June 4, 1963 C. D. DOSKER 3,091,817

INSULATION, METHOD OF CONSTRUCTION, AND ELEMENTS

Filed June 25, 1958 3 Sheets-Sheet 1

FIG. 1

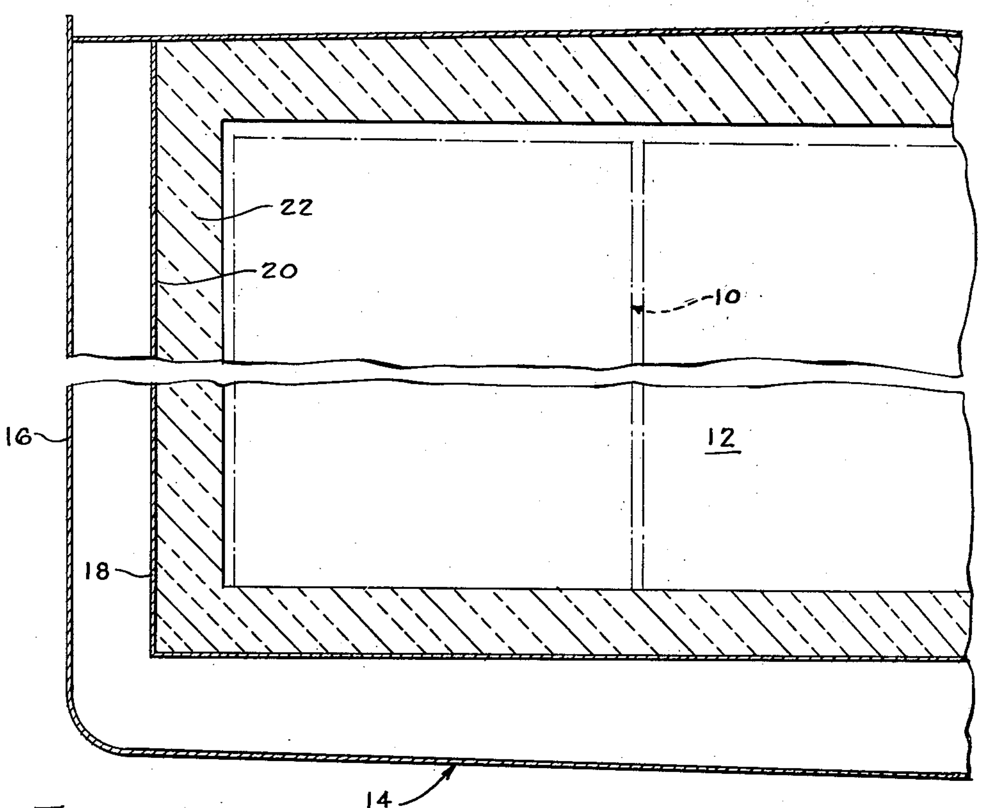


FIG. 2

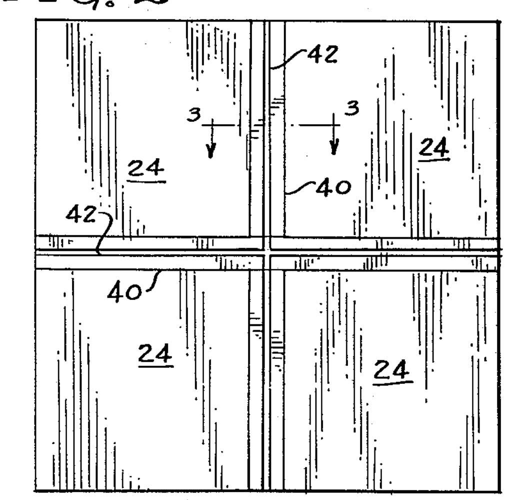
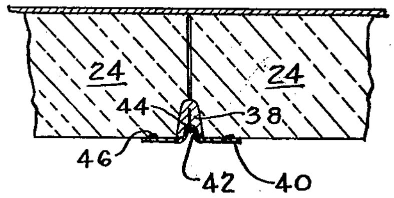


