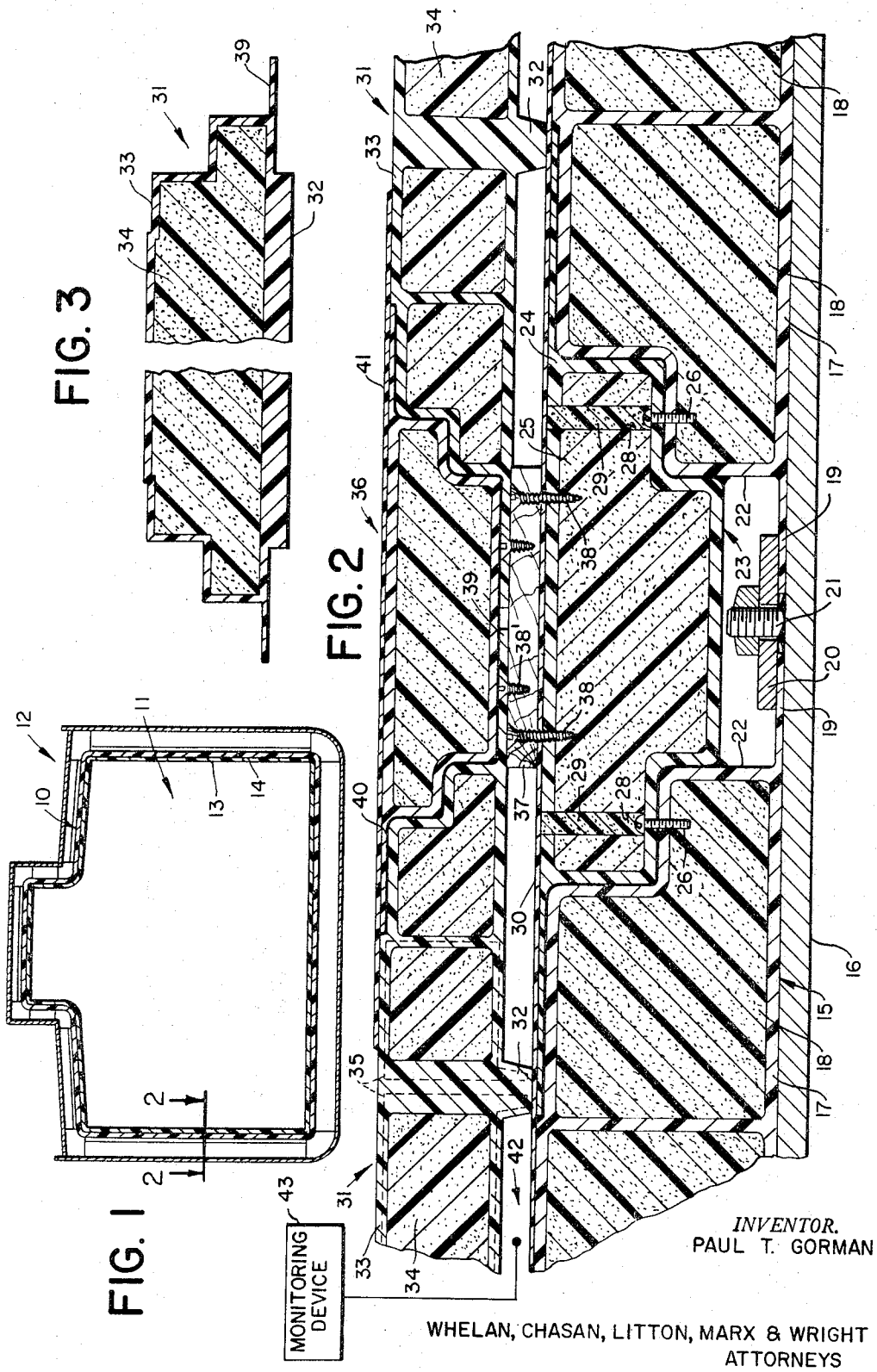
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CRYOGENIC CONTAINER

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CRYOGENIC CONTAINER

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ABSTRACT OF THE DISCLOSURE

An insulated container for low temperature liquids made from two separate and distinct layers of insulation panels. The panels consist of polyurethane foam encapsulated in fiberglass reenforced polyester resin. The warm side panels are attached to a rigid steel structure, the joints between panels being made liquid-tight with plug pieces similar in material and construction to the panels. A second layer of insulating panels is attached to the first layer and spaced a small distance away therefrom by means molded into the second layer of panels. The space between the two layers of panels is used to detect leaks in the cold side panels.

