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CRYOGENIC PUMPING APPARATUS

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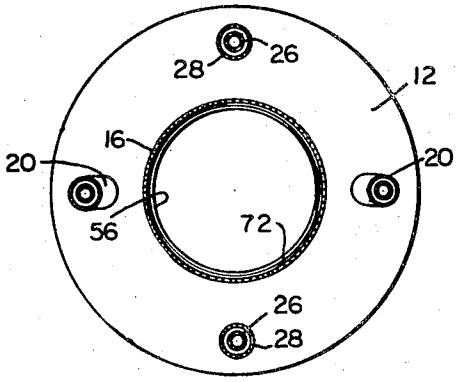


FIG. 2

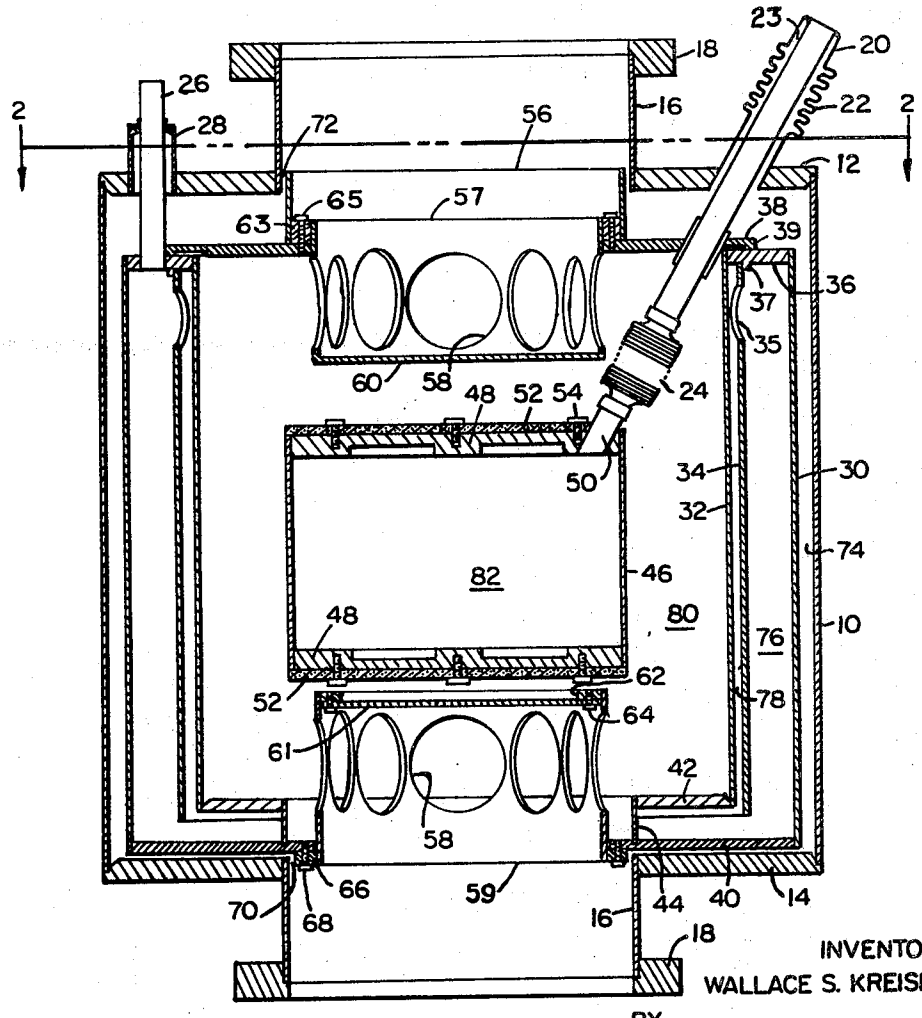


FIG. 1

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CRYOGENIC PUMPING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A cryogenic apparatus for either high vacuum pumping or cold trapping use. The apparatus includes an inner container for cryogenic liquid, an enclosing annular container defining an inner vacuum chamber and a peripheral chamber for cryogenic liquid, and an outer housing forming a further vacuum chamber. The housing has tubulations at either end so that two external enclosures can be evacuated simultaneously. Radiation shields may be attached in either end of the annular container, and molecular sieve sorption plates on either end of the inner container; both can be removed through the tubulations.

