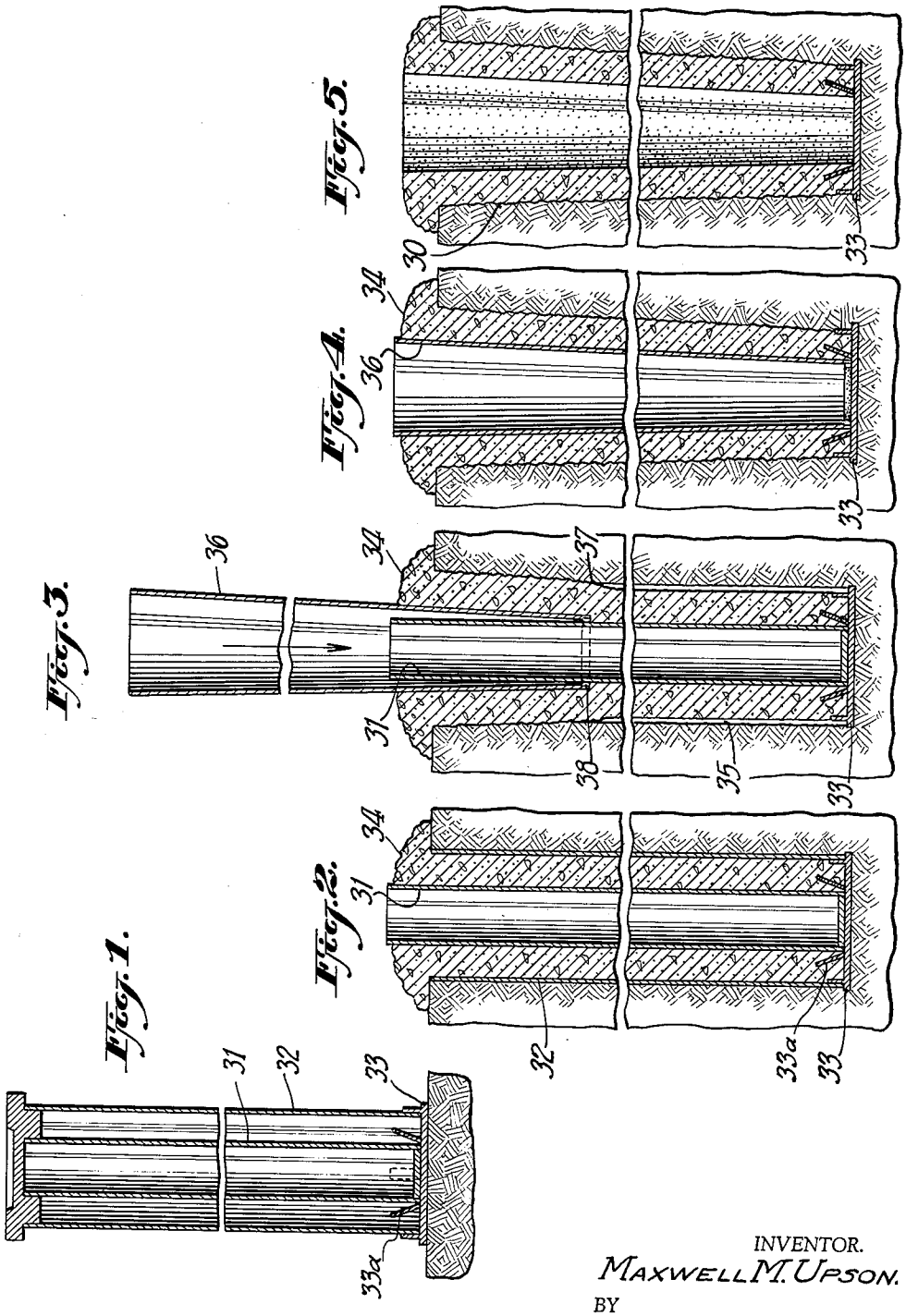
May 21, 1963 M. M. UPSON 3,090,204

METHOD OF FORMING CONCRETE SHELL IN GROUND

Filed March 17, 1959 3 Sheets-Sheet 1



INVENTOR.
MAXWELL M. UPSON.
BY
Ward, Heal, Haselton, Orme & McElhannon
ATTORNEYS.

