United States Patent [19]

Jackson

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[45] **Aug. 20, 1974**

[54] **CONTAINERS FOR LIQUEFIED GASES**

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[21] Appl. No.: **181,711**

[52] **U.S. Cl.** .... **220/9 LG,** 220/15

[51] **Int. Cl.** **B65d 25/18,** B65d 25/00

[58] **Field of Search** .... 220/9 LG, 15; 114/74 A

[56] **References Cited**

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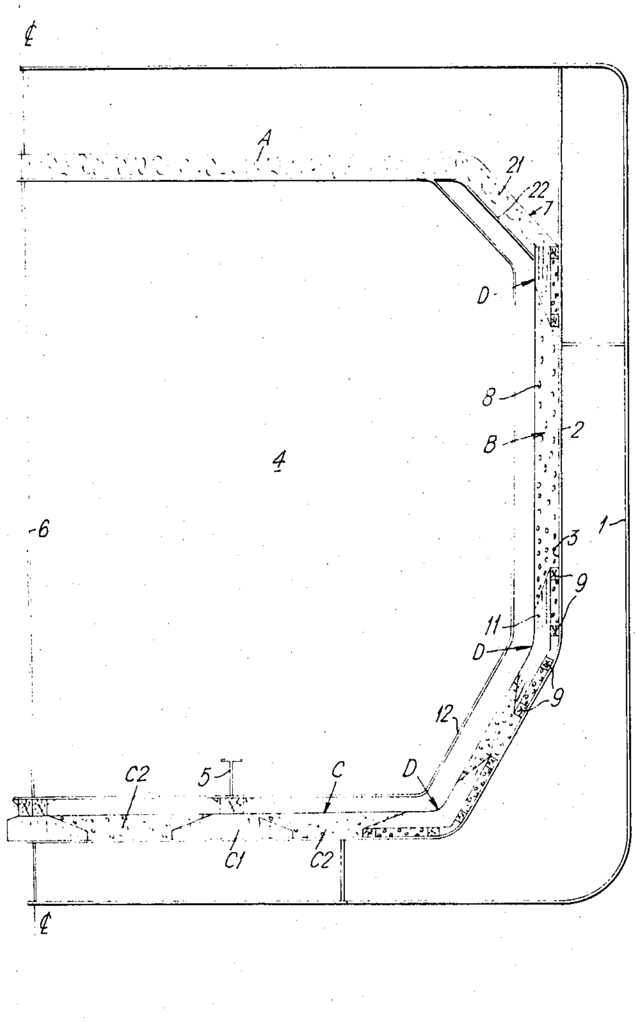
[57] **ABSTRACT**

A large-scale self-supporting insulated metal tank for cryogenic fluids such as liquid natural gas, in which the insulation lining the bottom of the tank has spaced sections of expensive load-bearing material capable of bearing the load of the filled tank under working conditions, with relatively inexpensive non-load-bearing insulation filling the bottom spaces between the sections of load-bearing insulation.

