

[54] **WELL DRILLING ROD AND CASING ASSEMBLING METHOD**

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[22] Filed: **Aug. 20, 1971**

[21] Appl. No.: **173,522**

[52] U.S. Cl.**175/57, 166/315, 173/164, 175/85, 175/171**

[51] Int. Cl.**E21b 3/02**

[58] Field of Search.....**175/52, 57, 85, 171; 173/1, 49; 166/77.5, 315**

[56] **References Cited**

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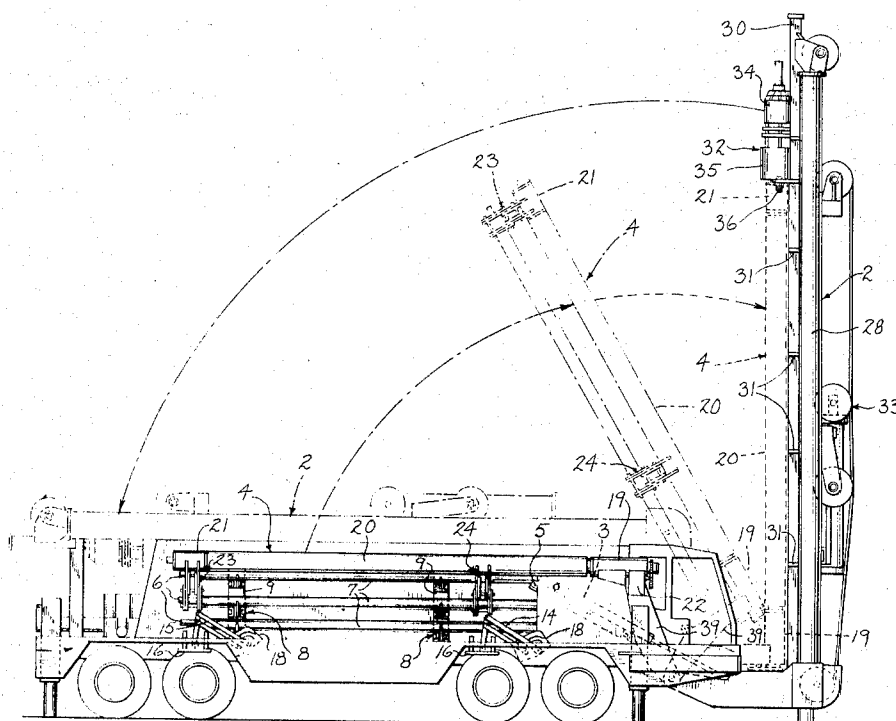
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[57]

ABSTRACT

A mast extends vertically from the front of a truck, and supports a drive unit which operates to rotate a drill, to grasp a casing segment, and to simultaneously drive them into a well. Drill pipe segments each with a surrounding casing segment are carried in a storage rack located on the truck, from which they are selected and lifted by a transfer arm to a vertical ready station alongside the mast. In subsequent steps, the upper ends of the drill segment and the surrounding casing segment are attached to the drive unit, their lower ends attached to the drill pipe and casing segment in the well, and then driven downward. In addition to applying a downward feed on the drill string and casing, the drive unit vibrates the casing to speed its insertion into the well.

