valve latch fingers 130 are released from latch shoulder 134 by engagement with lower release finger 146 as a part of release tube or cage 114. The continued downward movement of slide valve 118 creates tension in spring means 124. (See FIG. 5.) Upon its release slide valve 118 is snapped upward, causing engagement of upper latch fingers 128 with latch shoulder 132 as shown in FIG. 6. In that position, pressure supply fluid is now diverted through port 140 into or through port 106 into upper power supply conduit 100.

During the drilling operation just described in which the lower bit loading unit was operative; that is, anchor shoes 66 were engaged in the wall of the well bore and pushdown piston 78 were exerting a force on the bit, resetting fluid was being forced from beneath piston 78 to port 88, resetting fluid conduit 86 and port 90 to beneath piston 46 thus driving upper housing 20 downwardly with respect to piston 46. During this process anchor shoe 36 are in a relaxed position and are not engaging the well bore wall. Also during this period, the area above piston 46 and cylinder 42 is not in communication with the high pressure fluid within mandrel 10 but rather is in communication through the valve control means to annulus 19. It is thus seen that as piston 78 reaches the lower part of its stroke within cylinder 70, piston 46 is driven to its uppermost position in cylinder 42.

Due to the snap-action of valve 118 power supply is fed to upper supply conduit 100 nearly instantaneously with the stopping of the power supply to the lower power supply conduit 92. As the power supply is cut off to the lower bit loading unit pressure is immediately released from pressure chamber 60 and cylinder 70 thus allowing the immediate retraction of anchor shoes 66 and stopping the downward thrust of thrust section 68. When piston 78, in the lower bit loading unit 16, is at its lowermost position, piston 46 in the upper bit loading unit is at its uppermost position in cylinder 42. Nearly instantaneous with slide valve 118 being in its uppermost position, power is supplied through port 106, upper supply conduit 100 through valve port 104 to (*a*) cylinder 42 above piston 46 and through port 102 (*b*) to anchor pressure chamber 30. Anchor section 22 is anchored securely to the borehole wall before there is any substantial downward movement of piston 46 with respect to upper housing 20. This can be accomplished by making throttle port 104 smaller than port 102 and it is also effected by the throttle, in effect, of the resetting fluid beneath piston 46. It can also be done by using resetting ports 88 and 90 as throttle ports.

Drilling continues by rotating mandrel 10 and this time the downward thrust is supplied by thrust section 24 of the upper bit loading unit and the reaction thrust is transferred to borehole wall by shoes 36 in the upper part of upper housing 20. During this time the lower bit loading unit is being reset; that is, lower housing 52 is being forced downwardly with respect to piston 78 by resetting fluid being forced from beneath piston 46 downwardly through resetting supply conduit 86 to the underside of piston 78 in the lower loading unit. During this itme anchor shoes 66 are in a retracted position and the lower unit moves readily downward. Lower unit housing 52 continues to move downwardly at twice the rate as piston 46 moves through its stroke in cylinder of the upper bit loading unit. As drilling progresses and as shown in FIG. 7, contact of valve release cage 114 with the upper portion of chamber 110 forces release finger 127 into engagement with valve latch fingers 128, moving them from contact with latch shoulder 132. Similarly, due to the potential tension created in spring means 124, valve 118 is snap-actingly forced downwardly. Latch fingers 130 are engaged with latch shoulder 134 to assume the starting position as shown in FIG. 4 when the cycle above described is repeated.

Referring now to FIGS. 8A and 8B, there is illustrated another embodiment and the best mode contemplated for carrying out the present invention. The apparatus shown in FIGS. 8A and 8B is similar to that shown in FIGS. 1A and 1B, for example, it has an upper bit loading unit and a lower bit loading unit. However, the resetting of the loading units is different. These differences are incorporated in FIGS. 8A and 8B and will now be discussed. More particularly, the resetting fluid conduit 86 and the port arrangement of the unit control section illustrated in FIG. 1B have been changed. A first fluid channel 150 extends from beneath piston 78 of the lower unit to above piston 46 of the upper loading unit. This fluid channel fluidly communicates with the lower portion of cylinder 70 beneath piston 78 to port 152. A port 154 in mandrel 10 fluidly connects fluid channel 150 with the interior of slide valve 118 when in the position shown in FIG. 8B. When the valve is in its lowermost position the interior of fluid channel 150 is in fluid communication through port 116, valve release tube 114 and through vent 112 to annulus 19. The upper end of fluid channel 150 is in fluid communication through port 104 with the upper side of piston 46 and pressure chamber 30 of anchor section 22.

