

APPLICATION FILED JUNE 26, 1911.

3 SHEETS—SHEET 1.



Fannie Huse

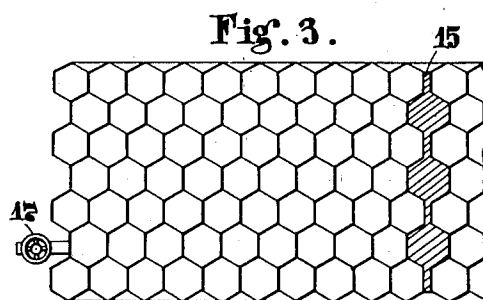
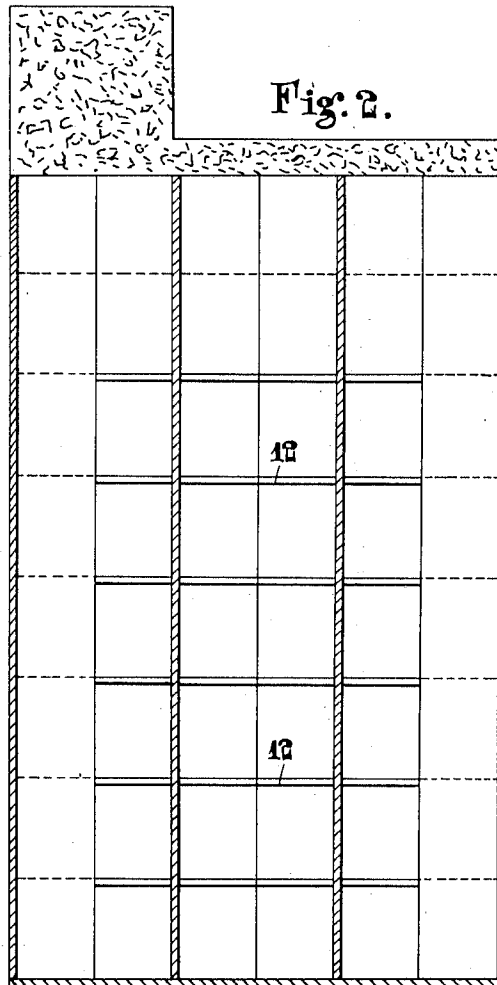
By Dodge and Sons,
Atly's.

F. G. LYNDE & E. R. CALTHROP.
CONSTRUCTION OF SEA WALLS, PIERS, PONTOONS, &c.
APPLICATION FILED JUNE 26, 1911.

1,054,224.

Patented Feb. 25, 1913.

3 SHEETS—SHEET 2.



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Inventors:
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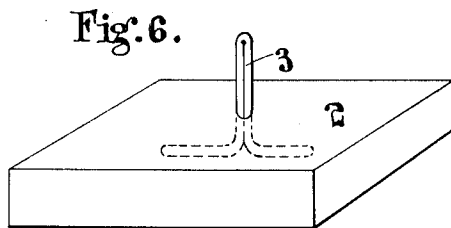
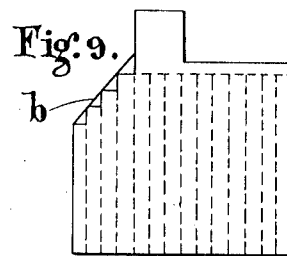
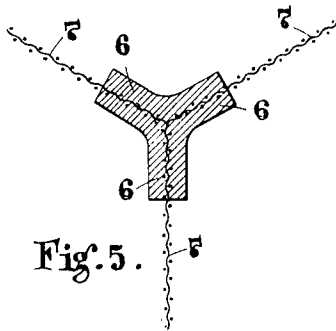
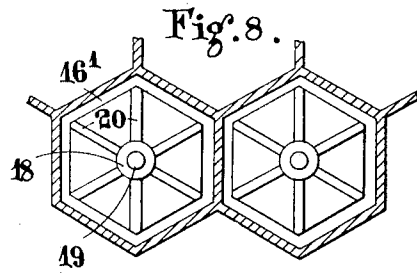
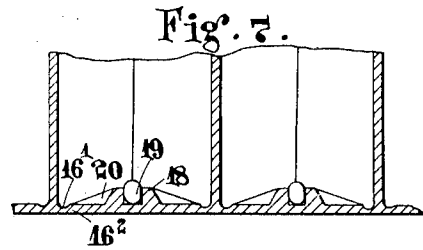
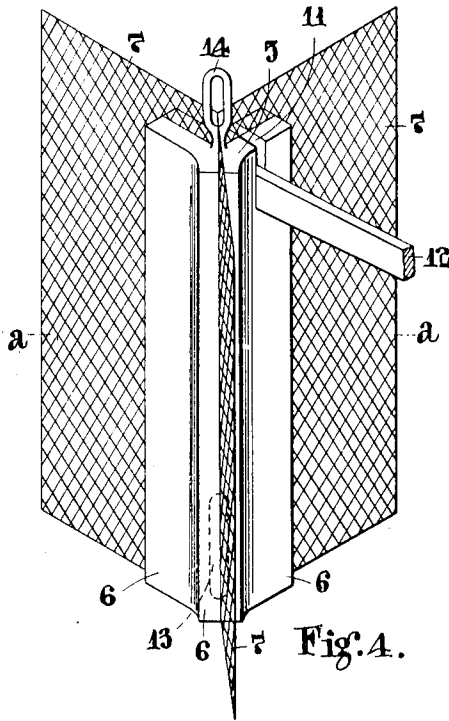
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CONSTRUCTION OF SEA WALLS, PIERS, PONTOONS, &c.
APPLICATION FILED JUNE 26, 1911.

