Sept. 8, 1936. H. P. FREAR 2,053,904

SHIP CONSTRUCTION

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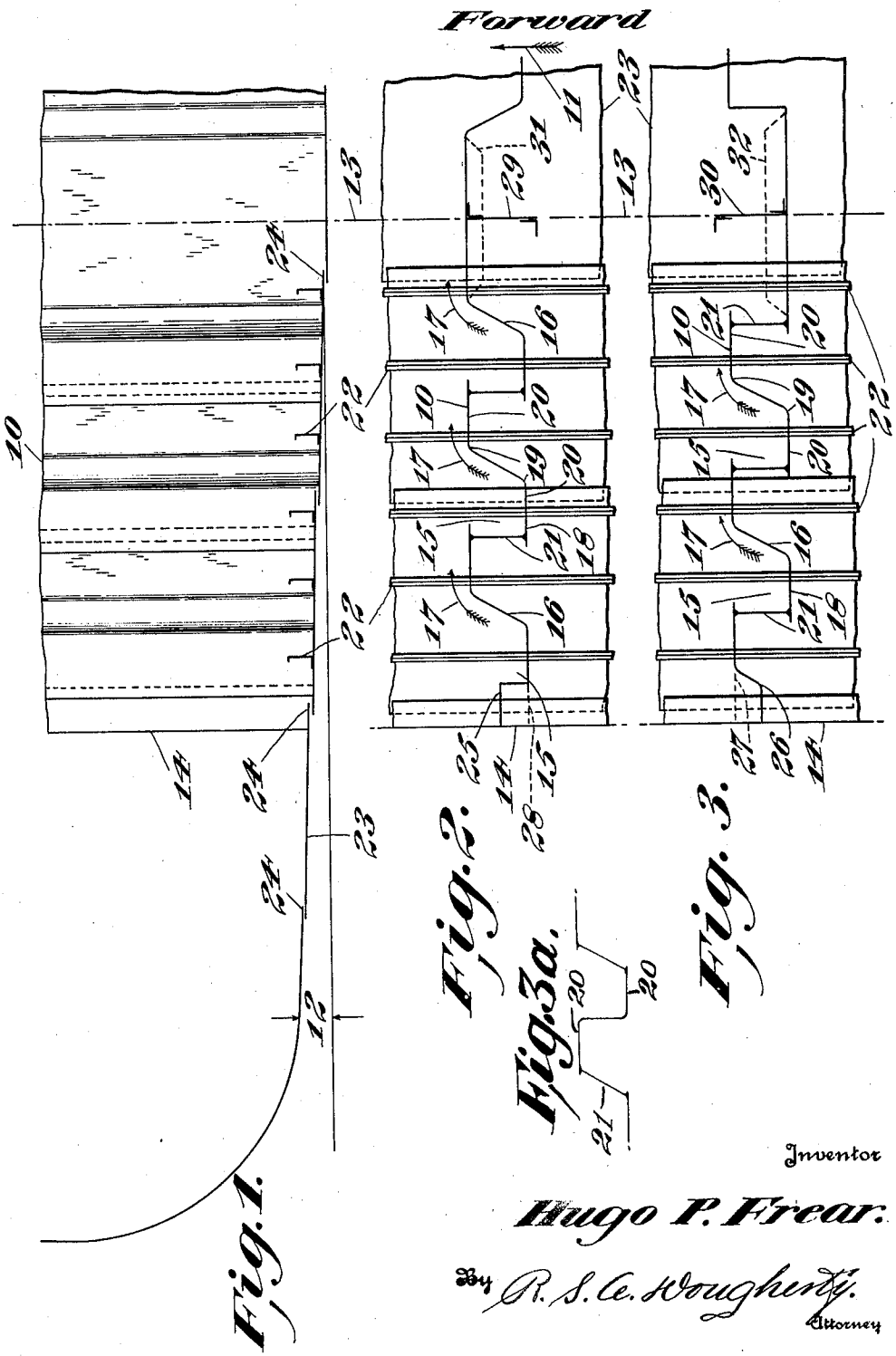

Fig. 1.

Fig. 2.

Fig. 3a.

Fig. 3.

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Sept. 8, 1936. H. P. FREAR 2,053,904

SHIP CONSTRUCTION

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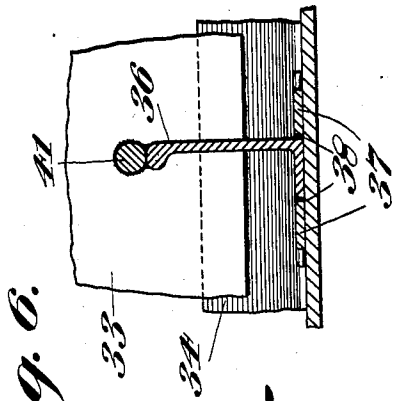

Fig. 6.

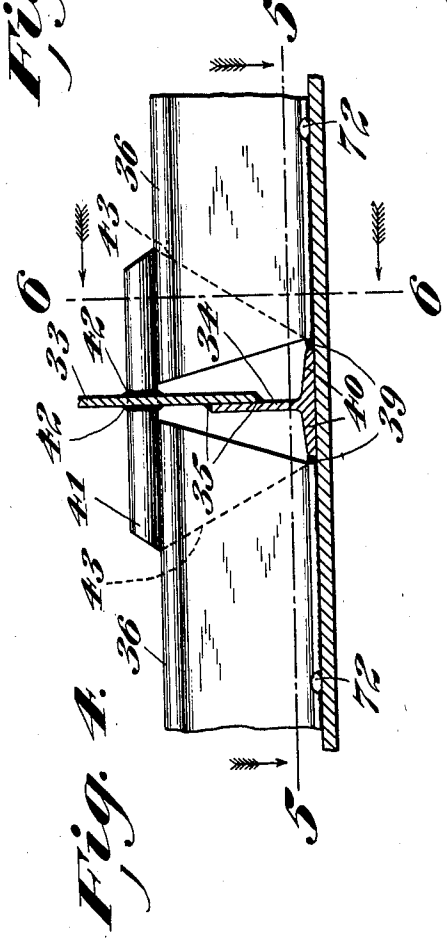

Fig. 4.

