Dec. 14, 1937. J. B. BROCKHURST 2,102,254

METHOD AND APPARATUS FOR BUILDING SEA WALLS

Filed May 21, 1934 3 Sheets-Sheet 1

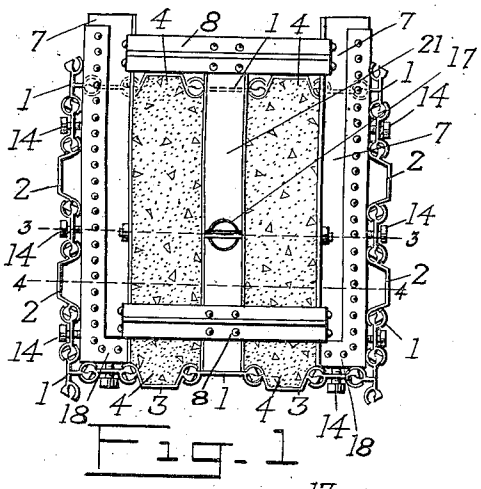


Fig. 1

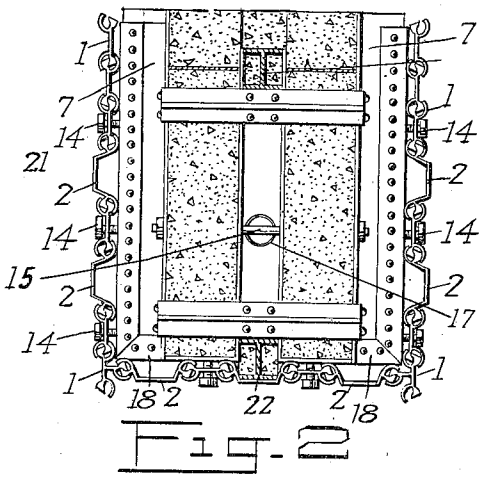


Fig. 2

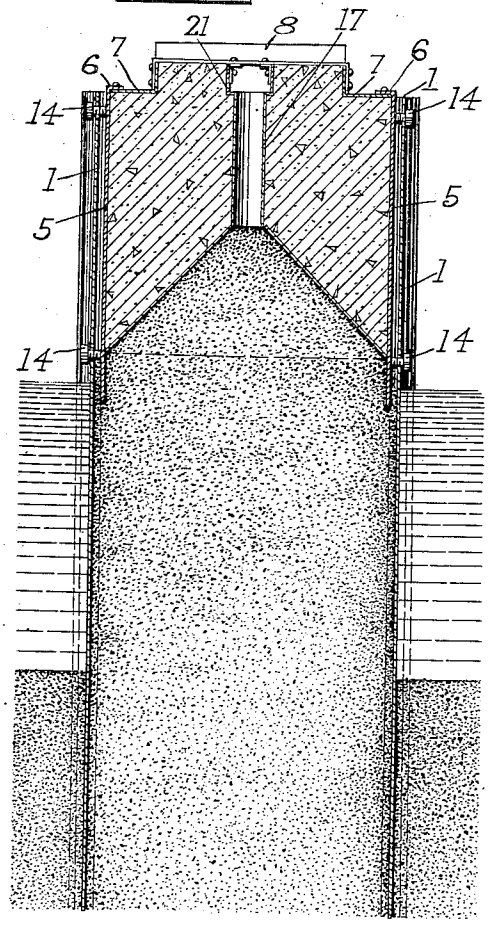


