June 8, 1965 C. L. GUILD 3,187,513

METHOD OF DRIVING PILES

Filed Aug. 24, 1962 5 Sheets-Sheet 1

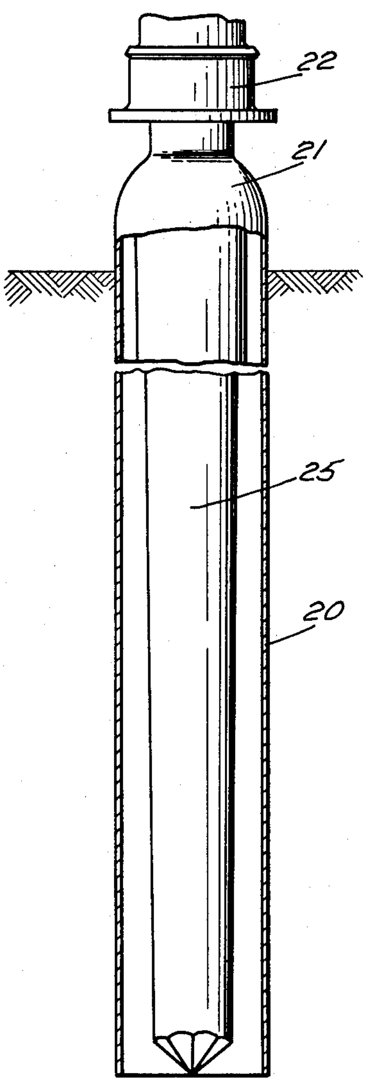

FIG. 1

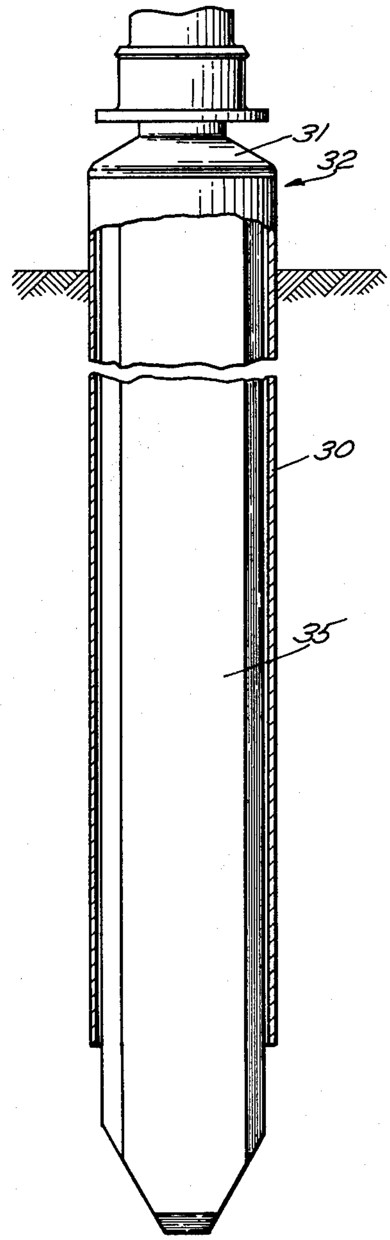

FIG. 2

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METHOD OF DRIVING PILES

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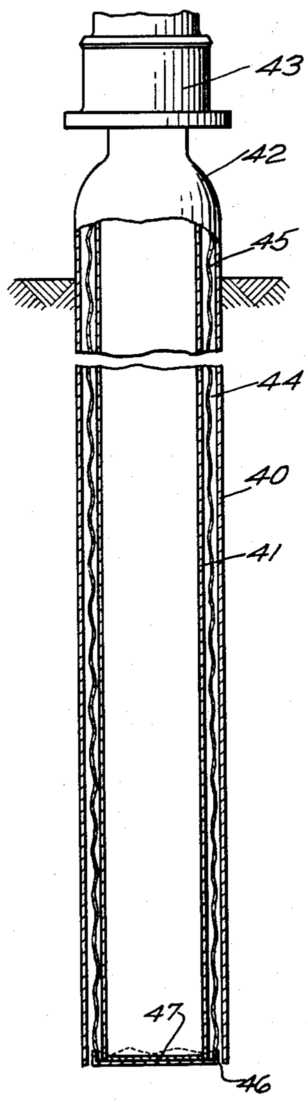

