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White

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(54) PILE DRIVING SYSTEMS AND METHODS EMPLOYING PRELOADED DROP HAMMER

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(73) Assignee: **American Piledriving Equipment, Inc.**, Kent, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 226 days.

(21) Appl. No.: **12/683,383**

(22) Filed: **Jan. 6, 2010**

(65) **Prior Publication Data**

US 2011/0162859 A1 Jul. 7, 2011

(51) **Int. Cl.**

E02D 7/14	(2006.01)
E02D 7/06	(2006.01)
E02D 7/12	(2006.01)

(52) **U.S. Cl.**

CPC ***E02D 7/125*** (2013.01)
USPC .... **173/1**; 173/89; 173/132; 173/200; 173/204; 173/206; 173/212; 173/138; 91/417 R; 91/408

(58) **Field of Classification Search**

USPC .... 173/1, 89, 132, 200, 204, 206, 212, 173/138; 91/417 R, 408; 405/228
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Michael R. Schacht; Schacht Law Office, Inc.

(57) **ABSTRACT**

A pile driving system for driving a pile. The pile driving system comprises a housing assembly, a hammer, a helmet member, and a lifting system. The housing assembly defines at least one vent opening is arranged at a first vent location along the drive axis, and at least one vent opening is arranged at a second vent location along the drive axis. When the hammer drops and is above the first vent location, ambient air flows from the main chamber through the vent openings formed at the first and second vent locations. When the hammer is below the first vent location and above the second vent location, ambient air flows from the main chamber through the vent openings formed at the second vent location. When the hammer is below the second vent location, air within the main chamber is compressed to preload the helmet member.

17 Claims, 7 Drawing Sheets

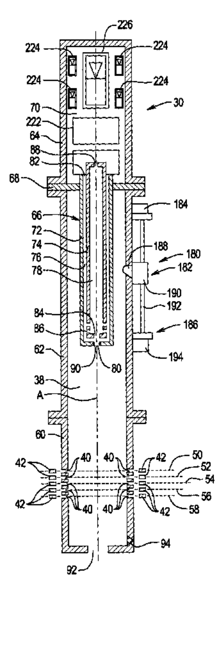

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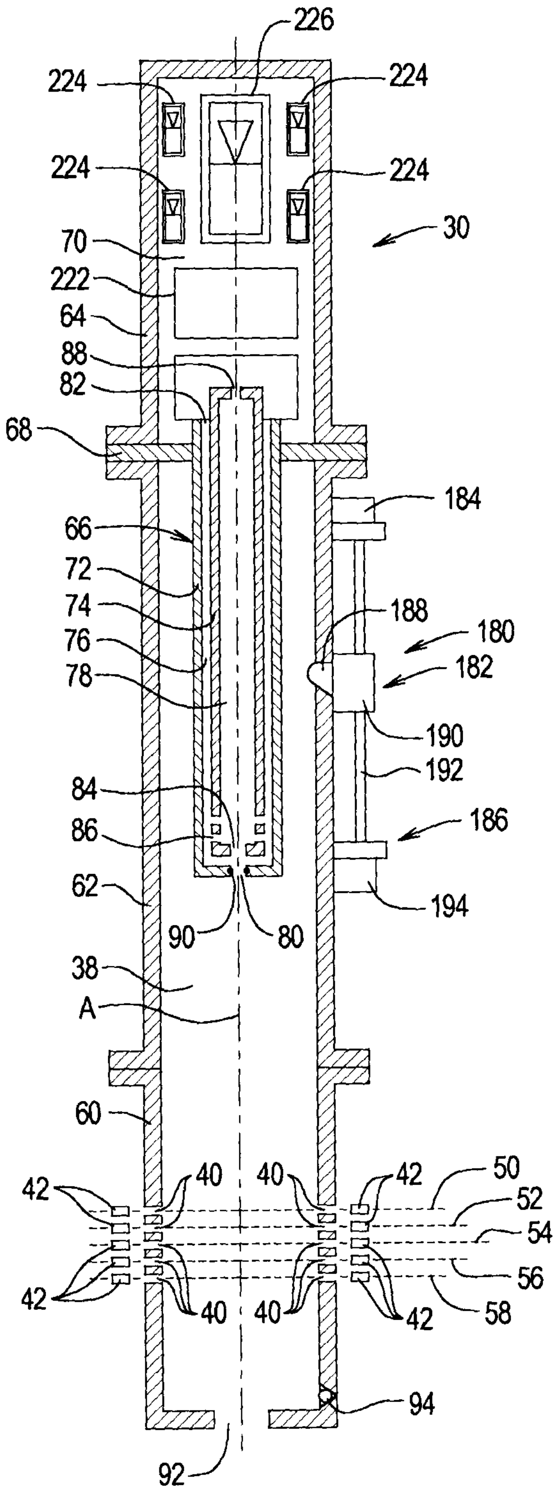
FIG. 1



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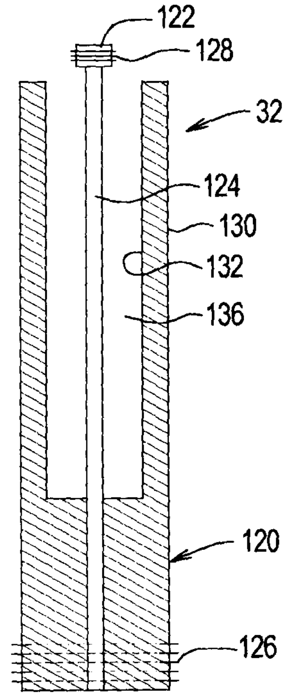

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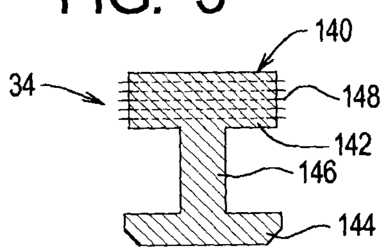

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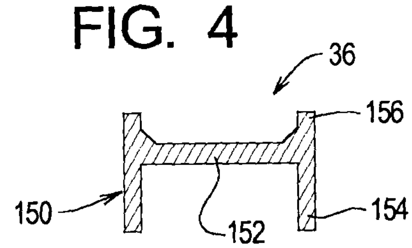

