

Sept. 1, 1925.

J. B. DICKIE

1,551,944

CONSTRUCTION OF SHIPS AND BOATS

Filed Feb. 12, 1924

2 Sheets-Sheet 1

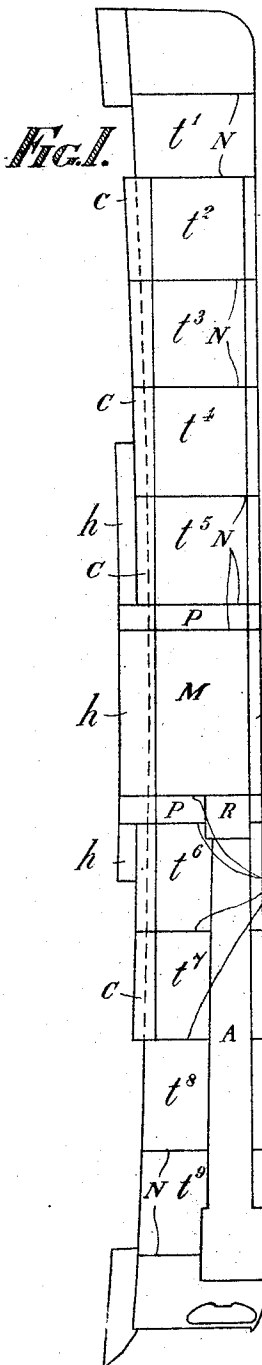


Fig. 2.

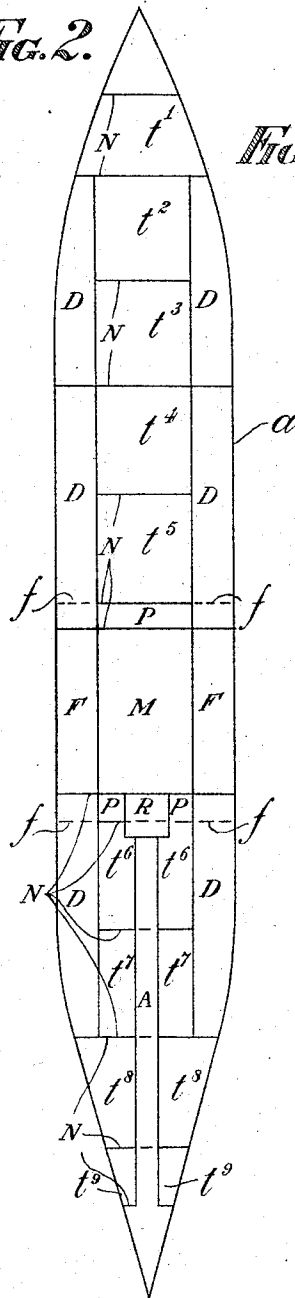


Fig. 3.

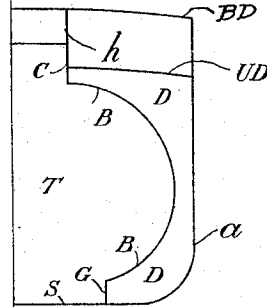


Fig. 4.

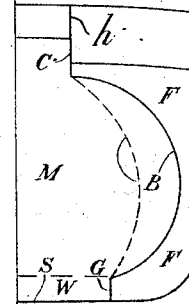


Fig. 5.

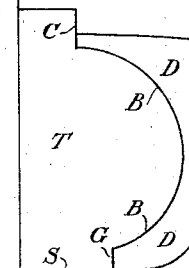
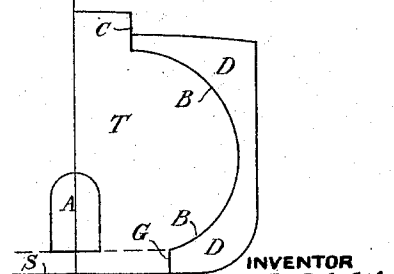


Fig. 6.



