SORPTION PUMP ROUGHING SYSTEM

Filed Jan. 24, 1968 3 Sheets-Sheet 1

Fig. 1.

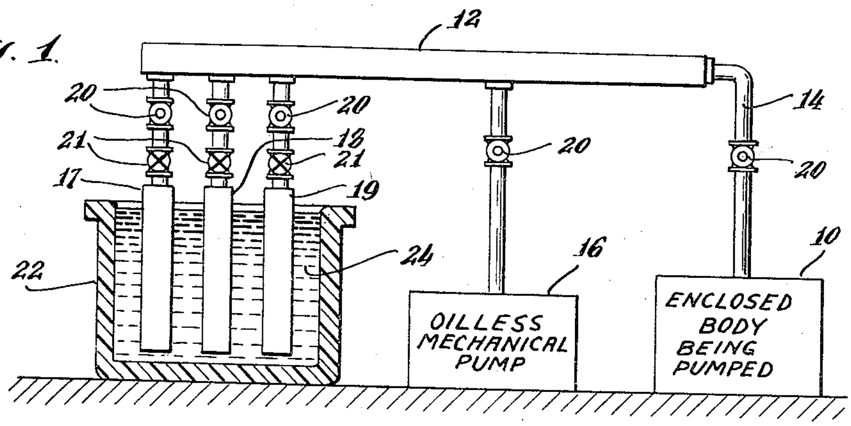
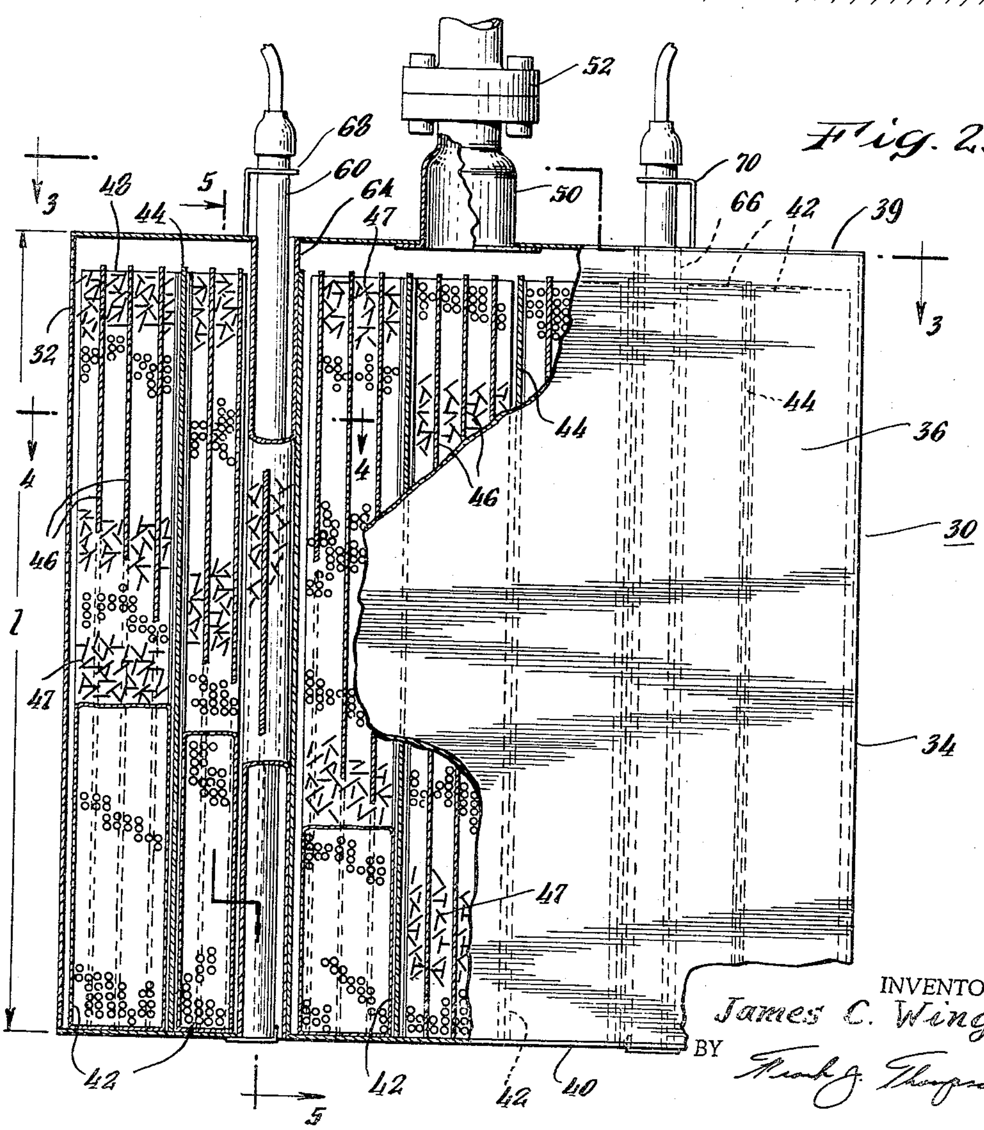


