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2,292,126

WELL DRILLING APPARATUS

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2 Sheets-Sheet 1

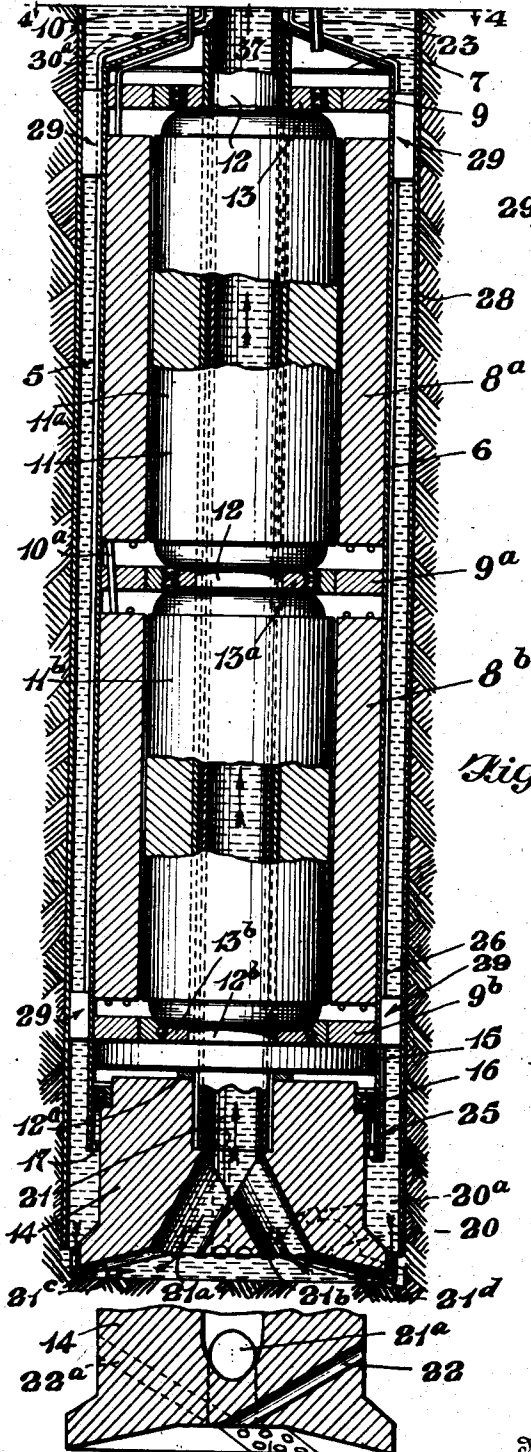


Fig. 1.

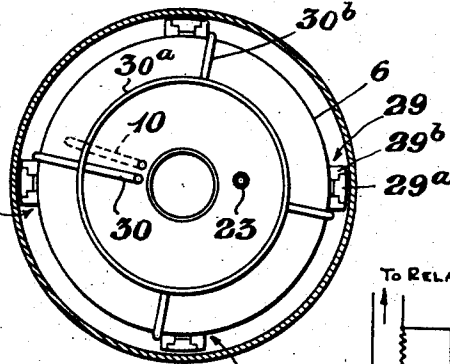


Fig. 4.

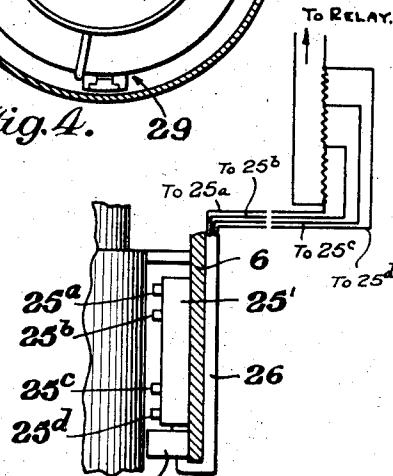


Fig. 5.

