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3,018,916

TANK CONSTRUCTION

Filed June 23, 1958

2 Sheets-Sheet 1

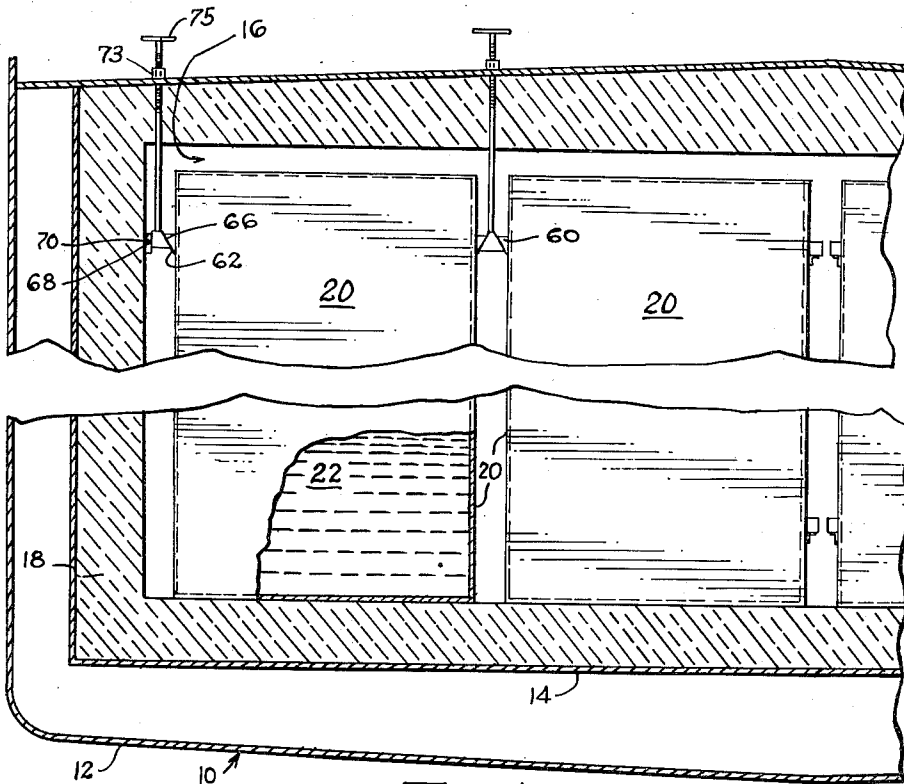


Fig. 1

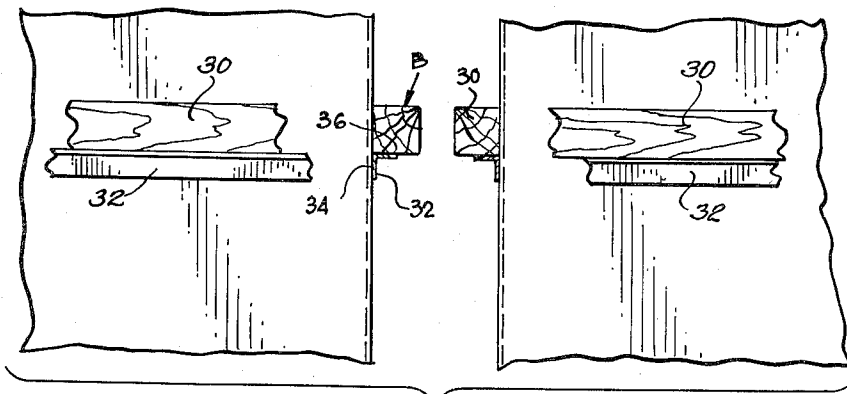


Fig. 2

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2 Sheets-Sheet 2

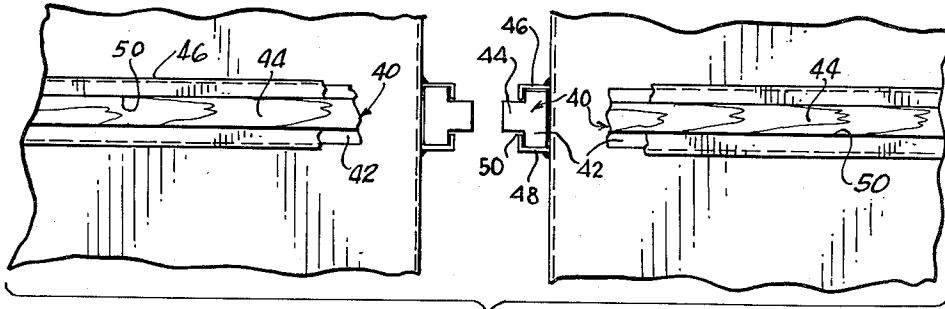


Fig. 3

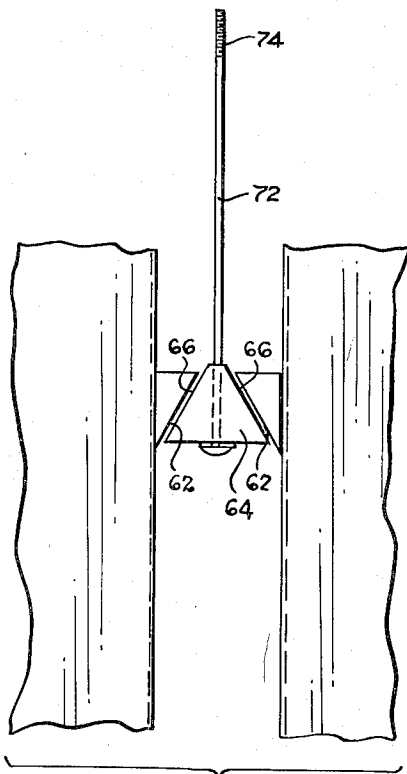


Fig. 4

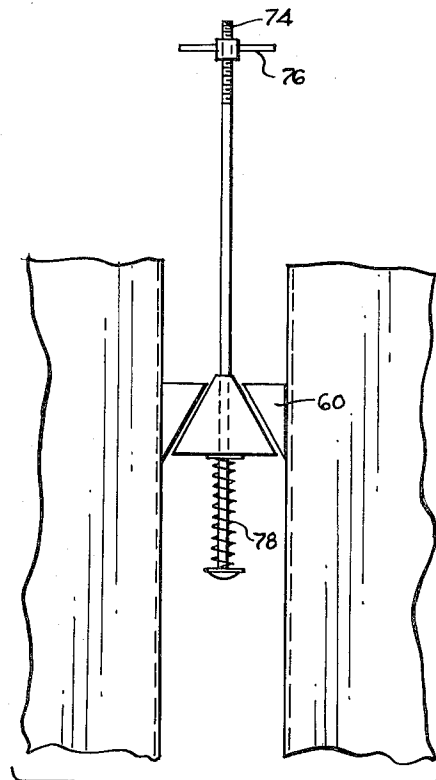


Fig. 5

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3,018,916

TANK CONSTRUCTION

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8 Claims. (Cl. 220-15)

This invention relates to the storage and transportation of a liquid which needs to be maintained at extremely low temperature, and it relates more particularly to a construction wherein use is made of one or more large tanks for the storage and transportation of a cold boiling liquefied gas, such as natural gas.

Since certain gases are available in various localities in excess supply while deficiencies exist in other areas, it is desirable to provide means for transportation of the gas from the source of plentiful supply to the area where a deficiency exists. In the case of natural gas, this distribution has been achieved by pipe line where transmission is effected of the gas while in a gaseous state. Transmission by pipe line is practical between sections connected by land, but pipe-line operation is not so practical between sections which are separated by large bodies of water, and even between relatively isolated sections connected by land. Thus, an industry is in the stage of development for the transportation of natural gas by means other than pipe line.

Because of the large volume of the natural gas, it becomes uneconomical to transport the gas in a gaseous state when housed in a container. However, the natural gas can be reduced to $\frac{1}{600}$ of its volume when transformed into the liquefied state. Thus the system that has developed comprises the liquefaction of the natural gas at the source of plentiful supply for transportation in the liquefied state to the area where a deficiency exists, where it is re-formed into a gas for use.

