

[54] **AIRGUN REPEATER POWERED PILE DRIVER**

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[51] Int. Cl. **E02d 7/10**

[58] Field of Search **173/1, 135, 127, 137, 91, 173/128, 139, 138; 61/53.5; 91/4 R, 232, 325**

[56] **References Cited**

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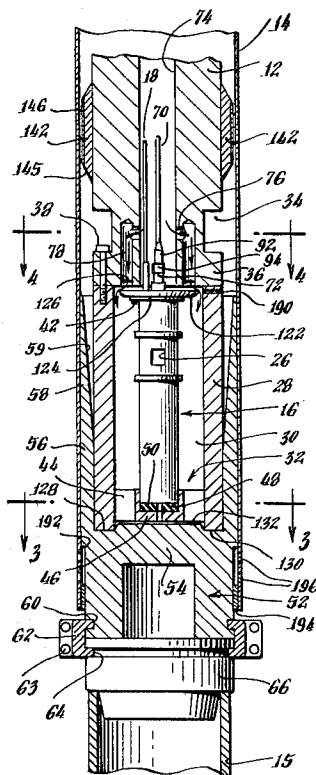
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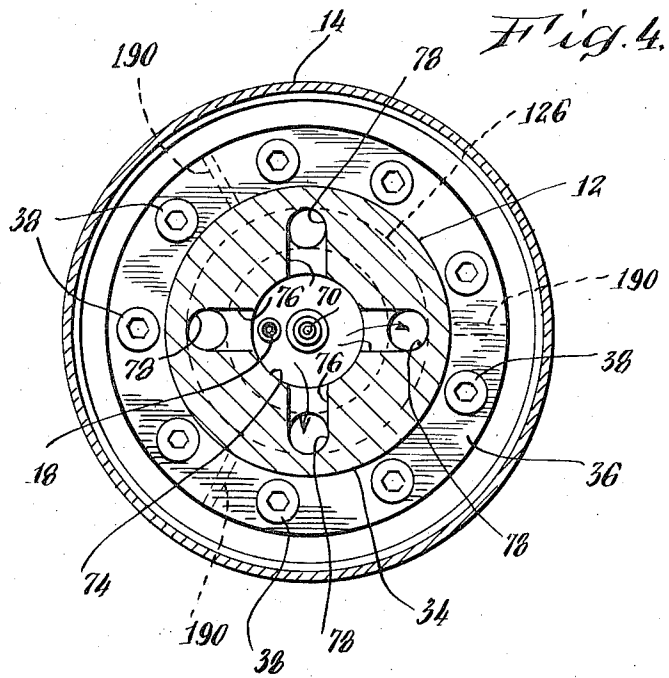
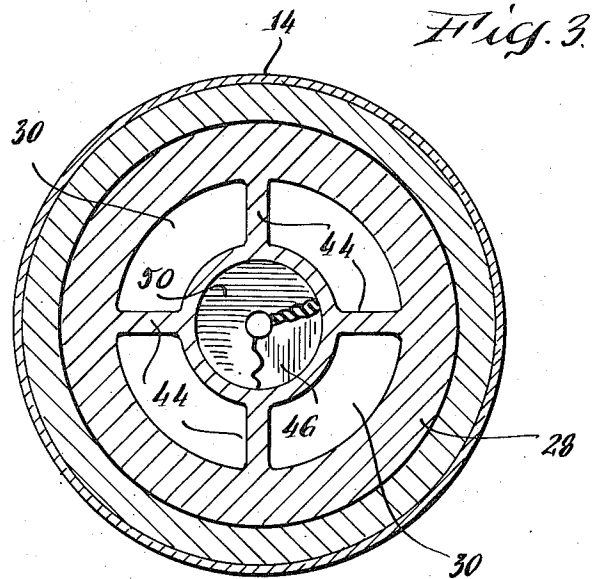
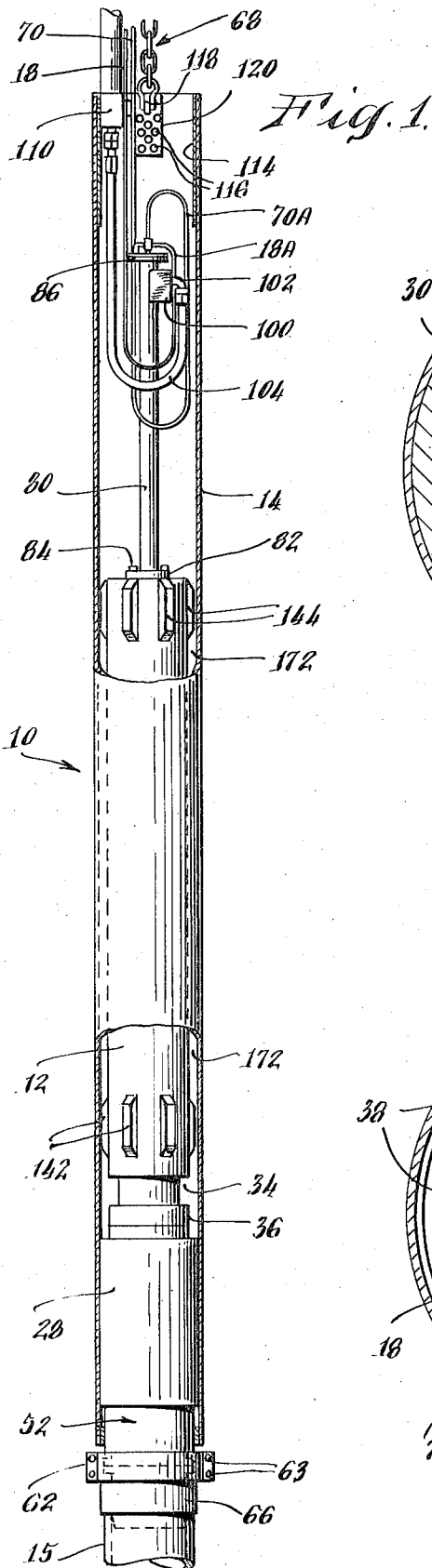
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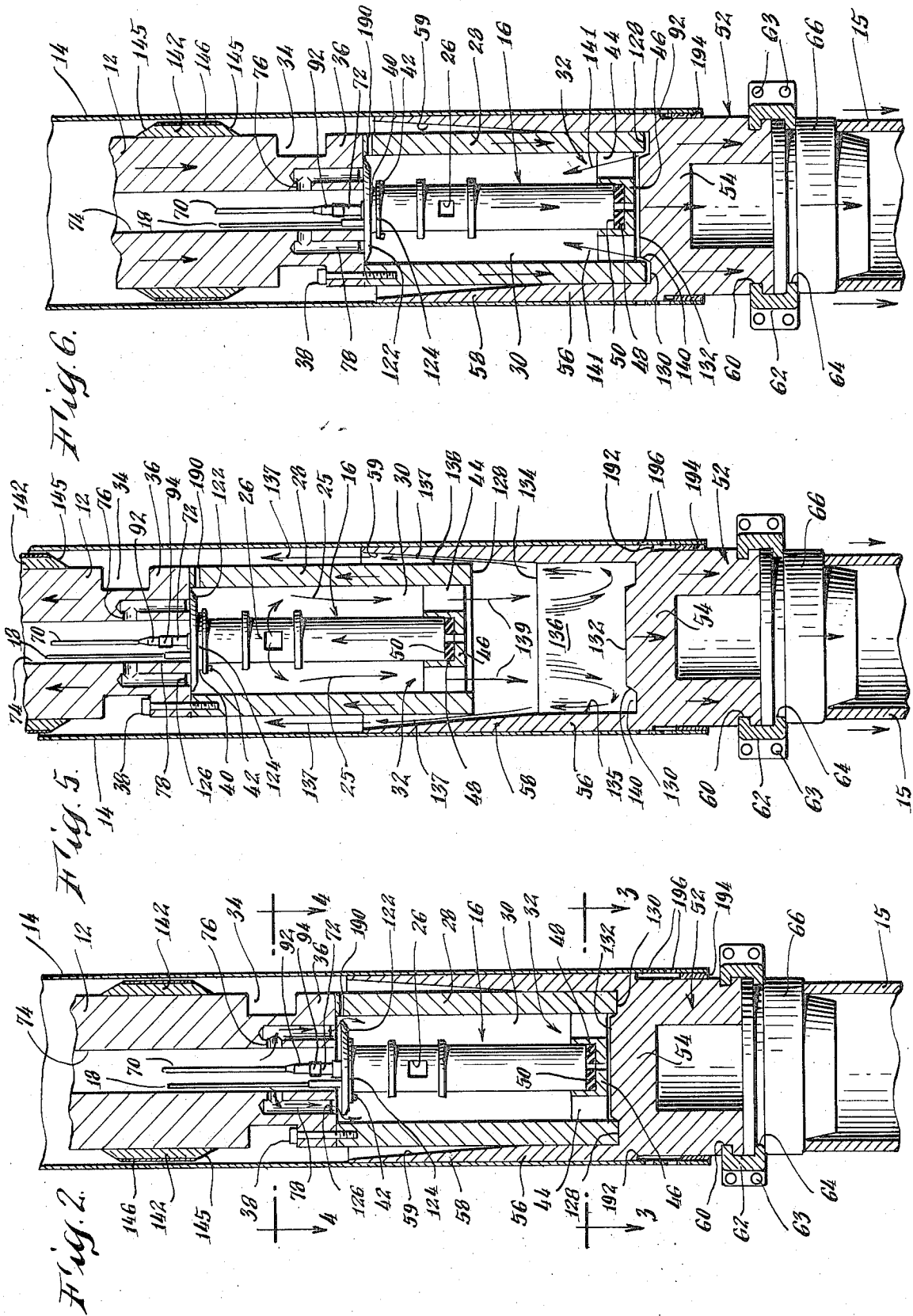
[57] **ABSTRACT**

