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Kelly et al.

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[54] **POST-TENSIONED PRESTRESSED PILE ASSEMBLY**

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[52] **U.S. Cl.** **61/56**

[51] **Int. Cl.**[2] **E02D 5/30**; E02D 5/58

[58] **Field of Search** 61/53, 53.5, 53.62, 56; 52/227, 677

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Attorney, Agent, or Firm—Shlesinger, Arkwright, Garvey & Dinsmore

[57] **ABSTRACT**

A post-tensioned prestressed pile assembly which includes a plurality of vertically arranged, tubular driving shell sections joined in end-to-end relationship. A combination pile driving point and anchoring plug is connected to the lowermost shell section. A tendon anchored to the combination driving point and plug extends through the longitudinal axis of the shell sections and is held in axial alignment by members located at intervals through the pile assembly. The tendon passes through a live end anchor in a driving head to permit jacking thereof for tensioning the tendon and placing the pile assembly in compression.

14 Claims, 7 Drawing Figures

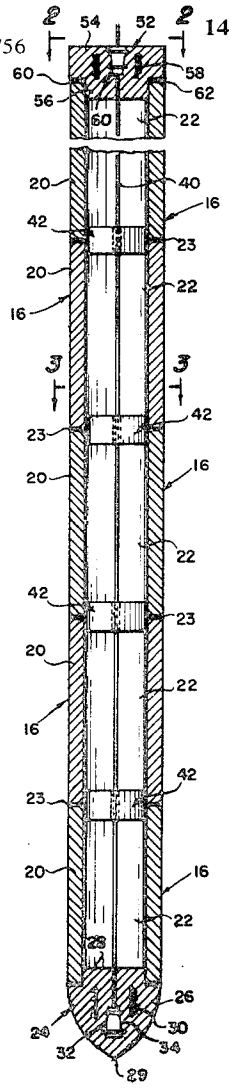


Fig. 1

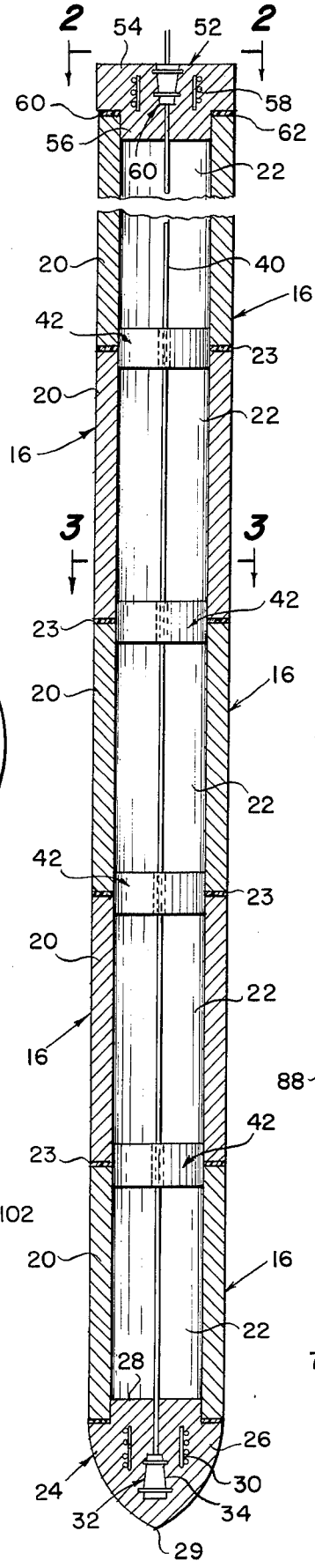


Fig. 2

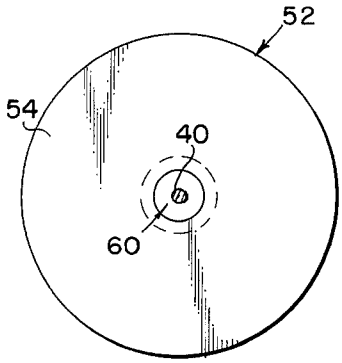
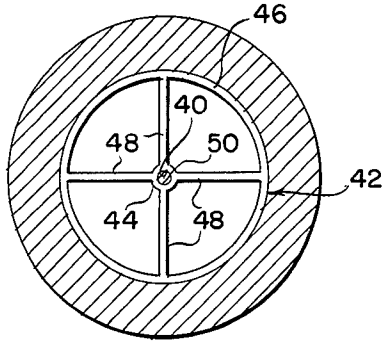


