Sept. 5, 1967 C. D. FORMAN ET AL 3,339,780

DUPLEX INSULATING PANEL

Filed Nov. 6, 1964

FIG. 1

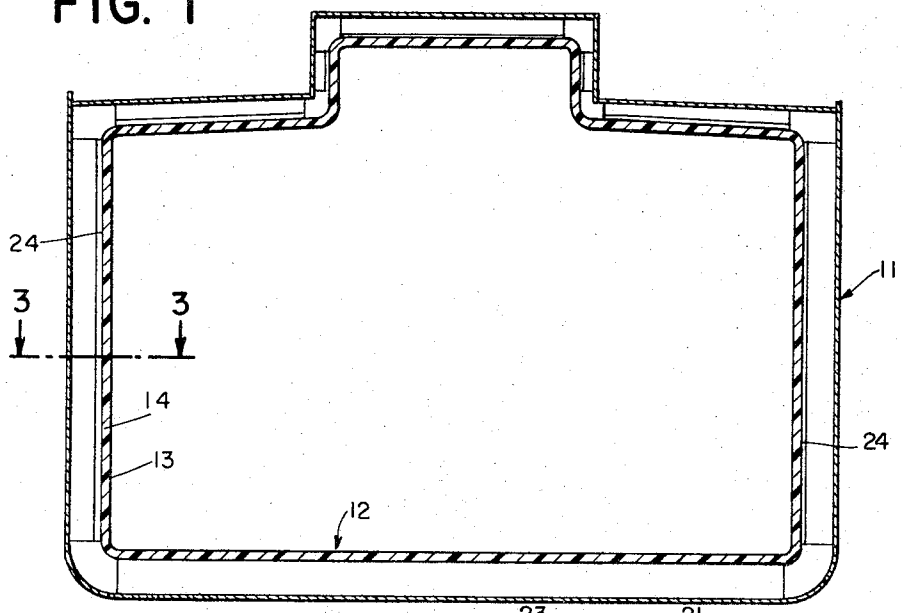


FIG. 2

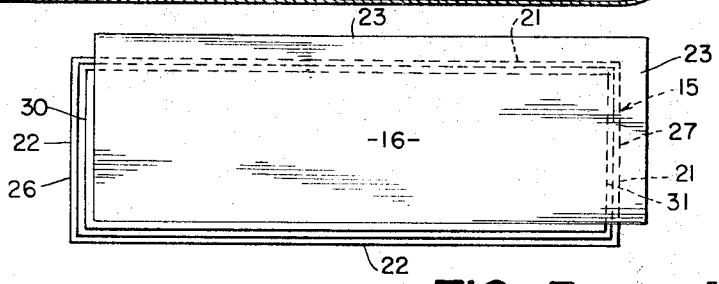
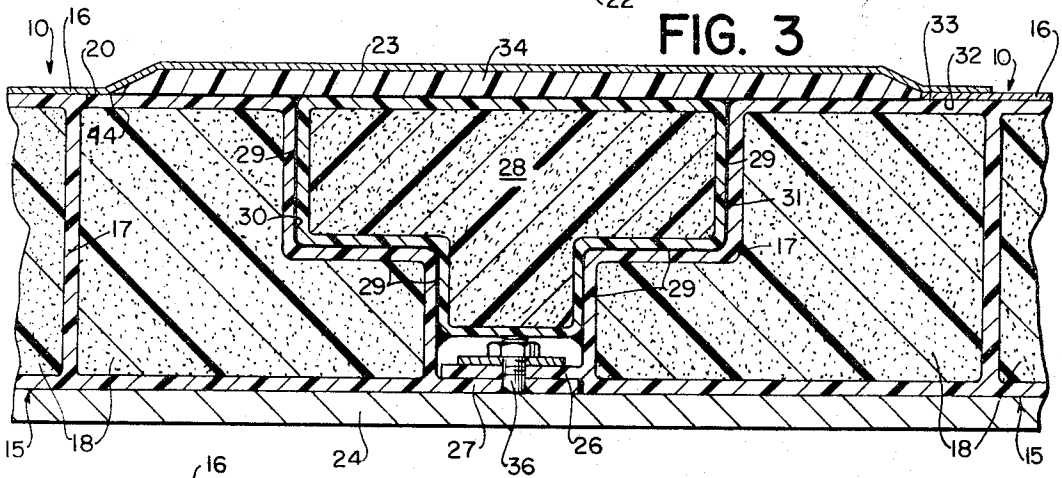


FIG. 3



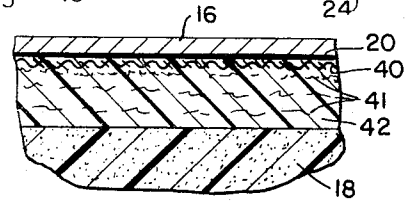


FIG. 4

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DUPLEX INSULATING PANEL

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ABSTRACT OF THE DISCLOSURE

A cryogenic insulation tank construction wherein said tank is prefabricated from individual panels having cellular plastic insulation and a bonded metal foil barrier extending beyond the periphery of the panel. The extending metal foil portion acts as sealing flaps with the foil edges on adjacent panels to form a liquid-tight primary barrier on the tank interior.

