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METHOD OF AND APPARATUS FOR MAKING CAST-IN-PLACE PILES

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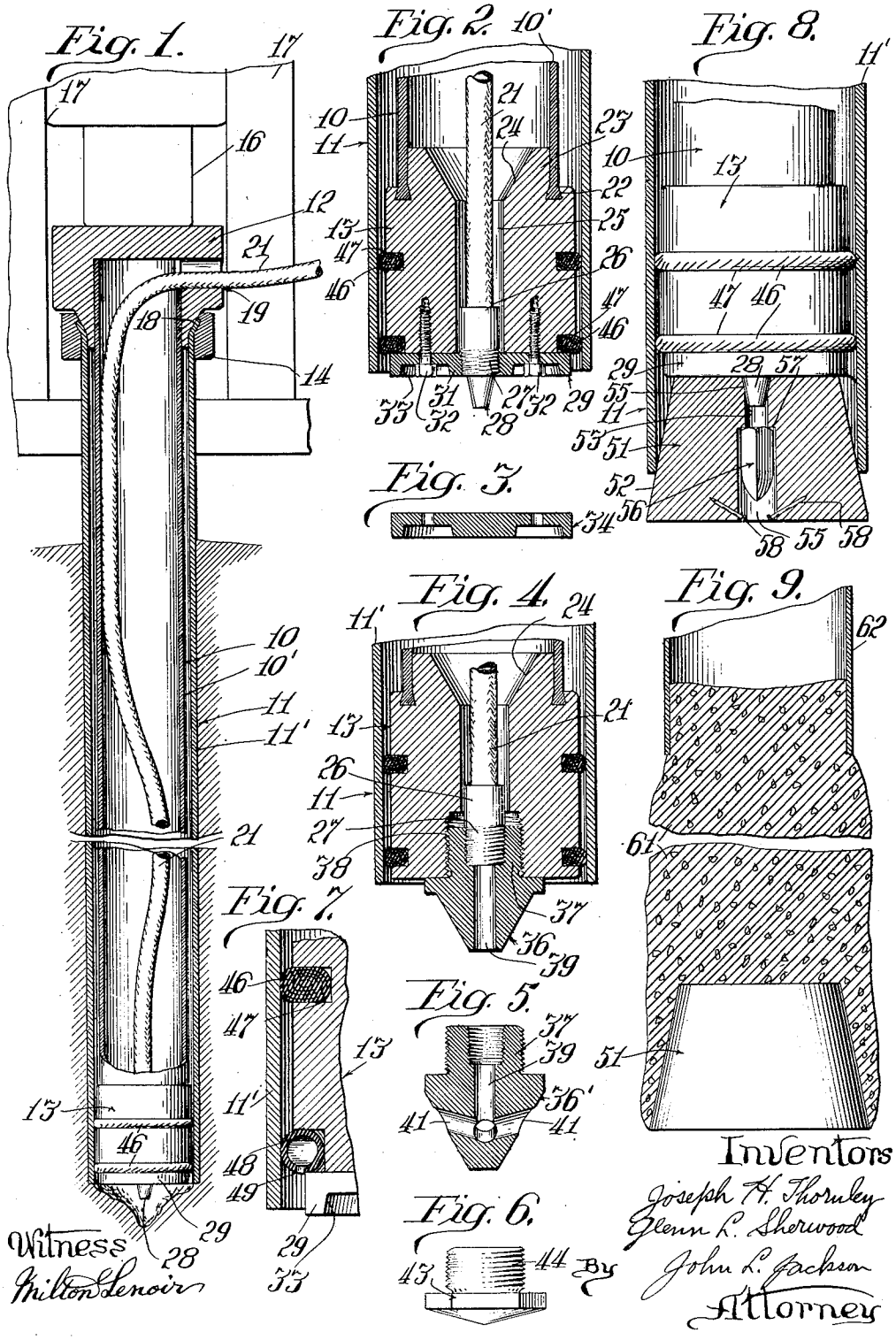

