April 3, 1962 E. A. SMITH 3,027,724

METHOD FOR MAKING AND INSTALLING CONCRETE PILES AND THE LIKE

Filed Dec. 17, 1958 3 Sheets-Sheet 1

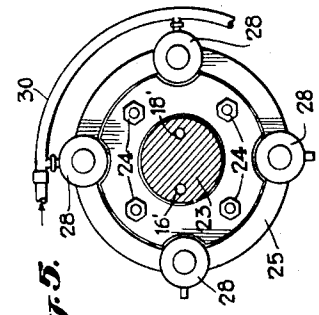


Fig. 5.

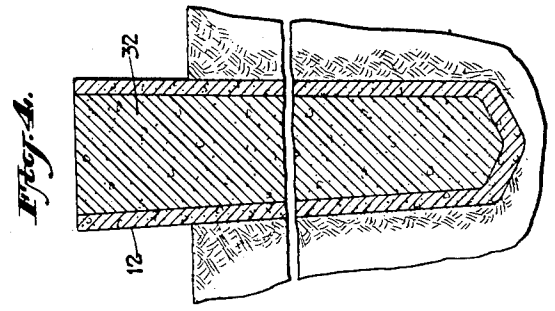


Fig. 4.

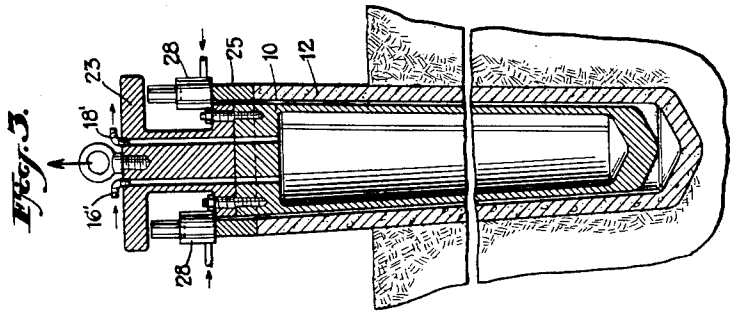


Fig. 3.

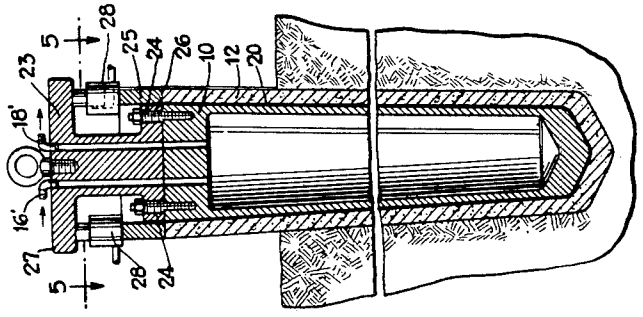


Fig. 2.

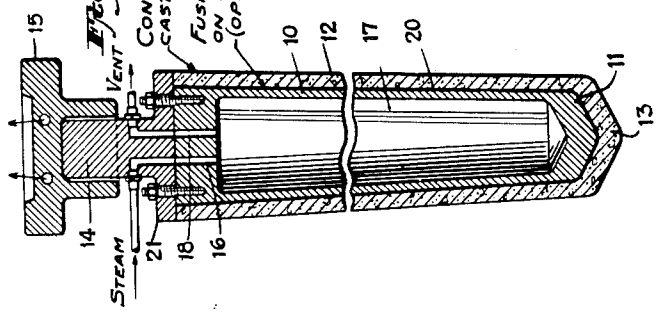


Fig. 1.

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Fig. 8.

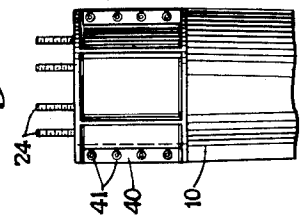


Fig. 9.

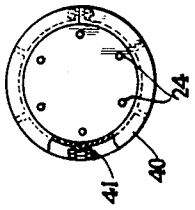


Fig. 7.

