

June 30, 1953

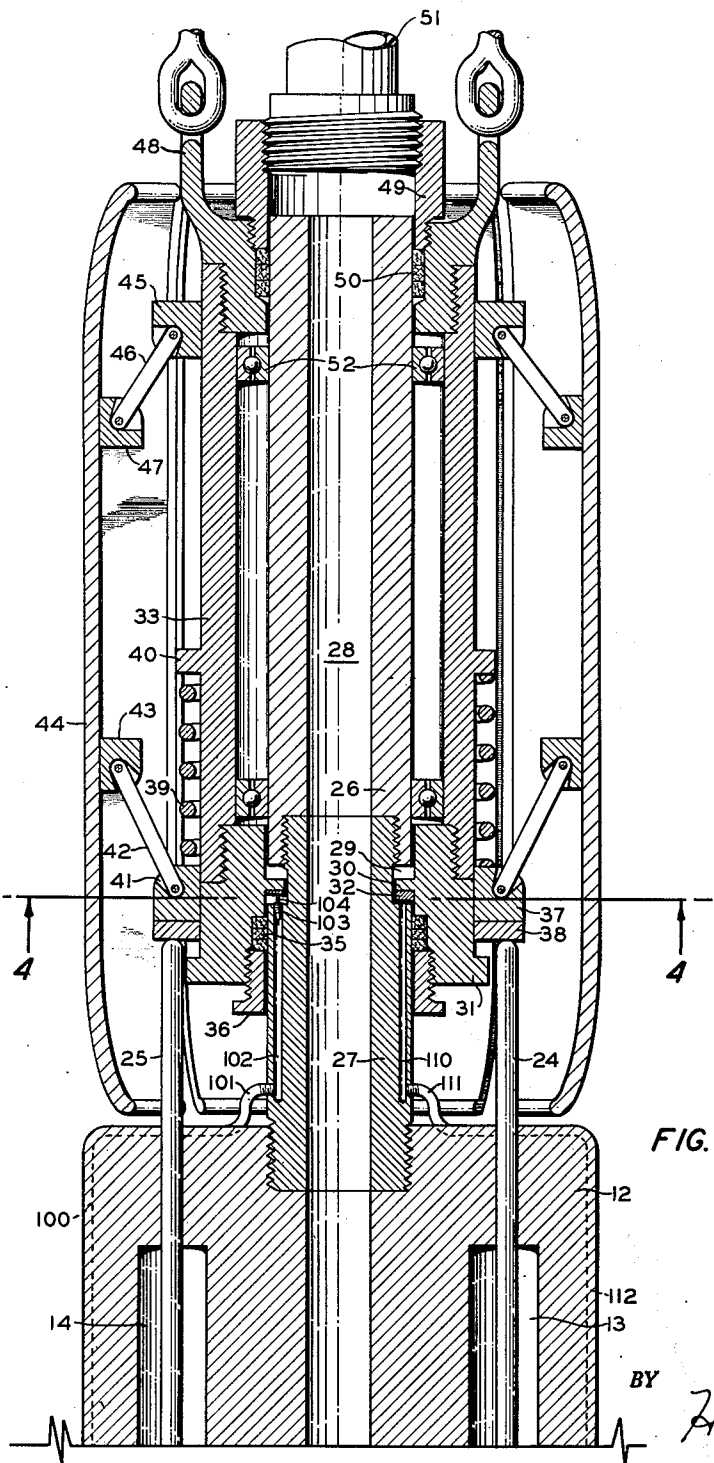
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2,643,860

ROTARY DRILLING MECHANISM

Filed May 22, 1950

4 Sheets-Sheet 1



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ROTARY DRILLING MECHANISM

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4 Sheets-Sheet 2

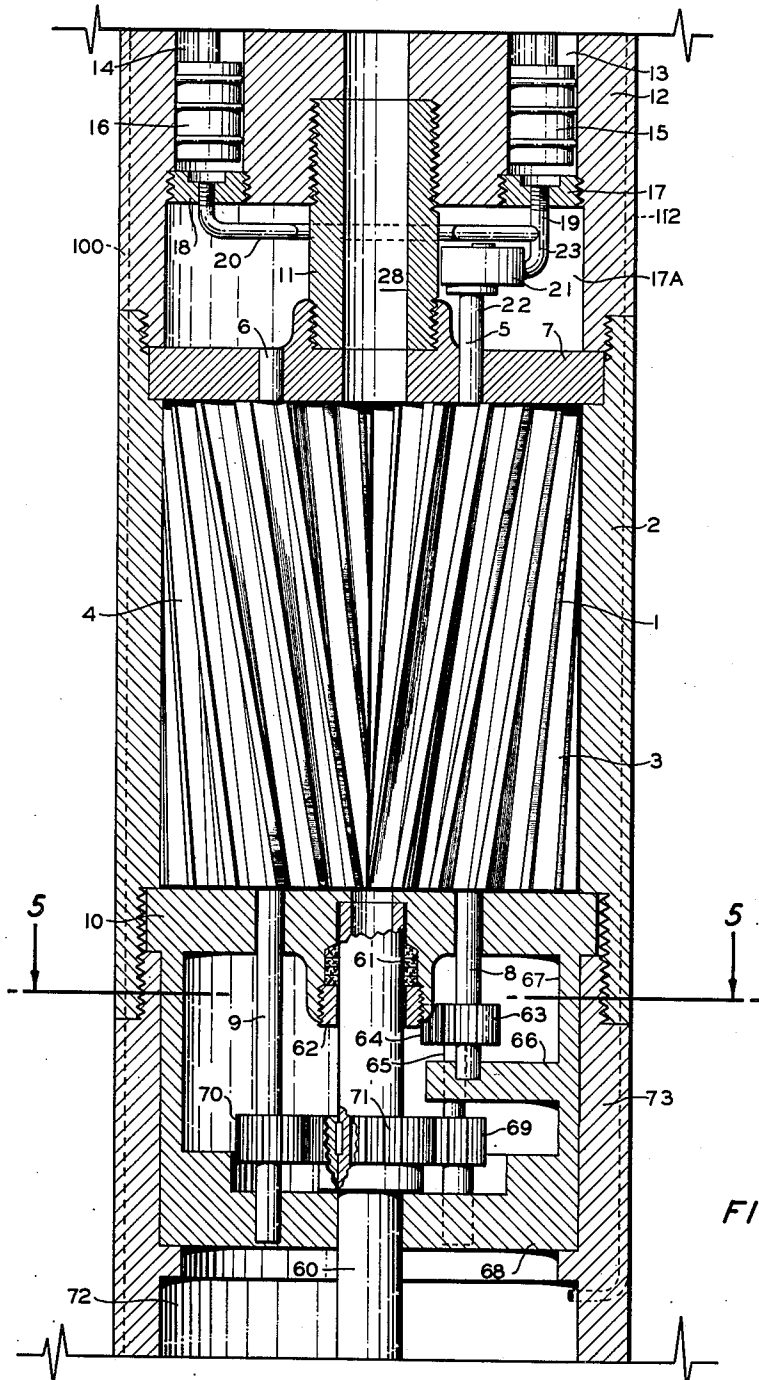


FIG. 2.