Fig. 3



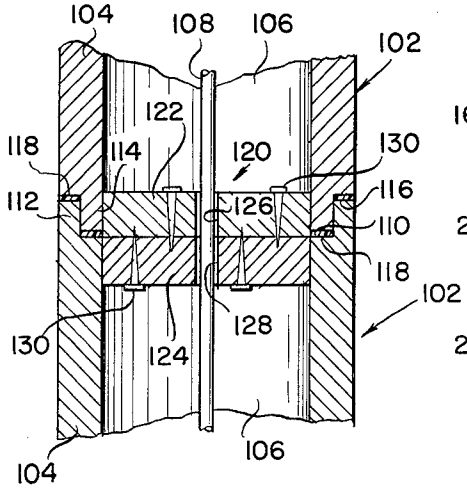


Fig. 6

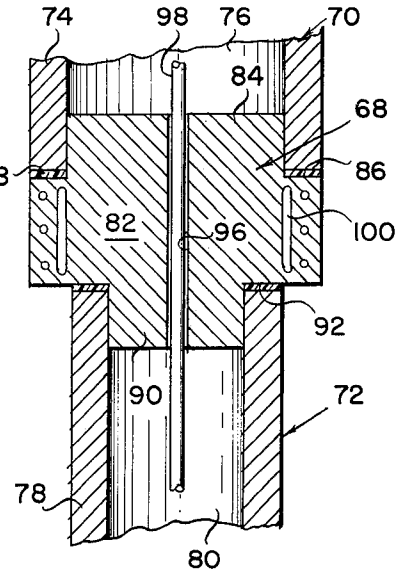


Fig. 5

Fig. 4

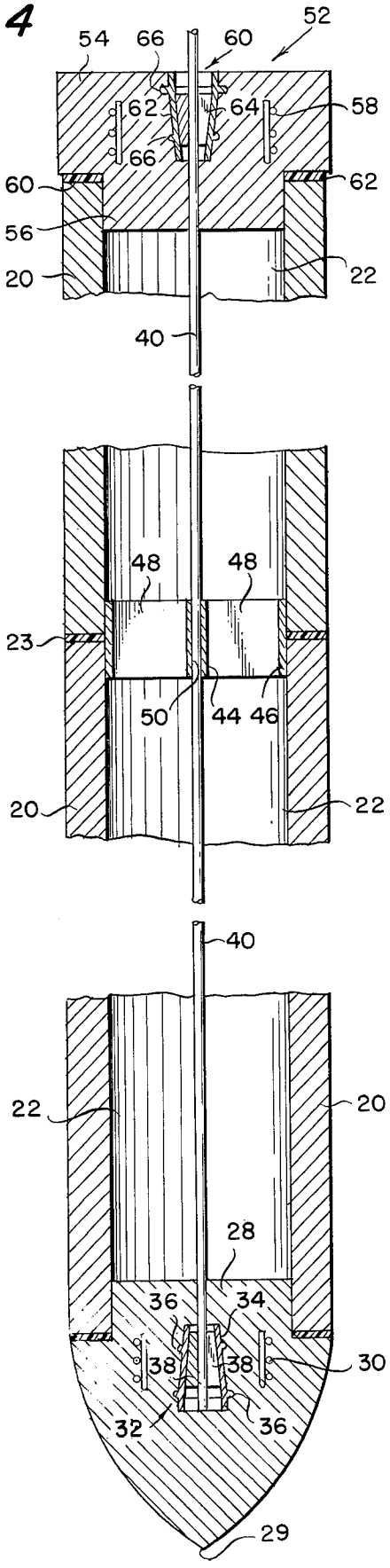
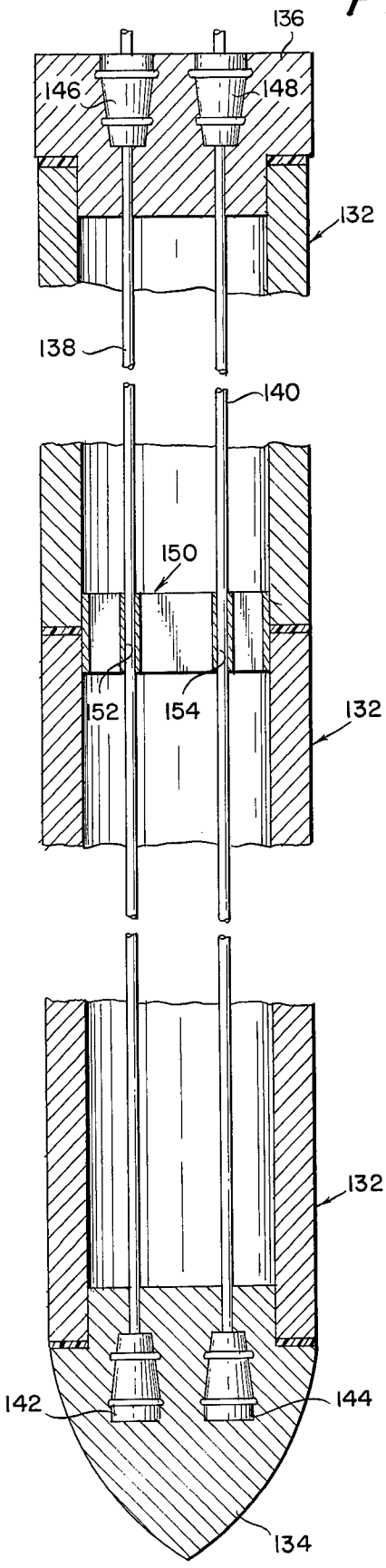

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Fig. 7


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POST-TENSIONED PRESTRESSED PILE ASSEMBLY

BACKGROUND AND OBJECTS

For many years, piles made of reinforced concrete have been precast and driven into the ground by use of conventional pile driving equipment. These piles are of solid construction, and are accordingly relatively heavy in proportion to their strength. U.S. Pat. No. 2,645,090 granted to William P. Kinneman et al. on July 14, 1953 discloses an improvement on the conventional arrangement wherein a one-piece or sectional concrete pile is employed, which pile is provided with a relatively small central bore extending longitudinally through the pile. A prestressing cable passes through the bore and is tensioned to place the pile in compression. Although the Kinneman pile is not of solid construction, the walls of the pile are, nevertheless, relatively thick in proportion to the size of the bore, thereby rendering the pile very heavy and difficult to handle, particularly where a sectional pile is to be constructed.

It is an object of this invention to provide a pile assembly comprised of a plurality of tubular shell sections of relatively short lengths, which may be assembled together in the field, the sections having a large bore extending through the pile, and provided with a tendon passing axially therethrough and anchored at both ends of the pile assembly, the tendon being adapted to be jacked through the pile to place the tendon under tension and the pile in compression.

Another object is to provide a pile assembly of the character described wherein the diameter of the bore of each pile section is substantially greater than the wall thickness thereof, thereby providing a pile which is relatively light in proportion to its strength and is readily assembled in the field to the desired length by unskilled labor.

A further object is to provide a pile assembly of the character described including members positioned within the bores of the pile sections at intervals for maintaining the tendon in axial relationship to the pile assembly.