Fig. 3

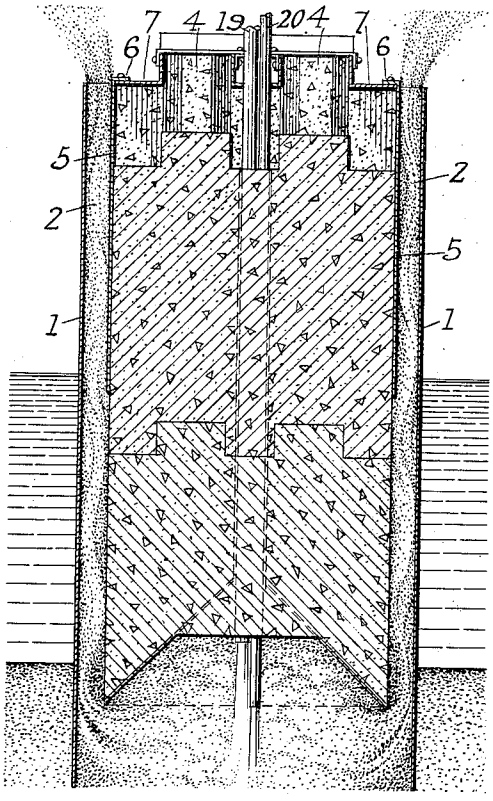


Fig. 4

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METHOD AND APPARATUS FOR BUILDING SEA WALLS

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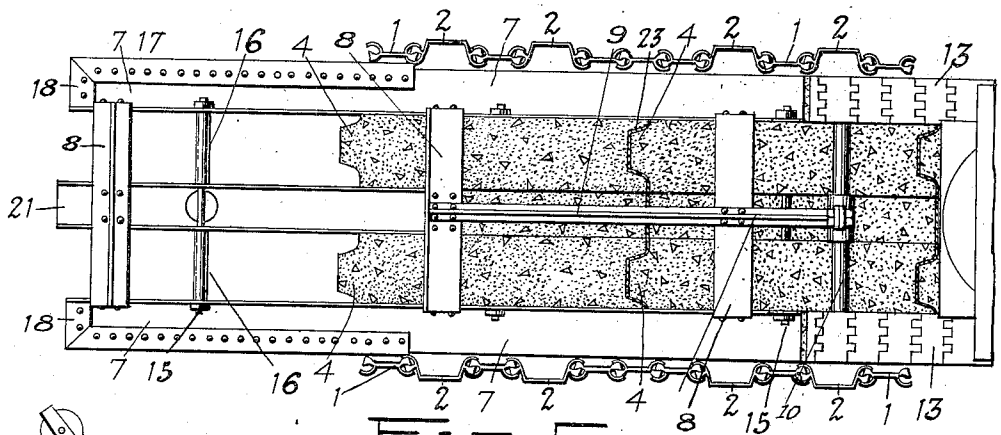