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ROTARY DRILLING MECHANISM

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4 Sheets-Sheet 3

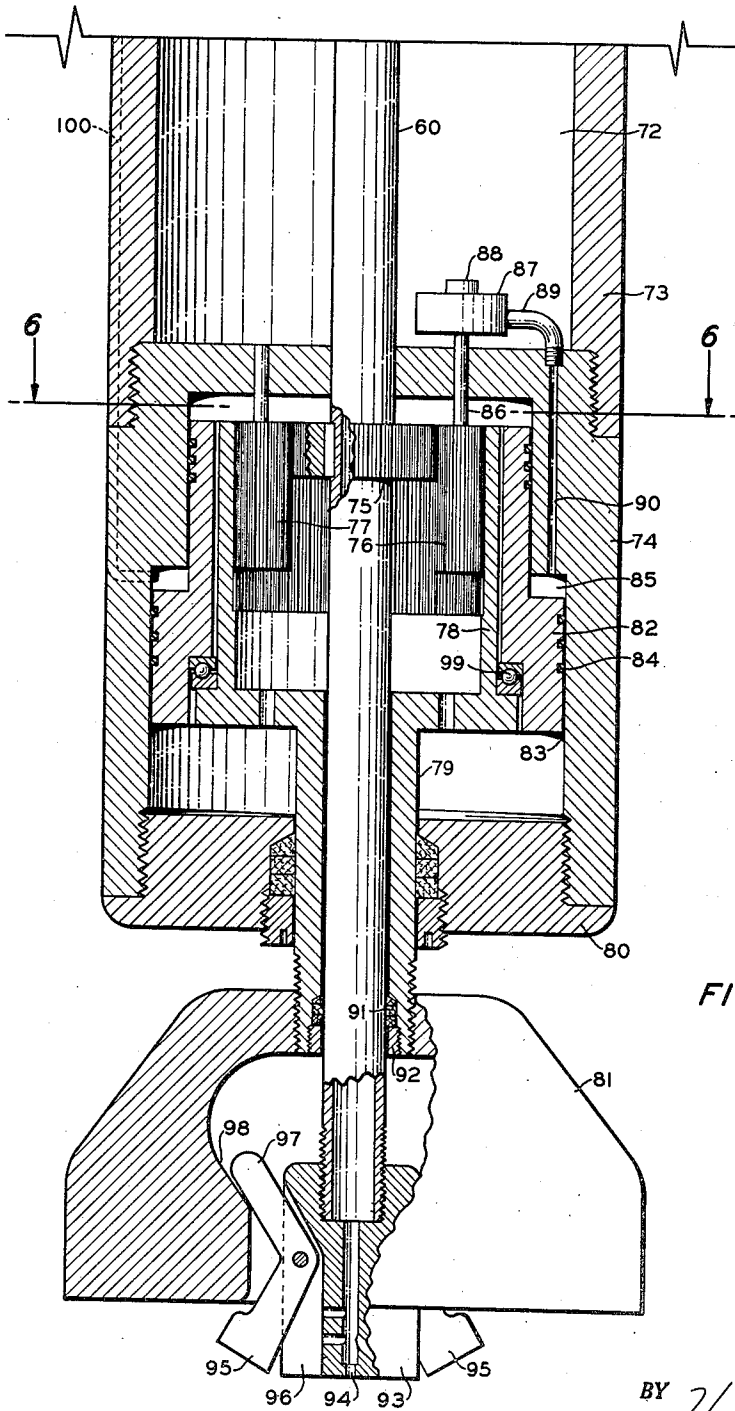


FIG. 3.

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ROTARY DRILLING MECHANISM

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4 Sheets-Sheet 4

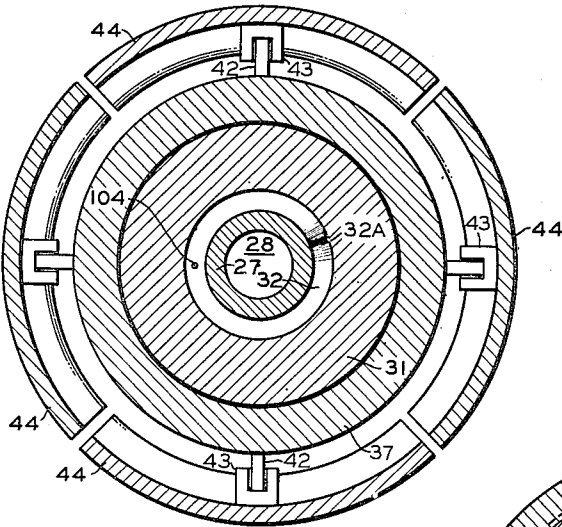


FIG. 4.

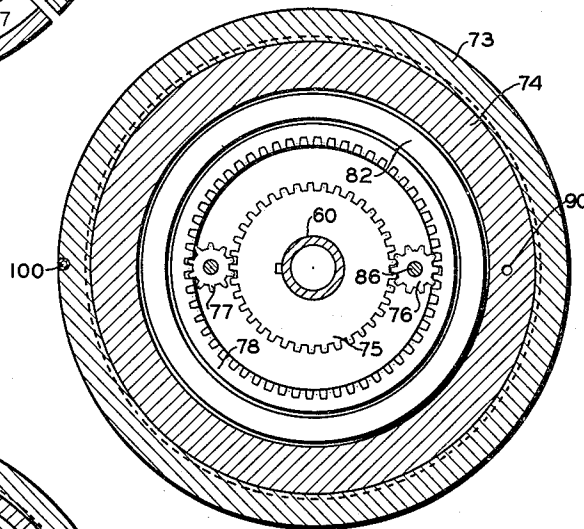


FIG. 6.

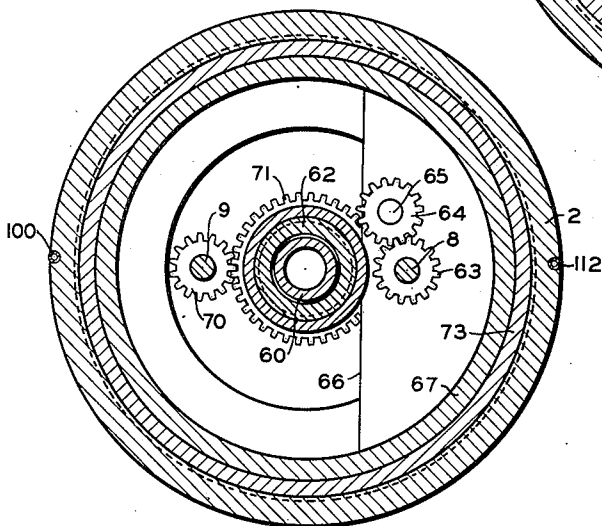


FIG. 5.

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2,643,860

ROTARY DRILLING MECHANISM

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Application May 22, 1950, Serial No. 163,350

13 Claims. (Cl. 255—4)

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This invention relates to a mechanism adapted for use in the drilling of wells through earthen strata. In one of its aspects, it relates to a bottom hole rotary drilling mechanism. In another of its aspects, it relates to a bottom hole drilling motor having balanced-torque counter-rotating bits adapted to drill through an earthen formation. In still another of its aspects, this invention relates to a means for balancing the torque of counter-rotating bits in a bottom hole drilling mechanism. In yet another of its aspects, this invention relates to a pair of counter-rotating bits adapted to have the torque necessary to rotate each, automatically balanced.

