Oct. 22, 1935. W. W. SMITH 2,018,423

SHEET PILING WALL STRUCTURE

Filed Aug. 25, 1932 8 Sheets-Sheet 1

Fig. 1.

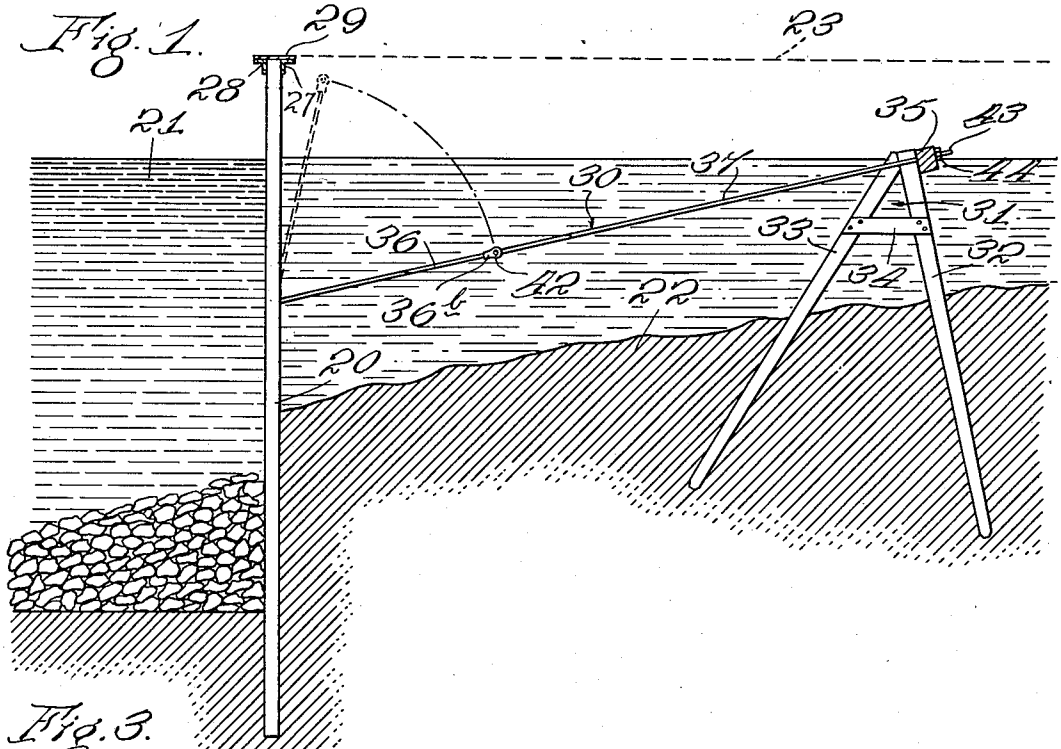


Fig. 3.

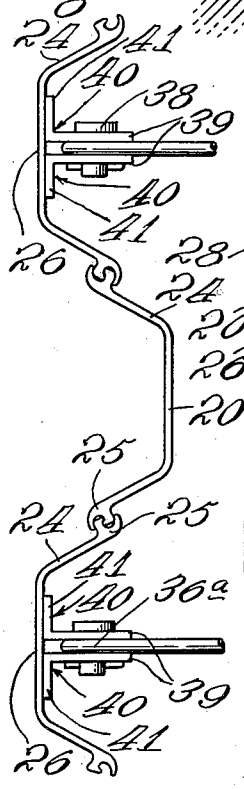
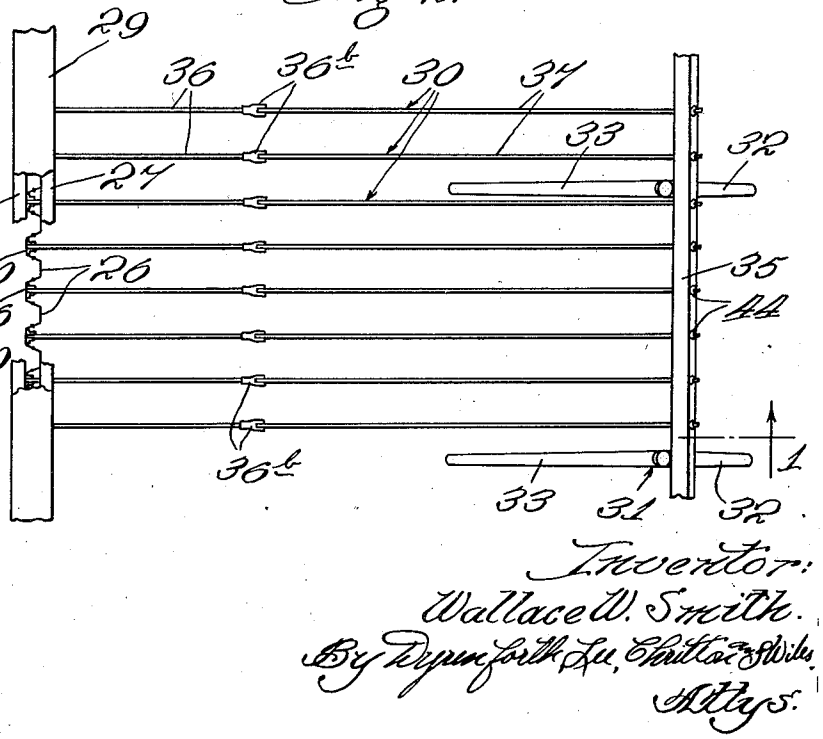


Fig. 2.



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SHEET PILING WALL STRUCTURE

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Fig. 4.

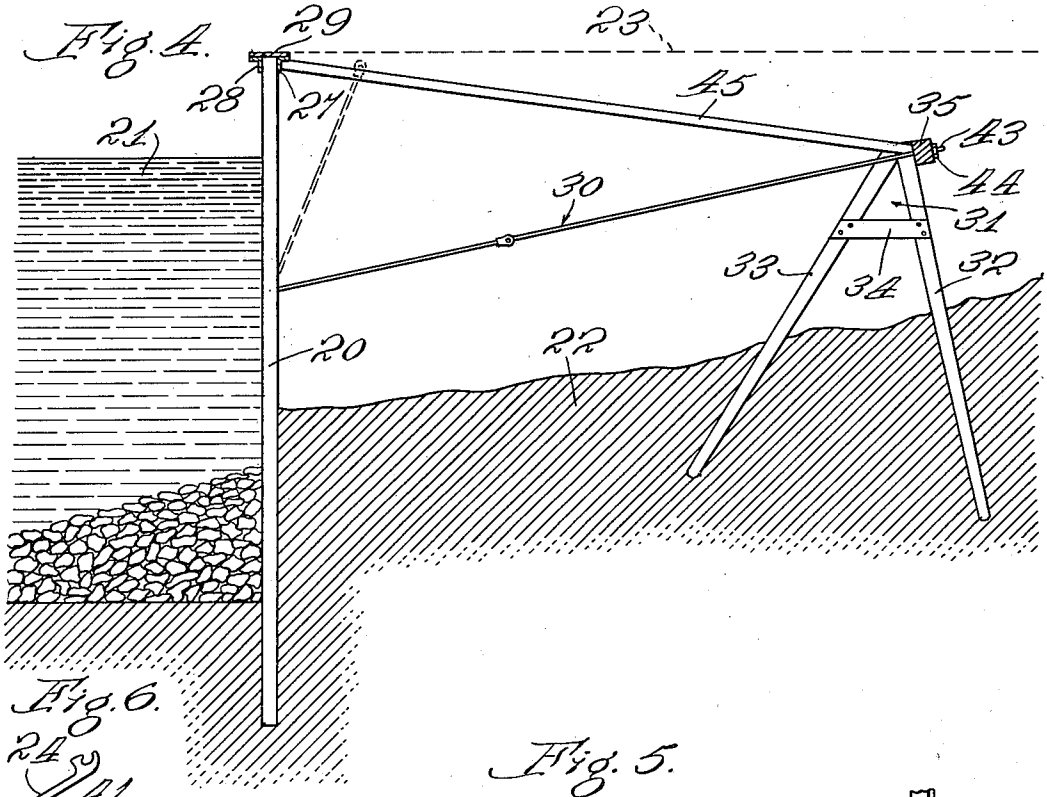


Fig. 6.