When transportation of the liquefied gas is effected in large volume, it is impractical to provide for transportation under substantial pressure because of the tremendous strengths that would be required to be built into the receiver. As a result, the liquefied gas will be housed in containers of large capacity maintained at about atmospheric pressure or slightly above. In the case of natural gas, which is composed mostly of methane, this means that the liquefied gas will have to be maintained at a temperature below its boiling point, or at a temperature below -240° F., depending somewhat on the amount of heavier hydrocarbons in the gas (methane boils at -258° F. at atmospheric pressure).

The invention will be described with reference to the storage and transportation of liquefied natural gas in aluminum tanks of many thousands of barrels capacity, one or more of which are housed in the hold of a ship which has been lined with a thick layer of insulation, such as panels of balsa wood, to minimize heat loss and vaporization of the liquefied gas from the storage tanks. The tanks are formed of aluminum, alloys of aluminum, copper, stainless steel, or the like austenitic steels, because steel plate of which such tanks are usually formed tend to lose their ductility at temperatures below -100° F. and thus are unable to stand up under the strain or load. For most efficient utilization of the limited space available in the hold of a ship or other storage and transportation means, it is desirable to make use of tanks of square or rectangular shapes, although tanks of other contours, including round, may be employed.

When these tanks are housed in a moving vehicle, such as a ship, which is subject to varied movements of tossing, rolling, pitching, and the like, it is desirable to provide means to protect the tanks against damage resulting from bumping one another or the walls of the insulated

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storage space. While a degree of stabilization can be achieved upon installation, it will be apparent that considerable contraction in the metal will take place when the metal tanks are cooled down from ambient temperature to a temperature as low as -258° F. or lower upon receipt of the cargo, so that the dimensional characteristics of the tanks will change to present considerable play or movement in use.

Thus it is an object of this invention to provide a means for protecting the tanks to minimize damage in use.

Another object is to provide means for holding the tanks in position one with respect to the other or the confining walls to prevent inadvertent and uncontrolled movement.

A still further object is to provide an adjustable means for taking up the space between the tanks or between the tanks and the adjacent insulated walls to block the tanks in position of use with a force sufficient to resist movement in response to movements of the conveyance means while permitting natural expansions and contractions to take place.

These and other objects and advantages of the present invention will hereinafter appear, and for purposes of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings, in which—

FIGURE 1 is a schematic elevational view in section of a fragmentary portion of a ship's hold in which the storage tanks embodying the features of this invention are mounted;

FIGURE 2 is an enlarged fragmentary elevational view partially in section of a modification in the tank construction shown in FIG. 1;

FIGURE 3 is a fragmentary elevational view, similar to that of FIGURE 2, showing a further modification in the tank construction;

FIGURE 4 is a fragmentary elevational view showing a still further modification; and

FIGURE 5 is a fragmentary elevational view, similar to that of FIGURE 4, showing another modification in the tank spacer means.

Referring now to the drawings for a description of the invention, the numeral 16 indicates a storage space lined with insulation 18 for housing one or more large metal tanks 20 adapted to be filled with a liquid 22 which needs to be maintained at extremely low temperature. The illustrated modification shows the storage space as the hold of a ship 10 which may be formed with an outer steel hull 12 and an inner hull 14 having balsa-wood panels mounted as a lining 18 on the inner surfaces thereof to provide an insulated hold space 16 in which the tanks 20 are housed. In this case, the tanks may be dimensioned to be thirty to eighty feet in either of the horizontal dimensions, and as much as 100 feet in height.

One of the concepts of this invention resides in the construction of the tanks with bumpers B on the outer walls to provide for a spaced relation between the tanks or between the tanks and the adjacent walls, and to minimize impacts which might otherwise lead to deterioration or destruction of the tanks or the insulation lining the storage space. Damage to the tanks or to the insulation would present a serious problem, not only because of the character of the cargo when filled with a liquefied natural gas or other gas but because the cost of the tanks represents a substantial proportion of the cost of the entire ship and replacement or repair of the tanks would require tie-up of the ship over a considerable period of time and necessitate removal of part of the ship's structure for enabling such replacement or repair.

The bumpers B are preferably formed of a relatively soft and resilient material which is capable of retaining

its desirable characteristics under the extremely low temperatures which would prevail on the outer walls of the tanks. Thus, the bumpers are preferably formed of bands or blocks which can girdle the tank or be arranged in suitable spaced-apart relation in supporting brackets secured to the outer walls of the tanks.

