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CONCRETE PILING AND PILING UNITS.

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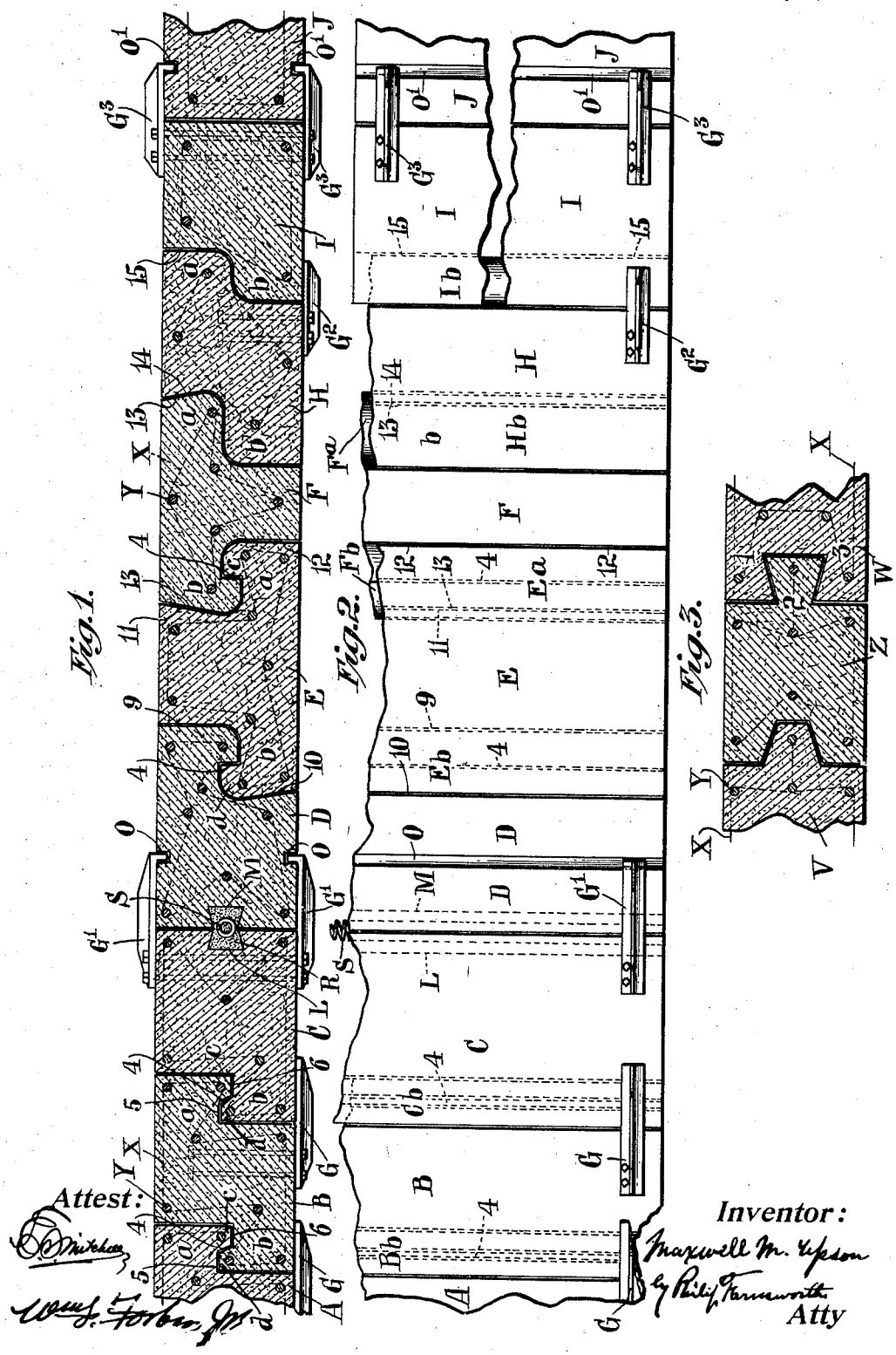

UNITED STATES PATENT OFFICE.

