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(54) **PILE MANDREL WITH EXTENDABLE REAMING MEMBERS**

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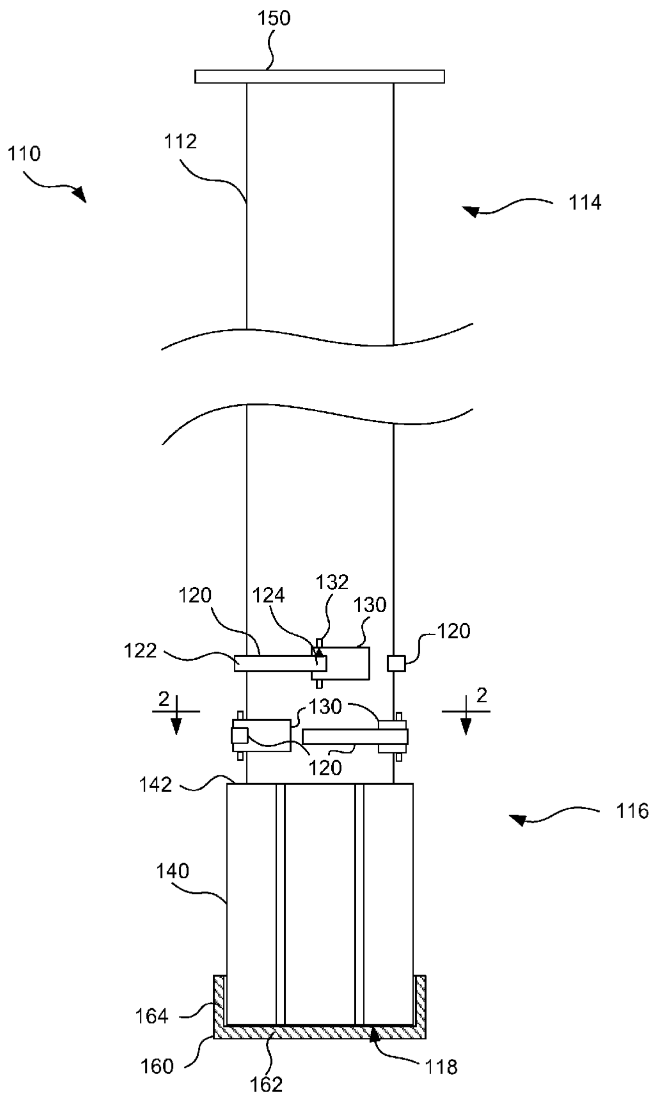
(57) **ABSTRACT**

A set of one or more reaming members is secured to a pile mandrel. Each reaming member is moveable between a first position where the reaming member extends a first distance from a center of the pile mandrel, and a second position where the reaming member extends a second distance from the center of the pile mandrel. An apparatus including a pile mandrel and one or more reaming members attached to the mandrel is driven into soil, creating a hole extending down from a surface of the soil. While the reaming member(s) are below the surface of the soil, the reaming member(s) are extended to an extended position; the pile mandrel is rotated with the reaming member(s) extended to ream a section of the hole to a second diameter that is larger than the first diameter; the reaming member(s) are retracted, and the mandrel is removed from the hole.



