June 23, 1936. M. M. UPSON 2,045,112

CONCRETE SEA WALL

Filed Aug. 26, 1933 4 Sheets-Sheet 1

FIG.1.

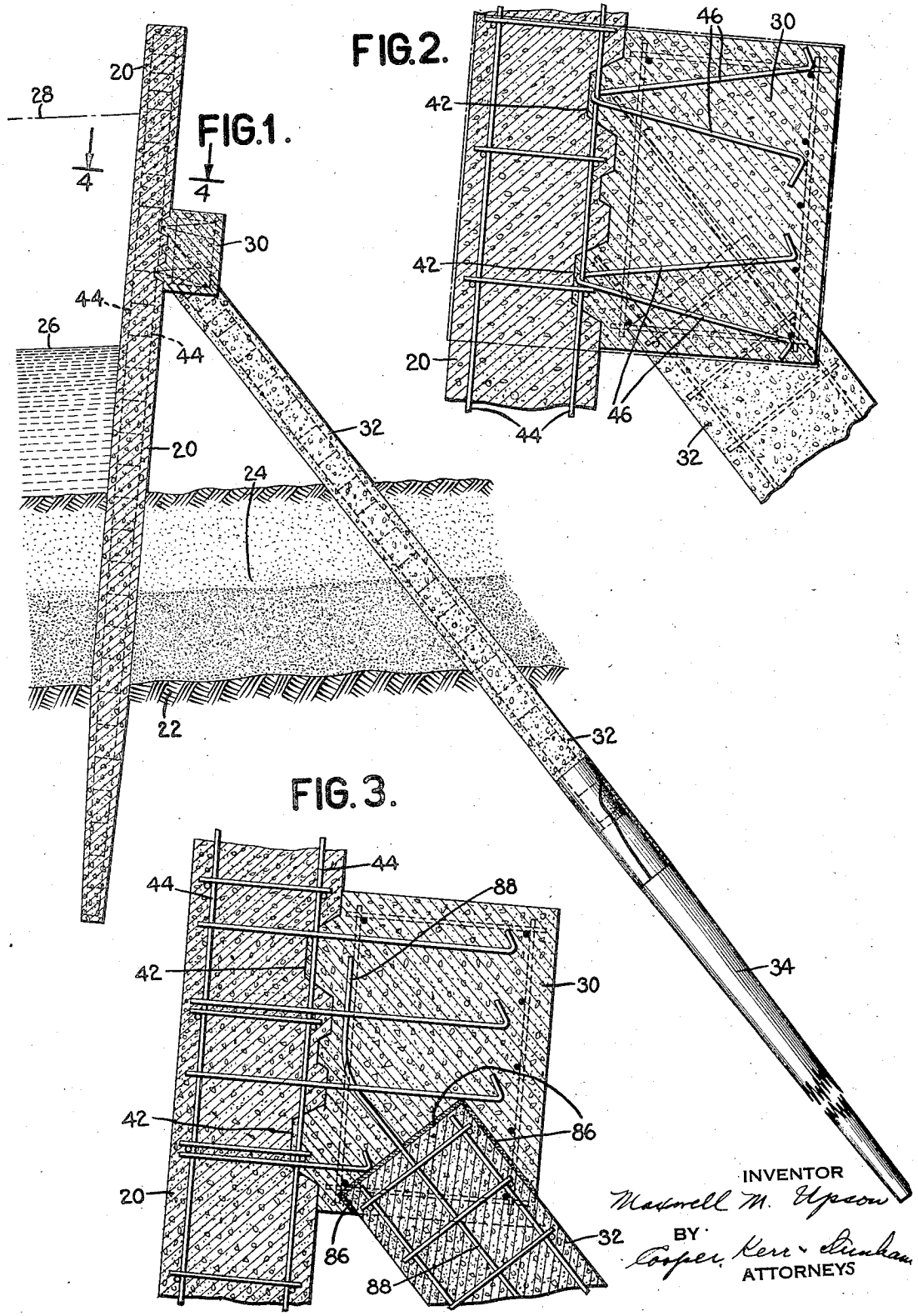

FIG.2.

FIG.3.

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FIG. 4.