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CONCRETE PILING AND PILING UNITS.

1,025,434. Specification of Letters Patent. Patented May 7, 1912.

Application filed April 9, 1910, Serial No. 554,388. Renewed September 26, 1911. Serial No. 651,462.

To all whom it may concern:

Be it known that I, MAXWELL M. UPSON, a citizen of the United States of America, and a resident of Englewood, New Jersey, have invented certain new and useful Improvements in Concrete Piling and Piling Units, the principles of which are set forth in the following specification and accompanying drawings, which disclose the form of the invention which I now consider to be the best of the various forms in which the principles of the invention may be embodied.

This invention relates to concrete piling and piling elements, for foundations, walls, cribs, coffer-dams, piers, wharves, bridges, bulkheads, buildings, and the like.

The object of the invention is a practical construction, physically and economically, of said nature for such purposes, and the invention consists of the structures hereinafter disclosed and claimed. One of the most serious difficulties encountered in this class of work is the extremely strong tendency toward the forcing of semi-solid or solid matter through the joints between the units of the piling.

A particular object of the invention is a practical concrete piling having joints which prevent the passage between the piling units of all such matter.

The following prior art has the disadvantages stated. Concrete piles with simple integral concrete tongue-and-groove interlock are manifestly weak at the joints, and therefore are not well adapted to resist strains at right angles to their length, and they are extremely liable to breakage in sinking into laterally-interlocking position with adjacent units; and furthermore, they do not at all resist strains along the line of the piling tending to pull the units apart and produce openings between the units, unless they are still further weakened by a modification constituting a longitudinal interlock. At the same time, some such interlock is extremely desirable, to keep the pile units from relative transverse and longitudinal movement, so as to permit a joint, preferably from top to bottom of the piling, which shall be of such character as to permanently prevent the passage through the piling of all semi-solid and solid matter. The mere prevention of longitudinal and transverse movement is not of itself sufficient to insure against passage of such matter, although the prevention of such movements is a long step in that direction. The special tongue-and-groove interlock of the art shown between units Z, W, Fig. 3, and constituting a vagrant joint in addition to interlocking, answers all requirements except the essential one of strength; that is, it is theoretically ideal, but is actually impractical because the interlocking projections are liable to breakage during sinking, so that the joint is never tight from the beginning. Combination steel and concrete piles wherein the steel comprises a structure forming a connecting bare steel web and a container for the concrete, either both web and container, or one or the other, and wherein there is a metal interlock, are excessively expensive and lack the mechanical advantages for foundation purposes, of a uniform, thick, and stable concrete structure. So also with sheet piling entirely composed of steel, which is not sufficiently rigid unless the mass of the material is increased to an economically prohibitive degree, as by increasing the thickness of the steel sheets or by providing extra angles to withstand the greatest strains. In any case, steel piling is most expensive, and has a short life resulting from rust and salt-water erosion; and protection of the steel from erosion, by mere coatings of concrete (as distinguished from a steel-reinforced concrete pile) simply increases its said excessive cost, without increasing the structural strength. Finally, any concrete piling unit which requires steel to constitute the interlock, is thereby made more expensive.

It has been possible, by steel piling, or by concrete piling having steel interlocks, to obtain the requisite strength and also suitably tight joints; the serious objection to these being the high cost. The greatest economy accompanies the use of concrete piling with concrete interlocks, but heretofore that has been considered impracticable, and for the following reasons. It has been possible, as in Fig. 3, to obtain all-concrete piling having theoretically tight joints, the difficulty, however, being that the joints could not be actually made tight on account of breakage during sinking of the structure

which was weakened in the attempt to obtain a vagrant joint to produce tightness and to interlock the piling units.