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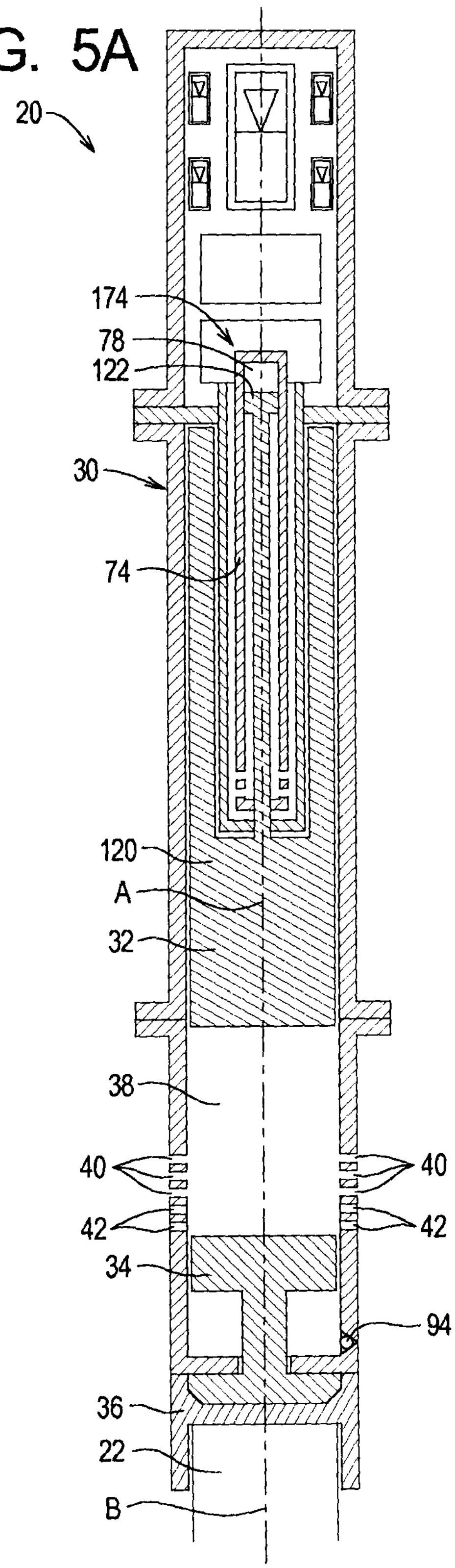
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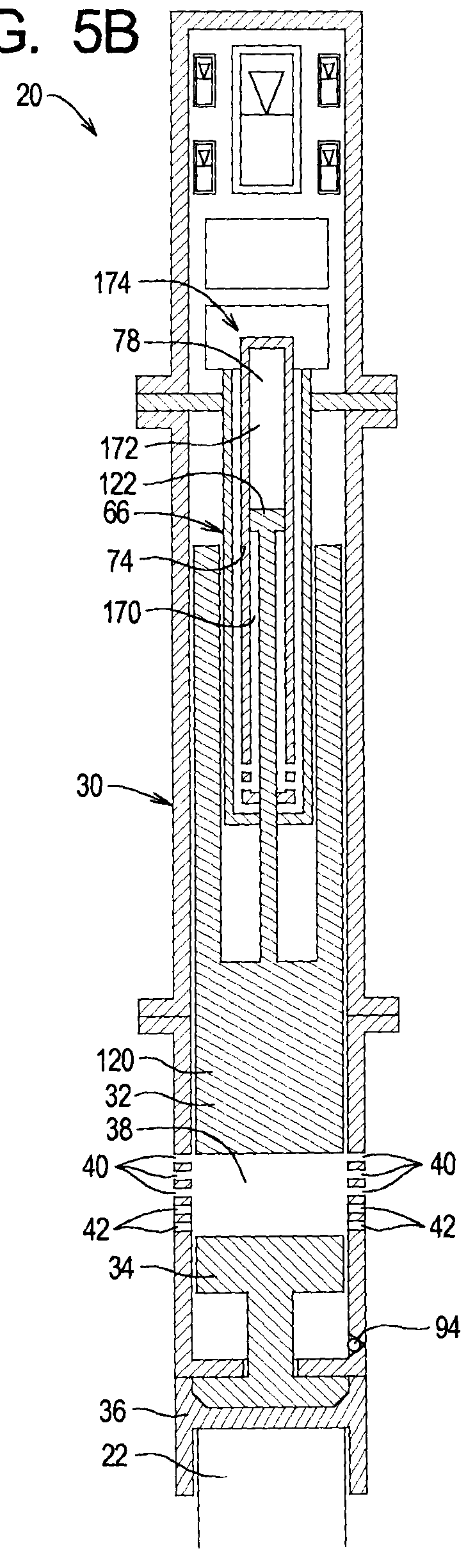
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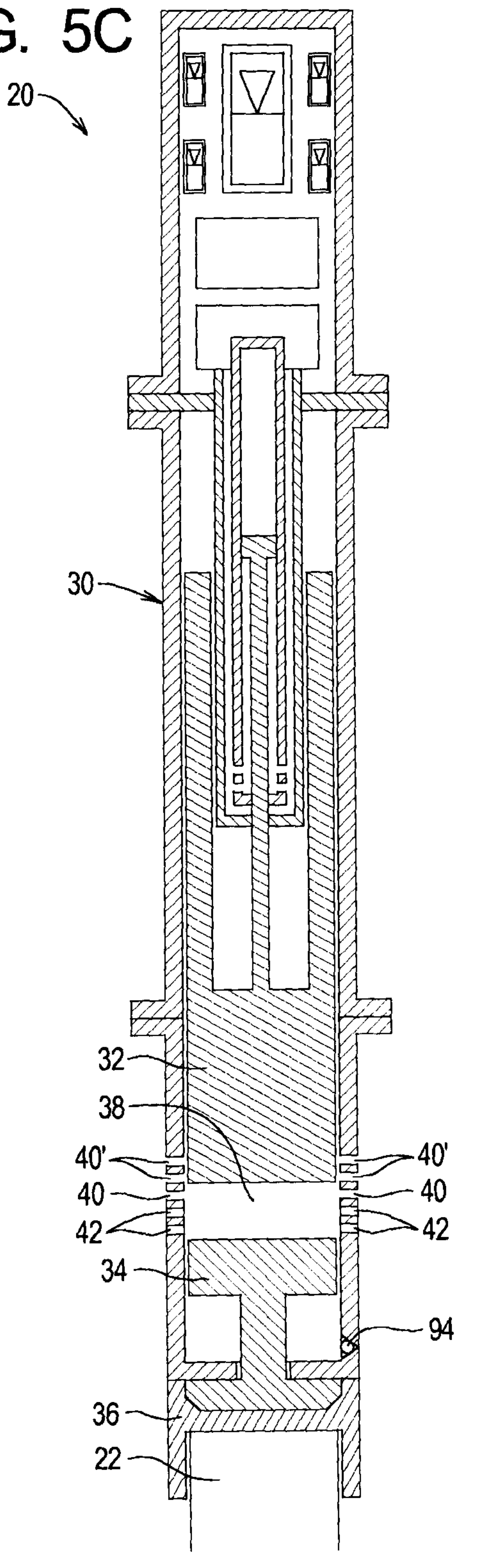
FIG. 5C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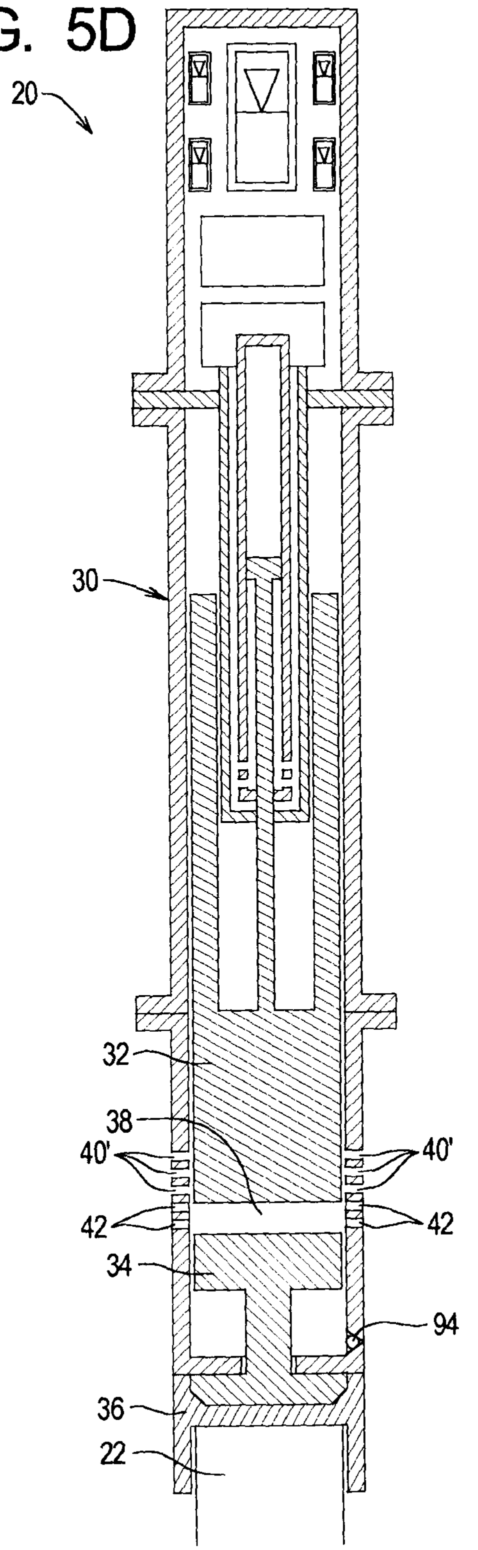
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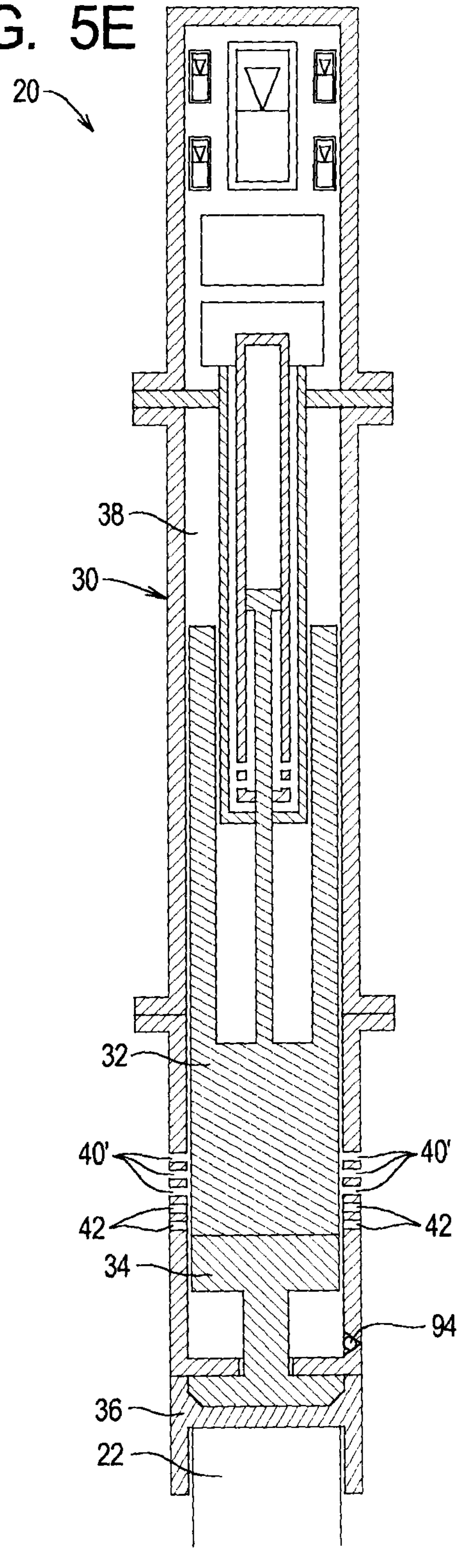