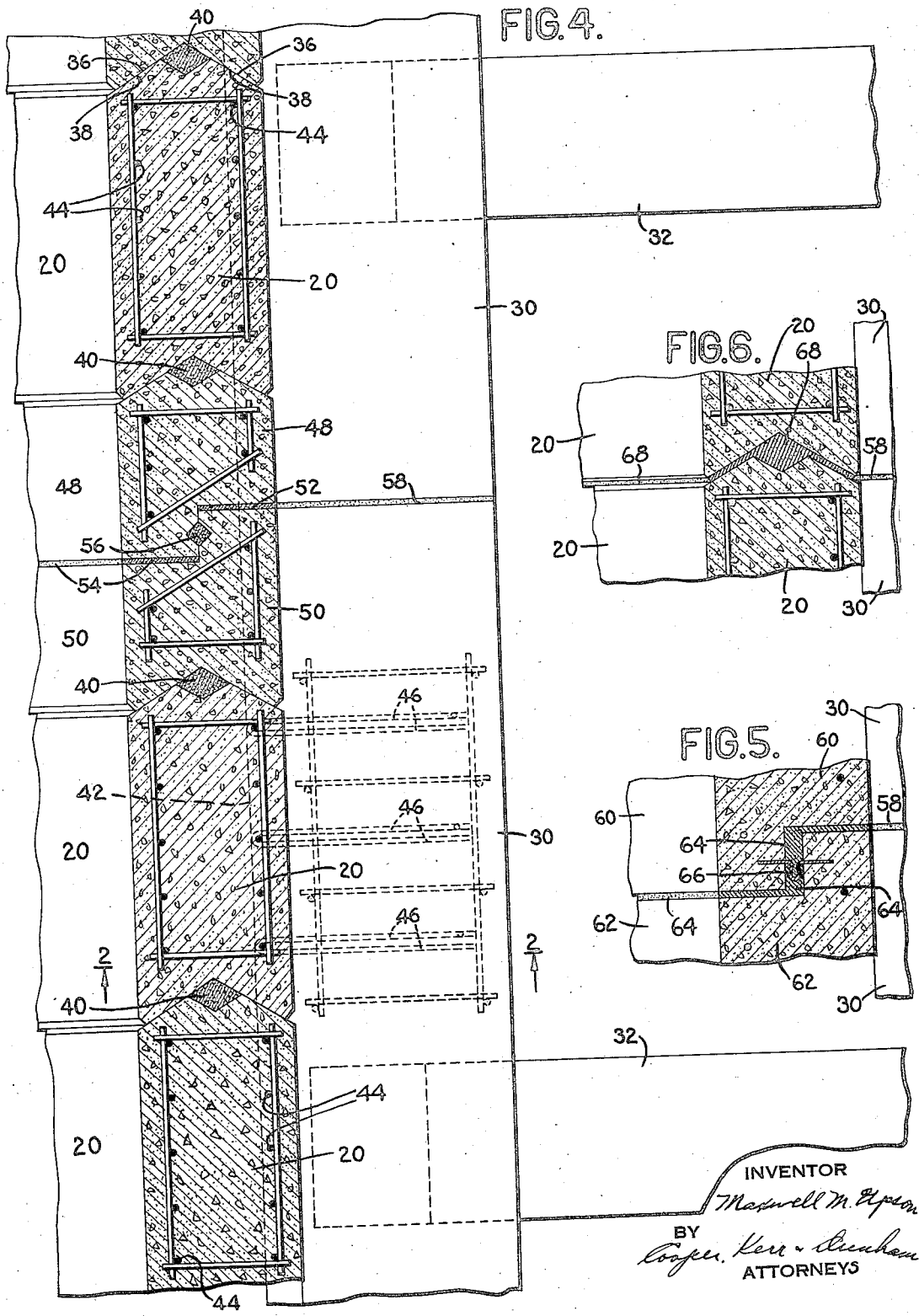

FIG. 6.

FIG. 5.

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FIG.7.

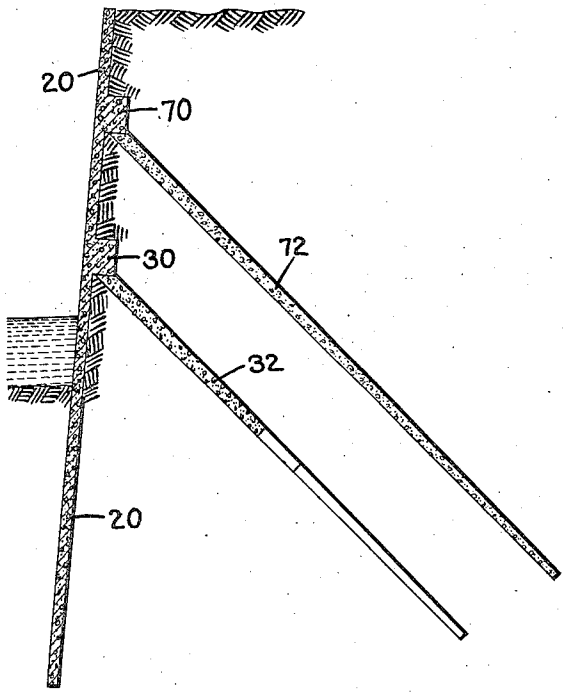


FIG.8.