The present invention relates to containment vessels for very low temperature liquids and more particularly to a new and improved integrated, double barrier construction for storing and transporting liquefied natural gases and the like at atmospheric pressures.

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 super-atmospheric 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 resisting the hydrostatic load of the liquefied gas, of preventing heat losses which would lead to subsequent vaporization 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 gas- and liquid-tight barriers in containers used for the storage of liquefied natural gases at cryogenic temperatures.

In accordance with the principles of the present invention, each of the gas- and liquid-tight barriers is fabricated from a contiguous array of specially contoured, effectively dimensionally stable plastic panels, which maintain their strength and integrity under the severe cooling effects imposed by a liquefied gas cargo. The walls of the tanks are fabricated from plural, matingly stepped panels of fiberglass reinforced polyester shells filled with polyurethane foam in general accordance with certain teachings of the copending Harold R. Pratt et al. application Ser. No. 394,287, filed Sept. 3, 1964, for "Insulation System." As a more specific aspect of the invention, a closed outer or secondary barrier may be formed directly against an enveloping support structure such as the cargo hold of a tanker and a similarly shaped, but smaller, inner or primary barrier is supported, in a predetermined spaced relation therewith, directly from the inner face of the outer barrier. As a further specific aspect of the invention, the predetermined spacing of the inner barrier from the outer barrier is established by integral reinforced foot elements which are molded with the panels and project therefrom.

In accordance with the invention, the space created between the inner and outer tanks is adapted to be monitored for the detection of gas, the presence of which would be an indication of leakage through the primary barrier. Furthermore, it will be understood that the intermediate space advantageously contributes to the thermal insulation of the cargo and the resultant isolation of the ship structure from the deleterious effects of the supercooled, liquefied gas.

For a more complete understanding of the invention and its attendant advantages, 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 the cargo hold of a tanker embodying the new and improved integrated barrier construction of the invention;

FIG. 2 is an enlarged, fragmentary, cross-sectional view taken along line 2—2 of FIG. 1 showing details of construction of the integrated, double barrier of the invention; and

FIG. 3 is a cross-sectional view of an insulating panel used in the construction of the inner barrier.

Referring to FIG. 1, the new container **10** may be formed in the cargo hold **11** of double hulled tanker **12** of a type constructed from mild steel plate and employed for cryogenic service. The container **10** includes an inner gas- and liquid-tight barrier **13**, which is adapted to contact directly the cryogenic cargo to be stored, and which, as the first line of resistance between the mild steel ship structure and the cargo, is designated the primary barrier. In accordance with regulatory codes and well-accepted practice for increasing the safety factor of the vessel, a second line of resistance between the ship and cryogenic cargo is provided in the form of an outer gas- and liquid-tight barrier **14** which is designated the secondary barrier.

In accordance with the principles of the invention, the primary and secondary barriers are fabricated from effectively, dimensionally stable panels especially constructed to retain their impermeability at the extremely low temperatures encountered in use (—258° F. with a liquefied methane cargo, for example). More specifically, and as shown in FIG. 2, the liquid- and gas-tight, effectively dimensionally stable secondary barrier **14** is established at the inside of the cargo hold **11** by securing stepped, plastic insulating panels **15** in a general end-to-end and side-by-side array to the inner hull plate structure **16** of the vessel **12** by mechanical and/or adhesive means in a manner which prevents their displacement. The panels **15** include molded fiberglass reinforced polyester shells **17** filled with polyurethane foam **18**, arranged and constructed in conformity with the teachings of the above-identified Pratt et al. application Ser. No. 394,287. As shown, the stepped insulating panels **15** include outer faces **19** at which they are glued by a suitable epoxy or other adhesive to the inner hull **16** and through the periphery of which they are clamped against the hull **16** by a plate **20** bolted down by a Nelson stud **21** extending inwardly from the inner hull **16**.

The gaps defined between the opposing stepped sides **22** of adjacent insulating panels **15** are filled by special mating plug pieces **23** which are likewise fabricated from fiberglass reinforced polyester shells **24** filled with polyurethane foam **25**. As shown in FIG. 2, the plug pieces **23** are appropriately and precisely stepped to mate with the panels **15** and are contiguously joined therewith by screws **26** and by a suitable epoxy or like adhesive. The

screws **26** are recessed in holes **28** formed in the plug pieces **23**, which holes are themselves plugged with insulating inserts **29** of polyurethane foam. To effect a continuous, liquid and gas impermeable secondary barrier **14**, the joints between adjacent panels **13** are overlaid with an adhesively secured fiberglass sheet **30**. The resultant secondary barrier construction is similar to and in most respects generally duplicates that described in the copending Pratt et al. application and, accordingly, is effectively dimensionally stable through the range of temperatures encountered in the contemplated cryogenic application, in addition to being gas- and liquid-tight and being capable of safely withstanding the hydrostatic load of the cargo.