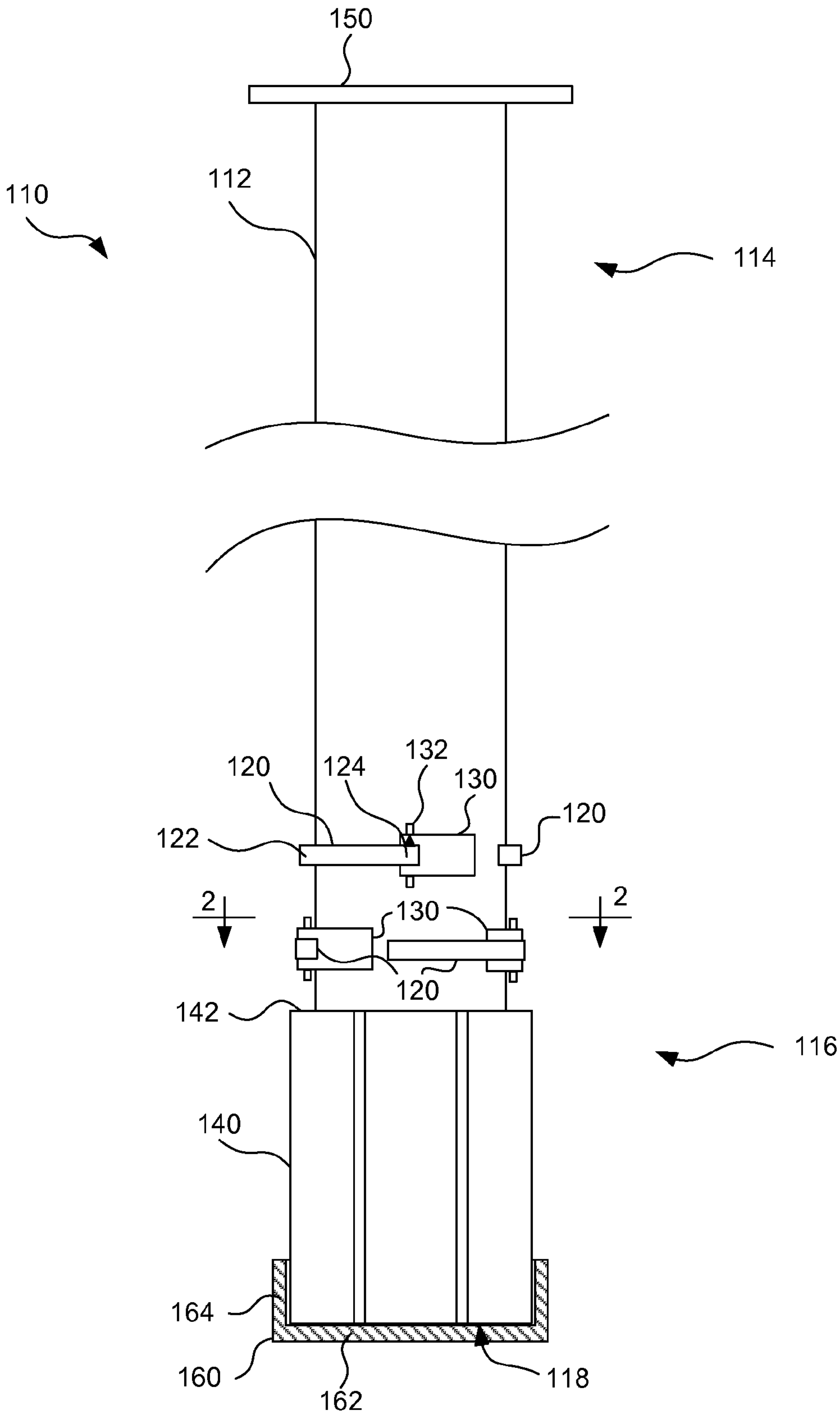

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Figure 1

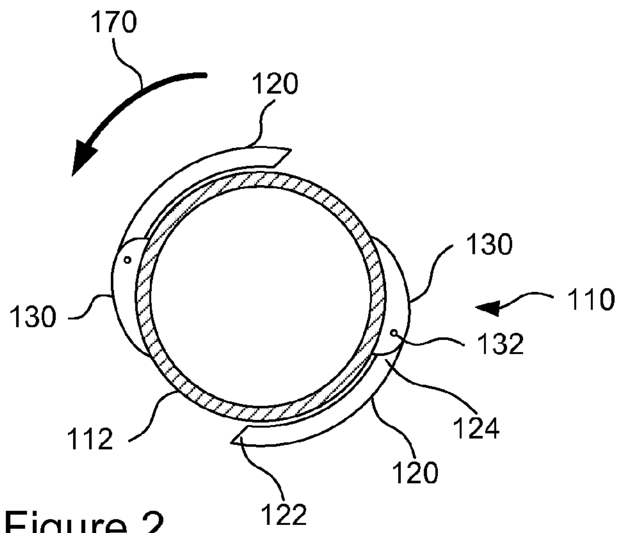

Figure 2

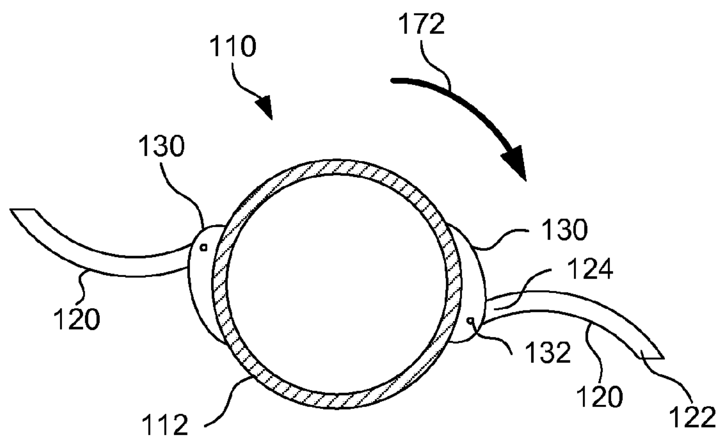

Figure 3

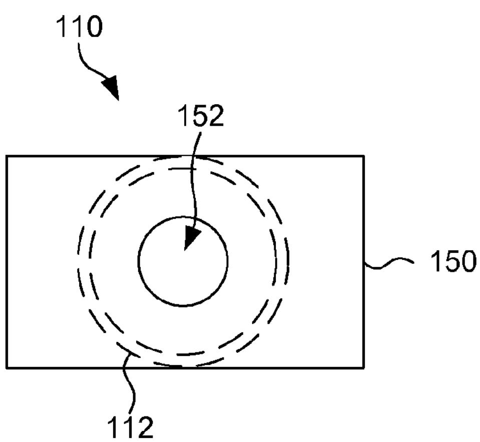

Figure 4

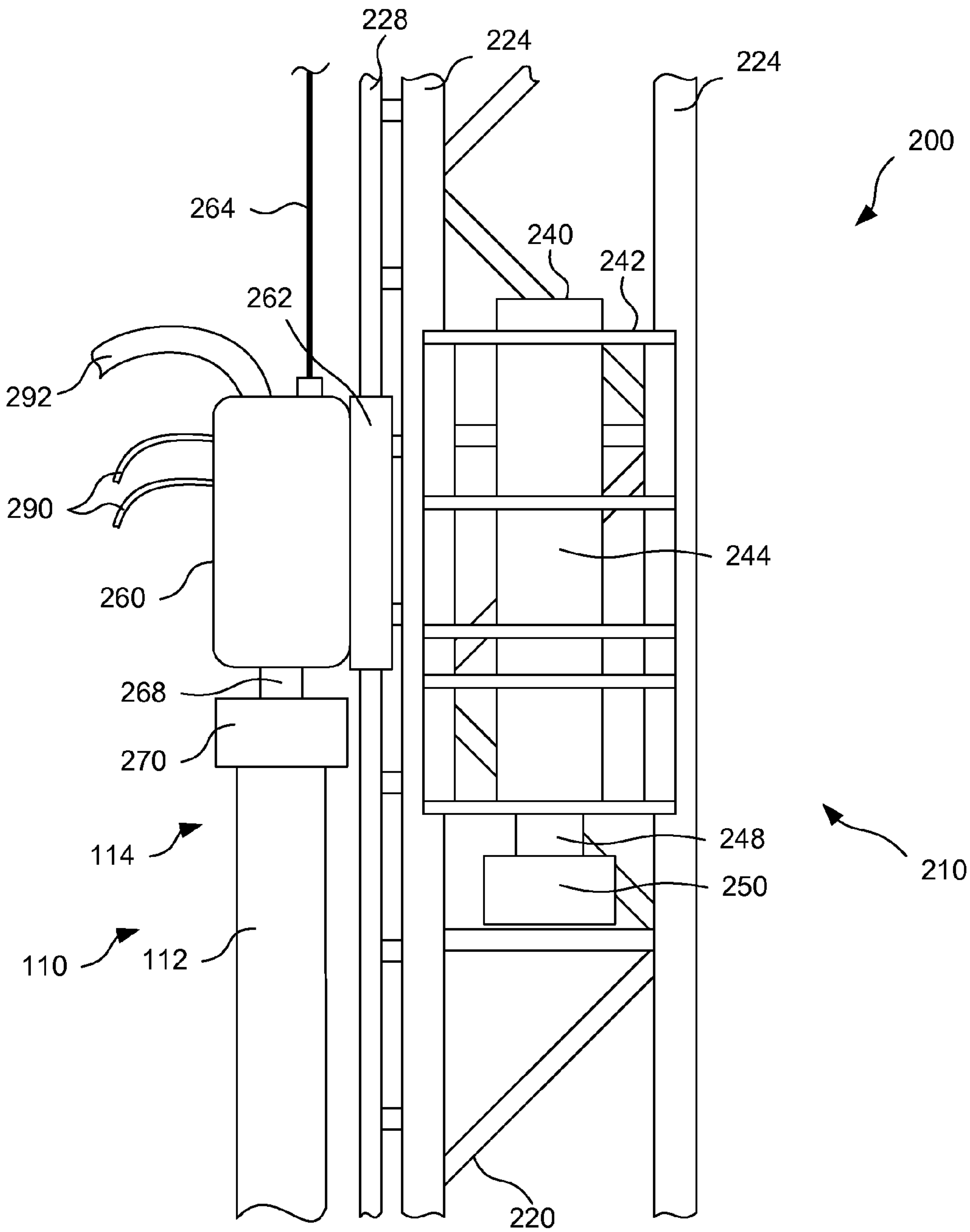
228
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Figure 5

