May 5, 1970 P. BESNARD 3,509,948

PILE DRIVING SYSTEM

Filed Sept. 20, 1968 3 Sheets-Sheet 1

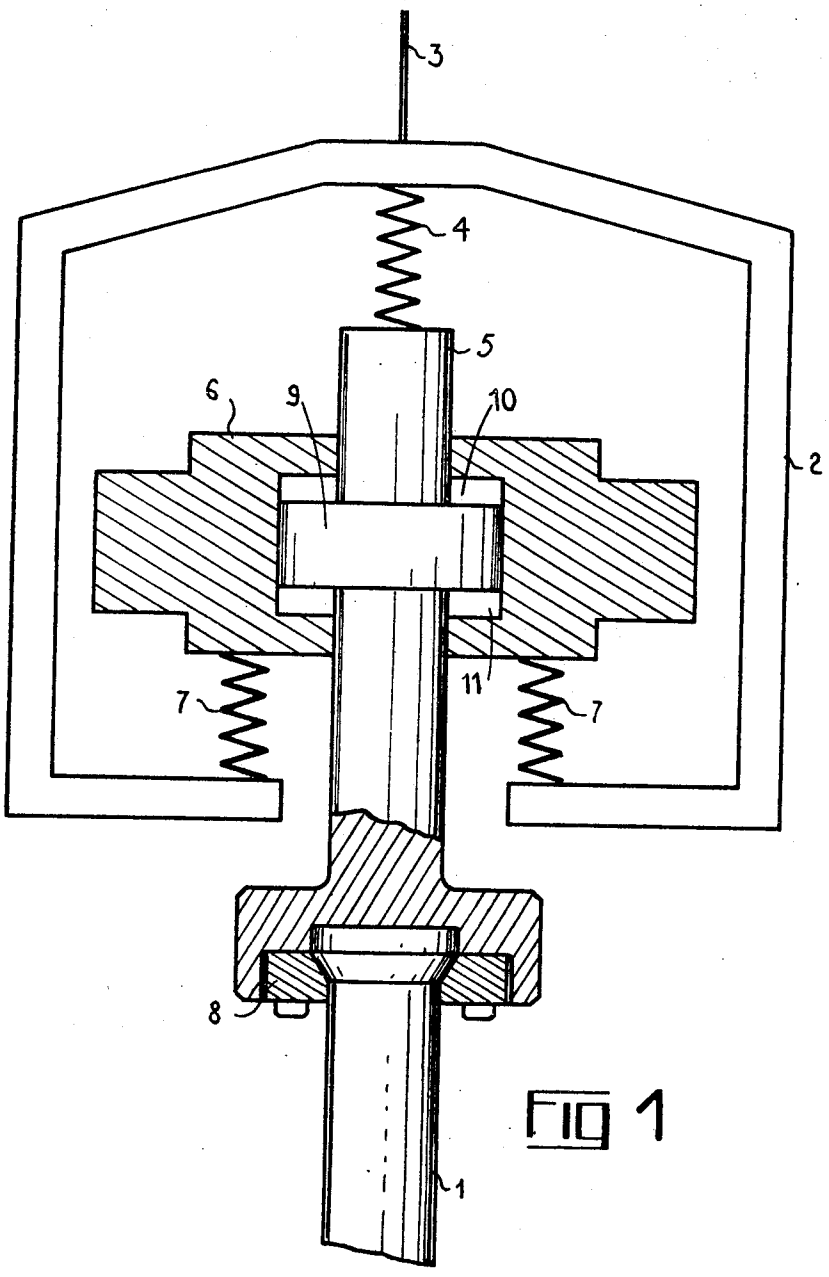

FIG 1

