

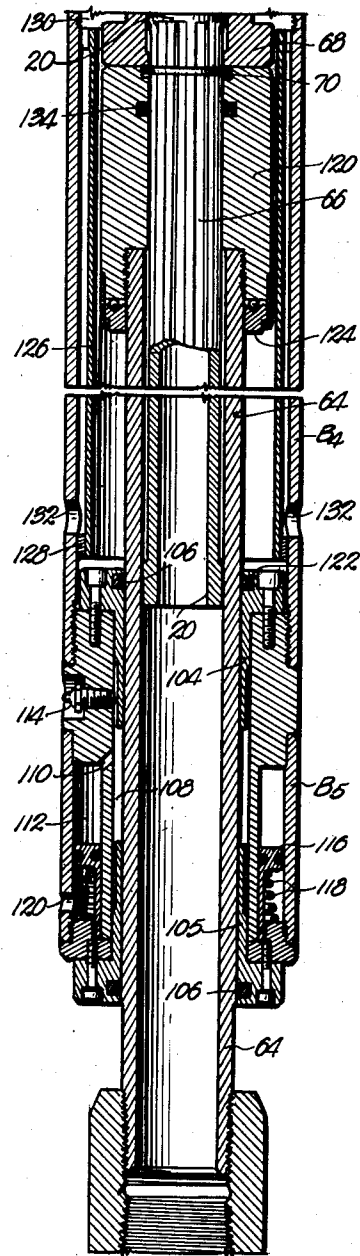
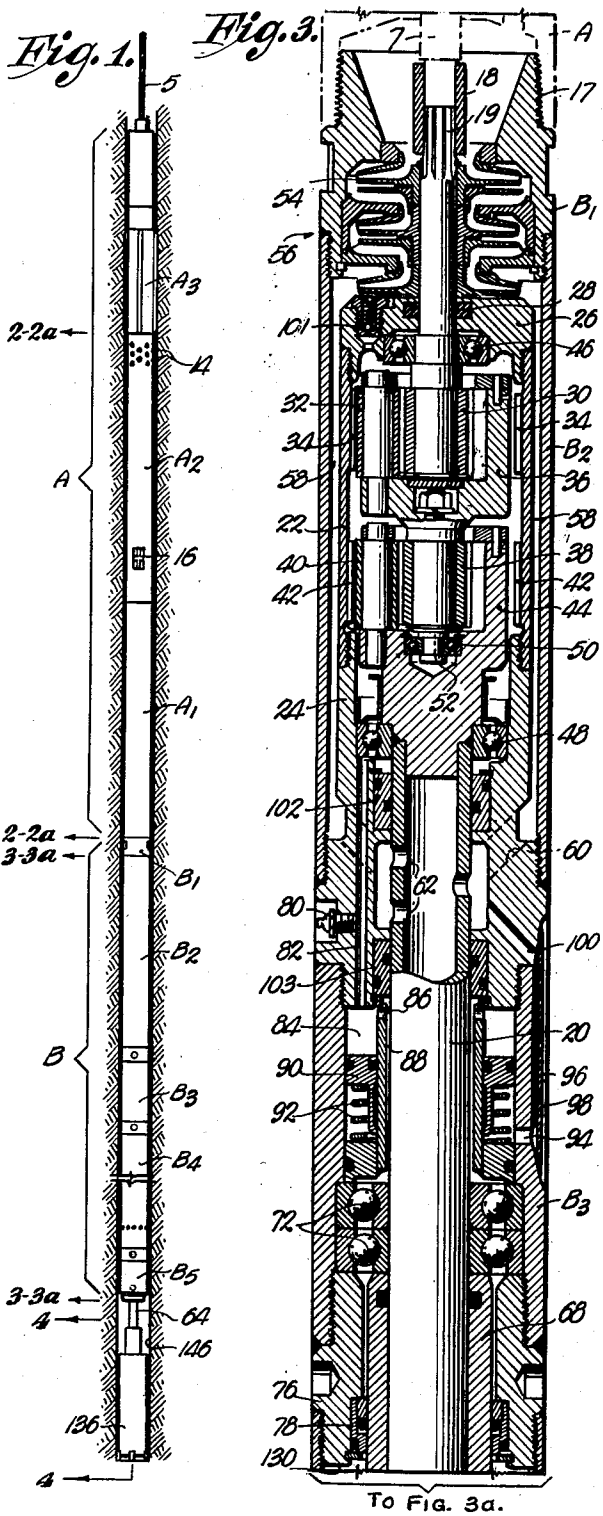
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A. ARUTUNOFF
DRILLING APPARATUS