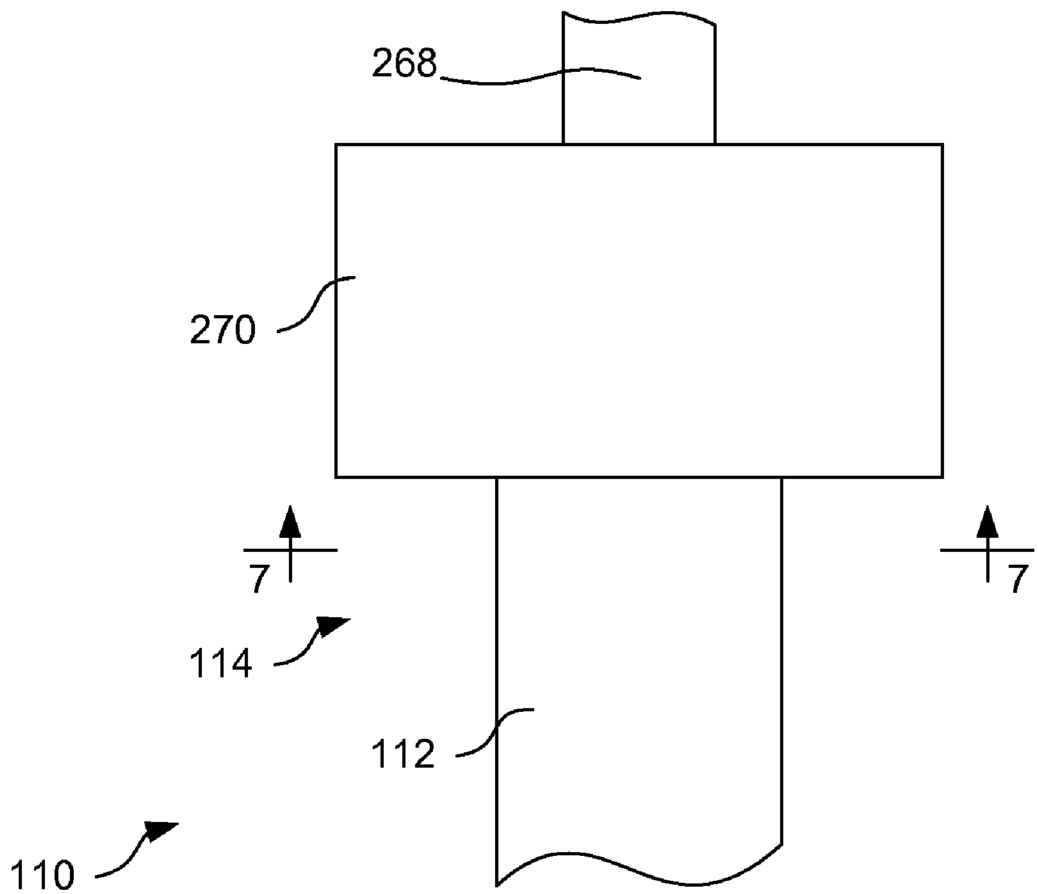

Figure 6

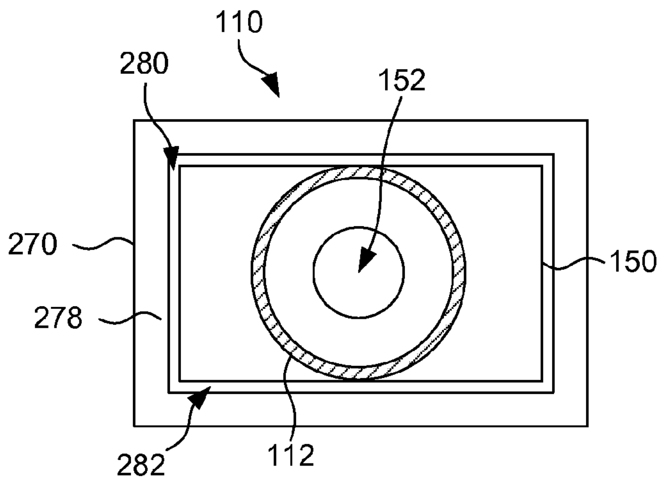

Figure 7

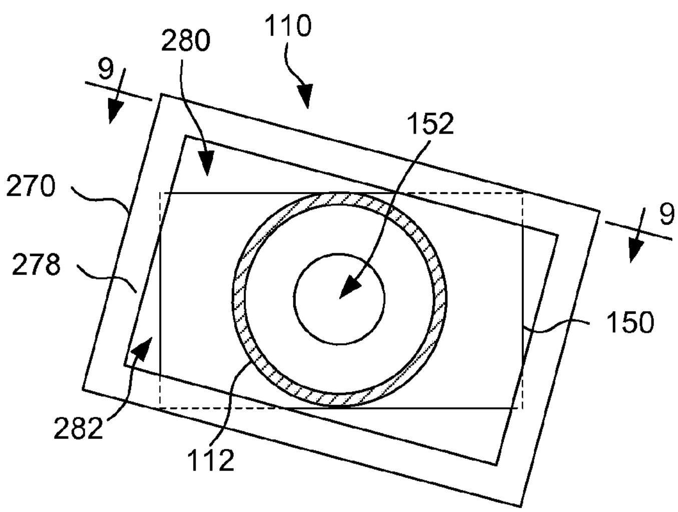

Figure 8

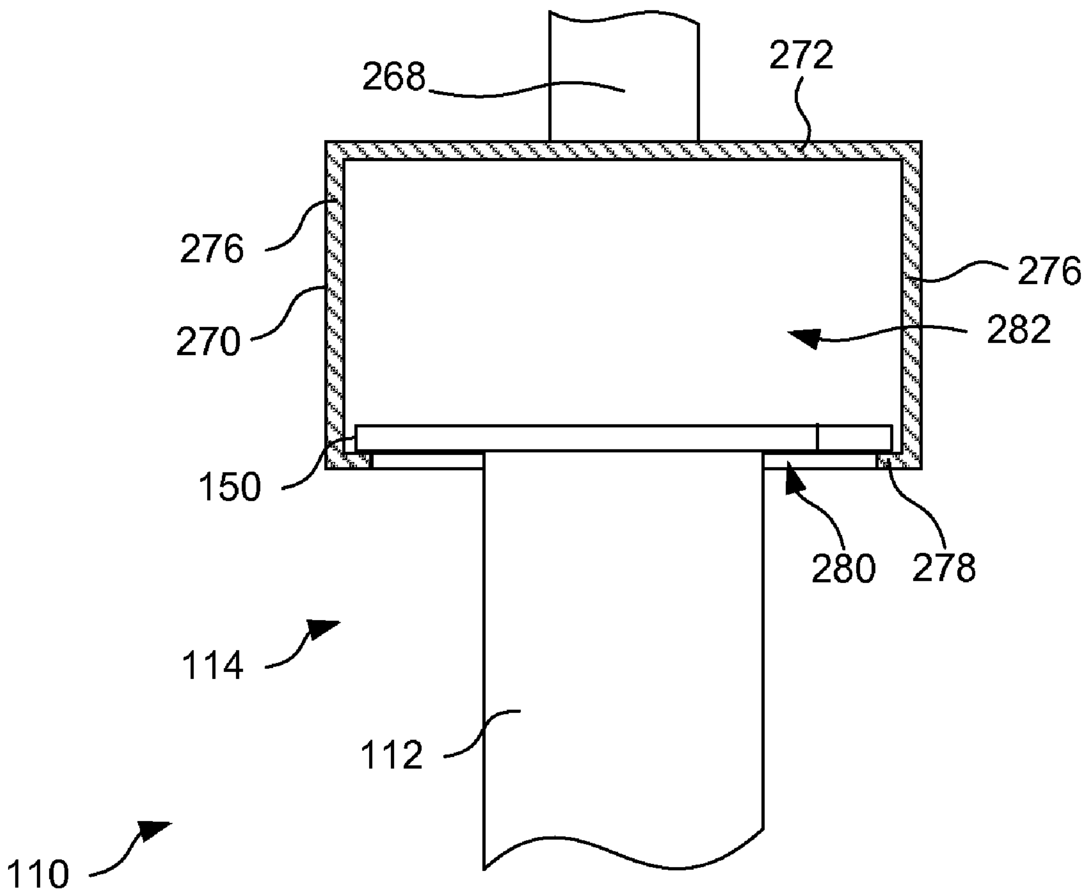

Figure 9

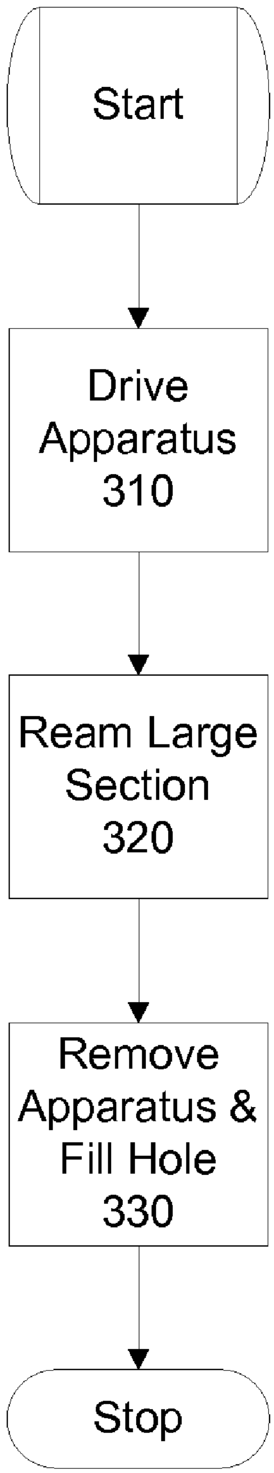
Start
Drive Apparatus 310
Ream Large Section 320
Remove Apparatus & Fill Hole 330
Stop

