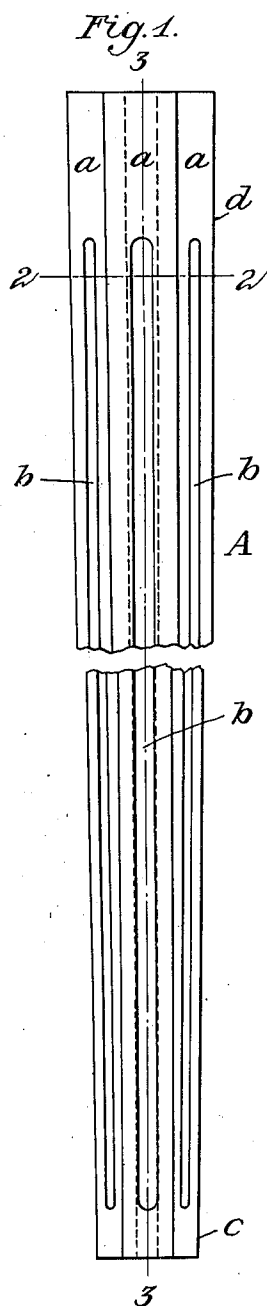
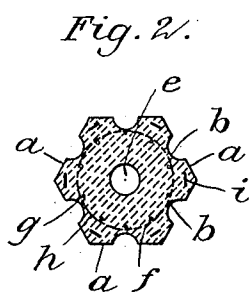
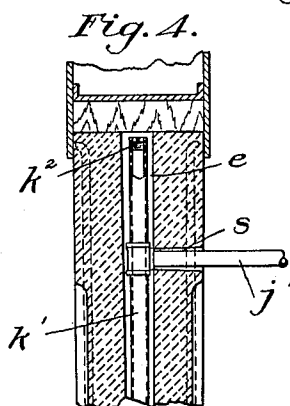
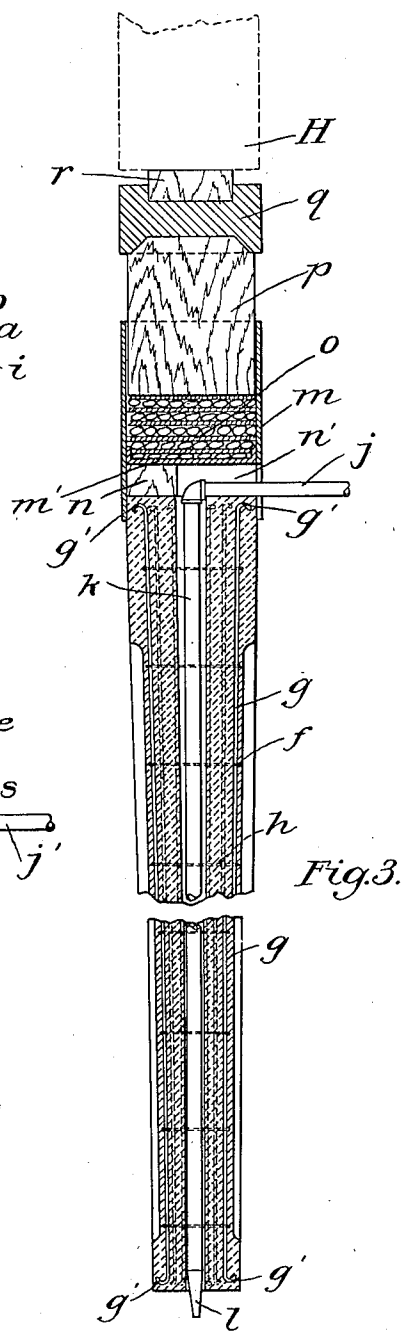


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F. B. GILBRETH.
CONCRETE PILE.

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CONCRETE PILE.

No. 885,337.

Specification of Letters Patent.

Patented April 21, 1908.

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To all whom it may concern:

Be it known that I, FRANK B. GILBRETH, a citizen of the United States, residing at New York, county of New York, State of New York, have invented an Improvement in Concrete Piles, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention relates to concrete piles and improvements for sinking the same, being more particularly concerned with the shape and construction of such piles and means for sinking the same.

My invention will be best understood by reference to the following description when taken in connection with the accompanying illustration of one specific embodiment thereof, while its scope will be more particularly pointed out in the appended claims.

