Jan. 3, 1961 E. J. QUIRIN 2,966,778

CAISSONS FOR WHARF CONSTRUCTION AND METHOD OF INSTALLING SAME

Filed Sept. 8, 1953 4 Sheets-Sheet 1

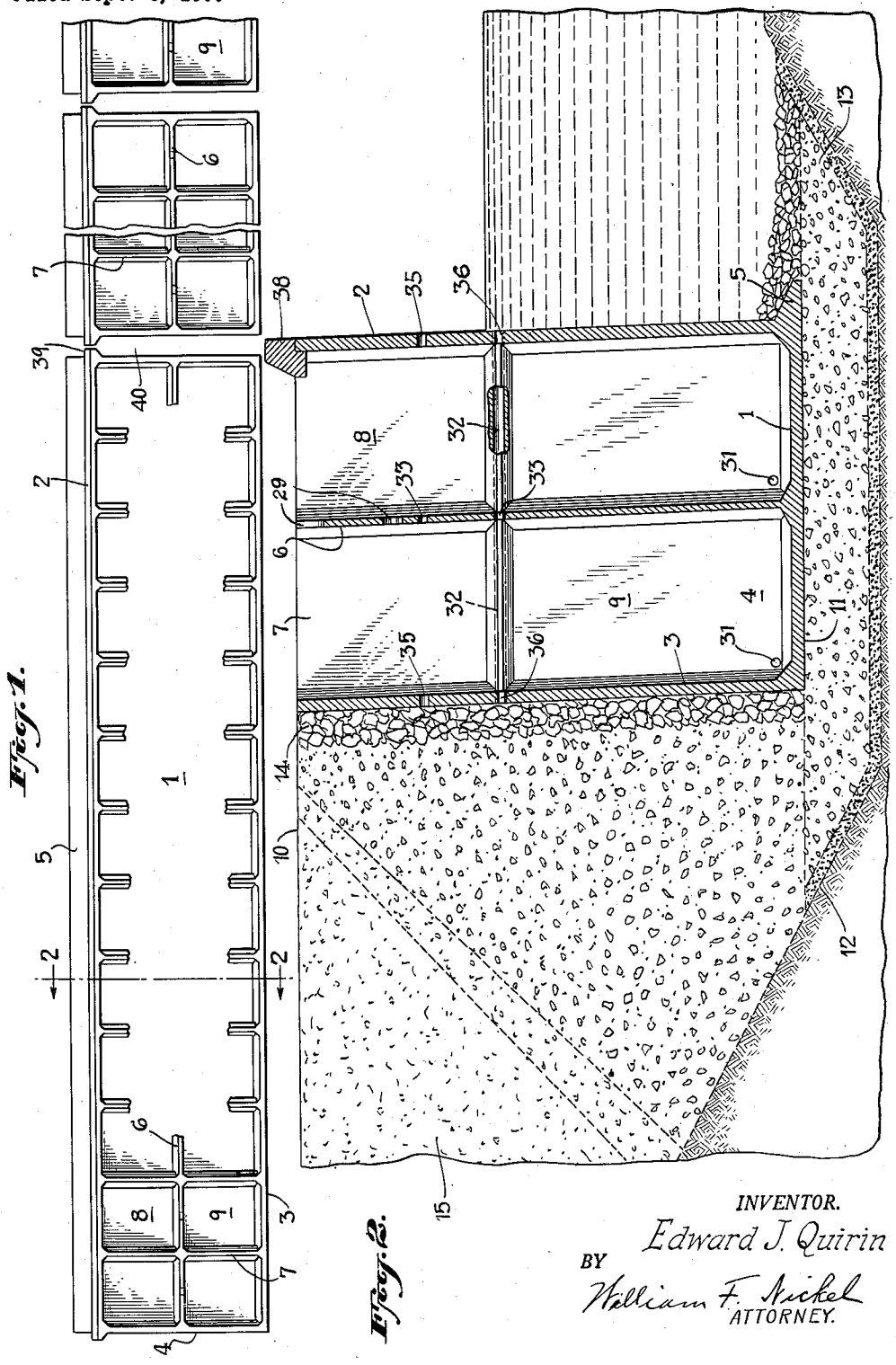


Fig. 1.

Fig. 2.

