

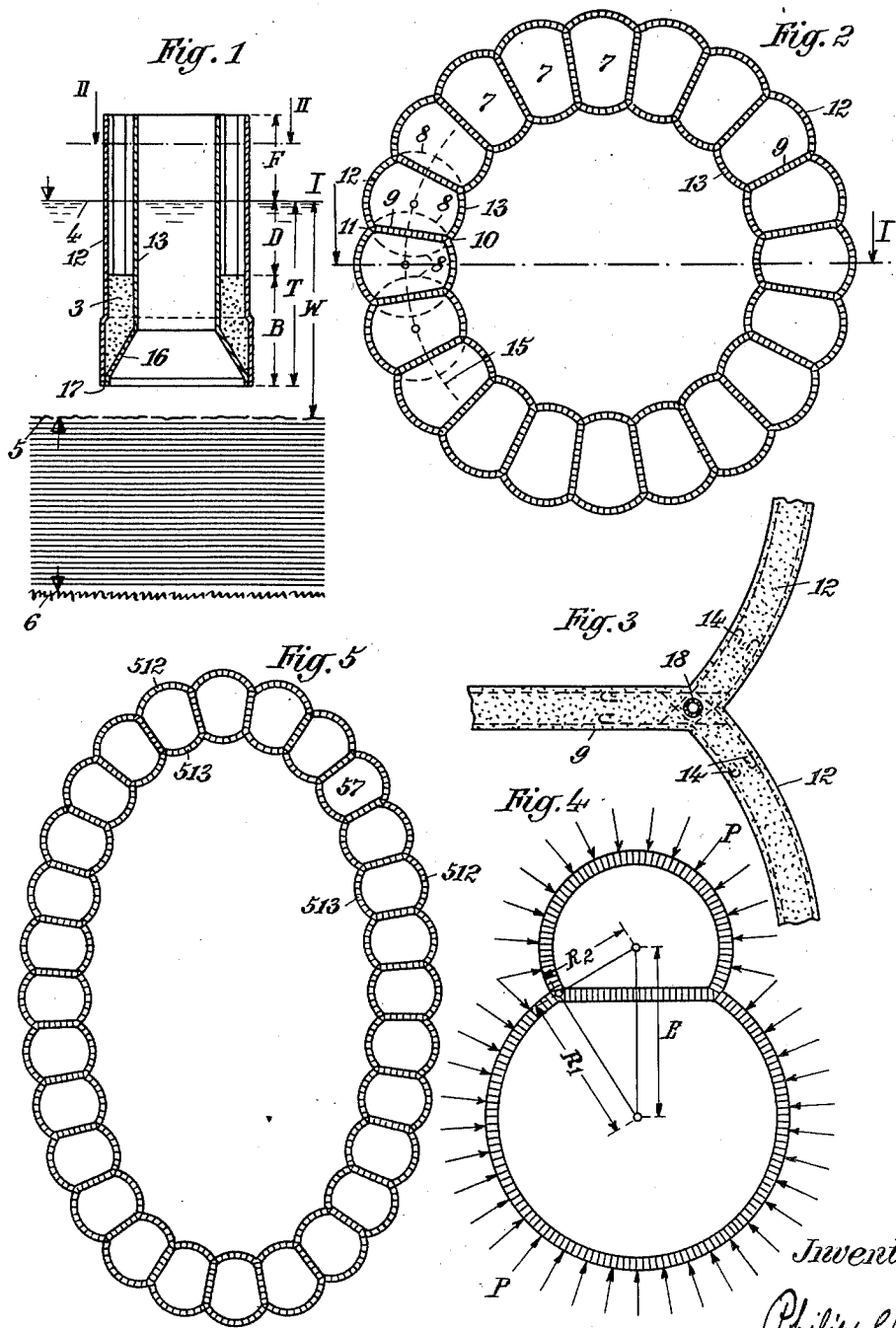
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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 6

