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A. P. ROBERTS

3,225,844

BIT WEIGHT APPLICATOR

Original Filed May 14, 1958

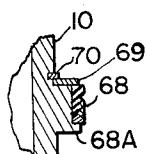
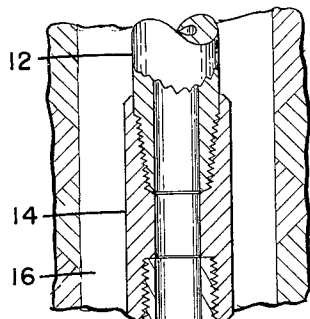


FIG. 3

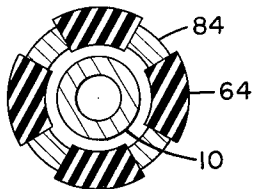


FIG. 2

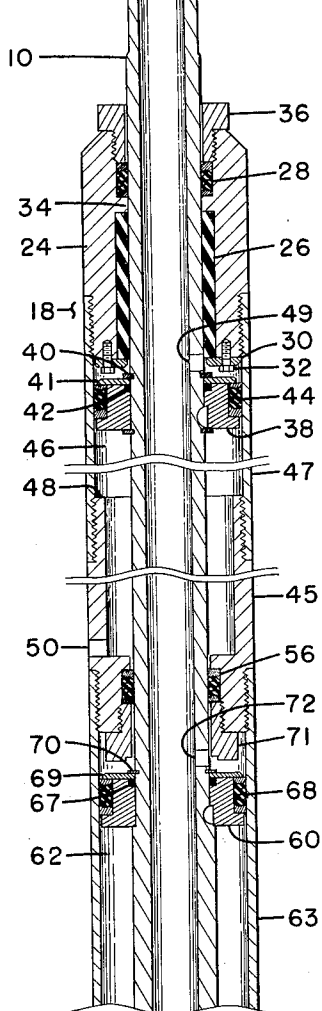


FIG. 1A

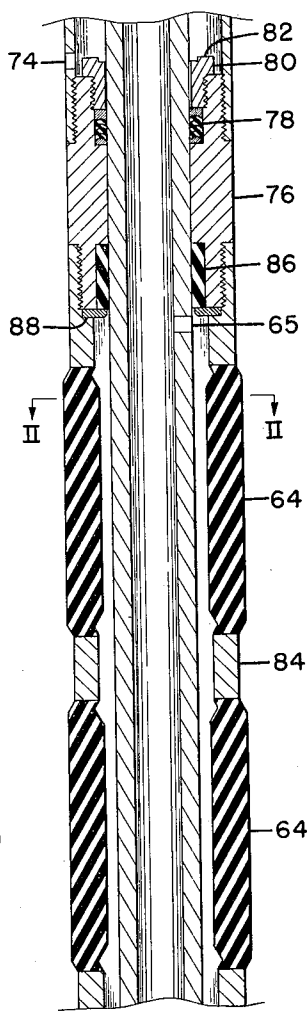


FIG. 1B

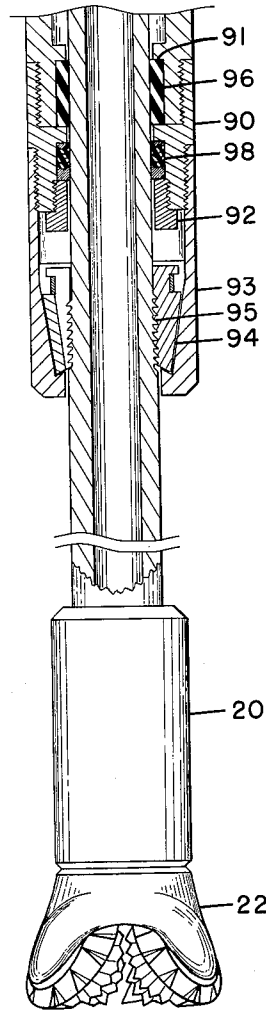


FIG. 1C

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3,225,844

BIT WEIGHT APPLICATOR

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Continuation of abandoned application Ser. No. 735,226, May 14, 1958. This application May 5, 1961, Ser. No. 110,604

19 Claims. (Cl. 175—230)

This application is a continuation of co-pending application Serial No. 735,226, filed on the 14th day of May 1958, and abandoned May 5, 1961.

