United States Patent [19]

Yegge

[11] **4,043,133**

[45] **Aug. 23, 1977**

[54] **STRUCTURE AND METHOD OF CONSTRUCTING AND TEST-LOADING PILE ANCHORED FOUNDATIONS**

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[51] **Int. Cl.**[2] **E02D 5/74**

[52] **U.S. Cl.** **61/50;** 61/39; 61/56.5; 52/166; 52/169.1

[58] **Field of Search** 61/39, 35, 50, 53.52, 61/53.5, 56, 56.5, 63, 31; 52/742, 230, 169, 166, 155

[56] **References Cited**

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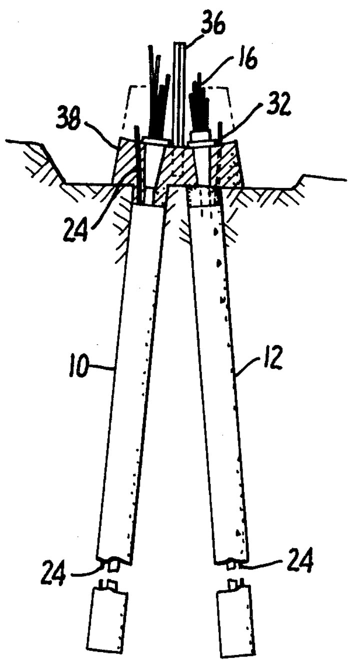
Attorney, Agent, or Firm—Naylor, Neal & Uilkema

[57] **ABSTRACT**

A method of constructing pre-tested concrete pilings and pile caps particularly for use in supporting structures, such as transmission line towers that are subjected to large overturning moments. One or more pile holes are bored, a small diameter sheathing containing one or more steel tendons is inserted and a concrete mixture is poured in the pile hole exterior of the tendon sheathing with the tendons anchored in the bottom of the pile. When the concrete has obtained sufficient strength, the tendon is stressed, thereby testing the tension-carrying capacity of the pile and its surrounding foundation soil. A concrete pile cap is thereafter joined to the pile, the tendons are again stressed and anchored to the pile cap and the tendon sheathing is filled with concrete grout to form a solid post-tensioned foundation that has been pre-tested at a force in excess of its design load.

7 Claims, 8 Drawing Figures



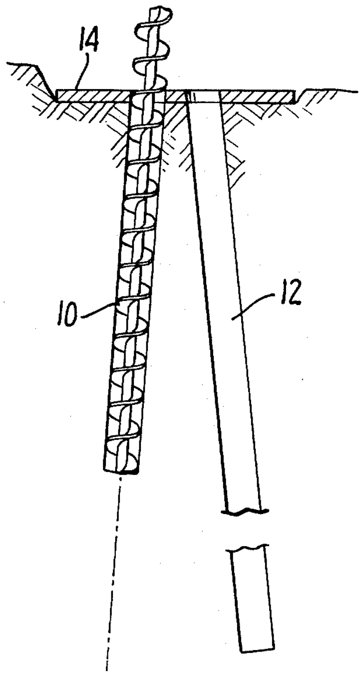


FIG. 1.

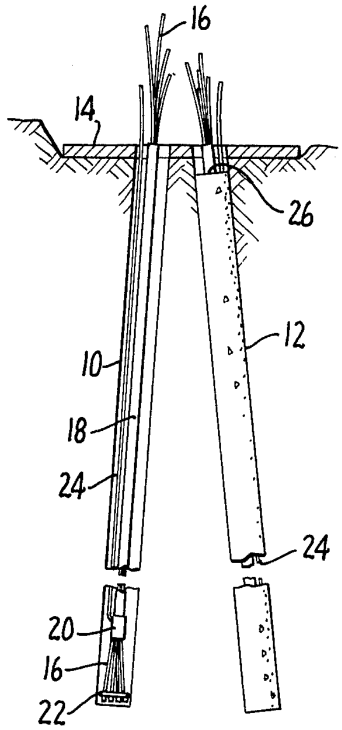


FIG. 2.

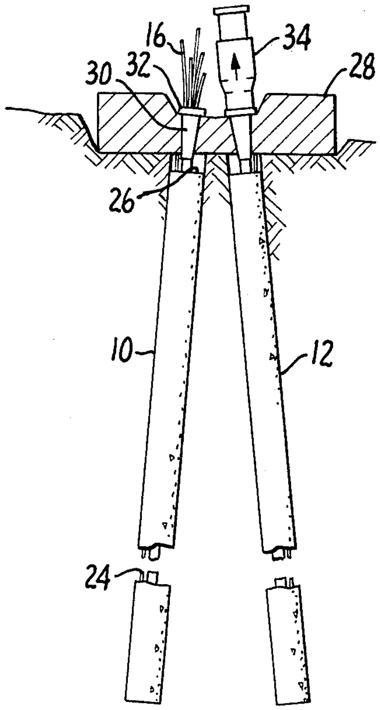


FIG. 3.