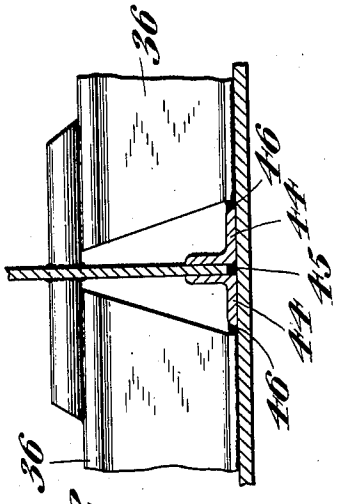

Fig. 7.

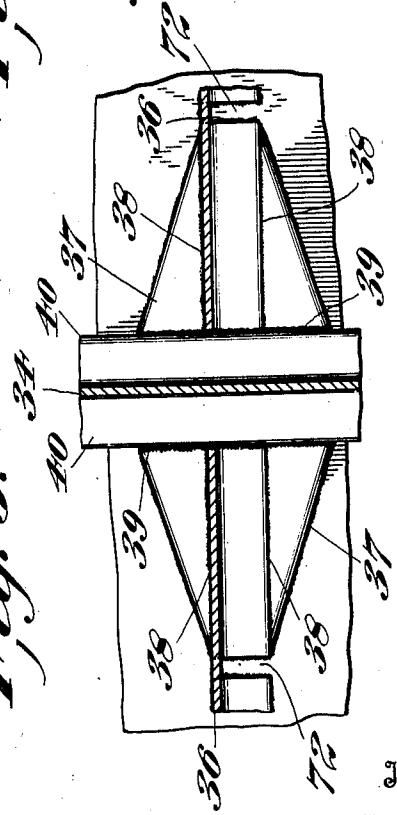

Fig. 5.

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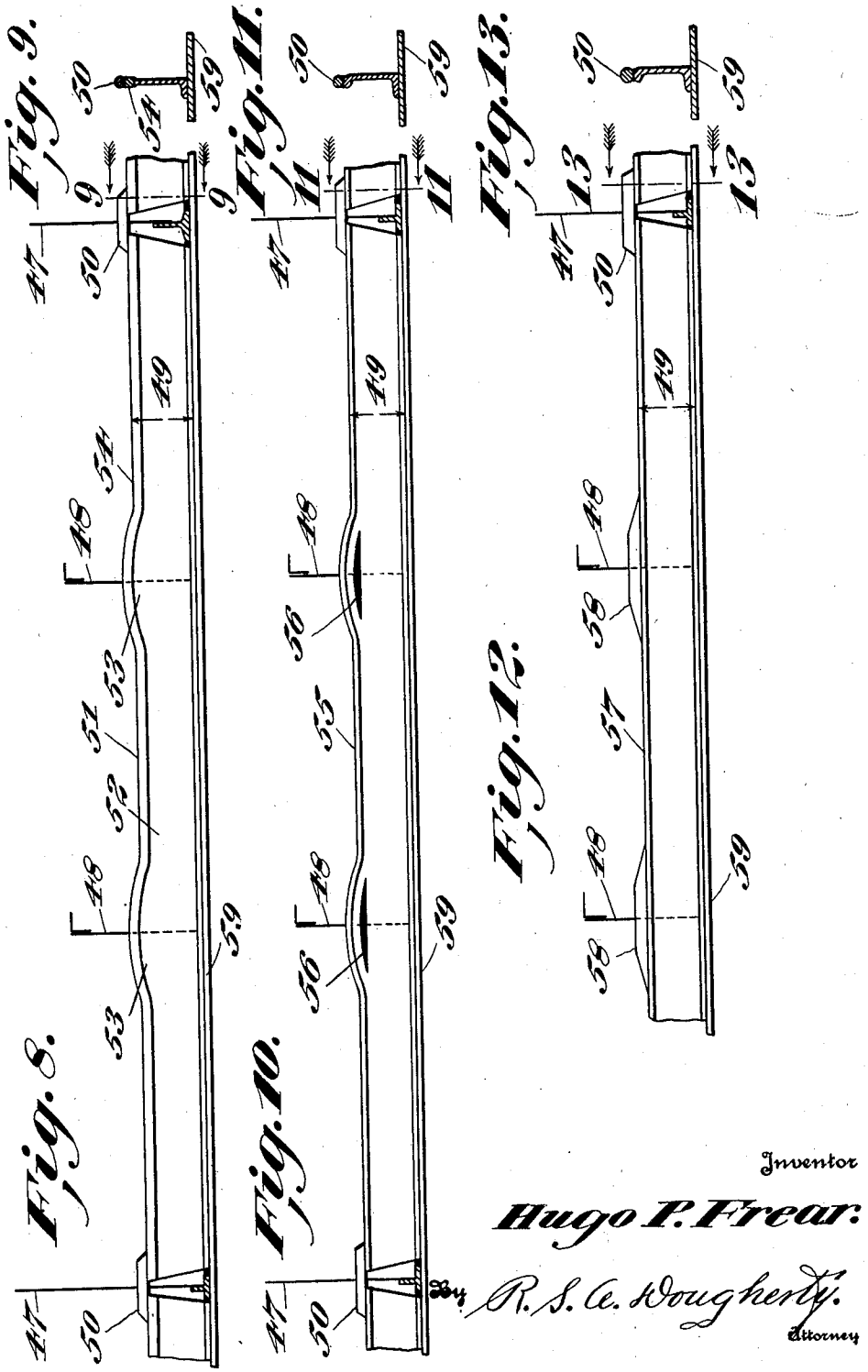
Sept. 8, 1936. H. P. FREAR 2,053,904

