Sept. 7, 1965 M. P. HNILICKA, JR 3,204,804

INSULATION DEVICE

Filed Oct. 29, 1962

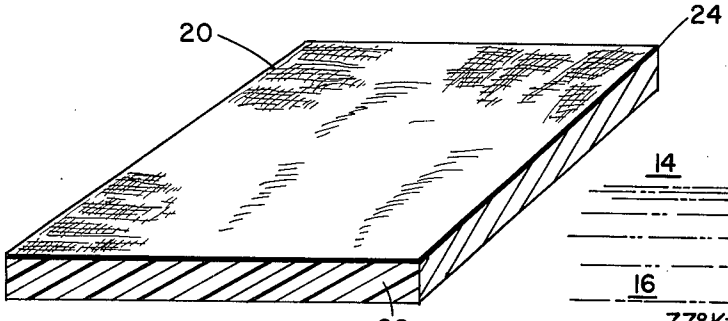
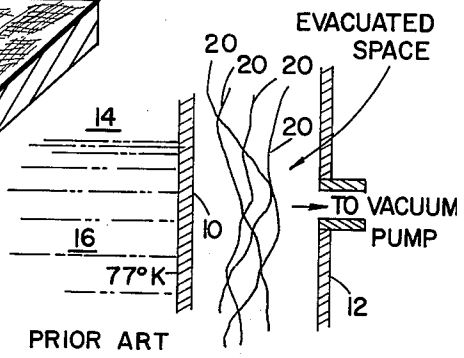


Fig. 1

PRIOR ART



PRIOR ART

Fig. 2

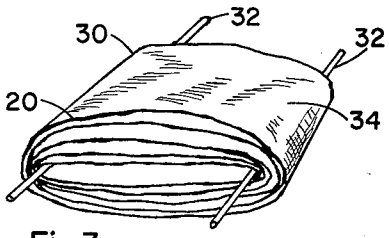


Fig. 3

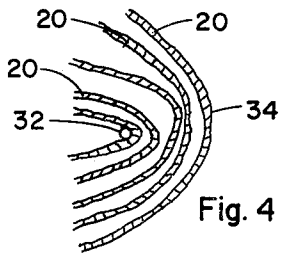


Fig. 4

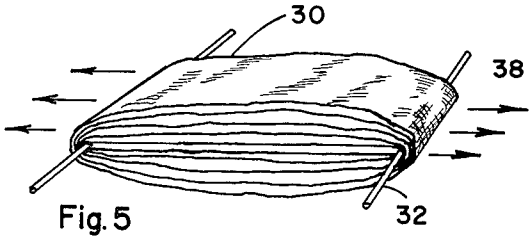


Fig. 5

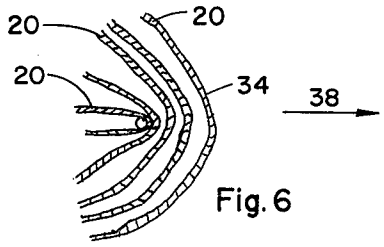


Fig. 6

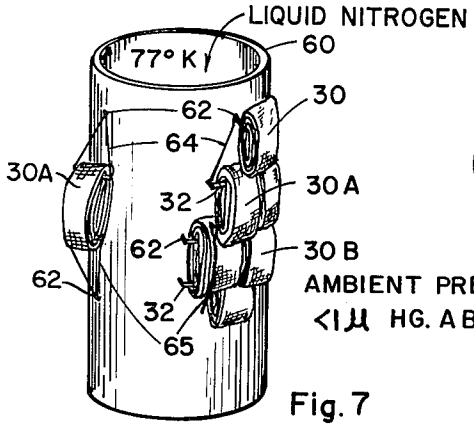


Fig. 7

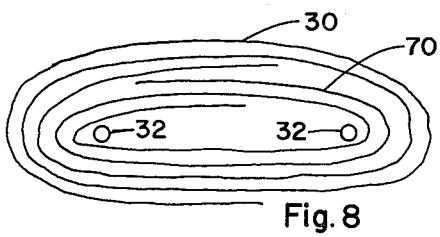


Fig. 8

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3,204,804

INSULATION DEVICE

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4 Claims. (Cl. 220—9)

This invention relates to an improvement in containers, such as storage tanks, pipelines, and the like, for holding materials at a temperature widely different from ambient temperatures and more particularly to containers for holding cryogenic fluids such as liquid nitrogen or liquid hydrogen.

In my U.S. Patent 3,018,016 I described an insulating apparatus comprising a cryogenic fluid container in an ambient pressure of less than 1 micron and a multilayer insulation surrounding the chamber, the insulation comprising a plastic film with a thin metallic coating, the layers of insulation being crumpled or the like to provide only point contact between layers to limit heat transfer by conduction between adjacent layers. The object of the present invention is to provide techniques for applying such insulation to the container and novel arrangements of the insulation itself which are particularly adapted for use in such techniques.