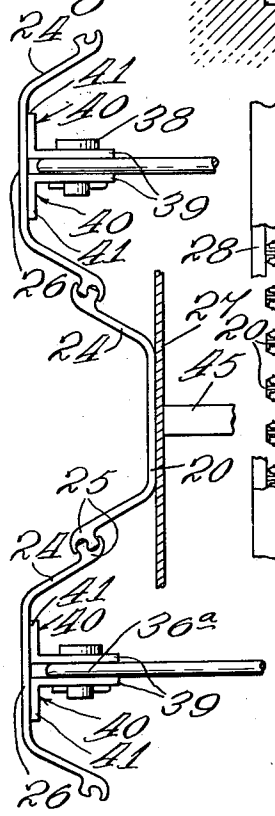
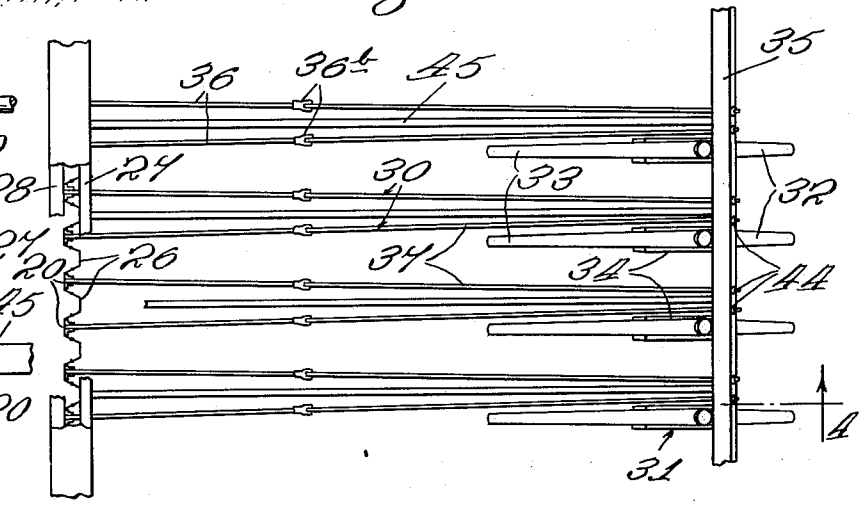


Fig. 5.



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SHEET PILING WALL STRUCTURE

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Fig. 7.

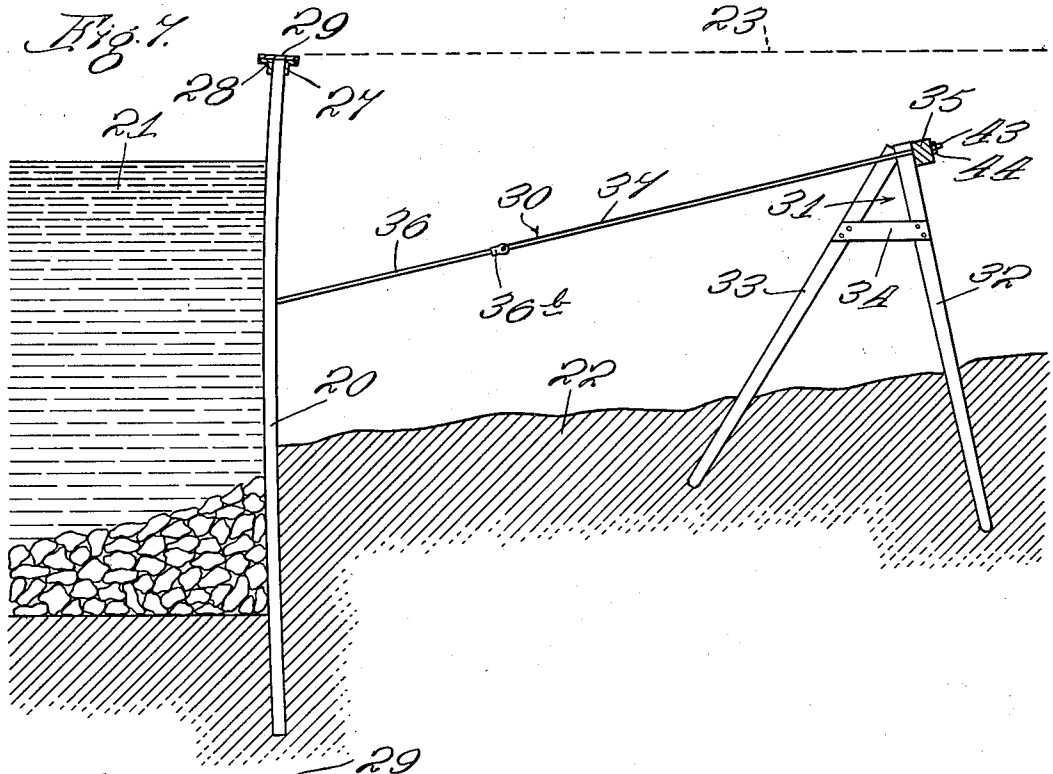
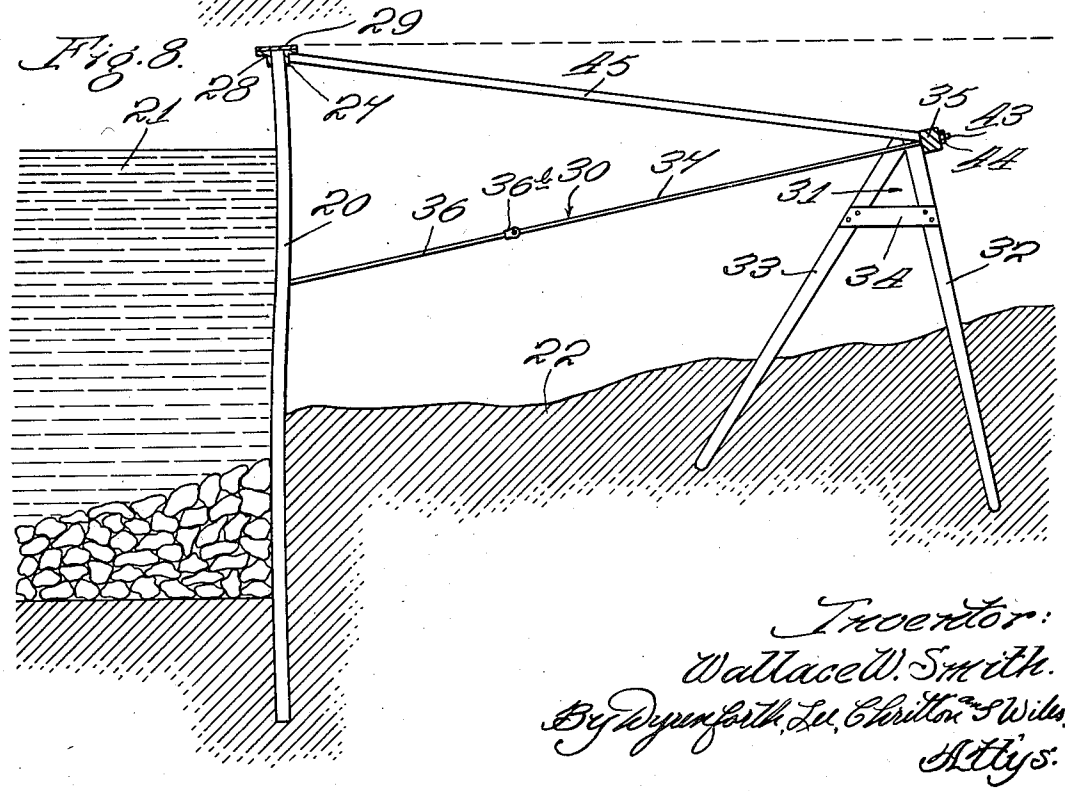