9 Claims, 10 Drawing Figures



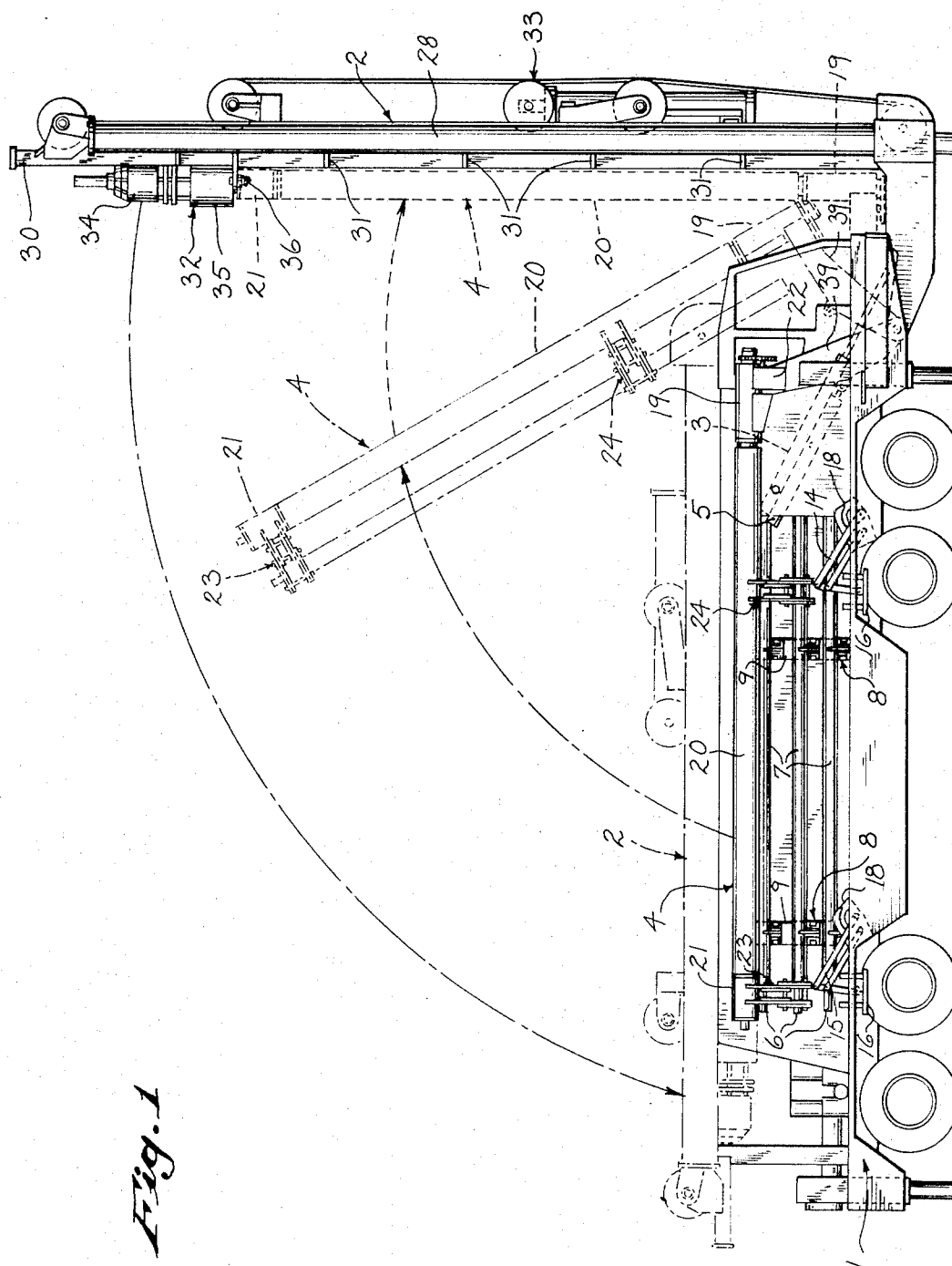


Fig. 1

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Fig. 2

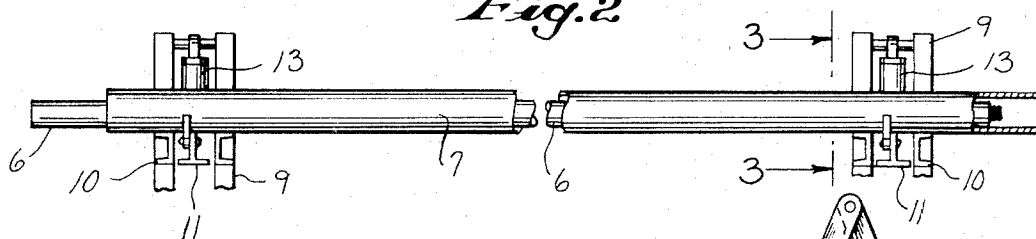


Fig. 3

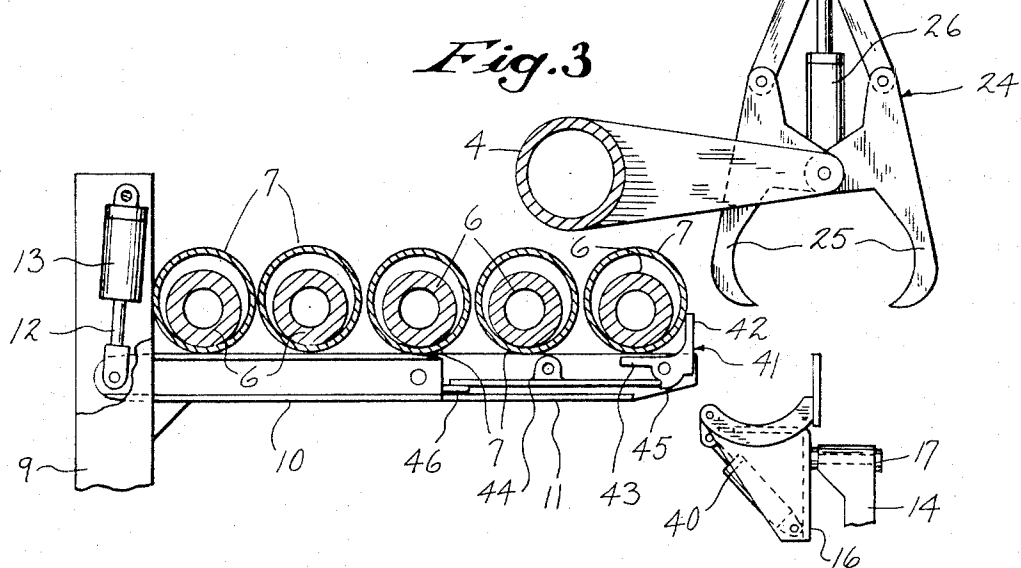
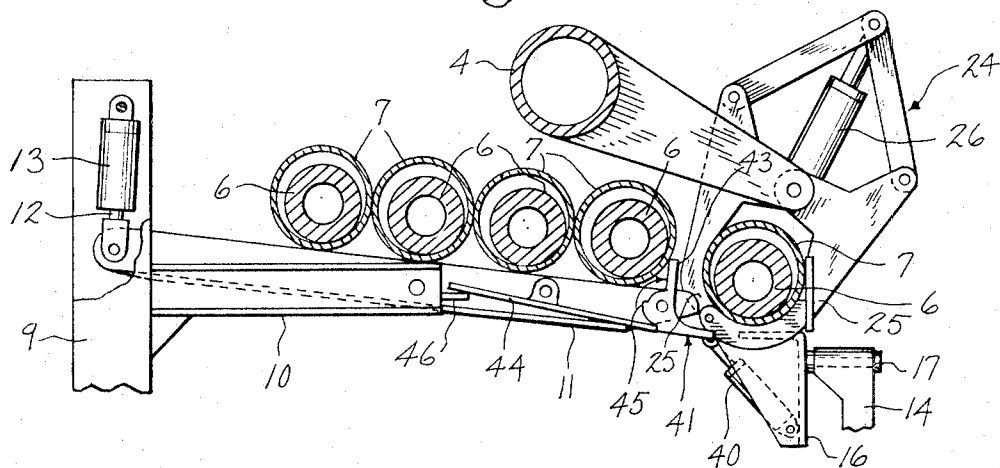