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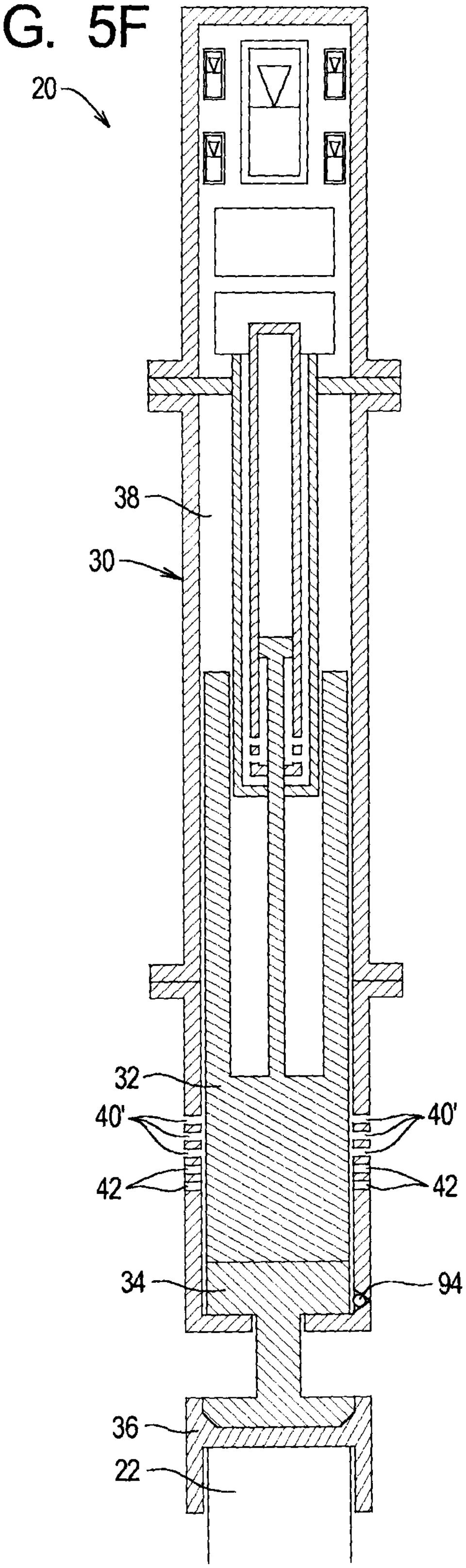

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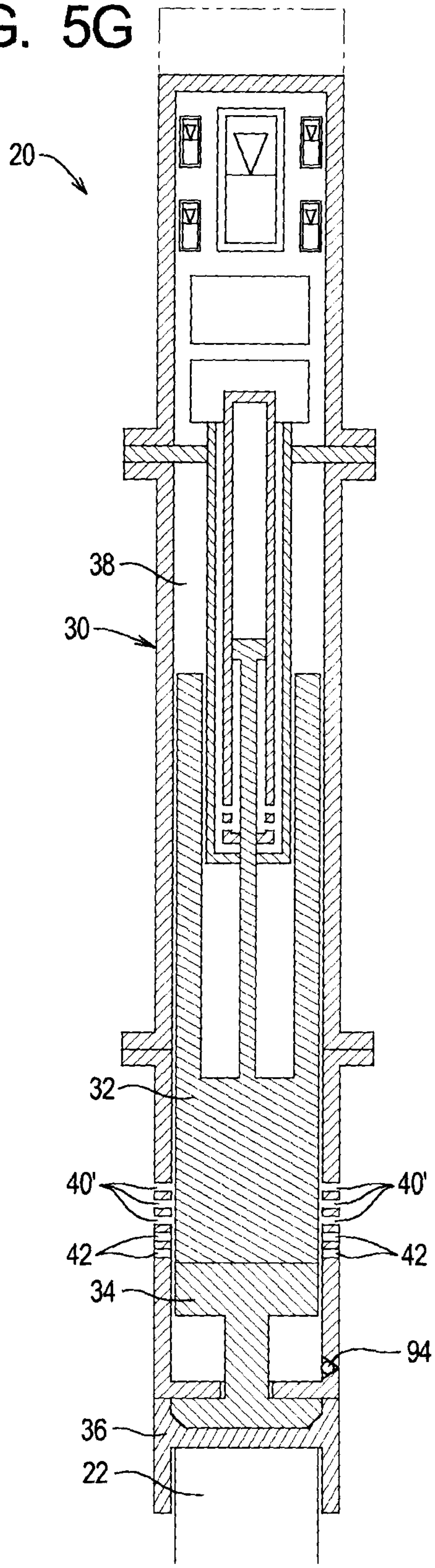