Fig. 8.

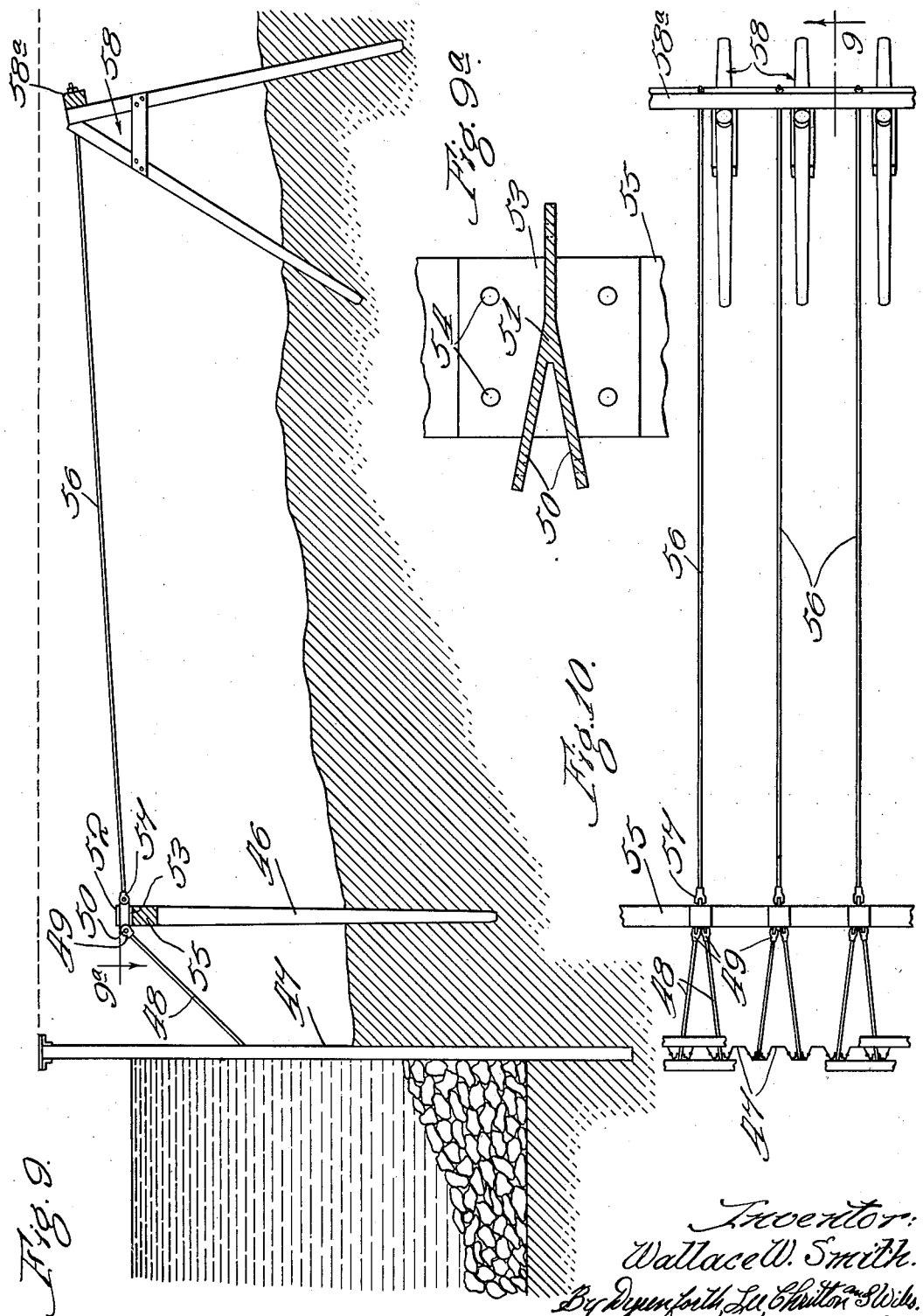


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SHEET PILING WALL STRUCTURE

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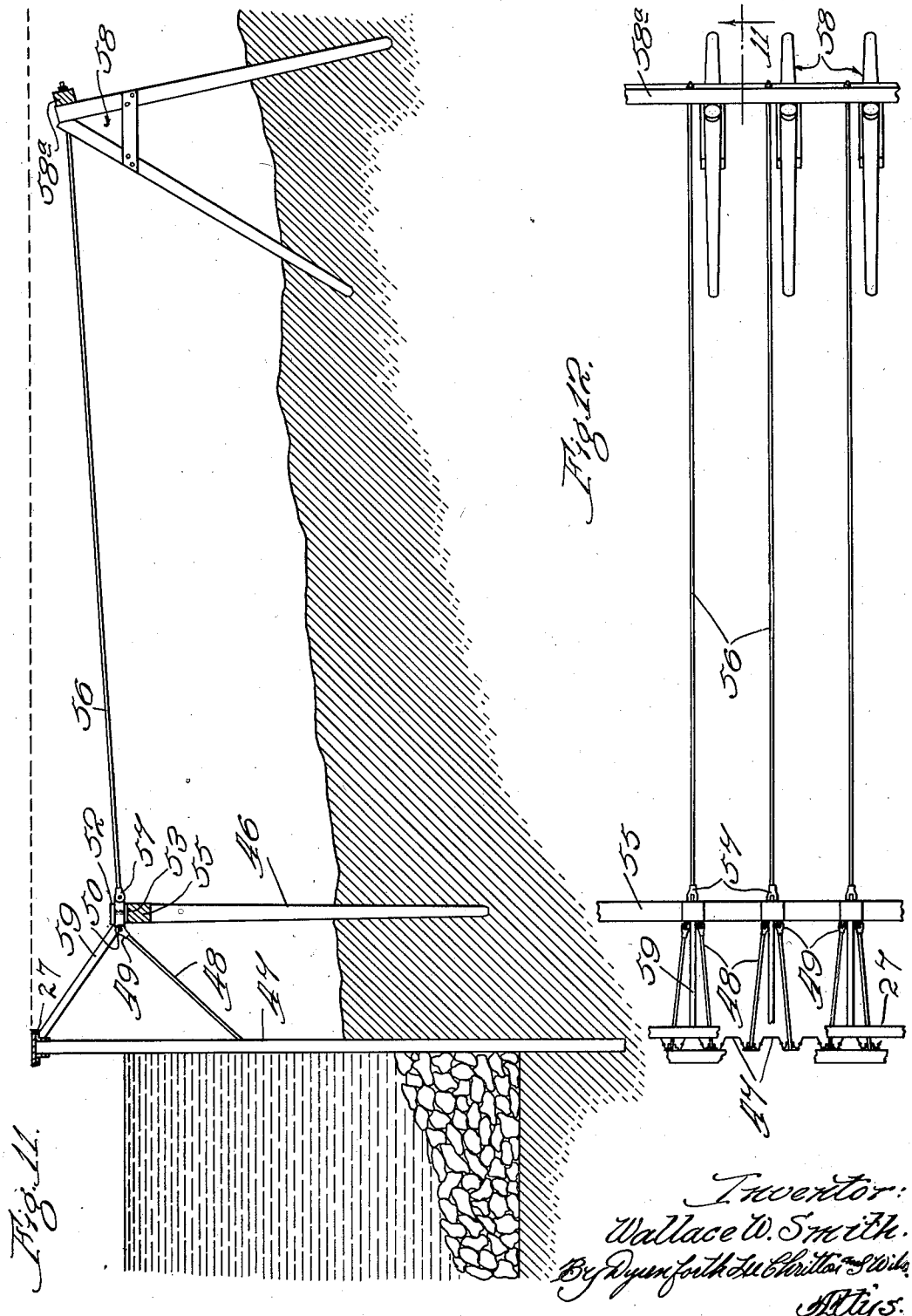