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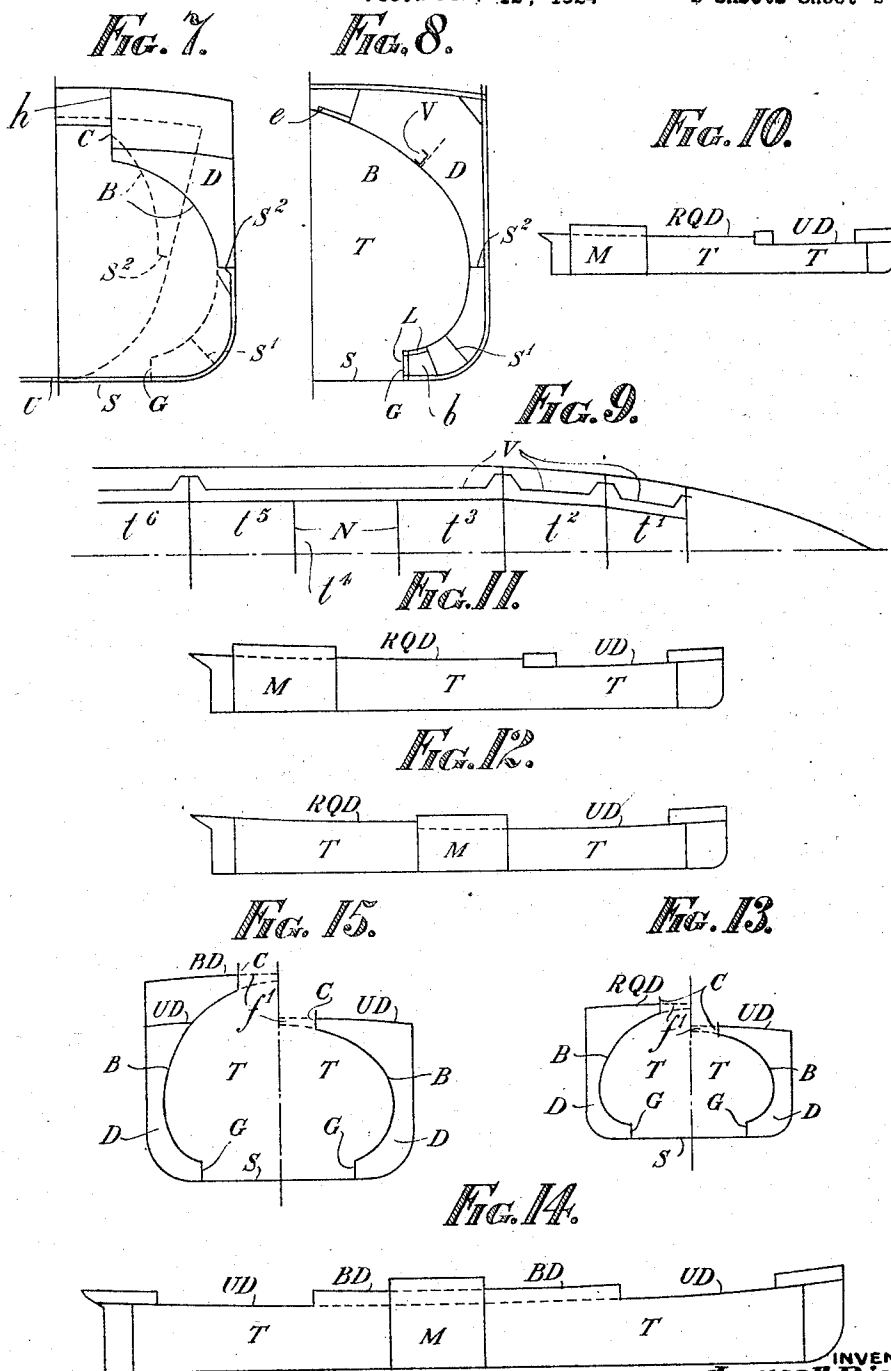
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2 Sheets-Sheet 2



WITNESSES
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UNITED STATES PATENT OFFICE.