In the drawings,—Figure 1 shows in side elevation, partly broken away, a pile embodying one form of my invention; Fig. 2 shows in plan a section on the line 2—2, in Fig. 1; Fig. 3 shows in sectional elevation and partly broken away, the pile illustrated in Fig. 1, together with the driving cap and jetting pipe in readiness for sinking the pile, and Fig. 4 shows a modified arrangement of the jetting pipe with reference to the pile.

Referring to the drawings and to the embodiment of my invention there disclosed for illustrative purposes, I have shown a formed or molded pile A which, while of simple construction, has features which render it extremely efficient as a pile and other features which assist to a marked degree in the facility and rapidity with which it may be sunk or positioned in the ground.

The pile shown has a hexagonal cross-section and is provided with plane sides or faces *a* in which, and preferably symmetrically disposed with reference to the pile center or axis, are formed grooves or corrugations *b*, which are here shown as substantially or approximately half round in cross-sectional outline and extending for the greater part of the pile length, but actually terminated short both of the bottom and the top so that at the former there is left a base or leading portion *c* of the full cross-sectional area and a head or top portion *d*, also of full cross-sectional area.

The pile body is preferably tapered, as shown, with a uniform or gradual taper from the head end of maximum diameter to the

leading end of minimum diameter and is also cored to provide a tapered central bore or jetting passage *e* to receive a jetting stream of water, or a pipe carrying the same to sink or assist in sinking the pile.

Suitable reinforcement, both longitudinally and laterally, is provided in the form of a skeleton metal frame *f* comprising a series of longitudinal members *g* with bent or overturned ends *g'*, the said members *g* being secured at intervals to the hoop-shaped members *h* which act to bind or hold them together. The size and number of the reinforcing members will of course be proportioned to the service for which the pile is designed. The reinforcement is preferably carried as near the sides of the pile as the presence of the grooves therein will permit in order to embrace as much of the pile material as possible and is preferably in the general form of a truncated cone, tapering with the pile from top to bottom. The shape of the reinforcing member *f* still leaves portions of the pile lying adjacent the longitudinal edges and between the grooves without local reinforcement. To strengthen these portions of the pile there may be and preferably are employed additional reinforcing members *i*, preferably metallic strips having bent ends. These are symmetrically arranged with reference to the two adjacent faces and closely adjacent to the intervening corner or edge.

The form of pile disclosed is molded into the shape shown and allowed to harden before sinking, this molding operation being carried on either at the place where the piles are to be used or elsewhere whence they may be transported to the place of use. Molds for the same are readily constructed out of planking cut to the required dimensions and lined with rounded strips suitable to form the grooves. The mold is set up lengthwise on the ground leaving open one or more of its upper sides through which the concrete is entered. The reinforcement is positioned by wiring it to the sides, or by suspension members entering through the open upper side, or both methods may be employed.

The central tapered core or mandrel is supported by the closed hexagonal end pieces of the mold through which it extends to leave a projecting portion at the head end of the mold. When the mold is filled with concrete the remaining upper side of the mold is placed in position and the pile allowed to set. After setting from one to two days the mold

is stripped from the pile and the latter allowed to harden for a further period, preferably for at least eight to ten days, when they are ready for use. During hardening it is desirable to supply moisture to the pile to facilitate the setting of the cement and the piles at that stage are therefore preferably covered with burlap or other suitable material which is kept saturated with water.

The described process of molding is not essential to my invention but in practice I have found it simple and efficient.

Ordinarily there is experienced considerable difficulty in finally withdrawing the central tapered core after the setting of the concrete. This difficulty I have wholly overcome by partially withdrawing the core when the concrete has partly solidified but before actually hardened or set. The extent of withdrawal will vary according to the degree of taper and length of core, etc., but in the illustrated instance when the concrete is in the first stages of setting the projected butt or head end of the core is given a partial turn and retracted a few inches. This is sufficient to free it from necessary contact with the concrete and can be done at such a stage that there will be but slight tendency for the concrete to settle or collapse. If it does settle or collapse, it will do so against the still closely adjacent sides of the core and the latter may again be turned or twisted and retracted a few inches further until finally it is entirely free from the then hardened concrete, leaving nevertheless a symmetrical and perfectly formed tapered bore. In practice the workman has merely to turn and slightly retract the bore during the early stages and thereafter repeat the operation once or twice and the core will be left free from the hardened interior of the bore.

