

[54] **PILING SYSTEM**

3,568,452 3/1971 Stifler, Jr. .... 61/53.6

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[57] **ABSTRACT**

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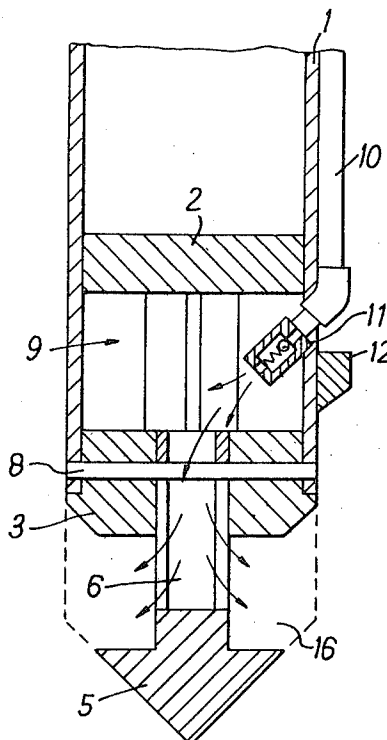
The apparatus comprises a hollow casting tube sealed near its lower end by a plate so that the pile driving hammer can be applied direct to the plate to force the tube into the ground. Cement-sand grout is passed to the space beneath the plate via a pipe passing externally of the casting tube whilst the tube is simultaneously lifted out of the ground.

[56] **References Cited**

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**7 Claims, 8 Drawing Figures**