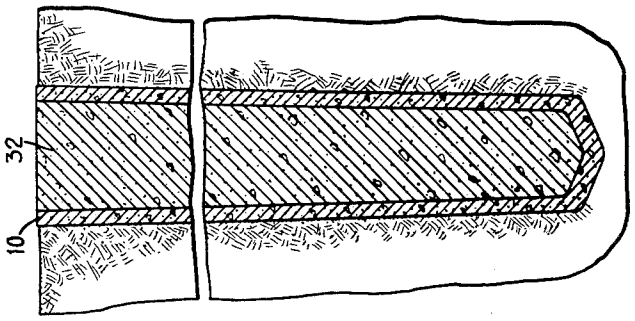
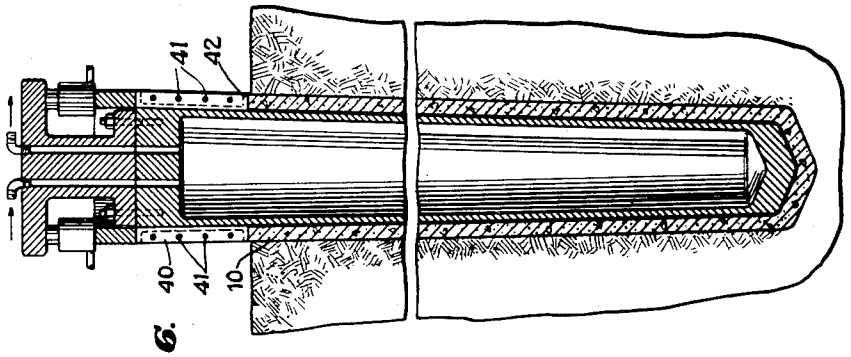


Fig. 6.



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Fig. 10.

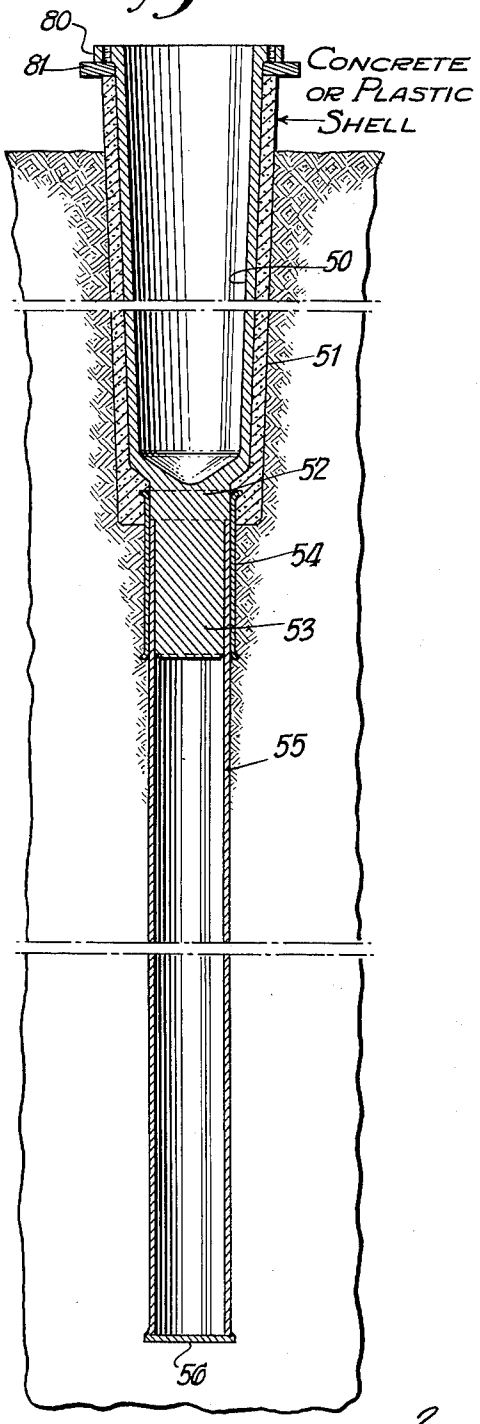


Fig. 11.

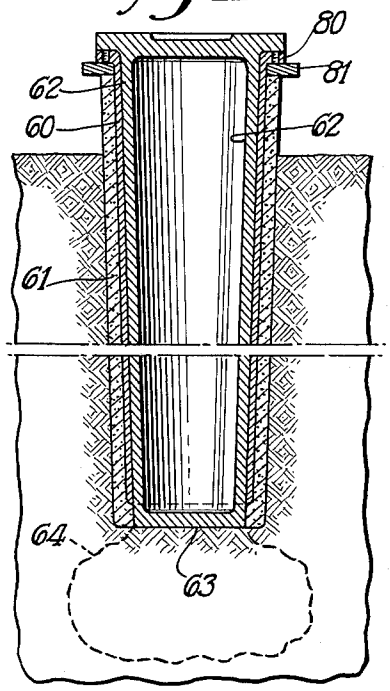
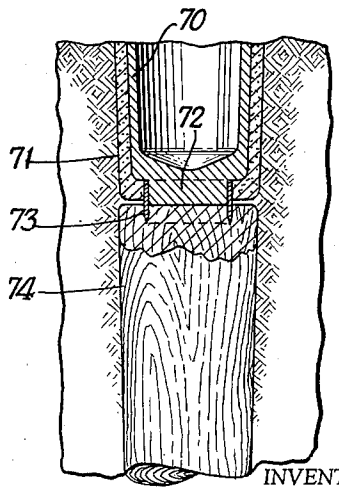