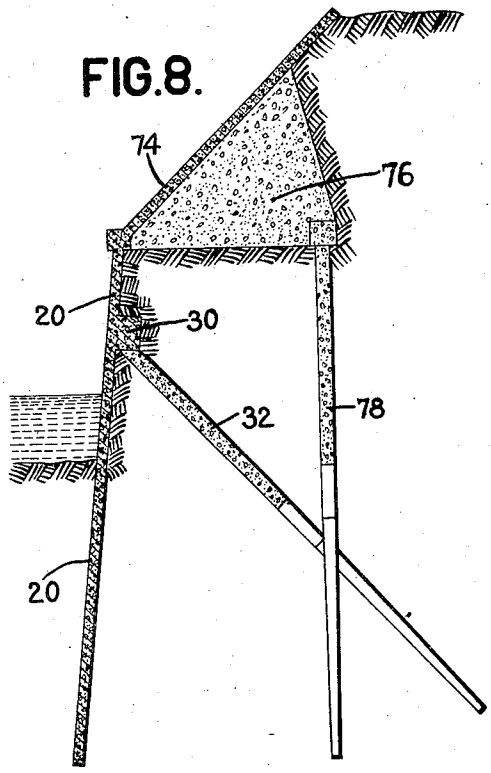
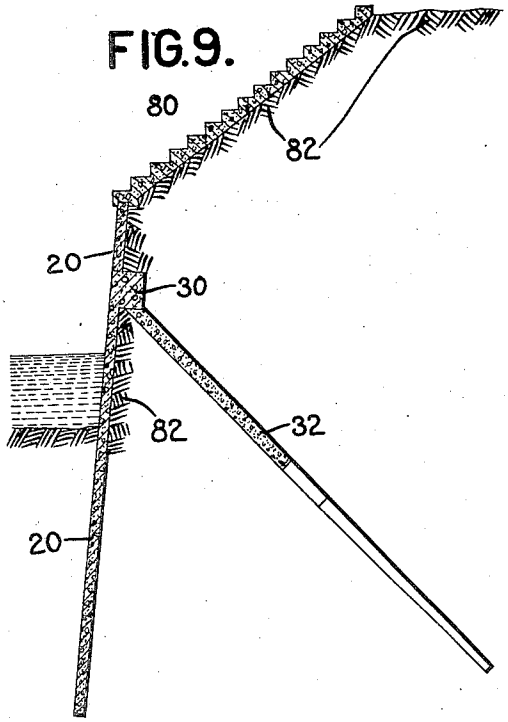


FIG.9.



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CONCRETE SEA WALL

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FIG.10.

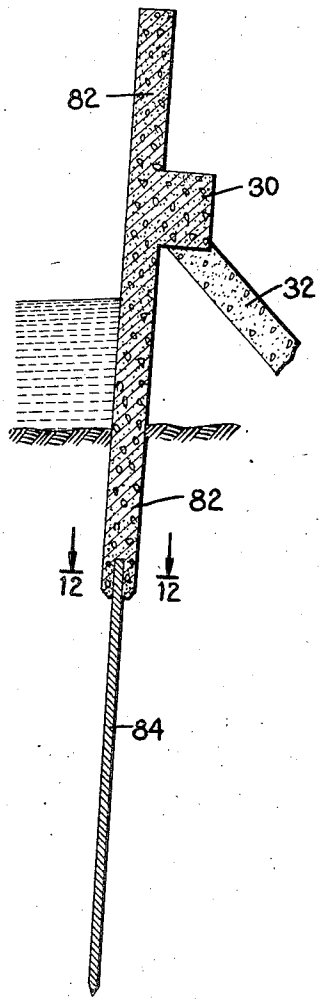


FIG.11.