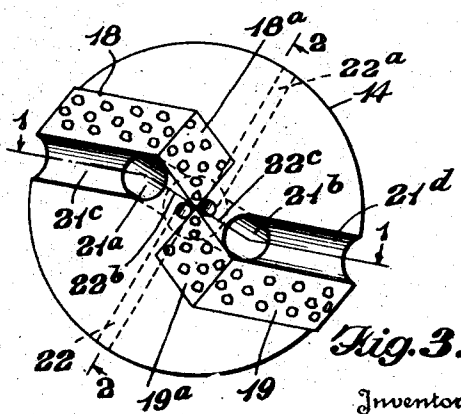


Fig. 3.

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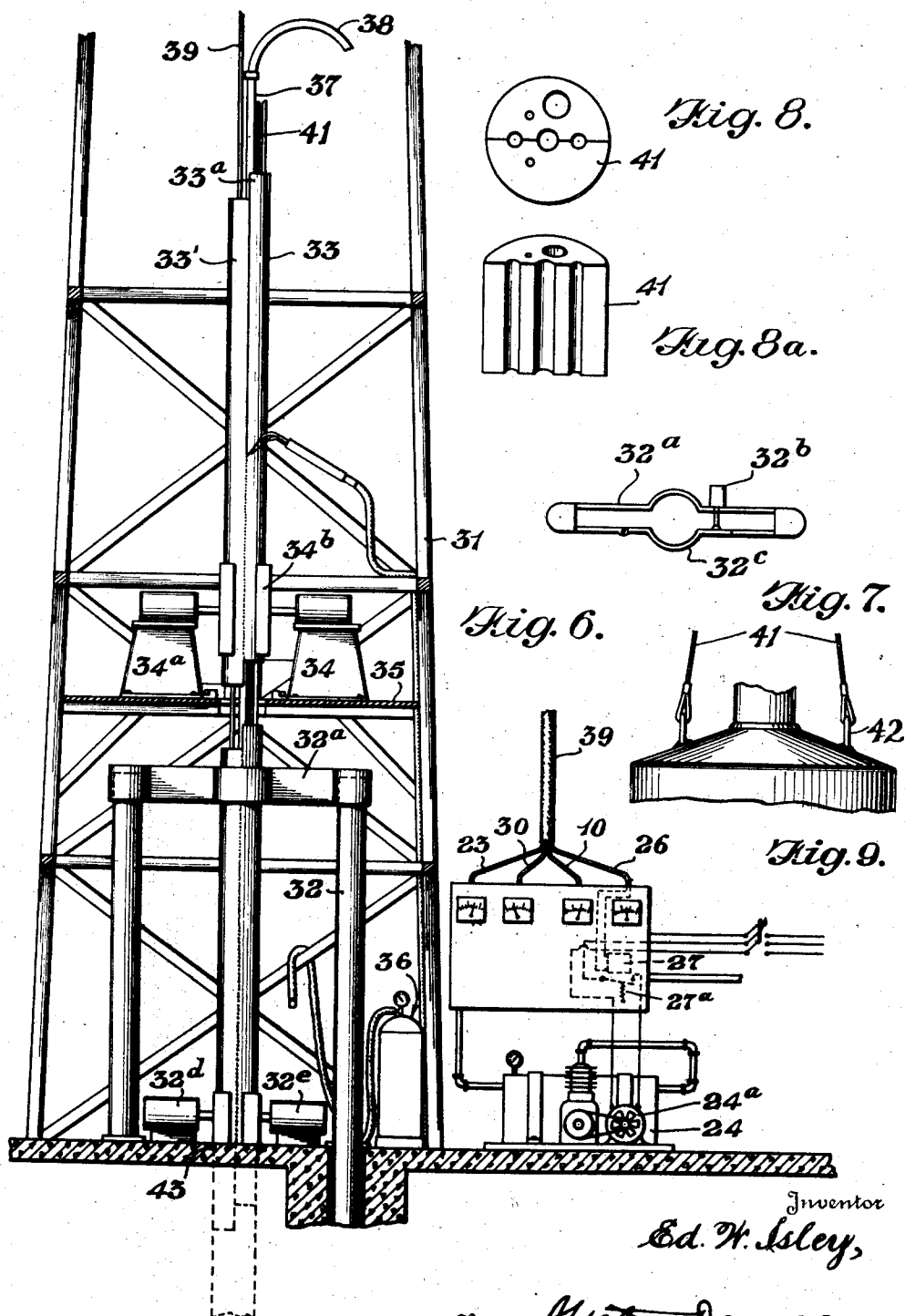
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UNITED STATES PATENT OFFICE

