

[54] **DRILLING MACHINE WITH DRIVING TOOL FOR CASING OR PIPE**

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[22] Filed: **July 2, 1973**

[21] Appl. No.: **375,509**

[52] U.S. Cl. **175/85**, 61/53.5, 173/129, 173/134

[51] Int. Cl. **F21b 19/00**, B25d 9/00

[58] Field of Search 173/116, 120, 132, 134, 173/137, 138, 90, 91, 129; 175/52, 85; 61/53, 53.5

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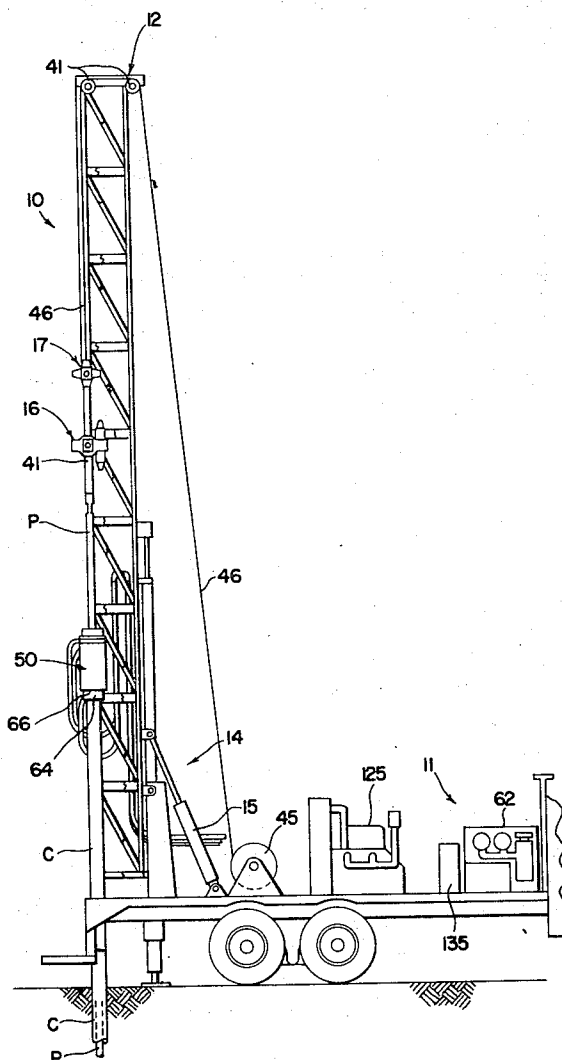
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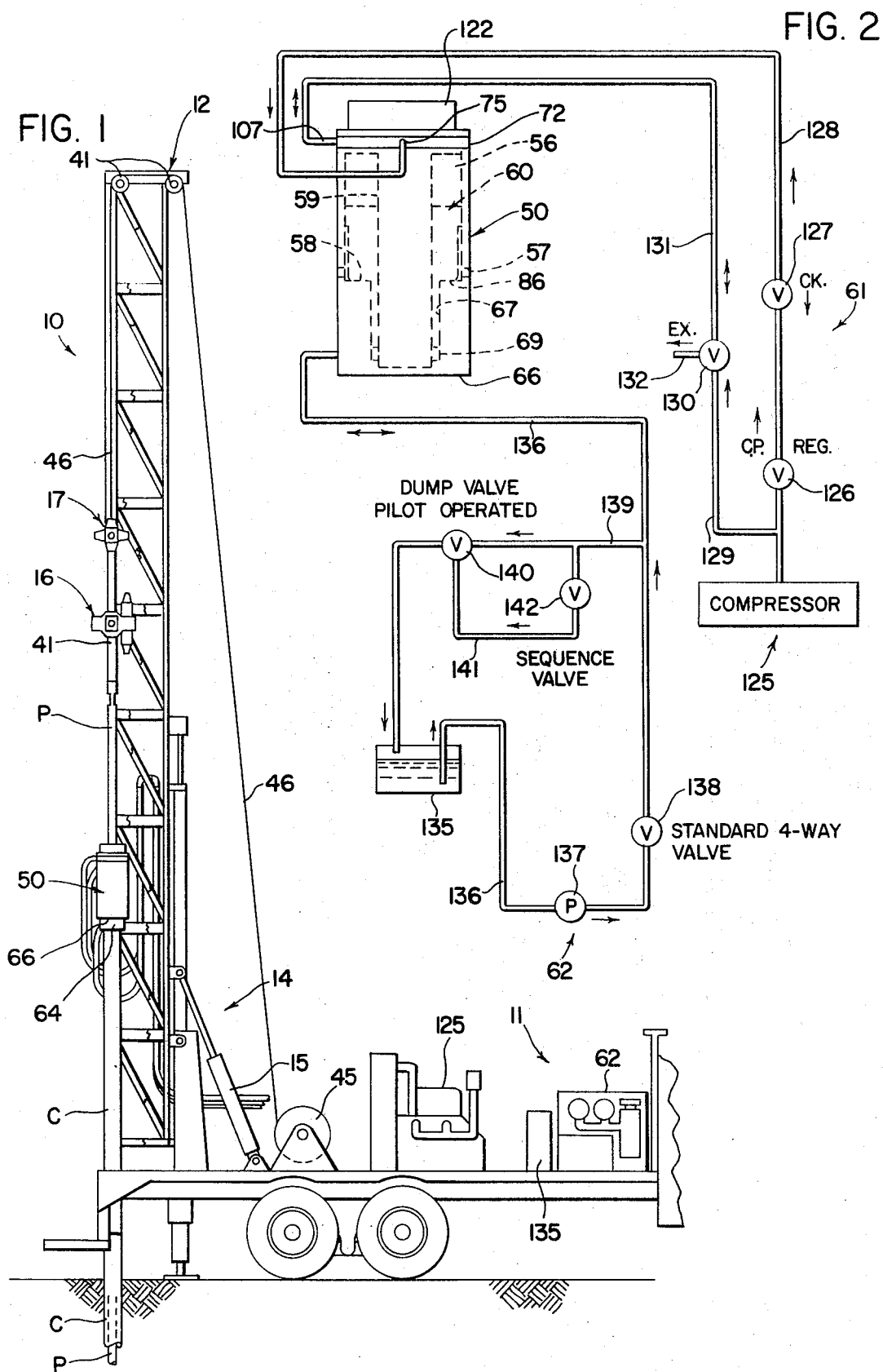
Primary Examiner—James A. Leppink
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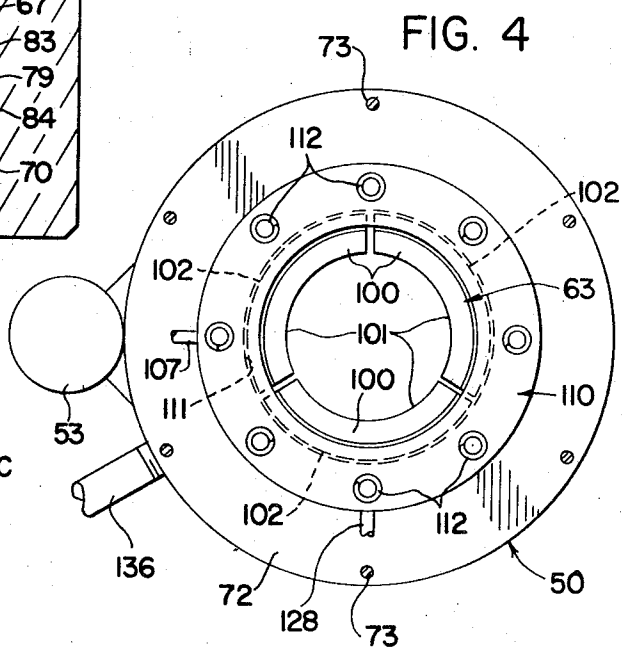
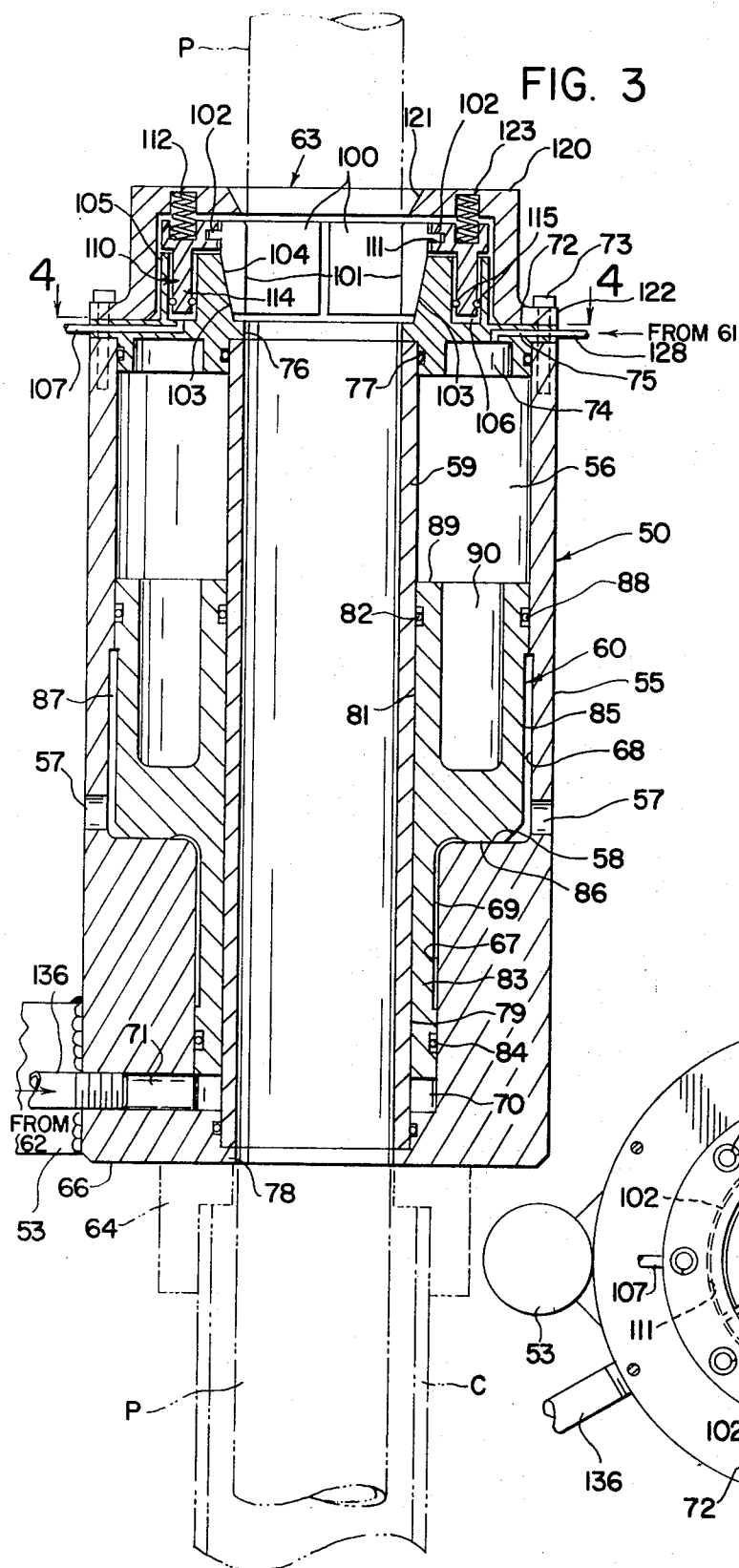
[57] **ABSTRACT**