Fig. 12.



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3,027,724

METHOD FOR MAKING AND INSTALLING CONCRETE PILES AND THE LIKE

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Filed Dec. 17, 1958, Ser. No. 781,083
9 Claims. (Cl. 61—53.7)

This invention relates to methods and equipment for making and installing piles of concrete and the like, this application comprising a continuation-in-part of applicant's application Serial No. 565,866, filed February 16, 1956, reference to which is hereby made.

The invention is more particularly concerned with methods for installing piles of concrete and the like by first installing a shell in the earth which is thereafter filled with the concrete. According to the invention, such shell is formed by applying concrete in plastic condition to a mandrel or by applying some other plastic material, such as of a synthetic resinous nature, and which will set and harden as a coating or shell on a mandrel, and the mandrel thus coated is driven into the earth at the location of the desired pile, the mandrel thereafter being withdrawn, leaving in the earth a shell of the concrete or plastic material, which shell may then be filled with concrete or the like to form the main body of the pile.

It has long been the practice to form so-called concrete piles by first driving into the earth a steel shell by the use of a removable mandrel or core contained therein and after such core is removed, the remaining shell is filled with concrete. Piles of this general type have the following advantages. First the steel shell may be driven with powerful blows into the desired position and in intimate contact with the earth without danger of leaving any surrounding air spaces which might permit the pile to settle. Secondly, upon withdrawal of the core from such driven shell, the shell is still left in intimate contact with the earth, whereby ground pressures are not in any way released or loosened. Third, it is then possible to inspect the entire interior of the shell to make certain that same is in perfect condition, free of leaks and torn or crushed areas. And finally, the shell may be then filled with concrete with assurance that a body of concrete will be cast which will be of the desired dimensions and strength throughout.

The formation of such pile shells of steel, however, despite their advantage of strength, is relatively expensive, and furthermore, if such shells have to be shipped from a steel mill to some remote or relatively inaccessible point where construction work is being undertaken, the expense and difficulties of shipment may become excessive, particularly as such shells are quite lengthy and heavy and also because they are bulky since they are not collapsible. To overcome these difficulties, some suggestions have been made that the pile shells be formed of concrete preferably at the places where the construction work is to be undertaken, but so far as is known, the methods proposed prior to the current invention for that purpose have not met with any very extended use because of the various difficulties involved.

In accordance with the present invention, strong and dependable concrete piles may be formed, however, with shells of concrete or plastic materials and which may be efficiently and relatively inexpensively formed and driven by the following combination of method steps.

First a coating or layer of concrete or of a resinous plastic material capable of setting and hardening and which is to form the pile shell is applied or cast upon the outside of a driving form or mandrel preferably of tapered shape. Such casting may be carried out in various ways, as for example by mounting the form in a vertical pit, the surrounding space of which is filled with the concrete or plastic material or by surrounding the form in horizontal position with an outside form spaced therefrom and which is filled with the concrete or plastic, or the coating may be simply applied to the form by the use of a spray gun or by brush application or with a machine impelling the coating onto the form from a belt, for example.

The mandrel used may, if desired, be of "stepped" form, that is, so that its succeeding lower portions (which may be suitably separable sections bolted or screwed together, if desired), are of smaller diameters similar to the case of well-known "stepped tapered" pile shells. The cross-section of the mandrel may be circular, or of other desired shapes and may, if preferred, be formed with vertical corrugations for lending a certain degree of yieldability for facilitating its withdrawal especially in case the interior of the hardened shell should be somewhat roughened or irregular.