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PILE DRIVING SYSTEM

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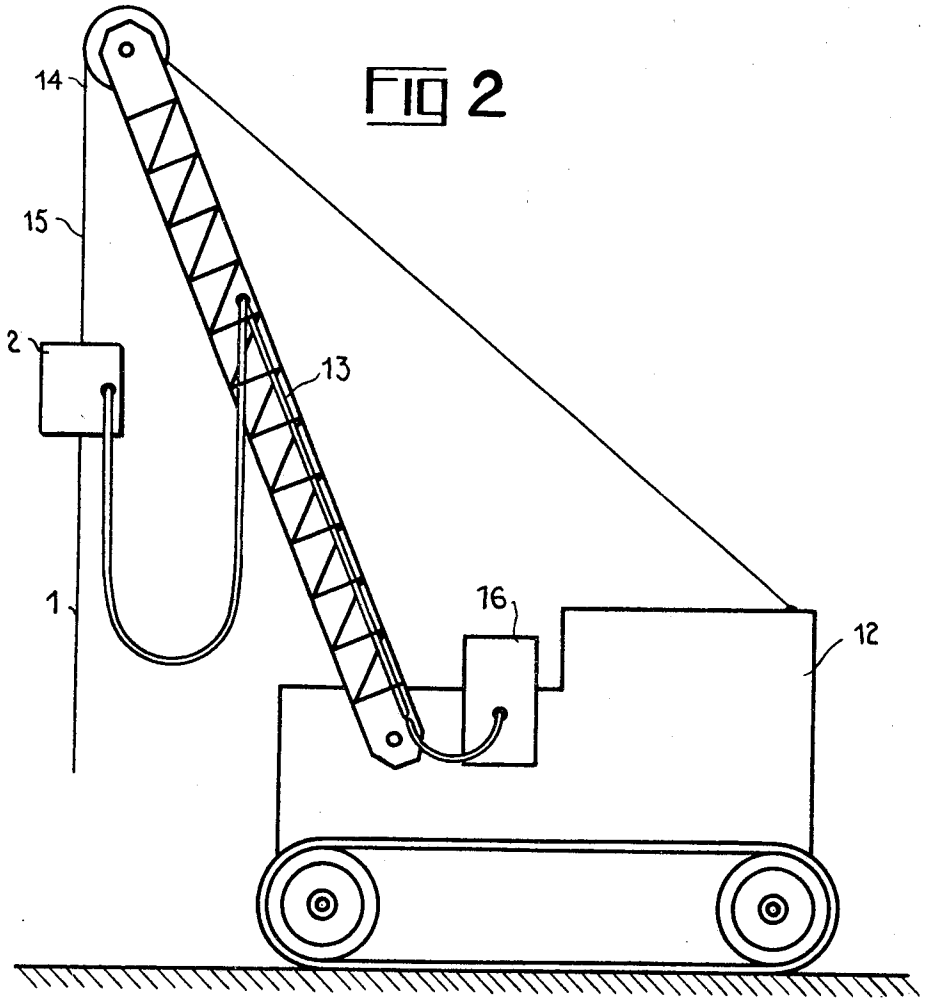
Fig 2