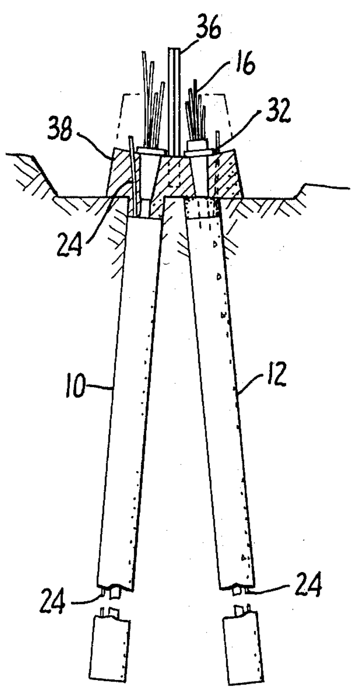


FIG. 4.

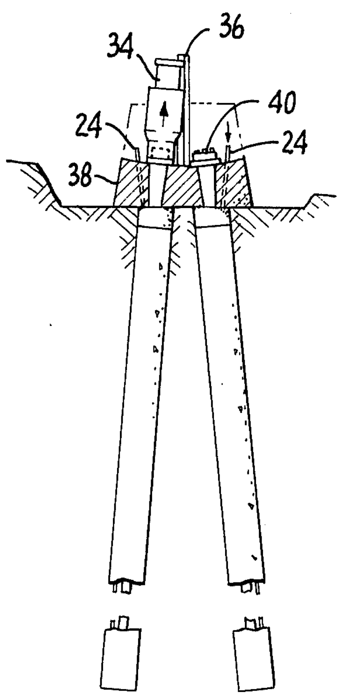


FIG. 5.

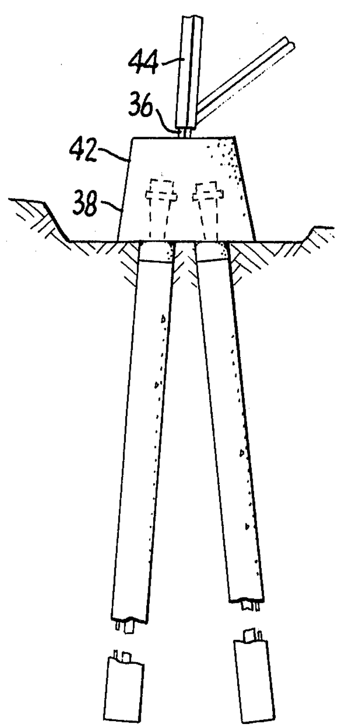


FIG. 6.

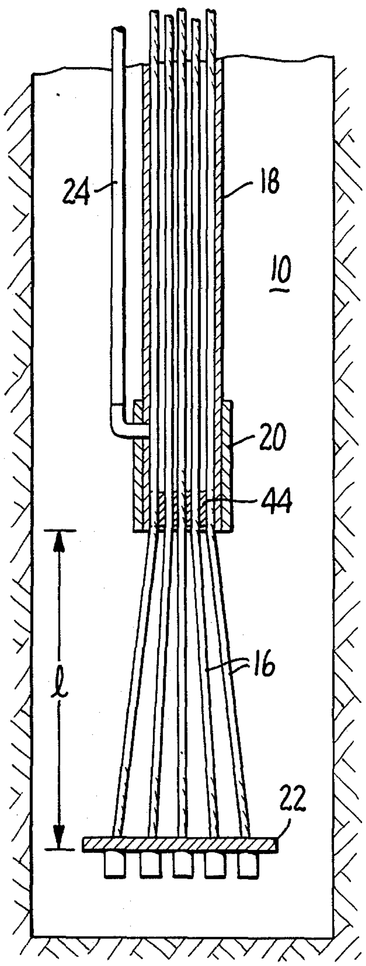

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FIG. 7.