May 21, 1963 M. M. UPSON 3,090,204

METHOD OF FORMING CONCRETE SHELL IN GROUND

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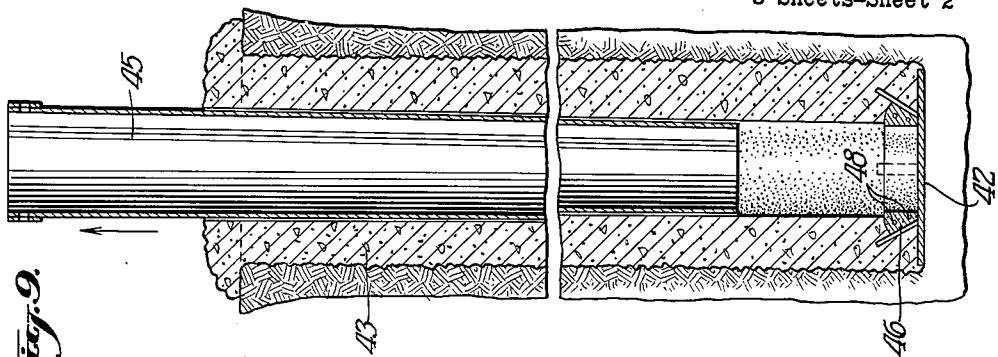


Fig. 9.

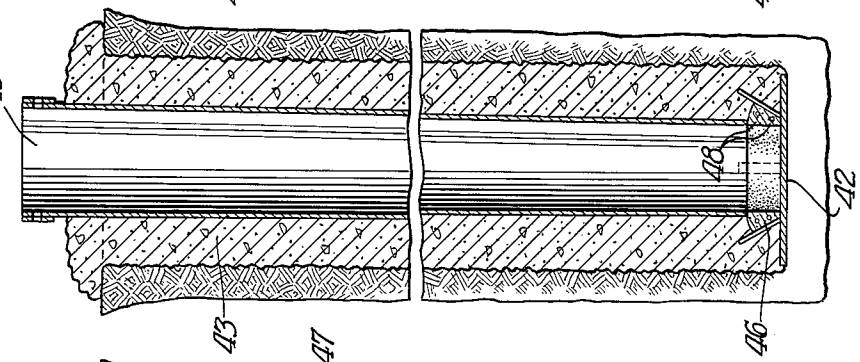


Fig. 8.

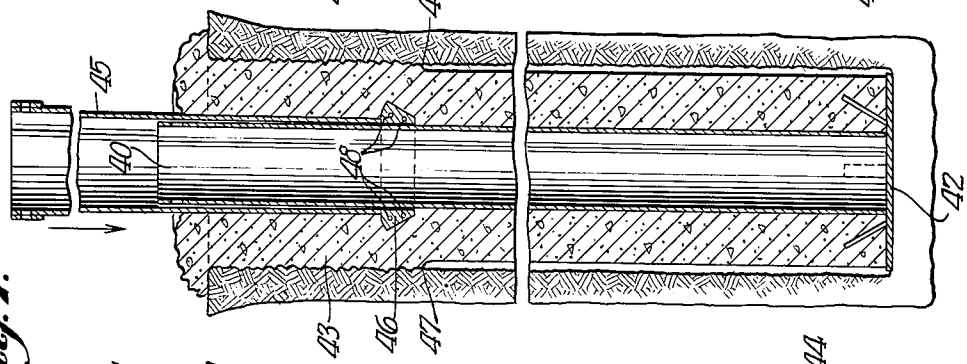


Fig. 7.

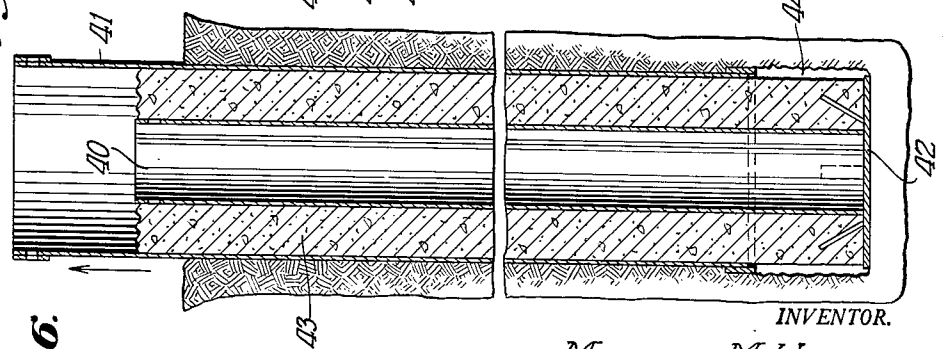


Fig. 6.