FIG. 3



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INSULATION, METHOD OF CONSTRUCTION, AND ELEMENTS

Filed June 25, 1958 3 Sheets-Sheet 2

FIG. 4

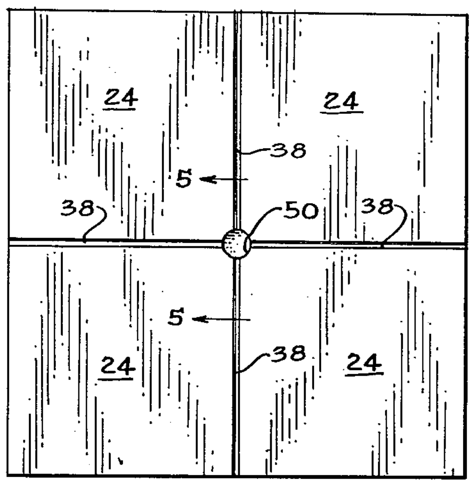


FIG. 5

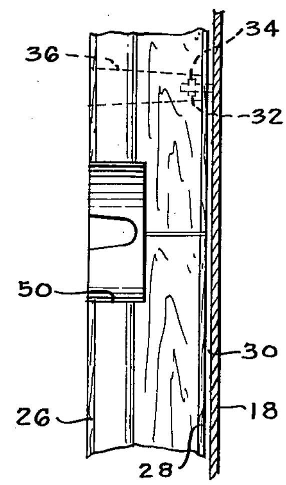


FIG. 6

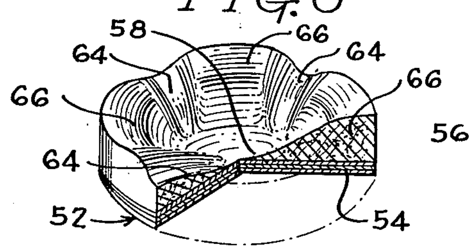


FIG. 7

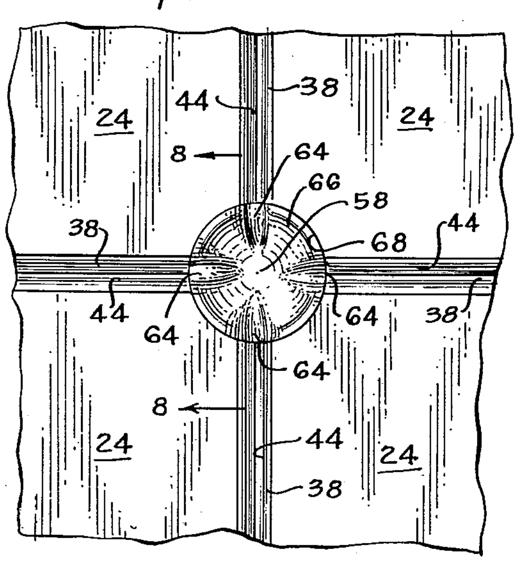
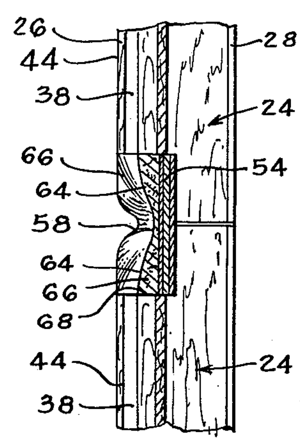