Fig. 5

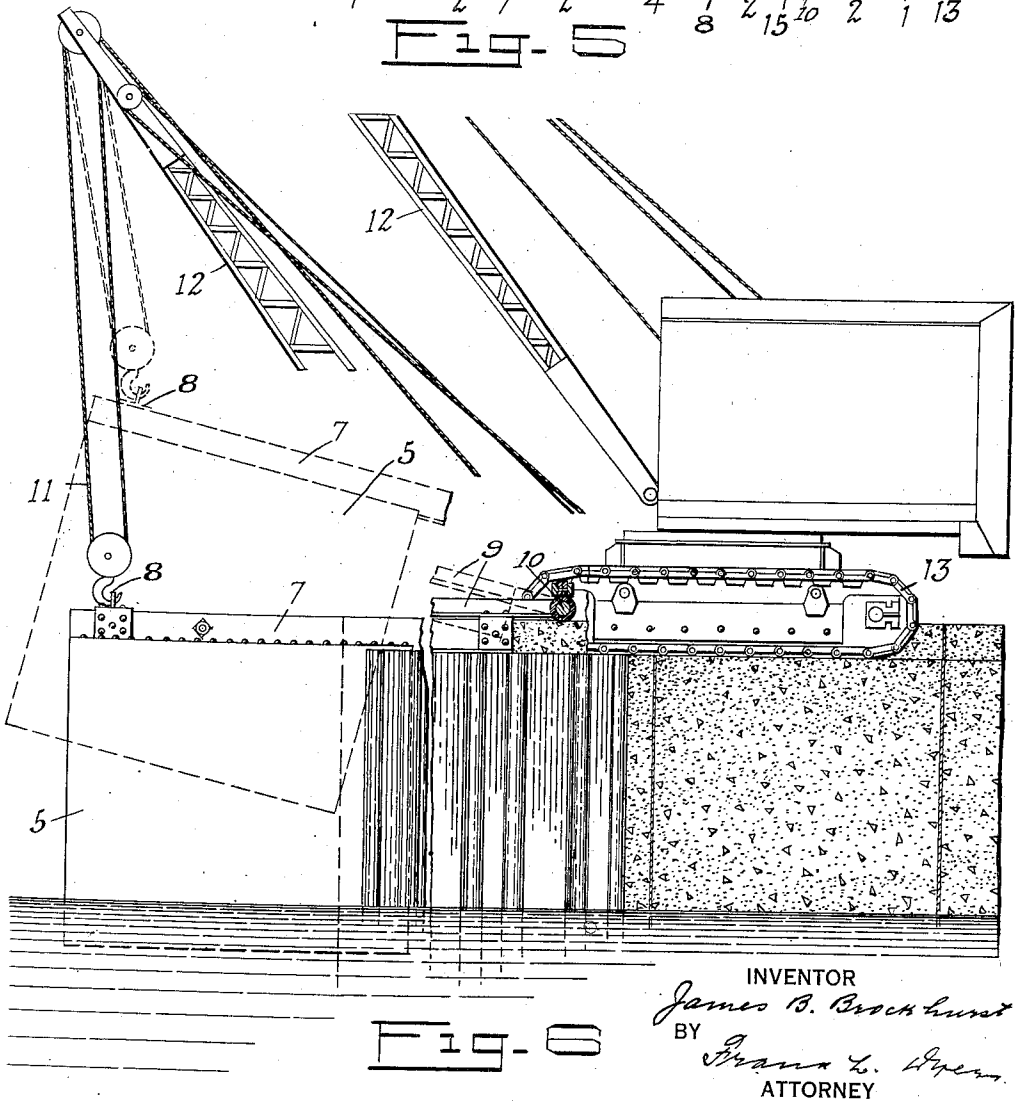


Fig. 6

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METHOD AND APPARATUS FOR BUILDING SEA WALLS

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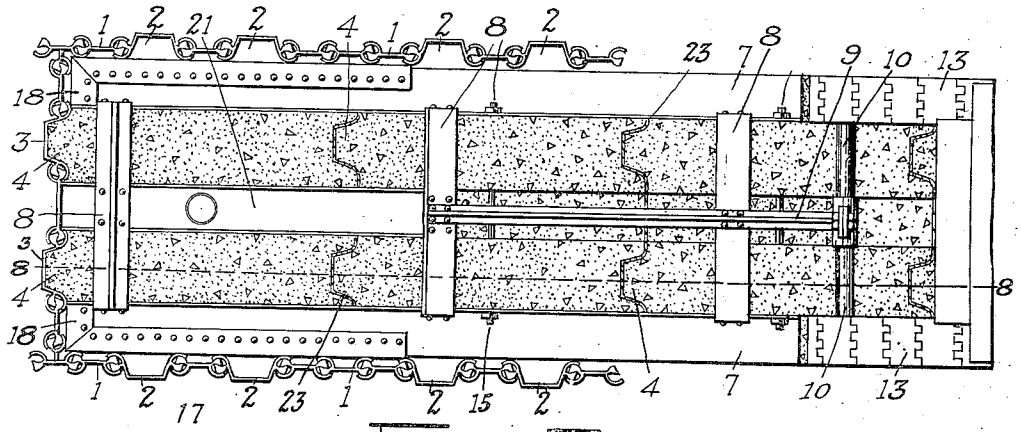


