J. S. WILLIAMS.

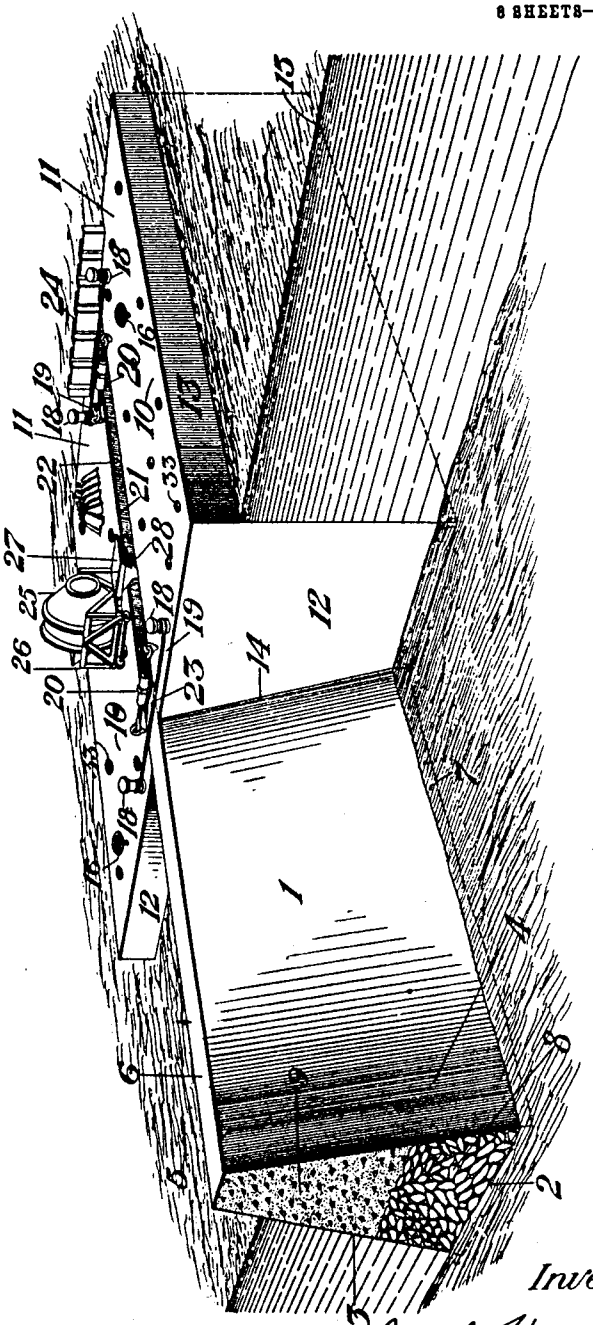
WATERWAY CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.

APPLICATION FILED MAR. 3, 1909.

1,051,043. Patented Jan. 21, 1913.

8 SHEETS—SHEET 1.

Fig. 1.



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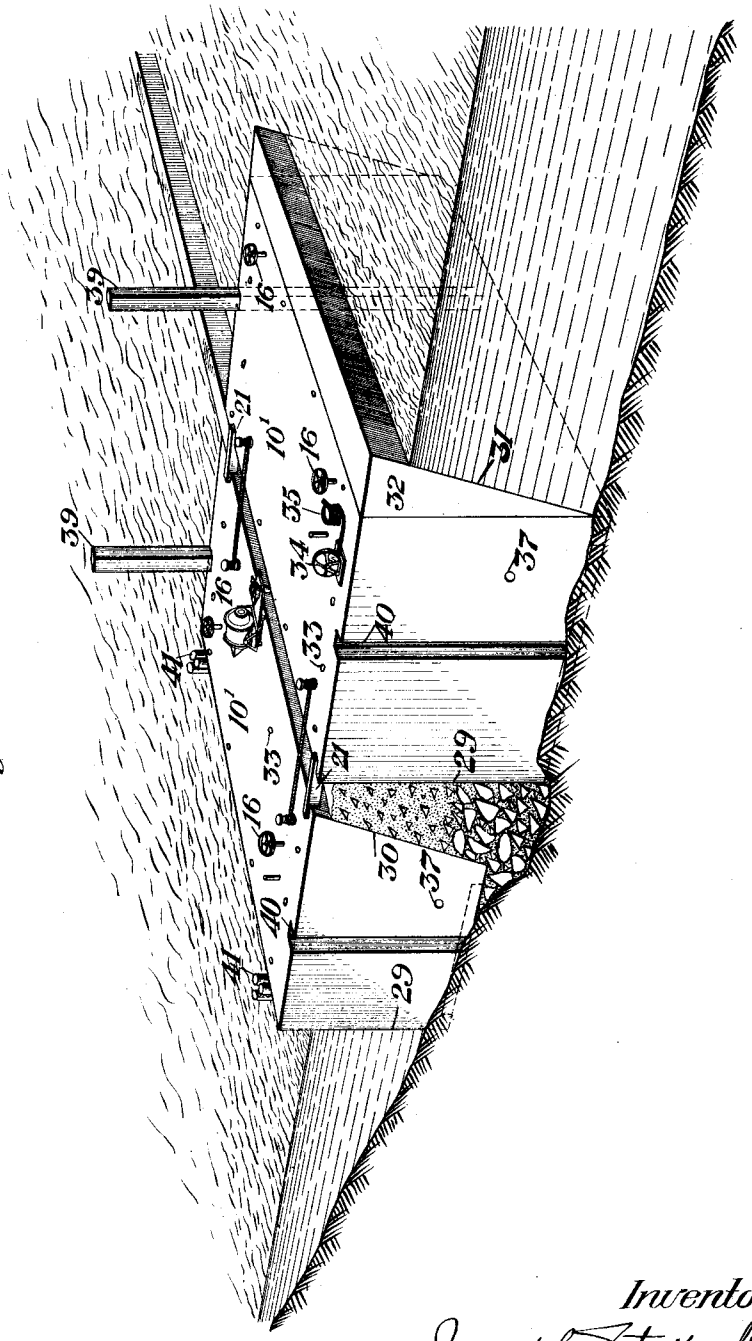
8 SHEETS—SHEET 2.

Fig. 2.



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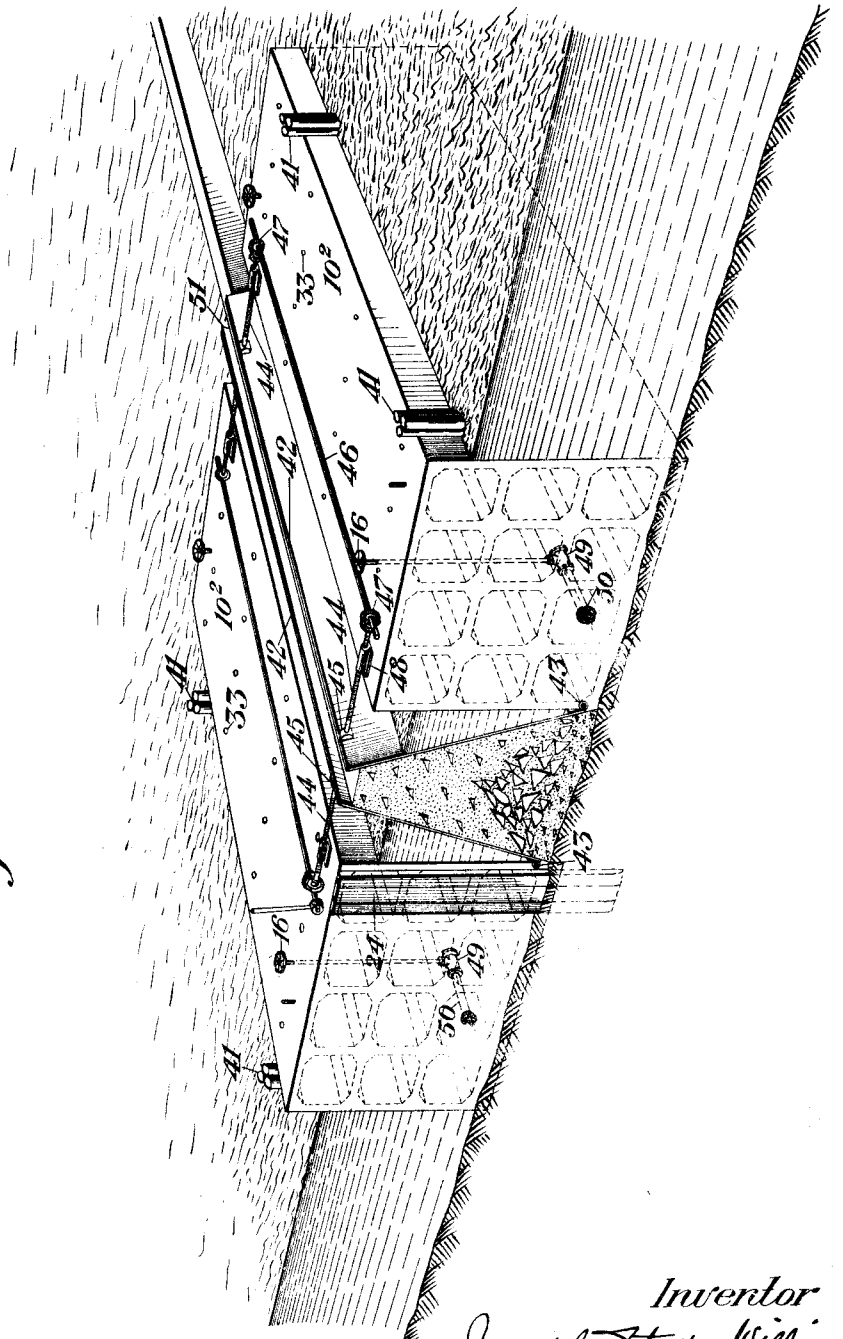
8 SHEETS—SHEET 3.