In accordance with the principles of the present invention, the primary barrier **13** is formed from effectively dimensionally stable plastic panels **31** generally similar to the secondary barrier panels **15**, but which also include molded-in feet **32** of sufficient strength to maintain a predetermined spaced relation with the secondary barrier to which the panels **31** are to be attached and to withstand the hydrostatic loads imposed thereupon. Accordingly, the panels **31** include fiberglass reinforced polyester shells **33** filed with polyurethane foam **34**. In accordance with a more specific aspect of the invention and as represented by broken lines at the left hand side of FIG. 2, fiberglass reinforcements **35**, which may be in cloth form during the molding process, surround the polyurethane and extend into each of the foot elements **32**. More particularly, in the formation of the inner panels, oversized sheets of fiberglass cloth may be wrapped about preformed polyurethane foam blocks and the end edges of the sheets may be extended outwardly therefrom and into foot portions of a special mold to provide adequate strengthening for the subsequently formed feet. The wrapped blocks may then be encapsulated with a polyester resin in the special molds employing procedures set forth at greater length in the above-identified application.

Although not being specifically shown elsewhere in the drawing, it is to be understood that fiberglass reinforces the polyester employed in the shell portions of the insulating panels and plug pieces and is present in predetermined amounts sufficient to provide the strength to withstand the thermal and hydrostatic stresses imposed by the particular liquefied gas that is to be contained. It should be further understood that in certain applications, it may be necessary or desirable to form spacing elements similar to the feet **32** on the secondary barrier panels rather than on the primary barrier panels or in addition thereto.

In accordance with the invention, the primary barrier **13** of the new and improved cryogenic container **10** is established by superimposing upon the secondary barrier **14** a contiguous end-to-end, side-by-side array of the stepped primary panels **31** and mating, stepped plug pieces **36**. Specifically, wooden anchor blocks **37** of a thickness equal to the desired spacing to be established between the barriers, and to the length of the feet **32**, are secured to the plug pieces by screws **38** of sufficient length to penetrate the encapsulated foam **25**. The outer faces of the primary panels **31** may then be fastened to the anchor blocks by screws **38'** extending through peripheral flanges **39**, as shown in FIG. 2. The gaps between adjacent primary panels are filled with the matingly stepped plug pieces **36** which are generally similar in shape and function to the plug pieces **23** of the secondary barrier and which are reliably secured in abutment with the panels **31** by a layer of interposed epoxy adhesive **40**. The impermeability of the thus-established primary layer is further assured by overlaying the joints between adjacent panels **31** and plug pieces **36** with adhesively secured fiberglass sheets **41** in a manner similar to that employed in the completion of the secondary barrier.

Advantageously, the overall thickness of the insulation required for the container is unequally distributed between the primary and secondary barriers, with the secondary barrier panels **15** being of substantially greater width, hence, bulk, than the corresponding dimensions of primary barrier panels **31**, as shown. In this manner, the mechanical load imposed by the primary barrier panels, themselves, upon the secondary barrier panels may be effectively reduced.

As an important aspect of the invention, the completed, spaced double barrier forms, in effect, a pair of similar tanks having an empty chamber **42**, therebetween, which chamber is maintained in constant communication with a detection mechanism, such as a gas monitoring device **43**. Thus, in the event of a crack in the primary barrier **13**, permitting the passage of cargo therethrough and potentially endangering the ship structure, leakage into the chamber **42** in the form of escaped gas will be immediately detected by the monitor **43** indicating the development of a failure in the primary barrier. In addition to representing an integral part of the safety system, the chamber **42** provides a degree of thermal insulation for the cargo, as will be readily appreciated.

From the foregoing it will be apparent that the new and improved cryogenic cargo container, embodying the principles of the invention, may be simply and efficiently constructed in a cargo hold of a tanker or the like. Moreover, creation of both the primary and secondary barriers from effectively dimensionally stable panels which are mutually spaced provides a relatively inexpensive yet very safe, reliable, and economical construction for containers of this type.