This invention concerns the drilling of boreholes, oil wells, and the like. It relates in general to a system for forcing a drill bit against the bottom of a borehole. It relates especially to a hydraulic weight applicator for applying force to a drill bit, thereby forcing the bit against the bottom of the borehole.

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. While the drilling fluid serves primarily to carry the rock cuttings from the drill bit to the surface, it also serves to lubricate and cool the drill bit. The drill bit obtains its rotary motion from the drill pipe which is rotated from the surface. It is known that the rate of penetration of a drill bit can be increased by increasing the force of the drill bit on the bottom of the borehole.

The usual method that has been tried for increasing the pressure of a bit on the bottom of a borehole is by the addition of several heavy drill collars between the drill bit and the drill string. This method, however, has not been completely satisfactory. While the addition of drill collars aids the penetration rate, this advantage is offset by the need for heavier surface equipment. The borehole also tends to deviate considerably from the vertical during drilling. Again, many 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.

In a broad aspect, this invention comprises means for forcing a bit against the bottom of a borehole. It includes an inner mandrel attachable at its lower end to a bit and at its upper end to a drill string. The inner mandrel is rotatable with respect to an outer case which surrounds the inner mandrel. Push-down means are positioned preferably between upper portions of the mandrel and the outer case and are of a character to forcibly move the inner mandrel longitudinally in the direction of the bit with respect to the case. Anchor means are located in the outer case spaced between the push-down means and the bit and are of a character to firmly grip the borehole wall so as to transfer the reaction thrust of the force exerted on the bit to the borehole wall.

This invention utilizes hydraulic pressure or other form of energy at the bottom of a borehole to apply bit weight or force, thereby eliminating objectionable features of the drill collar. A preferred apparatus embodiment of the invention comprises a hydraulic push-down section in the upper portion of the apparatus and a hold-down section in the lower portion thereof. The push-down section includes a series of push-down pistons attached to a rotatable inner mandrel which in turn is adapted to be attached at its upper end to a drill string and at its lower end to a drill bit.

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The inner mandrel and pistons are slidably and rotatably surrounded or encased by an outer housing or case. The upper part of the case forms a cylindrical annulus with the inner mandrel and is adapted to receive the pistons. Below this annulus and forming part of the outer case is a wall anchor section which preferably comprises hydraulically operated wall anchor blocks adapted to grip the wall of the well bore, thus holding the outer case in a fixed position when actuated by drilling fluid that is forced down the drill string and through the mandrel under pressure. A pressure drop of a considerable amount results as the fluid passes through the drill bit. The pressure differential between drilling fluid within the inner mandrel and that in the annulus between the drill pipe and the borehole is used to actuate the pistons, thus forcing the mandrel and bit downwardly. The wall anchor device is used to transfer the reaction of the force incurred on the bit to the borehole wall. In operation, then, the mandrel is forced downwardly, thus forcing the bit against the rock face or bottom of the borehole and increasing the penetration rate. In the preferred arrangement of the wall anchor section and the push-down section wherein the former section is between the wall anchor section and the bit, any tendency of the borehole to deviate from a straight direction—as caused for example by the compression or buckling of the mandrel—is counteracted by the case being under tension. Keeping the case under tension tends to hold the apparatus straight.

Various objects and a better understanding of this invention will be obtained from the following description which illustrates the best mode contemplated for carrying out the invention.

FIGURES 1A, 1B, and 1C are views which together illustrate the details of a preferred embodiment of this invention, with FIGURE 1A illustrating an upper portion in section, FIGURE 1B illustrating an intermediate portion in section, and FIGURE 1C illustrating the lower portion partly in section.

FIGURE 2 is a sectional view taken along the lines II—II of segment FIG. 1B of FIGURE 1.

FIG. 3 illustrates a fragmentary portion of the apparatus in section showing the piston as an integral part of the mandrel.