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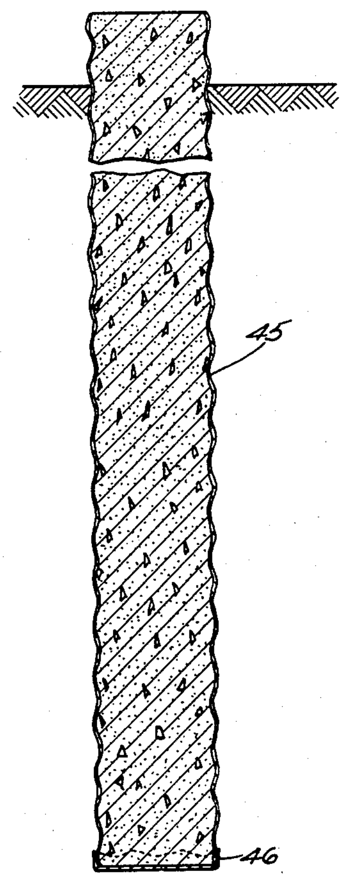

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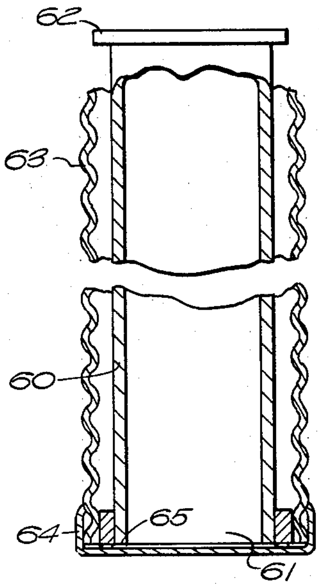

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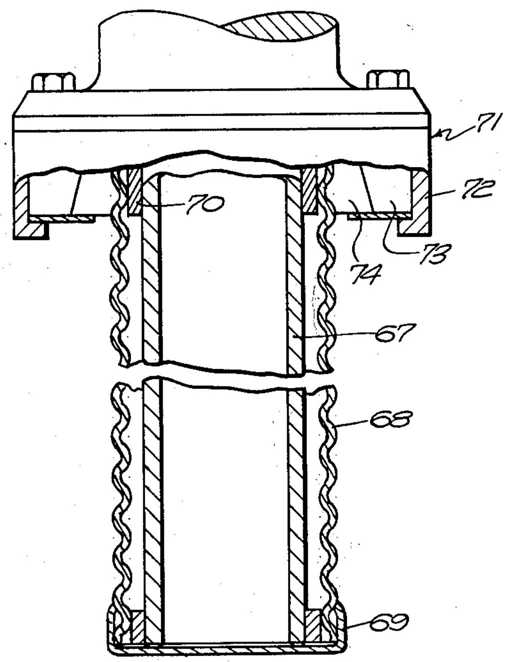

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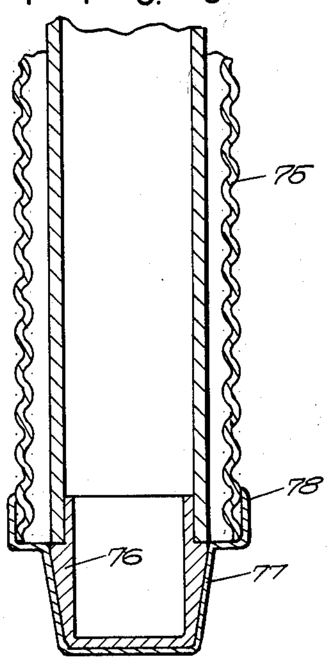

