

DESCRIPTION

HEAT INSULATION STRUCTURE FOR CYLINDRICAL TUBE

5 **Technical Field**

[0001]

10 The present invention relates to a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided a plurality of layers of heat insulating walls in a cylindrical form and with different diameters formed of arcuate heat insulating members divided in a circumferential direction and an axial direction of the cylindrical tube.

15 **Background Art**

[0002]

20 Such heat insulation structure for a cylindrical tube is provided for heat insulation of the cylindrical tube by covering an outer circumference portion of the cylindrical tube in which cold fluid such as LNG, LPG, etc. flows, with a plurality of layers of heat insulating walls in a cylindrical form and with different diameters formed of arcuate heat insulating members.

[0003]

25 According to one exemplary conventional heat insulation structure for a cylindrical tube, a plurality of heat insulating members juxtaposed in a circumferential direction of the cylindrical tube for forming a plurality of respective layers of heat insulating walls are provided in such a manner that an adjacent pair of heat insulating member end portions thereof are coupled to each other via an elongate member formed elongate along the axial direction of the cylindrical tube and engageable with the pair of heat insulating member end portions at each one of plurality of opposed positions located in the circumferential direction of the cylindrical tube where the end faces are placed in abutment against each other (see e.g. Patent Document 1).

35 [0004]

Incidentally, though description thereof being omitted in Patent

Document 1, normally, a band-like leak proof body having adhesiveness is affixed to be mounted astride a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube in the heat insulating wall positioned on the outermost side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls. Further, at each one of a plurality of opposed positions where circumferential end faces of the heat insulating wall positioned on the outermost side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls are placed in abutment against each other, a band-like leak proof body having adhesiveness is affixed astride the pair of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube, so that formation of a gap between the heat insulating members adjacent each other in the outermost heat insulating wall is suppressed.

Prior Art Document **[0005]**

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2016-194368.

Disclosure of the Invention

Problem to be Solved by Invention

[0006]

With the conventional cylindrical tube heat insulation structure, between the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed of the inner side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls, a large gap can be formed. So, there was inconvenience that improvement of the heat insulation performance is not possible.

[0007]

More particularly, the heat insulating member is shrunk when being cooled by the cold fluid flowing in the cylindrical tube. Therefore, even if a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube are arranged without any gap therebetween, when these heat insulating members are cooled and

shrunk, a large gap can be formed between the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube.

[0008]

5 Incidentally, the plurality of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube are coupled via a pair of heat insulating member end portions thereof via the elongate member at each one of the opposed positions located in the circumferential direction of the cylindrical tube where the end faces are
10 placed in abutment against each other, thus suppressing formation of such large gap between the pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube.

[0009]

15 The present invention has been made in view of the above-described state of the art and its object is to provide a cylindrical tube heat insulation structure that can suppress formation of a large gap between a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube.

20 **Solution**

[0010]

 According to the present invention, there is provided a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid
25 flows, there are provided a plurality of layers of heat insulating walls juxtaposed in an axial direction of the cylindrical tube, the plurality layers of heat insulating walls being provided in a cylindrical form and with different diameters formed of arcuate heat insulating members divided in a circumferential direction and an axial direction of the
30 cylindrical tube, according to an inventive characterizing feature of the structure:

 for a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of at least the heat insulating wall disposed on the inner side in the radial direction of the cylindrical
35 tube of the plurality of layers of heat insulating walls, a coupling body having a pair of retaining portions is configured to insert the pair of

retaining portions to the respective outer face of the pair of heat insulating members to the radially inner side of the cylindrical tube.

[0011]

Namely, for at least a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of at least the heat insulating wall disposed on the inner side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls, a coupling body having a pair of retaining portions is configured to insert the pair of retaining portions to the respective outer face of the pair of heat insulating members to the radially inner side of the cylindrical tube.

[0012]

Therefore, when the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube are cooled and shrunk, mutual departing displacements thereof in the axial direction of the cylindrical tube can be effectively suppressed by the retaining action of the coupling body. Thus, formation of a large gap between a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube can be suppressed.

[0013]

In short, with the cylindrical tube heat insulation structure according to the present invention, formation of a large gap between a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube can be suppressed.

[0014]

According to a further characterizing feature of the cylindrical tube heat insulation structure of the present invention:

the coupling body has a U-shape having the retaining portions at opposed ends of a shaft-like body; and

a plurality of the coupling bodies are attached to a plurality of portions in the circumferential direction of the cylindrical tube.

[0015]

Namely, the coupling body is provided as a U-shaped body having the retaining portions at the opposed ends and a plurality such configured coupling bodies are attached at a plurality of portions in the circumferential direction of the cylindrical tube. With this, when the

pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube are cooled and shrunk, mutual departing displacements thereof in the axial direction of the cylindrical tube can be effectively suppressed by the retaining action of the coupling body.

5 [0016]

And, it is inexpensively possible to configure the coupling body in the U-shape having the retaining portions by e.g. a molding work of synthetic resin. Thus, cost reduction of the coupling body is made possible.

10 [0017]

In short, with the further characterizing feature of the cylindrical tube heat insulation structure according to the present invention, cost reduction of the coupling body is made possible.

[0018]

15 According to a still further characterizing feature of the cylindrical tube heat insulation structure of the present invention:

the coupling body includes a band-like member bendably deformable, with the retaining portions being provided in juxtaposition along a longitudinal direction of the band-like member at width-wise opposed ends of the band-like member; and

20 the coupling body is attached as being wound about outer face portions of the pair of heat insulating members.