Fig. 7

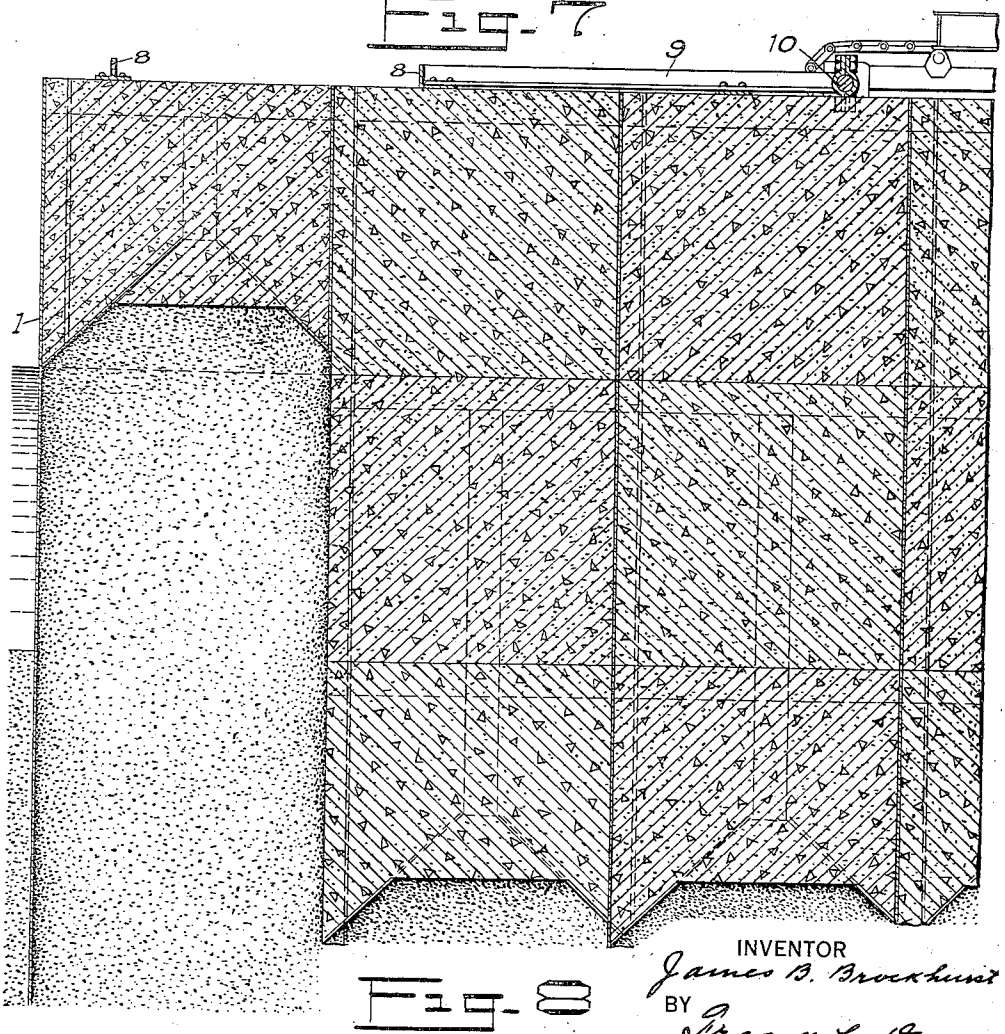


Fig. 8

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UNITED STATES PATENT OFFICE

2,102,254

METHOD AND APPARATUS FOR BUILDING SEA WALLS

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Application May 21, 1934, Serial No. 727,449

16 Claims. (Cl. 61—52)

My invention relates to improvements in method and apparatus for building sea walls and the like, such as breakwaters, groins, abutments, piers and other massive structures and foundations for said structures. These usually extend from the shore or sea line into progressively deeper water, although in the building of an abutment or pier for a bridge, for example, the entire massive structure will be located beyond and outside of the shore line.

Generically the method to be hereinafter described and claimed is disclosed in Letters Patent, dated May 22, 1934, No. 1,959,812.

The essential object of my invention is to provide a method and apparatus by which a sea wall or other massive structure of concrete blocks of great size and weight may be progressively built downward from above the water said blocks being arranged in vertical tiers extending vertically from a datum line sufficiently far below the bottom as to secure a fixed support to such a distance above the water level as may be required in the particular case. These vertical tiers are arranged continuously end to end with interlocking joints against displacement both vertically and horizontally, whereby the resulting structure is practically as strong as if it were monolithic.

In carrying my invention into effect, I propose first to construct a coffer dam preferably of interlocking steel sheet piling, said coffer dam extending to a datum line a sufficient distance below the bottom as to prevent undermining as will be presently explained. I then locate within this coffer dam a suitable form designed to produce a concrete block of massive size. The dimensions of these blocks depend upon the special conditions and the forces to which the structure as a whole is to be subjected. Ordinarily I propose to make these blocks in the form of cubes varying from six feet to nine feet or more in size. When greater speed of building is required, the blocks may be made longer and higher whereby fewer blocks are required for a given length and depth, and delays due to seasoning a greater number of blocks avoided. The molds or forms in which these massive concrete blocks are cast may comprise the side walls, preferably of sheet metal, and one or both end walls composed of sections of the steel sheet piling constituting a portion of the coffer dam. After the initial tier of massive blocks has been placed, the mold or form for the succeeding tier may be constituted of a front wall consisting for the most part of said sheet steel piling and a rear wall presented by the preceding tier of concrete blocks or rather a sheet or layer of elastic water proof material applied to said preceding tier.

Outside of the mold or form and at the sides thereof, the coffer dam will present vertical discharge channels through which sand, gravel or other detritus may be ejected to permit the lowering of a block when the same has set as will be described.

The vertical dimensions of the side walls of the form or mold will be several inches greater than the height of the concrete block to be cast therein.

In forming the first tier of blocks, a coffer dam will be first erected extending a sufficient distance below the surface and ordinarily above the water line. This coffer dam will extend upwardly to a height corresponding substantially to that of the proposed structure and will contain in its upper part a form or mold corresponding to the first block to be cast, said form or mold being composed in part of the steel sheet piling or other elements of which the coffer dam is built.