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PILE DRIVING SYSTEM

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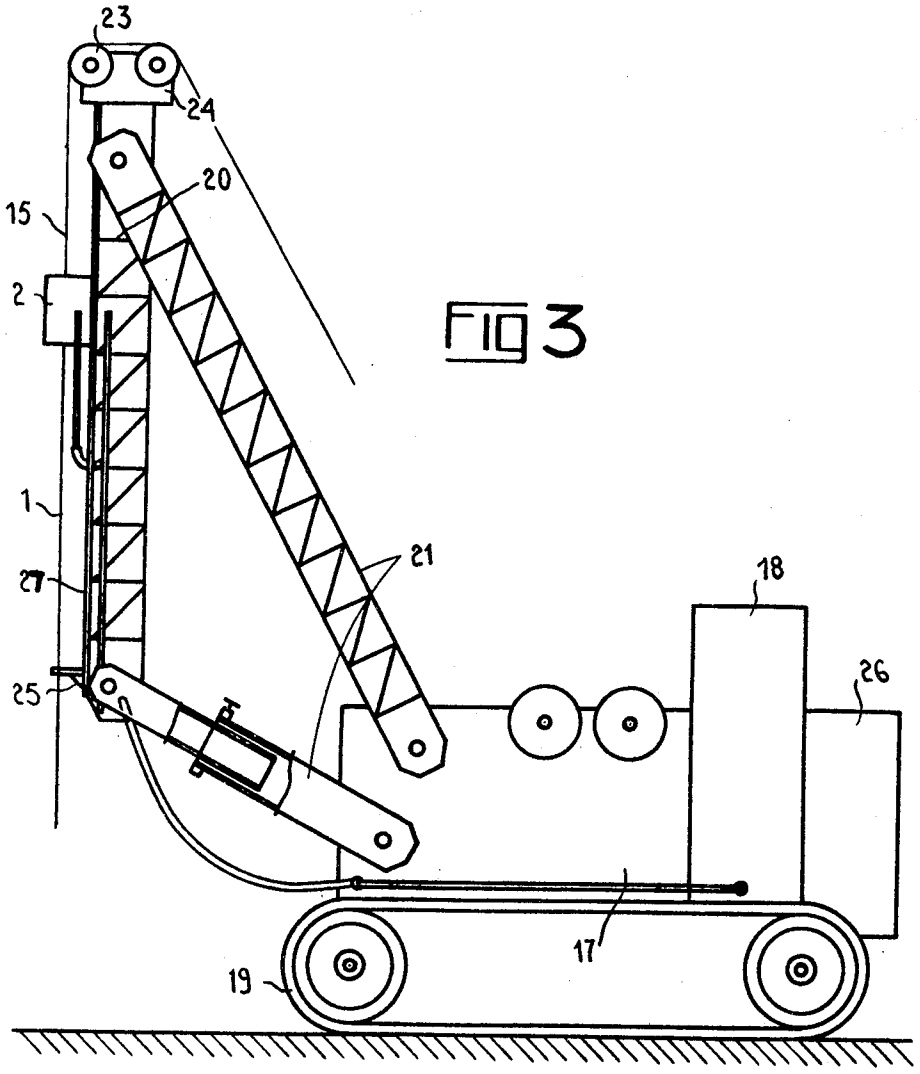

Fig 3

United States Patent Office 3,509,948
Patented May 5, 1970

3,509,948

PILE DRIVING SYSTEM

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Filed Sept. 20, 1968, Ser. No. 761,066
Claims priority, application France, Sept. 28, 1967, 122,627
Int. Cl. E02d
U.S. Cl. 173—44 6 Claims

ABSTRACT OF THE DISCLOSURE

A housing, for example suspended on a crane or on pile driving guides, has a vibrator suspended therein by means of springs. The vibrator has an element movable in the direction to drive the pile and connect it thereto, as well as a reaction body. A first spring supports the reaction body within the housing and a second spring supports the housing on the movable element of the vibrating mass, so that the vibrating mass is low, while the static load of the weight of the entire vibrator and housing presses the pile to be driven into the soil.

The present invention relates to pile driving systems, and more particularly to apparatus to secure posts, piles, pylons, poles and the like in the soil, and generally to place any heavy mass in the soil.

When driving piles or posts into the soil, two masses are of importance, namely the mass subject to dynamic, that is usually vibratory movement, and a static load of the pole itself. In the usual vibrator type pile driving machines, the static mass usually is formed by the weight of the entire pile driving assembly, and is also more or less entirely subjected to dynamic force. A heavy weight, permitted to drop or to vibrate with, or against the pile to be driven, is used. The reaction of the heavy weight forms the useful force. It is also, however, applied to a large mass, so that the level of accelerating force applicable against the top pile is limited.

It is an object of the present invention to provide a pile driving equipment in which dynamic, that is vibratory forces and static loads are separated, so that higher acceleration of movement of the vibrating element is possible.