Other objects are to provide a pile assembly which is of shell-like construction which may be filled with concrete or other material after driving, if desired; to provide a pile assembly wherein shell sections of different diameter may be connected together by a step taper joint, and to provide a pile assembly which may employ one or more tendons extending therethrough as dictated by the prestress requirements of the installation.

Other objects will be manifest from the following description of the present invention taken in connection with the attached drawings.

DESCRIPTION OF THE FIGURES OF THE DRAWINGS

FIG. 1 is a fragmentary, longitudinal, sectional view of a pile assembly constructed in accordance with the present invention, portions thereof being shown in elevation;

FIG. 2 is an end elevational view taken from 2—2 of FIG. 1, looking in the direction of the arrows;

FIG. 3 is a transverse sectional view taken along line 3—3 of FIG. 1 and viewed in the direction of the arrows;

FIG. 4 is an enlarged fragmentary, longitudinal, sectional view of the pile assembly of the present invention, showing to advantage details of construction;

FIG. 5 is a fragmentary, sectional view of a step taper joint constructed in accordance with the present invention;

FIG. 6 is a fragmentary, longitudinal, sectional view of a modified form of the present invention; and

FIG. 7 is a fragmentary, longitudinal, sectional view of another modified form of the present invention, illustrating the use of multiple tendons.

DESCTIPTION OF THE FORM OF INVENTION ILLUSTRATED IN FIGS. 1 TO 4

In FIG. 1, there is illustrated a pile assembly constructed in accordance with the present invention which comprises a plurality of like, hollow shell sections 16 of uniform diameter throughout which are joined in end-to-end relationship. Shell sections 16 may be of precast concrete, steel, plastic or any other suitable material. Each section 16 includes a wall 20 of uniform thickness and a longitudinal bore 22, the diameter of the bore being at least several times larger than the wall thickness of the pile section. This provides a pile assembly which is relatively light in proportion to the strength thereof. In accordance with the present invention, the sections are preferably of five to ten feet in length and the thickness of the section walls one-half inch to eight inches. Although larger diameter sections may be employed, with pile driving equipment presently available, shell sections of four inches to fifty-four inches in diameter are preferable.

In this form of the invention, gaskets 23 made of neoprene or other appropriate material are interposed in the joints between adjacent section walls, for effecting a tight seal therebetween.

As shown to advantage in FIGS. 1 and 4, the lowermost sections 16 of the present pile assembly is in interfitting engagement with a combination pile driving point and anchoring plug 24 which includes a main body section 26, the upper portion of which is reduced at 28 for insertion into an end of lowermost shell section 16. The lower extremity of main body section 26 is pointed as indicated at 29 for facility in driving the pile into the ground. The combination point and plug may be made of concrete, steel, plastic or other construction. Reinforcing means comprising steel mesh or the like is indicated at 30.

A conventional concrete anchor 32 is positioned in main body section 26. Anchor 32 may be constructed in accordance with U.S. Pat. No. 3,703,748 and includes a tapered casing 34, the outer periphery of which is provided with reaction flanges 36. Tapered wedge segments 38 are positioned within tapered casing 34 and grippingly engage the tendon 40 extending between the segments. Tendon 40 may be of any desired size and may be of single wire or multi wire construction.

Tendon 40 extends upwardly and axially through the pile assembly as indicated in FIGS. 1 and 4, the tendon passing through combination tendon centering and sectional aligning members 42 which span the joints between adjacent shell sections. Tendon centering and sectional aligning members 42 may be of concrete, metal, plastic, wood or other suitable construction. As shown to advantage in FIG. 3, members 42 are preferably of open, wheel-like design, to permit passage of

concrete or other material from one section to another, if desired. Each section includes an inner circular portion **44** and a concentric, larger outer circular portion **46**, portions **44** and **46** being joined by a plurality of spaced webs or connectors **48** radiating from inner circular portion **44**. The inner diameter of circular portion **44** is slightly larger than the diameter of tendon **40**, thereby providing a bore or passage **50** through which the tendon passes. The outer diameter of each member **42** is substantially equal to the inner diameter of shell sections **16** in order to effect a friction fit between members **42** and the shell sections. By placing members **42** so that they span the joints between adjacent shell sections, the sections are maintained in axial alignment. Of course, if desired, members **42** may be solid and provided with a central bore to accommodate the tendon.