A second fluid channel 156 extends from adjacent lower anchor pressure chamber 60 in the lower loading unit to approximately piston 46 in the upper loading unit. Second fluid channel 156 fluidly communicates with the under side of piston 46 into cylinder 42 through port 158. Second conduit 156 fluidly connects with pressure chamber 60 of the lower anchor section through port 160 and to the upper side of piston 78 in cylinder 70 through port 162. When in the position illustrated in FIG. 8B, second fluid conduit 156 is in fluid communication through port 164 to 116 and vent 112 to the annulus 19.

When slide valve 118 is in its lower position the interior of conduit 156 is in fluid communication with the interior of mandrel 10 and the interior of conduit 150 is in fluid communication with the annulus 19.

A brief description will now be given of the operation of the device shown in FIGS. 8A and 8B. The device is assembled and connected to the lower end of a string of drill pipe and is then lowered into the bottom of a well bore. Drilling fluid under pressure is forced downwardly through mandrel 10. When the valve mechanism is in the position shown in FIG. 8B, fluid conduit 150 is in fluid communication with the high pressure fluid in mandrel 10. Anchor section 22 is anchored to the borehole wall and downward pressure is exerted on piston 46 through mandrel 10 to bit 12. The anchor shoes of section 22 are anchored securely to the borehole wall before sufficient fluid is passed through port 104 above piston 46 to cause piston 46 to move substantially. High pressure fluid is also in fluid communication with the under side of piston 78 of the lower bit loading unit and drives the lower outer housing 52 rapidly downwardly. When valve 118 is in the position shown in FIG. 8B, fluid conduit 156 is in fluid communication with the lower pressure annulus 19. This permits the lower anchor section to be relaxed as shown while the upper loading unit is anchored to the borehole wall and is supplying thrust to the bit. The upper portion of cylinder 70 above piston 78 of the lower unit is also in fluid communication with the exterior of the housing. This permits the outer housing to be pushed rapidly downwardly by the high pressure fluid entering cylinder 70 beneath piston 78. The lower portion of cylinder 42 beneath piston 46 in the upper loading unit is also fluidly connected to the low pressure exterior of the units.

As outer housing 52 of the lower unit moves downwardly it snap-actingly moves valve 118 to a second position. When the valve is in its lower position, it is readily seen that conduit 156 is in fluid communication with the high pressure fluid within mandrel 10 and fluid conduit 150 is in fluid communication with the relatively low pressure annulus 19 exterior of the units. When in this position, the lower anchor shoes 66 are nearly instantaneously expanded against the wall of the borehole and high pressure fluid enters cylinder 70 above piston 78 and begins to exert a downward force on the mandrel. The slight throttling effect of fluid through port 162 permits shoes 66 to be anchored securely before substantial movement is obtained between the lower housing and the mandrel. When valve 118 is in its lower position, the anchor section of the upper loading unit is relaxed as pressure chamber 30 is in fluid communication with the low pressure area as is also the portion of cylinder 42 above piston 46. However, the lower part of cylinder 42 below piston 46 is in fluid communication with the high pressure fluid in fluid conduit 156 and the high pressure fluid acts on face or shoulder 155 of the lower part of cylinder 42 driving upper housing 20 downwardly and resetting it where it remains reset until drill 12 is drilled the length of the stroke of piston 78 at which point valve 118 is snap-actingly moved to its upper position and the cycle is repeated. In the apparatus shown in FIGS. 8A and 8B, the weight is applied most of the time to the lower unit. This is desirable as it is preferred to load the bit as close to the bit itself as is possible. In this embodiment, the length of the stroke of the upper unit compared to the lower unit is preferably rather short. In fact, the stroke of piston 46 may be as small as one-fourth or less of the stroke of piston 78 of the lower unit. This is possible as the upper unit is in operation only the length of time it takes the lower unit to be reset. This resetting time will depend upon such factors as the length of the stroke of piston 78, the weight of the lower housing, the viscosity of the drilling fluid, the differential pressure existing across the bit, diameter and length of the fluid conduits, etc. However, for a unit in which the stroke of piston 78 is about 10 ft. and under normal drilling conditions the time for the lower unit to reset is in the range of about 20 to 30 seconds or less. It is thus seen that in the system shown in FIGS. 8A and 8B that the anchor shoes closer to the bit 12 are in operation all the time except for this brief resetting period. This tends to permit a straighter hole to be drilled during the drilling operations.

