

[54] **DRIVING OF HOLLOW TUBULAR MEMBERS**

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

[58] Field of Search **61/53.54, 53.5, 53.7;**
173/1, 91, 135; 181/5; 114/206; 175/6

[56] **References Cited**

UNITED STATES PATENTS

3,646,598 2/1972 Chelminski 61/535

FOREIGN PATENTS OR APPLICATIONS

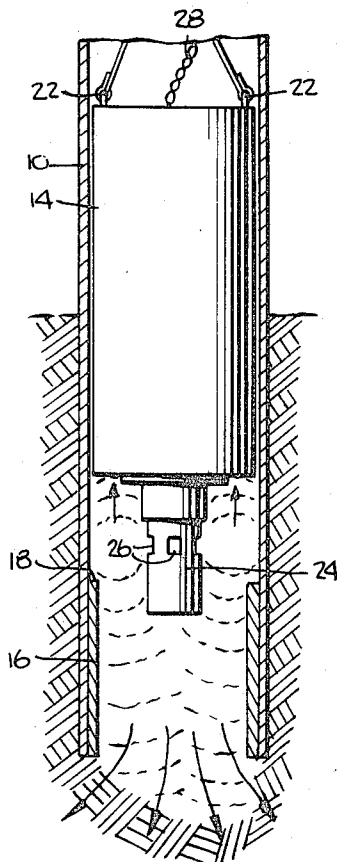
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Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper
& Scinto

[57] **ABSTRACT**

A hollow tubular member such as an open ended pile shell is driven by a sequence of explosions near its lower end. These explosions evacuate the lower end and loosen the earth beneath the member. The explosions also lift a massive element within the tubular member and this element falls back and drives the member into the loosened earth.

10 Claims, 6 Drawing Figures



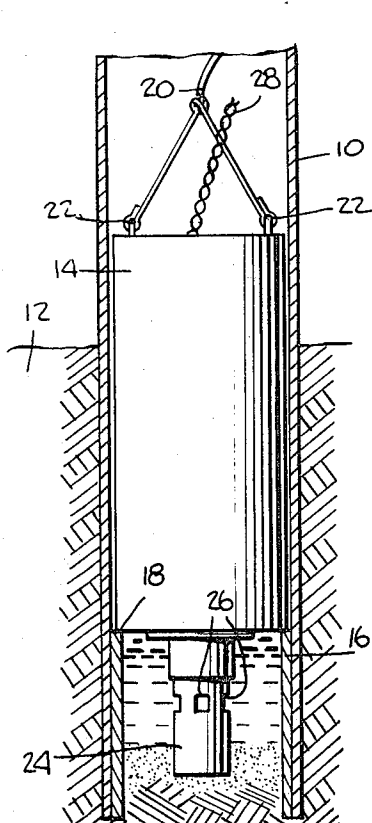


Fig. 1.

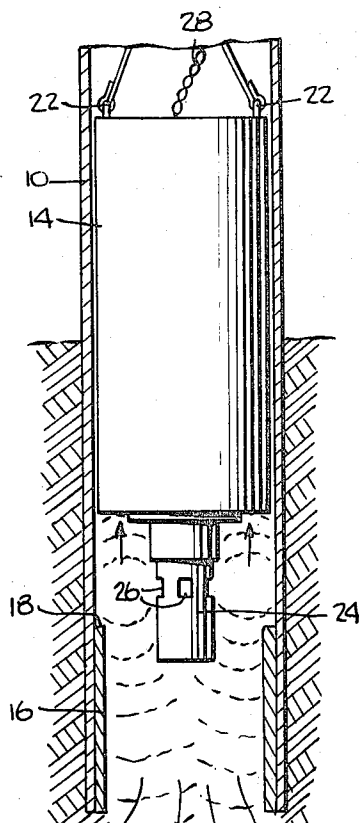


Fig. 2.