An airgun repeater powered pile driver embodying the present invention is capable of driving piles of various types and sizes including immense piles to be driven down into the earth and can be operated totally submerged, partially submerged or entirely in the air. A first driving impulse down upon the pile commences when the airgun repeater is fired into a discharge chamber and continues for a relatively long time interval while the discharge chamber wall of great strength remains effectively telescoped within a closely surrounding sleeve as the massive weight above the airgun moves upwardly. Thereafter, the released high pressure gas intermixed with water can escape upwardly between the rim of the discharge chamber wall and the surrounding sleeve. A second driving thrust is provided when the rim of the discharge wall impacts down with respect to a driving head at the bottom of the surrounding sleeve. The pile driver can also be operated within the bore of very large diameter piles.

10 Claims, 12 Drawing Figures







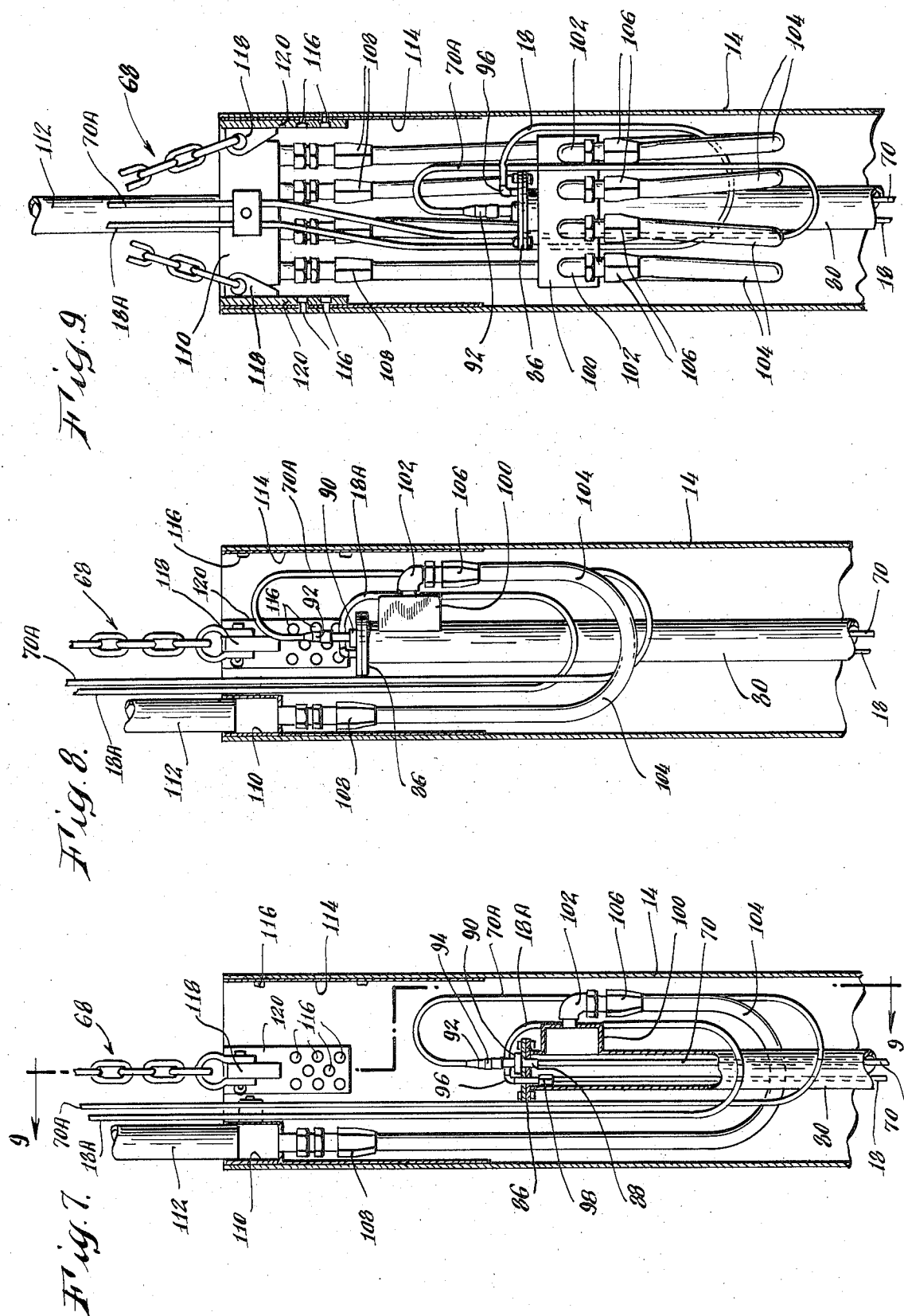


Fig. 10.