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WELL DRILLING APPARATUS

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5 Claims. (Cl. 255—4)

This invention relates to an apparatus for drilling deep earth formations, primarily oil wells and the like, and has for its objects:

To provide a method of and apparatus for drilling oil wells and like deep earth formations in an economical, simplified and more efficient manner with respect to prior known methods; More specifically, to provide an improved method of feeding a drill unit of the advancing motor type together with the coacting well casing;

To provide an effective means for removing sludge and cuttings resulting from the drilling operation;

To improve and render more efficient well drilling apparatus of the advancing motor type; And to generally improve apparatus relating to drilling oil wells and like deep earth formations.

The method involves the use of drilling apparatus of the advancing motor type, the casing units being joined and fed into the formation or bore being drilled progressively and under accurate control as the drilling proceeds. The casing sections are constructed and joined in a manner such as to permit their joinder and feed without requiring removal of the drilling apparatus or disconnection of the overhead rigging. Means are provided whereby the sludge and drill cuttings are removed through pressure applied in the casing around the sludge pipe or central tubing, the water or other fluid being forced under pressure around and upwardly through the drill head and into the sludge pipe and thence upwardly to the earth's surface, where it is discharged to a suitable point.

More specifically stated, the method includes the steps of advancing a drill unit into the earth to form a well hole or bore of the desired diameter and depth, simultaneously advancing the well casing with the drill unit, forcing fluid, preferably water, under pressure downwardly through the casing and then upwardly through the drill head and into and on upwardly through the sludge pipe or central tubing, the casing being made up of segments or half sections which are joined, preferably by welding, both along their longitudinal and circumferential seams as they are fed downwardly with the drilling unit.

The various features of improvement and advantage of the method and apparatus will become apparent in view of the following description taken in conjunction with the drawings, wherein:

Fig. 1 is a substantially central vertical section of a motor driven drill unit embodying the features of the invention positioned in the lowermost outer casing section, the view through the drill head being taken substantially on the line 1—1, Fig. 3 and the unit being shown at work in a well bore or like earth formation;

Fig. 2 is a fragmentary sectional view of the drill head taken substantially on the line 2—2, Fig. 3;

Fig. 3 is a bottom plan view of the drill head;

Fig. 4 is a transverse section taken substantially on the lines 4—4, Fig. 1;

Fig. 5 is an enlarged fragmentary sectional detail view of a portion of the lower section of the well casing and adjacent motor housing and drill head illustrating a pressure control switch for the motor housing;

Fig. 6 is a view in section and elevation of a type of overhead rigging and coacting welding, clamping and casing feed apparatus which may be used in carrying out the present method;

Fig. 7 is a detail top plan view of the casing clamping and feed jack;

Figs. 8 and 8a are, respectively, detail views in plan and elevation of a type of plug which may be used for sealing the upper end of the casing; and

Fig. 9 is a view in elevation of the upper extremity of the drill motor housing and sludge pipe and overhead rigging connections.

Referring to the drawings in detail and first to Figs. 1 to 5, inclusive, which show the drill unit and coacting parts, the numeral 5 generally designates a motor which is of a construction particularly adapting it to the present improved method. Accordingly, the motor comprises a housing 6 having a chamber 7 formed therein in which a suitable fluid is introduced in a manner and for a purpose to be described. A stator winding is positioned in the housing, said stator being made up in sections 8a and 8b. Between each section are retainer and bearing rings 9, 9a, and 9b, the respective stator windings 8a and 8b being electrically connected through the ring 9a as at 10a. An electrical operating cable 10 serves to conduct current from an overhead source of supply to the motor.

Within the stator sections 8a and 8b an armature 11 is mounted and is also preferably made up of a plurality of sections 11a and 11b, which are mounted on a central tubular or hollow armature shaft 12. The armature sections are supported in bearings 13, 13a and 13b which are fitted into the bearing rings 9, 9a and 9b.