FIG. 8



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INSULATION, METHOD OF CONSTRUCTION, AND ELEMENTS

Filed June 25, 1958

3 Sheets-Sheet 3

FIG. 9

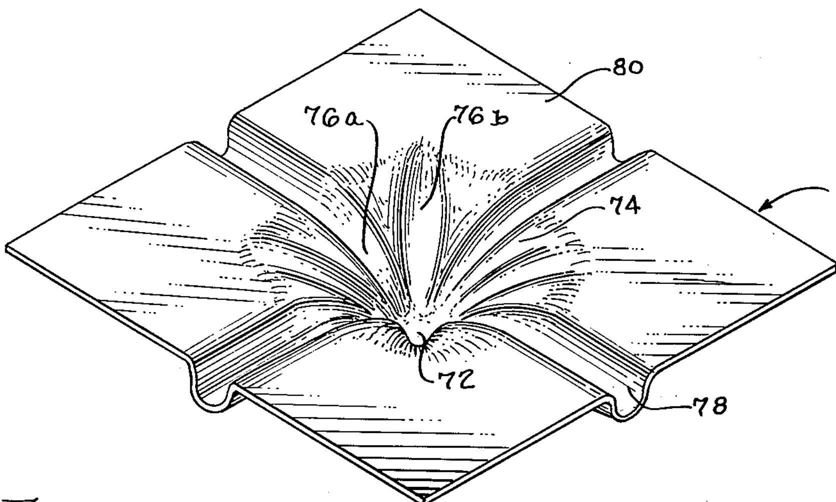


FIG. 10

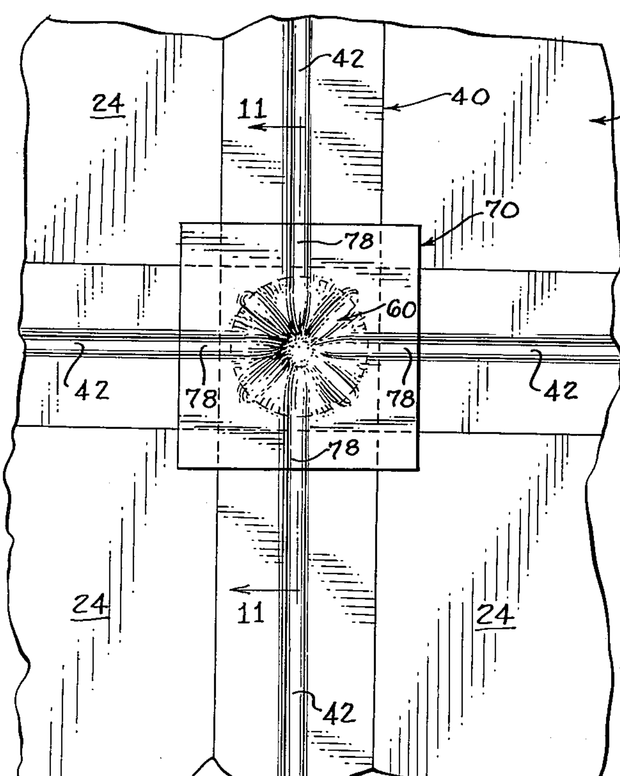
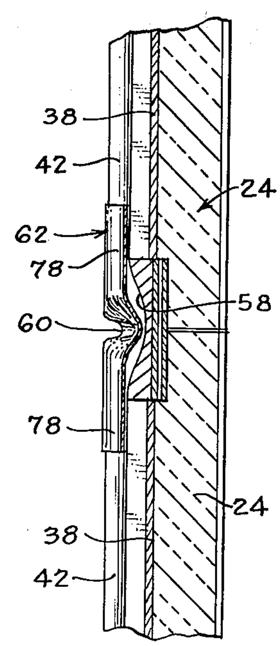


FIG. 11



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United States Patent Office
3,091,817
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1

3,091,817
INSULATION, METHOD OF CONSTRUCTION, AND ELEMENTS

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Filed June 25, 1958, Ser. No. 744,427
13 Claims. (Cl. 20—4)

This invention relates to the storage and transportation of a material which needs to be maintained at extremely low temperature, and it relates more particularly to the construction of a large insulated space in which one or more containers are housed for maintaining the refrigerated cargo at extremely low temperature with a minimum amount of heat loss.

