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HIGH VACUUM SPACE SIMULATOR

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Sheet 1 of 2

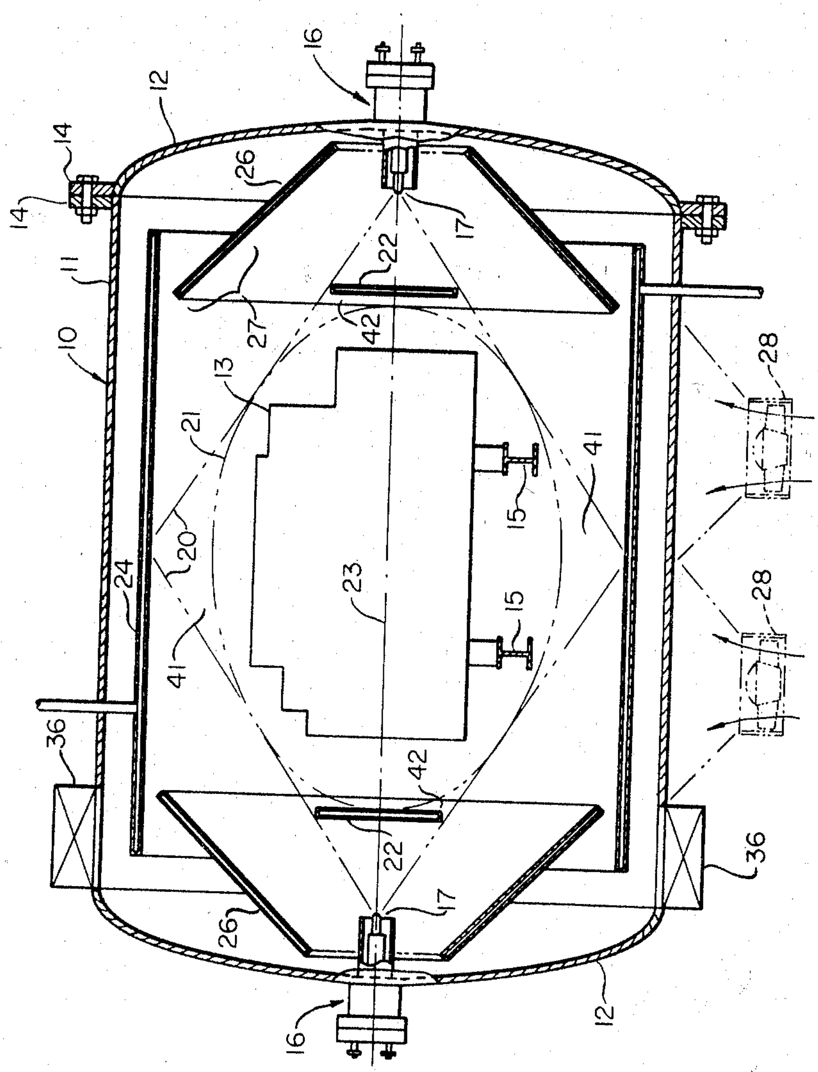

FIG. 1

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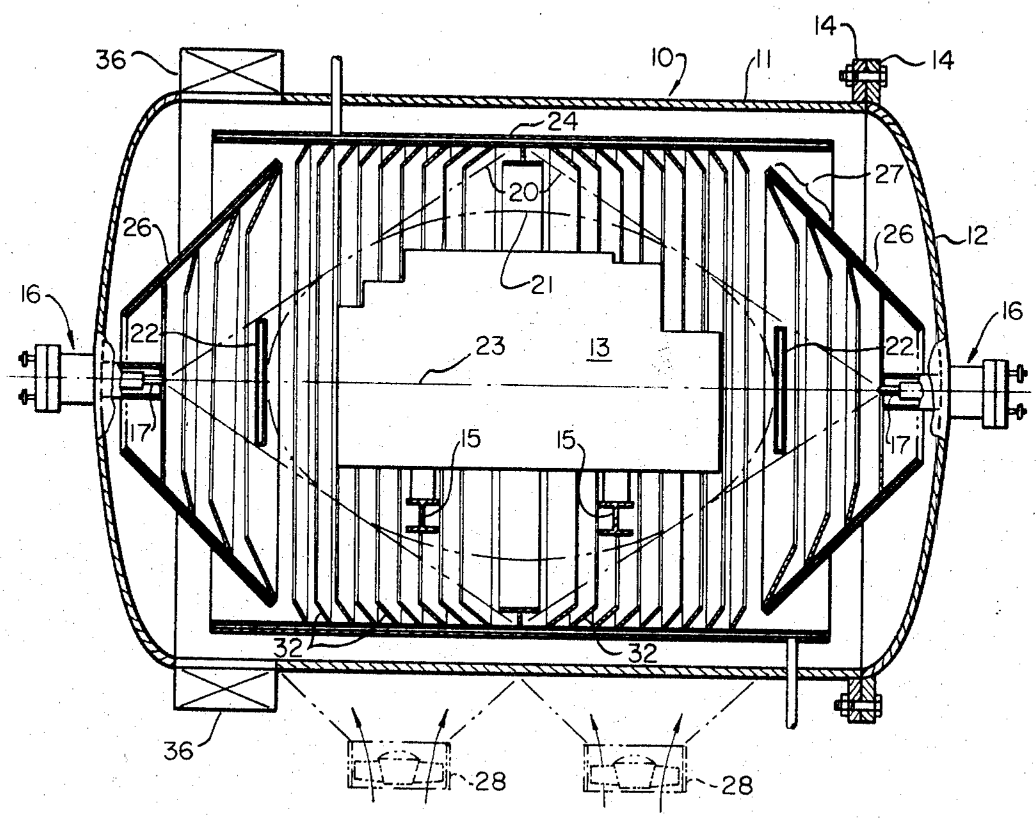

FIG. 2

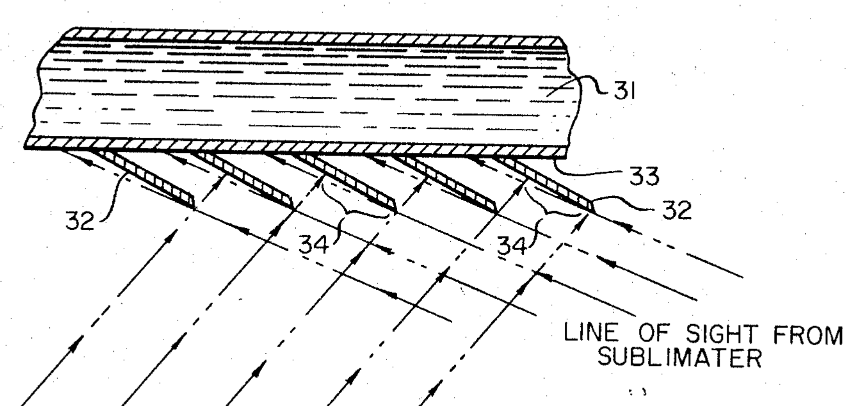

FIG. 3

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HIGH VACUUM SPACE SIMULATOR

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ABSTRACT OF THE DISCLOSURE

High vacuum pump space chamber for receiving a workpiece in a simulated outer space vacuum environment. Shielding defines a work space in the chamber free of sublimated getter material. An imaginary envelope entirely surrounds the workpiece. Molecules of gas passing outwardly through the envelope enter a surrounding pumping zone laid down by screened sublimators, and are pumped so as not to return into the envelope. The envelope defines the most limiting "flow passage" for molecular flow away from the workpiece to the pumping region.

This invention relates to high vacuum apparatus and more particularly to high vacuum apparatus useful in simulating, within a chamber, conditions of outer space whereby a workpiece may be disposed and subjected to such conditions.

In most vacuum systems employing a space chamber for receiving a workpiece, an undesirable differential pressure develops across the workpiece due to the fact that the pumping is mainly done from an end of the system. Thus, a pressure gradient exists across the workpiece, and when space simulation work is undertaken, molecules of gas which leave the surface of the workpiece will be influenced by the gradient and travel toward the pump. The amount of molecular flow from the workpiece is restricted by the least cross-sectional area of any intervening tubulation, including that of the chamber itself in cases where the pump and workpiece are disposed within the same chamber. Pumps are accordingly "conductance limited."

It is a general object of the present invention to provide an improved high vacuum apparatus.

It is another object of the invention to provide an improved high vacuum pumping apparatus which overcomes previous conductance limiting conditions.

It is still another object of the invention to provide a high vacuum pumping apparatus adapted to receive a workpiece and dispose same in conditions closely approximating those existing in outer space.