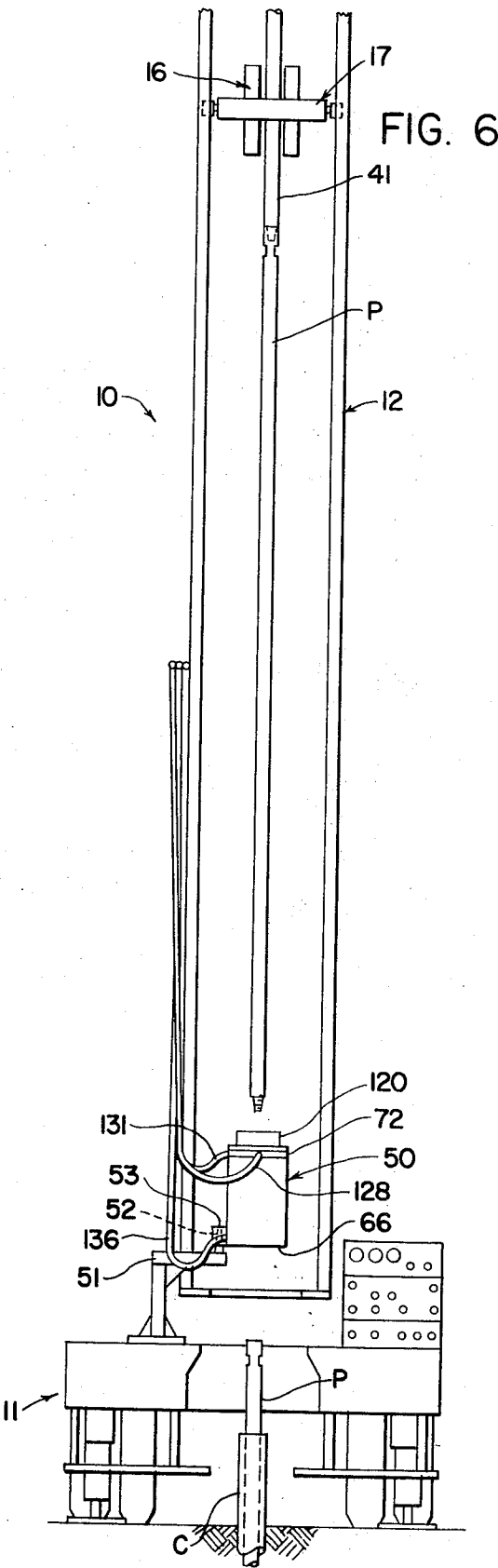
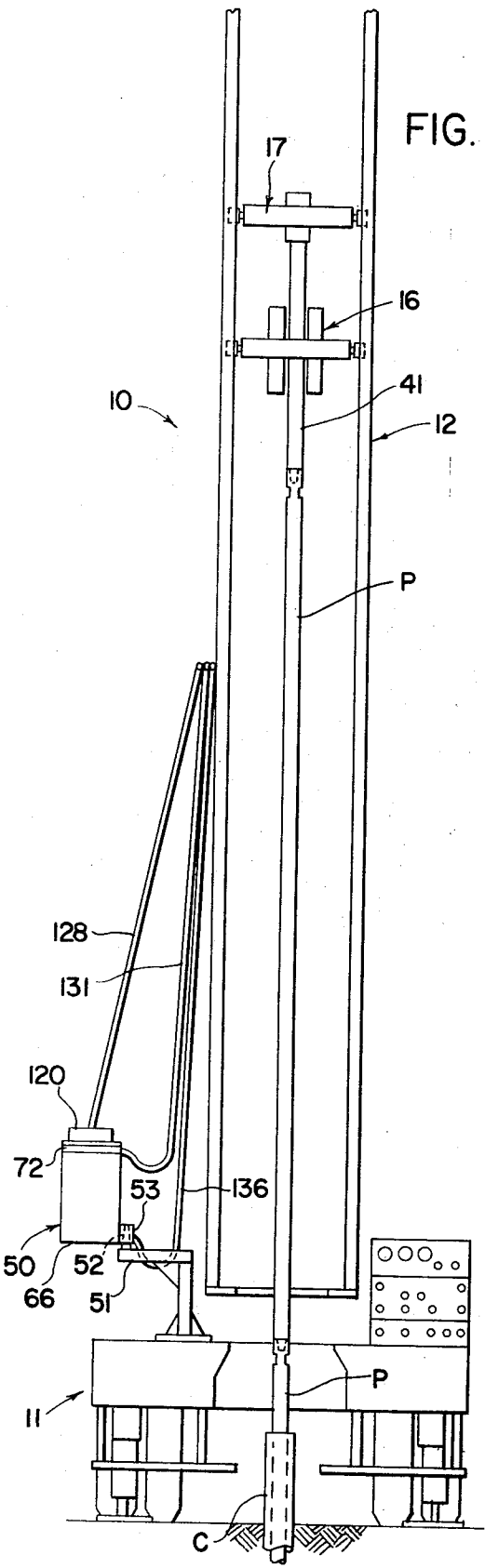
A drilling machine having a tower with drill power means movable lengthwise thereon and carrying drill pipe sections. The drilling machine carries a driving tool for casing sections or pipe. The driving tool has pneumatic-hydraulic actuation and is mounted to be positioned coaxially of a drill pipe section. The driving tool is used to impact a casing section relative to the drill pipe sections.