In accordance with the invention, I take long strips of metallized, plastic, as described in my Patent 3,018,016 and wind it in the form of an elliptical spiral. In a preferred embodiment, this is accomplished by holding two dowels apart from and parallel to each other and winding the insulation about the two dowels to form the elliptical spiral. The natural tendency of the insulation material is to form a loose spiral so that adjacent layers make very loose contact with each other at only widely spaced points, but do not lie flush against each other. This is ideal for use in the insulating apparatus of Patent 3,018,016 since it provides a pre-assembled insulation slab which may be applied to a container wall. That is, the spirals can be formed as a standard article of manufacture and applied to the container wall in overlapping relation to each other like shingles on the roof of a house. This provides economy and flexibility in insulating cryogenic fluid chambers.

A second and equally important aspect of the insulating slabs is that they have little tendency to be flattened out by stresses due to their own weight, motion and thermal conditions. This is particularly useful in insulating cryogenic fluid tanks and pipelines in space vehicles wherein liquid hydrogen tanks may be subject to a variety of these stresses. Similar problems arise in cryogenic tanks used on trucks and railroad cars. If the stresses caused the adjacent layers of insulation material to flatten out and touch each other over large areas of contact, there would be substantial heat transfer through the abutting layers. The insulating slabs of the present invention are designed to avoid this tendency.

The invention accordingly comprises, as an article of manufacture, the insulating slabs and, as an apparatus, a container insulated by overlapping insulating slabs, the article the apparatus comprising the respective constructions, combinations of elements and arrangements of parts, which are exemplified in the following detailed disclosure and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing wherein:

FIG. 1 is a dragrammatic, partially sectional view of a piece of the thermal insulation utilized in my invention;

FIG. 2 is a schematic view of a portion of a cryogenic

fluid container insulated in accord with the disclosure of my prior Patent 3,018,016;

FIG. 3 shows an article comprising a slab of thermal insulation according to the present invention;

FIG. 4 is an enlarged view of a corner of the article of FIG 3;

FIG. 5 shows the article of FIG. 3 under stress loading which tends to flatten out the slab;

FIG. 6 is an enlarged view of a corner of FIG. 5;

FIG. 7 is a schematic view of a pipeline partially insulated with overlapping slabs;

FIG. 8 is a schematic view of another embodiment of the invention.

Referring now to FIG. 1, there is shown a piece **20** of thermal insulation which comprises a substrate **22** coated with a thin film of metallic coating **24**. The substrate is preferably an organic plastic selected for its low lateral conductivity. The thickness of the substrate is on the order of ¼ mil. The metal coating preferably has a thickness less than a few microinches so as to provide only slight lateral conduction in the plane of the metal coating. However, the coating is thick enough so that its emissivity is less than .06.

Referring now to FIG. 2 there is shown a portion of a liquid nitrogen container comprising an inner vessel **10** adapted to confine liquid nitrogen **16** in a space **14**. An outer chamber **12** surrounds the inner chamber **10** and defines therewith a space **13** which is evacuated through a suitable outlet **18** to a free air pressure less and .1 micron Hg abs. A plurality of layers **20** of metallized plastic are provided in evacuated space **13**. As illustrated, these layers make only point contact with each other at random locations and serve as radiant heat barriers due to the low emissivity of the metal coating.

Reference is made to Patent 3,018,016 for a fuller discussion of the choice of materials and number of layers of material in relation to the insulating problems to be overcome. It is only important to note for present purposes that it is of the essence to limit contact between adjacent layers of material. In the prior art, this is accomplished by crimping the insulation and wrapping multiple layer blankets about the vessel to be insulated.

FIG. 3 shows the article of the present invention. A long piece of metallized plastic **20** (as shown in FIG. 1) is wrapped into the form of a loose elliptical spiral. Each additional turn makes a new ellipse which is essentially coaxial with the ellipse formed by the previous turn. The spiral is wound about two spaced, parallel dowels **32** which serve as foci for the ellipses.

In wrapping the elliptical spiral by hand, the resilience of the organic plastic substrate insures that a loose spiral will be obtained which random point contact between adjacent layers of the material. Machines can be used to wrap the spiral. These should be arranged so that a loose spiral is obtained. One preferred technique is to wrap the material around a mandrel to form cylindrical spiral and then removing the mandrel and flattening the cylinder to a loose ellipse. The foci forming supports can then be inserted.