3 Claims, 4 Drawing Figures



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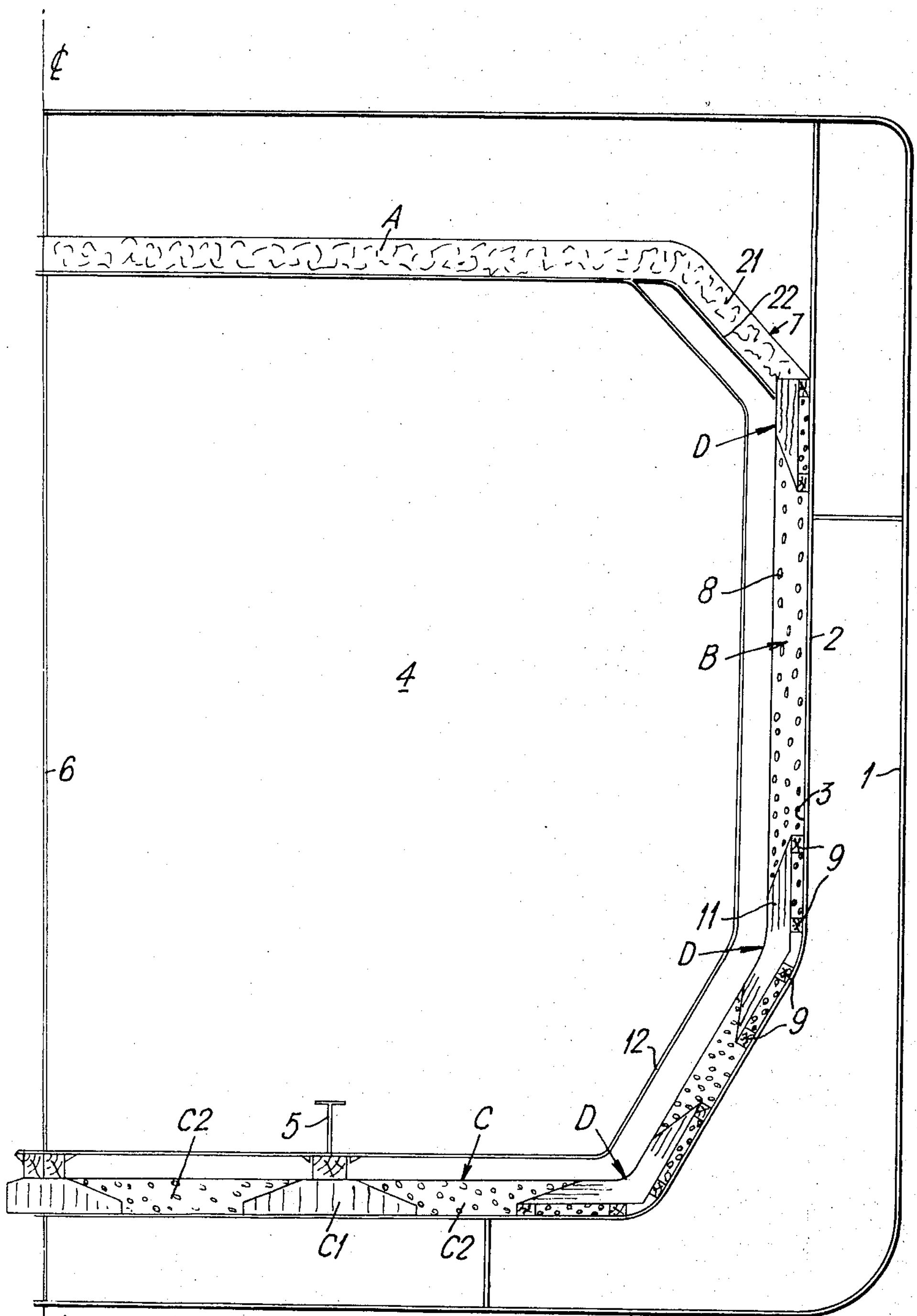

Fig. 1.