2,654,572

Filed Oct. 15, 1949

2 Sheets-Sheet 1



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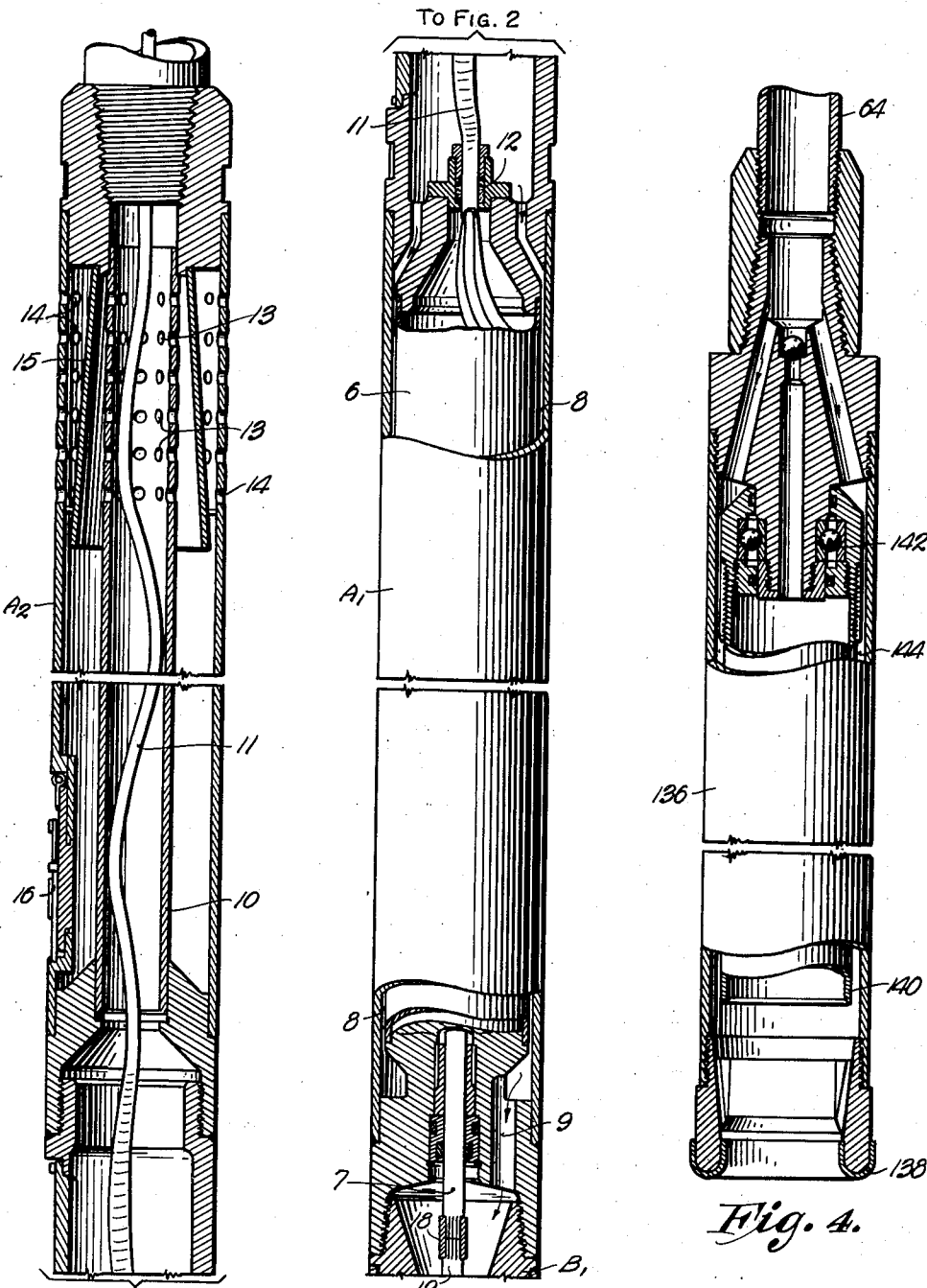
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To Fig. 2a
Fig. 2.