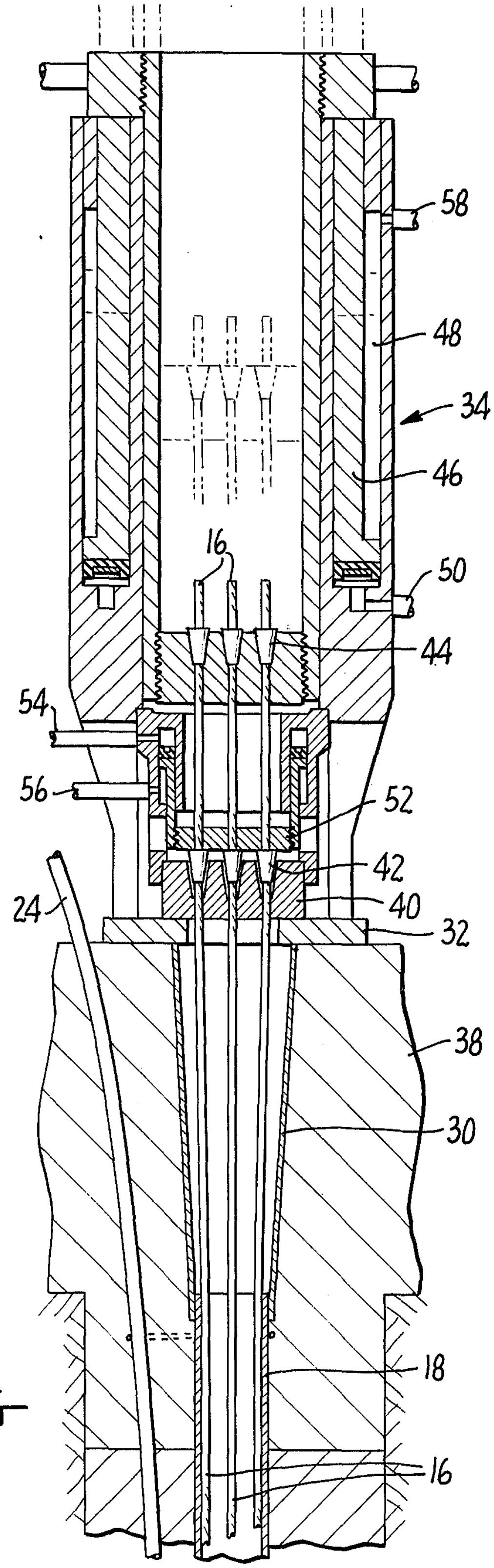
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FIG. 8.

STRUCTURE AND METHOD OF CONSTRUCTING AND TEST-LOADING PILE ANCHORED FOUNDATIONS

BACKGROUND OF THE INVENTION

This invention relates to the construction of concrete piling and more particularly to a method of constructing, on the site, a structure foundation which includes one or more concrete piles post-stressed to the pile cap to form a rigid unitary foundation for a structure, such as an electrical transmission line tower, that may be subjected to severe overturning moments or uplifting forces as well as the downward gravity loads. The invention is particularly valuable for use in the construction of transmission line towers in remote areas where all construction material may be transported to the site by helicopters, thereby obviating the need for costly access roads.

SUMMARY OF THE INVENTION

Briefly described, the invention includes the steps of boring a pile hole to the appropriate design depth, inserting one or more steel cable tendons loosely contained in and extending from, the ends of a tubular metal tendon sheath running coaxially through the length of the bored hole, and then pouring a concrete mixture in the hold within one or two feet of the ground surface, but not within the tendon sheath, so that the lower end of the tendon is firmly anchored in the bottom of the concrete pile but is loose within the tendon sheath. When the concrete has attained sufficient compressive strength, the tendon is stressed to approximately 125% of the design load of the pile to test the tension capacity of the pile and its surrounding soil. The upward force applied to the pile by means of the stressing tendon has its reaction against the temporary jacking pad, which pad is separated from the pile in such a way that no part of the reaction to the applied force is taken at the top of the pile. Since it is known that a pile's resistance to a downward load is at least equal to (and normally greater than) its capacity to resist uplift, the minimum value at which the pile will support downward loads is established by the performance of the pile under the uplift load applied. Thereafter, the tendon is de-tensioned, a pile cap is poured to connect with the pile top, the tendon is again stressed to the design load, the tendon is anchored to the pile cap, and cement grout is then pumped into the tendon sheathing to form a solid unitary pre-tested pile and cap.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings that illustrate the preferred embodiment of the invention:

FIG. 1 is a profile view illustrating the boring, through a template, of two diverging pile holes;

FIG. 2 is a profile view illustrating the placement of the tendons and the tendon sheath;

FIG. 3 is a profile view illustrating the placement of a jacking pad and tendon jack;

FIG. 4 is a profile view illustrating the pouring and connection of a permanent pile cap;

