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ULTRA HIGH VACUUM DEVICE

3,137,551

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2 Sheets-Sheet 1

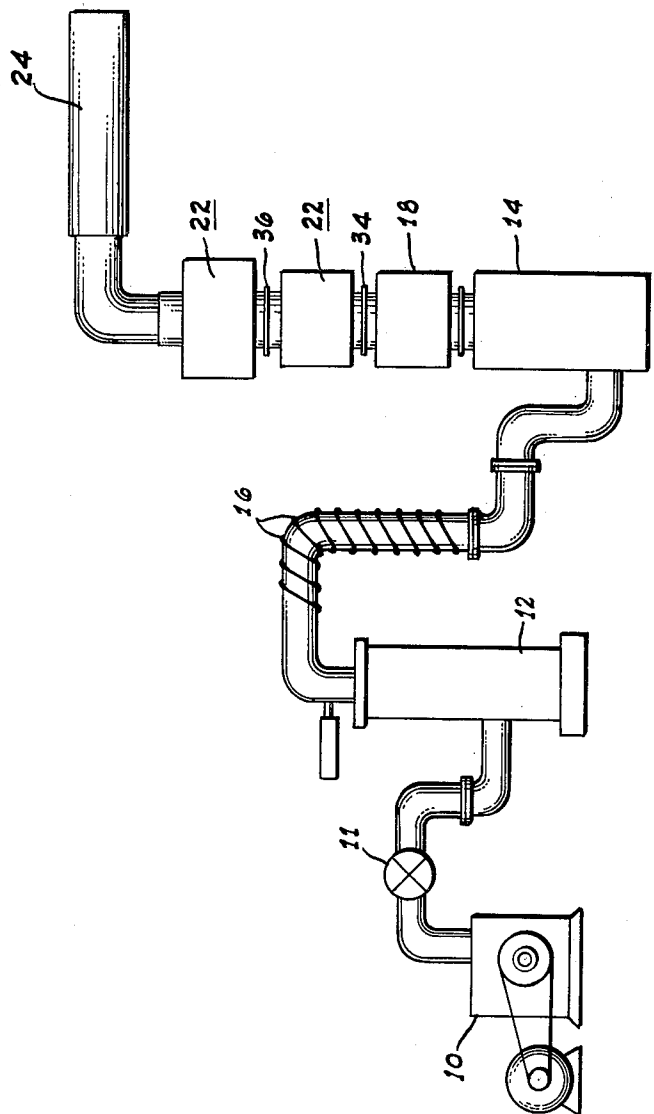


Fig. 1.

INVENTOR.
JOHN T. MARK
BY *L. A. Larsen*
ATTORNEY

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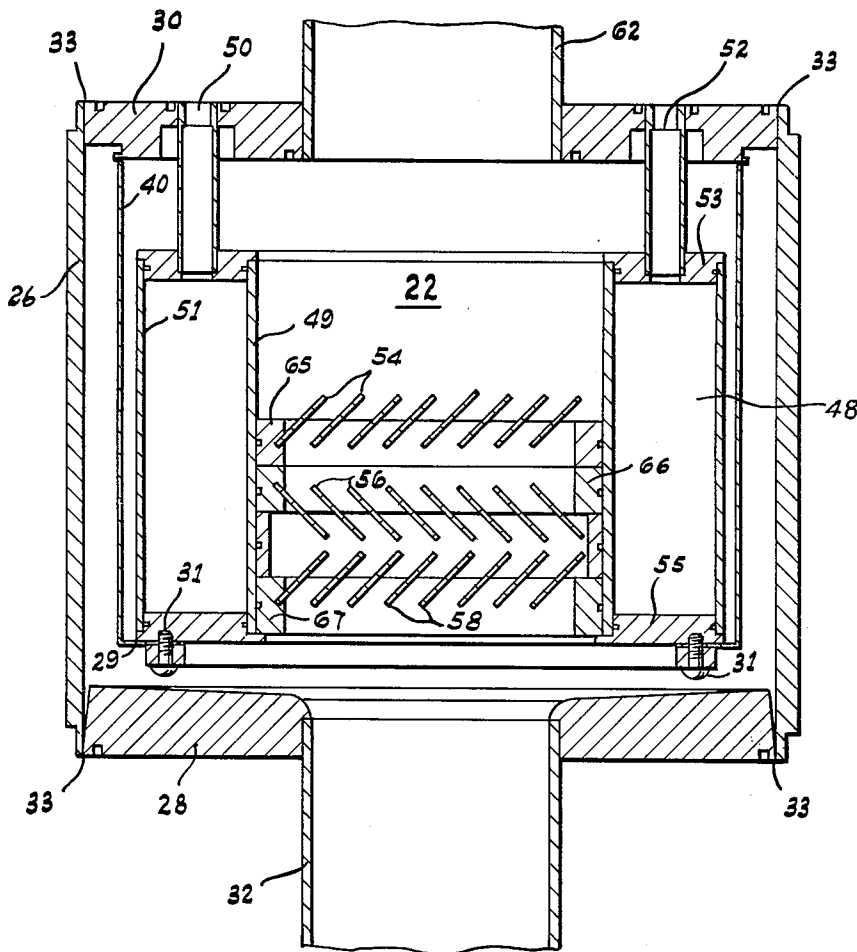