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CAISSONS FOR WHARF CONSTRUCTION AND METHOD OF INSTALLING SAME

Filed Sept. 8, 1953 4 Sheets-Sheet 2

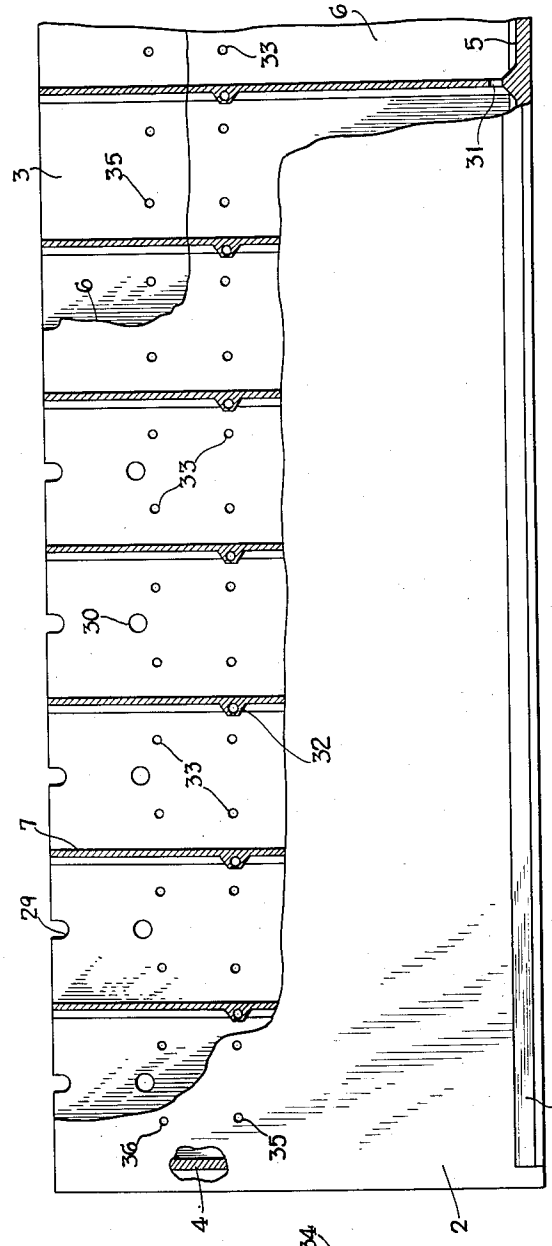


Fig. 3.

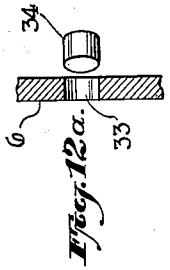


Fig. 12a.

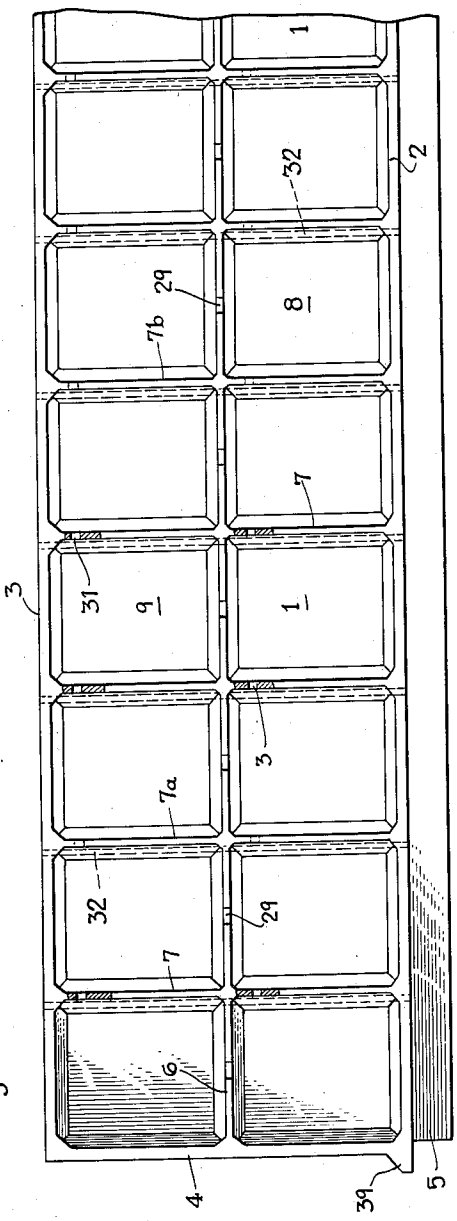


Fig. 4.

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CAISSONS FOR WHARF CONSTRUCTION AND METHOD OF INSTALLING SAME

Filed Sept. 8, 1953 4 Sheets-Sheet 3

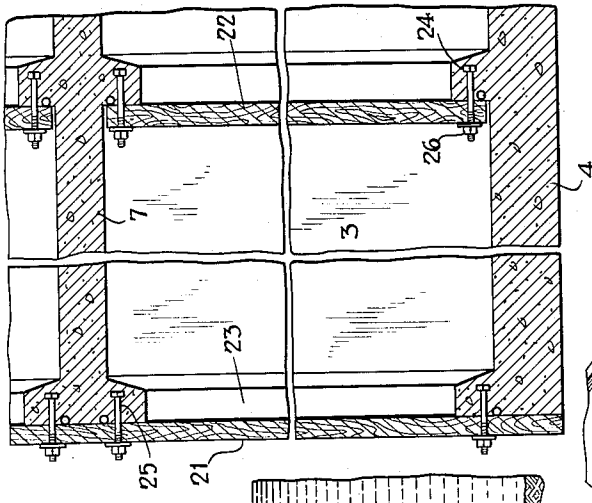


Fig. 6.

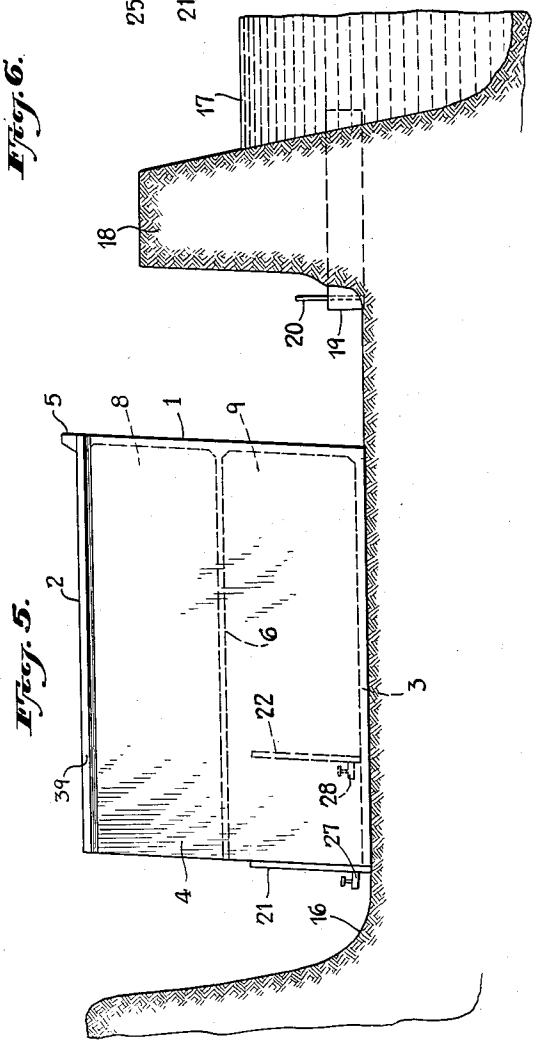


Fig. 5.