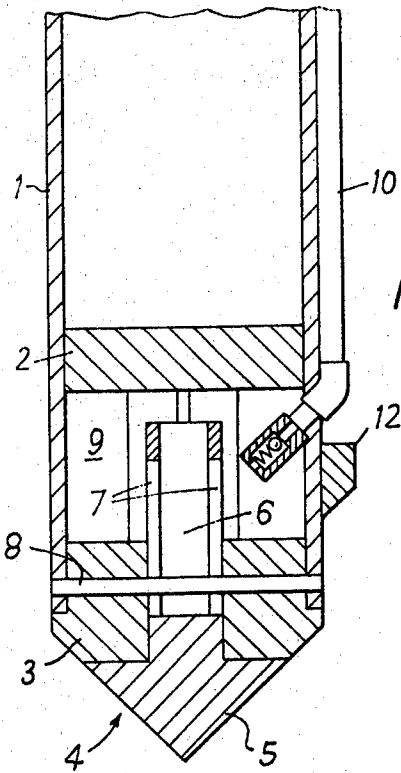


FIG. 1

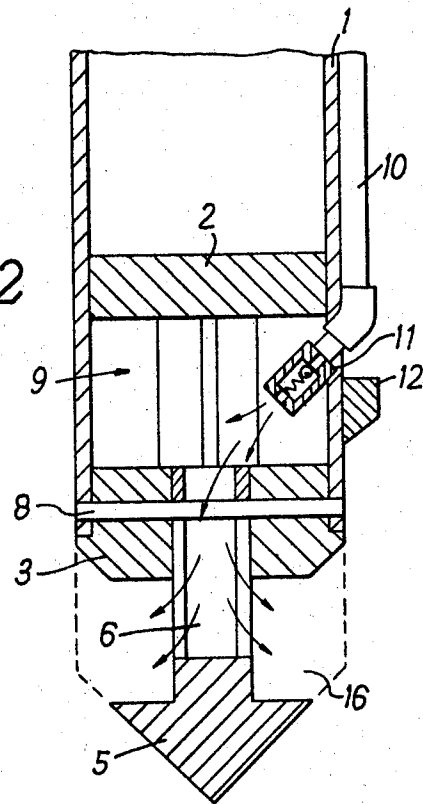
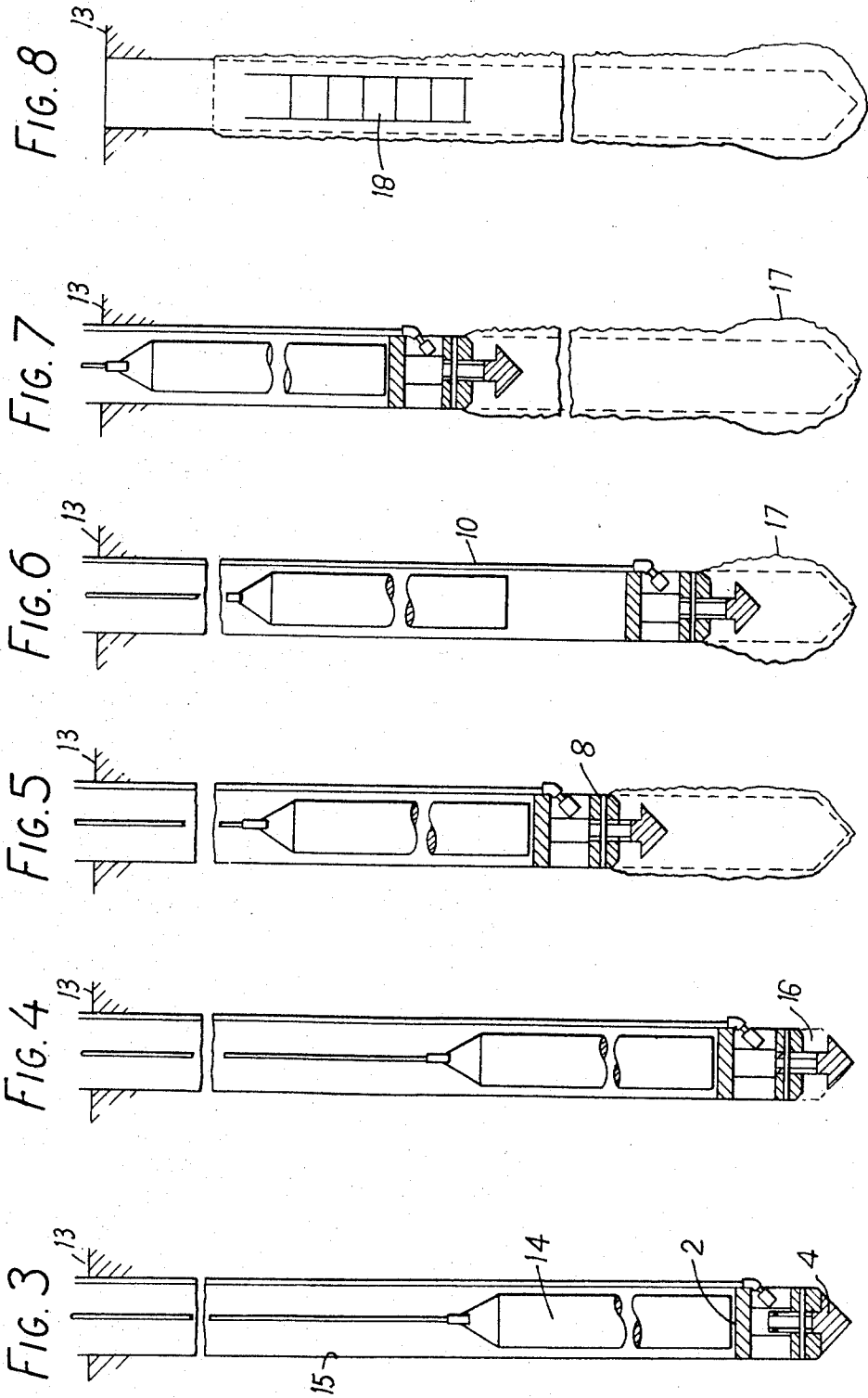


FIG. 2



# 1

## PILING SYSTEM

The present invention relates to a method and apparatus for casting a subterranean concrete pile.

In accordance with one aspect of the invention there is provided apparatus for casting a subterranean concrete pile, said apparatus comprising a tube for sinking into a ground formation in which the pile is to be cast, a sealing member extending internally across the tube at a position adjacent one end thereof and a releasable end plug for closing said one end of the tube to form a chamber for receiving cement-sand grout and conduit means positioned externally of the tube for passing the grout under pressure from ground surface into the chamber.

In use of the apparatus the tube is driven into the ground by means of a hammer, with that end of the tube which is closed by the end plug being the lower end. If desired the end plug may be formed with a pointed shape so as to assist entry into the ground formation. The apparatus of the invention has the advantage that the interior of the tube is unobstructed so that the driving hammer can be placed within the tube.

In accordance with a further aspect of the invention there is provided a method of forming a subterranean concrete pile, said method comprising the steps of sinking a tube to the ground formation in which the pile is to be cast by applying hammer blows to a sealing member extending internally across said tube to seal a lower end thereof, and passing a cement-sand grout under pressure into the space beneath said sealing member by means of a conduit positioned externally of the tube, whilst simultaneously raising the tube so as to fill the bore formed by the sinking of the tube.

