

Feb. 1, 1966

J. C. SIMONS, JR

3,232,031

DIFFUSION PUMP COLD TRAP

Filed Aug. 28, 1962

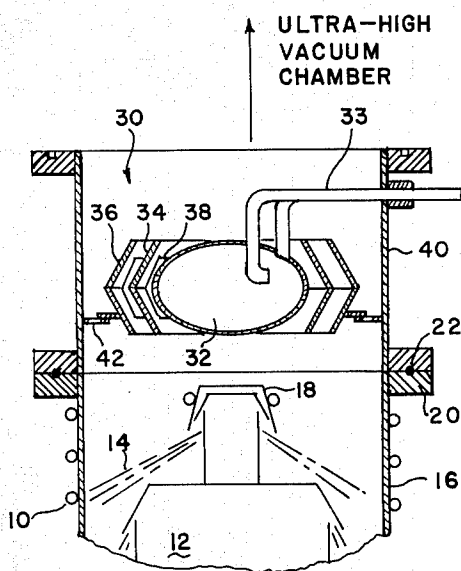


FIG. 1

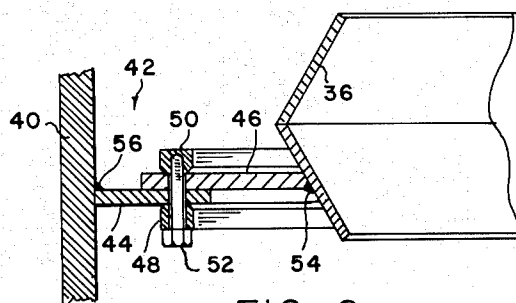


FIG. 2

1

3,232,031

DIFFUSION PUMP COLD TRAP

John C. Simons, Jr., Weston, Mass., assignor, by mesne assignments, to National Research Corporation, Cambridge, Mass., a corporation of Massachusetts
Filed Aug. 28, 1962, Ser. No. 219,999
3 Claims. (Cl. 55—269)

The present invention relates to the production of ultra-high vacuum, as defined in the American Vacuum Society Standards:

High vacuum ----- 10^{-3} to 10^{-6} torr (mm. Hg abs.).

Very high vacuum --- 10^{-6} to 10^{-9} torr.

Ultra high vacuum --- 10^{-9} torr and below.

Generally, the use of vapor diffusion pumps is preferred for ultra high vacuum work because of the greater economy of the former for handling large throughputs and greater ease of maintenance of the former. However, diffusion pumps tend to be limited by backstreaming and oil creep problems, which are aggravated by the fact that the vapor pressures of commercially available diffusion pump fluids, at room temperatures, are above 10^{-9} torr. Thus, there is a substantial tendency for the working oil vapor to re-evaporate from the water-cooled wall of the diffusion pump and to climb up the pump wall. This limits the ultimate vacuum which the pump can produce.

It is therefore the object of this invention to provide a pumping system, including a diffusion pump, which is arranged to limit backstreaming and oil creep and make ultra high vacuum operation feasible.

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

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a diagrammatic, schematic view of a preferred embodiment of the invention; and

FIG. 2 is a partial section of a detail of the apparatus indicated in FIG. 1.

The phenomenon of backstreaming is generally attributed to back scatter of vapor phase oil molecules towards the pump inlet and re-evaporation of condensed oil from the pump wall near the inlet. Creeping of oil takes place due to capillary action of liquid phase pump oil and by successive re-evaporation and condensation of pump oil. Cryogenically cooled surfaces combat all these problems since they limit re-evaporation and liquid flow along a surface. It is well known in the art to define the path of pumped gas by cryogenically cooled surfaces in an optically dense arrangement so that oil molecules traveling from the pump to the vacuum chamber will be trapped. The present invention entails a recognition of the importance of cooling all possible leakage paths and the location of those leakage paths.