Also shown in FIG. 8B is a spiraling preventer 170 which is added about the mandrel 10 just above bit 12. The spiraling preventer may be made an integral part of mandrel 10 and includes a series of spaced-apart hard surface skates or shoes 171 spaced about the circumference of the mandrel. The face 172 of each skate 171 is preferably a hard surface. The diameter D of the spiraling preventer 170 as shown in FIG. 10 is approximately equal or slightly greater than the relaxed diameter of the anchor shoes and less than the gage diameter of the bit. This spiraling preventer 170 stops or reduces spiraling (bit walking) and prevents substantial reduction of the "drift" diameter of the hole. This permits more readily advancement of the outer case after resetting of the tool.

Turning now to FIGS. 11A, 11B and 11C there is illustrated still another embodiment of the invention. In this embodiment both the upper and the lower loading units are operative to exert a force on the bit at all times except for a brief resetting time for each bit loading unit. Controls are provided such that the units are reset at different times. Illustrated thereon is an upper loading unit 180 and lower loading unit 182. Mandrel 188 is connectable at its upper end to a string of drill pipe not shown and at its lower end to a bit 190. Mounted about mandrel 188 is upper housing 184 and lower housing 186. The upper housing and the lower housing are interconnected in a nonrotatable, longitudinally slidable relationship through spline joint 192 which includes external splines on an upper reduced portion of the lower housing and internal splines 196 in the bore of the lower end of upper housing 180. The splined connection between the upper housing and the lower housing prevents rotation of a housing as it is being reset. This feature protects the anchor shoes as they cannot be rotated when retracted. Upper housing 180 is rotatably supported from mandrel by upper bearing 198, intermediate bearing 200, and lower bearing 202, which are supported within internal recesses in the housing in a known manner. These bearings can be of the fluted rubber type similarly as bearing 26.

An annular cylinder 210 is formed between the outer wall of mandrel 188 and the interior of housing 184. Upper seal 204 and intermediate seal 206 disposed between housing 184 and mandrel 188 aid in making annular cylinder 210 relatively fluid tight. Mounted in annular cylinder 210 is an annular piston 214 which is carried by or made integral with mandrel 188. A seal 216 is provided between piston 214 and the interior of cylinder 210. Piston 214 carries bearing 218 to prevent excessive lateral deformation of seal 216. Immediately below annular cylinder 210 is pressure chamber 212 formed in a recessed portion of housing 184 and the interior of mandrel 188. A lower seal 220 is provided just above bearing 202 between housing 184 and mandrel 188. Thus, seals 220 and 206 aid in making chamber 212 relatively fluid tight. Resiliently and sealingly mounted in ports in the wall of housing 184 adjacent pressure chamber 212 are a plurality of anchor shoes 222 which are similar to anchor shoes 36 described above in relation to FIG. 1A.

As shown in the upper portion of housing 184 is valve operating chamber 224 which is vented at 226 to the relatively lower pressure existing during drilling conditions within the annulus between the apparatus and the borehole wall. Operating in valve operating chamber 224 is a D-slide valve 228 and its component parts which are similar to the valve shown in FIG. 1B as operating within valve operating chamber 110. The valve operatively surrounds mandrel 188 and includes annular release cage 230 which has a plurality of ports 232. Slide valve 228 is connected to valve release cage 230 by resilient spring means 234. Attached to slide valve 228 are a plurality of spring loaded latch fingers 236 which are adapted to be latched or unlatched to or from respective upper shoulder 238 and lower shoulder 240. Positive stops 242 and 244 on mandrel 188 limits the vertical travel of valve 228 with respect to the mandrel.

Stops 242 and 244 on mandrel 188 are so designed in relation to slide valve 228 that power port 246 in the wall of mandrel 188 is in fluid communication with the interior of annular valve 228 in any position of the valve between upper stop 242 and lower stop 244. Mounted adjacent the wall of the interior mandrel 188 is a power supply conduit 248. This conduit is in fluid communication with pressure chamber 212 and annular cylinder 210 above piston 214 through ports 250 and 252. Port 250 can be slightly larger than port 252 and thus when fluid pressure is applied, the anchor section is secured to the borehole wall prior to any substantial movement of housing 184 with respect to piston 214. Port 254 is provided in the wall of mandrel 188 below port 246. When slide valve 228 is in its uppermost position against stop 242 as shown in FIG. 11C, power supply conduit 248 is in fluid communication through ports 232 and 226 with the annulus between the tool and the borehole wall. However, when valve 228 is in its lowermost position as against stop 244, port 254 is in fluid communication with the interior of the valve; thus power conduit 248 is in fluid communication with the interior of mandrel 188.