In addition to the fact that ordinary tongue-and-groove interlocked concrete piling units afford no interlock resistance to strains longitudinal of the piling, it is practically impossible to reinforce the pile-projections adjacent the groove in such manner as to obviate danger of breakage by strains at right angles to the piling, both during installation and after the pile is in position. Even the attempt to accomplish such result is accompanied by great trouble and expense.

This invention includes and provides concrete sheet-piling and units therefor, which may entirely lack all metal parts except the ordinary internal reinforcing used in piles which are pre-molded, this novel piling having a simple concrete interlock against strains longitudinally and transversely of the piling, and forming a tight joint, without in anywise seriously weakening the structure. This invention makes it possible to use as a piling element, the ordinary simple pre-molded concrete pile, with a specially molded but simple concrete joint-face, and without any external covering or container or metallic interlock, and capable of being grounded or sunk in any of the modes customary in the case of concrete piling units.

I have found that a concrete wall of sheet piling made up of the pile units of this invention, is substantially even stronger and more rigid than a continuously molded wall of concrete would be, and that it acts to substantially the same degree as that in preventing the passage through the piling-wall of semi-solid and solid matter. The advantage in installation of this substitute for a continuously molded wall, is made clear from a consideration of the fact that the piles of this invention are manufactured as separate individual units either in or out of their grounded positions, but preferably out, and before sinking or grounding; and when so pre-molded they are of such small size and convenient shape that they can be readily handled, and grounded in the ordinary way, as by water-jetting or driving, or both, and without the necessity of the preliminary trench-excavation required for a continuously-molded concrete wall. In the case of water-jetting, the units may have a water passage, as well known.

Of the drawings, Figure 1 is a horizontal section of the piling shown in Fig. 2 in elevation, and embodying the invention hereof; and Fig. 3 is a horizontal section showing concrete piling of the prior art.

The concrete piles shown may consist of the material commonly used, *i. e.*, comprising cement, sand, and broken stone or gravel, the stone or gravel being preferably used for economy. The piles may be molded in any known way, and may, and preferably do, contain the usual vertical steel reinforcing rods or equivalents shown at Y as mutually supported by wires or stirrups X, in the usual way. The concrete of the piles is indicated in Fig. 1 in section by the cross-hatching.

In Fig. 3 the concrete piling of the prior art is shown as consisting of concrete piling units V, Z, W. The ordinary concrete tongue-and-groove interlock between V and Z obviously lacks any interlock against strains longitudinally of the piling, so that the joint might spread or open up in the direction of the length of the piling, sufficiently to permit the passage through it of semi-solid and solid matter. The tongue-and-groove acts simply against transverse strains and as a centering guide for the unit in sinking it alongside its adjacent and previously sunk unit. The special concrete tongue-and-groove interlock between units Z and W takes care of both transverse and longitudinal strains tending to separate the units, but at the sacrifice of requisite strength of a unit having dimensions small enough to be practicable for handling and installation. Thus the material at 1, 2 and 3 is most seriously reduced in thickness, and throughout the vertical length of the unit, so that this construction is actually impracticable, the interlocking projections being liable to breakage during sinking, or afterward, at 1, 2 or 3. The joint itself however, owing to its shape which produces the interlock against longitudinal movement, whereby the joint possesses a vagrant, devious or wandering character, is ideally adapted to prevent the forcing through it of semi-solid and solid matter. The trouble is that the structure is too weak to insure the maintenance of this otherwise ideally tight joint. On the other hand, the permanently tight integral concrete interlocking joint of this invention, such as those between concrete pile units of Fig. 1, not only serves to prevent spreading of the joint and units longitudinally, and reduction of the joint by movement of the units transversely, but permits all necessary strength of material, such that the joint-face projections are not liable to breakage and the joint is maintained tight permanently. Thus, at A, B, C, Fig. 1, joint 4 at an angle to the length of the piling, prevents longitudinal displacement of the units from each other, and therefore prevents spreading of the joint, thus doing the work of either one of the diverging faces of the special tongue-and-groove joint between units Z and W, Fig. 3. Joints 5 and 6, Fig. 1, at oppositely disposed longitudinal projections *a*, *b* of unit B, do the work done by the special tongue-and-groove joint between Z and W, Fig. 3, as to preventing displacement of the unit from adjacent