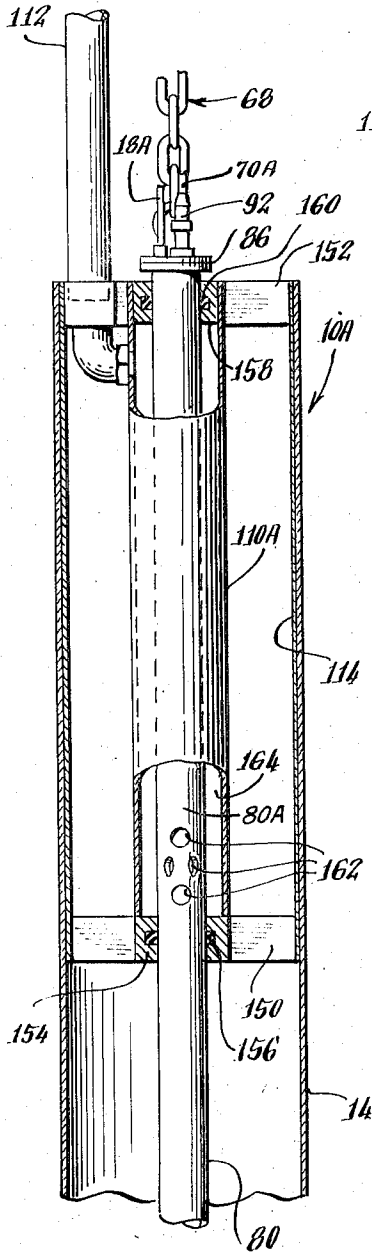


Fig. 11.

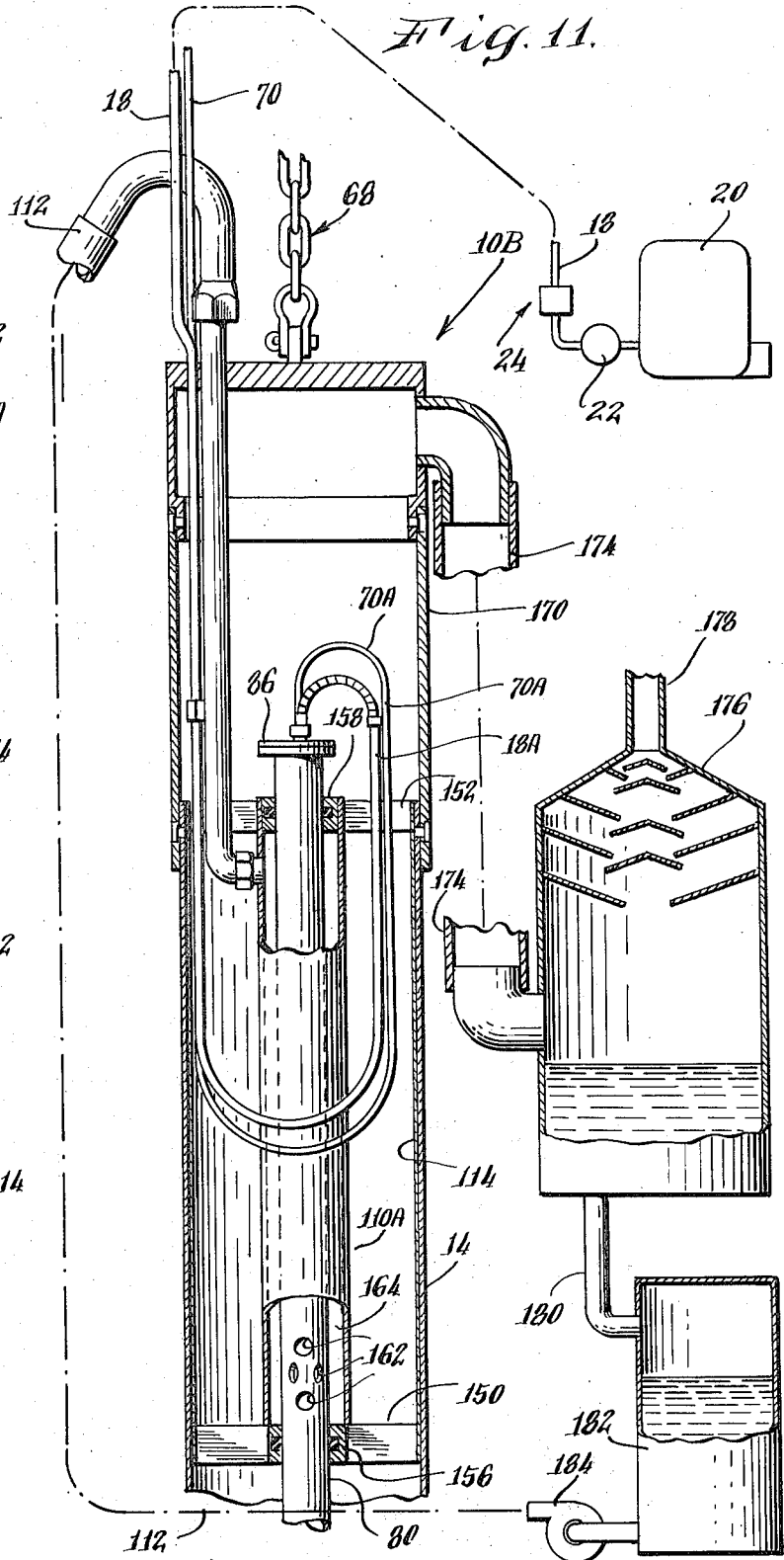
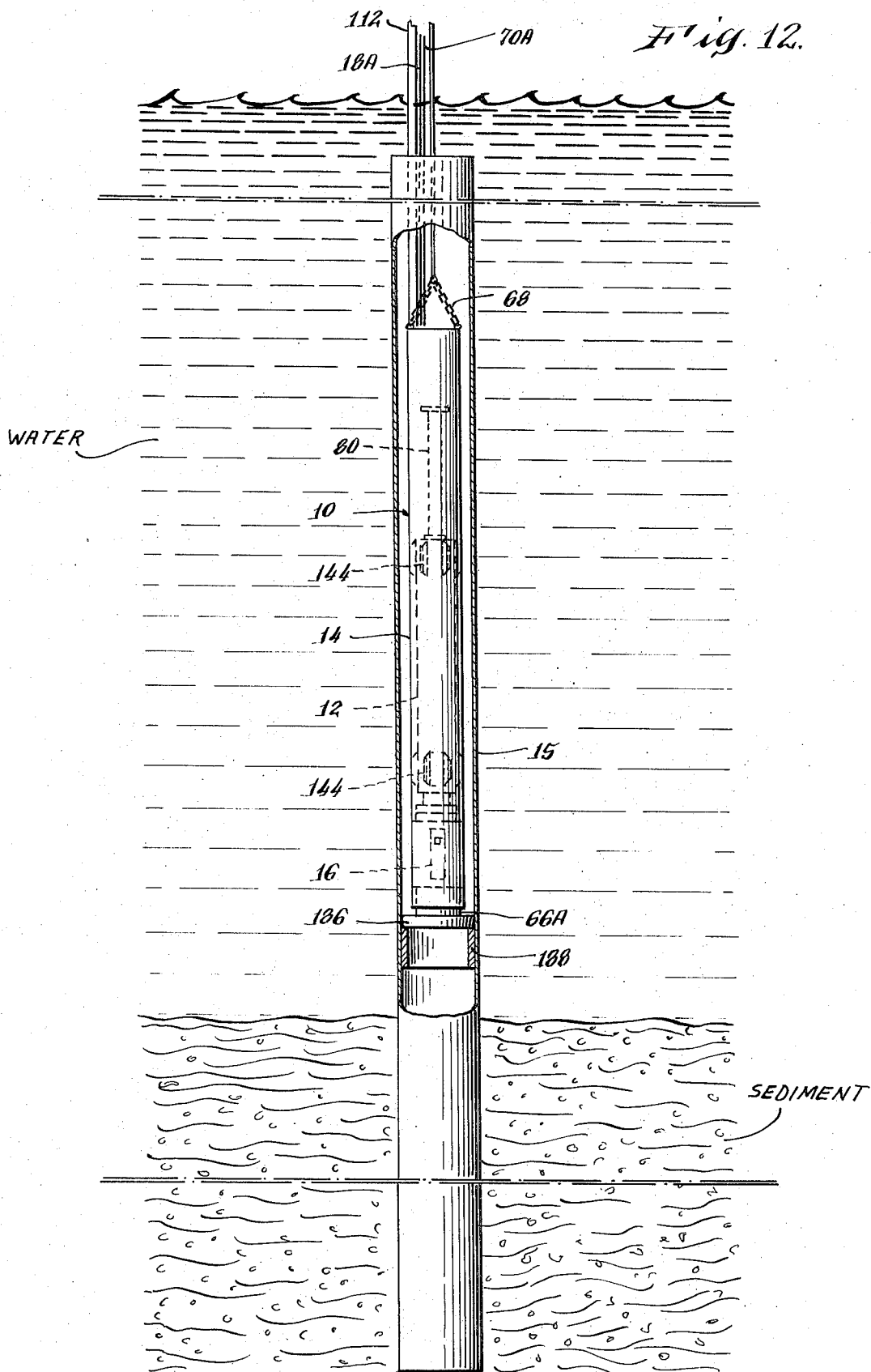