Fig. 2.



INVENTOR.
James C. Wing
BY Frank J. Thompson
ATTORNEY.

Fig. 3.

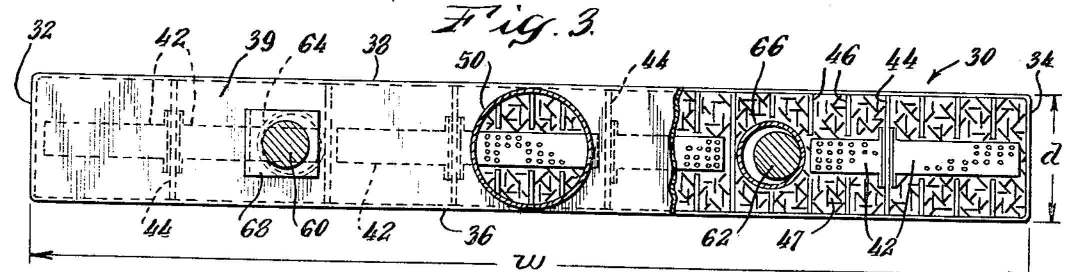


Fig. 4.

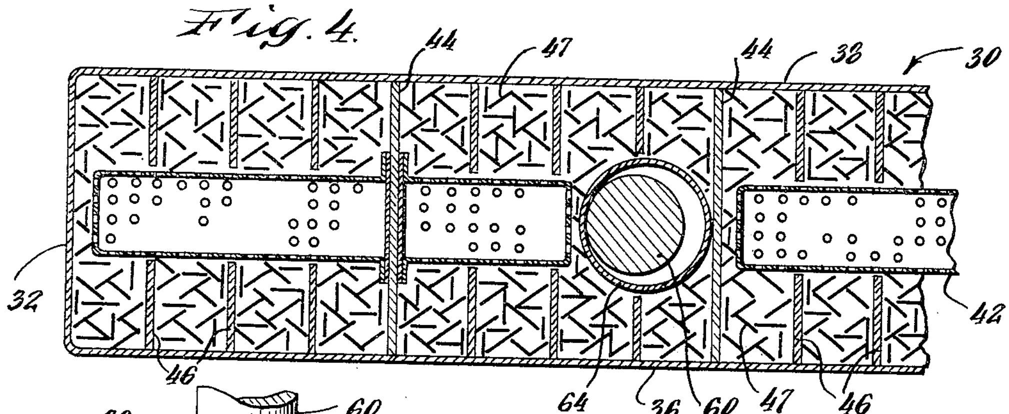


Fig. 5.