1,054,224.

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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

FRANCIS GASCOIGNE LYNDE, OF KNEBWORTH, AND EVERARD RICHARD CALTHROP, OF LONDON, ENGLAND, ASSIGNORS TO THE VIBROCEL COMPANY, LIMITED, OF LONDON, ENGLAND.

CONSTRUCTION OF SEA-WALLS, PIERS, PONTOONS, &c.

1,054,224.

Specification of Letters Patent.

Patented Feb. 25, 1913.

Application filed June 26, 1911. Serial No. 635,453.

To all whom it may concern:

Be it known that we, FRANCIS GASCOIGNE LYNDE and EVERARD RICHARD CALTHROP, subjects of the King of Great Britain, residing, respectively, at Knebworth, in the county of Hertford, and at London, in the county of Middlesex, England, have invented new and useful Improvements in the Construction of Sea-Walls, Piers, Pontoons, Floating Stages, Foundations, and other Structures, of which the following is a specification.

This invention has reference to cellular structures of reinforced concrete.

It has for its object to provide a new or improved method of and means for the construction of sections of cellular formation of very considerable size and weight adapted to form units in the construction of a sea wall breakwater pier or other similar structure or which may be employed as foundations for lighthouses or as submerged or floating obstructions to navigation or as pontoons and floating stages and generally for concrete structures of an analogous nature.

Various methods have from time to time been suggested in the construction of sea and retaining walls and analogous structures of reinforced concrete whereby cellular structures may be produced adapted to be floated and towed into the desired position and there submerged. All of such methods have however been more or less costly while the size of the structures produced has been limited. Under the present invention we are enabled to economically produce units or sections of reinforced concrete in coherent masses of a size weight and strength far exceeding any heretofore suggested which can when employed for marine work be built afloat in sheltered positions without scaffolding and without the employment of heavy machinery and by reason of their buoyancy and seaworthiness be then towed if necessary many miles to the site they are designed to occupy arranged in exact positions and instantaneously submerged.

Sections or units constructed under our

improved method can be sunk on mud bottoms without previous preparation of the ground while for harbors and quays dredging the site will form a sufficient foundation.

With these ends in view our invention consists in the method and the means as hereinafter more fully explained whereby a structure of considerable size and weight may be produced composed of a number of vertical hexagonal cells of reinforced concrete mechanically vibrated mainly while *in situ* before it becomes set thus consolidating and compacting the particles together driving out air and surplus moisture rendering it free from minute hair-cracks and increasing to a remarkable extent its density and resistance to crushing stress while at the same time rendering it waterproof. The vibration of the concrete before it becomes set may be effected in any suitable manner, preferably by applying a mechanically or power-driven hammer to the shuttering forming the molds for the concrete, whereby a series of rapidly-delivered blows may be given to said shuttering. Owing to the greatly augmented strength possessed by vibrated concrete we are enabled to construct the component parts of the cells much thinner and lighter than would be possible with unvibrated concrete a point of considerable importance for it will be understood that in the construction of a cellular unit of very large dimensions from unvibrated concrete the walls and other component parts would in order to possess the necessary strength have to be of such a thickness that the buoyancy of the section would be destroyed.