INVENTOR.
MAXWELL M. UPSON
BY
Ward Neal Haselton Orme & McElhannon
ATTORNEYS.

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Fig. 10.

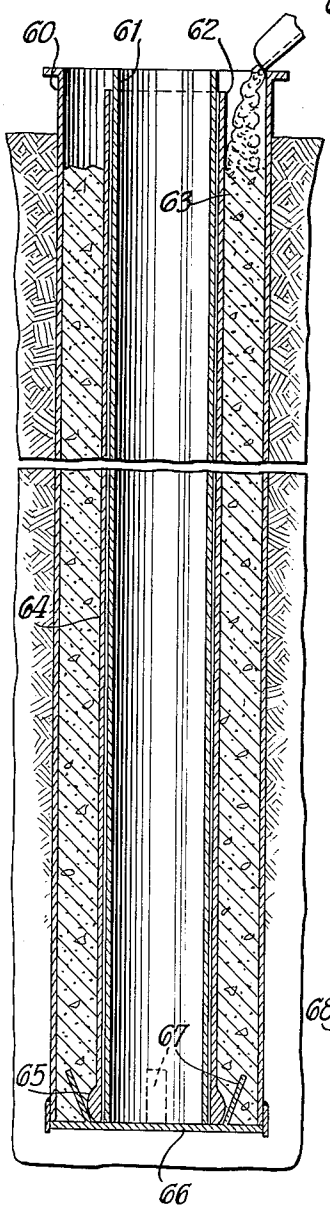


Fig. 11.

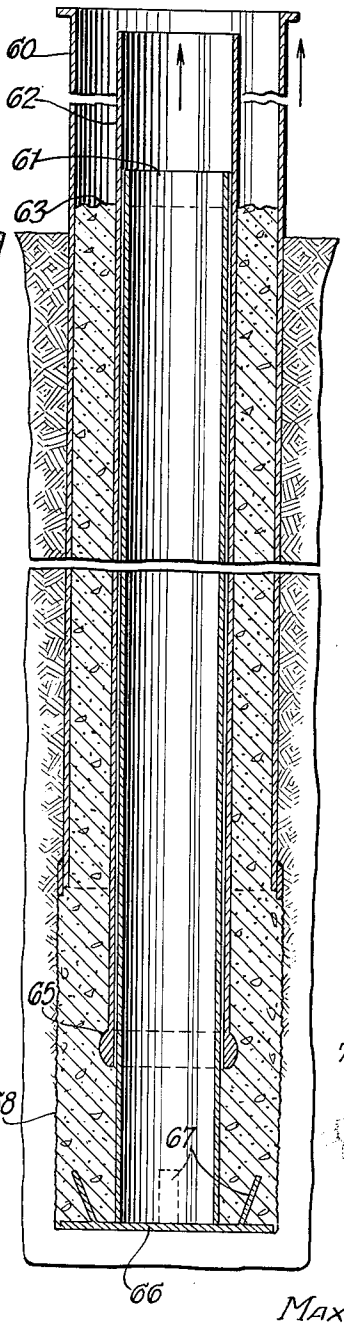
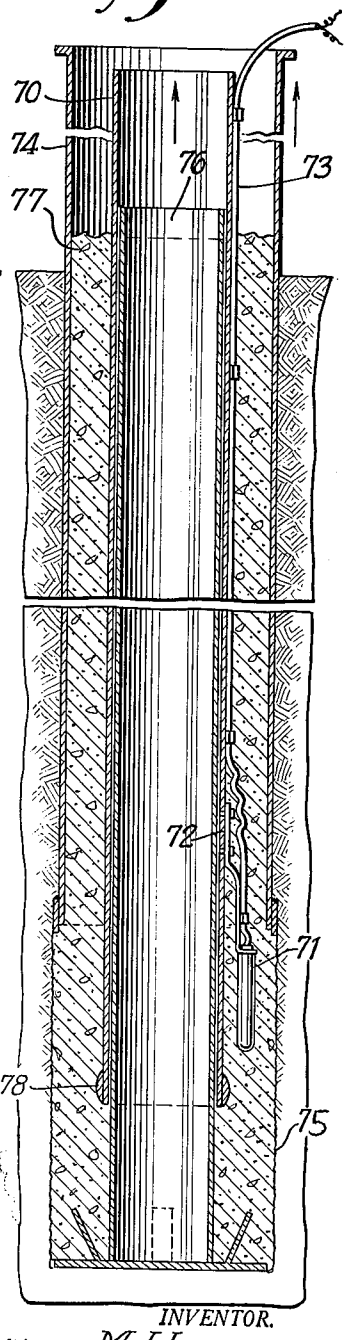