SHIP CONSTRUCTION

Filed July 19, 1934 7 Sheets-Sheet 3



Sept. 8, 1936. H. P. FREAR 2,053,904

SHIP CONSTRUCTION

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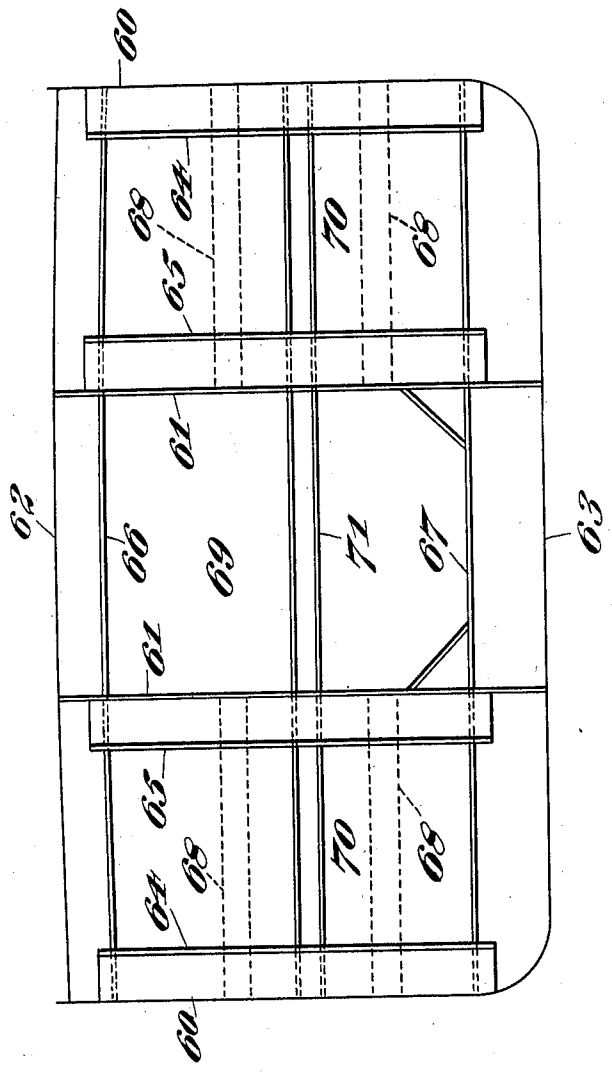
Fig. 14.



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Sept. 8, 1936. H. P. FREAR 2,053,904

SHIP CONSTRUCTION

Filed July 19, 1934 7 Sheets-Sheet 5

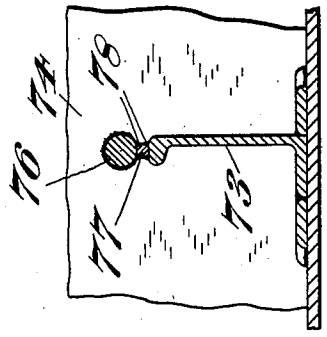

Fig. 16.

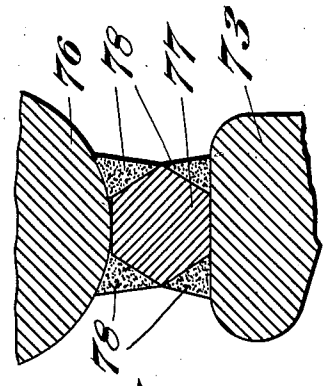

Fig. 17.

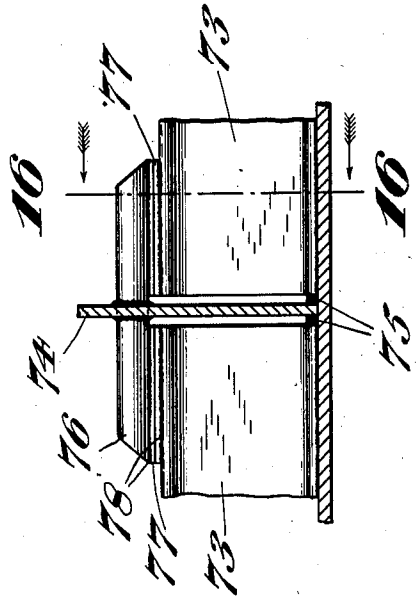

Fig. 15.

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SHIP CONSTRUCTION

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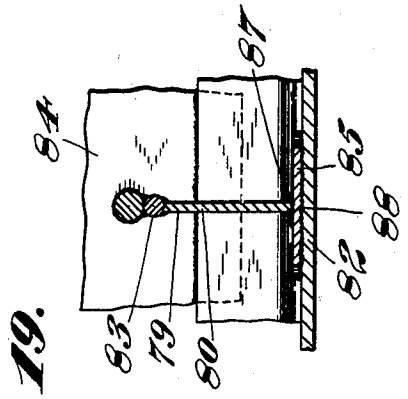

Fig. 19.

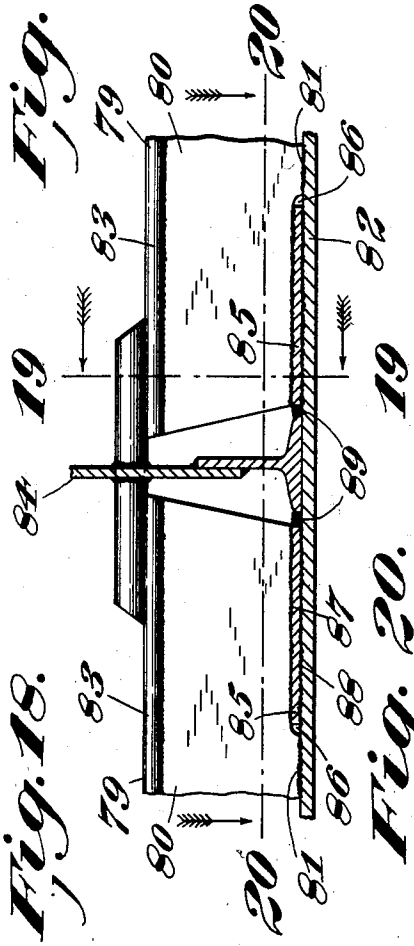

Fig. 18.