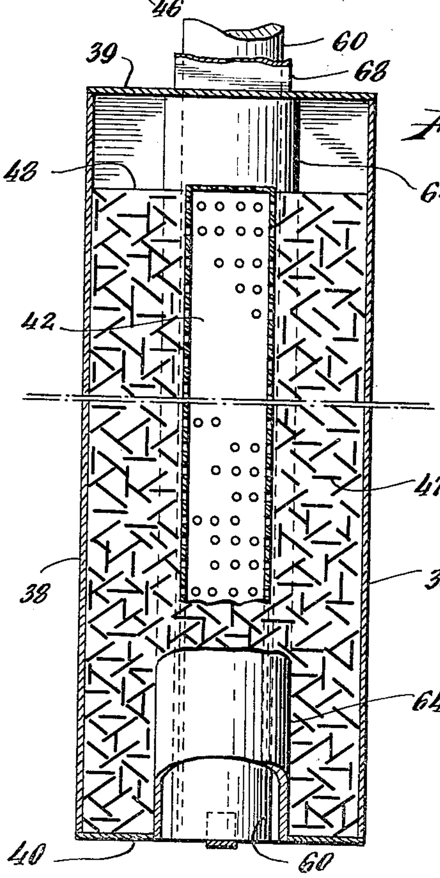
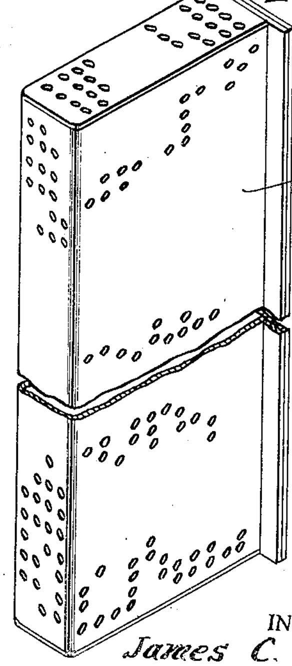
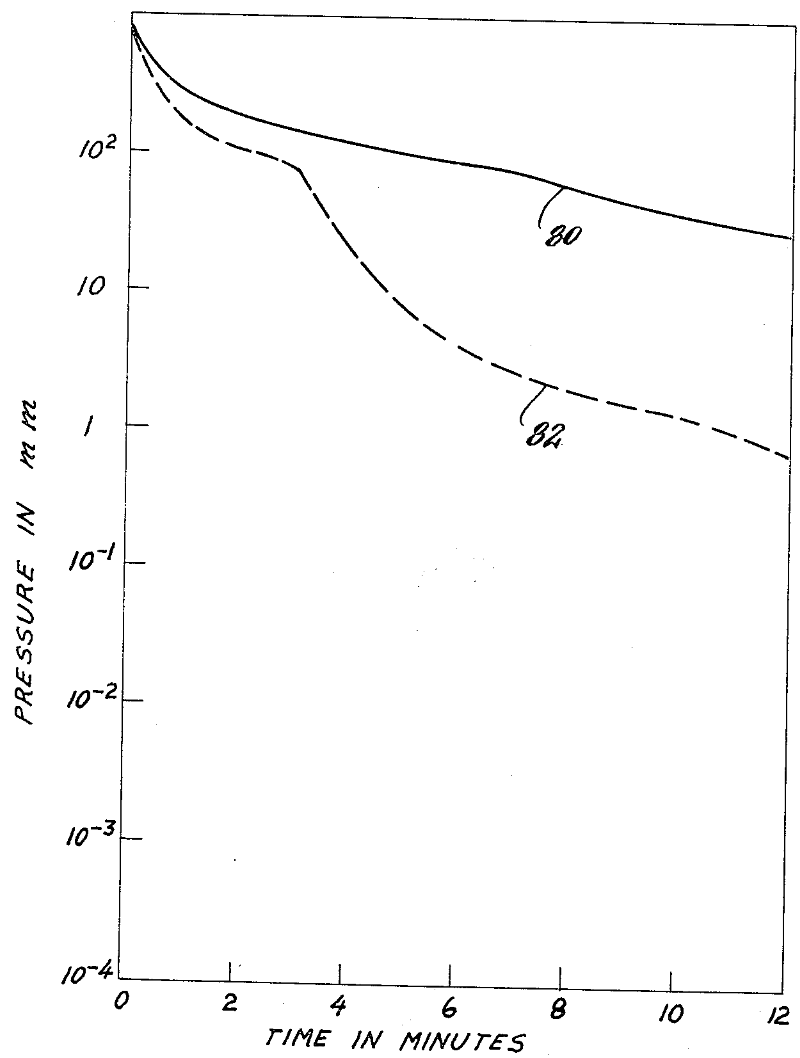


Fig. 6.