JAMES BLACK DICKIE, OF GLASGOW, SCOTLAND.

CONSTRUCTION OF SHIPS AND BOATS.

Application filed February 12, 1924. Serial No. 692,417.

To all whom it may concern:

Be it known that I, JAMES BLACK DICKIE, B. Sc., M. I. N. A., a subject of the King of Great Britain, residing at 142 Terregles Avenue, Glasgow, Scotland, have invented certain new and useful Improvements in or Connected with the Construction of Ships and Boats, of which the following is a specification.

10 This invention relates to the construction of ships and boats.

A steel vessel built to carry oil in bulk has usually, as a fundamental feature, a longitudinal middle-line bulkhead throughout the length of the oil tanks, and this bulkhead, together with transverse bulkheads, divides the part of the vessel where oil is carried into tanks of suitable sizes. These bulkheads are all of flat plates, stiffened by angles, bulb angles or other appropriate profiles.

It is known, however, that a flat steel plate is less able to withstand fluid pressure than a curved plate, and this invention proposes to substitute longitudinal bulkheads of curved form for the usual flat middle line bulkhead.

Formerly, also, the engines and boilers were placed amidships, and the middle line bulkhead was discontinued here, as vessels of this class were single screw vessels and the space on the centre line was occupied by the propelling machinery. Signs of weakness were apparent in the hull structure at the discontinuities of the middle line bulkhead, and almost all recent oil tank steamers have their propelling machinery arranged at the after end, and their middle line bulkhead continued, without break, throughout the length of the oil tanks. This however, has led to very serious inconveniences in the trim of the vessel, and in order that such a vessel may not trim too much by the head in loaded condition, it has been necessary to reserve a part of the length formed as a cargo hold, where oil cannot be carried. This cargo hold is rarely used, and in practice amounts to little more than an addition to the size and running expenses, (the latter as regards tonnage taxation) of the vessel from which no profitable return is ever made. The same reason, that of trim, generally forbids the use, as bunkers or oil fuel tanks, of the spaces alongside the propelling machinery at the after end of the vessel, and

it is customary to have an oil fuel tank immediately abaft and another immediately forward of the cargo oil tanks. This leads to a concentration of the weight of the cargo over a comparatively small proportion of the length of the vessel, and as a vessel of this type has generally no "bridge" or superstructure above the upper deck, the "loading" of the ship, considered as a "girder", can only be regarded as very unsatisfactory.

It is, therefore, the object of the invention to provide improved oil, grain and other cargo vessels in which all of the disadvantages above set out are obviated, and to improve the seaworthiness and stability of the vessels, to decrease the sluggishness of the latter in response to the action of waves and to movement of the cargo during rolling of the vessels and to generally improve the construction, adaptability, capacity and strength of the latter, and the behaviour of the same at sea and in port.

According to one feature of the invention two or more curved spaced longitudinal bulkheads are substituted for the usual flat middle-line longitudinal bulkhead, and said curved bulkheads are arranged on each side of the longitudinal centre line of the vessel.

Another feature of the invention consists in that the curved bulkheads may extend from the overhead coaming plates, the upper deck, or other upper portions of the vessel right down to the bottom shell plating, the principal bottom girders, or other lower portions of the vessel, or down to any point situated between said plates, deck or upper portions and said plating, girders or lower portions. The curved bulkheads are continued without break as far forward and aft as the form of the vessel permits.

The curved bulkheads, together with the bottom shell plating and the thwartship bulkheads of the vessel, form the boundary surface of cargo oil tanks, and these tanks may be of circular cross-sectional shape or of any cross-sectional shape having two or more curved surfaces.

Yet another feature of the invention consists in that this construction of oil tank having upper curved surfaces may be applied to the ends of the vessel where the form of the latter prevents extension of the curvature of said oil tanks to the bottom of the vessel.