Fig. 2.

INVENTOR.
JOHN T. MARK
BY
L. A. Larsen
ATTORNEY

1

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John T. Mark, Lancaster, Pa., assignor, by mesne assignments, to the United States of America as represented by the United States Atomic Energy Commission
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6 Claims. (Cl. 55-269)

This invention relates to a system for producing an ultra high vacuum and particularly to an improved liquid nitrogen trap for use in an ultra high vacuum system.

In order to design a vacuum system which is capable of efficiently evacuating a large space, and one which is capable of attaining an ultra high vacuum, it has been found that the trap, or traps, used within the system: (1) should offer a minimum impedance in the pumping system; (2) all of the walls of the trap should remain constantly cold; (3) there should be no path around the cold surfaces whereby molecules of a diffusion pump fluid could migrate from a low vacuum region to a high vacuum region; and (4) the consumption of the cooling fluid in the trap should be held to a minimum.

It is therefore an object of this invention to provide a new and improved trap for an ultra high vacuum system.

It is a further object of this invention to provide a novel ultra high vacuum system including an improved trap that is capable of maintaining a vacuum of the order of 2×10^{-10} mm. of Hg.

These and other objects have been accomplished in accordance with this invention by providing an ultra high vacuum system including a novel liquid nitrogen trap. The novel trap is formed by suspending a tank, which is made of a high thermal capacity metal, inside of a vacuum chamber from the lower edge of a thin walled tube of low heat conductivity within which the tank is carried. The tank, in which a coolant fluid may be circulated, preferably includes a plurality of cooled interrupted short chevron baffles through which the evacuated atmosphere is drawn. The baffles are also made of a high thermal capacity metal.

The invention will be more clearly understood by reference to the accompanying two sheets of drawings wherein:

FIG. 1 is a partially schematic view of an ultra high vacuum system utilizing this invention; and,

FIG. 2 is a sectional view of a novel vacuum trap in the arrangement of FIG. 1.

Referring specifically to FIG. 1, the vacuum system shown comprises a mechanical pump 10 which may be a pump of a type commercially available from the Kinney Manufacturing Company known as the Kinney KC 46 two stage, gas ballast, mechanical pump. Connected to the mechanical pump 10 through a valve 11 is a mercury diffusion type booster pump 12 which may be of the type that is commercially available from the Consolidated Electrodynamics Corporation known as the MHG 900 mercury booster pump.

Connected to the booster pump 12 is a mercury diffusion pump 14 which may be of the type commercially available from the Consolidated Electrodynamics Corporation and commercially known as a MHG 900 mercury pump. Between the mercury diffusion pump 14 and the mercury diffusion booster pump 12 are a plurality of cooling baffles 16 which prevent fluid from the mercury booster pump 12 from reaching the mercury pump 14. The baffles 16 may be cooled to approximately minus 35°C. , by circulating a cooling fluid such as Freon about the passageway containing baffles, so that mercury will be condensed in the baffled passageway and drawn back toward the booster pump 12.

Connected to the input of the mercury diffusion pump

2

14 is a region 18 including a plurality of cooling baffles which, when cooled to approximately minus 35°C. , condenses most of the particles of mercury from the mercury diffusion pump 14 and thus, these condensed mercury particles fall downwardly and back into the mercury diffusion pump 14. The baffles in the region 18 may be cooled by employing Freon as a coolant.