Fig. 12.



INVENTOR.
MAXWELL M. UPSON.
BY
Ward, Neal, Haselton, Deme & McElhannon.
ATTORNEYS.

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3,090,204
METHOD OF FORMING CONCRETE SHELL IN GROUND

Maxwell M. Upson, Englewood, N.J., assignor to Raymond International Inc., New York, N.Y., a corporation of New Jersey

Filed Mar. 17, 1959, Ser. No. 800,018
4 Claims. (Cl. 61—53.66)

This invention relates to improved methods and apparatus for making cast-in-place concrete piles and, more particularly, such type piles having a protective shell formed of concrete.

Cast-in-place concrete piles having a permanent protective steel shell have met with widespread commercial success, but due to steel costs and shortages, attempts have been made over the years to develop satisfactory cast-in-place concrete piles which do not require such steel shells. Applicant has discovered and disclosed means and methods for accomplishing this long sought all concrete pile in his United States Patent No. 2,421,666 and copending application Serial No. 558,261 filed January 10, 1956 now abandoned, together with a continuation-in-part thereof filed on December 29, 1958, Serial No. 783,286 now U.S. Patent No. 3,034,304, dated May 15, 1962. Prior to applicant's inventions aforesaid, the various attempts at forming all concrete piles have been characterized by certain disadvantages as are more fully set forth in said copending application Serial No. 783,286. Many of these prior attempts involved the so-called shellless type piles, wherein a temporary metal casing is first driven into the ground, concrete then poured within same and the casing removed. A basic deficiency of this type of pile lay in the fact that, although initially a good bearing contact was developed between the ground and temporary casing during driving, upon removal of that casing there was no assurance that a correspondingly good bearing contact would develop between the ground and concrete. The instant invention provides a method and apparatus for overcoming this and other disadvantages of the prior art.

The instant invention, like the inventions described in applicant's above-mentioned copending applications provides for the formation in the ground of a tubular concrete shell between a mandrel or core and spaced apart temporary outer casing, said shell being then adapted to receive the cast-in-place concrete pile. According to the invention, after the mandrel and surrounding casing seated on a boot have been positioned in the ground at the desired driving location and fluid concrete provided therebetween, wedging means, positioned between the mandrel and concrete, are moved longitudinally relative to said mandrel and serve to force the still unset concrete mix particles radially outward into close gripping relation with the ground. According to its particular design the wedging means may alternatively either be moved longitudinally downward or upward relative to the mandrel to perform the aforesaid function. Thus according to one embodiment, the wedging means may comprise a downwardly tapered cylinder whose lower end is adapted to closely embrace the mandrel exterior. In this embodiment the mandrel and surrounding spaced apart outer casing with their lower ends both seated on a pile point or boot are driven in the ground, and concrete mix in the fluid condition positioned between mandrel and casing either prior to, during or after driving. The outer casing is then pulled and the wedging cylinder forced downwardly between the mandrel and wet mix. Due to the tapered design of the wedging means, such downward movement thereof relative to the mandrel will force the concrete radially outward into firm gripping relation with the ground,

and will also free any bond between concrete and mandrel, leaving the latter ready for easy and prompt removal. This action of the wedging cylinder also serves to compact the mix particles tightly together, thereby forming a dense concrete shell. The mandrel may then be removed and re-used in forming another shell while the wedging cylinder is in turn left in position in the ground and serves as an inner stiffener shell until the concrete sets sufficiently to withstand ground pressures, and the same is then pulled leaving the concrete shell ready for visual inspection and reception of the concrete pile.