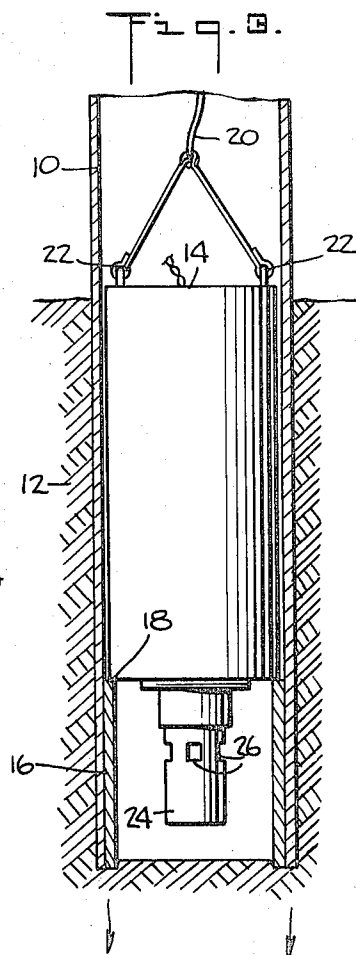


Fig. 3.

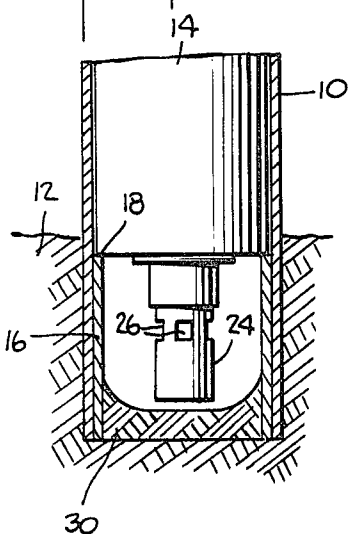


Fig. 4.

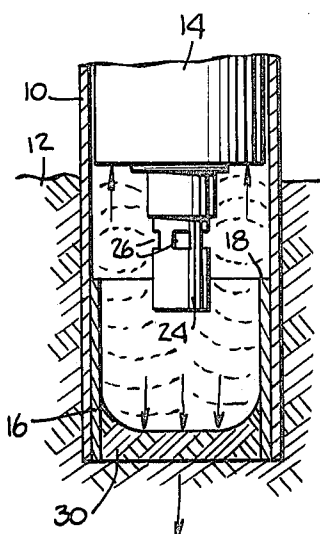


Fig. 5.

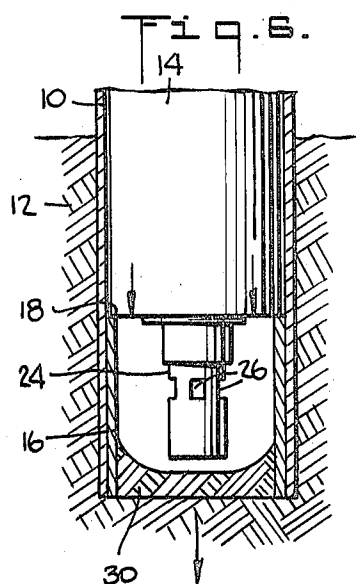


Fig. 6.

DRIVING OF HOLLOW TUBULAR MEMBERS

The present invention relates to driving arrangements and more particularly it concerns the driving of hollow tubular members downwardly into the earth.

The present invention is especially suited to the driving of pipes, shells or caissons down through soft or silty soil having a high water content. Such soils are found in marshes, swamps and in sea beds and in other locations. In the past, difficulties have been experienced in driving of hollow tubular members down through soft, wet soil to solid bearing strata. Where the element being driven has a closed bottom, it experiences a tendency to float upwardly because of its large displacement and because of the lack of substantial frictional restraint along its lateral surface. Under such conditions the driving characteristics of a closed end tubular member are quite poor. On the other hand, where the member being driven is of the open bottom type, the floating tendency is eliminated and the driving characteristics are improved because the wet soil can freely enter up into the interior of the member. However, when the member reaches a bearing stratum or any other relatively solid region which must be drilled out for further driving or final setting, the interior of the member must first be evacuated of the soft wet soil which entered into it before the proper drilling or driving tools can be applied. This evacuation of soft wet soil has proven to be tedious, time consuming and expensive.

The present invention overcomes these problems of the prior art. It is possible by means of the present invention, to drive an open ended hollow tubular member down through soft wet soil with a minimum of effort and without an accumulation of soil in the interior of the member. There is thus provided a self purging driving system for driving hollow, open ended members down through soft water bearing soil.

According to the invention a succession of explosions are produced near the bottom of a hollow tubular member to be driven. Each explosion causes a loosening or an evacuation of earth immediately beneath the lower perimeter of the member. Following each explosion, and before the loosened or displaced earth can return to its former position, the member is forced down into the region loosened or evacuated by the immediately preceeding explosion. Also, by locating the source of the explosions inside the hollow tubular member near its lower end, the explosions further serve to evacuate from the lower end of the member any earth which has entered up into it.