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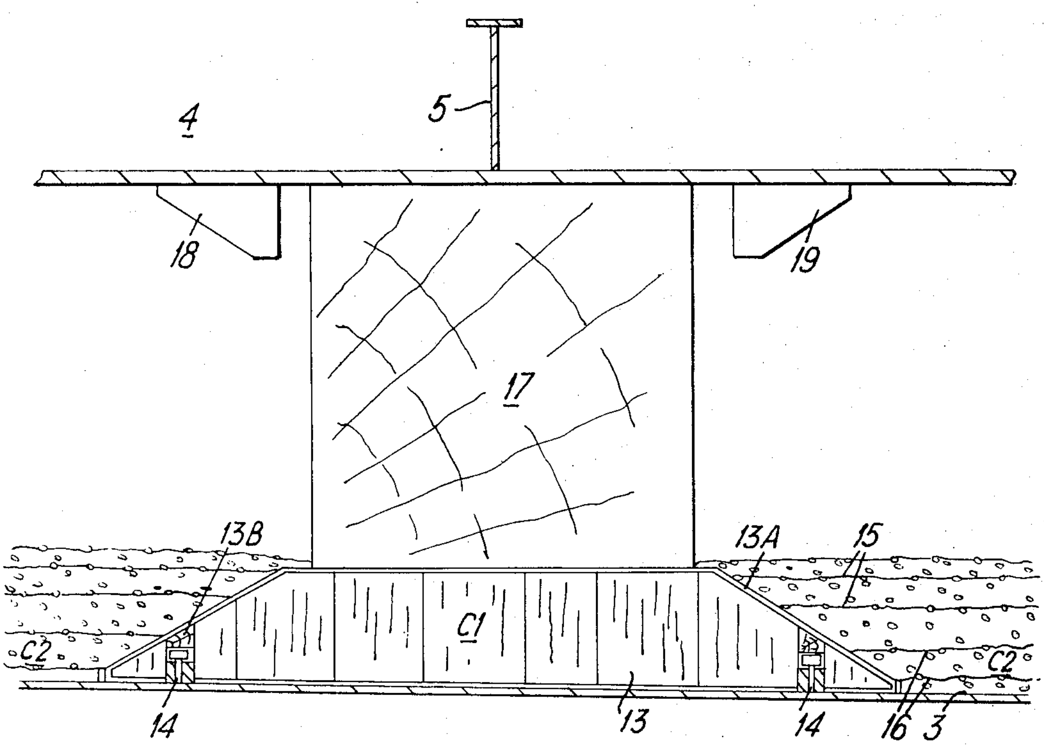

Fig. 2.

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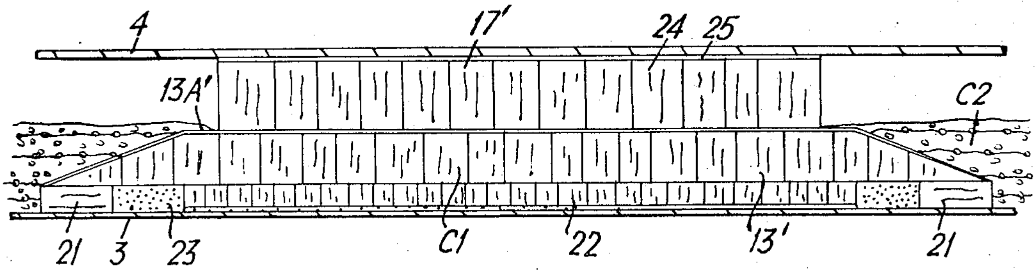
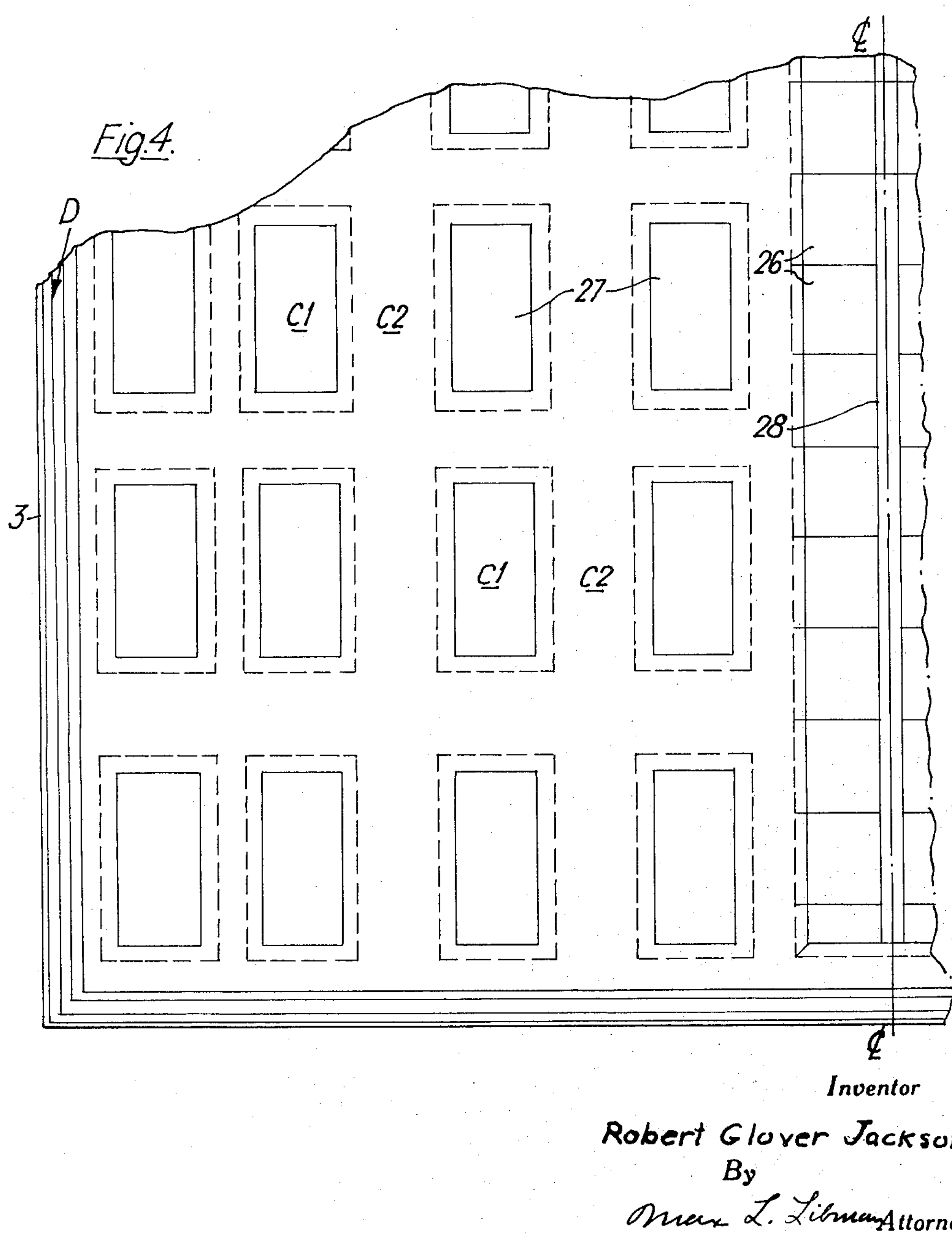