Fig. 3.



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1,051,043.

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8 SHEETS—SHEET 4.

Fig. 8.

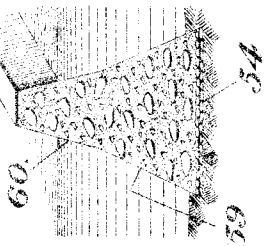


Fig. 7.

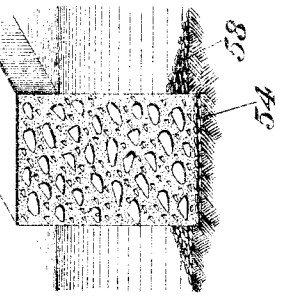


Fig. 6.

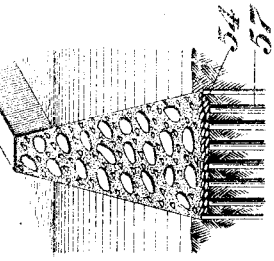


Fig. 5.

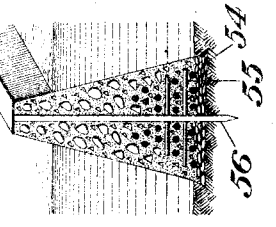


Fig. 4.

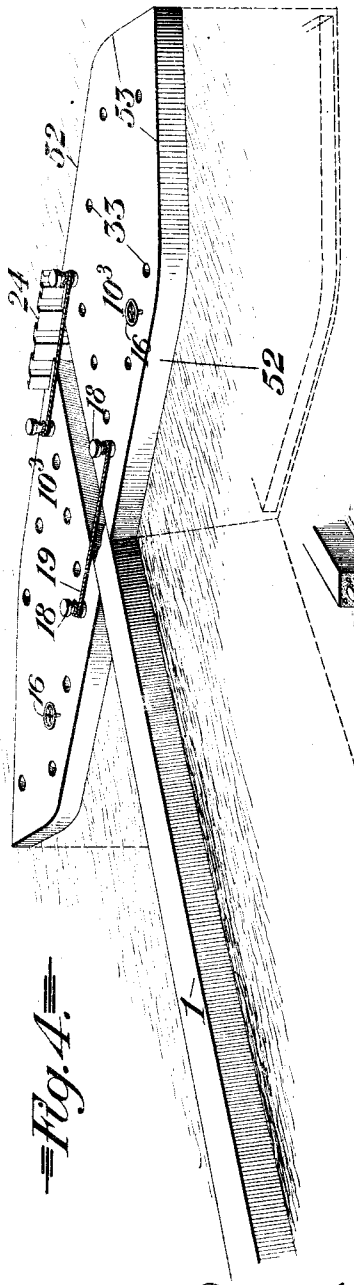
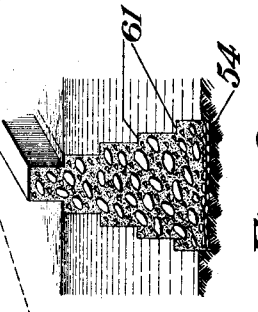


Fig. 9.



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WATERWAY CONCRETE AND REINFORCED CONCRETE CONSTRUCTION,

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1,051,043.

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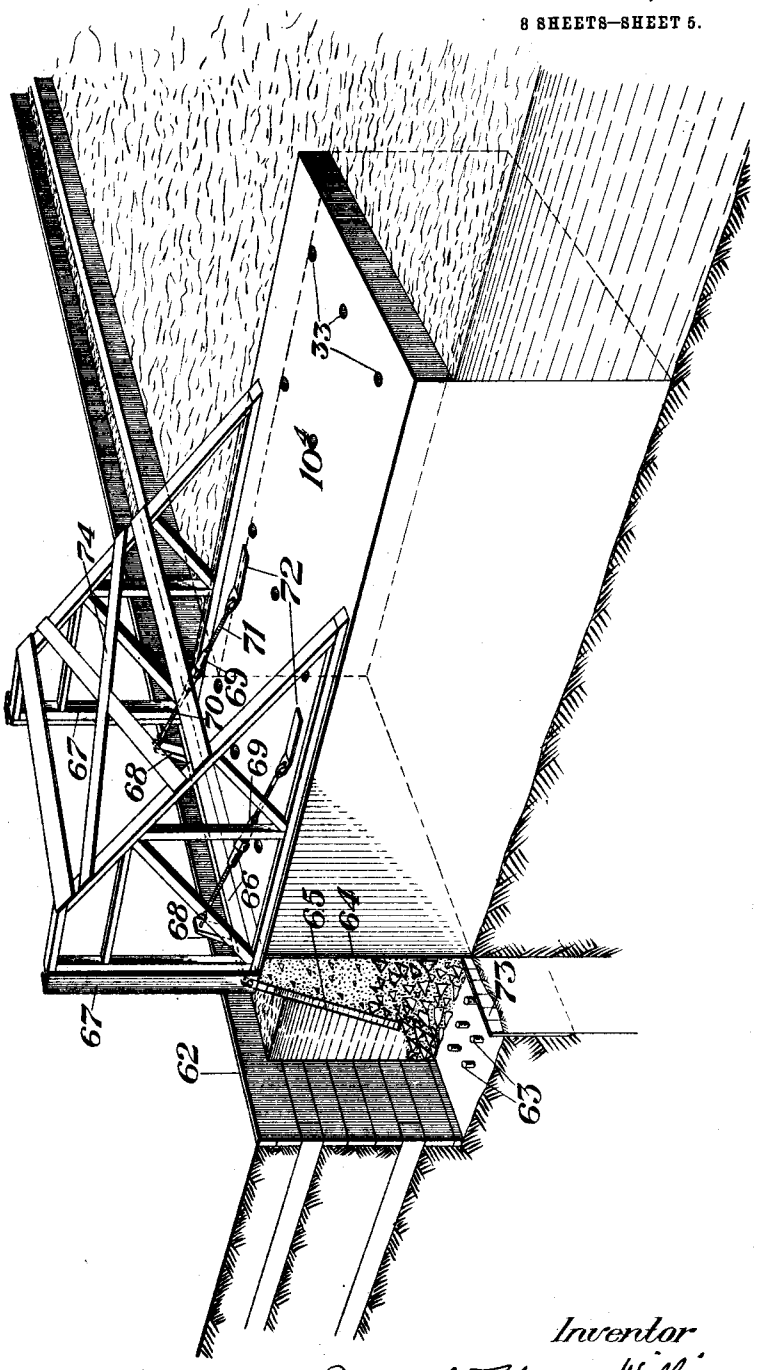
8 SHEETS—SHEET 5.

Fig. 10.



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8 SHEETS—SHEET 6.

Fig. 12.

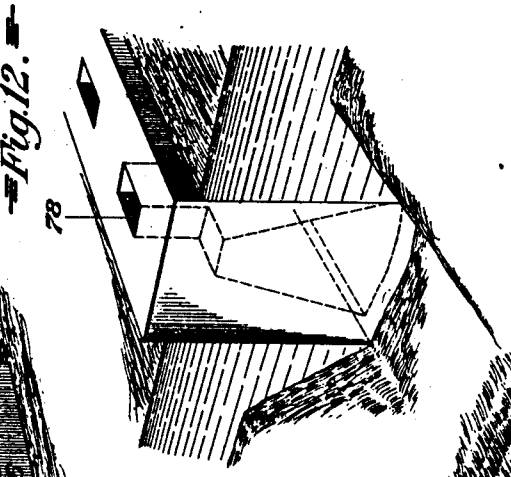


Fig. 15.