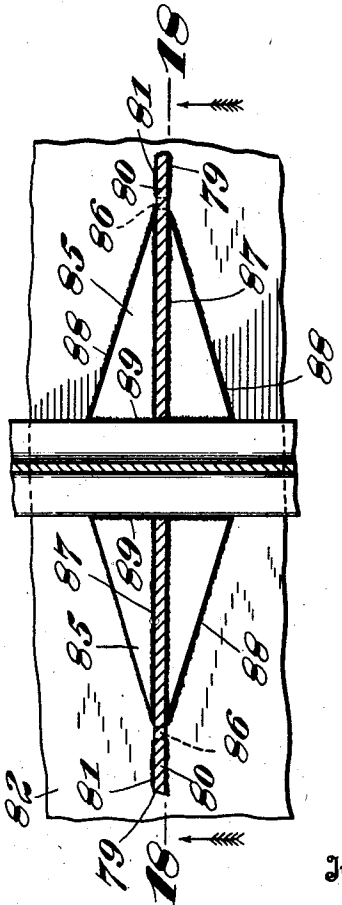

Fig. 20.

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SHIP CONSTRUCTION

Filed July 19, 1934 7 Sheets-Sheet 7

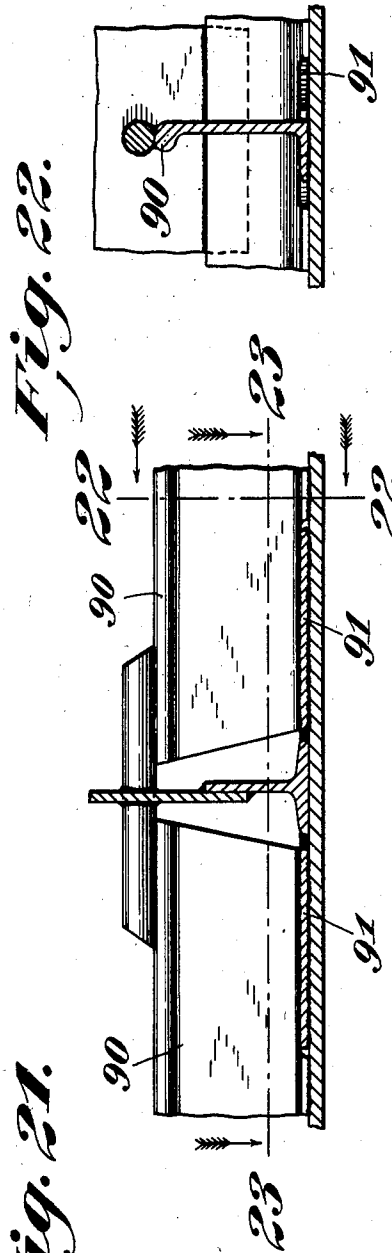

Fig. 21.

Fig. 22.

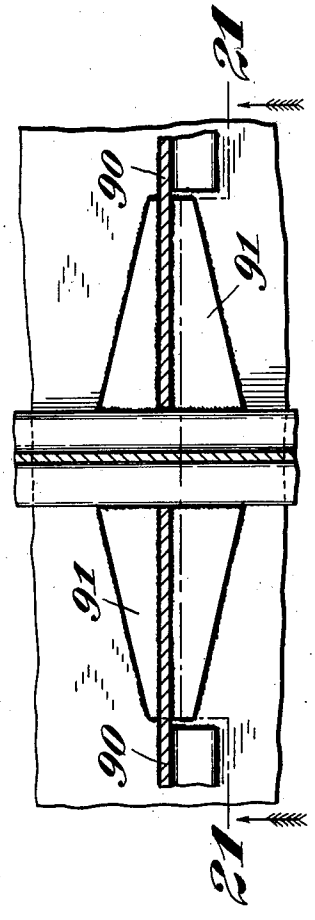

Fig. 23.

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Patented Sept. 8, 1936

2,053,904

UNITED STATES PATENT OFFICE

2,053,904

SHIP CONSTRUCTION

Hugo P. Frear, New York, N. Y., assignor to Bethlehem Shipbuilding Corporation, Ltd., a corporation of Delaware

Application July 19, 1934, Serial No. 735,923

3 Claims. (Cl. 114—79)

My invention relates to improvements in the structure of floating vessels or ships of all types, but especially to vessels designed to carry liquid cargo in bulk, commonly called tankers, and built on the quasi longitudinal system of framing.

The nature and disposition of the liquid cargo in these tankers is largely responsible for limiting their life or usefulness due to excessive corrosion and to harmful stresses, both local and over-all, not experienced to the same extent in other vessels.

Excessive corrosion of the internal hull structure of cargo oil compartments of ocean going tankers is due to a variety of causes and combinations of the same, of which inefficient drainage, location, and fatigue of material at points of concentrated stresses are probably the greatest accelerating factors. The correlation of excessive corrosion and excessive stresses is generally acknowledged and improvements in design effected to decrease either of these destructive factors will result in benefit to the other, and a decrease in both will add greatly to the life of the ship.

The improvements embodied in my invention make it possible to effect a substantial saving in weight without reducing the thickness of scantlings even after plowing back into the structure sufficient weight to materially increase the thickness of such parts found by experience and measurement to be most susceptible to rapid corrosion.

I also improve drainage and relieve the plating at points of fatigue and concentrated stress by correcting the cause rather than by adding weight to the said plating. It is universally acknowledged that a channel section is subject to more rapid corrosion than a bulb section. Bulb sections rolled in this country are limited to 10" or under and it has not been possible to employ these in American built tankers except in the upper parts of the vessel. With my invention I am able to use bulb sections exclusively throughout the cargo spaces of a tanker of the largest dimensions even where in present designs 18" channels are used on the bottom.

In vessels constructed to carry liquid cargo in bulk the machinery is usually located aft. This necessitates a distribution of cargo on account of which the greatest over-all stresses in the plating are in the sagging condition or when the vessel is in the hollow of a wave, the deck plating being in compression and the bottom plating being in tension. In longitudinally framed vessels the continuity of strength in the plating is greatly impaired due to the fact that the longitudinal stiffeners attached to the plating are cut through by the bulkheads, thereby causing discontinuity and harmful concentration of stress in said plating in way of said bulkhead, resulting in cracks in the plating and leaky rivets at the end of said longitudinals.