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SHEET PILING WALL STRUCTURE

Filed Aug. 25, 1932 8 Sheets-Sheet 5



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SHEET PILING WALL STRUCTURE

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Fig. 13.

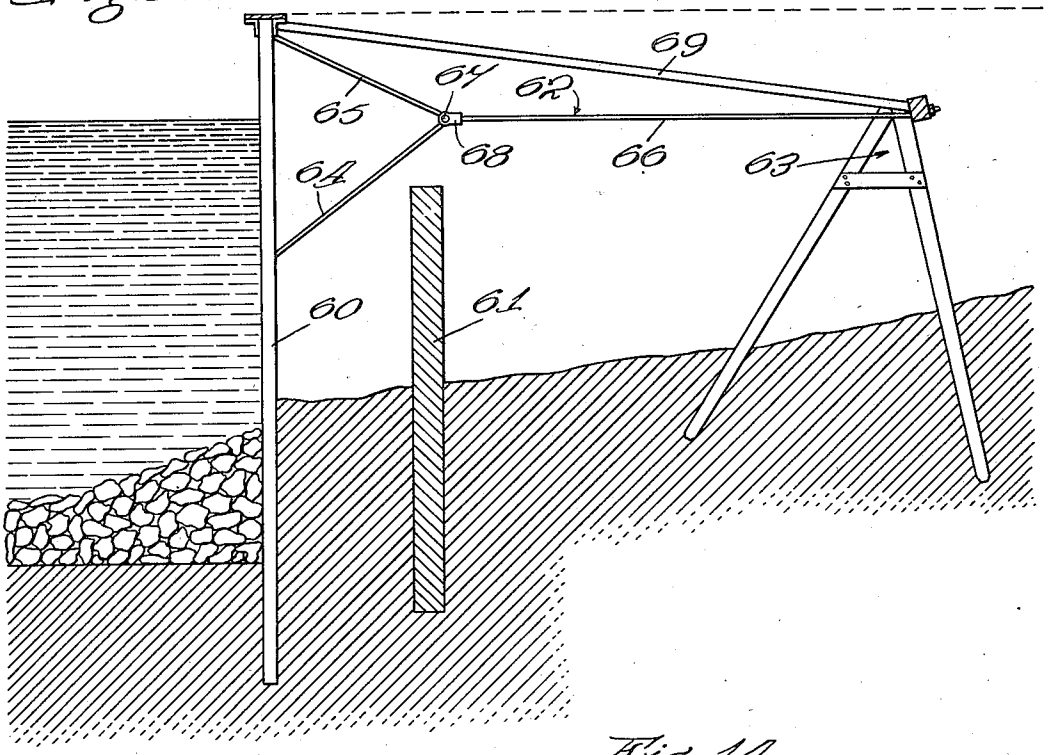
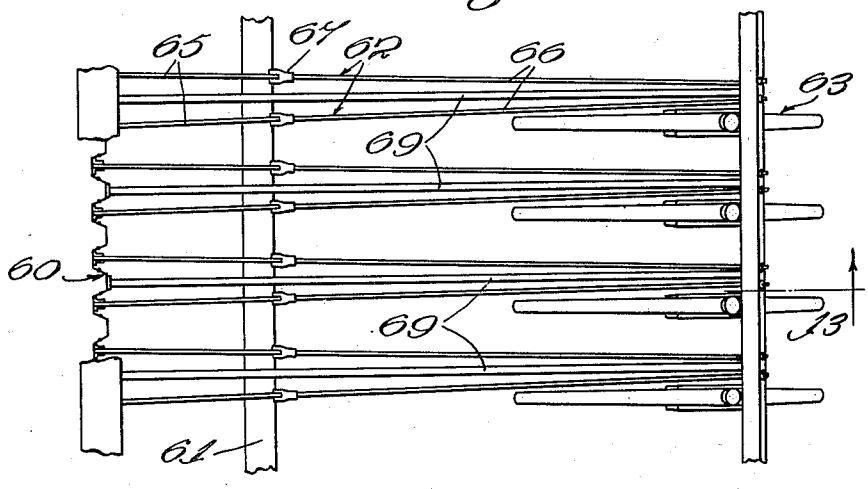


Fig. 14.



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SHEET PILING WALL STRUCTURE

Filed Aug. 25, 1932 8 Sheets-Sheet 7

Fig. 15.