In its broadest aspect our invention contemplates a structure for the purposes described composed of vertical hexagonal cells of reinforced vibrated concrete the whole of the component parts being incorporated and interknitted to form a section or unit.

More specifically stated the invention consists in first forming a concrete base of the desired area erecting thereon at predetermined distances apart a number of vertical pillars of vibrated concrete having metallic fabric embedded in and projecting there-

from intermeshing the projecting metallic fabric of contiguous pillars casting vertical walls of concrete *in situ* to connect said pillars and embrace the metallic fabric to form a tier of vertical hexagonal cells of similar size vibrating said walls to consolidate and increase the strength of the concrete and superposing other tiers of similarly constructed vertical cells upon the tier above described all in such a manner that the whole of the component parts of each cell and each tier of cells are incorporated and interknitted together to form a section of the desired size.

In accordance with our invention a section or unit intended for marine work such as in the building of a sea wall for example is constructed by first forming in a suitable position—such as a dry or floating dock—a concrete base and erecting for example one two or more tiers of vertical hexagonal cells thereon in the manner above described transporting the structure so formed to deep water and partially submerging it such as by loading the cells. The construction of the section is now proceeded with by building tier upon tier of cells in a similar manner the necessary degree of submergence being obtained during its erection by appropriately loading the cells. When the section is of the desired height it may then be floated or towed into position it is designed to permanently or temporarily occupy as for example to form a section in a sea wall or breakwater and the cells completely or partially filled with suitable material.

The aforesaid vertical pillars of reinforced concrete are during their manufacture submitted to mechanical vibration by any suitable form of apparatus and the reinforcement embedded therein is so arranged that it may when said pillars are in position be intermeshed with or connected to the reinforcement of the contiguous pillars the concrete walls or webs being then cast between and joining the aforesaid vertical pillars and incorporating the reinforcement in such a manner as to form a structure of vertical hexagonal cells in which all the component parts are incorporated. The said concrete walls are also submitted to mechanical vibration before being allowed to set as also is the base upon which the structure is built thus rendering the whole of the concrete compact and watertight and greatly increasing its resistance to tension and compression strains.

In constructing a sea wall for example a number of sections produced in the manner described are floated or towed into the desired position as near adjacent to each other as possible and any intervening spaces between the sections filled in with cement or the like in any appropriate manner.

Means are provided when constructing

the base portion on shore without the aid of a dock whereby communication may be established between the cells and the water in which they are immersed at high tide for a purpose to be hereinafter described.

Where it is intended to instantaneously submerge a section in any particular position the bottoms of the cells may be constructed in such a manner as to be fractured by explosives so as to admit water to the cells.

Now in order that our invention may be readily understood and carried into practice by those familiar with the art to which it appertains we will now proceed to describe the same in detail and for a correct understanding of our invention reference should be had to the accompanying drawings in which:—

Figure 1 illustrates in perspective view a portion of a section or unit for a sea wall for example showing the general arrangement of parts in various stages of construction. Fig. 2 is a vertical section through a complete section or unit and Fig. 3 is a diagrammatic plan view drawn to a smaller scale of a complete section or unit joined to the end of a contiguous section or unit. Fig. 4 shows in perspective view one of the vertical pillars employed in our improved construction and Fig. 5 is a section of same taken along the line *a-a*. Fig. 6 is a detail view hereinafter referred to. Fig. 7 illustrates the arrangement we employ for fracturing the bottoms of the cells. Fig. 8 is a plan view of the same. Fig. 9 is a diagrammatic view of a modified form of section for a sea wall.

In carrying our invention into practice we first form in a suitable position—such as a dry or floating dock for example or at a point upon shore some distance below high water mark—a level bed 1 of sand of suitable area in which appropriate drain pipes may be arranged the sides of said bed being banked up to form a support for the sides of the foundation or base plate the construction of which we will now proceed to describe.

