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Hartzell

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[54] **PILE DRIVING**

[75] Inventor: **Carl Daniel Hartzell**, Oakland, N.J.

[73] Assignee: **Raymond International Inc.**, New York, N.Y.

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[51] **Int. Cl.** **E02d 7/26**

[58] **Field of Search** 61/53.5, 53.7, 53.72, 61/63; 175/21, 56

[56] **References Cited**

UNITED STATES PATENTS

3,620,026	11/1971	Mallard	61/53.72 X
3,406,524	10/1968	Blenkarn et al.	61/53.5
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Primary Examiner—Jacob Shapiro

Attorney—Joseph M. Fitzpatrick et al.

[57] **ABSTRACT**

Method and apparatus for driving a tubular pile into the ground characterized by filling and retaining a column of liquid in a substantially static condition in the pile, said column extending from substantially the bottom of the pile to a point located a predetermined distance below the top of the pile, while applying driving forces directly to the top of the pile.

8 Claims, 4 Drawing Figures

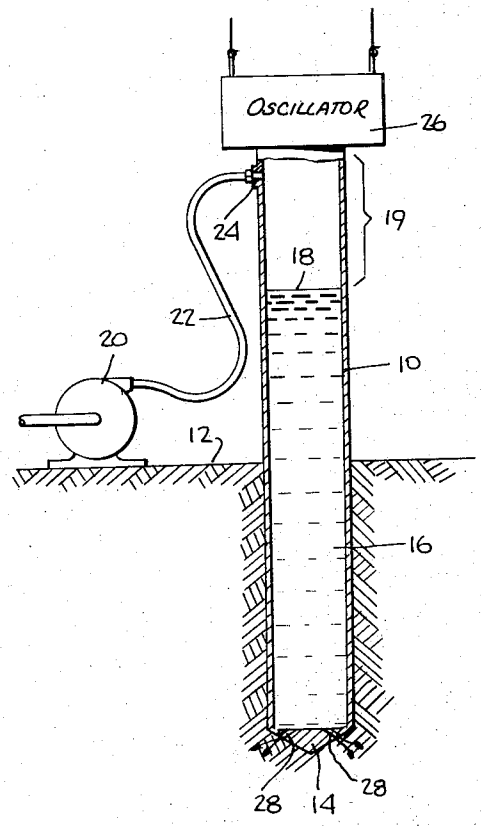


Fig. 3.
16
28
28
14
10

Fig. 4.
16
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14
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12

Fig. 2.
OSCILLATOR
26
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Fig. 1.
OSCILLATOR
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PILE DRIVING

This invention relates to a method and apparatus for driving piles into the earth, suchas are used for building or other structural foundations, or the like.

While many different types of apparatus for driving piles have been used with reasonable success heretofore, my contribution to the art is the provision of new apparatus which is an improvement over such prior art apparatus, as will become apparent as the description proceeds. Related patents in this art include U.S. Pat. No. 3,406,524 issued Oct. 22, 1968; U.S. Pat. No. 3,312,295 issued Apr. 4, 1967; U.S. Pat. No. 2,975,846 issued Mar. 21, 1961 and U.S. Pat. No. 2,743,585 issued May 1, 1956. U.S. Pat. No. 3,406,524 is directed to the vibratory driving of tubular piles by providing a column of liquid inside the pile and applying a cyclic stress directly to the upper part of the liquid column by means of a fluid piston at approximately the resonant longitudinal frequency of the column of liquid. According to the patent, the alternating component of the pressure in the liquid column is transmitted to the confining wall of the pile which is in contact with the ground in order to produce alternating radial deformation of the pile so as to decrease the skin friction between the pile and the contacting ground. Separate means are employed for simultaneously applying an axial force to the pile. In U.S. Pat. Nos. 3,312,295; 2,975,846 and 2,743,585, the outside of the tubular pile is surrounded with the same fluid which is on the internal side of the pile. That is, these piles are for use in underwater installations, and the fact that there is water inside the pile is incidental to the driving of the pile. In U.S. Pat. Nos. 2,975,846 and 2,743,585, the bottom of the tubular pile is left completely open. In U.S. Pat. No. 3,312,295, the liquid contained therein is in an essentially rapidly flowing condition, thereby providing a generally washing action at the impacting face of the pile.

In order to accomplish the desired results, I provide, in one form of my invention, a new and improved method of driving a substnatially closed bottom tubular pile comprising the steps of filling the pile with a column of liquid which extends from substantially the bottom of the pile to a point located a predetermined distance below the top of the pile. The next step, according to my method, is retaining the fluid in substantially static flow condition while applying driving forces, either by vibrations or hammer blows, to the top of the pile , thereby to effect a water hammer-like action for driving the pile.