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METHOD OF DRIVING PILES

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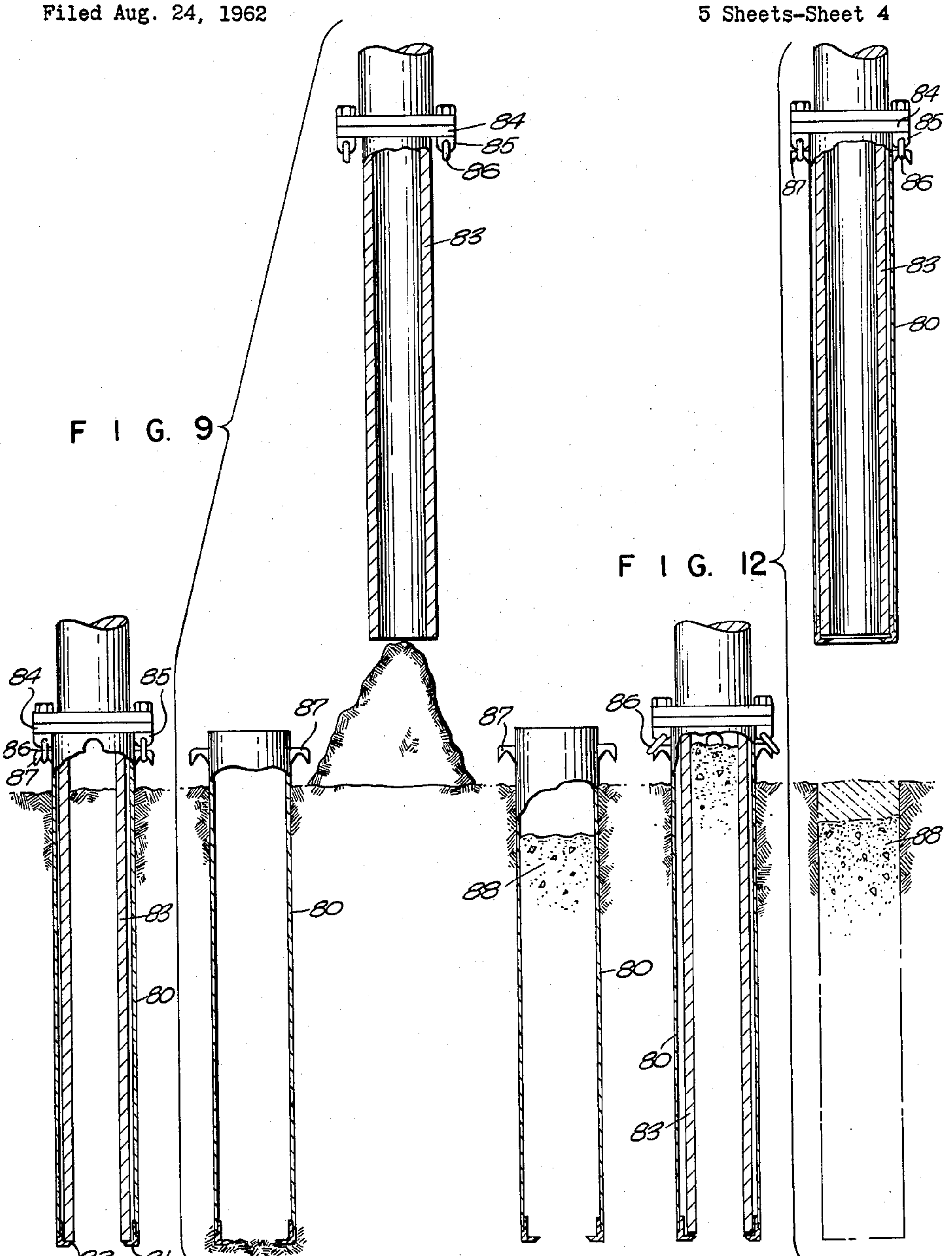