The pile described when placed or positioned for sinking may be sunk largely or wholly with the aid of a water jet carried through the central bore *e*, the latter acting as an induction passage either for the water or a pipe carrying the water. While the water may be delivered under pressure directly to the bore at the head end of the pile and discharged in the form of a jet at its leading end, it is preferably delivered by the laterally extending supply pipe *j* to the removable jetting pipe *k* connected thereto, the latter being of a diameter slightly less than the smallest diameter of the bore. The jetting pipe *k* preferably extends into and through the pile for substantially its entire length and has at its end the tapered nozzle *l*, the contracted nose of which projects slightly beyond the leading end of the pile.

The pile having been positioned and water under pressure delivered to the jetting pipe, the pile may be entirely sunk, if desired, by the erosive action of the water jet formed at its leading end, or assistance may be had by

simultaneously ramming or otherwise forcing the pile at its head end, or such forcing action may be used alone. As certain features of my invention, however, are related primarily to the jetting action, reference will first be made thereto. The water discharged through the nozzle forms a powerful jet which strikes the underlying earth, loosens or displaces it and then carries the earthy water up and about the sides of the pile, while the latter settles into the excavation thus progressively formed.

The facility and rapidity with which sinking is effected obviously depends upon the erosive capacity of the water, and, since the erosive power of water increases approximately with the sixth power of its velocity, slight changes in the frictional resistance offered the water in its passage to and from the point of application of the jet will, for a given pressure head, strikingly affect the erosive efficiency of the jet and the rapidity of sinking.

In the illustrated embodiment of my invention, the metallic jetting pipe *k* provides an induction passage of minimum frictional resistance for the water passing to the nozzle. The water, if permitted, would naturally return to the surface either in a relatively thin film up the sides of the pile, encountering a relatively great frictional resistance or by forcing an irregular path of still greater resistance through the adjacent and dense earthy matter. In the case of the illustrated pile, however, the water returns up the side of the pile in the grooves or corrugations *b*, which are so shaped and formed as to provide eduction passages offering a minimum frictional resistance. While these passages may be variously formed or shaped, the illustrated shape provides a passage having a minimum frictional resistance for a given capacity, providing moreover, a groove of sufficient size and depth to permit the water to come up in several well defined, compact streams. If the eduction passages are too shallow or not sufficiently defined, they tend to clog and fill with earth as the pile settles and the water is obliged to spread instead of forming a compact stream. This not only offers increased resistance to the water, but also results in tearing away and displacing the adjacent densely packed earth and gravel at the sides of the pile, which, were it not displaced, could be relied upon to better support and sustain the sunken pile. With the surface eduction passages illustrated, the water with the earthy matter carried thereby, confines itself almost wholly to the channels or passages provided and spurts up at the ground level in well defined streams.

The corrugations *b*, if desired, might be extended the entire length of the pile, but the absence of the grooves at the extreme leading end of the pile not only renders the entire

cross-sectional area of the hexagon available as a base for the pile to rest upon, as well as rendering the pile less apt to fracture during handling, but the jet is thereby compelled to spread laterally and is distributed more effectively and evenly at that point. Stopping the grooves short of the head end of the pile also results in strengthening the head somewhat, which is sometimes important where it is designed to hammer or ram the pile.

Where jetting is employed it is desirable to avoid an eccentric jet formation which will tend to settle the pile obliquely, but on the contrary to maintain a central jetting action which will sink the pile vertically from its initially selected position. For this purpose it is desirable not only to have the jet arranged centrally with reference to the pile, but also to present a plurality of eduction paths of substantially equal resistance, symmetrically arranged with reference to the jet, so that the jet will be maintained true with reference to the pile axis. For this reason, among others, I preferably construct the pile with the cross-section of a regular polygon and arrange a single groove in each face thereof, the grooves being symmetrical with reference to the pile axis. Other cross-sectional forms may be used when desired, but the hexagonal cross-section permits the formation of the grooves without unduly undercutting the longitudinal edges. It also permits the reduction of the grooves to a reasonable number, a point of advantage since subdivision into a large number of grooves materially increases the resistance to the jetting water.