[0019]

25 Namely, the coupling body includes a band-like member bendably deformable, with the retaining portions being provided in juxtaposition along a longitudinal direction of the band-like member at width-wise opposed ends of the band-like member and this coupling body is attached as being wound about outer face portions of the pair of heat insulating members. With this, when the pair of heat insulating members

30 adjacently juxtaposed in the axial direction of the cylindrical tube are cooled and shrunk, mutual departing displacements thereof in the axial direction of the cylindrical tube can be effectively suppressed by the retaining action of the coupling body.

[0020]

35 And, with a simple operation of attaching and winding the coupling body about the outer face portions of the pair of heat insulating

members, the coupling body can be attached to the heat insulating members in such a manner that the plurality of retaining portions are juxtaposed in the circumferential direction of the cylindrical tube. Thus, the attaching operation of the coupling body can be made simple.

5 [0021]

In short, with the still further characterizing feature of the cylindrical tube heat insulation structure according to the present invention, the attaching operation of the coupling body can be made simple.

10 [0022]

According to a still further characterizing feature of the cylindrical tube heat insulation structure of the present invention:

15 a band-like axial-side leak proof body having adhesiveness is affixed to be mounted astride a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on the outermost side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls.

[0023]

20 Namely, a band-like axial-side leak proof body having adhesiveness is affixed to be mounted astride for a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on the outermost side in the radial direction of the cylindrical tube.

25 [0024]

Therefore, when the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on the outermost side in the radial direction of the cylindrical tube are cooled and shrunk, mutual departing displacements thereof in the axial direction of the cylindrical tube can be effectively suppressed by the retaining action of the coupling body. Thus, formation of a large gap between a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on the outermost side in the radial direction of the cylindrical tube can be suppressed.

35 [0025]

In short, with the cylindrical tube heat insulation structure according to the present invention, formation of a large gap between a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on the outermost side in the radial direction of the cylindrical tube can be suppressed.

[0026]

According to a still further characterizing feature of the cylindrical tube heat insulation structure of the present invention:

the plurality of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube to form the plurality of the respective heat insulating walls, at each of a plurality of opposed portions located in the circumferential direction of the cylindrical tube where end faces thereof are placed in abutment against each other, are coupled with a pair of adjacent heat insulating member end portions thereof being coupled to each other via an elongate member that is formed elongate along the axial direction of the cylindrical tube and engageable with the pair of heat insulating member end portions; and

at each of the plurality of opposed portions of the heat insulating wall disposed on the outermost side of the plurality of heat insulating walls in the radial direction of the cylindrical tube, a band-like circumferential-side leak proof body having adhesiveness is affixed to be mounted astride a pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube.

[0027]

Namely, since the plurality of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube to form the plurality of the respective heat insulating walls, at each of a plurality of opposed portions located in the circumferential direction of the cylindrical tube where end faces thereof are placed in abutment against each other, are coupled with a pair of adjacent heat insulating member end portions thereof being coupled to each other via an elongate member that is formed elongate along the axial direction of the cylindrical tube and engageable with the pair of heat insulating member end portions, formation of a large gap between the plurality of heat insulating

members juxtaposed in the circumferential direction of the cylindrical tube can be suppressed.

[0028]

Moreover, the plurality of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube of the heat insulating wall on the outermost side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls, at each one of the plurality of opposed portions located in the circumferential direction of the cylindrical tube where end faces thereof are placed in abutment against each other, can be retained with mutually departing displacement thereof along the circumferential direction of the cylindrical tube being effectively prevented by the band-like circumferential-side leak proof body which is affixed to be mounted astride the pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube.

[0029]

Therefore, when the pair of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube of the outermost heat insulating wall are cooled and shrunk, mutually departing displacement thereof along the circumferential direction of the cylindrical tube can be effectively suppressed by the retaining action of the band-like circumferential-side leak proof body. Thus, formation of a large gap between the pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube of the outermost heat insulating wall can be suppressed appropriately.

[0030]

In short, with the still further characterizing feature of the cylindrical tube heat insulation structure of the present invention, formation of a large gap between the pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube of the outermost heat insulating wall can be suppressed appropriately.

[0031]

According to a still further characterizing feature of the cylindrical tube heat insulation structure of the present invention:
in opposed side faces of the heat insulating members adjacently

juxtaposed in the axial direction of the cylindrical tube, there are formed engagement portions engageable in the axial direction of the cylindrical tube.

[0032]

5 Namely, since engagement portions engageable in the axial direction of the cylindrical tube are formed in opposed side faces of the heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube in each one of the plurality of heat insulating walls, formation of a gap between the pair of heat insulating members
10 adjacently juxtaposed in the axial direction of the cylindrical tube can be suppressed even more effectively.

[0033]

 Namely, when the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube are cooled and
15 shrunk to tend to move apart from each other along the axial direction of the cylindrical tube, there will only occur reduction in the engagement amount in the axial direction of the cylindrical tube of the engagement portions engageable in the axial direction of the cylindrical tube, and formation of a gap between the pair of heat insulating members
20 adjacently juxtaposed in the axial direction of the cylindrical tube can be suppressed.

[0034]

 In short, with the still further characterizing feature of the cylindrical tube heat insulation structure of the present invention,
25 formation of a gap between the pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube can be suppressed even more effectively.