Referring now to FIG. 1, there is shown a diffusion pump 10 with a vapor jet assembly 12 emitting streams of vapor, as indicated at 14, against the water-cooled wall 16 of the pump. The vapor jet assembly is provided with a "cold cap" 18, in accordance with the teaching of the Power Patent 2,919,061, granted December 29, 1959. This cold cap, by eliminating the over-divergent portion of the vapor jet 14, cuts backstreaming by approximately 98%. Residual backstreaming and oil transport is completely eliminated by the novel cold trap described below.

2

The pump is provided with an inlet flange 20 and sealing means indicated as a single ring 22. It should be understood that it will often be necessary to turn to more complex sealing means such as double O-rings, refrigerated seals, and the like, which are known in the art.

The cold trap 30 comprises an oblate shell 32 for containing a cryogenic fluid such as liquid nitrogen and feed and return lines therefor, one of which is indicated at 33. The oblate shell is surrounded by annular chevrons 34 and 36 which are connected to the shell by a plurality of ribs 38, selected for their high thermal conductivity. The annular gap between the outermost chevron 36 and the wall 40 is bridged by an annular ring assembly 42 which is connected to both members 36 and 40. The connection to wall 40 is a vacuum-tight weld. The connection to chevron 36 is structural; there are leakage paths. However, these are optically dense and cryogenically cooled. The ring 42 is of high thermal conductivity, as described below.

Thus, the backstreaming vapors from the pump 10 are confined to optically dense paths defined entirely by cryogenically cooled baffles. Creep along the wall is blocked by baffle 42. The use of the cold cap for reducing the backstreaming problem by two orders of magnitude in the first instance makes this baffle practical for long term use. Without the cold cap an excessive amount of backstreaming vapor would be collected by trap 30, forming thick layers of "ice" (solidified oil). It should be understood however that other techniques for achieving a rough reduction in backstreaming may be employed in lieu of a cold cap. For instance, a water-cooled baffle or an elbow pipe could be interposed between the pump 10 and cryogenic baffle 30. The use of the cold cap is preferred since it avoids the penalties in bulk, cost and loss of conductance presented by these additional baffles.

Referring now to FIG. 2, details of the ring 42 are shown. The ring is divided into two portions 44 and 46 to provide for assembly and disassembly. The outer portion 44 is made of steel and the inner portion 46 of oxygen-free copper, a good thermal conductor. The portions are welded or brazed to the wall 40 and outermost chevron 36, respectively and when assembled, they are secured by annular clamping rings 48 and 50 which are drilled and threaded to receive bolts 52 at a plurality of symmetrically spaced locations. For example, in a nominal 10-inch trap, 24 bolts would be provided. The annular clamping rings are provided to prevent slight leakage paths due to buckling between bolts. A minimal amount of leakage is still possible between the portions 44 and 46. However, this is inhibited since portion 46 is at cryogenic temperature. The structural connection between portion 46 and chevron 36, a plurality of spaced tack welds 54, is open to leakage. However this leakage path is defined by two cryogenically cooled members 46 and 36. There is sufficient contact between members 46 and 36 to permit heat transfer by conduction. The weld at the junction of wall 40 and member 44 is an annular vacuum-tight weld 56.

It will be noted that the cross-section dimensions of the ring 42 are small compared to the cryogenic shell 32 of FIG. 1. Thus heat transfer from the outer wall 40 does not strain the capacity of the cryogenic cooling system. The relatively poor thermal conductivity of outer portion 44 also limits losses. However, water cooling of the wall 40 may be provided to limit this cooling loss. An essential feature of the instant invention is the recognition that water cooling of wall 40, alone, does not solve the problem of backstreaming and creeping along the wall in the ultra high vacuum range. Cryogenically cooled surfaces are necessary for this purpose.

The cold trap can be disassembled by removing bolts 52. The reassembled trap can repeat its performance in preventing any backstreaming or creeping because of the novel design described above. It will now be appreciated that various types of cold traps can be modified to incorporate the principles of the instant invention. For instance, the cooled surfaces could consist entirely of baffles with no central shell containing coolant. The cooling could be provided by separate pipes or thermoelectric means.