FIG. 5H

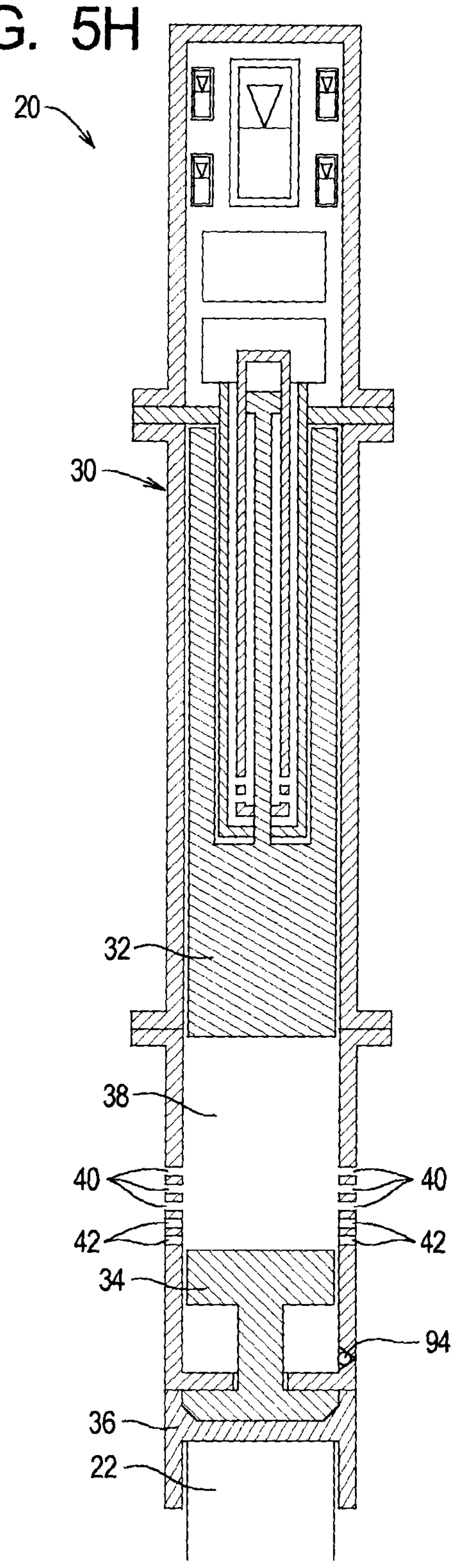
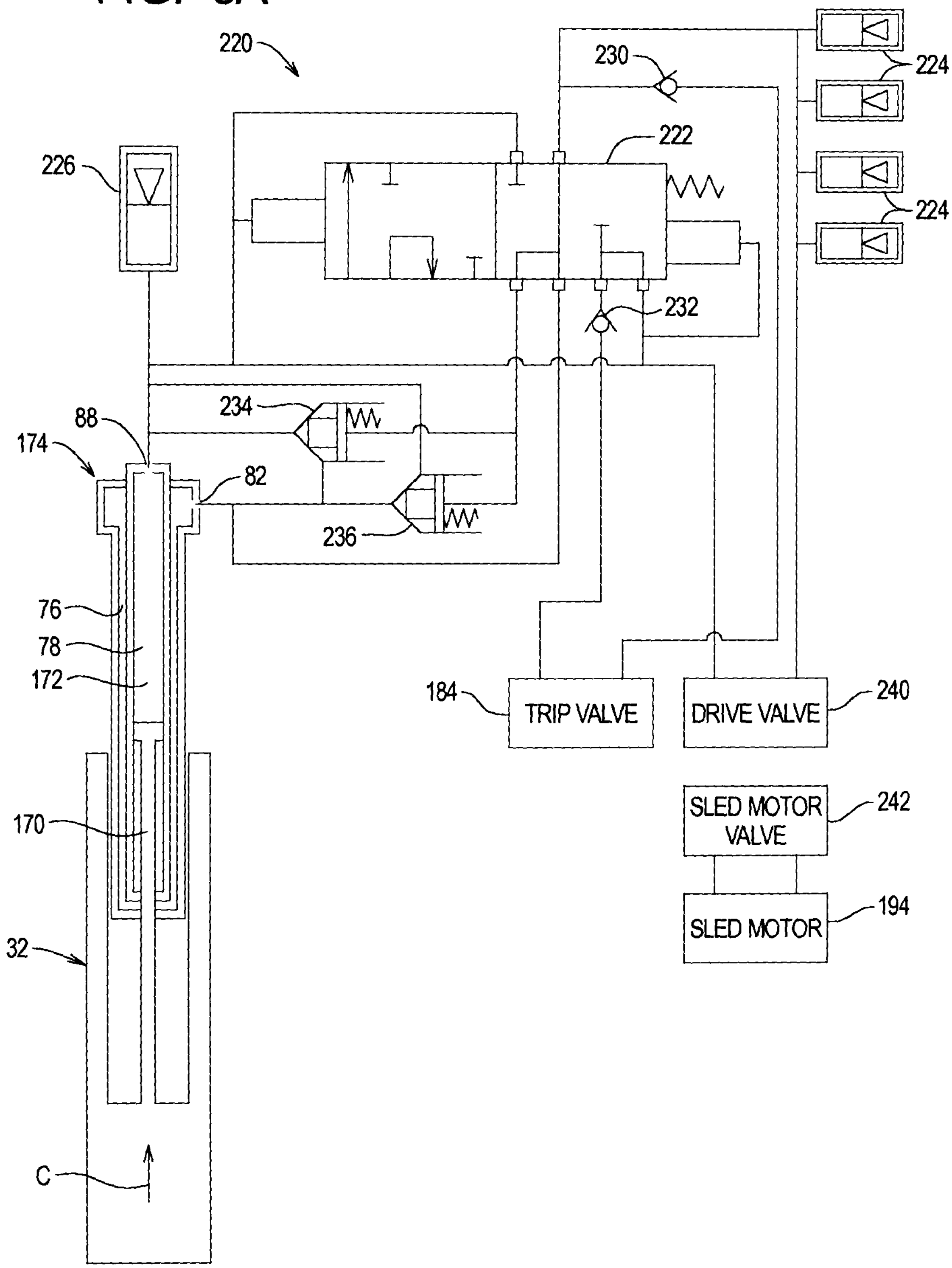