Upon the bed 1 we place at predetermined distances apart a number of vibrated concrete blocks 2—illustrated in detail in Fig. 6—which have been previously manufactured each of said blocks being provided with an upstanding dowel 3. Concrete is now filled on the bed 1 up to or slightly above the upper surfaces of said blocks 2 and vibrated thus consolidating it and embedding the blocks 2 therein so forming a level concrete surface from which the dowels 3 project as shown at 4 in Fig. 1.

The pillars 5 which as hereinafter explained are cemented upon the dowels 3 to form the angles of the cells are previously manufactured by casting in appropriate

molds and as shown in Figs. 4 and 5 are provided with three projecting longitudinal ribs 6 from each of which metallic reinforcement 7 projects as shown said reinforcement 7 being incorporated in the pillars 5 during manufacture. Said pillars are formed with slots 11 in which metal or other bars 12 are adapted to be inserted during erection of the structure said bars extending horizontally and angularly, or horizontally, or angularly, at desired angles to strengthen and brace the whole together and each pillar 5 is also provided with a hole 13 at one end and a dowel 14 at the other whereby they may be rigidly cemented together the dowels 14 being preferably of the form shown in Fig. 4 thus providing convenient means whereby they may be carried or hoisted into position.

A tier of vertical pillars 5 having been arranged upon and cemented to the upstanding dowels 3 of the blocks 2 the projecting metallic fabric 7 is then interlaced as shown at 8 in Fig. 1 thus forming a plurality of hexagonal cells of metallic fabric the concrete pillars 5 forming the angles thereof. Temporary shuttering 9 is now arranged upon each side of each of the projecting ribs 6 thus producing molds in which concrete is placed to form vertical walls 10 serving to connect the pillars 5 rigidly together and to embed the fabric 7 therein said concrete being vibrated before setting to consolidate and strengthen it. The edges of the ribs 6 of the pillars 5 are preferably roughened as also are the ends so as to permit of the concrete forming the walls or partitions 10 uniting firmly thereto. When the walls 10 are sufficiently set the shuttering is of course removed.

The structure thus far described comprises a base portion having a tier of vertical hexagonal cells firmly incorporated therewith and from each pillar and each connecting wall forming said cells the dowels 14 and the metallic fabric 7 project as will be clearly seen upon reference to Fig. 1. Another tier or other tiers of hexagonal cells is or are now superposed upon the first tier by securing similar pillars 5 upon the pillars of the bottom tier intermeshing the metallic fabric and casting connecting walls between them all in a manner similar to that above described and the structure thus formed is then transported to deep water and partially submerged such as by loading the cells with lean concrete gravel or rubble. The construction of the section is now proceeded with at the surface of the water by building tier upon tier of hexagonal cells the necessary degree of submergence being obtained during its erection by loading the cells as above described or by the admission of water into some or all of them. The outside edges of the section are faced with concrete

as the building of the structure proceeds as indicated at the right hand side of Fig. 1 but we prefer to leave the bottom of the section unfaced for some little distance up in order that the buoyancy of the section may not be affected and also that the lower portion of the cells may more readily fracture in the event of the section being bedded upon uneven ground.

When the section is of the desired height it may then be towed or floated into the position it is designed to permanently or temporarily occupy as for example to form a section in a sea wall or breakwater and there submerged the cells being completely or partially filled. The sections having been arranged as near adjacent to each other as possible the intervening spaces are filled in with cement or the like as indicated at 15 in Fig. 3 thus bonding them firmly together and producing a structure which owing to its hexagonal cellular formation is well calculated to effectively resist the immense strains to which a sea wall breakwater or the like is subjected. The tops of the sections are concreted or otherwise finished off to form a road or other way as indicated in Fig. 2.

It will be obvious that a section may be produced in which the top or bottom surface may be either horizontal or inclined or partly horizontal and partly inclined with respect to the base by constructing the vertical cells of different heights and in the desired relation to each other to attain this end and this construction is shown diagrammatically in Fig. 9 which illustrates a section for a sea wall having an apron portion b.

In some cases such as when constructing the base portion on shore without the aid of a dock it may be desirable to establish communication between the cells and the water in which they are immersed at high tide so that as the tide rises the structure will be prevented from floating while when the structure is sufficiently mature access of water may be prevented so enabling the structure to be floated when desired. This may be accomplished by forming apertures 16 in the walls 10 during construction of the first tier of cells and providing a suitable valve such as indicated at 17 Fig. 3 whereby the admission of water may be controlled.