FIG. 5 is a profile view illustrating the post-tensioning of a completed pile to the pile cap;

FIG. 6 is a profile illustrating the completed pile cap with installed stub angle;

FIG. 7 is a detailed elevation view of the lower end of the tendon sheath with the extending tendons anchored to an anchor plate; and,

FIG. 8 is a detailed elevation view of the pile top and illustrates the placement and structure of the tensioning jack.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Turning now to a detailed description of the invention, FIG. 1 is a sectional elevation view illustrating the boring of two diverging pile holes **10** and **12.** Prior to this boring operation, the ground surface has been excavated to a footing or beam line and a boring template **14** has been installed. Pile holes **10** and **12** may, in most cases, have a diameter of only twelve to fourteen inches and their depth will, of course, be dependent upon the consistency and nature of the subsoil and the various design loading on the structure.

In FIG. 2, piling holes **10** and **12** have been completely bored to the design depth. Inserted throughout the length of hole **10** and extending above the ground surface are one or more steel tendons **16.** Tendons **16** are loosely encased in a tendon sheathing **18,** which preferably is a galvanized steel conduit that may be spirally wound to reduce wobble within the piling holes. The lower end of sheathing **18** is provided with a collar **20** from which the tendons **16** extend to be spread and anchored to an anchor plate **22.** As will be subsequently explained in detail, a plastic grout tube **24** enters the sheathing collar **20** and extends up through the piling hole and through the boring template **14** where it remains above ground surface for a future step in the construction process.

Upon installation of the tendons **16** and the tendon sheathing **18,** concrete is poured into that portion of the piling hold outside of the sheathing **18** and up to a level **26** approximately one foot below the bottom surface of template **14.** As will be explained in connection with FIG. **7,** a mastic is packed in the lower end of collar **20** to prevent the poured concrete from seeping around the tendons **16** and into the tendon sheathing **18.**

After the concrete has attained a sufficient compressive strength, the drilling template **14** is removed and is replaced with a temporary jacking pad **28,** as illustrated in FIG. **3.** Jacking pad **28** is a large surfaced steel or concrete structure suitably bored to receive the tendons **16,** an anchorage trumpet **30** and a bearing plate **32.** Jacking pad **28** is provided with two upper surfaces that are pitched at an angle normal to the longitudinal axes of piling holes **10** and **12** to receive a tensioning jack **34.** The illustrated jack **34** is of the type disclosed in my U.S. Pat. No. 3,597,830.

As will be discussed in detail in connection with FIG. **8,** the tensioning jack **34** is connected to the end of each tendon **16** and the tendons are stressed to 125% of the design load of the pile. By stressing the tendons in this manner, the tension capacity of the pile and its surrounding soil is tested to assure that uplift forces will not dislodge the pile. Likewise, the compressive load-carrying capacity of the pile is also tested as this capacity is at least as great as the tension capacity. Furthermore, the force exerted by the bottom of the jacking pad **28** can be used when desired to effectively test the vertical downward load-carrying capacity of the sub-surface soil. Since there is a space of approximately one foot between the top level **26** of the poured pile and the bottom surface of the jacking pad **28,** sub-surface soil consolidation may be achieved by continuing the test load until the desired consolidation is obtained. When the test has been completed and any desired soil compaction has been obtained, tendons **16** are de-tensioned and the tensioning jack **34** and the temporary jacking pad **28** are removed.

FIG. **4** is a sectional elevation view illustrating that after removal of the temporary jack pad **28,** a concrete form is placed, a bearing plate **32** and trumpet **30** assembly is attached to the top of the tendon sheathing **18,** the desired stub angle **36** is installed and the lower portion of the bearing cap **38** is poured from the top of the existing concrete piles and the ground surface to the lower surface of the bearing plate **32.**

After the lower portion of the piling cap has attained sufficient strength, the tendons **16** are threaded through a suitable anchor head **40,** as illustrated in FIG. **5.** The tensioning jack **34** is reinstalled and the tendons **16** are stressed to their design load and permanently anchored to anchor head **40.** This post-stressing step renders the pile cap **38** and each of the pilings into a solid unitary structure so that compressive loads applied downward upon the piling cap **38** will be carried by the pilings **10** and **12,** as well as by the cap **38.**

After tendons **16** have been stressed and anchored to the anchor head **40,** a cement grout is pumped through the plastic grouting tube **24** and the interior of the tendon sheathing **18** and anchor head **40** is filled with grout. This grouting prevents corrosion of the steel tendons **16** and further adds to the solidarity of the pilings.