Another feature of the invention consists

in that this disposition of the longitudinal bulkheads allows the propelling machinery of a vessel whether single or twin screw, to be placed where desired, whether amidships, at the after end or in any intermediate position of the vessel, as may be most convenient, and is suitable to be adopted for the construction of all classes of vessels carrying oil, grain or other similar cargo in bulk, such as towed barges, self-propelled barges and ocean-going oil tankers and grain-ships.

Yet another feature consists in that the construction is such that the spaces alongside the propelling machinery and the cargo oil tanks can be used partially or wholly as bunkers or oil fuel tanks.

The spaces outside the cargo tanks can be adapted as water ballast tanks and therefore are not liable to tonnage dues, and consequently give a vessel constructed according to the invention a great advantage over oil tank vessels constructed on any other system in which the forward cargo hold and summer tanks are always taxed although they may not be used.

The spaces outside the curved bulkheads may be framed generally on the transverse system or they may be framed longitudinally.

According to still another feature of the invention the cargo of an oil tanker, grain-ship or similar vessel is distributed over a greater proportion of the length of the vessel, that is, up to from 70% to 75% as against 50% to 55% in the usual type of oil tanker, grain-ship and like vessels, and, consequently, a great improvement is effected in the "loading" of the "girder" with consequential reduction in the maximum bending moments and the stresses set up thereby. Also, the "girder" itself, with a preponderating proportion of material well removed from its neutral axis as, for example, on the lower side, the bottom shell plating, the bottom girders and the lower part of the plating of the curved bulkheads, and on the upper side, the upper part of the plating of the curved bulkheads, the coamings and the deck and side shell plating, has a better disposition of material to withstand these stresses, than in the case of an oil tank vessel of usual construction.

The invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a longitudinal sectional elevation at the centre line of a vessel and illustrating a convenient manner of applying the invention to an oil tank vessel;

Figure 2 is a horizontal sectional view through the oil tanks, engine and boiler rooms, and other spaces;

Figures 3, 4, 5 and 6 are half transverse sectional elevations taken, respectively, in way of the bridge and clear of the machin-

ery space, in way of the bridge and through the machinery space, forward of the bridge, and abaft the bridge.

Figure 7 is a half transverse sectional elevation showing a modified construction in which the curved bulkheads extend partially down the sides of the vessel;

Figure 8 is a view similar to Figure 7 and illustrating another modified construction in which the curved bulkheads are longitudinally framed, and

Figure 9 is a part horizontal sectional view through the oil tanks and embodying the construction shown in Figure 8;

Figures 10, 11 and 12 are longitudinal centre-line sectional elevations of vessels of various sizes and illustrating three further modified methods of carrying out the invention, and

Figure 13 is a double or staggered transverse sectional elevation of the vessels shown in Figures 10, 11 and 12;

Figure 14 is a longitudinal centre-line sectional elevation of another modified form of vessel, and

Figure 15 is a double or staggered transverse sectional elevation of the vessel illustrated in Figure 14.

In all of the figures like parts are designated by similar reference letters.

In the drawings, A, Figures 1, 2 and 6, represents the shaft tunnel or alleyway built as a separate oil-tight structure above the line of the deep girders strengthening the bottom shell, R the thrust block recess, and P the pump rooms, of which rooms two are indicated as being suitable for a vessel of this design. The pump rooms are contained within the curved bulkheads B, and the after one is astride of part of the thrust recess R. The bottom of the vessel adjacent to the machinery space M may be formed into a double bottom W, Figures 1 and 4, and be used for carrying reserve feed-water or water ballast.

The oil tanks t' . . . t'' in Figures 1, 2 and 3 are formed by the bottom shell plating S, the principal bottom girders G on either side of the centre line of the vessel, the curved bulkheads B with their coaming plates C overhead, and the transverse bulkheads N, Figures 1, 2 and 9. These transverse bulkheads N may also be completed between the oil tanks and the outer shell plating a to form the main transverse bulkheads of the vessel. The coamings C are united in the same straight line with the engine and boiler side casing, and elsewhere within the bridge space may be extended to the bridge deck BD overhead, all as shown at h , Figures 1, 3, 4 and 7, and thus made to contribute in the most advantageous manner to the longitudinal strength of the vessel.