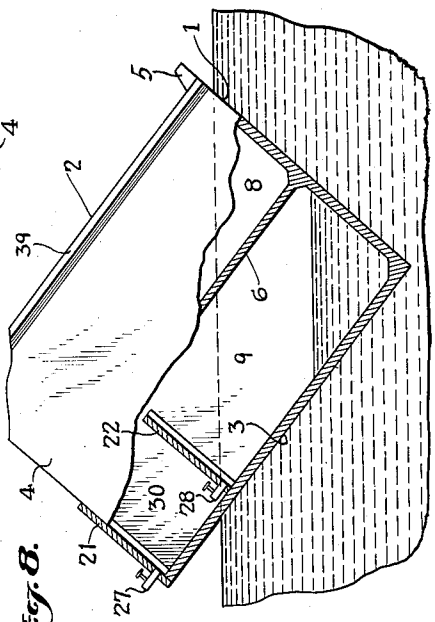


Fig. 8.

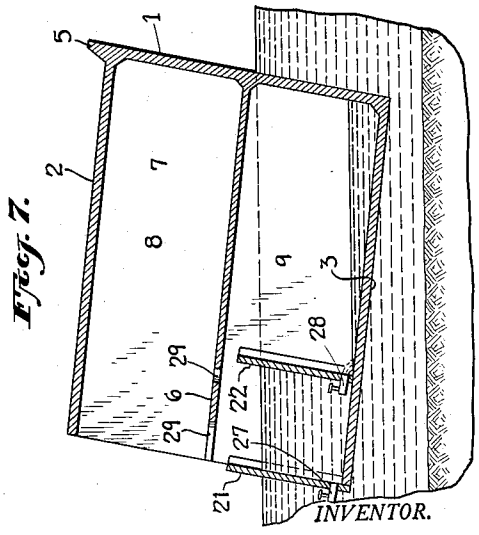


Fig. 7.

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CAISSONS FOR WHARF CONSTRUCTION AND METHOD OF INSTALLING SAME

Filed Sept. 8, 1953 4 Sheets-Sheet 4

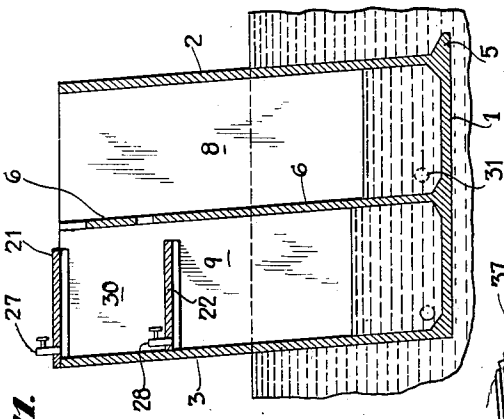


Fig. 11.

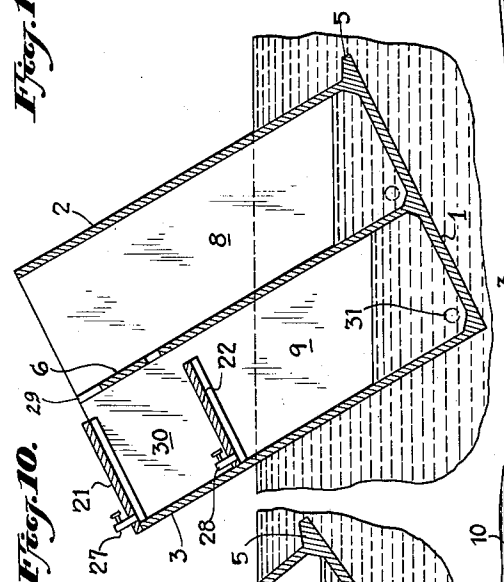


Fig. 10.

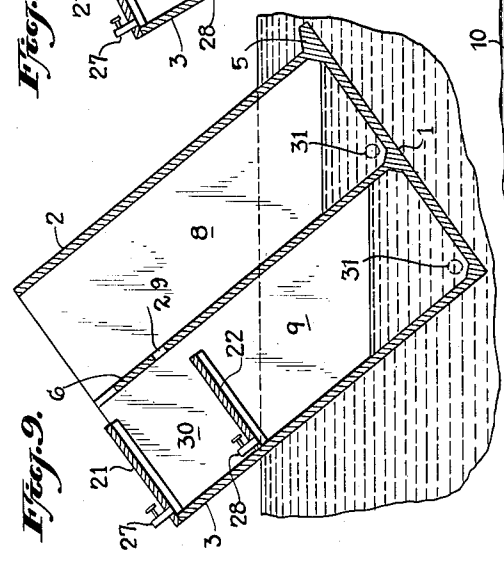


Fig. 9.