INVENTOR.
James C. Wing
BY
Frank J. Thompson
ATTORNEY.

Fig. 7.



INVENTOR.
James C. Wing
BY Frank J. Thompson
ATTORNEY.

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SORPTION PUMP ROUGHING SYSTEM

James C. Wing, Mountain View, Calif., assignor to The Perkins-Elmer Corporation, Norwalk, Conn., a corporation of New York

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ABSTRACT OF THE DISCLOSURE

A cryosorption pump adapted for positioning in a bath of liquid coolant comprises an enclosed parallelopiped-shaped body formed of high thermal conductivity metal and having an inlet thereof for the entry of gases being pumped. Means define a generally unrestricted gas passageway through a length of the body and provide a continuous access along the length of the passage to a surrounding volume of the enclosed body. This volume contains a molecular sieve sorption material for pumping gases when it is cooled to the temperature of liquid nitrogen. A plurality of elongated metal strips are mounted in thermal transfer relationship with the enclosure body and extend through the volume containing the sorption material. Through this arrangement, efficient thermal transfer is provided between an external coolant and the molecular sieve material while the gases being pumped are provided a substantially unrestricted passageway to the sieve material. The pump thereby provides a substantially improved pumping characteristic for the quantity of molecular sieve material utilized.

This invention relates to vacuum pump arrangements. The invention relates more particularly to a cryosorption roughing pump arrangement.

A known technique for evacuating an enclosed atmosphere to a relatively low pressure involves the use of rough or coarse pumping means for initially pumping the enclosure from atmospheric pressure, for example, to a reduced pressure on the order of 10^{-3} torr. At this pressure level, an alternate pumping means such as an electronic ion pump which is better adapted for pumping the atmosphere to lower pressure levels is utilized.

In view of the undesirable introduction of contaminants such as hydrocarbons into the atmosphere when an oil type roughing pump is utilized, cryosorption pumping techniques for relatively clean rough pumping have been employed. Generally, cryosorption pumping is effected by cooling molecular sieve material to the temperature of liquid nitrogen. At this temperature the molecular sieve material removes gases from the enclosed atmosphere through the mechanisms of absorption and adsorption.

In known arrangements the cryosorption pump comprises a generally cylindrically shaped metallic body containing the molecular sieve material and is supported in a coolant reservoir containing liquid nitrogen. A cryogenic container formed of polystyrene is a conventional reservoir for supporting the coolant. Tubes or tubular coils extend through the body for permitting the liquid nitrogen to flow internally of the body for cooling the inner portions of the relatively low thermal conducting sieve material.

The pumping speed and corresponding efficiency of a cryosorption pump are largely dependent upon the operating temperature of the molecular sieve material. Greatest pumping efficiency occurs when the molecular sieve material is maintained at the temperature of liquid nitrogen. However, the sorption mechanism results in the generation of heat which tends to raise the operating temperature of the molecular sieve material and disadvantageously reduces the pumping rate.

Accordingly, it is one object of this invention to provide an improved cryosorption pump.

Another object of the invention is to provide a cryosorption pump having improved thermal transfer means for cooling a sorption material.

Another object of the invention is to provide a cryosorption pump having improved means for maintaining molecular sieve material at liquid nitrogen temperatures.

The facility with which atmospheric gases being evacuated flow to and come into contact with the sieve material is also a determinative of the pumping rate. Known cryosorption pump arrangements of the cylindrical type present a relatively restricted passage for these gases. Attempts at reducing the gas passage restrictions result in a relatively large and bulky pump body not readily compatible for use with present coolant reservoirs.

Another object of the present invention is to provide a cryosorption pump which substantially reduces restrictions in the gas passage without materially increasing pump body size.

Various pumping techniques such as sweeping employ a plurality of cryosorption pumps operated in sequence for trapping slowly sorbed gases, such as helium and neon. Known pump body configurations are not readily adaptable for positioning more than one of the bodies in the same coolant reservoir. A sequential pumping arrangement thereby becomes bulky and unwieldy.

