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(54) IMPROVED METHOD AND APPARATUS FOR INSTALLING SUPPORT COLUMNS, SUCH AS CONCRETE PILES

(71) I, JERRY ANNALDO STEDING, a citizen of the United States of America, of 4605 Meadow Valley Drive, N.E. Atlanta, Georgia, 30305, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an apparatus and to a method for use with a pile driving hammer for forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced into the column cavity in a fluid condition and which becomes solid upon curing.

In accordance with the invention we provide an apparatus for the above purpose comprising:—

a) a plow point adapted to be driven into the ground to a desired depth,

b) a pusher adapted for releasably engaging the plow point and for transmitting the driving force of the pile driving hammer to the plow point, said pusher including a plurality of longitudinally extending rib sections which form a cross-sectional configuration that affords a maximum void area for the introduction of fill material thereabout while minimizing the cavity engaging peripheral surfaces, and

c) a mobile hopper disposed to surround the pusher at the upper end of the column cavity and including means to selectively control the flow of fill material into the column cavity. A plow point pusher adapter may be removably secured at the forward portion of the pusher for effecting a tight frictional engagement with the plow point.

The plow point pusher adapter may have upper and lower corners which are rounded to facilitate easy insertion into and removal from the plow point. Means may be provided e.g. in the plow point or at the lower portion of the pusher, for attaching reinforcing steel for introduction into said column cavity.

The upper portion of the pusher may be

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provided with a quick release drive head adapter including a locking means for releasably securing the drive head adapted to the pusher. Preferably the hopper includes scale means calibrated for indicating the quantity of fill material in the cavity. The pusher may also include scale means for indicating the quantity of fill material required to fill a bore opening formed by the plow point, the scale means being graduated to indicate the amount of fill material at increments of penetration of the plow point within the earth's surface.

In more detail the invention includes apparatus for use with a pile driving hammer for forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced in a fluid condition into the column cavity being formed and which becomes solid upon curing comprising:—

a) a plow point adapted to be driven into the ground to a desired depth,

b) a pusher adapted for releasably engaging the plow point and for transmitting the driving force of the pile driving hammer to the plow point, the said pusher being of axially elongated hollow tubular construction throughout its length having a tube wall surrounding the hollow interior providing a cross-sectional configuration that affords a large void area for the introduction of fill material,

c) a plurality of radial openings formed in the tube wall to permit the fill material to be transferred between locations outwardly of the pusher and locations inwardly of the pusher within the hollow interior during progressive filling of the cavity from the top downwards in response to formation of the cavity by movement of the plow point,

d) a mobile hopper disposed to surround the pusher at the upper end of the column cavity having a bottom opening sized to correspond substantially to the maximum cross-sectional area of the plow point and receive the pusher therethrough,

e) downwardly sloping walls in the lower region of the hopper converging to locations

closely adjacent to the perimeter of the bottom opening for guiding the fill material in the hopper along downwardly converging paths towards the vertical center axis of the opening,

f) means to selectively control the flow of the fill material into the column cavity.

The invention also includes a method of forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced into the column cavity in a fluid condition and which becomes solid after curing comprising the steps of:—

a) locating a mobile hopper at a selected location on the earth's surface where a support column is to be formed,

b) placing a plow point, which is adapted to be driven into the ground to a desired depth, within the hopper,

c) placing an intermediate pusher in releasable engagement with the plow point,

d) filling the hopper with a quantity of fill material,

e) forming a cavity of selected size and depth in the earth's surface by transmitting a driving force to the plow point by means of the pusher within the confines of the fill hopper,

f) selectively introducing the filling material into the cavity by gravity, and

g) removing the pusher from the fill material, the said pusher either including a plurality of longitudinally extending rib sections occupying substantially less cross-sectional area than the cross-sectional area of the cavity being formed while minimizing the cavity engaging peripheral surfaces or being of a tubular construction having a plurality of radial openings formed therein which will permit the fill material to be transferred between locations outwardly of the pusher and locations inwardly of the pusher during the progressive filling of the cavity from the top downward in response to formation of the cavity by movement of the plow point and the hopper being disposed to surround the pusher at the upper end of to column cavity.