The puddling action of the water upon the adjacent earth is such that when the sinking has been completed and the water drained away, the earth tends to settle in and about the pile so closely that the skin friction upon the latter is greater than when the pile is driven without the use of the jet. This action may sometimes be enhanced by shutting off the jet just before the pile is fully sunken and completing the sinking by the action of the hammer or other forcing means from above, which causes the pile to settle firmly in the adjacent softened earth. The grooves, however, not only assist in sinking the pile, but act to increase the perimeter of the pile section and thereby sensibly increase the skin or surface friction of the pile, which in many instances must be largely relied upon to sustain the supported weight. In the illustrated pile the formation of the grooves is such that while sensibly increasing the surface friction of the pile, there is left a solid body portion susceptible of effective reinforcement and well adapted to resist all strains to be met with. In connection with the cored interior the grooved sides produce a particularly effective pile structure, for, with a given quantity of concrete, the surface exposed to contact with the earth is first increased by

the provision of the core and again considerably increased by the provision of the grooves without, however, weakening the main body portion of the pile, provided the latter be suitably reinforced in some such way as is shown in the drawings. In practice I have found that a pile having the cross-section of a regular polygon with grooved sides, and particularly when centrally cored, will strike a good balance between high skin friction and interior strength.

A hammer, or other forcing means, adapted for simultaneous use with the jet, may be applied continuously therewith or used merely to finally settle the pile when the same approaches its sunken position. In either case, if a hammer is used, it is desirable to interpose some cushioning means between the hammer and the head of the pile. In Fig. 3 I have indicated conventional by dotted lines the head *H* of the hammer, which may be of any suitable or usual construction. Between the hammer head, however, and the head of the pile is interposed a cushioning device which comprises the cap or casing *m*, of sheet iron or other suitable material, which for simplicity of construction may be made cylindrical in form. The casing is provided with an interior fixed diaphragm *m'* by which it is supported upon the pile head through the interposition of a spacing block *n*, so that its depending sides overlap and loosely embrace the end of the pile. The spacer block has a laterally extending slot *n'* to admit the supply pipe *j* from the side, the casing also being cut away to clear the pipe. Within the casing and above the diaphragm is placed a body of cushioning material *o* of any suitable nature, which, for example, may consist of loose pieces of rubber hose interposed between layers of hemp or old rope ends. Upon the cushioning material rests the wooden plunger block *p* loosely slidable in the upper open end of the casing and surmounted by the iron follower *q* in which is centrally seated the wooden cushion block *r*, adapted directly to receive the blow from the hammer. The casing and the follower are provided with means (not shown) to engage the vertical hammer guides (also not shown) and assist in guiding the pile when the latter is sunk.

When the hammer is in operation its blows are transmitted to the pile through the plunger *p*, cushioning body *o*, diaphragm *m'* and the block *n*, the cushioning body at each blow of the hammer yielding sufficiently to the plunger *p* to cushion the blow and prevent injury to the hammer. During driving, water may be freely admitted to the jetting pipe without interference with the driving apparatus. In some cases it may be desirable to enter the water at some point below the top thereof instead of between the end and the driving apparatus. This may

be readily accomplished, as is shown in Fig. 4, avoiding entirely the driving apparatus, by forming in the molded pile the lateral opening *s*, through which the supply pipe *j'* may be inserted and there coupled to the jetting pipe *k'*, the end of the latter being closed by the plug *k*². After the pile has been completely sunk, the jetting pipe is withdrawn and, if desired, the bore may be filled with concrete, or concrete and metal reinforcement, or the pile left in its original cored condition.

While I have shown and described one form of my invention, it is to be understood that I am not limited to the details or the form or relative arrangement of parts disclosed, but that extensive modifications may be made therein, without departing from the spirit thereof.

20 Claims—

1. A concrete pile having the cross-section of a regular polygon, an interior water induction passage and a plurality of exterior water eduction passages affording substantially equal resistance to the passage of water.

2. A concrete pile having a hexagonal cross-section, an interior central jetting passage and a plurality of exterior grooves in the pile sides symmetrically arranged with reference to the jetting passage.

3. A tapered concrete pile having the cross-section of a regular polygon, an interior induction jetting passage and eduction grooves in the sides of the pile symmetrically arranged with reference to the outlet and the jetting passage.

4. A concrete pile having an interior downwardly directed jetting passage and corrugated or grooved sides, the corrugations or grooves terminating short of the leading end.

5. A concrete pile having a substantially similar cross-section from end to end and provided with grooved sides, the corrugations or grooves extending a portion of the pile length only.

6. The combination with a concrete pile having an interior induction passage, of a removable jetting pipe extending substantially the length of said passage.

7. The combination with a concrete pile having a central interior induction passage, of a removable jetting pipe within said passage, said pipe being provided with a contracted nozzle.

8. The combination with a concrete pile having an interior water induction passage, of a jetting nozzle projecting from the leading end of the pile and adapted to receive water conducted through the said passage.

