Jan. 17, 1967 H. R. PRATT 3,298,345

DOUBLE HULLED SHIP

Filed Nov. 13, 1964

FIG. 1

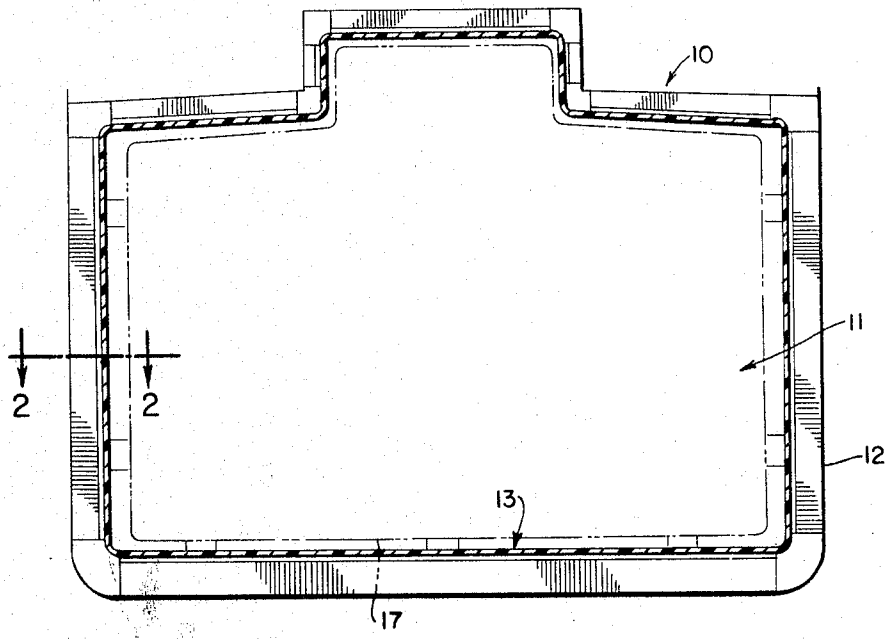


FIG. 2

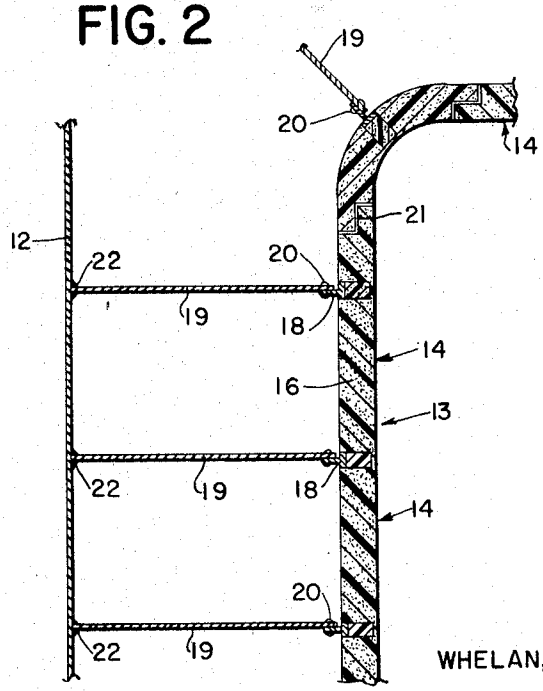
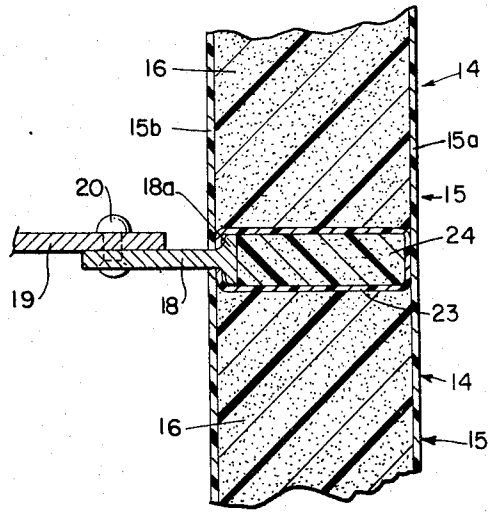


FIG. 3



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DOUBLE HULLED SHIP

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The present invention relates to cargo ships and, more particularly, to tankers adapted to transport cryogenic cargoes, such as liquefied gases at atmospheric pressures.