Many means have been suggested to compensate for said discontinuity and concentration of stress due to cutting the longitudinals. Most of said means have only been partially successful due to said means employed at the inner edges of said longitudinals being inadequate and eccentrically loaded or by fitting doublings at the outer edge designed to strengthen the plating rather than correct the cause of said discontinuity by tying the ends of said longitudinals on each side of said bulkheads together.

We know that forces due to the working of a vessel in a sea may strain the plating and from "Hooke's generalized law" the stress in the plating is proportional to the strain. We also known that if any of said strain is transmitted from said plating to said longitudinals, while an unknown quantity, it is imparted to the outer edge of said longitudinals when attached to said plating.

From applied mechanics, tests, and typical "photoelastic determinations" we know that if said transfer of strain takes place, principal strain lines are created in the longitudinals which focus and start with maximum intensity at the outer edge at the ends of said longitudinals adjacent said bulkheads and gradually spread inwardly of said longitudinals with diminishing intensity as distance from the bulkhead increases. The focusing of said principal strain lines at the ends of said longitudinals contribute to concentrated stress and micro-structure changes in the plating resulting in fatigue, cracks, and accelerated corrosion. It is therefore reasonable to conclude that connecting the ends of said longitudinals across the bulkheads at the outer edges should be more effective in restoring longitudinal strength to the plating than by connecting the inner edges of said longitudinals across said bulkheads. Furthermore connecting the ends at the outer edge across the bulkheads reduces the effect of the shearing stresses whereas the fittings of doublings merely stiffens the plating without altering the condition of the interrupted longitudinals.

On the other hand the longitudinal stiffeners have work to perform in supporting the plating through resisting bending moments caused by

pressure from liquid cargo or test heads, and no one really knows how much additional work they may reasonably be expected to do towards contributing strength to the plating beyond providing rigidity. If said stiffeners were stressed to the yield point by bending alone, it is inconceivable that there would be any strength remaining to contribute longitudinally to the plating. However, it is obvious that any possible contribution available would increase as the bending stresses in said stiffeners decreased. We know that there is a concentration of stresses in the plating and in the riveting where the stiffeners are cut at the bulkheads—cracks in the plating immediately at the ends of the stiffeners and loose rivets at the ends of the stiffeners confirm this. We also know that at least a large part of the said concentration of stresses is directly attributable to shearing stresses in said rivets solely as a result of the stresses due to bending moments in the stiffeners.

For example, assume that the stiffener is a uniformly loaded continuous beam supported at the ends by said bulkheads and at 10 foot intervals by transverse web beams, and that the said stiffener supports a strip of plating 2.5 feet wide, and that a test head of 42 feet of salt water at 35 cubic feet to the ton is being applied. Then

$$\frac{10\times42\times2.5}{35}=30 \text{ tons},$$

which is the load on the 10 foot span of said stiffener. One half of 30 tons, or 15 tons, is supported at each end of each span and is equal to both the maximum vertical shear at the said ends of each span and to the longitudinal shearing stresses in the rivets adjacent the said ends of each span. These longitudinal shearing stresses in the rivets are equal and opposed on the opposite sides of the bulkheads and of the web beams. However, the effect of the shearing stresses on the rivets is not uniform. Where the longitudinal stiffeners are continuous at the web beams they act to resist the shearing stresses in the adjacent rivets, while no such resistance is present at the cut ends of the stiffeners at the bulkheads. In the latter case the shearing stresses become direct forces acting longitudinally and are added to the normal stresses of the plating. It should be noted that this addition to the normal stresses of the plating is solely due to the bending moments of the stiffeners as though the vessel were at rest and not in any way to the working of the vessel.

From the above it is obvious that if any material for longitudinal strength, in addition to giving rigidity, is imparted to the plating by the longitudinals it must largely be at the outer edge of the longitudinals close to the plating. It is equally obvious that if continuity of the longitudinals where cut at the bulkheads is to be restored, either in whole or in part, means should preferably be employed at the outer edge of the longitudinal other than mere attachment to or receipt of strength from the same plating that the longitudinal is intended to strengthen. Furthermore, actual experience has shown that rivet connections to said longitudinal ends do not stand the test of time.

Another feature common in ship design is to make the stiffeners, or longitudinals, of uniform cross section notwithstanding the fact that there is a great discrepancy in both the bending and the shearing stresses at different points in the length of the stiffener, and that the maximum bending and shearing stresses coincide at the bulkheads and at the web beams. The bending stresses midway between the bulkheads and the web beams, or midway of each span of the stiffener are not only very much less than at the ends of the span but the shearing stresses in both the longitudinal and in the rivets attaching the longitudinal at this midway point are reduced to zero. From applied mechanics and experience we know that a strength member is stronger longitudinally when the unit stresses throughout are uniform rather than otherwise, and that a member acting longitudinally either under tension or compression is stronger when free from bending or shearing stresses. It is obvious therefore that a more efficient longitudinal results when it is so designed as regards cross sectional area that it is more nearly uniformly stressed throughout its length regardless of the varying bending moments at the supports and midway of said supports.

In single deck tankers with two longitudinal bulkheads it has been common practice to strengthen the ship's sides and longitudinal bulkheads by means of vertically disposed stiffening webs. These vertical webs in turn have been fitted with horizontal braces in the wing tanks which tie each of the ship's sides to its adjacent longitudinal bulkhead. When the wing tanks are under test the braces act as ties in tension and resist equal and opposite forces tending to bend the ship's side out and the longitudinal bulkhead in. However, when the central tank is being tested the condition of load on the vertical webs are of a different character resulting in a difference in deflections of said webs which on that account casts doubt on the value of the support that the ship's side wall web can receive from the bulkhead web, or vice versa. The reason for this is that the bulkhead web has a distributed load from the pressure in the central tank, while the ship's side web has the transmitted load concentrated at two points through the braces acting as columns or struts. It is an object of my invention to reduce the uncertainties in the stresses of the vertical webs and at the same time make a considerable saving in weight by substituting for the two braces on each side of the ship a single continuous transverse brace, the description and details of which will appear hereinafter.

It is the object of my invention to eliminate the aforementioned weaknesses in the structure of a vessel.