The necessary amount of the space at

the centre line between the curved bulkheads B, which space elsewhere forms the oil tanks T, t' or t'' . . . t'' , is given up as at M to the propelling machinery, and the spaces outside the curved bulkheads B in way of the machinery may be used as fuel oil tanks as shown at F in Figures 2 and 4, or they may be extended as far forward and aft as the bulkheads f in Figure 2. Also, the curved bulkheads B may be modified, as shown dotted in Figure 4, adjacent to the machinery, as far as the latter permits, in order to increase the capacity of the fuel oil tanks F, the longitudinal strength being maintained by retaining the bottom girders G and the coamings C unbroken. Part of the cargo oil tanks forward and abaft of the machinery space M may be used as oil fuel bunkers, if desired and as may be arranged.

The bottom of each oil tank may be a rectangular surface of steel plating, and the framing to be employed here may be either of transversely disposed profiles strengthened by deep widely spaced longitudinal plate girders, or of longitudinally disposed profiles strengthened by deep widely spaced transverse plate girders.

The spaces D outside the oil tanks are sufficiently large to give the necessary displacement and transverse stability to the vessel, and they may be framed generally on the transverse system, each unit consisting of a side frame attached to the inner surface of the shell plating, a frame or stiffener on the outside of the oil tank bulkhead B, and a deck beam overhead, all of suitable profiles, and efficiently connected together with floor plate below and beam knee and bracket above, and strengthened as may be necessary by a horizontal plate stringer at about the middle of the height.

If desired the spaces D may be framed generally on the longitudinal system. For instance, the construction may be in accordance with Figures 8 and 9, in which the bilge stringer S' , the side stringer S^2 and the girder V are the principal elements of the framing of the curved sided tanks. These three elements may each be fitted in one length between two adjacent transverse bulkheads outside of the cargo oil tanks and carried without break past the intermediate internal divisional transverse tank bulkheads. Advantage is taken of the increase in resistance of the plating to deformation under fluid pressure, due to its curvature, to dispense, in moderate sized tanks, with local stiffening, the plating being increased in thickness if necessary; in larger tanks, where this increase in thickness of the plating would be impracticable, additional stiffening may be given to the plating by fitting either horizontally or vertically disposed profiles in such number and of such strength as may be required. The

floor may be dispensed with and the ends of the frames can be united by means of a bracket plate b and short connecting angles L, L to the principal bottom girders G and to the plating of the cargo oil tanks, and the bilge shell plating and the cargo oil tank plating can be mutually strengthened by a diagonally placed plate girder or stringer extending from and connecting the inside of the shell plating at the bilge to the outside of the lower part of the cargo oil tanks. This construction, while giving sufficient strength to the curved side bulkheads of the cargo oil tanks, provides, at the same time, a greater amount of material disposed continuously in a longitudinal direction, with consequential increase in the moment of resistance of the section of the vessel.

When increased capacity is required for the carriage of very light oils the portions of the curved bulkheads B and their supporting stiffeners disposed below the level of the side stringers and extending from the latter as far as the principal bottom girders G, may be partially or wholly dispensed with. For instance, the curved bulkheads may be such as shown at B, Figure 7, extending from the overhead coaming plates C to the level of said stringers S^2 .

As the ends of a vessel are generally of such form that the provision at these points of curved bulkheads extending to the bottom of the vessel is impracticable, the usual transversely framed construction may be adopted but the restricted curved bulkheads above described in connection with Figure 7, may also be utilized at said parts. Thus, the greater breadth at the deck of a vessel would enable the curved bulkheads to be carried fore and aft a greater distance away from amidships near the deck than near the keel. A suitable form at the ends of the vessel is indicated by the thick dotted lines in Figure 7. With this construction at the ends of the vessel the same advantages are obtained as at amidships in that the breadth at any point of the free liquid surface is considerably reduced with consequent improvement in stability and seaworthiness, and the weight of the cargo oil is reduced where the weight of the ship and cargo combined is in excess of the buoyancy; as a consequence of the last advantage of the "loading" of the "girder" is more favourable.