FIG. 8 FIG. 9 FIG. 10 FIG. 11 FIG. 12

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METHOD OF DRIVING PILES

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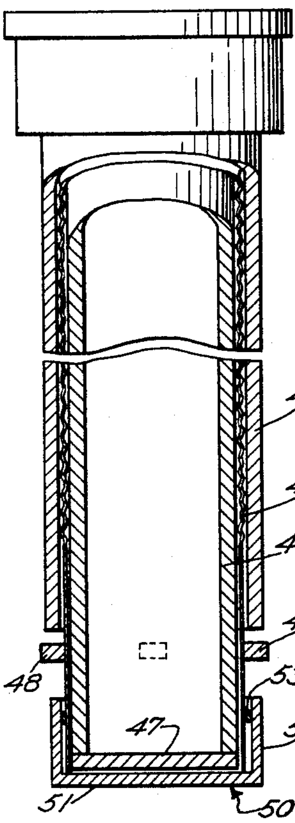

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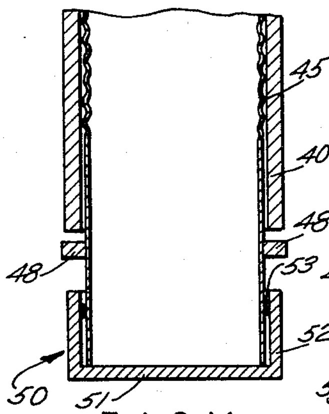

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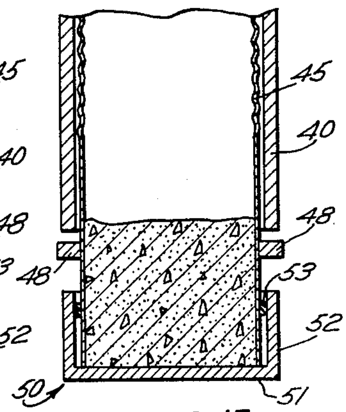

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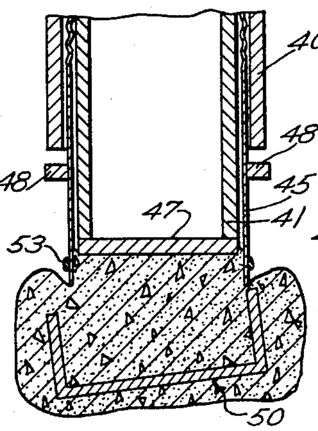

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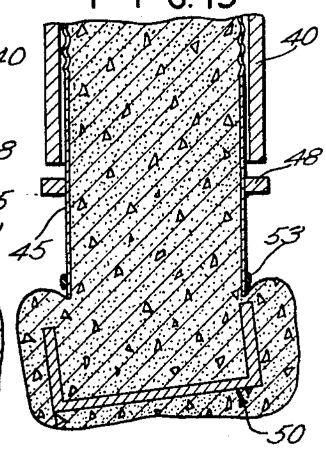

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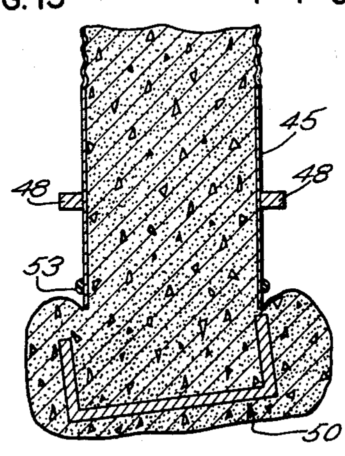

F I G. 18

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3,187,513

METHOD OF DRIVING PILES

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Filed Aug. 24, 1962, Ser. No. 219,313
2 Claims. (Cl. 61—53.5)

This invention relates to methods of driving piles and more particularly to a method of driving not only thin wall pile shells without the use of an internal mandrel but also other types of piles in a more efficient fashion and is a continuation-in-part of my application Serial No. 148,452, filed October 30, 1961, now abandoned. Also in certain aspects thereof, it relates to the method of cast-in-place concrete piles, both with and without enlarged concrete footings which are sometimes known as bulb piles.