It is an object of this invention to provide an insulated space of the type described, and it is a related object to provide elements and a method for the use of same in the fabrication of the insulated space.

These and other objects and advantages of this invention will hereinafter appear and for purposes of illustration, but not of limitation, an embodiment of the invention is shown in the accompanying drawings, in which—

FIGURE 1 is a schematic elevational view partially in section of the insulated hold of a ship embodying the features of this invention;

FIGURE 2 is a plan view in elevation of a portion of the wall construction of the insulated space;

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a plan view similar to that of FIGURE 2 but at a later stage of assembly;

FIGURE 5 is a sectional view taken along the line 5—5 of FIGURE 4;

FIGURE 6 is a perspective view of an insulation block employed in the practice of this invention;

FIGURE 7 is a plan view similar to that of FIGURES 2 and 4 at a still further stage of assembly showing the block of FIGURE 6 in position of use;

FIGURE 8 is a sectional view taken along line 8—8 of FIGURE 7;

FIGURE 9 is a perspective view of a corner expansion member embodying the features of this invention;

FIGURE 10 is a plan view similar to FIGURES 2, 4 and 7 showing the final stage of assembly, and

FIGURE 11 is a sectional view taken along the line 11—11 of FIGURE 10.

Description of the invention can best be made with reference to particular materials to be maintained under a predetermined set of conditions, but it will be understood that the inventive concepts can have application to other materials having an entirely different set of conditions for storage or transportation but wherein a common problem exists with respect to the need to insulate a large space in which a material which needs to be maintained at extremely low temperature is to be housed.

Thus, description will be made with reference to the problem of the transportation of large volumes of a natural gas which is liquefied at a source of plentiful supply for transportation by ship to an area where a deficiency exists and where the liquefied gas can be reconverted to a gaseous state for use. Transportation in a liquefied state is desirable because the same volume of gas can be carried in about 1/600 of the space when reduced from a gaseous state to a liquefied state but, to maintain the liquefied gas in a liquefied state, it is necessary to hold the liquid at a temperature below its bubble point or its critical vaporization point. In the case of methane, comprising the major proportion of natural gas, this means that the liquid must be held at a temperature of about

2

—258° F. or less, depending upon the amount of heavier hydrocarbons in the gas when, as is desirable, the liquefied gas is housed in suitable containers or tanks at about atmospheric pressure.

The storage tanks **10** will be of large dimension for housing a suitable quantity of the liquefied gas. Use may be made, for example, of tanks having a capacity of from 1 to 20,000 barrels and which, when formed to rectangular shape, may have a width and length of from 3–90 feet and a height 7–100 feet. These tanks will be located in the hold space **12** of a ship **14**. This raises a number of problems common even to land storage tanks. The steel hull **16** of the ship cannot be cooled to a temperature as low as the liquefied natural gas without raising some very obvious and serious problems related to the strength of the metal and the build-up of ice on the portions of the hull having water in contact therewith. Thus, in practice, an inner hull **18** will be provided in closely spaced-apart relation to the outer main hull **16** and the inner hull will thus define the hold space **12** in which the storage tanks **10** are located.

In order to minimize heat loss into the tanks, it is desirable to insulate the entire hold space, as distinguished from the individual tanks. The provision of an inner hull makes available a relatively flat and smooth inner surface **20** onto which the insulation **22** can be mounted. As a result, it has been determined that the coverage of the large surface area defining the hold space can most economically and most efficiently be achieved by the prefabrication of large panels **24** of a built-up insulation, which panels can be mounted onto the walls defining the storage space to provide an insulation lining.

In my copending application Serial No. 646,001, filed March 14, 1957, of which this application is a continuation-in-part, and in my copending applications Serial No. 743,541, filed June 23, 1958, entitled "Insulation Panels for Thermally Insulating a Storage Space," Serial No. 743,630, filed June 23, 1958, entitled "Means and Method for Mounting Prefabricated Panels of Insulation," now Patent No. 3,026,577, and Serial No. 743,539, filed June 23, 1958, entitled "Insulation Structure and Means for Manufacture," description is made of the insulation panels and their method of assembly to form the insulated space.