A further object of the invention is to provide a cryosorption pump having a body configuration adapted for use with one or more similar configurations in one coolant reservoir.

In accordance with the present invention a cryosorption pump adapted for positioning in a bath of liquid coolant comprises an enclosed parallelopiped-shaped body formed of high thermal conductivity metal and having an inlet thereof for the entry of gases being pumped. Means define a generally unrestricted gas passageway through a length of the body and provide a continuous access along the length of the passage to a surrounding volume of the enclosed body. This volume contains a molecular sieve sorption material for pumping gases when it is cooled to the temperature of liquid nitrogen. A plurality of elongated metal strips are mounted in thermal transfer relationship with the enclosure body and extend through the volume containing the sorption material. Through this arrangement, efficient thermal transfer is provided between an external coolant and the molecular sieve material while the gases being pumped are provided a substantially unrestricted passageway to the sieve material. The pump thereby provides a substantially improved pumping characteristic for the quantity of molecular sieve material utilized.

These and other features and objects of the present invention will become apparent with reference to the following specification and the drawings, wherein:

FIG. 1 is a diagram illustrating a rough pumping system having a cryosorption pump constructed in accordance with features of this invention;

FIG. 2 is an elevation view partly cut away and partly in section form, illustrating the cryosorption pump of the present invention;

FIG. 3 is a view, partly in section, of the pump taken along line 3—3 of FIG. 2;

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2;

FIG. 5 is a sectional view taken along line 5—5 of FIG. 2;

FIG. 6 is a view of a screen body utilized in the pump of FIG. 2; and

FIG. 7 is a chart illustrating the comparative performance between a pump constructed in accordance with features of this invention and a prior cryosorption pump.

Referring now to FIG. 1, an enclosed body **10** which is to be evacuated is coupled to a manifold **12** by suitable tubing **14**. Pumping means comprising an oilless mechanical pump **16** and a plurality of cryosorption pumps **17, 18** and **19** are also coupled to the manifold. Suitable valves **20** are provided for coupling these pumps individually or in parallel to the manifold and thus to the body **10**. Relief valves **21** are provided between the valves **20** and the pump bodies **17, 18** and **19** for venting pumped gases after use, as indicated in greater detail hereinafter. The oilless mechanical pump **16** comprises a blower having an impellar driven by an electrical motor. The cryosorption pumps each include molecular sieve material for sorption pumping of the body **10**. These pumps are immersed in a cryogenic container **22** containing liquid nitrogn **24**. The cryosorption pump bodies are supported by the manifold **12**, thereby providing envelopment of the pumps **17, 18** and **19** by the liquid nitrogen. The various tubulations and fittings are sealed in a conventional manner for vacuum use.

FIGS. 2–6 illustrate in detail one embodiment of a cryosorption pump constructed in accordance with features of the present invention. The pump is shown to include a parallelopiped-shaped enclosed body **30** formed of light gauge, thermally conductive sheet metal. A particularly suitable material is 200 nickel. The particular parallelopiped-shaped body illustrated includes a first pair of relatively narrow, planar, oppositely-disposed elongated side members **32** and **34** of length *l* and depth *d* and relatively broad, planar, oppositely-disposed elongated side members **36** and **38** of length *l* and width *w*. A pump body enclosure is formed by these side members and a top surface member **39** and a lower surface member **40**. These members may be separate pieces which are welded to the body, or they may represent integral segments folded over and seam-welded to form the enclosure.

A screen body **42**, illustrated in perspective in FIG. 6 is provided for defining a substantially unrestricted path in the pump enclosure for gases being pumped from the enclosed body **10**. A plurality of such screen bodies are provided and are positioned for extension centrally along the length of the pump body. The screen body is formed of a light gauge metal, such as 304 stainless steel, having perforations located on surfaces thereof. The perforation size is selected to prohibit a molecular sieve particle from passing through the perforations. One surface of the screen body is spot welded to an associated stiffener **44**, which stiffeners are in turn spot welded to the pump body surfaces **36** and **38**. The screen bodies are thereby firmly secured within the enclosed pump body.