Also shown is a resetting conduit 256 which is in fluid communication with the part of annulus cylinder 210 below piston 214. The interior of conduit 256 is also in fluid communication with port 258 and in the position shown resetting conduit 256 is in fluid communication with the interior of mandrel 188. However, when slide valve 228 is in its lower position against stop 244, port 258 is not covered by valve 228 and thus the part of cylinder 210 below piston 214 is in fluid communication through conduit 256, ports 232 and 226 with the annulus between the tool and the borehole.

Attention will now be directed toward lower loading unit 182. Lower loading unit 182 contains a pushdown section and wall anchor section similarly as upper loading unit 180. The pushdown section includes annular cylinder 260 and piston 262 which is mounted on the mandrel 188. Below annular cylinder 260 is pressure chamber 264 in which anchor shoes 266 are mounted in the wall of housing 186 similarly as shoes 222 in the upper loading unit. The lower housing 186 is rotatably and longitudinally movable, in relation to mandrel 188 and is supported therefrom by upper bearings 268, intermediate bearings 270, and lower bearing 272. Associated with these bearings are upper seal 274, intermediate seal 276, and lower seal 278. These seals and bearings are carried in grooves or otherwise by the housing in a known manner. Piston 262 is also provided with a seal 280 and bearing 282 similarly as seals 216 and bearing 218 of piston 214.

The valve control mechanism for actuating and resetting the lower unit will now be discussed. A valve operating chamber 284 is provided between the interior of the lower end of upper housing 184 and the exterior of reduced portion 296. The valve mechanism in valve operating chamber 284 is similar to D-slide valve 228 and its associated parts, except the slide valve 286 and its associated parts are actuated by a relative movement between upper housing 184 and lower housing 186, whereas slide valve 228 is actuated by a relative movement between mandrel 188 and upper housing 184. Extending upwardly into valve operating chamber 284 is an upper reduced portion 296 of lower housing 186 which is decreased in size and has an internal bore approximately the size of the external diameter of the mandrel 188. An annular power supply conduit 288 is provided in a recessed portion of upper reduced portion 296. The longitudinal length of annular conduit 288 is such that the port 290 is in communication with the power conduit 288 during the entire stroke of piston 262. Upper seal 292 above annular conduit 288 and lower seal 294 below annular conduit 288 are carried by reduced portion 296 of the lower housing. Slide valve 286 is resiliently supported from annular release cage 298 in which is provided relief port 300. A port 302 is provided in the wall of upper housing 184 to vent valve operating chamber 284 to the annulus between the apparatus and the borehole wall.

Slide valve 286 has longitudinal movement between upper stop 304 and lower stop 306. The interior of annular slide valve 286 is in fluid communication with power conduit 288 through port 308. Port 308 is arranged in relation to the annular slide valve and stops 304 and 306 such that it is always in fluid communication with the interior of annular slide valve 286; thus the interior of slide valve 286 is always in fluid communication with the interior of mandrel 188. In the position shown a power fluid conduit 310 is in fluid communication with interior of annular valve 286 through port 312 and with annular cylinder 260 above piston 262 and with pressure chamber 264 of the anchor section of the lower loading unit. In the position of the valve as shown annular cylinder 260 below piston 262 is in fluid communication through relief conduit 314 through ports 300 and 302 to the annulus.

Above stop 304 is upper shoulder 316 and below lower stop 306 is lower shoulder 318. These shoulders 318 and 316 function with respect to the valve operating mechanism similarly as stops 238 and 240 of the upper valve arrangement in relation to the slide valve 228. The upper part of valve operating chamber 284 has a downwardly facing shoulder 320 which is arranged to contact the upwardly facing shoulder 322 of relief cage 298. Likewise, the lower part of relief cage 298 forms a shoulder 324 which is arranged to contact the upwardly facing shoulder 326 of the lower portion of valve operating chamber 284.

Port 312 and port 315 are arranged to contact the upwardly facing shoulder 326 of the lower portion of valve operating chamber 284.

Port 312 and port 315 are arranged such that when slide valve 286 is in the position shown, port 312 is in fluid communication with the interior of the slide valve and 315 is exterior of the slide valve. However, when the slide valve 286 is in its lower position, that is against stop 306, port 312 is above the annular slide valve and port 315 is in communication with the interior of the slide valve. In other words, in the position shown pressure chamber 264 of the anchor section and the upper part of cylinder 260 of the pushdown section is in fluid communication through conduit 310 through port 312 and the valve with the interior of mandrel and the lower side of chamber 260 below piston 262 is in fluid communication through conduit 314 and 315 to the exterior of tool.

