

- [54] **EARTH DRILLING APPARATUS AND METHOD**
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[51] Int. Cl. **E21b 19/14, E21b 3/00, E21c 1/00**
[58] Field of Search **175/52, 85; 173/28, 147**

[56] **References Cited**

UNITED STATES PATENTS

2,956,782	10/1960	Mistrot	175/85 X
3,177,944	4/1965	Knights	175/85 X
3,190,378	6/1965	Davey et al.	173/147 X
3,340,938	9/1967	Wilson	173/28
3,670,831	6/1972	Winter et al.	175/52
3,719,238	3/1973	Campbell et al.	173/28 X

Primary Examiner—David H. Brown

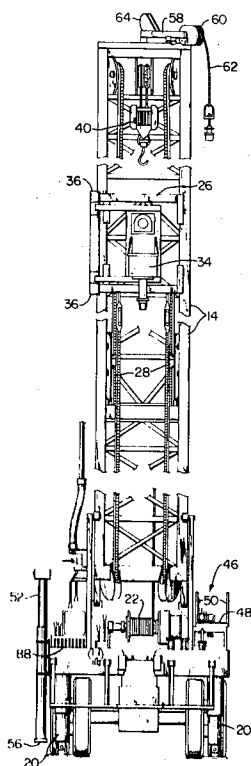
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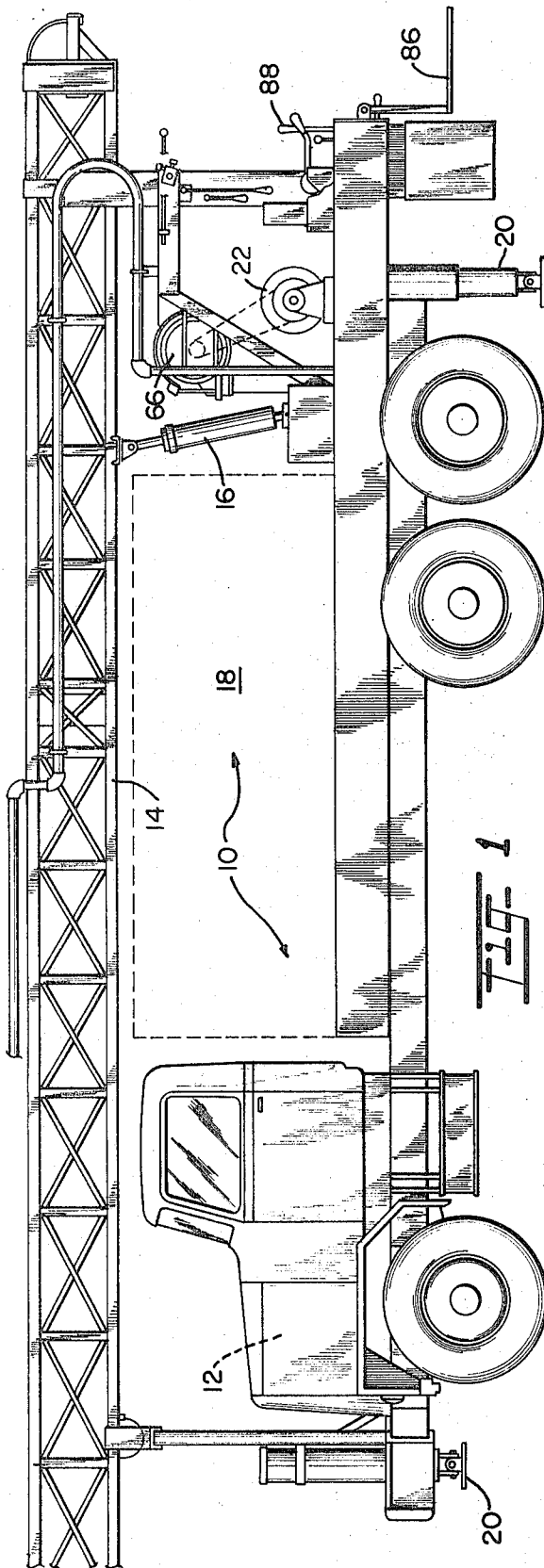
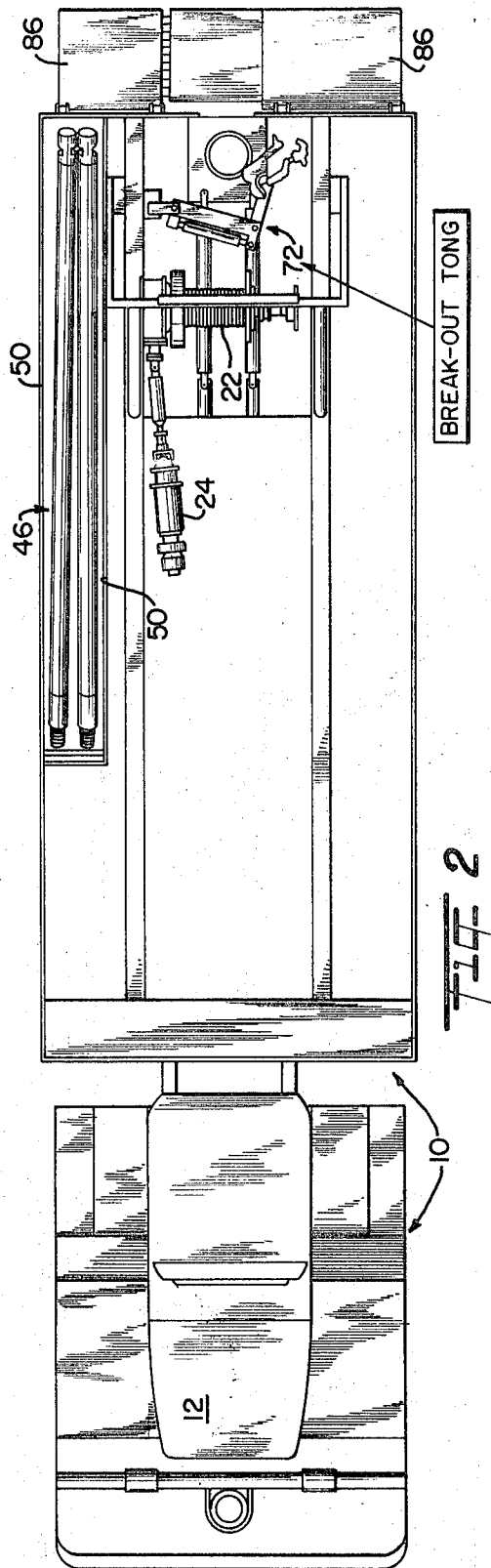
[57] **ABSTRACT**