The upper end of the pile assembly of the present invention is provided with a head or driving block **52** which includes an upper main body portion **54**, the diameter of which is such that a portion thereof overlies the upper edge of topmost shell section **16**. Main body portion **54** issues into a lower section **56** of reduced cross-sectional area for fitting within topmost shell section **16**, the diameter of said lower section being substantially equal to the internal diameter of the shell section. Head or driving block **52** may be made of concrete, steel or other suitable material. Reinforcing means are indicated at **58**.

In accordance with the present invention, a live end anchor **60** is set in the central portion of head or driving block **52**. Anchor **60** may be of any suitable construction such as set out in U.S. Pat. No. 3,703,748 and includes a tapered casing **62** within which are positioned tapered jaw segments **64**, between which tendon **40** passes. Reaction flanges are indicated at **66**.

By virtue of the reduction of the cross-sectional area of head or driving block **52**, there is provided a shoulder **60** which overlies the upper edge of topmost shell section **16** and is separated therefrom by means of a gasket **62** which is preferably similar in construction to gasket **23**.

OPERATION

In use of the pile assembly of the form of invention illustrated in FIGS. **1** to **4**, the pile sections may be assembled in the field in tendon centering and section aligning members **42** inserted at the joints between the sections, preparatory to training the tendon from anchor **32** through each successive tendon centering and section aligning member. After the tendon is passed through live end anchor **60**, any desired tension may be applied to the tendon to place the pile sections in compression, following which the pile is driven into the ground by convention pile driving means.

The prestress forces exerted by tendon **40** extend through the pile casing while the pile is being driven and during the life of the pile after it has been placed. If desired, concrete, sand or other materials may be placed in the pile sections as required, and the construction of tendon centering and section aligning members **42** is such that the concrete or other material may flow therethrough into the lowermost pile section.

DESCRIPTION OF THE FORM OF INVENTION ILLUSTRATED IN FIG. 5

In FIG. **5**, there is illustrated a modified form of the present invention relating to the use of a step taper joint **68** for connecting shell sections **70** and **72** which are of different diameter. Shell section **70** includes a circular wall **74** and a bore **76**. Shell section **72** includes a circular wall **78** having a bore **80**. Just as in the form of invention illustrated in FIGS. **1** to **4**, the diameter of bores **76** and **80** is several times greater than the thickness of walls **74** and **78**.

Step taper joint **68** includes a main or central body section **82**, the upper limit of which is reduced in cross-sectional area to provide an upper body portion **84**, the diameter of which is substantially equal to the internal diameter of shell section **70**. This permits interfitting engagement of upper body portion **84** within bore **76** of shell section **70**. By reducing the diameter of main body portion **82**, an annular shoulder **86** is thereby formed which serves as a stop to limit the longitudinal movement of shell section **70** over step taper joint **68**. A sealing gasket **88** of neoprene or other suitable material is interposed between the lower edge of shell section wall **74** and shoulder **86**. The width of shoulder **86** is substantially the same as the thickness of wall **74** so that the outer periphery of main body section **82** is substantially flush with that of shell section **74**.

The lower part of main body portion **82** is reduced in cross-sectional area to a greater extent than upper body portion **84** to provide a lower body portion **90**, the diameter of which is substantially equal to the internal diameter of bore **80** of shell section **72**, in order to permit interfitting frictional engagement of the lower body portion with a terminal of shell section **72**. An annular shoulder **92** formed by main body section **82** and lower body portion **90** serves as a stop to limit longitudinal movement of shell section **72** over body portion **90**. A sealing gasket is interposed between the terminal of shell section **72** and shoulder **92**.