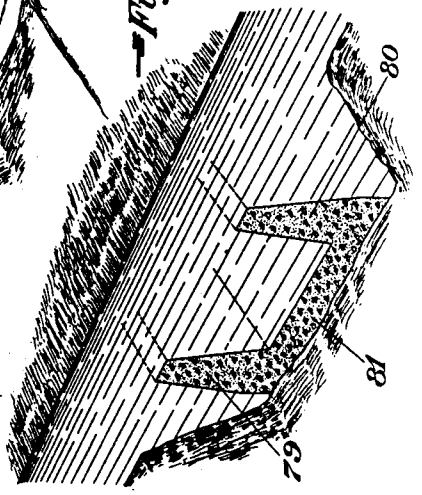
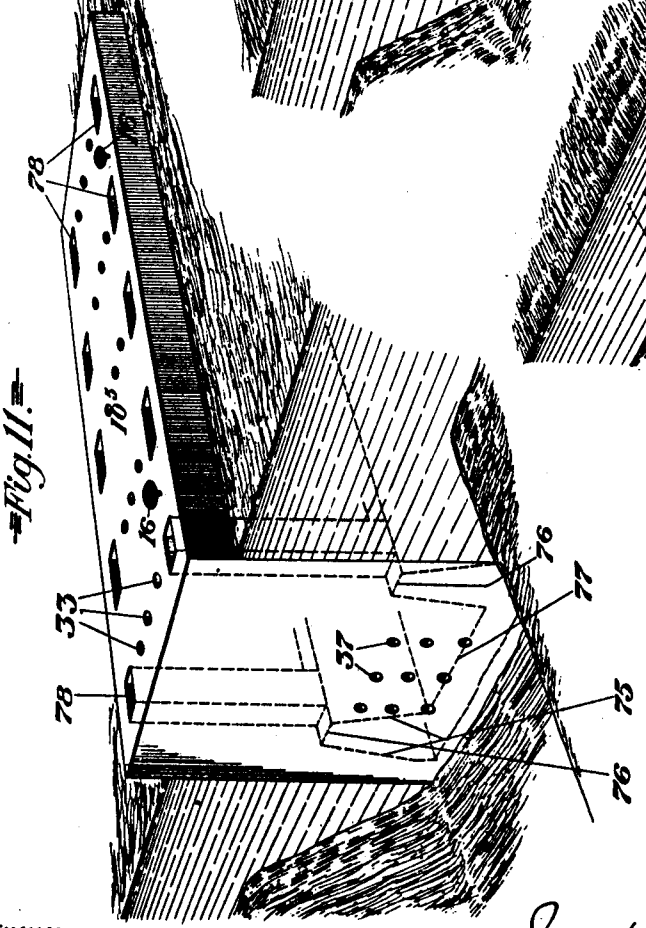


Fig. 11.



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8 SHEETS—SHEET 7.

Fig 14.

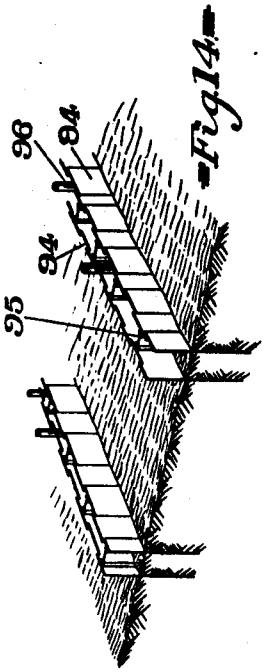


Fig 15.

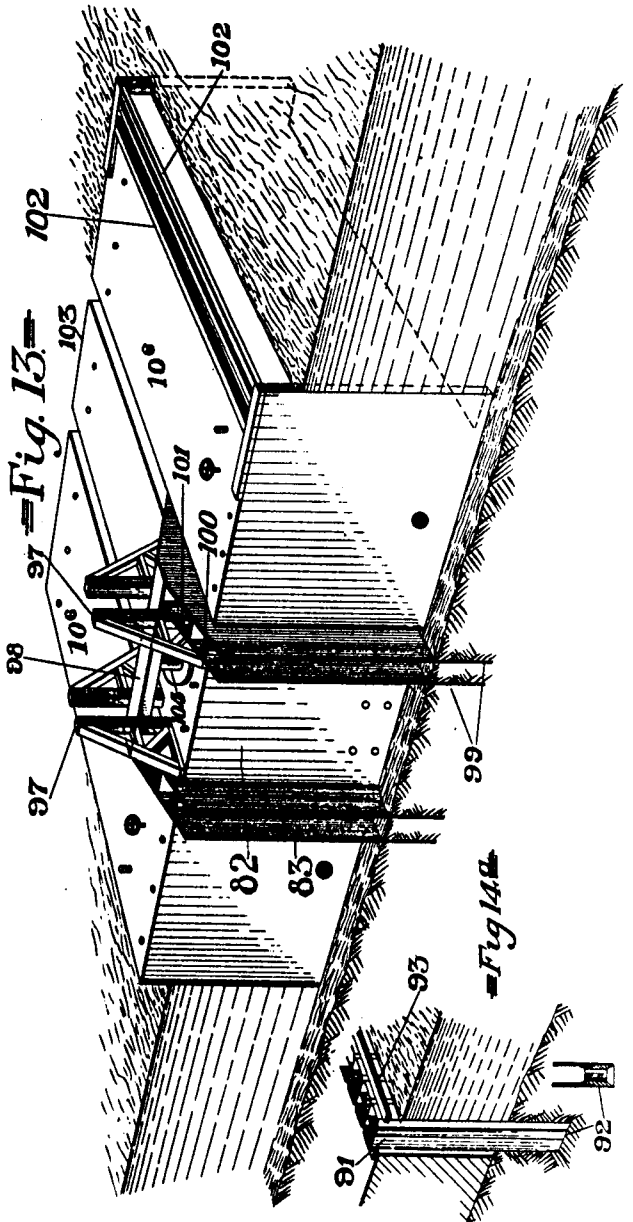
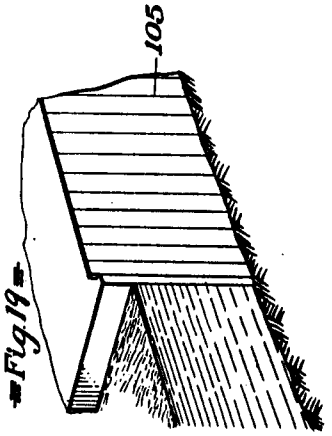


Fig 14a.

Fig 19.



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APPLICATION FILED MAR. 3, 1909.

1,051,043. Patented Jan. 21, 1913.

8 SHEETS—SHEET 8.

Fig. 17.

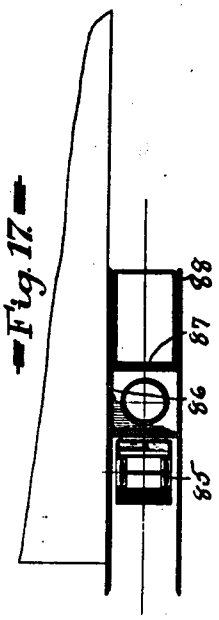


Fig. 16.

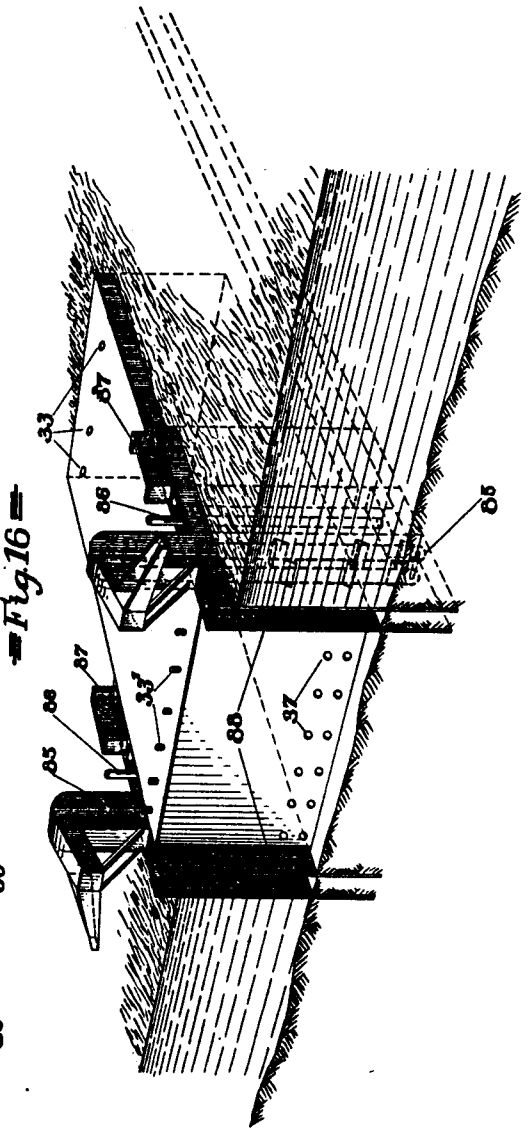
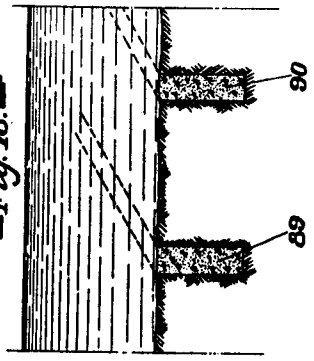


Fig. 18.