According to another embodiment of the invention, the wedging means to be moved longitudinally downward relative to the mandrel may comprise a cylinder and an enlarged or bulbous wedging ring adjacent its lower end, said ring being either separate from or detachably connected to the cylinder. In this embodiment the wedging means is likewise forced downwardly between mandrel and wet concrete after the former has been driven in the ground, and the outer casing removed, and under the action of the enlarged wedging ring the concrete particles are forced radially outward into close gripping relation with the ground and are compacted together so as to form a dense pile shell.

According to still other embodiments, as mentioned above the wedging means may be designed so as to perform its concrete wedging during upward longitudinal movement thereof relative to the mandrel. In these embodiments the wedging means may be positioned between mandrel and outer casing prior to pouring the concrete and then after the assembly has been driven in the ground and the wet concrete mix provided in position for forming the shell, the outer casing is pulled and the wedging means moved longitudinally upward relative to the mandrel. In such embodiments the wedging means may for example comprise a cylinder having an enlarged or bulbous wedging ring at its lower end which upon upward movement relative to the mandrel will force the concrete mix radially outward into close gripping contact with the ground, or alternatively the wedging means may for example comprise a cylinder with or without an enlarged wedging ring at its lower end but having one or more conventional vibrators attached to its lower end, which may be activated as the wedging means is withdrawn so as to force the concrete out into contact with the ground. In either or both of these last two embodiments the wedging means may, if desired, be moved upwardly after or simultaneously with the removal of the casing.

It should be understood that, if desired, in each of the foregoing embodiments, the temporary outer casing may be initially freed from the ground and the pile point load bearing capacity pre-tested by use of reaction lift devices such as, for example, shown and described in connection with FIGS. 2*a* and 2*b* of applicant's said copending application filed December 29, 1958, Serial No. 783,286.

It should be understood that, when desired, the concrete shells of this invention may form the top section of a multisection pile shell wherein there would be attached to their lower end a length of metal pipe or a conventional step tapered, standard tapered, or straight sided cylindrical metal pile shell, the upper driving ring of the metal shell taking the place of the boot. Furthermore, it should be understood that the boot at the lower end of the concrete pile shells herein disclosed could form the driving head for a lower solid section of H-beam or other design, thereby forming a composite pile structure. In the formation of such composite pile shells the wedging cylinder may also find important usage as an inner stiffener cylinder which permits prompt re-

moval of the expensive core right after driving, thereby readying that core for immediate re-use. Likewise in such composite pile shells, said tapered cylinder may be used to perform the concrete wedging action described more in detail in connection with the noncomposite concrete shells.

Further objects, features and advantages of the invention hereof will appear from the detailed description given below taken in connection with the accompanying drawings which form a part of this specification and illustrate by way of example preferred embodiments of the invention.

In the drawings:

FIG. 1 is a vertical sectional view, partly broken away of a hollow mandrel and spaced outer casing seated on a boot according to the invention prior to driving;

FIG. 2 is a view similar to FIG. 1 but showing the mandrel and boot positioned in the ground at the desired driving location, the wet concrete mix poured around the mandrel;

FIG. 3 is a view similar to FIG. 2, but showing the outer casing removed and a wedging means according to one embodiment of the invention comprising a downwardly tapered cylinder performing its concrete wedging function during downward longitudinal movement of the wedging means relative to the mandrel;

FIG. 4 is a view similar to FIG. 3 but showing the mandrel removed with the tapered cylinder remaining in place during setting of the concrete;

FIG. 5 is a view similar to FIG. 4 but showing the tapered cylinder removed and the concrete shell completed in accordance with the invention;

FIG. 6 is a view similar to FIG. 2 but showing the outer casing being removed prior to insertion of the wedging means;