Fig. 12.



AIRGUN REPEATER POWERED PILE DRIVER DESCRIPTION

This invention relates to an airgun repeater powered pile driver adapted to deliver two powerful downward thrusts to the pile being driven upon each actuation of the airgun repeater. It appears to me that this invention is an important technological forward jump in the art which is patentable with respect to my prior U.S. Pat. Nos. 3,604,519 and 3,646,598.

Advantageously, the airgun repeater powered pile driver embodying the present invention is capable of driving piles of various types and sizes including immense piles to be driven down into the earth and can be operated totally submerged, partially submerged or entirely in the air. A first driving impulse down upon the pile commences when the airgun repeater is fired into a discharge chamber and continues for a relatively long time interval while the discharge chamber wall of great strength remains effectively telescoped within a closely surrounding sleeve as the massive weight above the airgun moves upwardly. Thereafter, the released high pressure gas intermixed with water can escape upwardly between the rim of the discharge chamber wall and the surrounding sleeve. A second driving thrust is provided when the rim of the discharge wall impacts down with respect to a driving head at the bottom of the surrounding sleeve.

The pile driver can also be operated to advantage within the bore of very large diameter piles.

The airgun repeater in the pile driver is energized with high pressure gas, which is usually compressed air. However, other pressurized gases, steam under pressure, or pressurized vapor, can be employed. Accordingly, as used herein the term "pressurized gas" or "high pressure gas" is intended to be construed broadly to include compressed air, steam, gaseous products of combustion, or other pressurized gas or vapor. In the illustrative embodiment, it is my preference to utilize compressed air as the pressurized gas for energizing the airgun repeater.

The various features, aspects and advantages of the airgun repeater powered pile driver of the present invention will become more fully appreciated from a consideration of the following detailed description in conjunction with the accompanying drawings, in which:

FIG. 1 is a longitudinally sectional view of an airgun-powered pile driver embodying the present invention, and particularly adapted for operation underwater, although the embodiment of FIG. 1 can also be used to advantage in the air;

FIG. 2 is an enlarged sectional view of the lower portion of the pile driver of FIG. 1 showing further aspects of the cooperative relationship of the elements and details of construction;

FIG. 3 is a cross-sectional view taken through the plane 3—3 in FIG. 2;

FIG. 4 is a cross-sectional view taken through the plane 4—4 in FIG. 2;

FIG. 5 is a view similar to FIG. 2 and showing the pile driver operation with the airgun and massive weight in their raised position after the airgun has been "fired" in a cycle of operation;

FIG. 6 is another view similar to FIG. 5 and showing the shock damping occurring during the delivery of the second driving impulse occurring near the end of a cycle of operation;

FIG. 7 is an enlarged longitudinal, sectional view of the upper portion of the pile driver of FIG. 1 showing further aspects of the flexible supply lines and hoses of the pile driver;

FIG. 8 is a view similar to FIG. 7 showing the raised position of the massive weight after the airgun has been "fired" in a cycle of operation;

FIG. 9 is a longitudinal, sectional view taken through the plane 9—9 of FIG. 7 showing the manifold and flexible hoses in further detail;

FIG. 10 is a longitudinal, sectional view similar to FIG. 7 showing a modified embodiment of the invention in which the flexible hose lines are replaced by a sliding seal telescoping manifold;

FIG. 11 is a longitudinal, sectional view of the upper portion of a modified embodiment of the present invention which is particularly adapted for operation in the air; and

FIG. 12 illustrates the pile driver of FIG. 1 being used underwater to drive a long hollow pipe pile in the interior thereof near the center of the pile itself for driving the pile into the earth beneath a body of water.