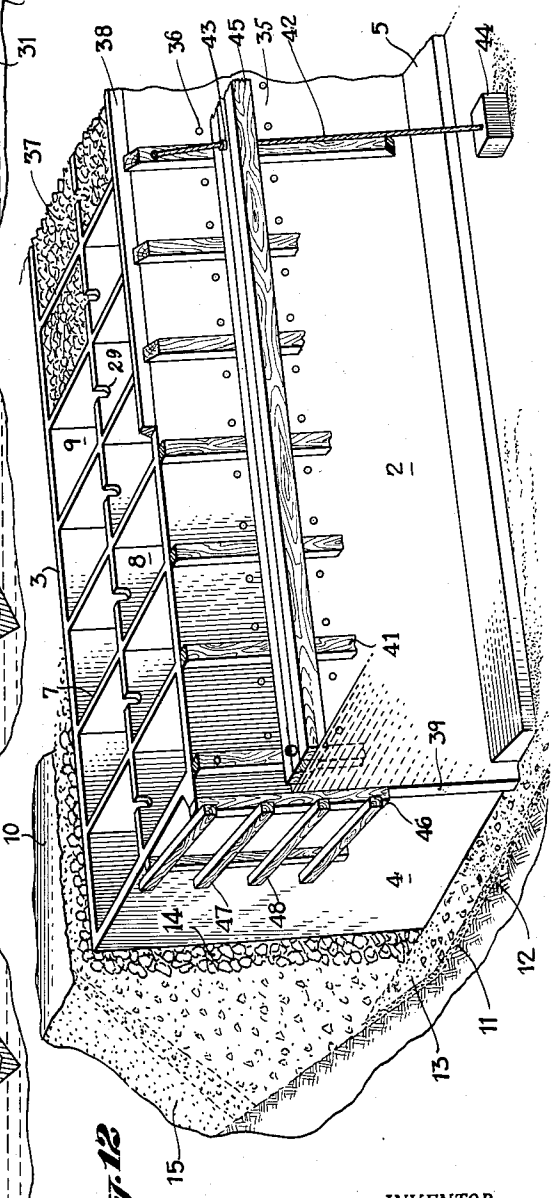


Fig. 12

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United States Patent Office 2,966,778 Patented Jan. 3, 1961

2,966,778

CAISSONS FOR WHARF CONSTRUCTION AND METHOD OF INSTALLING SAME

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Filed Sept. 8, 1953, Ser. No. 378,816

7 Claims. (Cl. 61—46)

This invention is an improvement in waterfront installations; particularly structures to be erected along the shore of a body of water at chosen sites requiring wharves and the like, to facilitate loading and unloading marine vessels.

In localities where there is a great difference between the water level at high and low tide, serious difficulties are encountered in the construction and maintenance of bulkhead wharves alongside of which ships of large draft are to be moored. When, for example, sheet piling is set up along the outer side of a wharf or dock and backed on the land side with earth or rocks, the pressure of the water at flood tide braces the piling and offsets to a large extent the outward horizontal thrust exerted by the weight of any earth fill between the piling and the bank or shore. Such thrust tends to overturn the piling, especially at low tide that is much below high tide, when the opposing water pressure is much diminished. Hence bulging and other distrotion and damage or wrecking of the wharf or pier, in whole or in part, may ensue.

A real problem must therefore be faced; and I have solved it by means of a row of concrete caissons or coffer-dams placed end to end to form a rugged massive retaining wall adjacent the water's edge, ballasted with stone or other heavy and bulky materials to withstand the pressure of the earth fill along the inshore side; while ensuring sufficient draft along the opposite or outer side. The coffer-dams or caissons are built by casting the concrete in shadow tidal basins, getting them afloat with one side under water, flooding them to swing the bottom down and the sides upright and at last moving them to the site; where they are settled upon a prepared bed at the proper depth under the water surface. The caissons or coffer-dams when finally in place are provided with ports or openings for the inflow and outflow of water as the tide rises and falls and will advantageously bear the weight of the earth along the inshore sides, as well as support a suitable top layer to make level areas or a platform for handling cargo.

The nature of the invention and other objects and advantages thereof will appear as the detailed specification proceeds; and the novel characteristics are defined in the appended claims. The improvement comprises both the structure employed and the method of erection, and is fully illustrated in the accompanying drawings. The disclosure, however, is explanatory only and minor alterations in construction and steps of proceeding may be adopted without deviation from the general design or plan which is embodied in the invention.

On said drawings:

Figure 1 is a top plan of part of a line of caissons forming a continuous wharf.

Figure 2 is a vertical cross section of a caisson according to this invention, in ultimate position, taken on line 2—2 of Figure 1.

Figure 3 is an elevation of said caisson viewed from the right of Figure 2.

Figure 4 is a top plan of the caisson of Figure 3.

Figure 5 is a side view of a caisson under construction at a tidal basin.

Figure 6 is a horizontal section of a detail.

Figures 7 to 11, inclusive, are cross sections of such a caisson in various preliminary stages of the setting up operation.

Figure 12 shows in perspective part of installation as it appears when completed; and

Figure 12*a* shows another detail.

As illustrated in Figure 1, the body of the wharf consists mainly of several caissons or coffer-dams arranged end to end along the line of a shore or bank **10**. See Figures 2 and 12. The caissons all have closed bottoms and open tops. They are constructed on the land near the site, floated, flooded with water to keep their open tops uppermost, and moved to the site to be sunk upon the earth under the water; the submerged soil having been previously prepared to receive them.