The present invention relates to containers for the storage and marine transportation of liquified gases and, more particularly, to new and improved, prefabricated duplex insulating panels which may be used to provide both primary and secondary liquid barriers in a container, such as may be formed in the cargo hold of a vessel.

In accordance with accepted practice and the provisions of applicable regulatory codes, container systems for the marine transportation of cargoes of liquified natural gases at atmospheric pressures, at which pressures the cargoes are at cryogenic temperatures, must include no less than a primary liquid-tight barrier and a secondary liquid-tight barrier to isolate the ship hull structure from the deleterious supercooling effects of the liquid gas cargoes. The present invention represents a new and improved integrated insulated tank construction; that is, a construction in which the aforementioned primary and secondary barriers are in the form of an integral unit rather than being independent of one another. Specifically, an insulated container having a metallic layer as a primary barrier and a thermal insulator as a secondary barrier, may be formed, in accordance with the invention, from novel prefabricated duplex panels having a base panel member of cellular plastic insulation and a bonded, superposed member of metal foil having sealing flap portions extending beyond the periphery of the base member at predetermined edges thereof.

More specifically, cladding of the new and improved duplex panels against a support surface, normally the inner hull of a tanker cargo hold, will contemporaneously array both barriers in their desired mutual relationship. Thereafter, sealing of the projecting free leading edges of the metal foil flap portions to the trailing foil edges of adjacent panels will establish an effectively continuous, liquid-tight primary barrier, which, as will be understood, is integrally supported by the secondary barrier provided by the insulating material. Thus, as an important aspect of the invention, the new and improved panels enable primary and secondary barriers to be completed substantially simultaneously and with a bare minimum number of operations to form an integrated cryogenic container.

As another important aspect of the invention, the new integrated container structure may be entirely constructed without expansion joints. Specifically, the base panel is fabricated in a form which is effectively dimensionally stable when subjected to extreme temperature gradients that exist between the relatively warm ship structure and the supercooled liquid cargo. In accordance with the principles of the invention, the overlying metal foil which,

if unsupported, would normally tend to shrink when subjected to cryogenic temperatures, maintains its integrity and strength through the intimate, integral bonding support offered by the dimensionally stable base panels. While internal stresses may be induced in the dimensionally stabilized, supported foil, they are of insufficient magnitude to impair the integrity of the bond between the base panel and foil or to interfere with the liquid-tight joints between adjacent united foil portions.

In accordance with a further important aspect of the invention, the novel duplex panels may be prefabricated by initially bonding a glass fiber cloth to an aluminum foil sheet by means of a suitable adhesive such as an epoxy. Thereafter additional glass fiber layers in the form of batts are superimposed on the initial glass fiber cloth layer to establish the basis for an integrally laminated structure. More specifically and as an important aspect of the invention, the metal foil with the adhered glass fiber cloth and the additional glass fiber reinforcement are maintained in predetermined relation in the mold form used for the manufacture of the base panel member. Then, during the molding formation of the base panel, itself, from a suitable plastic resin, the resin is homogeneously dispersed throughout the glass fiber reinforcing batts and the glass fiber cloth to unite integrally the metal foil with the base panel member in a new and improved laminate.

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 cross-sectional view of an insulated cargo hold;

FIG. 2 is a plan view of duplex insulating panels embodying the principles of the invention;

FIG. 3 is an enlarged, fragmentary cross-sectional view, showing details of construction of adjacent leading and trailing edges of the new and improved insulating panels, taken along line 3—3 of FIG. 1; and

FIG. 4 is a further enlarged, fragmentary cross-sectional view, showing details of the integrated bonding of the metal foil to the base panel member.

Referring to the drawing, the new insulating panels **10** are designed especially to be used to clad the cargo holds of a double-hulled tanker **11** to form a closed, insulated container **12**, having a primary liquid-tight barrier **13** integrated with a secondary liquid-tight barrier **14**, as schematically represented in FIG. 1.