Referring to FIGS. 1 and 2 of the drawings in greater detail, the airgun-powered pile driver 10 of the present invention includes a massive cylindrical weight 12 which is movable up and down within an elongated cylindrical housing 14 for driving a pile 15, only the upper end of which is shown in FIG. 1. Secured to the lower end of the massive weight 12 is an airgun repeater 16. This airgun repeater 16 may advantageously be such as is described in my U.S. Pat. Nos. 3,310,128 and 3,379,273. The airgun repeater may be repetitively actuated (hereinafter called "fired"). Each time the airgun is fired, it abruptly releases a charge of very high pressure gas, e.g., compressed air. This pressurized gas for the airgun repeater is supplied through a high pressure airline 18 from a suitable source, such as a multiple stage air compressor 20 (for example, as illustrated in FIG. 11) connected to a compressed air storage tank or receiver 22, associated with a filter and shut off and bleed valves generally indicated at 24.

As described in these patents, fuel may be mixed with a charge of compressed air in the airgun repeater 16 and burned in it for further raising the pressure therein before the abrupt discharge of high pressure gas, which occurs each time it is fired. When the airgun 16 is fired, the pressurized gas is abruptly discharged, as shown by the arrows 25 in FIG. 5, through a plurality of ports 26 (only one is seen in FIGS. 1, 2 and 5).

During operation of the pile driver, the airgun repeater 16 is typically charged with compressed air at high pressures, for example, in the range from 1,000 to 3,000 pounds per square inch; however, higher or lower pressures may be used. The actual pressure employed to operate the airgun depends upon its size, the size of the massive weight 12, the size of the pile, and the characteristics of the earth material into which the pile is being driven, and this pressure provides a convenient parameter for control of the pile driving operation.

Secured to the lower end of the massive weight 12 is a cylindrical wall 28 which completely encircles the airgun 16 and defines a discharge chamber 30 having an open mouth 32 facing downwardly. The cylindrical wall 28 extends down below the lower end of the airgun. This cylindrical wall 28 is formed of strong mate-

rial because it serves a number of functions as will be explained further below.

In order to secure the strong cylindrical wall 28 to the lower end of the massive weight 12, there is an annular recess 34 formed near the lower end of the weight 12 defining a flange 36. A plurality of attachment bolts 38 pass through holes in this flange 36 and are screwed into the top of the wall 28.

For holding the airgun repeater 16, there is a mounting ring 40 which surrounds the upper end of the airgun with a plurality of bolts 42 screwed through this ring into the lower end of the massive weight 12. Within the mouth 32 of the chamber wall 28, there are a plurality of radial struts or vanes 44 connected to a centrally located retainer socket element 46. This retainer 46 has a well 48 therein for holding the lower end of the airgun repeater 16. Shock absorbing pad means 50 of resilient material, for example of polyurethane, rubber or other shock absorbing resilient material are seated in the socket 48 beneath the lower end of the airgun. If desired, similar shock absorbing pad means (not shown) may be located within the mounting ring 40 between the upper end of the airgun 16 and the lower end of the cylindrical weight 12.

Operatively associated with the airgun 16 and the chamber wall 28 is a movable impulse transmitting member 52 including a driving head 54 with an upstanding cylindrical sleeve 56. This sleeve 56 closely surrounds the outer surface of the chamber wall 28. Above the cylindrical sleeve 56 and integral therewith is a tapered sleeve 58 having an inner surface 59 which progressively recedes in an upward direction from the outside surface of the wall 28.

The impulse transmitting member 52 has a circumferential groove 60 adapted to be connected by a ring clamp 62 secured by clamp bolts 63 to a groove 64 in a detachable pile driving adapter 66 which engages the pile 15 being driven. The pile 15 is shown as a large pipe pile being driven underwater.

In FIG. 1, the pile 15 and the entire pile driver 10 are assumed to be submerged underwater (not shown) with the pile driver being suspended from the top by a chain sling 68 supported from a large crane (not shown) on a barge or ship.

Although a pipe pile 15 is shown, it is to be understood that this is illustrative and that the pile driver 10 of this invention can be used to drive any type of drivable pile, such as an H-beam pile, timber pile, etc. Moreover, in addition to being capable of driving piles from their upper ends, attention is invited to FIG. 12, which shows that the pile driver 10 embodying the present invention can be used to drive hollow piles by being placed in the interior of such piles. When it is desired to drive a different size of pile or a different type of pile, then the ring clamp 62 is temporarily disconnected and a different adapter 66 is inserted for providing the desired coupling to the pile to be driven.

In order to control the firing of the airgun repeater 16, there is an electrical control cable 70 connected to a solenoid operated valve 72 mounted on the airgun. By transmitting an electrical signal through the cable 70, the valve 72 is actuated to fire the airgun 16, as will be understood by reviewing the two patents discussed above. In this way the pile driver 10 can be remotely controlled to produce cycles of operation which are repeated at frequent intervals, as may be desired by the user, for example, approximately every 2 seconds.

Alternatively, the pile driver 10 can be arranged to be self-operating. This is accomplished by replacing the solenoid operated valve 72 by a pressure-responsive release valve which is set at a predetermined release pressure as desired by the user. Thus, the airgun 16 becomes self-firing. As soon as the pressure of the pressurized gas therein has reached this pre-set release pressure, the airgun fires. An advantage of making the airgun self-firing is that the control cable 70 and associated connections can be omitted. The repetition rate of the cycles of operation when the airgun is self-firing is controlled by the user by controlling the rate at which pressurized gas is fed through the high pressure line 18 into the airgun. The faster this gas is supplied to the airgun, the sooner it will fire, and the more frequent will be the cycles of pile driver operation, and vice versa.

The massive weight 12 is provided with an axial through-bore 74 for accommodating the firing control cable 70 and the high pressure airline 18. The airgun repeater 16 is located adjacent to the lower end of the bore 74 for connection to the electrical cable and to the high pressure supply line 18.

The discharge chamber 30 is normally filled with water prior to the firing of the airgun 16. To supply water to this chamber for maintaining the airgun submerged during operation, a continuous flow of water is pumped down through the axial passage 74. To feed this liquid from passage 74 into the chamber 30, there are four radial distribution passages 76 (please also see FIG. 4), which branch off from the axial passage 74 near the lower end of the weight 12. These radial passages 76 communicate with four vertical passages 78 feeding down into the top of the discharge chamber 30 around the airgun 16. Thus, water is continuously fed down into the discharge chamber. This liquid flow also serves to purge any trapped air out of the discharge chamber before the airgun repeater 16 is fired.