The terms "concrete" and "concrete and the like" as used herein in referring to the material of the shell, are intended to include so-called "mortar" (in which no gravel is used) as well as "grout" which consists mostly of cement. The concrete may also be bituminous, consisting for example of sand and gravel mixed with an asphalt material which will suitably harden, or made of bituminous material in the form of a water emulsion mixed with cement, sand and gravel. The concrete may be reinforced by steel wire, wire mesh, or small rods, if desired, or by fiberglass, either in short lengths mixed therewith in the concrete mixer or in the form of longer fibrous or woven material wrapped around the mandrel and impregnated or covered by the concrete mixture or the like.

It may be noted that the plastic bituminous mixtures will harden more rapidly than the usual concrete mixtures, thus making it possible to conduct operations continuously with a smaller number of mandrels needed for the job. In case concrete is used, it will be desirable to use a quick-setting cement. It is particularly desirable to use a mixture which will harden rapidly so as to minimize the investment of mandrels which otherwise will be very considerable if large numbers of piles are driven per day.

Optionally, the form or mandrel may be coated with a suitable easily fusible material before the concrete or other shell-forming material is applied, for instance a thin layer of sulphur, or of a bituminous material such as a readily softenable asphalt, so that ultimately when the form is to be removed from the driven shell, the fusible material may first be melted to facilitate release of the form from the shell.

The shell-forming material as thus applied to the form is allowed to harden and optionally, in order to minimize the number of forms required for numerous piles, such hardening may be accelerated by the use of steam or other well-known methods.

While the invention will be more particularly and specifically described as adapted for the use of a shell of concrete, generally similar methods may be used for making the shell of synthetic resinous materials preferably of self-setting types including epoxy, thiokol, polyester, epoxy thiokol, epoxy polyester resins and mixtures thereof, all of which, together with accelerators therefor, are available commercially and will afford sufficient strength and rigidity so that the shell layer thereof need not be as thick ordinarily as in the case where concrete is used. Such resins as applied may be reinforced by first applying to the mandrel a layer or layers of fiberglass cloths, mats or fibers which are subsequently impregnated with the poly-

ester resin. It may be noted that the aforementioned resins need not be employed full strength, but may be extended or filled with an inert material, for example sand, thus greatly reducing the cost of the plastic material for a given thickness of shell.

In case the shell, whether of concrete or plastic material, is to be cast about the mandrel by the use of a mold, the mold might for example comprise a precast or preformed and relatively thin-walled enclosure, made in sectional lengths if desired, which may be slid onto the mandrel and of a size so that there is a considerable clearance space between same and the mandrel, such clearance space then being filled with the plastic material or concrete to form the main body of the shell in bonded relation to the mandrel. And the outer shell used as a mold may remain bonded in place to form a part of the total shell of the assembly as driven into the ground. In case such an outer mold shell is applied in sectional lengths, the plastic or other material such as used to fill the clearance space about the mandrel, may also be used to seal the joints between the sections of such outer molding shell.

The form with the hardened shell thereon is driven into the ground as an assembled unit. The rigid form or mandrel forms a "backing" for supporting all areas of the shell against cracking. Preferably the form is designed so that it will apply portions of the driving impacts to the top end of the shell, to the interior of the bottom and also along the sides of the shell by reason of the bond between the shell and the tapered form.

If other piles are to be driven nearby, the form is preferably left in the shell until such other piles are driven, so as to support the shell against any possibility that the shell will be crushed by uneven ground pressures. Thereafter the form is released from the shell and withdrawn. The interior of the shell may now be readily inspected and if in satisfactory condition, same may be filled with concrete or the like to complete the pile.

However, if for any reason it is found that the pile shell has cracks or leaks, or any portion thereof has collapsed after the form is withdrawn, then another pile shell may immediately be driven in the same location.

Thus a method is provided having the same general advantages above noted, which accrue when steel pile shells are used, and in addition there is a substantial saving of expense for the steel and the expense and difficulties of shipping steel shells to remote or inaccessible locations. Furthermore, it may be noted that, if upon inspection of steel pile shells after same are driven, it is found that they are not in satisfactory condition, then another shell cannot be properly driven in the same place because there then would be the danger of occurrence of air spaces between the shells, so that after rusting, the pile may tend to settle into such spaces, which are thus generally considered objectionable, but which are entirely avoided by the use of concrete or plastic shells. That is, if a new shell is driven at the location of a previously driven imperfect shell, the redriven shell will merely be surrounded by unobjectionable lumps of concrete or plastic without the retention of air spaces.