Each caisson has the over-all shape of an elongated box with closed bottom **1**, deep sides **2** and **3**, and ends **4**. The sides and ends are respectively parallel to each other, with the ends **4** perpendicular to the bottom, but the parallel sides **2** and **3** are canted or tilted in the same direction, so that the angle they make with the bottom are each different from a right angle, as is made clear on Figures 2, 5, 7, 8, 9, 10 and 11. The caissons thus lean backward, so to speak, towards the shore and have greater stability; and the stability is further increased by a long projecting toe or ledge **5** along the outer side **2** at the bottom **1**.

The interior of each caisson has a full length longitudinal partition or bulkhead **6** standing midway of both sides and parallel thereto; and transverse partitions or bulkheads **7** reaching from one side to the other, and parallel to the ends **4**. These partitions all extend up from the bottom to the top of the caisson and divide the interior of the caisson into two long rows of compartments **8** and **9**. When the caissons have been sunk at the site and rest with the bottom **1** on the earth under the water, the compartments are all loaded and filled with rocks which act as ballast, holding the caissons upright and preventing displacement, as long as the ground under them remains firm enough to support their weight. The earth under the water at the site of erection is first scooped or dredged to present a shallow trench or bed **11** near the shore line **10**, as shown in Figures 2 and 12. The trench receives a layer of sand **12** and then is filled level with stone and gravel **13**. The partition **6** is parallel to the sides **2** and **3**.

After the caissons have been correctly located end to end on this bed **11**, the sapec between the inshore sides **3** of the caissons and the bank or shore **10** is filled with stone **14**, piled against the side **3** and other materials **15** back of the layer **14**, till a level stretch of ground is obtained substantially flush with the tops of the caissons; the height of the sides **2** and **3** and the depth of sinking of the caissons being calculated in advance to give this result.

The caissons all have considerable length and when several are disposed end to end at the site, a wharf or pier several hundred feet in length can easily and quickly be constructed. The ballast in the compartments **8** and **9** enables the caissons to withstand the pressure of whatever material is dumped in to fill the space between the land and the sides **3**, and the ledges **5** along the bottom at the outer side **2** help to offset such pressure. With the walls **2** and **3** slanted and the caissons heavy enough, the ledegs **5** can be omitted.

Each caisson is preferably made of reinforced concrete and is built in a shallow tidal basin close to a body

of water but separated from it by a dam or dike along the shore, and pumped out dry. When the basin is flooded later the caisson or coffer-dam is floated out and towed to the chosen site in the manner indicated on Figures 5 to 11 inclusive.

The caissons are cast by pouring concrete into molds put up in the tidal basin **16** near the large body of water **17**. The surface of the basin is excavated to a required depth below the level at high tide of the water **17**, and protected by the dike or dam **18**. This dike has conduits or flumes **19** running through it at the level of the floor of the basin **16**, and each conduit is controlled by a gate valve **20**, so that the basin can be flooded and drained at will. Each caisson is built in the basin with the side **3** prone and the other side **2** above it; the bottom **1** being slanted or tilted slightly and the ends **4** upright. When the bottom, sides and ends have set and hardened, the caisson will be as it appears in Figure 5.

Each caisson needed in the operation is then equipped with temporary bulkheads, disposed parallel to the bottom, and located so as to close in part what will later be the open top of the structure. The temporary bulkheads are indicated at **21** and **22** and extend across the bulkheads **7** and ends **4**. The bulkheads **21** and **22** for each caisson are wide enough to cover most of the distance between the side **3** and long central bulkhead **6**, but terminate short of the bulkhead **6**. Each bulkhead **21** consists of separate lengths or sections, arranged end to end and attached by bolts and nuts or other means in a leakproof manner to the edges of the sides **3** and partitions **7**.

The side **3** of each caisson has internal ribs **23**, and the bulkheads **7** and ends **4** have internal ribs **24**, and the bulkheads **21** and **22** are secured to the ribs by bolts **25** and nuts **26**. As indicated in Figure 6 for the bulkheads **22** the ribs **23** and **24** are located well within the open ends of the compartments **9**, and for the bulkheads **21** the ribs are at the open ends of the compartments; all ribs being of course parallel to the bottom **1**. The temporary bulkheads **21** and **22** thus confine between the cross partition **7** a series of chambers **30**, and these bulkheads **21** and **22** carry valves **27** and **28**, respectively, close to the side **3**. Above each chamber **30** the long middle bulkhead **6** has manholes **29** in the middle of each length between the bulkheads **7**.

The bulkheads **21** and **22** can be provided with gaskets to be compressed against the ribs **23** and **24** and make a water tight fit. When the caisson is to be floated, the valves **20** are opened; and the basin **16** is flooded with water flowing through the conduits **19**. The valves **27** are opened in advance, but the valves **28** in the bulkheads **22** are kept closed. Hence water enters and rises in the chambers **30**; and the weight of the water in the chambers or tanks **30** holds the coffer-dam in horizontal position with the side **2** and ledge **5** uppermost. The draft of the caisson is less than the depth of the water in the basin at high tide; and the caisson can be towed into deeper water; after the dike **18** is breached; and righted, preparatory to towing it to the site and sinking it on the bed **11**.

Some of the transverse bulkheads **7** have ports or holes therein and others are imperforate or without such holes or ports. The latter are indicated at *7a* and *7b*, Figure 4. Each bulkhead *7a* has a single bulkhead **7** between it and the adjacent end **4**. Hence the ends and sides of the caisson and the bulkheads *7a* enclose a group of four compartments **8** and **9** at each end of each caisson; and the bulkhead **7** nearest to each end has ports or openings **31** on each side of the central bulkhead **6**, said ports being near the bottom **1**. One of said ports in the bulkhead **7** is near the side **3**, and the other near the bulkhead **6** and between it and the opposite side **2**. Thus the two compartments **9** of this group between the side **3** and bulkhead **6** are in communication with each other and so are the other two compartments **8** of this group on the other side of the bulkhead **6**. Therefore a single hose line, when the caisson is being swung up or righted, can supply water to the two compartments of this group, or conduct water out, as may be required. The hose is passed into the caisson at the top.