The dowels **32** are preferably supported from the cold wall of the container to be insulated. These constitute the sole linkage transmitting stress from the supporting wall to the slab **30**. Referring now to FIG. 5 the slab **30** is shown in a condition of longitudinal stress indicated by the arrows **38**. The stresses are transmitted to the insulation via the dowels **32** which tend to separate. Any relative movement is taken up by the resilience of the material which increases its resistance to deformation as more layers are subjected to the separating force. Abutting of adjacent layers is limited to the innermost layers and essentially to the ends thereof in proximity to the

dowels. This is illustrated in FIGS. 4 and 6 which show a corner of the slab **30**. In FIG. 4, the slab is in the relaxed condition of FIG. 3 and in FIG. 6 the slab is in the stressed condition of FIG. 5.

The reason that abutting of adjacent layers is essentially limited to the innermost layers can be explained as follows. In the process of wrapping the loose spiral, the outer loops are longer than the inner loops. Since stresses are transmitted to the slab only via dowels **32**, the inner elliptical loops are stretched taut, as illustrated in FIGS. 5–6, while the outer loops are not contacted. As more inner loops are stretched taut, they provide an ever-increasing resistance to longitudinal stresses transmitted to the slab via the foci forming supports, dowels **32**. Thus, the innermost elliptical loops of the continuous spiral provide an inner tension member which takes up stresses.

It is also possible, within the scope of the present invention, to provide a discrete sheath which acts as the inner tension member. Such a sheath could comprise a closed elliptical loop of a strong plastic such as Mylar. The dowels **32** could be inserted into this loop to form its elliptical foci and the insulation material can be wrapped around the sheath as a continuous spiral. The resultant product would look essentially the same as the slab **30** of FIG. 3. Another method of providing the sheath is to make an inner spiral **70** of a material heavier than Mylar, as shown in FIG. 8 and to wrap the insulation material around the inner spiral. The inner spiral can also be interleaved with the first few loops of the spiral of insulating material. In either event, the inner spiral should be selected for its strength and low heat conductivity. The inner spiral can be a mesh rather than a solid material since this reduces lateral heat conductivity.

FIG. 7 shows a section of a pipeline **60** for conveying liquid nitrogen. The pipe is partially covered with the insulating slabs **30** of FIGS. 3–6. Each of the slabs may be as much as 50 feet in length. Two types of supports for mounting the slabs are shown.

One type of support is shown as strings **64** and **65** attached to dowels **32** of slab **30A** of the slabs and to a bracket anchored to the pipe **60**. Another mode of support is to anchor the dowels **32** directly to such brackets **62** as shown on slab **30B**. Alternatively, the dowels **32** can be part of a frame which is in turn supported from the container.

Several variations may be employed within the scope of the invention. The dowels which serve as foci of the spiral ellipses may be replaced by the supporting strings. Any tendency of the strings to cut the insulation can be avoided by providing protective sheaths around the strings or as an inner elliptical sheath between the foci and the spiral ellipse, as discussed above.

An additional advantage of the elliptical slab arrangement of the thermal insulation is that it can take up longitudinal stresses in the direction of either focus of the ellipse. This freedom of operation makes the slabs particularly suitable for cryogenic containers in space vehicles.

The overlapping relation of the slabs in FIG. 7 reduces edge losses. While the foci of the elliptical slabs may be connected to other supports, it is preferred to mount them on the cryogenic chamber as shown in FIG. 7. This is the least complex and most compact arrangement since the insulation should be close to the cryogenic container and it preserves freedom of design of components located outside the container, such as the outer wall **12** of FIG. 1.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description, or shown in the accompanying drawing, shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an insulated container for confining a liquefied gas at cryogenic temperatures when used in ambient pressures of less than 1 micron, said container having a gas-tight wall and an insulating blanket supported against the exterior surface of the wall, an improved insulating blanket comprising a plurality of overlapping insulation slabs, each of said slabs comprising flexible, plastic sheet, with a metal coating, the metallized plastic being constructed to provide an emissivity of less than .06 and a composite lateral heat conductivity of less than 10×10^{-6} watts per square per ° K. at 300° K., wound around two thermally isolated spaced supporting surfaces in the form of a multilayer spiral ellipse, having its foci in the region of said spaced surfaces, the metallized sheet being deformed as by crumpling so that contact between adjacent layers of the spiral ellipse is limited essentially to random point contact, the spaced surfaces associated with each slab being connected to supporting means for holding the slab in its position relative to the container, whereby the innermost turns of the spiral act as a tension member arranged in the interior of each slab to take up stresses transmitted to the slab via said surfaces, and a second tension member provided within the above said tension member.

2. The container of claim **1** wherein the spaced, supporting surfaces consist of spaced, parallel dowels supported from the container wall.

3. The article of claim **1** wherein the second tension member consists of a closed elliptical loop of a plastic material.

4. The article of claim **1** wherein the second inner tension member consists of a spiral wound loop of plastic material which is metallized and deformed, as by crumpling, to provide point contact between adjacent turns of the spiral.

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