Fig. 4



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Fig. 5

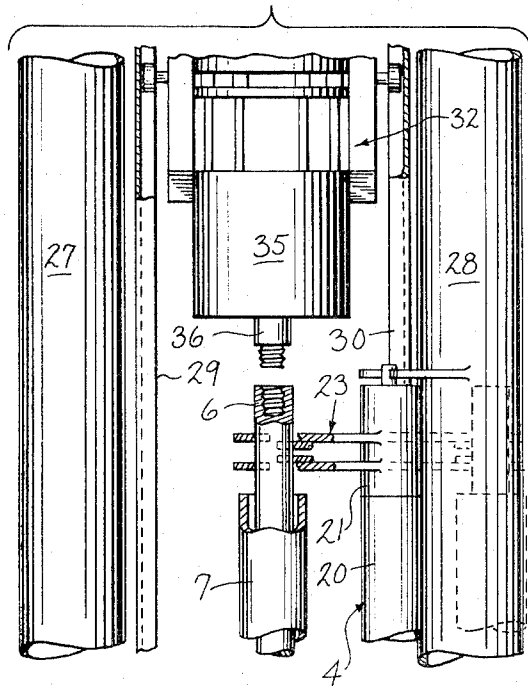


Fig. 6

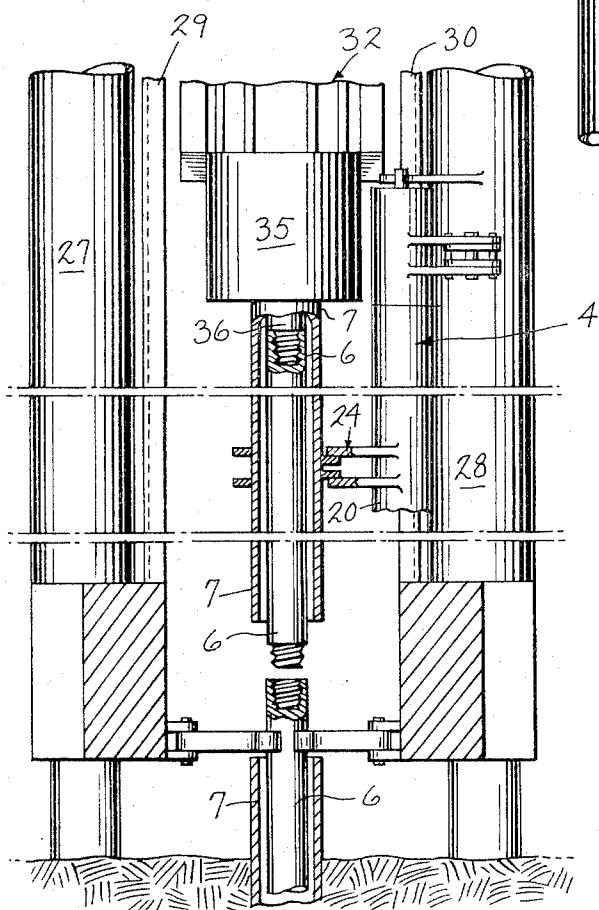
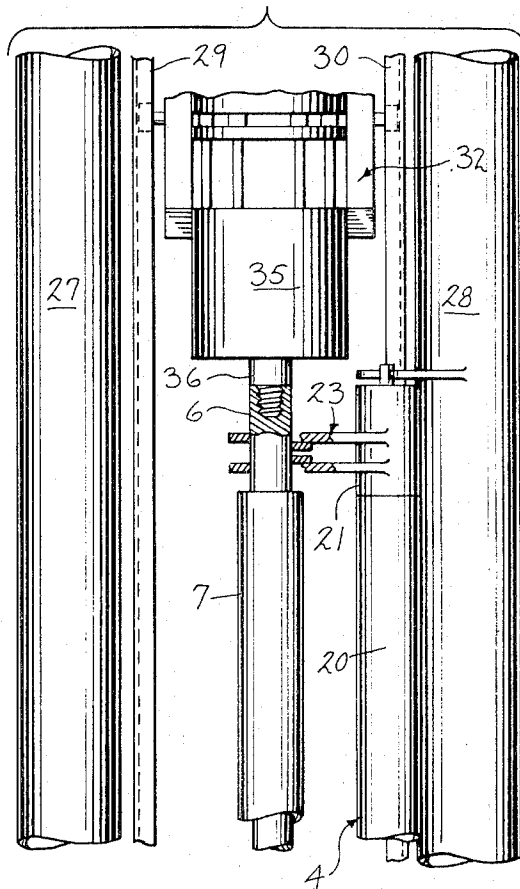
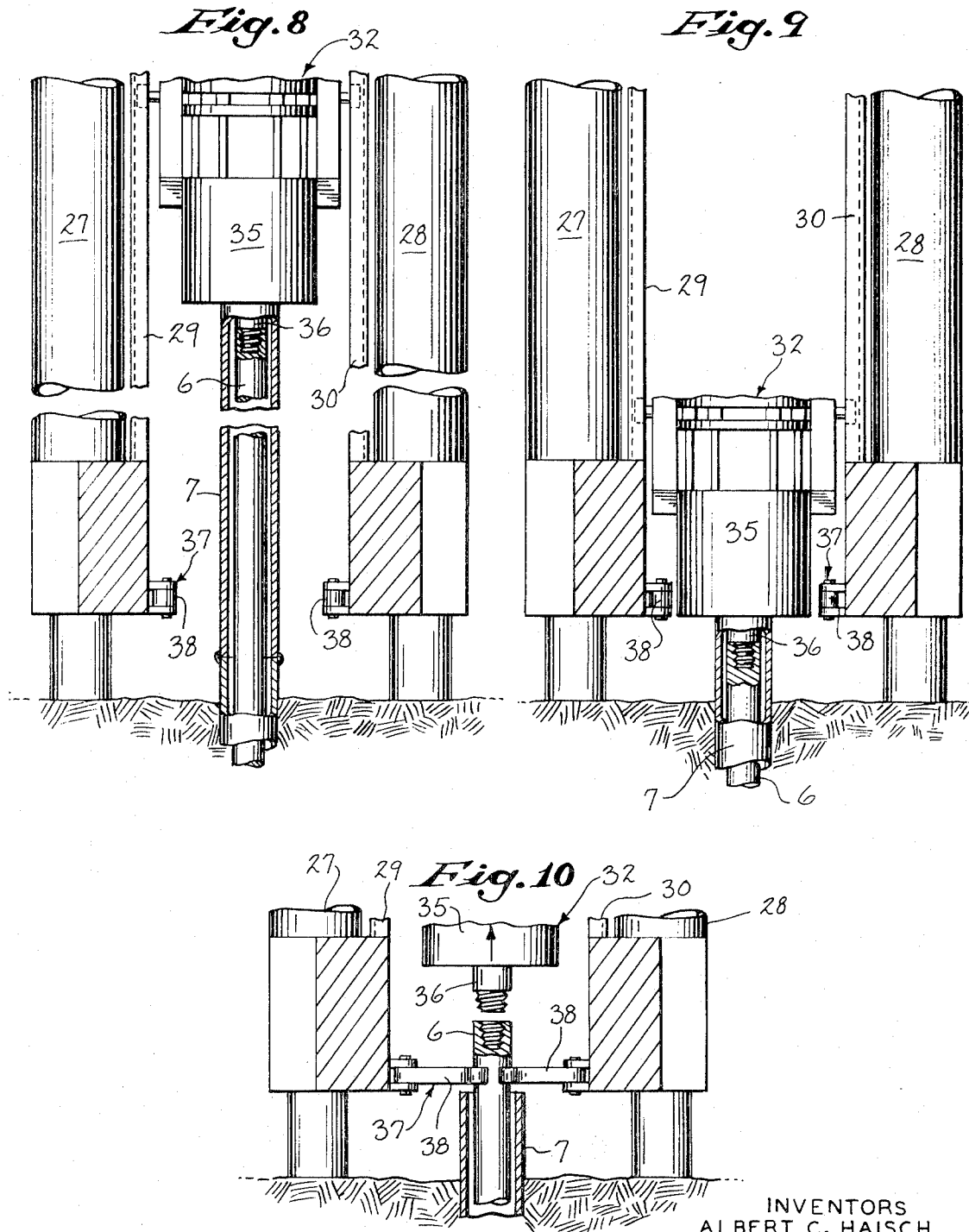


Fig. 7

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WELL DRILLING ROD AND CASING ASSEMBLING METHOD

BACKGROUND OF THE INVENTION

The field of the invention is drills used to drill water, gas, and oil wells, of the type requiring the insertion of a casing into the well to prevent the sides of the well from collapsing and, or prevent the entrance of contaminants into the well.