The next imperforate bulkhead *7b* without ports has six compartments between it and the bulkhead *7a*, and the two intervening transverse bulkheads **7** have openings **31** in the same locations as in the bulkhead **7** next to the end **4**. Hence this group has three compartments **8** between the side **2** and bulkhead **6**; and three other compartments **9** between the side **3** and bulkhead **6** similarly connected; and these compartments **8** can also be flooded or evacuated in unison. The total number of compartments and the number in each group can be varied; but each caisson may contain five groups; between the side **2** and bulkhead **6**, one group of two compartments **8** at each end and three groups of three compartments each between the groups at the ends **4**, with the intermediate transverse bulkheads all having openings **31** as above described.

While the building of the caisson is in progress, ladders and other supports, mold forms, etc. are used, and a catwalk is put up along the edge of the middle bulkhead **6**. Bits and cleats, not shown, for mooring and towing lines are attached where needed to the sides at the open ends of the compartments.

The basin is kept closed off from the sea by the temporary dike **18**, and has its floor at the mean lower water level. The average rise of the tide, from mean low to mean high water, is, for example, approximately 20 feet. Thus, with the flume gates **20** opened, it is possible to flood the construction basin with a depth of water to about 20 feet, when the tide is highest.

When the completed caisson is ready for a trial at floating, it is first cleared of all dunnage (forms, scaffolds, debris, rain and curing water), all holes **31** in the transverse bulkheads **7** are cleared of obstructions. These holes are in all the transverse bulkheads, except the four bulkheads *7a* and *7b* which separate the groups of the compartments **8** and **9**.

Two sets of draft gages, not shown, are provided on each of the exterior faces of the ends of the caisson, to aid in determining the list and trim as well as the draft of the caisson when this is afloat. The two sets are so arranged that they will give normal draft readings when the water line is parallel to the sides **2** and **3** or the bottom **1**, or the caisson, respectively.

A depth gage, not shown, is installed in each of the chambers **30**. These gages are set vertically and indicate the depth of water ballast in the tanks. Depth gages, not shown, are also installed in the compartments **8** of the caisson between the side **3** and bulkhead **6**, and four depth gages, not shown, which determine the depth of water in the basin at the various stages of tide are installed near the four corners of the caisson.

Two clinometers, also not shown, with a 90° range, are installed, one on each of the two exterior faces of the ends of the caisson, at the upper corners near the side **2**. The purpose of the clinometers is to establish the transverse list of the caisson when it comes afloat and during the careening or righting stage. Longitudinal trim can only be accomplished after readings taken from the draft gages.

The draft at which the caisson will float freely and the amount of water ballast required to avoid list and trim are estimated, but the actual, correct values of draft and amount of ballast can be determined only when trial is made. The caisson can stay afloat within the flooded basin only while the tide is at or near the high mark. Therefore, the time available for the floating operation during one high tide period is limited. If adjustments of the quantity of water ballast in the chambers **30** must be made in order to correct the list and trim of the caisson, there will not be sufficient time for floating and towing

the caisson out of the basin, all during one high tide. If, instead, the correct amount of ballast is pre-determined during a previous trial, the floating operation will be expedited considerably.

At low tide, then the gates **20** in the dike flumes **19** are opened. The valves **28** in bulkhead **22** are closed, those in bulkhead **21** are open. Thus, as the tide rises, the water level will rise equally and simultaneously in the whole tidal basin **16** and water enters the ballast holds or chambers **30** of the caisson. During this time men on rafts are stationed at the four corners of the caisson so that they will be able to read at intervals the caisson's draft gages and the basin's depth gages. Men, also on rafts, are stationed in the ballast tanks, to read the ballast depth gages.

When the reported water level in the ballast tanks or chambers **30** reaches three-quarters (¾) or so of the estimated final level, the valves **27** in the long bulkhead **21** are closed so that no more water will enter the ballast tanks **30**. As the tide rises further, the water depth in the basin will gradually approach the level at which it is estimated that the caisson will be buoyed up fully. By this time all mooring lines must be in place, but with a reasonable amount of slack. At a certain moment the lower horizontal side of the caisson will begin to rise from the floor of the basin; due to the fact that bottom and adjacent parts are heavier, the corner between the bottom **1** and side **2** will remain aground. More water is now allowed to enter the ballast tanks **30** by opening and regulating the valves **27** in the bulkheads **21**, so that the angle of list, read from the clinometers, will never exceed 1 to 2 degrees, corresponding to 1 to 2 feet difference in the readings of the draft gauges on the outside of the ends **3**. Thus, when said corner is lifted from the floor of the basin, and the caisson is fully waterborne, there should be a small list or difference in draft between the parts of the caisson at the left in Figure 5 and the parts along the bottom **1**, of the caisson, the latter being the lower. The reason for this list is that the amount of ballast water introduced so far in the tanks **30** is not yet sufficient to counterbalance completely the heavier weight of the bottom and adjacent parts. By close regulation of the valves **27** in the bulkhead **21**, enough additional water is then allowed to enter the tanks **30** so as to reduce the list. When the clinometer indicates 0° and the draft readings are equal, the valves **27** and **28** are closed.