Connected to the input of the Freon baffle 18 is a three-bounce chevron baffle, liquid nitrogen trap 22 in accordance to this invention. The trap 22 will be explained in greater detail in connection with FIG. 2. Connected to the input of the liquid nitrogen trap 22 is a chamber 24 which is to be exhausted to a pressure of approximately 2×10^{-10} mm. of Hg or better.

Referring now specifically to FIG. 2, there is shown an enlarged sectional view of the liquid nitrogen trap 22 in accordance with this invention. The trap 22 comprises an elongated hollow cylinder or tube 26. A pair of apertured end plates 28 and 30 are provided each extending across a different end of the cylinder 26. The end plates 28 and 30 are welded to the cylinder 26 at areas 33. The apertured end plate 28, which is positioned at the output end of the cylinder 26 adjacent to the Freon baffle 18 of FIG. 1, includes a hollow cylindrical member or pipe 32 which may be stainless steel and which is welded to the output end plate 28. The pipe 32 is also welded to a flange 34 (of FIG. 1).

Spaced closely adjacent to (in this case approximately $\frac{3}{8}$ inch) the inner wall of the hollow cylinder 26, is a relatively thin migration baffle and heat radiation shield in the form of a hollow cylinder 40. The migration baffle 40, which prevents both volume and surface migration of particles, is supported on the input end plate 30 by a vacuum tight weld thereto. Spaced from the output end plate 28 is a flanged end 29 of the migration baffle 40 through which screws 31 extend. The hollow cylinder 40 is made of a material such as stainless steel which is a poor heat conductor and is also made as thin as possible so that heat conduction axially through the cylinder 40 is maintained at a minimum. Furthermore, the hollow cylinder 40 is highly polished for maximum heat reflectivity.

Connected to the input end plate 30 is a cooling assembly comprising an annular tank 48. The tank 48 is formed by a pair of coaxial tubes 49 and 51 having their ends sealed by annular members 53 and 55 which are brazed vacuum tight thereto. The tank 48 may be filled with liquid gas, e.g. liquid nitrogen, by means of a fill pipe or inlet tubing 50, and exhausted through a vent pipe or outlet tubing 52. The pipes 50 and 52, like cylinder 40, are of a poor thermal conducting material, such as stainless steel, and have very thin walls. The tank is supported by means of the screws 31 which extend through a high heat conducting compression ring which is in firm contact with the flanged end 29. The tank 48 is made of a high thermal capacity metal, such as copper, so that all portions of the tank 48 will readily be maintained at the temperature of the cooling fluid during operation, even though the tank is only partly filled with cooling fluid. Also, it should be noted that the tank is relatively massive, as compared to its supports and the shield 40, so that the entire space enclosed within the inner tube 49 remains substantially at the temperature of the cooling fluid. The inlet and outlet tubes 50 and 52 may be welded to the annular member 53 and through the end plate 30. It should be noted that the liquid nitrogen tank 48 is suspended in a vacuum tight space and is positioned so that the gases being exhausted pass through a plurality of chevron baffles 54, 56 and 58 rather than around the migration baffle 40. The chevron baffles 54, 56 and 58 are also made of a high thermal capacity material, such as copper, and are silver brazed to obtain

good thermal contact with the inner wall of the tank 43 so that the baffles are maintained at the same temperature as that of the tank and of the cooling medium. The baffles 54, 56, and 58 are in the shape of strip-like members or slats, each is supported on a different metal ring 65, 66 and 67. The rings 65, 66 and 67 are also of a high thermal capacity metal. The baffles in each set are parallel to each other and each baffle extends from opposite wall portions of the inner tube 49. It should be noted that the baffles are arranged so that no line of sight travel can occur without the particles bouncing from, for example, baffles 54 to baffles 56. Thus the chevron baffle plates 54, 56, and 58 provide a minimum of three molecular bounces, and an average in this embodiment of approximately 90 molecular bounces of the gas particles to be exhausted, as well as a similar number of bounces of any particles of mercury which may escape the Freon trap 18 in FIG. 1. It is to be especially noted that the baffles 54 are separated from the baffles 56, and the baffles 56 are separated from the baffles 58. Because of this separation between baffles 54, 56, and 58, in accordance with this invention, it is possible to conduct extremely large amounts of gases, as compared to the chevron type traps found in the prior art, where the chevrons were continuous. The reason for this is that the probability of molecular diffusion toward exhaustion through the maze of chevrons, of the type described, is greatly increased over prior arrangements. For example, traps made in accordance with this invention, having a 10 inch opening, have flow rates of approximately 2,000 liters per second. Also, it should be noted that the inlet and outlet tubes form seals with the annular flange 53, and with the end plate 30, so that the cooling fluid is confined within the tank 48 without particles of this fluid being exposed to the space within the vacuum chamber of the trap 22.