BRIEF DESCRIPTION OF THE DRAWINGS

30 [0035]

 Fig. 1 is a side view in vertical section showing attached states of heat insulating members,

 Fig. 2 is a cutaway perspective view showing attached states of the heat insulating members,

35 Fig.3 is a section view taken along III-III line in Fig. 1,

 Fig.4 is a section view taken along IV-IV line in Fig. 1,

Fig. 5 is an exploded perspective view showing relation between a coupling member and a heat insulating member,

Fig. 6 is a front view showing relation between a connecting member and the heat insulating members,

5 Fig. 7 is a perspective view of the connecting member,

Fig. 8 is a perspective view showing a mode of attachment of a coupling body,

Fig. 9 is an enlarged perspective view of the coupling body,

10 Fig. 10 is a perspective view showing an attachment mode of a coupling body in a second embodiment,

Fig. 11 is a perspective view showing the coupling body of the second embodiment,

Fig. 12 is a side view showing a heat insulating member in a third embodiment,

15 Fig. 13 is a front view showing an attachment mode of a heat insulating member in the third embodiment,

Fig. 14 is a perspective view showing a mode of engagement of the heat insulating member in the third embodiment,

20 Fig. 15 is a perspective view showing a mode of engagement of a heat insulating member in a fourth embodiment, and

Fig. 16 is a perspective view showing a mode of engagement of a heat insulating member in a fifth embodiment.

MODES OF EMBODYING THE INVENTION

25 **[0036]**

[First Embodiment]

Next, a first embodiment of the present invention will be explained with reference to the accompanying drawings.

(General Configuration of Heat Insulation Structure)

30 As shown in Fig. 1 and Fig. 2, there is provided a cylindrical tube 1 in which cold fluid such as LNG, LPG, etc. is caused to flow. On the outer circumferential portion of this cylindrical tube 1, a plurality of heat insulating members P formed of urethane foam made by foaming urethane resin are attached in juxtaposition along the circumferential
35 direction and the axial direction of the cylindrical tube 1.

[0037]

Each one of the plurality of heat insulating members P extends in an arcuate form (semi-circular form in this embodiment) along the circumferential direction of the cylindrical tube 1, with a predetermined thickness along the radial direction of the cylindrical tube 1 and is made by cutting a base material elongate in the axial direction of the cylindrical tube 1 to a predetermined length in the axial direction of the cylindrical tube 1.

Namely, the heat insulating members P are provided as arc-shaped (semi-circular in this embodiment) members separated or split in the circumferential direction of the cylindrical tube 1 and in the axial direction of the cylindrical tube 1.

Incidentally, as shown in Fig. 5, in the following discussion, the radially outer side face of the heat insulating member P is defined as an outer face 3 and the radially inner side face thereof is defined as an inner face 4, the opposed faces in the circumferential direction are defined as end faces 5 and the opposed faces in the axial direction are defined as side faces 6, respectively.

[0038]

In this embodiment, the heat insulating members P are attached to form three layers of heat insulating walls.

Namely, as the heat insulating members P, there are provided a large-diameter heat insulating member PL having the greatest diameter, an intermediate-diameter heat insulating member PM having an intermediate diameter and a small-diameter heat insulating member PS having the smallest diameter (see Fig. 3 and Fig. 4).

Incidentally, under the superposed or stacked state of the heat insulating members P, the outer face 3 of the large-diameter heat insulating member PL is located on the outermost side, the inner face 4 of the large-diameter heat insulating member PL and the outer face 3 of the intermediate-diameter heat insulating member PM are disposed side by side with a same diameter, the inner face 4 of the intermediate-diameter heat insulating member PM and the outer face 3 of the small-diameter heat insulating member PS are disposed side by side with a same diameter, and the inner face 4 of the small-diameter heat insulating member PS is disposed side by side with the outer circumferential face of the cylindrical tube 1 with a same diameter,

respectively.

[0039]

At opposed end portions of the cylindrical tube 1, flanges F are provided. As these flanges F are coupled with flanges of adjacent cylindrical tubes 1 with using bolts, there is formed a flow passage through which the cold fluid is caused to flow.

The plurality of heat insulating members P will be attached one after another from the one end portion to the other end portion of the cylindrical tube 1, thus being attached at the portion adjacent one end portion of the cylindrical tube 1, at the portion adjacent the other end portion of the cylindrical tube 1 and the portion(s) corresponding to the portion therebetween.

[0040]

Referring to the mode of disposing the heat insulating members P side by side in the axial direction of the cylindrical tube 1, the mode of disposing the small-diameter heat insulating members PS and the mode of disposing the large-diameter heat insulating members PL having the largest diameter are same; whereas, the mode of disposing the intermediate-diameter heat insulating members PM is different.

Namely, the small-diameter heat insulating member PS, the intermediate-diameter heat insulating member PM and the large-diameter heat insulating member PL are formed to have a basic length (e.g. 1 m) along the axial direction of the cylindrical tube 1.

[0041]

And, respecting the small-diameter heat insulating members PS and the large-diameter heat insulating members PL, these will be arranged such that the heat insulating members P having the basic length are disposed side by side from one end portion toward the other end portion of the cylindrical tube 1. Whereas, respecting the intermediate-diameter heat insulating members PM, these will be arranged such that after heat insulating members P having a half the basic length (e.g. 0.5 m) are arranged at the one end portion of the cylindrical tube 1, the heat insulating members P having the basic length will be arranged one after another toward the other end portion of the cylindrical tube 1.

[0042]

At the portion adjacent the other end portion of the cylindrical tube 1, the axial lengths of the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL will be determined appropriately in correspondence with the axial length of the cylindrical tube 1.