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

In the drawings:

FIG. 1 is a vertical sectional view through a concrete shell as molded on a mandrel assembly in accordance with the invention;

FIG. 2 is a view showing the concrete shell and mandrel assembly after the shell has been driven into the earth, and showing the position of the parts as the mandrel assembly is ready to be released from within the shell;

FIG. 3 is a view similar to FIG. 2 but showing the relationship of the parts just after the mandrel assembly has been upwardly displaced in the shell and is ready to be withdrawn;

FIG. 4 is a vertical sectional view through a concrete pile shell as driven into the earth in accordance with the invention, and after such shell has been filled with concrete;

FIG. 5 is a horizontal sectional view taken substantially along line 5—5 of FIG. 2;

FIG. 6 is a view similar to FIG. 2, but showing a somewhat modified form of the invention;

FIG. 7 is a view similar to FIG. 4, but illustrating a concrete pile as made with the embodiment of FIG. 6;

FIG. 8 is a view of the upper end portion of the assembly of FIG. 6 after removal of the jacking head therefrom;

FIG. 9 is a top view of the parts shown in FIG. 8;

FIG. 10 is a vertical sectional view illustrating another embodiment of the invention for providing a composite type of pile having a lower portion formed of a length of metal pipe, for example;

FIG. 11 is a vertical sectional view illustrating a further embodiment of the invention whereby a pile may be formed having a bulbous lower end; and

FIG. 12 illustrates a still further embodiment of the invention in vertical section and comprising a composite type of pile with a lower portion formed with a length of wooden piling.

Referring now to the drawings in further detail, a mandrel, driving form or core member is shown at **10**, which may for example comprise a rigid hollow member of cast steel. This member as shown preferably is tapered so as to have its larger cross-section at the top, the diameter gradually and preferably uniformly diminishing toward the bottom, which terminates preferably as a bluntly conical portion as at **11**. The degree of taper may vary considerably depending upon the dimensions of the desired pile, but in a typical case, the taper may for example be in the neighborhood of $\frac{1}{32}$" per foot of the vertical dimension. In some cases, however, it may be preferred to have a much steeper taper, for example of about 0.4" per foot, which is comparable to the taper used for many tubular steel pile shells.

The mandrel **10**, as shown, is enveloped by a layer of concrete or plastic material **12** which may be molded thereon as by any of the methods hereinabove mentioned. The thickness of this layer may depend to a considerable extent upon the dimensions of the desired pile, but in the usual case, a layer of from 1–5" thick will be ample if of concrete and same may contain varying amounts of reinforcing material such as inexpensive wire mesh, although in some cases it is contemplated that that may not be necessary especially if plastics, such as above mentioned, are used to form the shell. In the usual case, the layer at the various heights along the mandrel may be of uniform thickness, so that the external surface thereof will have a taper corresponding to that of the mandrel, although of course it will be understood that, if desired, the lower portions of the layer might be somewhat thicker so that the external surface will conform to an elongated cylinder and with usually somewhat thickened wall areas or even bulbous, if desired, at the lower end **13**.

As shown, the upper end of the mandrel **10** may have bolted thereto a head piece **14** to be surmounted by a pile driving cap **15** of suitable known type such as commonly used in connection with pile driving equipment.

Usually in order to minimize the number of mandrels necessary for making a considerable number of piles, provision should be made for accelerating the setting of the concrete layer **12** (if concrete is used) after same has been applied. Any of the well known methods for this purpose may be used, for example, steam may be admitted to heat the mandrel through a cavity **16** connected

to a suitable source of steam supply, and the interior chamber **17** of the mandrel may be vented as through a cavity **18** as shown.

If difficulty at a later stage in the method is encountered in extracting the mandrel from within the shell after the shell is driven, this difficulty may be overcome by coating the mandrel **10** with a suitable fusible coating, as indicated at **20**, prior to application of the concrete. This coating, for instance, might comprise a thin layer of sulphur, asphalt or the like bituminous material, or other easily fusible or easily softened material, which upon heating the mandrel internally at the desired time, will fuse or soften and thus permit easy removal of the mandrel upwardly from the shell. Preferably the coating should be a material which upon fusing or softening will tend to adhere to the mandrel rather than the concrete, or which upon heating will drain to the bottom of the shell and not leave any coating on the interior wall surfaces of the shell, into bonding contact with which it is desired eventually to pour and cast a body of concrete to complete the pile. Easily fusible material formed of various synthetic thermoplastic materials might for example be used for the purpose. In some cases where undue adherence of the mandrel within the shell may be encountered, the difficulty might be overcome by introducing into the mandrel or circulating through the mandrel, a liquid refrigerant through the cavities **16**, **18**, for thereby contracting the mandrel with respect to the shell to facilitate easy separation thereof.