Briefly described, the panels are prefabricated into units of 4 x 8 feet or into units of 8 x 8 feet, or larger, and a thickness of about 10–20 inches. They are formed with inner and outer face plies **26** and **28**, respectively, of a high strength material, such as plywood, and with a relatively thick section **30** inbetween formed of a material characterized by mass integrity and low heat conductivity, as represented by a highly porous, low density wood such as balsa wood or quippo, or a honeycomb structure formed of paper, treated or coated paper, or thin wooden plies.

The panels **24** are mounted onto the side walls **18** and on the floor by bolt and nut means wherein the bolts **32** fixed to the metal supporting wall extend inwardly through spaced-apart openings provided in the insulation panels to enable insertion of a nut and washer assembly **34** which is brought into pressing engagement against the inner face of the plywood panel **28** to secure the plywood facing and the integral panel to the wall. The openings **36** through which the assembly is achieved are subsequently plugged with insulating material to complete the panel. The panels are thus independently mounted on the wall in side-by-side and end-to-end relation substantially completely to cover the entire surface.

It will be apparent that, at the time that the insulation panels are installed, the ambient temperature may be somewhere within the range of 70–100° F. When, however, the tanks or tank mounted within the insulated space are filled with the liquefied natural gas, the temperature conditions existing adjacent the inner faces of the panels will be somewhere in the range of about −350° F. The wide temperature drop will result in considerable contraction in the outer portions of the insulation panels such that a spaced relationship will develop therebetween in use. Such spacing between the panels in use is undesirable for a number of reasons. In the first place, convection currents can flow through the space to minimize the effect of the insulation and to increase the heat loss to the material in the tanks. In the second place, the lack of a sealing relationship between the panels makes it possible for liquid escaping from the tanks or spilled in filling or the like, to flow outwardly into contact with the metal walls, with the resulting reduction in the temperature of the metal to dangerous levels. Many other objections could be enumerated.

Thus, it is desirable to provide a means for blocking the openings between the panels and to provide a fluid-tight seal therebetween notwithstanding the changes in the dimensions of the openings as effected by the expansion and contraction movements taking place in the panels as the temperature falls and rises with introduction and removal, respectively, of the liquefied cargo.

The blocking of the openings devolped between the linear side walls of adjacent panels can be taken care of by the use of elongate slotted splines **38** fitted into contiguous grooves provided in the linear edge portions of adjacent panels and adhesively bonded along their side walls to the adjacent side wall portions of the panels. The slotted spline will enable deflection of the adjacent portions with the panels during expansion or contraction while the base of the spline maintains its integrity to provide the interconnection between the panel sections. This is more fully described in my copending application Serial No. 743,539, filed June 23, 1958, "Insulation Structure and Means for Manufacture."

The sealing relation between the linear edges of the adjacent panels is achieved by the use of an elongate expansion strip **40** formed of a fluid-impervious material having a central bulbous portion **42** which is loosely received in a groove **44** provided in the inner face of the slotted spline, while the lateral edge portions **46** of the expansion strip are adhesively secured in sealing relation to the underlying face portions of the adjacent panels **24**. Thus, the effective width of the sealing strip can be varied by adjustment in the depth of the bulbous portion to provide a continuous sealing relationship between the panels independently of the spline, as was more specifically described in the aforementioned copending application.

The remaining difficulty resides in the blocking of the openings developed at the intersections between three or four panels, and to provide a fluid-tight seal therebetween notwithstanding the relative movements between the panels in the direction toward and away from each other responsive to expansions and contractions which normally take place in use.

Thus, it is another object of this invention to provide a means and materials for effecting a block at the intersections between panels and to provide an expansion joint which effects a fluid-tight seal between the panels notwithstanding relative movements of the panels in expansion and contraction.