SUBJECT MATTER OF THE PRESENT INVENTION

A movable element is directly connected to the pile or post to be driven, in order to transfer thereto the useful dynamic force. A movable element, in form of a piston, with hydraulic vibrators, and the post to be driven, are the only elements of the machine which are subject to vibration, and thus to dynamic force. The machine parts may be constructed so that they have only a small mass, small certainly with respect to the mass of the entire pile driving equipment, so that high accelerating forces can be developed. The reaction mass of the equipment is applied to the piston by means of a resilient elastic element, such as springs, or air cushions, in order to provide a static downwardly directed load component to the pile to be driven without, however, having any appreciable vibration. Thus, complementary counterweights to absorb return shocks of the reaction mass are not necessary and the vibrations applied to the pile to be driven are not attenuated. The soft springy suspension of the dead weight of the reaction mass with respect to the vibrating body further limits metal fatigue within the structure itself and increases the efficiency of energy transfer from the dynamic part of the machine.

The vibrator itself is preferably a hydraulic machine, carrying an element movable in the direction of the mass to be driven into the soil, and connected thereto for example by a collar. The reaction mass, within which the movable element is located, is retained in a housing by means of a first set of resilient springs, such as air cushions; the housing itself is supported on the movable element by a second set of resilient means such as air cushions or other springs. The entire equipment may be supported for example by a cable from a construction crane, or may be guided on guide rails forming part of a battering ram.

The structure, organization and operation of the invention will now be described more specifically in the following detailed description with reference to the accompanying drawings in which:

FIG. 1 is a schematic vertical cross-sectional view of a pile driving system in accordance with the present invention;

FIG. 2 is a schematic representation of a complete pile driving equipment mounted on a construction crane; and

FIG. 3 is a schematic illustration of pile driving equipment using a battering ram.

Referring now to FIG. 1: a housing **2** is supported from a cable **3**. Within housing **2**, a reaction mass **6** is located, having a central bore through which a movable element **5**, movable in the direction of a pile **1** to be driven into the soil, is located. Pile **1** is connected to movable element **5** by means of a collar **8**.

The reaction mass is formed with a cylinder, shown as a pair of chambers **10**, **11**, within which a piston **9**, connected to movable element **5**, is slidable.

Resilient means, such as air cushions **7**, **7** (shown, for purposes of illustration, as springs in the drawing) support a reaction mass **6** within the housing **2**. Unless the housing **2** is suspended from cable **3** it, itself, is supported by means of a resilient element **4**, which may again be an air cushion, or any other spring, from movable element **5**. Hydraulic connections, to admit hydraulic fluid to chambers **10**, **11**, alternately, to effect vibration of element **5**, are drilled into reaction mass **6**; such connections, being wellknown, are not shown in the figure for simplicity.

Operation: Before starting driving of pile **1**, the apparatus is adjusted. Springs **7** are adjusted in such a manner that they will support the vibrating element **6** substantially horizontally within the housing, that is in line with the pile to be driven, and substantially in the center thereof. Thereafter, housing **2** to which the pile **1** is attached by means of the collar is lifted by cable **3**, the pile **1** is set at its intended position of placement. Thereafter, by admitting hydraulic fluid in chambers **10**, or **11**, the horizontal axis of piston **9** of the movable element is leveled and brought into coincidence with horizontal axis of the reaction mass **6**. Then resilient element **4** is adjusted in such a manner that, when the housing **2** rests freely on pile **1** (that is, cable **3** is slack) no hydraulic pressure differential will occur within cylinder chambers **10** and **11**. adjustment of the spring tensions being completed, the machine is ready to be placed in operation.

FIG. 2 illustrates, schematically, an entire pile setting apparatus. Housing **2**, to which a pile **1** (shown schematically) is attached, is held by a cable **15** passing over a pulley **14**, attached to a boom **13**, on a traveling crane **12**. Traveling crane **12**, as usual, will include a counterweight, motors, lifting and inclination controls for housing **2** and for the boom and the like.

Hydraulic supply **16** is connected by means of piping to the hydraulic vibrator in housing **2**.