This method of operation allowed by the apparatus of the present invention has two distinct advantages:

Firstly, since substantially all the force of the hammer is applied only to the sealing member, it is only necessary for the lower part of the tube and the sealing member to be sufficiently strong to withstand the force of the hammer. The upper part of the tube may be formed by a number of separate tubes of much lighter construction. These upper tubes are stacked one upon the other to line the hole left by the casting apparatus as it is sunk into the ground formation.

The second advantage of the above method of operation arises by virtue of the fact that it is now possible, if desired, to halt the simultaneous passage of grout into the bore and raising of the tube at some intermediate position, whereupon hammering may be resumed to force the tube back into the ground a predetermined distance. This being done, the hammering is stopped and the operation of simultaneously passing grout into the bore and raising the tube is resumed. The effect of the resumed hammering is to form an enlarged bottom end to the pile, a feature which has advantages to be discussed hereinafter.

In a preferred embodiment of the invention said one end of said tube is securely fitted with an annular member, said end plug being adapted to close the aperture left by the annular member to form said chamber.

The end plug is preferably constructed such that, whilst being releasable to allow cement-sand grout out of the chamber, it is not completely detachable from the remainder of the apparatus. If this is not done the end plug remains at the bottom of the pile and is not recoverable.

# 2

In order that the invention may be better understood an embodiment thereof will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a cross-sectional side elevation of an apparatus according to the invention in which the end plug is in place;

FIG. 2 is a view similar to FIG. 1 in which the end plug is released to allow grout out of the chamber; and

FIGS. 3 to 8 illustrate a typical sequence of pile forming operations performed with the apparatus of the present invention.

Referring to FIGS. 1 and 2 the casting apparatus comprises a heavy casting tube 1, for example of steel, near to the lower end of which is securely welded a plate 2 which can also be of steel. Plate 2 serves two purposes — first that of a sealing member in order to seal off the lower end of the tube 1 and second that of an anvil for receiving the blows of a hammer (not shown) whilst the apparatus is being driven into the ground. For this reason the casting tube 1 and especially the plate 2 must be of strong heavy construction. The casting tube may be formed in any length convenient to the construction and correct operation of the apparatus. It is not necessary for the tube to be of such a length that it completely leaves the hole left by the apparatus as it is driven into the ground. For this purpose, separate tubes (not shown) of equal outside diameter are stacked upon tube 1 as the apparatus sinks into the ground. Since very little strain is placed upon them these latter tubes may be of much lighter construction.

The end of the tube 1 is securely fitted with an annular member 3 which forms a seating for an end plug 4. Plug 4 comprises a lower end portion 5 and an upwardly extending pillar 6. As seen from FIGS. 1 and 2, pillar 6 is of tubular construction for most of its length, opposite sides of the tubular part being formed with elongate apertures 7 extending longitudinally of the pillar. These apertures 7 are designed to co-operate with a retaining rod 8 which passes through the wall of tube 1 and through annular member 3. In this way, end plug 4 is movable between the position shown in FIG. 1 in which the bottom end of the tube 1 is completely sealed off to form a chamber 9, and the position shown in FIG. 2 in which the end plug is released to allow the contents of chamber 9 to escape downwardly.

The external surface of end portion 5 and the annular member 3 is shaped, for example conically as shown, to facilitate passage in the ground.

The cement-sand grout or other suitable material for forming the pile is passed into chamber 9 from above ground by means of a supply pipe 10 which passes alongside tube 1 and turns at its lower end through the wall of tube 1 into the chamber and is provided with a non-return valve 11. Valve 11 may be of any known construction, for example a simple ball and spring type as shown. A shoulder 12 is formed as a projection on the side of tube 1 in order to protect the supply pipe from damage during sinking of the apparatus into the ground.

The method of operation of the apparatus is shown as a sequence in FIGS. 3 to 8 and is as follows:

The Figures show diagrammatically the method of forming a vertical pile. Ground level is indicated by reference numeral 13.

3

The casting apparatus is first driven into the ground to the required depth by means of an internal hammer 14 (see FIG. 3). During this operation the end plug 4 is closed as shown in FIG. 1, the force of the hammering serving to provide a tight seal to prevent entry of ground material into chamber 9. As the apparatus sinks into the ground, further tubes are added on top of tube 1 in order to line the bore 15 produced by the apparatus.