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UNITED STATES PATENT OFFICE.

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WATERWAY CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.

1,051,043. Specification of Letters Patent. Patented Jan. 21, 1913.

Application filed March 3, 1909. Serial No. 481,070.

To all whom it may concern:

Be it known that I, JOSEPH STOKES WILLIAMS, a citizen of the United States, residing at Riverton, in the county of Burlington, State of New Jersey, have invented a new and useful Waterway Concrete and Reinforced Concrete Construction, of which the following is a specification.

My invention is intended to be applied in the construction forming an establishment of bulk heads, dykes, shore or levee walls, sea walls, wharves, piers, foundations, and all other structures in or on waterway beds and constructions.

The purpose of my invention is to facilitate the construction of these various waterway structures and to improve their stability, efficiency and economy.

A further purpose of my invention is to make use of forms, or molds which can be cheaply and conveniently placed and removed, which are capable of successive uses and which present, or provide large units of construction in their capacity.

A further purpose of my invention is to provide for establishing large completed sections or units of construction successively and progressively along the lines of construction to completion.

A further purpose of my invention is to float guides or forms for such concrete constructions to place, to aline the same, and to anchor them securely in alinement while in use as forms.

A further purpose of my invention is to sink the floatable and floated guides or forms in alined position or vary their ballast to secure anchorage in alined position along one or both sides of the construction to be completed.

A further purpose of my invention is to make use of guides or forms for concrete construction which are floated to place and sunk or lowered to alined operative position, to float the same again free from the construction for which they have acted as forms, and to successively use the same in the construction of other sections of the same concreting or in other work of similar nature.

A further purpose of my invention is to make use of the surface, as, for example, side of a vessel or of a frame work or member carried or supported thereby as a guide or form in concrete construction along or in waterways.

A further purpose of my invention is to make use of the surface or interior of a vessel (whose side or frame or member attached thereto is being used as a guide or form) for the receipt and support of the materials and apparatus of which the concrete is being formed or by which the concrete is mixed or distributed.

A further purpose of my invention is to provide a space between a movable guide or form and another movable guide or form or fixed wall as the case may be, close the ends of the space so provided and fill the space with concrete to any desired height below, up to or above the surface of the water.

A further purpose of my invention is to provide a surface for a removable form intended to be used in concrete construction beneath the water, which surface reduces or prevents adhesion of the concrete thereto.

A further purpose of my invention is to provide a floatable guide or form capable of being sunk beside or along the line of construction whether the bed be graded or alined or not, which floatable form when sunk shall extend above the surface of the water.

A further purpose of my invention is to provide a floatable and sinkable form or guide for concrete construction which when sunk shall extend above the surface of the water and support a working platform or provide such platform for carrying on generally the operations of construction and receiving material and placing or discharging same in the chambers formed thereby.

A further purpose of my invention is to provide in one construction a form or guide for limiting concrete work, giving definite form and shape thereto, a working platform for receiving, mixing and distributing the same, and a dock for use of vessels supplying the materials.

A further purpose of my invention is to provide for variant or variable contour of concrete structure with the same floatable and sinkable guide or form therefor by securing the form adjustably angularly upon or against the side of the floatable structure.

A further purpose of my invention is to float adjustable or detachable forming or contouring surfaces for concrete to place,

vary the ballast of the supporting structure or the relative positions of the form and floating support therefor until the form is in alined position for use and, either by the same act or separately, to anchor the form floatable support or both in the required position.

A further purpose of my invention is to dredge, excavate or otherwise prepare the base or foundation upon which a concrete structure is to be placed, to float limiting walls or forms or such structure to place, to aline the same and sink or otherwise anchor them in operative position, to close the ends of the space thus formed and to fill the space to the desired height with concrete.

A further purpose of my invention is to provide a form or mold for concrete construction to place suction apparatus either in the form or mold where it is separate from the floating structure or in the floating structure itself or sides or ends thereof but preferably in the bottom of one or both of these, sink the form or mold or the floating structure or both to approximate position in alinement, dredge the space if not previously excavated beneath the form or mold or beside it or beneath or beside the floatable structure by means of the exhaust apparatus so supplied, doing this exhausting either locally or generally beneath or beside the form or mold or floatable structure until the required position and stability have been reached or requisite excavation shall have been made, complete the alinement if necessary and fill in the concrete against the form or mold.

A further purpose of my invention consists in forming the sides and closing the ends of a space intended to contain concrete and part of which is below the surface of the water, in filling the same with concrete, in shifting the side limiting walls of the form or mold progressively to include an adjoining corresponding space with or without removal of the limiting end wall of the section last completed, and in filling the second space with concrete against the end of the first space or the form comprising the limiting end wall thereof.

A further purpose of my invention consists in successively forming side and end walls about spaces in line with each other, parts of which lie beneath the surface of the water, and in filling the said spaces successively with concrete.

A further purpose of my invention consists in floating side walls of concrete formers to place, anchoring them in alined operative position, placing the concrete between them to complete the section, refloating said walls, and moving them to alined positions with their trailing ends lapping the portions of the concrete already formed in the previous position of the walls and repeating the operation to successively and continuously establish the concrete construction with the precise and predetermined contour represented by the faces of the formers.

A further purpose of my invention consists in providing floating docks and platforms with adjustable sides capable of movement angularly, vertically and otherwise with respect thereto, of adjusting these sides to the angle or position required for a concrete construction of the desired section in floating them into place in alinement and sinking them to anchorage with the adjustable sides in position to act as formers for the concrete, in closing the ends of the space thus formed, in filling the space with concrete to the desired height, in moving the docks and platforms with the sides connected therewith to a new position with the sides overlapping the section of concrete previously constructed in anchoring the sides in alinement overlapping said section, inclosing the remaining or open end of the space formed between the sides in their new positions, in filling this space with concrete, and in repeating the operation for the purpose of obtaining continuity of concrete construction.

A further purpose of my invention is to provide floatable forms or guides for concrete construction and means for anchoring them in position to receive and provide the contour for the concrete wall.

A further object of my invention is to provide floatable forms or guides for concrete construction having the forming surface angularly disposed, and means for anchoring these forms in operative position to determine the contour of the concrete construction.

A further purpose of my invention is to accommodate the floats and the forming members thereof or thereon in size, angle and contour to meet the requirements of the particular structure or side of concrete structure to which they are to be applied.

A further purpose of my invention is to provide a pair of floatable and sinkable vessels or members to be placed one on each side of the concrete structure in contemplation, which vessels or members shall comprise or support the forms by which the sides of the concrete structure are determined.

A further purpose of my invention is to make use of suitable excavation or dredging and channeling to provide a base or bed for concrete construction, and to place the concrete by forcing it into the path excavated.

A further purpose of my invention is to establish single or multiple lines of wall construction in or along a bed of a waterway or a dredged, graded or alined chan-

nel thereof, by means of floatable, sinkable and refloatable apparatus for concrete chambering and wall formation, which shall be capable of continuous and repeated use interchangeably for the several purposes intended, which shall force the concrete into the chamber provided through the passages by which the excavation has been accomplished and which shall receive the excavated material and supply the concrete upon or from a platform carried thereby.

A further purpose of my invention is to supply a construction and method of excavation, dredging, channeling and alining beds for concrete construction, with or without the use of the shore line or a fixed abutment to limit one surface of said construction.

A further purpose of my invention is to supply a method or process of concrete construction upon beds or foundations beneath the surface of the water and in which floatable formers or supports for formers for one or both sides of the concrete are anchored in position with the forming surface or surfaces in the requisite location to act as limiting surfaces determining the conformation of the concrete.