Fig.3.

Fig.4.



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CONTAINERS FOR LIQUEFIED GASES

This invention relates to containers for the bulk storage or transport of liquids at temperatures greatly differing from ambient temperatures and is a modification of the invention described and claimed in U.S. Pat. No. 3,595,424 July 27, 1971, for "Containers for Liquefied Gases," which is concerned with the thermal insulation of such containers.

According to the invention of the above-identified Patent, such a container is characterized in that less highly stressed parts of said thermal insulation comprise rigid foamed plastics material sprayed in situ internally on the outer rigid shell while more highly stressed parts thereof are of load-bearing thermal insulating material of higher strength.

Two constructional examples of the invention are described in said Patent, one, with reference to FIGS. 1 to 3 of the drawings accompanying that Patent, being concerned with a container of the kind comprising a self-supporting tank and the other, with reference to FIG. 4, being concerned with a so-called integrated tank container.

In discussing a container of the kind comprising a self-supporting tank, the above Patent indicates that the section of the thermal insulation lining the bottom of the outer rigid shell and supporting the bottom of the tank is wholly of load-bearing material of high compressive strength. Whilst the arrangement described therein is advantageous for acting as a secondary barrier to the liquid as well as supporting the load of the tank and the liquid contained therein and, in the case of a marine tanker incorporating such tanks, for supporting any fluctuating loads applied thereto during tans-shipment of the liquid, in practice the cost of the materials and labor for assembling such an insulation section is high compared with the foamed thermal insulation sections described for the side walls of the outer rigid shell.

