

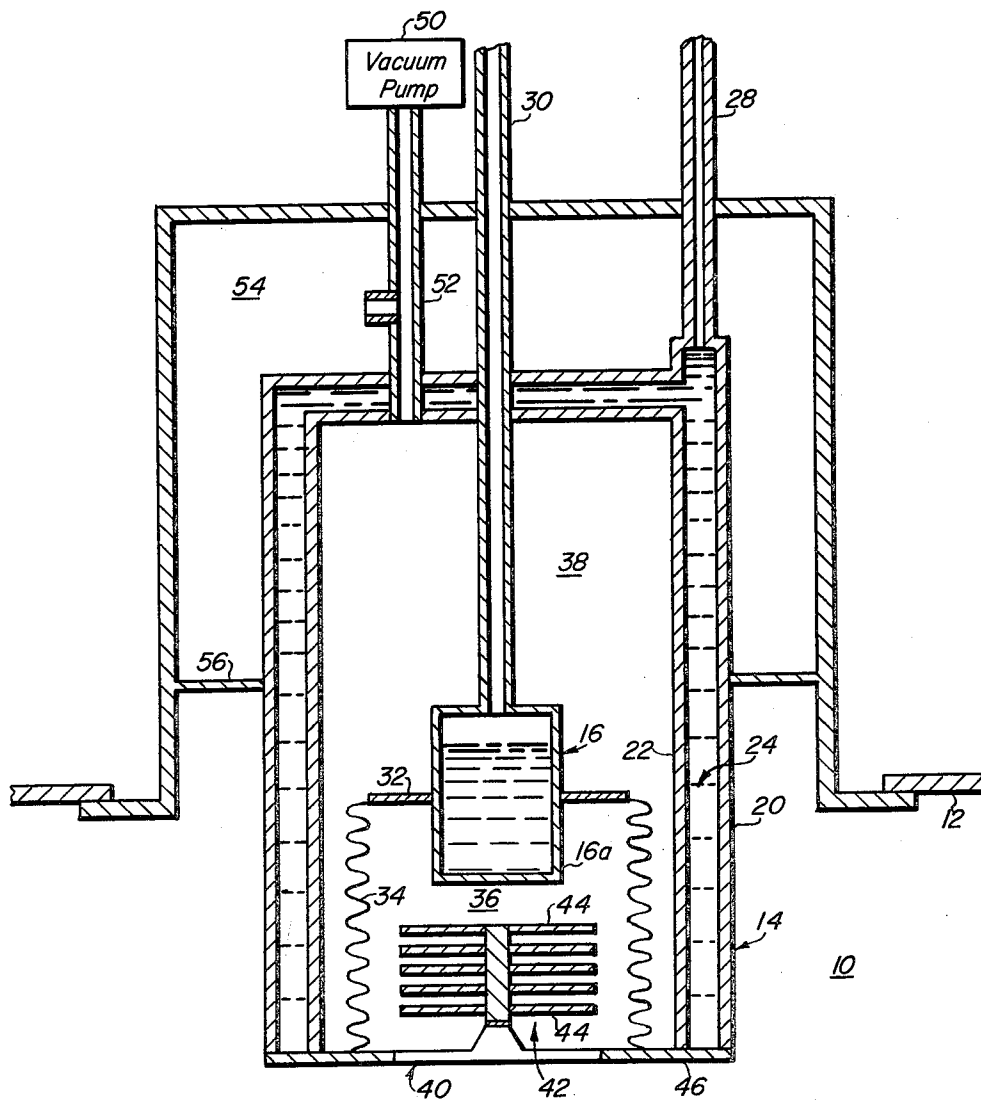
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PUMPING DEVICE

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PUMPING DEVICE

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11 Claims. (Cl. 230—69)

This invention relates to pumps. More particularly, it relates to high-vacuum pumps.

The principal object of the invention is to provide a system which will produce lower pressures than can be obtained simply through using a diffusion or high-vacuum pump by introducing an improved cryogenic pump into the system.

A second object of the invention is to condense residual vapors within a chamber by means of a cryogenic pump having an inner and an outer container so that the consumption of cryogenic fluid is minimized.

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

The present invention accordingly comprises a high-vacuum cryogenic pump with a double-walled outer container supported within a vacuum chamber. The outer container holds a cryogenic liquid such as liquid nitrogen. The pump also includes an inner container holding an even colder cryogenic liquid such as liquid helium. The inner container is spaced inside the outer container and the parts of said pump arranged so that substantially no radiant energy can reach the inner container directly from outside the outer container and so that the vapors in the chamber to be evacuated can pass by diffusion into contact with the inner container. In a preferred embodiment, there is provided a separate evacuated chamber between portions of the inner and the outer containers. In a preferred embodiment, the outer surfaces of the outer container are reflective to radiant energy and the inner surfaces of the outer container adjacent the diffusion path for the gases to be pumped are ideally black.