These and other objects will be more clearly apparent from the following detailed description of preferred embodiments of the invention when taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic sectional view taken through a centerline vertical plane showing the invention;

FIGURE 2 is similar to FIGURE 1 showing another embodiment according to the invention; and

FIGURE 3 is an enlarged detail view, in section, of a portion of FIGURE 2.

In general, the high vacuum apparatus comprises means forming a high vacuum space chamber. Sublimators evaporate getter material onto surfaces within the chamber. Shielding defines a work space within the chamber free of sublimated getter material, whereby the work space is adapted to contain a workpiece to be subjected to high vacuum conditions from which molecules of gas form an outward gas flow therefrom.

The shielding blocks a portion of the distribution of the sublimated getter material thereby protecting the work space from receiving evaporant therein. Surfaces adapted to receive the evaporated getter are formed within the space chamber and arranged to provide a pumping zone or shell substantially entirely enveloping the work space. Thus, the paths of molecules flowing outwardly from the workpiece follow pressure gradient lines which pierce the imaginary bounding surface of an envelope containing the workpiece thereby defining the most limiting flow passage for molecular flow from the workpiece to the pumping region.

Accordingly, an imaginary envelope entirely surrounds the workpiece whereby as molecules of gas pass outwardly through the imaginary envelope they enter a pumping zone and tend not to return, as by rebounding, for example. Since all molecules flow outwardly into an initial exposure with respect to an active pumping zone, the chances of molecules rebounding backwardly into the work space are considerably reduced whereby, to a great extent, outer space conditions are simulated. As is known, molecules emanating from a workpiece disposed in outer space would, in general, pass outwardly and do not return to the workpiece, except as might be occasioned by the gravitational influence of the workpiece itself upon the molecules.

According to the embodiment shown in FIGURE 1, apparatus of the foregoing general description is disclosed. Means forming a high vacuum space chamber **10** include the cylindrical shell **11** formed with a demountable closure **12** at one end so as to be adapted to be removed to permit a workpiece **13** to be positioned within space chamber **10**. Accordingly, flanges **14** are adapted to be bolted to form a sealed closure. I-beams **15** or other suitable means provide a base to support workpiece **13**.

The opposite ends of chamber **10** support a suitable sublimator assembly **16**. One such assembly **16**, for example, is of a type adapted to bombard an elongated charge **17** of getter material by a diffused electron shower surrounding same to produce sublimation outwardly from the getter charge. Preferably, sublimator assemblies **16** are, therefore, of the type wherein charge **17** is adapted to be projected gradually forwardly into chamber **10** as the material thereof is evaporated. The charge **17** is of an active metal for pumping gas such as titanium metal. One such sublimator is presently sold by Ultek Corporation of Palo Alto, Calif.

The work space **20** includes the imaginary spheroidal envelope **21** forming the limiting flow "passage" area for molecules leaving workpiece **13**. A pair of circular plates **22** disposed coaxially of the axis **23** of charges **17** serve to block a portion of the discharge of each sublimator assembly **16** so as to define a getter-free work space within the chamber. Workpiece **13** is thereby shielded from direct receipt thereon of sublimated getter material.

As shown in FIGURE 1, means forming a workpiece-enveloping pumping zone comprises pumping surfaces disposed to receive sublimated getter material. The surfaces are arranged to substantially entirely enshroud imaginary envelope **21** and workpiece **13** therein and are further disposed with respect thereto so that workpiece **13** "sees" substantially only pumping surfaces. Thus, the outflowing molecules of gas piercing envelope **21** from the workpiece make initial contact with surfaces which actively attempt to pump the molecules, thereby minimizing the probability of rebounding such molecules backwardly through envelope **21**.

While it is readily evident that the workpiece **13** has no capability of "seeing," this term is to be understood as having reference to substantially all lines of sight originating on all points of the surface of workpiece **13**. Thus, every line of sight originating from the surface of workpiece 13 extends outwardly from the workpiece to a pumping zone defined as in FIGURE 1 by pumping surfaces enveloping envelope 21.

Pumping surfaces are provided by a cylindrical member 24 disposed within chamber 10 coaxially of axis 23. Member 24 is open at each end to receive a pair of opposed frusto-conical members 26 forming pumping surfaces of revolution diverging axially and radially away from respective ones of the opposed charges 17. The outer margin 27 of each member 26 is received within the ends of member 24 to intercept line of sight emission via envelope 21.

From the disposition of members 24, 26, it will be readily apparent that line of sight emission of evaporant from charges 17 serves to lay down a film of greater material upon the inner surfaces of members 24, 26 so that gas molecules emanating from workpiece 13 will contact the film and be taken out of circulation within chamber 10 (i.e., "pumped").

