ABSTRACT OF THE DISCLOSURE

An all-metal mercury diffusion pump capable of withstanding high baking temperatures and including an annular water jacket joined to the barrel of the pump by an expansion joint. The water jacket also substantially encloses the vacuum fore-line and the condensate return line, and an isolation chamber separates the pump boiler from the pump manifold.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

This invention relates in general to vacuum pumps and in particular to an all-metal mercury diffusion pump. Various forms of mercury diffusion pumps are commercially available and they fall generally into two categories. One category, generally limited in its use to laboratory environments consists of glass pumps which are inherently fragile and difficult or impossible to construct in large sizes. The other category consists of metal pumps which are not so stringent in size but are generally so constructed that they cannot be baked at high temperatures. Some attempts have been made to provide metal pumps which can withstand at least some baking, but because integral cold traps are incorporated, baking must be restricted to relatively low temperatures. Another disadvantage of conventional metal pumps is the absence of any means for viewing the pumping fluid or the condensate.

Insofar as glass pumps are concerned, high temperature baking is clear impractical because differential expansion effects between the inner and outer surfaces lead to breakage during heating and cooling cycles. It is, therefore, a principal object of the present invention to extend the low pressure capability of mercury diffusion pumps.

It is another object of the present invention to make feasible the operation of mercury diffusion pumps at temperatures in excess of those presently utilized.

Still another object of the present invention is to simplify the structure of mercury diffusion pumps and to facilitate their disassembly for cleaning and inspection.

A further object of the present invention is to permit the viewing of pumping fluid and condensate in mercury diffusion pumps.

The present invention consists generally in a pump composed almost entirely of metal, principally relatively low-carbon stainless steel. Although incidental elements of the apparatus are composed of Kovar or Pyreex, for all practical purposes, the pump is defined as an all-metal pump. The pump can withstand heating to temperatures in excess of 475° C. resulting in a thorough cleaning of the pump during bakeout under vacuum. The geometry of the jet assembly and the incorporation of a highly efficient annular water jacket of radically different design greatly extend the low pressure capability of the pump. Moreover, a glass segment is provided in the return line to permit monitoring of the condensate return action and a glass port in the boiler enclosure of the pump permits viewing of the surface of the pumping fluid. Specific design features such as the incorporation of an isolation chamber between the manifold and the boiler and the interposition of an expansion diaphragm between the pump barrel and the annular water jacket implement the efficient operation of the pump.

Perhaps the key component of the pump is the manifold, to the top of which the water jacket and jet assembly are welded in such a fashion that the manifold is well-cooled during normal pump operation. The annular base of the water jacket substantially surrounds the manifold, being interrupted only by a plug in the water jacket through which a passage is formed. Portions of the condensate return line and the fore-vacuum line are combined in the walled passage through the water jacket whereby the dual-purpose line is cooled. The fore-vacuum line is continued through an annular passage external to the water jacket which lengthens the cooling path. For a better understanding of the present invention together with other and further objects, features and advantages, reference should be made to the following specification which should be read in conjunction with the appended drawings in which:

FIGURE 1 is an elevation, partly in section, of a preferred embodiment of the vacuum pump; and

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1.

In FIG. 1 there is shown an ultra-high vacuum connecting flange 12 by which the pump may be joined to the system to be evacuated. The flange may be of the type known as a Conflat flange and it is welded to a pump barrel 14. The barrel is preferably made of 304 low-carbon stainless steel as are all other elements of the pump with the exception of those specifically noted as being of other materials. Also, all welded joints between mating elements are made by Heliarc and, wherever practical, within an inert atmosphere welding chamber filled with a gas such as argon. These precautions are taken to avoid any oxidation.

The pump barrel 14 is enclosed along much of its length by a water jacket 16. At the upper end of the water jacket 16 a flared portion 18 is connected to the pump barrel 14 by means of an expansion diaphragm 20.

The water jacket 16 is terminated at its lower end adjacent a portion of a pump manifold 22. The outer part of the manifold 22 is a sleeve member 23 of larger diameter than that of the water jacket 16.

Welded to the top surface of the manifold is a lower jet assembly which includes a lower vapor tube 25 flared back upon itself at a point above the manifold. A top jet 26 of relatively small diameter, shaped and wrapped to direct vapors in a generally downward direction, an upper vapor tube 27 and a lower jet cap 28 are welded together in a separate assembly designed to fit slidably into the lower vapor tube 25. A bayonet-type joint may be provided to assure proper positioning of the unit. The top jet 26 is disposed at a point within the pump barrel 14 below the upper limit of the water jacket. The lower jet
cap 28 is spaced along the upper vapor tube 27 at a considerable distance from the top jet 26 and it, too, is designed to direct the vapor stream generally downwardly.

Welded to the bottom surface of the manifold is an isolation chamber 30 through which the lower vapor tube 25 passes centrally. A pump boiler 32 is welded to the isolation chamber 30 in such a manner that a re-entrant configuration is provided. Although no detail is shown because the structures are conventional, the heater for the boiler may be a simple Nichrome wire contained within a housing 34. Also, the exterior of the boiler may be suitably insulated by the use of stacked rings of Marininite 36 which may be joined together by steel rods. The top jet 26, the upper vapor tube 27, and the cap 28 of the lower jet being welded together may be removed through the top of the pump barrel for inspection or cleaning.