To Fig. 2
Fig. 2a.

Fig. 4.

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DRILLING APPARATUS

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5 Claims. (Cl. 255-4.8)

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The present invention relates in general to the drilling of oil wells, and it deals more particularly with an improvement in a drilling tool of the type shown in my co-pending applications Serial Nos. 711,959, now U. S. Patent Number 2,609,182, filed November 23, 1946, and 60,709, filed November 18, 1948.

In those applications I disclosed a drilling unit suspended on a cable which is capable of being payed out to advance the drill downwardly into the earth, the suspended unit including the motor connected to the drill through the reduction gearing and a pump also driven by the motor for circulating drilling mud.

It is important that working parts, such as the circulating pump and the reduction gearing, be readily replaceable at the first sign of wear, and one of the objects of the present invention is to provide a self-contained unit including all of these working parts, which unit is easily attached to the motor and easily disconnected therefrom for servicing.

Another important object is to provide a drilling device of the character indicated, that is capable of receiving a core bit and has means to facilitate removal of the core sample from the formation after it has been drilled.

Using a cable-suspended drilling tool of the type shown in my earlier applications, it has been customary in the past, after drilling a core, to reel in the cable thereby to elevate the tool with a core retained in the core barrel; however, because the core is connected at its base to the native formation, a considerable strain is imposed on the cable in breaking it loose. One of the main objects of this invention, therefore, is to provide an arrangement for breaking off a core without subjecting the cable to this severe strain. An important feature resides in the provision of a lost motion connection between the drilling unit proper and the core barrel whereby the unit may be given an initial upward momentum before the core barrel is lifted, the full inertia of the upwardly moving mass of the device being utilized to impart an upward blow to the core barrel or bit.

Another object of the invention is to provide an improved form of reduction gearing and means for sealing the same against intrusion of drilling fluid or other foreign matter. To this end I employ multi-stage planetary gearing and a novel arrangement for maintaining the successive stages in proper working relationship.

Other and further objects of the invention, together with the structural features of novelty whereby the objects are achieved, will appear in the course of the following description of the invention.

In the accompanying drawings which form a part of the specification and are to be read in

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conjunction therewith, and in which like reference numerals are employed to indicate like parts of the various views:

Fig. 1 is a side elevation of my drilling device showing the same in a bore hole,

Figs. 2 and 2a are enlarged longitudinal cross section of the upper portion of the drilling unit,

Figs. 3 and 3a are enlarged longitudinal cross sections of the lower portion of the drilling unit, and

Fig. 4 is an enlarged longitudinal cross section of the core bit and barrel.

Referring first to Fig. 1, my drilling device is an elongated cylindrical unit comprising an upper assembly A and a lower assembly B, the two being threaded together at their junction and supported by a cable 5. It will be understood that the cable is connected at its upper end to a derrick or hoist (not shown) by which the cable may be payed out during a drilling operation and reeled in after the drilling operation in order to lift the drilling unit to the surface.

The upper assembly A includes section A₁ housing an electrical motor, a bailer section A₂ above the motor and an anti-rotation device A₃ having shoes for gripping the wall of the well bore to prevent rotation of the drill as a whole during the drilling operation; the construction of the anti-rotation device is fundamentally like that shown in my aforementioned applications and since it forms no part of the present invention, it has not been shown in detail here.