In accordance with the principles of the invention, each of the new and improved panels includes an insulating base panel **15**, and an overlying metal foil **16** bonded to the upper surfaces thereof. In the illustrated embodiment, the base panel **15** consists of a glass fiber reinforced, externally stepped, plastic shell structure **17** filled with polyurethane foam **18**, while the metal foil **16** advantageously is aluminum. The base panel **15**, which advantageously includes integral lower flanges **26**, **27**, is so designed and constructed as to experience very little, if any, significant expansion or contraction when subjected to the wide temperature ranges encountered in the storage of cryogenic materials and therefore may be considered to be effectively dimensionally stable. Preferably, the base panels **15** are generally similar in construction to the dimensionally stable insulating panels disclosed in more detail in the copending Harold Pratt et al. application Ser. No. 394,287, for "Insulation System," filed Sept. 3, 1964.

With reference to FIG. 2, the base panels **15** are in the shape of a rectangle, having typical dimensions of about twenty-five feet by five feet. Two consecutive sides of the panels are designated as leading edges **21**, and the remaining two sides are designated as trailing edges **22**.

In accordance with the principles of the invention, a

major body portion of the aluminum foil skin **16** is initially bonded to a glass fiber cloth **40** by means of an epoxy **20** or other suitable adhesive. Thereafter reinforcing layers of glass fiber batts containing fibers **41** are superimposed on the initial foil-cloth structure to provide additional strength and reinforcement of the ultimately formed shell **17**. As will be understood, the glass fiber cloth **40** functions as a bonding and reinforcing agent to unite in an integral manner the foil sheet and the above-described shell structure **17**. As an important aspect of the invention, the integration of the glass fiber reinforced shell **17** with the glass fiber cloth-foil structure is effected as part of the molding operation of the shell **17**, itself. Thus the new and improved duplex panel is completed by aligning the foil-cloth structure and superimposed glass fiber batts in a special mold form and then molding the shell form **17** from a suitable polyester resin **42** in the presence of an appropriate catalyst. As shown in FIG. 4, the glass fiber fibers **41** of the batt will be homogeneously dispersed through the resultant laminate, which is subsequently cured (by heat, if required) after the molding operation. The molded, glass fiber reinforced resin shell **17** will thus be intimately and integrally bonded to the foil **16** through the interstices in the glass fiber cloth layer **40** in a single molding operation.

In the illustrated form of the invention, the epoxy **20**, and the glass fiber cloth **40**, used in the strengthening and bonding of the metal foil **16** are located inwardly of the leading edges **21** to accommodate the use of a connecting strip **34**, as will be explained in greater detail hereinafter.

As shown, the metal foil extends perpendicularly outwardly beyond the leading edges **21** while being inwardly spaced from the trailing edges **22**. Thus, the peripheral foil edge or flap portions **23**, in accordance with an important aspect of the invention, may be hinged upwardly about the outwardmost line of integral bonding **44** (FIG. 3) to facilitate mutual arrangement of pluralities of the new prefabricated panels **10** to clad completely a cargo hold to form a closed insulated container.

Cladding of the inner hull of a cargo hold with the new and improved insulated panels of the invention may be accomplished with expediency and facility, as should be appreciated. Specifically, to form an insulated container wall including primary and secondary liquid barriers, the new panels are progressively arranged in a general, end-to-end and side-by-side relation and are secured to an appropriate supporting surface such as an inner hull wall **24** by a stud bolt **36** (welded or otherwise connected to the hull) extending through the lower flanges **26**, **27**. Advantageously, the flange **26** is located along the trailing edge of the base panel and is disposed in an offset relation to the flange **27**, which is located along the leading edge of the base panel and is in the bottom plane of the base panel **15**. This arrangement accommodates the illustrated overlapping of adjacent flanges.

As explained in the above-identified copending application, the gap between facing stepped sides **30**, **31** of the adjacent insulating panels is filled with an appropriate plug piece **28** of glass fiber reinforced plastic filled with polyurethane. The plug **28** has a property of dimensional stability corresponding to that of the base panel member **15**. As shown, the plug piece has a T-shaped cross section conforming with the contours of the gap and is secured, in a liquid-tight manner, by an adhesive layer **29** to leading and trailing sides **30**, **31**, respectively, of adjacent panel members **15**. This particular insulating structure will thus provide an effectively, dimensionally stable, secondary barrier, as explained in detail in the above-identified copending application.

