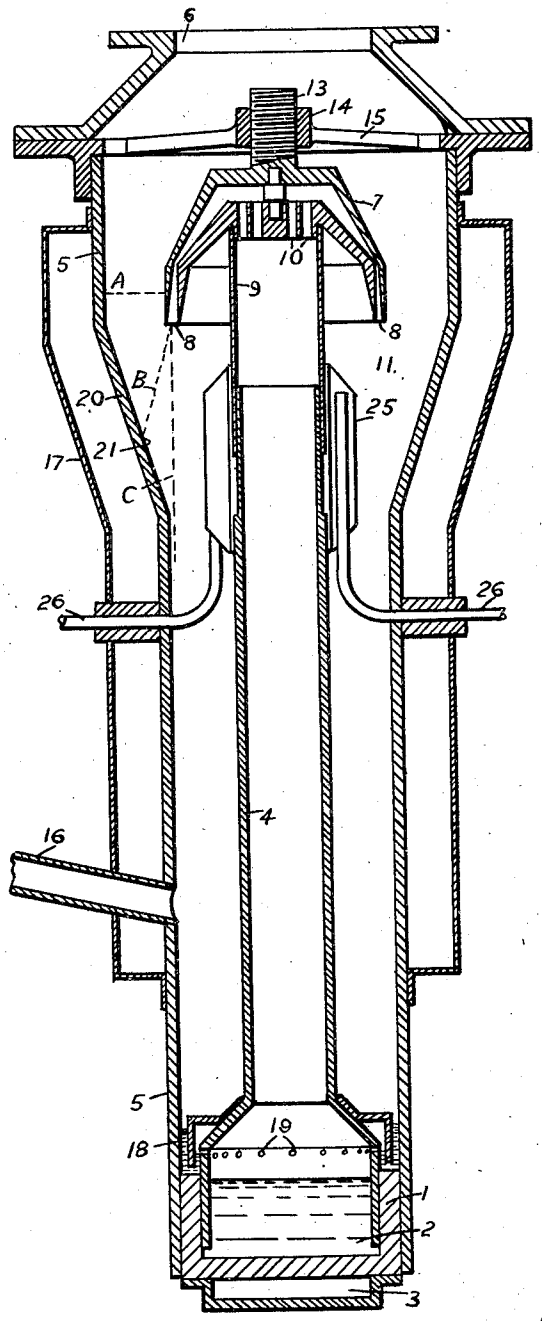
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VACUUM PUMP OF THE VAPOR TYPE

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VACUUM PUMP OF THE VAPOR TYPE

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4 Claims. (Cl. 230—101)

1

This invention relates to vacuum pumps of the vapor type.

The principal object of the invention is a pump which, for a given flow of mercury vapor, has a higher rate of evacuation or pumping speed over a wide range of pressures, than any pump heretofore known.

Another object is a pump which can be adjusted to give a maximum rate of evacuation for any given vacuum.

Mercury is the liquid usually vaporised in vapor pumps, but other liquids such as oils, are employed. The mercury vapor pump of usual form consists of a central tube surrounded by an outer tube; mercury vapor is generated by a boiler at the bottom of the central tube and flows through an annular jet formed at the top of the central tube and directed down the annular space between the two tubes. The top of the annular space is connected with the vessel to be evacuated and the bottom is connected with the backing pump. The outer tube is water cooled and causes the mercury vapor to be condensed. Air is withdrawn from the vessel to be evacuated through the annular space between the jet and the outer tube, and the rate of evacuation depends in large measure on the area of this annular space.

In pumps as heretofore made, it has been found that, for any given set of conditions, there is an optimum width of this annular space, a smaller width diminishing the rate of evacuation by restriction of the flow of air, while a larger width also diminishes the rate, but because there is a back flow of air which makes the pumping inefficient.

In pumps according to the invention, for the given set of conditions, the width of the annular space can be substantially increased without impairing the efficiency of pumping, and thereby the rate of evacuation increased.

The pressure in the pump diminishes from the inlet, that is the space above the annular space, to a minimum at a point below the annular space just below the jet orifice and from there increases rapidly to a maximum at a point approaching the outlet to the backing pump, this maximum necessarily being higher than the pressure in the outlet.

Assuming the pressure in the inlet to be one-fiftieth of that in the outlet, there is a large pressure difference tending to cause a back flow of air towards and through the annular space, and such back flow can be prevented only by the impact of the mercury molecules on the air molecules.

It has been found that the back flow can be prevented by ensuring that the density of the mercury vapor (assuming adequate velocity of the molecules), is high enough at all points of the cross-section of the pump from the centre annulus of the jet to the outer wall, at a level above the points where the air pressure is high.

2

Now the jet of mercury vapor usual in pumps is found to have a high density over a cone with angle of about 15 degrees from the axis, but a rapidly falling density at larger angles.

In the pump according to the invention, adequate density of the vapor is secured at all points of the said cross-section by so forming the body of the pump that a portion of the jet contained within an angle of 15 degrees from the axis covers the whole of the said cross-section, and that the length of the jet to this cross-section is short enough to ensure adequate density in the vapor.

According to the invention, the outer tube diminishes in diameter at a point near jet orifice level, so that the length of vapor jet measured along a cone with angle 15 degrees from the pumping direction does not exceed 2.6 times the width of the annular space at jet orifice level. The outer tube may have an upper portion of substantially constant diameter down to a point near jet orifice level, an intermediate portion of diminishing diameter at least down to a point struck by the vapor jet along a cone with angle 15 degrees from the pumping direction, and a lower portion of substantially constant diameter down to the outlet. The jet may then be adjustable in height relatively to the outer tube from a position in which the jet orifice is on the level of the bottom of the upper portion of the tube to a higher position, whereby the variation in height of the jet varies the ratio of the said length of vapor jet to the width of the said annular space.