The object of the present invention is to provide, in the case of a container of the kind comprising a self-supporting tank, an alternative insulation arrangement for the section lining the bottom of the outer rigid shell which (i) renders sufficient support for the bottom of the tank, (ii) is capable of acting as a secondary barrier, and (iii) utilizes at least in part the thermal insulation arrangement described and claimed in the above Patent for the side walls of the outer rigid shell, with consequent savings in cost.

According to the present invention, in a container for the bulk storage or transport of liquids at temperatures greatly differing from ambient temperature and comprising a self-supporting tank surrounded by thermal insulation in an outer rigid shell, the section of insulation lining the bottom of said shell supporting said tank, said section of insulation comprises bearer members of load-bearing thermal insulation rigidly fixed to and spaced over the bottom of said shell, and rigid foamed plastics material sprayed in situ in the spaces between said bearer members, the planes of junction between said bearer members and said rigid foamed plastic material extending obliquely to the plane of the walls of said shell.

Preferably, each bearer member comprises a plywood faced layer of balsa wood panels faced with plywood and rigidly secured to the bottom of said shell.

Conveniently a load-bearing block is secured to the upper face of each layer of panels and is adapted to support the tank clear of the rigid foamed plastics material.

Alternatively, each load-bearing block comprises a second layer of balsa wood panels and the upper face of this second layer may have a facing providing good frictional engagement with the floor of the tank.

Conveniently, in the case of a marine tanker, the floor of the tank may be provided with a keying arrangement comprising two lines of brackets, the spacing of each line relative to the lines of bearer members being such that one line of brackets acts against a line of bearer members to locate the tank when the tank is at ambient temperature and the other line of brackets similarly acts against said line of bearer members when dimensional changes have taken place in the tank as a result of it being subjected to the temperature of the liquid cargo.

In order that the invention may be readily understood, a marine tanker incorporating a container for liquefied natural gas (LNG) constructed in accordance with this invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. **1** is a transverse vertical half-sectional view through the tanker;

FIG. **2** is an enlarged sectional view showing a detail of a bottom section of the thermal insulation;

FIG. **3** is an enlarged sectional view showing an alternative arrangement of the detail of FIG. **2**; and

FIG. **4** is a fragmentary plan view of a bottom section of the thermal insulation.

Referring to FIG. **1** of the drawings, the tanker comprises an outer hull **1** and an inner hull **2.** The inner hull together with two transverse bulkheads (not shown) define a cargo hold **3.** It will be appreciated that a number of such cargo holds may be provided. Disposed within the cargo hold **3** is a self-supporting tank **4** which is of a metal not subject to cold embrittlement at the temperature of the LNG, e.g., aluminum or 9 percent nickel steel. The tank **4** is of sufficient thickness and suitably stiffened by inner frame members, one being indicated at **5,** to contain the liquid; a centerline bulkhead **6** is provided within the tank. The tank **4** is surrounded by thermal insulation generally indicated at **7,** which lines the cargo hold **3.** FIG. **2** is not drawn to scale, and in particular the insulation is shown to a larger scale than the tanker for clarity.

The thermal insulation **7** comprises a section A lining the top of, and extending a short distance down to the sides of the cargo hold **3,** sections B lining the sides of the hold and a section C lining the bottom of the hold.

Each section B of the thermal insulation, which is substantially the same as described for section B in the Patent above referred to, comprises a constant thickness of rigid closed cell polyurethane **8** sprayed in layers onto the main portions of the side walls of the cargo hold **3.** However, in this construction, layers of nylon mesh are incorporated within the thickness of the polyurethane instead of layers of hessian mat as described in the above Patent.