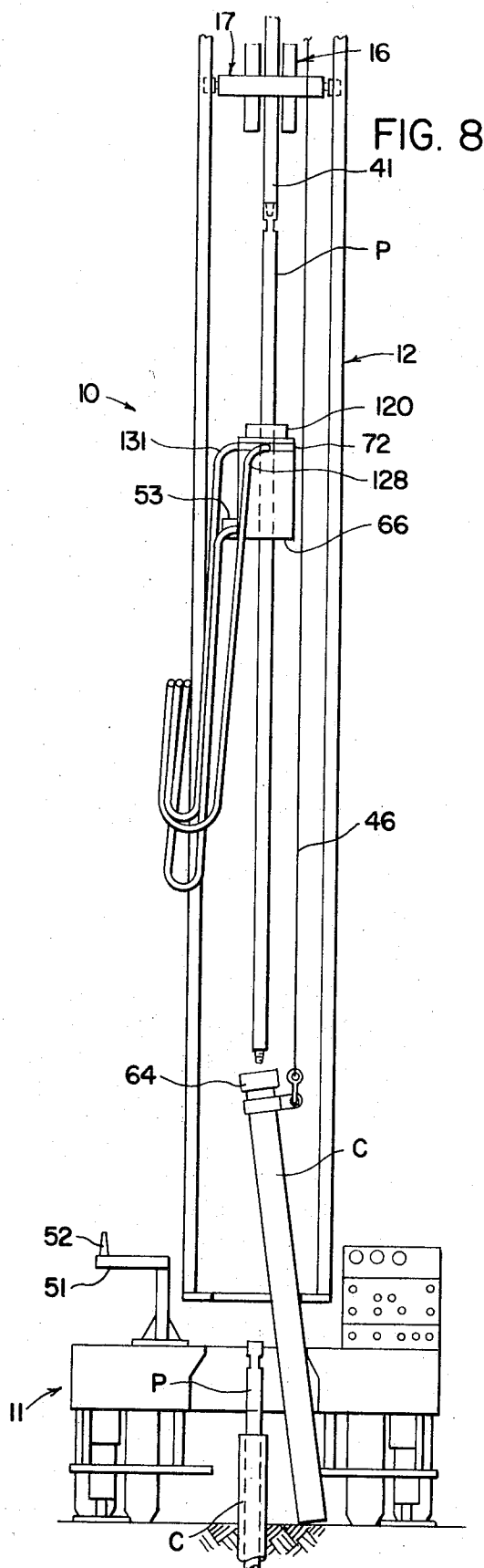
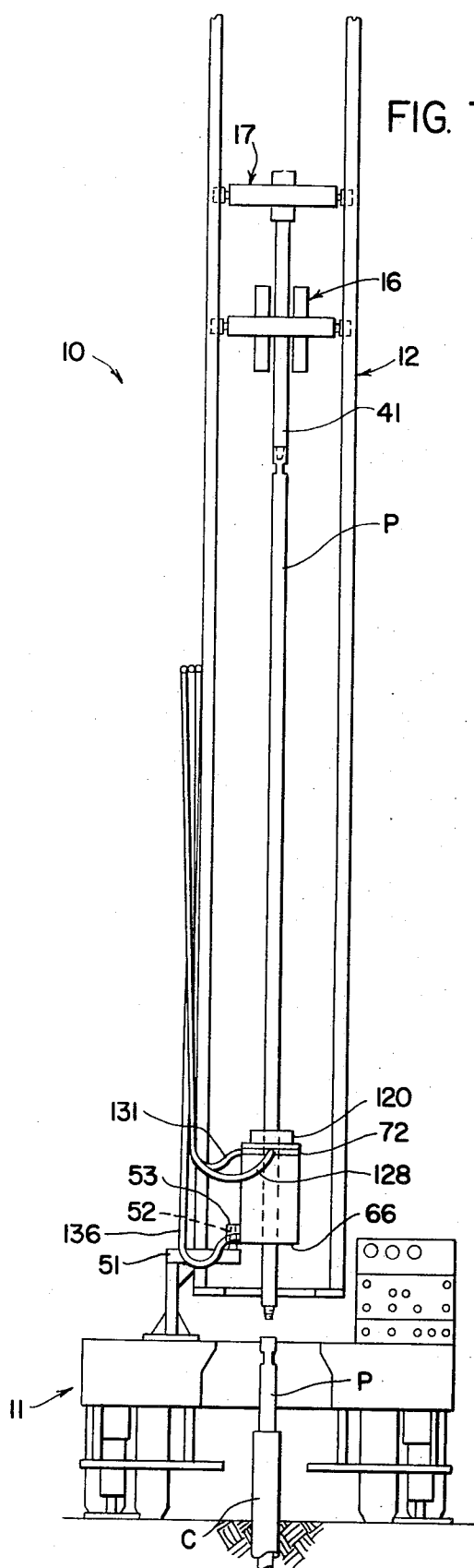
5 Claims, 10 Drawing Figures