Also the spaces D or any part or parts of them either alongside the cargo oil tanks or alongside the machinery, may be utilized as fuel oil bunkers, and the trim of the vessel may be regulated by having these fuel oil bunker spaces at the fore end as well as at the after end. Or these spaces may be adapted for the carriage of water ballast. Generally an oil tanker is subjected to the

most severe stresses when she is in ballast, as water ballast is carried in some of the cargo oil holds, which are separated from each other by empty cargo oil holds, and this brings about an alternation of excess of weight and excess of buoyancy over a considerable proportion of her length, with consequent severe shearing and bending stresses. In the improved design fewer cargo oil holds are utilized for this purpose and the remainder of the water ballast is carried in the spaces D, thus distributing a considerable part of the weight of ballast over a greatly increased proportion of her length.

Figure 8 also illustrates further means of increasing the capacity of oil tankers in way of "erections" such as a "bridge deck" or a "raised quarter deck," by raising the upper curved side bulkheads B above the level of the side stringer to a point underneath such "erection deck", and this is more fully illustrated in Figures 10 to 15.

Thus, Figures 10, 11 and 12 shew vessels having raised quarter decks RQD aft of "midships" and with the engines either aft or amidships as shewn, and in Figure 13 the right hand half represents the section in way of the forward holds which have the upper deck UD as their top boundary, and the left hand half represents the section in way of the after holds which have the raised quarter deck RQD as their top boundary.

Figure 14 illustrates a vessel with engines amidships and with poop bridges and fore-castle erection, and in Figure 15 the right hand half represents the section in way of the forward and after holds which have the upper deck UD as their top boundary, and the left hand half represents the section in way of the midship holds which have the bridge deck BD as their top boundary.

In these figures the shaft tunnel and transverse tank divisional bulkheads are not shewn, nor are any details of the framing of the oil tanks T.

By constructing vessels according to the various methods illustrated in Figures 10 to 15, the trim of the vessel may be entirely controlled by the weight and fore and aft disposition of the cargo oil carried in the cargo oil tanks, and no necessity will exist for a cargo hold forward in vessels with the propelling machinery fitted aft. Also in vessels with a midship bridge where the maximum bending moment is one of hogging due to the excess of buoyancy over the weight of cargo amidships, this maximum bending moment is considerably reduced by having an addition to the weight of cargo carried in the midship tanks.

The plating of the upper curved side bulkheads may stop at the hatch side coamings, which may be carried forward and aft

in the form of a trunk over the cargo oil holds, but if it is required to plate the deck over, as may be the case, when, for example, accommodation is to be arranged at any given position, the plating of the oil tanks may be continued right across the centre line under the deck thus preventing the oil from coming in contact with the deck plating overhead; this feature is shown in full lines at *e* in Figure 8 and in dotted lines *f* in Figures 13 and 15.