Figure 10

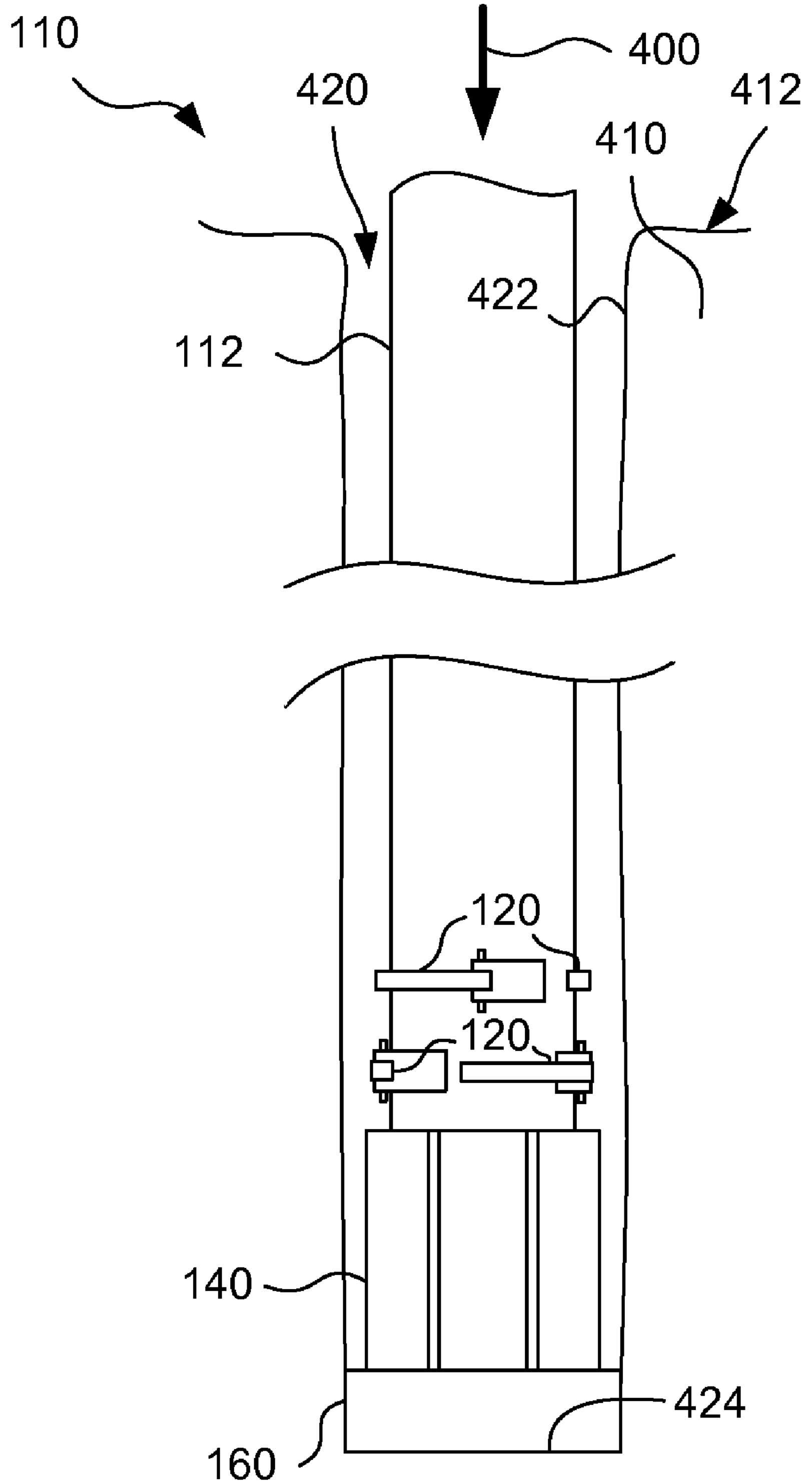

Figure 11

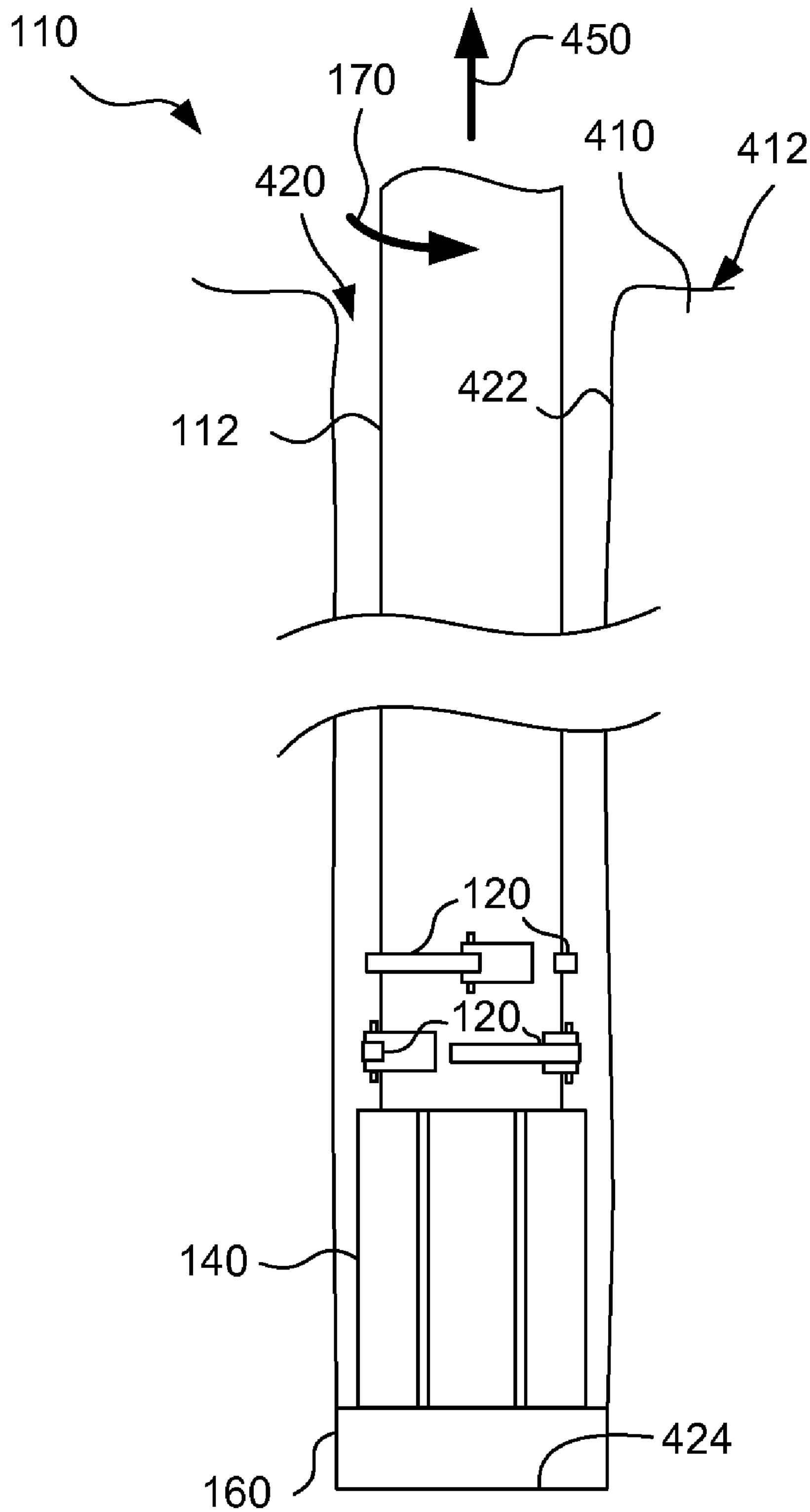

Figure 12

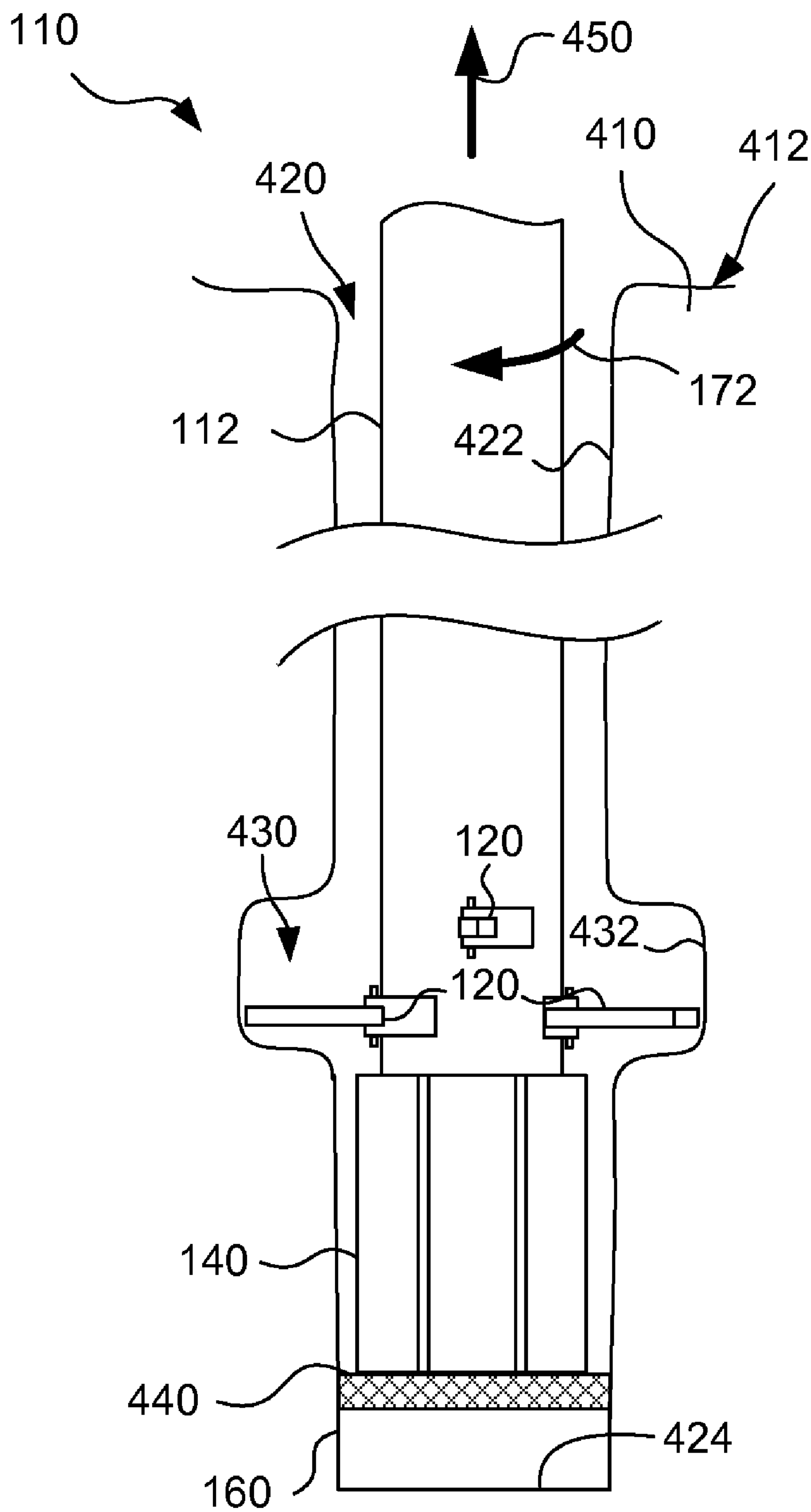

Figure 13

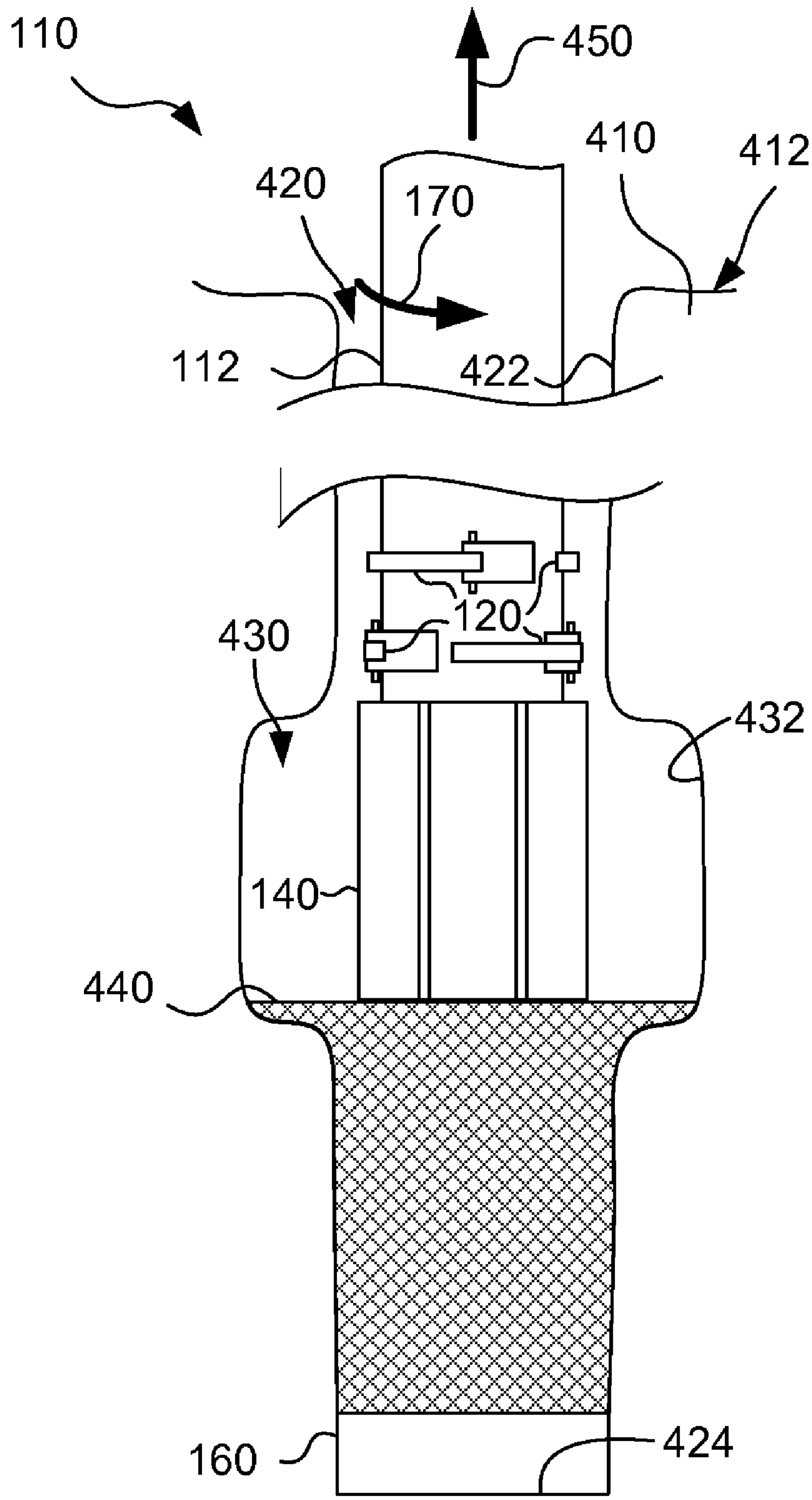

Figure 14

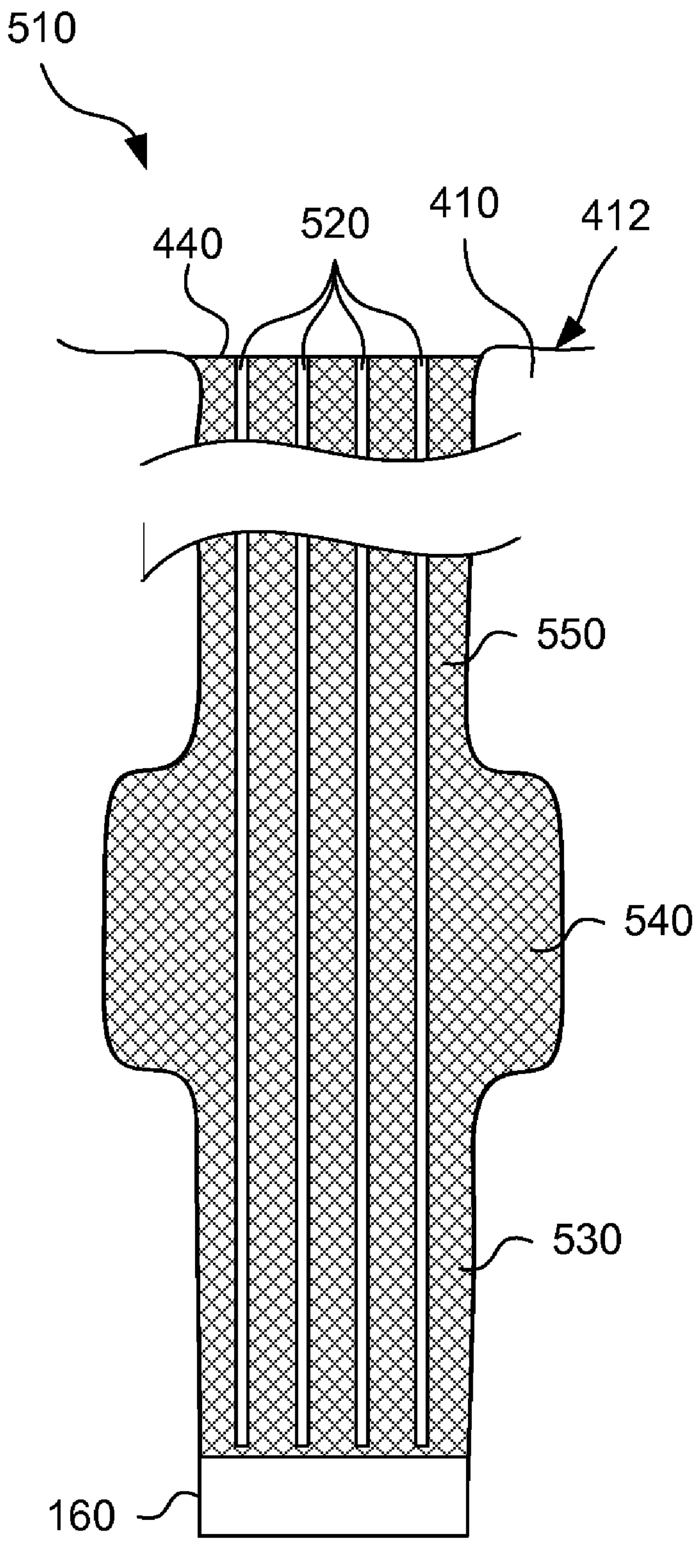

Figure 15

PILE MANDREL WITH EXTENDABLE REAMING MEMBERS

TECHNICAL FIELD

[0001] The description relates generally to forming piles and more particularly to a pile mandrel with extendable reaming members.

BACKGROUND

[0002] In modern engineering practice, piles in the ground are used to improve naturally poor foundations. By the use of piles, structural loads are transmitted to lower levels of the soil (as used herein, soil refers to loose soil as well as compacted soil and rock), generally via friction, but sometimes by bearing, or a combination of both. A piled foundation is often a requirement of the building codes where unsuitable soil fails to provide the required level of support to foundations and footings. This is done to prevent the settling or collapse of structures due to insufficient foundation support, and to ensure even and equal settling of a structure after construction.

[0003] Many different types of support piles have been used. Timber was perhaps the first piling material while other materials including steel and concrete were used later. Steel piles include HP sections and steel pipe (usually concrete filled). Concrete piles can be either precast (including both the reinforced and pre-stressed types) or cast-in-place. Cast-in-place concrete piles can further be separated into the non-displacement type (typically auger-cast-piles where soil is removed from the hole and brought to the surface) or the displacement type (where soil is forced to be displaced downwardly and/or to the side of the hole, but the soil is not brought to the surface). Cast-in-place concrete displacement piles may be cast directly against the surrounding soil. Enlarged base piles are also cast directly against the surrounding soil. Cast-in-place concrete displacement piles may also be cast against a metal pipe or metal shell, which has previously been driven into the ground. It has been known to vibrate a pile pipe, or even to turn it with a drill, to break the pipe free from the surrounding soil and remove it.

[0004] One displacement-type method of forming cast-in-place concrete piles includes driving a hollow steel mandrel into the ground with a boot or foot covering a hole at the bottom of the mandrel. After the mandrel is driven to the desired depth, the steel mandrel is removed, and the boot remains in the ground at the bottom of the resulting hole. Concrete is fed through the steel mandrel to fill the hole as the mandrel is being driven into the ground, as it is being removed from the ground, or both. After the mandrel is removed, rebar or some other reinforcing material may be inserted into the concrete before the concrete solidifies.

