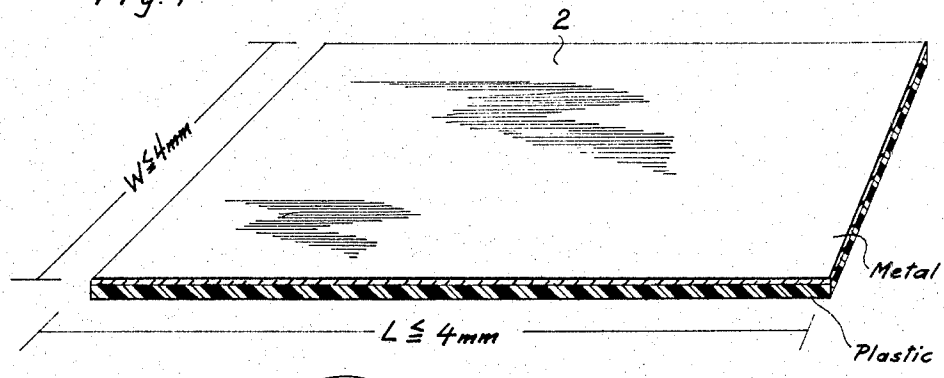
Nov. 12, 1968 A. HOFMANN 3,410,443

THERMALLY INSULATING FILLER

Filed May 17, 1966

Fig. 1



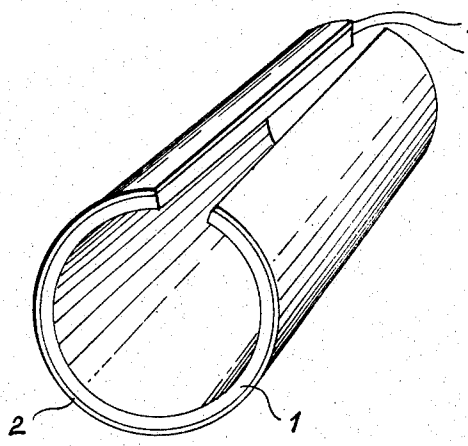
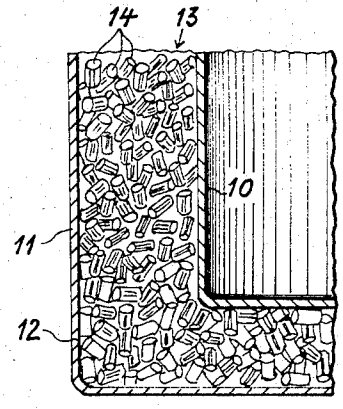


Fig. 2

Fig. 3



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THERMALLY INSULATING FILLER

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ABSTRACT OF THE DISCLOSURE

Rigid thermally insulating filler bodies composed of aluminum foil laminated to rectangular plastically deformable thermally insulating synthetic-resin foil, opposite ends of the rectangle being bent toward one another to impart a generally cylindrical tubular configuration to the body. The body is open at its opposite axial extremities, while the ends of the rectangle, which are turned toward one another, do not overlap and define a gap between them along a generatrix of the body.

My present invention relates to a thermally insulating filler adapted to be disposed between walls to constitute a thermal barrier between regions of different temperatures and to a method of making such filler.

The provision of thermal barriers between regions of different temperatures is common in the insulating art and the use of such fillers has become common place in the interwall compartments of double-wall vessels used for storing, transporting and processing low-boiling-point liquids such as the liquefied gases obtained from air-rectification processes. Thus a Dewar-type vessel can be constituted with an interwall compartment between an inner wall retaining the liquefied or low-boiling-point gas and an outer jacket, and this space evacuated after filling with a thermally insulating material. Earlier methods of insulating such vessels and double-wall partitions between a relatively high-temperature plenum and a relatively low-temperature plenum have involved the use of layers of insulating material provided with heat-reflective surfaces of a metal (e.g. aluminum) having a high degree of heat reflectivity, and an insulating layer of low thermal conductivity carrying the heat-reflective layer. Such insulating barriers are relatively expensive to manufacture and are difficult to adapt to small-sized vessels and interwall compartments or to intricate vessel shapes. Another prior method of insulating an interwall compartment has been to fill the compartment with particles of a thermally insulating material, in the mass of which are distributed particles of a heat-reflective metal. While such fillers are adequate for many purposes (e.g. for intricately shaped and small-size vessels) they have the significant disadvantage that evacuation of the interwall compartment results in an entrainment of some of the particles therefrom so that there is, on the one hand, a loss of the insulating material and, on the other hand, a dust problem which can be solved only by the provision of relatively expensive and frequently inefficient dust-removal devices. Furthermore, powdery masses of this character are difficult to handle and tend to segregate thereby resulting in a reduction of the heat-barrier effect. Last not least, the known insulating powders have a relatively high specific gravity, thus causing an undesired increase in the weight of the vessel.