However, the axial lengths of the small-diameter heat insulating member PS, the intermediate-diameter heat insulating member PM and the large-diameter heat insulating member PL adjacent the other end portion of the cylindrical tube 1 are configured to exceed 1 m, in order to form a space for attachment of a coupling member 7 (see Fig. 5) as an "elongate member N" which will be described later.

[0043]

Further, respecting the intermediate-diameter heat insulating member PM, as the intermediate-diameter heat insulating member PM having the half the basic length (e.g. 0.5 m) is to be disposed at the portion adjacent the one end portion of the cylindrical tube 1, at the portion adjacent the other end portion of the cylindrical tube 1, the axial length of the small-diameter heat insulating member PS, the axial length of the large-diameter heat insulating member PL and the axial length of the intermediate-diameter heat insulating member PM will be different.

In the instant embodiment, the axial length of the intermediate-diameter heat insulating member PM is set to a length which is a sum of the axial length of the small-diameter heat insulating member PS and the large-diameter heat insulating member PL and the half of the basic length (e.g. 0.5 m).

[0044]

Moreover, at the intermediate portions excluding the portion adjacent the one end portion of the cylindrical tube 1 and the portion adjacent the other end portion of the cylindrical tube 1, the arrangement (to be referred to simply as "basic attachment arrangement" hereinafter) for attaching the heat insulating members P in juxtaposition along the circumferential direction of the cylindrical tube 1 remains the same, but the attachment arrangement (to be referred to simply as "end portion attachment arrangement" hereinafter) of attaching the heat insulating

members P in juxtaposition along the circumferential direction of the cylindrical tube 1 at the portion adjacent the other end portion of the cylindrical tube 1 differs from the above-described basic attachment arrangement. Next, the basic attachment arrangement and the end portion attachment arrangement will be described one after the other.

[0045]

Incidentally, at the portion between the flange F of the cylindrical tube 1 and the heat insulating member P, there is charged heat insulating material D such as glass wool. And, at the portion corresponding to the upper portion of the flange F of the cylindrical tube 1, with an arrangement similar to the basic attachment arrangement, arc-shaped flange heat insulating members Q are disposed in two layers.

[0046]

(Basic attachment arrangement)

In this basic attachment arrangement, as shown in Fig. 3, the plurality of arc-shaped (semi-circular shape in the instant embodiment) heat insulating members P divided along the circumferential direction of the cylindrical tube 1 are provided on the outer circumferential portion of the cylindrical tube 1 with end faces thereof being placed in abutment against each other, at a plurality of opposed positions located along the circumferential direction of the cylindrical tube 1 respectively, with these heat insulating members P being coupled to each other through mutual coupling of an adjacent pair of heat insulating member end portions thereof via coupling members 7 (example of the elongate members N) formed elongate along the axial direction of the cylindrical tube.

Incidentally, the length of the coupling members 7 is set equal to the axial length of the heat insulating member P and also the coupling members 7 are formed of urethane resin, like the heat insulating members P.

[0047]

As shown in Fig. 3 and Fig. 5, at the respective pair of heat insulating member end portions coupled via the coupling member 7, as an engaging groove portion U for the coupling member 7, a receded groove portion 8 receded in a square form from the end face in the circumferential direction of the cylindrical tube is provided with a retaining groove portion 8a which is receded to the radially outer side of

the cylindrical tube 1 at the portion of this receded groove portion 8 on the radially outer side of the cylindrical tube 1.

[0048]

And, as shown in Fig. 5, the coupling member 7 has a cross sectional shape that includes a main body coupling portion 7A to be engaged in the receded groove portion 8 of each one of the pair of heat insulating member end portions and a pair of retaining coupling portions 7a engageable with the retaining groove portion 8a.

[0049]

Therefore, in this basic attachment arrangement, with the semi-circular heat insulating members P being juxtaposed in the circumferential direction of the cylindrical tube 1 on the outer circumferential portion of this cylindrical tube 1, the coupling member 7 will be moved along the longitudinal direction (the axial direction of the cylindrical tube 1) to be engaged with the receded groove portion 8 of each one of the pair of heat insulating member end portions, whereby the heat insulating members P will be attached to the outer circumferential portion of the cylindrical tube 1 (see Fig. 5).

[0050]

More particularly, firstly, the small-diameter heat insulating members PS will be attached to the outer circumferential face of the cylindrical tube 1. Next, the intermediate-diameter heat insulating members PM will be attached to the outer circumferential faces of the small-diameter heat insulating members PS. Lastly, the large-diameter heat insulating members PL will be attached to the outer circumferential faces of the intermediate-diameter heat insulating members PM.

Under the above-described state in which the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL have been attached, on the outer circumferential portion of the cylindrical tube 1, a plurality (three) of heat insulating wall portions provided in the cylindrical form and with the different diameters by the plurality of arc-shaped (two semi-circular) heat insulating members P coupled with each other via the coupling members 7 are provided to form multiple layers.

[0051]

Also, the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL are attached in such a manner that the opposed position where the end faces of the small-diameter heat insulating members PS are placed in abutment against each other and the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1 and similarly the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other and the opposed position where the end faces of the large-diameter heat insulating members PL are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1.

[0052]

(End portion attachment arrangement)

In the end portion attachment arrangement, as shown in Fig. 4, the above-described semi-circular heat insulating members P halved in the circumferential direction of the cylindrical tube 1 are used as the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube 1.

And, the heat insulating members P are provided on the outer circumference portion of the cylindrical tube 1 in such a manner that at the respective two opposed positions in the circumferential direction of the cylindrical tube 1 where the end faces thereof are placed in abutment against each other, the adjacent pair of heat insulating member end portions are coupled with each other via the elongate connecting members B (example of the "elongate member N) along the axial direction of the cylindrical tube 1.

