

PATENT SPECIFICATION (11)

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(54) VACUUM-INSULATED CONDUIT JOINTS

(71) We, BOC LIMITED, of Hammer-smith House, London, W6 9DX, England, an English company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—
 This invention relates to vacuum-insulated conduit joints. Such conduit is designed to reduce the transmission of heat from the surroundings to the fluid passing through the conduit. For this purpose, the conduit proper is enclosed in a jacket which is spaced from the conduit, the resultant space normally containing layers of so-called 'superinsulation material'. Such material is normally of thin plastics which is a poor thermal conductor, and also a good reflector so as to reduce the transmission of heat by radiation between the jacket at ambient temperature and the conduit at the temperature of, say, liquid nitrogen, which is -196°C . The said space is also evacuated (of air) so as to reduce transmission of heat between the jacket and conduit by conduction and convection.
 In such vacuum-insulated conduit, the problem arises of joining successive lengths of conduit together, because such conduits are normally made in standard lengths of about eight metres. While it would be feasible to connect the length of conduit and of jacket together by peripheral welds, this would be a time-consuming, and therefore expensive, process.
 The present invention aims at providing vacuum-insulated conduit in which the problem of mechanically connecting the conduit lengths together is separated from the problem of thermally insulating the resultant joints, by the use of a prefabricated muff, to provide an overall joint which is simple to make, and therefore inexpensive, while being of very low thermal conductivity.
 By 'muff' in this specification is meant a sleeve adapted to circumscribe a mechanical

joint between two lengths of vacuum-insulated conduit, the sleeve being itself of low thermal conductivity, and being effective to prevent the ingress of moisture-laden warm air into the space between the muff and the joint.
 Accordingly the present invention provides a joint between two lengths of vacuum-insulated and jacketed conduit, the joint being as claimed in the appended claims.
 The present invention will now be described by way of example with reference to the accompanying drawing, which is an axial cross-section through a joint and muff of the present invention.
 The joint to be insulated by the muff 2 is between two lengths of conduit 4, which would normally, in use, carry a cryogenic fluid such as liquid nitrogen between a reservoir (not shown) and a work location at which the liquid nitrogen is to be vaporised either to provide an inert atmosphere or to extract heat.
 Beyond the muff 2, the conduit 4 is provided with a coaxial jacket 6 of a relatively thick gauge metal which is strong enough to resist both the mechanical forces imposed on it during use and the pressure of the atmosphere when the inside of the jacket is evacuated.
 In accordance with one feature of the present invention, at the end of each length of jacket 4, the jacket is welded to a thin sleeve 8 of stainless steel or like material which has the necessary mechanical strength and is of poor thermal conductivity.
 As can be seen in the drawing, the left-hand length of conduit 4 ends in a flange 10 provided with uniformly-spaced blind holes. The flange 10 is welded to both the conduit 4 and the inner end of sleeve 8 in a vacuum-tight manner.
 Similarly welded to the adjacent end of the right-hand length of conduit 4 is a flange 12 provided with a series of plain passages aligned with the blind holes in flange 10. The two flanges are able to be secured together by means of a series of screws 14, of which the under-surfaces of the heads bear on the exposed end

face of flange 12.

A sleeve 16 of thin stainless steel, similar to sleeve 8, is secured to the inner end of the right-hand length of outer jacket 6. The inner end of sleeve 16 is welded to a support 18 also of thin stainless steel. The support 18 is in the shape of a hollow, half ring having a U-shaped radial cross-section. This shape permits the support 18 to be welded to both the inner end of sleeve 16, that is the end of sleeve 16 nearest the flanges 10, 12, and the adjacent part of the inner end of the right-hand length of conduit 4. The last weld is spaced from the inner end of the conduit by a distance which is related to the length of the screws 14 so that the screws are able to fit in the space between flange 12 and support 18 before being passed through the passages in flange 12 and screwed home into the tapped holes in flange 10. In other words, the end of sleeve 16 nearest the flanges 10, 12 is spaced axially from the flange 12 by a distance greater than the length of a screw 14.