Background of the invention

Ultra-high vacuums can be obtained in known cryogenic pumps, by the capture of gas molecules on extremely cold surfaces from enclosed volumes which have already been reduced to very low pressures by mechanical or diffusion pumps. Previously known cryogenic pumps have utilized a series of enclosures to insulate a container of liquid helium, at a temperature of approximately 4° Kelvin, for the capture of most gases. Helium, neon, and hydrogen are not easily captured on metal surfaces, but the attachment of molecular sieve sorption plates to the container resolves the difficulty. The helium container is conventionally enclosed by a vacuum chamber from which the gas is to be pumped, and this is in turn enclosed by an insulating container of liquid nitrogen, at a temperature of about 77° Kelvin.

Summary of the invention

The present invention is directed toward the provision of an improved cryogenic pump apparatus which is adaptable for simultaneous attachment to two external chambers, or to the top or bottom of a single chamber; and which is so constructed that the gas sorption surfaces are readily accessible for cleaning or replacement. Improved radiation shielding is attained without interfering with the aforementioned advantages.

The improved cryogenic pump is also adaptable for use as a high vacuum conductance cold trap. Previously known cryogenic pumps have not provided this versatility. A cold trap serves to prevent the flowback of the vapor of liquids used in high vacuum diffusion pumps, such as mercury or oil, into a space being evacuated.

The improved cryogenic apparatus includes an outer housing, which has a pair of tubulations at opposite ends. These permit alternative connection to the top or bottom of an external vacuum chamber, or simultaneous connection to a pair of such chambers. Either tubulation which is not so connected is enclosed by a vacuum-sealed cover. This arrangement permits the apparatus to be used as a cold trap, one tubulation being connected to an evacuated chamber, and the other to a mechanical or diffusion pump.

Within the outer housing is mounted an annular container having openings in either end, and these are aligned with the tubulations so that full access to the interior of the container is available. The annular container forms a peripheral chamber for cryogenic liquid, ordinarily liquid nitrogen; and defines an outer vacuum chamber within the housing. An inner container for cryogenic liquid is

mounted within the annular container, also accessible for cleaning purposes or for attachment of molecular sieve sorption plates.

Radiation shields of a cup-shaped form are provided, having solid bases to shield the inner container against radiation entering through the tubulations, and side walls formed with high-vacuum conductance openings. These shields are mounted in the openings at the ends of the annular container, in such a way that they are also removable through the tubulations for access to the interior.

Fill and vent pipes project into the housing, one pair extending into the inner container to supply it with liquid and support it in spaced relation within the annular container, and another pair extending into the peripheral chamber to supply it with liquid and support the annular container in spaced relation within the housing. The apparatus is principally formed of a material of low thermal conductivity such as stainless steel; but the radiation shields, and the end portions of the annular container which support them, are made of a material having higher conductivity, such as copper, for conveying heat received by radiation to the peripheral liquid chamber. This increases the effectiveness of the insulation of the inner liquid chamber constituting the pumping or gas-trapping element.

Description of the drawing

FIGURE 1 is a developed quarter-sectional view in elevation of a preferred form of the apparatus; and

FIGURE 2 is a sectional plan view, taken along 2—2 in FIGURE 1, looking in the direction of the arrows.

Description of preferred embodiment

An outer cylindrical housing **10** is formed by an annular shell **11**, enclosed at its upper and lower ends by flat disks **12** and **14** secured by gas-tight circumferential welds. The disks are centrally apertured to receive cylindrical tubulations **16** terminating in vacuum flanges **18**, either of which is suitable for hermetic sealing connection to a vacuum chamber to be evacuated, or for sealing off by a blank disk. An annular container **30** comprises an annular shell **31** enclosed at its lower end portion by a stainless support plate **40**, and at its upper end by a stainless ring **36** welded to a copper plate **38**. An annular cryogenic liquid chamber **76** is defined about the periphery of the container **30** by an inner cylindrical shell **32**. The container **30** defines an annular outer vacuum chamber **74** within the housing **10**, and an inner vacuum chamber **80** within the shell **32**. The elements of the container are joined by gas-tight welds.