units, in the direction transversely of the piling, thus preventing reduction of the joint in that direction. This is all done without weakening the structure, because, in Fig. 1, between adjacent units, such as A and B, there is only one joint 4 which interlocks against longitudinal movement, this being located substantially midway of the transverse thickness of the units. This permits maximum thickness, transversely of the unit, of the longitudinal projections *a*, *b*; and it also permits maximum thickness, longitudinally of the unit, of the transverse projections *c*, *d* from longitudinal projections *a*, *b*. In Fig. 3, on the other hand, the material at some or all of the parts 1, 2, 3 of the joint between Z, W, must be too weak, because there are two inclined tongue-faces, one at each side of the longitudinal center, and each necessarily substantially remote from that center, thus producing three cooperating projections transversely of two adjacent units. In Fig. 1, the location of the joint 4 substantially at the transverse center of the unit, limits to two, the necessary number of coöperating projections transversely of two adjacent units, thus permitting maximum thickness of the material of the projections. This drawing of unit B, Fig. 1, clearly shows that the transverse width of each longitudinal projection *a*, *b* may be nearly half the transverse thickness of the concrete pile unit, as compared with the special tongue-and-groove joint between units Z, W of Fig. 3, where the thickness of material at 1, 2 or 3 must be approximately only one-third of the transverse thickness of the unit. This joint between units A and B, Fig. 1, however, also possesses the same vagrant character as that between Z and W, Fig. 3, which is so desirable a feature in preventing the forcing of matter through the joint of the piling, provided that this vagrant joint be maintained tight. The placing of cement in this vagrant joint, if desirable, will further increase the improbability of the passage of matter through the piling, and constitute the piling substantially a continuous wall. A desirable manner of filling the joint to make it absolutely tight is to slush the contact-faces with cement-mortar just prior to sinking.

In sinking unit A alongside sunken unit B, means is preferably provided to coöperate with projections *a*, *b* to center A alongside of B, because there is as yet no unit to the left of A to coöperate with B in keeping A from transverse movement away from the line of the piling in the direction of projections, *a*, *b* away from each other. This means may consist of an auxiliary guide G (Fig. 1), which may be of metal or wood or any other suitable material, and located on the free or non-contacting side of the unit A, opposite projection *a*. This auxiliary guide may be secured to one of the units A or B, such as B, by means of the bolts shown, which are embedded in the concrete. Guide G is secured to the lower portion of the unit (Fig. 2), and extends longitudinally beyond the face of A which contacts with unit B. Thus, the guide G, while A is being sunk, serves to keep the lower portions of projections *a*, *c* of A, in tight engagement with the lower portions of projections *b*, *d* of B; and as the sinking progresses, the portions of projections *a*, *b*, *c*, *d* above auxiliary guide G are held tightly together on account of the entire unit being held in vertical alinement in the ordinary manner between the walling-pieces of the pile-driver or other suitable vertical guides. As indicated in Fig. 2, the guide G is sunk with the pile unit and there remains in the mud or earth. It is immaterial as to which unit a guide G is secured, so long as it serves its stated function of assisting to center the unit during sinking. The projections *a* and *c*, etc., are to be understood as preferably extending from top to bottom of the pile unit, as shown in Fig. 2, to thereby give maximum strength to prevent the passage of semi-solid and solid matter through the piling at any portion of its height, and particularly they are to be understood as extending near the bottom in order to serve as guides coöperating with auxiliary guide G during sinking. But obviously, the preferred forms may be widely varied within the invention, as for example, the guides G might be duplicated and be located also near the top of the units. But no upper auxiliary guide G is needed for unit B, because projection *a* of B at the right is oppositely disposed with respect to projection *b* of B at the left, so that after unit B is sunk along unit C and A along B, so that B is held between A and C, B is kept from transverse movement in either direction by virtue of the opposite disposition of the projections on the respective contact-faces of unit B. Here the only needed function for G is to preserve alinement of B with C during the sinking of B. Furthermore, the invention may be embodied in forms, hereinafter disclosed, wherein the coöperating sinking guide is not auxiliary to the unit, as is G, but may be an integral portion of the concrete unit itself, thus dispensing with all auxiliaries such as G.