It is, therefore the principal object of the present invention to provide an improved thermally insulating filler which is readily adaptable to small-size vessels and intricate vessel shapes and thus can completely and efficiently be disposed in the interwall compartment of a double-wall vessel to constitute a thermal barrier.

A further object of this invention is to provide an easily handled heat-insulating filler with both heat-reflective and thermally nonconductive character which is free from the disadvantages resulting from the use of prior (e.g. powdery) filler-type barriers.

Yet another object of my invention is to provide a relatively simple and economical method of making an improved filler for disposition between walls separating a region of relatively high temperature from a region of relatively low temperature.

These objects and others which will become apparent hereinafter, have been attained, in accordance with the present invention, through the provision of a filler adapted to constitute a thermal barrier and composed of three-dimensional filler bodies consisting of a heat-reflective metallic layer overlying a plastically deformable, thermally insulating, synthetic-resin foil layer. The present invention thus involves the application of a heat-reflective metallic layer to a thermoplastic foil and thereafter bending the laminate thus produced into a three-dimensional curved body with the metallic layer lying outwardly of the thermoplastic foil. Advantageously, the bending of the strips of laminate is effected by heating them beyond the plastic limit of the foil, whereupon the metallic layer having a greater coefficient of thermal expansion, spreads to a somewhat greater extent than the spread of the thermoplastic and produces, without other mechanical distortion of the laminate, a curved or generally cylindrical configuration which is retained upon cooling of the body because the temperature to which the laminate is raised during the heating step exceeds the plastic or flow limit of the resin. The thermoplastic is advantageously a polyester (e.g. a polyterephthalic-acid ester and the heating temperature is in excess of the softening point thereof while the metallic layer is an aluminum film. The loose-packed specific gravity of a filler of this type should be of the order of about 20 kp./m.^{3}. The laminate sections are advantageously severed from a laminate sheet into strips of uniform size with a maximum length and width of 4 mm. so that the cylindrical bodies produced upon heating will have a circumference of 4 mm. or less as well as an axial length of at most 4 mm.; a satisfactory minimum dimension is about 1 mm.

It will be apparent that this method provides a packing body and a packing which is both economical to manufacture and highly suitable for use as a filler in the interwall compartments of double-wall vessels and partions. The interwall compartment can be evacuated to very low pressures without danger of entrainment of the packing and without atmospheric pollution, and because of the ease of handling, many of the other problems hitherto encountered in insulating fillers are avoided.

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a perspective view of a laminate strip prior to thermal rolling to form an insulating body in accordance with this invention;

FIG. 2 is a perspective view of the curved three-dimensional body; and

FIG. 3 is a fragmentary cross-sectional view through a portion of a double-wall vessel containing the packing of the present invention.

Referring first to FIG. 3, it will be seen that a double-wall vessel for the storage, transportation and handling of low boiling-point liquefied gases can consist of an inner wall **10** of glass or metal which is spacedly surrounded by an outer wall **11** of similar or different material, the walls **10** and **11** defining between them an evacuatable

interwall compartment **12** which is filled with random packing **13** of three-dimensional insulating bodies **14** as illustrated in FIG. 2.