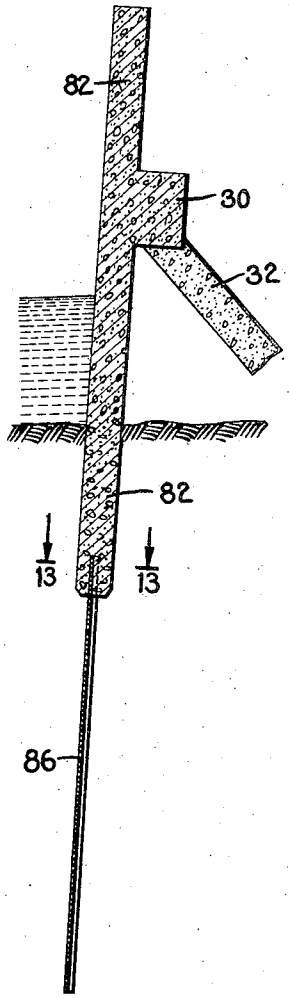


FIG.12.

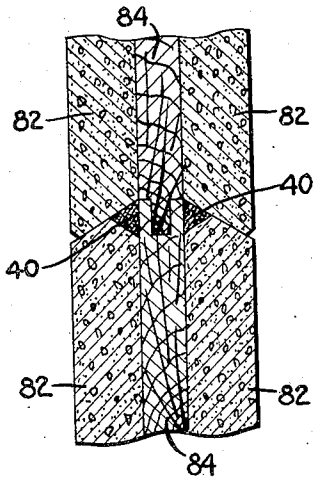
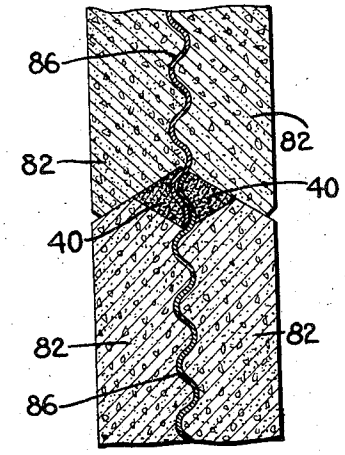


FIG.13.



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Patented June 23, 1936

2,045,112

UNITED STATES PATENT OFFICE

2,045,112

CONCRETE SEA WALL

Maxwell M. Upson, Englewood, N. J., assignor to Raymond Concrete Pile Company, New York, N. Y., a corporation of New Jersey

Application August 26, 1933, Serial No. 686,910

13 Claims. (Cl. 61—39)

This invention pertains to sea walls of concrete.

As illustrated and described, the wall comprises a series of reinforced concrete sheet piles driven into the ground in close contact with each other. They are driven at an angle so that waves are deflected upwardly, thus avoiding scouring in front of the wall and reducing the strain on the structure. Rigidity of the structure is aided by batter piles driven at intervals behind the wall and secured thereto by a concrete beam integral with the sheet piles and with the heads of the batter piles. This beam prevents relative movement of the sheet piles longitudinally of the wall, thus permitting the formation of permanent water-tight joints between the sheets by simply pouring grout into spaces provided for that purpose in the contacting edges of the piles. Suitable expansion joints are provided at intervals in the wall.

An object of the invention is the formation of a sea wall of precast members locked together to prevent leakage through the wall.

Another object is the formation of a sea wall of precast members locked together by a cast-in-place beam, the lower part of the wall extending far below the underlying earth thereby preventing passage of water underneath the wall, and the upper part of the wall extending in cantilever form above the beam.

Another object is the formation of a permanent wall requiring the minimum of material and providing the maximum of strength and rigidity where wave and water pressure is greatest.

Another object of the invention is the formation of a sea wall having precast vertical members and a cast-in-place horizontal beam so intimately interconnected with the vertical members that the material in the vertical members may be used in calculating the strength and stiffness of the beam.

Further and other objects and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate what are now considered preferred embodiments of the invention.

Fig. 1 is an end view of one form of the invention.

Fig. 2 is an enlarged sectional view on the line 2—2 of Fig. 4, showing one method of interconnecting the sheet piles, beam, and batter piles.

Fig. 3 shows another method of interconnecting the sheet piles, beam, and batter piles.

Fig. 4 is an enlarged cross-section on the line 4—4 of Fig. 1, showing an expansion joint and details of interlocking reinforcements between the horizontal beam and one of the sheet piles.

Figs. 5 and 6 are fragmentary views showing different types of expansion joints.