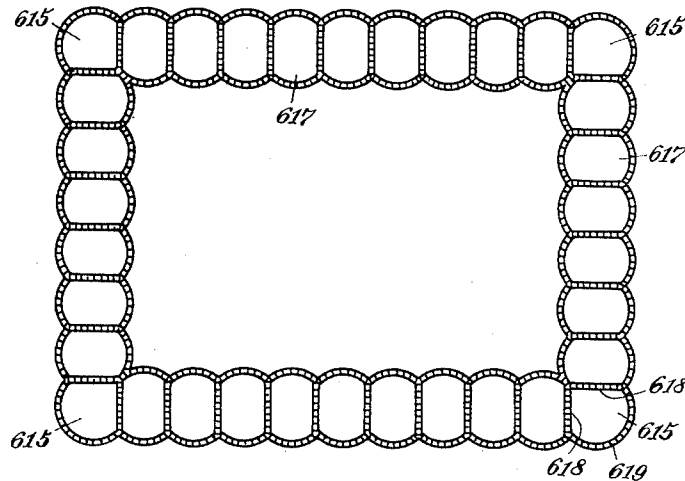
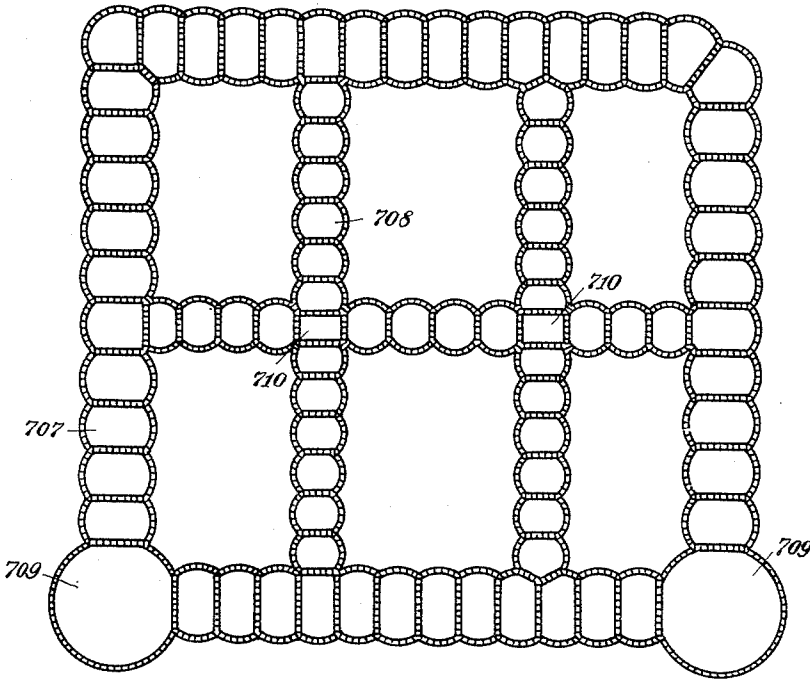


Fig. 7



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1

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2 Claims. (Cl. 61—81)

My invention relates to a caisson such as is used for erecting structures, e. g., bridge pillars, light houses, etc., in the open sea or in lakes or rivers. For constructions of that kind a caisson substantially in form of a shaft adapted to be sunk in upright position must be lowered, sometimes to considerable depth, until it rests on the bottom of the sea. The walls of such a caisson are provided with cavities which are open at the top and render the caisson capable of floating. In order to gradually sink the floating caisson, concrete is filled into such cavities progressively until the caisson hits the bottom. The shaft or shafts formed by the caisson are then emptied in order to gain access to the bottom of the sea for the performance of the required dredging or other work.

Caissons of this kind are usually made of wood or sheet metal. In either case the walls are reinforced by a suitable supporting structure. The caisson so formed is assembled above the water level and is then launched and floated to the site. There the cavities provided in the walls are gradually filled with concrete whereby the caisson is sunk. As the caisson is gradually lowered, the walls are extended at the top so as to always extend sufficiently above the water level. This operation is continued until the lower end of the caisson touches the bottom of the sea. The lower end of the caisson is formed by an edge. As soon as the same rests on the solid ground of the sea bottom, the work of filling up the hollow walls of the caisson may be expedited until finally the concrete structure thus formed extends above the water level and may be upwardly extended by the use of the customary concrete forms. At the same time the caisson may be further lowered by suitable steps such as a dredging operation, if required, until it rests on the rock bottom.

With great depths difficulties are liable to be encountered during that stage of the process in which the caisson is being sunk. From the weight of the structure, the level up to which the hollow walls of the caisson must be filled up with concrete in order to reach the desired depth may be figured out. Immediately above the concrete the hollow walls are subject to considerable water pressure and they must be capable of resisting such pressure during any stage of the lowering operation. With caissons of the customary structure, the greatest stresses are set up in the walls during the sinking operation at a level corresponding substantially to half the depth of the sea. In other words, if the depth amounts to 150 ft. which is not at all unusual, the walls of the caissons must be capable of sustaining a water head of 75 ft., i. e., a load of 22 tons per square meter or 4000 lbs. per square ft. The caisson structures known prior to my invention if designed to sustain such a high pressure are extremely expensive and heavy.

If wood is used for the structure of the caisson, the consumption thereof becomes so excessive that even in countries abundant of wood such wooden structures have been abandoned.

Also it is considered objectionable to embody such big quantities of wood in the pillar or other structure to be erected. In order to overcome such difficulty various courses have been adopted. One method used in erecting big structures is that using domed caissons. Another one is the method using an artificial island. The first method has the object to utilize the buoyance of the shaft for the purpose of reducing the depth of the body. Thus it was possible with the use of domed caissons when erecting the pillars of the San Francisco-Oakland Bridge

2

(West Bay) to reduce the stresses exerted on the hollow walls of the caissons by 50%. But an analysis of this construction shows that the advantage attained in this way had to be purchased at the cost of an increased risk and additional expense incurred in connection with other work. Constructing artificial islands will be the more expensive the greater the depth is.

