STAVE SECURED SECTIONAL INSULATED CONDUIT

Figs. 1, 2, 3, 4

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This invention relates to means for transmission of a liquid having a temperature differing widely from the ambient temperature. It relates more particularly to a conduit through which extremely cold liquid can be moved over a substantial distance without loss of liquid by leakage and without breakdown of the transmission means by reason of wide variations in temperature to which the conduit will be exposed.

The concepts of this invention will be set forth with reference to the movement of a cold boiling liquefied gas, as in the transportation of the gas from a storage means to a transportation means or in the transportation of the liquefied gas from the transportation means to another storage means.

As is well known, liquefied natural gas is available in excess amounts in certain regions while deficiencies exist in others. To eliminate such deficiencies it becomes desirable to make the natural gas available from the source of excess supply to the area where the deficiency exists. Where such areas are connected by land, transmission can be effected with the materials in a gaseous state by the use of interconnected transmission lines. Where, however, the areas are separated by a large body of water or by a long distance, it has been found to be more economical to liquefy the natural gas whereby its volume is reduced in the ratio of 600 to 1 for transportation of the natural gas in a liquefied state to the area where the deficiency exists, where it can be re-formed to the gaseous state for use.

In practice, it is contemplated that the natural gas will be liquefied and placed in storage adjacent the liquefaction facilities to build up a supply sufficient for filling the tanks of the transportation means. Sometimes the station of supply or the station of use may be some distance from the transportation means, such that it will become necessary periodically to effect movement of the large volume of liquefied gas for a predetermined distance over land from the land storage means to the transportation means.

The difficulties in the movement of large volumes of liquefied gas over land stem, in part, from the extremely low boiling point temperature of the liquid, especially when it has to be maintained at a temperature below about —250°F. When, as preferred, the material is transported at an ambient atmospheric pressure. Many additional problems arise when the liquefied gas is periodically discharged from the storage tanks to load the ship's tanks or vice versa. Under such circumstances, the means in which the liquid is transported will be contacted only for a short period of time with intermittent exposures for longer periods of time to ambient temperature. As a result, the components of the transmission means will be subjected to repeated cycles of temperature changes in the order of about 350°F.

Most metals are incapable of use under such low temperature conditions by reason of their loss in ductility, while others embody limitations with respect to stabilities as affected by the repeated fluctuations in temperature.

In general, all materials capable of use as a structural element are characterized by expansions and contractions to some degree in response to temperature change. Thus, problems arise as to the construction of materials, their method of assembly and use in moving large quantities of a liquefied gas or other extremely cold liquid in a continuous or in an intermittent stream, and it is a problem to effect such suitable construction of low cost and readily available materials which may be assembled in a simple and efficient manner in fabricating the final structure.

It is an object of this invention to produce and to provide elements for producing a means for moving large quantities of a liquid which needs to be maintained at a temperature differing widely from the ambient temperature, and it is a related object to produce a means of the type described for the transmission of a liquefied gas over land either in a continuous or preferably in an intermittent stream.

More specifically, it is an object of this invention to produce and to provide elements for producing a flume-type of transmission line which embodies structural strength and stability for movement of a cold liquid at a high rate of flow over a substantial distance.

It is another object to produce a conduit constructed of a combination of elements capable of use under extreme cold to which the elements might be continuously or periodically exposed; which is subject to little, if any, leakage of the liquid in use; which is capable of being constructed of prefabricated elements; which is constructed of readily available and inexpensive materials; which requires little maintenance by way of upkeep and repair, and which embodies durability for operation under heavy loads or under slight internal pressures for the transmission of liquid therein.

These and other objects and advantages of this invention will hereinafter and for purpose of illustration, but not of limitation, embodiments of the invention are shown in the accompanying drawings, in which:

FIGURE 1 is a perspective view of a fragmentary portion of the flume embodying the features of this invention;

FIGURE 2 is a sectional elevational view of a stave employed in the construction of the flume;

FIGURE 3 is a perspective view similar to that of FIGURE 1 of a modification in a flume embodying the features of this invention; and

FIGURE 4 is a sectional view through one of the staves employed in the flume of FIGURE 3.