FIG. 6A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SLED MOTOR
194
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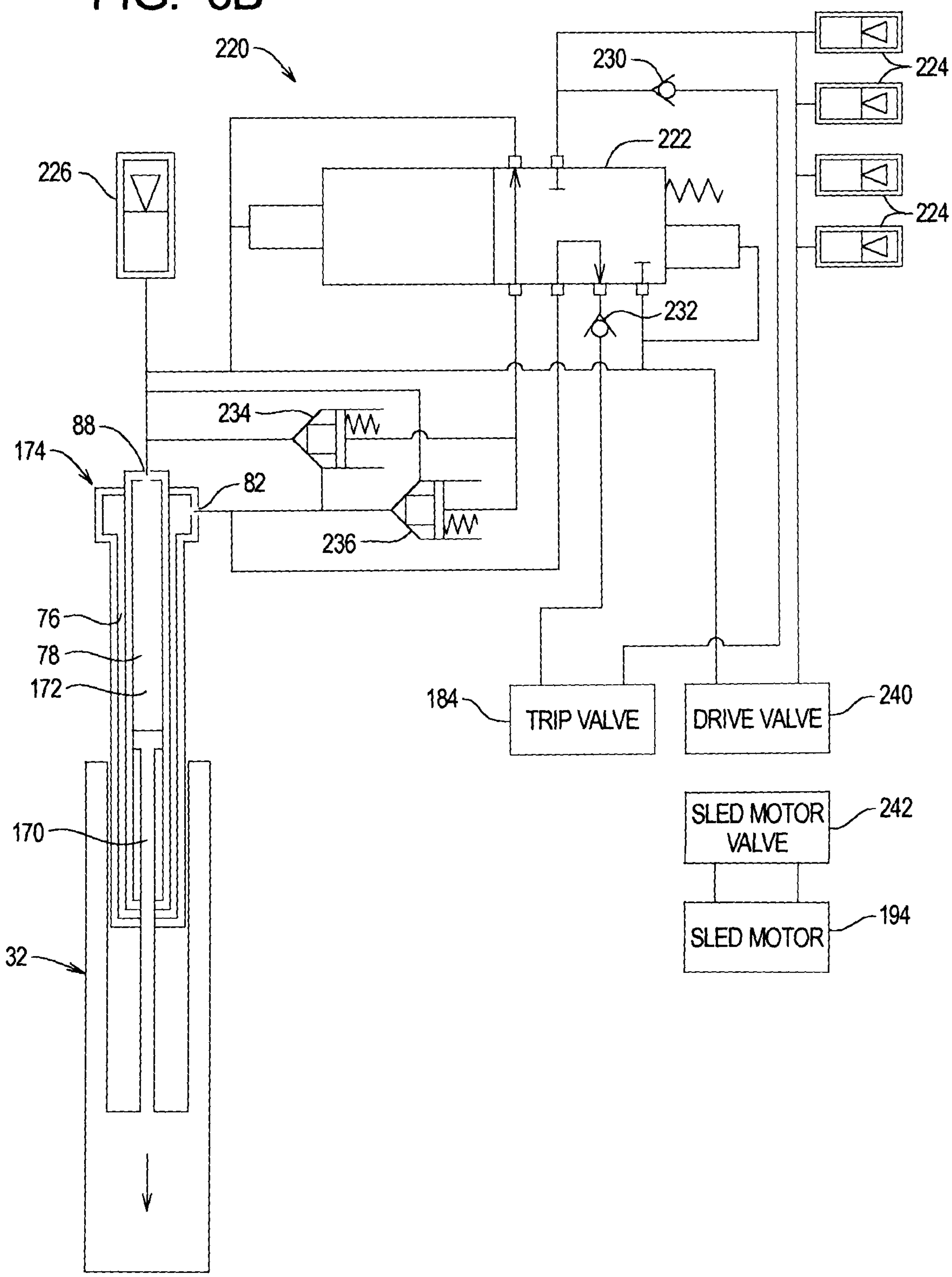
C

FIG. 6B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SLED MOTOR VALVE
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170
SLED MOTOR
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32

PILE DRIVING SYSTEMS AND METHODS EMPLOYING PRELOADED DROP HAMMER

TECHNICAL FIELD

The present invention relates to methods and apparatus for inserting elongate members into the earth and, more particularly, to drop hammers that create pile driving forces by lifting and dropping a hammer to apply a driving force to the top of a pile.

BACKGROUND OF THE INVENTION

For certain construction projects, elongate members such as piles, anchor members, caissons, and mandrels for inserting wick drain material must be placed into the earth. It is well-known that such rigid members may often be driven into the earth without prior excavation. The term "piles" will be used herein to refer to the elongate rigid members typically driven into the earth.

One system for driving piles is conventionally referred to as a diesel hammer. A diesel hammer employs a floating ram member that acts both as a ram for driving the pile and as a piston for compressing diesel fuel. Diesel fuel is injected into a combustion chamber below the ram member as the ram member drops. The dropping ram member engages a helmet member that transfers the load of the ram member to the pile to drive the pile. At the same time, the diesel fuel ignites, forcing the ram member and the helmet member in opposite directions. The helmet member further drives the pile, while the ram member begins a new combustion cycle. Another such system is a drop hammer that repeatedly lifts and drops a hammer onto an upper end of the pile to drive the pile into the earth.

Diesel hammers seem to exhibit fewer problems with tension cracking in concrete piles and pile driving helmets than similarly configured external combustion hammers. The Applicant has recognized that the combustion chambers of diesel hammers pre-load the system before the hammer impact and that this preloading may explain the reduction of tension cracking in concrete piles associated with diesel hammers.

The need thus exists for improved drop hammers that induce stresses in the pile driven that are similar to the stresses induced by diesel hammers.

SUMMARY OF THE INVENTION

The present invention may be embodied as a pile driving system for driving a pile comprising a housing assembly, a hammer, a helmet member, and a lifting system. The housing assembly defines a drive axis, a main chamber, and a plurality of vent openings that allow fluid to flow into and out of the main chamber. At least one vent opening is arranged at a first vent location along the drive axis, and at least one vent opening is arranged at a second vent location along the drive axis. The second vent location is spaced along the drive axis from the first vent location. The hammer supported within the main chamber for movement relative to the housing assembly between an upper position and a lower position. The first and second vent locations are located between the upper and lower positions. The helmet member is supported by the housing assembly for movement relative to the housing assembly between a first position and a second position. The lifting system displaces the hammer from the lower position to the upper position during each cycle. When the hammer drops and is above the first vent location, ambient air flows from the main chamber through the vent openings formed at the first and second vent locations. When the hammer drops and is below the first vent location and above the second vent location, ambient air flows from the main chamber through the vent openings formed at the second vent location. When the hammer drops and is below the second vent location, air within the main chamber is compressed to preload the helmet member prior to contact between the hammer and helmet member.

The present invention may also be embodied as a method of driving a pile comprising the following steps. A housing assembly defining a drive axis and a main chamber is provided. At least one vent opening is formed in the housing at a first vent location along the drive axis. At least one vent opening is formed at a second vent location along the drive axis. The second vent location is spaced along the drive axis from the first vent location. A hammer is supported at least partly within the main chamber for movement relative to the housing assembly between an upper position and a lower position; the first and second vent locations are located between the upper and lower positions. A helmet member is supported for movement relative to the housing assembly between a first position and a second position. The hammer is displaced from the lower position to the upper position during each cycle.

Ambient air is allowed to flow from the main chamber through the vent openings formed at the first and second vent locations when the hammer is moving down and is above the first vent location. Ambient air is allowed to flow from the main chamber through the vent openings formed at the second vent location when the hammer is moving down and is below the first vent location and above the second vent location. Air within the main chamber below the hammer is compressed to preload the helmet member prior to contact between the hammer and helmet member when the hammer is below the second vent location.

The present invention may also be embodied as a pile driving system for driving a pile comprising a housing assembly defining a drive axis, a main chamber, and a plurality of vent openings that allow fluid to flow into and out of the main chamber. At least one vent opening is arranged at a first vent location along the drive axis. At least one vent opening is arranged at a second vent location along the drive axis; the second vent location is spaced along the drive axis from the first vent location. At least one of a plurality of plugs is engaged with at least one of the vent openings to obtain a desired compression profile. A hammer is supported within the main chamber for movement relative to the housing assembly between an upper position and a lower position; the first and second vent locations are located between the upper and lower positions. A helmet member is supported by the housing assembly for movement relative to the housing assembly between a first position and a second position. The lifting system displaces the hammer from the lower position to the upper position during each cycle.