If a surface layer of gas molecules is condensed upon the walls of the cryogenic pump, the accommodation coefficient (the ratio of molecules condensed to molecules incident upon a surface) will decrease. The present invention avoids that problem in that neither of the cryogenic liquids is placed in either of the two containers until the pressure within the chamber is low enough (e.g. 10^{-4} mm. Hg abs.) so that most of the gases adsorbed on the walls of the chamber are removed and the chamber is "outgassed." When the chamber is outgassed, then the "warmer" of the refrigerants is introduced to the outer container of the cryogenic pump to condense all gases remaining within the chamber which will be condensed by the "warmer" cryogenic liquid. When the warmer cryogenic liquid is liquid nitrogen, it will condense water vapor, CO_2 , hydrocarbons and the like. Since the inner chamber is still at an elevated temperature with respect to the liquid nitrogen cooled outer container, the condensation surface of the inner chamber will remain free of all condensed vapors. Thereafter the "colder" liquid (i.e. liquid helium) is poured into the inner container and substantially all of the residual gases, except helium and a small amount of hydrogen are condensed immediately.

Referring now to the drawing, there is illustrated a schematic, sectional, fragmentary view of one preferred

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embodiment of the invention. The space to be evacuated is generally indicated at 10, only a small portion of the confining wall of the vacuum system being shown at 12. The cryogenic pump of the present invention is supported in a portion of the chamber 10 and comprises an outer container generally indicated at 14 and an inner container generally indicated at 16. The outer container preferably includes wall 46 and two walls 20 and 22 defining a space 24 therebetween for receiving liquid nitrogen through a filling tube 28. The inner container 16 is arranged to receive liquid helium through a filling tube 30. The inner container 16 supports a wall 32 and a wall 34 which is flexible. These walls 32 and 34 separate space 36 from space 38, as will be more fully described hereinafter. Wall 46 supports the other end of wall 34. The space 36 is in free communication with the space 10 to be evacuated through an opening 40. A radiation shield 42, comprising a plurality of radiation heat barriers 44, is supported above the opening 40 in position to permit ready diffusion of gases therepast. The shields 44, wall 34 and wall 46 prevent direct impingement of radiant energy from chamber 10 onto the inner container 16. The inner surface of walls 32 and 34 facing space 36 are preferably blackened to prevent reflection of radiant heat.

The space 38 outside the walls 32 and 34 is arranged to be evacuated to a low pressure, for example 10^{-3} mm. Hg abs. or lower, by means of a vacuum pump 50 which is connected to an evacuation tube 52. Tube 52 also preferably communicates with a space 54 adjacent the upper end of the outer container 14. A wall 56 preferably isolates the space 54 from the chamber 10.

In a preferred embodiment of the invention, the various portions of the pump are preferably formed of metal to permit ready outgassing by being heated to elevated temperatures. The physical supports, such as the wall 56 and tubes 28, 30 and 52, are preferably formed of thin stainless steel of low conductivity to serve as insulators. Outer container 14 can be formed of stainless steel or a heat conductor, such as copper, when it can be conveniently suspended by a system preventing undue heat transfer.

In the operation of the system described above, vacuum chamber 10 will be evacuated by a suitable pump, not shown, and the system will be heated during pumpdown so as to drive off adsorbed gases and liquids. During this time, chambers 10, 36, 38 and 54 will be maintained at essentially the same pressure. With diffusion and mechanical vacuum pumps, a pressure on the order of 10^{-4} mm. can be readily attained. At this time, particularly at elevated temperatures, most of the adsorbed gases are removed from the system. Liquid nitrogen is then introduced to the outer container 14 by means of filling pipe 28 so as to lower the temperature of the outer container to -190°C . This temperature is sufficiently low to condense water vapors, carbon dioxide, residual hydrocarbons and the like. This temperature will not condense hydrogen, the noble gases, carbon monoxide or oxygen at the low pressure in the system. Thereafter, liquid helium is introduced into the inner container 16 through the filling pipe 30. This cools the surface of inner container 16a to a temperature of -268.9°C . (4.2°K .) so that all residual gases in the system other than helium and a small amount of hydrogen are condensed on surface 16a.