The oldest and simplest method of using floatable shafts having hollow walls has so many advantages that an attempt to eliminate the main disadvantage of the excessive consumption of materials and of the excessive cost of building the floatable body is deemed worthwhile. In the customary structures known prior to my invention the outer walls of the caisson consist of bords or sheet metal subject to bending stresses and, therefore, usually reinforced by steel braces.

It is the primary object of my invention to so re-design the walls of the caisson shaft as to render them subject to mere pressure stresses or internal thrust set up by the water pressure, as distinguished from bending stresses.

I attain this object according to my invention by composing the walls of the caisson shaft of adjoining rigidly connected tubular cells open at the top and so arranged and disposed as to form a caisson shaft of the desired shape, the walls of the shaft subjected to the water pressure having an arcuate profile pressure stresses being set up in said arcuate walls by the water pressure directed towards the central axis of each cell.

Preferred embodiments of my invention will be described hereinafter with reference to the accompanying drawings in which

Fig. 1 is a longitudinal section through a caisson being shown in the act of being sunk, said section being taken along line 1—1 of Fig. 2;

Fig. 2 shows a cross-section through a caisson embodying the present invention taken along line 2—2 of Fig. 1;

Fig. 3 shows part of Fig. 2 on an enlarged scale;

Fig. 4 is a diagrammatic cross-sectional representation of two adjoining tubular cells illustrating the water pressure acting thereon;

Fig. 5 is a cross-section through a caisson having an oval shape;

Fig. 6 is a cross-section through a square caisson designed in accordance with my invention;

Fig. 7 is a cross-section through another variety of a caisson embodying the principle of my invention.

My novel caisson comprises a body which, as shown in Fig. 1, constitutes a shaft open at the bottom and at the top. The walls of the body consist of adjoining tubular cells 7 which have substantially partitions 9 extending transversely of the wall of the shaft. The outer walls 12 of the cells are formed to bulge outwardly while the inner walls 13 bulge inwardly. From a consideration of the cross-sectional profile of the cells as shown in Fig. 2 it will appear that such profile is formed by intersecting circles 8 whose centers are located on a common circle 15 concentric with the caisson. The cells 7 are closed at their bottoms by a conical wall 16 co-axial with the circle 15 thus forming a sharp bottom edge 17 adapted to penetrate the layer of mud or sand indicated between the lines 5 and 6 and to firmly seat upon solid ground.

It will thus appear that the hollow wall of the shaft is constituted by tubular cells having a cross-sectional profile formed by an outer arc 12, by an inner arc 13 concentric therewith and by straight lines 9 connecting the ends of the arcs 12 and 13 and constituting the boundaries of the profiles of the adjoining cells 7. In other words, the tubular cells have a cross-sectional profile formed by the intersecting circles 8. The partitions 9 may be continuous walls or may be truss structures composed of radial and diagonal braces leaving openings between them establishing a communication between the adjoining cells.

The weight of the structure is so related to the volume of the cells 7 that the whole structure is capable of floating as shown in Fig. 1. The tubular cells are progressively filled with concrete as indicated at 3 in order to sink the caisson. The distance B of the concrete level from the edge 17 required to reach a certain depth T can be computed. It will appear from Fig. 1 that the walls

3

12 and 13 are subject to a maximum water pressure at the depth D. With caissons of the type known prior to my invention the distance B amounted as a rule to about half the amount of the total depth T. Therefore, the walls were subject to a maximum water pressure equaling the pressure prevailing at half the depth W of the sea. In my novel caisson structure this pressure sets up mere pressure stresses and no bending stresses in the walls 12 and 13 and in the partitions 9. Therefore, my novel caisson is capable of resisting unusually high water pressure as will be encountered at very great depth even though the walls 9, 12 and 13 may be made comparatively thin. The adjoining rigidly interconnected tubular cells will mutually support each other thus avoiding the risk of local breakage.

Since the walls of the caisson thus formed are subjected by the water pressure to mere pressure stresses, braces such as used in the known caissons to take up the considerable bending stresses set up in the walls may be dispensed with whereby the weight of the structure and the consumption of material are reduced.

Although any suitable material may be used to build up the tubular cells 7, I have found that particularly favorable effects may be obtained by producing the walls from reinforced concrete as shown in Fig. 3 in which the re-inforcing wires or rods are indicated at 14. When producing the walls from such concrete to which a suitable light weight filling material may be admixed, scavenging pipes may be embodied within the walls of the cells by embedding them, for instance, along the lines of intersection of adjoining cells as indicated at 18 in Fig. 3 showing the cross-section of an embedded tube which terminates at the bottom edge 18. The tubes serve to issue water jets from their mouths removing the mud or soil therebelow in order to permit the caisson to penetrate the strata lying above the solid ground.