When the apparatus has reached the required depth cement-sand grout is injected under pressure via supply pipe 10 into chamber 9 whilst the apparatus is simultaneously raised. The end plug 4 is forced open to the position shown in FIG. 2 to allow grout 16 to escape from the chamber (see FIG. 4). As the apparatus is raised still further the grout fills up the space left beneath the apparatus the plate 2 serving to prevent escape of grout up tube 1 (see FIG. 5).

The raising of the apparatus may be performed with the winch of the pile rig (not shown) through a multi-port tackle arrangement acting on lifting lugs (not shown) provided on the top of tube 1. In this way the upper tube lining sections are pushed upwards, which operation is facilitated by their lighter construction.

If desired the raising operation may be halted, for example at the position shown in FIG. 5 whereupon the lifting tackle is disengaged and the hammer 14 made ready for redriving. The apparatus is then driven downwards by means of the hammer. This has the effect of forming an enlarged base 17 for the pile (see FIGS. 6 to 8) as well as increasing still further ground penetration of the grout. During this operation grout flow in the reverse direction is prevented by the valve 11.

The formation of an enlarged base increases the end bearing value of the pile and thus the ultimate bearing capacity. The ultimate bearing capacity is also dependent upon the frictional resistance between the pile and the surrounding ground. This frictional resistance is already high by virtue of the increased ground penetration of the grout brought about by supplying the grout under pressure. However, as mentioned above the operation of forming an enlarged base by hammering increases still further ground penetration of the grout, and hence the frictional resistance between pile and ground.

The ability to form an enlarged base in this way is one of the principal advantages of the apparatus of this invention, and arises from the fact that the interior of the tube 1 is unobstructed, allowing the hammer to operate within the tube directly on the casting apparatus rather than through the intermediary of the upper tube linings.

After forming the enlarged base the apparatus is raised again in the normal manner while simultaneously applying grout under pressure. The apparatus is raised at a rate which is calculated to maintain a predetermined pressure beneath the plate 2 so that lateral compaction of the ground surrounding the pile is effected.

4

As the apparatus reaches ground level the grouting pressure is gradually reduced to prevent excessive penetration of the grout into the ground near the surface (see FIG. 7).

When the apparatus has been completely withdrawn a steel reinforcement cage 18 may be lowered into the grout and held in position as shown in FIG. 8.

If desired a layer of coarse sand or other material may be placed on top of plate 2 during hammering to reduce the noise created by a direct metal to metal contact. However, since the hammering is mostly done underground, noise is not much of a problem.

I claim:

1. Apparatus for casting a subterranean concrete pile, said apparatus comprising a tube for sinking into a ground formation in which the pile is to be cast, an immovable sealing member extending internally across the tube at a position adjacent one end thereof and adapted to receive hammer blows of a pile driver, a releasable end plug for closing said one end of the tube to form a chamber for receiving cement-sand grout and conduit means positioned externally of the tube for passing the grout under pressure from ground surface into the chamber.

2. Apparatus as claimed in claim 1 wherein said one end of said tube is securely fitted with an annular member, said end plug being adapted to close the aperture left by the annular member to form said chamber.

3. Apparatus as claimed in claim 2 wherein said end plug is fitted with a hollow cylindrical extension which is sized to be slidable within the aperture left by the annular member, said extension being open at its upper end and having openings adjacent its lower end so that grout may pass through the extension to form the pile.

4. Apparatus as claimed in claim 3 wherein said extension has two oppositely disposed elongate apertures each extending along a generator thereof, and wherein said one end of the tube is further fitted with a transversely extending retaining rod, which rod passes through the aperture left by the annular member, and said two elongate apertures formed in the end cap extension to thereby limit the movement of the end cap relative to the tube.

5. Apparatus as claimed in claim 1 wherein the lower end of said conduit means is provided with a one-way valve to prevent backflow of grout from the chamber.

6. Apparatus as claimed in claim 1 wherein said conduit means includes a grout supply pipe which is positioned against the external surface of the tube and extends along the tube to a position just beyond said sealing member whereupon the pipe passes through the tube wall and into said chamber.

7. Apparatus as claimed in claim 6 wherein an extension is formed on the wall of the tube at a position just below the position at which the pipe passes through the tube wall to protect the end of the pipe from damage as the tube is sunk into the ground formation.

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