Fig. 7 shows a modification of the invention to form a higher wall.

Fig. 8 shows an embodiment of the invention in which the wall is surmounted by an apron for combating wave action, the structure being self-supporting.

Fig. 9 shows an embodiment similar to that of Fig. 8 except that the apron is supported by an earth fill.

Fig. 10 is a modification in which composite sheet piles are used, the upper portions being concrete as before and the lower portions being of wood.

Fig. 11 is similar to Fig. 10 except that the lower portions are of sheet steel.

Fig. 12 is a cross-section on the line 12—12 of Fig. 10.

Fig. 13 is a cross-section on the line 13—13 of Fig. 11.

The wall as illustrated in Figs. 1 to 4 inclusive comprises a series of reinforced concrete sheet piles 20 in contact with each other and driven at an angle, with their lower ends in the impervious stratum 22, well below any water bearing sand or soil 24. The normal water level is at 26 and the estimated ultimate water lever is at 28.

The sheet piles are integral with longitudinal beam 30, and are braced by batter piles 32, the heads of which are embedded in beam 30 so that they also form an integral part of the structure. The batter piles may be of any suitable design, a composite type being shown, having a wooden lower section 34. The sheet piles and bracing piles are precast. They are driven to position and then beam 30 is cast in place to complete the structure.

The sheet piles, as shown (Fig. 4), have their edges so shaped as to engage each other as at surfaces 36, 38, to preserve their alignment and to provide spaces to be filled with grout 40 to prevent all leakage through the wall.

The rear sides of sheet piles 20, where beam 30 is to be cast, are notched or recessed as at 42 to receive some of the concrete of the beam and to expose some of the vertical reinforcing bars 44 of the sheet piles, permitting reinforcing bars 46 of the beam to loop around bars 44, thus

binding the beam and sheet piles into an integral mass. This feature results in a great saving of material in the structure, because in calculating the strength of the beam the compression of the concrete of the piles directly opposite the beam may be included, thereby greatly reducing the necessary thickness of the beam. In calculations for compression the cross-section of the beam may be considered as bounded by the broken lines surrounding the beam and part of the pile (Fig. 2).

At intervals the structure is provided with expansion joints, one form being shown in Fig. 4, in which one of the regular sheet piles **20** is replaced by a two-piece pile having the same overall shape and dimensions as the other piles and having an expansion joint between its two parts. The two parts forming the expansion pile are designated **48** and **50**. The parts partially overlap each other and would partially abut each other were it not for the fact that the abutting surfaces are separated by layers of expansible material **52** and **54** which may be asphaltum or something similar. The overlapped slip-joint surfaces are recessed to provide a vertical cavity in the pile which is filled with expansible material **56**. Beam **30** has a joint aligned with joint **52** and filled with similar material **58**.

A modified form of expansion joint is shown in Fig. 5, the two parts of the sheet pile being **60** and **62**, and the joint being otherwise similar to that shown in Fig. 4 except that the overlapping portions of the pile are separated by expansible material **64**, and a sheet of metal having a U-fold **66** is embedded in the overlapping portions of the pile with fold **66** in the asphaltum. This metallic member provides extra security against leakage when the pile sections move relatively to each other.

Fig. 6 shows still another form of expansion joint in which no special two-part sheet pile is used. This joint is formed between two of the regular piles by simply keeping their normally abutting edges out of contact and filling the space thus provided with asphaltum **68**.

Fig. 7 shows an embodiment of the invention in which an unusually high wall is required. This requirement is met by simply letting the sheet piles project to the proper height and providing an extra longitudinal beam **70** and bracing piles **72** above the regular beams.

Fig. 8 shows an embodiment in which the regular structure is surmounted by an apron **74** which, at intervals of its length, has webs **76** resting on piles **78**.

Fig. 9 shows still another embodiment having a superimposed apron **80** resting on the earth fill **82** behind the wall.

It is sometimes desirable, for reasons such as economy, to use composite sheet piles having their upper portions of concrete substantially as described, and their lower portions, below water level, of wood, sheet metal or other material. Such a structure with lower part of wood is shown in Figs. 10 and 12. The upper pile **82** is of concrete, while the lower part is of wooden planks **84**, with their upper ends precast into the lower ends of piles **82**, the joints in the planking coming in the spaces between the edges of the concrete piles in the grout filling **40**. Of course the joints in the planning are of water-tight design such as the tongue and groove shown in Fig. 11.