The stroke of pistons 214 and 262 are preferably about the same length. The stroke of piston 214 is preferably slightly greater than the length of the "stroke" or longitudinal movement between mandrel 188 and upper housing 184 which is required to snap-actingly move valve 228 from one position to the other. This prevents piston 214 from being forced against the lower upwardly facing surface of annular cylinder 210. The "stroke," or movement of the upward housing with respect to the lower housing necessary to actuate valve 286 from either position, is preferably about the same as the "stroke" required to actuate valve 228.

Having described the structural features of the embodiment on FIGS. 11A, 11B and 11C, attention will now be directed briefly toward its operational features. The tool is connected in a conventional manner to the lower end of a string of drill pipe by connecting mandrel 188 to a tool joint not shown. The tool is lowered to the bottom of a drill hole. Drilling fluid is then circulated downwardly through mandrel 188 under pressure and bit 190 is rotated by rotating the drill pipe at the surface which in turn rotates mandrel 188. The particular relative position of upper housing 184 and lower housing 186 when operation is initiated does not matter as the two units of the tool automatically assume their proper relationship upon initial actuation of one or both control valve means by the upper loading unit. It will further be assumed for purpose of description of operation of the tool that initially lower valve 286 is in the position shown in FIG. 11B and the valve 228 is in its lowermost position against stop 244. In this position fluid under pressure is anchoring both the upper loading unit and the lower loading unit to the borehole wall by anchor shoes 222 and 266 respectively. Fluid under pressure is also urging pistons 214 and 262 downwardly thus forcing the drill bit against the bottom of the borehole and the reaction thrust is being transferred to the walls of the borehole being drilled. As drilling progresses, mandrel 188 is moved downwardly through the upper and lower loading units. As it moves downwardly, it takes with it annular valve release cage 230 similarly as described above in relation to valve 118. When the mandrel reaches a downward position relative to upper housing 184, slide valve 228 is snap-actingly moved to its upper position against stop 242 thus assuming the position shown in FIG. 11C in a manner similarly described above in relation to the snap-acting movement of a similar D-type slide valve in operating chamber 110. Valve 228 snapped back into its position shown in the drawing, is against upper stop 242 at which time annular pressure chamber 212 and upper side of piston 214 are vented to the annulus which is of a lower pressure than interior of mandrel 188. When in this position, cylinder 210 below piston 214 is in fluid communication through annular valve 228 with interior of mandrel 188. The upper loading unit housing, with its anchor section retracted, is forced downwardly. The downward movement of upper housing 184 causes lower shoulder 225 of the upper part of operating chamber 224 to strike the upwardly facing shoulder 227 of release cage 230, thus forcing the slide valve to its lower position, that is against stop 244 at which time the anchor shoes 222 engage the wall of the borehole and power is applied to the upper side of piston 214. It will be noted here that port 252 is designed such that flow is restricted sufficiently so that the anchor section is anchored before a great deal of force is applied against piston 214.

The downward movement of upper housing 184 causes shoulder 320 of the lower valve operating chamber 284 to strike the upper shoulder 322 of the lower release cage 298. This continued downward movement of the upper housing then causes valve 286 to be snap-actingly moved downwardly such that pressure chamber 264 of the anchor section of the lower loading unit 182 and cylinder 260 above piston 262 are in fluid communication with the annulus. At the same time cylinder 260 beneath piston 262 is in direct fluid communication with the interior of the mandrel 188 through ports 315 and 308. Fluid pressure thus forces the lower housing 186 downwardly to the end of its stroke, valve 286 is snap-actingly moved back to the position as shown in FIG. 11C. In this position the anchor shoes are driven outwardly against the borehole wall and fluid pressure is applied against the upper side of piston 262, thus exerting a downward force on the mandrel, thus forcing the bit 190 downwardly against the bottom of the borehole.

In the operation of the apparatus shown in FIGS. 11A, 11B and 11C upper loading 180 and the lower loading unit 182 are both in operation and exerting a downward force on the drill bit at all times except when being reset. However, the upper loading unit is reset at a different time from the lower loading unit such that one of the units is applying downward force on the drill bit at all times. As shown, valve 228 is snap-actingly moved to its lower position at about the same time that valve 286 is moved to its lower position. The anchor section of the upper unit is nearly instantaneously anchored when valve 228 gets in its lowermost position and is anchored approximately as fast as the anchor section shoes 266 of the lower unit are retracted. Likewise, the pushdown section of the upper loading unit is actuated immediately as the anchor section is anchored to the borehole. Thus, for all practical purposes one of the loading units is operative at all times during the resetting period of the tool. Except for its resetting time, each unit is operative at all times during drilling operations. The resetting time for each unit is rather brief, being only a matter of a few seconds.