The center portion of the end plate 30 is provided with a hollow cylinder or pipe 62, which may be of a material such as stainless steel and which is welded to the end plate 30. One end of the hollow cylinder 62 is adapted to be sealed to the container 24 to be evacuated as shown in FIG. 1. A specific example of a successfully operated trap 22 is as follows:

Part	Length	Thick-ness	Material	OD	ID
Cylinder 26	18.25	0.25	SS	17.25	17.00
Shield 40	13.5	0.03	SS	16.62	16.50
Outer tube 51	8.00	0.75	Cu	16.50	16.75
Inner tube 49	8.00	0.75	Cu	13.00	12.25
Flange 55		0.50	Cu	16.50	11.75
Flange 53		0.37	Cu	16.50	12.25
Fins 54, 56, 58	.884	0.025	Cu		
Supports 67	.500	1.000	Cu	12.25	11.25
Flange 29		.062	SS	16.59	10.500
End plate 30		.75	SS	17.00	10.500
Inlet pipe 50		.030	SS	1.15	1.12
Tube 32	any	.134	SS	10.500	10.000
Tube 62	any	.109	SS	10.500	10.000

NOTE.—All dimensions represented in inches.

A trap such as that shown in FIG. 2 was made of non-magnetic material, stainless steel, for a particular application and was constructed in such a manner as to permit the trap to be cooled to the temperature of liquid nitrogen or to be baked at a temperature of approximately 450° C. With two of these traps in series in advance of a Freon-cooled baffle, pressures of 2×10^{-10} mm. of Hg or better, have been obtained in the vacuum area 24 for long periods of time. With the use of two traps 22 both of the traps 22 were baked at 450° C., and then the trap nearest the pump was cooled and filled with liquid nitrogen. After several hours of bake out, the outer trap was cooled, the apparatus degassed, and the second trap filled with liquid nitrogen to bring the vessel pressure down to 2×10^{-10} mm. of Hg range.

Because the tank 48 and the chevron type baffles 54, 56 and 58 are made of a high thermal capacity material, it

has been found that, even though the trap cooling fluid container is only partially full of cooling fluid and the level of the cooling fluid may change, still ultra high vacuums may be achieved. In other words, the entire tank 48 and the chevron baffles remain substantially at liquid nitrogen temperatures so long as there is liquid nitrogen within the tank 48. Thus, once the trap has been cooled to liquid nitrogen temperature, and the liquid nitrogen has boiled away, the trap will rise in temperature less than 10° C. in the following period of 24 hours. This is due to the high thermal capacity of the massive tank.

It should be understood that the trap 48, in accordance with this invention, may include a larger or smaller number of baffles and a larger or smaller number of chevrons per baffle as long as the chevrons of one baffle are separate from the chevrons of an adjacent baffle, and the chevrons of successive baffles obstruct straight line travel of the molecules of gas.

Thus, this invention provides a novel cooled vacuum trap, one or more of which may be used to provide an improved ultra high vacuum system for yielding extremely low pressures.

What is claimed is:

1. A vacuum trap comprising a hollow tubular member, a cooling fluid tank completely suspended within said tubular member, said tank being made of a high thermal capacity metal, means for supporting said tank within said member including a vacuum seal between said tank and said member that forms a vacuum chamber therebetween, inlet and outlet means communicating with the interior of said tank, said tank defining a passageway therethrough extending in coaxial relation to and communicating with axially spaced regions of said tubular member, and a cooling structure supported in said passageway, said structure including a support engaging the inner wall of said tank, and a plurality of baffles mounted on said support and disposed in an array to permit air to pass therethrough.