In the drawing, mandrel 10 is a hollow cylindrical member or arbor which is supported from and connected to a conventional tubular drill pipe 12 through drill tool joint 14. Drill pipe 12 is suspended from the surface in borehole 16. Mandrel 10 extends through outer case or housing 18 and is rotatable with respect to case 18. Two vertically spaced push-down pistons 38 and 60 which are attached to mandrel 10 are disposed in annular cylinders 46 and 62 which are formed in the annulus between housing or case 18 and mandrel 10. A drill bit 22 is attached to the lower end of mandrel 10 by tool joint 20. Thus, as shown in the drawing, mandrel 10 provides a rigid connection between drill bit 22 and drill string 12. The particular advantages of such a connection will be discussed in greater detail hereinafter.

Below the annular cylinders 46 and 62 is a wall anchor or hold-down section which includes hold-down anchor blocks 64. Hydraulically expansible hold-down anchor blocks 64 are disposed in the wall of case 18 and are of a type that rigidly holds the outer case in a fixed position against the wall of the borehole when actuated. As shown in FIGURE 2, there are four of these anchor blocks spaced about the circumference of the case 18. However, the number used is not critical. The individual anchor blocks are normally preferably composed of an expansible material such as rubber molded around a metal core. When acted upon by a pressure between the interior of the

mandrel 10 and outer frame 84, the anchor blocks are expanded outwardly to contact and firmly grip the wall of the hole. A suitable hydraulically operated anchor block has been developed by Drilco Oil Tools, Inc., Midland, Texas. Mechanically operated side wall anchor assemblies, which may be adapted for use in this invention have also been developed. One such mechanically operated anchor which is commercially available is manufactured by Halliburton Oil Well Cementing Company and is illustrated on page 2261 of the 22nd edition of the composite catalogue of Oil Field Equipment and Services (1957), published by Gulf Publishing Company, Houston, Texas.

As the anchor blocks 64 are spaced one from the other, circulating fluid may pass upwardly through the annulus between the outer housing and the borehole wall through the space between the anchor blocks; in other words, the anchor blocks do not block the annular passageway. As illustrated, there are two sets of anchor blocks spaced vertically in the hold-down sections. However, this number is dependent upon the number of hydraulic pistons employed and the pressure applied, as the reaction thrust of the hydraulic pistons must be transferred to the borehole wall through the anchor blocks. Likewise, the number of pistons used will vary, depending upon the forces desired to be exerted upon the bit.

Having described the principal structural components of the apparatus, attention is now directed toward the various packing, bearing, seal, and port arrangements illustrated in FIGURE 1. Case 18, as illustrated, is composed of several members which are attachable to form case 18. Mandrel 10 may similarly be made up of several parts which fasten together to form one integral rigid member. This arrangement aids in fabrication and assembly.

At or near the upper end of case member 18 is a packing-and-bearing assembly which is carried by the case member. This includes a tubular end member 24 which is adapted to receive bearing 26 and packer 28. Bearing 26 is preferably composed of rubber but may be of other materials such as bronze or phenolic resin. Bearing 26 is held in place by bearing plate 30 which is secured by nut 32. Packing 28 serves to seal annulus 34 between the mandrel 10 and the case 18 and is held in place by packing retainer nut 36. Packing 28 may be any conventional type packing and is preferably a V type.

Piston member 38 is rigidly attached to mandrel 10 and is adapted to fit into annular cylinder 46 and have free vertical movement therein, with the upper limit being determined by nut 32 and the lower limit being determined by shoulder 48. Piston 38 is sealed with the mandrel by seal 42 and with the outer case by packing 44. Snap ring 40 holds plate 41 secure, which retains seal 42 and packing 44. Seal 42 may preferably be an O-ring, and packing 44 may be similar to packing 28. A port 49 is provided in the mandrel 10, establishing fluid communication between the interior of the mandrel and the annular cylinder 46 above piston 38. A port 50 is provided in the case 18 below shoulder 48 to provide fluid communication between that part of cylinder 46 below piston 38 and the annular space between the case and the borehole wall. The outer wall of cylinder 46 is composed of two members—namely, an upper tubular member 47, which is adapted to be attached to tubular end member 24, and a lower tubular member 45 which attaches to the lower end of tubular member 47 and forms shoulder 48 and has an inner shoulder member at the bottom which holds packing 56 in place, thus sealing the lower end of cylinder 46.