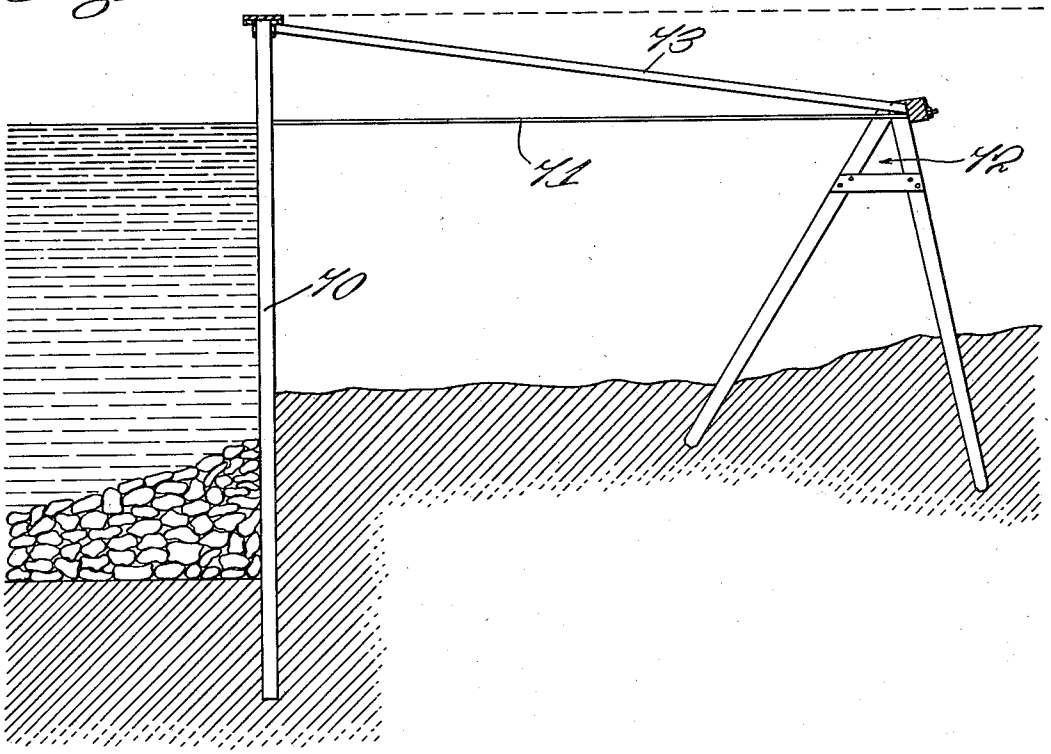
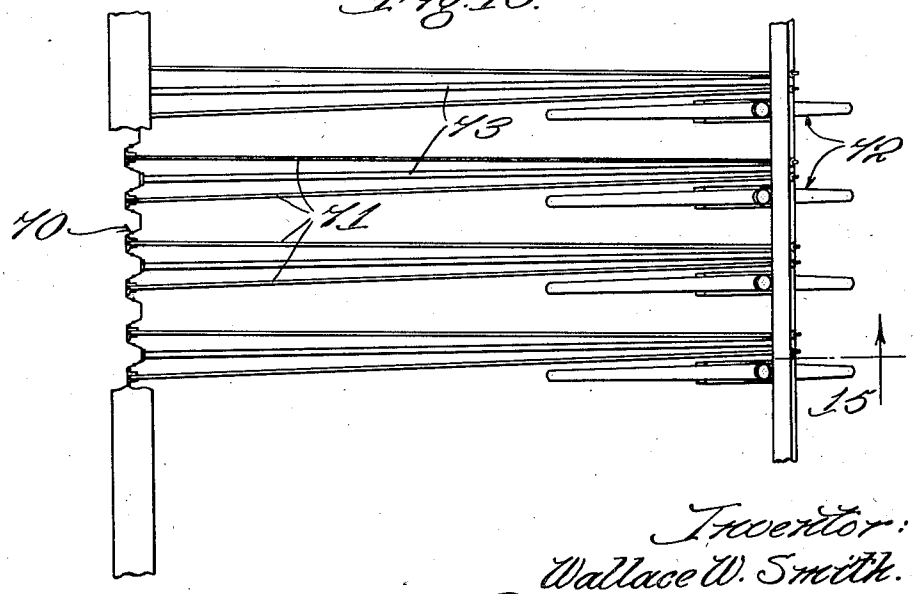


Fig. 16.



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SHEET PILING WALL STRUCTURE

Filed Aug. 25, 1932 8 Sheets-Sheet 8

Fig. 17.

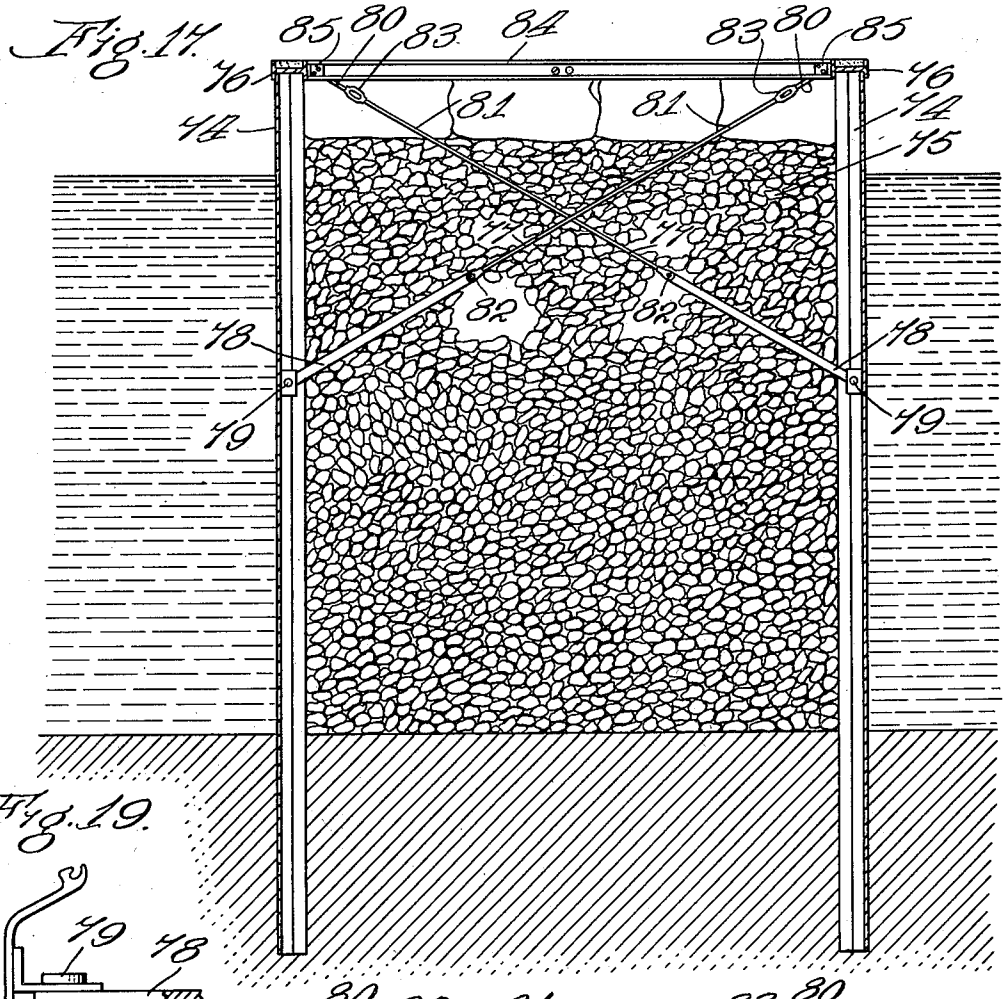
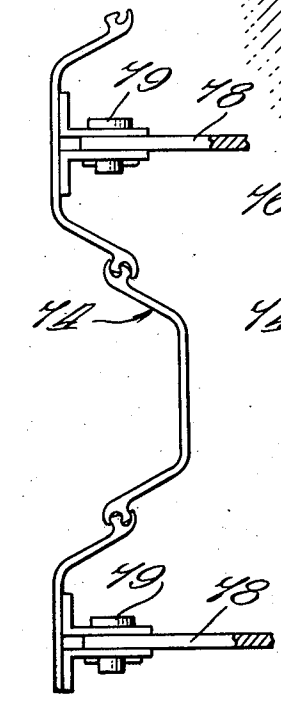


Fig. 19.



