

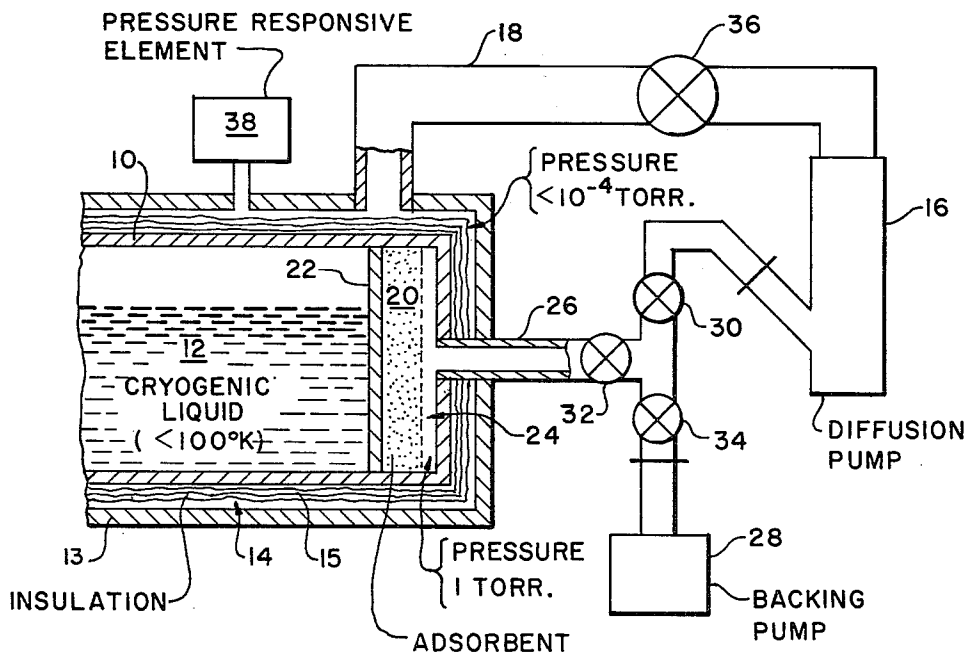
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INSULATION DEVICE

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INVENTOR.

BY

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INSULATION DEVICE

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This invention relates to the insulation of containers and particularly to maintaining the efficiency of vacuum insulation of containers for cryogenic liquids and other materials conventionally stored or transported at very low temperatures.

Recently developed "superinsulations" of the general type described in British Patent 853,585 or my copending application S.N. 842,139, filed September 24, 1959, now Patent No. 3,018,016, derive their impedance to heat flux from the effect of multiple radiation barriers. The absence of residual gas conduction by evacuation to high vacuum is essential to proper function of all these "superinsulations."

Thus, a major problem involved in the use of these types of insulation is that of maintaining a high vacuum during the required insulation period. For example, should a slight leak occur the absolute pressure of the system will rise and the thermal conductivity of the system will increase. This increase is due to the increase in thermal conduction by the increased residual gas in the insulated vacuum space.

Accordingly, it is a principal object of the invention to provide an insulation unit of simple construction which will maintain a high insulation vacuum over long insulation periods.

Another object of the present invention is to provide an insulated container and means by which the vacuum is self-renewing and self-sustaining.

A further object of this invention is to provide an insulation container which will sustain a high vacuum in the evacuated space and which is a complete unit having virtually no moving parts.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure and the scope of the application of which will be defined 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 which is a schematic, diagrammatic sectional illustration of one preferred form of apparatus embodying the present invention.

Briefly stated, the objects of the invention are accomplished by providing a vacuum-tight container for an adsorbent material which is preferably positioned within the insulated container so as to be cooled to cryogenic temperatures. The adsorbent material is connected by suitable conduit means to the discharge port of a diffusion pump. The diffusion pump is positioned outside of the vacuum vessel but connected so that it can evacuate the insulating portion of the vessel. Thus there is provided a novel arrangement wherein the adsorbent material, when at cryogenic temperature, acts in the capacity of a "backing pump" for the diffusion pump. The advantages of such an arrangement will now be described in detail.

It has been proposed in prior art methods that an adsorbent material be inserted into the evacuated insulation space to maintain the vacuum. According to prior art methods, the adsorbent material is arranged in the vacuum space so that it is in direct communication with the vacuum space.

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In order to chill the adsorbent it has been the practice to place the adsorbent in contact with the insulated vessel so that when the vessel is filled with a liquefied gas, for example, the adsorbent will come to the same low temperature as the liquefied gas. An adsorbent such as calcium zeolite "A" described in U.S. Patent No. 2,900,800, when at -180°C. and at 1 torr (1 mm. Hg abs.) can adsorb 200 volumes of gas at standard temperature and pressure (STP) for each volume of adsorbent. At the same temperature (-180°C.) but at a pressure of 10^{-5} torr, the same adsorbent can adsorb only 0.07 volume of gas at STP for each volume of adsorbent.