A second cylinder 62 is positioned below cylinder 46 and has an outer tubular member 23 which is attached to tubular member 45, preferably as shown. Piston 60 is disposed in cylinder 62 and is provided with seal 67 which is similar to seal 42, packing 68 which is similar to packing 44, and plate 69 and snap-ring 70 which are similar

to plate 41 and snap-ring 40. Nut 71 serves to compress and hold packing 56 in place. A port 72 is provided within the wall of the mandrel to establish fluid communication between the interior of the mandrel and that part of cylinder 62 which is above piston 60. Likewise, a port 74 is provided at the lower end of cylinder 62 to establish fluid communication between the interior of the cylinder and the annulus between the case and the borehole wall.

A tubular connecting joint 76 serves to connect the lower end of tubular member 63 with the hold-down anchor section. Packing 78, which may be similar to packing 28, is held in place by nut 80. Nut 80 has a shoulder 82 which limits the lower travel of piston 60 and is arranged with relation to port 74 so that port 74 is not closed when the piston is in its lower position. The apparatus is so designed that the distance between the limits of travel of pistons 38 and 60 are the same.

Support member 84 for holding in place and supporting the anchor blocks is fastened to tubular connecting joint 76 preferably by threads as indicated. A bearing 86 is provided between the case 18 and the mandrel 10 and is held in place by a recess in connecting joint 76 and by plate 88 which prohibits vertical movement of the bearing. A port 65 is provided in the mandrel below bearing 86 and is used for inflating the wall anchors.

The lower end of frame 84 is adapted to be connected to a lower tubular connector 90 which holds bearings 96 and packing 98. Shoulder 91 secures bearing 96 in place, and nut 92 secures packing 98 in place.

The lower end of tubular connector 90 is adapted to be attached to an automatic bottom device 93. An automatic device similar to that illustrated herein is commercially available and is illustrated in the Composite Catalog for 1957 published by Gulf Publishing Company of Houston, Texas, on Page 5050 with the Texas Iron Works of Houston, Texas, the manufacturer. The automatic bottom device 93 has fitted segments 94 which are adapted to engage mating threads on mandrel 10. The function of this device will be described hereinafter. To release the mandrel from the outer case it is necessary to rotate the mandrel in a right-hand direction, thus unscrewing the mandrel downwardly out of segment 94. To re-engage the automatic bottom device, it is merely necessary to lift the mandrel upwardly with respect to the surrounding case. The threads of the spring-actuated segments 94 move outwardly as the threads 95 of the mandrel move upwardly. This action is due to the wedge-shaped cross section of the threads. Thus, re-engagement is accomplished without the necessity of rotating the mandrel in a left-hand direction.

FIG. 3 illustrates a piston member as an integral part of the mandrel. Piston member 60A is quite similar to piston 60 except that piston member 60A is an integral part of mandrel 10. Piston member 60A, for example, is alternatively positioned similarly as piston 60 in cylinder 62 and is provided with packing 68 which is held in place by plate 69 and snap ring 70.

Having thus described the structural components of this invention, attention is now directed toward the manner in which it operates. As the assembly is lowered into a borehole, the mandrel is fixed to the case 18 through automatic bottom device 93. When the bit reaches the bottom of the hole, circulation of drilling fluid is commenced and the pressure of the drilling fluid inflates the anchor blocks. At the same time, pressure of the drilling fluid is exerted on top of pistons 38 and 60 which tends to force the case 18 up with respect to the mandrel 10 until such time as the anchor blocks are expanded sufficiently to transfer this thrust to the borehole walls. However, the automatic bottom device holds the case and mandrel in a fixed position until released, thereby permitting the anchor blocks to become firmly anchored before they are required to transmit the reaction thrust of the pistons to the walls of the borehole. After the anchor

blocks are fully inflated and anchored to the borehole wall, the outer case will resist any movement vertically or rotationally. The mandrel 10 which is attached to the drill string is then rotated to the right until it is freed of the automatic bottom device, which is done automatically as drilling commences.