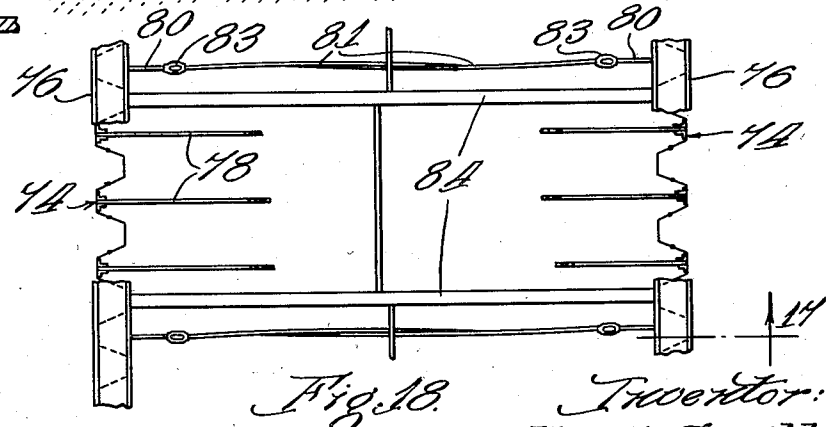


Fig. 18.

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Patented Oct. 22, 1935 2,018,423

UNITED STATES PATENT OFFICE

2,018,423

SHEET-PILING WALL STRUCTURE

Wallace W. Smith, Chicago, Ill., assignor to Inland Steel Company, Chicago, Ill., a corporation of Delaware

Application August 25, 1932, Serial No. 630,444

20 Claims. (Cl. 61—39)

My invention relates, more particularly, to steel sheet-piling structures, as for example to form the walls of a dock and along one side of which the filling extends or a breakwater formed of spaced apart walls with filling interposed therebetween.

As a preface to the following description it may be stated that my invention presents, generally stated, two phases, one directed to the feature of the tie rods by which the piling structure is anchored in place to resist the thrust of the filling back of it, and the other phase relating to the provision of braces or struts so disposed as to increase the resistance of the sheet piling to the forces exerted by the filling and tending to flex the sheet piling, and thereby permit of the use of sheet piling presenting commensurately less inherent resistance to flexing with consequent saving in material.

As to the first-referred-to phase of the invention, it may be stated that, as is known, the lower the points of connection of the tie rods with the sheet piling, within certain limits, the greater the resistance of the sheet piling to flexing under the forces exerted against it by the filling. However, as the fill-side of the piling is immersed in water substantially to the level of the water at the water side of the piling, it is not possible in the case of structures as hitherto provided, to make the connections of the tie rods with the sheet piling at the most desirable low elevation without employing divers for this purpose, with resultant great expense.

It is therefore one of the objects of my invention to provide for the connection of the tie rods with the sheet piling at such low elevations without requiring divers for this work.

As to the other of the above-referred-to phases of the invention it may be stated that as structures have hitherto been constructed, the sheet piling, under the forces exerted by the filling and resisted by the tie rods, is flexed into a single curvature vertically the sheet piling bowing outwardly between its lower edge and the points of connection of the tie-rods therewith and curving rearwardly as a continuation of the upper arc of its bowed portion, above said points of connection.

My object in this connection is to provide a construction whereby the inward deflection of the sheet piling at the portion thereof above the points of connection of the tie-rods with the sheet piling, will be prevented thereby causing a reverse flexure of the upper portion of the sheet piling which causes the sheet piling to be much more highly resistant to the forces exerted by the filling permitting of the use of sheet piling of commensurately less inherent resistance to flexing than otherwise would be required with consequent saving in material.

Other objects of the invention will be apparent from the following description.

Referring to the accompanying drawings:

Figure 1 is a broken sectional view of a dock-wall structure constituting one embodiment of my invention.

Figure 2 is a broken plan view of the structure of Fig. 1.

Figure 3 is an enlarged fragmentary plan view of the sheet-piling forming an element of the structure of Figs. 1 and 2 with the adjacent tie-rods associated therewith.

Figure 4 is a view like Fig. 1 of another embodiment of the invention.

Figure 5 is a plan view of the structure of Fig. 4.

Figure 6 is an enlarged fragmentary plan view of the sheet piling of Figs. 4 and 5 and the adjacent tie-rods and struts.

Figure 7 is a view like Fig. 1 and of the construction therein shown illustrating the flexing of the sheet piling.

Figure 8 is a view like Fig. 4 and of the structure therein shown illustrating the manner in which the sheet piling flexes.

Figure 9 is a view like Fig. 1 and of still another embodiment of the invention.

Figure 9^a is an enlarged plan sectional view taken at the line 9^a on Fig. 9 and viewed in the direction of the arrow.

Figure 10 is a broken plan view of the structure of Fig. 9.

Figure 11 is a view like Fig. 1 of still another embodiment of the invention.

Figure 12 is a broken plan view of the structure of Fig. 11.

Figure 13 is a view like Fig. 1 of still another embodiment of the invention.

Figure 14 is a broken plan view of the structure of Fig. 13.

Figure 15 is a view like Fig. 1 of still another embodiment of the invention.

Figure 16 is a broken plan view of the structure of Fig. 15.

Figure 17 is a view like Fig. 1 of a breakwater construction embodying my invention.

Figure 18 is a broken plan view of the structure of Fig. 17; and

Figure 19, a fragmentary plan view of the

sheet piling of Figs. 17 and 18 with the adjacent tie-rods.

Referring to Figs. 1, 2 and 3 which show a dock-wall structure embodying the first-referred-to phase of my invention, 20 represents sheet-piling driven to position to form the wall at one side of which the body of water, represented at 21, extends, and at the opposite, land, side of which filling would be positioned on the ground represented at 22 as for example to the level indicated by the dotted line 23.

The sheet piling may be of any desirable form. As shown it is formed of vertically disposed sheet-piling sections 24 of a well known channel form alternate ones of which are reversely disposed as shown and connected together by interlocking slip-joint-forming portions 25 which, in this particular construction, are located midway between the planes occupied by the web portions 26 of the sections 24. The upper edge of the structure formed of the piling sections 24 is provided with a wale, forming stiffening means, shown as formed of angle irons 27 and 28 secured to the web portions 26 at the opposite sides of the sheet piling, and extending substantially the full width of the sheet piling and a plate 29 extending along the tops of the horizontal flanges of the angle plates 27 and 28 and secured thereto in any desirable way.

The wall structure also comprises tie rods 30 acting in tension at the land-side of the wall and connected with the sheet piling 20 and with anchorage structure comprising anchors 31 shown as formed of pairs of anchor piles 32 and 33 driven into the ground to converge upwardly and braced as indicated at 34, and a cross timber 35 extending along the series of piles 32 and 33 and connected therewith.

The tie rods 30, shown as connected with the outermost row of web portions 26 and with the cross-timber 35, each comprises a plurality of sections 36 and 37, the rod sections 36 being pivotally secured to the web portions 26 referred to, as by pivot pins 38 extending through eyes 36a on the rod-section 36 and carried by the opposing spaced-apart flanges 39 of angles plates 40 secured at their other flanges 41 to the web portions 26 referred to, the other ends of the rod-sections 36 being connected at clevises 36b with the adjacent ends of the rod sections 37, as by pivot pins 42. The rod sections 36 extend at their inner, threaded, ends 43 through the cross-timber 35, and are provided with nuts 44 screwing thereon for adjusting the tension of the tie rods.

The rod sections 36 which, in practice, would be connected with the sheet piling 20 as stated before the latter is driven to place, are preferably of such length that when swung upwardly substantially into the dotted position shown in Fig. 1 they will extend at their upper ends slightly below the top edge of the sheet piling 20 and in the final position to which the sheet piling is driven they will extend above the level of the water on the land-side of the wall structure and which level is the same as the level of the water at the opposite side of the wall as shown in Fig. 1.