I now partially fill the coffer dam with sand, to a point within the form or mold and arrange this sand preferably in the form of a truncated cone, whereby the concrete block cast thereon will be formed with an inversely shaped cavity on its under side outlined with sharp shearing bottom edges. I now place within the form or mold and in contact with the truncated face of the sand, a tube or pipe of metal or other suitable material sufficiently large to permit of the removal of sand or other detritus therethrough as will be further explained and to receive water and air pipes to be used in a subsequent operation. Thereupon I cast within the form or mold a mass of concrete which when set will be formed with interlocking top and front faces and with a recessed bottom provided with sharp shearing edges whereby the initial massive block of a tier is placed above its ultimate position in the sea bottom within the coffer dam in the above described manner.

After the concrete has set and is sufficiently hard it then becomes necessary to lower the block. This is effected by introducing water and compressed air pipes within the central tube above referred to and forcing water and air, under pressure into the body of sand below the block. The combined action of the water and air causes the sand to be blown out under the bottom of the side edges of the mold or form and up and out through the discharge channels at the side between said mold or form and the coffer dam or up and out through the central vertical opening. This removal of the sand causes the concrete

block to slowly descend by gravity until its upper face has reached a point, say, twelve inches above the lower edges of the side walls of the form or mold whereby the material beneath a block is displaced.

The front and rear faces of the coffer dam or the front face of the coffer dam and the rear interlocking sections of the preceding tier of blocks, as the case may be, act as guides for the descending block, whereby a block is guidingly secured above its ultimate position in the sea bottom. The foregoing operations may be reversed, that is to say, water and air pipes may be introduced within the discharge channels of the coffer dam at one side and the sand ejected through the discharge channels at the other side and the central vertical opening. When a very massive block is to be lowered to a depth too great for the removal of the material beneath by air and water pressure the vertical central passage may be increased in size to permit the operation of a clam shell bucket for removal of said detritus.

The upper face of the first block which has thus been lowered constitutes the bottom of the form or mold for the next block. This is molded in the same way preferably with a central tube therein for the passage of the water and air pipes and the removal of the detritus therethrough. Being cast directly upon the first block and with an interlocking joint between the two blocks, a bond will be secured between both blocks to supplement the bonding effect due to gravity and the interlock between them. After the second block has set and is sufficiently hard both blocks are lowered by streams of water and compressed air blowing out a further amount of sand from beneath the first block.

In this operation it will be understood that exhaust channels below the side walls of the mold will be formed between the coffer dam and the descending blocks. After the second block has been cast and lowered with its interlocking upper face, the third block is cast and all three blocks are then further lowered in the same way. These successive operations are continued until the first tier has been completed, with the lowermost block sufficiently below the surface as to receive rigid support, whereby a massive concrete tier is built progressively downward by adding concrete above and displacing the material beneath the bottom of the tier. The central vertical opening and concave bottom are now filled with concrete according to well known practice.

It now becomes necessary to erect the second tier of blocks in advance of the first tier. This is done by extending the coffer dam outwardly a sufficient distance to accommodate the second tier of blocks, the sides of the form or mold being also advanced outwardly to provide for the casting of the successive blocks constituting the second tier. In casting the blocks of the second and succeeding tiers the rear face of the mold or form will be formed by the outer face of the preceding uppermost block or rather this face of the mold will be formed preferably of a sheet of elastic impregnated material which is made use of in order to permit the blocks to descend by gravity. Without this added material the blocks of the second and successive tiers might fail to descend due to the bonding effect. My Patent No. 1,959,812 shows a precast block guidingly secured above its ultimate position in the sea bottom and further shows how the material beneath the block is displaced as the block is lowered.

When precast blocks are used as shown in said patent the massive blocks are placed in position substantially above their ultimate position in the sea bottom. The said blocks may be provided with a face of elastic material affixed to the side of the block and positioned against the face of the next preceding top block, and the said block may be shaped with a hollow conical bottom provided with sharp shearing edges and vertical central opening and lowered according to the present method or the method described in said patent may be employed for this purpose. When the depth of water is too great to permit of the use of a coffer dam the blocks may be cast in a form buoyed up by pneumatic caissons and lowered guidingly. The size of the form must necessarily be built higher as the mass is progressively lowered and the capacity of such pneumatic caissons must be progressively increased to conform with the increased weight of the tier.