Incidentally, the length of the connecting member B is set equal to the axial length of the heat insulating member P and also the connecting member B is formed of urethan resin, like the heat insulating member P.

[0053]

At each one of the pair of heat insulating member end portions at

the above-described two opposed portions, as a groove-like engaging portion V in which the connecting member B is to be engaged, a receded portion 10 which is receded from the end face 5 in the tangential direction of the cylindrical tube 1 is formed with an inner surface 10u and an outer surface 10g juxtaposed along the radial direction of the cylindrical tube 1, both surfaces being formed as flat surfaces extending along the tangential direction of the cylindrical tube 1.

Incidentally, the "tangential direction of the cylindrical tube 1" in the above discussion means the tangential direction of the cylindrical tube 1 at the opposed positions where the end faces 5 of the pair of heat insulating members P are placed in abutment against each other.

[0054]

Further, the receded portion 10, as indicated by virtual lines in the Fig. 6 illustration, is formed by cutting away a side portion 8b positioned aside a retaining groove portion 8a of the receded groove portion 8 provided in the basic attachment arrangement.

Namely, in the instant embodiment, the heat insulating member P is configured to have the receded groove portion 8. And, in the basic attachment arrangement, this heat insulating member P is used as it is. Whereas, in the end portion attachment arrangement, the portion positioned aside the retaining groove portion 8a of the receded groove portion 8 is cut away to form a square-shaped receded portion 10 and the heat insulating member P with such receded portion 10 formed therein is used as the semi-circular heat insulating member PA.

[0055]

And, the connecting member B at the two opposed positions is configured, as shown in Fig. 7, as an elongate square-shaped body 11 having a cross section in the form of a square having flat faces along the inner surface 10u and the outer surface 10g of the receded portion 10 of each one of the pair of heat insulating member end portions.

Incidentally, as the corner portions of the square-shaped receded portion 10 are formed arcuate, the cross sectional shape of the elongate square-shaped member 11 is a "roundish-cornered square shape".

[0056]

Moreover, in the instant embodiment, the elongate square-shaped body 11 having the square-shaped cross section is formed

of an elastically deformable material (urethane resin) and each one of a pair of engaging portions 11A of this elongate square-shaped body 11 engageable with the adjacent receded portions 10 defines a slit 12 which separates the engaging portion 11A in the radial direction of the cylindrical tube, as shown in Fig. 7.

Incidentally, the thickness of the elongate square-shaped body 11 is set to about 15 mm, whereas the width of the slit 12 is set to about 2 mm.

[0057]

Therefore, in the case of this end portion attachment arrangement, the heat insulating members P will be attached to the outer circumferential portion of the cylindrical tube 1 by the following procedure.

Firstly, to the receded portions 10 formed at the opposed end portions of one heat insulating member P of the halved semi-circular heat insulating members P, the elongate square-shaped body 11 will be engaged.

Incidentally, in order to engage the elongate square-shaped body 11 into the receded portion 10, the elongate square-shaped body 11 will be engaged (inserted) in the receded portion 10 in association with moving of this elongate square-shaped body 11 in the longitudinal direction. Alternatively, the elongate square-shaped body 11 will be engaged in the receded portion 10 in association with moving of this elongate square-shaped body 11 in the direction of the receding direction of the receded portion 10.

[0058]

Thereafter, the one heat insulating member P having the elongate square-shaped body 11 engaged therein will be attached in abutment against the outer circumferential portion of the cylindrical tube 1.

In succession, as the other heat insulating member P is moved closer to the cylindrical tube 1, to the elongate square-shaped body 11 engaged with the opposed end portions of the one heat insulating member P, the receded portions 10 formed at the opposed end portions of the other heat insulating member P will be brought into engagement while being moved in the tangential direction of the cylindrical tube 1 at

the opposed portions where the end faces 5 of the pair of heat insulating members P are placed in abutment against each other.

[0059]

More particularly, firstly, the small-diameter heat insulating members PS will be attached to the outer circumferential face of the cylindrical tube 1. Next, the intermediate-diameter heat insulating members PM will be attached to the outer circumferential faces of the small-diameter heat insulating members PS. Lastly, the large-diameter heat insulating members PL will be attached to the outer circumferential faces of the intermediate-diameter heat insulating members PM.

Under the above-described state in which the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL have been attached, on the outer circumferential portion of the cylindrical tube 1, a plurality (three) of heat insulating walls provided in the cylindrical form and with the different diameters by the halved semi-circular heat insulating members P are provided to form multiple layers.

[0060]

Also, like the basic attachment arrangement, the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL are attached in such a manner that the opposed position where the end faces of the small-diameter heat insulating members PS are placed in abutment against each other and the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1 and similarly the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other and the opposed position where the end faces of the large-diameter heat insulating members PL are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1.

[0061]

(Heat Insulation Enhancement Arrangement)

In the instant embodiment, for enhancing the heat insulation between the plurality of heat insulating members P attached to the outer circumferential face of the cylindrical tube 1, namely, the heat insulation between the adjacent heat insulating members P, a heat insulation enhancement arrangement is provided.

Namely, the plurality of heat insulating members P attached to the outer circumferential face of the cylindrical tube 1 are shrunk when being cooled by the cold fluid flowing inside the cylindrical tube 1. As a result, gaps will be formed between the respective adjacent heat insulating members P, thus tending to cause reduction in the heat insulation performance. For this reason, the heat insulation enhancement arrangement is provided for enhancing the heat insulation performance.