To facilitate the assembly of the armature sections together with their bearings in the bearing rings 9, 9a and 9b, the said bearing rings are each given a graduated or stepped clearance in order to permit the bearing unit 13 to pass 5 through the rings 9a and 9b and given a press fit in its ring 9; the bearing unit 13a to clear or pass through the ring 9b and given a press fit in the ring 9a; and the bearing 13b to fit into the ring 9b. In other words, the bearing rings 9, 9a and 9b have their diameters increased in stepped relation just sufficiently to permit the bearings 13, 13a and 13b to clear the same and yet have a press fit in their respective bearing rings. This facilitates the assembly of the armature sections and bearings as a complete unit from the lower or outer open end of the motor housing.

By forming the stator in sections, the stator bars may be made of a length commensurate with maximum efficiency. This is of particular advantage where the motor required is of unusual length.

The drill head is generally indicated at 14 and is of a particular construction in order to carry out the present method. A gear reduction unit 15 is connected to the lower end of the tubular armature shaft 12, and said latter shaft has a driving connection through the unit 15 with a ring 12a on which the drill head 14 is mounted, a thrust bearing 16 being disposed in the lower end of the motor housing to take the back thrust of the drill head. At the bottom of the motor housing a flow check ring 17 is provided for a purpose which will be hereinafter specified. The bits or cutting elements used may be of any suitable type, that herein shown being of the diamond impregnated type and made in sections indicated at 18, 18a, 19 and 19a. The sections 18a and 19a may be suitably clamped or otherwise secured in place. The sections 18 and 19 are mounted independently of the sections 18a and 19a and are pivotally supported in order to permit the bits to clear the well casing in the event the drilling unit is removed after the drilling operation has been started. Accordingly, each section 18 and 19 is mounted on a pivoted holder 20, said holder being formed with a limiting stop 20a which limits the downward pivoting movement of the bit and also holds the latter in a position such as to cause the bit to automatically contact the earth's surface or bottom of the bore and move back into drilling or cutting position when the unit is lowered into the bore.

As heretofore stated, the sludge removing fluid, which is preferably water, is introduced into the top of the casing and is forced down around and up through the drill head and back upwardly through the sludge pipe or central string of tubing. To provide for this method of sludge removal, the top of the casing is sealed off and the water is forced under pressure down around the motor housing. The drill head is formed with a main central passage 21 which communicates with a hollow sludge pipe section 21' projected through the armature shaft 12. The said central passage 21 opens out at its lower end into the bottom of the drill head through passages 21a and 21b. These passages 21a and 21b communicate at the bottom of the drill head with grooves 21c and 21d, said grooves being disposed adjacent and along the drill bits or cutting elements 18 and 19 so that as the water flows inwardly to the passages 21a, 21b, it automatically cleans and lubricates the bits. To carry out the

same operation with respect to the bits 18a and 19a, the drill head is formed with additional ducts or inlet passages 22 and 22a which open at their outer inlet ends through the body of the drill head and converge downwardly and communicate with bottom grooves 22b and 22c, the latter grooves being disposed along the bits 18a and 19a and communicating with the central uptake passages 21a and 21b.

To maintain a reacting pressure in the motor housing and ensure against leakage of water into the bearings and other vital operating parts of the motor as well as to ensure against explosion in the well bore due to ignition of inflammable gases, a suitable non-combustible fluid such as nitrogen, or a fluid strongly impregnated with nitrogen, is introduced under pressure from the earth's surface through a flexible conduit or tube 23 and into the chamber 7 provided in the motor housing 6. This nitrogenous fluid being non-combustible and yet relatively light, is maintained at a pressure such as will substantially equalize the hydrostatic pressure on the outside of the motor casing, the nitrogen being fed under pressure through the medium of a suitable compressor 24, note Fig. 6, which may be electrically driven and controlled through the medium of a switch structure generally indicated at 25 in Fig. 1 and an example of which is illustrated more or less in detail in Fig. 5. This switch is positioned in the bottom of the motor housing adjacent the drill head 14, note Fig. 1, and in the form shown comprises an insulated block 25' having a series of bridging contacts 25a, 25b, 25c and 25d. These contacts connect through separate leads with a relay circuit leading to a relay 27, note also Fig. 6, for starting and stopping motor 24a which drives compressor 24. The separate contact leads have interposed therebetween resistance units of predetermined values.