It has been established that the transportation of gases, such as natural gas, hydrogen, oxygen, methane, and the like, to remote locations, may best and most efficiently be accomplished by reducing the volume of the gas through its conversion into the liquid state. Such a conversion enables the storage volume requirements to be greatly reduced (approximately six-hundredfold for a given quantity of methane gas, for example) and, as should be appreciated, enables the most efficient transfer of the gas to a remote area.

In order to transfer liquefied gas in a practical and economical manner in relatively large volumes, it is necessary to store the liquefied gas at approximately atmospheric pressure, since large containers built to withstand superatmospheric pressures would be impractical, if not impossible, to construct for use on seagoing tankers or the like. However, liquefied gases maintained at atmospheric pressures have extremely low vaporization points, ranging from about —435° F. for liquefied hydrogen, to —28° F. for liquefied ammonia, and these unusually low temperatures of the liquids present certain problems in the design and production of insulated cargo containers. Specifically, the containers must be capable of preventing heat losses which would lead to subsequent volatilization of the stored liquefied gas and of withstanding the internal stresses that may be induced therein by the large temperature gradient through the walls of the container. In addition, the ship must be safeguarded against uncontrolled flow of the low temperature liquid into contact with parts of the structure which could be damaged thereby. Accordingly, for the purposes of safety and reliability and in accordance with accepted regulatory codes, it has been a well established practice to provide at least two liquid-tight barriers in containers used for the storage of liquefied natural gases at cryogenic temperatures.

One typical arrangement for transporting a liquefied gas involves the use of aluminum or stainless steel storage tanks, constituting primary barrier means, independently supported by a secondary liquid-tight barrier. Another known arrangement involves the use of so-called "integral" construction where the primary barrier is directly supported by the secondary barrier. In this type of cargo transportation, double hulled ships have been widely employed and found suitable. Specifically, in one system, the inner hull of the cargo hold of such a vessel is clad with suitable thermal insulation and supports an independent cargo tank therein. Alternatively, a metallic liner is superimposed upon an insulation-clad cargo hold to form a so-called "integral" container.

The present invention is directed particularly to, and represents a significant improvement in, the so-called "integral" system, but is also applicable to systems utilizing separate cargo tanks. More specifically, a new ship structure is provided in which cargo hold bulkhead and the

inner hull structure, itself, of a double-hulled ship are constructed of an effectively dimensionally stable, liquid-tight, thermal insulating material having sufficient strength to form the hold structure of the ship and to contribute to the overall structural integrity and sea worthiness of the ship in a manner not unlike that of conventionally employed steel plate inner hull constructions. Thus, as will be more fully explained, the new inner hull structure not only functions as an insulating member and secondary liquid tight barrier of a cryogenic cargo container, but it also forms an integral structural member of the ship.

The new ship advantageously is built with a conventional outer hull and includes a new inner hull and bulkhead structure fabricated with new and improved hull and bulkhead panels made in accordance with general precepts set forth in detail in copending United States application Serial No. 394,287, filed September 3, 1964, by Harold R. Pratt et al., for "Insulation System." In accordance with the invention of the copending application, insulating panels are formed with fiberglass reinforced polyester resin shells filled with polyurethane foam and constructed to be effectively dimensionally stable under service conditions involving large temperature differentials between their inner (cold) and outer (warm) walls. As an important specific aspect of the present invention, the new and improved hull and bulkhead panels include special molded-in mounting plates which are structurally integral with the panels and are united with web frame elements welded to the ship's outer hull to space the completed inner hull therefrom.