In conformity with another form of the invention, there is provided apparatus for pile driving characterized by a substantially closed bottom tubular pile for containing a column of liquid therein which extends from substantially the bottom of the pile to a point located a predetermined distance below the top of the pile. Oscillator means are provided for applying vibratory forces directly to the top of said pile.

There has been outlined rather broadly the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are, of course, additional features of the invention that will be described more fully hereinafter. Those skilled in the art will appreciate that the conception on which this

disclosure is based may readily be utilized as the basis for the designing of other structures for carrying out the several purposes of the invention. It is important, therefore, that this disclosure be regarded as including such equivalent constructions as do not depart from the spirit and scope of the invention.

One embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawings, forming a part of the specification, wherein:

FIG. **1** is a longitudinal medial, sectional view showing a tubular pile containing a column of liquid being driven into the ground in accordance with the concept of this invention;

FIG. **2** is a view similar to FIG. **1**, but showing the tubular pile towards the end of the driving operation;

FIG. **3** is an enlarged, medial, longitudinal, sectional view of the lower end of the column of liquid between the "water hammer" effects; and

FIG. **4** is an enlarged view similar to FIG. **3**, but showing the lower portion of the column of the pile during the "water hammer" effect.

In the embodiment of the invention illustrated, the apparatus for pile driving includes an elongated tubular pile **10** for driving into the ground **12**. A bottom or boot-plate **14** is mounted on the bottom of the pile **10**, and a column of liquid **16** is contained therein. The column extends from the bottom of the pile to a level **18** located a predetermined distance **19** below the top of the pile. The liquid is supplied by suitable means such as a pump **20** which discharges through an inlet pipe **22** to an inlet opening **24** provided in the pile for the purpose. Any suitable liquid may be employed such as water, for example.

Oscillating means **26** are provided for applying a vibratory force directly to the top of the pile. Such oscillating means may be of any suitable type, such as mechanical, hydraulic or electronic, for example. The frequency of the vibrations are such as to effect a water hammer-like action at the bottom of the pile when the lower end of the pile **10** and the column of liquid **16** tend to expand as seen in FIG. **4**, thereby forcing the earth therearound away. This is, the lower end of the pile and the column of liquid alternate at a high frequency between their positions as seen in FIG. **3**, and their positions as seen in FIG. **4**, so that the pile can move downwardly.

The bottom or boot plate **14** is provided with openings **28** to provide a jet action adjacent the bottom of the pile for assisting in the driving of the pile by softening the surrounding soil.

In operation, the method of driving the closed bottom pile to the ground involves first supplying the pile **10** with a column of liquid **16**. As can be seen in the drawing, this column extends from substantially the bottom of the pile to a level **18** located a predetermined distance below the top of the pile. Thereafter, driving forces from the oscillating means are applied directly to the top of the pile to effect a water hammer-like action for driving the pile. This water hammer serves to drive the pile much more effectively than is the case where driving forces are applied to the water column itself or are applied to the pile without the column of water.

The present invention provides an improved method and apparatus for driving piles which permits more rigid and effective driving of the pile, which minimizes

or eliminates losses inherent in prior art system,s which is superior in simplicity, ecomony and efficiency as compared to prior art such methods and apparatus.

Although a particular embodiment of the invention is herein disclosed for purposes of explanation, various modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains.

I claim:

1. A method of driving a substantially closed bottom tubular pile comprising the steps of providing a column of liquid inside said pile, said column extending from substantially the bottom of the pile to a level located a predetermined distance below the top of said pile, retaining said column in substantially static flow condition while applying driving forces directly to the top of said pile.

2. A method of driving a substantially closed bottom tubular pile according to claim **1**, wherein said driving forces are vibratory.

3. A method of driving a substantially closed bottom tubular pile according to claim **1**, further comprising the step of directing a plurality of jets of fluid substantially downwardly from the bottom of the pile while applying said vibratory force directly to the top of said pile.

4. Apparatus for pile driving, said apparatus comprising a substantially closed bottom tubular pile containing a column of liquid therein, said column of liquid extending substantially from the bottom of the pile to a level located a predetermined distance below the top of said pile, and driving means connected to said pile for applying driving forces directly to the top of said pile.

5. Apparatus for pile driving according to claim **4**, wherein said driving means comprises a vibratory driver.

6. Apparatus for pile driving according to claim **4**, further including means for supplying liquid to said tubular pile.

7. Apparatus for pile driving according to claim **4**, further comprising a boot-plate at the bottom of said pile.

8. Apparatus for pile driving according to claim **7**, wherein said boot-plate is formed with at least one downwardly directed opening therethrough.

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