The switch operates as follows:

Should the water rise past the ring 17 and reach a point such as will bridge the upper contacts 25a and 25b, the resistance between the plus and minus sides of the relay circuit will be reduced to a point such as will permit sufficient current to flow in the said circuit to close the relay and start the compressor motor 24a. The relay closes against the tension of a spring 27a which may be adjusted to a point which will permit the relay to remain closed until the flow of current in the relay circuit drops to a predetermined amperage. Therefore, after the compressor has been driven until the pressure in the motor housing 6 reaches a point such as will combat the rising water and cause the same to lower to a level which will clear the contact 25d, the flow of current in the relay circuit will be reduced to a point such as will cause the spring 27a to throw the relay to open position, thereby shutting off the motor and stopping the compressor 24. It will be obvious, however, that any other suitable type of switch for accomplishing the same result may be utilized.

The ring 17 reduces the space between the bottom of the motor housing and drill head and counteracts rapid influx of water due to sudden changes in pressure in the well bore.

As heretofore noted, the motor driven drill unit is lowered into the bore or earth formation within the lowermost section of the casing. This lowermost section is indicated at 28, note Fig. 1; and to anchor and center the motor in the proper drilling position in the said casing section 28, means in the form of expandible shoes 29 are provided and are spaced at approximately uni-

form distances circumferentially around the interior of the casing section 28 between the motor housing 6 and said section. These shoes are preferably hydraulically operated and as shown consist of gripping members in the form of plungers 29a which are mounted in hydraulic cylinders 29b and may be provided with a suitable gripping surface. The hydraulic fluid may be supplied to these shoes through flexible conduit 30, which at its lower end feeds into a common circular or annular conduit 30a, which in turn communicates with the respective shoes through flexible connections 30b. As herein illustrated, there are two sets of shoes, one adjacent the upper extremity of the motor housing and the other adjacent the lower extremity thereof. Obviously, these shoes could be made of a length approximating that of the motor housing instead of being made in spaced aligned pairs or can be made in any other form suitable for the particular installation involved.

An important feature in the present invention is the method of joining or connecting the casing sections as the drill unit advances into the bore, the method being such as to obviate the necessity for uncoupling the central tubing sections and external operating connections. Referring to Fig. 6, the overhead or derrick framework is generally indicated at 31, and mounted in the base thereof is an hydraulic casing feed jack generally indicated at 32, having an hydraulically operated gripping cross head 32a, note particularly Fig. 7, which is adapted to grip the casing and lower the latter into the well bore as the drill advances. This cross head is provided with an hydraulic cylinder 32b which is connected to a hinged or pivoted gripping section 32c. By proper regulation of the operating fluid admitted to cylinder 32b, the cross head may be caused to grip the casing or release the latter whenever desired, or at the will of an operator. Coacting with the hydraulic jack 32 are a pair of hydraulic clamping or gripping members 32d and 32e which grip and hold the joined casing to support the latter when the jack is released and raised to its upper feeding position.

The casing sections are each made up of half segments indicated at 33 and 33'. The sections have their ends stepped or staggered as at 33a to provide a lapped fit and render the welded connection at this point more secure. The respective sections or halves are applied around the central tubing string and operating connections with their edges in registration and welded both along their vertical joints and their end joints. In order to hold the respective halves in proper welding relation, suitable hydraulic gripping members 34 and 34a are mounted on a platform 35 carried by the frame or derrick 31, each of the grippers being provided with an hydraulic clamping or gripping member 34b adapted to engage the adjacent casing section. The weld may be effected in any suitable manner, the welding apparatus being generally indicated at 36. The preferred manner of welding is to provide a beveled edge at the seam and use welding material.

The central tubing string or sludge pipe is indicated at 37, note Figs. 2 and 6, and has connected to the upper end thereof a flexible conduit 38 which serves to lead off the sludge and drill chippings and conduct the same to a suitable point. By referring to Fig. 2, it will be noted that the lower end of the sludge pipe 37 connects with the hollow or tubular section 21' which is

projected through the armature shaft, said section 21' in turn projecting into the passageway 21 of the drill head.