A further purpose of my invention is to supply a method and apparatus for forming or contouring concrete upon a subaqueous base or foundation bed or in such a bed by means of floatable molds or mold-carrying supports, which supports may carry the molds for both sides of the concrete or be the molds for one side of the concrete and if desired, carry the mold for the other side thereof.

A further purpose of my invention is to protect the sides of a subaqueous excavation during the time of cutting the same or after cutting and before or during the filling of the same with concrete or both.

A further purpose of my invention is to progressively excavate and fill with concrete within a subaqueous bed and to a predetermined depth and level.

A further purpose of my invention is to supply a construction and method of excavation, dredging, channeling and alining beds for concrete construction, with or without reinforcement, and of employing floatable, sinkable and transportable concrete chambering, receiving and forming vessels or members in suitable alinement along the line of construction, so that hundreds or thousands of tons of concrete construction can be accurately and expeditiously placed and contoured in each position or shift of the chambering and forming members and equipments.

In the use of the term "concrete" I intend here to include also the various forms of reinforcement thereof which may be desirable in all or any of the constructions to which I have referred above or do hereinafter refer. It is my purpose also to make use of such fillers as may be useful in individual cases, especially in large constructions, where the cost is materially reduced thereby without corresponding loss in value.

For the purpose of illustrating my invention I have shown in the accompanying drawings several forms of my invention which are at present preferred by me for the reason that they present safe, reliable and economical methods and means of accomplishing the result and attaining requisite standards of stability with complete uniformity and reliability, but it is to be understood that the various elements and instrumentalities of which my invention consists can be variously arranged and organized and that my invention is not limited to the precise arrangement and organization of these instrumentalities or to the precise manner or method of operation thereof herein shown and described.

Figure 1 is a perspective, partially interrupted, illustrating one form of my invention. Fig. 2 is a perspective, partially interrupted, showing a modified form of my invention. Fig. 3 is a perspective interrupted in part of a further modified form of my invention. Fig. 4 is a perspective of a further modified form of apparatus used in my invention. Figs. 5, 6, 7, 8 and 9 are perspectives interrupted in part of a few of the forms of concrete construction which my methods and apparatus are intended to produce. Fig. 10 is a perspective, partially interrupted, of a further modified form of my invention. Fig. 11 is a perspective, partially interrupted, showing a further form of my invention. Fig. 12 is a perspective of a modification of the form shown in Fig. 11. Fig. 13 is a perspective, partially interrupted, showing a further form of my invention. Fig. 14 is a perspective, partially interrupted, of another embodiment of my invention. Fig. 14ª shows a perspective and sectional view of means for placing concrete. Fig. 15 is a perspective of a construction of the type intended to be made by the apparatus shown in Fig. 11. Fig. 16 is a perspective, partially interrupted, of a still further form of my invention. Figs. 17 and 18 are sectional and perspective views of the construction shown in Fig. 16 and the result of the method of its operation. Fig. 19 represents a perspective showing a modified form of sheathing.

Similar numerals of reference indicate corresponding parts in the figures.

Referring to the drawings:—1 designates a concrete construction, by which as above indicated, I intend throughout to include any of the permissible forms of reinforced concrete, whether this reinforcement be by longitudinal, transverse, diagonal or vertical

members or bars or piles or by any other suitable means. I intend also to include all of the permissible variations in base or mixture, material or proportion thereof. In the illustration of Fig. 1, I have shown this concrete construction as tapered uniformly from a natural or excavated bed 2 thereof along sides 3 and 4, extending from a point beneath the water beyond the surface 5 of the water and formed with a top 6. Evidently it may be either straight or tapered and may taper in either direction, having the top either smaller or slightly larger in width than the bottom thereof, as for reinforcement within the bed. It may also be stepped or curved and the two sides may differ in any desired way as to contour or slope. The concrete may also terminate beneath the surface of the water or at any required height above it.

In Fig. 1, I have indicated the concrete structure 1 as set along an excavated channel shown in dotted lines at 7, which excavation may be continuous or interrupted according to the nature of the bed or alinement required. In the structure shown in Fig. 1, I have preferred to make use of boulder concrete in the lower portion at 8 and a normal mixture in the upper portion at 9 though evidently either of these might be used for the entire structure. While I have shown a portion of this concrete structure completed for the purpose of better illustration of my process and of the use of the apparatus illustrated, I will describe the same as beginning upon the first section of concrete to be constructed and passing from that point to the adjoining section illustrated as under construction in Fig. 1. In this form I make use of floatable structures 10, comprising top surfaces 11, end walls 12, side walls 13 14 and bottom walls 15. Because the slopes of the two sides of the structure 1 are equal these two floatable structures are shown in Fig. 1 as duplicates, but it is not necessary that this should be the case. Upon each of the floatable structures I place ballast pipes or water valves 16 for the purpose of permitting water to flow into the structures to sink them totally or to any desired degree and upon each of them I place a pump, as shown in Fig. 2 for the purpose of emptying the water out of them for reflotation and otherwise for filling the chambers above the water level. Evidently this could be accomplished by an independent pumping mechanism carried by a separate vessel. For convenience in holding these two structures in fixed relative position or bringing them to this position I have shown means comprising posts 18 and flexible connections 19 and screw couplings 20 with suitable terminals thereof. Any other suitable spacing means or blocks may be used to assist in the purpose of securing the correct spacement 21. Evidently any well known means might be employed for bringing these floatable structures into desired relation and maintaining them there. The side walls 14 in this structure of Fig. 1 are intended to constitute forms or molds to limit the concrete and determine the contour of its sides. They form a chamber or space within which the concrete is placed and coöperate with means hereinafter described closing the ends thereof. In Fig. 1 the end closures of the space 22 are respectively the end 23 of the section of concrete already constructed and the sheet piling at 24.

I provide for the mixing of the concrete in any suitable manner as by a mixer 25 and I mount any such form of mixer upon a truck 26 rolling upon the surface 11 of one or both of the floatable molds or formers or upon tracks thereon so as to move substantially parallel with the line of construction. I may make use of a distributing hopper 27 and discharge pipe 28 which latter may be flexible or telescopic or otherwise adapted to apply the concrete to the surface of the construction already laid to secure uniformity of distribution and opportunity for as well as uniformity in setting.

In starting a concrete construction with apparatus of the general type indicated in Fig. 1, I excavate or dredge or otherwise aline the bed where this is necessary, float the forms to approximate position and aline and anchor them. I much prefer securing my anchorage by sinking the floatable forms and do that by allowing the water to enter them and by pumping in water above water level. I determine the position and alinement of the forms by any suitable survey means and where necessary guide them to their sunk position as by the means shown in Fig. 2, making use of the posts, flexible connection, screw and spacing block shown or of other means for determining and maintaining the relative position of the two forms where this is found necessary.

Side lines of piling may be made use of to tentatively determine the position of the forms and to guide them in longitudinal movement for the purpose hereinafter described throughout the line of construction. Such piles are shown in Fig. 3. I preferably sink the forms by altering their ballast through valves or pipes 16 letting the water flow therein to any required extent. In this manner I form a space between these two forms which so far as thus described is open at the ends. In the first section constructed I close both ends with sheet piling such as is shown at 24 or in any other suitable manner unless I chance to begin my structure where I already have a closed end as against a dock or pier. The closure for the ends could of course be another floatable and sinkable construction or mold. An advantage of the

metal sheet piling lies in the corrugated or ribbed conformation of the end thus obtained and the consequent interfitting of the parts of adjoining sections. This advantage could of course be obtained in other ways.

As thus described I have a space lying between the forms and closed at its ends in any suitable manner. This space need not be emptied of the water normally therein. The surface of the forms is entirely suitable for docking purposes to act as decks and platforms for the receipt and storage of the materials and for the complete operation of handling the same from the time of their delivery by the vessels to their distribution as concrete. Reinforcement may be effected at any desired stage or stages in the construction either along the bed or within the chamber at any angle and at any height as previously suggested.

When the concrete has been filled in to the desired height either above or below the surface of the water as the completion of the work may require and has set sufficiently the floatable forms are freed from water sufficiently to float the same and are towed or moved along the line of construction to such a position that their trailing ends lap the forward end of the construction already completed when they are alined and sunk to form a chamber having the forward end of the last construction as a limiting end wall and the same side walls as before, namely the sides of the floatable forms or molds. The remaining end of the chamber is closed by means of sheet piling or other suitable means and the operation of mixing and filling is repeated to complete a duplicate as nearly as may be required of the previous construction. Continuity of construction with precision is thus obtained.