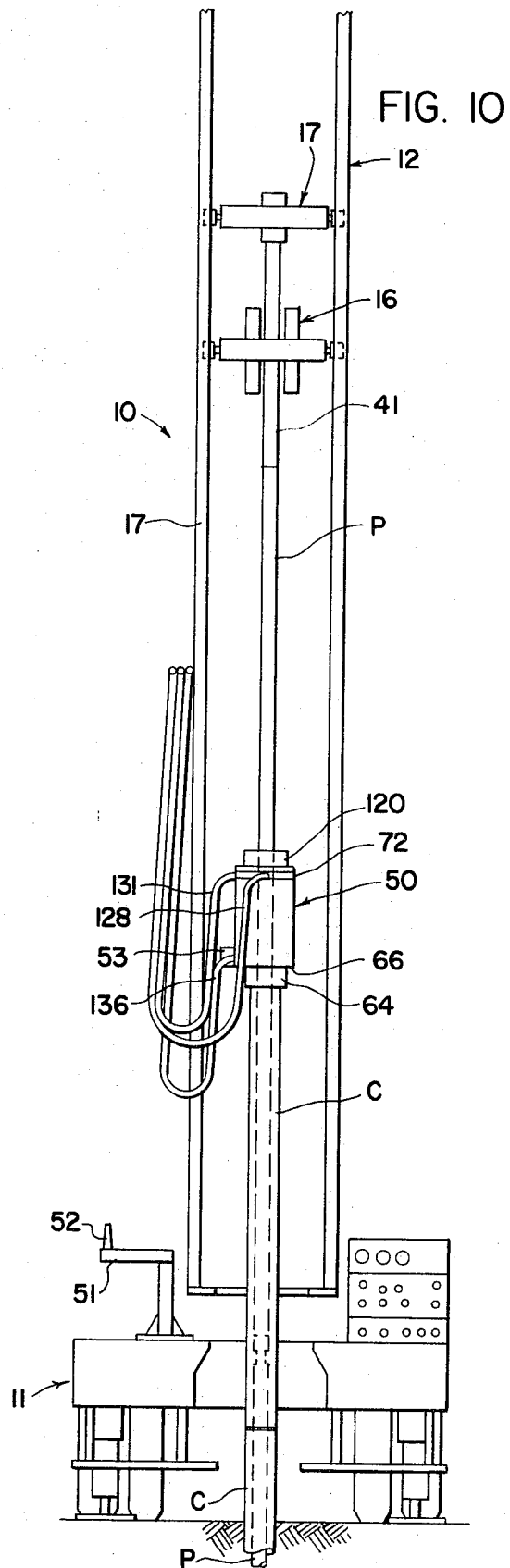
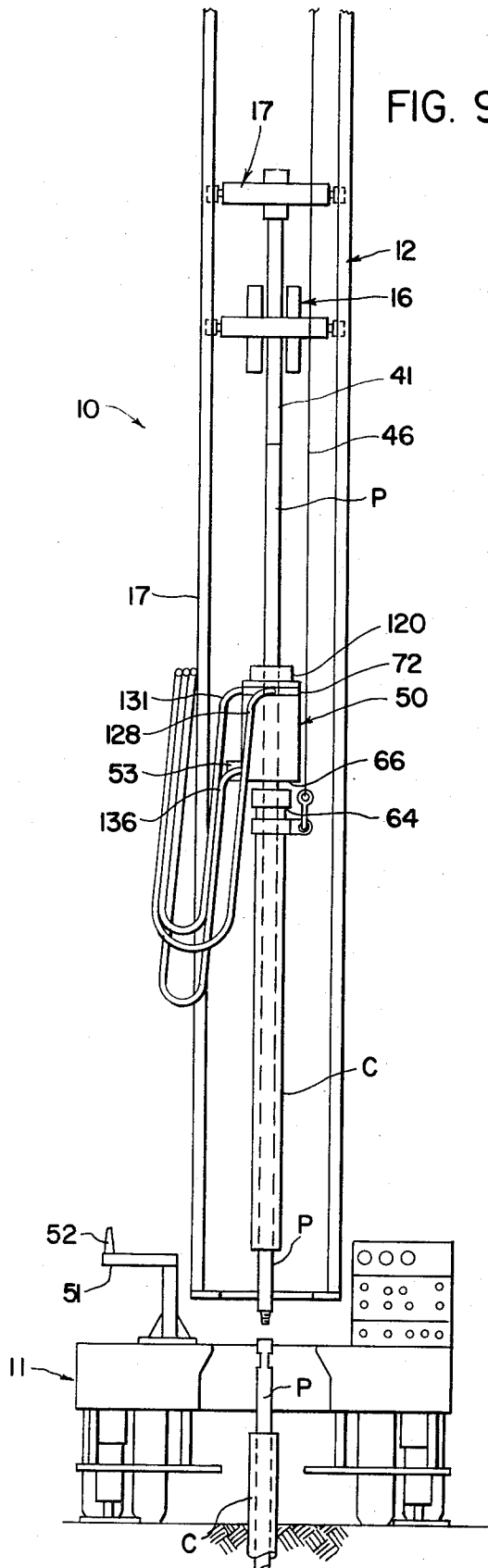