According to prior art methods, one liter of zeolite "A," for example, when placed in the evacuated space at a pressure of 10^{-5} torr and at a temperature of -180°C. , can keep adsorbing gas at 10 liters per second for 170 hours.

In contrast, one liter of zeolite "A," according to the present invention, can be placed in a vacuum-tight container comprising an "adsorbent space" which is preferably positioned in heat transfer relation to the liquefied gas so as to be chilled to the temperature of the liquefied gas (e.g. -180°C.). The adsorbent space is not directly connected open to the evacuated insulation space (which is at 10^{-5} torr) but is, instead, connected to the outlet of a pump which is arranged to pump the insulation space. This pump, which can be a diffusion pump, has inherently a high compression ratio, allowing discharge into a forepressure of for example 1 torr. Hence, the diffusion pump pumps gas from the evacuated insulation space to maintain a pressure of 10^{-5} torr in the "insulation space" and discharges the pumped gas, after compression, into the "adsorbent space" at a pressure which can attain 1 torr. Thus the zeolite "A" adsorbent, while at a temperature of -180°C. , will be adsorbing gas at 1 torr and not at 10^{-5} torr as in prior art methods and apparatus. Since the adsorption capacity rapidly increases with pressure, 1 liter of zeolite "A" can hold 200 liters of gas at 1 torr, and the liter of zeolite "A" will keep adsorbing gas at 10 liters/sec. for 432,000 hours or about 2500 times longer than that of the prior art apparatus.

The advantages of the present invention are more readily apparent when the insulation period is determined for a system having a leak, for example, of 0.1 micron liters per second (1×10^{-4} torr liters/second). One volume of zeolite "A" adsorbent at -180°C. and at a pressure of 10^{-5} torr could maintain the evacuated space at 10^{-5} torr for approximately six days. The same adsorbent material at -180°C. , when arranged to adsorb pumped gas, after compression by a diffusion or other suitable pump to a pressure level of 1 torr, can maintain the evacuated space at 10^{-5} torr in the presence of a leak of 0.1 micron liter per second for approximately 48 years.

Referring now to the drawing there is shown one preferred embodiment of the present invention. The insulated container comprises an inner vessel 10 adapted to confine a cryogenic liquid 12, the liquid being at a temperature of less than 100°K. and at about atmospheric pressure. An outer chamber 13 surrounds the inner chamber 10 and defines therewith a space 14 which is evacuated to a free air pressure on the order of 10^{-2} to 10^{-3} microns Hg abs. (10^{-5} to 10^{-10} torr). Space 14 contains a "superinsulation" schematically indicated at 15. A diffusion pump 16 is connected by a conduit 18 to the space 14 to be evacuated so as to maintain the evacuated space 14 under high vacuum.

An adsorbent material 20 is held in heat transfer relationship with the cryogenic liquid by means of a wall 22 separating an end portion of the tank 10 to provide a separate chamber 24. Chamber 24 is connected by means of a pipe 26 to the foreline of diffusion pump 16 and also to the backing pump 28. Three valves, (30, 32 and 34) are provided to permit operation of

the backing pump and diffusion pump in any predetermined sequence. A valve 36 is also provided for isolating the diffusion pump from the insulation space 14. A suitable pressure responsive element 38 is preferably provided for monitoring the vacuum in the insulation space 14. In a preferred embodiment of the invention the pressure responsive element automatically controls the operation of the diffusion pump and turns it on when the pressure in space 14 has risen much above 1×10^{-5} torr.

In a preferred embodiment of the invention the inner tank 10 is formed of stainless steel and the insulation 15 comprises crinkled metallized plastic of the type described in my copending application, Serial No. 842,139, filed September 24, 1959. The adsorbent material 20 is preferably a commercially available zeolite "A" of the type described in U. S. Patent 2,900,800. The diffusion pump 16 is a standard oil vapor or mercury vapor diffusion pump and the pump 28 can be a small mechanical vacuum pump. When the insulated container is mounted on a trailer, for example, the backing pump 28 can be removed from the system after the initial evacuation thereof and the adsorbent 20 then acts as the backing pump for the diffusion pump 16.