In one modification, shown in FIG. 2, use is made of bands 30 of wood which extend continuously about each of the tanks in vertically spaced-apart relation. The wooden bands 30 can be supported on suitable brackets such as metal flanges 32 fixed along one edge 34 to the outer wall of the tank, while the ledge 36 extends outwardly as a flange for a distance less than the thickness of the band 30 but greater than the difference between the amount of contraction which takes place in the tank as compared to the amount of contraction which would take place in the wooden band when reduced in temperature from the ambient temperature of installation to about the temperature of the cargo.

In a preferred modification, shown in FIG. 3, the bumpers are formed of wooden blocks 40 having a base portion 42 and a button portion 44 of smaller dimension than the base extending outwardly from a central portion of the base. The wooden blocks are mounted in a metal housing 46 secured to the outer wall of the tank by conventional metal-joining means and formed with a space 48 therein dimensioned to receive the base portion 42 of the block and having an opening 50 in the outer wall through which the button 44 can extend. The base portion of the block can be of various shapes such as squares, rounds, or the polygonal shapes. Similarly the button 44 can be circular in cross section or of an elongate shape to engage a length of the adjacent tank or to cooperate with bumpers on adjacent tanks to prevent metal contact, as illustrated in FIG. 3.

While the bands or buttons may be formed entirely of wood, laminated wood, or metal or plastics, the outer ends of the bands or buttons should be formed of a softer or more resilient material such as of a soft or highly porous wood (balsa wood), or of a soft resilient plastic or elastomeric material such as polyethylene, polybutylene, polysiloxane, rubber, synthetic rubber, and foamed modifications thereof.

A further important concept of this invention resides in the construction whereby the tanks are substantially interconnected in a manner to militate against relative movements other than tension resulting from the forces of nature in expansion or contraction.

For this purpose, the walls of the tanks are provided with members 60 extending outwardly from the lateral surfaces thereof with the outer edges 62 of the members being inclined inwardly and downwardly to provide a cam edge adapted to be engaged by a wedge member 64 mounted for vertical shifting movement relative to the members, and in which the shiftable members are also preferably formed with one or more cam edges 66 inclined in a direction substantially parallel to that of the cam edge 62 of the extension.

When the extensions or members 60 are provided on the adjacent walls of adjacent tanks, or on the outer wall of a tank and the adjacent wall of the insulation, one or both of the extensions may be formed with the described cam edge, as illustrated in FIG. 4, for operative engagement with the vertically shiftable inverted V-shaped wedge member 64. In the alternative, one of the extensions may be formed with a straight edge, while the other is formed with a cam edge, as illustrated to the left in FIG. 1, for cooperation with a wedge member shiftable vertically therebetween having a cam edge 66 in operative engagement with the cam edge 62 of the extension and a straight edge 68 in sliding engagement with the straight edge 70 of the other extension, as illustrated in FIG. 1.

It will be apparent that as the operating wedge member 64 is displaced upwardly between the extensions, the

spaced relation between the extensions will be increased so that the contraction of the tanks can be compensated to provide a tensioned relationship between the tanks. Such tensioned relation can be controlled to provide resistance to relative movements between the tanks as would otherwise normally be effected by the normal gyrations of the ship, but insufficient to resist relative movement due to expansion or contraction.

If, after a tensioned relationship has been established upon insulation of the tanks, the tanks are further cooled down by the introduction of the cold cargo, contraction will take place to increase the spaced relationship between the tanks. It is thus desirable to provide means for enabling adjustment of the position of the wedge 64 by displacement in the upward direction to take up the greater spacing which currently exists. In the alternative, if the tanks heat up and expand to decrease the spaced relationship, it is desirable to be able to lower the wedge members so as not to allow the forces of nature to build up a strained relationship which might otherwise cause deformations to take place.