In order that the invention may be more clearly understood reference is now directed to the accompanying drawings, given by way of example, in which:—

Figure 1 is an exploded perspective view showing one embodiment of the apparatus of my present application;

Figure 2 is a side elevational view in partial cross-section of the quick release drive head adapter arrangement of my present invention;

Figure 3 is a cross-sectional view taken along line 3—3 in Figure 2;

Figure 4 is a partial elevational cross-sectional view of the plow pusher in its relationship to the pusher and plow point element;

Figure 5 is a cross-sectional view taken along line 5—5 in Figure 4;

Figure 6 is a side elevational cross-sectional view of the fill hopper as shown in Figure 1;

Figure 7 is a perspective cut-away cross-sectional view of a portion of the hopper shown in Figure 6;

Figure 8 is a cross-sectional elevational view of an alternative hopper wherein the hopper is a wheeled vehicle;

Figure 9 is a cut-away perspective view of the hopper as shown in Figure 8;

Figure 10 is a side elevational view in partial cross-section of an alternative embodiment of a pusher;

Figure 11 is a side elevational view in partial cross-section of an alternative embodiment of the plow point pusher arrangement showing means therein for securing reinforcing rods thereto;

Figure 12 is a side elevational view in partial cross-section of a further alternative embodiment of a pusher element;

Figure 13 is a top plan cross-sectional view taken along line 13—13 in Figure 10;

Figure 14 is a cross-sectional view taken along the lines 14—14 in Figure 11;

Figure 15 is a cross-sectional view taken along line 15—15 in Figure 12;

Figures 16, 17 and 18 are schematic cross-sectional elevational views showing the steps of installing short length reinforcing steel;

Figure 19 is a further alternative embodiment of a hopper arrangement showing as a cross-sectional elevational view of means for introducing spooled reinforcing material;

Figure 20 is a cross-sectional view taken along line 20—20 in Figure 19;

Figure 21 is a cross-sectional view taken along line 21—21 in Figure 19;

Figure 22 is an exploded perspective view of a break-off plate positioned forwardly of the lower portion of a pusher element;

Figures 23, 24 and 25 are schematic cross-sectional elevational views showing the installation of a break-off plate;

Figure 26 is a cross-sectional view of a pusher formed by welding cut portions of an H-beam;

Figure 27 is a cross-sectional view of a pusher formed having an +-shaped cross-sectional configuration made up of four angles which are welded together along the respective adjoining edges and intermittently or continuously along the length thereof.

Figure 28 is an exploded perspective view of the further embodiment of the apparatus utilized to form and install a pile;

Figure 29 is a perspective view of an alternative pile pusher having apertures formed into its walls;

Figures 30—33 are schematic side elevational cross-sectional views showing the

sequential steps of forming a pile which includes a casing;

Figures 34—37 are schematic side elevational cross-sectional views showing the sequential steps of forming a pile in the earth's surface which is of a consistency that tends to migrate into the cavity that is formed and where the preformed cavity is of a larger diameter than the plow point;

Figure 38 is a side elevational view showing the cross-section of a pusher and plow point used in the steps shown in Figures 34—37;

Figure 39 is a top plan sectional view taken along the lines 39—39;

Figure 40 is a partial cross-sectional view showing the method by which the pusher is disengaged from the plow point; and

Figures 41—44 are schematic side elevational cross-sectional views showing the sequential steps of forming a pile in the earth's surface which tends to migrate into the cavity that is formed and where the preformed cavity is of a smaller diameter than the plow point.

Referring to Figure 1, which is an exploded perspective view, there is one embodiment of the novel apparatus that is utilized to install a concrete pile. The drive head adapter 1 is provided with an aperture 2 to receive a locking pin 3 which, when connected, is aligned with an enlarged aperture 4 formed at the upper portion of the pusher 5 for attaching pusher 5 to the adapter head 1. The top of the pusher 5 is provided with four triangular-shaped plates or filler blocks 6. These plates 6 reinforce and present an abutting surface for the pusher 5 and also provide a solid mass surrounding the aperture 4. It will be noted that the aperture 4 is an elongated slot so as to prevent any stress from being transmitted to the locking pin 3 during the driving movement of the pile hammer (not shown). This prevents binding of the locking pin 3 with the aperture 4 on the pusher 5 and aperture 2 of the drive head adapter and allows easy disengagement. The locking pin 3 is provided with cotter pins 7 to secure it in locked position during driving operation. It will also be seen that a chain 8 is provided on the upper portion of the pusher 5 and with both ends of the chain 8 being welded at one point 8¹ on the pusher. The chain 8 is provided to hold pieces of reinforcing steel 10 adjacent the pusher when so desired. It will also be noted that a vibrator 9 may be placed at a selected point on the pusher 5 to cause a vibration of the pusher 5 during its extraction from the poured concrete pile and in this way facilitate a more compact and uniform feeding of the fill material into the area left when the pusher 5 is extracted. A similar effect can be achieved by placing a vibrator on the fill hopper 20 and employing a vibra-