In order to feed water down into the central passage 74 and to support the electrical cable 70 and the high pressure line 18, there is an upstanding pipe line 80 attached to the top of the cylindrical weight 12. A flange 82 is connected by screws 84 to the weight 12. At its upper end, the standpipe 80 has a watertight end cap 86 secured to it. The control cable 70 is supported by an electrical connector 88 held by a clamp 90 on the end cap 86.

A flexible control cable 70A extends down into the top of the cylindrical housing 12 with a slack loop and is attached by a connector 92 to the other connector 88. The connectors 92 and 88 can be disconnected by unscrewing a threaded collar 94. Between these connectors, there is a gasket to provide a watertight connection when the collar 94 is tightened.

A flexible high pressure gas supply line 18A also runs down into the pile driver housing 12 with a slack loop. The line 18A is fastened to a horizontal elbow hose fitting 96 with a downward leg secured through the end cap 86 having a hose connection 98 to the top end of the line 18 within the standpipe 80.

As shown most clearly in FIGS. 7, 8 and 9 on the side of the upper end of the standpipe 80, there is a water manifold box 100. This manifold 100 has a plurality of elbow pipe connections 102. A plurality of flexible water hoses 104 are attached by connections 106 to the downwardly extending legs of the multiple pipe connections 102. These hose lines 104 each has a slack

loop and they are positioned in side-by-side relationship, being connected at their upper ends by connectors 108 attached to a second stationary water manifold 110. A large diameter water supply hose 112 feeds into this stationary manifold 110, and a pump (not shown) serves to feed water through the hose 112.

The reason for utilizing the multiple hoses 104 in side-by-side relationship is to provide the desired delivery capacity for the water while at the same time providing a high degree of flexibility and clearance within the cylindrical housing 14 to accommodate up and down motion of the stand pipe 80 which occurs during each driving cycle.

To provide for servicing of the components, namely, the electrical, water and high pressure gas supply lines, fittings, and connectors in the upper end of the pile driver housing 14, there is a removable sleeve 114 which closely fits into the housing 14 and is removably secured in position by a plurality of attachment screws 116. When it is desired to service these components, the screws 116 are removed and the sleeve 114 is pulled up out of the housing 14 to expose such components.

The chain sling 68 is connected to a pair of eyes welded to heavy steel pads 120 on opposite sides of the pile driver detachably secured by multiple screws 116 to both the sleeve 114 and to the housing 14.

As the water flows down through the central passages 74 and branch passages 76 and 78, this flow pushes a check valve member 122 down against an annular stop shoulder 124 on the mounting 40. Thus, the water has free access, as seen most clearly in FIG. 2, to enter into the discharge chamber 30. The check valve member 122 is in the form of a ring which encircles the mounting 40. An annular channel 126 interconnects the lower ends of the vertical passages 78 to facilitate entering flow of the water into the discharge chamber.

As will be explained further below, when the air gun 16 is fired, the sudden surge of pressure in the discharge chamber 30 pushes the check valve 122 up to block momentarily the channel 126 and to block passages 78. Thus, the abrupt pressure rise in the chamber 30 is confined and is directed downwardly through the open mouth 32.

The operation of the pile driver 10 will be explained in further detail: When the pile driver members are sitting in their normal rest position (as shown in FIGS. 1, 2, 7 and 9) immediately before firing of the airgun 16, water fills the chamber 30, and the lower rim 128 of the cylindrical wall 28 is seated down in an annular groove 130 in the driving head 54. In this initial position, the wall 28 is closely telescoped within the surrounding sleeve 56 while the rim 128 seats down in the groove 130 to provide an essentially closed discharge chamber 30 in which the water is confined by the rigid wall 28. This water in the discharge chamber is confined below the lower end of the weight 12 and above the driving head 54.

The air gun repeater 16 may be electrically fired or may be self-firing, as discussed in detail above. Immediately after the airgun has been fired, high pressure gas is abruptly released through the ports 26 into the discharge chamber 30 producing a sudden or violent increase of pressure in this chamber. This sudden surge of pressure thrusts down against the top surface 132 of the driving head 54, and also pushes up against the

check valve ring 122 and against the lower end of the weight 12.

As shown in FIG. 5, an immense thrust is delivered downwardly onto the driving head 54. At the same time, an upward driving force is delivered up against the massive weight 12 causing this weight to jump upwardly, as illustrated in FIG. 5.

The advantageous telescoping relationship between the cylindrical wall 28 and the closely surrounding cylindrical sleeve 56 maintains the confined relationship of the water and of the released high pressure gas in the region 136 above the driving head 54. This confined relationship is continued until such time as the rim 128 has raised above the line of demarkation 134 between the cylindrical inner surface 135 of the sleeve 56 and the outwardly sloping generally conical surface 59. This confinement by these telescoping parts produces a protracted downward thrust upon the driving head 54.

In effect, the region 136 within the cylindrical surface 135 forms an extension of the discharge chamber 30 thereby providing an expandable chamber which confines the released pressurized gas and water therein for a significant interval of time after the pressurized gas is initially released into the chamber 30. The arrows 139 (FIG. 5) illustrate the downward flow of the released pressurized gas and water from the chamber 30 into the extension chamber 136.

As shown in FIG. 5, after the rim 128 has moved above the line of demarkation 134, the immense pressure within the combined extended chamber 30-136 drives the water and air (or other pressurized gas) upwardly, as indicated by the elongated flow arrows 137. This expulsive flow 137 is very rapid, as indicated by the length of the arrows 137, for it occurs through the clearance space 138 between the rim 128 and the sloping surface 59. Initially, this clearance space is small and so the initial expulsive flow 137 is of high velocity. As the discharge chamber wall 28 continues to move upwardly, the clearance space 138 progressively enlarges, the pressure in the chamber 30-136 falls, and so the expulsive flow 137 diminishes in velocity.

The force of gravity slows the upward motion of the massive weight 12 and causes it to fall back downwardly toward its initial position. As shown in FIG. 6, when the rim 128 of the chamber wall 28 falls back down into the shock-damping groove 130, a second powerful driving impulse is delivered to the driving head 54 for thrusting the pile downwardly into the earth. As shown in FIG. 6, the water which remained trapped in the groove 130 produces a dashpot shock-damping action because the inner wall 140 of this groove 130 slopes inwardly progressively restricting the upward flow 142 of the trapped water as the rim 128 enters this groove.