A plurality of elongated, relatively thin stiff strips **46** of metal function as heat transfer fins and extend from the surfaces **38** and **36** inwardly toward the screen bodies **42**. These strips of metal **46** are brazed to and supported by the surfaces **36** and **38** and are formed of a high thermal conductivity material such as 200 nickel. As illustrated in FIGS. 2 and 4, these strips of metal along with the screen bodies **42** compartmentize the inner pump body.

A sorption material **47** comprising a conventional molecular sieve material such as crystalline calcium aluminosilicates are disposed in the body and fill these compartments to a level **48**, as indicated in FIG. 2. An inlet conduit **50** is welded to the upper pump body surface **39** and provides access to the interior thereof for gases which are being pumped from the body **10** via the manifold **12**. An opposite end of the conduit **50** is coupled to a demountable coupling **52**. The gases being pumped from body **10** flow through the conduit **50** and find substantially unrestricted access to the molecular sieve material via the screened body **42** along the length of the pump body **30**.

This pump body arrangement is particularly advantageous in that it provides a relatively high degree of thermal conductivity between the liquid nitrogen **24** and the molecular sieve material **47** throughout the body. The heat generated during the sorption process is thereby efficiently conducted away from the molecular sieve material, thereby maintaining the molecular sieve material substantially close to liquid nitrogen temperature and effecting a relatively highly efficient pumping operation. Furthermore, the gases entering the pump body through inlet **50** find access to the molecular sieve material via a substantially unrestricted passageway through the plurality of screen bodies **42**. It has been found that a pump constructed in accordance with the features of this invention for a particular weight of molecular sieve material exhibits substantially improved pumping characteristics over prior cryosorption pumps.

FIG. 7 is a pressure-versus-pumping-time characteristic illustrating the comparative performance of a pump constructed in accordance with features of the present invention and a prior cylindrical pump. Curve **80** illustrates the performance of the prior pump while curve **82** illustrates the performance of the present pump. The test was conducted under similar conditions for each pump in which three pounds of sieve material was employed in a 188L system. The system was initially at atmospheric pressure and each pump was subjected to a room-temperature bakeout and a ten-minute prechill.

The cryosorption pump is conditioned for re-use after a pumping operation is completed by raising the temperature of the molecular sieve mateiral to about 25° C. or above. The gases which were adsorbed and absorbed during the pumping operation are thereby exhausted through the relief valves **21**. To this end, electrical heater rods **60** and **62** are positioned in tubular members **64** and **66**, respectively, which extend through the pump body. The tubular members are welded to upper and lower surfaces **39** and **40**, and the heater rods extend for the length of the body and are secured in physical contact with the tubes by heater supports **68** and **70** for providing efficient thermal coupling therebetween. The pump body is therefore advantageous in that it includes relatively noncomplex means for reprocessing the molecular sieve material.

The evacuation of body **10** illustrated in FIG. 1 is typically effected by initially operating the oilless mechanical pump **16** while the cryosorption pumps **18** are decoupled from the vacuum system by the valves **20**. The pump **16** is found to sweep out on the order of 80% of the atmospheric gases contained in the body **10**. A first pump **17** of the cryosorption pumps is then coupled to the manifold after pump **16** is decoupled. Pump **17** pumps for a relatively short period of time and then is decoupled. A second pump **18** of the pumps is coupled to the manifold. Similarly, the third pump **19** is coupled to the manifold after the second pump **18** is decoupled. This method is particularly advantageous in that it effects a sweeping of the neon and helium components and provides for trapping of these components by other gases susceptible to molecular sieve pumping. Decoupling during a gas flow to the pumps also effects trapping.

A cryosorption pump has been described which is particularly advantageous in that relatively high and efficient thermal conductivity is provided for maintaining molecular sieve pump material at liquid nitrogen temperatures to thereby effect efficient pumping. The pump arrangement provides improved access to the pump material for gases being pumped. In addition, the parallelopiped pump body configuration is adaptable for locating a plurality of such pumps in one cryogenic container.

While I have illustrated and described a particular embodiment of my invention, it will be understood that various modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.