torless pusher, and furthermore, vibrators could be provided on both the pusher 5 and the hopper 20 to work in unison. Also provided along the length of the pusher 5 is indicia 55 to indicate during installation of a pile the depth of the plow point 42 and thereby provides a measuring means for determining the depth of a given pile. Also, depth may be measured by simply using a predetermined length for the pusher 5 which then does not require any indicia. Also it will be seen that there is an aperture 11 provided adjacent the lower end of the pusher 5 which is suited to receive a coupling (not shown) which is connected to a harness (not shown). The harness may be attached to hooks 12 on the fill hopper 20 in order to lift the hopper 20 away from the pile site by use of the pusher 5.

As seen in Figure 4, the plow point pusher adaptor 16 is removably secured to the pusher and has a plurality of side walls 13 to engage firmly the wall 14 of plow point 42. The plow point pusher adaptor 16 is provided with notches or cut-outs 15 at its bottom pushing plate 17 so that pieces of reinforcing steel 10 can be hooked under the plow point pusher adaptor 16 and driven down into the pile along with the fill material while enabling the pusher 5 to be extracted and disengaged from the reinforcing steel as shown in Figure 10. The top and bottom edge of the plow point pusher adaptor 16 has rounded corners to facilitate easy insertion into and removal from the plow point 42 as shown in Figure 1. The pusher 5 drives the plow point 42 down through the fill hopper 20 which will be discussed later in more detail. The fill hopper 20 consists of four vertical sides 21 with four adjacent inclined sides 22 which form sloping walls for the fill material to be fed through aperture 26 provided within the fill hopper 20. The fill hopper 20 is provided with suitable structure 23 to enable it to be firmly positioned on the pile site.

As shown in Figure 6, the fill hopper 20 is provided with two telescoping cylindrical pipes 24 and 25. The inner pipe 25 is fixed to the bottom surface of the fill hopper 20 and is provided with a plurality of apertures 26 to let the fill material to flow therethrough and into the cavity created by the driving of the plow point 42 into the soil. By raising and lowering the outer pipe 24 by means of handles 28 moving along inclined ramps 29, the flow of the fill material is thereby selectively controlled. When pipe 24 is raised, it allows passage of the fill material through apertures 26. Since outer pipe 24 has no apertures, when it is lowered down the inclined ramp 29 it thereby cuts off the flow of the fill material into the pile cavity. Hopper 20 also is provided with four angled members 30 which are attached to the bottom

of the fill hopper and which bite into the soil and form a sealing engagement to prevent flow of the fill material from seeping out of the bottom of the fill hopper onto the soil surface.

The embodiment of a fill hopper 20, shown in Figures 1, 6 and 7, would be employed where trucks can drive the fill material to location of the pile to be formed and dump it into the hopper 20 or where fill material can be pumped to the location and into the hopper 20 or where fill material can be swung by crane and bucket to said location or where fill hopper may be filled and lifted or carried to pile location. When none of these above methods are feasible, the hopper shown in Figure 8 may be employed.

In Figure 8, the fill hopper 20¹ is provided with side walls 21¹ and inwardly sloped walls 22¹ which are connected to an upstanding pipe 31 which is fixed to the bottom of the fill hopper 20¹. Upstanding pipe 31 is provided with a plurality of apertures 33 about its periphery which may be selectively aligned with apertures 33 in a telescoping pipe 34 of smaller diameter than pipe 31. In this embodiment, the inner pipe 34 acts as the gate valve to turn off or on the flow of fill material into the pile cavity and by virtue of inclined ramps 35 cooperating with handles 36 provided at the top of pipe 34, the pipe can be raised to shut off the flow of fill material or lowered to a position where apertures 33 and 32 will coincide with each other and thus initiate a flow of fill material into the pile cavity. A length of non-apertured pipe 37 is provided at the bottom of pipe 34 and this pipe portion provides a chute within which the fill material can flow into the pile cavity. It also provides a short length of pipe to be pushed into the soil and thereby provides a seal to prevent fill material from running out onto the ground surface instead of going into the pile cavity. This same section of non-apertured pipe 37, when the inner pipe 34 is raised, acts as a seal to block the flow of fill material through apertures 32 in the fixed outer pipe 31. There is an annular sealing ring 31¹ fixed to the bottom of the fill hopper 20 which slidably abuts a peripheral outer surface of inner pipe 34 to prevent flow of fill material between the fill hopper 20 and the outside wall of pipe 34. Pipe 34 has an annular sealing ring 34¹ which is fixed at a point on its outer walls so as to abut sealing ring 31¹ and accomplish a more complete sealing while at the same time acting as a stop for the downward descent of pipe 34 and to insure that apertures 32 and 33 coincide with each other to initiate the flow of fill material. The fill hopper 20¹ is provided with suitable structure 38 which provides an area to mount a set of wheels 39