It should be understood that the specific structure herein illustrated and described is 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 cryogenic container including

(a) a rigid support structure,

(b) an impermeable outer tank of a predetermined closed configuration,

(c) said outer tank comprised of a series of outer contiguous stepped panels of polyurethane foam encapsulated by fiberglass reinforced polyester resin,

(d) means securing said outer panels at their outer faces to said support structure,

(e) means interposed between and securely bonding adjacent ones of said outer panels,

(f) outer overlay means superimposed upon the joints between said adjacent outer panels and thereby enhancing the impermeability of said outer tank,

(g) an impermeable inner tank of smaller dimensions than said outer tank but of a predetermined closed configuration similar to said outer tank,

(h) said inner tank comprised of a series of inner contiguous stepped panels of polyurethane foam encapsulated by fiberglass reinforced polyester resin,

(i) anchor block means interposed between said inner and outer tanks and secured to the latter,

(j) means securing said inner panels at their outer faces to said anchor block means,

(k) spacing means integrally associated with at least one of said series of inner and outer stepped panels at opposing faces thereof,

(l) means interposed between and securely bonding adjacent ones of said inner panels,

(m) inner overlay means superimposed upon the joints between said inner panels and thereby enhancing the tank impermeability of said inner tank,

(n) said inner and outer tanks defining a chamber therebetween, and

(o) detection means in communication with said chamber for detecting the presence of cargo therein.

2. A cryogenic container in accordance with claim **1**, in which

(a) said spacing means comprise integral foot elements formed on said inner panels.

3. A cryogenic container in accordance with claim 1, in which

(a) said means securing said outer panels to said support structure include mechanical clamping means and adhesive means, and

(b) said anchor block means comprise wood blocks of predetermined thickness substantially equal to the predetermined spacing between said tanks.

4. A cryogenic container in accordance with claim 1, in which

(a) said outer stepped panels are of substantially greater thickness than said inner stepped panels.

5. A gas- and liquid-tight wall construction for a cryogenic container, comprising

(a) a generally planar supporting structure of mild steel plate,

(b) spaced stud means projecting inwardly from said supporting structure,

(c) a plurality of first peripherally stepped insulating panels arrayed in face-to-face contact with said supporting structure and in a predetermined array defining gaps therebetween, said first insulating panels including peripheral flange means at the outer faces thereof,

(d) bolted clamping plate means associated with said stud means and mounting said first panels against said support plate,

(e) first stepped plug panels contiguously interposed between said stepped surfaces of said first insulating panels,

(f) screw means fastening said first plug panels to said first insulating panels,

(g) overlay means sealing the joints between said first insulating panels and said first plug panels,

(h) wooden anchor blocks of predetermined thickness secured to the outer faces of said first plug panels,

(i) a plurality of second peripherally stepped insulating panels arrayed in predetermined spaced relation with said supporting structure and in a predetermined array defining gaps therebetween, said second insulating panels including integral foot elements substantially equal in length to the thickness of said anchor blocks and peripheral flange means associated with the outer faces thereof,

(j) means securing said second insulating panels to said wooden anchor blocks,

(k) second stepped plug panels contiguously interposed between said stepped surfaces of said second insulating panels,

(l) means securing said second plug panels to said second insulating panels, and

(m) overlay means sealing the joints between said second insulating panels and said second plug panels.

6. A wall construction in accordance with claim 5, in which

(a) said insulating panels and said plug pieces comprise fiberglass reinforced polyester shells filled with polyurethane foam,

(b) said integral foot elements comprise extensions of said fiberglass reinforced polyester shell.

7. A cryogenic container for incorporation in a seagoing tanker or the like, including

(a) a rigid support structure,

(b) an impermeable outer tank of a predetermined closed configuration,

(c) said outer tank comprised of a series of outer contiguous stepped panels of polyurethane foam encapsulated by fiberglass reinforced polyester resin,

(d) means securing said outer panels at their outer faces to said support structure,

(e) an impermeable inner tank of smaller dimensions than said outer tank but of a predetermined closed configuration similar to said outer tank,

(f) said inner tank comprised of a series of inner contiguous stepped panels of polyurethane foam encapsulated by fiberglass reinforced polyester resin,

(g) means securing said inner panels at their outer faces to said outer panels,

(h) integral spacing feet associated with one of said inner and outer panels and serving to maintain said inner tank in fixed, spaced relation to said outer tank.

8. The cryogenic container of claim 7, in which

(a) said integral spacing feet are formed in the encapsulating resin of the panels forming one of the tanks,

(b) said panels including reinforcing sheets of fiberglass cloth wrapped about panels of polyurethane foam and having end edge margins projecting outward therefrom and into said spacing feet to constitute the reinforcement thereof.

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