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ROTARY EARTH DRILLING APPARATUS AND METHOD

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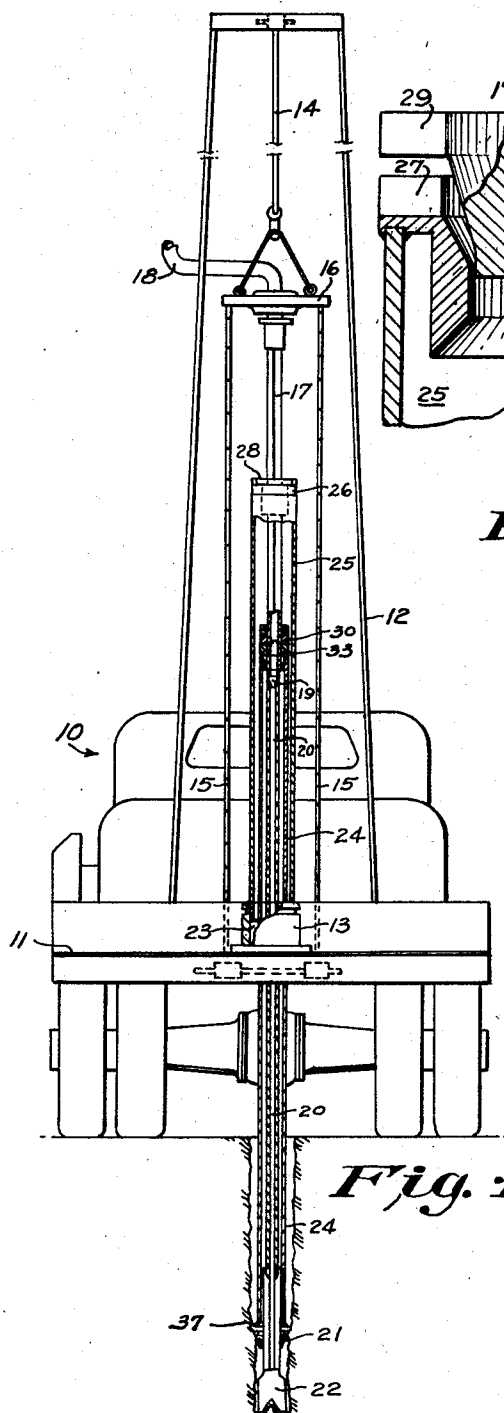


Fig. 1

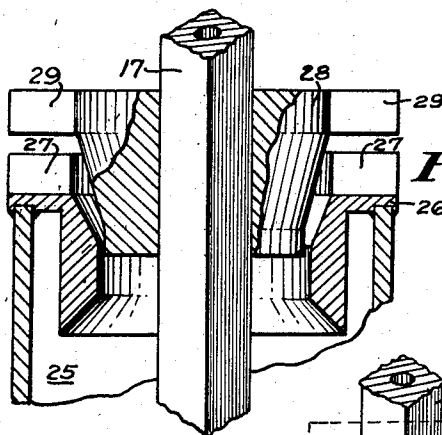
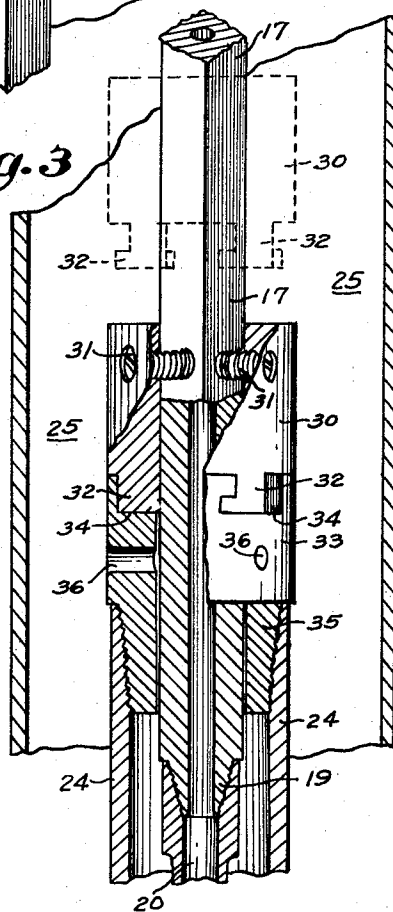