After the concrete or other material constituting the shell has become firmly set, the assembly of FIG. 1 is driven to the desired depth or footing in the earth at the location of the desired pile, and by the use of any of the usual typese of pile driving hammers. Upon superficial consideration, it might be assumed that it would be substantially impossible to cast a shell of concrete or the like onto a mandrel as shown in FIG. 1, with the concrete bonded in place sufficiently securely to allow the assembly to withstand the powerful impacts of a pile driving hammer without cracking the shell when being driven into the compacted earth usually encountered in pile driving. Cracking of the shell might also be expected to be encountered in endeavoring to jack up or hammer upwardly the mandrel in order to remove it after driving of the shell. However, actual tests have proven that with an assembly such as of FIG. 1, it is quite possible to cast such a shell as shown, to drive it intact and later to remove the mandrel in view of the following facts. First, as will be noted, the headpiece has its peripheral portions **21** extending out to overlie the upper end of the cast concrete shell so that an accurately formed upper end edge is provided on the concrete, against which a substantial part of the force of the driving impacts may be applied. Furthermore, a substantial part of the force of such impacts will be applied by the bottom end **11** of the mandrel directly to the lower end wall **13** of the shell, whereby the initial penetration of the earth occurs. Thus the lower end portion **13** which penetrates into the earth and forms the greater part of the hole for the pile, is firmly backed by the lower end of the steel mandrel. Furthermore, portions of the forces of the impacts will also be transmitted from the tapered side walls of the mandrel to the shell portions bonded thereto, and these forces will be widely and uniformly distributed over the entire internal wall surface areas of the shell. Thus there will be no excessive forces applied to the interior of the concrete shell at any particular localized areas, particularly for the reason that the shell was cast or bonded directly in contact with or onto the mandrel surfaces (or the fusible coating thereon, if used) so that there will be no spaces between the mandrel and any part of the interior of the shell. Under these circumstances, it will be apparent that the strains in the shell will at all times be very nearly the same as the strains in the adjacent areas of the steel mandrel, thus affording the minimum liability that the shell will crack with respect to the mandrel.

After the shell has been driven, as shown in FIG. 2, the headpiece **14** may be unbolted and removed and replaced by a jacking headpiece **23**, secured to the mandrel **10** as by the same bolts **24** previously used for securing the headpiece **14** in place. But before the headpiece **23** is applied, a jacking ring **25** is preferably placed so that its lower annular edge will rest against the accurately formed annular upper end edge of the concrete shell. It will be noted that the lower end of the jacking head **23** has a lower bolting flange **26** of a diameter sufficiently small to fit within the ring **25**. The upper end of the jacking head **23**, however, has a peripheral flange **27** of greater diameter and whereby a plurality of hydraulic jacks or the like as at **28** may be inserted at spaced points, around between the ring **25** and the flange **27**.

If the mandrel has a fusible coating such as of sulphur or the like thereon, steam or other hot fluid may be introduced as through conduit **16'** to heat the mandrel and thus melt or soften the coating, the fluid being vented as through vent pipe **18'**.

The jacks may be interconnected as by an annular manifold pipe **30** (FIG. 5) for the hydraulic fluid, and as such jacks are actuated, they will force the jacking headpiece **23** to rise, together with the mandrel **10** as bolted thereto, in the manner shown in FIG. 3. The mandrel, headpiece, jacks and jacking ring **25** may now all be lifted up and away, leaving the hollow driven pile shell, which may be cut off at the desired level above the ground, if necessary, by known methods. Then, if after inspection such shell is found to be satisfactory, it is filled by pouring in a mass of concrete as indicated at **32**, which is allowed permanently to set and to form with the shell a permanent pile as shown in FIG. 4.

In many cases it may be desired to use the same assembly of metal parts for making concrete pile shells of various different lengths. For this purpose, as shown in FIG. 6, the upper portion of the mandrel **10** may be embraced by a filler band or ring **40** which may be split for convenience of application and removal, so that the two halves thereof may be secured together as by bolts **41**. However, of course, this ring need not necessarily be split, but may be formed of one integral piece slidable upwardly into the position shown and so that its upper annular edge surface will initially firmly engage the flange on the headpiece **14** (FIG. 1) while the upper end of the concrete shell at **42** (FIG. 6) is being cast directly against the lower annular edge of the ring **40**. It will be understood that rings as at **40** of various heights may be provided depending on the desired length of the pile shell to be formed. For instance, as shown in FIG. 6, a ring **40** was selected high enough so that when the pile shell **10** was driven into place, its upper end was flush with the surface of the earth.