9. A concrete pile having an interior tapered bore extending completely through the pile.

10. A tapered concrete pile having an in-

terior tapered bore extending completely through the pile.

11. A concrete pile having the cross-section of a regular polygon, central independent reinforcing means, and reinforcement also for the corners of said pile.

12. A concrete pile having the cross-section of a regular polygon, and independent reinforcement immediately adjacent the longitudinal edges thereof.

13. A concrete pile having plane sides, central reinforcing means and independent reinforcement immediately adjacent the longitudinal edges thereof.

14. A concrete pile having a reinforcement comprising a plurality of longitudinal rods, members arranged at intervals uniting the same in a composite structure, and additional separate reinforcing rods outside of said composite structure.

15. A tapered concrete pile having the cross-section of a regular polygon and a plurality of exterior longitudinal grooves.

16. A tapered concrete pile having a horizontal cross-section of a regular polygon and a plurality of half-round exterior longitudinal grooves.

17. A concrete pile having the cross-section of a regular polygon and provided with a plurality of substantially half-round exterior longitudinal grooves extending part way only the length of the pile, said pile being formed with a substantially uniform taper from one end to the other.

18. A concrete pile having the cross-section of a regular polygon and provided in each side face with a half round exterior longitudinal groove extending part way only the length of the pile, an interior axially arranged jetting passage having an outlet at the leading end of the pile, and an interior composite tapered reinforcing structure for the body of the pile, said pile being formed with a substantially uniform taper from one end to the other.

19. A concrete pile having means permitting the production of a forwardly directed water jet at the leading end of the pile and having also a plurality of well defined, longitudinal grooves in the sides of the pile, said grooves being of suitable formation to return the water therethrough.

20. A concrete pile having means permitting the production of a central water jet at the leading end of the pile and having also a plurality of well-defined longitudinal grooves in the sides of the pile located symmetrically with reference to the jet at the leading end thereof.

21. A concrete pile having means permitting the production of a water jet at the leading end of the pile and having a plurality of well-defined longitudinal grooves adapted to return the jetting water up the sides of the

pile in unobstructed streams, said grooves being so formed and located that the minimum distance from the pile axis to the side thereof lies through the said grooves.

5 22. A concrete pile having means permitting the production of a water jet at the leading end of the pile and having also at least four longitudinal grooves arranged about its sides and adapted to return the jetting water
10 in unobstructed streams.

23. A concrete pile having jetting means at the forward end thereof and having means for returning the water to the surface with a substantial minimum of frictional resistance
15 and in a series of unobstructed streams.

24. A concrete pile having jetting means at the forward end thereof, and having means for returning the water to the surface with a substantial minimum of frictional resistance and in a plurality of streams of substantially equal erosive capacity.
20

25. A concrete pile having jetting means at the forward end thereof and having means for returning the water to the surface in compact streams having substantially equal erosive capacity.

26. A concrete pile having a cross section of a regular polygon and having jetting means at the forward end thereof, and having means upon each face thereof for returning the water to the surface in compact streams having substantially equal erosive capacity.
0

27. A concrete pile having longitudinal
5 grooves upon its sides and forwardly directed jetting means at the leading end, said grooves being shaped to provide return water passages of low frictional resistance, and sym-

metrically disposed with respect to the jet, whereby substantially equal erosive action is
40 secured about the pile.

28. A concrete pile having longitudinal grooves upon its sides and a central water jet at the leading end, said grooves being shaped to permit the jetting water to encounter a
45 low frictional resistance in returning to the surface, and being arranged concentrically with respect to said jet, whereby substantially equal erosive action is secured about the pile and the same will sink substantially
50 vertically.

29. A concrete pile provided at its leading end with a forwardly directed water jet and upon its sides with a series of longitudinal grooves which are shaped to permit the jetting water to return to the surface thereto with a substantial minimum of frictional resistance, whereby an effective erosive action is secured.
55

30. A concrete pile having the cross section of a regular polygon, central reinforcing means, and reinforcing means for the corners of the pile, said pile having longitudinal exterior grooves.
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31. A concrete pile having the cross section of a regular polygon, and reinforcement immediately adjacent the longitudinal edges thereof, said pile having longitudinal grooves upon the surface thereof.
65

In testimony whereof, I have signed my
70 name to this specification, in the presence of two subscribing witnesses.

FRANK B. GILBRETH.

Witnesses:

THOMAS B. BOOTH,
EDITH E. CHAPMAN.