In the illustrative embodiment of the invention a massive element is mounted to move up and down freely within the hollow tubular member and to rest upon an internal ledge or shoulder near the bottom of the member. The explosions, which are produced between the bottom of the massive element and the bottom of the tubular member, serve both to produce the above described loosening or evacuation of earth and to drive the massive element upwardly. Thereafter, when the massive element falls back to the ledge or shoulder it drives the tubular member down into the loosened or evacuated region.

According to a further feature of the invention the driving of the hollow tubular member automatically adapts itself to a different principle of operation as the tubular member passes from a soft water bearing stratum

to a more compact stratum. When the more compact stratum is encountered, the explosions, instead of evacuating soil from the bottom of the tubular member, actually compact the soil and form a solid plug therein. Subsequent explosions thereafter continue to drive the tubular member as though it were of the closed end type.

There has thus 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 arrangements for carrying out the several purposes of the invention. It is important therefore, that this disclosure be regarded as including such equivalent arrangements 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 drawing, forming a part of the specification, wherein:

FIG. 1 is an elevational view, taken in section, of a pile shell and driving arrangement in which the present invention is embodied; and

FIGS. 2-6 are views similar to FIG. 1 but showing the various elements thereof as they appear in different stages of a driving sequence.

As can be seen in FIG. 1 a hollow open ended pile shell 10 of tubular steel is inserted endwise into soft water bearing earth 12, for example, in a marsh or sea bottom. A massive cylindrically shaped element 14 is fitted into the pile shell 10 and is freely moveable up and down therein. An internal sleeve 16 is secured to the lower end of the pile shell 10. This sleeve serves to provide a stiffening or reinforcement for protection of the pile shell during driving; and it additionally serves to provide a ledge or shoulder 18 on which the massive element 14 rests. A cable 20 is attached to eyes 22 at the upper end of the massive element 14 for lifting it into or out from the shell 10. The cable 20 may be operated from a crane winch or other suitable device (not shown).

A compressed air explosion producing device 24 is suspended from beneath the massive element 14 so that when the massive element is at rest on the shoulder 18 of the sleeve 16, explosions produced by the device 24 originate at a central location between the bottom of the massive element 14 and the bottom of the pile shell 10. The explosion producing device 24 has ports 26 through which blasts of high pressure air emanate whenever the device is detonated. Compressed air for powering the device 24 and for controlling its detonation is supplied via air lines 28 which extend from external pressure supply and control sources (not shown) down through the pile shell 10 and the massive element 14.

Any device capable of producing explosions of sufficient intensity in succession, preferably at a controlled rate, is suitable for the present invention. An example of an explosion producing device of the type contemplated is that shown in U.S. Pat. No. 3,310,128 to S. V. Chelminski. That device accumulates a store of com-

pressed air which it releases suddenly upon the occurrence of a compressed air pressure impulse.

Operation of the above described driving arrangement will now be described in connection with FIGS. 1-6. As shown in FIG. 1 the space surrounding the explosion producing device is essentially liquid although a certain amount of mud and silt will ooze up inside the bottom of the pile shell. While there is probably no definite break line between solid and liquid material within the bottom portion of the pile shell it may be expected that in the vicinity of the ports 26 the material is essentially liquid whereas below the ports the material has a higher solids content.

When detonation of the explosion producing device 24 takes place, as illustrated in FIG. 2, a high pressure, large volume but short duration blast of air exits from the ports 26. This blast is confined laterally by the walls of the pile shell 10 and the sleeve 16. Thus the blast action and reaction forces are directed longitudinally within the pile in both upward and downward directions. The downward effects of the blast force the solids and any associated liquid beneath the ports 26 downwardly and out through the bottom of the pile shell 10. Also the earth just under the pile shell 10 is loosened and to a certain extent it may be evacuated by downward and/or lateral displacement, as shown in FIG. 2.

The upward effects of the blast from the device 24 act to lift the massive element 14 and any liquid above the ports 26 upwardly in the pile shell 10. Thus, as shown in FIG. 2, the massive element 14 is raised up off the shoulder 18.