It will be understood that the mandrel assembly need not necessarily be so constructed as to be jacked up with respect to the shell. For example, provisions may be made for facilitating its withdrawal in the manner of the mandrel of United States patent to Upson No. 2,421,666, reference to which is hereby made.

Referring now to the embodiment of FIG. 10, there is shown a mandrel **50** (corresponding to the mandrel **10** above described) with a plastic or concrete coating or shell **51** applied thereto, like that of the shell **12** above described. The mandrel is formed at its lower end with an extension portion **52** surrounded by the lower end portions of the shell **51** and a further extension preferably of somewhat reduced diameter as at **53**. A sheet metal sleeve **54** is provided to closely fit the extension portion **52** of the mandrel, the lower portion of the shell being cast to embrace this part of the sleeve. The sleeve extends down as shown to form a receptacle for

receiving a length of metal pipe as at 55 which is to form the lower portion of a composite pile, the upper portion of the pipe being slidable into position on the extension 53 of the mandrel. It will be apparent that the coating or shell 51 may be applied in the same manner as above described in connection with other figures of the drawings. And after the assembly has been arranged as shown in FIG. 10, it may be driven into the ground. A boot or lower end closure 56 for the pipe will engage the ground and such boot, together with the pipe, will provide rigid means for initially forming a hole in the ground of a diameter nearly as large as that required to receive the shell 51. Thus by this arrangement, in addition to providing a structure with the advantages of an inexpensive composite pile having a lower portion formed of a length of steel pipe, the arrangement is further particularly advantageous for use in connection with the cast shell by reason of the fact that it permits the assembly to be driven into the earth with less danger of cracking or breaking such shell.

With the embodiment shown in FIG. 11, the mandrel, as indicated at 60, is surrounded by a shell 61, like shell 51, and which may have an open end at the bottom. When driving this arrangement, a core 62 is inserted therein and the lower end of the core 63 being closed, it will serve to close the lower end of the shell 61 during the operation of driving. After such driving, the core 62 may be withdrawn. Then wet concrete may be poured into the interior of the mandrel 60 and such mass of concrete may be suitably subjected to sufficient pressure at its upper surface to force wet masses of concrete out through the bottom end of the shell to form a bulbous footing as at 64 for the finished pile. Thereafter the mandrel 60 may be withdrawn and the interior of the shell 61 filled with concrete to complete the pile.

With the embodiment shown in FIG. 12, a mandrel 70 is here shown surrounded by a concrete or plastic shell 71, as in the case of the above embodiments. But here the lower end portion 72 of the mandrel is embraced by a wedge ring 73 about the upper portion of which the shell is cast and the lower edge of which is adapted to penetrate into the top end of a wooden pile 74 for forming the lower portion of a composite pile. Here, as in the case of FIG. 10, the wood pile may serve to penetrate the earth first and to thus provide a hole nearly large enough to receive the cast shell which follows. With this form of composite pile for some purposes and in some locations, the advantages of the invention above described may be attained for the upper portion of the pile whereas the lower portion may be relatively inexpensively formed of wood.

With the forms of the invention shown in FIGS. 10 to 12, inclusive, since the lower end of the mandrel will not bear against any extensive area of the shell portions bonded thereon, it is desirable that the upper end of the mandrel be formed with peripheral flanges as shown at 80 in FIGS. 10 and 11, which flanges will extend out to overlie the upper end edges of the shells 51 or 61, so that such flanges can serve to transmit the force of driving impacts to the upper end edges of the shells. However, these flanges 80, if they should bear directly against the upper end edges of the shells, would render the shell edges inaccessible for engagement by the jacking ring such as at 25 in FIGS. 2 and 3, when extracting the mandrel. To avoid this difficulty, steel rings as at 81 may be interposed between the flanges 80 and the upper end edges of the shells, when the shells are being cast. These steel rings 81 are so shaped as to extend outwardly beyond the flanges 80, as will be noted. And when it is desired to extract the mandrel, a jacking ring as at 25 in FIGS. 2 and 3 may then be used of a diameter such as to engage these outwardly protruding portions of the steel ring 81, whereupon a jacking head and jack means similar to those of FIGS. 2 and 3 may be used in cooperation with the steel rings 81 for extracting the mandrel. For driving the assemblies as of FIGS. 10 to 12, inclusive, a head piece can be used similar to that of FIG. 1, and after completion of driving, such head piece may be removed and replaced by a jacking arrangement and jacking ring means similar to those of FIGS. 2 and 3 and similarly bolted in place with respect to the mandrel for extracting the mandrel by applying upward pressure thereto reacting downwardly against the steel ring 81 and thence against the upper end edges of the shells.