In the present drilling operations using "top drive" equipment, it is standard practice to first drill the well and then insert the casing. Drill pipe segments are successively raised, attached at one end to the drill string and driven downward by a rotary drive unit attached to the top end. When drilling deep wells, the weight of the drill string itself provides the necessary downward driving force on the drill head, however, when drilling shallower wells such as water wells, a downward feed force is applied to the drill string by the rotary drive unit. When drilling is completed, the drill string is removed from the well and casing segments are successively welded together and driven downward into the well.

This drilling method is both time consuming and costly. To drill the well, individual drill pipe segments are hoisted up to the vertical drill mast by means of a block tackle arrangement. They are then either used immediately or, as disclosed in U.S. Pat. No. 3,212,593 issued to Reischl on Oct. 19, 1965, are stored with several other drill pipe segments in the vertical ready position, from which position they are easily transferred for subsequent use. In either case, drilling is repeatedly stopped while drill pipe segments are raised to the vertical and attached to the drill string. When the desired depth is reached, the procedure is reversed by withdrawing the drill string from the well and detaching drill pipe segments. Repeated delays are again encountered as drill pipe segments are detached and lowered from the mast back to their storage position. After the drill is completely removed, casing segments are successively hoisted to the vertical, as was done in the drilling operation, and then inserted into the well.

When drilling through unconsolidated soils, such as sand and gravel, mud is pumped into the well as it is being drilled to prevent the walls from collapsing. Mud is pumped from a storage pond on the surface, through the hollow drill string, out the drill bit, and upward out of the well to remove the drilled particles and support the well walls. The equipment necessary to handle mud and the cost of cleaning up the drill site after drilling is completed, is time consuming and costly.

SUMMARY OF THE INVENTION

The present invention comprises an earth drilling method wherein drill pipe segments, each accompanied by a surrounding casing segment, are hoisted to a vertical ready station; the upper ends of both the drill pipe segment and the surrounding casing segment are attached to the drive unit on the mast; the lower end of the drill pipe segment is connected to the top end of the drill string in the bore hole; the lower end of the surrounding casing segment is attached to the top end of the casing in the bore hole; and the drill and casing segments are both driven downward together by rotating the drill and applying a downward feed force to the casing. Insertion of the casing is enhanced by vibrating it during drilling.

A general object of the invention is to provide a drilling method which substantially reduces the time required to drill a hole and insert a casing. The drill and casing segments are hoisted to the vertical ready position together, attached to the drive unit, and driven into the bore hole together. The time previously spent inserting the casing after the hole was drilled is eliminated by performing this step concurrent with the drilling portion of the operation.

Another general object of the invention is to provide a method of boring wells into unconsolidated soils without the necessity for using mud. The simultaneous insertion of the casing into the bore hole contains and seals the soil formations from the well as they are penetrated. The drill bit is positioned slightly in advance of the bottom, or leading edge of the casing and has a size comparable to the diameter of the casing. The leading edge of the casing is bevelled to enlarge the bore hole as it advances and the cuttings generated by the drill bit or casing are carried upward and out of the bore hole by a flushing medium such as air.

Another object of the invention is to provide a more efficient drilling method by automatically selecting a drill and surrounding casing segment from the storage rack and transferring them to a vertical ready station while the previous drill-casing segment is being driven into the hole by the drive unit.

The foregoing and other objects and advantages of the invention will appear from the following description. In the description reference is made to the accompanying drawings which form a part hereof, and in which there is shown by way of illustration and not of limitation a preferred method. Such preferred method and accompanying structure does not represent the full scope of the invention, but rather the invention may be employed in many different ways, and reference is made to the claims herein for interpreting the breadth of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in elevation of a drilling rig which employs the invented method,

FIGS. 2 through 4 show the steps in selecting a drill and casing segment from the storage rack located on the drilling rig of FIG. 1, and

FIGS. 5 through 10 show the steps of inserting the selected drill and casing segment into the bore hole.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A drilling rig designed to use the method of the present invention is shown in FIG. 1. The rig includes a wheeled truck 1 having a mast 2 pivotally attached to its front end, with a pair of hydraulic cylinders 3 connected to the truck 1 and mast 2 to raise the mast 2 from a horizontal transport position (shown in phantom in FIG. 1) to an upright drilling position. Also pivotally attached to the front of the truck 1 is a transfer arm 4 operated by a third hydraulic cylinder 5 connected between the truck 1 and transfer arm 4. The arm 4 is operated between a horizontal pick position, and an upright, ready position adjacent the mast 2. The drilling rig is described more fully in the copending application Ser. No. 173,519 entitled "Mobile Drilling Unit".

