No. 720,997. PATENTED FEB. 17, 1903.

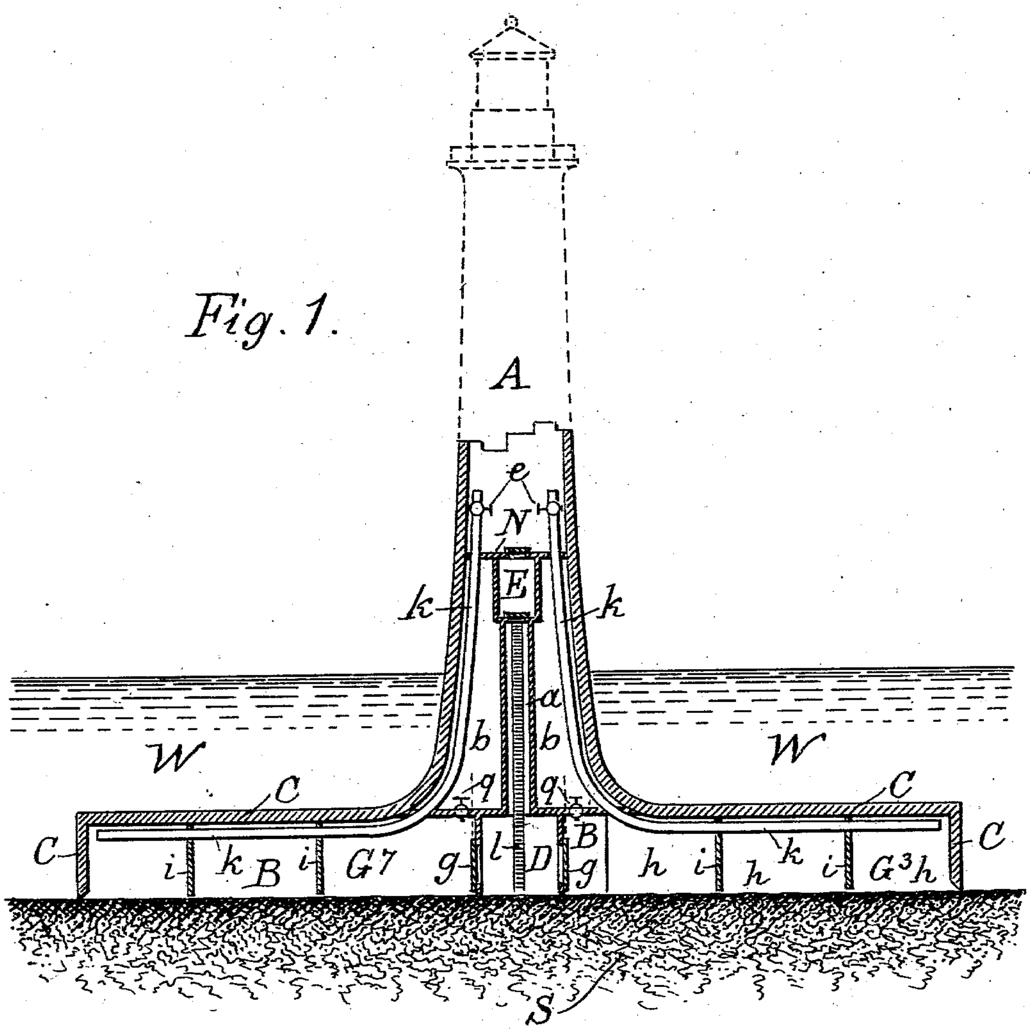
E. BECKER.

ART OF ESTABLISHING SUBAQUEOUS FOUNDATIONS.

APPLICATION FILED OCT. 7, 1902.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 1.



Witnesses:

Joseph Becker

Mary E. Cowell.

Inventor:

Edmund Becker

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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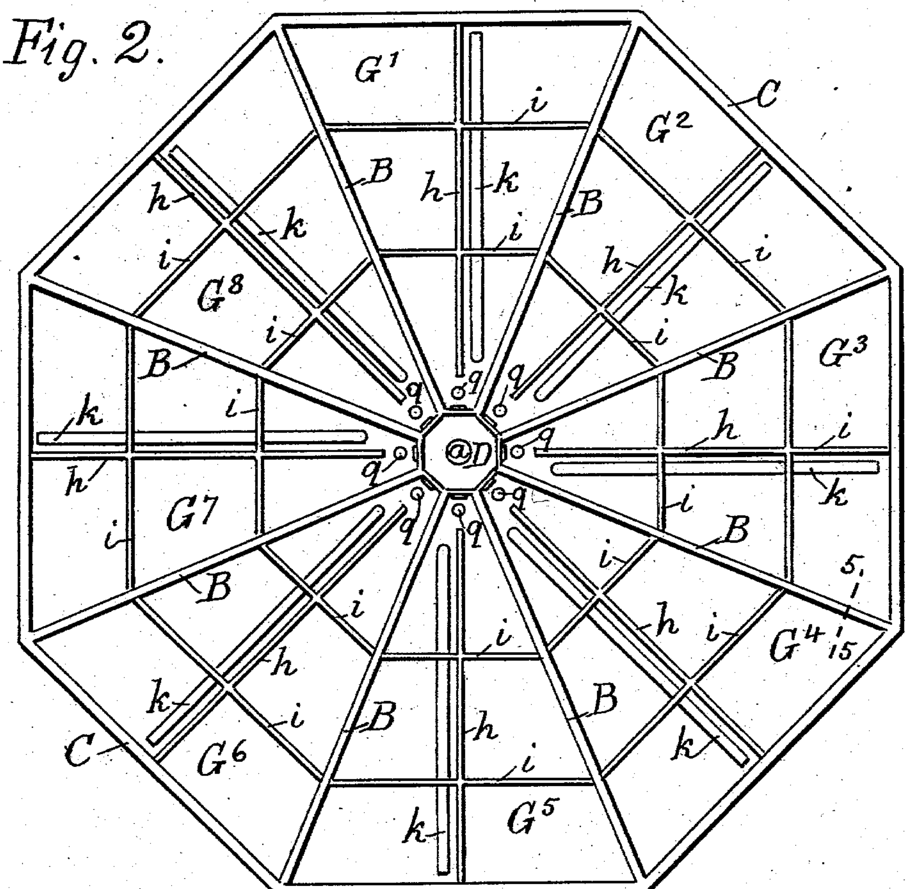
NO MODEL. 5 SHEETS—SHEET 2.

Fig. 2.



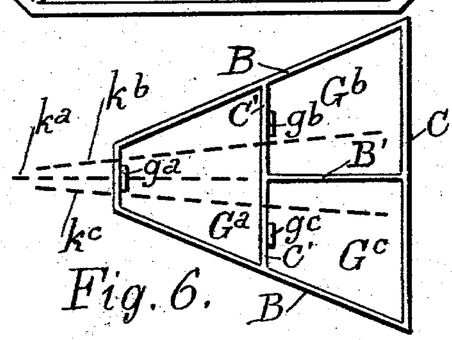


Fig. 6.

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NO MODEL. 5 SHEETS—SHEET 3.

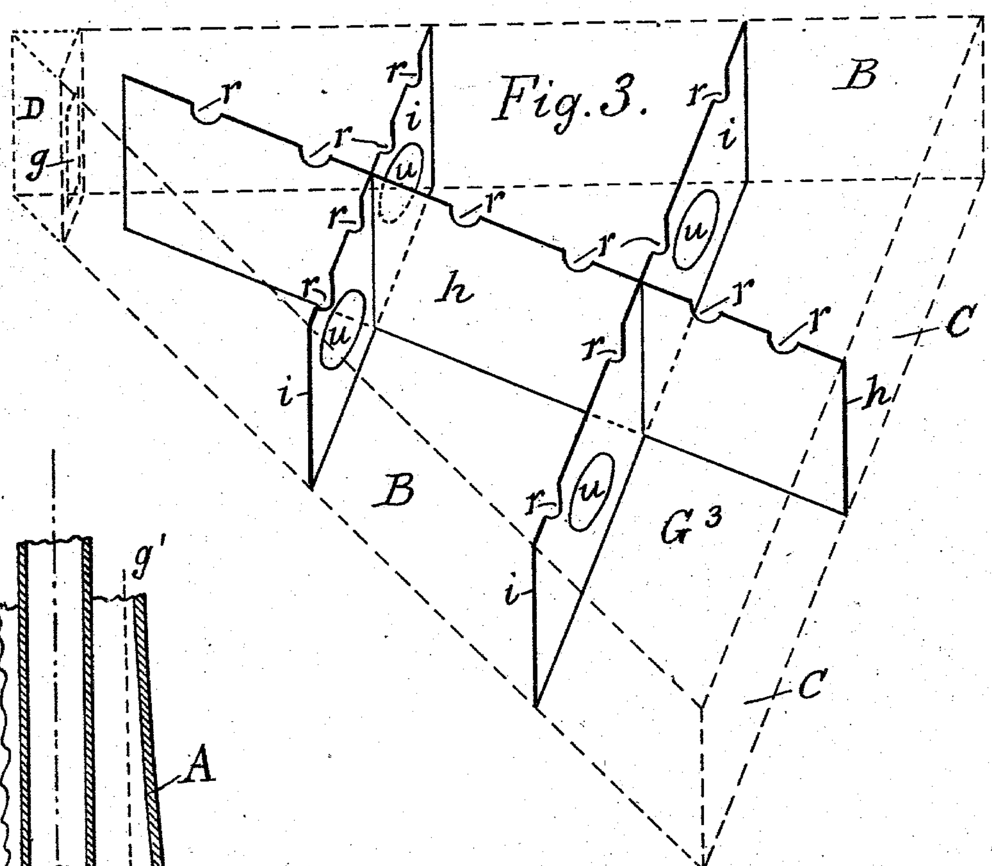

Fig. 3.