Fig. 2

Fig. 3



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ROTARY EARTH DRILLING APPARATUS AND METHOD

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4 Claims. (Cl. 255—1.8)

This invention relates to a new apparatus and method of earth drilling which permits the landing or lowering of casing or surface pipe in the hole simultaneously with the drilling operation.

In drilling well bores with rotary drilling machines, which bores are to be cased in order to serve their purpose, the conventional procedure is to drill a hole of sufficient diameter, remove the drilling tools, and thereafter attempt to run the casing into the hole. Such casings serve two purposes: to seal off the well bore from fluids in the surrounding formations, or to protect the well bore from caving sidewall material. This procedure is inefficient under difficult drilling conditions, as when loose gravel formations, boulders, glacial drift, talus material or the like are present, and which may cause sidewall bridging or cave-ins after the drill string is removed and before the casing can be landed. Under such conditions the bore hole must be redrilled, possible several times, before the casing can be placed.

Another hazard incidental to landing casing in an open hole occurs in connection with the completion of underground petroleum products storage reservoirs. These consist of a series of salt solution cavities which are commonly separated by baffles of insoluble shale and/or marl. After the drilling tools have been removed from the cavity series, it is extremely difficult and occasionally impossible to again locate the hole because there are no side walls to guide the casing.

A principal object of the invention is therefore to provide means and a method of drilling whereby the casing may be lowered into the well simultaneously with the drill, the casing accompanying the drill bit in close proximity, thus avoiding the difficulties described above.

This invention is particularly adaptable to the portable, truck-mounted rotary drilling rigs widely used in the drilling of water wells, seismograph shot holes for geophysical operations, and in the aforesaid drilling for underground reservoirs. In such truck-mounted rigs, the rotary table which drives the drill, being mounted in the truck platform, is about three feet above ground, thus discouraging the idea of lowering sections of casing while drilling is in progress, since the length of the casing sections, in the absence of the present invention, would have to be less than this clearance. Casing conveniently comes in ten foot lengths, which may be used according to the example of the invention described hereinafter. Greater casing lengths may be used by increasing the height of parts of the device, namely the derrick and torque tube. The use and cost of casing lengths substantially shorter than ten feet would become relatively disadvantageous for the reason that much rig time would be consumed in coupling relatively short casing lengths together, and the substantially higher cost in casing thread would make their use impractical.

Accordingly, another object of the invention is to provide means whereby casing lengths may be simultaneously lowered during the drilling operation in rigs where the drilling platform is at low level, and lower to the

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ground than the casing length to be used. This is made possible by a feature of the invented apparatus which may be termed a torque driving tube, which encloses the upper portions of the casing and drill string and transmits rotary movement to the latter by connection at a point higher from ground surface than the length of a standard unit of casing.

A further advantage of the invention resides in novel connections between the torque driving tube and kelly bar, and between the kelly bar, casing, and drill pipe, whereby the operator may selectively: (1) rotate the casing and drilling tools simultaneously; (2) rotate only the drilling tools; (3) rotate and apply downward pressure on and lower the drilling tools; or (4) apply downward pressure upon and simultaneously rotate and lower both the casing and drilling tools. This makes possible selecting a method whereby it is not necessary to rotate the casing, as when the bore hole is being opened up, or whereby the casing, equipped with a casing shoe, can be rotated to assist its entry into the hole along with the drilling tools.