to the fill hopper in order to transport it to the pile site. There is a handle 40 provided on the fill hopper which presents a means for the hopper to be pushed or pulled to the pile site.

As seen in Figure 9, the fill hopper 20¹ is shown with the outer pipe 31 and inner pipe 34 in a closed position which would thus prevent flow of material into the pile cavity.

Shown in Figure 10 is an alternative embodiment of pusher 5¹¹ provided with cut-outs or notches 15 on its bottom pushing surface 18 which will enable reinforcing steel 10 to be introduced into the pile cavity while allowing the pusher 5¹¹ to be extracted leaving the steel 10 in place. This particular pusher 5¹¹ is provided with arcuate cut-outs 41 to provide a reduced cross-sectional area of the pusher 5¹¹ and thus enable more fill material to enter the pile cavity during the driving operation. This pusher has the top plan cross-section of a cross as shown in Figure 13. The dash-dot lines represent the area of flow for the fill material which follows generally the cross-sectional area pushing plate 17 on the plow point 42 being driven by the plow point pusher.

Shown in Figure 11 is an alternative plow point pusher 5¹¹¹ with the reinforcing steel 10 in this embodiment being attached through apertures 43 provided in the bottom pushing plate 17 of plow point 42. Reinforcing steel 10 is inserted through these apertures 43 and bent over to form a hook to thereby pull the reinforcing steel down in the pile cavity to be left there with the plow point 42 upon extraction of the pusher 5¹¹¹.

This alternative plow point pusher has the top plan cross-sectional shape of a "Y" as shown in Figure 14. Also the reinforcing steel 10 may be passed through apertures 43 and welded in place.

Shown in Figure 12 is yet another alternative plow point pusher 5¹¹¹¹. In this embodiment, the plow point pusher 5¹¹¹¹ is of an irregular cross-sectional area and consists of a flat plate portion 44 and two structural rib portions 45. The reinforcing steel 10 in this embodiment is spot welded to the inner surface of plow point 42. The top plan cross-section of this shape is shown in Figure 15. While a number of ways for attaching the reinforcing steel have been described in relation to certain pushers and their plow points, it should be noted that these variations of pushers and plow points can be used in various combinations with each other.

Figures 16, 17 and 18 show how short lengths of reinforcing steel can be installed in a pile cavity that needs only a small portion of steel in its upper portion. This pusher 5¹¹¹¹¹ is provided with projections 46 which engage an annular ring 47 positioned at the desired location on the pusher 5¹¹¹¹¹ whereupon the pusher 5¹¹¹¹¹ is driven down into the ground

to a desired depth. Upon extraction of the plow point pusher 5¹¹¹¹, the annular ring 47 and the reinforcing steel 10 which is spot welded thereto are left at a desired intermediate depth within the confines of the filled pile cavity as shown in Figure 17. Figure 18 is the end result of the finished pile after extraction of the pusher 5¹¹¹¹ with the reinforcing steel left at an intermediate point and includes a reinforcing cap portion 48 of sufficiently larger size than the pile. This steel cap 48 is left with the pile in order to prevent breakage of the exposed pile top by grading machines, or other potential hazards that would present a danger of breakage to the pile. This cap 48 can be smaller than pile diameter and inserted into pile to the depth required.

Shown in Figure 19 is a fill hopper 20¹¹ which employs the gate valve as shown in Figure 6, except that the dimensions of the two cooperating pipes that act as a flow valve are of sufficiently larger diameter in order to accommodate odd shaped plow point pushers. The fill hopper 20¹¹ is provided with two reel mechanisms 50. These reels 50 may be moved inwardly and a length of reinforcing material 51 may be attached to the plow point 42¹¹ by spot welding or other suitable means. When the plow point pusher 5 drives the plow point into the soil, the reinforcing material is fed down the pile cavity with the plow point until it reaches a desired depth, whereupon the reinforcing material is snipped from the reels 50 and left in place within the finished pile. After cutting the reinforcing material, the reels 50 would be moved back to their non-operative position, thereby allowing free extraction of the plow point pusher 5.