It will be noted that I make use of flotation to transport and locate the main molds for the concrete and that I may float all of the molds to place using all of the same general character, *i. e.*, supported upon or part of a float and capable of being set by sinking the float and removed by reflotation thereof. It will be further noted that the number, character and size of the molds to be used will be determined by the individual circumstances of the construction required. For example, where the shore line, a pier or some other formation is to be faced or already performs the function of the inner or a boundary wall or form but one other such form will be required unless it be necessary or desirable to close the ends by floatable and sinkable means, which means can of course be corrugated, ribbed or otherwise shaped freely as of course is also the case with any of my molds or forms, which may differ both in detail and in general contour.

It will be apparent that any form of valve mechanism for allowing water to enter my floatable support may be made use of and that any kind of pump and connections may be applied to reduce the ballast and float the support. Any type of mixer may be used and the means of spacing several such supports or of drawing or maintaining them in relative position may be applied. A variety of guiding means may also be made use of to insure accurate placing of the supports when they have been sunk in position or are being so sunk, and tugs, shore lines or any other means of transportation or placing before or after sinking would of course come within my invention.

I contemplate securing the mold face to my support by any suitable means, making it integral with one of the sides thereof, separate but secured thereto rigidly, detachably or adjustably, or in any other suitable manner by which it becomes operative in connection with said support.

In Fig. 2 my floatable supports 10′ are shown with one side 29 of each perpendicular to the surface of the water, which side in one case is shown as carrying the mold face in operation against the concrete and with the other sides 30 and 31 at an angle with respect to the perpendicular, the side 30 being tapered as an integral part of the support and in this instance shown as carrying the operative mold face of this particular support, and the side 31 being upon a part 32 initially separate therefrom but attached thereto temporarily or permanently according to the requirements of the particular case. Of course either side or either end of any of these supports could be made use of for the molding operation.

In the form in Figs. 1 and 2 I show tubes 33 which are extended vertically or if required, at an angle thereto, through my floatable supports for the purposes of fluid excavation or hydraulic dredging. It is my purpose to make use of these by connection with any suitable pump such as 34, which I preferably connect detachably therewith as by a hose 35, but evidently a rotary pump and connections can be permanently attached to these tubes or any standard fluid dredging apparatus mounted upon a separate vessel or support may be connected therewith. As my invention does not reside in the character of this pump nor in the specific connections by which it is operatively joined with these tubes, I have shown it by conventional showing only.

I make use of a pump of any suitable character which may be the same pump 34 if desired to withdraw the water ballast from my floatable support or supports in order to refloat them and for that purpose connect any such pump of any character by hose or piping 35 to water ballast chambers, see Fig. 2. I have shown apertures 37 in the ends of my supports to indi-

cate that the fluid excavating means may be applied to any other surface of my floatable supports whether side or end for use in lateral excavation as may be required.

Where fluid excavation of the bed is suitable by reason of the character thereof or desirable for any reason either to provide for proper foundation for the concrete or more secure placing of the support when sunk I sink the support or supports until the fluid excavating apparatus is in operative relation with the bottom or side which is to be removed in whole or in part, connect the pump and complete the excavation to the required extent, following up as may be necessary by the continued sinking of the support or lateral or end movement thereof. When this excavation has been completed or when desired without excavation, preliminary or otherwise, I may make use of the tubes 33 as guides for the placing of piles by any suitable pile driver mounted upon or in proximity to my support. To avoid confusion of the drawing I have not illustrated this pile driver even conventionally. Pile drivers are well known in the art.

For convenience in placing my support or supports it is often desirable to guide them in their movement while being sunk to place. A large variety of guides would prove suitable for this purpose and in illustrating the form in Fig. 2 where posts 39 fit within grooves 40 it has not been my purpose to suggest that these are the only or even markedly the best guides which may be made use of. They are effective for the purpose and the posts 39 can be readily and quickly set in the bed after the survey or other means has determined the location of the supports.

In Fig. 2, I have shown the two supports as sunk to different levels, as may evidently at any time be permissible and desirable where there is natural inequality in the bed. For additional bracing of the supports when in place as well as when being set I may make use of piles 41.

In the form shown in Fig. 3 I have removed a portion of the sheet piling closing the open end of the space between the forms or molds, in this case comprising separate wings or frames 42 pivoted to the supports at 43 and held in position by means of screws 44 attached to these wings or frames rotatively at 45 and arranged to operate upon each wing or frame in unison by means of member 46 and gearing 47 which causes the screws to turn within the nuts 48. In this Fig. 3 the valve at 49 by which water ballast is let into my support or supports through pipe 50 is shown in greater detail.

The trailing ends 51 of my mold have been shown as overlapping the section of concrete just previously constructed which is convenient though not essential if they fully meet this completed section so that it affords closing means for the end or if other provision be made for uniting the two ends adjoining. I have also preferred to withdraw the closure to the open end or ends of the space between the molds, preferably sheet piling as before stated, but the piling or other closure might of course be left in place where the expense of its withdrawal, the additional anchorage given to it or other reason makes this desirable.

I have considered my method and apparatus as operating upon a subaqueous bed whether this bed be a natural one or be dredged or otherwise prepared, and my method and apparatus provide for the dredging where necessary with either subsequent or coincident placing of concrete within the same. In the structure in Fig. 3 I have shown means for varying the angle of the sides of the finished concrete throughout wide limits with the same apparatus, and in most of the constructions illustrated by me it is immaterial whether the completed concrete be intended to terminate below, at or above the surface of the water.

In Fig. 4, I have shown floatable supports 10^3 of the type having one of the sides of the support act at the forming surface for the concrete and with that nomenclature prefer to call the surfaces 52 ends, notwithstanding that in this particular illustration they might be called sides with equal propriety. It is immaterial whether a side or end act as the forming surface or carry it. I have preferred to have these ends approximately perpendicular to the side acting as the former or mold in proximity thereto but slope them away either in tapered or curved form as at 53 for the purpose of relieving the pressure of the current or diverting it to avoid excessive strain upon the support both when in flotation and when sunk.

In Figs. 5 to 9 inclusive I illustrate various cross sections of wall capable of construction by the apparatus which I have described, as an illustration of their variety but without intention to suggest much less assert that these are all of the contours or types since such is evidently not the case. In Fig. 5 I illustrate a double taper upon a dredged bed having a preponderance of rock at the bottom thereof at 54, transversely reinforced at 55 and in effect vertically reinforced as well as additionally anchored by pile 56. In Fig. 6 I illustrate a wall also of double taper upon a dredged base which has been reinforced or strengthened by piles 57 upon which reinforced base and initial preponderance of rock 54 is used. In Fig. 7 I illustrate a wall of rectangular cross section upon a dredged base and laterally reinforced by rock at 58. In each of the forms of Figs. 7, 8 and 9 there is also a preponderance of rock at the bottom at 54. In Fig. 8 the cross section is tapered with a

greater slope near the bottom than at the top in order to lower the center of gravity and relatively increase the width of base. The taper at 59 may bear any desired relation to the taper at 60 in such a form, but as suggested, the taper of 60 should preferably be more nearly vertical than the taper at 59. In the form shown in Fig. 9 the same general effect may be attained as in the other figures but by means of steps 61. The height and width of the steps there shown is the same for each step as for every other step corresponding more nearly to Figs. 5 and 6 than to Fig. 8.

In Fig. 10, I have shown a wall or abutment 62 in proximity to which the concrete construction is to be built and have shown the bed as reinforced by piles at 63. One end 64 of the floatable support 10^4 acts as a mold for the concrete upon one side and the opposite side is molded by the wing or frame 65 pivoted in a frame 66 which is vertically movable in guides 67. After the height is set the angular position of the wing 65 can be adjusted by means of arm 68 and adjustment 69 acting upon bolts 70 and 71 attached respectively to these arms and to anchorages 72. I have shown sheet piling at 73 for the purpose of reinforcing the bed. The guides are supported by any suitable frame work 74.

I recognize that the result attained in Fig. 10 where both molds are carried by the same floatable structure and one at least is adjustable angularly and vertically with respect to the support could be attained by a variety of other constructions and that some advantage might result without either or both of the adjustments for the wing, but in this latter case some of the advantage in flexibility of the system would be sacrificed as it would not meet the variety of shapes required in general use without reconstruction and as it might be difficult to free it from the concrete after construction, particularly if the taper of the wall or walls were slight. Of course the construction shown in Fig. 10 could be used with a float whose main former face was also angularly adjustable to taper both sides.