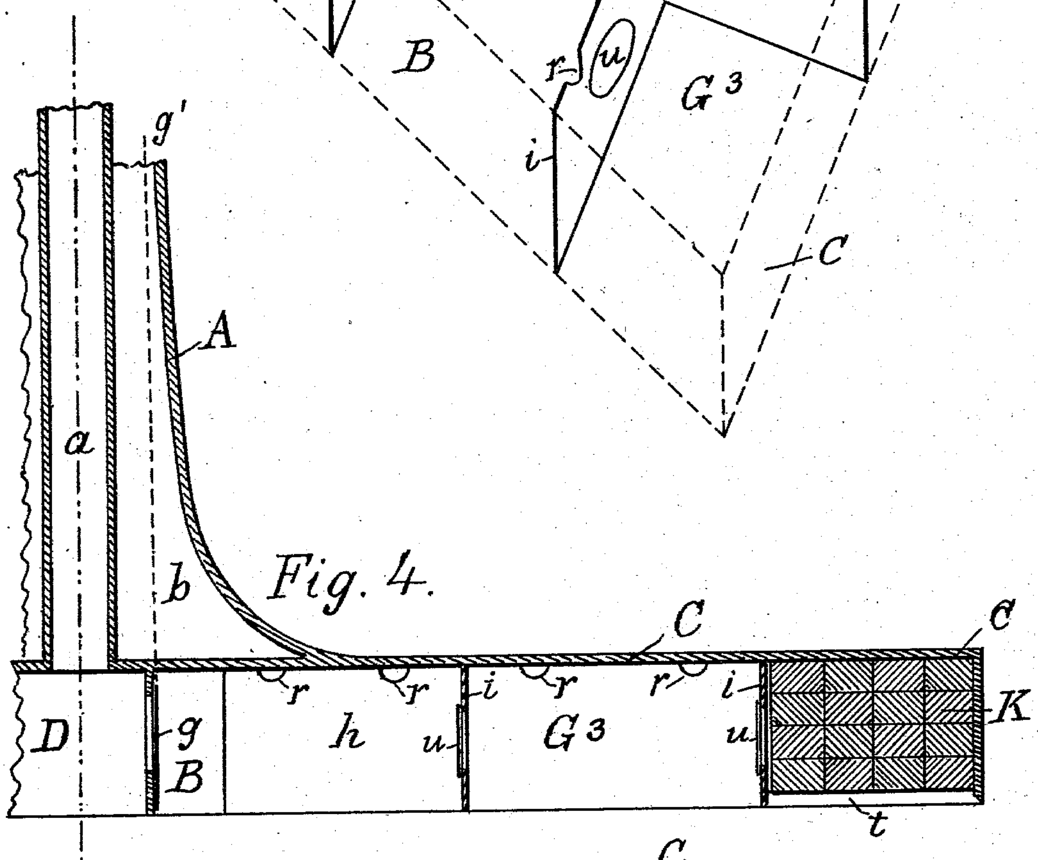

Fig. 4.

Witnesses:

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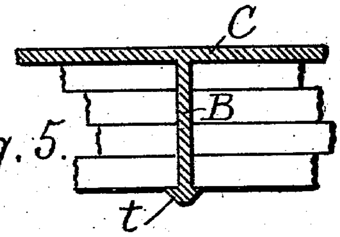

Fig. 5.

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NO MODEL.