[0005] One type of cast-in-place concrete pile is the bell pile. A bell pile includes one or more bottom or mid-sections that flare outward and downward in a frustroconical or bell shape. Thus, these sections have larger diameters than the remainder of the pile. Such large diameter sections below the surface can be advantageous because they increase the pile's resistance to upward forces on the pile. As an example, a typical process for forming a bell pile includes: (1) centering, (2) starting to drill, (3) inserting a stand pipe, (4) feeding bentonite into the hole in the soil, (5) drilling to the specified depth, (6) inserting a belling bucket, (7) reaming the bore hole bottom with the belling bucket, (8) measuring the depth, (9) setting up an iron reinforcement cage, (10) inserting a tremie tube, (11) cleaning slime with an air lift, (12) filling the hole with concrete, and (13) removing soil that was brought to the surface during drilling and belling.

SUMMARY

[0006] The present inventor recognized shortcomings of prior pile forming tools and techniques. For example, bell piles are difficult and expensive to form because of the steps involved, and because bell piles are formed with a non-displacement process. Non-displacement processes result in soil being brought to the surface. Thus, that soil must be disposed of, which can be a costly and difficult process, especially if the subterranean soil has been contaminated. Displacement-type steel pipe pile techniques that fill the pipe with concrete and leave the pipe in the ground are expensive because of the price of the steel pipes, and such piles do not produce sufficient resistance to upward lift forces in many situations. Displacement-type concrete pile techniques that remove the steel pipe-type mandrel from the ground can also suffer from insufficient resistance to upward forces in many situations, and it is often difficult to remove the mandrel because of frictional forces between the mandrel and the surrounding soil.

[0007] Accordingly, there existed a need to provide a way to form piles that overcomes one or more of these problems. The described embodiments address this need, which has not heretofore been recognized and addressed.

[0008] According to one embodiment, a pile mandrel can be adapted to be driven into soil by a pile hammer. The pile mandrel can define a top opening located near a top end of the pile mandrel, with the top opening being positioned to receive grout to be fed through the pile mandrel. The pile mandrel can also define a bottom opening located near a bottom end of the pile mandrel, with the bottom opening being positioned to pass grout from the pile mandrel. A set of one or more reaming members can be secured to the pile mandrel. Each of the one or more reaming members can be moveable between a first position where the reaming member extends a first distance from a center of the pile mandrel, and a second position where the reaming member extends a second distance from the center of the pile mandrel.

[0009] When the pile mandrel has been driven into soil, interaction between the one or more reaming members and the soil can bias each of the one or more reaming members between the first and second positions. In addition, rotating the pile mandrel in a first direction can bias each of the one or more reaming members toward the first position, and rotating the pile mandrel in an opposite second direction can bias each of the one or more reaming members toward the second position.

[0010] According to another embodiment, a set of one or more reaming members can be mounted on a pile mandrel. Each of the one or more reaming members can be moveable between a first position where the reaming member extends to a first radius from a center of the pile mandrel and a second position where the reaming member extends to a second radius from the center of the pile mandrel. In addition, a hammer can be adapted to drive the pile mandrel into soil, and a drill can be adapted to rotate the pile mandrel while the pile mandrel is at least partially in the soil. Rotation of the pile mandrel while the one or more reaming members are in the soil can bias the one or more reaming members between the first and second positions.

[0011] According to yet another embodiment, an apparatus is driven into soil. The apparatus can include a pile mandrel and one or more reaming members attached to the mandrel. Driving the apparatus into the soil can include displacing the soil outwardly and downwardly from the pile mandrel, creating a hole extending down from a surface of the soil. While the one or more reaming members attached to the pile mandrel are below the surface of the soil, the one or more reaming members can be extended from a retracted position to an extended position; the pile mandrel can be rotated with the reaming member(s) in the extended position to ream a section of the hole to a second diameter that is larger than the first diameter; and the one or more reaming members can be retracted from the extended position. The pile mandrel can be removed from the soil, the hole can be filled with a substantially liquid material, such as grout, and the substantially liquid material can be allowed to solidify.

[0012] This Summary is provided to introduce a selection of concepts in a simplified form. The concepts are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Similarly, the invention is not limited to implementations that address the particular techniques, tools, environments, disadvantages, or advantages discussed in the Background, the Detailed Description, or the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. **1** is a front view of a driven apparatus of a pile forming apparatus according to one embodiment.

[0014] FIG. **2** is a sectional view taken along line **2-2** of FIG. **1**, but not showing the enlarged diameter section of the pile mandrel formed by reinforcing plates.

[0015] FIG. **3** is a sectional view similar to FIG. **2**, except that the reaming members are in an extended position in FIG. **3**, while they are in a retracted position in FIGS. **1-2**.

[0016] FIG. **4** is a top view of the driven apparatus of FIG. **1**.

[0017] FIG. **5** is a cut-away front plan view of a pile forming apparatus according to one embodiment.

[0018] FIG. **6** is an enlarged cut-away front view of the drill head and the top of the driven portion of the pile driving apparatus of FIG. **5**.

[0019] FIG. **7** is sectional view taken along line **7-7** of FIG. **6**.

[0020] FIG. **8** is a sectional view similar to FIG. **7**, but illustrating the mandrel interface plate being engaged by the rotation of the drill head.

[0021] FIG. **9** is a sectional view taken along line **9-9** of FIG. **8**.

[0022] FIG. **10** is a flowchart illustrating a method of forming a pile according to described embodiments.

[0023] FIG. **11** is front cut-away view of the driven apparatus of FIG. **1** being driven into soil.

[0024] FIG. **12** is a view similar to FIG. **11**, but with the driven apparatus being raised and rotated.

[0025] FIG. **13** is a view similar to FIG. **12**, but with the reaming members extended to form a large diameter section of a pile hole.

[0026] FIG. **14** is view similar to FIG. **13**, but with the reaming members retracted after having formed a large diameter section of a pile hole.

[0027] FIG. **15** is a front partially sectional cut-away view of a pile with a subterranean large diameter section.

[0028] The description and drawings may refer to the same or similar features in different drawings with the same reference numbers.

DETAILED DESCRIPTION

[0029] Referring to FIGS. **1-3**, a driven apparatus (**110**) for forming cast-in-place piles is illustrated. The driven apparatus (**110**) includes a hollow mandrel (**112**) having a top end (**114**) and an opposing bottom end (**116**). Near the bottom end (**116**) of the mandrel (**112**), the driven apparatus (**110**) includes reaming members (**120**). As will be described in more detail below, after the driven apparatus (**110**) has been driven downward to form a pile hole in surrounding soil, the mandrel (**112**) can be rotated in a forward direction to loosen the mandrel from the surrounding soil (see FIG. **2**). The mandrel (**112**) can then be pulled up from the hole. As the mandrel (**112**) is being pulled up, grout can be fed through the mandrel (**112**) to fill the pile hole. Once the mandrel (**112**) has begun to be raised from the bottom of the pile hole, the mandrel (**112**) can be rotated in a backward direction (see FIG. **3**). This rotation forces the reaming members (**120**) to engage the surrounding soil, thereby pivoting the reaming members (**120**) to an extended position shown in FIG. **3**. With the reaming members (**120**) in this extended position, the mandrel (**112**) can continue to be raised while rotating it in the backward direction so that the reaming members (**120**) ream a subterranean large diameter section of the pile hole. When a sufficient large diameter section has been reamed, the mandrel can be rotated in the forward direction to rotate the reaming members back into the retracted position shown in FIGS. **1-2**. The mandrel can then be raised out of the pile hole. Grout can be fed through the mandrel (**112**) to fill the pile hole with grout as the mandrel (**112**) is being raised. This results in a pile having a subterranean large diameter section, with a small diameter section above the large diameter section.

[0030] These tools and techniques produce substantial benefits that are not present in or predictable from prior pile forming tools and techniques. Because the pile can include a subterranean large diameter section, the pile can have a greater resistance to upward forces than conventional cylindrical piles with no such large diameter sections. Such conventional piles can be pulled up without displacing a significant amount of soil. However, for the pile with the large diameter section to be pulled up, the soil above the large diameter section would have to be displaced. In addition, cast-in-place piles can be formed inexpensively with the tools and techniques described herein. This is in part because the described technique is a displacement technique that does not bring significant amounts of soil to the surface, so there is no need to dispose of such surface soil. In addition, typically only a small boot on the bottom of the mandrel of the driven apparatus is left in the ground. Thus, the material cost for each pile is less than in many prior displacement cast-in-place techniques, where an entire steel pipe was left in the ground for each pile.

[0031] The subject matter defined in the appended claims is not necessarily limited to the benefits described herein. A particular implementation of the invention may provide all, some, or none of the benefits described herein. Although operations for the various techniques are described herein in a particular, sequential order for the sake of presentation, it should be understood that this manner of description encompasses rearrangements in the order of operations, unless a particular ordering is required. For example, operations described sequentially may in some cases be rearranged or performed concurrently. Techniques described herein with reference to flowcharts may be used with one or more of the systems described herein and/or with one or more other systems. In addition, the apparatuses defined herein may be used in a manner other than the described methods or techniques. For example, in some situations the driven apparatus described below may be driven into the ground, rotated only in the forward direction or not rotated at all, and removed without extending the reaming members. This could result in a pile without the large diameter section described below (such as the pile hole of FIG. **12** filled with grout and possibly with reinforcing members), which may be desirable in some applications. Moreover, for the sake of simplicity, flowcharts may not show the various ways in which particular techniques can be used in conjunction with other techniques.