Earth drilling apparatus of the generally conventional type comprising a wheel supported vehicle having a

pivoted derrick or mast which is moveable between a substantially horizontal transport position above the vehicle and a substantially vertical drilling position adjacent the rear end of the vehicle, the mast having a rectilinearly moveable carriage supporting a drilling head. It is characterized by a longitudinal drill pipe storage compartment adjacent one side of the vehicle, a pivoted boom at the top of the mast for transferring a drill pipe from the storage compartment to a temporary vertical holding position, the drilling head being pivotally mounted to its carriage for movement above the upper end of the holding position at which the pipe is connected to the drilling head, the drilling head and its attached pipe then being moveable to drilling position, this procedure continuing until the drilling reaches a desired depth. In the removal of the pipe string, the drilling head is moved to an inoperative clearing position laterally of the drill pipe axis and a traveling hoist block, moveable along such axis, is attached to the uppermost pipe of the string. The string is then elevated one pipe increment, the uppermost pipe disconnected from the string therebelow, and the hoist block lowered. At or near the commencement of lowering, the lower end of the disconnected pipe is manually guided into the rear end of the storage compartment and as the traveling hoist block lowers, it slides forwardly into the storage compartment to its original position therein.

9 Claims, 7 Drawing Figures





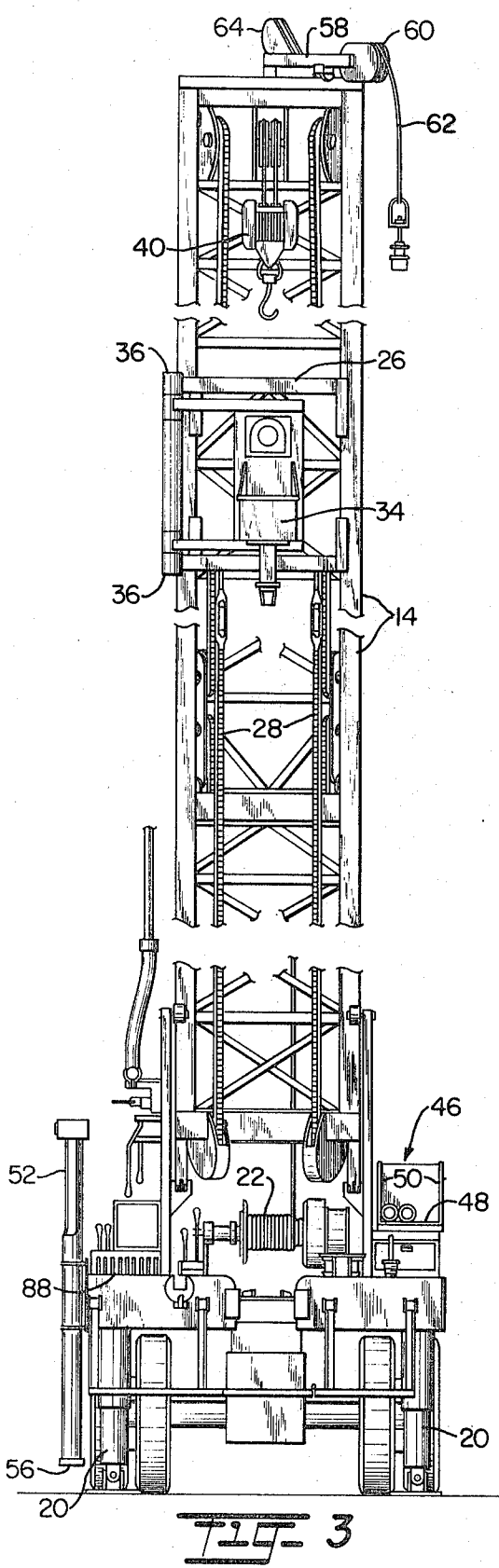


FIG- 3

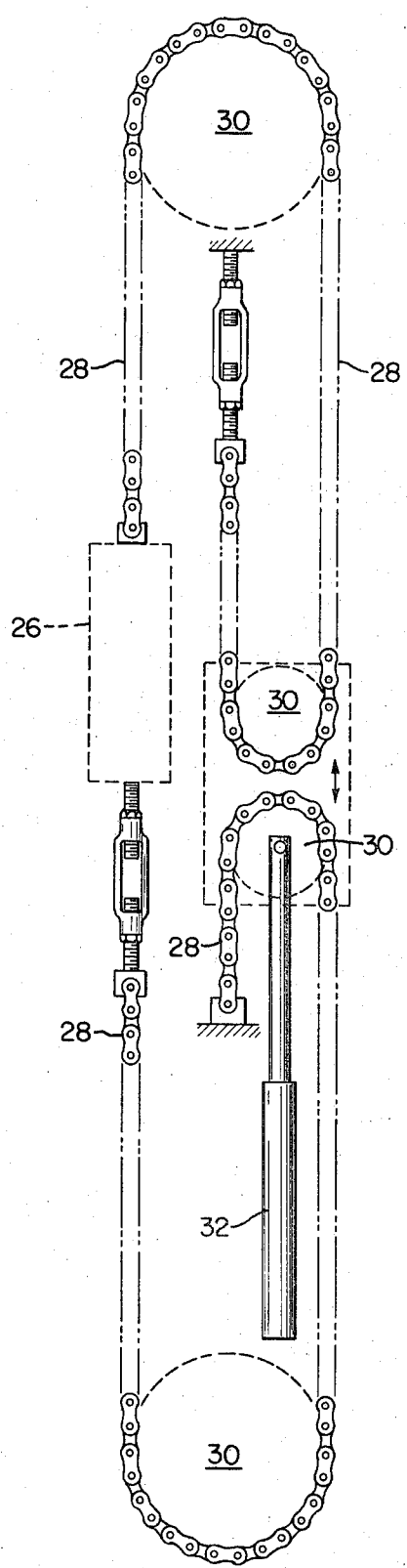
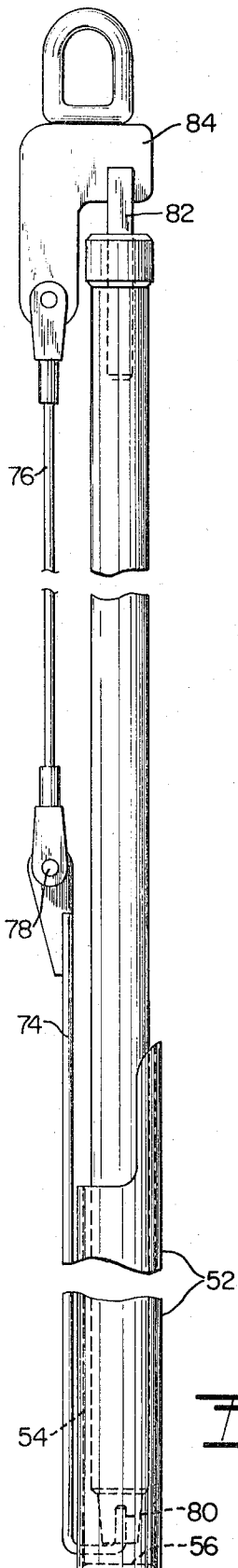
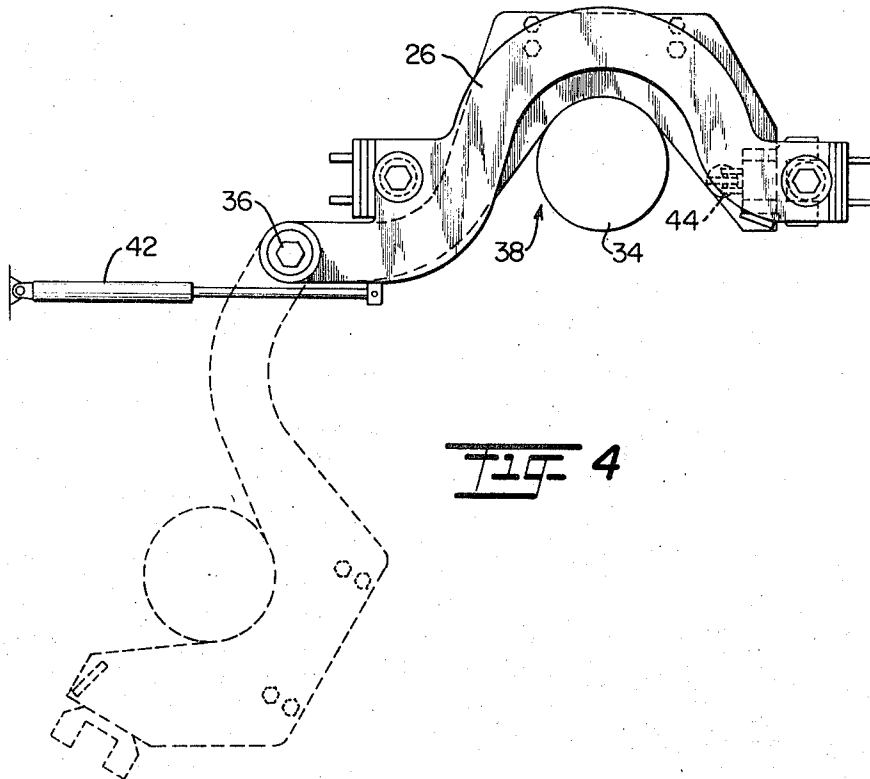
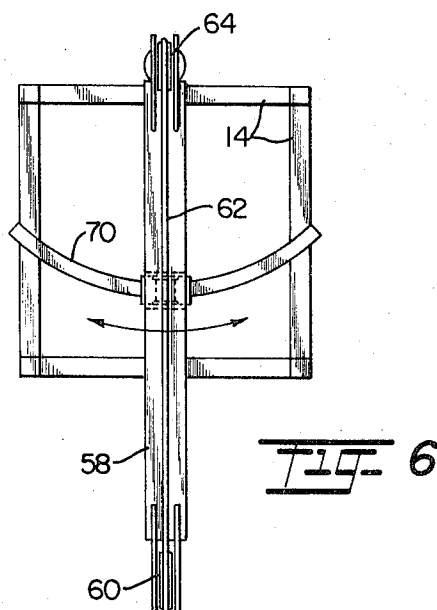