The individual insulating bodies can, as may be seen from FIGS. 1 and 2, be formed from a rectangular laminate (FIG. 1) whose sides have a length and width of, say, 1 to 4 mm. and which can be cut uniformly to these dimensions from a sheet or strip. The laminate comprises a substrate **1** in the form of a thermoplastic synthetic resin upon which an aluminum layer **2** is deposited by conventional means (e.g. vapor deposition). The aluminum layer **2** is thus firmly bonded to the substrate **1**. While aluminum has been found to be highly suitable as the material constituting the heat-reflective layer **2**, it will be understood that substantially any metal having a high heat reflectivity and a relatively large coefficient of thermal expansion can be used for the purpose indicated. The thermally insulating substrate **1** can consist of any thermoplastic having a coefficient of thermal expansion of less than that of the metallic layer and poor thermal conductivity and, for these purposes, synthetic resin foils of polyesters such as the methyl esters of polyterephthalates can be used. The only limitation of significance in this regard is that the vapor pressure of the synthetic resin or its components is such as to prevent vaporization of the resin at the low pressures sustained in the interwall compartment.

The rectangular sections illustrated in FIG. 1 are then curved to form three-dimensional hollow bodies as illustrated in FIG. 2 by heating a multiplicity of the rectangular laminate sections simultaneously in a controlled-temperature oven maintained at a temperature above the softening point of the resin (e.g. about 100° C. for the resin indicated) for a short period just sufficient to permit the aluminum layer to expand and the flow point of the resin to be exceeded. The sections are, consequently, rolled automatically by the thermal effect to a cylindrical configuration (FIG. 2) with the metallic layers disposed along the outer surfaces of the bodies. After this heat treatment, the bodies are cooled and, since the resin layers become rigid, the cylindrical configuration is retained. The packing bodies thus manufactured can be introduced directly into the interwall compartment **12** without further deformation. The bodies themselves are sufficiently rigid in their cylindrical state to preclude densification during evacuation and it has been found that best results are obtained when a loose filling of the mass has a specific gravity of about 20 kp./m.^{3}. The filler has a sufficiently large porosity to permit evacuation of the interwall compartment to a pressure level of about 10^{-4} Torr, thereby eliminating substantially any thermal conductivity effect of residual gases and the thermal barrier is thus particularly suited for low temperature technology or cryogenic applications. Inasmuch as the heat-reflective layers are disposed along the outermost surface of each of the bodies, substantially all of the radiated heat directe dat the barrier is internally reflected and an exceptionally effective block to thermal flow is achieved.

The thermal conductivity of the mass is substantially lower than any which can be obtained by powdery fillers so that a barrier using the improved filler of the present invention can be made less thick than conventional barriers, thereby reducing the size and weight of the vessel. Furthermore, material costs and afterhandling expenses, as well as spatial requirements for storage of the filler are reduced to a minimum. The improved filler also can be employed in the most intricate interwall compartments and thus eliminates the need for various types of fillers for different applications and can be handled without the development of dust. Another advantage of this invention is that the insulating body need be provided only along its outer face with a metallic layer and by varying the dimensions of the rectangular section it is possible to modify the packing density or loose specific gravity of the mass.

I claim:

1. A thermal-insulation system for a double-wall vessel having an evacuated interwall compartment, said system comprising a thermally insulating filler disposed in said compartment and composed of a piled mass of relatively rigid filler bodies, each of said filler bodies being of a generally cylindrical configuration and composed of a rectangular plastically deformable thermally insulating synthetic-resin laminated with a metallic heat-reflective layer with opposite ends of the rectangle being bent toward one another to impart a generally cylindrical tubular configuration to the body, said body being open at opposite axial extremities, said ends being spaced from one another to define therebetween a gap along a generatrix of the body, the metallic heat-reflective layer lying along the exterior of the body.

2. A thermal-insulation system as defined in claim **1** wherein said bodies have axial length and circumferences of at most 4 mm., said metallic layer is composed of aluminum and said synthetic resin is a polyterephthalate ester.

3. A thermal-insulation system as defined in claim **2** wherein said mass has a loose-packed specific gravity of the order of 20 kp./m.^{3}.

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