FIG. 7 is a view similar to FIG. 6 but showing the outer casing completely removed and a wedging means according to an alternative embodiment of the invention wherein the wedging means comprises a cylinder and an enlarged bulbous ring adjacent its lower end and performing its concrete wedging function during downward longitudinal movement thereof relative to the mandrel;

FIG. 8 is a view similar to FIG. 7 but showing the wedging means fully inserted and the mandrel removed;

FIG. 9 is a view similar to FIG. 8 but showing the wedging means cylinder being removed with the enlarged bulbous wedging ring remaining in position at the bottom of the mandrel;

FIG. 10 is a vertical sectional view partly broken away of still another embodiment of the invention showing the wedging means with an enlarged bulbous lower end first positioned between casing and mandrel and the concrete then being poured;

FIG. 11 is a view of the embodiment of FIG. 10 but showing the wedging means and casing being pulled with the wedging means performing its concrete wedging function during upward longitudinal movement thereof relative to the mandrel;

FIG. 12 is a view similar to FIG. 11 but showing still another embodiment of the invention wherein the wedging means comprises a cylinder with vibrating means to force the wet concrete radially outward during upward longitudinal movement thereof relative to the mandrel.

Referring now in more detail to the drawings and particularly to FIGS. 1–5 thereof, a concrete shell **30** may be formed in accordance with one embodiment of the invention as follows. As shown in FIGS. 1 and 2, a mandrel **31**, and a spaced surrounding casing **32** may be seated on a boot **33** as shown in FIG. 1 and driven in the ground at the desired driving location by conventional hammer means (not shown). It should be of course understood that the casing and boot may, if desired, be first driven in the ground and the mandrel then positioned therewithin. In either event, means may be provided for centering the mandrel relative to the casing, such as for example three or more centering lugs **33***a* provided on the boot. Wet concrete mix **34** may be poured into the space between the mandrel and casing either prior to, during or after driving. The casing **32** may then be pulled out of the ground as shown in FIG. 3 prior to complete setting of the mix. Such removal will tend to leave a void **35** between the mix and the ground, all of which may not be taken up by the normal elastic compression of the soil. Therefore, wedging means are provided to force the mix particles radially outward from the mandrel into close gripping contact with the ground. In this embodiment the wedging means as shown comprises a downwardly tapered wedging cylinder **36** which is adapted to be forced down between the mandrel and the mix as shown in FIG. 3. Such downward longitudinal movement of the wedging means relative to the mandrel will obviously not only force the concrete into close gripping contact with the ground, as shown at **37**, but will also free the mandrel **31** for ready removal and will serve to compact the particles of mix together so as to provide a dense shell. Moreover, a wiping lip or gasket **38** may be provided at the lower interior of this wedging cylinder designed to hug closely the mandrel exterior, whereby during downward movement thereof the exterior of the mandrel will be automatically wiped clean of any concrete particles which might otherwise tend to cling thereto. In this connection the exterior of the mandrel should preferably be very smooth so as to facilitate ready removal of any concrete particles by gasket **38**. Thus the mandrel will be automatically cleaned and ready for immediate reuse in the formation of another shell without the need of awaiting final setting of the concrete of the first shell. This automatic cleaning feature is of great practical importance, since it will substantially cut down the time consumed in placing the mandrel in position for the next driving operation. With the mandrel being clean, free and ready for reuse, the same may be promptly pulled leaving the tapered cylinder **36** in place in the ground as shown in FIG. 4 until the concrete has set sufficiently to withstand normal ground pressures, whereupon the wedging cylinder is also removed, leaving only the finished pile shell as shown in FIG. 5. Thereafter the interior of said shell may be filled with concrete so as to form the complete concrete pile as shown and described in applicant's said copending application Serial No. 783,286, filed December 29, 1958.