In normal drilling operations a pressure drop of about 500 p.s.i. or more occurs as the drilling fluid passes through the drilling bit. It is thus seen that there is a 500 p.s.i. pressure differential available for driving the pistons and also for inflating the hydraulic anchor blocks. As the outer case is firmly anchored to the well bore by the anchor blocks, the pistons force the drill bit against the bottom of the drill hole with a considerable pressure. For example, assuming that the area of the top of the piston is approximately twelve square inches, one piston could cause a total of 6,000 pounds downward thrust on the bit. For two pistons, as shown in the drawing, this downward thrust is increased to 12,000 pounds. This total thrust could be increased, of course, by adding additional pistons to the assembly. The number of pistons used may vary from one to any practical number required. Drilling then continues until the borehole has advanced a distance equal to the vertical travel limit of the piston. At this point in the operation, the inner mandrel is lifted so that threads 95 on inner mandrel 10 engage the threaded segments 94. Pressure on the drilling fluid is then released so as to disengage the anchor blocks, and the assembly is then lowered until the bit rests upon the bottom of the borehole. The assembly is so designed that, when the threaded segments 94 are engaged in the threads 95 of the mandrel, the pistons are in their upper position insofar as their travel limit with respect to the outer case. When the bit is on the bottom of the borehole and the anchor blocks have been securely anchored to the borehole wall, the mandrel is turned to the right, which forces threaded segments 94 upwardly and outwardly, thus disengaging the mandrel from the surrounding case. The push-down pistons then are operative to force the bit against the bottom of the borehole. This operation is repeated as drilling progresses.

When the anchor blocks are securely anchored to the borehole wall and the pistons are forcing the bit against the borehole, the inner mandrel, from the pistons to the drill bit, is under compression which forces the bit against the bottom of the borehole, thereby increasing the penetration rate. In the preferred embodiment as shown, the outer case is in tension from the wall anchors to the top of the upper cylinder 46. It is known that when a steel member such as case 18 is under tension, it tends to be held in a straight line and will not buckle or bend. Therefore, by having the case under tension, it will overcome any buckling effect or tendency which the inner mandrel, which is under compression, may have. It is thus clearly seen that, in addition to forcing the bit against the well bore, in order to increase the penetration rate, this invention also assures the drilling of a straight hole. The drill string can also be put under tension by "lifting" up on the top of the drill string at the surface. For example, if the pistons are exerting 12,000 pounds of downward force on the lower portion of the inner mandrel and an upward lifting force of 6,000 pounds is applied at the top of the drill pipe, the drill pipe is under a 6,000 pounds tensile loading. This tends to keep the drill pipe straight and therefore also aids in assuring that a straight hole will be drilled.

A tool described as the preferred embodiment herein has been developed, constructed and tested in the actual drilling of boreholes in the earth. When the tool is inserted within a drill string, the mandrel rigidly connects the drill bit to the drill string. This is an important feature of the tool, as it permits close control of the axial or downward load on the bit through the drill string from the surface of the earth. For example, this feature readily permits the tool to be used during reaming operations.

As a word of explanation, during the drilling of earth formations a bit sometimes becomes worn resulting in a hole which is tapered and has a gradually reducing diameter. Therefore, in order to resume drilling with a new bit of gaged diameter it becomes necessary to ream the tapered portion of the borehole with the next succeeding bit. Due to the gradually reducing hole diameter, however, large lateral forces will be exerted on the succeeding bit for a rather small axial drilling load. These lateral forces, if sufficient, will permanently deflect the cutting structure of the bit inwardly. This type of deflection or deformation is sometimes referred to as bit pinching. The pinching forces may also cause large tangential forces which in turn will prevent rotation of the bit. In reaming operations it is therefore frequently necessary to greatly reduce the axial load on a bit so as to maintain the lateral forces on the bit within limits which do not cause permanent inward deflection of the cutting structure.

The axial load on a bit used with a tool of this invention at the bottom of a drill string can be controlled from the surface of the earth simply by manipulating the drill string—i.e., by adjusting the weight of the string which is supported by the derrick. The load may also be controlled by controlling the flow rate of drilling fluid through the tool. However, this latter type of control causes substantial deviations from the optimum flow rate of the drilling fluid.