Step taper joint **68** is further provided with a longitudinal axial bore **96** through which a tendon **98** is adapted to pass, the bore maintaining axial alignment of the tendon through the step taper joint. Proximate the outer periphery of step taper joint **68**, main body section **82** is provided with reinforcing means **100** which may be in the form of steel mesh or other suitable conventional reinforcing materials. The length of main body portion **82** of step taper joint **68** may be varied according to the needs of the particular installation.

DESCRIPTION OF THE FORM OF INVENTION ILLUSTRATED IN FIG. 6

In FIG. **6** there is illustrated a modified form of the invention illustrated in FIGS. **1** to **4**, wherein the pile assembly is formed of a plurality of like shell sections **102** having wall portions **104** and bores **106** through which a tendon **108** passes. In this form of the invention, instead of providing a flush joint between adjacent shell sections, there is provided a stepped arrangement for insuring exact alignment of the sections when joined together to form a pile assembly. For this purpose, one end of each wall section is formed to provide an inner annular recess **110** and an outer annular flange **112**, the width of each of which is one-half the thickness of wall **104**. In like manner, the opposite end of each pile section includes an inner annular flange **114** and an outer annular recess **116**, the width of both of which is equal to one-half the thickness of wall **104**. This permits ready inter-engagement of adjacent pile

sections as shown to advantage in FIG. 6. A suitable gasket between the pile sections is indicated at 118.

In FIG. 6 there is also illustrated a modified form of a tendon centering and sectional aligning member which is designated 120. Member 120 is preferably of solid wooden construction and includes an upper part 122 and a like, lower part 124, which are provided with axial bores 126 and 128, respectively, for the passage of tendon 108 therethrough. Parts 122 and 124 are located at the terminal edge portions of adjacent sections 102 and are secured together by nails or other suitable fastening means 130, so that the member entity spans the joint between the adjacent sections. Member 120 is in frictional engagement with the interior wall of sections 102.

DESCRIPTION OF THE FORM OF INVENTION ILLUSTRATED IN FIG. 7

In FIG. 7, there is illustrated another modified form of the pile assembly of the present invention. In this form, the assembly comprises a plurality of pile sections 132 having a combination pile driving point and anchoring plug 134 and a head or driving block 136, all of which parts are similar in construction to that set out in connection with the form of invention illustrated in FIGS. 1 to 4.

In accordance with the modified form of the invention, there are provided a plurality of tendons 138 and 140 which extend through the pile assembly. Tendons 138 and 140 are secured at their lower end to anchors 142 and 144 which are positioned in combination pile driving point and anchoring plug 134. The upper ends of tendons 138 and 140 are secured to live end anchors 146 and 148 respectively, which are held by head or driving block 136. Anchors 142 and 144 are similar in construction to anchor 32 and live end anchors 146 and 148 are similar to anchor 60.

Tendon centering and section aligning members are indicated 150 and these may also be similar in construction to the equivalent members 42 in the form of invention illustrated in FIGS. 1 to 4. In this form, however, there is provided a pair of bores 152 and 154 through which tendons 138 and 140 are trained in order to insure proper alignment thereof throughout the length of the pile assembly. Additional tendons may be added to the pile assembly as required by the particular installation.

The pile assembly of the present invention is of relatively light-weight construction in comparison with its strength, and the sectional arrangement thereof facilitates assembly of the pile in the field by unskilled labor.

The present invention further lends itself to versatility in the use of pile sections and tendons in a wide range of sizes in order to meet the requirements of any given installation, and even to permit the use of pile sections of different sizes in the same installation. With the present invention, also, the tendon employed for tensioning the pile assembly is constantly maintained in axial alignment with the pile assembly in order to insure proper compressive forces being exerted on the pile sections at all times.

While there has been herein described and claimed the presently preferred forms of this invention, it is understood that such has been done for purposes of illustration only, and that various changes may be made therein within the scope of the appended claims.