In accordance with the practice of this invention the desired relationship is effected preferably after the linear splines **38** and expansion strips **40** have been installed. Thereafter, a cylindrical opening **50** is routed out about a center which corresponds to the intersection between the panels so that, in a 4-corner construction, a sector constituting about ¼ of the cylindrical opening will be defined by the corner portions removed from each of the panels. The opening **50** should be sufficiently large to intersect each of the splines leading into the intersection but not so large as to extend beyond the lateral edges of the linear expansion strips **40**. The opening should be of a depth greater than the thickness of the plywood facing **24** but not so deep as to extend through the insulation layer **30**. In practice, with a 4 x 8 or 4 x 16 panel or any other dimension inbetween, it is sufficient if the diameter of the opening is from 6 to 18 inches and if it is formed to a depth of from 3 to 9 inches. If it were possible to route out a square section or a rectangular section, the opening **50** could be made square or of other shape with an equivalent portion of the opening lying in each of the panels. If the openings are provided by preforming the recesses in the panels in advance of their installation, it would be possible to make use of an opening of a different shape in cross-section.

The opening **50** at the intersection is adapted to be plugged with a block **52** shaped to correspond to the cross-section of the opening for receipt therein in fitting relation. The block can be formed of a resilient material preferably having insulating characteristics and a mass integrity sufficient to maintain its unity upon flexure of sections thereof which are secured for movement with adjacent panels. In the illustrated modification, the block comprises a cylindrical section of composite construction having a base portion **54** formed of balsa or the like wooden slabs cross-plied with a resorcinol or other suitable adhesive or glue. Because of the complex curvature desired to be built into the upper surface of the portion **56** secured to the base, it is desirable to fabricate the upper portion of materials which can be molded to a set stage. For this purpose, use can be made of wooden chips, such as chips of balsa wood, mixed with a polyester or the like molding resin for bonding during the molding operation. When suitable dies and jigs are economical to provide, the complex curvature can be cut into the block, thereby to enable the entire block to be formed of laminated slabs or other wooden blocks.

The curvature at the top is such as to provide a cavity **58** in the central portion for enabling a bulbous section **60** in a corner expansion joint **62** to be received loosely therein to provide the same effect as the linear expansion strip **40**, to provide for the compound movements occasioned by the relative movement between the plurality of panels making up the intersection. In the illustrated modification, the compound curvature in the upper portion of the block comprises the described cavity in the central portion and shallow valleys **64** or recessed portions of curvilinear shape extending continuously outwardly from the central cavity into endwise alignment with the splines to form a substantial continuation of the linear recesses formed therein. The areas **66** between the aligned recessed portions **64** are adhesively bonded to the adjacent walls **68** of the panel sections to tie in each quadrant of the block with its respective panel to effect a joint therebetween. Thus, movement of the panel in expansion or contraction will be directly transmitted to the attached section of the block which, when assisted by the separation from other sections by the recessed portion, will be able to flex for movement with the panel sections without destroying the integrity of the block.

The corner expansion joint **70** comprises a sheet material which can be molded or otherwise formed to a desired shape. The sheet can be fabricated of various materials characterized by imperviousness to fluids and a flexibility or resiliency under the temperature conditions existing in use. For example, the corner expansion joint can be formed of a metal sheet or of a molded plastic or laminated sheet faced with a metallic film such as of aluminum or stainless steel. It can be formed of a resinous plastic capable of retaining its strength and flexibility at the low temperature conditions existing, or it can preferably be formed of such plastic or resinous material reinforced or further flexibilized by the incorporation of a fabric of glass or other suitable fibers. Instead, the expansion joint can be fabricated of a wooden sheet constructed of thin wooden cross-plies interbonded and suitably coated or impregnated with a resinous material to provide fluid imperviousness.