The lower assembly B includes five separate sections connected end to end, section B₁ housing the pump for circulating drilling fluid, section B₂ containing the speed reduction gearing, section B₃ supporting the main thrust bearings, section B₄ comprising the lost motion knocker mechanism, and section B₅ housing the main bearings for the drill shaft.

Referring now to Figs. 2 and 2a which show the upper assembly A, the motor is in a sealed housing 6 spaced inwardly from the outer shell A₁ and its shaft 7 extends vertically downward from the housing to a point approximately level with the bottom of the shell. The annular space 8 around the motor housing forms a fluid passageway communicating at its lower end through a duct 9 with the open upper end of the lower assembly B. The annular passageway 8 communicates at its upper end with a standpipe 10 extending centrally through the bailer shell A₂. The power leads 11 for the motor extend through a packing gland 12 in the motor housing upwardly through the pipe 10 and thence to the surface, preferably being incorporated in the supporting cable 5 as explained in my prior applications.

The central pipe 10 has perforations 13 at its upper end these being disposed opposite perforations 14 in the outer shell, the two sets of perfora-

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tions being separated, however, by a depending annular baffle 15. A door 16 is provided in the bottom of the bailer for removing cuttings which accumulate therein.

The construction of the lower assembly B of my device is detailed in Figs. 3 and 3a. This assembly is provided with external threads 17 at its upper end and to receive the internally downwardly extending motor shaft 7 by means of a splined coupling 18 is the pinion shaft 19 which drives a vertically aligned hollow shaft 20 through multi-stage planetary gearing now to be described.

The latter gearing is enclosed in a stationary housing 22 spaced inwardly from the shell B₂ and supported by the connecting frame member 24 which also serves to form the lower end of the inner housing. The upper end of the said housing is closed by a cap 25 through which shaft 19 enters, the entrance being sealed by packing 28 around the shaft.

The first stage of planetary gearing comprises a sun gear 30 on the lower end of shaft 19 and a plurality of planet gears 32 meshing with the sun gear and also with the internal teeth 34 of a ring gear formed integral with the housing 22. The planet gears, arranged in a circle about the sun gear in conventional fashion, are carried by a yoke 36 which has a downwardly extending shaft on which is fixed the sun gear 38 of the second stage of planetary gearing.

The second stage is like the first in that it has planet gears 40 meshing with the sun gear 38 and also with teeth 42 of a ring gear formed on the inside of housing 22. The planet gears of the second stage are carried by yoke 44 which has downwardly extending stub connected to the hollow shaft 20 for driving same.

As will readily be understood by those versed in the art, rotation of the sun gear 30 causes planet gears 32 to travel in an orbit around the sun gear, turning yoke 36 and gear 38 at reduced speed. Gear 38 in turn causes planet gears 40 to travel in an orbit and rotate yoke 44 and shaft 20 at still slower speed.

The high speed driving shaft 19 is supported by a bearing 46, and the low speed driven shaft 20 by a bearing 48. An important feature resides in the provision of a bearing 50 to which the lower end of the intermediate speed shaft (i. e., the downwardly extending shaft of yoke 36) is secured by a bolt 52. Except for this arrangement, the upper yoke 36 could be perfectly free to shift axially relative the lower yoke and also relative the upper sun gear 30, a situation which would give rise to deleterious bouncing, hammering and excessive wear on the parts; but this is prevented by the tying of the two yokes together as regards their vertical spacing, the arrangement nevertheless permitting the yokes to turn at different ring speeds as is required in their normal operation.

Affixed to shaft 19 are the impellers 54 of a multi-stage centrifugal pump 56. In operation, this pump draws liquid from the space in the well surrounding the unit, into the bailer through apertures 14 (see Fig. 2) then around baffle 15 and through apertures 13 into pipe 10; the liquid is drawn downwardly through the pipe, then through the annular passageway 8 around the motor and through ducts 9 into the pump intake. After passing through pump 56, the fluid is discharged under pressure into the annular space 58 around housing 22 and flows through ducts 60 and apertures 62 into the hollow shaft 20; this connects to an extension shaft 64 which in turn

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directs the fluid into the bit to lubricate same and carry away the cuttings. As explained in detail in my co-pending application Serial No. 711,959, these cuttings are collected by sedimentation when they enter the bailer A₂ through ports 14.