5 SHEETS—SHEET 4.

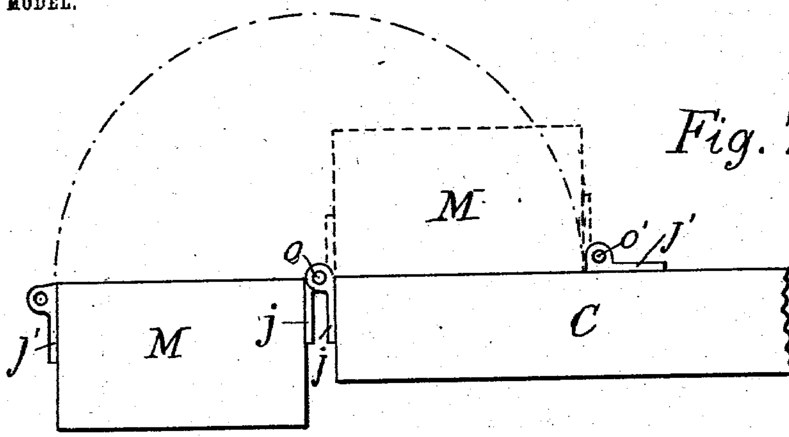
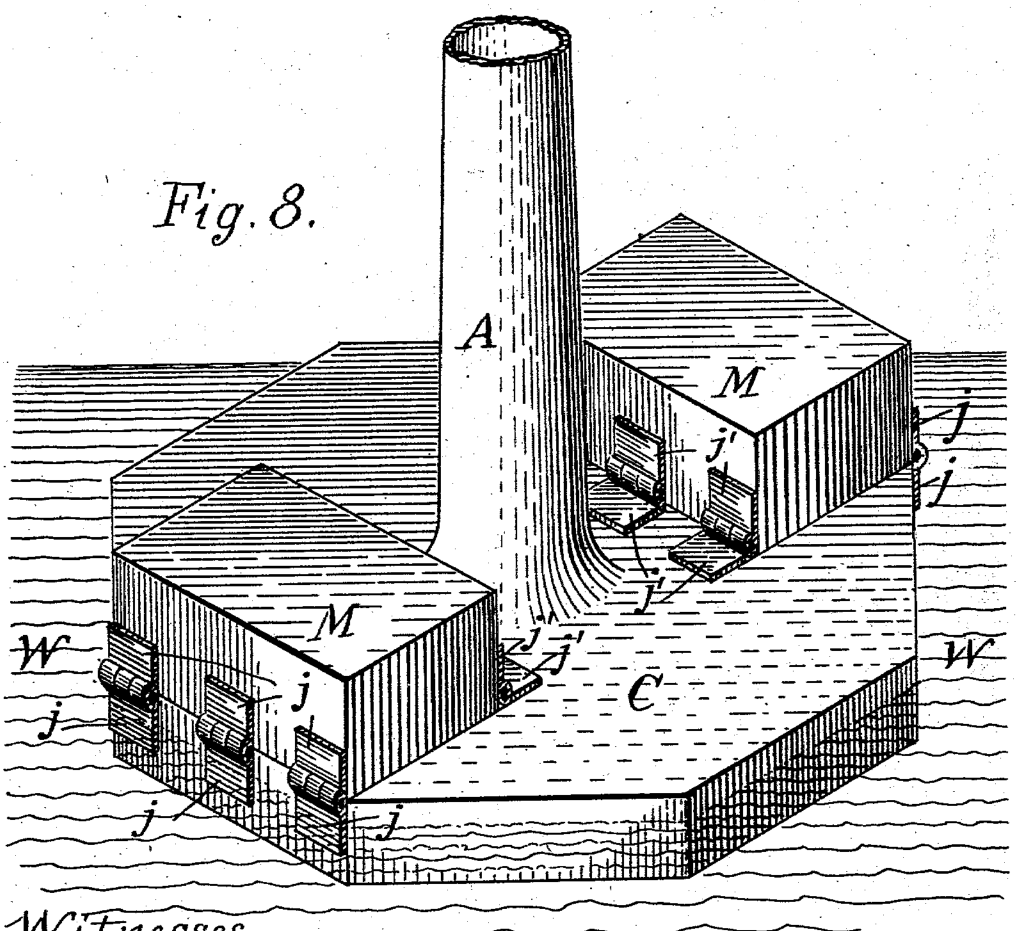


Fig. 7.

Fig. 8.



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NO MODEL. 5 SHEETS—SHEET 5.

Fig. 9.