Piles which are constructed of thin wall material and which are known in the trade as mandrel driven cast-in-place piles have been successfully used and driven but have involved the use of internal mandrels to which the driving force is applied and which expand outwardly against the inner wall of the pile shell. Such mandrels are expensive to manufacture and maintain. It is desirable, therefore, to find a simpler method to insert thin wall pile shells into the ground. It is also desirable under some circumstances to drive wooden and precast concrete piles into the ground, but such piles do not have the same strength characteristics as do a metal pile and are liable to fracture under the process of driving the same into the ground. Accordingly by use of a mandrel that will assist in guidance of a pile and in some cases preform the hole and which mandrel can later be withdrawn, it is possible to drive such thin wall wooden and concrete type piling. In the case of the thin wall piling, various alternates are available such as utilizing an internal mandrel together with the external mandrel, an internal mandrel alone or an external mandrel alone.

The mandrels under consideration are basically cylindrical mandrels which can be inserted either internal or external to the pile. This type of mandrel also lends itself quite well to utilizing it in the formation of concrete footings or bulbs at the lower end of a pile, and this comes about since once the thin wall type of shell is driven into the ground with the use of one of these mandrels, the mandrel need only be withdrawn whereupon concrete can be poured into the inserted pile shell to a certain depth and then an internal mandrel is lowered into the pile shell to force the concrete that is now in place at the lower end of the shell out into the surrounding earth or other strata so that it forms a ball shape. After the concrete has been driven out into this general ball shape, the internal mandrel is then withdrawn and the pile shell is then completely filled with concrete. In case the pile shell is being driven into a wet formation, means can be provided across the bottom of the shell to keep the pile closed during the driving process and yet permit the removal of this closure when it is desired to drive the concrete outwardly into the bulbous formation.

It is a main object of this invention to provide a method and means of driving piles into the ground by using a mandrel in close proximity to the pile.

A further object of the invention is to provide a method and means of driving piles into the ground by using an internal mandrel located in close proximity to but free of a thin wall pile.

A further object of the invention is to provide a method and means of driving piles into the ground by the use of an external and internal mandrel with an annular space therebetween for insertion of the thin wall pile shell.

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In accordance with another object of the invention, a removable cap is placed over the pile shell at the bottom end thereof which may be readily removed by suitable forces being placed thereon.

In the drawings:

FIG. 1 is an elevational view partly in section illustrating the general arrangement of a wooden pile and its associated mandrel;

FIG. 2 is a view similar to FIG. 1 showing a pre-cast concrete pile in position;

FIG. 3 is a view similar to FIG. 1 showing a thin wall pile with an internal mandrel as well as an external mandrel;

FIG. 4 is an elevational view partly in section of a thin wall pile filled with concrete after being driven;

FIG. 5 is an elevational view partly in section showing a thin wall pile with an internal mandrel and an end boot;

FIG. 6 is an elevational view partly in section showing a thin wall pile together with an internal mandrel and a special driving head coupled to both the mandrel and the thin wall pile;

FIG. 7 is another elevational view partly in section illustrating a boot arrangement for an internal mandrel and a thin wall pile shell;

FIGS. 8–12 are diagrammatic views of successive operations of forming a cast-in-place concrete pile;

FIG. 13 is an elevational view partly in section of a thin wall pile with an internal and external mandrel and a removable boot on the bottom of the pile shell; and

FIGS. 14 to 18 are diagrammatic views of successive operations of forming a bulb at the bottom of a pile shell.

Referring now to FIG. 1, there is shown a mandrel 20 which is of general cylindrical shape supported at its upper end by a cap 21 that is in turn fastened in a suitable fashion (not shown) to the lower end 22 of a driving means. The preferred driving means in the instant situation is a sonic driver which establishes longitudinal elastic vibration of the pile and mandrel and is of a type generally disclosed in the Bodine Patent No. 2,975,846. The pile 25, which is illustrated in this figure as a wooden pile, may be suitably secured to the mandrel head 21 by clamp means (not shown), and thus the mandrel 20 together with the pile 25 is subjected to elastic longitudinal vibrations. The resonant frequency of the wooden pile 25 is slightly different from that of the metallic mandrel, and thus the standing wave patterns vary. When excited, however, the end of the mandrel and the pile impacts against the earth so that penetration is had by both the mandrel 20 and the pile 25. As the mandrel and pile penetrate the earth, the rapid impact situation continues and the mandrel 20 serves to displace the earth surrounding the pile taking up the largest load of penetration by fluidizing the earth at the lower end thereof. This permits easy insertion of the pile 25. After the pile has been driven to its designed depth, the pile is uncoupled from the head 21 and the mandrel 20 is withdrawn by maintaining elastic vibrations in the mandrel so as to displace the earth surrounding the walls thereof effectively to fluidize the same and permit easy withdrawal by a rapid push-pull action at the frequency of vibration. As an alternate arrangement the pile 25 may be loosely held within the mandrel 20, the fluidizing of the earth by the mandrel permitting penetration by the pile 25.