One object of the novel construction above described is to prevent the breakage, during sinking, of those integral parts of the piling-units which interlock the units against longitudinal and transverse movement, so as to provide and maintain a tight joint. This object is also accomplished by the joint between units C and D, Fig. 1, wherein the longitudinal and transverse interlock consists of concrete or grout R in re-

cesses L, M in the joint-faces of the units C, D, the concrete being placed in the cavity formed by the facing recesses after C has been sunk alongside D; C being guided into place along D by means of lower guides G^1 on both free or non-contacting sides of C (Figs. 1 and 2). If desired, a steel helix S may be placed in the space L, M after the units C, D are in place and before the space is filled with concrete; but this is simply to reinforce the narrow part of the concrete joint and need not and preferably does not comprise a metallic interlock between units C and D. In fact, the reinforcement S is of the same general nature as the ordinary internal reinforcing X, Y, except that it is located as a part of the novel structure in the part thereof having the least strength, although the grout or concrete R will set integrally to a sufficient extent with the concrete of the pile-units C, D, so that the concrete at L or M is in fact a projection integral with unit C or unit D respectively, the peculiarity of the construction being that the concrete structure R does not exist until after the units are in place. The statements made above as to guide G, apply also to guides G^1. Also the guides G^1 are turned inward at the right to enter lateral grooves O in unit D, to keep unit C close to D during sinking. There is no liability to breakage during the sinking, in this form of joint, because the recesses L, M may be made small and the adjacent projections thick, as compared with the projections of Fig. 3, and because the projections adjacent to recesses L, M of Fig. 1 are not subjected to interlocking strains during sinking. After these units C, D are sunk and the recesses filled with concrete or grout, the units become consolidated into what is substantially a continuous wall, even if the contracting faces of the pairs of projections adjacent the recesses be not sealed together by cement. In any case, this form provides a tight joint which cannot possibly be penetrated by solid or semi-solid matter.

A simple and complete form of the invention, lacking any separate or auxiliary guides either at bottom or top, is shown at the joints of unit E with units D and F. Here there is the longitudinally-interlocking joint 4 substantially as at A, B and C. In addition, the joint-faces, as at the portions 10 and 11, may be inclined, as shown, to serve as centering guides to coöperate with projections *a*, *b*, *c*, *d* during sinking, and also for transverse locking after sinking. These inclined portions 10, 11 prevent transverse movement of unit E in the direction of the longitudinal projections *a*, *b* of units D, E, F transversely away from each other, and therefore permit both longitudinal projections *a*, *b* of unit E to be located on the same side of the longitudinal center, instead of on opposite sides as in unit B. But even if projections *a*, *b* of unit E be oppositely disposed as in unit B, the inclinations such as 10, 11 of the joint-faces of E, would serve as coöperative guides during the sinking of E. Thus, when the projections *a*, *b*, and the inclined portion 11 of unit E and the correspondingly inclined part 13 of unit F, extend substantially to the bottom of the unit, as they preferably do, they serve to center unit E in place during sinking alongside adjacent unit F. Of a given unit E, any two or more of the joints 9, 10, 11, 12 may be inclined for this purpose, provided only that at least one is inclined at each joint face of the unit at such angle as to cooperate with a projection *a* or *b* in centering the unit in sinking and to keep the joint tight thereafter. The form shown at the right of unit E is preferable, however, where the inclined portion 11 is the side of the joint-face of the unit E which is opposite to projection *a* of said unit, and not the face of the projection itself, so that the centering strains are distributed across the entire transverse thickness of the unit. The inclined portions, as 10, 11, can be inclined sufficiently to so serve as coöperative centering guides durng sinking and as transverse interlocks after sinking, without seriously weakening the structure, by virtue of the fact that the location of the longitudinal interlock 4 substantially at the center of the transverse thickness of the unit, permits considerable length to be given to the longitudinal projections *a*, *b* in the direction of the piling, so as to compensate in material for that lost by forming the inclinations 10, 11. The inclinations are to be understood as being on the contacting face of a unit, whether on the contacting face of a projection from the unit, or otherwise.