The corners of the cargo hold **3** defining the side walls, i.e., the top, bottom and vertical corners, are lined with corner sections D of load-bearing thermal insulation which is substantially the same as that described for section A in the above Patent; it has been found, particularly in the case where the container is for LNG, that the temperature gradient across the insulation, of the order of 160° C. for LNG at normal atmospheric pressure, imposes critical stresses across the polyurethane in view of its relatively high co-efficient of expansion which is of the order of 40 to 50 $\times 10^{-6}$ metres per metre per ° C. over the range of densities for the polyurethane as quoted in the above Patent. These critical stresses are particularly significant around the edges of the polyurethane sections and if the corners of the cargo hold comprised sprayed layers of preformed fillets of this material as suggested in the above Patent as a possibility for the vertical corners, the combined effect of the critical stresses from adjacent wall sections could lead to the corner sections cracking, e.g. by pulling away from the corners of the cargo hold. Each corner section D thus comprises timber ground strips **9** secured at regular intervals around their respective corners of the cargo hold **3** and panels **11** of balsa wood faced with plywood secured, for example by a suitable adhesive to the ground strips **9.** In addition, as shown in FIG. **1,** in this construction the tank **4** is provided with a lower chamfer **12** and the cargo hold is similarly shaped. Hence the side walls of the cargo hold **3** are provided with an intermediate wide-angled corner to which a further corner section D is secured. The junctions between the sections B and corner sections D are again substantially as described in the above-identified Patent, the line of each junction extending at an angle to the plane of the wall of the cargo hold other than a right angle. Also in this construction the nylon mesh layers are secured to the surface of the corner sections D by a suitable adhesive rather than via slots as described in the above Patent; for each section B the two inner most layers of nylon mesh extend continuously therethrough while the two outermost layers extend a relatively short distance into the polyurethane from each corner section D.

Turning now to section C of the thermal insulation, in accordance with the invention, this is provided with a combined polyurethane and load-bearing insulation, the latter providing local areas of support for the bottom of the tank **4** rather than a continuous support as is the case with the section A insulation described in the abovecited Patent. Section C comprises basically a composite of the section B insulation and the load-bearing insulation construction of the corner sections D, both described above. Thus, referring also to FIG. **2** of the drawings, spaced lines of load-bearing insulation sections C1, extending longitudinally of the ship are secured to the floor of the cargo hold **3.** As mentioned, above these lines of insulation sections are of similar construction to the corner sections D and comprise layers of balsa wood panels **13** faced with plywood **13A** the edges of which extend at an angle to the plane of the hold floor. It will be appreciated however that the maximum strength requirement for the C1 sections is perpendicular to the plane of the hold floor whereas that for the corner sections D is parallel to the planes of the floor and walls of the hold and hence, since balsa wood is stronger in the direction parallel to its grain, the direction of the grain for the balsa panels of the C1 sections is at right angles to the grain direction for the corner sections D. Also, because of the load-bearing requirement for the C1 sections, no timber grounds are provided and instead the layers of panels **13** are secured directly to the hold bottom by means of bolts **14** passing through counterbored apertures adjacent the inclined edges of the panel **13,** the counterbore **13B** being plugged after fixing and covered by the plywood facing **13A** as shown in FIG. **2.** Because no timber grounds are provided the thickness of each C1 section is increased by the thickness of said timber grounds. The sections C2 between the C1 sections and between the outermost C1 sections and their adjacent corner sections D are filled with layers of polyurethane in exactly the same manner as previously described for section B. It will be noted that FIG. **2** shows the nylon mesh layers described previously, the two innermost layers being referenced **15** and the two outermost **16.**

Each section C1 rigidly and securely supports a load-bearing block **17,** of, for example, a dense wood such as yellow pine, and the bottom of the tank **4** is seated on the blocks **17;** it will be appreciated that the number and spacing of the sections C1 and hence the blocks **17** over the floor of the cargo hold **3** is such that, between them, these blocks provide sufficient strength to support the static loads of the tank and stored LNG as well as any fluctuating loads arising during the transshipment of the LNG. Should it be necessary to strengthen the blocks **17** against the effects of rolling shear, these blocks can be formed with horizontal and/or vertical laminations of, for example, plywood.

As shown in FIGS. **1** and **2,** one section C1 coincides with the centerline bulkhead **6** of the tank **4** and preferably each of the other sections C1 coincides with a longitudinally extending bottom frame member **5** for the tank.