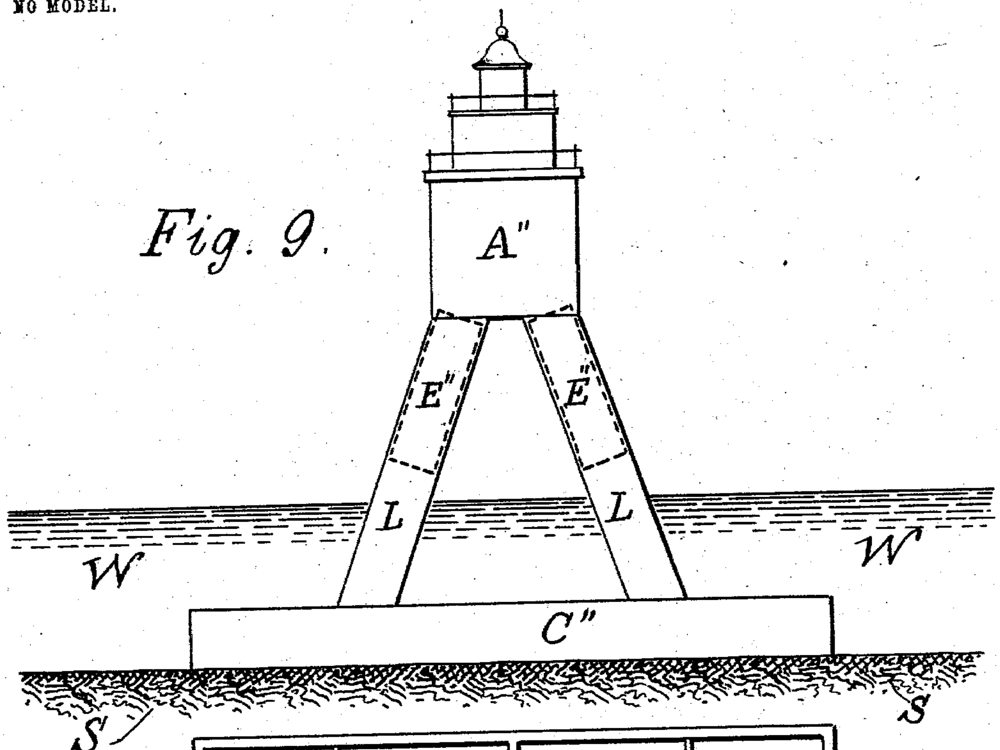
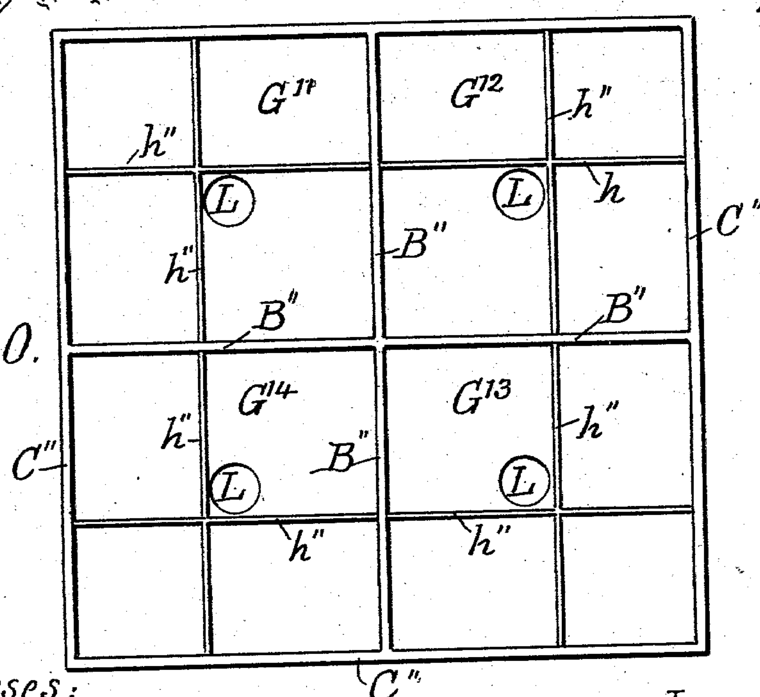


Fig. 10.



Witnesses:

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Inventor:

Edmund Becker

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

EDMUND BECKER, OF WASHINGTON, DISTRICT OF COLUMBIA.

ART OF ESTABLISHING SUBAQUEOUS FOUNDATIONS.

SPECIFICATION forming part of Letters Patent No. 720,997, dated February 17, 1903.

Application filed October 7, 1902. Serial No. 126,272. (No model.)

To all whom it may concern:

Be it known that I, EDMUND BECKER, a citizen of the United States, residing at Washington, District of Columbia, have invented certain new and useful Improvements in the Art of Establishing Subaqueous Foundations, as set forth in the following specification.

My invention relates more particularly to the pneumatic or plenum process of establishing foundations, with the view of specially adapting such process to the carrying out of the method described in my application filed May 10, 1902, since become Patent No. 710,658. According to said prior application the tower or pier to be erected must have an extended footing, which may be solid or hollow and the detail construction of which is not set forth, as said prior application is purely generic and contemplates the use of different systems of sinking according to circumstances and conditions. When the pneumatic or plenum process is the one to be used, this extended footing must be built as an air-caisson and, according to the usual practice, it would require a chamber substantially such as diagrammatically shown in Figure 1 of the said patent—that is, sufficiently large to give access to all parts of the sea-bottom that may be covered by the footing. The use of an air-chamber so extensive would call for special precautions of a kind well known in the art to insure that the steps of my process shall be carried out with that degree of certainty which I deem desirable. Thus if the sea be rough and the structure is expected to pitch or roll enough to raise the edge of the footing clear out of the water the engineer in charge would, as a matter of course, add a temporary or so-called "false" bottom to be used during the floating operation and to be taken off before grounding, its sole purpose being to retain the air and keep out the water while the structure is in transit from the place of construction to destination. Moreover, after the structure has been grounded the engineer would load it with auxiliary ballast to keep it firmly grounded during the excavating operation, when the caisson has to be filled with air.

The principal objects of my present invention are to make the use of a false bottom optional and to also avoid during the excavating operation the necessity for any other ballast than water. I attain these and other useful objects by the use of separate air compartments or chambers which constitute as many small independent caissons that may be worked singly or together at will, and each of these small caissons or chambers is preferably subdivided by vertical partitions into smaller communicating chambers, which I shall hereinafter call "cells."