Preferably, surfaces of members 22, 24, 26 are cooled by forming them at coolant circulating panels adapted to receive a cooling liquid such as refrigerated water. When cryogenic cooling is desired, the panels may receive liquid nitrogen or liquid helium for super-cooling the surfaces thereof.

Thus, members 22, 24, 26 may be double walled members adapted to receive and circulate coolant 31, FIGURE 3, such as liquid helium, water or nitrogen refrigerant.

In some instances air cooling may be employed. For this purpose, the inner cylindrical member 24 would not be required. The outer chamber wall would act as the sublimation surface. Forced air could be directed over the chamber wall for cooling by fans such as shown at 28.

As shown in the embodiment of FIGURE 2, optical baffle means have been interposed between the getter film and work space 20 to substantially minimize reflection of energy backwardly into envelope 21 due to the existence of the applied getter film which is characteristically somewhat reflective. Thus, circumferentially extending around the interior of members 24 and 26, a plurality of axially spaced frusto-conical annular fins 32 are supported in overlapping relation to extend generally in the direction of a source of getter material being sublimated and spaced to permit arriving getter material to pass therebetween. From inspection of FIGURE 3, it will be noted that fins 32 are arranged at a slight angle to the direction of the arriving evaporant whereby a portion 34 of that surface of each fin 32 which faces imaginary envelope 21 receives no deposit of getter material thereon, while the reverse surface of the fin becomes coated with the getter film, as do the hidden cylindrical surface portions 33.

In simulating conditions of outer space (where a workpiece would be expected to "look out" upon black conditions so as to return little or no energy back to the workpiece), the surface portions 34 are preferably suitably blackened so as to simulate such conditions. By depositing getter material on the back sides of fins 32 as well as upon cylindrical surfaces 33, the gettered area is substantially increased so as to produce additional pumping.

Finally, means for pumping noble gases have been provided in each embodiment so as to add pumping speeds for gases not handled by the sublimation device and/or the cryogenic panels.

It has been observed that, for example, in the case of liquid nitrogen-cooled panels, argon would probably need to be pumped by suitable means, such as ion pump elements 36 encircling one end of chamber 10. On the other hand, in the case of helium-cooled panels, the helium would, to some extent, tend to cryopump even the noble gases.

Operation of the apparatus proceeds as follows; assuming the prior accomplishment of suitable fore-pumping of chamber 10 and the prior entry of workpiece 13 onto supports 15:

Sublimator assemblies 16 are energized to sublimate titanium or other getter material from charges 17. The titanium evaporant is broadcast generally outwardly from the end of each charge 17. Plates 22 respectively intercept a coaxial conical portion of the discharge of titanium atoms being sublimated from each assembly 16. Accordingly, plates 22 define a pair of opposed frusto-conical volumes 20 free of titanium atoms. The remainder of the evaporated titanium atoms proceeds outwardly from charges 17 until the atoms contact the reverse surfaces of fins 32 and cylindrical surfaces 33 of member 24, and corresponding surfaces of members 26. Accordingly, active metal getter is ready to trap gas molecules emanating from workpiece 13.

Molecules of gas emanate from a workpiece in a vacuum when the pressure passes below a given point depending on the nature of the workpiece and various other factors, as is known. Molecules travelling outwardly therefrom move toward the pumping surfaces due to the existence of a pressure gradient between the workpiece and the pumping zone located at and adjacent the pumping surfaces. As the outwardly travelling molecule encounters the pumping zone where the gettered titanium is trapping gas, the molecule will be influenced toward the getter material since that is the region of lowest pressure. Thus, in the embodiment of FIGURE 2, it can be understood that while workpiece 13 is "looking" optically only at black surface portions 34 which are uncoated by titanium, the molecules will become trapped by the nearby titanium due to the influence of the low pressure found at the sublimed layer. In FIGURE 1, of course, the molecules are not optically baffled from the getter layer.

Molecules of gas encountering surfaces of members 24, 26 lose a great amount of their energy to the cooled pumping surfaces and, therefore, remain in contact with such surfaces for longer periods than where the pumping surfaces have not been cooled. The longer that the molecules remain adjacent to the pumping surfaces, the greater is the probality that such molecules will be chemisorbed or physisorbed thereat. While the so-called "sticking time" increases with decreasing temperature of the pumping surfaces, the propensity to become chemisorbed diminishes with diminishing temperature, and accordingly, at some point a trade-off between these two competing considerations may be necessary.