FIG. 3 illustrates a different arrangement to guide and place the piles to be driven. Again, housing **2**, to which a pile **1** is attached, is suspended by a cable **15**. A battering ram, having a motor **18**, supplying both motive power for the entire equipment as well as for the hydraulic vibrator, is placed on a platform **17** running on track **19**. A pair of upright frames **20** are secured to platform **17** by linkage arms **21**. Uprights **20** are provided with parallel guide rails **27**, to guide housing **2** in the direction in which the pile is to be set.

Housing **2** is lifted, or lowered, by cable **15**, which passes through the notch of pulley assembly **23**, secured to uprights **20** on a headpiece **24**. A lower guide **25** is placed at the bottom of uprights **20** in order to positively guide pile **1** to be driven. Hydraulic supply **26** is connected by means of partly rigid, partly flexible tubing, to the hydraulic vibrator within housing **2**.

In the apparatus of the present invention, only the movable element **5** within the vibrator, the collar, and the pile **1** to be driven, are subject to vibration, so that high-accelerating forces can be developed. This is possible due to the spring suspension of the vibrator within the housing. The presence of the resilient elements within the housing permit uncoupling of housing **2** from the vibratory forces, thus avoiding metal fatigue of its components, as well as transfer of vibratory forces to the frame, or battering ram assembly holding housing **2** in position. The reaction mass **6** is so dimensioned that it will have very little vibration itself, so that any vibration that it will be subjected to will be small and the amplitude thereof highly attenuated. Thus, non-useful energy, which has to be supplied by the hydraulic vibrator, is reduced and the efficiency of transfer of dynamic force to the pile to be driven enhanced. Due to the de-coupling of static masses from the vibratory element without reducing the vibratory effect on the pile itself, the speed of driving of the pile is increased.

The present invention has been described in connection with pile driving equipment used in heavy construction. Various changes and modifications may be made as determined by applications or uses, such as when driving well pipe or the like, within the scope of the invention concept. The present invention is applicable to any objects to be driven into the ground, which will hereinafter, generically, be referred to as a "mass."

I claim:

1. Pile driving system for driving a mass into the ground, having

a housing **(2)**;

a vibrating means **(6, 9, 10, 11)** having an element **(5)** movable in the direction of driving said mass and a reaction body **(6)**;

and resilient means interconnecting said vibrating means, said mass, and said housing,

characterized in that

said resilient means comprises

a first resilient suspension means **(7)** supporting said reaction body **(6)** in said housing **(2)**;

a second resilient suspension means **(4)** supporting said housing **(2)** and said resiliently supported reaction body **(6)** therein on said movable element **(5)** of the vibrating means; and the mass of the vibrating element is small with respect to the mass of the housing and said reaction body

whereby, upon vibration of said vibrating means, said movable element **(5)** and said mass to be driven will be vibrated, while static pressure will be applied by the weight of said housing, said reaction body and said vibrating means within said housing, and said reaction body is isolated from vibrations by said first and second resilient means.

2. Pile driving system according to claim **1** wherein said vibrating means is a hydraulic vibrator.

3. Pile driving system according to claim **1** wherein said resilient means are air-cushions.

4. Pile driving system according to claim **1**, including a support crane supporting said housing.

5. Pile driving system according to claim **1** including a pair of vertical guide rails **(27)**, pulleys **(23)** at the top of said guide rails, and means supporting said housing from said pulleys, said housing being vertically slidable on said guide rails.

6. Pile driving system according to claim **1** wherein said vibrating means comprises

a cylinder chamber **(9, 10)** formed in said reaction body **(6)**,

a piston **(9)** connected to said movable element **(5)** within said cylinder chamber, and

fluid means alternately admitting fluid under pressure to opposite sides of said piston in said cylinder chamber to vibrate said piston and with it said movable element **(5)** and said mass **(1)** to be driven.

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U.S. Cl. X.R.

173—162; 175—56