For handling of the mold or form and for shifting and placing the coffer dam to effect the progressive growth of the massive structure, I make use of an apparatus of the type disclosed in my patent above referred to.

Said apparatus may also be equipped with a suitable pump preferably of the rotary type for supplying large quantities of water under sufficient pressure and also with a suitable air compressor.

When building a wall as shown in said patent the mold or form may be omitted and the precast block placed in position directly upon the sand within the coffer dam and lowered into the bottom according to the present method.

In order that the invention may be better understood attention is directed to the accompanying drawings forming a part of this specification and in which

Figure 1 is a top view showing the coffer dam with mold sections therein for forming the blocks of the initial tier.

Figure 2 is a plan view of showing a part of the coffer dam and illustrating a modified arrangement in which piles are used to secure additional support.

Figure 3 is a section on the line 3—3 of Figure 1 illustrating the formation of the lowermost block in any of the tiers previous to the lowering of the same.

Figure 4 is a section on the line 4—4 of Figure 1 showing two blocks being lowered in place and illustrating also the portion of the uppermost block of the preceding tier.

Figure 5 is an elevation showing the top of two tiers and a portion of the third tier, with the mold or form in position for forming an added tier of blocks but showing the coffer dam incompleted. Fragmentary parts of the movable apparatus are also shown in this view. This figure shows the form advanced in position, acting as a guide for pumping in the steel sections of the coffer dam.

Figure 6 is a side elevation of the parts shown in Figure 5, showing only a portion of one side of the coffer dam, illustrating in dotted lines the raising of the mold or form and in full lines the lowering of the mold or form to its new position. This figure shows how the metal plates of the form are advanced and positioned.

Figure 7 is a view somewhat similar to Figure 5 except that the coffer dam is shown complete and illustrating also a block in the outer tier. This figure shows the coffer dam pumped in

around the form and further shows a block cast within the form.

Figure 8 is a vertical sectional view on the line 8—8 of Figure 7. This figure shows the interlocking extensions of the preceding blocks and the front channels of the coffer dam performing the functions of guiding and maintaining means for lowering a block.

In all the above views corresponding parts are represented by the same numerals of reference.

Referring first to Figures 1 and 3, a coffer dam 1 is shown as extending all around the concrete blocks which are to constitute the initial tier of blocks. Preferably this coffer dam is made of interlocking steel sheet piling of a type well known, driven down to any depth below the surface as shown for example in Figure 3. The placing of this piling can be done in any suitable way.

For instance, the movable apparatus shown particularly in Figure 6 and which crawls along the top of the completed structure as will be presently explained may be equipped with suitable mechanisms by which the piling constituting the coffer dam may be placed in position or removed and shifted to a new position.

Some of the sections of the coffer dam are in the form of channels 2—2 and 3—3. The former channels 2—2 are located at the sides and constitute discharge ducts as clearly shown in Figure 4. The other channels 3—3 are at the ends and result in the formation of interlocking protuberances 4—4 on the front and rear faces of the concrete block.

Mounted within the coffer dam are plates 5—5 which constitute the sides of the mold or form. These plates are bent over at 6 and each plate is riveted as shown to a heavy angle iron 7. The angle irons 7 rest upon the upper faces of several of the preceding blocks and extend beyond this structure to form a space in which the next succeeding tier of blocks is to be made and lowered as shown particularly in Figures 5 and 7. The angles 7—7 are connected at suitable points by cross pieces 8—8 and the whole structure, namely, sides 5, the angles 7 and the cross pieces 8—8, is pivotally connected by a heavy bar 9 to a shaft 10 of the movable apparatus.

By attaching a cable 11 to one of the cross pieces 8, a crane 12 carried by the movable apparatus may elevate the parts 5, 7 and 8 to the inclined position shown in Figure 6 after which the apparatus is moved or crawls along on top of the structure, to lower the form sides 5 to the new position shown in Figure 6. The apparatus makes use of endless chain treads 13 by which the apparatus is supported on the structure and driven along on top of the same substantially in the way disclosed in my patent above referred to.