The specific tool referred to above, which has actually been built and tested, is about 37 feet long and weighs approximately 2,200 pounds. It is designed for use in 6¾" diameter boreholes and can exert at least 40,000 pounds of force on a bit. It is therefore capable of replacing up to about 900 feet of costly, hard-to-handle, heavy conventional drill collars of sizes normally used in drilling 6¾" diameter holes. This tool has been tested extensively in shallow depths and in an actual field test was used with a 6¾" bit to drill nearly 500 feet of hole. It is of particular interest to note that in the field test it was necessary to use the tool in reaming a large part of the hole which had been drilled below gage by a previous bit. These reaming operations progressed very satisfactorily and simply by manipulating the force on the bit through the drill string, while at the same time maintaining optimum flow rates of the drilling fluid. The mechanical weight control on the bit was made possible by the rigid connection between the bit and the bit driving member in the form of the drill string.

It will be noted that the foregoing description has been concerned primarily with merely one preferred structural embodiment of the invention. It will be apparent that numerous modifications may be incorporated within the apparatus without departing from the spirit or scope of the invention.

What is claimed is:

1. A hydraulic bit weight applicator for use in a rotary drilling system for drilling boreholes in which a bit having interior conduits is suspended in a borehole by a drill string rotatable from the surface of the earth, which comprises a mandrel adapted to be attached at its upper end to the lower end of said drill string and at its lower end to said bit and being further adapted to establish fluid communication between the interior of said drill string and the interior conduits of said bit, a case positioned about said mandrel and adapted to slidably, rotatably, and sealingly enclose said mandrel, releasable means for attaching said case rigidly in at least the longitudinal direction to said mandrel, expandible anchor members positioned in the lower part of said case, fluid port means between said mandrel and the interior of said anchor members, a hydraulically actuated push-down section positioned between the upper portion of said case and said mandrel, conduit means establishing fluid communication between the interior of said mandrel and the interior of said push-down section whereby said mandrel is forced downwardly with respect to said case upon the introduction of fluid under pressure within said mandrel.

2. A hydraulic bit weight applicator for use in a rotary system of drilling boreholes in which a bit is suspended in a borehole by a drill string rotatable at the surface of the earth which comprises a mandrel adapted to be attached between the lower end of said drill string and said bit, a case sealingly, rotatably and slidably supported from said mandrel and with an upper portion of said mandrel and an upper portion of said case defining an annular cylinder, a piston member attached to said mandrel and adapted to fit into said annular cylinder, releasable means for attaching said case to said mandrel, means establishing fluid communication between the interior of said mandrel and the upper portion of said cylinder above said piston, conduit means establishing fluid communication between the lower portion of said cylinder below said piston and the exterior of said case, hydraulically operated wall anchor means in said case below said cylinder, and conduit means establishing fluid communication between the interior of said mandrel and the interior of said wall anchor means.

3. An apparatus as defined in claim 2 in which said piston member is an integral part of said mandrel.

4. A hydraulic bit weight applicator for use in a rotary system of drilling a borehole in which a bit containing fluid passageways is suspended from a drill string rotatably supported from the surface of the earth which comprises a tubular mandrel adapted to be adapted to be attached between the lower end of said drill string and said bit and to establish fluid communication between the interior of said drill string and fluid passageways in said bit, a case spaced about said mandrel and forming an annular space therebetween; an upper, a lower, and an intermediate sealing and bearing support means adapted for slidable and rotatable movement of said mandrel with respect to said case and with an annular cylinder being defined between said upper and said intermediate sealing and bearing means; a piston member supported from said mandrel and adapted to fit into said annular cylinder, a first port in said mandrel establishing fluid communication between the upper portion of said cylinder above said piston and the interior of said mandrel, a second port establishing fluid communication between the interior of said cylinder below said piston and the exterior of said case, hydraulically operated expansible wall anchor means mounted in the wall of said case and positioned between said intermediate and said lower sealing and bearing means, means for preventing longitudinal movement between said mandrel and said case while said anchor means are being secured to the borehole wall, another port in said mandrel establishing fluid communication between the interior of said mandrel and the interior of said anchor means whereby when drilling fluid is circulated down through said mandrel, said anchor means are expanded and said piston exerts force through said mandrel to force said bit against the bottom of said borehole with reaction thrust of such force being transmitted to the walls of said borehole through said case and said wall anchors thereby maintaining said case under tension.