For a more complete understanding of the present invention, reference should be made to the following detailed description taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a transverse cross-sectional view of a new and improved double hulled ship embodying the principles of the present invention;

FIG. 2 is a fragmentary cross-sectional view taken along line 2—2 of FIG. 1; and

FIG. 3 is an enlarged fragmentary cross-sectional view of the new and improved hull and bulkhead panels showing details of their construction.

Referring to FIG. 1, the new ship **10** typically is in the general full form configuration of a tanker, as evidenced by its generally rectangular transverse cross section taken through a cargo hold **11**. The outer hull **12** and many sections of the ship remote from the hold areas may be conventionally constructed from steel plate in accordance with known techniques.

As indicated in FIG. 1, the ship **10** includes an inner hull structure, designated generally by the reference numeral **13**, which, together with appropriately located transverse bulkheads or cofferdams (not specifically shown) form the individual cargo holds **11** for the containment of the low temperature liquid cargo. In accordance with the invention, the inner bulkhead structure **13**, and advantageously also the transverse bulkheads or cofferdams, are constructed from a series of adjoined, individual insulating panels **14**. The individual panels are most advantageously constructed according to the beforementioned Pratt et al. application and are provided with fiberglass reinforced, polyester resin outer shells **15** filled with polyurethane foam **16**, as shown best in FIG. 3. The individual panels may be partitioned interiorly by divider webs (not shown)

extending between the inner and outer walls 15*a*, 15*b* of the panel shell, and the panels are so supported and secured as to be relatively immobilized against gross distortions of shape resulting from substantial temperature differentials from the inner to the outer walls 15*a*, 15*b*. It is understood, in this respect that the strength of the fiberglass reinforced shell walls exceeds the stresses induced by temperature differentials under service conditions, as set forth more fully in the copending Pratt et al. application Serial No. 394,287. The inner hull panels 14, being both dimensionally stable and of high strength are able to contribute significantly to the strength of the overall ship structure, much in the nature of a conventional steel plate inner hull construction. Thus the new inner hull structure serves in the double capacity of a primary structural element and an advantageous insulating and container means.

Importantly and as another aspect of the invention, the individual hull and bulkhead panels 14 are arrayed contiguously and are appropriately sealed or otherwise interconnected to define a continuous, impermeable secondary barrier for liquefied gases at cryogenic temperatures and atmospheric pressures. In this connection, it will be understood that as a structural member of the ship, the inner hull 13 must be unaffected, dimensionally or otherwise, by the cargoes to be carried. Advantageously, the adjacent panels are joined by stepped or other overlapping edge configurations, as indicated generally at 21 and secured by a suitable combination of mechanical and adhesive fastening means.

A cargo-resistant, primary barrier schematically indicated at 17 is located inside the individual cargo holds defined by the inner hull 13 and transverse cargo hold bulkheads, advantageously constructed in the same manner as the inner hull 13, to define in each cargo hold of the ship 10, a closed, insulated cargo container as shown in FIG. 1. Advantageously, the primary barriers 17 may be of types disclosed in more detail in copending applications of Charles D. Forman et al. for "Cryogenic Insulation System," Serial No. 411,397, filed Nov. 16, 1964 and for "Cryogenic Insulation System," Serial No. 411,527, filed Nov. 16, 1964. It could also be possible to utilize separate tanks of materials such as aluminum or stainless steel, in accordance with more conventional practices.

In accordance with the principles of the invention, the hull panels 14 have embedded therein T-shaped mounting plates 18, made of steel or a like material having substantial strength, which are overlapped with and joined to inwardly extending steel web plates 19 by bolts or rivets 20 adjacent the inner hull structure 13. As shown, the web plates 19 themselves are joined to the ship's outer hull 11 by suitable welds 22.