In Figs. 7 and 8 we have illustrated the arrangement we employ whereby the bottoms of the cells may be fractured to instantaneously submerge the structure at any exact position. The floors 16' of the cells are formed with an annular weakening channel 16' and with a central recessed portion 18 adapted to receive an explosive cartridge 19 connected by wires to similar cartridges in the other cells said wires being in communication with a source of electricity in such a

manner that said cartridges may be simultaneously exploded when desired so fracturing the bottoms at the weakened portion 16' and admitting water thus sinking the structure in the desired position. The floors 16 of the cells may if desired be strengthened by ribs 20.

The lowest tier of cells may be constructed sufficiently thin and fragile as to crumple up in the event of the section being bedded upon an uneven surface.

A cellular construction under this invention may be made to form a pontoon and employed as a base for building other sections upon the weight of which submerges the pontoon section which may then be sunk clear of the new section such as by providing valves in the pontoon adapted to admit water to the cells.

In the construction of a pontoon employed as a base for building sections upon the cells of the structure may be divided into groups so that air may be pumped into or water pumped from any desired group of cells to maintain an approximately level deck. The new section may then be moved away and the pontoon section raised such as for instance by pumping air into it or water out of it when it may be again used for a similar purpose.

A cellular structure in accordance with this invention possesses that lightness and buoyancy combined with strength which is necessary for the ends in view. The manufacture of the structure under vibration and the particular cellular formation herein described renders it well calculated to effectively resist the immense strains to which it is subjected when employed for sea walls breakwaters and the like and the absence of vertical horizontal or diagonal joints in its walls renders it safe from disruption under the impact of wave action.

What we claim is:—

1. The method of forming cellular structures, which consists in the following steps: forming a base; securing pillars or columns thereto in geometrical relation, each column having a reinforcing element projecting toward the like members of the other columns; securing the adjacent reinforcing elements together; and finally casting concrete walls between the pillars to embed the reinforcing elements.

2. The method of forming reinforced vibrated concrete cellular structures, which consists in the following steps: forming a base; erecting reinforced concrete pillars or columns thereon in geometrical relation; intermeshing the metallic reinforcement of contiguous pillars; and casting walls between said pillars to embed the metallic re-

inforcement to form a plurality of hexagonal cells similar in size.

3. The method of forming cellular structures of reinforced vibrated concrete, which consists in the following steps: forming a base; vibrating said base *in situ*; securing thereto a plurality of concrete pillars having metallic reinforcement embedded therein and projecting therefrom; intermeshing the projecting metallic reinforcement of contiguous pillars; casting concrete walls between the pillars to embed the reinforcement and connect the pillars to form a tier of hexagonal cells; vibrating said walls *in situ*; erecting a plurality of reinforced pillars upon said tier; intermeshing the metallic reinforcement of said pillars with each other and with the metallic reinforcement of the tier below; casting walls between said pillars to embed the reinforcement and to connect the pillars to form a second tier of hexagonal cells; vibrating said walls *in situ*; and erecting a plurality of tiers of similarly formed hexagonal cells upon the structure so formed, until it is of the desired size.

4. The method of constructing and submerging a cellular structure, which consists in erecting upon a vibrated concrete base a plurality of vertical hexagonal cells; transporting the structure to deeper water; erecting upon the previously-formed cells superposed hexagonal cells tier by tier at the surface of the water; loading said cells to partially submerge the structure as the erection proceeds; and finally fracturing the bottoms of the cells to wholly submerge the structure.

5. The method of forming reinforced cellular structures, which consists in the following steps: placing corner pillars or columns in geometrical relation, each column having a reinforcing element extending toward a like member of the next adjacent column; connecting said adjacent reinforcing elements; and finally embedding said elements from column to column in a wall of vibrated concrete.

6. The method of constructing a unit for use in the construction of a sea wall or analogous structure which consists in erecting superposed tiers of vertical hexagonal cells of similar size of reinforced vibrated concrete partially submerging the structure by loading the cells finishing the top of the structure to form a road way and fracturing the bottoms of the cells to submerge the structure in the desired position.

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