By making the entire structure solely out of concrete I avoid the disadvantage, inherent in the prior use of wood, of embodying a foreign material in the finished pillar or other structure. Moreover, I secure the further advantage of an inexpensive and rapid construction of the caisson by the use of such efficient equipment as sliding concrete forms which will speed up the work and thus reduce the time required to lower the caisson to a minimum. Experience has shown that the lowering speed depends entirely on the rapidity of the work of extending the walls of the caisson upwardly. Since all of the cells may be made with continuous walls permitting of the use of sliding concrete forms, the walls will become perfectly smooth whereby the penetration by the caisson of the layer of mud or sand indicated between lines 5 and 6 in Fig. 1 is materially facilitated. My improved caisson has an extremely low weight amounting to but one-third up to one-half of the displaced water. This will tend to reduce the ratio of D : B shown in Fig. 1 and will thus reduce the maximum water pressure to be encountered in the course of the sinking operation.

Preferably, I use a concrete of a particularly small specific weight for producing the cellular structure in order to keep the weight to a minimum.

Fig. 4 serves to prove the theory that in a caisson constructed in accordance with my invention mere circumferential pressure stresses are set up in the walls under the effect of the external water pressure even should adjoining cells intersecting one another have different radii designated R1 and R2 in Fig. 4. The water pressure indicated by the arrows P in Fig. 4 will set up a pressure amounting to P.R1 in the outer wall of the larger cell while a pressure of P.R2 will be set up in the wall of the smaller cell. By simple geometrical analysis it may be shown that the inner partition connecting the lines of intersection of the two cylinders will be subject to the pressure P.E, the distance of the two axes of the two cylindrical cells being designated E.

Fig. 5 shows an example of a caisson having an elliptical cross-section embodying the principle of my invention. The wall of the caisson is composed of adjoining parallel tubular cylindrical cells having intersecting circular cross-sections, the intersecting segments of adjacent cells being replaced by a straight wall forming a parti-

4

tion common to both cells. It will be apparent from a consideration of Fig. 5 that in accordance with the principle of my invention the walls 512 and 513 of each of the adjoining cells 57 are formed by sections of a cylinder and are, therefore, curved to better resist the external water pressure.

Fig. 6 represents a caisson having a rectangular cross-section, the shorter sidewalls and the longer sidewalls being constituted by adjoining cylindrical cells 617 arranged to intersect each other. The corners of the caisson are formed by tubular cells 615, having a cross-section formed by two walls 618 extending at right angles to one another and by an arc of a circle, designated 619. Here again the water pressure prevailing inside and outside of the caisson will set up mere pressure stresses in the walls of the cells and not any bending stresses.

In Fig. 7 I have shown a caisson of a substantially rectangular cross-section provided with internal partitions subdividing the caisson into six shafts. It will be noted that both the outer walls of the caisson as well as the partitions are made up of adjacent tubular cells having the shape of cylinders with opposite flattened sections. Moreover, it will be noted that there are such cells 707 of larger diameter forming the outer walls of the caisson and cells 708 forming the partitions and that the corner cells 709 approach very closely true cylinders. Cells 710 situated within the intersections of the partitions of the caisson are box-shaped having straight walls since they are not subjected to any external water pressure.

While I have described my invention by reference to various preferred embodiments thereof, I wish it to be clearly understood that my invention is in no way limited to the details of such embodiments but is capable of numerous modifications within the scope of the appended claims.

What I claim is:

1. A caisson for erecting structures in open water, said caisson comprising a unitary body structure forming a shaft, said shaft being open at the bottom and at the top, said body consisting of adjoining tubular cells formed of reinforced concrete impervious to water, said cells creating continuous impervious walls of said caisson, said tubular cells being open at their tops and closed at their bottoms by a conical wall common to all of said cells and co-axial with said body, said cells being of a lateral cross-section so as to displace sufficient water to float said caisson, said cells being adapted to be gradually filled up with concrete for the purpose of sinking said caisson in upright position, the outer and inner walls of said cells above said conical wall being formed by arcuate members of continuous vertical extent, with one of the arcuate members of each of said cells facing the outside of said casing, and the other of said arcuate members facing the inside of said casing, said arcuate members being concentric and having adjacent ends interconnected by straight wall-forming members, all of said members being formed of said concrete, said wall forming members extending laterally of the outer and inner surfaces of said cells and laterally of said caisson, the structure being such that every one of the walls is exposed to compression stress, exclusively.

2. The caisson of claim 1, in which the outer arcuate members bulge outwardly and the inner arcuate members bulge inwardly of said body.

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