FIG 5



EARTH DRILLING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

In the drilling of holes in the earth it is common practice to mount a drill derrick or mast on a vehicle which may be readily moved to the drill site. The mast, which is disposed in a generally vertical position during the drilling operation, is usually pivoted near its lower end to the vehicle for movement to a generally horizontal position when the vehicle is being transported over a road or other terrain so that it may clear overhead obstructions, lower the center of mass of the vehicle, and more securely affix the mast to the vehicle during its movement. Since a drill string is conventionally formed of sections of drill pipe of predetermined length detachably connected together with threaded joints or the like, it is also conventional practice to provide the apparatus with some form of drill pipe storage compartment containing the sections from which they may be sequentially removed as the drilling progresses in depth. Similarly, when the sections are removed from the drill hole they are sequentially returned to the magazine. Various forms of magazines and drill pipe transfer apparatus have been devised to effect the drilling as above outlined. For example, in U.S. Pat. No. 2,972,388 to Thornberg, a rotary magazine is carried by the mast and is sequentially indexed so that a drill pipe therein may be aligned with a drill pipe driving head rectilinearly movable along the mast. In this form of apparatus the mast remains in its erect position during the entire drilling operation. In another form, as exemplified by U.S. Pat. No. 3,158,213 to O'Neill et al, the mast also remains erect and mechanism is provided for transferring a single horizontal pipe to the vertical mast. As will be apparent, if it is desired to transfer more than one pipe from the horizontal position, apparatus, such as a crane, or the like, must be employed to replenish the pipe removed from the horizontal position. As will be apparent from these exemplary constructions one of the problems encountered in the drilling of holes in the earth resides in the manner in which drill pipes are successively supplied to a drilling head for forming the drill string and the manner in which the pipes are returned to a position of repose, such as in a storage compartment, as the drill string is removed from the drilled hole.

SUMMARY OF THE INVENTION

The present invention bears similarly to the prior art to the extent that drill pipe is transferred from a magazine to a drilling head, the pipes are sequentially attached together as drilling proceeds to the desired depth, and the uppermost pipes are sequentially disconnected from the pipe string and returned to the storage compartment. Broadly, the present invention differs from the prior art in the manner in which the drill pipes are handled between removal from the storage compartment and return thereto.

It is characterized by a mast or derrick disposed adjacent one end of a vehicle, the mast having a rectilinearly movable carriage having a drilling head which may be moved away from the drilling axis, a hoist block moveable along such axis, a pivoted boom carried by the upper end of the mast, swingable between a position above the rear end of the storage compartment to a transfer or holding position at which the drilling head

may be coupled to the upper end of the drilling pipe. Just prior to the transfer aforesaid, the pipe is deposited in a socket for holding it in vertical position after which it is disconnected from the pivoted boom. A pipe handling device is supported by the lower end of the boom cable to facilitate attachment and detachment to and from a pipe in the storage compartment and detachment from the pipe after it has been deposited in the socket. The boom thus serves the purpose of transferring pipes from the storage compartment to the socket and the traveling block serves the purpose of periodically lifting the pipe string and returning the uppermost pipe thereof to the magazine.

A principal object of the invention, consonant with the foregoing, is the provision of improved apparatus and method of handling drill pipe from its storage position on a vehicle having a horizontal drill pipe storage compartment until it is returned thereto after completion of a drilled hole.

Another object is to provide a drilling mast with a swingable boom at its upper end for transferring a pipe from the storage compartment to a vertical holding socket at which position a drilling head may be coupled to the upper end of the pipe.

Another object is to provide a moveable carriage on the mast which swingably carries a drilling head for movement between a pipe coupling position and a drilling position.

A further object is to provide a traveling hoist block in the mast for returning pipes from the pipe string to the magazine.