As shown in FIGS. 1-3, when the transfer arm 4 is in its horizontal pick position, it is parallel to and located

immediately above a three-tier storage rack 8 containing the drill and casing segments 6 and 7. The storage rack 8 is comprised of identical fore and aft supporting structures each supporting structure having an upright base 9 attached to and extending upward from the truck bed 1. Three brackets 10 attach and extend outward in cantilevered fashion from each base 9 to form the three tiers upon which drill and casing segments 6 and 7 are stored. Pivotaly attached to the end of each bracket 10 is a rocker arm 11. The outer end of each rocker arm 11 extends well beyond the outer end of its supporting bracket 10, and its other end connects to an extendable rod 12 of an unload hydraulic cylinder 13 mounted in the base 9. Each rocker arm 11 is connected to an unload cylinder 13 and retained coincident with its horizontal bracket 10. When a drill and casing segment 6 and 7 are to be unloaded, the unload cylinders 13 of the selected tier are actuated and the attached rocker arms 11 are tilted causing the selected drill-casing segment to unload by rolling off.

To prevent the discharge of an entire supply of drill-casing segments on a tilted tier, a retainer 41 is rotatably attached to the outer end of each rocker arm 11. As shown in FIGS. 3 and 4, the retainers 41 each have two arms 42 and 43 extending radially outward at a ninety-degree angle. A trip bar 44 is rotatably attached to the side of the rocker arm 11 and operates against a ratchet 45 on the retainer 41 to prevent its rotation when the rocker arm 11 is level. The arm 42 extends upward to retain the stored drill-casing segments on the storage rack 8. When the rocker arm 11 is tilted, the trip bar 44 is rotated by a flange 46 extending from the end of the bracket 10 and the retainer 41 is allowed to rotate ninety degrees bringing the arm 43 into an upright attitude. One drill-casing segment is allowed to roll off and the rest are retained by the arm 43. A bias spring (not shown) rotates the retainer 41 back to its cocked position when the rocker arm 11 is again leveled.

Referring to FIGS. 1-4, two crank arms 14 and 15 are connected to the truck bed 1, outboard the ends of the rocker arms 11. Each crank arm 14 and 15 has a carriage 16 rotatably attached to its upper end by means of a pin 17. The crank arms 14 and 15 are swung and by operation of a series of linkages and cams 18, the two carriages 16 are translated vertically in unison to unload positions alongside a selected tier of the three tiers of the storage rack 8 where they receive unloaded drill-casing segments. The carriages 16 include load cylinders 40 which are operable to lift drill-casing segments from the carriages 16 back onto the storage rack 8. The storage rack, carriages, and crank arms are more fully described in the copending application Ser. No. 173,197 "Well Drill Transfer Mechanism".

Referring to FIGS. 1-4, the transfer arm 4 has a tubular pedestal portion 19 connected to the front end of the truck 1 by a pivot arm 39. Rotatably connected to the top end of the pedestal 19 is a tubular body portion 20, which in turn supports a tubular cap portion 21 rotatably attached to its top end. The body 20 and the cap 21 are rotated as a single unit by a hydraulic motor 22 located at the base of the pedestal 19, while the cap 21 is rotated singly by means of a hydraulic motor (not shown in the drawings) located inside the cap 21.

Connected to and extending outward from the transfer arm cap 21 is an upper mandible 23. Similarly, connected to and extending outward from the lower end of

the body portion 20 is a lower mandible 24. As shown in FIGS. 3 and 4, the mandibles 23 and 24 each include jaws 25 connected to be opened and closed about a selected drill-casing segment by a hydraulically operated clamping cylinder 26. The transfer arm and mandibles are also more fully described in the copending application "Well Drill Transfer Mechanism".

Referring to FIGS. 1 and 5, the mast 2 is constructed of two tubular stanchions 27 and 28 connected together in spaced parallel relationship. Extending along the length of the stanchions 27 and 28 are tracks 29 and 30, each rigidly attached to a respective stanchion 27 and 28 by a plurality of equally spaced brackets 31. The tracks 29 and 30 run parallel to one another and have a channel-shaped cross section with the open side of each facing the other. A drive unit 32 is slidably connected to the tracks 29 and 30, and is propelled along them by a hydraulic cylinder actuated rope and pulley hoist and feed assembly 33 attached to the back of the mast 2. This feed assembly 33 is standard, and other methods such as rack and pinion or worm gear systems can be substituted to propel the drive unit 32 up and down the mast 2.

The drive unit 32 is comprised of a rotary drive section 34 and a power chuck section 35. The power chuck section 35 is resiliently suspended from the underside of the rotary drive section 34 and completely encircles a spindle 36 which extends downward from the rotary drive section 34. The lower end of the spindle 36 is threaded for engagement with a drill segment 6. A hydraulic motor (not shown in the drawings) located in the rotary drive section 34 rotates the spindle 36 in either the forward direction for drilling and attachment to a drill segment 6, or in the reverse direction for disengaging the spindle 36 from the drill stem. The power chuck section 35 is adapted to grasp the upper end of a casing segment 7 as shown in FIG. 7. The power chuck section 35 includes a vibrator (not shown in the drawings) connected to its back side which when actuated vibrates the resiliently mounted chuck section 35 and the attached casing segment 7. The drive unit 32 is more fully described in the copending application Ser. No. 173,523 entitled "Drilling Apparatus".