One great advantage of this practice is that the water contained in the unworked chambers virtually acts as ballast and that the sinking of the footing into the soil at different parts of its periphery can, as I have discovered, be controlled at will by working the chambers *seriatim* in a certain order. The sinking may further be controlled by shifting solid ballast, which may be moved from one chamber to the other or taken out entirely should it be desired to refloat the structure to change its location. With water or solid ballast acting on one side to sink the footing and air in the opposite side to buoy it up the structure can easily be tilted about a horizontal axis to level the footing and righten the superstructure. The righting moment is dependent more upon the leverage than upon the magnitude of the righting forces, and therefore efforts which with the relatively narrow foundation of the old practice would be inefficient are by my system made highly-important auxiliaries in the process of erection. Moreover, the righting moments required in my system are comparatively small, because the caisson is never sunk to any great depth into the soil. Furthermore, as my caisson can perfectly well be sunk while inclined righting is not necessary and is not resorted to until the end of the sinking operation. In this respect my practice differs materially from the old, in which great precautions must be taken to guide the caisson in its descent and to keep it as nearly plumb as possible throughout the whole of the sinking operation.

A further important advantage of my invention is that the partitions can be and are designed to divide up the mass of water that may be contained in the footing during the floating operation and to effectually prevent such mass, especially when a false bottom is used, from rushing bodily from side to side in synchronism with the waves—action which might endanger the stability of the structure.

In the accompanying drawings, in which similar letters are applied to similar parts, Fig. 1 is a sectional elevation of a light-tower embodying the principles of this and my prior application. Fig. 2 is an inverted plan of the footing, showing the same divided into eight sector-shaped chambers, each forming an independent caisson element which is subdivided into six communicating cells. Fig. 3 is a perspective diagram view of one of the chambers. Fig. 4 is a view similar to Fig. 1, on an enlarged scale, but limited to one of the chambers and showing one of the cells thereof filled with removable solid ballast. Fig. 5 is a sectional elevation on line 5 5 of Fig. 2, showing how the removable ballast is supported within the footing. Fig. 6 on Sheet 2 is an inverted plan of a modified form of sector subdivided into three separate chambers, each of which has its own air-pipe and can be worked as an independent air-chamber and to a certain extent as an independent caisson element. Figs. 7 and 8 show preferred forms of auxiliary floats to be used only where the sea is very rough or where the footing is not in itself sufficiently buoyant. Figs. 9 and 10 show a modified form of tower and footing in which the intermediate part of the structure is subdivided into four diverging columns which serve as four separate air-shafts.

A represents a light-tower provided with an integral extended footing C, embodying the principles of my application above referred to, as well as those of the present application. As seen in Fig. 1, the structure appears as it is after completion of the fourth or grounding operation of the process disclosed in my said prior application. The operations that remain to be performed are the fifth, or excavating to sink the footing into and flush with the soil, and the sixth, or completing the tower.

In Fig. 1 the uncompleted part of the tower is indicated in dotted lines and is supposed to have been omitted to reduce draft and permit of towing the structure over shoals from the place of construction to the place of final erection and also to give the structure as much floating stability as possible.

The footing C, as seen in Fig. 2, is octagonal in plan view and is divided by eight vertical radial bulkheads B into eight sector-shaped compartments or caisson elements G' to G^8, which I shall hereinafter call "chambers." Each of these chambers communicates with a central chamber or vestibule D by means of a manhole, which may be hermetically closed by a door g, mounted so it may be opened from either side, and the locks on the gates are further provided with rods, (indicated in the figure by dotted line g',) which rods may be led to any other part of the structure from which it may be found desirable to unlock the doors. Leading upward from vestibule D is an air-shaft a, made not wider than required to admit materials and men and in which is fixed a vertical ladder l. At the upper end of the shaft a is an air-lock E, which opens onto a platform N, preferably at a higher level than the water on the outside. On platform N are mounted the pumping and other machinery that may be required to work the caissons. This machinery being of the ordinary kind has been omitted from the illustration. Between shaft a and the inner walls of the tower A is thus left a space b, which may be hermetically closed or else left to communicate freely with the atmosphere through a hatch in platform N. This space b is eventually used for storing either water or solid ballast, as will be explained hereinafter. Each of the eight sector-shaped chambers or caisson elements has a pipe k, leading from the extreme farther end near the ceiling radially inward, then upward in the tower A, up through platform N, where it is provided with a three-way cock e, by means of which the said pipe may be entirely closed or connected with the air-pump to admit air into the caisson element or opened to let air escape from the caisson into the atmosphere.

At the inner end each caisson element has a cock q, which is preferably operated through a connection from platform N and which may be opened to allow the air of the caisson to escape when the footing C is inclined and the air of the caisson collects at the inner end of the chamber.

Each one of the caisson elements or chambers is subdivided into smaller communicating cells by a radial partition h and transverse partitions i i. Openings u in the transverse partitions i i and an interruption at the inner end of radial partition h permit the men to move about freely in each chamber or caisson element from cell to cell. During the floating operation openings u should remain closed, and therefore I provide partitions h and i with small openings r, by means of which the air-pressure of each chamber is equalized throughout all its cells.