It is another object of my invention to design a transverse bulkhead stiffened by vertically extending trapezoidally shaped alcoves which will have satisfactory drainage to insure minimum corrosion and also result in a saving of weight, and to further reduce said corrosion by eliminating areas of excessive unit stresses in the ship's plating and riveting which stresses in turn act to accelerate the corrosion in these areas.

Another object of my invention is to provide continuity of strength in the longitudinals of the ship's framing where cut by the bulkheads.

Another object of my invention is to provide continuity of strength in the longitudinals of the ship's framing where cut by the bulkheads by welding additional metal to connect the ends of the longitudinals where cut by the bulkhead and to have this additional welded metal of a preferred shape as will hereinafter be described and set forth.

Another object of my invention is to reduce to normal the unit stresses developed in the ship's

plating at the line of the transverse bulkheads and transverse web members.

Another object of my invention is to provide longitudinal structural members designed to be more uniformly stressed at their points of varying reactions when acting as beams, whereby a considerable saving in weight may be had.

Another object of my invention is to make a considerable saving in the weight of the framing of the ship over the usual framing with its initial saving in cost and future savings due to added capacity and reduced tolls.

The novel features will be more fully understood from the following description and claims taken with the drawings, in which:

Fig. 1 represents a diagrammatic part section of a bulk liquid carrying vessel to illustrate a rear elevation in part of a transverse bulkhead embodying my invention;

Fig. 2 is similar to Fig. 1 but in plan view;

Figs. 3 and 3*a* are modifications of Fig. 2;

Fig. 4 is a partial section through a vessel illustrating one form of continuing the strength of longitudinals through the bulkheads;

Fig. 5 is a cross section taken along the line 5—5 of Fig. 4;

Fig. 6 is a cross section taken along the line 6—6 of Fig. 4;

Fig. 7 is similar to Fig. 4 illustrating a modification in the bulkhead;

Fig. 8 is a partial section through a vessel illustrating one form of longitudinals embodying my invention;

Fig. 9 is a cross section taken along the line 9—9 of Fig. 8;

Fig. 10 is a modification of Fig. 8;

Fig. 11 is a cross section taken along the line 11—11 of Fig. 10;

Fig. 12 is another modification of Fig. 8;

Fig. 13 is a cross section taken along the line 13—13 of Fig. 12;

Fig. 14 is a diagrammatic section of a vessel illustrating my invention relating to a continuous cross brace;

Fig. 15 is similar to Fig. 4 in that it illustrates a modification in the bulkhead, and in addition shows my improved form of welding;

Fig. 16 is a cross section taken along the line 16—16 of Fig. 15;

Fig. 17 is an enlarged view in part of Fig. 16;

Fig. 18 is a cross section taken along the line 18—18 of Fig. 20;

Fig. 19 is a cross section taken along the line 19—19 of Fig. 18;

Fig. 20 is similar to Fig. 5 illustrating a modification thereof;

Fig. 21 is a cross section taken along the line 21—21 of Fig. 23;

Fig. 22 is a cross section taken along the line 22—22 of Fig. 21; and

Fig. 23 is similar to Fig. 5 illustrating a modification thereof.

Referring now to Figs. 1, 2, and 3 of the drawings which illustrate my improved transverse bulkhead, wherein 10 is the bulkhead stiffened vertically by shaping the plating to form a series of spaced alternately oppositely facing channels of trapezoidal shaped cross section. This type of bulkhead is designed to be used in combination with tankers of quasi longitudinal construction and in association with a substantial dead rise of the bottom.

On account of tankers of this type trimming excessively by the stern while and after being discharged, the pump suctions are located at the lowest points, which are at the after ends of the tanks, or on the forward side of the transverse bulkheads. It is therefore obvious that with the vertical channels facing forward, unless the side of the channel nearest the pump suction sloped or converged in that direction and the dead rise was sufficient to counteract the effect of trim by the stern then the drainage forward from the channels would not be complete.

In Fig. 2 the forward direction is indicated by the arrow 11, and in Fig. 1 the dead rise is indicated by 12. In Figs. 1, 2, and 3 the center line of the vessel is indicated by 13, and a side transverse bulkhead by 14. Figs. 2 and 3 show alternative dispositions of the vertical channels. In each case the center channel is modified to facilitate making the trapezoidal shaped channels symmetrical on each side of the vessel. In Figs. 2 and 3 the channels 15 are shown facing forward, with the sloping side 16 of the trapezoid sloping toward the center 13 of the vessel. Arrows 17 indicate the direction of drainage. It will be noted that the trapezoidal shaped channels have three vertical panels acting to stiffen the bulkhead.

Preferably my design of bulkhead is made up of a series of plates welded together, and preferably in the following manner. Plate 18 should be an obtuse angled Z shape in cross section having the knuckles 19, thereby comprising two parallel panels 20 and one obtuse angularly disposed panel 16. Plate 21 at right angles to panels 20 connects the adjacent ends of the plates 18 by being welded thereto. This provides a flexible construction and facilitates using the plates as received from the mill without any shearing, planing, or other machine work. The aligned longitudinal stiffeners 22 of the vessel, shown diagrammatically, are cut through at the bulkheads by the panels 20. The ends of the stiffeners 22 on each side of the panels 20 terminate in close proximity thereto. It should be noted that the lateral spacing of the vertical channels in the bulkheads corresponds to that of the stiffeners and that the ends of the stiffeners are in overlapping relation by virtue of projecting into respective adjoining channels. 23 is the bottom plating and 24 are seams of the same. Connection of the transverse bulkhead 10 to the side longitudinal bulkheads may be as shown at 25 in Fig. 2 or at 26 in Fig. 3. Further modification of this connection is shown at 27 in Fig. 3 or at 28 in Fig. 2. 29 and 30 in Figs. 2 and 3 respectively are vertical web stiffeners. 31 and 32 in Figs. 2 and 3 respectively are spaced local stiffeners.

In making the lateral panels or plates 21—at right angles to the plates 20 I gain the maximum benefits as stiffeners and do not lose any advantage in drainage qualities.

It is obvious of course that the panels 16 could be welded to the plates 20 if found desirable, and that the Z section could be right angled comprising the plates 20 and the plate 21, as shown in Fig. 3*a*, without departing from the spirit of my invention.