The upper and inner surfaces of the steel rings 81 should be carefully finished so as to provide true uniform contact with the adjacent upper end and flanged portions of the mandrel so that, when driving impacts from the driving head means are applied to the latter, the force of the impacts will be uniformly transmitted through the rings 81 and thence to the upper end edges of the shells cast in contact therewith.

Although certain preferred 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. Method for forming and installing pile shells of concrete and the like which comprises casting a layer of the concrete upon the exterior of a rigid metal mandrel which forms a mold for the interior surface of such concrete layer, then after such concrete layer has hardened and become bonded as a rigid mass with respect to the mandrel, driving the mandrel into the earth with such layer thereon directly engaging the earth under pressure resulting from the driving, at the location of a desired pile, and extracting the mandrel from within the concrete, thereby leaving the concrete in the earth to provide a concrete pile shell.

2. Method for forming and installing piles of concrete and the like which comprises casting a layer of concrete upon the exterior of a rigid metal mandrel, then after such concrete layer has hardened and become bonded as a rigid mass with respect to the mandrel, driving the mandrel into the earth with such concrete layer thereon directly engaging the earth under pressure resulting from the driving, at the location of the desired pile, extracting the mandrel from within the concrete, thereby leaving in the earth a concrete pile shell, and then filling such shell with concrete.

3. Method for forming and installing pile shells of concrete and the like which comprises casting a layer of concrete upon and covering the side and bottom end surfaces of a tapered rigid mandrel, then after such concrete layer has hardened and become bonded in place, driving the mandrel into the earth with such concrete layer thereon directly engaging the earth under pressure resulting from such driving, at the location of a desired pile, and extracting the mandrel from within the concrete, thereby leaving the concrete in the earth to provide a concrete pile shell.

4. Method for forming and installing pile shells of concrete and the like which comprises casting a layer of the concrete upon the exterior of a rigid mandrel which has been coated with a readily fusible material, then after such concrete layer has hardened and become bonded in place, driving the mandrel into the earth with such concrete layer thereon directly engaging the earth under pressure resulting from such driving, at the location of a desired pile, heating the interior of the mandrel to soften said coating, and then extracting the mandrel from within the concrete, thereby leaving the concrete in the earth to provide a concrete pile shell.

5. Method for forming and installing pile shells which comprises casting upon the exterior of a rigid mandrel a plastic layer of material which will harden and become rigid, then after such layer is hardened as a rigid mass

upon the mandrel, driving the mandrel into the earth with such layer thereon directly engaging the earth under pressure resulting from the driving, at the location of the desired pile, and extracting the mandrel from within the plastic layer thereby leaving in the earth a pile shell formed of the hardened plastic and aadapted to be filled with concrete to form a pile.

6. Method in accordance with the foregoing claim 5 and in which the material used for forming the plastic layer comprises a synthetic resin which is applied in plastic condition and is thereafter self-hardening to a rigid condition.

7. Method in accordance with the foregoing claim 5 and in which a length of metal pipe is applied to the lower end of the mandrel before the mandrel is driven into the earth, such length of pipe in conjunction with the shell being adapted to form the lower portion of a composite pile, the lower end of the mandrel when extracted from the shell being slidably disengageable from the upper portion of the length of pipe.

8. Method in accordance with the foregoing claim 5 and in which a wooden pile is applied to the lower end of the mandrel before the mandrel is driven into the earth, such wooden pile in conjunction with the shell being

adapted to form the lower portion of a composite pile, the lower end of the mandrel when extracted from the shell being disengageable from the upper portion of the wooden pile.

9. Method in accordance with the foregoing claim 5 and in which a hollow mandrel is used and the mandrel and shell are formed with openings at their lower ends and a core is located in the mandrel during driving, such core having a bottom closure which closes said openings during the driving, the method being further characterized in that after driving the mandrel such core is extracted whereupon a mass of concrete is forced down through said openings to form a bulbous footing for a pile.

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