According to another embodiment of the invention as shown in FIGS. 6 to 9, a mandrel **40**, spaced apart casing **41** and boot **42** may be driven in the ground, concrete **43** positioned therebetween and the casing **41** then pulled (FIG. 6). Such removal of the casing may leave a void space as indicated at **44**, which is undesirable. In this embodiment the wedging means comprises a cylinder **45** and an enlarged bulbous wedging ring **46** adjacent to its lower end, which, as shown in FIG. 7, is forced down between the concrete **43** and mandrel **40**, such downward longitudinal movement of the wedging means relative to the mandrel serving to force the wet concrete mix particles radially outward into close gripping contact with the ground as shown at **47**. Also, as described above in connection with the embodiment in FIGS. 1–5, this downward movement of the wedging means serves also to compact the concrete mix particles, thereby forming a dense pile shell. As indicated, in this embodiment, cylinder **45** may comprise a slight downward taper, if desired, to aid in ease of removal. As shown in FIG. 8, after the wedging means has been forced down over the entire length of the mandrel **40**, the mandrel may be removed as soon as desired even before the concrete has fully set. The enlarged bulbous wedging ring **46** may be separate from cylinder **45**, with the latter merely resting on and exerting pressure against the ring during the downward travel relative to the mandrel shown in FIG. 7, or said ring may be detachably secured to the cylinder, as

for example by paper tape, light wire or the like, which upon slight upward pull of the cylinder will break and will permit removal of the cylinder with the ring remaining in place at the location of the boot. Thus as shown in FIG. 9, after the concrete has set sufficiently to withstand normal ground pressure, the cylinder 45 is pulled upwardly with ring 46 remaining in place resting on the boot. This wedging ring 46 of course may be formed of any suitable material, for example for reasons of economy it is shown formed of concrete which may, if desired, have reinforcing rings 48 positioned therein. It will be of course understood that in the embodiment of FIGS. 6 to 9 the remainder of the pile shell and pile is completed in accordance with the method described in connection with FIGS. 1–5 above.

Turning now to FIGS. 10–12, there are disclosed two further embodiments of the invention wherein the wedging means performs its function of compacting the concrete mix and wedging same radially outward into close gripping relationship into the ground during longitudinally upward movement of the wedging means relative to the mandrel. Thus in FIG. 10, it will be seen that a temporary outer casing 60 and inwardly spaced mandrel 61 are driven in the ground and a wedging means 62 positioned around the mandrel prior to pouring the concrete 63. In this embodiment wedging means 62 comprises a cylinder 64 having an enlarged bulbous ring 65 at its lower end. As shown in FIG. 10 with the mandrel 61, wedging means 62 and casing 60 all resting on a boot 66 having centering lugs 67 and driven in the ground, the concrete 63 in the fluid condition is poured within the casing. Thereupon, as shown in FIG. 11, with mandrel 61 remaining in position in the ground, casing 60 may be pulled upwardly and the wedging means 62 likewise pulled upwardly, either at the same time the casing is being pulled or thereafter, whichever is desired. Preferably, as shown, casing 60 may first be pulled up a slight distance by itself and thereafter as the casing's upward movement continues the wedging means 62 may be simultaneously withdrawn. If desired, of course casing 60 may be completely removed and the wedging means then pulled upwardly. In any event during this upward movement of the wedging means its enlarged wedging ring 65 will force the concrete mix radially outward into close gripping contact with the ground so as to fill the void left by the casing, as shown at 68. According to still another embodiment of the invention as shown in FIG. 12, the wedging means may comprise a cylinder 70 and conventional vibrator means 71 secured to its lower end as at 72, with the vibrator being connected by line 73 with a suitable source of electric power not shown. One or more of these vibrator means 71 may be positioned as shown in the space between wedging cylinder 70 and the temporary outer casing 74. Then, as in the embodiment of FIG. 11, either simultaneously with or after removal of the outer casing 74, whichever is desired, the cylinder 70 and its attached vibrator means are also withdrawn, as shown, and the vibrator means activated so as to force the particles of concrete mix radially outward into close gripping contact with the ground as shown at 75, thereby filling any void left by the outer casing. Preferably, as shown, the casing 74 may first be pulled up a short distance and thereafter, as the casing's upward movement continues, the cylinder 70 with its vibrating means 71 may then be pulled up simultaneously. As described in the embodiment of FIGS. 10 and 11, so also in the embodiment of FIG. 12 the wedging means comprising cylinder 70 and vibrator means 71 is positioned around the mandrel 76 prior to pouring the concrete 77. If desired, the wedging means cylinder 70 may also be provided at its lower end with an enlarged bulbous ring 78 designed to cooperate with the vibrator to force the concrete radially outward into close gripping relation with the ground. In both the embodiments of FIGS. 10, 11 and 12, after the wedging means have been removed as described, and the concrete allowed to set, the mandrel (61 or 76 as the case may be) is removed, thereby forming a hollow concrete shell ready for reception of a cast-in-place concrete pile. It will be understood to facilitate the removal of mandrel 61 and 76, the exterior surfaces thereof may be suitably treated with a material such as paraffin or other compound of the type commonly used to render more easy the removal of forms from concrete.