The lower portion of hollow shaft 20 is splined as shown at 66. At the upper end of the splined section is a collar 68 keyed to the splines so that it rotates with the shaft. A split locking ring 70 on the shaft prevents downward movement of the collar, and upward movement is prevented by bearings 72 which comprise the main thrust bearings of my unit. The upper portion of the collar is of reduced diameter and between this portion and the stationary side wall of the connecting member 76, is a rotary seal 78 of any conventional or suitable design.

For lubrication and protection of the bearings thus far described, as well as of the planetary gearing and associated parts, the housing 22 is filled with lubricating oil or light grease introduced through nipple 80. This nipple communicates with a duct 82 through which the lubricant may flow upwardly through and around bearing 48, through and around the planetary gearing, filling the housing completely to the top cap 26. Duct 82 also leads downwardly to a piston chamber 84 which in turn, through apertures 86, communicates with the annular space 88 around shaft 20, and hence with the bearings 72.

Piston 90 in said chamber is urged upwardly by a coiled compression spring 92 supplemented by the pressure of fluid admitted behind the piston through aperture 94. The latter aperture connects with a chamber 96 formed on the exterior of the tool by a shallow recess covered by plate 98, this chamber being connected by a duct 100 with a fluid passageway maintained under pressure by the discharge of centrifugal pump 56.

In preparing my device for use, the lubricant is forced under pressure through nipple 80 until it fills the gear housing 22 (air being driven out through the relief valve 101 during this process) and fills the space around bearing 72 down to the seal 78. Spring 92 compressed by the pressure applied to the lubricant during filling, and thus maintains the lubricant under pressure after filling has been completed. When the unit is lowered into the well and drilling is commenced, the well fluid pumped therethrough causes additional pressure to be applied to the underside of the piston, further pressurizing the lubricant as explained above.

Fluid seals 28, 78, 102 and 103 are provided for the purposes of preventing leakage at the points they protect, and although they are as effective as it is possible to make them within the limits of commercial practicability, they may occasionally, as a result of wear or otherwise, nevertheless permit some small amount of liquid to pass. On one side of each seal is a zone containing well fluid under pressure; on the other side of each seal is a zone containing lubricant under a pressure exceeding that of said well fluid, at least by an amount equal to the force applied on the piston by spring 92. Accordingly, in the event of leakage at any seal, it will be leakage of lubricant into the well fluid rather than vice versa, so there is no possibility of the lubricant protecting the gearing and bearings from being contaminated by intrusion of well fluid. The importance of this in preventing wear and damage to the working parts will be self evident to those versed in the art.

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The hollow extension shaft 64 is rotatably and slidably supported in a pair of axially spaced sleeve bearings 104 and 105 each of which contains a sealing gland 106. The space 108 between the bearings communicates through aperture 110 with a piston chamber 112 and this entire space is filled with lubricant introduced through nipple 114. On the opposite side of piston 116 is a spring 118 exerting an upward force, the action of the spring being supplemented by pressure of well fluid admitted behind the piston through port 120. In the event there is any leakage through seals 106 it will be clear from the earlier explanation that, because the lubricant pressure exceeds well pressure by an amount equal to the force exerted by spring 118, the leakage will take the form of a slow extrusion of lubricant through the bearings rather than intrusion of well fluid into the bearings. This prevents the damage to the bearings which would take place if foreign matter were to enter same, and the supply of lubricant can be replenished periodically as needed through nipple 114.

Secured to the upper end of shaft 64 is a heavy annular collar 120 which will be referred to hereinafter as the anvil or knocker; the bore of this collar has splines meshing with the splines 66 on the shaft 20, whereby the rotation of shaft 20 is transmitted to shaft 64 even though the knocker and its attached shaft travel axially relative to shaft 20. Collar 68 acts as an upper stop for the knocker and an enlarged head 122 on bearing 104 acts as a lower stop. Since head 122 is stationary and knocker 120 often is rotating when they engage, the knocker carries on its underside a loosely supported bearing race 124 that actually contacts the head and minimizes the frictional resistance that otherwise would exist between the relatively rotating parts.