In Figs, 4, 5, 6, and 7 is shown the embodiment of my invention for maintaining the continuity of strength of the longitudinal stiffeners where cut at the transverse water-tight bulkheads, and by reason of the said continuity of the stiffeners to maintain the continuity of the strength in the bottom plating. In Figs. 4, 5, and 6 the bulkhead plating 33 is shown suitably attached to the bulkhead boundary bar 34 as by welding 35. The longitudinal stiffeners 36 have their outer or plat-

ing flanges strengthened and extended in breadth on both sides and toward the ends by means of the flange extension plates 37 welded as at 38 to the stiffeners 36. As assembled in the finished vessel the extension plates 37 together with the cut ends of the stiffeners 36 are welded as at 39 to the plating flanges 40 of the boundary bar 34. 41 is preferably a round tie rod passing through the bulkhead plating 33 and welded or fused to the adjacent ends of the aligned longitudinal stiffeners 36. It is also welded water tight to the bulkhead plating 33 as at 42. For small longitudinal stiffeners where the test head is low or for those farthest from the bottom the connecting tie rod 41 may be eliminated and the ends of the stiffeners may be snipped off as indicated in dotted lines at 43. In this connection it is believed that the eccentric pull on a 6" longitudinal, or smaller, is practically negligible especially with the pull concentrated at the outer edge.

In Fig. 7 I show a modification to the design shown in Figs. 4, 5, and 6. In this modification the boundary bar comprises two angle bars 44 suitably attached to the bulkhead plating and has the heels of the bars 44 welded together as at 45, and the horizontal flanges of the bars 44 welded as at 46 to the flanges of the stiffeners 36 in a manner similar to that shown in Figs. 4 and 5.

The extension plates 37 may be increased or reduced, or be limited to one side only of the stiffeners 36 as the exigencies of interference of plate or other circumstances in design demand.

By reason of the flange extension plates 37 being welded to the stiffeners 36, and both in turn welded to the boundary bar 34 the continuity of strength at the outer flange of the stiffeners 36 is maintained; and by reason of the tie rod 41 welded or fused to the inner flanges of the stiffeners 36 the continuity of strength at the inner flange is maintained. Furthermore by proper proportioning of the extension plates 37 and the tie rod 41 the continuity of strength in the stiffener through the bulkhead both longitudinally and as a beam may be maintained. The pull of the aligned stiffeners 36 is carried through the bulkhead without cutting the boundary bar 34 or the passing of doublings under the bar, thereby avoiding the objection of increasing the number of plies for riveting and the difficulty of making and keeping tight. The flanges 40 of the boundary bar 34 are neutral as far as performing any longitudinal work on the plating goes, so that the effect of joining the aligned longitudinal stiffeners 36, as described, is to restore the plating to exactly the same condition it would have been in if the stiffeners had not been cut.

In Figs. 18, 19, and 20 I show a modification to the design shown in Figs. 4, 5, and 6. In this modification the longitudinal stiffeners 79 comprise a web plate 80 welded as at 81 along its outer edge to the ship's plating 82 and having welded along its inner edge the reenforcing bar 83. At the ends of stiffeners 79 where cut by the bulkheads 84 the outer edge of the web plate 80 is coped out to accommodate the flange plate or bracket 85. The cope in the web plate 80 is allowed to extend beyond the end of the flange plate 85 to provide a drain opening 86. The flange plate 85 is welded to the web plate 80 as at 87 and is welded to the ship's plating 82 and to the bulkhead 84 as shown at 88 and 89, respectively.

In Figs. 21, 22, and 23 I show another modification to the design shown in Figs. 4, 5, and 6. In this modification the longitudinal stiffeners 90 comprise an angle bulb beam. The stiffeners 90 are coped at the ends to accommodate the flange plate 91 in a similar manner as just described for the stiffeners 79.

It is obvious that as a modification one of the boundary bars 44 in Fig. 7 could be eliminated, or that both bars could be dispensed with, as is illustrated in Fig. 15, and that in these cases the longitudinal stiffeners 73 would be welded to the bulkhead 74 by the weld metal 75.

Referring now to Figs. 8, 9, 10, 11, 12, and 13 I shall now describe my method of improvement in continuity and uniformity of stresses throughout the length of the longitudinal stiffeners between bulkheads. As I have described hereinbefore, it has been customary to make the longitudinal stiffeners of uniform cross section regardless of the fact that they are called upon to resist forces of considerable difference in intensity at different points on their length, due mainly to their acting as continuous beams uniformly loaded. In both shearing and bending the maximum stresses occur at the bulkheads and the web beams, while midway of these points the bending stresses are much less and the shearing stresses on the rivets and longitudinals are reduced to zero. By proportioning the longitudinal stiffener at its points of greatest resistance and at its points of less resistance so as to maintain its stresses more nearly uniform, I gain the advantages of a vessel of greater strength and continuity on the same weight of material, or a vessel of equal strength on a less weight of material. Furthermore I am enabled to lower the bending and shearing stresses where maximum in order that more of the strength of the longitudinal will be available to apply to the longitudinal strength of the vessel as a whole.

I find that the above advantages can be realized if separate calculations for section moduli of the longitudinal stiffeners are made, respectively at the points of support (the bulkheads and web beams) and midway between the points of support, by the following formulæ:

Notation used in the formulæ

L=Length of span in feet
w=Unit load on span in tons per foot of span
H=Test head of water in feet, assumed applied to stiffener area
S=Spacing in feet between stiffeners
M=Bending moment in stiffener due to loading
I=Moment of inertia of stiffener with plating
Y=Distance of neutral axis from inner edge of stiffener

$Z=\frac{I}{Y}$= Section modulus

f=Unit stress
fZ=Moment of resistance
35 cu. ft. of salt water=One ton (2240 pounds).

As is well known in good design the bending moment must equal the moment of resistance, or $M=fZ$. If we wish to keep the stress at the points of support the same as that midway of the supports, then we can figure for the relative values of section moduli from:

$$Z=\frac{L^2HS}{2\times 35f}$$

for midway supports; and

$$Z=\frac{L^2HS}{35f}$$

for in way of supports. From which by cancelling out equivalent values we see that the section modulus midway of the supports is much less than that required in way of the supports.