Figures 20 and 21 show the plow point 42¹¹ in relation to the plow point pusher 5 and the relation at the plow point 42¹¹ with a screen-type reinforcing material 51.

On occasion, a pile might be overfilled with fill material over and above the desired grade level. When this occurs, it is possible to extract the pusher 5 from the pile while the fill material is still soft and secure a break-off plate 52 on the bottom portion of the pusher 5. Then the pusher 5 is pushed back down into the filled pile cavity to the desired final cast elevation 60. At this point, the pusher 5 is then extracted, leaving only the break-off plate 52 at the desired elevation in the pile, which is shown in Figures 22 through 25.

As seen in Figure 22, there is a break-off plate 52 and the bottom portion of a pusher 5. The break-off plate 52 is provided with cut-out areas 53 which allow the fill material to sift through these cut-outs 53 as it is pushed to the desired depth. The material from which the cut-outs are formed consists of four flaps 54 which are bent up and fric-

tionally engage the bottom 18 of the pusher 5. This break-off plate 52 is made of plastic, thin steel, or other suitable material to form a weak joint or fracture plane in the concrete pile, thereby allowing the pile to be easily separated from the excess material at the elevation at which the break-off plate 52 is inserted.

Figures 23, 24 and 25 are schematic figures showing the steps of operation to install a break-off plate 52.

Shown in Figure 26 is a pusher configuration that utilizes an H-beam which is cut longitudinally along its web into two sections; whereupon these sections are welded together with the flanges of each in abutting contact to form the top plan of a cross.

Figure 27 is a cross-sectional view of a pusher of + -shape.

Referring to Figure 28, which is an exploded perspective view of a further form of apparatus necessary to install a plow, there is shown a drive head adapter 1¹ adapted to receive a plow point pusher 100 by means of aligned apertures 2¹ and 6¹ in the drive head adapter 1¹ and the upper portion of the plow point pusher 100. The apertures, when in alignment with each other are suited to receive a dowel pin 3¹ that is fitted with cotter pins 7¹ to secure the dowel pin 3¹ during the driving operation. The plow point pusher 100 is of an "H" beam configuration and is provided longitudinally with indicia I to indicate the depth of the pile. This plow point 142 is suited to be driven through a complementary aperture of slightly larger diameter in the fill hopper 20¹¹. The fill hopper 20¹¹ embodied here is a round hopper with a cylindrical upstanding wall section which joins with inwardly directed cone shaped walls 22¹¹. The conical walls 22¹¹ then join with a short cylindrical section 30¹ of sufficient length to provide a seal with the surface of the earth and prevent seepage of fill material out of the soil surface. The hopper 20¹¹ is also provided with a suitable frame 23¹ to enable the hopper to sit firmly on the soil surface during the driving operation. The interior of the hopper is provided with indicia 255 to indicate the amount of fill material that has been transferred to the cavity. It may be by volume or may be calibrated as to the units of length of pipe.

Figure 29 is an alternative plow point pusher 101 which consists of a pipe provided with apertures 108 to allow the fill material to fill the inner cavity of the pipe during the driving operation. At the top of the pipe there is provided an aperture 104 to allow this plow point pusher to be fixed to a suitable driving head adapter by means of a dowel pin type arrangement as shown in Figure 28.

In Figures 30—33 are embodied the steps

necessary to install a pile which has a corrugated metal jacket J within the confines of the pile cavity. In Figure 30 it will be seen that a fill hopper H is employed with a large aperture A so as to allow a plow point with an enlarged pusher plate P to be driven therethrough. The diameter of the pusher plate P is of course the diameter of the pile to be driven. The plow point pusher 100 presents a peripheral area on the top of the plate P whereby a corrugated metal pipe can rest. As the plow point 242 is driven down as seen in Figure 31, the corrugated metal jacket J is driven down with the plow point 242 and fill material flows into the space between the cavity left by the plow point and the outer walls of the corrugated metal jacket leaving as seen in Figure 32 a pile which, at its bottom, has a point with an upstanding corrugated metal pipe left therein which is surrounded by fill material. This particular type pile is desirable in certain applications where it may be necessary for the pile to be inspected. After inspection the inner cavity of the corrugated metal pipe can then be filled to complete the pile.