[0032] Referring still to FIGS. **1-4**, and describing the driven apparatus (**110**) in more detail, the driven apparatus (**110**) includes the pile mandrel (**112**) having a top end (**114**) and an opposite bottom end (**116**), defining a bottom hole (**118**) where grout can exit the mandrel (**112**). The mandrel (**112**) can be a round steel pipe, such as standard steel pipes that are typically used for piles and as mandrels for existing pile driving techniques. However, the pipe could be made of some other material that is sufficiently strong and durable, and it could have some other shape, such as a hollow octagonal cross section. The reaming members (**120**) can be curved claw-shaped steel rods with square cross sections. Each reaming member (**120**) illustrated in FIGS. **1-4** includes a tip (**122**) that is sloped outwardly away from the mandrel. In the retracted position, the tip sits adjacent to the mandrel and the rod bends around the mandrel to a base (**124**) of the reaming member (**120**). A reaming member support (**130**) supports each reaming member (**120**). The reaming member supports (**130**) can be curved steel supports welded to the mandrel (**112**). Each support (**130**) defines a recess that receives the base (**124**) of a corresponding reaming member (**120**). A support pin (**132**) extends through each support (**130**) and through the base (**124**) of each reaming member (**120**). Thus, the support pin (**132**) secures the corresponding reaming member (**120**) to the corresponding reaming member support (**130**), but allows the reaming member (**120**) to pivot between the retracted position shown in FIG. **2** and the extended position shown in FIG. **3**. The pin (**132**) can be any type of conventional pin that will hold the reaming member in place, such as an all-threaded rod. Other types of fasteners, such as screws, bolts, and hard-rolled pins could be used as alternatives to an all-threaded rod. Each reaming member (**120**) is prevented from pivoting outward beyond the extended position by contact with the corresponding reaming member support (**130**), and is prevented from pivoting inward beyond the retracted position by contact with the mandrel (**112**). Many other configurations and shapes of reaming members and supports are possible and will be apparent to those skilled in the art. For example, the reaming members could be flattened fins or round rods, rather than square cross-sectioned rods.

[0033] Referring still to FIGS. **1-4**, the driven apparatus (**110**) includes shield plates (**140**) that are secured to the mandrel (**112**), such as by welding, to create a larger diameter section of the mandrel (**112**) below the reaming members (**120**). The shield plates (**140**) form an annular shoulder (**142**) below the reaming members (**120**). The shield plates (**140**) can shield and protect the reaming members (**120**) and reaming member supports (**130**) from the surrounding soil as the driven apparatus (**110**) is driven into the soil. The shield plates can be a unitary part (rather than multiple plates), and they can be an integral part of the mandrel (**112**). As an alternative, the shield plates can be secured in some way other than by welding, such as with bolts or other fasteners.

[0034] An interface plate (**150**), which can be a generally rectangular plate as illustrated, is secured to the top of the mandrel (**112**). The interface plate (**150**) can be secured by welding or in some other manner. The interface plate (**150**) defines a centrally located top grout hole (**152**) (see FIG. **4**) therein so that grout can be pumped through the top hole (**152**) in the plate (**150**) and the mandrel (**112**), and into the hollow mandrel (**112**) when filling a pile hole with grout.

[0035] Referring to FIG. **1**, the driven apparatus (**110**) also includes a boot (**160**) that protects the bottom end (**116**) of the mandrel (**112**) and forces soil outward to form a hole with a larger diameter than the mandrel (**112**) itself, as the driven apparatus (**110**) is driven into the soil. The boot (**160**) includes a round steel bottom plate (**162**) that is positioned below the bottom of the mandrel (**112**) as well as a hollow cylindrical side wall (**164**) that extends up from the periphery of the bottom plate (**162**) and around the bottom of the mandrel (**112**). Alternatively, the side wall can have a diameter less than the diameter of the bottom plate, and the side wall can extend upwardly within the hollow bottom of the mandrel (**112**). As yet another alternative, the boot can include an outer wall extending around the bottom of the mandrel (**112**) (as illustrated) and an inner wall extending up within the bottom of the mandrel (**112**), so that the mandrel (**112**) is seated between the two walls of the boot. One such configuration may be more advantageous for one type of soil, and another such configuration, or even some other boot configuration, may be more advantageous for another type of soil. The boot (**160**) is not fastened to the mandrel (**112**), and it is typically left in the bottom of a pile hole when the remainder of the driven apparatus (**110**) is removed.

[0036] As illustrated in FIG. **2**, when the driven apparatus (**110**) is rotated in a forward direction (**170**) while the reaming members (**120**) are in a pile hole, the reaming members (**120**) are biased by surrounding soil into the retracted position. On the other hand, when the driven apparatus (**110**) is rotated in a backward direction (**172**) with the reaming members (**120**) in a pile hole, the tips (**122**) of the reaming members (**120**) engage the surrounding soil to pivot the reaming members outwardly to the extended position shown in FIG. **3**. Thus, when the driven apparatus is in the soil, the reaming members (**120**) can be pivoted between the retracted and extended positions by simply rotating the driven apparatus (**110**) in the forward direction (**170**) or the backward direction (**172**). Alternatively, the reaming members (**120**) can be biased between the forward and reverse positions in some other manner, such as by using springs, rams, or drive motors.

[0037] Referring now to FIGS. **5-9**, a pile forming apparatus (**200**) is illustrated. The pile forming apparatus (**200**) includes a driving apparatus (**210**) that includes an upright guide structure (**220**) that includes main vertically extending guides (**224**) and side vertically extending guides (**228**). The guide structure (**220**) can be made of standard steel, as with other standard pile driving guide structures. A hammer (**240**) includes a hammer support structure (**242**) that supports the hammer and engages the main guides (**224**) so that the hammer (**240**) rides vertically up and down on the main guides (**224**). The hammer (**240**) can include a cylinder (**244**) that can house a piston that is attached to a downwardly extending hammer shaft (**248**), which is in turn secured to a downwardly extending hammer head (**250**). The hammer head (**250**) can open downwardly to receive the interface plate (**150**) and the top end (**114**) of the mandrel (**112**) so that the hammer can force the driven apparatus (**110**) downwardly into the soil. The hammer (**240**) can be a conventional type of pile driver, such as a drop hammer, a diesel hammer, a hydraulic impact hammer, or a vibratory driver.

[0038] Referring still to FIGS. **5-9**, the driving apparatus (**210**) also includes a drill (**260**), which includes a drill support structure (**262**) that engages the side guides (**228**) so that the drill (**260**) can ride vertically on the side guides (**228**). A drill support line (**264**), such as a rope or a steel cable extends up from the drill (**260**) so that the drill (**260**) can be raised or lowered by raising or lowering the drill support line (**264**). The drill also includes a downwardly-extending drill shaft (**268**) that is secured to a drill head (**270**) that extends down from the drill shaft (**268**) so that the drill (**260**) can be operated to rotate the drill head (**270**).

[0039] The drill head (**270**) can be formed of steel plates, and can include a ceiling (**272**), walls (**276**) that extend down from the ceiling (**272**), a bottom lip (**278**) that extends in from the bottom of the walls (**276**). (See FIG. **9**.) Thus, the bottom lip (**278**) forms a rectangular opening (**280**) into a cavity (**282**) formed by the ceiling (**272**), walls (**276**), and lip (**278**) of the drill head (**270**). If the drill is hydraulic, then it can be powered by hydraulic lines (**290**), although the drill could be powered by an electric motor or in some other manner. A grout supply line (**292**) also extends to the drill (**260**) to feed grout through the drill (**260**).

[0040] The opening (**280**) in the drill head (**270**) is sized so that it can receive the interface plate (**150**) of the driven apparatus (**110**). (See FIG. **7**.) Thus, the interface plate can extend through the opening (**280**) and into the cavity (**282**) in the drill head (**270**). (See FIG. **9**.) The drill (**260**) can be a conventional drill such as the drills that are used to rotate augers in non-displacement pile driving techniques. The drill (**260**) and the hammer (**240**) can both be secured to the same support structure (**220**), as illustrated in FIG. **5**, or they can be supported by separate structures and/or operate independently of each other.