The corner expansion joint is formed with a bulbous central portion **60** of complex curvature which, in the illustrated modification, comprises a downwardly extending conically shaped portion having its apex **72** at the center with a ribbed side wall portion **74** having recesses **76** inbetween extending outwardly angularly from the apex. One group of angular-shaped recesses **76*a*** is aligned to merge with linear grooves **78** extending to the edge of the sheet **70** for alignment with the grooves formed in the splines **38** and the bulbous portions **42** of the corresponding linear expansion joints **40** for establishing an interfitting relationship therewith, when in the assembled relation. Other recesses **76*b*** extend up the side walls of the bulbous central portion between the recesses **76*a*** to provide a continuous series of peaks and valleys arranged to extend perimetrically outwardly about the bulbous portion to permit compound movements in expansion and contraction as occasioned by the forces by relative movements of the panels interconnected to the expansion joint at the intersection.

The corner expansion joint is formed with flat body portions **80** extending outwardly beyond the bulbous portion of the grooves **76*a*** and **76*b*** to overlap the linear expansion strips **40** and part of the panels forming the intersection, and the overlying portions, including the overlapping interfitting grooves **78** and **42**, are adhesively bonded one to the other to effect a fluid-tight seal therebetween. The central portion of the corner expansion joint is kept free of the adjacent surfaces to permit the desired flexure for expansion and contraction without the development of such forces as would disturb the sealing relation which has been established.

It will be understood that the various compound curvatures of the bulbous portion may take other arrangements and shapes, their purpose being to distribute the forces imposed by the movements of the panels in expansion and contraction whereby the bulbous portion can flex to compensate for such movements without causing breakdown or the separation of parts. Ordinarily, the curvature of the underlying block will tend to correspond somewhat with the curvature of the bulbous portion so as to enable the bulbous portion to be received therein so that no portion of the expansion joint will project beyond the panels, whereby relatively flush surfaces are presented. In effect, the compound curvature in the face of the block will provide some backing and suport for the bulbous portion without interfering with the complex movements in the operation thereof.

It will be understood that changes may be made with respect to the construction and composition of the various elements described and in their method of assembly in the insulation, and that other changes may be made in the details of construction and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. An insulated space of large dimension comprising relatively thick panels of a thermal insulating material mounted on a supporting wall in end to end and in side by side relation as a substantially continuous insulating lining and in which the panels are subject to dimensional change in response to expansions and contractions in use, means for interconnecting the panels at their corner intersections to block openings formed therebetween by expansions and contractions of the panels comprising a recess in the corner portions of each of the corner intersections of each of the panels dimensioned to have a depth less than the thickness of the panels to define therebetween a contiguous opening having a depth less than the thickness of the panels and a bottom formed into adjacent corner portions of the panels, and a unitary resilient insert of an insulating material shaped to be received in fitting relationship within said opening

substantially completely to fill the opening, the side walls of said insert and the adjacent side walls of the panels forming the corner intersections being adhesively joined in face to face relation, said opening at the intersections of the panels being of cylindrical shape having its center at about the corner section between the panels and in which said insert is of cylindrical shape having a diameter corresponding to the diameter of the opening and a height slightly less than the depth of the opening.

2. An insulated space of large dimension comprising relatively thick panels of a thermal insulating material mounted on a supporting wall in end to end and in side by side relation as a substantially continuous insulating lining and in which the panels are subject to dimensional change in response to expansions and contractions in use, means for interconnecting the panels at their corner intersections to block openings formed therebetween by expansion and contractions of the panels comprising a recess in the corner portions of each of the corner intersections of each of the panels dimensioned to have a depth less than the thickness of the panels to define therebetween a contiguous opening having a depth less than the thickness of the panels and a bottom formed into adjacent corner portions of the panels, and a unitary resilient insert of an insulating material shaped to be received in fitting relationship within said opening substantially completely to fill the opening, the side walls of said insert and the adjacent side walls of the panels forming the corner intersections being adhesively joined in face to face relation, said insert comprising a continuous base section and a top section having a concave central portion and recessed portions extending laterally outwardly from the concave portion to the edge of the insert in linear alignment with the meeting linear edges of adjacent panels making up the corner section.