Figures 34 through 37 are the steps necessary to install a pile where it might be necessary to establish the pile bottom on solid rock or rock strata. The first step necessary as seen in Figure 34 is a drill a hole, the bottom of which would be as close to the desired rock strata as possible. Next a fill hopper H¹ is placed over the cavity and a plow point pusher with a plow point attached thereto of the type which will be discussed in more detail in connection with Figures 38—40, is dropped through the fill hopper to the bottom of the excavated hole and the plow point 342 is then driven further to a depth to establish a solid base as closely adjacent the rock as possible. Then the pusher 300 is extracted and the hopper H¹ taken away leaving a suitable pile as shown in Figure 37.

As mentioned previously, it will be seen that when lowering a plow point pusher with a plow point of a size smaller than the hole in which it is lowered, that the plow point would disengage itself from the pusher and drop off into the cavity by gravity. To overcome this problem, there is embodied in Figures 38—40 a structure to retain the plow point 342 to the pusher 300 in the initial stage of lowering it into an enlarged cavity. This consists of a pusher 300 having at its lower end an aperture 310 which when placed in the upper walls of a plow point would be in alignment with a pair of apertures 320 in the said walls of the plow point 342. When so aligned, a small dowel pin 330 is placed therein which engages the plow point to the pusher. After the pile has been completed, and the fill material is within the confines of the cavity, the pusher can then be extracted

from the plow point since the weight of the fill material on the plow point will be sufficient to secure it in place during this extraction, and as seen in Figure 40, the dowel pin used to secure the two members during installation is simply bent out of engagement with the plow point.

There are certain types of soil such as clay, for instance that tend not to consolidate, which is to say that they are of a compaction which tends to migrate into the cavity being formed. Where soils do not want to consolidate the pile can usually be driven into the soil but the cavity created by the plow point pushing plate will tend to close up and thereby pinch or restrict the fill material causing undesirable weak points in the pile. Figures 41—44 show diagrammatically a method of installing a pile in these non-consolidating soils. As shown in Figure 41 the first step is to drill a hole in the soil at the desired pile location similar to that shown in Figures 34—37, except the diameter of the drilled hole is smaller than the diameter of the plow point plate. After the hole is drilled a fill hopper H¹¹¹ is placed over the hole and a plow point 442 is driven therethrough via a plow point pusher 400 as shown in Figures 42 and 43. The excavation of the excess soil need be only enough to provide access for the plow point to consolidate the remaining soil within a pile hole under the pressure of the pusher whereby when the plow point pusher is extracted a clean pile will be established as seen in Figure 44.

It is further recognized that piles of considerable length can be formed by utilizing an elongated plow point which can be of the length of approximately one-half the length of the elongated pile. The plow point pusher utilized in conjunction with such an elongated pile is of a construction that provides a shoulder intermediate its length for abutting contact with the rear of the plow point. This type of plow pusher can be left in the ground.

WHAT I CLAIM IS:—

1. Apparatus for use with a pile driving hammer for forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced into the column cavity in a fluid condition and which becomes solid upon curing comprising:—

a) a plow point adapted to be driven into the ground to a desired depth,

b) a pusher adapted for releasably engaging the plow point and for transmitting the driving force of the pile driving hammer to the plow point, said pusher including a plurality of longitudinally extending rib sections which form a cross-sectional configuration that affords a maximum void area for the introduction of fill material thereabout

necessary to install a pile which has a corrugated metal jacket J within the confines of the pile cavity. In Figure 30 it will be seen that a fill hopper H is employed with a large aperture A so as to allow a plow point with an enlarged pusher plate P to be driven therethrough. The diameter of the pusher plate P is of course the diameter of the pile to be driven. The plow point pusher 100 presents a peripheral area on the top of the plate P whereby a corrugated metal pipe can rest. As the plow point 242 is driven down as seen in Figure 31, the corrugated metal jacket J is driven down with the plow point 242 and fill material flows into the space between the cavity left by the plow point and the outer walls of the corrugated metal jacket leaving as seen in Figure 32 a pile which, at its bottom, has a point with an upstanding corrugated metal pipe left therein which is surrounded by fill material. This particular type pile is desirable in certain applications where it may be necessary for the pile to be inspected. After inspection the inner cavity of the corrugated metal pipe can then be filled to complete the pile.

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from the plow point since the weight of the fill material on the plow point will be sufficient to secure it in place during this extraction, and as seen in Figure 40, the dowel pin used to secure the two members during installation is simply bent out of engagement with the plow point.