[0041] As noted above, the driven apparatus (**110**) can be positioned so that the top end (**114**) of the mandrel (**112**) extends into the cavity (**282**) in the drill head (**270**), as illustrated in FIGS. **5-9**. In this drilling position, grout can be fed through the drill (**260**), down through the top grout hole (**152**) in the interface plate (**150**) and the mandrel (**112**), and through the mandrel (**112**). The grout can thereby be fed into a pile hole through the opening at the bottom of the mandrel (**112**). Moreover, as illustrated in FIG. **8**, when the drill head (**270**) is rotated, the walls (**276**) of the drill head (**270**) engage the interface plate (**150**) of the driven apparatus (**110**) to rotate the driven apparatus (**110**). Additionally, in this engaged position, when the drill (**260**) is pulled up, the lip (**278**) of the drill head (**270**) engages the interface plate (**150**) to pull the driven apparatus (**110**) up as well (except that the boot is left in a pile hole rather than being pulled up). (See FIG. **9**.)

[0042] Referring now to **10-15**, the use of the pile forming apparatus (**200**) will be described. As illustrated in FIG. **10**, in general the use includes driving the driven apparatus into the soil to form a pile hole (**310**); reaming a large diameter subterranean section in the pile hole (**320**); and removing the driven apparatus and filling the hole (**330**).

[0043] More specifically, referring to FIG. **11**, the driven apparatus (**110**) is driven in a downward direction (**400**) into soil (**410**). To do this, the driven apparatus (**110**) is placed with the boot (**160**) resting on the soil surface (**412**), and the driven apparatus is driven down, such as with successive blows from the hammer (**240**). As the driven apparatus (**110**) is forced down, the boot (**160**) displaces the soil (**410**), forcing the soil to the side, and thereby forming a pile hole (**420**) with a diameter approximately equal to the diameter of the boot (**160**). However, soil (**410**) may collapse inward to some extent after the boot (**160**) passes so that some sections of the pile hole (**420**) may have a smaller diameter than the boot (**160**), and some sections may have a larger diameter than the boot (**160**). After the boot (**160**) has been driven down to desired depth, the boot rests on a floor (**424**) of the pile hole (**420**)

[0044] The hammer (**240**) (see FIG. **5**) can then be lifted off the driven apparatus (**110**), and the drill head (**270**) can be positioned over the interface plate (**150**), as shown in FIGS. **5-9**. As illustrated in FIG. **12**, the driven apparatus (**110**) (except for the boot (**160**)) can then be rotated in the forward direction (**170**) to break the remaining driven apparatus loose from the boot (**160**) and from the side surface (**422**) of the pile hole (**420**). As the remaining driven apparatus (**110**) is rotated, it can begin to be lifted in an upward direction (**450**) by pulling up on the drill (**260**) (FIG. **5**). As this happens, grout (**440**) that is fed through the mandrel (**112**) is emptied into the pile hole (**420**) (see FIGS. **13-15**).

[0045] As illustrated in FIG. **13**, the remaining driven apparatus (**110**) can then be rotated in the backward direction (**172**) so that the reaming members (**120**) pivot to the extended position. As the driven apparatus (**110**) continues to be rotated and lifted, the reaming members (**120**) ream out a subterranean large diameter hole section (**430**) with a side surface (**432**) having a larger diameter than the side surface (**422**) of the remainder of the pile hole (**420**).

[0046] Once a desired size of the large diameter hole section (**430**) has been reamed, then the remaining driven apparatus (**110**) is rotated in the forward direction (**170**) and is continued to be raised, as illustrated in FIG. **14**. This continues until the driven apparatus (**110**) is entirely removed from the pile hole (**420**), and the pile hole (**420**) is filled with grout (**440**) to the desired height. One or more reinforcing members (**520**), such as rebar or a reinforcing cage, can then be inserted in the grout (**440**) to form the resulting pile (**510**) illustrated in FIG. **15**.

[0047] The resulting pile (**510**) illustrated in FIG. **15** includes the boot (**160**) at its bottom, with grout (**440**) filling the boot (**160**) and extending up from the boot (**160**). The reinforcements (**520**) are held within the grout (**440**). The pile includes a bottom small diameter section (**530**) extending up from the boot (**160**), a large diameter section (**540**) with a larger diameter than the small diameter section (**530**), and a top small diameter section (**550**) with a smaller diameter than the large diameter section (**540**) (typically approximately equal to the bottom small diameter section (**530**)). The pile could include additional interspersed large and small diameter sections, as specified for a particular project. Also, the large diameter section(s) could be located higher or lower on the pile, as specified for a particular project.

[0048] While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention. For example, the reaming members could be used with another type of mandrel, such as a mandrel with additional flow spaces to assist in the flow of grout into the pile hole. Such a mandrel and associated apparatus is described in U.S. Pat. No. 4,992,002, issued Feb. 12, 1991, which is incorporated herein by reference. As another example, the reaming members may be positioned in some other manner on a driven apparatus. For example, the reaming members could be located closer to the bottom of the mandrel than in the illustrations shown herein.

I claim:

1. An apparatus comprising:

a pile mandrel that is adapted to be driven into soil by a pile hammer, the pile mandrel defining:

a top opening located near a top end of the pile mandrel, the top opening being positioned to receive grout to be fed through the pile mandrel; and

a bottom opening located near a bottom end of the pile mandrel, the bottom opening being positioned to pass grout from the pile mandrel; and

a set of one or more reaming members secured to the pile mandrel, each of the one or more reaming members being moveable between a first position where the reaming member extends a first distance from a center of the pile mandrel, and a second position where the reaming member extends a second distance from the center of the pile mandrel, the second distance being different from the first distance.

2. The apparatus of claim **1**, wherein each of the one or more reaming members comprises a curved bar.

3. The apparatus of claim **1**, wherein each of the one or more reaming members is pivotally connected to the pile mandrel.

4. The apparatus of claim **1**, wherein, when the pile mandrel has been driven into soil, interaction between the one or more reaming members and the soil can bias each of the one or more reaming members between the first and second positions.

5. The apparatus of claim **1**, wherein, when the pile mandrel has been driven into soil, rotating the pile mandrel in a first direction biases each of the one or more reaming members toward the first position.

6. The apparatus of claim **1**, wherein, when the pile mandrel has been driven into soil, rotating the pile mandrel in a first direction biases each of the one or more reaming members toward the first position, and rotating the pile mandrel in an opposite second direction biases each of the one or more reaming members toward the second position.

7. The apparatus of claim **1**, wherein the set of one or more reaming members comprises multiple reaming members.

8. The apparatus of claim **1**, wherein the set of one or more reaming members comprises multiple rows of reaming members.

9. An apparatus comprising:

a pile mandrel;

a set of one or more reaming members mounted on the pile mandrel, each of the one or more reaming members being moveable between a first position where the reaming member extends to a first radius from a center of the pile mandrel and a second position where the reaming member extends to a second radius from the center of the pile mandrel, the second radius being different from the first radius;

a hammer that is adapted to drive the pile mandrel into soil; and

a drill that is adapted to rotate the pile mandrel while the pile mandrel is at least partially in the soil;

wherein rotation of the pile mandrel while the one or more reaming members are in the soil biases the one or more reaming members between the first and second positions.

10. The apparatus of claim **9**, wherein:

rotation of the pile mandrel in a first direction while the one or more reaming members are in the soil causes the one or more reaming members to engage the soil to bias the one or more reaming members toward the first position; and

rotation of the pile mandrel in a second direction, which is opposite to the first direction, while the one or more reaming members are in the soil causes the one or more reaming members to engage the soil to bias the one or more reaming members toward the second position.

11. The apparatus of claim **9**, wherein the drill is adapted to engage the pile mandrel to lift the pile mandrel while the pile mandrel is at least partially in the soil.

12. The apparatus of claim **11**, wherein the drill is adapted to simultaneously rotate and lift the pile mandrel while the pile mandrel is at least partially in the soil.

13. The apparatus of claim **9**, wherein each of the one or more reaming members is able to pivot between the first position and the second position.

14. The apparatus of claim **9**, wherein the drill and the hammer are secured to a single support structure.

15. A method comprising:

driving an apparatus into soil, the apparatus including a pile mandrel and one or more reaming members attached to the mandrel, wherein driving the apparatus into soil includes displacing the soil outwardly and downwardly from the pile mandrel, creating a hole extending down from a surface of the soil, the hole having a first diameter;

while the one or more reaming members attached to the pile mandrel are below the surface of the soil:

extending the one or more reaming members from a retracted position to an extended position;

rotating the pile mandrel with the one or more reaming members in the extended position to ream a section of the hole to a second diameter that is larger than the first diameter; and

retracting the one or more reaming members from the extended position;

removing the pile mandrel from the soil;

filling the hole with a substantially liquid material; and

allowing the substantially liquid material to solidify.

16. The method of claim **15**, wherein extending the one or more reaming members comprises rotating the pile mandrel in a first direction.

17. The method of claim **16**, wherein extending the one or more reaming members comprises engaging the soil with the one or more reaming members.

18. The method of claim **16**, wherein retracting the one or more reaming members comprises rotating the pile mandrel in a second direction.

19. The method of claim **18**, wherein retracting the one or more reaming members comprises engaging the soil with the one or more reaming members.

20. The method of claim **15**, further comprising lifting the pile mandrel while rotating the pile mandrel with the one or more reaming members in the extended position.

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