Cryogenic liquid, ordinarily nitrogen, is supplied to the chamber **76** by a pair of thin-walled fill and vent tubes **26**, mounted in a re-entrant fashion in suitable apertures in the upper disk **12** by thin-walled outer tubes **28**, with circumferential gas-tight welds. This facilitates alignment of the parts in assembling the apparatus. The tubes **26** are also welded in appropriate apertures in the ring **36**, so as to support the entire container **30** in spaced relation within the housing. The tubes are spaced 180° apart about the upper disk **12**, as shown in FIGURE 2.

The cooling action of the peripheral liquid chamber **76** is enhanced by a cylindrical copper shield **34**, spaced circumferentially about the shell **32** for the improved conduction of heat into the cryogenic liquid from the stainless ring **36** and plate **38**. Holes **35** are formed near the upper end of this shield to permit equalization of vapor pressure, and thus an equalization of the liquid level, inside and out.

The lower end of the chamber **76** extends radially inwardly between a stainless plate **40** and a plate **42**, which are welded peripherally to the shells **31** and **32**, respec-

tively. The chamber is terminated and sealed by a collar **44** interconnecting the plates **40** and **42**.

It is a function of the elements **34**, **36**, **38** and **40** to conduct heat effectively from copper radiation shields **57**, **60** and **59**, **61** into the liquid chamber **76**. Substantially all other parts of the apparatus are made of a relatively low thermal conductivity material, such as stainless steel, which will also take a smooth polished finish of high emissivity.

The radiation shields are cup-shaped, having solid base portions **60** and **61** to shield the interior of the container **30** against radiation received through the tubulations **16**. The side wall portions **57** and **59** are cylindrical, and are formed with series of high-vacuum conductance openings, holes or slots **58** to permit easy passage of gas molecules.

The upper shield **57**, **60** is welded to an attachment ring **63**, and removably secured to the plate **38** by means of screws **65**. This shield can thus be removed readily through the upper tubulation **16**. The lower radiation shield **59**, **61** has a different construction, incorporating a separate base portion **61** secured by screws **64** to a mounting ring **62**, which is welded to the wall portion **59** of the shield. The wall portion itself is removably attached to the plate **40** by means of a mounting ring **66** and screws **68**, so that the entire shield can be removed through the lower tubulation **16**.

It is to be noted that the mounting ring **66** forms a clearance passage **70** about the lower tubulation, and that there is also a clearance between the plates **14** and **40**, to communicate the outer vacuum chamber **74** with the tubulation and so provide for the evacuation of this chamber by the pump. Also, the upper plate **38** bears a collar **56** to form a narrow annular passage **72** connecting the outer vacuum chamber with the upper tubulation for the same purpose.

In the center of the apparatus, a cylindrical inner container **46** is provided for cryogenic liquid, ordinarily helium; this container is supported in spaced relation to the other elements by a pair of fill and vent tubes **20** of thin-walled construction. These tubes pass through suitable apertures in the disk **12** and plate **38**, and communicate with the container **46** at end portions **50**, which are welded in openings in an upper end plate **48** of the container. Each tube has a flexible bellows portion **24** to accommodate thermal expansion, and a re-entrant bellows portion **22** to facilitate alignment of the parts in assembling the apparatus, and to provide a vacuum jacket **23** around the tube. The pair of tubes **20** are spaced 180° apart, and at 90° to the pair of tubes **26**, as shown in FIGURE 2. The container **46** comprises a cylindrical shell welded circumferentially to upper and lower plates **48**, thus enclosing a chamber **82** for cryogenic liquid.

In the arrangement shown, molecular sieve sorption plates **52**, of a conventional material such as zeolite, are removably attached to the top and bottom plates **48** of the inner container by means of screws **54**. The blind holes in which these screws are threaded should be vacuum-vented (not shown) to permit assembly of the plates **52** in close contact with the plates **48**.

All of the surfaces of the apparatus should be polished to a mirror finish to increase their emissivity, and thus reduce the heat influx by radiation.

The apparatus may be employed as a cold trap and baffle by filling both of the chambers **76** and **82** with liquid nitrogen. It will then be effective as a high vacuum conductance cold trap for oil or mercury vapors of diffusion and mechanical pumps, water vapor, and other condensible gases entering either tubulation. The vacuum conductance may be increased by removing the radiation shields **57**, **60** and **59**, **61**, with some loss of vapor-trapping efficiency and an increase in the liquid nitrogen consumption rate.