[0062]

Such heat insulation enhancement arrangement includes an inner side reinforcement arrangement provided for the heat insulating walls formed by the small-diameter heat insulating members PS and the intermediate heat insulating members PM and an outer side reinforcement arrangement provided for the heat insulating walls formed by the large-diameter heat insulating members PL. Next, the inner side reinforcement arrangement and the outer side reinforcement arrangement will be explained one after another. It is noted that in the Figs. 1-6 illustrations, the description of the heat insulation reinforcement arrangement is omitted.

[0063]

(Inner Side Reinforcement arrangement)

In the inner side reinforcement arrangement, as shown in Fig. 8, for a portion where the end faces 5 of the pair of heat insulating members P disposed side by side in the circumferential direction of the cylindrical tube 1 are placed in abutment against each other, an adhesive tape (moisture proof butyl tape) 13 having gas-tightness is affixed and also for the heat insulating members P adjacent at the portion where the side faces 6 of the heat insulating members P disposed side by side in the axial direction of the cylindrical tube 1 are placed in abutment against each other, a coupling body W having a pair of retaining portions Wa is attached.

[0064]

Referring more particular to the arrangement of attaching the coupling body W to the adjacent heat insulating members P, the coupling body W having the pair of retaining portions Wa is inserted respectively to the radially inner side of the cylindrical tube 1 for the outer surface portions of the pair of small-diameter heat insulating members PS adjacent each other in the axial direction of the cylindrical tube 1 and the pair of the intermediate-diameter heat insulating members PM adjacent each other.

Incidentally, the pair of small-diameter heat insulating members PS adjacently juxtaposed in the axial direction of the cylindrical tube 1 and the pair of intermediate-diameter heat insulating members PM adjacently juxtaposed correspond to a pair of heat insulating members P which form the inner side heat insulating wall in the radial direction of the cylindrical tube 1 of the plurality of layers (three layers) of heat insulating walls formed on the outer circumferential portion of the cylindrical tube 1 and which are adjacently juxtaposed in the axial direction of the cylindrical tube 1.

[0065]

In the instant embodiment, as shown in Fig. 9, the coupling body W is configured to have the retaining portions Wa on the width-wise opposed end sides of a bendably deformable band-like member 14 and the coupling body W is attached as being wound about the outer surface portions of the pair of heat insulating members P.

More particularly, the band-like member 14 is made of Tarpaulin which comprises a polyester fiber fabric sandwiched by soft synthetic resin films. And, to this band-like member 14, the retaining portions Wa formed by sharpening treatment with synthetic resin are added.

[0066]

Therefore, as the band-like member 14 has no adhesiveness, after this band-like member 14 is wound about the outer surface portions of the pair of heat insulating members P, on this wound band-like member 14, a small-width tape 15 having adhesiveness is wound to suppress detachment of the band-like member 14.

[0067]

(Outer Side Reinforcement arrangement)

In the outer side reinforcement arrangement, as shown in Fig. 8, astride a pair of large-diameter heat insulating members PL adjacently juxtaposed in the axial direction of the cylindrical tube 1, a band-like first leak proof body 16 (an example of the "axial-side leak proof body") having adhesiveness is affixed. And, at each of the plurality of (two) opposed positions where the end faces 5 of the large-diameter heat insulating members PL disposed side by side in the circumferential direction of the cylindrical tube 1 are placed in abutment against each other, astride the pair of large-diameter heat insulating members P disposed adjacent in the circumferential direction of the cylindrical tube 1, a band-like second leak proof body 17 (an example of the "circumferential-side leak proof body") having adhesiveness is affixed.

[0068]

Incidentally, as may be apparent from the above explanation, the heat insulating wall formed by the large-diameter heat insulating members PL corresponds to the heat insulating wall which is located on the outermost side in the radial direction of the cylindrical tube 1 of the plurality of (three) heat insulating walls.

[0069]

Moreover, in the instant embodiment, on the entire outer circumferential faces of the large-diameter heat insulating members PL, a square-shaped third leak proof body 18 having adhesiveness is affixed for further enhancement of the heat insulation performance.

Incidentally, the first leak proof body 16, the second leak proof body 17 and the third leak proof body 18 are formed respectively by using e.g. a tape (ALGC tape) produced by applying a rubber-based adhesive agent having good bonding force to a substrate formed of an aluminum foil and a glass cloth affixed to each other.

[0070]

Incidentally, as the order of affixing the first leak proof body 16, the second leak proof body 17 and the third leak proof body 18 respectively, advantageously, the third leak proof body 18 will be affixed first and then the second leak proof body 17 will be affixed and lastly the first leak proof body 16 will be affixed.

[0071]

[Second Embodiment]

Next, a second embodiment will be explained. In this, it is noted that this second embodiment differs from the first embodiment in the structure of the coupling body W. The rest of its structure is identical to that of the first embodiment. As such, only differences thereof from the first embodiment will be discussed below and discussion on the identical structure to that of the first embodiment will be omitted.

[0072]

As shown in Fig. 10 and Fig. 11, the coupling body W has a U-shape having retaining portions Wa at opposed ends of a shaft-like body 20A having a rectangular cross section. Specifically, the coupling body W is configured as a U-shaped frame body 20 formed of synthetic resin.