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METHOD OF AND APPARATUS FOR MAKING CAST-IN-PLACE PILES

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The present invention pertains generally to the art of producing foundation piles, and has as one of its objects to provide an improved method of and apparatus for making cast-in-place concrete piles. More specifically in this regard, the invention aims to provide an improved construction of core and casing for sinking the hole in the ground preparatory to forming the pile therein. Such core and casing are so constructed and arranged that the hole can be sunk by a combination jetting and driving operation, which is particularly efficacious in sandy and other loose soils. The jet discharge occurs down through the core, being arranged to discharge substantially centrally of the lower end of the core so that there is no tendency to jet the hole out sideways with consequent lateral slewing of the core and casing. One of the features of the construction is the ability to convert the core and casing for use either in a combination jetting and driving operation or for use in a driving operation only.

Another object of the invention is to provide improved packing means between the lower end of the core and the side walls of the casing so as to prevent the water and soil from passing upwardly into the casing, thereby retaining the interior of the casing substantially dry and free of soil for the subsequent formation of the concrete pile. This packing means is of considerable importance when using the core and casing in a combination jetting and driving operation, since the successful formation of the cast-in-place pile requires that the interior of the casing be maintained substantially dry and free of soil.

Another object of the invention is to provide improved means for closing the lower end of the casing so that the core can be withdrawn, preparatory to forming the concrete pile in the casing, without permitting the entrance of water and soil into the casing. This closure means is of particular utility in loose, wet soils which tend to enter the lower end of the casing as soon as the core is withdrawn. In its preferred construction, such closure means is in the form of a plug which seats in the lower end of the casing and which has a jet passage therethrough controlled by a check valve which permits the high pressure stream of water from the core to pass downwardly through said jet passage during the operation of jetting and driving the hole, but which prevents the return flow of water back into the casing at the completion of the jetting operation. Such closure plug is left in the bottom of the hole upon the removal of the casing, in which location it serves as a base member for the cast-in-place pile.

Other objects and advantages of our invention will appear from the following detailed description of the preferred apparatus and method for carrying out the invention. In the drawings accompanying this description:

Figure 1 is a vertical sectional view through the core and casing, illustrating the latter engaged in the operation of sinking a hole.

Figure 2 is a vertical, sectional view on a larger scale, through the lower end of the core and casing.

Figure 3 is a sectional view showing the closure element for the base end of the core, when the hole is to be sunk by a driving operation only.

Figure 4 is a sectional view similar to Figure 2, showing a modified construction.

Figure 5 is a sectional view of a modified form of jet nozzle.

Figure 6 is a sectional view of a closure element such as is employed with the construction shown in Figure 4.

Figure 7 is a fragmentary sectional view illustrating a modified form of packing ring.

Figure 8 is a vertical sectional view showing the use of the closure plug which engages in the lower end of the casing; and

Figure 9 is a vertical sectional view illustrating one of the operations in the formation of the cast-in-place pile.

Referring to Figure 1, the core and casing are indicated at 10 and 11 respectively. The main stem portion of the core consists of a length of heavy pipe or tubular shell 10', and similarly the main portion of the casing consists of a length of heavy pipe or

shell 11′, which surrounds the core. Secured to the upper end of the core stem 10′ is a driving head 12, and secured to the lower end thereof is a base member 13. Mounted on the upper end of the casing shell 11′ is a collar 14 which forms a shoulder under which a hoisting yoke is engaged when it is desired to pull the casing up out of the ground.

The core and casing are driven by a pile driving hammer which is fragmentarily illustrated at 16, such hammer being guided between the leads 17 of a typical pile driver derrick. The upper ends of the core and casing receive the guiding influence of the derrick leads, either through direct engagement of the core head 12 therewith or through the engagement of the core head with the base of the hammer 16. The driving blows imparted to the core head 12 are transmitted to the upper end of the casing 11 either through direct engagement of the under side of the core head with the collar 14, or through an angularly shaped surface 18 on the under side of the core head which maintains the outwardly swaged joint between the casing shell 11′ and the collar 14.