The various connections leading from the overhead supply down to the drilling unit are initially of a length sufficient to accommodate the approximate depth of the bore and are preferably encased in a single cable 39. Each of the respective operating connections is brought out from the common casing 39 at the top of the well and separately connected to their respective operating units through suitable indicating instruments and controls mounted on a panel board 40.

To seal off the upper end of the casing a suitable plug 41 is provided, note Figs. 8 and 8a, and is preferably made up of half sections formed with holes to accommodate the respective operating connections. These plugs are preferably of the pneumatic expandible type capable of withstanding any reasonable range of operating pressure.

A lifting cable 41 is connected at 42 to the top of the motor housing and extends upwardly through plug 41 to a suitable hoisting device, not shown. The connection to the ring 42 is preferably made at equally spaced points, or 180°, to avoid side drag. This cable may also serve to carry some of the weight of the unit at extreme depths.

A sealing ring 43, note Fig. 6, is positioned around the casing at the top of the bore to reduce leakage between the casing and wall of the bore.

The apparatus operates as follows: In starting the bore the first or lower casing section 28 may be a solid wall cylinder. In other words, there is no necessity to utilize welded half sections at this point. The motor-driven drill unit is installed in this section and anchored through the medium of shoes 29. The drill unit and its coacting casing section are placed in the jack 32 and the latter adjusted to feed at the proper rate. The jack is preferably controlled manually through suitable valve connections, although it may conceivably be controlled automatically. As the drill cuts its way into the earth, the casing section 28 and drill advance as a unit. Assuming the plug 41 is in position in the top of the casing, water under pressure is introduced into the casing through conduit 44 and around the motor housing, the water passing in at the bottom of the drill head through grooves 21c and 21d, and upwardly through the ports 21a and 21b into the passage 21 and thence on upwardly through the pipe section 21' and sludge pipe 37. The water also flows in through drill head ports 22 and 22a and into the passages 21a and 21b. As heretofore noted, this effects cleaning of the drill bits while removing cuttings and earth from the bottom of the bore.

As the unit advances into the bore, sections of casing are added on, the respective sections being made up of half segments which are welded together and also joined at their ends in staggered relation by welding as heretofore noted. As will be understood, as each section is joined on, the plug 41 is released and raised upwardly to the mouth of the casing. When a section is joined on, the gripping devices 32d and 32e are released and the hydraulic jack 32 is operated to feed the casing and drill unit downwardly as the drill advances. In Fig. 6, said jack 32 is shown in raised position gripping the top of a newly added section. By using an hydraulic feed of this type,

an accurate control for the advancing drill is provided.

Should the water rise to a point around the drill head where it will bridge the contacts 25a and 25b, the compressor 24 will immediately start and build up pressure in the motor housing 6 until the water is forced outwardly or downwardly to a level approximating the contacts 25c and 25d. By using nitrogen, or a nitrogenous fluid for maintaining the desired pressure in the motor housing, fire hazards are materially reduced. Cooling is primarily effected by the water circulating on the outside of the motor housing.

Since the area of the sludge pipe is relatively small in comparison with that of the casing, ample velocity of flow for efficient sludge removal is assured at all times without requiring suction to assist such removal. In other words, the method permits the supply of an ample volume of water under suitable pressure to ensure the desired velocity of flow in the sludge pipe.

Due to the accurate control of feed in the casing and drill unit, the chances of drifting the casing as it advances downwardly are materially reduced.

The equipment required is relatively light as compared with that used in the conventional well drilling apparatus, and this fact coupled with the fact that the well is progressively encased as the drilling proceeds, materially facilitates operation of the apparatus from floating or anchored barges, so that submerged areas may be drilled substantially as easily as dry land areas. The fact that the drill is guided from the start by the casing further aids in submerged area drilling.

By introducing a suitable fluid under pressure into motor housing as heretofore explained, the use of mechanical seals is avoided, which is a material advantage in advancing motor drilling equipment.