[0073]

And, the plurality of coupling bodies W (U-shaped frame bodies 20) are attached to a plurality of positions in the circumferential direction of the cylindrical tube 1 in such a manner as being inserted to the radially inner side of the cylindrical tube 1 respectively for outer face portions of a pair of small-diameter heat insulating members PS adjacently juxtaposed in the axial direction of the cylindrical tube 1 and a pair of intermediate-diameter heat insulating members PM adjacently juxtaposed in the axial direction of the cylindrical tube 1.

[0074]

In the instant embodiment, when the respective coupling bodies W (U-shaped frame bodies 20) are to be inserted to the outer face portions of a pair of small-diameter heat insulating members PS and a pair of intermediate-diameter heat insulating members PM adjacently juxtaposed in the axial direction of the cylindrical tube 1, the shaft-like body 20A and the retaining portions Wa are inserted to the outer face portions of the small-diameter heat insulating members PS and the intermediate-diameter heat insulating members PM with the shaft-like body 20A and the retaining portions Wa of one side face being oriented in its posture into opposition to the outer faces of the small-diameter heat insulating members PS and the intermediate-diameter heat insulating members PM.

[0075]

Incidentally, as a mode of inserting the coupling body W (U-shaped frame body 20) to the outer face portions of the small-diameter heat insulating members PS and the intermediate-diameter heat insulating members PM, the retaining portions Wa may be inserted to the outer face portions of the small-diameter heat insulating members PS and the intermediate-diameter heat insulating members PM with keeping the leading ends of the retaining portions Wa under an erect posture in opposition to the outer faces of the small-diameter heat insulating members MS and the intermediate-diameter heat insulating members PM and also placing the shaft-like body 20A in abutment against the outer faces of the small-diameter heat insulating members MS and the intermediate-diameter heat insulating members PM.

[0076]

Further, in the instant embodiment, for the portion where the coupling body W (U-shaped frame body 20) has been attached, an detachment resistant tape (moisture proof butyl tape) 21 having air-tightness and adhesiveness is affixed to be wound along the circumferential direction of the cylindrical tube 1.

[0077]

[Third Embodiment]

Next, a third embodiment will be explained. This third embodiment illustrates a structure for engaging the small-diameter heat insulating member PS, the intermediate-diameter heat insulating member PM and the large-diameter heat insulating member PL adjacently juxtaposed in the axial direction of the cylindrical tube 1 in the axial direction. The rest of its structure is identical to that of the first embodiment. As such, only differences thereof from the first embodiment will be discussed below and discussion on the identical structure to that of the first embodiment will be omitted.

[0078]

Namely, as shown in Figs. 12-14, in side faces of the heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1, engagement portions K engageable in the axial direction of the cylindrical tube 1 are formed.

Specifically, in one side face 6 of a pair of side faces 6 of the heat insulating member P, an arc-shaped protruding portion Ka is formed as the engagement part K, wherein in the other side face 6, as the engagement part K, there is formed an arc-shaped receded portion Kb engageable with the protruding portion Ka.

[0079]

And, the arc-shaped protruding portion Ka and the arc-shaped receded portion Kb of the heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 are configured to be engageable with each other.

Namely, when the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 are cooled by the cold fluid flowing in the cylindrical tube 1 and shrunk to tend to move apart from each other along the axial direction of the cylindrical tube 1, there will only occur reduction in the engagement amount in the axial direction of the cylindrical tube 1 of the engagement portions K engageable in the axial direction of the cylindrical tube 1, and formation of a gap between the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 can be suppressed.

[0080]

Incidentally, when the coupling body W is provided, it is conceivable to omit the engagement portion K and conversely, when the engagement portion K is provided, it is conceivable to omit the coupling body W. However, with provision of both the coupling body W and the engagement portion K, formation of a gap between the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 can be suppressed in a reliable manner.

[0081]

[Fourth Embodiment]

Next, a fourth embodiment will be explained. This fourth embodiment differs from the third embodiment in the respect of the structure of the engagement portion K. The rest of its structure is identical to that of the third embodiment. As such, only differences thereof from the third embodiment will be discussed below and

discussion on the identical structure to that of the third embodiment will be omitted.

[0082]

5 Namely, as shown in Fig. 15, in each one of the pair of side faces 6 of the heat insulating member P, as the engagement portion K, the arc-shaped receded portion Kb is formed.

10 And, to the arc-shaped receded portions Kb formed in the side faces 6 of the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1, semi-circular relay cylindrical bodies 22 are engaged, whereby the side faces of the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 are engaged with each other in the axial direction of the cylindrical tube 1.

15 Incidentally, the relay cylindrical body 22 may be formed annular also.

[0083]

[Fifth Embodiment]

20 Next, a fifth embodiment will be explained. This fifth embodiment differs from the third embodiment in the respect of the structure of the engagement portion K. The rest of its structure is identical to that of the third embodiment. As such, only differences thereof from the third embodiment will be discussed below and discussion on the identical structure to that of the third embodiment will be omitted.

[0084]

Namely, as shown in Fig. 15, in each one of the pair of side faces 6 of the heat insulating member P, as the engagement portion K, the arc-shaped protruding portion Ka is formed.

30 Further, there is provided a semi-circular connecting cylindrical body 23 having, in its opposed faces, receded grooves 23a engageable with the arc-shaped protruding portion Ka.

Incidentally, the connecting cylindrical body 23 may be formed annular also.

35 **[0085]**

And, to the arc-shaped protruding portions Ka formed in the side

faces 6 of the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1, the connecting cylindrical body 23 is engaged, whereby the side faces of the pair of heat insulating members P adjacently juxtaposed in the axial direction of the cylindrical tube 1 are engaged with each other in the axial direction of the cylindrical tube 1.