The knocker is encircled by an annular baffle 126 spaced inwardly from the wall of the main housing and extending vertically throughout the distance traveled by the knocker. At its bottom, the baffle is connected to the housing by a ring 128 but at the top of the baffle there is a compartment 130 connecting the space inside and outside the baffle. As knocker 120 travels downwardly along shaft 20, there is an increase in volume of the liquid space inside baffle 126 which causes the fluid to be drawn over the baffle from the outer annular chamber, the latter fluid being replaced by well fluid drawn into the housing through ports 132. As the knocker subsequently ascends, the liquid space within the baffle again decreases causing the excess fluid to be driven back over the baffle and out through ports 132. The admission and escape of liquid from the knocker chamber in this fashion insures that the knocker may move up and down freely at all times. The volume of the space outside of baffle 126 somewhat exceeds the maximum change in the liquid space inside the baffle and since ports 132 are located near the bottom of the baffle, none of the well fluid entering through these ports (or the cuttings that may be carried by such fluid) ever reaches the top of the baffle; in other words, no sediment or injurious foreign matter may reach the working parts housed within the baffle. Sealing ring 134 in the knocker prevents entrance of foreign matter from the stream being pumped through the shafts 20 and 64.

Any suitable type of bit may be screw-threadedly attached to the lower end of shaft 64, one form of core bit being shown in Fig. 4. This

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comprises an outer barrel 136 rotating with the shaft and having cutters 138 around its lower edge. An inner barrel 140 receives the upstanding core left by the downward advance of the cutters, this barrel being mounted on bearings 142 so that it may remain stationary with the core despite the rotation of the outer barrel. Preferably, devices are provided on the inner barrel permitting the entrance of the core but preventing retrograde movement of the core once it has entered; these have not been shown in detail for they are conventional and form no part of the present invention. The well fluid pumped downwardly through shaft 64 passes through the annular space 144 between the two barrels to lubricate the cutters and drive the cuttings away therefrom, upwardly around the exterior of my unit to the ports 14 (Fig. 2) where they enter and are collected.

In lowering my unit on its cable 5 into a well to drill a core, it will be clear that the weight of the bit, shaft 64 and knocker 120 will cause said shaft to be extended from the lower end of the housing and the knocker to rest on the enlarged head 122. When the bit reaches the bottom of the hole its advance naturally stops, but the operator continues to pay out the cable, allowing the balance of the unit to descend (during the course of which shaft 64 recedes into the housing) until the large collar 68 comes to rest on knocker 120. The weight of the entire unit now is imposed on the bit. Motor 6 is started, and with the mass of the entire device urging the rotating bit downwardly, the cable 5 slowly is paid out in order to drill the desired core and permit the core barrel 140 to advance over the same; during drilling, well fluid is circulated as outlined above and as described more fully in my co-pending application Serial No. 711,959 now U. S. Patent No. 2,609,182.

Motor 6 is halted when the drilling of the core is completed, it being understood that the core still is connected at its base or root to the native formation so that it is necessary to break it loose in order to lift it to the surface for examination. In the case of hard, impervious formation this obviously will require considerable force.

The operator nevertheless can accomplish the detachment of the core easily with my unit, simply by reeling in cable 5 with his hoist. The hoist is started slowly to avoid imposing undue strain on the cable as it commences to lift the heavy mechanism in the bore hole; the fact that the core barrel 144 is securely anchored to the core, produces no substantial resistance to the initial upward movement of the device, since the shaft 64 simply is drawn out of the housing as the housing travels upwardly, the bit, shaft and knocker 120 in effect being left behind. Smoothly and gradually the operator accelerates the upward movement of the mechanism so that when shaft 64 finally reaches the limit of its extension, the upward momentum of the heavy apparatus, now moving quite rapidly, causes enlarged head 122 to strike the knocker with an abrupt hammer blow that, transmitted to the core, breaks the latter loose from its moorings and carries it along with the unit to the surface. All of the inertia of the heavy equipment, all the kinetic energy gathered during the initial upward movement, is embodied in this blow, and accordingly there is almost no perceptible increase in the tension on the cable 5 as the blow is struck. Thus have I eliminated the possibility of break-

ing the cable by subjecting it to undue strain in the course of removing the core from the bore hole.