A certain degree of rebounding will occur notwithstanding the foregoing construction. This rebounding will be greater in the embodiment of FIGURE 2 than in that of FIGURE 1. It follows, however, a cosine function at the pumping surfaces and accordingly, where rebounding is initiated from those portions 34 of fins 32, there is a high likelihood that the rebounding molecules will next contact the sublimated film laid down on cylindrical surfaces 33 and on the reverse surface of fins 32.

From the foregoing, it will be readily evident that there has been provided improved high vacuum apparatus whereby molecular flow passes outwardly from a workpiece in all directions, limited conductance-wise substantially only by the surface area of imaginary envelope 21 and hence is considered not to be conductance limited by cylindrical tubulation flow passages, as previously. The foregoing observation is somewhat of an understatement since it will be appreciated that the volumes 41, 42 generally are included within space 20 and can contain portions of a workpiece whereby molecular flow outwardly from within volumes 41, 42 can also proceed toward pumping zones enveloping space 20.

It will be further evident that the apparatus described above eliminates problems of pumping conditions caused by existence of a pressure gradient existing across a workpiece such that, for example, molecules emanating from the workpiece at that end which is remote from a pump must ultimately change direction and rebound their way to the other end of the pump in order to be taken out of circulation.

I claim:

1. In high vacuum apparatus, means forming a high vacuum space chamber, sublimator means for evaporating getter material onto surfaces within said chamber, shielding means defining a work space within the chamber free of sublimated getter material and adapted to contain a workpiece to be subjected to high vacuum conditions thereby developing an outflow of molecules therefrom, and means presenting surfaces which are disposed to receive getter material evaporated thereon from said sublimator means in a manner serving to form a pumping zone substantially entirely enveloping said work space to provide initial interception of said molecules.

2. In high vacuum apparatus, means forming a high vacuum space chamber, sublimator means at each end of the chamber for evaporating getter material therefrom onto surfaces within said chamber, means blocking a portion of the discharge of each of said sublimator means to define a work space within the chamber adapted to contain a workpiece shielded from direct receipt thereon of sublimated getter material, the last said means serving to line-of-sight shield said work space from directly receiving getter material from said sublimator means, surfaces forming a pumping zone substantially entirely enveloping said work space and disposed to directly receive getter material sublimed thereon from said sublimator means, and disposed with respect thereto so that a workpiece disposed in said work space "sees" substantially only said pumping zone.

3. High vacuum apparatus according to claim 2 wherein said pumping zone includes surface portions disposed to receive getter thereon and surface portions shielded therefrom, the last named portions serving to optically baffle the first named portions from line-of-sight emission from said work space to a degree and extent such that said work space "sees" substantially only said last named portions.

4. High vacuum apparatus according to claim 3 wherein the first named surface portions comprise portions of a first surface of revolution about an axis extending between said sublimator means, and said last named portions comprise a plurality of second surfaces of revolution spaced along said axis and lying at a substantial angle to said first surface of revolution to form gaps between said second surfaces of revolution to pass evaporant to said first surface of revolution from said sublimator means, said second surfaces of revolution lying in spaced overlapping relation, confronting substantially all portions of said work space.

5. High vacuum apparatus as in claim 2 wherein said surfaces forming a pumping zone are adapted to receive a coolant.

6. High vacuum apparatus comprising means forming a high vacuum space chamber, sublimator means at each end of the chamber for evaporating getter material therefrom onto surfaces within said chamber, means blocking a portion of the discharge of each of said sublimator means to define a work space within the chamber adapted to contain a workpiece shielded from direct receipt thereon of sublimated getter material, the last said means serving to line-of-sight shield said work space from directly receiving getter material from said sublimator means, means presenting surfaces substantially entirely enveloping said work space and disposed to directly receive getter material sublimed thereon from said sublimator means, and disposed with respect thereto so that a workpiece disposed in said work space is enveloped substantially entirely within a pumping zone, the last named means forming pumping surface portions disposed to receive getter thereon and surface portions shielded therefrom, the last named portions serving to optically shield the first named portions from line-of-sight emission from said work space to an extent such that the work space "sees" substantially only said last named portions, means for cooling said pumping surfaces, and ion pump means encircling said space chamber and adapted to pump gas therein.

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U.S. Cl. X.R.

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