In recent years, the quest for oil has led to the drilling of deeper and deeper wells into the earth. Today it is not unusual to drill wells from ten to fifteen thousand feet in depth and it is becoming common practice to drill exploratory wells to depths of twenty thousand feet. As the search for oil becomes more and more intensive, it is expected that the average depth of producing as well as exploratory wells will increase until wells having a depth of over twenty to thirty thousand feet will be common. In the drilling of the greater majority of wells, it is presently conventional to employ a rotary drilling rig having a tubular drill string which rotates in the bore hole to force a drilling bit attached to one end of the drill string through the earthen formation. The cuttings formed by the drill bit as it penetrates the formations are removed from the well bore by maintaining mud circulating within the bore. As the well progresses in depth, the drilling string becomes longer and longer and heavier and heavier, more and more of its weight must be borne by the drilling device and associated drilling lines since the "weight" or pressure imposed by the drill bit on the formation for optimum drilling is generally considerably less than the dead weight of the drill string. The natural buoyancy of the drill string in the mud circulated within the well bore, helps to lessen the load borne by the drilling lines. Although satisfactory drilling lines are presently available to support loads that might be encountered in drilling wells twenty to thirty thousand feet in depth, satisfactory drill pipe capable of supporting itself and in addition act as a shaft that is more than four miles in length are not now available. Further, a suspended string of drill pipe approximately twenty-three to twenty-four thousand feet in length, made from the best grade of drill pipe presently available, will theoretically break of its

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own weight. Consequently, if wells twenty to thirty thousand feet deep are to be drilled, ways must be found for drilling wells other than driving a shaft four miles or more in length.

One way to eliminate the above problem would be to provide a bottom hole drilling mechanism comprising a suitable motor adapted to drive a drill bit connected to the motor, and such means have been tried in the past. The assembly of the motor and drill bit is lowered by means of a cable to the bottom of the bore hole, thereby eliminating the need for the long string of drill pipe. However, as can be appreciated, some means must be provided to prevent the drilling motor from rotating in the bore hole since the action of the drilling bit upon the earthen formation will induce a rotative torque upon the drilling motor. Ordinarily, there is provided as a sole means for preventing such rotation of the drilling motor, a rather complicated system of dogs which are attached to the motor and which grasp the sides of the bore hole in an effort to prevent rotation of the drilling motor. Such efforts to prevent rotation of the drilling motor are ordinarily unsuccessful or impractical because of the enormous torque induced by the rotative bit and because, at various times, the dogs will encounter loose formations which do not permit them to grasp the sides of the bore hole firmly enough to prevent rotation of the drilling motor in the bore hole.

It has been further suggested by the prior art that counter-rotating bits be employed in order to balance and cancel out the opposing torques applied to the motor turning such bits. As is obvious, the torque induced by each of the counter-rotating bits will vary from formation to formation and it is practically impossible to predict the torque which will be necessary to be exerted on each bit as it passes through successive formations. Further, one bit will become dull before the other thereby varying the torque necessarily applied to each bit in order to maintain the drilling rate constant and the torques balanced.

It has now been found that the torque necessary to rotate counter-rotating bits can be automatically balanced and equalized by providing a means for extending or retracting one of the bits with respect to the other and, at the same time, varying the bite of one of the bits to change its torque with respect to the torque necessary to drive the other bit. It has also been found that the extension or retraction of one of the bits and the concomitant variation of the bite of one of the bits to balance the torque of the bits can

be automatically regulated by providing a means for extending one of the bits wherein such means is actuated by any rotation of a normally stationary housing or casing associated with the counter-rotating bits. In such fashion, any unbalanced net torque of the counter-rotating bits which acts to rotate the housing associated with said bits is rebalanced.

It is an object of this invention to provide a rotary drilling mechanism suitable for use in the drilling of wells.

It is another object of this invention to provide a rotary drilling mechanism having counter-rotating bits and a means for effectively balancing the torque of such bits.

It is still another object of this invention to provide a means for balancing the torque induced by the drilling bits of a bottom hole drilling mechanism.

Yet another object of this invention is to provide a rotary drilling mechanism adapted to drill through earthen formations which vary one from the other in their drillability without causing the drilling motor to rotate in the bore hole.

Still yet another object of this invention is to provide counter-rotating bits having a means for automatically balancing the torque necessary to rotate each of the bits.

In order to even better understand this invention, it will be described in a particular preferred embodiment thereof as illustrated in the attached drawings. In the drawings, Figures 1, 2 and 3, when considered with each other, illustrate a preferred embodiment of the rotary drilling mechanism of this invention. Thus, Figure 1 represents the top portion of the drilling mechanism, Figure 2 represents an intermediate portion which attaches to that shown in Figure 1, while Figure 3 represents a lower portion of the drilling mechanism which attaches to the bottom portion of the section shown in Figure 2. Figure 4 is a cross sectional view taken on the line 4-4 of Figure 1. Figure 5 is a cross sectional view taken on the line 5-5 of Figure 2, and Figure 6 is a cross sectional view taken on the line 6-6 of Figure 3.

In describing the embodiment illustrated in the drawings, consider that Figure 1 is superimposed above Figure 2 and that Figure 3 is placed below Figure 2, thereby illustrating the complete embodiment of the preferred drilling mechanism of this invention.

A motor 1 is provided within a fluid-tight compartment defined by housing or casing 2 and can be any type of positive-displacement, rotating-type element fluid actuated motor. This motor 1 can be a gear-type, helical screw-type or other type of motor adapted to be driven by means of a fluid pressure applied to rotate its elements. As shown, motor 1 has rotating screws or rotors 3 and 4 which are supported in parallel relationship by shafts 5 and 6 inserted in upper motor housing plate 7 and by shafts 8 and 9 inserted in lower motor housing plate 10. Upper and lower motor housing plates 7 and 10 are spaced in a fixed parallel position and can be situated in grooves in housing 2 as shown. The plates should be provided at their external circumferences with a packing means (not shown) such as asbestos rope or rubber rings adapted to prevent the passage of fluids around the ends of the plates. Attached to the upper housing plate 7 is a fluid conduit comprising a nipple 11 which is joined to a housing 12, as shown. Situated in housing 12 are a hydraulically extensible means

which can be cylinders 13 and 14 which are adapted to contain pistons 15 and 16. The lower ends of cylinders 13 and 14 are closed by cylinder heads 17 and 18. Cylinder heads 17 and 18 can be recessed at the surface facing pistons 15 and 16 and are adapted to receive conduits 19 and 20 in their opposite surfaces in a manner such that a fluid passageway is provided between pump 21 and cylinders 13 and 14.

Alternatively, cylinders 13 and 14 and pistons 15 and 16 can be replaced by other hydraulically extensible means such as a bellows. As many individual hydraulically extensible elements can be provided as is desired. Ordinarily, at least two and preferably three such elements should be employed.

