The present invention concerns heat insulation under vacuum, including means of reflecting infra-red radiation, and intermediate means of a material of low heat conductivity, in particular for containers of liquefied gas at low temperature such as liquid nitrogen, oxygen, hydrogen and helium.

It is known that for insulation maintained under vacuum to eliminate the transmission of heat by gaseous convection an important fraction of the heat flux at low and very low temperature is provided by infra-red radiation towards the cooler walls of the insulation. Means have already been proposed for stopping this flux by arranging reflecting means such as polished metal sheets or metal flakes, in its path. These sheets or flakes must naturally be kept separated from each other because of their high thermal conductivity. For this purpose either thin sheets of fibres of low thermal conductivity, or a powder on a material possessing the same property are used. Insulation of the type defined in U.S. patent application Ser. No. 196,986, filed May 23, 1962, now Patent No. 3,218,816, and assigned to the assignee of the present application in which the sheets of insulating fibres consist of a fabric formed from these fibres, and in which there are empty spaces between the weft and warp threads, has shown itself to be particularly efficient.

Hitherto the material generally used for the thin sheets has been glass, by virtue of the ease of manufacture of glass fibres of very small diameter (a few microns or even less). For insulating powders, various oxides such as silica gels, diatomaceous earth, or the natural silicates known as perlite have been used. Although such thermal insulation allows for the storage of liquefied gases for several days with acceptable losses by vaporization, the development of the use of extremely volatile gases such as hydrogen or helium in the liquid state, require the development of heat insulation still more efficient than that already known, in order to keep the liquefied gases for long periods in containers whose insulation is not to increase the volume excessively.

It has been discovered according to the invention that, in contrast to what one would have expected, the residual thermal conduction in known insulation is largely due to the fact that the material of the intermediate means, such as glass, silica gel or perlite, has a high absorption coefficient for infra-red radiation. Although a consequence of this property is to reduce the transmission of infra-red radiation from a reflecting means situated in a relatively warm zone towards the adjacent reflecting means situated in a relatively cooler zone, it has been found that this favourable effect was more than compensated by the undesirable effect due to the diminution in the reflection coefficient of the reflecting means because of its contact with particles of a partially absorbing material ("soiling" effect of the reflecting means).

According to the invention the thermal insulation is characterised in that the material of the given intermediate means possesses a high infra-red transmission coefficient, at least in the range of wave lengths corresponding to the heat emission in the temperature zone in which the intermediate means is situated.

FIGURE 1 is a graph showing transmission coefficient T in percent as a function of the infra-red wavelength, and FIGURE 2 shows a structure of heat insulation material in a diagrammatic, schematic, cross-sectional view of a preferred embodiment of the invention.

Few materials exist which possess a high infra-red radiation transmission coefficient through the full spectrum of wave-lengths. It is however the case for polytetrafluoroethylene, generally sold under the trademark "Teflon." This material is particularly suitable in the temperature zone between 150° and 75° K. In the temperature zone between ambient temperature and 250° K. arylic pentaselenide, As2Se3, can also be used, and in the zone between 250° K. and 150° K. polyethylene or polystyrene may be used.

By way of illustration, FIG. 2 of the drawing shows a thermal insulation structure made up by the stacking of thin sheets 4 of polished aluminium, separated by sheets 5 each comprising a polytetrafluoroethylene fabric of thickness 0.16 mm. The average mesh width of the fabric is 2 mm. and each thread of the fabric comprises 15 elementary fibres of polytetrafluoroethylene of 18 microns diameter, the diameter of the thread obtained being 160 microns. The area density of the fabric obtained is 23.6 gm./m.². The polytetrafluoroethylene used had an infra-red transmission coefficient, in the wavelength range between 25 and 45 microns inclusive, of between 75 and 85% (see graph in FIG. 1 showing the transmission coefficient T (in percent) as a function of the infra-red wavelength). Such insulation gives a heat transmission coefficient appreciably less than an equivalent insulation in which the intermediate sheets are of a fabric of glass fibres of similar diameter, because of the reduction in the reflecting power of the screens due to their contact with the glass fibres, which have a large absorption coefficient for the radiation.

The thermal insulation structure thus far described is disposed in a vacuum space 3 afforded by the inner wall 1 and the outer wall 2 of a container for liquefied gases.

What we claim is:

1. A heat insulating structure for containers for liquefied gases at low temperatures, comprising in an evacuated space between an inner and an outer wall, a plurality of reflective polished aluminium sheets spaced apart within said evacuated space and being substantially parallel to said container walls for reflecting infrared radiation, and intermediate spacing means comprising sheets of a woven fabric of polytetrafluoroethylene, which there are empty spaces between the weft and the warp threads, said spacing means being disposed between said aluminium sheets and between said aluminium sheets and at least one of said container walls and in contiguous relation therewith, and possessing a high infrared transmission coefficient in the wavelength range for heat emission in the temperature zone in which said intermediate means is situated.

2. The invention according to claim 1 in which said intermediate means is effective from 75° K. to 150° K.

5. A heat insulating structure for containers for liquefied gases at low temperatures, comprising in an evacuated space between an inner and an outer wall, a plurality of reflective polished aluminium sheets spaced apart within said evacuated space and being substantially parallel to said container walls for reflecting infrared radiation, and intermediate spacing means comprising sheets of a woven fabric of a polymer from the group consisting essentially of polyethylene and polystyrene, being effective from 150° K. to 250° K., in which there are empty spaces between the weft and the warp threads, said spacing means being disposed between said aluminium sheets and between said aluminium sheets and at least one of said container
walls and in contiguous relation therewith, and possessing a high infrared transmission coefficient in the wavelength range for heat emission in the temperature zone in which said intermediate means is situated.

4. A heat insulating structure for containers for liquefied gases at a low temperatures, comprising in an evacuated space between an inner and an outer wall, a plurality of reflective polished aluminum sheets spaced apart within said evacuated space and being substantially parallel to said container walls for reflecting infrared radiation, and intermediate spacing means comprising sheets of a woven fabric of arsenic pentaselenide, being effective from 250° K. to ambient room temperature, in which there are empty spaces between the weft and the warp threads, said spacing means being disposed between said aluminum sheets and between said aluminum sheets and at least one of said container walls and in contiguous relation therewith, and possessing a high infrared transmission coefficient in the wavelength range for heat emission in the temperature zone in which said intermediate means is situated.

References Cited

UNITED STATES PATENTS

- 1,151,321 8/1915 Woodward.
- 2,910,763 11/1959 Lauterbach.
- 3,007,596 11/1961 Matsch 220—9
- 3,199,715 8/1965 Psivanis 220—9
- 2,804,886 9/1957 White.
- 3,136,680 6/1964 Hachberg 161—189

FOREIGN PATENTS

- 488,767 12/1952 Canada.

THERON E. CONDON, Primary Examiner.
JAMES R. GARRETT, LOUIS G. MANCENE, Examiners.