In the form shown in Fig. 11 I have shown a floatable support 10^5 whose under surface is grooved as shown in end elevation at 75, 76 and 77 to the shape of the concrete construction which is to be formed. The contour or under surface indicated therefore, in this type, constitutes the mold or form for the concrete and the pipes or tubes 33 and 37 constitute excavating tubes or permit the insertion of tubes by which the material of the bed may be removed to the required extent vertically or laterally. While I have shown these tubes or passageways as covering but a small portion of the top and end surfaces, it will be evident that they may be spread over as much of either surface as may be required to provide for either vertical or horizontal feeding or both. The passages 78 provide entrance for concrete along the top 76 of the space formed by the dredging operation. Concrete can be inserted through all of these passages and the surface be smooth and made uniform by slight longitudinal movement of the mold if this prove necessary in individual cases. It will not always be required.

In Fig. 15 I have shown the structure resulting from the operation of the device illustrated in Fig. 11 when operated by the method described. In these side walls 79 and 80 are formed integrally with the connecting base 81 which is firmly placed upon a dredged channel.

In Fig. 12 I show a construction capable of operation to form or mold a single wall of the type indicated at 79 and 80 and in which the excavation can be made by hydraulic means through the passages 78 or through pipes or tubes 33, 37 (see Fig. 11) which I have not considered it was necessary to here illustrate. In both of the forms 11 and 12 the form or mold should be rested in position after the concrete has been completely formed in order that it may be supported while setting. In both of the illustrations 11 and 12 the channel is shown ahead of the floatable mold or former as dredged preliminary by any suitable form of dredge or excavator though the two structures operated by the method described are capable of doing their own dredging. In both cases also when doing their own dredging they could be sunk to a lower dredging position and afterward raised to mold and finish, or the dredging can be done by adjustable members through the tubes, passageways or channels with molding and finishing as above stated. This raising could be accomplished by variation in ballast, by separate mechanical means or by closing the passages 78 and putting pressure on the concrete and bed.

In Fig. 13, I have shown two floats 10^6 sunk into alinement on the bed with a centrally located member 82 between them, which can be raised and lowered thereto by varying the ballast or by any other suitable means, for excavating thereunder and for raising and lowering the working organs 83 for sub-pier or wall and bed excavation and concrete reception and formation. Both the side or float members are adapted to be lowered and raised by varying water ballast and otherwise as in the other cases and are provided with fluid excavating appliances for use where needed. The member 82 is also provided with bottom and end excavating means and may be of any required or desired contour for excavating and forming or molding purposes. The

sides of the side members 10^6 as well as of the member 83 may be used for forming purposes and 83 or 82 and 83 together may be moved along their sides vertically and otherwise to coöperate in the molding or forming process for establishing concrete on one or more sub-walls of the foundation; and if desired a concrete bed between can be laid by raising the member 82 sufficiently to provide a determined depth over bed and to form construction similar to that shown in Figs. 11 and 15.

In Fig. 14 I have shown removable wearing plate surfaces 94 adapted for use on my various forms. In the form shown in Fig. 16 I make use of one or more excavators, of which I have shown two on each side thereof, namely, conveyers 85 and fluid excavators 86 in line with channel ways 87 for the concrete, and have shown in the form a trailer or former at 88 for limiting, leveling and receiving the concrete as the structure there shown is moved forward either continuously or step by step to cut and concrete a channel or a multiple of such channels. Fig. 17 shows a section of one of these cutting and concreting organs as will be seen from similar figures of reference on Fig. 16, and Fig. 18 shows a pair of walls such as could be formed by the structure seen in Fig. 16, said walls being numbered respectively 89 and 90. Traveling excavators, of course, may not be used in many locations as the suction would be effective, operating along the faces in substitution of or in conjunction with the traveling organs as will be understood by reference to Figs. 16 and 17.

In the forms shown in Figs. 13, 14 and 15 I have illustrated methods and apparatus of constructing continuous walls with definite, predeterminable height for foundation or other purposes, preferably subaqueous but not necessarily so, by means of spaced sheet piling, tubular piling side by side and juxtaposed, or other hollow structures in which successive pairs or mating sections are sunk, hydraulically or otherwise excavated, and filled with concrete, the piling being removed to allow contact and jointing of the soft concrete when the required filling has been attained. I illustrate tubular piling 91 of preferably rectangular section, using cutting face, or hollow cutting point 92 and guide 93 and juxtaposed in any manner such as shown in Fig. 14^a. Interlocking may be used to insure close union or alinement. But two parallel rows are shown. Evidently these could be indefinitely multiplied in any direction to provide continuous, solid formation of concrete below the bed or in the bed or adjoining but separate walls of any shape or contour. In Fig. 14 I have used two rows of sheet piling 94 spaced laterally and formed into temporary sections for excavating and filling purposes by structural shapes or piling here shown as 95. Any transverse member would answer this purpose. I also show interior longitudinal reinforcement by piles 96. In Fig. 13, I have shown floatable and sinkable structures 10^6 with member 102 centrally alined between them and also floatable and adapted to be raised and lowered. The member 103 is shown equipped with and carrying the guide members 97 and framing 98 with downwardly projecting operating parts 99 whereby the framing 98 and members 99 can be adjusted vertically along the horizontal lines of work. These also operate the suction and concrete laying organs indicated at 100 and 101, respectively, similar to arrangements shown in Figs. 16 and 17. The constructions illustrated in Figs. 14 and 14^a could of course be used between the plates 99 and would then constitute suction tubes or passages for the purpose there illustrated. In Fig. 13 I show also guides 102 for sheet piling such as for example are illustrated in Fig. 14.

The combined cutting, excavating and concrete laying apparatus of Fig. 13 is similar to the structure of Fig. 16 in its purpose from most standpoints. Each differing from the other in some important features. The side supporting members 10^6 in Fig. 13, floatable and sinkable along the line of construction and supporting the intermediate dredge 103 or alining the same also adds stability and flexibility to the system there shown. The hydraulic piston 104 provides for quick and reliable adjustment of the height of the cutting members and the excavating and filling means carried thereby or associated therewith.

In Fig. 19 at 105 I have shown side sheathing suitable for use in connection with any of the floatable and sinkable structures which I have illustrated and replaceable when worn out or when sheathing of a different character is desired.

It will be seen that the several means which I have shown for carrying out the purposes indicated constitute but a few of a number of possible means therefor and that other methods of construction are also applicable without departing from my invention. Evidently there must be some limit to the number of constructions and methods required to be illustrated as indicative of the breadth of invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:—

1. The method of constructing concrete work in or about waterways which consists in securing a mold or former to the side of a vessel, in floating it to approximate position, in sinking it to alined position, in placing the concrete against the mold, and

in refloating the vessel and thus removing the mold or former when the concrete has set.

2. The method of constructing concrete work in or about waterways which consists in forming a surface of a vessel as a mold or former for concrete work, in floating the vessel to approximate position, in sinking the vessel so as to bring the mold or former surface into alined position, in placing the concrete against the surface, and in refloating the vessel when the concrete has set.

3. The method of constructing concrete work in or about waterways which consists in forming concrete between surfaces of floatable vessels sunk to alined position, and in refloating the vessels to remove them from the concrete after it has hardened.

4. The method of constructing concrete work in or about waterways which consists in sinking vessels to define the required space for concrete, in closing the ends of the space so formed, and in filling the space so formed with concrete.

5. The method of constructing concrete work in or about waterways, which consists in floating a vessel carrying a mold or former to approximate position, in adjusting the mold or former with reference to the side of the vessel either before or after said flotation, in sinking the vessel until the mold or former is in the required position, and in placing the concrete against the mold or former.

6. The method of forming the surface of concrete under water, which consists in sinking a floatable structure until its forming point occupies the required boundary position for the concrete, and in placing the concrete against said forming part.

7. The method of contouring concrete under water, which consists in floating a mold of the required contour into approximate position, in alining and sinking this mold to exact position, in placing the concrete against or within the mold, and in refloating the mold to remove it from the concrete.

8. The method of forming concrete under water, which consists in floating molds or formers to position on opposite sides of the position of the concrete to be constructed, in sinking them so that their adjoining surfaces shall constitute coöperating molds or formers for said concrete, in closing the space between said molds or formers, and in filling the space to the required height with concrete.

9. The method of forming concrete under water, which consists in floating molds or formers to position on opposite sides of the position of the concrete to be constructed, in sinking them so that their adjoining surfaces shall constitute molds or formers for said concrete, in closing the space defined by said molds or formers, in filling the space to the required height with concrete, and in removing the forms or molds by refloatation.