[0086]

[Other Embodiments]

Next, other embodiments will be explained one after another.

(1) In the foregoing embodiments, there was disclosed the case in which the heat insulating member P has a semi-circular shape halved in the circumferential direction of the cylindrical tube 1. However, the invention is not limited thereto. In the basic attachment arrangement, the heat insulating member P may be split into three or more parts along the circumferential direction of the cylindrical tube 1. Also, in the end portion attachment arrangement, the heat insulating member P may be split into an even number of parts of four or more along the circumferential direction of the cylindrical tube 1 and the semi-circular heat insulating member PA may be formed by interconnecting these.

[0087]

(2) In the foregoing embodiments, there was disclosed the case in which the heat insulating members P are attached to the outer circumferential portion of the cylindrical tube 1 in the basic attachment arrangement and the end portion attachment arrangement. However, it is also possible to embody such that the heat insulating members P are attached along the entire length of the cylindrical tube 1 in the end portion attachment arrangement.

[0088]

(3) In the foregoing embodiments, the connecting members B, the coupling members 7 and the heat insulating members P are formed of a same material. However, the connecting members B, the coupling members 7 and the heat insulating members P may be formed of different materials.

[0089]

(4) In the foregoing embodiments, the material of the heat

insulating member P is urethane resin. However, the material of the heat insulating member P is not limited thereto. For instance, the material of the heat insulating member P may be a synthetic resin such as polyethylene resin, nitrile rubber (NBR), etc. or a natural resin such as natural rubber (NR), or the like. Similarly, the material of the connecting member B and the coupling member 7 may be a synthetic resin such as polyethylene resin, nitrile rubber (NBR), etc. or a natural resin such as natural rubber (NR), or the like.

[0090]

(5) In the foregoing embodiments, there was disclosed the case in which the coupling body W is not attached to the heat insulating member P of the outermost heat insulating wall in the radial direction of the cylindrical tube 1 of the plurality of layers of heat insulating walls. However, it is also possible to embody with attaching the coupling body W also to the heat insulating member P of the outermost heat insulating wall.

[0091]

(6) In the foregoing embodiments, there was disclosed the case in which on the outer circumferential portion of the cylindrical tube 1, three layers of heat insulating walls are formed as a plurality of heat insulating walls. However, it is also possible to embody with forming two layers of heat insulating walls or four or more layers of heat insulating walls.

[0092]

Incidentally, the structures disclosed in the foregoing embodiments (including the further embodiments) may be used in any combinations with the structures disclosed in any other embodiment unless contradiction results from such combinations. Further, it is noted that the embodiments disclosed in this detailed disclosure are only exemplary and embodiments of the present invention are not limited thereto, but may be modified in any appropriate matter within a range not deviating from the object of the present invention.

DESCRIPTION OF REFERENCE SIGNS

[0093]

1: cylindrical tube

	5:	end face
	6:	side face
	14:	band-like member
	16:	axial-side leak proof body
5	17:	circumferential-side leak proof body
	20A:	shaft-like body
	K:	engagement portion
	N:	elongate member
	P:	heat insulating member
10	W:	coupling body
	Wa:	retaining portion

CLAIMS

1. A heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of the cylindrical tube in which cold fluid flows, there are provided a plurality of layers of heat insulating walls juxtaposed in an axial direction of the cylindrical tube, the plurality of layers of heat insulating walls being provided in a cylindrical form and with different diameters formed of arcuate heat insulating members divided in a circumferential direction and an axial direction of the cylindrical tube;

wherein for a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube, in only the heat insulating wall disposed on an inner side in the radial direction of the cylindrical tube among the plurality of layers of heat insulating walls, a coupling body having a pair of retaining portions is provided so that the pair of retaining portions are inserted to respective outer face portions of the pair of heat insulating members to radially inner side of the cylindrical tube,

the coupling body includes a band-like member bendably deformable, with the retaining portions being provided in juxtaposition along a longitudinal direction of the band-like member at width-wise opposed ends of the band-like member,

the coupling body is attached as being wound about outer face portions of the pair of heat insulating members, and

the band-like member is made of Tarpaulin which comprises a polyester fiber fabric sandwiched by soft synthetic resin films.

2. The cylindrical tube heat insulation structure of claim 1, wherein a band-like axial-side leak proof body having adhesiveness is affixed to be mounted astride a pair of heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube of the heat insulating wall disposed on an outermost side in the radial direction of the cylindrical tube of the plurality of layers of heat insulating walls.

3. The cylindrical tube heat insulation structure of claim 1 or 2, wherein:

the plurality of heat insulating members juxtaposed in the circumferential direction of the cylindrical tube to form the plurality of the respective heat insulating walls, at each of a plurality of opposed portions located in the circumferential direction of the cylindrical tube where end faces thereof are placed in abutment against each other, are coupled with a pair of adjacent heat insulating member end portions thereof being coupled

to each other via an elongate member that is formed elongate along the axial direction of the cylindrical tube and engageable with the pair of heat insulating member end portions; and

at each of the plurality of opposed portions of the heat insulating wall disposed on the outermost side of the plurality of heat insulating walls in the radial direction of the cylindrical tube, a band-like circumferential-side leak proof body having adhesiveness is affixed to be mounted astride a pair of heat insulating members adjacently juxtaposed in the circumferential direction of the cylindrical tube.

4. The cylindrical tube heat insulation structure of any one of claims 1-3, wherein in opposed side faces of the heat insulating members adjacently juxtaposed in the axial direction of the cylindrical tube, there are formed engagement portions engageable in the axial direction of the cylindrical tube.