Bolts 14—14 pass through certain sections of the coffer dam and may be tightened against the side walls 5—5 of the mold, whereby the mold is vertically aligned. When the mold is to be removed after the final block of a tier has been finished these bolts are eased off so as to relieve pressure between the mold and the block, and thus permit the mold to be readily moved to its new position. Tie bolts 15 are passed through metal tubes 16 carried in the top block of a tier of blocks and also through the vertical flanges of the angles 7. When the apparatus is to be moved forward to start a new tier of blocks, the several tie bolts 15 are moved into the holes next in advance, thereby determining exactly how far forward the mold is to be moved in order to form the blocks of the new tier. Extending down within the mold is a tube 17 with its top end within a channel 21 and its bottom end resting upon the sands as shown in Figure 3.

As shown at Figures 1, 2, 6, and 7 the sides of the molds 5 at the forward end are inturned at 18 so as to constitute a short mold section at these corners.

In pouring a block, the space within the coffer dam is filled with sand or other detritus as shown in Figure 3 and this sand at its upper end is preferably formed into the shape of a frustrum of a cone, the base of which lies some distance above the lower edges of the sides 5, say perhaps a foot. When concrete is cast in the mold the resulting block will be formed with a hole in the middle corresponding to the pipe 17 and will be formed with a lower cavity of conical shape as shown particularly in Figure 3 provided with sharp shearing bottom edges. Pipes 19 and 20 for water and compressed air, respectively, are now introduced in the pipe 17 and the sand beneath the block is scoured out and blown up through the channels 2—2 as shown in Figure 4. This permits the block to move slowly downwards by gravity and the operation is continued until the top of the block is somewhat above the lower edges of the form plates 5.

A channel 21 preferably connects two of the cross pieces 8 so as to form a central trough in the east block. As a result, the top of the block will be formed with interlocking ribs as shown particularly in Figure 4. The next block is cast in the same way directly upon the first block and both blocks are lowered by the action of water and compressed air until the top of the second block is about a foot above the lower edge of the moldplates 5—5. Thereafter succeeding blocks are molded and lowered until a tier of the desired height has been secured.

The end portion of the coffer dam 1 corresponding with the front of the tier of blocks is then removed after which the tie rods 15 are removed and the screws 14 are loosened thus freeing the mold sections 5—5. Thereupon these mold sections with the angles 7—7 are raised to an inclined position as shown in Figure 6 and the treads 13 are advanced to the distance between the tie rod 15—15. The mold plates 5—5 are then moved into working position as shown in full lines, Figure 6 after which the tie rods 15 are introduced in the succeeding holes.

Thereupon the coffer dam 1 is completed around the plates 5—5 whereby the blocks for the next succeeding tier will be built and lowered successively as I have already explained. As shown in Figure 7 it is desirable that the walls of the coffer dam should extend rearwardly some distance behind the space where the work is being done in order to provide strength and prevent undue leakage in the discharge.

As shown in Figure 2 I may make use of piles 22 which may be ordinary H-beams filled with concrete. These piles may be handled and placed in the massive structure described in my above mentioned patent and packed with elastic material as shown in Patent 1,877,493 and if used will add materially to the strength and rigidity of the resulting massive structure.

When blocks are cast in the second and succeeding tiers, the rear wall of the mold will obviously be formed by the front face of the top

block of the preceding tier. If the concrete were cast directly in contact with this concrete face of the preceding tier difficulty might be experienced in lowering the blocks due to bonding effect. I therefore prefer to cover the front face of the preceding uppermost block with a layer 23 of a suitable elastic material which adheres to the block being cast and moves down with that block when the latter descends by gravity. A suitable material for this purpose is ordinary wall board made of bagasse and having a thickness between one-quarter and one-half inch, or linoleum floor felt may be used. If desired this material may be impregnated with a suitable water proofing agent of any suitable character such as a bituminous compound. The presence of this material provides an expansion joint between adjacent tiers of blocks.

It will be noted that the vertical opening within each vertical tier of blocks will be filled with air and that the introduction of compressed air and water as explained beneath the tier to remove material thereunder will have a buoyant effect upon the tier.

What I claim is:

1. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in placing successive massive blocks in the upper portion of the said coffer dam, and in lowering the blocks by scouring out the material beneath the block and discharging it between the block and the coffer dam.

2. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in casting successive massive concrete blocks in a mold in the upper portion of said coffer dam and in lowering the blocks after setting by scouring out the material beneath the block and discharging it between the mold and the coffer dam.

3. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in constructing a mold in the upper part of said coffer dam, in filling the coffer dam and the lower portion of said mold with sand, casting a massive concrete block within the mold and in lowering the block after setting, by gravity, by scouring out the sand below the block and discharging it between the mold and the coffer dam.

4. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in filling the coffer dam with sand, placing a massive block within the coffer dam and lowering the block, by gravity, by scouring out the sand below the block and discharging it between the block and the coffer dam.

5. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in filling the coffer dam with sand, in placing a massive concrete block in the said coffer dam upon the sand and in lowering the block by gravity by scouring out the sand below the block by streams of water and compressed air so as to discharge the sand between the block and the coffer dam.

6. The method of building a sea wall or the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in filling the coffer dam with sand, in placing a massive concrete block within the said coffer dam and in forcing water and compressed air centrally through the said block to scour out the sand below the block and discharge the same between the block and the coffer dam whereby the block will descend by gravity.

7. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in constructing a mold in the upper portion of said coffer dam, in filling the coffer dam with sand above the level of the bottom of said mold, in forming the sand into the shape of a conic frustrum, in casting a massive concrete block within said mold to thereby form the block with a conical depression in its bottom and in lowering the block after setting by gravity by scouring out the sand from beneath it and discharging the same between the mold and coffer dam.

8. The method of building sea walls and the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in constructing a mold in the upper part of said coffer dam, in filling the coffer dam with sand above the level of the bottom of the mold, in casting a massive concrete block in said mold upon the sand and in lowering the block by gravity after setting by scouring out the sand below the block by streams of water and compressed air so as to discharge the sand between the mold and coffer dam.

9. The method of building a sea wall or the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in constructing a mold in the upper portion of the coffer dam, in filling the coffer dam with sand above the level of the bottom of the mold, in casting a massive cement block in said mold, and in forcing water and compressed air centrally through said block to scour out the sand below the block and discharging the same between the mold and the coffer dam whereby the block will descend by gravity.

10. The method of building a sea wall or the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in constructing a mold in the upper part of the coffer dam, in filling the coffer dam with sand above the bottom of said mold, in casting a massive concrete block within the mold, in causing said block to descend by gravity by scouring out the sand beneath it and discharging it between the mold and the coffer dam, in casting a second block within the mold upon the first block and in causing both blocks to descend by a continual scouring of the sand from beneath the first block and so on.

11. The method of building a sea wall or the like which consists in erecting a coffer dam extending below the bottom of the desired structure, in filling the coffer dam with sand, in placing a massive concrete block within the coffer dam upon the sand, in causing the said block to descend by gravity by scouring out the sand beneath it and discharging it between the block and the coffer dam, in placing a second block within the coffer dam upon the first block and in causing both blocks to descend by a continual scouring of the sand from beneath the first block and so on.

12. The method of adding successive tiers of blocks to a sea wall under construction, which consists in extending a coffer dam around the forward face of said structure and extending below the bottom thereof, in constructing a mold in the upper part of said coffer dam one face of said mold being formed by a portion of the front

face of the structure, in filling the coffer dam with sand above the bottom of said mold, in casting a massive concrete block in said mold, and in causing the block after setting to descend by gravity by scouring out the sand beneath it and discharging the same between the mold and the coffer dam.

13. The method of adding successive tiers of blocks to a sea wall under construction, which consists in extending a coffer dam around the forward face of the said structure and extending below the bottom thereof, in filling the coffer dam with sand, in placing a massive concrete block upon the sand within the coffer dam, and in causing the block to descend by gravity by scouring out the sand beneath it and discharging it between the block and the coffer dam.

14. The method of adding successive tiers of massive blocks to a sea wall or the like under construction which consists in extending a coffer dam from the forward edge of the said structure and extending below the bottom thereof, in placing a massive concrete block faced with an elastic waterproof material within the coffer dam against the face of the preceding block and causing the block to descend by gravity by scouring out the sand beneath it and discharging it between the block and the coffer dam.

15. Apparatus for constructing a sea wall or the like comprising a coffer dam extending below the bottom of the desired structure, a mold in the upper portion of said coffer dam, discharge ports between the mold and the coffer dam, a body of sand within the coffer dam entering the lower part of said mold, means for casting a massive block in said mold, and means for scouring out the sand below the block after setting and discharging the same through said discharge ports.

16. Apparatus for building a sea wall or the like comprising a coffer dam made of interlocking panels extending below the bottom of the structure, a mold in the upper portion of said coffer dam, a supply of sand in said coffer dam extending above the bottom of said mold, means for casting a massive concrete block in said mold and water and compressed air pipes extending through the block for scouring out the sand beneath it and discharging the same between the mold and the coffer dam whereby the block will descend by gravity.

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