For use as a vacuum pump, the inner chamber **82** is filled with liquid helium, and the outer chamber **76** with liquid nitrogen. The apparatus will pump substantially all gases, with the possible exceptions of helium, neon, and hydrogen, without using the sorption plates **52**; these are generally employed to aid in pumping the aforementioned three gases. However, the tubes **20** can be connected to a mechanical vacuum pump to lower the vapor pressure of the gaseous helium above the surface of the liquid helium in the chamber **82**; this will lower the temperature of the liquid to a value below 4.2° Kelvin, and cool the surface of the inner container **46** sufficiently to pump helium, neon, and hydrogen without resorting to the use of molecular sieve sorption plates.

While I have described preferred embodiments of my improved cryogenic pumping apparatus by way of illustration, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the true spirit and scope of the invention, which I therefore intend to define in the appended claims without limitation to the details of the foregoing embodiments.

What I claim is:

1. High vacuum cryogenic pump apparatus comprising:

an outer vacuum housing having walls extending into a pair of tubulations at opposite ends thereof for selective sealing connection to vacuum chambers and closures;

an insulating container received within said housing and defining a vacuum chamber;

a pair of radiation shields removably attached in opposite end portions of said insulating container each in alignment with one of said tubulations to shield said vacuum chamber, said tubulations being constructed and arranged for removal of said shields therethrough, said shields being formed with high vacuum conductance openings communicating said vacuum chamber with said tubulations;

and a further container received within said vacuum chamber of said insulating container for receiving cryogenic liquid.

2. Apparatus as recited in claim **1**, in which said radiation shields are cup-shaped, each having a solid base portion extending transversely of said tubulations to shield said further container, and side wall portions extending lengthwise of said tubulations and formed with said openings.

3. Apparatus as recited in claim **1**, together with a pair of molecular sieve sorption plates removably attached to opposite end portions of said further container, said tubulations being constructed and arranged for removal of said plates therethrough.

4. High vacuum cryogenic pump apparatus comprising:

an outer vacuum housing having walls extending into a pair of tubulations at opposite ends thereof for selective sealing connection to vacuum chambers and closures;

an annular container received within said housing in spaced-apart relation thereto to form an outer vacuum chamber therebetween, said container defining a sealed annular chamber extending about the outer periphery of said container for receiving a first cryogenic liquid, said container further defining an inner vacuum chamber within said annular chamber sealed against fluid communication therewith;

a pair of radiation shields removably attached each in one of said end portions of said container in alignment with a corresponding one of said tubulations to shield said inner vacuum chamber, said tubulations being constructed and arranged for removal of said shields therethrough, said shields being formed with high vacuum conductance openings communicating said inner vacuum chamber with said tubulations;

and a further container received within said inner vac-

uum chamber of said annular container for receiving a second cryogenic liquid.

5. Apparatus as recited in claim 4, in which said annular chamber extends into heat transfer relation with at least one end portion of said container, said end portion and said shield attached therein being formed of materials having relatively high thermal conductivity for heat transfer to said annular chamber, and the remainder of said container being formed of materials having relatively low thermal conductivity for insulating the apparatus.

6. Apparatus as recited in claim 5, together with a shell of material of relatively high thermal conductivity in heat-transfer relation with one of said end portions and extending into said annular chamber for heat transfer to liquid contained therein.

7. Apparatus as recited in claim 4, in which said outer vacuum chamber is in fluid flow communication with said tubulations for evacuation by the apparatus.

8. Apparatus as recited in claim 4, together with at least one fill and vent tube extending into said housing, supporting said annular container therein, and communicating with said annular chamber for supplying said first cryogenic liquid thereto; and at least one further fill and vent tube extending into said housing and said annular container, supporting said further container within said annular container, and communicating with said further container for supplying said second cryogenic liquid thereto.

9. High vacuum cryogenic pump apparatus comprising:

an outer vacuum housing having walls extending into a pair of tubulations at opposite ends thereof for selective sealing connection to vacuum chambers and closures;

an annular container received within said housing in spaced-apart relation thereto to form an outer vacuum chamber therebetween, said housing containing an inner cylindrical shell, said container and said shell defining a sealed annular chamber extending about the outer periphery of said container, means for supplying cryogenic liquid to said chamber, said container further defining an inner vacuum chamber within said annular chamber having a pair of openings at opposite ends thereof aligned with said tubulations;

and a further container received within said inner vacuum chamber of said annular container for receiving cryogenic liquid.

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