The blocks **17** as well as providing support for the tank **4** may be used to hold said tank in a located position. To achieve this, two sets of brackets **18, 19** are secured to the bottom of the tank **4** and are arranged such that when the tank is at ambient temperature the brackets **18** are in contact with and act against those sides of their respective blocks **17** facing towards the centerline of the tank to keep the tank in position, and when the tank is cooled down and loaded with LNG the brackets **19** act against the opposite faces of their respective blocks **17.** It will be appreciated that in this latter condition the tank **4** will have contracted toward its center under the effect of the cold of the LNG and hence, during assembly of the brackets **19** under ambient conditions, appropriate spacings must be left between them and their respective faces of the blocks **17** to cater for this thermal contraction. As a further refinement the spacing of the brackets **19** may be modified such that during rolling of the tanker at sea, at least the major part of the loading at any instant is taken by those brackets **19** and blocks **17** on that side of the tank centerline which is away from the side to which the tanker is heeled; this provides the advantage that the effective head of LNG and hence the loading on said side of the tank centerline is significantly less than that of the other side.

With reference to FIG. **3,** in an alternative arrangement of the sections C1 of thermal insulation, the layers of balsa wood panels **13** faced with plywood **13A** are secured to spaced timber ground strips **21** in a manner similar to that described hereinbefore for the corner sections D. However, in order to strengthen the sections C1 to ensure that they have sufficient ability to withstand static and fluctuating loads from the tank

4, each layer of panels **13'** has secured thereto a second layer of balsa panels **22** which seats between the respective ground strips **21**. The second layer of panels **22** is thinner than the ground strips **21** to allow for irregularities in the floor of the cargo hold **3** and the spaces left between this layer, the cargo hold **3** and the ground strips **21** are filled with a suitable loadbearing mastic **23**. Also, in this alternative arrangement, the loadbearing blocks **17'** for supporting the floor of the tank **4** comprise a third layer of balsa wood panels **24** secured to the plywood facing **13A'** of the layer of panels **13'**. The layer of panels **24** is also provided with a plywood facing **25** to provide good frictional engagement between the **C1** sections and the floor of the tank when the latter is filled with cargo so that there is less likelihood of the tank **4** tending to slide during transshipment thereby effectively reducing the potential loading of the keying arrangement **18, 19**.

Referring now to FIG. **4**, this shows a typical layout of the **C1/C2** thermal insulation over the floor of the cargo hold **3**. In this layout a line of abutting **C1** sections of insulation extend along the length of the hold floor at the longitudinal centerline of the tanker. Also, lines of **C1** sections **27** of insulation are spaced on either side of the sections **26** in parallel relationship, each line **27** comprising a number of spaced island sections so as to provide a multiplicity of discrete areas of support over the floor of the tank **4**. As discussed hereinbefore the number, spacing, and support area of the lines of **C1** sections **26, 27** will be such as to provide adequate support for the tank **4** against all expected static and fluctuating loads to which the tank will be subjected during trans-shipment. Also, in this layout, the line of sections **26** is shown with a keyway **28** extending along the longitudinal centerline of the tanker for receiving a mating key provided on the floor of the tank **4**. Such a keying arrangement provides an alternative to the keying arrangement **18, 19** described hereinbefore with reference to FIG. **2** and is similar to that described in British Pat. No. 854,708. As described in that Patent the tops of the tanks **4** may be stabilized in relation to the decks of the tanker to reduce the possibility of the tank **4** rocking on the **C1** sections of insulation.

Tests have indicated that a thermal insulation system such as described above for the sides and bottom of the cargo hold **3** is tight against LNG and hence would provide a secondary barrier to the LNG if the tank **4** should rupture. In particular, tests have been carried out on a full scale joint of load-bearing insulation and polyurethane constructed substantially as described above at a normal operating temperature, and under fluctuating load conditions many times more severe than would be encountered in normal operation of a tanker at sea with no evidence of rupture.