In FIG. 2 a similar arrangement is shown wherein a mandrel 30 is supported on a head 31 and a pre-cast concrete pile 35 may be attached to the head 31 by suitable clamp means generally designated at 32. An identical action takes place with this concrete pile 35 as took place with the wooden pile 25 so far as operation is concerned, and as above, the pile 35 may be loosely held within the mandrel 30.

Referring now to FIG. 3, there is illustrated the apparatus used for driving the thin wall pile shell by the use of an internal and external mandrel. Here an external mandrel 40 and an internal mandrel 41 are separately secured in spaced relationship to a common mounting head 42 that is attached to the driving means 43. The pile shell 45 is loosely inserted in between the mandrels 40 and 41 as in annular space 44. The thin wall pile is provided with a steel boot 46 welded in place to form a watertight unit. The internal mandrel 41 is provided with bottom closure plate 47 that bears against the inner face of this boot 46. This plate 47 is securely welded to the lower end of mandrel 41. It will be apparent that the entire structure is tied together to the driving means by the head 42 and associated parts, and thus both mandrels are set into longitudinal elastic vibration by the use of the preferred driving means as aforesaid. The fact that the thin wall pile shell is supported between two mandrels prevents any deformation of the thin wall pile shell from a bending standpoint, and it is supported substantially throughout its length in the narrow annular space 44.

From a practical standpoint, assuming that the thin wall pile shell is a 12-inch nominal diameter pile shell, the internal diameter of this pile shell will be 11¼ inches and the outside diameter of the inner mandrel 41 may have the dimension of 10¾ inches, the external mandrel 40 will have an internal diameter of 13 inches, and thus it will be seen that the thin wall pile shell is effectively supported in the narrow annular space 44. The external mandrel 40 effectively displaces the earth by fluidizing the same as the entire structure is driven. The end wall 47 of the inner mandrel 41 provides the necessary support for the boot of the pile shell. After the structure is driven into the ground to the required depth, both mandrels 40 and 41 are withdrawn, leaving the thin wall pile shell 45 in the ground. In actual practice it has been found in some soil conditions that there is some slight withdrawal of the pile shell when the mandrel withdrawal occurs, and thus in such instances it may be necessary to overdrive for depth in order to compensate for this slight withdrawal. After the thin wall pile is in place, it is then filled with concrete as shown in FIGURE 4 resulting in a cast-in-place concrete pile.

In FIG. 5 there is illustrated another form of pile driving arrangement for driving a thin wall pile shell by the use solely of an internal mandrel. Here an internal mandrel 60 is composed merely of a cylindrical shell having an open end as at 61 and a driving head end 62. The pile shell 63 loosely surrounds the mandrel 60 and is provided at its lower end with a usual boot 64 that may be welded or otherwise secured thereto to form a watertight unit. The inner mandrel 60 thus bears against this lower boot as at 65, and as the inner mandrel is set into longitudinal vibration, some of these vibrations will be transmitted therefor to the boot 64, thus fluidizing the earth at the lower end of the pile shell. In this fashion with merely fluidizing the earth at the lower end of the pile shell, it has been found that the shell will readily penetrate the earth and, of course, when penetration to the designed depth has been secured, the inner mandrel may be withdrawn. Since in this particular embodiment the pile shell is being firmly gripped by the surrounding earth as it penetrates, the undesirable effect of a slight withdrawal of the pile shell has not been noticed as was the case with the embodiment of FIG. 3.