OPERATION

The drilling rig is located over the drilling site and a selected drill-casing segment is removed from the storage rack 8 and translated to a vertical drilling position over the drill site. A drill bit (not shown in the drawings) is attached to the lower end of the drill pipe segment and the upper ends of the drill-casing segments are attached to the drive unit 32. The drill-casing segment is driven downward into the soil. Succeeding drill-casing segments are translated in similar fashion attached to the drill string in the bore hole and driven downward by the drive unit 32. The method by which these succeeding drill-casing segments are used to both drill the well and insert the casing will now be described in detail.

As shown in FIG. 2, each drill pipe segment 6 is arranged in the storage rack 8 inside a casing segment 7. A short section of the drill segments 6 extend out the back end of their surrounding casing segments 7. As shown in FIGS. 3 and 4, when a combined drill-casing segment is to be removed from the storage rack 8, the carriages 16 are translated to an unload position

slightly below the level of the tier upon which the selected segment is located. The two unload cylinders 13 for that tier are actuated to tip the rocker arms 11, and the drill-casing segment is discharged to an unload station in the awaiting carriages 16. After receiving the selected drill-casing segment, the carriages 16 are translated upward to locate the drill-casing segment in a pick station where it can be reached by the mandibles 23 and 24 on the transfer arm 4. In the preferred embodiment, the pick station is coincident with the unload station for the top tier of the storage rack 8, however it may be desirable in some instances to lift the drill-casing segment upward and forward to better align the upper mandibles 23 with the exposed section of the drill segment 6 extending out of the surrounding casing segment 7.

The upper and lower mandibles 23 and 24 are swung downward to pick up the drill-casing segment by rotating both the body 20 and cap 21 with the hydraulic motor 22. Each drill-casing segment is aligned in the storage rack 8 such that when it is unloaded onto the carriages 16, the upper mandible 23 grasps the exposed top end of the drill segment 6 and the lower mandible 23 firmly grasps the lower end of the casing segment 7 when the clamping cylinders 26 are actuated. After pick-up, the third hydraulic cylinder 5 is actuated and the transfer arm 4 is raised to its vertical ready position alongside the mast 2. The drill-casing segment is held in this vertical position (hereinafter referred to as the ready station) until the drive unit 32 is propelled to the top of the mast 2. As shown in FIG. 5, after the drive unit 32 has been raised, the transfer arm 4 is rotated by the hydraulic motor 22 to swing the drill-casing segment from the ready station (shown in phantom lines in FIG. 5) to a drilling position directly under the drive unit 32.

As shown in FIGS. 6 and 7, the next step in the procedure is the attachment of the drill-casing segment to the drive unit 32. This is accomplished by simultaneously lowering the drive unit 32 and rotating its spindle 36, screwing it into the top end of the drill segment 6. The clamping cylinder 26 on the upper mandible 23 is actuated to open the jaws 25 thus releasing the drill segment 6, and the cap 21 is rotated by the hydraulic motor in the cap 21, swinging the upper mandible 23 clear of the drive unit 32. The drive unit 32 is then lowered and the upper end of the casing segment 7 is inserted into the power chuck section 35. The chuck 35 is actuated to grasp and retain the casing segment 7. The clamping cylinder 26 is then operated to open the jaws 25 on the lower mandible 24 thus releasing the casing segment 7, and the transfer arm body 20 is rotated, swinging the lower mandible 24 clear of the drive unit 32.

The final step is connection of the drill-casing segment to the drill stem and casing in the well. The top end of the drill stem protrudes from the well and is held above its surrounding casing by the wrenching mechanism 37 located at the base of the mast 2. The drill segment 6 is lowered by the drive unit 32 and rotated to screw its lower end into the tightly held drill stem. As shown in FIG. 8, after the drill segment 6 is connected the jaws 38 of the wrenching mechanism 37 are opened and the drive unit 32 is again lowered until the casing segment 7 butts against the top end of the casing protruding from the well. The casing segments are joined

together by an appropriate means such as welding, and drilling is commenced.

The drill stem is rotated by the spindle 36 and a downward feed force is applied to both the drill stem and casing by the drive unit 32. Insertion of the casing 37 is enhanced by supplementing the downward feed pressure with vibrations, applied to it by the power chuck section 35.

Drilling proceeds and the drive unit 32 is fed down the mast 2 until it reaches the base as shown in FIG. 9. At this point, rotation of the spindle 36 is stopped and the casing segment 7 is released from the grasp of the power chuck section 35. The drive unit 32 is hoisted a short distance to expose the top end of the drill string to the jaws of the wrenching mechanism 37, which are closed tightly around it. As shown in FIG. 10, the spindle 36 is then disconnected from the drill string by simultaneously rotating it in reverse direction and hoisting the drive unit 32.