In Figs. 11 and 13 the wooden planks are replaced by corrugated sheets of metal **86** having their edges overlapping in grout **40**, the overlap extending to the bottom of the pile to prevent leakage.

Under certain conditions, for instance where the upper end of the brace pile is not opposite the center of pressure, it is advantageous to fit the head of the brace pile into a cushioned socket in the longitudinal beam, as shown in Fig. 3 instead of casting the beam and bracing pile integral, as in Figs. 1 and 2. A layer **86** of asphaltum or other resilient material lines the socket in the beam to provide a flexible joint between beam and pile, thus reducing flexure strains in the brace pile. Reinforcing rods **88** extend from the center of the brace pile into the beam to prevent their separation if tension stresses should occur, tending to pull the head of the pile from the socket.

It is to be understood that the invention is not limited to the specific construction herein illustrated and described but may be embodied in other forms without departure from its spirit as defined by the appended claims.

I claim—

1. A wall comprising a row of preformed concrete sheet piles, in combination with a concrete beam lengthwise of the wall at the rear and below the top thereof and integral with said piles, substantially as described.

2. A wall comprising a row of preformed concrete sheet piles, in combination with piles for bracing said sheet piles, and a concrete beam at the rear of and lengthwise of the wall integral with said sheet piles and bracing piles.

3. A wall comprising a row of preformed concreate sheet piles, in combination with a concrete beam at the rear of and lengthwise of the wall below the top thereof and integral with said piles, and reinforcing bars common to said piles and said beam, for the purpose set forth.

4. A wall comprising, in combination, a row of preformed concrete sheet piles, reinforcing bars in said piles, a concrete beam lengthwise of the wall below the top and at the rear thereof integral with said piles, and reinforcing bars in said beam engaging said bars in said piles.

5. A sea wall comprising a row of concrete sheet piles, means in the abutting edges of said piles for forming cavities between said piles and vertically thereof, fillings of grout in said cavities, and a concrete beam lengthwise of the wall below the top thereof and integral with said piles.

6. A sea wall comprising a row of concrete sheet piles, means in the abutting edges of said piles for forming cavities between said piles and vertically thereof, fillings of grout in said cavities, a concrete beam lengthwise of the wall below the top thereof and integral with said piles, and bracing piles having their heads embedded in said beam.

7. A sea wall comprising in combination, a row of concrete sheet piles, a concrete beam integral with said piles below the top thereof, and means for sealing the joints between said piles to prevent leakage of water therethrough.

8. A sea wall comprising a row of concrete sheet piles, in combination with a concrete beam lengthwise of the wall and integral with said piles, and expansion joints at spaced intervals in said wall, each of said expansion joints including a layer of expansible material through one of said sheet piles, said layer comprising a portion parallel to the wall face and two portions extending from the ends of said parallel portion to

the front and rear surfaces of the pile respectively; said parallel portion including a U-shaped metal sheet having its edges embedded in the adjacent concrete of the pile.

9. A wall comprising a row of concrete sheet piles, in combination with piles for bracing said sheet piles, and a concrete beam lengthwise of the wall integral with said sheet piles, the heads of said bracing piles being in cushioned sockets in said beam.

10. A wall comprising a row of concrete sheet piles, a concrete beam lengthwise of the wall integral with said sheet piles, cushioned sockets in said beam, bracing piles having their heads in said sockets and reinforcing bars extending from the centers of said piles into said beam, substantially as described.

11. A sea wall comprising a row of preformed concrete sheet piles, in combination with a concrete beam lengthwise of the wall at the rear and below the top thereof and integral with said piles, and expansion joints including a layer of expansible material through one of said sheet piles at spaced intervals along said wall.

12. A sea wall comprising a row of preformed concrete sheet piles, in combination with a concrete beam lengthwise of the wall at the rear and below the top thereof and integral with said piles, and expansion joints at spaced intervals in said wall, including a layer of expansible material through one of said sheet piles, said layer comprising a portion parallel to the wall face and two portions extending from the ends of said parallel portion to the front and rear surface of the pile respectively.

13. A sea wall comprising a row of preformed concrete sheet piles, in combination with a concrete beam lengthwise of the wall at the rear and below the top thereof and integral with said piles, and expansion joints at spaced intervals in said wall including a vertical cavity in said beam, a slip joint extending lengthwise of the wall from said cavity and slots from the ends of said slip joint to the front and rear of said pile, said cavity and said slots being filled with expansible material.

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