If desired the spaces between the side and bottom walls of the tank and the cargo hold may be at least partially filled with additional relatively cheap thermal insulation material, e.g., fibreglass. Where fibreglass is provided in the spaces between the side walls of the tank and hold this may be supported, as described in the U.S. Pat. No. 3,595,424 above referred to, on the face of the insulation system, or on the outer surface of the tank. In either arrangement a supporting framework (not shown) may be provided to retain the fibreglass in position.

It will be appreciated that the position of the section A insulation is such that it is not essential for it to be capable of acting as a secondary barrier although it is desirable that it be splash-tight. This in this construction a relatively cheap insulation is provided comprising fibreglass **21** faced with plywood **22**.

I claim:

1. A container for the bulk storage or transport of liquids at temperatures greatly differing from ambient temperature and comprising a tank surrounded by thermal insulation in an outer rigid shell, with a section of said insulation lining the bottom of said shell and supporting said tank,

b. wherein said section of insulation comprises individual compact members of load-bearing thermal insulation rigidly fixed to and spaced apart from each other both transversely and longitudinally over the bottom of said shell,

c. and rigid foamed plastic material sprayed in situ in the spaces between said compact members, the total area of said plastic material being much greater than the total area of said load-bearing members,

d. wherein the planes of junction between said compact members and said rigid foamed plastic material extend obliquely to the plane of the walls of said shell, so as to lie more nearly horizontal than perpendicular,

e. wherein each compact member comprises a layer of balsa wood panels faced with plywood and rigidly secured to the bottom of said shell,

f. wherein a load-bearing block is secured to the upper face of each layer of panels and is adapted to support the tank clear of the rigid foamed plastic material,

g. wherein each load-bearing block comprises a second layer of balsa wood panels,

h. wherein each first mentioned layer of panels is secured to the bottom of the shell via spaced timber grounds and a third layer of balsa wood panels is secured to the bottom face of the first layer of panels and set in mastic within the space between said grounds.

2. A container for the bulk storage or transport of liquids at temperatures greatly differing from ambient temperature and comprising a tank surrounded by thermal insulation in an outer rigid shell, with a section of said insulation lining the bottom of said shell and supporting said tank,

b. wherein said section of insulation comprises individual compact members of load-bearing thermal insulation rigidly fixed to and arranged in spaced lines over the bottom of said shell,

c. and rigid foamed plastic material sprayed in situ in the spaces between said compact members,

d. wherein the planes of junction between said compact members and said rigid foamed plastic material extend obliquely to the plane of the walls of said shell, so as to lie more nearly horizontal than perpendicular,

e. wherein each compact member comprises a layer of balsa wood panels faced with plywood and rigidly secured to the bottom of said shell,

f. wherein each layer of panels is secured to the bottom of the shell via spaced timber grounds and a second layer of panels is secured to the bottom face of the first layer of panels and set in mastic within the space between said grounds.

3. A container for the bulk storage or transport of liquids at temperatures greatly differing from ambient temperature and comprising a tank surrounded by thermal insulation in an outer rigid shell, with a section of said insulation lining the bottom of said shell and supporting said tank,

b. wherein said section of insulation comprises individual compact members of load-bearing thermal insulation rigidly fixed to and spaced over the bottom of said shell,

c. and rigid foamed plastic material sprayed in situ in the spaces between said compact members, the total area of said plastic material being greater than the toal area of said load-bearing members,

d. wherein the planes of junction between said compact members and said rigid foamed plastic material extend obliquely to the plane of the walls of said shell, so as to lie more nearly horizontal than perpendicular,

e. wherein each compact member comprises a layer of balsa wood panels faced with plywood and rigidly secured to the bottom of said shell,

f. wherein a load-bearing block is secured to the upper face of each layer of panels and comprises a second layer of balsa wood panels,

g. wherein each first mentioned layer of panels is secured to the bottom of the shell via spaced timber grounds and set in mastic within the space between said grounds.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,830,396 Dated August 20, 1974

Inventor(s) Robert G. Jackson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover page insert -- [30] Foreign Application

Priority Data Great Britain 48749/70 Oct. 14, 1970 --.

Signed and sealed this 18th day of February 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
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