It also will be noted that I have succeeded in combining all of the working parts of my apparatus which are subject to wear (pump, gears, bearings, etc.) in a single, one-piece unit B which is readily attachable to and detachable from the driving unit A for servicing. In the event that any of these working parts require removal for replacement or repair, a substitute unit B may be employed with a motor unit in order to avoid the expense of rendering the whole tool idle while the service work is being carried out. The separability of parts A and B also facilitates transportation of the tool from the site of one job to the site of another, it being self evident that the overall length of the tool when completely assembled is too great to permit convenient shipping thereof.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinbefore set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of the claims.

Inasmuch as many possible embodiments of the invention may be made without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

1. Submersible drilling apparatus comprising a housing suspended on a cable, a rotatable and axially movable vertical shaft extending through an aperture in the bottom of the housing, a bit on the lower end of the shaft, an enlarged head on the upper end of the shaft within the housing, stops above and below the head in said housing limiting the axial movement of said shaft, an auxiliary chamber communicating at its lower end with the space outside of the housing and communicating at its upper end with the space inside the housing, the volume of the auxiliary chamber exceeding the maximum change in volume in the housing caused by shifting of the shaft from its uppermost to lowermost position, and a prime mover in said housing connected to said shaft for rotating same.

2. Submersible drilling apparatus comprising a housing suspended on a cable, a rotatable and axially movable vertical shaft extending through an aperture in the bottom of the housing, a bit on the lower end of the shaft, an enlarged head on the upper end of the shaft within the housing, stops above and below the head in said housing limiting the axial movement of said shaft, an annular baffle in the housing encircling the shaft and spaced inwardly from the walls of the housing to form an annular passageway communicating at its upper end with the space inside said baffle, means bridging the space between the baffle and the walls of said housing at the bottom of said baffle to close said passageway, at least one aperture in the wall of the housing near the bottom of the baffle connecting said passageway with the space outside of said housing, the volume of said passageway above said aperture exceeding the maximum

change in volume inside said baffle caused by shifting of said shaft from its uppermost to lowermost position, and prime mover in said housing connected to said shaft for rotating same.

3. Drilling apparatus comprising a housing suspended on a cable, a prime mover in said housing, a shaft extending downwardly from said prime mover, said shaft comprising a pair of telescoping sections splined together, one of said sections connected to said prime mover and driven thereby, a bit mounted on the lower end of said other section, an enlarged head within the housing secured to the upper end of said other section, an enlarged stop secured on said one section for rotation therewith and adapted to be engaged by said head in the uppermost position of the latter, thrust bearings between said stop and the housing for transmitting the weight of the housing through said stop and head to said other shaft section, and a shoulder on the housing below said head for striking said head responsive to an upward movement of the housing.

4. Submersible drilling apparatus comprising inner and outer housings rigidly connected together and suspended on a cable, speed reduction mechanism in the inner housing, a driving shaft extending from said mechanism upwardly through an aperture in the top of the inner housing, a prime mover connected to said shaft, a hollow driven shaft extending from said mechanism downwardly through an aperture in the bottom of the inner housing, a fluid seal between each of said shafts and said inner housing, said hollow shaft having an aperture communicating exteriorly of said inner housing with the space between said two housings, pumping means connected to said driving shaft for pumping fluid through said space and into said hollow shaft, a lubricating and sealing medium within said inner housing, a piston having one face engaging said lubricating and sealing medium, and a duct extending from the other face of the piston to the space between said two housings whereby the fluid pressure in said space causes said piston to pressurize said lubricating and sealing medium.

5. Apparatus as in claim 4 including a spring urging said piston in a predetermined direction to augment the force applied thereto by said fluid pressure.

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