5. An apparatus as defined in claim 4 in which said piston member is an integral part of said mandrel.

6. An apparatus insertable in a drill string for forcing a bit against the bottom of a borehole comprising a mandrel attachable at its lower end to said bit and at its upper end to said drill string, a case surrounding said mandrel in a longitudinally slidable and rotatable relationship therewith, push-down means positioned between upper portions of said mandrel and said case for exerting a force on said inner mandrel longitudinally thereof in the direction of said bit with respect to said case, anchor means located in said outer case spaced longitudinally below said push-down means and of a character to transfer reaction thrust of the force exerted on the bit to the borehole wall, and means for preventing substantial longitudinal movement between said mandrel and said

case while said anchor means are being secured to the borehole wall.

7. An apparatus attachable to the lower end of a string of drill pipe for forcing a bit against the bottom of a borehole comprising a mandrel attachable at its lower end to said bit and at its upper end to said string of drill pipe, a case surrounding said mandrel in a slidable, rotatable and fluid tight relationship therewith, push-down means positioned between upper portions of said mandrel and said case for forcibly moving said mandrel longitudinally in the direction of said bit with respect to said case, means for releasably holding said case in a position fixed longitudinally with respect to said mandrel, anchor means located in said case spaced longitudinally below said push-down means and adapted to transfer reaction thrust of the force exerted on the bit to the borehole wall, said anchor means being further characterized in having anchor blocks circumferentially spaced one from the other.

8. An apparatus for use in rotary borehole drilling systems including a string of drill pipe and a drill bit which comprises: a mandrel; means to rigidly attach one end of said mandrel to said bit; second means to attach the other end of said mandrel rigidly to said drill string; an outer case mounted around said mandrel in a longitudinally slidable and rotatable relation therewith; push-down means positioned between said mandrel and said case operable to exert a force on said mandrel longitudinally thereof in the direction of said bit and to exert the reaction thrust of such force on said case; anchor means attached to said outer case and of a character operable to transfer the reaction thrust to the borehole wall; and releasable means operable to prevent substantial longitudinal movement between said mandrel and said case while said anchor means are being secured to the borehole wall.

9. An apparatus insertable in a drill string for forcing a bit against the bottom of a borehole comprising: a mandrel rigidly connectable at one end to said drill string and at the other end to said bit; a case mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; push-down means positioned between said mandrel and said case operable to exert a force on said mandrel longitudinally thereof in the direction of said bit and to exert the reaction thrust of such force on said case; means to transfer the force on said mandrel to said bit; anchor means attached to said case and spaced longitudinally below said push-down means and of a character to transfer the reaction thrust to the borehole wall; and releasable means operable to prevent substantial longitudinal movement between said mandrel and said case while said anchor means are being secured to the borehole wall.

10. In a rotary drilling method wherein a stream of drilling fluid is circulated through a string of drill pipe suspended in a borehole and a drill bit is supported from the string, the improvement which comprises: rotating said bit and said string in rigid longitudinal relation, generating a pressure differential within the circulating stream of drilling fluid in the vicinity of the bit, applying a downward axial thrust to the bit from said drill string in response to said pressure differential, and transmitting the resultant upward reaction thrust from said drill string to the wall of the borehole.

11. A method as defined in claim 10 wherein an independent axial force is applied to the string of drill pipe at the surface to aid in controlling the axial force applied to the bit.

12. In a rotary drilling system for drilling a borehole which includes a drill string and a bit, the improvement which comprises: a rigid mandrel connecting said drill string to said bit and having a passage to convey fluid therebetween, the exterior surface of said mandrel defining a piston, a housing surrounding said mandrel in rotatable and longitudinally slidable relation therewith and defining a cylinder for said piston; port means in said man-

drel to provide fluid communication between said mandrel and said cylinder above said piston; second port means in said housing to provide fluid communication between the cylinder below said piston and the exterior of said housing; wall anchor means mounted on said housing spaced longitudinally below said cylinder and operable to anchor said housing to the wall of the borehole; and releasable means for preventing substantial longitudinal movement between said mandrel and said housing while said anchor means are being secured to the borehole wall.