A characteristic common to all the above novel structures comprising interlocks against movement of units longitudinally of the piling, is that the units have a non-centering integral concrete interlock against strains longitudinally of the piling. That is to say, the integral portion of the unit which comprises the interlock against longitudinal movement does not of itself serve to center during sinking, (as is the case at Z, W, Fig. 3), but either does not assist at all in centering, as at C, D, or assists only by preventing transverse movement in one direction, as at A, B, C and D, E, F. The concrete interlock against movement longitudinally of the piling is integral with the unit in all such cases, in the sense that it is a molded part of the concrete unit, whether cast as a projection of a unit before the unit is sunk, or, as at C, D, molded with the joint-faces of the units in recesses therein after the sinking of the units. The longitudinal interlock is non-centering in

that it alone cannot serve to center the unit which is being sunk, with respect to an adjacent sunk unit. Some coöperating means for centering is required, if centering is to be assured, because, in the case of the use of a single projection *a* (from unit B), this can guide only as to one direction of the two possible directions of transverse movement. Thus, at A, B, C the means coöperative with the interlocking projections *a*, *b*, to guide the unit as to both transverse directions, *i. e.*, to center it, is the guide G; at D, E, F it is the inclined portion 10 or 11; at C, D, one of the pair of guides G^1 coöperates with the other, etc. At Z, W, Fig. 3, on the other hand, the pair of inclined joints of the special tongue, both of which coöperate with the groove in the adjacent unit to interlock the two units against relative movement longitudinally of the piling, also coöperate with each other to center the unit Z during sinking alongside unit W. There is also a characteristic common to all of the novel forms wherein a piling-unit-projection is employed, as between A, B, C and between D, E, F. This is that the joint-face of a unit has only a single longitudinally-interlocking projection, and this single projection has only a single longitudinally-interlocking joint-face which face is in a plane angularly disposed with reference to the plane of the meeting or opposing side of the pile; so that at the joint-faces of two adjacent units there are only two coöperative longitudinally-interlocking projections and only one longitudinally-interlocking joint; all as distinguished from the prior art, as at Z, W, Fig. 3, where there are three longitudinal projections and two longitudinally-interlocking joints. A further characteristic of the projection-form of the invention is that the single longitudinally-interlocking joint is located substantially midway of the transverse diameter of the unit. The projection is from one side of the contacting face; and the thickness of the projection, on account of the central location of the longitudinally-interlocking joint-face, is nearly half the transverse thickness of the entire unit. The effect is as if the special tongue-and-groove joint at Z, W (Fig. 3) were altered by removing a portion of the tongue along a line parallel with the piling, then removing the projection 1 from the other unit, then moving the remaining tongue-portion into the place of projection 1, and finally enlarging the projection 3 of the other unit to cause it to come into interlocking engagement with the remaining single interlocking joint-face of the remnant of the tongue. It is this elimination, in this invention, of the double longitudinally-interlocking joint at Z, W, Fig. 3, which makes desirable some coöperative centering means during sinking, notwithstanding that transverse movement of a unit of the completed piling may be prevented by the opposite disposition of the two longitudinal projections from the respective contact faces of a unit, as at B, Fig. 1.