In certain soil conditions the hole in which the pile is to be formed can be sunk more rapidly by a combination jetting and driving operation, i. e., by forcing a high pressure discharge of water into the soil below the core and casing, and concurrently therewith imparting driving blows to the core and casing from the pile driving hammer 16. Under soil conditions most frequently encountered, however, it is more desirable to sink the hole solely by a driving operation. The necessity of having two types of apparatus for these different soil conditions is objectionable, and one of the features of the present invention is the provision of one form of apparatus which can be readily converted for operating under either soil condi ion. Owing to the extreme vibration which is set up in the core in the driving thereof, it is preferable that the water jet apparatus be removed from the core when the hole is to be sunk solely by a driving operation, and one of the features of the invention is the arrangement whereby this is made possible.

Referring to Figure 1, it will be seen that the core head 12 is provided with a relatively large opening 19 in the side thereof, this opening communicating with the hollow interior of the core shell 10′. When the apparatus is to be used in a combined jetting and driving operation, a heavy flexible hose or like conduit 21 is inserted through the opening 19 and is threaded down through the core for connection with a jet opening in the core base 13.

Referring to Figure 2, it will be seen that such base is rigidly secured to the lower end of the core shell 10′, the latter preferably having a swaged joint engagement in an annular groove or recess 22 in the top of the base. An annular neck portion 23 extends upwardly within the shell 10′, and this neck portion is formed with a tapered or funnel shaped opening 24 which serves to guide the water conduit 21 down into the jet passage 25 which extends axially down through the base 13. Suitably secured to the lower end of the conduit 21 is a nipple 26 which is externally threaded at 27 for effecting attachment to the base. If desired, the nipple 26 may be provided with a nozzle extremity 28 through which the water is discharged down into the soil below the core. In the construction shown in Figure 2, the attachment of the nipple 26 to the core base 13 is effected through a removable plate 29. This plate has a central boss 31 which is internally threaded for receiving the threaded portion 27 of the nipple. The plate is secured to the bottom of the core base by cap screws 32 which pass up through openings into the plate and tap into threaded holes in the core base. The under side of the plate 29 may be formed with recesses or pockets 33 for receiving the heads of the cap screws 32.

When the core and casing are to be used in a combined jetting and driving operation, a cord having a suitable weight at the end thereof is inserted through the opening 19 in the driving head 12 of the core, and this weighted cord is threaded down through the core and through the base 13, the tapered opening 24 guiding the same down through the jet passage 25. The hose 21 with the nipple 26 attached thereto is then fastened to the upper end of the cord and is drawn down through the core to bring the nipple 26 down below the base 13. The attaching plate 29 is then screwed over the threaded portion 27 of the nipple, and the assembly of the device is completed by securing said plate to the base 13 through the placing of the cap screws 32. These operations are, of course, performed while the core and casing are supported above ground level between the derrick leads 17. A source of water supply under pressure is connected to the upper end of the hose 21 so that concurrently with the driving of the core and casing a jet discharge will occur down through the nozzle 28 for jetting out the soil in advance of the core and casing.

When the apparatus is to be used for sinking a hole solely by a driving operation it is desirable that the hose 21 be removed from the core, so as to avoid subjecting the same to the severe vibration and whipping movement which is set up in the hose under the impulse of the driving blows on the core. In removing the hose it is desirable that the base end of the core be closed off completely so as to prevent soil being driven up into the hollow core, and to prevent the entrance of

water therein. At this time, the attaching plate 29 is released, the nipple 26 is disconnected therefrom, and the hose and nipple are pulled up out of the core. A closure plate 34, such as shown in Figure 3, is now substituted for the attaching plate 29. This closure plate is provided with openings for receiving the cap screws 32, and is generally similar to the attaching plate 29, except that the central portion thereof is solid for closing off the lower end of the jet passage 25. The operations of removing the hose 21 and substituting the closure plate 34 for the attaching plate 29 can be quickly and easily performed, and thereupon the apparatus is ready for use in the driving operation.