Still further objects, advantages and salient features will become more apparent from the detailed description to follow, the appended claims, and the accompanying drawing to now be briefly described.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation of the subject of the invention, certain components disposed in the central portion thereof being omitted;

FIG. 2 is a top plan of FIG. 1, certain components also being omitted;

FIG. 3 is a rear elevation of FIGS. 1 and 2;

FIG. 4 is a detail of a carriage and drilling head carried by same;

FIG. 5 is a detail of pull-down apparatus associated with the carriage;

FIG. 6 is a detail of a pipe handling boom; and

FIG. 7 is a detail of a pipe handling accessory employed with a hoisting cable associated with the boom.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

General

Referring now to the drawing, and first to FIGS. 1 to 3, the subject of the invention comprises a steerable vehicle 10, propelled by an internal combustion engine 12, the rear end of which carries a mast or derrick 14 pivoted adjacent its lower end to the vehicle and which may be elevated from the transport position of FIG. 1 to the operative drilling position of FIG. 3 under control of a hydraulic ram 16. The dotted space 18 below the mast contains a power source, such as an internal combustion engine, an air compressor, and hydraulic pumps, all driven by such engine. The air compressor is employed for removing drillings from the bored holes

and actuating pneumatic tools and the hydraulic pumps are employed for operating the various hydraulic motors of the system, these devices being generally conventional and similar to their counterparts as disclosed, for example, in U.S. Pat. No. 3,670,831 which relates to another type of drilling apparatus employed for a purpose like the present invention. Hydraulic steadying jacks 20 are also conventional. Since the construction so far described is generally conventional, detailed illustration thereof has been omitted to simplify the disclosure. It differs, however, from the patent just referred to, by the addition of a hoisting or draw-works reel 22 driven by a hydraulic motor 24. The mast is also of generally conventional construction in that it slideably carries a vertically moveable drilling head carriage 26 operated by suitable chains 28, trailed about sprockets 30, this system being operated by double acting hydraulic rams 32 for pulling down the drilling head carriage with desired force during drilling and for raising the carriage when it is desired to add an uppermost pipe to the drilling pipe string.

Carriage and Drilling Head

Drilling head 34 is of generally conventional construction powered by a reversible hydraulic motor and having a hollow spindle, the lower end of which is provided with tapered threads for detachably connecting same to the upper end of a drill pipe. Its upper end is swivelly connected to a flexible air hose for delivering air to the interior of the drill string, this construction also being generally conventional and hence not illustrated. It differs, however, in that the drilling head is connected to the carriage by a pivot pin 36 so that the drilling head may be swung about a vertical axis to a position laterally of the drilling axis. The carriage, moreover, as best shown in FIG. 4, is arched to provide a space 38 through which a vertical hoisting or draw work cable and block 40 may move when the drilling head is moved laterally away from its drilling position to the dotted position. A reversible hydraulic ram 42, connected to the head, serves to move the drilling head between the positions referred to. As best shown in FIG. 4, moveable latches 44, operated by a ram (not shown) are provided to lock the drilling head to the carriage during the drilling operation and for releasing same for movement of the drilling head away from drilling position.

Magazine

Pipe storage compartment 46 is disposed along one side of the vehicle and parallel to the lowered position of the mast. It is in the nature of an elongated trough having a bottom 48, sides 50, and is open at its top and rear end. It is to be understood that pipe may be located in a truck or trailer or even on the ground with the magazine being eliminated or not used all of the time.

Transfer Support

Pipe holder or support (or "rat" hole) 52 comprises a tube having a slot 54 extending through its wall between opposite ends thereof and having a closure 56 at its lower end upon which a pipe may rest. It may be connected to the vehicle adjacent its rear end, during the drilling operation and detached therefrom when the vehicle is moving to or from a drilling locus, this being desirable since its lower end would otherwise contact road or field irregularities. Support 52 may be located elsewhere on or in relation to the vehicle body and clo-

sure 56 or the bottom of the tube may have cushioning means for supporting pipe thereon.

Transfer Boom

Jib boom 58 is connected to the upper end of the mast for pivotal movement about a vertical axis, its outer free end having a sheave 60 over which a hoisting cable 62 is trained. Cable 62 is also trained around sheave 64 and thence to a winding drum 66 which may be power operated by a hydraulic motor 24. The length of the boom is such that cable 62 may be disposed vertically above the rear end of a pipe in the magazine to a position vertically above support or rat hole 52. Briefly, at this point, the cable is attached to a drill pipe in a storage compartment or on the ground or in a truck, using the pickup device shown in FIG. 7. If the pipe is stored in the storage compartment, as it is elevated, the pipe slides rearwardly out of the storage compartment until it is in vertical position. The boom and pipe are then swung over support 52 and lowered, depositing the pipe in vertical position in the support. When in this position, its upper end is in alignment with the drilling head spindle when the drilling head is swung away from its drilling position, as shown in the dotted position, FIG. 4. An arcuate track 70 on the top of the mast is preferably employed on which a roller, carried by the boom, may roll, the pivotal point thus being adjacent sheave 64. If desired, the boom may be mounted by a hydraulic motor or ram, like ram 42.