The centrifugal type pump 21 is attached by means of pump shaft 22 to shafts of the rotating element 3 of motor 1. The discharge side of pump 21 can be connected by conduit 23 to conduits 19 and 20 in such manner that the fluid pumped by pump 21 is discharged into cylinders 13 and 14 between pistons 15 and 16 and cylinder heads 17 and 18, respectively. Pistons 15 and 16 are adapted to reciprocate in cylinders 13 and 14, responsive to fluid pressure exerted by pump 21 and have piston rods 24 and 25, respectively, which extend through housing 12 to coact with a dog-extending mechanism described below. Pump 21 can be driven by other means than motor 1 such as by a fluid-actuated motor other than motor 1 or by an electrical motor.

As shown in Figure 1, a means for conducting an actuating fluid to motor 1 can comprise a hollow tube 26 which is attached by means of nipple 27 to the upper portion of housing 12 in such a manner that a fluid can be passed through passageway 28 which extends through tube 26, nipple 27 and housing 12 to discharge into fluid-tight compartment or housing 2 and therein cause the mud motor to be actuated. Annular groove 29 is formed between mud tube 26 and nipple 27 and is adapted to receive therein a cammed projection or lip 30, which extends from bushing 31, as shown. Tube 26 and nipple 27 can be formed as one piece which can have, if desired, groove 29 formed therein. Referring to Figures 1 and 4, cammed projection 30 is shown as an annular lip extending from bushing 31. The entire lower side of lip 30 is formed as an annular cam 32 which is sloped along the lower surface of lip 30. Thus, cam 32 can be an annular ring whose thickness varies along its circumference and changes from a maximum thickness to a minimum thickness at point 32A of Figure 4.

Bushing 31 is rigidly attached to an annular gyration control frame 33 and is adapted to receive mud tube 26 in rotative relationship at its upper end. The lower portion of bushing 31 is likewise adapted to permit nipple 27 to rotate therein and is packed therefrom by means of packing 35 and packing ring 36. Surrounding bushing 31 is a collar 37 adapted to slideably reciprocate on the lower portion of frame 33. A thrust ring 38 can be interposed between collar 37 and piston rods 24 and 25 to provide for free rotation therebetween. Spring 39 surrounds gyration control frame 33 and is adapted to press against spring retaining shoulder 40 and collar 37. Pivoted in recess 41 of collar 37 is dog arm 42 which is also pivoted at its outer end in member 43 attached to dog 44. At the upper end of gyration control frame 33 is rigidly attached an upper support 45 having a dog arm 46 pivotally mounted therein. The other end of dog arm 46

is likewise pivotally mounted in member 47 attached to dog 44.

A lifting lug 48 is attached to gyration control frame 33 at its upper end and is adapted to receive mud tube 26 in a rotative relationship. A bushing 49 is inserted in lifting lug 48 to serve as a packing ring for packing 50 and to receive mud hose 51 therein.

Thus, as shown in Figure 1, a sub-assembly comprising mud tube 26, nipple 27 and housing 12 is adapted to rotate by means of bearings 52 with respect to another sub-assembly comprising mud hose 51, bushing 49, lifting lug 48, gyration control frame 33, bushing 31 and packing ring 36.

Referring to Figure 2 a hollow cylindrical inner bit driving shaft 60 is rotatably mounted in the drilling assembly casing and can be received in lower motor housing plate 10. It can be adapted to conduct fluid discharged from motor 1 there-through. Packing 61 and packing ring 62 is provided, as shown, to permit shaft 60 to rotate in fluid-tight relationship with respect to lower housing plate 10.

A means is provided for motor 1 to rotate shaft 60. Although a preferred means is by suitable gearing as described below, it can consist of belts and pulleys or a combination thereof with gears. In the preferred form, rotative element 3 of motor 1 has a central shaft 8 extending through plate 10 and has drive gear 63 attached thereto. Coacting with drive gear 63 is reversing gear 64 supported on shaft 65 which passes through support member 66 attached to gear housing 67. The lower end of shaft 65 supports driving gear 69 and is further received in gear shaft support plate 68. Rotative element 4 of mud motor 1 is adapted to drive driving gear 70 through shaft 9 which is likewise received in gear shaft support plate 68, as shown. Driving gears 69 and 70 coact with driven gear 71 which is rigidly attached to inner bit shaft 60.

Inner bit shaft 60 extends through a lower hydraulic fluid reservoir 72 contained in a housing 73 and through a further housing 74, as shown in Figure 3. A drive gear 75 is rigidly attached to inner bit drive shaft 60 and is adapted to coact with reverse idler gears 76 and 77. Idler gears 76 and 77 are, in turn, the driving gears for inner female ring gear 78. Female ring gear 78 terminates at its lower end as outer bit drive shaft 79 which extends through a bottom plate 80 attached to housing 74. An outer bit 81 is attached to outer bit drive 79. Outer bit 81 has cutting means disposed along its lower surface in a manner well-known to the art. Piston member 82 is adapted to permit ring gear 78 to rotate therein by means of bearings 99. The piston member 82 can be keyed or fixed in a non-rotative relationship to housing 74 with which it is adapted to slideably coact along the surface 83 and is packed therefrom by means of packing 84. Thus, a hydraulic cylinder 85 is formed between piston member 82 and housing 74, as shown.

Bearing shaft 86 of idler gear 76 extends through housing 74, as shown, and has attached to its upper end a centrifugal pump 87 having a suction 88 and a discharge conduit 89 connected to fluid passageway 90, as shown.

Although it is preferred that outer bit drive shaft 79 be driven by suitable gearing such as that just described by means of power supplied from inner bit drive shaft 60, outer bit drive shaft 79 can be rotated directly by motor 1 or by a second motor (not shown), operatively connected

thereto by means of suitable gearing, belts and pulleys or combinations of the same. Further, pump 87 can be driven directly by motor 1 similarly to pump 21 or by means of any other rotative element in the drilling assembly. Also, pumps 87 and 21 can be driven by the same element and can be supplied with hydraulic fluid, such as oil, from a common source or reservoir (not shown) thereby combining reservoirs 72 and 17A.

Inner bit drive shaft 60 is adapted to pass in slideable and rotative relationship through outer bit drive shaft 79, packing 91 and packing ring 92 and to receive at its outer end inner bit 93 having mud passageway 94 therethrough. Inner bit 93 has a cutting edge along its lower surface adapted to drill through an earthen formation. One or more equalizing reamers 95 are pivoted in slots 96 of inner bit 93 and are adapted to have their lower ends extended laterally from inner bit 93 as a result of the coaction of their upper ends 97 with the inner surfaces 98 of outer bit 81 when inner bit 93 is extended with respect to outer bit 81.

A fluid discharge passageway 100 is situated in housings 74, 73, 2 and 12 to thereby connect hydraulic cylinder 85 via conduit 101 to passageway 102 in nipple 27 and to discharge around valve 103 into annular groove 29. Valve 103 is a Dill valve which is a form of a tire core valve and can be the type shown in U. S. Patent 2,365,423 issued to Charles MacSporran. It is adapted to be opened by coaction of stem 104 with cam 32 when nipple 27 and the casing dependent therefrom as well as valve 103 is rotated with respect to cam 32. Thus, rotation of nipple 27 and valve 103 along the inclined surface of cam 32 causes stem 104 of valve 103 to be pushed down to unseat valve 103 or is raised to seat valve 103 depending upon the direction of rotation of the nipple and valve with respect to the cam. In this fashion, the amount which valve 103 is opened is directly dependent upon the amount valve 103 is rotated along the surface of cam 32. Alternatively, valve 103 can be a screw-stem type valve, such as a needle or glove valve, and can have a gear attached to its stem which coacts with a female ring gear rigidly attached to frame 33 in such a manner that rotation of nipple 27 and the valve causes the valve stem gear to turn thereby opening and closing the valve in accordance to the rotation of nipple 27. A discharge fluid passageway 110 is situated in nipple 27 and continues via conduit 111 and passageway 112 in housings 12, 2, and 73 to discharge hydraulic fluid from groove 29 into lower hydraulic reservoir 72.