Figure 4 illustrates a modified method of attaching the nipple 26 to the core base 13. In this instance a nozzle member 36 is secured to the core base, and the nipple 26 is secured to said nozzle member. The nozzle comprises an externally threaded neck portion 37 which screws into a threaded counter bore 38 formed in the lower end of the base 13. The threaded portion 27 of the nipple 26 screws into a threaded counter bore in the upper end of the neck portion 37. The water is discharged down through a nozzle passage 39 which extends down to the tip of the nozzle.

Figure 5 illustrates a modified form of nozzle member 36'. In this construction the passage 39 communicates with a plurality of branch passages 41 which open outwardly through the tapered outer sides of the nozzle. These branch passages are preferably slightly inclined in an upward direction towards their points of discharge from the nozzle. The object of the construction shown in Figure 5 is to prevent soil being forced into the nozzle passage under the impact of the driving blows, and thus clogging the nozzle. It will be evident that there will be practically no tendency for the soil to be forced into the upwardly inclined branch passages 41, the pressure of the water discharged therethrough being ample to maintain these passages clear at all times. The manner of attaching the nipple 26 to either form of nozzle 36 or 36', and of mounting such nozzle in the core base 13 will be obvious from the foregoing description. When the jetting apparatus is removed, as for placing the core and casing in condition for a driving operation, the jet passage 25 is closed by screwing a plug 43 up into the threaded counter bore 38. Such plug is illustrated in Figure 6 and comprises a solid neck portion 44 which is threaded for engaging in the counter bore 38.

To make the combined jetting and driving operation practicable, it is important that an effective seal be maintained between the lower end of the core and the inner walls of the casing 11. If water and soil should be allowed to flow upwardly between the core and casing in any appreciable quantities, it will be evident that the soil may bind the core in the casing, and the presence of the water and soil therein will hinder or prevent the subsequent formation of the pile in the casing.

We have provided an improved form of packing means between the lower end of the core and casing which effectively prevents the entrance of water and soil between the two. Referring again to Figure 2, it will be seen that the core base 13 is of slightly smaller diameter than the interior of the casing so that the core can slide freely therein. The intervening space between the two is closed off by one or more packing rings 46, two of such rings being shown. Each ring engages in an annular groove 47 formed in the outer surface of the core base. The attaching plate 29 may be extended across the bottom groove 47 to hold the lower packing ring 46 in place. Each packing ring consists of a length of tarred rope which is forced into the groove 47. The width or vertical dimension of the groove is narrower than the normal diameter of the rope, so that the latter must be compressed into the groove, with the result that the outer sides of the rope are caused to project outwardly into close fitting engagement with the inner wall of the casing. This provides an efficient form of packing ring and one which can be renewed cheaply and with little difficulty.

In Figure 7 we have shown a modified form of packing ring consisting of a length of heavy rubber hose, or a continuous hollow rubber ring, designated 48. A plurality of spaced holes 49 are provided in the under side of this ring, in position to permit the entrance of the water which is confined below the core base into the ring. This water, which is under pressure, will expand the ring so as to force the outer side thereof outwardly into close sealing engagement with the side walls of the casing. This expansible form of ring is preferably employed at the lower end of the core base, with a rope ring 46 mounted in the upper groove 47, although, if desired, the expansible type of ring 48 may be employed in both grooves. When employing a jet nozzle of the type shown in Figures 4 and 5, the lower groove 47 is spaced upwardly from the lower edge of the core base 13 so that the upper and lower walls of the groove will be defined by the core base.