Partitions h and i might be made removable and might be entirely removed immediately after grounding; but I prefer to retain them, so they shall serve as permanent stiffeners of the footing. Some of the cells, preferably those adjoining the periphery of the footing, have on their radial walls near the bottom cleats t, upon which the ballast K rests. This ballast, which can be fixed to the foundation in any manner and which adds to the weight of the footing, can be of stone, concrete, or metal. I have shown it as of cast-iron bars, because cast-iron is three times denser than masonry and is more easily handled. I have shown it at and near the periphery, because it is there in the place most advantageous to the stiffness of the foundation and counteracts the weight of the superstructure at the center. This ballast is not put in place until the foundation has been sunk into the soil to the required depth.

The footing and the greater part of the tower A having been built and the platform N fitted with pumps and other necessary machinery, the doors *g* and *u* and cocks *e* and *q* having been closed, the structure is launched and towed to the place of final erection for grounding. During the launching operation enough air is imprisoned in the footing to float the structure.

Any tendency the water in the chambers might have to rush about within the foundation during rolling and pitching while the structure is afloat is interfered with by the partitions B, *i*, *h*. This confinement of the water also serves to prevent any important loss of air whenever the structure rolls or pitches enough to lift one of its edges clear out of the water.

Any losses of air through leakage or otherwise being compensated for by the working of the pumps, the structure can easily stand a very rough sea. However, as a safeguard a false bottom could be added, as is done in the usual practice.

When the structure has reached destination, it is sunk by allowing the inclosed air to escape first by opening cocks *e* and *q*. The whole footing then fills with water, and the space *b* also fills with water, which comes through the open cocks *q*. When the inside level is the same as the outside level, cocks *q* are closed to retain the water in space *b*, which water serves as ballast to hold the structure grounded. Should the structure be refloated for any reason, the water in *b* is expelled. Although the water in *b* would not generally be heavy enough to keep the structure down when all the chambers are filled with air, I prefer to not fill *b* with solid ballast until it is certain that the foundation need not be refloated, and therefore during the excavating operation air should be forced only in those chambers that require it for working them or for exerting a buoyant action, as explained earlier. The means to be used for excavating and for removing the excavated material will depend upon the nature of the soil to be removed and, being of the usual construction, is not illustrated. Should any wreck or other obstruction prevent sinking and it be impractical to remove the same, the structure can be refloated.

When the structure has been brought into the position desired, any spaces left between the soil and the ceiling of the caisson should preferably be filled with solid material to take the load off the cutting edge, and thereby secure the foundation. When the soil is of easy penetration, the caisson will sink therein until stopped by contact of the soil with the ceiling of the caisson. In such case no excavating is required except for righting. In filling I prefer to use kentledge K for the peripheral cells, as shown in Fig. 4, and the rest of the footing may be filled with sand or concrete.

The necessity for a false bottom can be entirely avoided by making the cells of a chamber non-communicating—that is, by closing openings *r*. In this case each cell should have its own air-pipe, and it becomes then an independent air-chamber. This form of construction is shown in Fig. 6, Sheet 2, in which the space corresponding to one of the chambers of Fig. 2 is divided by bulkheads B′ C′ into three chambers G^a G^b G^c, provided, respectively, with independent air-tubes, which are indicated in the drawings by dotted lines k^a k^b k^c and which are in every respect similar to pipes *k*. Bulkhead C′ is provided with doors g^b and g^c, which can be closed hermetically. The chambers G^a G^b G^c, with the corresponding central chamber or vestibule, constitute twenty-five separate air-chambers, each having relatively great height and little horizontal extent, so that when the structure is afloat and rolls or pitches any chamber which was emerged during a lurch is on coming back to the water at any angle possible in practice again water-sealed before it has lost any appreciable amount of air.

When the footing has considerable extent, the tower or pier part of the structure may be considerably widened without fear of spreading scour to the edge of the footing. There is no object in making the tower wider than necessary for interior room and for stiffness; but it is well when practicable to strengthen the connection of the tower with the footing by an easement, such as indicated in Figs. 1 and 4. The size of this easement will depend upon conditions. If current and scour be small, the easement can be increased to extend to the extreme edge of and itself constitute the footing. As explained in my Patent No. 710,658, above mentioned, any desirable degree of stability can be obtained by horizontally extending the footing, and as the extension can in the system herein described be made by adding chambers or by extending the original chambers stability and buoyancy can both be increased at will and at the same time; but when the footing C is made of little horizontal extent or when for any other reason it has very little excess of buoyancy and it becomes desirable to increase the buoyancy of the structure to secure its safety in all weather and against mishaps I provide auxiliary floats proportioned to keep the structure afloat even when the foundation is filled with water. This feature is illustrated in Figs. 7 and 8 in the form of two floats attached on top of the footing C. Where scour is to be feared, these floats M must, according to my first patent, be detached before the structure is grounded, and therefore I provide a fastening means which permits of easily releasing the two floats at the same time, preferably a mechanical release to insure positive action.