What we claim is:

1. A post-tensioned prestressed pile assembly comprising:
a. a plurality of like, tubular shell sections arranged in vertical end-to-end relationship,
b. each of said shell sections comprising a wall of uniform thickness and a bore of uniform cross-sectional area,
c. the diameter of the bore of each of said tubular shell sections being substantially greater than the wall thickness,
d. a combination pile driving point and anchoring plug,
e. said pile driving point and anchoring plug including a main body section, the upper portion of which is reduced for insertion into an end of the lowermost shell section and the lower extremity being pointed for facility and driving the pile unit into the ground,
f. an anchor positioned in said main body section,
g. a head including a main body section, the lower portion of which is reduced for insertion into an end of the topmost shell section,
h. a live end anchor set in the main body section of said head,
i. tendon means extending longitudinally and centrally of the bores of said shell sections,
j. one end of said tendon means being connected to said anchor positioned in the main body section of said pile driving point and anchoring plug,
k. the opposite end of said tendon means extending through said live end anchor of said head, whereby said tendon means may be jacked for placing said tendon means under tension and said pile sections under compression, and
l. spaced alignment members disposed within the bore of the shell sections and spanning the joints between adjacent shell sections,
m. each of said spaced alignment members including an outer portion in frictional engagement with the walls of said shell section,
n. each of said spaced alignment members further including an inner portion having bore means through which said tendon means extend,
o. each of said spaced alignment members further including means connecting said outer and inner portions.

2. The pile assembly of claim 1, wherein:
a. the diameter of the bore of each of said pile sections is at least twice as large as the wall thickness of the pile sections.

3. The pile assembly of claim 1, wherein:
a. said tendon means includes a single tendon extending along the longitudinal axis of the assembly between said combination pile driving point and anchoring plug means and the live end anchoring means of said head,
b. the bore means of the inner portion of said spaced alignment means lying along the longitudinal axis of the assembly.

4. The pile assembly of claim 1, wherein:
a. said tendon means comprise at least two tendons extending longitudinally through the bores of said shell sections between said combination pile driving point and anchoring plug and said head, and
b. said bore means of the inner portion of each of said spaced alignment members comprise at least two bores.

5. The pile assembly of claim 1, wherein:
a. each of said spaced alignment members are of one-piece construction.
6. The pile assembly of claim 1, wherein:
a. said spaced alignment members comprise two sections, and
b. means for securing said sections together.
7. The pile assembly of claim 1, wherein:
a. said spaced alignment members are of solid construction.
8. The pile assembly of claim 1, wherein:
a. said spaced alignment members are of open construction to permit passage of granular or cementitious material therethrough.
9. The pile assembly of claim 8, wherein:
a. each of said spaced alignment members comprise an inner circular member,
b. said inner circular member having at least one bore through which said tendon means passes,
c. an outer circular member in spaced, concentric relationship to said inner circular member,
d. the outer periphery of said outer circular member being in frictional engagement with the inner periphery of said shell sections, and
e. spaced connectors joining said inner and outer circular members.
10. The pile assembly of claim 9, wherein:
a. the bore of each of said spaced alignment members is coincident with the longitudinal axis of said pile assembly.
11. The pile assembly of claim 1, wherein:
a. the wall edges of each of said pile sections are uniplanar, and
b. sealing means are interposed between opposing wall edges of adjacent wall sections.
12. The pile assembly of claim 1, wherein:
a. one terminal of each pile section is formed to provide an inner annular recess and an outer annular flange of like size, and
b. the opposite terminal of each pile section is formed to provide an inner annular flange and an outer annular recess, whereby pile sections can be interfitted together, and
c. sealing means interposed between the edges of adjacent pile sections.
13. The pile assembly of claim 1, wherein:
a. said pile sections are of different diameter, and
b. joint means connecting said different diameter pile sections together.
14. The pile assembly of claim 13, wherein:
a. said joint means is a step taper member and comprises a main body portion,
b. the upper part of said main body portion being reduced to provide an upper portion adapted to fit within the end of one shell section,
c. the lower part of said main body portion being reduced to provide a lower portion adapted to fit within the end of the other shell section.

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