2. A vacuum trap comprising an elongated hollow metallic tubular member, a pair of end plate members one closing partly only, each end of said tubular member, a cooling fluid tank means completely supported within said tubular member and having an opening therethrough, a support, and migration baffle member extending from said cooling fluid tank means to one of said end plate members and forming a vacuum chamber between said tubular member and said tank, and a plurality of baffle means extending across the opening in said tank means, said baffle means including a metal support engaging said fluid tank and a plurality of metallic baffles engaging said support and positioned in an air pervious array, whereby said baffles cool air passing through said array, said tubular member having openings at the ends thereof adapted to be connected to inlet and outlet means for air, said tank means having an opening for admitting a coolant thereto.

3. A vacuum trap as in claim 2 wherein said baffle means are made of copper and said support and migration baffle member is made of stainless steel.

4. A liquid nitrogen trap for cooling evacuated gas passing therethrough, comprising a hollow stainless steel jacket, apertured stainless steel end plates spanning the ends of said jacket, an annular liquid nitrogen tank completely within said jacket, said tank having a support connected to one of said end plates and forming separate, co-axial, cylindrical, oppositely directed, dead-ended chambers between said jacket and said tank so that the evacuated gases pass only through the space defined by the inner wall of said tank, a plurality of chevron type baffles spanning said space, said baffles and said tank being made of a metal having a higher heat conductivity than stainless steel, and inlet and outlet tubes for said tank sealed through said one of said end plates.

5. A vacuum trap comprising: (a) a chamber which is adapted to be evacuated, said chamber having end walls and side walls, (b) a duct connected to an opening in each

5

of said end walls and in substantial coaxial relation, (c) an annular tank completely within said chamber having a hollow cylindrical portion in register with said ducts, said tank being spaced from the walls of said chamber, (d) a plurality of groups of chevron type baffles mounted in said hollow cylindrical portion, and in heat transfer relation to the inner wall of said tank, said groups being disposed in spaced parallel planes, the baffles in each group being spaced from each other and tilted in a common direction, the baffles in adjacent groups being tilted in different directions, each group of baffles being spaced from the baffles in adjacent groups, said annular tank having relatively thick walls made of a metal of high thermal capacity, (e) inlet and outlet ducts extending through a wall of said tank, for admitting cooling fluid to said tank, and (f) a combined shield and support member surrounding the sides of said tank in spaced relation therewith and fixed to one end wall of said chamber and engaging in hermetically sealed relation the end of said tank remote from said end wall, said member being cylindrical and in coaxial relation with respect to said tank, said member being relatively thin and made of a metal of low thermal capacity, (g) whereby said vacuum trap facilitates a relatively high rate of gas flow therethrough, impedes a surface flow of gases in by-passing relation to said hollow cylindrical portion of said tank, and preserves said tank in thermally insulated relation with respect to the walls of said chamber.

6. A vacuum trap comprising: (a) a chamber having end walls vertically spaced, (b) two ducts sealed through said end walls in substantially coaxial relation for evacuating said chamber, (c) an annular cooling tank completely within said chamber, (d) inlet and outlet means communicating with the interior of said tank, whereby

6

said tank is adapted to receive and to hold cooling fluid, said tank being spaced from the end walls and side walls of said chamber and having relatively thick walls made of a relatively high thermal capacity metal, whereby a partial filling of said tank with cooling fluid serves to cool the tank to a substantially uniform temperature, (e) and means between and spaced from said tank and the side walls of said chamber for supporting said tank in said chamber, said supporting means comprising a cylindrical member made of a relatively low thermal capacity metal and having relatively thin walls of one end of said cylindrical member being hermetically fixed to the upper end wall of said chamber, the other end of said member extending downwardly and hermetically fixed to the lower end of said tank, whereby said member tensionally supports said tank and isolates said outer surface of the outer wall of said tank.

References Cited in the file of this patent

UNITED STATES PATENTS

1,433,258	Buckley	Oct. 24, 1922
1,535,157	Hughes et al.	Apr. 28, 1925
2,386,298	Downing et al.	Oct. 9, 1945
2,636,655	McFee	Apr. 28, 1953
2,703,701	Simpelaar	Mar. 8, 1955
2,703,969	Lindsey	Mar. 15, 1955
2,865,560	Franceschini	Dec. 23, 1958
2,904,665	Gordon	Sept. 15, 1959

FOREIGN PATENTS

773,456	Great Britain	Apr. 24, 1957
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