3. An insulated space as claimed in claim 2 in which the portions of the insert between the recessed portions are adhesively bonded to the adjacent walls of the panels in the area of the top section between the recesses of the insert.

4. A member for joining panels at their corner intersections to prevent the formation of an opening therebetween responsive to relative movement between the panels, each of said panels being formed with a recess in the corner portion to confine a contiguous opening therebetween, said member comprising a composite block of resilient material dimensioned to be received within the opening in fitting relation and having a continuous base portion free of any openings and a top portion formed with a concave portion at the center, recesses formed in said top portion radiating outwardly from said concave portion to the lateral edges of the member at angles of about 90° to subdivide the top portion into separated sections capable of flexure with the panels upon joinder.

5. An insulated space of large dimension comprising relatively thick panels mounted on a supporting wall in end to end and in side by side relation as a substantially continuous lining and in which the panels are subject to dimensional change in response to expansions and contractions in use, means for interconnecting the panels at their corner intersections to effect a sealing relationship therebetween while permitting relative movements between the panels responsive to expansions and contractions comprising a recess in the corner portions of each of the panels providing a contiguous opening therebetween, and a corner expansion member formed of a fluid impervious, resilient sheet material dimensioned to be greater than the dimension of the opening to extend in overlapping relation with portions of each of the corner panels beyond said opening and having a bulbous portion which is received within said opening, and means for securing the overlapping portions of the corner expansion member to the underlying sections of the panels.

6. An assembly as claimed in claim 5 in which the

corner expansion member comprises a sheet of fiber reinforced plastics.

7. An assembly as claimed in claim 5 in which the corner expansion member comprises a metal sheet.

8. An assembly as claimed in claim 5 in which the corner expansion member comprises a laminate of a fibrous sheet bonded with resinous material and a metal faced ply.

9. An assembly as claimed in claim 5 in which the corner expansion member is formed with embossments radiating outwardly from the central bulbous portion to the edge of the sheet in linear alignment with the linear edges between adjacent panels.

10. An assembly as claimed in claim 5 in which the bulbous portion is in the form of an inverted conical section having curvilinearly ribbed side walls radiating upwardly and outwardly from the apex.

11. An assembly as claimed in claim 10 in which some of said curvilinearly ribbed side walls of the bulbous portion continue as embossments through the remainder of the sheet in linear alignment with the linear edges between adjacent panels.

12. An insulated space comprising relatively thick panels of thermal insulating material mounted on a supporting wall in end to end and in side by side relation as a substantially continuous lining and in which the panels are subject to dimensional change in response to expansions and contractions in use, means for interconnecting the panels at their corner intersections to block openings formed therebetween by expansions and contractions of the panels and to provide a fluid-tight seal between the panels comprising a recess in the corner portions of each of the corner intersections of the panels to provide a contiguous opening therebetween, an insert of resilient material shaped to be received in fitting relation within said opening and having a depression in the central portion of the top wall thereof, the sides of said insert being adhesively joined to the abutting side walls of the panels forming the corner intersection, a corner expansion member formed of a fluid impervious, resilient sheet material dimensioned to be greater than the dimension of the opening to extend in overlapping relation with portions of each of the corner panels beyond said opening, said corner expansion member having a central bulbous portion which is received within the depression of the insert, and means securing the overlapping portions of the corner expansion member to the underlying sections of each of the panels.

13. An assembly as claimed in claim 12 in which the insert is formed with a top face having recessed portions therein extending laterally from the central depression to the edge of the insert in linear alignment with the linear edges of the adjacent panels making up the corner intersection and in which the corner expansion member is similarly formed with recessed portions extending outwardly from the central bulbous portion in linear alignment with the meeting linear edges of the adjacent panels whereby the latter are received within the recesses of the insert.

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