The fastening means shown comprises loose pintle-hinges $j\,j$ and $j'\,j'$. When the structure has been launched in still water, it can of course be made to float without the aid of the chambers M. These are then brought alongside and can be easily tilted to bring their hinge-sections j into working relation with the corresponding hinge-sections j, fixed to the footing C, and the pintles O are driven in. The two floats are then thrown over about their hinges $j\,j$ onto the footing, as indicated in dotted lines in Fig. 7, and the hinge-sections $j'\,j'$ are connected by a second pintle O'. Hinges $j'\,j'$ act not as hinges, but merely as fasteners, and can be replaced by any other form of fastener.

When the current is strong and it becomes desirable to reduce the section of the tower to a minimum, I use a multicolumnar tower—that is to say, I divide up the intermediate part of the structure into a number of parallel or inclined towers of greatly-reduced section. A preferred form of this construction is shown in Figs. 9 and 10. Here the footing is square, as seen in the inverted plan Fig. 10, and is divided by bulkheads B'' into four caisson elements or chambers G^{11} G^{12} G^{13} G^{14}, each of which is again subdivided by partitions h'' into four small communicating cells similar to those of Fig. 2.

Rising substantially from the middle of each of the chambers G^{11} G^{12} G^{13} G^{14} are four hollow columns L L L L, which are of sufficient diameter to allow the passage of materials and men and which serve as four separate air-shafts. They lead above into air-locks E'' and through these to a suitable platform, which corresponds in function to the platform N of Fig. 1. The process of erection is substantially the same as for the structure of Fig. 1, even as to the use of floats, if these be necessary.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. A subaqueous foundation comprising an extended base and bulkheads projecting downwardly from the periphery and from intermediate parts of the said base to form separate air-chambers open below and adapted to be operated independently on the plenum system, and other vertical but open partitions in each of said chambers to equalize the air-pressure in each chamber and serving with the intermediate bulkheads to prevent the contained water from rushing bodily about within the structure.

2. A caisson consisting of a chamber open below and vertical air-tight partitions to divide the chamber into separate caisson elements, an air-shaft common to all the caisson elements, each caisson element being provided with a hermetically-closing door leading to the common air-shaft.

3. A tower or pier having an integral extended base provided with downwardly-extending bulkheads to form a caisson-chamber under the base and also provided with detachable floats.

4. A subaqueous foundation comprising two or more pillars united under water, substantially at the level of the submerged ground, by a footing which extends laterally beyond range of the scour that may obtain about any one, or all, of the said pillars.

5. A marine structure comprising a tower or pier with an integral laterally-extended base and bulkheads projecting downwardly from the periphery and from intermediate parts of the said base, to form separate air-chambers open below.

6. A marine structure comprising a tower or pier with an integral laterally-extended base and bulkheads projecting downwardly from the periphery and from intermediate parts of the said base, to form separate air-chambers open below and adapted to be operated independently by the plenum system.

7. A pneumatic caisson divided into adjacent caisson elements and an air-shaft common to all of the said elements.

8. A marine structure comprising a tower or pier with an integral laterally-extended base, consisting of a caisson comprising separate air-chambers adapted to be operated independently by the plenum system.

9. A marine structure comprising a tower or pier with an integral laterally-extended base consisting of a chamber open below and having vertical air-tight partitions to divide the chamber into separate caisson elements.

10. A marine tower or pier having its lower part extended in the shape of a peripheral series of chambers, each chamber being adapted to be independently filled with air and ballast in any proportion.

11. A marine tower or pier having its lower part extended in the shape of a peripheral series of chambers, each chamber being open below and adapted to be independently filled with air and ballast in any proportion.

12. The combination with a marine tower or pier, of a footing having peripheral chambers, said footing being extended horizontally away from the tower or pier to secure great leverage for the vertical forces that act on the chambers.

13. The combination with a marine tower or pier of a footing having peripheral chambers open below, said footing being extended horizontally away from the tower or pier to secure great leverage for the vertical forces that act on the chambers.

14. A marine tower or pier having a substantially flat footing extended to afford sufficient support for the completed structure, when resting on the surface of the submerged soil where the structure is to be erected, said footing having bulkheads projecting downwardly from its under face to form air-chambers open below.

15. A marine tower or pier having a substantially flat footing extended to afford sufficient support for the completed structure, when resting on the surface of the submerged soil where the structure is to be erected, said

footing having bulkheads projecting downwardly from its periphery and from intermediate parts thereof to form air-chambers open below.

16. A marine tower or pier having an integral extended footing containing a buoyant air chamber or chambers and transverse obstructions arranged at intervals within said chamber or chambers and adapted to prevent any water that may be contained in the footing from bodily rushing about in synchronism with the oscillations of the structure.

17. A marine tower or pier having an integral extended footing containing a buoyant air chamber or chambers open below and transverse obstructions arranged at intervals within said chamber or chambers and adapted to prevent any water that may be contained in the footing from rushing about in synchronism with the oscillations of the structure.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EDMUND BECKER.

Witnesses:
JOSEPH BECKER,
MARY E. COWELL.