After the hole has been sunk to the desired depth, the core is lifted out of the casing so as to permit of the formation of the pile in the casing. When operating in certain soil conditions, as for example where the soil is comparatively dry, the core can be withdrawn without the possibilty of soil or water rising within the casing. Very frequently, however, soil conditions are encountered at he bottom of the hole which will

result in water and soil flowing upwardly into the casing as soon as the core is withdrawn. When operating under these conditions, it is desirable to retain the lower end of the casing closed, after the removal of the core, until the concrete can be dumped into the casing for the formation of the pile. For such situations, we employ a plug member 51 which is seated in the lower end of the casing above ground level before the driving operation is started. Such closure plug may be constructed of wood, or in the form of a precast concrete block, and has a sloping outer surface 52 which becomes wedged in the lower end of the casing. As we shall hereinafter describe, the plug is left in the ground at the base of the finished concrete pile, and accordingly it is desirable to make the plug of an inexpensive material, such as wood or concrete. These materials do not have much resistance against shatter, particularly from outwardly acting disruptive stresses consequent on driving blows being transmitted to the plug. However, we overcome this difficulty by the wedging taper fit between the sloping outer surface 52 of the plug and the edge of the casing, which wedging fit confines the plug and serves to cause some of the downward forces acting through said casing to be transmitted to the plug as inwardly acting compression stresses in said plug for preventing fracture thereof. This sloping outer surface 52 may be coated with tar or some similar material to effect watertight sealing engagement with the end of the casing. When such plug is employed, a suitable spacing element is preferably interposed between the under side of the core head 12 and the hoisting collar 14 on the upper end of the casing, so that the lower end of the casing will be extended down below the core base a sufficient distance to grip the plug, the driving blows being transmitted to the plug, however, from the core 10 for forcing the plug down through the soil. The plug is preferably constructed so that it can be employed in the combined jetting and driving operation, at which time the jet discharge will pass down through the plug into the soil below the same. To this end, the plug is formed with a central jet passage 53 extending axially of the plug. The upper end of this passage has a tapered counter bore 54 for establishing a close fitting engagement over the jet nozzle at the lower end of the core. It will be understood that this counter bore 54 will be made comparatively small for receiving the nozzle extremity 28 shown in Figure 2, or will be made comparatively large for receiving the nozzle member 36 of Figure 4, depending upon which construction is employed. The lower end of the passage 53 is also provided with a relatively large counter bore 55 in which is located a check valve 56. This valve member preferably consists of a wood plug, either of square or fluted cross section, for permitting water to pass downwardly around the valve member. The upper edge of said valve member is rounded to have seating engagement with the lower circular edge 57 of the reduced passage 53, such edge forming a valve seat for the valve member 56. To prevent the valve member from dropping down out of the counter bore 55, a plurality of nails 58 may be toe-nailed into the sides of the counter bore to have their heads disposed below the valve plug, or in the case of a precast concrete plug, any suitable projection or projections can be embedded in the concrete for preventing displacement of the valve member.

After the closure plug 51 has been seated in the end of the casing the core and casing are sunk by a combined jetting and driving operation, wherein the water discharged from the core passes downwardly through the central passageway 53 of the closure plug for jetting out the soil below the plug, and concurrently therewith driving blows are transmitted to the core and casing for forcing the plug downwardly through the soil. It will be noted that the jet discharge is axial with respect to the plug so that uniform jetting of the soil to each side is assured. When the hole has been sunk to the desired depth the jetting and driving operations are discontinued, and the core is lifted out of the casing. At this time, the plug effectively seals the lower end of the casing against the entrance of water and soil, the valve member 56 by its engagement against the seat 57 preventing return flow of water through the passage 53.

The operation of separating the closure plug 51 from the end of the shell is preferably performed through a comparatively long slug or charge of concrete 61 (Fig. 9) which closes the end of the casing against the entrance of water and soil as the plug and casing separate from each other. As soon as the core 10 is withdrawn at the conclusion of the driving and jetting operation, the charge of concrete 61 is dumped into the casing upon the closure plug 51. Thereupon a suitable ram or core is lowered into the casing to bear upon the upper end of the charge 61, such ram or core consisting of the same core which has been previously used in sinking the hole, with its jet passage closed against the entrance of concrete, or consisting of any other suitable ram or core for exerting downward pressure on the concrete. Reversely acting forces are now set up in the charge of concrete 61 and in the casing 11 to force the closure plug 51 from the lower end of the casing. This may be accomplished by pulling upwardly on the casing and at the same time establishing a downward pressure against the upper end of the ram or core, either by holding a stationary abutment against the upper end thereof, or by impart-