It will be understood that the foregoing and other advantages not stated herein are inherent in the improved method and apparatus; and that certain changes in construction and design as well as in the steps of the method may be made without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. Drilling apparatus comprising, in combination, a drill unit of the advancing motor type including a motor having a housing encasing the operating parts of the motor, said housing being formed with a chamber, a drill head operatively connected to the lower end of said motor, a casing for the bore being drilled, means anchoring the motor housing in the lower extremity of said casing with said drill head exposed in drilling position clear of the housing and casing, a sludge pipe projecting downwardly through the casing and communicating through said motor housing and drill head with the bore being drilled, means for introducing sludge water under pressure into the casing around the motor housing, water passing into the sludge pipe through said drill head and unit, means for introducing a fluid medium under pressure into the chamber of the motor housing to maintain a counteracting pressure in the housing, and means controlled by the level of the water in the motor housing for regulating the operation of said pressure-introducing means.

2. Drilling apparatus comprising, in combination, a drill unit of the advancing motor type in-

cluding a motor having a housing encasing the operating parts of the motor, said housing being formed with a chamber, a drill head operatively connected to the lower end of said motor, a casing for the bore being drilled, means anchoring the motor housing in the lower extremity of said casing with said drill head exposed in drilling position clear of the housing and casing, a sludge pipe projecting downwardly through the casing and communicating through said motor housing and drill head with the bore being drilled, means for introducing sludge water under pressure into the casing around the motor housing, water passing into the sludge pipe through said drill head and unit, means for introducing a fluid medium under pressure into the chamber of the motor housing to maintain a counteracting pressure in the housing, and means controlled by the level of the water in the motor housing for regulating the pressure in said housing, said pressure controlling means including an electric switch actuated through fluctuation of water in the bore.

3. Drilling apparatus comprising, in combination, a drill unit of the advancing motor type including a drill head and a motor for driving said head having a housing, a casing for the bore being drilled, means anchoring said motor housing in the lower extremity of the casing and in spaced relation to the wall of the casing with the drill head exposed below the housing and casing in drilling position, a sludge pipe projected downwardly through the casing and communicating through said motor with said drill head, the drill head being formed with passages communicating the sludge pipe with the bore being drilled, means for introducing sludge water under pressure into the casing around the motor housing, said drill head having cutting elements secured thereto and projecting beyond the bottom surface thereof and said surface being formed with flow channels paralleling and lying adjacent to said cutting elements and communicating with said passages to direct the water in cleaning contact with said cutting elements and thence upwardly through the passages in the drill head and into and on upwardly through the sludge pipe.

4. Drilling apparatus comprising, in combination, a drill unit of the advancing motor type including a rotatable drill head and a motor having a housing and an armature shaft of hollow construction to which said drill head is operatively connected, said drill head having cutting elements secured in the bottom thereof, a casing, means anchoring said motor housing in the lower extremity and in spaced relation to the wall of said casing with the drill head and cutting elements exposed below said housing and casing in drilling position, means for feeding the casing together with the drill unit and motor simultaneously into the bore being drilled as the drilling operation proceeds, a sludge pipe projected downwardly through the casing and communicating through said armature shaft with said drill head, the drill head being formed with passages communicating said sludge pipe with the bore being drilled, said passages having inlets located adjacent said cutting elements and the bottom surface of the drill head being formed with flow channels constituting extensions of said inlets and lying contiguous to the cutting elements, and means for introducing sludge water under pressure into the casing around the motor housing, the water passing around the drill head and into said flow channels and inlets and

thence upwardly through the drill head and sludge pipe.

5. Drilling apparatus comprising, in combination, a drill unit of the advancing motor type including a rotatable drill head and a motor having a housing and an armature shaft of hollow construction to which said drill head is operatively connected, said drill head having cutting elements secured in the bottom thereof, a casing, means anchoring said motor housing in the lower extremity and in spaced relation to the wall of said casing with the drill head and cutting elements exposed below said housing and casing in drilling position, means for feeding the casing together with the drill unit and motor 15

simultaneously into the bore being drilled as the drilling operation proceeds, a sludge pipe projected downwardly through the casing and communicating through the armature shaft with the drill head, said drill head having an uptake passage formed therethrough in communication with the sludge pipe, said uptake passage having inlets located adjacent said cutting elements and said drill head being formed with intake ports arranged to conduct sludge water from the exterior of the drill head to said inlets, and means for introducing sludge water under pressure into the casing around the motor housing and drill head.

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