DRILLING MACHINE WITH DRIVING TOOL FOR CASING OR PIPE

CROSS-REFERENCE TO RELATED APPLICATIONS

The subject matter of this invention is related to the subject matter of co-pending application titled Impact Apparatus, Ser. No. 375,508, filed July 2, 1973.

BACKGROUND OF THE INVENTION

The present invention relates to improved drilling machines, for wells, piling bores or the like, particularly adapted for mounting on trucks or vehicles or otherwise portable bases. U.S. Pat. No. 3,708,024, January 1972, Class 175, sub-class 52, was granted to the inventor for a drilling machine.

The invention also relates to a driving tool for casing sections or pipe mounted on the drilling machine. Therefore, the field of art to which the invention pertains is a "pile driver" (Class 61/73).

The driving tool uses pneumatic-hydraulic or air-oil systems for actuation. Therefore, in another sense, the field of art to which the invention pertains may be considered as a "fluid pressure operated work device," as classified in Class 92, sub-classes 10, 30 or 198.

A recent U.S. patent, U.S. Pat. No. 3,474,870, October 1969, discloses a tube driving apparatus having a frame in which a tubular ram is mounted to be reciprocated into driving engagement with a laterally projecting part of a driven member extending coaxially through the drum, and is classified in Class 173, sub-class 91.

The prior art driving tools for casing or pipe, whether hoisted or raised or pressure fluid actuated, have had an inherently large mass, a weight such that when moved the $f=ma$ calculation would provide the necessary impact energy. However, a heavy driving tool will add to the overall weight of a portable drilling machine.

Whatever the form of the prior art driving tools, the disadvantages thereof generally include complexity of the supporting structure, the increased weight factor, a low efficiency in terms of energy input versus work performed, a low efficiency in operation relative to the drill pipe, and a slow rate or low frequency in the work performing cycle.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved drilling machine.

It is a further object to provide an improved drilling machine having a tower with drill power means movable lengthwise thereon and carrying drill pipe sections, the machine also carrying a driving tool for casing sections or pipe.

Still further, it is an object to provide a driving tool, for a drilling machine, with pneumatic-hydraulic or air-oil actuation.

Still further, it is an object to provide a driving tool, for a drilling machine, which does not require complex supporting structure, does not greatly increase the weight of the drilling machine, has a high efficiency in terms of energy input versus work performed, and a fast rate or high frequency in the work performing cycle.

These and other objects of the present invention, and the advantages thereof, will be apparent in view of the Detailed Description of the Invention as set forth below.

In general, a drilling machine according to the invention has a tower with drill power means movable lengthwise of the tower and carrying drill pipe sections. The drilling machine also carries a driving tool for casing sections or pipe.

The driving tool has a hammer barrel with an interior bore vented to atmosphere intermediate the ends thereof. The interior bore has a smaller diameter portion at one end communicating with the larger diameter portion at the other end. The bore is vented radially of a large diameter portion. The area between the small and large diameter bore portions provides a generally transversely extending anvil surface. A plate having an open central portion closes the large diameter bore portion. A spindle element extends from the plate coaxially through the bore and terminates adjacent the end of the small diameter portion. A piston element is movable within said bore coaxially around the spindle element. The piston element has a small diameter portion slidably received within the small diameter bore portion and a large diameter portion slidably received within the large diameter bore portion. The large diameter bore portion is adapted for connection to a constant source of pneumatic pressure. The small diameter portion of the bore is adapted for connection to an intermittent source of hydraulic pressure. The piston element is reciprocated relative to the anvil surface, to provide impact energy, by an intermittent application of hydraulic pressure.