When the hammer drops and is above the first vent location, ambient air flows from the main chamber through the vent openings formed at the first and second vent locations according to the compression profile. When the hammer drops and is below the first vent location and above the second vent location, ambient air flows from the main chamber through the vent openings formed at the second vent location according to the compression profile. When the hammer drops and is below the second vent location, air within the main chamber is compressed to preload the helmet member prior to contact between the hammer and helmet member according to the compression profile.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a somewhat schematic section view of an example housing assembly of a pile driving system of the present invention;

FIG. **2** is a somewhat schematic section view of an example hammer assembly of a pile housing assembly of the present invention;

FIG. **3** is a front elevation view of an example anvil assembly of a pile driving system of the present invention;

FIG. **4** is a section view of an example helmet of pile driving system of the present invention;

FIGS. **5**A-**5**H are somewhat schematic views of an example pile driving system of the present invention illustrating an example operation cycle; and

FIGS. **6**A and **6**B are schematic drawings illustrating first and second operating modes of a hydraulic system that may be used as part of a pile driving system of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Turning initially to the drawing, depicted in FIGS. **5**A-**5**H therein is a pile driving system **20** constructed in accordance with, and embodying, the principles of the present invention. As shown in FIGS. **5**A-**5**H, the pile driving system **20** is configured to drive a pile **22**. The example pile driving system **20** comprises a housing assembly **30** (FIG. **1**), a hammer assembly **32** (FIG. **2**), an anvil assembly **34** (FIG. **3**), and a helmet assembly **36** (FIG. **4**).

FIG. **5**A illustrates that the pile driving system **20** defines a drive axis A (also shown in FIG. **1**) and that the drive axis A is aligned with a pile axis B defined by the pile **22**. FIG. **1** illustrates that the housing assembly **30** defines a main chamber **38**, while FIG. **5**A further illustrates that housing assembly **30** supports the hammer assembly **32** within the main chamber **38**. The anvil assembly **34** is partly disposed within the main chamber **38** and is thus supported by the housing assembly **30**. The helmet assembly **36** is placed on top of the pile **22** and is adapted to engage the anvil assembly **34**. The hammer assembly **32**, anvil assembly **34**, helmet assembly **36**, and pile **22** all are capable of moving relative to the housing assembly **30** along the drive axis A.

As perhaps best shown in FIG. **1**, at least one vent opening **40** is arranged in a plurality (two or more) of spaced vent locations along the drive axis A. FIG. **1** also shows that the housing assembly **30** further comprises a plurality of vent plugs **42** that may be used to close any of the vent openings **40**. The example vent openings **40** are threaded holes formed in the housing assembly **30**. The example vent plugs **42** are threaded to mate with the threaded vent openings **40**. Threading one of the vent plugs **42** into one of the vent openings **40** substantially prevents fluid such as air from flowing through the plugged vent opening **40**.

FIG. **1** illustrates that the vent openings **40** of the example housing assembly **30** are arranged or formed at a first vent location **50**, a second vent location **52**, a third vent location **54**, a fourth vent location **56**, and a fifth vent location **58**; these vent locations **50**-**58** are spaced from each other along the drive axis A. Typically, a plurality of the vent openings **40** are angularly spaced around the circumference of the housing assembly **30** at each of the vent locations **50**-**58**.

Accordingly, the vent openings **40** and plugs **42** can be used as will be described in further detail below to control the flow of fluids, and in particular air, into and out of the main chamber **38** defined by the housing assembly **30**. By controlling the flow of fluids into and out of the main chamber **38** at different axially spaced vent locations, the pile driving system **20** allows the operator to vary a pre-strike load applied on the anvil assembly **34**, helmet assembly **36**, and pile **22**.

During operation, the pile driving system **20** moves through an operating cycle as will now be described with reference to FIGS. **5**A-**5**H. When operating, the drive axis A of the pile driving system **20** is typically substantially vertical, but may be canted or angled slightly with respect to vertical depending upon the nature and use of the particular pile being driven. In the following discussion, the drive axis A will be considered substantially upright or vertical, and any directional terms should be read in the context of a substantially vertical or upright drive axis A as depicted and described.

In a pre-drop mode, the hammer assembly **32** is in a raised position relative to the housing assembly **30**. The anvil assembly **34** is in a pre-strike position relative to the housing assembly **30** when the pile driving system **20** is in the pre-drop mode.

When the pile driving system **20** is in a free-fall mode, the hammer assembly **32** falls from the raised position (FIG. **5**A) to a first intermediate position (FIG. **5**B). While the hammer assembly **32** falls from the raised position to the first intermediate position, air below the hammer assembly **32** flows freely out of one or more of the unplugged vent openings **40** formed in the housing assembly **30**. As described above, air will not flow out of any vent opening **40** plugged by one of the vent plugs **42**.

When the hammer assembly **32** is above the first intermediate position, air is able to flow out of all unplugged vent openings **40**. The cumulative cross-sectional area of the uncovered and unplugged openings **40** in the pre-compression mode is at a maximum when the system **20** is in the free-fall mode. The operator will typically leave enough vent openings **40** unplugged such that the hammer assembly **32** free-falls. The term "free-fall" is thus used herein to refer to a situation in which resistance to downward movement of the hammer assembly **32** by fluids such as air below the hammer assembly **32** is negligible. Therefore, in the free-fall mode compression of air within the main chamber **38** below the hammer assembly **32** is negligible.

Referring now to FIG. **5**C, the pile driving system **20** is depicted in a pre-compression mode in which the pressure of air within the main chamber **38** below the hammer assembly **32** begins to increase. In the pre-compression mode, the hammer assembly **32** blocks passage of air through one or more of the unplugged vent openings **40**. However, at least some of the vent openings **40** are still uncovered and unplugged, so air within the main chamber **38** below the hammer assembly **32** is able to flow out of the main chamber **38** through any such uncovered and unplugged vent ports, but such flow is restricted in comparison with the free-fall mode. Unplugged but covered vent openings are identified using the reference character **40'** in the drawings.

The cumulative cross-sectional area of the uncovered and unplugged vent ports in the pre-compression mode is less than that of the unplugged ports in the free-fall mode. In the pre-compression mode, fluids such as air within the hammer assembly **32** begin to compress because the flow through the vent openings **40** is restricted. Accordingly, in the pre-compression mode, pressure within the main chamber **38** below the hammer assembly **32** increases, causing the anvil assembly **34** and the helmet assembly **36** to move towards the pile **22**.

As the hammer assembly **32** moves in the pre-compression mode between the positions depicted in FIGS. **5**B and **5**D, the cumulative cross-sectional area of the vent openings **40** through which fluids may pass gradually decreases.

As the hammer assembly **32** continues to fall, the pile driving system **20** enters a compression mode as shown in FIG. **5**D. In the compression mode, the hammer assembly **32** passes and thus covers all unplugged vent openings **40**, preventing flow of air out of the main chamber **38** through any of the vent openings **40**. Accordingly, in the compression mode, the fluids within the main chamber **38** below the hammer assembly **32** can only compress, significantly increasing the pressure within this portion of the main chamber **38**. Increased pressure within the main chamber **38** below the hammer assembly **32** causes the anvil assembly **34** and the helmet assembly **36** to move towards and tighten against the pile **22**.

The hammer assembly **32** continues to fall, eventually completely compressing the air within the main chamber **38** below the hammer assembly **32** and striking the anvil assembly **34** as shown in FIG. **5**E. The pile driving system **20** enters a drive mode when the hammer assembly **32** comes into contact with the anvil assembly **34**. By the time the hammer assembly **32** strikes the anvil assembly **34**, the compressed fluids within the main chamber **38** have fully tightened the anvil assembly **34** against the helmet assembly **36** and the helmet assembly **36** against the pile **22**.

Continued downward movement of the hammer assembly **32** in the drive mode is transferred through the anvil assembly **34** and the helmet assembly **36** to the pile **22**, displacing the pile **22** as shown by a comparison of FIGS. **5**E and **5**F. The anvil assembly **34** is in an upper position relative to the housing assembly **32** at the beginning of the drive mode (FIG. **5**E) and in a lower position relative to the housing assembly **32** at the end of the drive mode (FIG. **5**F) at the beginning of the drive mode.