In the operation of the system shown with no cryogenic liquid in the tank 10, the adsorbent chamber 24 is first preferably evacuated while the adsorbent 20 is at ambient temperature. This is achieved by operating the backing pump 28 with valves 34 and 32 open and valve 30 closed. When a predetermined low pressure of the order of 1 torr is obtained, the valve 32 is closed and valves 30 and 36 are opened to evacuate the insulation space 14. With the diffusion pump operating, this space is evacuated to a low pressure less than 10^{-4} torr. Thereafter valve 32 is opened while valves 36, 30 and 34 are closed and the tank 10 is filled with cryogenic liquid 12. This will tend to lower the pressure in the insulation space 14 even below the pressure obtained with the diffusion pump. Assuming that there are no leaks in the system it will remain indefinitely at this low pressure. However, if there is a small leak, the pressure in the insulation space 14 will gradually rise. When it reaches a pressure on the order of 1×10^{-5} torr, the pressure sensing element 38 starts the diffusion pump 16, opens the valve 36 as well as valve 30. As a result of this, gases leaking into the space 14 are pumped out through the diffusion pump 16 where they are compressed up to a pressure on the order of 1 torr and adsorbed by the cold adsorbent 20. When the pressure in the insulation space 14 drops to a predetermined low value the pump 16 is turned off and the valves 36 and 30 are again closed. During this operation it is apparent that backing pump 28 serves no useful purpose and need not be connected to the system and can be disconnected after initial pumpdown.

While one preferred embodiment of the invention has been described above, numerous modifications can be made without departing from the spirit of the invention. For example, numerous other adsorbents such as carbon, silica gel, alumina and other adsorbent materials having high adsorptive capacity at low temperature can be employed. Additionally a heater can be provided for assisting in initial pumpdown of the adsorbent. While a diffusion pump is preferred to compress the gases from the insulation space, other types of pumps may be employed. Similarly, other types of multiple radiation shields may be utilized in place of the preferred metallized plastic type described in my above-mentioned copending application.

Depending upon the use to which the insulated container is to be subjected, it may be made more or less automatic in its operation. Thus, for example, the pressure responsive element 38 can be utilized to start an automatic sequence of operations which will involve the heating of the diffusion pump and opening of valves

36 and 30 to permit evacuation of the space 14. When a predetermined low pressure has been achieved, the reverse sequence of operations can be automatically achieved by the pressure responsive element to provide closing of the valves 30 and 36 and removal of power from the diffusion pump. When such a system is mounted on a trailer, it can be battery-operated to provide complete independence of any external power supply. While it is preferred that space 14 be initially evacuated, it can have a pressure of a condensable gas such as CO_2 which is completely condensed to evacuate the space when a cryogenic liquid is provided in the inner tank 10.

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 shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. An insulated vessel comprising an inner chamber to be maintained at a predetermined low temperature below about 100°K. , an outer chamber spaced from said inner chamber and sealed to form a vacuum-tight insulation space therebetween, and means for maintaining said vacuum-tight insulation space at a pressure less than 10^{-5} torr, said means comprising a vacuum-tight container having therein an adsorbent material arranged in heat exchange contact with said inner chamber so as to be cooled to a temperature below 100°K. and pump means for removing gases from said vacuum-tight insulation space and compressing said gases to a pressure on the order of 1 torr, the discharge from said pump being connected to the container for said adsorbent material so that said adsorbent material can adsorb said compressed gases.

2. An insulated vessel comprising an inner chamber to be maintained at a predetermined low temperature below about 100°K. , an outer chamber spaced from said inner chamber and sealed to form a vacuum-tight insulation space therebetween, and means for maintaining said vacuum-tight insulation space at a pressure less than 1×10^{-5} torr, said means comprising a vacuum-tight container having therein an adsorbent material arranged in heat exchange contact with said inner chamber so as to be cooled to a temperature below 100°K. , pump means for removing gases from said vacuum-tight insulation space and compressing said gases to a pressure which is at least 100 times greater than the pressure to be maintained in said insulation space, and means for conducting said compressed gases to said cold adsorbent material.

3. An insulated vessel comprising an inner chamber to be maintained at a predetermined low temperature, said inner chamber being defined by a first wall, a second wall outside of said first wall and spaced therefrom, said walls being sealed to form a vacuum-tight space therebetween, a vacuum-tight container of gas-adsorbent material constructed and arranged to be in thermal contact with said inner chamber, a plurality of radiant heat barriers surrounding said inner wall and said vacuum-tight container, conduit means in said second wall connecting said vacuum-tight space with a diffusion pump and conduit means constructed and arranged so that said adsorbent material receives gases discharged from said diffusion pump.

4. An insulated vessel comprising an inner chamber to be maintained at a predetermined low temperature below about 100°K. , an outer chamber spaced from said inner chamber and sealed to form a vacuum-tight insulation space therebetween, a plurality of radiant heat shields in said insulation space, means for maintaining said vacuum-tight insulation space at a pressure less than 1×10^{-5} torr, said means comprising a vacuum-tight container having therein an adsorbent material arranged in heat exchange contact with said inner chamber

so as to be cooled to a temperature below 100° K., a vacuum pump capable of pumping said insulation space to a pressure less than 1×10^{-5} torr and compressing said gases to a pressure which is at least 100 times greater than the pressure to be maintained in said insulation space, and means for conducting said compressed gases to said adsorbent material, and means responsive to the pressure in said insulation space for controlling the operation of said vacuum pump.

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