The plate closing the large diameter bore portion carries thereon a chucking mechanism coaxially of the spindle element and having a series of jaws for engaging a drill pipe section passing through said spindle element.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary side view of a drilling machine and driving tool according to the invention with the drill tower in a vertically erect working condition;

FIG. 2 is a schematic view, showing the drilling machine driving tool according to the invention and connections to sources of pneumatic and hydraulic pressure;

FIG. 3 is a view in section showing the driving tool, with the piston element having been reciprocated against the anvil surface to provide impact energy;

FIG. 4 is a top plan view, taken substantially as indicated on line 4—4 of FIG. 2;

FIGS. 5—10, inclusive, are a series of views illustrating the operation of a drilling machine and driving tool according to the invention, with,

FIG. 5 showing the drill pipe in well drilling operation or condition; and

FIG. 6 showing the drill pipe string broken or disconnected and the driving tool moved into a position of alignment with a drill pipe section; and

FIG. 7 showing the drill pipe having been lowered through the driving tool; and

FIG. 8 showing a casing section being hoisted over a drill pipe section and below the driving tool which has been raised; and

FIG. 9 showing the casing section on or over the drill pipe section; and

FIG. 10 showing the driving tool in operation to impact a casing section.

DETAILED DESCRIPTION OF THE INVENTION

A drilling machine 10 using a driving tool according to the invention, indicated generally by the numeral 50, is carried on the portable chassis such as the bed of a motorized vehicle or truck 11. Operation of the drilling machine 10 requires various components also mounted on the truck 11 including an engine, a reduction gear power transfer unit, pressure fluid or hydraulic pumps, a mud pump, a water injector pump, air compressors, coolers, storage tanks, outriggers and controls for selective actuation thereof. These components are conventional for rotary-type drilling machines and so are not described in further detail.

The drilling machine 10 operates with multiple sections of conventional drill pipe P. Each drill pipe section has an upper end with interior threads and a lower end with corresponding exterior threads.

The drilling machine has a tower 12 carried by mechanical means indicated generally by the numeral 14. The drill tower 12 is selectively raised and positioned by power means indicated generally by the numeral 15.

The drill tower 12 is constructed with a series of latticed beams and columns and transverse and side plates to provide an elongated rectangular frame. The frame provides mounting and support for several components of the drilling machine 10 used with but not constituting the subject matter of the invention.

The drill power means movable lengthwise or linearly of the tower 12 and having a rotating spindle 41 for threaded connection to a drill pipe section P, is indicated generally by the numeral 16.

A track means for guiding linear movement of the drill power means 16 is indicated generally by the numeral 17.

Reference is made to U.S. Pat. No. 3,708,024, for such further disclosure of a drilling machine 10 and a truck 11 having thereon elements 12, 14, 15, 16, 17 and 41, as is required to more fully understand the invention.

Referring to FIG. 1, a drilling machine 10 using a driving tool 50 will preferably have a hoist winch 45, mounted on the bed of the truck 11, for a cable 46. The cable 46 is trained over pulleys 47 at the top of the tower 12 and is used to pick up and position casing sections C relative to the drill pipe P and the driving tool 50.

As best shown in FIGS. 5 and 6, the driving tool 50 is adapted to be positioned coaxially of and in alignment with the drill pipe P by a swing table 51 mounted on the bed of the truck 11, adjacent the tower 12. The table 51 has a dowel or pin 52 engaging a bracket block 53 extending laterally of the lower end of the driving tool 50. Any suitable means or structure for positioning the driving tool 50 coaxially of a drill pipe string could be used without departing from the subject matter of the invention.

Referring to FIGS. 3 and 4, the driving tool 50 has a hammer barrel referred to generally by the numeral 55, an interior bore referred to generally by the numeral 56, an interior bore vent as at 57, an anvil surface referred to generally by the numeral 58, a spindle ele-

ment referred to generally by the numeral 59, and a piston element referred to generally by the numeral 60.

As shown in FIG. 2, a source or supply of pneumatic energy, or air under pressure, is referred to generally by the numeral 61. A source of supply of hydraulic energy, or oil under pressure, is referred to generally by the numeral 62.

The driving tool 50 is positioned relative to the drill pipe P and to a casing section C by a chucking mechanism referred to generally by the numeral 63. The chucking mechanism 63 is selectively actuated by pneumatic pressure from the source 61. During the driving of a casing section C, a collar 64 is fitted over the upper end of a casing section C.

Referring to FIG. 3, a hammer barrel 55 is preferably cylindrical; for ease of fabrication, as by forging and for compactness. However, other exterior geometric configurations could be provided without departing from the subject matter of the invention. In any form, the hammer barrel would have a hardened or strengthened transverse or bottom impacted area or surface 66 for contact with the casing collar 64.

The interior bore 56 extending axially of the hammer barrel 55 has a smaller diameter or lower portion 67 and a larger diameter upper portion 68. Illustrative diameters and dimensions of the bore portions 67 and 68, as well as of the other components of the driving tool 50, are set forth below.

The bore vent 57 opens radially of the large diameter bore portion 68. The area between the bore portion 67 and 68 provides the anvil surface 58. As shown, the anvil surface 58 extends transversely of the hammer barrel 55 for contact with the piston element 60. However, other surface configurations, such as a concave anvil surface for contact with a convex piston element surface, could be used without departing from the subject matter of the invention. Therefore, the anvil surface may be broadly described as "generally transversely extending."

The lower or small diameter bore portion 67 has an annular chamber 69 extending axially around the spindle element 59 and having a manifold 70 communicating with an exteriorly opening conduit 71, adapted to be connected to the source of hydraulic pressure 62 for reacting against the lower end of the piston element 60.