In using the tool of this invention, drill pipe above the tool will normally be held in tension in order to prevent buckling and undue wearing of the tool joints. In cases where it is desired to apply less force to the bit than is normally furnished by the tool, the tension in the drill string can be increased by applying upward force to the drill string at the surface with the rig equipment to lessen the effective force of the bit. One instance where it is frequently desirable to do this is in reaming operations. The ability to control the force applied to the bit in this manner is a particular advantage of the tool of this invention. Further, this reduction of force on the bit is accomplished by reduction of the flow rate of the drilling fluid. A reduction in the quantity of the fluid circulated reduces the fluid available for cooling and lubricating the bit and lifting cuttings from the borehole and is therefore to be avoided. The use of a mandrel which extends through the tool and furnishes a rigid connection between the drill string and the bit as disclosed herein readily permits control of the force on the bit.

While there are above described but a limited number of embodiments of the process and system of the invention herein presented, it is possible to produce still other embodiments without departing from the inventive concept herein disclosed. It is therefore desired that only such limitations be imposed on the appending claims as are stated therein.

What is claimed is:

1. An apparatus for forcing a bit against the bottom of a borehole comprising in combination: a mandrel attachable at its lower end to a drill bit, a lower case mounted around one portion of said mandrel in a longitudinally slidable and rotatable relationship therewith, first pushdown means positioned between said mandrel and said lower case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such load on said lower case; first anchor means attached to said lower case and operable upon actuation to transfer said reaction thrust to the borehole wall; an upper case mounted around said mandrel longitudinally above said lower case and in a longitudinally slidable and rotatable relationship with said mandrel; second anchor means attached to said upper case and operable upon actuation to engage the borehole wall; means operable in a first condition to de-actuate said first

anchor means and said first pushdown means and to actuate said second anchor means and in a second condition to actuate said first pushdown means and said first anchor means and de-actuate said second anchor means.

2. In a rotary drilling apparatus for drilling a borehole including a drill bit and a drill string assembly and means for circulating fluid through said assembly and said borehole, the improvement which comprises: a rigid mandrel connectable within said drill string and having a conduit for the flow of fluids therethrough, a first housing surrounding said mandrel and rotatable and longitudinally movable therewith between upper and lower positions, first thrust transfer means interposed between said mandrel and said first housing and actuatable to thrust said mandrel downward relative to said first housing, first wall anchor means on said first housing actuatable to lock said first housing to the wall of said borehole, a second housing surrounding said mandrel and spaced longitudinally from said first housing and rotatable and longitudinally movable between upper and lower positions on said mandrel, second thrust transfer means interposed between said mandrel and said second housing and actuatable to thrust said mandrel downward relative to said second housing, second wall anchor means in said second housing actuatable to lock said second housing to the wall of said borehole, control means operable upon said first housing reaching said lower position to sequentially actuate said first wall anchor means and said first thrust transfer means, said control means being further operable upon said first housing reaching its upper position to de-actuate said first wall anchor means and said first thrust transfer means and to actuate said second transfer means and said second wall anchor means.

3. An apparatus as defined in claim 2 in which the first and second housing are telescopically connected in a non-rotatable manner.

4. An apparatus for forcing a bit against the bottom of a borehole comprising in combination: a mandrel attachable at its lower end to a drill bit, a first case mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; first pushdown means positioned between said mandrel and said first case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said first case, first anchor means attached to said first case and operable upon actuation to transfer said reaction thrust to the borehole wall; a second case mounted longitudinally from said first case around said mandrel in a longitudinally slidable and rotatable relationship with said mandrel; second pushdown means positioned between said mandrel and said second case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said second case; second anchor means attached to said second case and operable upon actuation to transfer reaction thrust to the borehole wall; control means operable in a first condition to actuate said first pushdown means and said first anchor means and to de-actuate said second anchor means and said second pushdown means and in a second condition to de-actuate said first anchor means and to actuate said second anchor means and said second pushdown means.

5. An apparatus as defined in claim 4 with the improvement of providing positioning means such that when said first case moves in one longitudinal direction with respect to said mandrel the second case moves in the opposite longitudinal direction.