After disconnection, the drive unit 32 is hoisted to the top of the mast 2 wherein connection is made to the next drill-casing segment poised in the ready station. The drill-casing segment is swung from the ready station, connected to the drive unit 32, and the cycle repeats itself. During drilling the transfer arm 4 is free to pick up the next drill-casing segment and bring it to the ready station. As a consequence, very little drilling time is lost during the transfer of the drill-casing segment to the drive unit 32.

When the desired depth is reached, the drill string is withdrawn from the well and the segments 6 are placed back in the storage rack 8. The withdrawal of the drill string is accomplished by essentially reversing the procedure used to drill the well. The spindle 36 is attached to the top end of the drill string and the drive unit 32 hoists it to lift one drill segment 6 clear of the surrounding casing. The top end of the next lower drill segment 6 is also lifted above the casing where it is grasped and held by the wrenching mechanism 37. The exposed joint between drill segments is loosened and the spindle 36 is rotated in reverse to complete the disconnection. The upper and lower mandibles 23 and 24 are swung around and actuated to firmly grasp the disconnected drill segment 6 and the spindle 36 is again rotated in reverse direction to disconnect the drive unit 32 from the top end of the drill segment 6. The transfer arm 4 transports the disconnected drill segment back to the carriages 16 adjacent the storage rack 8, and returns to the ready station to await withdrawal of the next drill segment 6 from the well. The transferred drill segment 6 is lifted from the carriages 16 onto the storage rack 8 by the load cylinders 40. As in the drilling procedure, time is saved by the concurrent transfer of drill segments 6 while the drive unit 32 is operating.

We claim:

1. A method for drilling a hole and inserting a casing, comprising the steps of:

transferring a drill segment with a surrounding casing segment from storage to a vertical drilling position directly above the hole;

retaining the drill segment in the drilling position by an upper mandible attached to a transfer arm and retaining the casing segment in the drilling position by a lower mandible also attached to the transfer arm;

attaching the drill segment to a rotatable spindle in the drive unit; releasing the drill segment from

the grasp of the upper mandible; grasping the casing segment by means of a chuck in the drive unit; releasing the casing segment from the grasp of the lower mandible; and rotating the drill segment by means of the drive unit to drill the hole,

applying a downward feed force on the casing segment by means of the drive unit to insert it into the hole as the hole is being drilled, and vibrating the casing segment during its insertion into the hole.

2. The method as recited in claim 1, wherein the lower ends of the drill and casing segments attached to the drive unit are connected to the top ends of the drill string and casing in the hole.

3. The method as recited in claim 2, wherein the drill string in the hole protrudes above the casing and is retained in this position by a wrenching mechanism, and the connection to the drill string and casing in the hole includes the steps of:

screwing the lower end of the drill segment into the top end of the retained drill string;

releasing the drill string from the grasp of the wrenching mechanism; and

welding the lower end of the casing segment to the top end of the casing in the hole.

4. A method for drilling a hole and inserting a casing, comprising the steps of:

transferring a drill segment with a surrounding casing segment from storage to a vertical ready station;

grasping the drill segment with an upper mandible;

grasping the casing segment with a lower mandible;

transferring the drill and casing segments from the ready station to a drilling position directly above the hole;

connecting the drill segment and casing segment to a drive unit;

releasing the drill and casing segments from the grasp of the upper and lower mandibles; and

rotating the drill segment by means of the drive unit to drill the hole, and applying a downward feed force on the casing segment by means of the drive unit to insert it into the hole as the hole is being

drilled.

5. The method as recited in claim 4, wherein the casing segment is vibrated by the drive unit during its insertion into the hole.

6. A method for drilling a hole and inserting a casing, comprising the steps of:

transferring a drill segment with a surrounding casing segment from storage to a vertical drilling position directly above the hole;

connecting the drill segment and casing segment to a drive unit;

connecting the lower ends of the drill and casing segments to the top ends of the drill string and casing in the hole;

rotating the drill string by means of a drive unit to drill the hole, and applying a downward feed force on the casing segment by means of the drive unit to insert it into the hole as the hole is being drilled; disconnecting the casing from the drive unit; grasping the drill string with a wrenching mechanism; and disconnecting the drill string from the drive unit.

7. The method as recited in claim 6 in which the drill string is raised a short distance to expose a portion thereof to said wrenching mechanism after the casing is disconnected from the drive unit.

8. The method as recited in claim 6 in which said drill string is removed from the hole one segment at a time by:

connecting the drive unit to the drill string;

hoisting the drill string to withdraw one drill segment from the surrounding casing;

grasping the drill string with the wrenching mechanism; and

disconnecting the said one drill segment from the drill string.

9. The method as recited in claim 8 in which each disconnected drill segment is grasped by a mandible on a transfer arm, disconnected from the drive unit, and lowered to a storage area by the transfer arm.

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