The mounting plate 18 of the T-shaped cross section may be of elongated form, to impart additional strength to the panel units, or they may be shorter elements, similar to projecting lugs. In either case, the enlarged head flange 18*a* is molded into the panel structure as close as possible to the outer or warm wall 15*b* of the panel shell, so as to be relatively unaffected by the low temperature cargo retained within the hold. In addition, it is advantageous to separately encapsulate the head flanges 18*a* in an internal, structural shell 23, substantially as shown in FIG. 3. The encapsulating shell 23, which may be of the same strong, temperature-resistant material as the main, outer panel shell 15, extends from one principal wall to the other of the panel shell and has its side walls spaced apart far enough to closely receive the head flange 18*a*. Inward of the head flange, the encapsulating shell is filled with a structural insulating material 24, such as polyurethane foam.

It will be readily appreciated that the new double-hulled ship structure, in accordance with the invention, realizes substantial advantages, by providing an inner hull structure which functions both as a thermal insulator and secondary liquid-tight barrier for a cryogenic container and as an integral structural member of the tanker, itself. The advantages of the invention are most readily realized through the use of special structural and insulating panels having fiberglass reinforced polyester resin outer shells, with an insulating filler such as foamed polyurethane. Such panels, properly constructed in accordance with the considerations set forth in the beforementioned Pratt et al. application, provide adequate strength and stability for incorporation as structural elements of a ship's inner hull and at the same time possess good insulating qualities. In addition, by molding into such panels a plurality of separately encapsulated mounting plates, projecting from the warm sides of the panels, it is made practical and expedient to utilize the panels in the construction of the ship's inner hull.

It should be understood that the specific mode of construction and the specific container structure herein illustrated and described are intended to be representative only, as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

What is claimed is:

1. A ship for transporting cargoes at cryogenic temperatures and atmospheric pressure comprising
   (a) a conventionally formed steel outer hull,
   (b) a plurality of contiguously arrayed inner hull plastic insulating panels defining a liquid-tight secondary barrier, and mounting means rigidly fixing said inner hull panels to said outer hull, said mounting means including,
   (c) rigid mounting plates embedded in said hull panels and extending perpendicularly outwardly therefrom,
   (d) rigid web plates welded to said outer hull and extending perpendicularly inwardly therefrom, and
   (e) means joining said mounting plates and web plates, whereby said inner hull plastic insulating panels define an integral inner hull spaced inwardly and fixed in spaced relation from said outer hull contributing a substantial rigidifying effect to said outer hull.

2. A ship according to claim 1, in which
   (a) primary barrier means are integrally supported by said inner hull.

3. A container structure for cryogenic cargoes and the like comprising
   (a) an outer steel ship hull,
   (b) an inner ship hull structure formed substantially of plastic thermal insulation material, said inner hull structure being secured in fixed spaced relation to said outer hull by rigid mounting means, said mounting means in cooperation with said plastic inner hull structure acting to rigidify the outer steel ship hull,
   (c) said thermal insulation being cargo-impermeable and constituting a secondary barrier, said thermal insulation material further including panels formed by a pair of spaced inner and outer substantially parallel shell walls separated by an insulating material, said mounting means including a plurality of mounting plates embedded in said panels projecting perpendicularly through and extending from said outer shell walls and means on the outer hull of the ship for rigidly engaging and supporting said mounting plates and
   (d) primary barrier means supported within said inner hull.

4. The container structure of claim 3, in which
   (a) said mounting plates have enlarged head flanges positioned within the panels and closely adjacent the outer shell walls thereof.

5. The container structure of claim 3, in which
   (a) the embedded portions of said mounting plates are

separately encapsulated in shell walls extending between the inner and outer shell walls of the panels, and

(b) the encapsulating walls are filled with an insulating material extending from the inner extremities of the mounting plates to the inner shell walls of the panels to protect said mounting plates from low temperature cargo.

6. The container structure of claim 5, in which

(a) the embedded portions of said mounting plates comprise enlarged head flanges, and

(b) said head flanges are retained in a position closely adjacent the relatively warmer outer shell walls of said panel.

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