The design considerations must also take account of loss of conductance inherent in baffling. Thus, the present invention entails a recognition of the critical areas of vapor backstreaming and the extension of cryogenic cooling to those areas rather than an indiscriminate multiplication of baffling.

Since certain changes may be made in the above apparatus 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. In an ultrahigh vacuum pumping system comprising a vertically arranged tubular diffusion pump with its inlet end connected to a vacuum chamber via a tubular cold trap coaxially aligned with and mounted over the diffusion pump in end-to-end relation therewith and means for effecting a rough reduction in backstreaming from the diffusion pump an improved cold trap comprising a vertically extending tubular wall, a baffle assembly of radially spaced apart concentric annular chevron baffles including an outermost chevron baffle and innermost chevron baffle located substantially in a horizontal plane, said chevron baffles being inclined with respect to the vertical axis of the cold trap and said horizontal plane to define at least one annular gas conductance path between adjacent chevron baffles, said gas conductance path being optically dense with respect to the inlet of the diffusion pump, said baffle assembly further comprising a central hollow shell located substantially in said horizontal plane and along the axis of the trap spaced from and encompassed by said innermost chevron baffle so that it is surrounded by said annular chevron baffles, the innermost chevron baffle and shell being constructed and arranged to define therebetween an annular gas conductance path which is optically dense with respect to the inlet of the diffusion pump, rib means constructed and arranged within said trap for transferring heat by conduction between said chevrons and said shell, means for conducting cryogenic fluid to and from the interior of said shell, the cold trap further comprising an annular supporting disk assembly physically united at all points of its periphery to and extending substantially horizontally from the tubular vertically extending wall of said cold trap to the said baffle assembly to support the baffle assembly from the wall,

the disk assembly consisting of inner and outer annular disks arranged horizontally and overlapping each other with the outer disk united at all points of its outer periphery to the vertically extending wall of said trap and the inner disk united to the outermost extending baffle at all points of the inner periphery of the inner disk to define a complete annular seal at the junction of said inner disk and outermost chevron baffle, and means constructed and arranged within said cold trap for clamping said disks together at their overlapping portions so that the supporting disk assembly presents an annular impenetrable barrier so that fluid flow through the cold trap is confined to said annular gas conductance paths.

2. The cold trap of claim 1 wherein the inner disk rests on top of the outer disk at the overlapping portion thereof and wherein the clamping means comprises a pair of rings bearing against the overlapped disks, said rings positioned one above and one below said disks, means constructed and arranged for forcing the rings toward each other.

3. The cold trap of claim 1 wherein the disks are constructed so that the inner disk is a more efficient thermal conductor than the outer disk.

References Cited by the Examiner

UNITED STATES PATENTS

2,112,037	3/1938	Malter	230—101
2,125,910	8/1938	Gardner.	
2,193,135	3/1940	Lamm	230—101
2,386,298	10/1945	Downing et al.	230—101
2,397,591	4/1946	Becker	230—101
2,703,673	3/1955	Winkler	230—101
2,919,061	12/1959	Power	230—101
3,024,625	3/1962	Fraunhofer et al. ..	230—101 X
3,075,689	1/1963	Stevenson	230—101
3,081,068	3/1963	Milleron	55—269 X
3,119,243	1/1964	Hnilicka et al.	
3,137,551	6/1964	Mark	55—444 X

FOREIGN PATENTS

1,028,734	4/1958	Germany.
1,037,644	8/1958	Germany.
1,074,208	1/1960	Germany.
773,456	4/1957	Great Britain.
795,895	6/1958	Great Britain.
888,249	1/1962	Great Britain.

OTHER REFERENCES

Ullman, Ralph J.: A Large Metal System Permitting Low Base Pressures, University of California, Radiation Laboratory, Livermore Site, Livermore, California, Document No. UCRL-4972, October 4, 1957, 7 pages.

REUBEN FRIEDMAN, *Primary Examiner*.