According to the apparatus and method of the invention, if the drill bit fails at any time it can be replaced, and the drilling tools may be removed at any time before or after the casing has been landed, and the well later completed by ordinary drilling means. These advantages contrast the invention with another known method of avoiding cave-ins which is practiced by attaching a bit to the end of the casing, the latter being rotated to serve the function of drill pipe, and wherein the bit may not be changed if it fails, and must be shot off and left in the well when the well is at the desired depth.

Another feature of the invention is the inclusion in the drill string of an underreamer (in itself conventional) which in inoperative condition has less diameter than the casing to be landed. This underreamer is selected in a size which, when the cutters thereof have been opened in the well below the casing, drills a hole of a diameter sufficient to receive the casing. The underreamer is of a type which may be closed at any time and withdrawn by the drill string. The presence of the underreamer in the combination makes possible a novel drilling method, the steps of lowering a drill string through a casing, and thereafter drilling and reaming a hole of greater diameter than said casing. This procedure may additionally be accompanied by selectively lowering and/or rotating the casing.

Other objects and advantages will be noted in connection with a description of the drawing which, for illustrative purposes, shows the invention as applied to a truck-mounted machine, it being apparent, however, that many principles of the invention will be applicable to other types of rig.

In the drawings:

Fig. 1 is an elevation, with parts in section, showing the invention as it would appear in a portable, truck-mounted, drilling rig, in the course of drilling a well;

Fig. 2 is an enlarged detail view, with parts in section, of the connecting means between the kelly bar and power coupling or torque tube; and

Fig. 3 is another enlarged detail view, with parts in section, showing the connections between the kelly bar and casing, and between the kelly bar and drill string.

In Fig. 1 the rear elevation of a truck 10 having a platform 11 is shown equipped with a derrick 12. On the platform 11 is mounted a power-driven rotary table 13, the source of power not being shown, but which normally is the truck motor. Derrick 12 may be of conventional design, constructed of tubular steel to a height above the truck platform of twenty-three feet, and being capable of folding flat above the truck when the latter is

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moved. Derrick 12 is provided with the usual cable assembly 14 for supporting the drilling tools and with the pull-down chains 15 for exerting downward pressure thereon, these chains also being powered from a source on the truck, not shown. At the end of the cable assembly 14 is the pull-down yoke 16 to which chains 15 are attached.

Yoke 16 supports the kelly bar 17 for rotational movement, the latter being square in section, and hollow for the purpose of conducting drilling mud or fluid into the well from a source leading into kelly 17 through flexible hose 18.

Kelly bar 17 supports the drill string at the threaded connection 19, to which is attached a section of drill pipe 20, beneath which is connected an underreamer 21 and roller drill bit 22, each of conventional design.

It will be appreciated that in a rig of the type described, the rotary table 13, if conventional, would be situated about three feet from ground level, and would be equipped with a hollow square internal bushing fitting the external diameter and shape of kelly 17, the latter being rotated to effect rotary drilling action of the bit. It will also be appreciated that casing could not be landed in the well simultaneously with drilling by these means, there being insufficient clearance between truck platform 11, rotary table 13, and ground level, as previously noted above. A specific example of the portable rig of the type so far described is the "Model 1000" Portable Drilling Rig made by Mayhew Machine & Supply Co., Dallas, Texas, illustrated in their catalogue by that name.

According to the invention, a rotary table 13 is provided having an internal bore 23 of sufficient diameter to permit the passage of the drill string, and also the passage of a section of casing 24. Accordingly, the rotary table 13 makes no driving connection with the drill string or casing 24 within its own dimensions. Instead, there is provided what may be termed a power coupling in the form of a torque tube 25.

Torque tube 25 may be constructed from a section of steel tubing having a larger diameter than the casing to be landed and hence may have substantially the same inner diameter as the bore 23 of rotary table 13. A conventional rotary table bushing (not shown in drawing) is welded to the lower end of the section of tube 25 to register as a spline fit with bore 23 which is octagonal. Tube 25 thus may be lifted from the rotary table if removal is desired to return the rig to a conventional design. The length of torque tube 25 is selected so that its upper end stands a distance above ground level in excess of the distance represented by the length of a section of casing to be landed in the well.