After the two flanges have been connected together by means of the screws 14, two bodies in the form of half rings 20 of a hygroscopic material can be fitted into the space between the heads of the screws 14 and the support 18. This happens shortly before the muff 2 is placed in position over the resultant mechanical joint, the function of the half-rings 20 being to absorb any residual and incoming moisture. The maximum radial dimension of each half ring 20 is less than the minimal radial distance to any part of the muff 2.

Before the mechanical connection of the two conduit lengths is made, the muff 2 has been previously slipped over the outer jacket 6 of one of the lengths of conduit, and slid along its length until after the two conduit lengths have been connected together. Thereafter, it is moved back until it occupies the position shown in the drawing.

The muff consists of a thick outer tube 22 and a thin inner tube 24. The tube 22 can be of any suitably-strong metal, whereas the inner tube 24 should be of stainless steel or other material of low thermal conductivity. At their ends, both tubes are welded to a pair of end rings 26 each having a uniformly spaced-apart series of tapped blind holes 28 such as are indicated on the left-hand side of the drawing. Associated with each end ring 26 is a clamping ring 30 having in it a complementary series of plain apertures. By means of screws 32, each clamping ring is able to be urged towards the outer end face of its associated end ring 26, when the muff has been finally positioned relatively to the joint.

As can be seen from the drawing, the outer end face of each end ring 26 has an inner, contiguous, frustoconical surface 34. Together with the inner end face of the associated clamping ring 30, surface 34 defines a circular space of triangular cross-section, in which is positioned an O-ring seal 36.

The inner diameters of tube 24, end ring 26 and clamping ring 30 are slightly greater than the maximum outer diameter of jacket 6, thus enabling the muff 2 to move fairly easily along the length of the jacket when the clamping ring 30 is clear of end ring 36. The inner diameter of the O-ring 36 is a sliding fit on jacket 6.

When the muff is in its desired final position, the screws 32 are inserted and tightened to force the clamping ring 30 towards its respective end ring 26. In so doing, the two rings cooperate to engage the O-ring and distort it from its normal circular cross-section into the illustrated substantially-triangular cross-section. Simultaneously with this distortion of shape, and because the minimum volume of the space for the O-ring is less than the volume of the O-ring, the O-ring is urged radially inwardly into engagement with the outer surface of jacket 6. When the screws 32 are tightened, so that there is no separation between rings 26 and 30, the O-ring 36 is pressed so firmly into contact with jacket 6 that it prevents any further axial movement of muff 2 relative to the joint, and also prevents moisture-laden warm air from flowing from the atmosphere into the unevacuated spaces in the interior of the inner sleeve 24 of the muff. This sealing is necessary because when the flanges 10 and 12, and the associated parts of the joints, have their temperature reduced to that of liquid nitrogen or other low temperature, the resultant temperature difference between the joints and the atmosphere tends to 'pump' moisture from the atmosphere to the joint, in that any migration of moisture is only towards the joint, because once moisture gets close enough to the joint it becomes frozen to it, and is therefore not free to return to the atmosphere.

Although this has not been shown in the drawing, because it would obscure the inner detail thereof, the spaces of annular cross-section between the jacket 6 and conduit 4, and between the tubes 22 and 24, are filled with layers of superinsulation material, such as of coated plastics film. Such superinsulation is usual in the case of vacuum-insulated conduits, and so will not be discussed herein in any greater detail. It is the interstitial spaces between the layers of superinsulation material which are evacuated of gas in order to enhance the thermal insulation properties of the respective spaces. The inner space in the muff 2 can be evacuated by way of a port 38, which is permanently connected to the outer tube 32 and which can be closed in a gas-tight manner so as to preserve the vacuum in the muff.

As can be seen in the drawing, one of the end rings 26 is provided with an outlet 40 to a radial passage 42 leading to a cylindrical groove 44 in the curved inner surface of ring 26 and inboard of bevelled face 34. Because the inner diameter of the ring is greater than the outside diameter of jacket 6, gas may flow from the

joint to the passage 42. Thus outlet 40 may include a pressure-relief device, such as a spring-biased non-return valve or a bursting disc. Such a device must be fitted to prevent an explosion in the event that liquefied gas leaks into the space between the muff and conduit and vaporises. The resultant high pressure is vented safely to atmosphere pending detection and repair of the leak.