6. An apparatus as defined in claim 4 in which the two cases are telescopically connected in a non-rotatable manner.

7. An apparatus as defined in claim 4 in which the mandrel is enlarged near its connection to the bit to a diameter substantially equal to the diameter of the first anchor means when such anchor means are in a retracted position.

8. In a rotary drilling apparatus for drilling a borehole including a drill bit and a drill string and means for circulating fluid through said assembly and said borehole, the improvement which comprises: a mandrel rigidly connecting said bit to said drill string and having a conduit for the flow of fluids therethrough; a first housing surrounding said mandrel and rotatable and longitudinally movable therewith between upper and lower positions; first thrust transfer means interposed between said mandrel and said first housing and actuatable to thrust said mandrel downwardly relative to said first housing; first wall anchor means on said first housing actuatable to lock said first housing to the wall of said borehole; a second housing surrounding said mandrel and spaced longitudinally above said first housing and rotatably and longitudinally movable between upper and lower positions on said mandrel; second thrust transfer means interposed between said mandrel and said second housing and actuatable to thrust said mandrel downwardly relative to said second housing; second wall anchor means in said second housing actuatable to anchor said second housing to the wall of said borehole; said first housing and said second housing telescopically connected in a non-rotatable manner; control means being operable upon said first housing reaching its lower position to sequentially actuate said first wall anchor means and said first thrust transfer means and to de-actuate said second anchor means and said second thrust transfer means; said control means being further operable upon said first housing reaching its upper position to de-actuate said first wall anchor means and said first thrust transfer means and to actuate said second transfer means and said second wall anchor means; housing positioning means operable such that when said first housing moves in one longitudinal direction with respect to said mandrel the second housing moves in the opposite longitudinal direction with respect to said mandrel.

9. In a rotary drilling system for drilling a borehole, including a drill string and a bit, the improvement which comprises: a hollow mandrel rigidly connecting said drill string to said bit and of a character to convey fluid from said drill string to said bit through its interior, the exterior surface of said mandrel defining a lower piston and an upper piston; a lower case surrounding said mandrel in a rotatable and longitudinally slidable relationship therewith and defining a lower cylinder for said lower piston, said lower case having an upper and a lower position with respect to said mandrel, said lower case further defining a valve operating chamber, such chamber being in fluid communication with the exterior of said lower case; a lower pressure chamber formed between said lower case and said mandrel; an upper case above said lower case and surrounding said mandrel in a rotatable and longitudinally slidable relationship therewith and defining an upper cylinder for said upper piston; an upper pressure chamber formed between the wall of said mandrel and said upper case; lower hydraulically expansible wall anchor means mounted in said lower case, the interior of said lower anchor means being exposed to said lower pressure chamber; upper hydraulically operated wall anchor means mounted in the wall of said upper case, the interior of said upper anchor means being exposed to said upper pressure chamber; a lower supply conduit within said mandrel extending from near the upper end of said lower case to within said lower cylinder above said lower piston and to within said lower pressure chamber; a first port means in the wall of said mandrel extending from the upper end of said lower supply conduit to the exterior of said mandrel; an upper supply conduit within said mandrel extending from about the upper end of said lower supply conduit to within said upper pressure chamber and the upper cylinder above said upper piston; a second port means in said mandrel spaced above said first port means and fluidly connecting the interior of said upper supply conduit with the exterior of said mandrel; a supply port in said mandrel spaced longitudinally intermediate be-

tween said first and said second ports; a sliding valve mounted in said valve operating chamber and having an upper and a lower position and alternately actuatable between its upper and lower positions by movement of said lower case to its upper position and its lower position respectively, said valve when in an upper position fluidly connects said supply port with said second port and fluidly connects the lower port with the exterior of the lower case, said valve when in a lower position fluidly connects said supply port with the lower port and fluidly connects the upper port with the exterior of said lower case; and a resetting fluid conduit establishing fluid communication between said lower cylinder below said lower piston and said upper cylinder below said upper piston.

10. An apparatus for forcing a bit against the bottom of the borehole comprising in combination: a mandrel attachable at its lower end to a drill bit, a first outer case mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; first pushdown means positioned between said mandrel and said first case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said case, first anchor means attached to said first case and operable upon actuation to transfer said reaction thrust to the borehole wall; a second case mounted longitudinally from said first case around said mandrel in a longitudinally slidable and rotatable relationship with said mandrel; second pushdown means positioned between said mandrel and said second case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said second case; second anchor means attached to said second case and operable upon actuation to transfer reaction thrust to the borehole wall; and control means operable to sequentially de-actuate said (*a*) first pushdown means and said first anchor means and (*b*) said second pushdown means and said second anchor means when in a first condition and to sequentially actuate said (*a*) first pushdown means and said first anchor means and (*b*) said second pushdown means and said second anchor means when in a second condition.