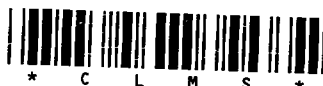
There are certain types of soil such as clay, for instance that tend not to consolidate, which is to say that they are of a compaction which tends to migrate into the cavity being formed. Where soils do not want to consolidate the pile can usually be driven into the soil but the cavity created by the plow point pushing plate will tend to close up and thereby pinch or restrict the fill material causing undesirable weak points in the pile. Figures 41—44 show diagrammatically a method of installing a pile in these non-consolidating soils. As shown in Figure 41 the first step is to drill a hole in the soil at the desired pile location similar to that shown in Figures 34—37, except the diameter of the drilled hole is smaller than the diameter of the plow point plate. After the hole is drilled a fill hopper H¹¹¹ is placed over the hole and a plow point 442 is driven therethrough via a plow point pusher 400 as shown in Figures 42 and 43. The excavation of the excess soil need be only enough to provide access for the plow point to consolidate the remaining soil within a pile hole under the pressure of the pusher whereby when the plow point pusher is extracted a clean pile will be established as seen in Figure 44.

It is further recognized that piles of considerable length can be formed by utilizing an elongated plow point which can be of the length of approximately one-half the length of the elongated pile. The plow point pusher utilized in conjunction with such an elongated pile is of a construction that provides a shoulder intermediate its length for abutting contact with the rear of the plow point. This type of plow pusher can be left in the ground.

WHAT I CLAIM IS:—

1. Apparatus for use with a pile driving hammer for forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced into the column cavity in a fluid condition and which becomes solid upon curing comprising:—

- a) a plow point adapted to be driven into the ground to a desired depth,
- b) a pusher adapted for releasably engaging the plow point and for transmitting the driving force of the pile driving hammer to the plow point, said pusher including a plurality of longitudinally extending rib sections which form a cross-sectional configuration that affords a maximum void area for the introduction of fill material thereabout



while minimizing the cavity engaging peripheral surfaces, and

c) a mobile hopper disposed to surround the pusher at the upper end of the column cavity and including means to selectively control the flow of fill material into the column cavity.

2. Apparatus according to claim 1 wherein a plow point pusher adapter is removably secured at the forward portion of the pusher for effecting a tight frictional engagement with the plow point.

3. Apparatus according to claim 2 wherein the plow point pusher adapter has upper and lower corners which are rounded to facilitate easy insertion into and removal from the plow point.

4. Apparatus according to any of the preceding claims and further characterized by the provision of means for attaching reinforcing steel for introduction into said column cavity.

5. Apparatus according to claim 4 wherein the means for attaching the reinforcing steel is provided in the plow point.

6. Apparatus according to claim 4 wherein the means for attaching the reinforcing steel is provided at the lower portion of the pusher.

7. Apparatus according to claim 4 when dependent on claim 2 wherein the plow point pusher adapter is secured at the forward end of the pusher and the means for attaching the reinforcing steel is provided at the lower portion of the plow point pusher adapter.

8. Apparatus according to claim 4 wherein the means for attaching the reinforcing steel is provided about the periphery of the pusher.

9. Apparatus according to claim 4 wherein the means for attaching the reinforcing steel is by welding the steel to the plow point.

10. Apparatus according to claim 1 wherein the upper portion of the pusher is provided with a quick release drive head adapter including a locking means for releasably securing the drive head adapter to the pusher.

11. Apparatus according to claim 10 wherein the locking means includes a locking pin and aligned apertures, one of which is formed in the adapter head and the other is formed in the pusher, one of the apertures being of a size to telescopically receive the locking pin and other aperture being of a size to provide clearance around the locking pin.

12. Apparatus according to claim 1 wherein means is provided for effecting sealing engagement between the hopper and the ground surface about the periphery of the pile.

13. Apparatus according to claim 1 wherein the hopper includes scale means

calibrated for indicating the quantity of fill material in the cavity.

14. Apparatus according to claim 13 wherein the pusher includes scale means for indicating the quantity of fill material required to fill a bore opening formed by the plow point, the scale means being graduated to indicate the amount of fill material at increments of penetration of the plow point within the earth's surface.