For this purpose, the wedge is provided with an elongate rod 72 extending upwardly from the top edge of the wedge to a position beyond the top of the tank. The end portion of the rod may be threaded as at 74 for threaded engagement with a fixed nut member 73 whereby, in response to the turning movement of the wheel 75, endwise displacement of the rod can be effected. In the alternative, the rod may be provided with a positionally fixed turnbuckle 76 by which endwise displacement of the rod 72 can be effected responsively to turning movement of the turnbuckle in one direction for raising, and in the opposite direction for lowering the rod and its connected wedge. Thus the wedge can be shifted positively vertically in response to manual control to achieve the desired tensioned relationship between the tank and the adjacent walls.

The human element can be, in great part, eliminated by interposing a tension spring 78 between the end of the wedge and the end of the shaft, as illustrated in FIG. 5. Thus the turnbuckle can be turned to provide a tensioned relationship through the spring which will urge the wedge into camming engagement with the extensions with sufficient force to prevent relative movements between the tanks responsive to the normal forces existing in use, but which will automatically take up the space or allow lesser space between the tanks in response to the forces of contraction and expansion respectively in the tanks.

It will be apparent that if such wedge constructions are provided in each of the walls of a tank of polygonal shape, or arranged in circumferentially spaced-apart relationship of less than 120° in circular tanks, the tanks will be supported relative to each other in all horizontal directions to provide a stabilized condition in transportation. Further, in the described arrangement, the relative vertical positions between the wedges and the extensions can be maintained while permitting the tanks to expand or contract in the vertical direction responsive to change in temperature. Thus, a flexibility is provided which enables the normal expansions and contractions to take place, while permitting maintenance of full control with respect to the movements of the tanks to prevent uncontrolled movements responsive to the normal gyrations or movements of the transportation means.

The extensions 60 may constitute metal members fastened or otherwise secured by metal-fastening means to the walls of the tanks, or they may represent wooden elements secured in the desired position to the walls of the tanks by suitable brackets. When the latter means are provided for maintaining control in the spaced relationship between the tanks, it will not be necessary to make use of the bumpers previously described, but both of the concepts may be employed in combination.

It will be understood that the bumper members de-

scribed may be arranged in laterally spaced-apart as well as vertically spaced-apart relation throughout the side-wall portions of the tanks to provide the necessary protection, but the wedge systems for maintaining camming engagement between the tanks will usually be provided near the upper end portions of the tanks for maintaining the spaced relationship, although additional units may be provided in other vertically spaced-apart portions for maintaining control of lateral movements of the tanks.

It will be understood that changes may be made in the details of construction, arrangements, operation, and materials of which the various elements are formed, without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In the storage and transportation of material in a tank which is subject to wide temperature changes in use, means for supporting the tank in spaced relation from an adjacent surface to minimize relative movements notwithstanding changes in dimension of the tank in response to temperature change comprising an abutment secured to a side wall of the tank, another abutment fixed to the adjacent surface spaced a short distance from and at the same level as the abutment on the tank, at least one of said abutments having an upwardly and outwardly inclined cam edge, an operating member shiftable vertically between said abutments and in operative engagement with the edges of the two abutments which face each other to take up the spaced relation between said edges, and means for adjusting the vertical position of said operating member.

2. An assembly as claimed in claim 1 in which both of the abutments are formed with cam edges which incline upwardly in the opposite directions in converging relation.

3. An assembly as claimed in claim 1 in which the vertically shiftable operating member is of wedge shape having upwardly and inwardly inclined edges in position operatively to engage the edges of the abutments.

4. An assembly as claimed in claim 1 in which a plurality of tanks are present and the tank abutments are provided on adjacent surfaces of adjacent tanks.

5. An assembly as claimed in claim 4 in which a plurality of abutments are provided on the walls of each of the tanks spaced less than 120 degrees apart.

6. An assembly as claimed in claim 1 which includes a supporting rod operatively connected at one end to the shiftable member and means for actuating the rod in a vertical movement to effect corresponding movement of the member between the abutments.

7. An assembly as claimed in claim 6 which includes spring means constantly urging the shiftable member upwardly relative to the supporting rod resiliently to urge the shiftable member into camming engagement with the abutment.

8. An assembly as claimed in claim 7 in which a part of the rod extends through and beyond the member and which includes a head in the end portion of the rod extending beyond the member and in which the spring means is interposed between the head end of the rod and the member whereby the spring force urging the member into camming engagement with the abutments can be adjusted by vertical movement of the rod.

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