As shown in FIGS. **5**G and **5**H, the pile driving system **20** next enters a return mode in which the hammer assembly **32** is returned into the pre-drop mode relative to the housing assembly **30**. As the hammer assembly **32** raises, the anvil member **34** moves from the lower position to the upper position as shown in FIG. **5**G. In FIG. **5**H, the pile driving system **20** is depicted in the same pre-drop mode depicted in FIG. **5**A, except that the pile **22** on which the pile driving system **20** rests has been displaced downwardly.

The use of a compression mode aligns the anvil assembly **34** and helmet assembly **36** with the pile **22** and also removes almost all play or slop between these various components before the hammer assembly **32** strikes the anvil assembly **34**. When the hammer assembly **32** eventually strikes the anvil assembly **34**, noise is reduced. Further, damage to the helmet assembly **36** and pile **22** is also reduced because the driving forces are applied to the helmet assembly **36** and pile **22** in a manner that reduces resonant vibrations, and the resulting stresses within the materials forming the helmet assembly **36** and the pile **22**.

The use of a pre-compression mode allows the operator to tune or adjust the pile driving system **20** for a particular pile type and soil conditions. And the use of provision of vent openings **40** located at different vent locations **50**-**58** and vent plugs **42** provides the operator with significantly more flexibility in the tuning or adjusting of the pile driving system **20**. The operator may thus develop a desired compression profile for a particular set of operating conditions by selecting the number and location of vent openings **40** that will be plugged or will remain unplugged. The desired compression profile can be created by an operator empirically onsite or can be calculated in advance.

Referring now to FIGS. **1**-**5**, **6**A, and **6**B, the details of construction and operation of the example pile driving system **20** will be explained in further detail. As shown in FIG. **1**, the housing assembly **30** comprises a first section **60**, a second section **62**, a third section **64**, a cylinder assembly **66**, and a support plate **68**. The first and second sections **60** and **62** are joined together to define the main chamber **38**. The third section **64** is joined to the second section **62** by the support plate **68** to define a hydraulics chamber **70**. The support plate **68** supports the cylinder assembly **66** partly within the main chamber **38** and partly within the hydraulics chamber **70**.

The cylinder assembly **66** comprises an outer cylinder **72** and an inner cylinder **74** coaxially supported to define an outer chamber **76** and a piston chamber **78**. The outer cylinder **72** defines a shaft port **80** and an inlet port **82**. The inner cylinder **74** defines a shaft port **84**, an inlet port **86**, and an exhaust port **88**.

A seal member **90** is arranged at the shaft port **80** defined by the outer cylinder **72**. The first housing section **60** defines the vent openings **40** and an anvil port **92**.

One or more check valves **94** are arranged in the housing assembly **30** at the bottom of the main chamber **38**. The check valves **94** prevent air from exiting the main chamber **38** when the pile driving system **20** is in the compression mode but to allow air to be drawn into the main chamber **38** when the pile driving system **20** is in the return mode.

Turning now to FIG. **2**, the example hammer assembly **32** will now be described in further detail. The example hammer assembly **32** comprises a hammer member **120**, a piston member **122**, a piston shaft **124**, a first set of ring seals **126**, and a piston seal **128**. The hammer member **120** defines an outer surface **130** and an inner surface **132**. The inner surface **132** defines a cylinder cavity **136**. The first set of ring seals **126** is arranged on the hammer member **120**, while the piston seal **128** is arranged on the piston member **122**.

As shown in FIG. **3**, the example anvil assembly **34** comprises an anvil member **140** defining an internal portion **142**, an external portion **144**, and a bridge portion **146**. A second set of ring seals **148** is arranged on the internal portion **142**.

FIG. **4** illustrates that the example helmet assembly **36** comprises a helmet member **150** having a plate portion **152**, a skirt portion **154**, and a flange portion **156**. The skirt portion **154** is configured to receive the upper end of the pile **22**, while the flange portion **156** is adapted to receive the external portion **144** of the anvil member **140**.

FIG. **1** further illustrates that the hydraulic chamber **70** defined by the third section **64** of the housing assembly **30** contains components of a hydraulic drive system as will be described in further detail below.

As indicated by FIGS. **5**A-**5**H, the housing assembly **30** supports the hammer assembly **32** such that the hammer member **120** is within the main chamber **38** and the piston member **122** is within the piston chamber **78** defined by the inner cylinder **74**. As perhaps best shown in FIG. **5**B, the piston member **122** divides the piston chamber **78** into a drive portion **170** and an exhaust portion **172**.

The piston member **122** and cylinder assembly **66** thus form a hydraulic actuator **174** capable of displacing the hammer assembly **32**. To raise the hammer assembly **32**, fluid is forced into the annular outer chamber **76** through the inlet port **82** defined by the outer cylinder **72**. Fluid flowing through the outer chamber **76** flows through the inlet port **86** defined by the inner cylinder **74** and into the drive portion **170** of the piston chamber **78**. Pressurized fluid within the drive portion **170** of the piston chamber **78** acts on the piston member **122** to displace the hammer assembly **32** upward as shown by a comparison of FIGS. **5**G and **5**H.

The example hydraulic actuator **174** is a single acting device that employs gravity to displace the hammer assembly **32** in one direction (downward) and hydraulic fluid to displace the hammer assembly **32** in the opposite direction (upward). To allow gravity to displace the hammer assembly **32**, the pressure on the hydraulic fluid within the drive portion **170** of the piston chamber **78** is removed. To facilitate raising of the hammer assembly **32**, little or no pressure should be exerted on the top of the hammer member **120** within the main chamber **38** or the top of the piston member **122** within the exhaust portion **172** of the piston chamber **78**.

Referring a moment back to FIG. **1**, depicted therein is a trip assembly **180** mounted on the housing assembly **30**. The trip assembly **180** comprises a trip mechanism **182**, a trip valve **184**, and a displacement system **186**. The trip mechanism **182** comprises a trip member **188** capable of engaging the hammer assembly **32** as the hammer assembly **32** moves within the main chamber **38**.

The displacement system **186** comprises a trip sled **190** that supports the trip mechanism **182**, a gear member **192**, and a sled motor **194**. Operation of the sled motor **194** causes of axial rotation of the gear member **192**. The gear member **192** in turn engages the trip sled **190** such that the trip sled can be moved along the drive axis A by operation of the sled motor **194**.

The displacement system **186** thus allows the location of the trip mechanism **182** to a desired trip position along the drive axis A. As will be described in further detail below, the trip position determines the height of the hammer assembly **32** when the pile driving system is in the pre-drop mode (i.e., the uppermost position of the hammer assembly **32**).

Referring now to FIGS. **6**A and **6**B of the drawing, depicted therein is an example hydraulic system **220** that may be used by the example pile driving system **20**. The hydraulic system **220** comprises a main control valve **222**, power accumulators **224**, and an exhaust accumulator **226**. The trip valve **184** and sled motor **194** are also depicted in FIGS. **6**A and **6**B in the context of the hydraulic system. Check valves **230** and **232** and cartridge valves **234** and **236** are arranged as shown to provide the functionality described below.

A conventional power pack represented by a drive valve **240** forms a source of pressurized fluid that is supplied to the system **220**. The power pack further provides a source of pressurized fluid through a sled motor valve **242** for activating the sled motor **194**; the sled motor **194** is activated independently from the rest of the hydraulic system **220**. The sled motor valve **242** may be implemented using the clamp valve of a conventional power pack.