The top of torque tube 25, as best seen in Fig. 2, is provided with a bushing 26 welded thereto. Bushing 26 upon its top surface carries a series of radial key slots 27. The internal diameter of bushing 26 is sufficient to give clearance to the casing size to be used. Connecting with bushing 26 to transmit rotary movement to kelly 17 is kelly bushing 28. Bushing 28 is provided with clutch dogs 29 for engagement with slots 27, and is internally bored with a square hole fitting the shape of kelly 17. Bushing 28 is slidable on kelly 17 and when engaged with bushing 26, as shown in Fig. 1, a driving connection is provided for rotating kelly 17 along with torque tube 25 and rotary table 13. Bushing 28 may be disconnected simply by raising the drill string out of torque tube 25.

The casing drive assembly mounted around kelly 17 adjacent its lower end consists of an upper bushing 30 bored square to fit the kelly 17, and tapped for set screws 31, as best seen in Fig. 3. The base of bushing 30 is provided with locking-type clutch dogs 32. Bushing 30 is slidable on kelly bar 17 except when locked by set screws 31.

Beneath bushing 30 is mounted a casing bushing 33 having a hollow bore making no engagement with kelly

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bar 17. Bushing 33 on its upper side contains radial slots 34 for locking engagement with dogs 32, and its lower side is formed as a hollow threaded nipple 35 to which may be attached a section of casing 24. Radial holes 36 bored in bushing 33 permit the escape of such drilling fluid as may return from the well inside the casing. To the end of casing 24 may be coupled a casing shoe 37 to assist the movement of casing 24 into the well. Casing shoe 37 may be of conventional design and consist, for example, of a hollow coupling of the same diameter as casing 24, having bits or teeth on its lower end. An example of this structure is seen in the "drill 14" of the patent to Church No. 2,088,025.

To initiate the drilling and casing operation according to the invention, a length of casing 24 is fitted with casing shoe 37 and is placed vertically in torque tube 25 with shoe 37 resting on the ground. Underreamer 21 and drill bit 22 are attached to kelly bar 17 and lowered into torque tube 25 internally of casing 24, with bushing 30 clamped to the kelly bar 17 in inoperative position and bushing 33 below bushing 30 on the kelly bar 17 in such position that it can be threadedly coupled to casing 24 when underreamer 21 has been placed in casing 24. Drilling is commenced by actuating the rotary table, the device being initially adjusted so that only the drill string will rotate. That is, kelly 17 will rotate pipe 20 and attached parts including underreamer 21 and drill bit 22 but will not rotate casing 24 because bushings 30 and 33 remain disconnected, as shown in dotted position of bushing 30, Fig. 3.

It will be understood that underreamer 21 is of the type which tends to open from the fluid pressure exerted by the circulation of drilling fluid. As soon as sufficient clearance is afforded from drilling beneath the end of casing shoe 37 its laterally movable bits or cutters may be opened and locked in this position. The cutters can be closed by lifting the drill string and jarring the cutters against a constriction in the hole such as casing shoe 37. An underreamer having the functional characteristics above described is made by Grant Oil Tool Co., Los Angeles, California, and is illustrated in their catalogue.

After a brief period of drilling, the hole will be sufficiently deep to permit the cutters of underreamer 21 to pass through and below casing shoe 37 so that underreamer 21 is actuated into operative position, as shown in Fig. 1. At this point, if the operator desires to land the casing simultaneously with the initial drilling operation (without first drilling a pilot hole), the drilling tools are raised sufficiently to render bushing 30 accessible above torque tube 25, and by adjusting screws 31 bushing 30 is lowered to a point on the kelly bar 17 where it will engage bushing 33 (fitted to the top of casing 24), set screws 31 then being locked on kelly bar 17. Operating in this mode, the drill bit will bore a hole of a diameter which is slightly less than the inside diameter of the casing, while the underreamer cutters will bore an annulus corresponding to the casing wall plus sufficient clearance to permit the casing to be lowered into the hole, casing 24 being rotatively downwardly forced into the hole in fixed sequence to drill pipe 20, underreamer 21, and bit 22.