Thus, in summary, it will be understood that two powerful driving thrusts are delivered during each cycle of operation of the pile driver 10. The first of these driving impulses is longer in duration than the second one. The first driving impulse occurs during the time interval after discharge of the pressurized gas from the airgun 16 into the discharge chamber 30. This first driving impulse continues until after the rim 128 has passed above the transition line 134, thus releasing the expulsive flow 137. The second driving impulse occurs when the lower edge 128 of the wall 28 strikes down into the shock-damping groove 130. By virtue of the

fact that water has been expelled along with the released gas, as indicated in FIG. 5 by the arrows 137, the massive weight 12 falls back down relatively quickly under the pull of gravity to deliver the second powerful driving thrust. FIG. 6 illustrates occurrence of this second driving thrust upon impact of the wall 28 down into the shock-damping groove 130. The chamber wall 28 is made very strong to withstand the sudden surge of pressure occurring upon discharge of the airgun repeater 16. It is also strong to withstand the compressive stress occurring when the rim 128 impacts down into the shock-damping groove 130. It is possible to omit the groove 130, thus causing the rim 128 to strike upon the top surface of the driving head 54 if such an impact driving action is desired. It is preferable, in my opinion, to include the shock-damping groove 130 to increase the operating life of the various parts.

If the pile is being driven into softer soil or sedimentary material, a larger downward motion of the driving head 54 occurs during the first driving thrust; whereas, if the pile is being driven into harder soil or more resistant strata, then the downward motion of the driving head 54 is lesser during this first driving thrust. Accordingly, when the pile is being driven into such harder material, the weight 12 tends to jump higher and consequently an increased force tends to occur during the second driving thrust, because the weight 12 has fallen from a somewhat greater height in the housing 14.

There are a plurality of vertically elongated guide shoes 142 and 144 at spaced positions around the lower and upper ends, respectively, of the massive weight 12. For example, there are six each of these guide shoes 142 and 144. Their lower and upper ends are tapered as indicated at 145. The outer surfaces of these shoes 142 and 144 are covered with wear runners 146 of bearing material. For example, when the cylindrical housing 14 is made of steel, the wear runners 146 are made of bronze bearing material. Thus, these runners 146 absorb most of the wearing action, and they are removed and replaced on the shoes 142 and 144 when they become worn out.

Alternatively, the runners 146 can be made of extremely hard wear resistant material. In this latter case, the housing 14 absorbs most of the wear and is replaced when it becomes worn out.

As shown in FIG. 8, the slack loops in the lines 18A, 70A and multiple lines 104 accommodate the upward movement of the standpipe 80 which occurs during each cycle of operation of the pile driver.

In the modified embodiment 10A of the pile driver of the present invention, the slack flexible lines and hoses 18A, 70A and 104 and associated components are replaced by an end portion 80A of the standpipe 80 which extends into a stationary cylindrical manifold 110A. This manifold 110A is held in place by a plurality of radial struts 150 and 152. The lower and upper struts 150 and 152, respectively, are attached as by welding to the removable sleeve 114. A seal ring 154 is mounted in watertight relationship in the lower end of the manifold 110A and has a sealing element 156 surrounding and engaging the standpipe 80-80A in sliding relationship. A second seal ring 158 is mounted watertight in the upper end of the manifold 110A with a sealing element 160 slidably engaging the standpipe 80-80A.

Water is fed into the manifold 110A from the large diameter hose 112. A plurality of ports 162 drilled in

the standpipe extension 80A permit the water to flow from the annular chamber 164 within the stationary manifold 110A into the standpipe 80-80A.

The length of the stationary manifold 110A between the first and second sealing rings 154 and 158 is sufficient to enable full travel of the movable standpipe 80-80A to occur without permitting the ports 162 to move outside of the chamber 164. The end cap 86 seals the upper end of the standpipe extension 80A.

In FIG. 11, there is shown a second embodiment 10B of the pile driver of the present invention in which an enclosure 170 is connected to the top of the housing 14. This pile driver 10B is particularly adapted for driving operations carried out in the air, although it is possible to use this pile driver partially or completely under water.

The enclosure 170 serves to catch the water which is expelled up through the clearance space 172 around the massive weight 12. The water which is caught travels out from the enclosure 170 through a large flexible hose line 174 extending to a water-air separator 176 positioned remotely from the pile driver 10B. The hose line 174 has sufficient diameter to provide plenty of room for the air and water to rush out from the enclosure 170. After the water has been separated from the air, the air is discharged back into the atmosphere through an outlet 178, while the water feeds through a line 180 extending to a reservoir 182. A pump 184 connected to the reservoir feeds the water through the hose line 112 back to the pile driver.

It is to be understood that the enclosure 170 can be used with either the embodiment of the pile driver 10, shown in FIG. 7, or the modified embodiment 10A, shown in FIG. 10. The enclosure 170 as sufficient headroom to permit the full extent of upward travel of the standpipe 80 to occur without interference.

FIG. 12 shows the pile driver 10 or 10A of this invention being used to drive a long hollow pipe pile 15. The adapter 66A connected to the lower end of the pile driver has an outwardly extending flange 186 which engages down upon an annular shoulder 188 secured to the interior of the pile 15. It is to be appreciated that the pile 15 being driven may have an interior diameter up to 10 or more feet. The annular shoulder 188 is secured in position by welding which can be accomplished on land in preparation for the driving operation by a man crawling into the interior of the pipe to weld the shoulder 188 in place. Thus, it will be understood that the shoulder 188 may be located at any appropriate position within the pile 15. For driving very long piles, such as those having a length of several hundred feet, the driving operation can be facilitated by locating the annular shoulder 188 near the longitudinal center point of the pile, such as shown in FIG. 12. The pile driver is lowered by the cable 68 into the pile until the flange 186 engages the annular shoulder 188. Then, the high pressure gas supply to line 18A and the water supply to hose 112 are turned on, and the pile driving operation is commenced.

Inviting attention back to FIG. 2, there are a plurality of relatively small passages 190 communicating with the top end of the discharge chamber 30. These passages permit the in-flow of water entering chamber 30 from passages 78 to purge out any air (or other gas) remaining in the chamber 30 after the weight 12 has dropped down to its initial position. After the purging has occurred so that the chamber 30 is again substan-

tially full of water to submerge the airgun 16, the cycle is ready to be repeated by again firing the airgun. These passages 190 are relatively small so that they do not permit the escape from chamber 30 of much of the pressurized gas released therein by the airgun.

The movable impulse transmitting member 52 is retained in the lower end of the housing 14 by a flange 192 which is positioned above a stop shoulder 194 secured in the lower end of the housing. The multiple vent holes 196 allow escape of water from between the flange 192 and the stop shoulder 194 when the member 52 is being driven down.

The various embodiments of the pile drivers of the present invention are particularly well adapted for driving enormous piles into the earth, either totally submerged or partially submerged or on land.

The massive weight 12 may, for example, lie in the range from 10,000 lbs. up to a quarter of a million pounds. The airgun repeater 16 may, for example, have a chamber volume from 300 cubic inches up to 10 cubic feet.