A solid portion or plugged area is formed at a point between the pump barrel 14 and the wall 16 of the water jacket. A diagonal opening passes through the solid portion to form a walled passage 36 running downwardly from the interior of the pump barrel above the manifold to the enlarged outer annular volume of the manifold.

The walled passage 36 has a dual function. Because it passes through the water jacket it is well cooled and mercury condensate flows freely through the passage to a trap 38 from whence it is returned to the boiler 32 as it rises above the trap level. The trap, of course, prevents vapor from the boiler reaching the pump barrel by a route which bypasses the central vapor tube 25. To permit viewing of the returning condensate, a glass segment 40 is incorporated in the mercury return line 42.

The other function of the walled passage 36 is that of the vacuum fore-line connection. The pumping path is through the passage 36, around the outer annular volume of the manifold to a tube 43 which penetrates the outer annular volume. The tube 43 communicates with a flanged connector 45 to which a fore-pump (not shown) is coupled.

Some details of the structure, particularly the vacuum fore-line connection, mercury drain lines and water-cooling lines may be seen in FIG. 2. For example, a supply line 44 and a drain line 46 for the annular water jacket are shown as is the flanged fore-line connection 45 and the annular pumping path. Any one of several conventional mechanical pumps may be attached to the fore-line connection 45 to provide a vacuum of approximately 10 to 20 microns.

As has been noted, the preferred pumping fluid is mercury and, typically, a quantity of about 6 lbs. of mercury has proven adequate in the pump boiler. A glass viewing port 48 which may be sealed to a Kovar member welded into the wall of the boiler 32 facilitates monitoring of the level of mercury in the boiler.

Construction details on the embodiment of the invention shown and described include a height of about 24 inches, a throat of about 3 1/2 inches and pumping speed of about 250 liters per second. The top jet is relatively small compared to the lower jet which is spaced at some distance from the lower jet. The emission of vapor from both jets is in a generally downward direction to enhance the probability of entraining gas molecules. Back diffusion of higher pressure gas is inhibited by the closer spacing of the lower jet to the barrel and the higher temperature of vapor emitted from that jet.

The annular water jacket maintains a uniform low temperature to improve the functioning of the condensation barrel wall 14 as compared to conventionally spiral and coiling coils.

The isolation chamber 30 serves to insulate the hot boiler 32 from the cold manifold during normal pumping operations. On the other hand, the isolation chamber 30 minimizes heat flow from the hot manifold to the boiler during bake-out. Bake-out at temperatures in excess of 100°C. is practiced, and the entire pump from the top large down to the manifold may be baked without difficulty. Pressures as low as 10^-12 torr. have been achieved.

Although what has been described and shown constitutes a preferred embodiment of the present invention, a reading of the foregoing specification will suggest numerous modifications and alternatives to those skilled in the art. Such variations are believed to be within the purview of the present invention which should be limited only by the spirit and scope of the appended claims:

What is claimed is:

1. In a pumping system which includes a volume to be evacuated and a fore pump, the combination therewith of a mercury diffusion pump which comprises a pump barrel, a jet assembly disposed in said barrel, a water jacket enclosing said barrel along at least that portion of its length within which said jet assembly is disposed, a pump manifold including an annular volume disposed at the base of said barrel and having at least a portion thereof in contact with said water jacket, means for vaporizing said mercury, said vapor being passed through said jet assembly and condensed upon the wall of said barrel, and means comprising in part a walled passage formed through said water jacket and communicating between the interior of said annular volume and said barrel for conducting condensed mercury back to said vaporizing means.

2. In a pumping system as defined in claim 1 the further combination of a fore-pump fore-line connection disposed in said annular volume in communication by way of said walled passage with said interior of said barrel.

3. In a pumping system as defined in claim 1, the combination in which said jet assembly includes a top jet spaced along said barrel from a lower jet, said lower jet being spaced more closely to the interior wall of said pump barrel than said top jet.

4. In a pumping system as defined in claim 3, the combination of caps disposed on said top jet and said lower jet to direct emitted vapors in a generally downward direction.

5. In a pumping system as defined in claim 4, the combination in which said top jet and the cap on said lower jet may be detached as a sub-assembly from said lower jet.

6. In a pumping system as defined in claim 1, the combination in which said means for vaporizing said mercury comprises a boiler and in which comprises an isolation chamber is interposed between said manifold and said boiler.

7. A mercury diffusion pump for use with a fore-pump comprising a pump barrel, an annular water jacket surrounding said pump barrel, an expansion joint connecting the top of said pump barrel to the top of said water jacket, a pump manifold disposed at the base of said pump barrel and also contacted by said water jacket, a jet assembly welded to the top of said manifold and extending upwardly into said pump barrel, an isolation chamber welded to the bottom of said manifold, a pump boiler welded to said isolation chamber, said manifold having a central opening formed therein, permitting communication between the area above said manifold and the area below said manifold, a sleeve member surrounding said water jacket and forming an outer annular manifold volume, a walled passage extending through said water jacket from a point above said manifold downwardly to said outer annular manifold volume, a mercury return line connected from said annular volume to said boiler whereby mercury may be returned to said boiler and means for connecting said annular volume to said fore-pump by way of an opening formed in said annular volume.

8. A mercury diffusion pump as defined in claim 7 including a transparent member incorporated in said return line to permit viewing of mercury return action.

9. A mercury diffusion pump as defined in claim 7 including a transparent member incorporated in the wall of said boiler to permit viewing of the mercury level in said boiler.
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