The importance of constructing vessels with curved bulkheads in the manner above described will be apparent from the following remarks: A most important precaution to take in handling vessels designed to carry liquid in bulk is that the stability be not in and way endangered. While filling a tank of the improved construction with curved side bulkheads extending downwards to the bottom of the vessel the liquid first entering the tank is confined to the space between the bottom girders G, G and, acting as ballast, may increase the stability of the vessel. After the bottom space is full the free liquid surface increases in breadth with consequent loss of stability, until the maximum loss is reached, when the free surface extends right across the greatest breadth of the tank. Further filling reduces this loss, so that if care be taken in the design to give sufficient stability in the worst condition as outlined above, the ship can never be put into an unstable condition by filling tanks of this shape. It should be an easy matter, therefore, to retain the vessel always upright at the loading berth with consequent advantage to all on board. In the case of vessels where the curved side bulkheads are stopped at about mid-height, even if the vessel becomes unstable during loading, she immediately regains her stability when the free liquid surface attains the level of the side stringers. It is a simple matter in design, therefore, to proportion the vessel so that any defect of stability in the initial stages of loading can only be small and cannot place her in a condition of danger. Even the initial loss of stability can be eliminated by making the centre girder oil-tight, increasing it in height if necessary and as may be determined by the form of the vessel. Again, oil tank vessels are notoriously dirty sea vessels; they do not readily respond to the action of the waves and ship a lot of water in a seaway; this may be explained in the following manner: First of all a tanker of the usual design and construction, fully laden, is very "stiff" owing to the low position of the centre of gravity of the cargo, and is therefore reluctant to respond to the action of the waves tending to cause rolling. Consequently the wave gains on the vessel and frequently a wave breaks aboard before

the vessel's inclination has become sufficient to expose the necessary height of free side of ship to the advancing wave. In the improved construction the centre of gravity of the oil cargo is relatively higher than in the ordinary design of tanker and the vessel is consequently less "stiff" and yields more readily before the advancing wave slope and this makes for a "drier" ship. Secondly, when a vessel is laden with an ordinary cargo, (the same not being a mobile cargo such as grain) the vessel and her cargo move to the seas as one, but this is not the case with an oil tanker. When an oil tanker, rolling amongst waves, has reached the outward limit of roll, and the form of the wave surface is such as to impress upon the hull a return motion towards the vertical, the liquid cargo has still momentum tending to carry it onward, and the ship can only respond to the influence of the wave surface as she overcomes and finally subdues the momentum of the cargo. This causes the "lag" or retardation in the rolling of the vessel with consequent decrease of height of side offered to the oncoming wave. Owing to these two causes, an excess of initial stability and tardiness in responding to change in the wave slope at any inclination, the vessel is "wet" and loses in seaworthy qualities, and even moderately bad weather can greatly reduce her speed at sea. If the cross section of the oil tank were a circle, the only action caused by rolling between the cargo oil and the tank would be that due to friction along the inner surface of the tank, and the "lag" would be almost negligible, as inertia would retain the cargo in its original position. It is the irregularities of surface in the ordinary oil tanker, particularly the lower corners of the expansion trunk, which are alternately giving and withdrawing motion to and from the cargo. The improved shape of oil tank with its comparative freedom from internal projections reduces in great part this useless expenditure of energy and more nearly approaches the ideal circular section already mentioned. Vessels of the improved construction should, therefore, other things being equal, behave better at sea than the usual forms of oil tankers. Now, with regard to the strength of the improved tubular tank, the deformation suffered by flat bulkhead plating under fluid pressure, between any two stiffeners, assumed to be strong enough to withstand the pressure without bending, and of sufficient length to avoid the influence of end connections, may be considered. The pressure can only be normal to the surface, and, if the stiffeners are vertical, the plating at any point will stretch only along a horizontal line. An adjacent point vertically above the first-mentioned point can only move through

a distance equal to that moved through by the latter and in a line parallel to the same. In the case of curved plating, as in the improved construction, as the pressure still remains normal to the surface at any point, two points in the same vertical plane can move to new positions only along diverging lines normal to the surface, or, in other words, the points are forced apart as they reach their new positions. In order to effect a deformation in the curved plating equal to any deformation in the flat plating, it will be necessary to exert an extra force sufficient to effect this separation, that is to say, the curved plating is stronger than the flat plating by an amount proportional to this extra force, and in consequence thinner plating may be used for curved bulkheads than for flat bulkheads to withstand the same fluid pressure. Similar reasoning also holds good in the case of vertical stiffeners on the curved side bulkheads of the oil tanks.