In operation, the drilling assembly shown in Figures 1, 2 and 3 is lowered into a bore hole until inner bit 93 and outer bit 81 are resting at the bottom of the hole. A fluid which can be drilling mud is pumped from the surface through mud hose 51 to the mechanism and passes through mud passageway 28 in mud tube 26, nipple 27, housing 12 and nipple 11 into mud motor 1 wherein the fluid pressure causes elements 3 and 4 to rotate in opposite directions. The mud is discharged from the mud motor through inner bit drive shaft 60 and mud passageway 94 in bit 93. Alternatively, the actuating fluid or drilling mud can be discharged from motor 1 through a conduit (not shown) extending from motor 1 to a point outside the housing 2 such as laterally thereof or through plate 80 to impinge upon the bottom of the bore hole near the counter-rotating bits. The rotation of element 3 causes drive gear

63 to rotate reverse gear 64 and driving gear 69, which, in turn, causes driven gear 71 to rotate inner bit drive shaft 60. Rotating element 4 of mud pump 1 likewise causes driving gear 70 to rotate driven gear 71 in the same direction as that caused by driving gear 69. Thus, the entire driving force of rotating elements 3 and 4 is applied to inner bit driving shaft 60 and, thence, to inner bit 93. In rotating inner bit shaft 60, drive gear 75 which is attached thereto causes reverse idling gears 76 and 77 to drive female ring gear 78 in a direction opposite to that of inner bit shaft 60. Since female ring gear 78 is attached by means of outer bit drive 79 to outer bit 81, the inner bit shaft 60 will thereby cause outer bit 81 to rotate in a direction opposite to that of inner bit 93.

The rotation of element 3 of mud pump 1 causes pump 21 to discharge fluid from upper hydraulic reservoir 17A into cylinders 13 and 14 thereby causing pistons 15 and 16 to push piston rods 24 and 25 against thrust ring 38. Thence, since thrust ring 38 and collar 37 are adapted to slide longitudinally upon gyration control frame 33, the hydraulic pressure exerted through pistons 15 and 16 will overcome the force of spring 39 and cause collar 37 to slide along gyration control frame 33, thereby causing the lower portion of dog arm 42 to push dog 44 against the sides of the bore hole. In so doing, dog arm 46 is likewise pivoted between members 45 and 47 to cause the upper portion of dog 44 to push against the sides of the bore hole. In this manner, the sub-assembly comprising dog 44, gyration control frame 33, lifting lug 48, bushing 49 and bushing 31 is forced to remain in a non-rotative fixed position with respect to the bore hole. This action also prevents any twisting of the mud hose 51.

When it is desired to remove the bottom hole drilling assembly from the bore hole, the pumping of drilling mud or other fluid through mud hose 51 is ceased thereby stopping mud motor 1 and pump 21. The hydraulic fluid in cylinders 13 and 14 drains through pump 21 into upper hydraulic fluid reservoir 17A thus permitting spring 39 to force collar 37 downwardly. As a result, dog arms 42 and 46 retract dogs 44 into a position such that the assembly can be readily withdrawn from the bore hole without dogs 44 dragging along the sides of the bore hole.

When the bottom hole drilling assembly is in drilling position at the bottom of the bore hole and bits 81 and 93 are rotating in opposite directions, different earthen formations will be encountered which will cause the torque necessarily applied to each bit to maintain its individual drilling rate to become unequal whereby one bit will tend to rotate more easily than the other. When this happens, there is a tendency for the unbalanced or net torque to rotate the entire bottom hole assembly. However, according to this invention, the unbalanced torque can be automatically rebalanced by adjustment of the relative longitudinal extension of outer bit 81 with respect to inner bit 93. As shown in the drawings, the rotation of reverse idler gear 76 by gear 75 and inner bit drive shaft 60 causes pump 87 to force hydraulic fluid from lower reservoir 72 into fluid passageway 90 and cylinder 85. The hydraulic pressure causes piston member 82 to slide downwardly thereby advancing outer bit 81 farther into the formation with respect to inner bit 93. In so advancing, surface 98 of outer bit 81 permits end 97 of equalizing reamer 95 to extend further laterally from bit 93 thereby causing

equalizing reamer 95 to decrease its bite from the bore hole. As a result, the torque applied to inner bit 93 to maintain its cutting action decreases with respect to that of outer bit 81.

When the torque which is necessary to rotate inner bit 93 decreases sufficiently, it will become less than that needed to rotate outer bit 81. When this happens, the net torque rotates the entire housing of the motor assembly comprising housings 74, 73, 67, 2 and 12 as well as nipple 27 attached thereto so that valve 103 is rotated with respect to cam 32, which is held stationary by gyration control frame 33 and dogs 44. As valve 103 is rotated, cam 32 depresses stem 104 to permit hydraulic fluid to escape from cylinder 85 and passageways 100 and 102 into passageways 110 and 112 and thence into lower fluid reservoir 72. As a result, the fluid pressure in cylinder 85 decreases since the pressure exerted by centrifugal pump 87 is proportional to the volume of fluid pumped. The decrease in fluid pressure in cylinder 85 permits piston member 82 to be raised by the force of the earthen formation pushing upwardly on outer bit 81. In thus raising outer bit 81 with respect to inner bit 93, equalizing reamers 95 are extended laterally from inner bit 93 to take a larger bite from the formation. In so doing, the torques necessary to rotate the inner and outer bits will become equal.

Should inner bit 93 be extended too far with respect to outer bit 81 so that the torque applicable to the inner bit becomes larger than that required by the outer bit, the resultant net torque will again rotate valve 103 along cammed surface 32 but in a direction opposite to that when the torque of the outer bit exceeded the torque of the inner bit as described above. Accordingly, the rotation of valve 103 by the excessive torque of the inner bit will cause stem 104 of valve 103 to rise and restrict the flow of hydraulic fluid through valve 103. The decreased flow of hydraulic fluid permits pump 87 to build up the pressure in cylinder 85 thereby advancing outer bit 85 with respect to inner bit 93 to thereby again balance the torque of the two bits.

It is to be noted that idler gears 76 and 77 are adapted to drive inner ring gear 78 and are further adapted to permit inner ring gear 78 to slide longitudinally with respect to the idler gears. Thus, the action of the hydraulic fluid in cylinder 85 in sliding piston member 82 along surface 98 of housing 74 and concomitantly causing inner ring gear 78 and outer bit drive 79 to be advanced or retracted does not disengage idler gears 76 and 77 from inner ring gears 78.