13. An apparatus insertable in a drill string for forcing a bit against the bottom of a borehole comprising in combination: a rigid mandrel attachable at its lower end to a drill bit and at its upper end to said drill string, an outer case mounted around said mandrel in a longitudinally slidable and rotatable relation therewith, push-down means positioned between said mandrel and said 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, anchor means attached to said outer case and of a character to transfer the reaction thrust to the borehole wall, and releasable means for preventing substantial longitudinal movement between said mandrel and said case while said anchor means are being secured to the borehole wall.

14. In a rotary drilling apparatus for drilling a borehole which includes a drill string and a bit, the improvement which comprises: a rigid mandrel insertable within said drill string, said mandrel having a longitudinal passage therethrough for conveying fluid; an outer case mounted around said mandrel in a longitudinally slidable and rotatable relation therewith; push-down means positioned between said mandrel and said 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; anchor means attached to said outer case and of a character to transfer the reaction thrust to the borehole wall; and releasable means for attaching said case to said mandrel.

15. In a rotary drilling apparatus for drilling a borehole which includes a drill string and a bit, the improvement which comprises: a mandrel rigidly connecting said drill string to said bit and of a character to convey fluid therebetween; a case mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; releasable interengaging means between said mandrel and said case operable to resist longitudinal movement therebetween; wall anchor means mounted on said case and operable to anchor said case to the wall of the borehole; and push-down means positioned between said mandrel and said case operable to exert a force on said mandrel longitudinally thereof in the direction of said bit and to exert the reaction thrust of such force on said case.

16. In a rotary drilling apparatus for drilling a borehole which includes a drill string and a bit, the improvement which comprises: a mandrel rigidly connecting said bit to said drill string; a housing member mounted around said mandrel in a longitudinally slidable and rotatable relationship therewith; push-down means positioned between said mandrel and said case operable to exert a force on said mandrel longitudinally thereof in the direction of said bit and to exert the reaction thrust of such force on said housing member; anchor means attached to said outer case and of a character to transfer the reaction thrust to the borehole wall; and means operable to prevent substantial longitudinal movement between said mandrel and

said case while said anchor means is being secured to the borehole wall.

17. In a rotary drilling system for drilling a borehole, including a drill string and a bit, the improvement which comprises: a mandrel for rigidly connecting said drill string to said bit and adapted to convey fluid from said drill string to said bit, the exterior surface of said mandrel defining a piston; a case surrounding said mandrel in rotatable and longitudinally slidable relationship therewith and defining a cylinder for said piston; port means in said mandrel to provide fluid communication between said mandrel and said cylinder above said piston; second port means in said case to provide fluid communication between the cylinder below said piston and the exterior of said case; and wall anchor means mounted on said case and operable to anchor said case to the wall of the borehole.

18. In a rotary drilling system for drilling a borehole, including a drill string and a bit, the improvement which comprises: a mandrel rigidly connecting said drill string to said bit and of a character to convey fluid from said drill string to said bit, the exterior surface of said mandrel defining a piston; a case surrounding said mandrel in rotatable and longitudinally slidable relationship therewith and defining a cylinder for said piston; port means in said mandrel to provide fluid communication between said mandrel and said cylinder above said piston; second ports in said case to provide fluid communication between the cylinder below said piston and the exterior of said case; wall anchor means mounted on said case and operable to anchor said case to the wall of the borehole; and means operable to prevent substantial longitudinal movement between said mandrel and said case while said anchor means is being secured to the borehole wall.

19. An apparatus attachable to the lower end of a string of drill pipe for forcing a bit against the bottom of a borehole comprising in combination: a mandrel rigidly attaching said bit to said string of drill pipe; a case surrounding said mandrel in a slidable, rotatable and sealing relationship therewith; push-down means positioned between upper portions of said mandrel and said case for forcibly moving said mandrel longitudinally in the direction of said bit with respect to said case; means for releasably holding said case in a position fixed longitudinally with respect to said mandrel; and anchor means located in said case spaced longitudinally below said push-down means and of a character to transfer reaction thrust of the force exerted on the bit to the borehole wall.

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