11. In a rotary drilling apparatus for drilling a borehole including a drill bit and a drill string assembly and means for circulating fluid through said assembly and said borehole, the improvement which comprises: a mandrel connectable within said drill string and including a conduit for the flow of fluids therethrough; a first housing surrounding said mandrel and rotatably and longitudinally movable therewith between upper and lower positions; first thrust transfer means interposed between said mandrel and said first housing; first wall anchor means carried by said first housing actuatable to lock said first housing to the wall of said borehole; a second housing surrounding said mandrel rotatably and longitudinally movable therewith between upper and lower positions and spaced longitudinally below said first housing in a non-rotatable and longitudinally movable relationship therewith; second thrust transfer means interposed between said mandrel and said second housing and actuatable to thrust said mandrel downwardly relative to said second housing; second wall anchor means carried by said second housing and actuatable to lock said second housing to the wall of said borehole; first valve control means operable when said first housing is in its upper position with respect to said mandrel to de-actuate said first thrust transfer means and said first wall anchor means and to drive said first housing downwardly with respect to said mandrel, and in its lower position operable to actuate said first thrust transfer means and said first wall anchor means; second valve control means operable to de-actuate said second thrust transfer means and said second wall anchor means when said first housing is in its lower position and to move said lower housing longitudinally from said first housing and being further operable to actuate said second thrust transfer means and said second wall anchor means upon said second housing reaching its lowermost position.

12. An apparatus for forcing a bit against the bottom of a borehole comprising in combination: a mandrel attachable at its lower end to a drill bit, a lower case mounted around one portion of said mandrel in a longitudinally slidable and rotatable relationship therewith, first pushdown means positioned between said mandrel and said lower case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such load on said lower case; first anchor means attached to said lower case and operable upon actuation to transfer said reaction thrust to the borehole wall; means to prevent substantial longitudinal movement of said lower case with respect to said mandrel prior to the actuation of said first anchor means; an upper case mounted around said mandrel longitudinally above said lower case and in a longitudinally slidable and rotatable relationship with said mandrel; second anchor means attached to said upper case and operable upon actuation to engage the borehole wall; means operable in a first condition to de-actuate said first anchor means and said first pushdown means and to actuate said second anchor means and in a second condition to actuate said first pushdown means and said first anchor means and de-actuate said second anchor means.

13. An apparatus for forcing a bit against the bottom of a bore hole comprising in combination: a mandrel attachable at its lower end to a drill bit, a first case mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; first pushdown means positioned between said mandrel and said first case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said first case; first anchor means attached to said first case and operable upon actuation to transfer said reaction thrust to the borehole wall; a second case mounted longitudinally from said first case around said mandrel in a longitudinally slidable and rotatable relationship with said mandrel; second pushdown means positioned between said mandrel and said second case for exerting a force on said mandrel longitudinally thereof in the direction of said bit and for exerting the reaction thrust of such force on said second case; second anchor means attached to said second case and operable upon actuation to transfer reaction thrust to the borehole wall; control means operable in a first condition to actuate said first pushdown means and said first anchor means, the actuation of said first pushdown means being impeded in relation to the actuation of said first anchor means, and to de-actuate said second anchor means and said second pushdown means and in a second condition to de-actuate said first anchor means and to actuate said second anchor means and said second pushdown means, the actuation of said second pushdown means being impeded in relation to the actuation of said second anchor means.

14. Apparatus for forcing a bit against the bottom of a borehole which comprises: a mandrel provided with means near the lower end thereof for connecting said mandrel to a bit; an upper loading and anchoring unit mounted on said mandrel, said upper unit including means for exerting a downward thrust on said mandrel and means for transferring the reaction thrust to the wall of the borehole when said upper unit is actuated; a lower loading and anchoring unit mounted on said mandrel, said lower unit including means for exerting a downward thrust on said mandrel and means for transferring the reaction thrust to the wall of the borehole when said lower unit is actuated; and control means for alternately actuating said upper unit and said lower unit.

15. Apparatus as defined in claim 14 wherein said upper and lower loading and anchoring units are telescopically interconnected in a non-rotatable manner.

16. Apparatus as defined in claim 14 including positioning means for applying force to said lower loading and anchoring unit to move said unit in one longitudinal direction with respect to said mandrel in response to the application of force tending to move said upper loading and anchoring unit in the opposite direction with respect to said mandrel.

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