In accordance with the practice of this invention, use is made of elongate segments 10 of an insulation material. The segments are interbonded one with another in side-by-side and in end-to-end abutting relation to produce an endless flume 12 or conduit through which the cold liquid can be moved in large volume, either in continuous or intermittent flow.

In the preferred modification shown in FIGURE 1, the conduit is in the form of a cylinder constructed of elongate segments or staves 10 of curvilinear shape. Such staves can be of semi-cylindrical section, requiring only two to be brought into interfitting edge-to-edge relation in construction of the cylindrical conduit, but it is preferred to subdivide the cylindrical section into a larger number of arcuate segments, preferably of equal angles, to enable design of but a single segment for mass production and assembly.

Each stave is formed of a relatively thick core 14 of a structurally strong, relatively rigid, dimensionally stable insulating material faced on its inner and outer surfaces with continuous panels 16 and 18 respectively formed of a harder, denser, and more wear-resistant material adhesively bonded to the core to provide a modular stave.

As the insulating core 14, use can be made of interbonded slabs of a highly porous, low density wood such as balsa wood, preferably in end grain arrangement in the stave. Instead, use can be made of a honeycomb structure formed of resilient treating paper, corrugated veneers, or the like.
As the facing sheets 16 and 18, it is desirable to make use of plywood panels formed of hardwood alternately cross-plied for maximum strength. The facing sheets can be further covered with a resinous layer or, with or without glass or fiber reinforcement, to provide for greater strength and flexibility and to improve the liquid imperviousness of the staves.

For use as a conduit, it is preferred to make use of a core dimensioned to about 2–6 inches in thickness and facilitate lots of about 1/8 to 1/5 inch in thickness. A core of greater thickness can be employed where better thermal insulation is desirable, but it is uneconomical to make use of a core having a thickness much greater than about 15 inches.

The perimetric edges, including the end walls 20 and the side walls 22, are formed with continuous slots 24 uniformly positioned therein for alignment between the slots in the edge of one stave with the corresponding slots of the staves arranged in side-by-side or in end-to-end relation therewith to form continuous slotted sections therebetween adapted to receive a spline 26 which enhances the interbonded relationship when the staves are adhesively joined together. The spline functions further by way of a load transmission device to equalize the stresses lengthwise and circumferentially in the conduit.

Use may be made of a metal spline but it is preferred to make use of splines formed of laminated wooden strips which are capable of being used in a stronger bonded relationship with the wooden staves and which is characterized by similar expansion and contraction characteristics. The slotted section can be formed in the insulation layer but it is preferred to anchor the spline in a section which is capable of absorbing greater thrusts and load. As a result, it is preferred to make use of splines having the perimetric edges formed of hardwood strips 28 dimensioned to have a thickness greater than the depth of the slot that is formed therein. It is sufficient to make use of a single slot and spline between the staves but two or more such slots can be arranged in parallel relationship where the elements are of sufficient thickness.

The arcuate segments 30 are thus adhesively joined in end-to-end and in side-by-side relation in forming the substantially continuous conduit. The staves are dimensioned to have a length which permits ease in handling and construction, such as a length up to 100 feet, and preferably lengths within the range of 25–50 feet. It is preferred to stagger the staves in end-to-end arrangement to avoid the alignment of the butt joints 30 and the corresponding development of lines of weakness. The staves can be staggered by a distance corresponding to the length of the staves divided by the number of staves in cross-section for maximum spacing.

The assembled staves can be encircled by metal bands arranged in longitudinally spaced-apart relation to clamp the sections in place and to reinforce and strengthen the assembly. Instead of, or in addition to, the metal bands, the cylindrical conduit can be wrapped with fiber glass preferably in the form of a unidirectional tape 32 impregnated or coated with a curable liquid resinous material, such as an unsaturated polyester resin, a polyisocyanate and the like. The strength of the restraining band 32 is maximized by the use of a tape of unidirectional glass fibers running circumferentially about the cylindrical member, but woven tapes can also be used.