Because the two lengths of conduit can be coupled together merely by means of screws 14, and the muff 2 can be positioned over the thus-completed joint, in a gas-tight manner, merely by means of screws 32, it will be seen that the present invention enables two lengths of vacuum-insulated conduit to be coupled together very simply and quickly.

WHAT WE CLAIM IS:-

1. A joint between two lengths of jacketed and vacuum-insulated conduit, in which each length of conduit ends in a flange; in which the flanges are in complementary pairs so that conduits may be connected together end-to-end by bolting or otherwise securing the flanges together in a fluid-tight fashion, and in which the resultant joint is bridged by a thermally-insulated muff in vacuum-tight contact with the jackets of both conduits at locations spaced longitudinally from the joint.

2. A joint as claimed in Claim 1, in which the muff includes a pair of end rings having two nested tubes extending between them, with the inner diameters of the inner tube and of the rings being slightly greater than the outer diameter of the outer jacket of the conduits; thermal insulation material in the space between the two tubes, which space has been evacuated of gas; an O-ring seal positioned adjacent to the outer end face of each ring, and a clamping ring adapted to be secured to a respective end ring so as to engage the respective O-ring seal between the end ring and itself, so that the seal is deformed radially and inwardly into air-tight engagement with the outer surface of the outer jacket as the clamping ring is being secured to the end ring.

3. A joint as claimed in Claim 2, in which at least one of the co-operating annular faces of the end ring and clamping ring is shaped to provide a space within which part of the O-ring is located, the minimum volume of the space being less than the volume of the O-ring.

4. A joint as claimed in Claim 3, in which the or each respective face is bevelled to provide a space of triangular radial cross-section along the axis of the conduit.

5. A joint as claimed in any of Claims 2 to 4, in which at least one of the end rings is provided with a passage extending between its inner and outer curved faces, the passage being fitted with a non-return valve permitting gas under pressure to flow from the joint to the

atmosphere under fault conditions.

6. A joint as claimed in any preceding Claim, in which the muff is provided with a sealable port by means of which a vacuum pump may be connected to the internal space of the muff when it is to be evacuated of gas.

7. A joint as claimed in Claim 2, or Claim 2 and any claim dependent therefrom, in which the inner tube of the muff is of thin material of poor thermal conductivity.

8. A joint as claimed in Claim 2, or Claim 2 and any claim dependent therefrom, in which the thermal insulation in the muff is in the form of layers of superinsulation material.

9. A joint as claimed in any preceding Claim, in which the outer jacket of the conduits terminate at locations spaced just inwardly of the locations of the ends of the muff in sleeves of thin material of poor thermal conductivity, the connection between the sleeves and the jacket, and the sleeves and the conduit or a member bonded thereto, being vacuum-tight.

10. A joint as claimed in Claim 9, in which one of the sleeves is connected at its end spaced from the respective jacket to an intermediate support member having a U-shaped radial cross-section, with one of the circular edges so formed being sealed to the conduit and the other being sealed to the sleeve.

11. A joint as claimed in Claim 10, in which the end of the respective sleeve nearest the flanges is spaced axially from the nearer flange by a distance greater than the respective dimension of the means used for securing the flanges together.

12. A joint as claimed in Claim 11, in which at least one body of hygroscopic material is positioned in the space between the respective flange and the intermediate support member, the maximum radial dimension of the body being less than the minimum radial distance to any part of the muff.

13. A joint as claimed in any preceding Claim, in which one of the flanges has in it a series of tapped blind holes, and in which the other flange has in it a series of plain passages aligned with the tapped holes which are intended to receive the screw-threaded ends of screws used to secure the flanges together.

14. A joint as claimed in any preceding Claim, in which the space between each conduit and its jacket and sleeve is largely filled with layers of superinsulation material.

15. A joint between two lengths of jacketed and vacuum-insulated conduit substantially as described herein with reference to, and as shown in, the accompanying drawing.

For the Applicant,

K.B. Weatherald,
Chartered Patent Agent.



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joint to the passage 42. Thus outlet 40 may include a pressure-relief device, such as a spring-biased non-return valve or a bursting disc. Such a device must be fitted to prevent an explosion in the event that liquefied gas leaks into the space between the muff and conduit and vaporises. The resultant high pressure is vented safely to atmosphere pending detection and repair of the leak.

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