In accordance with the principles of the present invention, a joint between foil skins **16** is effected and made liquid tight, forming a primary barrier, by flattening and sealing the leading flap portions **23** of the metal foil skin (which may be initially folded upwardly to facilitate arrangement of adjacent panels) over the insert-filled gap and flush against the trailing edge foil portions **32** of the foils **16** of the adjacent panels with an adhesive **33**. Advantageously, but not necessarily, an additional dimensionally stable, connecting strip **34** may be included in the completion of the joint. As shown, the strip bridges or extends over the filled gap between the leading and trailing edges of adjacent panels. When employed, the strip **34** is fastened to the adjacent panels by an appropriate adhesive **35**. It will be appreciated that, where desired or found necessary, mechanical fasteners may be employed in lieu of or along with the adhesive **35**.

The new and improved duplex panels greatly facilitate the construction of closed insulated containers of the type having integrated primary and secondary barriers. As may be readily appreciated, the cladding of the cargo hold of a ship with the new panels provides two barriers in substantially one operation. Moreover, the duplex panels are particularly advantageous for construction of an insulating container without the use of mechanical expansion joints.

It should be understood that the specific prefabricated duplex panel 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 prefabricated duplex insulating panel forming primary and secondary barrier walls and including

(a) a base panel of insulating material having a predetermined high dimensional stability at cryogenic temperatures and forming a secondary barrier wall, said base panel including a polyurethane foam interior and a glass fiber reinforced resin outer shell and

(b) an aluminum metal foil member forming a primary barrier wall and having a predetermined lesser dimensional stability at cryogenic temperatures than said base panel,

(c) said foil having body portions and flap portions,

(d) bonding means including a glass fiber cloth, adhering said body portions of said foil to said base panel, whereby said bonded portions of said foil have an increased dimensional stability at cryogenic temperatures substantially equivalent to that of said base panel,

(e) said flap portions extending beyond the periphery of said base panel and being freely movable relative thereto.

2. an insulated wall structure forming a primary and secondary barrier and comprising

(a) a plurality of generally rectangular base panels having predetermined trailing and leading edges, said edges being of stepped configuration, stepped-edge plug means adapted to fit between individual ones of said panels, adhesive sealing means joining said plug means to adjacent ones of said panels whereby said panels and said plug means form a secondary barrier wall,

(b) a plurality overlying metallic foil sheets having body portions and flap portions,

(c) bonding means securing said body portions to a surface of said base panel at portions spaced inwardly from said leading edges,

(d) said metal foil flap portions extending beyond said leading edges and of sufficient length to extend beyond said plug means,

(e) said flap portions being adapted for hinging movement toward and away from the surface of said base panel, and second bonding means securing said flap portions over said plug means and to said body por-

tions of adjacent metal foil sheets whereby said metal foil sheets define a liquid tight primary barrier integrally supported by said base panels.

3. An insulated wall structure comprising

(a) a plurality of insulating panels arrayed in side-by-side, end-to-end relation to define an effectively continuous, liquid-tight secondary barrier, said insulating panels including a polyurethane foam interior and a glass fiber reinforced resin outer shell,

(b) said insulating panels being effectively dimensionally stable when subjected to cryogenic temperatures,

(c) individual metal foil sheets superimposed on individual ones of said insulating panels,

(d) first bonding means including a glass fiber cloth adhesively securing body portions of said foil sheets to the respective panels in first predetermined limited areas of said insulating panels,

(e) said foil having peripheral flap portions extending beyond the peripheries of the respective panels to which they are bonded, and

(f) second bonding means adhering said flap portions to said body portions of adjacent metal foil sheets,

(g) whereby said metal foil sheets define a liquid-tight primary barrier integrally supported by said insulating panels.

4. An insulated cargo container including

(a) a support structure defining a predetermined closed geometric configuration,

(b) a plurality of insulating panels being effectively dimensionally stable at cryogenic temperatures, said panels including glass fiber reinforced resin outer shells filled with polyurethane foam,

(c) means securing said panels to said structure in side-by-side, end-to-end relation to insulate the same and to define a liquid-tight secondary barrier,

(d) individual metal foil sheets associated with selected ones of said insulated panels,

(e) first bonding means including epoxy glass fiber cloth securing said metal foil sheets to predetermined areas of said selected insulated panels,

(f) each of said metal foil sheets extending beyond said selected panels and into partial overlapping relation with adjacent foil sheets,

(g) second bonding means adhesively securing said sheets in said overlapping relation to define a liquid-tight primray barrier integrally supported by said insulating panels.

5. An insulated container in accordance with claim 4, in which

(a) said metal foil sheets are aluminum.

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