ing driving blows thereto. After the casing has been freed from the closure plug 51 and has moved upwardly therefrom the concrete is free to expand outwardly into direct contact with the earth walls of the hole. If desired, driving blows may be continued on the ram so as to cause the charge of concrete to flare or bell outwardly below the lower edge of the casing for the purpose of producing a flared or expanded pedestal portion of larger diameter than the column portion of the pile. It will be noted that the concrete will flow outwardly around the sides of the closure plug 51, the latter becoming embedded in the concrete, in which position it remains as a base element for the pile. Upon the completion of these operations, the ram or core is withdrawn, and a light shell 62 is lowered into the casing 11 to have its lower end bear upon the charge of concrete 61, or to become embedded therein. Thereupon additional concrete is dumped into the shell 62 to form the column portion of the pile extending up to ground level, this additional concrete bonding with the lower charge 61. Any suitable reinforcing means may be inserted in the shell 62 prior to the dumping of this additional concrete. As the final step, the casing 11 is then withdrawn, the completed pile consisting of a lower base portion 61 of concrete and the long column portion composed of the light shell 62 and its filling of concrete, suitably reinforced if desired.

As an alternative method of forming the pile, the light shell 62 may be omitted entirely and the additional concrete, which is superposed over the base charge 61, may be dumped directly into the casing 11. Prior to the setting of the concrete, the casing is withdrawn, suitable reaction pressure being held against the upper end of the column of concrete, if need be, to strip the concrete out of the casing. According to this latter method, the concrete column portion of the completed pile will contact directly with the earth walls of the hole throughout the entire length of the pile.

What we claim as our invention and desire to secure by Letters Patent is:

1. In apparatus for making cast-in-place piles, the combination of a core and casing for sinking the hole in which the pile is to be cast, a water jet carried by said core, and a closure plug having a push fit in the lower end of said casing and having a passageway therein through which said jet discharges its stream of water down into the soil below said plug, said plug being releasable from said casing by vertical separating pressure exerted between said plug and casing after the hole has been sunk to the desired depth for remaining in the hole when the casing is withdrawn.

2. In apparatus for making cast-in-place piles, the combination of a core and casing for sinking the hole in which the pile is to be cast, a jet passage extending down through said core, a closure plug seating in the lower end of said casing, said plug having a passage therethrough communicating with the jet passage in said core for discharging water into the soil below said plug, and a check valve in said plug for preventing return flow of water and soil through said second named passage, said plug being releasable from said casing by the exertion of separating pressure on said plug and casing after the hole has been sunk to the desired depth.

3. The method of making cast-in-place piles which comprises driving a core and casing down into the ground with a closure plug in the lower end of said casing, the lower end of said core terminating short of the lower end of said casing, said plug having sealing engagement in the lower end of said casing and being driven by said core, withdrawing said core after the hole has been driven, and dumping concrete into said casing and separating said casing from the plug by pressure applied to the concrete.

4. The method of making cast-in-place piles which comprises driving a core and casing down into the ground with a closure plug closing the lower end of said casing, discharging water down through said closure plug for jetting out the soil progressively with the driving operation, and after the hole has been sunk to the desired depth withdrawing the core, dumping concrete into the casing, and separating the closure plug from the casing.

5. The method of making cast-in-place piles which comprises driving a core and casing down into the ground with a closure plug closing the lower end of said casing, withdrawing the core after the hole has been sunk to the desired depth, dumping a charge of concrete into the casing, inserting a ram into said casing above the charge of concrete, forcing the separation of said closure plug and casing through said charge of concrete, lowering a light shell in said casing into engagement with said charge of concrete, and substantially filling said shell with concrete.