The sheet piling 20 having been driven to final position as shown, the rod sections 37 are connected with the free ends of the rod sections 36 by the pivot pins 42 and these sections then relatively swung toward straightened position, the sections 37 being inserted through the cross-timber 35 and the nuts 44 then applied to the tie rods and adjusted. It will be obvious that, if the sheet piling is not in true alignment after driving, it may be brought to alignment by tensioning some of the tie rods more than others or in extreme cases by leaving some of the rods loose, whereupon the latter will be tensioned against the nuts by pressure of the filling when placed.

By providing the tie rods 30 in sections as stated, they may be connected with the sheet piling 20 to extend at such points of connection at any desired elevation in the finished structure without requiring the connecting of any parts while submerged in the water. Thus as shown in Fig. 1 the tie rods 30 may be connected with the piling at an elevation far below the level of the water and highly effective in the functioning of the sheet piling in resisting flexing forces to which it is subjected by the filling charged into the ground at the land-side of the wall.

Referring to Figs. 4, 5 and 6, which also show a dock-wall structure, the structure therein shown incorporates not only the sectional tie rod feature of the preceding figures but also the other of the above referred to phases of my invention. This structure is the same as that shown in Figs. 1, 2 and 3, the same numerals being applied to similar parts, with the addition of means interposed between the upper portion of the sheet piling 20 and the anchors 31 for resisting deflection of the top edge portion of the sheet piling, toward the filling, under the forces exerted by the filling and outwardly flexing the sheet piling, these means comprising struts, or braces, 45, connected, as for example, by welding, to the angle irons 27 at the land-side of the wall structure and, in any suitable way, to the cross-timber 35.

The functioning of the struts 45 is illustrated by the comparative showings in Figs. 7 and 8 representing, respectively the structures shown in Figs. 1 and 4; Fig. 7 showing the manner in which the sheet piling 20 flexes under the forces exerted thereagainst by the filling when no such struts are used, from which showing it will be noted that the sheet piling flexes into a single bowed condition; and Fig. 8 showing the manner in which the sheet piling flexes when associated with the struts 45, from which showing it will be noted that the sheet piling 20 assumes double reverse curvature with the plane of contra-flexure between the points of connection of the tie rods with the sheet piling and the lower edge of the sheet piling, thereby greatly enhancing the stiffness of the sheet piling and permitting of the use of sheet piling having much less inherent resistance to flexing and thus of much lighter weight, for any given amount of force to be resisted, than in the case of a structure in which the struts 45 are omitted.

Figs. 9 and 10 illustrate the first above referred to phase of my invention as incorporated in a dock wall structure built adjacent, and beyond, a line of piling, such as a previously installed dock wall and represented at 46.

In this construction the sheet piling represented at 47 is shown as of the same construction as the sheet piling of the preceding figures of the drawings.

The tension means co-operating with the sheet piling 47 comprise tension rods represented at 48 and connected at one end with the sheet piling as in the case of the rods 36 in the preceding figures of the drawings, these rods being provided in pairs and converging as shown and con-

nected at their other ends, formed with clevises 49, to ears 50 provided on webs 51 connected with upper and lower plates 52 and 53 superposing, and spiked through holes 54 in the plate 53 to, a timber 55 secured to the top of the piling 46. The tension means also comprise rods 56 connected at clevises 57 with the webs 51 and extending to anchorage structure represented generally at 58 and of the construction shown in the preceding figures to which these rods are secured in a similar manner as shown.

The sheet piling 47 is thus anchored to the anchorage 58 which resists the tensile stresses exerted in the rods 56 by the sheet piling 47 under the forces exerted by the filling at the land side of the sheet piling.

As will be apparent the provision of the tie rods 48 pivoted to the sheet piling 47 permits of the connecting of the tie rods with the sheet piling at a relatively low elevation with the advantages as hereinbefore set forth.

The construction shown in Figs. 11 and 12 is the same as that shown in Figs. 9 and 10, to similar parts of which the same numerals are applied, except for the addition of struts or braces represented at 59 which extend between the upper terminal edge of the sheet piling 47 and the members which connect together the rods 48 and 56 and serve the same purpose as the struts of the preceding figures of the drawings, the struts 59 being secured to the sheet piling as for example at the angle iron 27 as shown and to the means connecting the rods 48 and 56, in any suitable way, as for example by welding them in position.

The construction shown in Figs. 13 and 14, which also involves the two above referred to phases of the invention, is likewise a dock wall structure and is provided where an obstruction, such as an old dock wall, would extend between the location of the sheet piling and the anchors and it is desired that the tension means for the sheet piling clear such obstruction.

This construction involves sheet piling 60, as for example as in the case of the construction of the preceding figures of the drawings, which would be located outwardly beyond an obstruction, such as an old dock wall represented at 61. Tie rods represented generally at 62 connect the sheet piling 60 with the anchorage structure represented generally at 63 and of the same construction as that shown in Figs. 1, 2 and 3, these tie rods being formed of a rod section 64 pivoted at its outer end to the sheet piling 60 at a relatively low elevation below the level of the water, a second rod section 65 pivoted at its outer end to the upper edge of the sheet piling 60 and a third rod section 66 connected, by means of a pin 67 carried by a clevis 68 on the outer end of this rod, with the inner ends of the rod sections 64 and 65 and at its inner end with the anchorage structure 63 as explained of the rod section 37 of Fig. 1, the length of the rod sections 64 and 65 being such that the tie rod structures referred to clear the wall 61.

The sheet piling 60 is associated with struts 69 shown as interposed between the top of the sheet piling 60 and the anchorage structure represented generally at 63 and located between the tension rods referred to of each pair thereof as shown, these struts serving the purpose of the struts as provided in accordance with the preceding figures of the drawings.

Figs. 15 and 16 show a dock wall structure having tie rods provided substantially at the water line in accordance with common practice, the dock wall structure shown having incorporated therein means in accordance with one of the phases of my invention for bracing or strutting the upper edge portion of the sheet piling.

In this construction the sheet piling represented at 70 and which by way of example may be the same as in the construction of the preceding figures of the drawings, is associated with single tie rods 71 connected at the water line with the sheet piling 70 and anchored to anchorage structure 72 as for example of the same construction as the corresponding anchorage structure of the preceding figures of the drawings.

To strut or brace the upper edge of the sheet piling 70, struts, or braces, 73 are interposed between the sheet piling 70 at its upper edge and the anchorage structure 72 and operate as in the case of the struts of the preceding figures of the drawings.

Figs. 17, 18 and 19 represent a breakwater construction embodying both phases of my invention. In this construction two sheet piling structures 74 spaced apart to receive the fill 75 and each shown as constructed of sheet piling sections as in the case of the construction of the preceding figures, are provided, their upper edge portions having wales 76, forming stiffening means, shown in the form of I-beams.

The sheet piling structures 74 are associated with tie rods 77 shown as connected with the sheet piling at a substantial distance below the water line and inclining upwardly toward the opposite sheet piling structure and connected at their upper ends with the wales 76, these tie rods thus extending in intersecting relation thereto as shown.

The tie rods 77 comprise lower sections 78 at the lower ends of which they are pivotally connected at 79 with the sheet piling 74 as in the case of the structures of the preceding figures of the drawings, upper sections 80 connected with the wales 76, and intermediate sections 81 which are connected at their lower ends, as by pivot pins 82, with the upper ends of the rod sections 78, and at their upper ends with the sections 80 by turn buckles represented at 83. Thus provision is made for connecting the tie rods with the sheet piling 74 at an elevation considerably below the level of the water and without requiring the use of a diver.