Pipe String Draw-Works

As will be apparent, withdrawal of the pipe string must be along the drilling axis. Since the drilling carriage and its drilling head are not employed for pipe string withdrawal, the drilling head must be moved away from its obstructing position on the drill string axis. Withdrawal is effected by a hoist block 40, cable connected to reel 22, which moves along the pipe string axis. As previously described, it may move through the space 38 formerly occupied by the drilling head when the drilling head is swung laterally away from the drilling axis. The hoisting block may then be lowered from its position above the drilling head, as shown in FIG. 3, to a position near the lower end of the mast at which position it may be connected to the upper end of the pipe string to effect connection (not shown). A taper threaded plug swivelly connected to a ring adapted to engage the block hook may be employed. Briefly, it is then raised somewhat in excess of one pipe length, disconnected from the pipe string, its lower end swung over the rear end of the magazine and then lowered. As it lowers, the front end of the pipes slide forwardly in the storage compartment as the angle of the pipe angularly changes from vertical to horizontal until the pipe is redeposited therein. This procedure is repeated until all pipes of the pipe string are redeposited in the magazine.

ACCESSORIES AND MISCELLANEOUS

Transfer Boom

Boom 58 may be telescopic (actuated by hydraulic cylinder) whereby sheave 60 can be positioned near the drilling axis so that line 62 can be used as a utility hoisting tool for handling tools and single lengths of casing into the hole or for bailing operations.

Breakaway

As is well known, taper threaded pipe couplings may be assembled with a minimum of torque. After drilling, however, their cooperating shoulders are tightly

jammed together and require considerable torque to break them free for easy relative rotation. It is thus conventional in the art to provide a clamp for holding the pipe string and a power operated pipe grasping jaw for rotating the uppermost pipe of the pipe string. Such a device 72, referred to as a break-out tong in the art, is employed and may be of any desired type, the construction illustrated in U.S. Pat. No. 3,670,831, previously referred to, being exemplary. As will be understood, after the joint is broken loose, the drilling head may be reversely powered rotated to complete separating the joint.

Pipe Transfer Sling or Pick-Up Device

Any suitable device may be employed to detachably connect the lower end of transfer cable 62 to a pipe disposed in the storage compartment or in a truck or the like. An exemplary form is disclosed in FIG. 7 which comprises a rod 74 and a cable 76 connected by a pivot pin 78, rod 74 having a pin 80 at one end and cable 76 having a pin 82 carried by a member 84 at the other end, pin 82 being considerably longer than pin 80. In the attachment of this device to a pipe in the magazine, pin 82 is inserted into the rear end of a pipe to about its full depth. Pin 80 is then slightly beyond the other end of the pipe. As the device is moved rearwardly pin 80 may enter the front end of the pipe but leaving pin 82 still in the rear end of the pipe. The pipe is thus now captured at opposite ends. The pipe is then withdrawn and erected and thence deposited in the transfer tube 52 until it rests on closure 56 at the lower end thereof, parts 74, 76 now lying along slots 54. When the sling is lowered slightly pin 80 may be disengaged from the lower end of the pipe and as the sling is raised pin 82 disengages from its upper end. As will be apparent, the specific sling is not germane to the invention.

As will be apparent, the drilling operation and transfer of pipes from the magazine or truck or ground and return thereto may be performed by a single operator standing on platform 86 who may operate controls 88 although in practice there normally is an operator and helper.

EXEMPLARY OPERATION SEQUENCE

1. Move vehicle to drilling site.
2. Raise mast to vertical or desired angle of hole to be drilled.
3. Set steady jacks.
4. Affix sling to a pipe in storage compartment assuming the latter is where pipe is stored.
5. Raise hoisting cable, removing pipe from storage compartment, until it is vertically suspended.
6. Swing pipe and hoisting boom over transfer tube.
7. Lower pipe into transfer tube and disconnect sling. Return sling to position over storage compartment.
8. Move drilling head over pipe, lower, and connect to upper end of pipe.
9. Raise drilling head to remove pipe from transfer tube.
10. Swing drilling head and its attached pipe to drilling position and lock thereat.
11. Lower drilling head, permitting pipe to pass through pipe guide.
12. Attach drilling bit to pipe and drill hole until upper end of pipe is near pipe guide.