15. Apparatus according to any of the preceding claims wherein said pusher member is H-shaped in cross-section.

16. Apparatus according to claim 1 wherein the plow point forms part of a column lead member comprising a portion having a cylindrical socket member of substantial length adapted to fit closely around the end of the pusher to aid in guiding the lead member in a plumb direction, and a cylindrical plate at the lower end of the lead member having a diameter greater than the external diameter of the socket member.

17. Apparatus according to claim 1 wherein the hopper includes a funnel-shaped portion.

18. Apparatus according to claim 1 wherein the means to selectively control the flow of fill material comprises first and second telescoping cylindrical concentric pipes, the first of the said pipes having apertures therein for passage of fill material from the interior of the hopper into the column cavity being formed and the second pipe being axially adjustable relative to the first pipe to form a gate for varying the effective size of the apertures against passage of fill material therethrough.

19. Apparatus according to claim 2 wherein the hopper has a bottom opening sized to approximate the maximum cross-sectional area of the plow point and the walls in the lower region of the hopper converge in downwardly sloping relation to locations immediately adjacent the bottom opening to guide the material along the downwardly sloping walls to the bottom opening.

20. Apparatus according to claim 2 wherein the pusher has an upper portion provided with a quick release drive head adapter including a locking means for releasably securing the drive head to the pusher.

21. Apparatus according to claim 20 wherein the locking means includes a locking pin and aligned apertures, one aperture being formed in the adapter head and the other aperture being formed in the pusher, one of the said apertures being of a size to telescopically receive the locking pin and the other aperture being of a size to provide clearance around the locking pin.

22. Apparatus for use with a pile driving hammer for forming in the earth's surface a support column, such as a pile, of a fill material that may be introduced in a



fluid condition into the column cavity being formed and which becomes solid upon curing comprising:—

- 5 a) a plow point adapted to be driven into the ground to a desired depth,
- b) a pusher adapted for releasably engaging the plow point and for transmitting the driving force of the pile driving hammer to the plow point, the said pusher being of
- 10 axially elongated hollow tubular construction throughout its length having a tube wall surrounding the hollow interior providing a cross-sectional configuration that affords a large void area for the introduction of fill material.
- 15 c) a plurality of radial openings formed in the tube wall to permit the fill material to be transferred between locations outwardly of the pusher and locations inwardly of the pusher within the hollow interior during progressive filling of the cavity from the top downwards in response to formation of the cavity by movement of the plow point,
- 20 d) a mobile hopper disposed to surround the pusher at the upper end of the column cavity having a bottom opening sized to correspond substantially to the maximum cross-sectional area of the plow point and receive the pusher therethrough,
- 30 e) downwardly sloping walls in the lower region of the hopper converging to locations closely adjacent to the perimeter of the bottom opening for guiding the fill material in the hopper along downwardly
- 35 converging paths towards the vertical center axis of the opening,
- f) means to selectively control the flow of the fill material into the column cavity.
23. A method of forming in the earth's
- 40 surface a support column, such as a pile, of a fill material that may be introduced into the column cavity in a fluid condition and which becomes solid after curing comprising the steps of:—
- 45 a) locating a mobile hopper at a selected location on the earth's surface where a support column is to be formed,
- b) placing a plow point, which is adapted to be driven into the ground to a desired
- 50 depth, within the hopper,
- c) placing an intermediate pusher in releasable engagement with the plow point,

d) filling the hopper with a quantity of fill material,

e) forming a cavity of selected size and depth in the earth's surface by transmitting a driving force to the plow point by means of the pusher within the confines of the fill hopper,

f) selectively introducing the filling material into the cavity by gravity and

g) removing the pusher from the fill material, the said pusher either including a plurality of longitudinally extending rib sections occupying substantially less cross-sectional area than the cross-sectional area of the cavity being formed while minimizing the cavity engaging peripheral surfaces or being of a tubular construction having a plurality of radial openings formed therein which will permit the fill material to be transferred between locations outwardly of the pusher and locations inwardly of the pusher during the progressive filling of the cavity from the top downward in response to formation of the cavity by movement of the plow point and the hopper being disposed to surround the pusher at the upper end of the column cavity.

24. A method according to claim 23 including the steps of feeding fill material into the cavity through a bottom opening in the hopper sized to approximate to the maximum cross-sectional area of the plow point and guiding the fill material towards the opening by causing the material to flow downwardly over downwardly converging hopper walls at the lower region of the hopper.

25. Apparatus for use in forming a column of material substantially as hereinbefore described with reference to the accompanying drawings.

26. A method of forming a column of material substantially as hereinbefore described with reference to the accompanying drawings.

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