The joint between units F and H illustrates the action of adjacent longitudinal projections *a*, *b* of the two adjacent units to prevent transverse displacement in the direction of the projections toward each other, and also the action of the inclination of the contact face at 13 as a means coöperative with said projections, to center the unit during sinking and to prevent transverse displacement in the direction of the projections away from each other; all being shown independently of any longitudinally-interlocking joint. However, independently of the inclination 14 of the contact face of unit H, the opposite disposition of the projections *a*, *b* serves to prevent transverse displacement of a unit from a complete piling, and in the lack of such inclination, useful during sinking, an auxiliary guide G^2 may be employed in sinking H with a straight face as at 15. In piling having joints such as those between F, H and I, lacking longitudinal interlocks, the transverse interlocks consisting of the longitudinal projections *a*, *b*, provide the desired tight or vagrant joints which will not be disturbed if the ends of the piling be securely anchored against longitudinal movement. It is preferable, however, to provide the longitudinally interlocking construction, in order to insure that the units may be initially sunk closely enough together to form a tight joint.

The joint between I and J illustrates the action of guides G^3 on both of the opposite free sides of the units, in keeping the units in place from transverse movements; the guides G^3, permissibly at top and bottom, entering recesses O^1 to keep the units in place from longitudinal movement. These guides and recesses can be used in any form of the invention, whenever desirable, and under certain conditions of installation, may provide a joint sufficiently tight although lacking the generally desirable vagrant character.

The ultimate product of the invention is a piling which is all-concrete, including the interlock, as concerns all but the desirable ordinary internal reinforcement; and the joints are preferably completely filled with cement or cement mortar, such that the effect, as to water-proofing and perpetual life, is that of a solid concrete wall, the cemented joints being permanently maintained tight by the special form of interlocking construction shown. This piling furthermore resembles a continuous concrete wall in being of uniform thickness, not increased at the joints, lacking any outer

covering, container or metal interlocks, and having full strength in the plane of the piling and at angles therewith. This piling may be adapted to any desired angle, by merely changing the shape of the molds for the individual piles. In short, it may be used under any conditions where steel piling is now used, and not only with high comparative economy, but with greatly increased stability and carrying capacity. Not only is the piling of this invention much more economical than steel piling for a given height of piling unit, but the economy is multiplied as a result of the fact that a given height of pile has a greater carrying capacity, owing to the more massive character of the concrete pile element and its substantially greater thickness, as compared with a steel piling of a cost at all comparable.

The expression "concrete pile" is used herein in its ordinary sense as meaning a pile of molded concrete, preferably with internally-molded metallic reinforcing means, but complete in and of itself, in that no casing, covering or any exterior protection means is desirable or necessary.

In cases where the tight interlocking or vagrant joint of this invention is not needed throughout the vertical length of the pile-units (*i. e.*, the height of the piling), the same may be dispensed with whenever desired. It is usually preferable that the novel joint extend from top to bottom, but there is no necessity of using the invention where it is not useful. It is clear that the units may be held together in accordance with the invention, by the novel joints which do not extend continuously from top to bottom, and if in any case, a tight or vagrant joint is not needed from top to bottom, the same need extend only so far as to hold the units together so as to maintain the joint tight at the levels where that is desirable. It is clear also that as few as two units of a long piling may embody the invention, as at a localized place where a tight joint may be desirable; and that therefore a piling may be within the invention even if only a portion of it be constructed in accordance therewith.

I claim:

1. A concrete sheet wall comprising a plurality of successively-adjacent concrete pile-units having a non-centering joint of concrete between two adjacent units, which concrete joint holds the joint-faces of said units against joint-spreading longitudinally of the piling.

2. Concrete piling comprising a plurality of successively-adjacent concrete pile-units having non-centering joints of concrete at the two joint-faces of a unit, which concrete joints hold said unit against joint-movement transversely of the piling.

3. Concrete piling comprising a plurality of successively-adjacent concrete pile-units having a non-centering joint of concrete between two adjacent units, which concrete joint holds said unit against joint-movement longitudinally and transversely of the piling.