In the illustrative embodiment of FIG. 1, the weight 12 is of steel having a length of 20 feet and a diameter of 2 feet and weighs in the order of approximately 28,000 pounds. The chamber wall 28 is of solid steel 4 inches thick and having an inside diameter of approximately 14 inches. The airgun repeater 16 has a volume of 1,000 to 2,000 cubic inches.

I claim:

1. An airgun repeater powered pile driver capable of being operated totally submerged, partially submerged or in air comprising an elongated cylindrical housing, an elongated cylindrical weight positioned entirely within this housing and movable up and down therein, said housing being longer than said cylindrical weight for permitting said weight to remain entirely therein while it moves up and down, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein for suddenly and repeatedly releasing pressurized gas into said discharge chamber, said wall having a small diameter passage extending therethrough communicating with the top end of the discharge chamber, means for feeding water into said discharge chamber for purging the gas out through said small diameter passage, said cylindrical wall having a lower rim, an impulse transmitting driving head movably mounted in the lower end of said housing beneath said rim, and an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said sleeve extending upwardly around said strong wall to the level of said small diameter passage when said strong wall is fully telescoped within said sleeve with said rim engaging down against said driving head.

2. An airgun repeater powered pile driver capable of operating totally submerged, partially submerged, or in air, comprising an elongated cylindrical housing, an elongated cylindrical weight positioned within this housing and movable up and down therein, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein for

suddenly and repeatedly releasing pressurized gas into said discharge chamber, said pile driver including means for admitting water into said discharge chamber and for permitting the escape of the gas therefrom, said cylindrical wall having a lower rim, an impulse transmitting driving head movably mounted in the lower end of said housing beneath said rim, and an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said cylindrical sleeve having an upward sleeve extension above it with an inner surface which progressively slopes outwardly in an upward direction providing an increasing clearance space between said rim and the outwardly sloping surface of said upward sleeve extension when said massive weight and strong wall are moving upwardly.

3. The airgun powered pile driver as claimed in claim 2, in which said outwardly sloping surface of said upward sleeve extension is conical with an outward upward flare.

4. An airgun repeater powered pile driver capable of operating totally submerged, partially submerged, or in air, comprising an elongated cylindrical housing, an elongated cylindrical weight positioned within this housing and movable up and down therein, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein for suddenly and repeatedly releasing pressurized gas into said discharge chamber, said pile driver including means for admitting water into said discharge chamber and for permitting the escape of the gas therefrom, said cylindrical wall having a lower rim, an impulse transmitting driving head movably mounted in the lower end of said housing beneath said rim, and an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said driving head having an annular groove therein engageable by said rim of said strong wall, said groove being adapted to retain water therein for providing a shock absorbing dashpot action when said rim impacts down into said groove.

5. An airgun repeater powered pile driver capable of operating submerged, partially submerged or in air comprising an elongated cylindrical housing, an elongated cylindrical weight positioned within this housing and movable up and down therein, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein to repeatedly abruptly release high pressure gas in said discharge chamber, said cylindrical wall having a lower rim, an impulse transmitting driving head movably mounted in the lower end of said housing beneath said rim, an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said weight having a central passage extending down therein, said weight having a plurality of branch passages in its lower end providing communication between the lower end of said central passage and the top of said discharge chamber for introducing water into said discharge

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chamber, said pile driver including means for removing the released gas from said discharge chamber, and a ring shaped check valve adapted to engage up against the lower end of said weight to block said branch passages when the high pressure gas is abruptly released in said discharge chamber.

6. An airgun repeater powered pile driver capable of operating totally submerged, partially submerged, or in air comprising an elongated cylindrical housing, an elongated cylindrical weight positioned within this housing and movable up and down therein, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein to repeatedly abruptly discharge high pressure gas into said discharge chamber, said cylindrical wall having a lower rim, an impulse transmitting driving head movably mounted in the lower end of said housing beneath said rim, an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said weight having a passage extending downwardly therethrough, a pipe connected to the top of said weight and extending upwardly therefrom, said pipe communicating with said passage, a stationary liquid supply manifold mounted on said housing, at least one slack flexible hose extending from the upper end of said pipe to said manifold for supplying liquid into the discharge chamber, and said pile driver including means for releasing the discharged gas from the discharge chamber.

7. An airgun repeater powered pile driver as claimed in claim 6, including an enclosure connected to the upper end of said housing for catching liquid expelled from said housing, a flexible hose extending from said enclosure, gas-liquid separator means connected to said hose, pump means for receiving the separated liquid, and a second hose line extending from said pump means to said stationary liquid supply manifold.

8. An airgun repeater powered pile driver comprising an elongated cylindrical weight, a strong cylindrical wall being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein, said cylindrical wall having a lower rim, an impulse transmitting driving head positioned beneath said rim and being adapted to be coupled to a pile to be driven, said weight having a passage extending downwardly therethrough for feeding liquid into said discharge chamber, a pipe connected to the top of said weight and extending upwardly therefrom, said pipe

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communicating with said passage, a stationary liquid supply manifold mounted on said housing, and at least one slack flexible hose extending from the upper end of said pipe to said manifold.

9. An airgun repeater powered pile driver capable of operating totally submerged, partially submerged or in air comprising an elongated cylindrical weight, a strong wall having an outer cylindrical surface and being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein for abruptly and repeatedly releasing a charge of high pressure gas into the discharge chamber, said cylindrical wall having a lower rim, an impulse transmitting driving head positioned beneath said rim adapted to be coupled to a pile to be driven, and an upstanding cylindrical sleeve connected to said driving head and extending upwardly therefrom in closely spaced telescoping relationship surrounding the outer cylindrical surface of said strong wall, said cylindrical weight having a passage extending vertically therethrough for feeding liquid into said discharge chamber, a pipe attached to the top of said weight and extending upwardly therefrom, means for feeding liquid into said pipe coupled to the top of said pipe and means for removing the released gas from the discharge chamber.

10. An airgun repeater powered pile driver capable of operating totally submerged, partially submerged, or in air comprising an elongated cylindrical weight, a strong cylindrical wall being attached to the lower end of said weight and extending downwardly therefrom defining a discharge chamber adapted to have an airgun repeater mounted therein for abruptly and repeatedly discharging high pressure gas into the discharge chamber, said cylindrical wall having a lower rim, an impulse transmitting driving head positioned beneath said rim and being adapted to be coupled to a pile to be driven, said weight having a passage extending downwardly therethrough for feeding liquid into said discharge chamber, a pipe connected to the top of said weight and extending upwardly therefrom, said pipe communicating with said passage, a stationary liquid supply manifold surrounding the upper end of said pipe and having first and second spaced sealing means slidably engaging said pipe and defining a manifold chamber in said manifold surrounding said pipe, said pipe having at least one opening therein providing communication between said manifold chamber and the interior of said pipe for feeding liquid into said pipe, and means associated with the discharge chamber for removing the discharged gas from the chamber.

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