Although certain particular embodiments of the invention are herein disclosed for purposes of explanation, various further modifications thereof, after study of this specification, will be apparent to those skilled in the art to which the invention pertains. Reference should accordingly be had to the appended claims in determining the scope of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. The method of forming a tubular concrete shell in the ground by means of a tubular casing, a tapered tubular wedging member of substantially smaller maximum diameter than the casing, a mandrel of sufficiently smaller diameter than the wedging member for slidable disposition therein, and a boot plate, said method comprising: positioning in the ground to a selected depth of penetration said casing and mandrel concentrically supported on said boot plate with liquid concrete filling the annular space between the casing and mandrel, withdrawing the casing before the concrete has set and forcing said tapered wedging member in telescoping relation with respect to said mandrel, downwardly therealong to displace said liquid concrete radially away from said mandrel and into gripping engagement with the earth bared by withdrawal of said casing, withdrawing the mandrel while retaining said wedging member in its downwardly thrust position to retain said concrete in tubular form until permanently set and thereupon withdrawing said wedging member.

2. The method of forming a tubular concrete shell in the ground by means of a tubular casing, a tubular wedging member of substantially smaller diameter than the casing and having a bulging, wedging ring detachably secured to its base, a mandrel of sufficiently smaller diameter than the tubular wedging member to be slidably disposed therein, and a boot plate, said method comprising: positioning in the ground to a selected depth of penetration, said casing and mandrel concentrically supported on said boot plate, with the annular space between said mandrel and casing filled with liquid concrete, withdrawing the casing before said concrete has set and forcing said wedging member telescopically downward along said mandrel until the wedging ring thereof is disposed adjacent said boot plate, thereby to force the liquid concrete radially outward away from the mandrel and against the surrounding earth bared by the withdrawn casing, withdrawing said mandrel while retaining said wedging member so disposed to retain said concrete in tubular form until permanently set, and thereupon withdrawing said tubular wedging member from the so-formed concrete shell with the ring member thereof detached and left in the ground.

3. The method of forming a tubular concrete shell in the ground by means of a tubular casing, a tubular wedging member of substantially smaller diameter than the casing and having a bulging wedging ring portion integral with the base thereof, a mandrel of sufficiently smaller diameter than the wedging member to be slidably disposed therein, and a boot plate, said method comprising: positioning in the ground to a selected depth of penetration, said casing, wedging member and mandrel concentrically supported on said boot plate, with liquid concrete filling the annular space between said casing and wedging member, withdrawing the casing and thereafter withdrawing the wedging member before the concrete has set whereby the ring member thereof forces the liquid

concrete radially outward away from the mandrel and against the surrounding earth bared by withdrawal of the casing, retaining the mandrel in place until the concrete has set, thereby to retain said concrete in tubular form during setting, and thereupon withdrawing the mandrel.

4. The method of forming a tubular concrete shell in the ground by means of a tubular casing, a tubular wedging member of substantially smaller diameter than the casing and having a bulging wedging ring portion integral with the base thereof, a mandrel of sufficiently smaller diameter than the wedging member to be slidably disposed therein, and a boot plate, said method comprising: positioning in the ground to a selected depth of penetration, said casing, wedging member and mandrel concentrically supported on said boot plate, with liquid concrete filling the annular space between said casing and wedging member, concurrently withdrawing the casing and wedging member before the concrete has set in the manner such that the base of the casing is continuously disposed at a higher elevation than the base of the wedging member throughout the withdrawal whereby the wedging ring of said wedging member forces the liquid

concrete radially outward away from said mandrel and into gripping engagement with the surrounding earth bared by the receding casing, retaining the mandrel disposed on the boot plate until the concrete has set, thereby to retain the same in tubular form during setting, and thereupon withdrawing the mandrel.

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