Again, the shell plating of an ordinary oil tanker is considerably weakened at the bulkheads by the very large number of holes punched for the rivets connecting the bulkhead boundary angle to the shell, and compensation has to be given by increasing the thickness of the shell plating in way of the bulkheads, and by fitting bulkhead liners or doubling plates and brackets. In the improved construction the side boundaries of the cargo oil tanks over a distance exceeding the half length amidships are the curved side bulkheads and, consequently, the shell plating is not weakened by an excessive number of rivet holes being punched in it at any transverse section in the region of greatest longitudinal stresses.

The tubular tank could be easy to construct as it would lend itself greatly to multiple punching, simplicity of erection and accessibility for hydraulic or pneumatic rivetting.

Summarizing the above remarks the improved shape and construction of the bulkheads and tanks as described ensure the following important features and advantages: The tank side plating and stiffeners of curved form give increased strength for same scantlings, or, conversely, allow a reduction of scantlings for same strength; the shape of the tank gives free choice for position of propelling machinery, whether single or twin screw and whether steam engines and boilers, internal combustion engines or electric drive; security as to stability, both in port, while loading or unloading, and at sea, either loaded or in ballast; improved motion in a seaway with increase of seaworthy qualities and a better retention of vessel's normal sea speed; a better distribution, both when the vessel is loaded and in ballast, of the "loading" of the "girder" to

which the vessel may be compared for purposes of longitudinal strength; an improvement in the disposition of material of the cross section of the vessel with consequent increase in the moment of inertia of the section about the neutral axis, or, in other words, an increase in the moment of resistance against bending for the same depth of vessel; permits of the transverse divisional oil-tight bulkheads in way of same being kept clear of the shell plating and consequently, the shell is not weakened by an excessive number of rivet holes at any transverse section; adaptability to the most economical methods of duplication of work in its construction, to simplicity of erection and accessibility for power riveting.

Although the invention has been described as particularly adaptable to the construction of oil tank vessels, it is equally applicable to other ships and boats designed to carry grain and similar bulk cargoes, and where it is necessary to give special consideration to the stability in order to prevent the vessel being placed in a position of danger due to any shifting of the cargo.

What I claim is:—

1. A ship or boat designed to carry oil or other cargo in bulk, comprising a plurality of spaced continuous longitudinal curved bulkheads arranged on each side of the longitudinal center line of the vessel to form tanks longitudinally of the vessel, said tanks being formed by the bottom shell plating, the principal bottom girders on either side of the center line of the vessel, transverse bulkheads, and longitudinal bulkheads, said longitudinal bulkheads being curved from the principal bottom girders to the hatch coaming plates.

2. A ship or boat according to claim 1, in which the propelling machinery of the vessel is disposed between the curved bulkheads amidships in any suitable position in-

termediate the ends of the vessel.

3. A ship or boat according to claim 1 in which the curved bulkhead portions of the cargo tanks at the ends of the vessel, and for such distances from the said ends as may be determined by the requirements of the cargo storage, extend downwardly to a point intermediate the upper and lower portions of the vessel.

4. A ship or boat according to claim 1, in which spaces provided outside the curved bulkheads and between the latter and the shell plating of the vessel are formed.

5. In a ship or boat according to claim 1, steel longitudinal bottom and upper girders and side and bilge stringers which are continued as far forward and aft as the curved bulkheads and as the size and form of the vessel permits.

6. A ship or boat according to claim 1, in which the upper portions of the curved bulkheads extend right across the center line of the vessel.

7. A ship or boat adapted to carry cargo in bulk, comprising spaced, longitudinal, curved bulkheads on each side of the center line of the vessel supported, in part, upon the principal bottom girders, and a plurality of transverse bulkheads forming cargo tanks longitudinally of the vessel with the bottom shell plating providing the bottom wall of said tanks, said longitudinal bulkheads being curved from the principal girders to the coaming plates.

8. A ship or boat in which the usual flat longitudinal middle line bulkhead is substituted by longitudinal bulkheads of curved form and in which said bulkhead, overhead coaming plates and bottom girders extend continuously without break as far as the size and form of the vessel permit.

In testimony whereof, I have hereunto signed my name.

JAMES BLACK DICKIE.