After assembly, the interior surface of the conduit can be coated with a fluid-impervious resinous material to provide a film on the face to minimize penetration of the liquid. Instead, a lining of metal or plastics can be introduced over the surface for contact with the liquid. The lining (not shown) may be incorporated as an inner or outer ply of the inner facing plywood panel and attached thereto in bonded or interbonded relation.

In FIGURES 3 and 4, illustration is made of a flume 40 of rectangular shape formed of interlacing side, bottom and top wall panels 42, 44, 46 and 48, respectively, formed of insulating material having a construction in cross section similar to that of the arcuate staves used in the fabrication of the cylindrical conduit.

The modification of FIGURES 3 and 4 illustrates an alternate method for joining the adjacent edge portions of the staves in sections in sealing and in interbonded relation. In this modification, a continuous slot 50 is provided in the engaged surface portion of one of the staves in closely spaced relationship with the edge for receiving a correspondingly arranged key 52 in the other, whereby the two are interlocked by a mechanical interlock to assist the bond which is effected by the use of adhesives. In the illustrated modification, the slots are provided in the top and bottom wall panels 42 and 48, while the keys 52 are arranged to extend outwardly from the opposite edges of the side wall members 44 and 46.

Where one of the pairs of walls is received between the others, such as the disposition of the side wall members 44 and 46 between the top and bottom wall members 42 and 48, the assembled relationship can be further enhanced by the use of tie rods 54 extending crosswise through longitudinally spaced-apart, aligned openings in the edge sections of the top and bottom wall panels 42 and 48 and through the intermediate portions of the side wall panels 44 and 46. The tie rods are stressed by the use of anchoring members 56 threaded onto the ends of the tie rods to effect a tensioned relationship for post-stressing or a connected staves.

In a representative arrangement of the elements, the flat staves 42, 44, 46 and 48 can be formed with a 1/8 inch outer ply 58 of hardwood, such as oak. The inner face ply 60 can be formed of three or more plies of maple which are cross-piled and built up to a thickness of about 1/8 of an inch, and the edge strips 62 can be formed of Douglas fir or the like hard and structurally strong woods.

The inner plywood facing sheet 60 can be formed with a metal sheet or plastic film bonded to its inner face or incorporated as an inner ply to increase fluid imperviousness. The end edges 64 of the staves can be mitre-jointed as described, or formed with aligned slots for receiving a spline extending crosswise therebetween for transmission of load and to enhance the interbonding relationship.

It will be apparent from the foregoing that I have provided structural elements capable of being manufactured on a mass production basis which are low in cost and readily available elements to produce elongate staves which can be assembled in a simple and efficient manner to form moving means in the form of a flume or conduit through which liquid can be made to flow in high volume, and which is capable of operation for continuous flow or intermittent flow without excessive losses of the liquid by leakage or vaporization. The elements of which the flume or conduit is formed can vary considerably in dimension, including the crosswise dimension and thickness as well as the lengthwise dimension but, where convenient, it is desirable to make use of elements formed to lengths of between 25–50 feet and to lengths up to 100 feet if methods of handling are available.

The conduit or flume is preferably supported above ground to enable the circulation of air about the outer surfaces for stability. It will be understood that changes may be made in the details of construction, arrangement and operation without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. A conduit for the transmission of large volume of a liquefied natural gas at about atmospheric pressure consisting of elongate staves arranged in end-to-end and side-by-side relation to form an annular housing, the meeting end edge of the staves being staggered so that no more than one abutting edge between staves occurs in any one cross-section and restraining bands surrounding
and wrapping tightly, said staves comprising an inner facing layer of \( \frac{1}{4} \) to \( \frac{1}{2} \) inch in thickness of a fluid and vapor impervious dense hardwood, an outer facing layer of \( \frac{1}{4} \) to \( \frac{1}{2} \) inch in thickness spaced from the inner facing layer to provide a confined space therebetween of about 2 to 6 inches in thickness and thermal insulating material consisting of balsa within the space between the facing layers, hardwood strips composing the perimetric edge sections of said staves which are slotted in a position to align the slots of adjacent staves in the assembled relation and in which the slotted portions extend inwardly for a distance less than the thickness of the hardwood strips and a hardwood spline extends crosswise between the staves and into the aligned slots.