6. The method of making cast-in-place piles which comprises driving a core and casing down into the ground, with the lower end of said casing closed by a releasable closure plug, discharging a stream of water down through said core and through said closure plug for jetting out the soil progressively with the driving operation, withdrawing the core after the hole has been sunk to the desired depth, dumping a charge of concrete into said casing, inserting a ram into said casing above the concrete and establishing opposing forces in said ram and in said casing for releasing said plug from the lower end of said casing, and forming the column

portion of the pile within said casing and thereafter withdrawing the casing.

7. The method of making cast-in-place piles which comprises imparting driving blows to a core and casing through the action of a pile driver, the lower end of said casing being closed by a releasable closure plug, concurrently with the driving operation discharging a high pressure stream of water down through said core and through said plug for jetting out the soil below said plug, withdrawing said core after the hole has been sunk to the desired depth, dumping a charge of concrete into said casing and inserting a ram therein, exerting opposite forces on said ram and on said casing for releasing said plug from said casing and for causing said concrete to expand laterally below the end of said casing, withdrawing said ram and inserting a shell into said casing and dumping additional concrete into said shell to form the column portion of the pile.

8. In apparatus for making cast-in-place piles, the combination of a core and casing for sinking the hole in which the pile is to be cast, said core comprising a base portion having sliding movement in said casing, a nozzle associated with said base portion, a conduit extending down through said core and adapted for connection with said nozzle for supplying water thereto, said conduit being removable from said core, a closure plug having a conical outer surface seating in the lower end of said casing below the base portion of said core, said closure plug having a passage therethrough adapted to communicate with said nozzle for discharging water into the soil below said plug simultaneously with the operation of driving said plug through said core and casing, and a check valve in said plug for preventing return flow of water and soil through said passage after the jetting operation has been discontinued, said plug being releasable from said casing by relative movement between said core and casing for leaving the plug in the bottom of the hole when the casing is withdrawn.

9. In apparatus for making cast-in-place concrete piles, the combination of a casing, a core within said casing, a closure member having a wedging push fit within the lower end of said casing and driven into the ground with the casing by vertical driving blows transmitted through said core, said closure member having a fluid discharge passageway therethrough, and a check valve associated with said passageway for preventing upward flow therethrough, said closure member being detachable from said casing by vertical reaction pressure acting on said closure member through a pile section within said casing, said closure member remaining in the ground after the core and casing have been withdrawn.

10. In apparatus for making cast-in-place concrete piles, the combination of a casing, a closure member having a push fit within the lower end of said casing and driven into the ground with the casing by vertical driving blows, said closure member having a fluid discharge passageway therethrough, and a check valve associated with said passageway for preventing upward flow therethrough, said closure member being detachable from said casing by a vertically acting separating pressure effective between said casing and said closure member, the latter remaining in the ground after the casing has been withdrawn.

11. In apparatus for making cast-in-place concrete piles, the combination of a casing, a core adapted to be driven down into the ground within said casing, the lower end of said core terminating short of the lower end of said casing in such driving operation, a closure plug of an inexpensive fracturable material having a tapered outer surface adapted to have a wedging water-tight fit within the lower edge of said casing, said plug extending up into said casing and engaging said core to be driven thereby, the wedging fit of said casing over said tapered surface serving to cause some of the downward forces acting through said casing to be transmitted to the plug as inwardly acting compression stresses in said plug for preventing fracture of the plug, and a passageway through said plug for discharging water in a soil jetting operation, said plug being detachable from said casing and remaining in the ground after the casing and core have been withdrawn.

12. The combination of a casing, a core adapted to be driven down into the ground within said casing, the lower end of said core terminating short of the lower end of said casing in such driving operation, a closure plug having a tapered outer surface adapted to have a wedging water-tight fit within the lower edge of said casing, the wedging fit of said casing over said tapered surface serving to confine said plug against outwardly acting disruptive stresses tending to shatter the same, said plug extending up into said casing and engaging said core to be driven thereby, said plug being detachable from said casing and remaining in the ground after the casing and core have been withdrawn.

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