In Figs. 8 to 13 inclusive, I show three constructions of longitudinal stiffening strength members designed to have greater continuity of strength by having greater uniformity in their resisting moment based on uniformity of stress as regards the points of support and midway of said points. The bulkheads 47 and the web beams 48 in each case are the points of support. In each case 49 indicates the size of stiffener required for the midway of supports points of stress as calculated by the said midway support formula set forth above. In order to have uniformity of stress and continuity of strength at the bulkheads I design the ends of the stiffeners in each case along the lines of my invention hereinbefore described with reference to Figs. 4 to 7 inclusive and calculate for strength by the said support formula set forth above. The tie rods 50 in the Figs. 8 to 13 inclusive correspond to the tie rods 41 of the Figs. 4 to 7 inclusive. To get the same strength into the stiffeners at the web beam points of support I modify the stiffeners at these points. In Figs. 8 and 9 I show one modification wherein the stiffener 51 is comprised of a plate web 52, or the like, swelled out as at 53 at the points of web beam support, and a round section 54, or the like, welded to the inner edge of the plate web 52. In Figs. 10 and 11 I show another modification of my invention in which the stiffener 55 is comprised of an angle bulb section, or the like, with the web split near the inner edge as at 56 at the points of web beam support and with the inner edge portion at these points bowed inwardly to increase the width of the stiffener, and the resulting aperture filled in by welding. In Figs. 12 and 13 I show another modification of my invention in which the stiffener 57 of angle bulb section, or the like, is strengthened at the points of web beam support by the fusing, or welding, of a suitably sized round section 58, or the like, to the inner edge of the stiffener 57.

All three types of longitudinal stiffeners that I have shown are continuous through and attached to the web beams 48, and are attached to the plating 59.

I come now to Fig. 14 which illustrates my improvement in cross-bracing the two sides and two longitudinal bulkheads of a single deck tanker, in such a manner that I not only reduce the uncertainties of conditions of stress in the vessel's framing, but I also make a considerable saving in weight over previous practice. In Fig. 14 are shown diagrammatically the sides 60, the longitudinal bulkheads 61, the deck 62, and the bottom 63, of a single deck tanker. The usual framing comprises the vertically disposed side webs 64, the longitudinal bulkhead webs 65, the deck web 66, and the bottom web 67, all of said webs being in the same transverse plane. In addition the framing comprises usually the two braces 68, indicated in dotted lines, fitted between the webs 64 and 65 on each side of the tanker. This arrangement provides for a central tank 69, and wing tanks 70. When the wing tanks 70 are under test, the braces 68 act as ties in tension and resist equal and opposite forces tending to bend the ship's side out and the bulkhead in. However, when the central tank 69 is under test the condition of load on the web 64 is of a different character than that on the web 65, which results in a difference in deflections of the webs 64 and 65, which on that account casts a doubt on the value of the support the web 65 can receive from the web 64, or vice versa. The reason for this is that the web 65 has a distributed load from the pressure in the tank 69, while the load on the web 64 is concentrated at two points through the braces 68 acting as columns or struts. In my improvement in lieu of the two braces 68 in the wing tanks I employ a tie member 71, about or a little below midway intermediate the deck 62 and the bottom 63, the said tie member 71 being attached to the webs 64 and 65, at both sides of the ship, and extending water tight through the bulkheads 61 from side to side of the vessel. The member 71 acts as a tie under all conditions of loading of the tanks 69 and 70. This places the webs 64 and 65 under identical conditions of load, regardless of which tank is being tested or if cargoes or ballast is carried solely in the central tank 69 or in the wing tanks 70.

In welding a round bar such as 41 to a bulb member such as 36 as shown in Fig. 6, and where there is considerable of flatness at the point where the round bar is to be welded, I have experienced difficulty in cramped spaces difficult of access in filling with weld metal the bottom of the recess formed by the round bar and the flat portion of the bulb due to arcing across the opening of the recess. To overcome this difficulty I prefer to separate the round bar from the bulb by means of an intermediate hexagonal bar and then to weld all three together, as I have illustrated in Figs. 15, 16, and 17 in which the round bar is designated as 76, the hexagonal bar as 77, the bulb bar as 73, and the weld metal as 78. The angles formed by the sides of the hexagonal bar 77 with the round bar 76 and the bulb bar 78 are ideal for depositing the weld metal 79.

In case it is necessary to provide for drainage through the longitudinals, I may do so by means of the slots 72 shown in Figs. 4 and 5. The edges of the slots are securely welded to the shell plating.

From the foregoing description it will be easily seen that I have a novel method of ship construction which is economical and particularly remedies defects which are inherent in prior methods of constructing a vessel in accordance with the so-called longitudinal system of framing. I do not wish it to be understood that my above described methods are limited in their application to vessels of the latter construction and it is manifest that certain of the structures are useful in connection with other well known types of ship construction.

The terms and expressions which I have employed are used as terms of description and not of limitation, and I have no intention, in the use of such terms and expressions, of excluding any equivalents of the features thereof, but recognize that various modifications are possible within the scope of the invention claimed.

This application is a continuation in part of my co-pending application, Serial No. 688,574, filed September 8, 1933.

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

1. A bulkhead construction, comprising obtuse angled Z sections, and web plates welded along opposite parallel edges in a right angled relation to the adjacent ends of the Z sections.

2. A bulkhead construction, comprising right angled Z sections, and web plates welded along

opposite parallel edges in an obtuse angled relation to the adjacent ends of the Z sections.

3. In a bulkhead construction, a continuous structure having a series of vertical stiffening channels alternately facing oppositely, the lateral sides of said channels being alternately right angled and obtuse angled and respectively parallel, while the longitudinal backs of each channel are alternately in alignment and consecutively parallel, the said channels being symmetrically arranged on each side of the ship's longitudinal median line in such a manner that in all channels facing in the same direction the said obtuse angled sides are either all sloping towards or are all sloping away from the said median line as regards the facing side of the channels.

HUGO P. FREAR.