I claim:

1. In a cryosorption pump having a pump body containing pump material for positioning in a bath of liquid coolant, an improved pump arrangement comprising:
a hollow parallelopiped-shaped body having a length thereof;
a quantity of molecular sieve material disposed in said body;
means defining a substantially unrestricted path through the length of said body for gases and providing continuous access to said material along said length;
a plurality of elongated heat conducting strips positioned within said body extending through the length thereof and in physical contact with said moleculai sieve material; and
means providing access to the interior of said body for gases to be pumped.

2. In a cryosorption pump having a pump body containing pump material for positioning in a bath of liquid coolant, an improved pump arrangement comprising:
a hollow parallelopiped-shaped body having a length thereof;
a quantity of molecular sieve material disposed in said body;
means defining a substantially unrestricted path through the length of said body for gases and providing continuous access to said material along said length; and
means providing access to the interior of said body for gases to be pumped.

3. In a cryosorption pump wherein a pump body containing pump material is adapted to be positioned in a bath of liquid coolant, an improved pump arrangement comprising:
a hollow parallelopiped-shaped body having a length thereof and formed of a material having a relatively high coefficient of thermal conductivity, said body having an inner surface thereof;
means defining a substantially unrestricted path for gases to be pumped along the interior length of said body and providing continuous access to an enclosed volume of said body along its length;
a plurality of elongated strips formed of a material having a relatively high coefficient of thermal conductivity secured to said inner surface and extending inwardly from said surface toward said means defining the unrestricted flow path;
a quantity of molecular sieve material disposed within said body and positioned intermediate said means, said inner surface and said strips; and
means providing access to the interior of said body for gases to be pumped.

4. The pump of claim 3, wherein said path-defining means comprises a hollow elongated inner body having a plurality of perforations located in a surface thereof.

5. The pump of claim 4 wherein said path-defining body is parallelopiped in shape and is formed of a screen material.

6. The pump of claim 5, including elongated means extending along the length of the body for supporting a heater element in thermal conductive relationship with said body.

7. In a cryosorption pump wherein a pump body containing pump material is adapted for positioning in a bath of liquid coolant, an improved pump arrangement comprising;
a hollow rectangular parallelopiped-shaped pump body having a length thereof formed by a plurality of metal surfaces, said body having a pair of parallel, oppositely-disposed surfaces;
an elongated inner rectangular body having perforated surfaces positioned within said body;
a plurality of elongated heat-conductive strips mounted in heat conducting relationship with said parallel surfaces and extending inwardly within said body toward said inner body;
a quantity of molecular sieve material disposed within said body having crystals thereof in physical contact with said pump body surfaces, said inner body and said elongated strips; and
means providing access to the interior of said body for gases to be pumped.

8. The pump arrangement of claim 7 including a plurality of inner rectangular bodies.

9. The pump arrangement of claim 8 wherein said inner bodies are formed of metallic screen.

10. The pump arrangement of claim 9 including a tubular member extending longitudinally through said body and means for supporting a heater rod in physical contact with said tubular member.

11. A cryosorption pump comprising:
a hollow rectangular-shaped pump body enclosure formed of metal;
said body having a length l, a width w and a depth d, where $l \approx w$, and $w \gg d$;
said body having a pair of oppositely-disposed surfaces defining the length and width for said body;
a plurality of inner rectangular parallelopiped-shaped bodies formed of a metal screen positioned centrally along the dimension d of said body and extending along the length of said body;
a plurality of elongated metal strips supported in a heat transfer relationship with said surfaces and extending in one direction along the length of said body and in another direction inwardly toward said inner bodies;
a metal tubular member extending through said body for positioning a heater rod therein;
a quantity of molecular sieve material disposed within said pump body and having crystals thereof in physical contact with said pump body surfaces, said inner bodies and said elongated strips;
a heater rod secured in contact with said tubular member; and
means providing access to the interior of said body for gases being pumped.

References Cited

UNITED STATES PATENTS

3,309,844	3/1967	Hemstreet et al.	62—55.5
3,335,550	8/1967	Stern	62—55.5
3,344,852	10/1967	Bergson	62—55.5
3,371,499	3/1968	Hagenbach et al.	62—55.5

LLOYD L. KING, Primary Examiner