When the casing 24 has been drilled in to ground level, additional sections of casing and drill pipe may be added to casing 24 and kelly 17, respectively, first by unscrewing nipple 35 and threaded connection 19, then clearing the kelly 17 from torque tube 25 and coupling them on. This is accomplished by counterclockwise rotation of kelly 17 while maintaining downward pressure on casing 24 and drill pipe 20. After sufficient casing has been landed, if it is desired to drill further as an open hole underreamer 21 may be removed, and the drilling may proceed in the usual manner.

By way of illustration, the following dimensions of the

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parts would apply to a typical truck-mounted rig embodying the invention:

Clearance between truck platform and ground	2½ ft. approx.
Height of derrick from ground	32 ft. approx.
Height of torque tube from ground	12-13 ft.
Length of casing section	10 ft.
Length of torque tube	8½ ft.
Diameter of casing section	5 in. I.D. 5¾ in. O.D.
Diameter of drill pipe	2¾ in. O.D. with ¾ in. tool joints.
Diameter of underreamer, cutter closed	4¾ in.
Diameter of underreamer, cutters open	6¼ in.

It will be appreciated, of course, that the principles of the invention are applicable to other types of rigs, large or small. For example, in a full size oil well drilling rig, it would be advantageous to land casing in lengths of about 35 feet, which is a standard length supplied by most mills. Use in such a rig of a torque tube according to the invention would obviate raising the drilling platform to a height of about 40 feet, or avoid digging a cellar beneath the rig to accommodate such 35 foot casing sections. The alternative, using shorter casing sections, is clearly more expensive and time-consuming.

It will also be appreciated that the method and means whereby a well may be drilled with the selective simultaneous rotation and lowering of casing, is applicable to rigs of any size.

What I claim is:

1. In a rotary drilling apparatus, including in combination, a drilling platform, a well casing, a drill string, a power drive rotary table mounted on said platform at a distance from the ground less than the distance represented by the length of a well casing section to be landed in the well, said rotary table being provided with a central aperture accommodating the passage of said well casing and said drill string, a derrick mounted above said rotary table having means including a source of power for suspending and lowering the casing and drill string into the well, means for rotating the drill string comprising a torque tube mounted on and extending upwardly from said rotary table to a point above ground level in excess of the length of a well casing section, said casing and said drill string being located internally of said

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torque tube, coupling means carried by said torque tube for rotating said drill string, other coupling means operatively connecting said drill string and said casing for rotating and lowering the casing simultaneously with said drill string, said other coupling means being selectively connectable.

2. The invention according to claim 1, wherein an underreamer is carried adjacent the said end of the drill string, said underreamer in inoperative position having a diameter smaller than that of the casing permitting its passage through the casing, said underreamer having protractile cutters, and means opening said cutters into operative position after passage of the underreamer through the casing, in which position said cutters are capable of drilling to a diameter in excess of the casing diameter.

3. The method of rotary well drilling employing a power-driven rotary table located at a fixed distance from the ground, a drill string, and casing to be landed in the well, which consists of placing a length of casing in said rotary table so that said casing protrudes to a point substantially above said rotary table, locating said drill string within said casing so that said drill string protrudes above said casing, connecting said rotary table to said drill string for rotation thereof at a point above said length of casing, rotating and forcing said drill string into the ground, and selectively coupling said casing to said drill string for rotating and forcing said casing into the ground in accompaniment with said drill string.

4. The method according to claim 3, including the further step of underreaming in advance of the casing to a diameter in excess of the casing diameter.

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