4. Concrete piling comprising a plurality of successively-adjacent concrete pile-units, two of which units adjacent to each other have each a single longitudinal projection of integral concrete from its joint-face, said projections having each an integral transverse projection of concrete from it, said transverse projections interlocking with each other against joint-spreading longitudinally of the piling.

5. Concrete piling comprising a plurality of successively-adjacent concrete pile-units, the two joint-faces of two adjacent units having each a single longitudinal projection of integral concrete, said two projections interlocking with each other to prevent joint-movement longitudinally of the piling and in one transverse direction; and means for preventing joint-movement in the opposite transverse direction and coöperative with said projections to provide and maintain a tight joint between said two adjacent units.

6. Concrete piling comprising a plurality of successively-adjacent concrete pile-units, the two joint faces of two adjacent units having each a single longitudinal projection of integral concrete, said two projections holding said two adjacent units from joint-movement in one direction transversely of the piling; and means for holding said two adjacent units from joint-movement in the opposite transverse direction.

7. Concrete piling comprising a plurality of successively-adjacent concrete pile-units, the two joint-faces of two adjacent units having each a single longitudinal projection of integral concrete, said two projections interlocking with each other to prevent joint-movement longitudinally of the piling and in one transverse direction; and an auxiliary guide secured to the free side of the piling and holding said two adjacent units from joint-movement in the opposite transverse direction.

8. Concrete piling comprising a plurality of successively-adjacent concrete pile-units, the two joint faces of two adjacent units having each a single longitudinal projection of integral concrete, said two projections holding said two adjacent units from joint-movement in one direction transversely of the piling; and an auxiliary guide secured to the free side of the piling and holding said two adjacent units from joint-movement in the opposite transverse direction.

9. A concrete sheet wall comprising a plurality of successively-adjacent concrete pile-units, the two joint-faces of two adjacent units having each a single longitudinal pro-

jection of integral concrete, said two projections interlocking with each other to prevent joint-movement longitudinally of the piling and in one direction transversely of the piling; and means secured to the free sides of the piling for holding said two adjacent units from joint-movement in the opposite transverse direction.

10. A concrete sheet wall comprising a plurality of successively-adjacent concrete pile-units, the two joint faces of two adjacent units having each a single longitudinal projection of integral concrete, said two projections holding said two adjacent units from joint-movement in one direction transversely of the piling; and means secured to the free sides of the piling for holding said two adjacent units from joint-movement in the opposite transverse direction.

11. A unite for concrete piling, consisting of a concrete pile having secured to its free side an auxiliary guide extending beyond the unit in the direction of its length longitudinally of the piling.

12. A unit for concrete piling, consisting of a concrete pile having a vertical recess formed in its free side.

13. A unit for concrete piling, consisting of a concrete pile having an integral concrete projection from a joint-face, said projection having a single locking-joint face at an angle with the piling length of the unit.

14. A unit for concrete piling, consisting of a concrete pile having from each of its joint-faces an integral concrete projection, each of said projections having a single locking-joint face at an angle with the piling length of the unit.

15. A unit for concrete piling, consisting of a concrete pile having from each of its joint-faces an integral concrete projection, each of said projections having a single locking-joint face at an angle with the piling length of the unit, said two projections and their locking-joint faces being disposed oppositely to each other on the respective faces of the unit.

16. A unit for concrete piling, consisting of a concrete pile having from each of its joint-faces an integral concrete projection, each of said projections having a single locking-joint face at an angle with the piling length of the unit, said two projections and their locking-joint faces being disposed correspondingly to each other on the respective faces of the unit.

17. A unit for concrete piling, consisting of a concrete pile having a vagrant joint-face, one portion of which is inclined at an angle to serve as an interlock longitudinally of the piling, and another portion of which is inclined to serve only to hold the unit from movement transversely of the piling.

18. Concrete piling comprising a plurality of concrete pile-units, two adjacent units having a vagrant joint possessing only a single longitudinally-interlocking portion.

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Witnesses:
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