FIG. **6** illustrates that, upon completion of the poststressing and anchoring step described above, the piling cap form is again installed and the concrete piling cap is completed by pouring an upper portion **42** that covers the anchor head **40** and the exposed ends of the tensioned tendons **16** which now become thoroughly and permanently anchored. Thereafter, the desired structure **44** may be installed.

FIG. **7** illustrates in detail the lower end of the tendon sheathing **18** with the attached collar **20** from which the tendons **16** extend. In most instances it is necessary to anchor the lower ends of the tendons **16** to an anchor plate **22** which effectively separates the ends of the tendons and prevents them from being pulled through the sheathing during the tensioning step described in connection with FIG. **3.** It has been found that, if the pile hole is sufficiently deep so that the length of the exposed tendons **16** extending from the collar **20** is five feet or greater, there is adequate anchorage by the tendons themselves and a bottom anchorage plate **22** may be omitted. FIG. **7** also illustrates that tendons **16** are sealed in the lower end of the collar **20** by a mastic seal **44,** which is installed prior to inserting the sheathing **18** into the piling hole **20** to prevent the poured concrete of the pile from entering the sheathing **18.** After the post-tensioning of the tendons **16,** as described in connection with FIG. **5,** cement grout is forced through the plastic grouting tube **24** that is connected to the collar **20** and the interior portion of the sheathing **18** is then filled with the cement grout to prevent corrosion of the cable and to add additional strength and rigidity to the sheathing section of the piling.

FIG. **8** is a detailed elevation view of the top end of the tendon sheathing **18** connected in a trumpet **30** that is embedded in the lower portion of the pile cap **38.** The tensioning jack **34** is installed in its position for the post-tensioning operation described in connection with FIG. **5.** As shown in FIG. **8,** the tendons **16** extend through the trumpet **30** and the bearing plate **32,** which overlies both the trumpet **30** and the top surface of the pile cap **38.** Atop the upper surface of bearing plate **32** is anchor head **40,** which is a thick steel disc drilled to receive tendons **16.** The tendon holes on the top surface of anchor head **40** are conically counterbored to receive gripper jaws **42.**

Tensioning jack **34** is installed on the bearing plate **32** and is aligned with the anchor head **40** so that tendons **16** extend through the center open portion of jack **34** where they are anchored by a second set of gripper jaws **44** connected to a hydraulic piston assembly in the tensioning jack **34.** This piston assembly includes an annular piston **46** adapted to slide within an annular cylinder **48** coaxially located in the housing of the jack **34.** An intake port **50** admits an hydraulic fluid under force into the cylinder area, forcing the annular piston **46** to apply tension to the tendons **16.** Installed within tensioning jack **34** and adjacent the anchor head **40** is a second piston **52** which, when activated by the application of pressure through intake port **54,** will apply a downward locking force against gripper jaws **42** to insure that the jaws lock tendons **16.** When presure is applied to the intake port **56** of the piston **52,** the piston releases its force against the gripper jaws **42.** This releasing function is necessary when it is desired to de-tension tendons **16** as described in connection with FIG. **3.** When it is desired to remove tensioning jack **34** after tendons **16** have been tensioned, pressure is admitted to intake port **54,** forcing piston **52** to lock the gripper jaws **42.** Pressure is then admitted to the intake port **58** to force the main tensioning piston **46** back down to its non-tensioning position. At this point, the gripper jaws **44** are loose and may be removed so that the entire tensioning jack **34** may be lifted from the bearing plate **32,** thereby leaving the tendons **16** firmly anchored in the gripper jaws **42** of the anchor head **40.**

CONCLUSION

Although a preferred embodiment has been illustrated and described, it should be understood that the invention is not limited to the specifics of this embodiment, but rather is defined by the following claims. For example, it is possible that the separate jacking pads illustrated in FIG. **3** might be omitted and that a pile cap with voids between the cap and the piles might be employed for use in the load-testing step. In such an arrangement, the voids between the cap and piles would be filled after load testing and prior to the final stressing step.

What is claimed is:

1. A method of making a pre-tested anchored foundation structure in which the anchor members carry compressive loads and resist upward loads including the steps of:

boring at least one pile hole into the sub-surface soil;

inserting into each pile hole a sheath containing one or more tendons, said tendons extending from the lower end of said sheath into the bottom end of said pile hole, and extending from the top end of said sheath above the surface of the soil;

forming a pile by pouring a concrete mixture into said hole to the exterior of said sheath, whereby the tendons extending from the lower end of said sheath become anchored to the bottom end of said pile but remain free for movement within said sheath;

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