2. A conduit for the transmission of large volume of a liquefied natural gas at about atmospheric pressure consisting of elongate staves arranged in end-to-end and side-by-side relation to form an endless housing, the meeting end edge of the staves being staggered so that no more than one abutting edge between staves occurs in any one cross-section and restraining bands surrounding and wrapping tightly, said staves comprising an inner facing layer of \( \frac{1}{4} \) to \( \frac{1}{2} \) inch in thickness of a fluid and vapor impervious dense hardwood, an outer facing layer of \( \frac{1}{4} \) to \( \frac{1}{2} \) inch in thickness spaced from the inner facing layer to provide a confined space therebetween of about 2 to 6 inches in thickness and thermal insulating material within the space between the facing layers, hardwood strips composing the perimetric edge sections of said staves which are slotted in a position to align the slots of adjacent staves in the assembled relation and in which the slotted portions extend inwardly for a distance less than the thickness of the hardwood strips and a hardwood spline extends crosswise between the staves and into the aligned slots.

3. A conduit for the transmission of a liquid which needs to be maintained at a temperature differing widely from ambient temperature, said conduit consisting of elongated staves arranged in end-to-end and in side-by-side relation to form an endless housing, said staves comprising flat panels whereby the housing is rectangular in shape, restraining bands to hold the staves in their assembled positions, said staves comprising an inner facing layer of a fluid and vapor impervious material having structural strength, an outer facing layer of material having structural strength spaced from the inner facing layer to provide a confined space therebetween and thermo-insulating material within the space between the facing layers, strips of material having structural strength composing the perimetric edges of said staves and the adjacent edges of adjacent staves being formed with a groove in one edge and a key in the other to be received in the groove in fitting relationship to key the staves one into the other, and a plurality of tie rods, each of said tie rods extending crosswise through vertically aligned openings in the edges of the top and bottom panels formed by said staves and through the central portion of a vertical panel situated between said top and bottom panels, and each of said tie rods being stressed by means threaded onto at least one end of a tie rod.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>351,969</td>
<td>Eastlick</td>
<td>Nov. 2, 1886</td>
</tr>
<tr>
<td>359,590</td>
<td>Allen</td>
<td>Mar. 22, 1887</td>
</tr>
<tr>
<td>485,809</td>
<td>Curtis et al.</td>
<td>Nov. 8, 1892</td>
</tr>
<tr>
<td>612,897</td>
<td>Ellis</td>
<td>Oct. 25, 1898</td>
</tr>
<tr>
<td>749,693</td>
<td>Kremmer</td>
<td>Jan. 12, 1904</td>
</tr>
<tr>
<td>788,189</td>
<td>Conrow</td>
<td>Apr. 25, 1905</td>
</tr>
<tr>
<td>868,819</td>
<td>Snoddy</td>
<td>Oct. 22, 1907</td>
</tr>
<tr>
<td>2,798,510</td>
<td>Martin et al.</td>
<td>July 9, 1957</td>
</tr>
<tr>
<td>2,806,810</td>
<td>Beckwith</td>
<td>Sept. 17, 1957</td>
</tr>
<tr>
<td>2,831,794</td>
<td>Emlendorf</td>
<td>Apr. 22, 1958</td>
</tr>
<tr>
<td>2,861,598</td>
<td>Corder et al.</td>
<td>Nov. 25, 1958</td>
</tr>
</tbody>
</table>

FOREIGN PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Country</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>60,771</td>
<td>Norway</td>
<td>Apr. 24, 1939</td>
</tr>
<tr>
<td>115,294</td>
<td>Great Britain</td>
<td>May 9, 1918</td>
</tr>
</tbody>
</table>