The upper end of the hammer barrel 55 and the large diameter bore portion 68 are closed by a plate 72 having an open central portion, attached as by bolts 73. The plate 72 has mounted thereon the chucking mechanism 63. The under surface of the plate 72 may also have an annular chamber 74 communicating with an exteriorly opening conduit 75, adapted to be connected to the source of pneumatic pressure 61 for reacting against the upper end of the piston element 60.

The open central portion of the plate 72 may have an annular flange 76 thereon to receive the upper end of the spindle element 59. Suitable pressure seals, such as "O-rings" 77 may be used to maintain a pressure sealed relation between the spindle element 59 and the top plate 72.

The spindle element 59 extends from the plate 72 coaxially through the bore 56 and terminates adjacent the lower end of the small diameter bore 67, as by seating against a shoulder or flange 78. The exterior surface 79 of the spindle element 59 forms the radially inner wall of the pressure chamber 69.

As shown, the spindle element 59 is cylindrical; for ease of fabrication, formed from a length of pipe or tubing. However, other geometric configurations could be used without departing from the subject matter of the invention. In any form, the spindle element 59 would have an axially directed surface 79 for slidably mounting the piston element 60 for movement within the bore 56 and an open central portion permitting passage of drill pipe P therethrough.

The piston element 60 has an interior bore with a surface 81 for mating engagement with the spindle surface 79. Suitable pressure seals, such as "O-rings" 82, may be used to maintain a pressure sealed relation between the spindle element 59 and the piston element 60.

The piston element 60 has a small diameter lower portion 83 slidably received within the small diameter bore portion 67 and movable within the pressure chamber 69. Suitable pressure seals, such as "O-rings" 84, may be used to maintain a pressure sealed relation between the bore portion 67 and the piston portion 83.

The piston element 60 has a large diameter upper portion 85 slidably received within the large diameter bore portion 68. The under surface 86 of the piston portion 85 is generally transversely extending for contact with the anvil surface 58.

The lower radial surface of the piston portion 85, adjacent the anvil contact surface 86, is relieved, as is the facing surface of the upper bore portion 68 to provide an annular chamber 87 communicating with the bore vent 57. The upper radial surface of the piston portion 85 carries suitable pressure seals, such as "O-rings" 88, which may be used to maintain a pressure sealed relation between the bore portion 68 and the piston portion 85.

The upper surface 89 of the piston portion 85 is provided with counter bores providing chambers 90 communicating with the chamber 74 in the top plate 72.

The chucking mechanism 63 is carried on the hammer barrel 55 coaxially of the spindle element 59 and has a series of, preferably three, jaw or chuck elements 100 for engaging and gripping a drill pipe section. Each jaw 100 has an inner face 101, a radially outwardly directed mounting flange 102, and a downwardly tapered and circumferentially curved outer face 103.

The outer face 103 of each jaw 100 is in sliding contact with a correspondingly tapered surface 104 of an actuating ring 105. Radially outwardly of the ring surface 104 is an annular groove providing a pressure chamber 106. The pressure chamber 106 communicates with an exteriorly opening conduit 107, adapted to be connected to the source of pneumatic pressure 61 for reacting against the lower end of a piston element 110.

Each jaw mounting flange 102 is slidably secured by a suitable fastening means within a radially inwardly directed slot 111 in a jaw piston element 110. The upper surface of each piston element 110 has a counter-bore seating a strong compression spring 112. The lower portion 114 of a piston element 110 is slidably received within the annular pressure chamber 106. Suitable pressure seals, such as "O-rings" 115 may be used to maintain a pressure sealed relation between the piston element 110 and the actuating ring 105.

The chucking mechanism 63 is closed by a top cap 120 having an axial opening or bore 121 and a radially directed flange 122 for attachment to the plate 72, as by bolts 73. The under surface of the top cap 120 has

a series of counter bores 123 for seating the strong compression springs 112 carried in counter-bores on the actuating ring 105.

Referring to FIG. 2, the source of pneumatic pressure 61 includes an "air" compressor 125 mounted on the truck 11, a constant pressure regulating valve 126, a check valve 127, and a conduit 128 adapted to be connected to the plate conduit 75. During operation of the driving tool 50, pneumatic pressure is continuously or constantly supplied via conduit 75 to the bore portion 68 and chambers 74 and 90 so as to react against the upper side of the piston element 60.

The source of pneumatic pressure 61 further includes a conduit 129 connecting the compressor 125 with the valve 130. The valve 130 communicates with a conduit 131 adapted to be connected to the actuating ring conduit 107. The valve 130 also selectively connects the conduit 131 to an exhaust or vent conduit 132. During operation of the driving tool 50, pneumatic pressure is selectively supplied to or exhausted from the pressure chamber 106 by operation of the valve 130. When pneumatic pressure is supplied to the chamber 106, the piston element 110 will be raised, compressing the springs 112, releasing or relieving the gripping force of the jaw faces 101 against the drill pipe P. Thereafter, exhaust of the pneumatic pressure from chamber 106 will permit the springs 112 to react to apply the gripping force of the jaw faces 101 against the drill pipe P.

The source of hydraulic pressure 62 includes a reservoir 135 mounted on the truck 11, supplying hydraulic fluid or "oil" to the hammer barrel conduit 71 via conduit 136, pump 137, and a standard four-way valve 138. During operation of the driving tool 50, the hydraulic pressure is intermittently applied against the lower side of the piston element 60. As shown, the hydraulic fluid is intermittently, selectively or sequentially "dumped" as by a piping and valve system including a lateral conduit 139, a pilot operated valve 140, a bypass conduit 141 and sequence valve 142.

The subject matter of the invention including a driving tool 50 carried on a drilling machine 10, providing for the raising of the piston element 60 away from the anvil surface 58 by the application of hydraulic pressure from source 62 so as to further compress the pneumatic fluid from source 61, and thereafter "dumping" the hydraulic pressure, is capable of developing relatively high $f=ma$ impact energy of the hammer barrel surface 66 against the casing collar 64.

DESCRIPTION OF OPERATION

A description of operation of a drilling machine 10 having a driving tool 50 is presented by the sequential views of FIGS. 5-10.