13. Clamp pipe and power break connection — reversely power rotate drilling head to complete disconnection with pipe.

14. Raise head to its uppermost position.

15. Continue transfer of tubes from storage compartment, to transfer tube, to drilling head and to pipe string until desired depth is drilled. Operations 4 through 7 are performed concurrently with operation 12 to minimize time increments to sequentially add drill pipes.

16. Disconnect drilling head from upper pipe of pipe string — swing to inoperative non-obstructing position.

17. Lower withdrawal hoist block and connect to upper end of pipe string.

18. Raise withdrawal hoist block.

19. Clamp pipe string against retrograde movement into drilled hole.

20. Disconnect upper pipe from pipe string.

21. Raise disconnected pipe until its lower end is at storage compartment level.

22. Manually swing lower end of pipe over rear end of storage compartment.

23. Lower withdrawal hoist, permitting pipe to slide forwardly into storage compartment to initial stored position.

24. Uncouple hoisting block from pipe, redeposited in storage compartment.

25. Repeat operations until all pipes of pipe string are redeposited in storage compartment.

What is claimed is:

1. An earthdrilling apparatus of the type including a vehicle having an elongated mast pivotally carried for movement between a generally horizontal transporting position above the vehicle and a generally vertical drilling position adjacent one end of the vehicle, the mast having a carriage rectilinearly moveable therealong and having a rotary drilling head carried thereby, the improvement, in combination, comprising:

a. said drilling head being connected to said carriage for lateral movement between a generally vertical pipe drilling axis and a parallel pipe transfer axis,

b. a drill pipe storage means for storing a plurality of drill pipes in a generally horizontal position from which they may be elevated to vertical position,

c. a movable boom carried by an upper portion of the mast having a depending first hoisting cable or the like, the lower end of which is adapted to be moved between a position above the rear end of a pipe disposed in the storage means, at which it may be detachably connected to a pipe therein, to an elevated position along the transfer axis at which it may be detached from the first hoisting cable and held thereat by temporary holding means, the rotary head adapted to be connected to the upper end of the pipe when it is moved to the transfer axis, and

d. a second hoisting cable supported by the mast having a lower end moveable along the drilling axis, the lower end of which is adapted to be removeably connected to the upper end of the uppermost pipe of a pipe string disposed along the drilling axis.

2. Apparatus in accordance with claim 1 including means for holding the pipe string against retrograde movement into the drilled hole when the uppermost pipe is detached therefrom and the lower end of the up-

permost pipe is guided into the storage means for redep-
osit therein as the second hoisting cable is lowered.

3. Apparatus in accordance with claim 1 wherein the
temporary holding means comprises a pipe support car-
ried by the vehicle for receiving and supporting a pipe. 5

4. Apparatus in accordance with claim 1 wherein said
moveable boom is mounted for pivotal movement
about a substantially vertical axis.

5. Apparatus in accordance with claim 1 wherein said 10
carriage is so constructed to form a space which may
be occupied by at least a portion of the drilling head
when it is disposed in drilling position, said space, when
the drilling head is disposed laterally of drilling posi-
tion, permitting a portion of said second hoisting cable, 15
or a portion of drill pipe, to occupy a portion of said
space.

6. Apparatus in accordance with claim 1 including
means carried by the lower end of said first hoisting
cable adapted to be connected to a pipe disposed in the 20

storage means and detached therefrom when the pipe
has been removed from the storage means and trans-
ferred to its vertical position for connection to the drill-
ing head.

7. Apparatus in accordance with claim 1 wherein said
mast is disposed adjacent the rear end of the vehicle,
an operator's platform affixed to the vehicle and dis-
posed rearwardly of and below the lower end of the
mast, and controls accessible to the operator, while on
the platform, for controlling the operation of the power
operated instrumentalities associated with the pipe
handling and drilling devices.

8. Apparatus in accordance with claim 1 wherein the
drilling head is pivotally connected to the carriage for
movement between said axes.

9. Apparatus in accordance with claim 8 including
means for detachably locking the drilling head to the
carriage when the drilling head is disposed on the drill-
ing axis.

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