In some applications it is advantageous to elastically vibrate the pile shell as well as the inner mandrel, and in this case an arrangement similar to that illustrated in FIG. 6 would be used. Here an inner mandrel 67 is surrounded by a thin wall pile shell 68 having a boot 69. At the upper end of the mandrel 67 and between the mandrel and the inner wall of the pile shell a circular washer 70 may be placed to firmly space the pile shell from the inner mandrel. To clamp the periphery of the pile shell 68, various means may be utilized, and to this end a driving head generally designated 71 is provided with a depending outer wall 72. Located interiorly of this outer wall 72 may be a plurality of wedgelike devices 73, 74, and it will be apparent to those skilled in the mechanical arts that by moving the parts 73 and 74 relative to each other and in particular by moving the part 74 upward as viewed in the drawing, a clamping action will be secured. Proper clamping can be attained by simultaneously pulling a number of the wedge parts 74 is unison, and in fashion a rigid connection is made to the upper end of the pile shell between thedriving head 71 and the shell. The lower end of the mandrel 67, as in the previous embodiment, .may also abut the boot 69, and in this fashion both the mandrel and the shell are set up in complete longitudinal vibration thoroughly fluidizing the earth along the longitudinal extent of the pile shell as well as at the lower end thereof.

In FIG. 7 an alternate form of a pile shell point is shown which is useful in many applications as it tends to center the pile shell around the mandrel which is otherwise loosely received thereabout. In this embodiment the mandrel 75 has rigidly coupled thereto a conical shaped boot end 76 which fits within a similarly shaped shell boot 77 that is attached to the lower end of the pile shell as by welding at 78. The taper that is used between the boot and the mandrel end may be of a variety to provide a locking taper and is preferably so constructed so that a mechanical connection is made to the lower end of the pile shell to transmit the longitudinal vibrations set up in the mandrel 75 to the boot 77, thus fluidizing the earth at the lower end of the pile shell and specifically surrounding the booth 77 as it penetrates the earth.

Referring now to FIGS. 8–12 of the drawings, a thin wall pile shell 80 is provided with a boot 81 having an open lower end thereof as defined by the opening 82. A cylindrical mandrel 83 is provided with a head 84 which has depending therefrom a plurality of lugs 85 carrying coupling links 86. The upper end of the pile shell 80 is provided with a similar number of projections 87 for cooperation with the links 86 so that effectively the pile shell 80 is loosely coupled to the mandrel at the upper end thereof. The lower end of the mandrel 83 abuts the boot 81 as at 87 and thus the lower end of the pile is energized to fluidize the earth as the arrangement penetrates. Because of the open end provided by the opening 82 in the boot 81, earth will be received within the cylindrical shell of the mandrel 83 as it penetrates the earth. After the predetermined depth of penetration has been achieved, exitation to the mandrel is stopped and the mandrel is uncoupled from the pile shell and withdrawn. The earth which is within the mandrel will remain within the mandrel, and when the mandrel is completely withdrawn and placed to one side, re-energization of the mandrel will dislodge the earth from within it and it can be deposited on the ground as shown in FIG. 9, thus leaving the pile shell 80 with an empty condition. At this point as illustrated in FIG. 10, concrete can be placed within the pile shell, the concrete being designated by the reference numeral 88, and at this point the mandrel can be re-inserted within the pile shell by energizing the mandrel so that it will penetrate the concrete. The links 86 may then be recoupled onto the pile shell 80 and by re-energizing the arrangement the entire pile shell and mandrel may be withdrawn, leaving merely concrete 88 within the hole as illustrated in FIG. 12. At this point of the operation we, therefore, have a cast-in-place concrete pile and the remaining void at the top of the pile may be filled in by hand to the level of the earth, together with any steel locking pins or other devices that may be desired for general constructional purposes.