Beginning with FIG. 5, during a drilling operation the drill pipe string will be rotated and lowered by the drill power means 16 into the well bore. The driving tool 50 mounted on the swing table 51 is positioned adjacent the tower 12.

Referring to FIG. 6, the drill pipe string is "broken" to begin a casing driving operation. The drill power means 16 is shut-down and raised on the tower 12. The swing table 51 is rotated to position the top cap bore 121 of the driving tool 50 coaxially of and in alignment with the first drill pipe section which remains connected to the power means 16. (The upper end of the second drill pipe section, remaining in the well bore,

may be selectively chucked during this operation by a suitable clamp means, such as indicated generally by the numeral 20 in the disclosure of U.S. Pat. No. 3,708,024, to which reference is made as may be required to more fully understand the invention.)

Referring to FIG. 7, pneumatic pressure from source 61 is supplied to "open" the jaws 100 of the chucking mechanism 63 and the drill power means 16 is lowered on the tower 12 so that the first drill pipe section passes through the spindle element 59 of driving tool 50.

FIG. 8, shows a section of casing C being hoisted by the cable 46 over the first drill pipe section and below the driving tool 50. The driving tool 50 has been raised from the position of FIG. 7, after exhaust of the pneumatic pressure from the chucking mechanism 63 to "close" the jaws 100.

FIG. 9 shows a casing section C on the first drill pipe section. The drill power means 16 is thereafter lowered and rotated to reconnect the drill pipe string.

FIGS. 8 and 9 both illustrate the operating position of the driving tool 50 on the first drill pipe section at the beginning of a casing driving operation. The driving tool 50 is positioned relative to the longer first drill pipe section at a height such that the shorter casing section C will fit completely over the drill pipe.

Relative movement of the driving tool from the "pick-up" position of FIG. 7 to the raised position of FIGS. 8 and 9, may be accomplished by either of two operating techniques. The first technique begins subsequent to FIG. 5, with a drill power means 16 being raised approximately 15 feet so that the drill pipe string is above the bottom of the well bore. Thereafter, the upper end of the second drill pipe section is chucked by a suitable clamp means, such as indicated generally by the numeral 20 in the disclosure of U.S. Pat. No. 3,708,024, to which reference is made as may be required to more fully understand the invention. After the second drill pipe section P is chucked, pneumatic pressure from source 61 is supplied to "open" the jaws of the chucking mechanism 63 and the drill power means 16 is lowered on the tower 12 until the drill pipe string bottoms on the well bore. The second technique begins subsequent to FIG. 7, with the drill power means 16 being raised a sufficient distance so that the casing section C may be hoisted thereover in the manner shown in FIG. 8. Thereafter, pneumatic pressure from source 61 is supplied to "open" the jaws 100 of the chucking mechanism 63 and the driving tool 50 is moved upwardly along the drill pipe as the casing section C is being hoisted by the cable 46.

FIG. 10 shows the driving tool 50 in operation to impact the casing section C.

ILLUSTRATIVE EMBODIMENT

Dimensions of one form of driving tool 50 which may be mounted on a drilling machine according to the invention are:

- i. hammer barrel 55, 25 inches high, 13.5 inches diameter, 750 pounds;
- ii. lower bore portion 67, 7 inches diameter and spindle element 5.5 inches diameter, provide 14.75 square inch piston area for lower piston portion 83;
- iii. upper bore portion 68, 12 inches diameter and spindle element 5.5 inches diameter, provide 89 square inch piston area for upper piston portion 85;

- iv. piston element 60, 6 inches stroke, 150 pounds;
- v. volume above piston element 60 when down [FIG. 3] on anvil surface 58, 856 cubic inches;
- vi. volume above piston element 60 when up against top plate 72, 320 cubic inches;
- vii. a pneumatic pressure compression ratio 2.7;
- viii. chucking mechanism 63, piston element 110 has 19.5 square inch piston area, three compression springs 112 with 1,000 pounds load capacity each.

It has been determined that 100 psi from air pressure source 61 will actuate the chucking mechanism 63. It has been further determined that 100 psi from air pressure source 61 and 2,000 psi from a hydraulic pressure source 62, will provide for the driving tool 50 an impact energy of 4,765 foot pounds (calculated at 80 percent efficiency) and at a frequency of 30 strokes per minute.

What is claimed is:

1. A drilling machine having a tower with drill power means movable lengthwise of said tower and carrying drill pipe sections, said drilling machine carrying a driving tool for casing sections,

said driving tool having a hammer barrel with an interior bore vented to atmosphere, said bore having a smaller diameter portion at one end communicating with a larger diameter portion at the other end, the area between said small and large diameter bore portions providing a generally transversely extending anvil surface, a plate having an open central portion closing said large diameter bore portion, a spindle element extending from said plate coaxially through said bore and terminating adjacent the end of said small diameter bore portion, a piston element movable within said bore coaxially around said spindle element, said piston element having a small diameter portion slidably received within said small diameter bore portion and a large diameter portion slidably received within said large diameter bore portion, the large diameter bore portion being adapted for connection to a constant source of pneumatic pressure, the small diameter portion of the bore being adapted for connection to an intermittent source of hydraulic pressure, said plate carrying thereon a chucking mechanism coaxially of said spindle element and having a series of jaws for engaging a drill pipe section passing through said spindle element.

2. A drilling machine according to claim 1, having a hoist winch thereon for a cable used to pick up and position casing sections relative to a drill pipe section and said driving tool.

3. A drilling machine according to claim 1, having a swing table adjacent said tower used to position said driving tool coaxially of a drill pipe section.

4. A chucking mechanism according to claim 1, which is actuated by pneumatic pressure to "open" said jaws.

5. A chucking mechanism according to claim 4, wherein said jaws are each carried by a piston element, each said piston element being received in a pressure chamber in an actuating ring, said actuating ring having a downwardly tapered and circumferentially curved surface for sliding engagement with a correspondingly tapered surface on the outer face of a jaw, said actuator rod seating compression springs reacting against said piston element, said chucking mechanism further having a top cap with an open central portion coaxially aligned with said spindle element, said top cap also seating said compression springs.

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