10. The method of constructing concrete work under water, which consists in floating the formers or molds for the sides of the concrete work to approximate position, in sinking and alining them to exact position, in closing the ends of the space between them by sheet metal piling, in filling the space to the required height with concrete, and in removing the side formers or molds by flotation.

11. The process of forming concrete construction under water which consists in floating a mold in proximity to the bed, sinking and suction-dredging it to alined position, forming the concrete against the mold, and refloating the mold.

12. The process of forming concrete construction under water which consists in dredging the bed, suction-dredging the adjoining surface and at the same time placing a mold thereon, placing concrete against the mold and floating the mold away from the concrete.

13. As a step in the process of forming concrete under water, the sub-process of surface suction-dredging the bed and alining the molds in proper relationship to the bed to confine and give determined form to concrete construction.

14. The process of forming concrete under water which consists in making any necessary preparation of the bed, and alining and at the same time seating a mold to confine the bed and in forming concrete against the mold.

15. The method of constructing concrete upon a foundation under water which consists in varying the ballast of a floating and sinkable mold, operating a hydraulic dredge through the mold, seating the mold to chamber the bed and placing concrete within the chamber so formed.

16. The method of constructing concrete upon a subaqueous foundation, which consists in ballasting the foundation and strengthening it with piles, in floating a mold to approximate position on each side thereof, in sinking and alining the molds to operative position by sinking the support carrying them, and in filling the space between the molds with concrete.

17. The method of constructing concrete upon a subaqueous foundation which consists in floating a mold in proximity to the bed and in operating means to aline the mold in proper engagement with the bed, of filling the mold to completion of the upper surface and removing the mold therefrom by flotation.

18. The method of constructing concrete upon a subaqueous foundation which consists in floating a mold to position along the

line of work, locating the mold in alinement and proper engagement with the bed by variation of ballast and fluid-dredging and in placing the concrete against the mold within the space confined by the mold.

19. In a device for molding concrete upon a subaqueous base, a floatable support, a mold face secured thereto, and means upon the support for reducing the strain of the current thereon.

20. In a device for molding concrete upon a subaqueous base, a floatable support, a mold face attached thereto, means for sinking the support, and a tapered or curved face upon that side of the support opposite the mold face.

21. The method of constructing concrete work upon or within a subaqueous base which consists in progressively chambering the area and space to be concreted, filling the chamber so formed with concrete and removing and replacing the mold organism along the line of construction by changing the ballast.

22. The method of constructing concrete work upon or within a subaqueous bed which consists in progressively chambering the space to be concreted by molds placed by variation of ballast and filling the space so formed with concrete, the mold so placed in each successive position overlapping the concrete last formed.

23. The method of forming concrete under water which consists in employing floatable and sinkable means for alining the bed and chambering it, and subsequently removing the mold by flotation.

24. The method of laying concrete progressively along a subaqueous bed which consists in progressively floating a mold into position along the line of work, varying its degree of flotation to a determined position of alinement and engagement with the bed, filling the space so formed with concrete to a determined height, refloating the molding members and progressively placing and operating the same along the line of work, lapping the previously completed concrete for each successive placing of the mold.

25. The method of forming a continuous wall within or upon a subaqueous bed which consists in supporting molds for the sides of the concrete upon a float, in varying the ballast of the float to sink and thus anchor the molds in the required position, in closing the ends of the space formed between the molds, in filling the space to the required height with concrete, in reducing the ballast to raise the floats, in advancing them to a position in alinement with the section of concrete thus constructed, in again sinking and anchoring them in alined position for a succeeding section, in closing the space thus formed, in filling this space with concrete, and again removing the molds.

26. The method of forming a continuous wall of concrete upon or within a subaqueous bed which consists in alining the bed at the places and to the depth required, in floating the molds for the sides of the wall to approximate position, in placing them by sinking the floats, in effecting a closure of the ends of the space thus formed, in filling the space with concrete, in raising the molds by flotation, in resinking them in alinement with the section of wall thus constructed, in effecting a closure of the space between the molds in each successive location, and in filling this space to the required height with concrete.

27. The method of constructing concrete walls upon subaqueous foundations which consists in supporting a mold or molds for said concrete by flotation, in placing said mold or molds by varying the ballast of the support and in filling the space between the mold or molds.

28. The method of constructing walls upon subaqueous foundations which consists in supporting a mold or molds for the sides of the walls by flotation, in placing the mold or molds, by sinking the support or supports, in effecting a closure of the ends of the space thus formed, in filling the space with concrete, in refloating the support or supports, in re-placing the mold or molds in alined position by again sinking the supports, in closing the end of the space thus formed and in filling this second space with concrete.

29. In a device for use in molding concrete, a float, a mold supported upon the float, and means to reduce the buoyancy of the float to set the mold in position.

30. In a device for use in molding concrete, a float having a side thereof formed as a mold for the concrete, and means for sinking the float.

31. In a device for use in molding concrete, a float having one side thereof adapted for use as a mold for the concrete, and means for anchoring the float.

32. In a device for use in molding concrete, a float adapted to have its height of flotation varied and fixedly supporting a mold for the concrete.

33. In a device for use in molding concrete, a float, one side of which is adapted as a mold for the concrete.

34. In a device for use in molding concrete, a float, means for sinking the float to place the mold, and means for raising the float to remove the mold.

35. In a device for molding concrete upon a subaqueous base, a molding surface, means for flotation of the mold, and means for adjustment of the position of the mold and its flotation means.

36. In a device for molding concrete upon a subaqueous base, a floatable support, a molding surface carried thereby, means for

varying the relative position of the support and surface, and means for sinking the support.

37. In a device for molding concrete upon a subaqueous base, a floatable support, a molding surface carried thereby and attached thereto, and means for varying the angular relation between the support and surface.

38. In a device for molding concrete upon a subaqueous base, a floatable support, a plurality of molding surfaces attached thereto and forming a space therebetween for the concrete, and means for sinking the support.

39. In a device for molding concrete upon a subaqueous base, a floatable support, and a plurality of molding surfaces attached thereto and forming a space therebetween for the concrete.

40. In a device for molding concrete upon a subaqueous base, a floatable support, a molding surface carried thereby and adjustable thereto, means for moving the surface with respect to the support, and means for sinking the support to anchor it.

41. In a device for molding concrete upon a subaqueous base, a pair of floatable supports, a molding surface carried by each support, means for varying the ballast of the supports to anchor the surfaces in required position, and means for closing the ends of the space formed between the surfaces.

42. In a device for molding concrete upon a subaqueous base, a pair of floatable supports, a molding surface carried by each support, means for anchoring the supports with the surfaces in alined position, and sheet piling for effecting a closure of the end of the space between the surfaces.

43. A combined dock, concrete platform and mold and means for varying the degree of flotation of the same.

44. In a device for molding concrete upon a subaqueous base, a floatable support, means for allowing water to enter the support to sink the same, means for refloating the support, and means for excavating by suction.

45. In a device for molding concrete upon a subaqueous base, a floatable support, means for varying its ballast to sink and refloat the same, and suction excavating apparatus operative upon the bed on the under surface of the support.

46. In an excavator for subaqueous work, a floatable mold, an excavator carried thereby, and means for letting water into the support to bring the excavator into proper relationship with the material to be excavated.

47. In an excavator for subaqueous work, a floatable mold, an excavator of fluid type carried thereby, and means for varying the ballast of the support to bring the excavator into operative position with respect to its work.

48. In a device for molding concrete upon a subaqueous base, a floatable support, openings therethrough, a suction excavator operative through said openings, means for sinking the support, and means for permitting piles or reinforcements to be driven or placed through said opening.

49. In a device for molding concrete upon a subaqueous base, a floatable support, a mold for the concrete carried thereby, guides for said supports, and means for sinking the supports along the guides.

50. In a device for molding concrete upon a subaqueous base, a floatable support, a mold for the concrete carried thereby, means for sinking the support, and piles bracing said support upon the side opposite the mold.

51. In a device for molding concrete upon a subaqueous base, a floatable support, a mold face secured to one side thereof, guides at the ends thereof, and means upon the support for coöperating with the guide to direct vertical movement of the support.

52. A vessel having a side thereof formed as a mold for concrete.

53. A vessel having a side thereof formed as a mold for concrete in combination with means for varying its floatable power.

54. A vessel having a side formed as a mold for concrete in combination with a deck therefor adapted to operate as a working platform in concrete construction.

55. In apparatus for placing concrete within subaqueous beds, the combination of dredging and concrete placing apparatus with floatable and sinkable structures for varying the height of the dredging and concrete placing apparatus.

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Witnesses:
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