The main control valve **222** operates in a first configuration (FIG. **6**A) and a second configuration (FIG. **6**B). In the first configuration, pressurized fluid is continuously supplied to the inlet port **82** of the outer chamber **76**. This pressurized fluid flows into the drive portion **170** of the piston chamber **78** as described above to raise the hammer assembly **32** as shown by arrow C in FIG. **6**A. When the hammer assembly **32** engages the trip member **188**, the trip valve **184** is actuated to remove or disable a raise signal applied to the main control valve **222**.

When this raise signal is removed, the main control valve **222** changes to the second configuration as shown in FIG. **6**B. In this second configuration, the main control valve **222** disconnects the drive portion **170** of the piston chamber **78** from the source of pressurized fluid. Gravity acting on the hammer assembly **32** displaces the hammer assembly **32** down, forcing fluid out of the drive portion **170** of the piston chamber **78**.

The main control valve **222** can be placed back into the first configuration manually or automatically based on a sensor, a time delay, or pressure level on the fluid within the drive portion **170** of the piston chamber indicating that the hammer assembly **32** is in its lowest position relative to the housing assembly **30**.

Given the foregoing, the Applicants have concluded that the operation of conventional drop hammer systems can be improved by establishing a pre-load state prior to impact that is generally similar to the compression state of a diesel hammer. The Applicants believe that the preload state will stretch out the compression force in the stress wave and thereby substantially reduce the possibility of tension cracking and damage in concrete piles.

What is claimed is:

1. A drop hammer for driving a pile comprising:

a housing assembly defining a drive axis, a main chamber, and a plurality of vent openings that allow fluid to flow into and out of the main chamber, where

at least one vent opening is arranged at a first vent location along the drive axis, and

at least one vent opening is arranged at a second vent location along the drive axis, where the second vent location is spaced along the drive axis from the first vent location;

a hammer supported within the main chamber for movement relative to the housing assembly between an upper position and a lower position, where the first and second vent locations are located between the upper and lower positions;

a helmet member supported by the housing assembly for movement relative to the housing assembly between a first position and a second position;

a lifting system capable of being operatively connected to and detached from the hammer, where the lifting system positively acts on the hammer to displace the hammer from the lower position to the upper position during each cycle, and

is released from the hammer to allow gravity to displace the hammer from the upper position to the lower position during each cycle; and

at least one plug; whereby

when the hammer drops and is above the first vent location, ambient air flows from the main chamber through the vent openings formed at the first and second vent locations;

when the hammer drops and is below the first vent location and above the second vent location, ambient air flows from the main chamber through the vent openings formed at the second vent location;

when the hammer drops and is below the second vent location, air within the main chamber is compressed to preload the helmet member prior to contact between the hammer and helmet member; and

the pile driving system operates in

a first mode in which the vent openings at the first and second locations are open, and

a second mode in which the at least one plug is configured to prevent fluid flow through the at least one vent opening at the second location.

2. A drop hammer as recited in claim **1**, further comprising a plurality of plugs for plugging a plurality of the vent openings.

3. A drop hammer as recited in claim **1**, in which the lifting system comprises a hydraulic actuator at least partly arranged within the main chamber.

4. A drop hammer as recited in claim **3**, in which the hammer defines a cylinder cavity, where the hydraulic actuator is disposed at least partly within the cylinder cavity when the hammer is in the upper position.

5. A drop hammer as recited in claim **1**, in which the housing assembly further defines a hydraulic chamber, where hydraulic components are arranged within the hydraulic chamber.

6. A drop hammer as recited in claim **1**, further comprising an anvil, where the compressed air within the main chamber preloads the helmet prior to contact between the hammer and the anvil.

7. A drop hammer method of driving a pile using a lifting system to that is attached to and detached from a hammer comprising the steps of:

providing a housing assembly defining a drive axis and a main chamber;

forming at least one vent opening in the housing at a first vent location along the drive axis, and

forming at least one vent opening at a second vent location along the drive axis, where the second vent location is spaced along the drive axis from the first vent location;

altering a compression profile with which the pile is driven by selectively plugging the at least one vent opening at the second vent location;

supporting the hammer at least partly within the main chamber for movement relative to the housing assembly between an upper position and a lower position, where the first and second vent locations are located between the upper and lower positions;

supporting a helmet member for movement relative to the housing assembly between a first position and a second position; and

operating the lifting system to positively displace the hammer to lift the hammer from the lower position to the upper position during each cycle;

operating the lifting system to release the hammer such that the gravity causes the hammer to drop from the upper position to the lower position during each cycle;

allowing ambient air to flow from the main chamber through the vent openings formed at the first and second vent locations when the hammer is moving down and is above the first vent location;

allowing ambient air to flow from the main chamber through the vent openings formed at the second vent location when the hammer drops down and below the first vent location and above the second vent location; and

compressing air within the main chamber below the hammer to preload the helmet member as the hammer drops and prior to contact between the hammer and helmet member when the hammer is below the second vent location.

8. A drop hammer method as recited in claim **7**, further comprising the step of plugging a plurality of the vent openings.

9. A drop hammer method as recited in claim **7**, in which the step of displacing the hammer from the lower position to the upper position comprises the step of arranging a hydraulic actuator at least partly within the main chamber.

10. A drop hammer method as recited in claim **9**, further comprising the steps of:

forming a cylinder cavity in the hammer; and

disposing the hydraulic actuator at least partly within the cylinder cavity when the hammer is in the upper position.

11. A drop hammer method as recited in claim **7**, further comprising the step of arranging hydraulic components within a hydraulic chamber defined by the housing assembly.

12. A drop hammer method as recited in claim **7**, further comprising the step of arranging an anvil such that compressed air within the main chamber preloads the helmet prior to contact between the hammer and the anvil.

13. A drop hammer for driving a pile comprising:

a housing assembly defining a drive axis, a main chamber, and a plurality of vent openings that allow fluid to flow into and out of the main chamber, where

at least one vent opening is arranged at a first vent location along the drive axis, and

at least one vent opening is arranged at a second vent location along the drive axis, where the second vent location is spaced along the drive axis from the first vent location;

a plurality of plugs, where at least one of the plugs is engaged with at least one of the vent openings to obtain first and second compression profiles;

a hammer supported within the main chamber for movement relative to the housing assembly between an upper position and a lower position, where

the first and second vent locations are located between the upper and lower positions;

a helmet member supported by the housing assembly for movement relative to the housing assembly between a first position and a second position; and

a lifting system system capable of being operatively connected to and detached from the hammer, where the lifting system

positively acts on the hammer to displace the hammer from the lower position to the upper position during each cycle, and

is released from the hammer to allow gravity to displace the hammer from the upper position to the lower position during each cycle; whereby

when the hammer drops, ambient air flows from the main chamber through the vent openings formed at the first and second vent locations according to the first compression profile;

when the hammer drops, ambient air flows from the main chamber through the vent openings formed at the first vent location according to the second compression profile; and

air within the main chamber is compressed to preload the helmet member prior to contact between the hammer and helmet member according to one of the first and second compression profiles.

14. A drop hammer as recited in claim **13**, in which the lifting system comprises a hydraulic actuator at least partly arranged within the main chamber.

15. A drop hammer as recited in claim **14**, in which the hammer defines a cylinder cavity, where the hydraulic actuator is disposed at least partly within the cylinder cavity when the hammer is in the upper position.

16. A drop hammer as recited in claim **13**, in which the housing assembly further defines a hydraulic chamber, where hydraulic components are arranged within the hydraulic chamber.

17. A drop hammer as recited in claim **13**, further comprising an anvil, where the compressed air within the main chamber preloads the helmet prior to contact between the hammer and the anvil.

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