Due to the shape and length of the caisson, there should not be any appreciable list from one end **4** to the other end. However, draft headings must be taken at both ends and, if they should indicate a difference greater than a few inches, the necessary adjustments in the ballast will have to be made.

With the caisson floating evenly, the water depth in all the tanks **30** and the outside draft are read accurately from the respective gages and are then recorded.

As the tide recedes, the caisson will again come to rest on the basin floor. However, if bulkheads **21** and **22** are reasonably leak-proof, the water is retained in the tanks **30**. This is done to avoid the necessity of re-gaging and re-adjusting that water when the caisson is to be towed out of the basin.

Next, the portion of the dike **18** to be used as outlet is breached, all the way down to the basin floor level, during periods of low tide. With the basin open to the body of water **17**, thus the caisson will alternately float and settle with the variations of the tide, but, being still correctly ballasted, it will always maintain its horizontal position. At the selected high tide, the caisson is towed out of the basin through the dike's breach and is moored in a convenient location until all preparations for the careening or righting operations are completed. The pumping equipment required for righting operation is made ready on rafts. A site is selected where there are not less than about 40 feet at low tide; and on a fairly calm day, the caisson is towed to the site and moored there by its two ends, with plenty of room and sufficient slack so as to permit the free rotation of the caisson during careening. The rafts carrying the pumping equipment are moored along the length of the caisson, at the open ends of the compartments **8**. Men are stationed, on the caisson, adjacent the manholes **29**, through which, by means of rods, they can operate the valves **28** on the inner bulkheads **22**. Temporary scaffolds or platforms are erected on the caisson to permit men to work safely at any angle within range covered by the careening.

When everything is ready, the valves **28** on the bulkheads **22** are opened and the water in the chambers **30** is allowed to flow past these bulkheads toward the bottom **1** of the caisson. Hence, the caisson will gradually rotate about a longitudinal axis. See Figure 7. It is estimated that, with the valves **28** fully open, it will take over ½ hour to turn the caisson through approximately 34°.

In the succeeding phase the pumps are set in motion and, through hoses, water is pumped into the compartments **8** of the caisson between the side **2** and bulkhead **6**. The water must be introduced uniformly into the groups of compartments **8** all along the length of the caisson, so that no longitudinal list or strain in the structure of the caisson will be created. Readings taken from the depth gages in the various compartments **8** will be the guide and the water will be regulated accordingly. As the compartments **8** of each group are in communication through the ports **31**, only one hose line for each group of such compartments **8**, or five lines in all, instead of a separate line for each requirement, is required.

The caisson thus swings successively through varying angles of tilt or list, as shown by Figures 8 to 11 inclusive. All through the stage of careening or righting to put the bottom **1** under the water, the clinometers on the two end faces of the caisson are watched and will indicate when the operation is completed. The draft gauges, now vertical at the four corners of the caisson, will give equal readings. The water in the compartments **9** along the side **3** will be somewhat deeper than in the compartments **8** along the side **2**.

The caisson can now be towed back to any convenient point and moored while preparations are made for sinking it at the shore line **10**.

In preparation for sinking the caissons at the site of the wharf, a catwalk is constructed along the outer face of the side **2** at the top, another along the face of the bulkhead **6** at the top, and several along the tops of the bulkheads **7**. These catwalks need not be shown. The bulkhead **21** also serves as a working platform above the side **3**. The caisson are towed to the shore line **10** and submerged so that they stand on the bed **11** with the bottoms **1** perfectly horizontal. Several trials with each casson may be necessary, water being pumped in and out of the compartments **8** and **9** to lift and settle the caisson till correct position is attained. During this stage outside water can flow free through the caissons from the outer side **2** to the inboard side **3** through ducts **32**, built into the transverse bulkheads **7**, just below the low tide level, the ends of these ducts in the sides **2** and **3** being open. Thus the water is maintained at the same level along the side **2** and **3** during the settling operation, and disturbance of the stability of the caissons is prevented.

When the sinking of the caissons has been satisfactorily performed by pumping water into the compartments **8** and **9** to the required depth, holes **33** in two horizontal rows are opened in the bulkhead **6**, two in each horizontal row of holes being between each two adjacent bulkheads **7**. These holes are formed in place when the caissons are built but are kept closed by plugs **34**. The upper row of holes **33** are just below the high water level and the lower row just under low tide level adjacent the conduit **32**. These holes are opened at low tide by men in boats or on rafts who knock out the plugs **34**. The upper and lower holes are matched by

upper and lower holes 35 and 36 at the same levels in the sides 2 and 3, which are also opened by removing the same kind of plugs 34. The water can now rise and fall with the tide in all the caissons, which are then filled from bottom to the tops with rock ballast 37 in the compartments 8 and 9, and the fill 14 and 15 is heaped in between the shore and the side 3. A coping wall 38 is cast along the top of the side 2 and earth is laid on the caissons and fill to make a smooth top surface. The adjacent ends of the caissons have vertical flanges 39 approaching each other and the space 40 between said ends is filled with rocks like the rocks 14.

To finish the wharf, vertical fenders 41 are attached to the outer wall 2 of each caisson by bolts embedded in the concrete. The fenders are all in line with the bulkheads 7, and to each fender near the top a steel cable 42 is affixed. The lower ends of these cables are anchored to concrete blocks 44 in the bed 11. Along the front of each caisson runs a floating fender 45 of wooden beams, with sleeves 43 through which the cables pass. The fenders are free to rise and fall with the tide but are kept in place at the water line by the cables 42. At the opposite ends of the entire wharf, the caissons have vertical beams 46 and 47, the former secured to the end flanges 39, and these beams are joined by horizontal wales 48 extending from the top down to low tide level to protect the ends of the wharf against vessels, barges or lighters that might bump against the ends.