As the system operates, some of the helium will inevitably boil off from the inner container 16 and will escape through the pipe 30 when it may be recovered. Accordingly, the liquid level in container 16 will drop. However, since space 38 is isolated from space 36 by the walls 32 and 34, substantially no gases, initially condensed on the surface 16a, will reevaporate through the space 36, al-

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though gases condensed on 16 in space 38 may be reevaporated into that space as the level of the liquid helium drops. This immobilization of gases on surface 16a will be maintained in space 36 so long as the level of liquid helium is maintained equal to or above the partition 32.

There are several variations and embodiments of the present invention. One of these is the use of activated charcoal to absorb molecules of gas surrounding the inner container. A second variation consists of replacing the heat shield 44 with a hollow heat-reflective baffle holding cryogenic liquid to cool gases entering the pump and insulate the pump from radiant energy. Another variation comprises using cryogenic liquid refrigeration to insulate the liquid helium inlet tube. One further embodiment of the invention includes completely surrounding the outer wall 20 of outer container 14 with a vacuum space.

The specific geometric patterns shown and mentioned here are illustrative and are not meant to be used in a limiting sense. The positions of the baffles, the methods of limiting radiant heat transfer by use of cryogenic fluid and the use of heat reflective surfaces are all important. However, there are numerous combinations and variations of geometry which will produce the same result and which are embodiments of the present invention.

While the invention is here described with respect to the use of liquid helium and nitrogen, it can be used with any cryogenic liquid which can be conveniently contained in the manner above described.

Certainly the size or shape of the baffle is not to be considered important except insofar as it retards the rate of heat transfer into the cryogenic pump.

Since certain changes may be made in the above process 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. Means for producing high vacuum comprising a cryogenic pump supported inside a vacuum chamber which is to be evacuated to a high vacuum, said cryogenic pump having an inner container holding a first cryogenic liquid and a double-walled outer container, the space between the double walls of the outer container being filled with a second cryogenic liquid, said double-walled outer container being spaced from and substantially completely surrounding said inner container so that substantially no radiant energy can strike said inner container directly from outside said double-walled outer container, said double-walled outer container including an opening providing communication between the vacuum chamber to be evacuated and the space defined by the inner wall of the double-walled container so that gas molecules can

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diffuse from said vacuum chamber into said space for sorption on the surface of the inner container.

2. The apparatus of claim 1 wherein said opening is provided with a heat shield.

3. The apparatus of claim 1 wherein said double-walled outer container is substantially completely within said vacuum chamber and is supported therefrom by a support means having low thermal conductivity.

4. The apparatus of claim 1 wherein a first portion of the space defined by the inner wall of the double-walled container is isolated from a second portion thereof by means of a wall member, said first portion being in communication with said opening and being bounded by a lower part of said inner container.

5. Means for producing high vacuum comprising a cryogenic pump supported inside a vacuum tank chamber, said cryogenic pump having an inner container holding a low-boiling cryogenic liquid and an outer container in heat exchange relationship with a higher-boiling cryogenic liquid, said outer container being spaced from and substantially completely surrounding said inner container so that substantially no radiant energy can strike said inner container directly from outside said outer container, said container including an opening providing communication between the vacuum chamber and the space defined by the inside of the outer container so that gas molecules can diffuse from said vacuum chamber into said space for sorption on the colder inner container.

6. The apparatus of claim 5 wherein a heat shield is supported by said outer container near said opening in position to intersect radiant energy passing through said opening towards said inner container.

7. The apparatus of claim 6 wherein said heat shield comprises a plurality of reflecting surfaces.

8. The apparatus of claim 6 wherein said heat shield is in heat exchange relationship with and is cooled by said higher-boiling cryogenic liquid.

9. The apparatus of claim 5 wherein said inner and outer containers are connected by means of a flexible wall.

10. The apparatus of claim 5 wherein said inner and outer containers are connected by means of a flexible wall and the inner surface of said wall has a low reflectance for radiant energy.

11. The apparatus of claim 5 wherein the inner container is arranged to hold liquid helium and a diaphragm is connected between said inner and outer containers leaving a portion of the outer surface of said inner container exposed to gases flowing in from outside the pump and a baffle structure reflective to light comprising cylindrical metal vanes connected together, said baffle structure being positioned so that no direct ray of radiant energy traversing said opening can impinge upon said inner container.

No references cited.

Notice of Adverse Decision in Interference

In Interference No. 93,406 involving Patent No. 2,985,356, N. Beecher, Pumping device, final judgment adverse to the patentee was rendered Dec. 1, 1964, as to claims 1 and 5.

[*Official Gazette January 19, 1965.*]