Thus, it is obvious from the foregoing that any unbalanced torque exerted by either bit 81 or bit 93 will act to unseat or seat valve 103, respectively, so that more or less fluid can be pumped by pump 87 with the resultant decrease or increase in pressure in cylinder 85 causing outer bit 81 to retract or extend into the formation thereby balancing the torque necessary to rotate each bit. As bits 81 and 93 encounter formations that vary one from the other in their ease of drilling, the torque necessary to turn each bit will be adjusted to be equal by automatically varying the bite of bit 93 into the formation. Such adjustment prevents any substantial strain upon dogs 44 whose principal function will be to prevent rotation of the gyration control frame and attached parts while the torques of the two bits are being adjusted. It is thusly obvious that dogs 44 need not be con-

stantly employed to prevent rotation of the drilling motor assembly. Accordingly, they need not be of exceedingly heavy construction nor need they be constantly in the grasp of a hard bore hole wall as would be necessary if they were the only means for preventing rotation of the drilling motor due to unbalanced torques of the counter-rotating bits.

Although the foregoing description has related to a preferred embodiment of the drilling apparatus of this invention and, accordingly, has been rather specific in its terms, it is apparent that many departures can be made from such embodiment without departing from the concept of the invention. Thus, housings 12, 2, 67 and 74 have been described as separate elements although it is obvious that two or more of these can be integrally combined into a single housing or casing. Also, flange joints can be substituted for the screwed joints shown.

Still further, although the operating means for moving collar 37 upwardly has been described as comprised of pistons and cylinders, the motive means for such collar can be a hydraulically extensible bellows attached to the top part of housing 12 in such a manner that the extension of the bellows will push thrust ring 38 and collar 37 upwardly to extend dogs 44 into the formation. Also, cylinder 85 and piston member 82 can be replaced by a hydraulic bellows or a series of parallel bellows adapted to push outer bit drive shaft 79 and outer bit 81 out and away from plate 80. In such case, it would be preferable to secure bearings 99 to a member sliding along the inner wall of housing 74 in order that female ring gear 78 could be held in proper alignment with idler gears 76 and 77.

For the sake of simplification of the attached drawings and the description thereof, many bearings and packing glands as well as other minor features have been omitted. Although such bearings and packing glands are highly desirable and necessary in a commercially operable mechanism, they do not aid but rather they tend to confuse a proper understanding of this invention. It is obvious to one skilled in the art just where and how such bearings, etc. should be installed.

While the invention has been described in connection with a present, preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention, the scope of which is defined by the appended claims.

I claim:

1. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a cylindrical casing, a hollow tube attached by a nipple to one end of said casing to form a fluid passageway through said tube and said nipple into said casing, said nipple and said tube having an annular groove at their juncture, a frame rotatably supporting said tube and said nipple, a plurality of dogs laterally expansible from said frame means of upper and lower arms and adapted to press against the walls of said bore hole when in an expanded position to prevent rotation of said frame, an annular lip extending from said frame into said annular groove at the juncture between said tube and said nipple, an annular cam depending from the lower surface of said lip, a screw-type fluid motor situated in a fluid-tight compartment in said casing, said compartment being connected to said fluid passageway in said tube and said nipple, 75

said motor being adapted to be driven by fluid passing into said fluid-tight compartment from said tube and comprising a pair of oppositely rotating rotors, a hollow inner bit driving shaft rotatably depending from said fluid-tight compartment containing said rotors and extending through the lower end of said casing, an inner drilling bit attached to said inner bit driving shaft externally of said casing, said inner bit comprising a cutting bit having a plurality of laterally expansible equalizing reamers pivotally mounted thereon, said inner bit further having a fluid passageway therein connecting internally to said inner bit drive shaft so that fluid discharged from said fluid motor will pass through said inner bit drive shaft and out said fluid passageway in said bit, a means for driving said inner bit drive shaft comprising a driven gear attached to said inner bit driving shaft, a driving gear coacting therewith to transmit rotative force from one of said rotors of said motor to said inner bit driving shaft, a second driving gear likewise coacting with said driven gear on said inner bit driving shaft, a reversing gear driving said second driving gear and being driven by a second rotor of said motor turning oppositely from the first said rotor through a third driving gear whereby said oppositely rotating rotors of said motor coact to drive said inner bit drive shaft, an outer bit adapted to rotate in an opposite direction around said inner bit and to be extended and retracted longitudinally with respect to said inner bit, said outer bit having an inner surface which coacts with the arms of said reamers so as to extend the opposite cutting ends of said reamers laterally from said inner bit when said outer bit is retracted and to contract said cutting ends toward said inner bit when said outer bit is extended, a rotatable outer bit driving shaft attached to said outer bit and slidably extending through said casing, a means for rotating said outer bit driving shaft in a direction opposite to that of said inner bit shaft comprising a female ring gear attached to said outer bit drive shaft, a plurality of reverse idler gears slidably coacting with and rotatably driving said female ring gear and being driven by a drive gear attached to said inner bit drive shaft whereby said inner bit drive shaft rotates said outer bit drive shaft in an opposite direction from its own rotation, a hydraulic piston attached to said female ring gear and forming a hydraulic cylinder with a portion of said casing, a centrifugal pump driven by one of said reverse idler gears and adapted to pump fluid from a lower hydraulic reservoir in said casing into said hydraulic cylinder to thereby cause said piston to extend said outer bit with respect to said inner bit, a first fluid passageway from said hydraulic cylinder through said casing and through said nipple to said annular groove between said tube and said nipple, a valve in said passageway, said valve having a stem adapted to be pushed down to unseat said valve and being further adapted to coact with said annular cam so that rotation of said nipple and said casing by the unbalanced torque of said counterrotating bits will cause said valve to become seated and unseated responsive to the rotation of said nipple and said casing to thereby regulate the flow of fluid through said pump and said passageway, a second fluid passageway connecting said annular groove with said lower hydraulic reservoir, a means for expanding said dogs against the walls of said bore hole comprising a plurality

of hydraulic cylinders actuated by hydraulic fluid from a pump driven by said mud motor, last said pistons having piston rods coacting with a collar slidably mounted on said frame, and pivotally mounted arms connecting said collar and said dogs so that when last said hydraulic pistons are actuated by fluid pressure, said piston rods push said collar along said frame to extend said dogs to grasp the walls of said bore hole.

2. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a cylindrical casing, a hollow tube attached by a nipple to one end of said casing to form a fluid passageway through said tube and said nipple into said casing, said nipple and said tube having an annular groove at their juncture, a frame rotatably supporting said tube and said nipple, a plurality of dogs laterally expansible from said frame and adapted to press against the walls of said bore hole when in an expanded position to prevent rotation of said frame, an annular lip extending from said frame into said annular groove at the juncture between said tube and said nipple, an annular cam depending from the lower surface of said lip, a fluid motor situated in a fluid-tight compartment in said casing, said compartment being connected to said fluid passageway in said tube and said nipple, said motor being adapted to be driven by fluid passing into said fluid-tight compartment from said tube, a hollow inner bit driving shaft rotatably depending from said fluid-tight compartment and extending through the lower end of said casing, an inner drilling bit attached to said inner bit driving shaft externally of said casing, said inner bit comprising a cutting bit having a laterally expansible equalizing reamer pivotally mounted thereon, said inner bit further having fluid passageways therein connecting internally to said inner bit drive shaft so that fluid discharged from said mud motor will pass down said inner bit drive shaft and out said fluid passageways in said bit, a means for driving said inner bit drive shaft comprising a gear train adapted to transmit rotative force from said motor to said inner bit driving shaft, an outer bit adapted to rotate in an opposite direction around said inner bit and to be extended and retracted longitudinally with respect to said inner bit, said outer bit having an inner surface which coacts with an arm of said reamer so as to extend the opposite cutting end of said reamer laterally from said inner bit when said outer bit is retracted and to contract said cutting end toward said inner bit when said outer bit is extended, an outer bit driving shaft attached to said outer bit and slidably extending through said casing, a means for rotating said outer bit driving shaft in a direction opposite to that of said inner bit shaft comprising a gear train connecting said inner bit drive shaft with said outer bit drive shaft, a hydraulic piston attached to said outer bit drive shaft and forming a hydraulic cylinder with a portion of said casing, a centrifugal pump adapted to pump fluid from a lower hydraulic reservoir in said casing into said hydraulic cylinder to thereby cause said piston to extend said outer bit with respect to said inner bit, a first fluid passageway from said hydraulic cylinder through said casing and through said nipple to said annular groove between said tube and said nipple, a valve in said passageway, said valve having a stem adapted to be pushed down to unseat said valve

and being further adapted to coact with said annular cam so that rotation of said nipple and said casing by the unbalanced torque of said counter-rotating bits will cause said valve to become seated and unseated responsive to said rotation of said nipple and said casing to thereby regulate the flow of fluid through said pump and said passageway, a second fluid passageway connecting said annular groove with said lower hydraulic reservoir, a means for expanding said dogs against the walls of said bore hole comprising a hydraulic cylinder and a piston actuated by hydraulic fluid and coacting with said dogs so that when last said hydraulic piston is actuated by fluid pressure, said dogs are extended to grasp the walls of said bore hole.

3. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a hollow tube attached to one end of said casing, a frame rotatably supporting said tube and said casing, a dog laterally expansible from said frame and adapted to press against the walls of said bore hole to prevent rotation of said frame, an annular cam supported by said frame, a fluid motor situated in said casing, and adapted to be driven by fluid passing into said motor from said tube, a hollow inner bit driving shaft rotatably mounted in said casing and extending through the lower end of said casing, an inner drilling bit attached to said inner bit driving shaft externally of said casing, said inner bit comprising a cutting bit having a laterally expansible equalizing reamer pivotally mounted thereon, said inner bit further having a fluid passageway therein connecting internally to said inner bit drive shaft so that fluid discharged from said mud motor will pass down said inner bit drive shaft and out said fluid passageway in said bit, a driving gear means connecting said motor and said inner bit drive shaft to drive said inner bit drive shaft, an outer bit adapted to rotate in an opposite direction around said inner bit and to be extended and retracted longitudinally with respect to said inner bit, said outer bit having an inner surface which coacts with an arm of said reamer to extend and retract the opposite cutting end of said reamer laterally from said inner bit, an outer bit driving shaft attached to said outer bit and slidably extending through said casing, a gear means rotating said outer bit driving shaft in a direction opposite to that of said inner bit shaft, a hydraulic pressure actuated piston attached to said outer bit drive shaft, means for supplying hydraulic fluid to actuate said hydraulic piston to thereby cause said piston to extend said outer bit with respect to said inner bit, a fluid passageway from said hydraulic piston, a valve mounted on said casing and located in said passageway, said valve operatively contacting said annular cam so that rotation of said casing by the unbalanced torque of said counterrotating bits will cause said valve to become seated and unseated responsive to said rotation of said casing to thereby regulate the flow of fluid through said passageway, a means for expanding said dogs against the walls of said bore hole comprising a hydraulic piston actuated by hydraulic fluid operatively connected with said dogs to extend said dogs to grasp the walls of said bore hole.

4. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a frame rotatably supporting said casing, a dog laterally expansible from said frame,

an annular cam attached to said frame, a fluid actuated motor situated in said casing, an inner bit driving shaft rotatably mounted in and extending through one end of said casing, an inner drilling bit attached to said inner bit driving shaft externally of said casing, said inner bit comprising a cutting bit having a laterally expandible equalizing reamer mounted thereon, a means operatively connected to said motor for rotating said inner bit drive shaft, an outer bit adapted to rotate in an opposite direction around said inner bit and to be extended and retracted longitudinally with respect to said inner bit, said outer bit having an inner surface which coacts with the arm of said reamer to extend and retract the opposite cutting end of said reamer laterally from said inner bit, a rotatable outer bit driving shaft attached to said outer bit and slidably extending through said casing, a means for rotating said outer bit driving shaft in a direction opposite to that of said inner bit shaft, a fluid actuated piston adapted to extend said outer bit with respect to said inner bit, a fluid release means associated with said piston comprising a valve mounted on said casing and operatively contacting said annular cam so that rotation of said casing by the unbalanced torque of said counterrotating bits will cause said valve to become seated and unseated responsive to said rotation of said casing with respect to said frame to thereby regulate the fluid pressure exerted against said piston, and a means for expanding said dog laterally from said frame.

5. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a fluid actuated motor mounted in said casing, a tube attached to one end of said casing and adapted to conduct fluid to said motor, a frame mounted in rotatable relationship with said tube and having attached thereto an annular cam, a plurality of laterally expandible dogs mounted on said frame, a hollow inner bit drive shaft depending from a fluid-tight compartment containing said fluid-actuated motor and extending from said casing to support an inner drilling bit attached to its outer end, a gear train driven by said motor and adapted to rotate said inner bit drive shaft, an outer bit drive shaft extending from said casing to support an outer bit attached at its outer end, said outer bit drive shaft being rotatably mounted around said inner bit drive shaft and being slidably mounted in said casing, a gear train driven by said inner bit drive shaft and adapted to rotate said outer bit drive shaft in a direction opposite to that of said inner bit drive shaft, last said gear train being further in a slidable relationship with said outer bit drive shaft, a hydraulic cylinder responsive to a fluid pressure exerted by a pump driven by last said gear train, a piston in said cylinder adapted to extend said outer bit drive shaft, and said outer bit with respect to said inner bit, a fluid passageway from said hydraulic cylinder to the suction of said pump, a flow regulating valve mounted on said casing and located in said passageway, said valve being opened and closed by coacting with said cam mounted in said frame in such a manner that when an unbalanced torque between said inner and outer bits causes said casing and said valve to rotate with respect to said cam and said frame such rotation will cause said valve to be opened or closed to regulate the hydraulic pressure in said cylinder to thereby regulate the amount said outer

bit is extended with respect to said inner bit, and an equalizing reamer pivotally mounted on said inner bit and having an arm which coacts with the inner surface of said outer bit to contract and extend the opposite cutting end of said reamer upon extension and retraction of said outer bit thus causing said inner bit to take a smaller or a larger bite from the walls of said bore hole to thereby balance the torques necessary to rotate said bits.

6. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a fluid actuated motor mounted in said casing, a tube attached to one end of said casing and adapted to conduct fluid to said motor, a frame mounted in rotatable relationship with said tube and having attached thereto an annular cam, a plurality of laterally expandible dogs mounted on said frame, a hollow inner bit drive shaft rotatably mounted in said casing and extending from said casing to support a drilling inner bit attached to its outer end, a gear train driven by said motor and adapted to rotate said inner bit drive shaft, an outer bit drive shaft extending from said casing to support an outer bit attached at its outer end, said outer bit drive shaft being rotatably mounted around said inner bit drive shaft and being slidably mounted in said casing, a gear train driven by said inner bit drive shaft and adapted to rotate said outer bit drive shaft in a direction opposite to that of said inner bit drive shaft, last said gear train being further in a slidable relationship with said outer bit drive shaft, a piston responsive to a fluid pressure and adapted to extend said outer bit drive shaft and said outer bit with respect to said inner bit, a fluid passageway from said hydraulic piston, a flow regulating valve mounted on said casing and located in said passageway, said valve being opened and closed by coacting with said cam mounted in said frame in such a manner that when an unbalanced torque between said inner and outer bits causes said casing and said valve to rotate with respect to said cam and said frame such rotation will cause said valve to be opened or closed to regulate the hydraulic pressure acting on said piston to thereby regulate the amount said outer bit is extended with respect to said inner bit, and an equalizing reamer mounted on said inner bit and having an upper arm which coacts with the inner surface of said outer bit to contract and extend the opposite cutting end of said reamer upon extension and retraction of said outer bit thus causing said inner bit to take a smaller or a larger bite from the walls of said bore hole to thereby balance the torques necessary to rotate said bits.

7. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a fluid actuated motor mounted in said casing, a frame mounted in rotatable relationship with said casing and having attached thereto an annular cam, a laterally expandible dog mounted on said frame, an inner bit drive shaft rotatably mounted in said casing and extending from said casing to support an inner bit attached to its outer end, a means operatively connecting said motor and said inner bit drive shaft and adapted to rotate said inner bit drive shaft, an outer bit drive shaft extending from said casing to support an outer bit attached at its outer end, said outer bit drive shaft being rotatably and slidably mounted in said casing, means for rotating said outer bit drive shaft in a direction op-

posite to that of said inner bit drive shaft, a hydraulically expansible means adapted to extend said outer bit drive shaft and said outer bit with respect to said inner bit, a flow regulating valve mounted on said casing and operatively connected with said hydraulically expansible means, said valve being opened and closed by coacting with said cam mounted in said frame in such a manner that when an unbalanced torque between said inner and outer bits causes said casing and said valve to rotate with respect to said cam and said frame such rotation will cause said valve to be opened or closed to regulate the hydraulic pressure in said hydraulic means to thereby regulate the amount said outer bit is extended with respect to said inner bit, and an equalizing reamer having an arm which coacts with the inner surface of said outer bit to contract and extend the opposite cutting end of said reamer upon extension and retraction of said outer bit thus causing said inner bit to take a smaller or a larger bite from the walls of said bore hole to thereby balance the torque necessary to rotate said bits.

8. A bottom hole drilling assembly adapted to drill a bore hole comprising, in combination, a casing, a fluid actuated motor mounted in said casing, a non-rotatable frame mounted in rotatable relationship with said casing and having attached thereto a cam, an inner bit drive shaft rotatably mounted in said casing and extending from said casing to support an inner drilling bit attached to its outer end, a means operatively connecting said motor and said inner bit drive shaft and adapted to rotate said inner bit drive shaft, an outer bit drive shaft extending from said casing to support an outer bit attached at its outer end, said outer bit drive shaft being rotatably and slidably mounted in said casing, means for rotating said outer bit drive shaft in a direction opposite to that of said inner bit drive shaft, a hydraulically expansible means operatively connected to and adapted to extend said outer bit with respect to said inner bit, a fluid flow regulating means mounted on said casing and operatively connected with said hydraulically expansible means and adapted to be opened and closed by coacting with said cam mounted in said frame in such a manner that when an unbalanced torque between said inner and outer bits causes said casing and said flow regulating means to rotate with respect to said cam and said frame such rotation will cause said flow regulating means to be opened or closed to regulate the hydraulic pressure acting on said hydraulically expansible means to thereby regulate the amount said outer bit is extended with respect to said inner bit, and an equalizing reamer having an arm which coacts with the inner surface of said outer bit to contract and extend the opposite cutting end of said reamer upon extension and retraction of said outer bit thus causing said inner bit to take a smaller or a larger bite from the walls of said bore hole to thereby balance the torque necessary to rotate said bits.

9. A bottom hole drilling assembly comprising, in combination, a casing rotatably mounted in a non-rotatable frame, an inner bit drive shaft rotatably mounted in said casing and extending therefrom, an inner drilling bit attached to said inner bit drive shaft, an outer bit drive shaft rotatably and slidably mounted in and extending from said casing, an outer drilling bit mounted on said outer bit drive shaft and adapted to rotate around said inner bit, means for rotating said outer and inner bits in opposite directions,

adjustable cutting means pivotally mounted on said inner bit for varying the bite of said inner bit responsive to the longitudinal extension of said outer bit with respect to said inner bit, and means for regulating the said longitudinal extension of said outer bit comprising a hydraulic expansible means cooperating with said outer bit to extend it responsive to hydraulic pressure in said hydraulic means and a fluid pressure regulating means mounted on said casing and operatively connected to said hydraulic means to vary the pressure therein responsive to the rotation of said casing caused by unbalanced torque of the counterrotating said inner and outer bits.

10. A drilling bit adapted to drill a bore hole comprising an inner bit, an outer bit rotating around said inner bit in a direction opposite therefrom and extensible longitudinally with respect to said inner bit, an equalizing reamer comprising a V-shaped member pivotally mounted to said inner bit at a midpoint of said V-shaped member, one arm of said V-shaped reamer coacting with an inner surface of said outer bit so that a retraction of said outer bit from the formation being drilled will cause the opposite cutting end of said V-shaped reamer to be extended laterally from said inner bit to thereby cause said inner bit to take a larger bite from said formation.

11. A drilling bit adapted to drill a bore hole comprising an inner bit, an outer bit rotating around said inner bit in a direction opposite therefrom an extensible longitudinally with respect to said inner bit, an equalizing reamer pivotally mounted to said inner bit, said reamer having an arm which coacts with an inner surface of said outer bit so that a retraction of said outer bit from the formation being drilled will cause the opposite cutting end of said reamer to be extended laterally from said inner bit to thereby cause said inner bit to take a larger bite from said formation.

12. A drilling bit adapted to drill a bore hole comprising an inner bit, an outer bit rotating around said inner bit in a direction opposite therefrom and slidable longitudinally with respect to said inner bit and an equalizing reamer operatively contacting said outer bit so that a retraction of said outer bit from the formation being drilled will cause a cutting edge of said reamer to be extended laterally from said inner bit to thereby cause said inner bit to take a larger bite from said formation.

13. A drilling bit adapted to drill a bore hole comprising an inner bit, an outer bit rotating around said inner bit in a direction opposite therefrom and slidable longitudinally with respect to said inner bit and an equalizing reamer having an upper arm and an opposite cutting edge, said reamer being mounted on said inner bit so as to cause said inner bit to take a larger bite from said formation when said outer bit is retracted from the formation being drilled.

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