Having described my invention, what I believe to be new is:

1. A caisson having closed bottom, sides and ends and an open top, a central longitudinal bulkhead extending between the ends, and transverse bulkheads extending between the sides and intersecting the longitudinal bulkhead, said transverse bulkheads and the longitudinal bulkhead dividing the interior of the caisson into compartments between said longitudinal bulkhead and said sides, some of said transverse bulkheads being imperforate and having one or more of the other transverse bulkheads and a group of said compartments between them and sealing the compartments of said group from the remaining compartments, the transverse bulkheads between said imperforate bulkheads having openings putting all the compartments of each group on one side of the central bulkhead into communication with one another, said openings being adjacent a side of the caisson for the compartments between the central bulkhead and said side, and adjacent the central bulkhead for the remaining compartments of the group between the central bulkhead and the opposite side.

2. A caisson having closed bottom, sides and ends and an open top, a central longitudinal bulkhead extending between the ends, and transverse bulkheads extending between the sides and intersecting the longitudinal bulkhead, said transverse bulkheads and the longitudinal bulkhead dividing the interior of the caisson into compartments between said longitudinal bulkhead and said sides, some of said transverse bulkheads being imperforate and having one or more of the other transverse bulkheads and a group of said compartments between them and sealing the compartments of said group from the remaining compartments, the transverse bulkheads between said imperforate bulkheads having openings putting all the compartments of each group one one side of the central bulkhead into communication with one another, said openings being adjacent a side of the caisson for the compartments between the central bulkhead and said side, and adjacent the central bulkhead for the remaining compartments of the group between the central bulkhead and the opposite side, the transverse bulkheads carrying ducts that are parallel to the bottom and pass through the longitudinal bulkhead, said ducts having both ends open in the sides of the caisson.

3. A caisson having closed bottom, sides and ends and an open top, a central longitudinal bulkhead extending between the ends, and transverse bulkheads extending between the sides and intersecting the longitudinal bulkhead, said transverse bulkheads and the longitudinal bulkhead dividing the interior of the caisson into compartments between said longitudinal bulkhead and said sides, some of said transverse bulkheads being imperforate and having one or more of the other transverse bulkheads and a group of said compartments between them and sealing the compartments of said group from the remaining compartments, the transverse bulkheads between said imperforate bulkheads having openings putting all the compartments of each group one one side of the central bulkhead into communication with one another, said openings being adjacent a side of the caisson for the compartments between the central bulkhead and said side, and adjacent the central bulkhead for the remaining compartments of the group between the central bulkhead and the opposite side, the transverse bulkheads carrying ducts that are parallel to the bottom and pass through the longitudinal bulkhead, said ducts having both ends open in the sides of the caisson, said caisson having a row of horizontal openings below the top in each side and in the central bulkhead and another row of horizontal openings below the first named row in each side and in the central bulkhead, the openings in both rows being between transverse bulkheads.

4. A caisson having closed bottom, sides and ends and an open top, a central longitudinal bulkhead extending between the ends, and transverse bulkheads extending between the sides and intersecting the longitudinal bulkhead, said transverse bulkheads and the longitudinal bulkhead dividing the interior of the caisson into compartments between said longitudinal bulkhead and said sides, some of said transverse bulkheads being imperforate and having one or more of the other transverse bulkheads and a group of said compartments between them and sealing the compartments of said group from the remaining compartments, the transverse bulkheads between said imperforate bulkheads having openings putting all the compartments of each group on one side of the central bulkhead into communication with one another, said openings being adjacent a side of the caisson for the compartments between the central bulkhead and said side, and adjacent the central bulkhead for the remaining compartments of the group between the central bulkhead and the opposite side, the transverse bulkheads carrying ducts that are parallel to the bottom and pass through the longitudinal bulkhead, said ducts having both ends open in the sides of the caisson, said caisson having a row of horizontal openings below the top in each side and in the central bulkhead and another row of horizontal openings below the first named row in each side and in the central bulkhead, the openings in both rows being between transverse bulkheads, said rows when the caisson is sunk and stands on the earth beneath a body of water being respectively below the high tide level and low tide level of said water.

5. The method of constructing a wharf which consists in building a caisson in position with both sides thereof horizontal and one below the other, and the bottom vertical, creating a temporary hold within said caisson along the lower side and remote from the bottom, filling said hold to balance the weight of the bottom, floating said caisson with said lower side submerged, evacuating said hold and weighting the caisson to turn it upright with the bottom lowermost, floating said caisson to the shore line of a body of water and sinking it there till it rests on the bottom under said water, and ballasting and anchoring the caisson to retain it in place.

6. A wharf comprising caissons disposed end to end at the shore line of a body of water, said caissons having sides tilted toward said shore line, rock ballast filling said caissons, rocks piled on the inshore sides of said caissons, and a fill of materials between said piled rocks and said shore line, said caissons each having two horizon-

tal rows of openings in the opposite sides, one row below the high tide level of the water and the other row below the low tide level thereof.

7. A wharf comprising caissons disposed end to end at the shore line of a body of water, said caissons having sides tilted toward said shore line, rock ballast filling said caissons, rocks piled on the inshore sides of said caissons, and a fill of materials between said piled rocks and said shore line, said caissons each having two horizontal rows of openings in the opposite sides, one row below the high tide level of the water and the other row below the low tide level thereof, said caissons each having a projecting ledge from the outer side at the level of the bottom thereof.

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