In FIG. 13 there is illustrated a mechanism similar to that shown in FIG. 3; thus like reference numerals will be used. In this case the pile shell 45 has welded adjacent the lower end thereof a number of lugs 48 that extend from the circumference of the pile. The lower end of the pile rather than being closed with a solid welded boot has placed thereon a boot 50 having a bottom wall 51 and side walls 52. The inner diameter of the side walls 52 is larger than the external diameter of the thin wall pile shell and should be on the order of 14 inches for a 12-inch thin wall pile. Between the outer surface of the pile shell and the inner surface of the wall 52, there is disposed an O-ring 53 which seals the boot 50 onto the pile 45 to keep out water and other foreign matter.

In this case as with the previous description, the outside mandrel 40 fluidizes the earth permitting the entire structure to penetrate the earth. The resilient mounting of the boot 50 by the O-ring coupling permits the boot to be isolated from the pile shell. Thus vibrations imparted from the closure plate 47 will not be conducted to the pile shell. When the entire structure has reached the designed depth, it is desirable to withdraw the inner mandrel 41. This is accomplished by uncoupling the outer mandrel 40 from the assembly and then pulling the inner mandrel upwardly without exciting the same. At this junction it might be noted that the lugs 48 are placed on the pile shell 45 to prevent the same from creeping upwardly as they will abut against the end of the outer mandrel 40.

If it is now desired to form a bulb at the bottom of the pile, the mandrels 40 and 41 are withdrawn a short distance on the order of 2 to 3 feet. Mandrel 40 is then disconnected from the head 42 and mandrel 41 withdrawn. Concrete is then placed into the bottom section of the pile with a sufficient quantity or charge to form a bulb of the desired volume. The inner mandrel 41 is then inserted into the interior of the pile shell until its end 47 contacts the upper surface of the concrete. The inner mandrel 41 is then energized with elastic longitudinal vibrations which forces the concrete out of the lower end of the pile shell 45 forcing the boot 50 off into the concrete bulb. The impacting of the concrete by elastic vibrations is of a magnitude great enough to displace the earth as the bulb of concrete is impacted beyond the lower end of the pile shell 45. The outer mandrel 40 is then reconnected to head 42 and with mandrel 41 the assembly is withdrawn in the same manner as mandrel 20, leaving shell 45 which is then filled with concrete. The completed structure is as shown in FIG. 18.

I claim:

1. The method of driving a thin wall pile which comprises the steps of providing a pair of elastic concentric mandrels coupled to a common head with an annular space therebetween, inserting a pile shell into said annular space, providing a detachable boot for the pile shell, creating continuous sonic elastic vibrations in and

along said concentric mandrels, introducing the mandrel and pile assembly into the ground and simultaneously therewith exerting a biasing force on said mandrels in a direction to said penetration into the earth, whereby the mandrels fluidize the earth to permit penetration, and after penetration of the pile shell and mandrels to the desired depth, the additional steps of uncoupling the outer mandrel from the common head, withdrawing the inner mandrel, charging the pile shell with concrete, reinserting the inner mandrel to be in contact with the fluent medium of the concrete, elastically vibrating said inner mandrel so that the lower end of said inner mandrel acts as a radiator of sonic waves into said fluid concrete, whereby the energy imparted to the concrete drives said boot from said pile shell and said concrete is driven out of the lower end of the pile shell and against the earth material, stopping said elastic vibrations in said inner mandrel, recoupling said outer mandrel to said head, creating sonic elastic vibrations in said mandrels, and exerting an upward biasing force to withdraw the same.

2. The method of driving a thin wall pile shell into the ground which comprises the steps of providing a cylindrical elastic mandrel with an open end, inserting said mandrel into a pile shell having an open lower end, acoustically coupling the pile shell to said mandrel, creating continuous sonic elastic vibrations in and along said mandrel and pile shell, inserting the mandrel and pile shell into the ground, whereby the assembly fluidizes the earth to permit penetration, terminating the creation of continuous sonic elastic vibrations, uncoupling the pile shell and mandrel, withdrawing the mandrel and removing it from axial alignment with said pile shell, energizing said mandrel with sonic vibrations whereby the earthen material within said mandrel is fluidized and flows out of the end of said mandrel, whereby a voided interior within the said pile shell is created.

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