As the pressure effects of the air blast dissipate, the surrounding earth and water, which were displaced by the blast tend to return to their original position. Because of the inherent viscosity and other factors resisting flow, this return movement takes place relatively slowly. On the other hand, the massive element 14, which upon dissipation of the air blast has no support, tends to fall back rather rapidly. As a result, the falling massive element 14 impacts the shoulder 18, as shown in FIG. 3 and drives the pile shell 10 downwardly into the region loosened or evacuated by the preceding blast before the displaced earth can return to the region. Following this driving action, the surrounding earth will continue to ooze up inside the bottom of the pile shell 10. By continuing the blasting in a succession of explosions the pile shell 10 can be driven downwardly without accumulation of soft earth throughout its interior. Consequently when the pile shell reaches a stratum of earth which requires extraordinary driving means, such as drilling or excavating, the necessary equipment can be lowered down through the pile shell without need to dig out any accumulation of mud or silt.

The technique of the present invention will automatically adapt itself to a different principle of driving when the pile shell encounters harder strata in the earth. When a harder stratum is reached, the more compact earth in this stratum becomes further compacted by the explosions and forms a plug 30 (FIG. 4) at the bottom of the pile shell. This plug 30 acts as a bottom cover and converts the shell 10 from the open end type to the closed end type.

The explosions which take place following the formation of the plug 30 do not force it out from the bottom of the pile shell. Instead, as can be seen in FIG. 5, the

plug 30, being frictionally locked to the pile shell, serves to pull the entire pile shell downwardly in response to the downward explosive forces. As can also be seen in FIG. 5, the upward reaction forces of the explosions continue to lift the massive element 14 upwardly off from the shoulder 18. Thereafter, when the massive element 14 falls back following dissipation of the blast, it impacts the shoulder 18 again and drives the pile shell further downwardly, as shown in FIG. 6. It will be appreciated that in the non-plugging driving phase, illustrated in FIGS. 1-3, a single downward force is imposed on the pile shell upon the occurrence of each blast, while on the other hand, in the plugged driving phase, illustrated in FIGS. 4-6, two successive downward forces are imposed on the pile shell upon each blast. The transition from non-plugged driving to plugged driving will occur automatically as the pile shell passes from one stratum to another in the earth.

Should excavation be required for further driving following a plugged driving phase it will be necessary to remove a certain amount of soil, namely that forming the plug, from the interior of the pile in order to reach the underlying soil. The quantity of soil present as a plug is appreciably less than if the pile had been driven conventionally, that is, from the top. Since the soil forming any plug during driving with the hammer is stiff enough to resist the explosive force of the driving device, the possibilities of water entering the pile during any subsequent drilling operation is greatly reduced.

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.

What is claimed and desired to be secured by letters patent is:

1. A method of sinking a hollow tubular member into the earth comprising the steps of producing a succession of explosions near the lower end of said member to loosen earth from the region immediately beneath the lower end of the member, and, in the intervals between the explosions, forcing the member downwardly into the region loosened by the immediately preceding explosion.

2. A method according to claim 1 wherein said explosions are produced within said member near its bottom end to evacuate soil out through said bottom end.

3. A method according to claim 1 wherein said forcing is obtained by hammer blows on said member.

4. A method according to claim 1 wherein said explosions are directed to lift a massive element which is guided to fall back upon and hammer said member following each explosion.

5. A method according to claim 1 wherein said explosions are of sufficient intensity to displace earth from the region beneath said tubular member.

6. A method of sinking a hollow tubular member into the earth comprising the steps of first driving said member through soft water bearing earth by producing a succession of explosions within said member near its lower end to force earth out from the bottom of said member and to loosen earth from the region immediately beneath the lower end of the member, and, in the intervals between the explosions, forcing the member downwardly into the region loosened by the immediately preceding explosion, thereafter, when the mem-

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ber has encountered more compact soil, continuing said explosions to compact soil within the lower end of the member into a plug which effectively closes the bottom of said member and which, in response to continued explosions, pulls the members further into the earth.

7. A method according to claim 6 wherein said explosions are directed to lift a massive element which is guided to fall back upon and hammer said member following each explosion.

8. A driving arrangement comprising, a hollow open ended tubular member, an intermittent explosion producing device mounted within said tubular member

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near one end thereof and means for forcing said tubular member into the earth in the direction of said one end.

9. A driving arrangement according to claim 8 wherein said means for forcing said tubular member comprises a massive element mounted for reciprocal movement along said tubular member and engageable with a shoulder on said tubular member.

10. A driving arrangement according to claim 9 wherein said explosion producing device is mounted on the bottom of said massive element.

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