The upper edges of the sheet piling 74 are braced against inward deflection under the forces exerted against them by the fill 75, by means of struts 84 shown as cross beams, extending from one to the other of the sheet piling structures 74 to which they are connected in any suitable way as through the medium of angle plates 85 connected to the ends of the struts and to the inner flanges of the wales 76.

Under some conditions the struts, when used, may engage the strut piling at a point considerably below the upper edge of the sheet piling, in which case the wales would be secured to the sheet piling section at the elevation at which the outer ends of the struts would be located.

While I have illustrated and described certain particular embodiments of my invention I do not wish to be understood as intending to limit it thereto as the same may be variously modified and altered and the invention embodied in other forms of structure without departing from the spirit of the invention.

What I claim as new, and desire to secure by Letters Patent, is:

1. A wall structure comprising sheet piling, anchored tie rods engaging said sheet piling and formed of sections certain of which are pivotally connected at one end with said sheet piling below the surface of the water for movement downwardly from a substantially vertical position and are of a length less than the distance from their pivots to the top of the piling, and pivoting means connecting said pivotally connected sections with the anchored ones of said sections.

2. A wall structure comprising sheet piling, tie rods associated with said piling, anchorage structure for the tie rods extending adjacent the surface of the water, said tie rods being formed of sections certain of which are pivotally connected at one end to said sheet piling below the surface of the water, and pivoting means connecting said pivotally connected sections with the adjacent ones of said sections and the opposite ends of said tie rods being connected with said anchorage structure adjacent the surface of the water.

3. A wall structure comprising sheet piling, tie rods engaging said sheet piling and formed of sections certain of which are pivotally connected at one end with said sheet piling below the surface of the water for movement downwardly from a substantially vertical position and are of a length no greater than the distance from the points of connection thereof with said sheet piling to the top of said sheet piling, pivoting means connecting said pivotally connected sections with the adjacent ones of said sections and the opposite ends of said tie rods being connected with anchorage structure adjacent the surface of the water, whereby the sections may be connected together without requiring a diver and then straightened to submerged condition of the connection.

4. A wall structure comprising sheet piling, tie rods associated with said piling, anchorage structure for the tie rods extending above the surface of the water, said tie rods being formed of sections certain of which are pivotally connected at one end to said sheet piling below the surface of the water and are of a length not greater than the distance from the points of connection thereof with said sheet piling to the top of said sheet piling, pivoting means connecting said pivotally connected sections with the adjacent ones of said sections and the opposite ends of said tie rods being connected with said anchorage structure adjacent the surface of the water, whereby the sections may be connected together without requiring a diver and then straightened to submerged condition of the connection.

5. A wall structure comprising sheet piling, structure located along the land side of said sheet piling, tension means for tying said sheet piling to said second-referred-to structure and comprising elements pivotally connected with said sheet piling, an anchorage structure, and means connecting said second-referred-to structure with said anchorage structure.

6. A wall structure comprising sheet piling, anchorage means for said sheet piling connected with the latter below its upper edge, and struts engaging said sheet piling above the connections of said means with said sheet piling for resisting inward deflection of the upper portion of said sheet piling under tension produced in said means.

7. A wall structure comprising sheet piling, anchorage structure, means for tying said sheet piling below its upper edge to said anchorage structure, and struts engaging said sheet piling above the connections of said tying means with said sheet piling for resisting inward deflection of the upper portion of said sheet piling under tension produced in said means.

8. A wall structure comprising sheet piling, anchorage means for said sheet piling connected with the latter below its upper edge, and struts engaging said sheet piling substantially at the top of said sheet piling for resisting inward deflection of the upper portion of said sheet piling under tension produced in said means.

9. A wall structure comprising sheet piling, anchorage structure, means for tying said sheet piling below its upper edge to said anchorage structure, and struts engaging said sheet piling substantially at the top of said sheet piling for resisting inward deflection of the upper portion of said sheet piling under tension produced in said means.

10. A wall structure comprising sheet piling, anchorage structure, means for tying said sheet piling below its upper edge to said anchorage structure, and struts engaging said sheet piling above the connections of said tying means with said sheet piling and engaging said anchorage structure for resisting inward deflection of the upper portion of said sheet piling under tension produced in said means.

11. A wall structure comprising sheet piling, anchorage means for said sheet piling connected with the latter substantially below the water level, and struts engaging said sheet piling above the points of connection of said means with said sheet piling resisting inward deflection of the piling under tension produced in said means.

12. A wall structure comprising sheet piling, anchorage means for said sheet piling connected with the latter substantially below the water level, and struts engaging said sheet piling substantially at the top of said sheet piling, resisting inward deflection of the piling under tension produced in said means.

13. A wall structure comprising sheet piling, anchorage structure, means for tying said sheet piling to said anchorage structure and engaging said sheet piling substantially below the water level, and struts engaging said sheet piling above the points of connection of said means with said sheet piling, resisting inward deflection of the piling under tension produced in said means.

14. A wall structure comprising sheet piling, anchorage structure, means for tying said sheet piling to said anchorage structure and engaging said sheet piling substantially below the water level, and struts engaging said sheet piling substantially at the top of said sheet piling, resisting inward deflection of the piling under tension produced in said means.

15. A wall structure comprising spaced apart sheet piling structures for receiving fill therebetween, and anchorage means for said sheet piling structures comprising sectional elements pivotally connected together, one section of each pivotally connected at one end with said sheet piling structures below the surface of the water, said anchorage means inclining upwardly and operatively connected at their upper ends with the opposite sheet piling structure.

16. A wall structure comprising spaced apart sheet piling structures for receiving fill therebetween, and anchorage means for said sheet piling structures comprising tie rods inclining upwardly from said sheet piling structures and operatively connected at their upper ends with the opposite sheet piling structures, said tie rods comprising elements pivotally connected at their

lower ends with said sheet piling structures below the surface of the water for movement downwardly from a substantially vertical position.

17. A wall structure comprising spaced apart sheet piling structures for receiving fill therebetween, anchorage means for said sheet piling structures connected with the latter below the upper ends thereof, and struts engaging said sheet piling structures above the points of connection of said means with said sheet piling structures for resisting inward deflection of the upper portions of said sheet piling structures under tension produced in said means.

18. A wall structure comprising spaced apart sheet piling structures for receiving fill therebetween, and anchorage means for said sheet piling structures comprising tie rods inclining upwardly from said sheet piling structures and operatively connected at their upper ends adjacent the surface of the water with the opposite sheet piling structures, said tie rods each comprising sections pivotally connected together, one section of each tie rod pivotally connected at its lower end below the surface of the water with one of the piling structures.

19. The method consisting in driving sheet piling having a tie rod connected thereto and temporarily in a substantially perpendicular position to a depth with the connection materially below the surface of the water, and from adjacent the surface of the water connecting anchoring means to the upper end of the said tie rod and swinging the latter downwardly from said substantially perpendicular position to operative position.

20. A wall structure comprising sheet piling, tie rods pivotally connected to said piling materially below the surface of the water, said tie rods being carried by said piling in substantially perpendicular position when the latter is driven, and anchoring means to which said tie rods are attached adjacent the surface of the water, the construction thus enabling installation and anchoring without the aid of a diver.

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