In the accompanying drawing which shows in a single figure by way of example a form of pump embodying the invention, in vertical section, the mercury boiler 1, containing mercury 2, with an electric heater in the space 3, supports the central vapor tube 4 and the outer tube 5, forming the body of the pump, which terminates above the inlet 6 of the pump. The annular jet 7, with annular orifice 8, is fixed on a tube 9 adapted to slide over the tube 4. The vapor from the mercury 2, passing up the tube 4, enters the jet 7 through holes 10 in the central body of the jet, and issues from the orifice 8 into the space 11 between the tubes 4 and 5 in the pumping direction, indicated by the dotted line C. The jet 7 is adjustable in height relatively to the tube 5 by means of the screw 13 engaging a nut 14 carried by a spider 15 fixed to the tube 5.

The outlet of the pump is the pipe 16 connecting the space 11 to the usual backing pump. The tube 5 is surrounded by a water jacket 17 to condense the mercury vapor which falls into the seal 18 and thence returns through holes 19 into the boiler 1.

The outer tube 5 has parallel walls at its upper part surrounding the jet 7, and the space between the tube 5 and jet 7, of width A as indicated by the dotted line, is the annular space

which has been referred to as determining in large measure the rate of evacuation of the pump. The outer tube 5 diminishes in diameter at the portion 20 with conical walls to the lower portion, which again has parallel walls. The extent to which the diameter is diminished and the position of the portion of the tube with non-parallel walls is determined as follows. A line is drawn from the jet orifice 8 at an angle of 15 degrees to the pumping direction C, to meet the wall of the tube 5 at a point 21. Calling the length of this line B, B must not exceed 2.6 A.

To secure this condition, while avoiding abrupt changes in diameter of the tube 5, the diameter must be diminishing at a point above 21, that is to say, at a point near the level of the jet orifice 8, though the diminution may continue upwards above this point. The diminution may continue below the point 21 as shown, to give the annular space 11 in the lower portion the desired width. In the drawing, B is equal to about twice A, and this a convenient ratio.

The action of the pump will be explained by assuming, by way of examples a series of pressures in the pump which can obtain in practice. If the pressure at the pump inlet 6 be .002 mm., of mercury and in the outlet 16, .100 mm., the pressure near the letter A will be, under the conditions assumed, .001 mm., and that near the letter B .0001 mm. The pressure in the space 11, a little above the outlet 16 will be about .120 mm., giving a pressure difference of .020 mm., to cause a flow of air from the space 11 into the outlet 16. There is, therefore, a rapid rise of pressure from a point near B to a point above the outlet 16, and consequently the air near and above the numeral 11 tends to flow upwards to the point near B. Upward flow can be prevented only by impact of the molecules of the mercury vapor on the air molecules, to drive them downwards against the pressure difference.

Now the density of the mercury vapor diminishes with increasing angle from the axis line C and it diminishes also with increasing distance from the jet orifice. The region of least density is, therefore, along the surface of tube 5, and it is along this surface that there is the greatest danger that a backward flow of air through the vapor jet may occur. Therefore it is essential for efficient pumping that the density of the vapor along a portion of the surface of the tube 5 be sufficient to ensure the air molecules being driven downwards against the pressure difference by impact on them of the mercury molecules.

By restricting the length of the line B with reference to the width A, in accordance with the invention, the density of the vapor at the surface of the tube 5 for a given air passage A is increased, and the vapor jet can act as a screen preventing any upward passage of air molecules.

The higher the pressure at the inlet 6, the higher is the pressure in the space 11, and therefore the greater the tendency of the air to flow back past the vapor jet. By means of the adjustment provided for the height of the jet orifice, the length of the line B may be decreased and the density close to the tube 5 increased, and thereby the pump may be adjusted to pump efficiently at high pressures, such as pressures above .01 mm.

As specifically described and claimed in co-pending application No. 596,036 a water jacket 25 may surround, but not touch, the tube 4, for a length just below the jet orifice downwards, the jacket having inlet and outlet pipes 26 by which it is continuously supplied with cold water.

As fully explained in the aforesaid co-pending application No. 596,036, the efficiency of the pump is further increased by the employment of this iner jacket since vapor molecules are thereby prevented from striking the hot tube 4 and achieving a random velocity which enables such molecules to collide with molecules issuing from the jet 8 and diminish the downward component of their velocity.

A vapor pump constructed as herein described may be superposed over a co-axial second vapor pump, the jets of the two pumps being supplied with vapor through two non-communicating passages from two non-communicating evaporating surfaces of two communicating masses of liquid, as specifically described and claimed in co-pending application No. 596,035.

We claim:

1. A vapor vacuum pump comprising a boiler, a central tube adapted to lead the vapor upwards towards the inlet of the pump, a water cooled outer tube surrounding the central tube having the pump outlet near the bottom of the tube, an annular jet at the top of the central tube adapted to direct vapor in the pumping direction into the annular space between the outer and central tubes, the outer tube diminishing in diameter at a point near jet orifice level to an extent determined by the length of vapor jet measured along a cone with angle 15 degrees from the pumping direction not exceeding 2.6 times the width of the annular space at jet orifice level.

2. A vapor vacuum pump comprising a boiler, a central tube adapted to lead the vapor upwards towards the inlet of the pump, a water cooled outer tube surrounding the central tube having the pump outlet near the bottom of the tube, an annular jet at the top of the central tube adapted to direct the vapor in the pumping direction into the annular space between the outer and central tubes, the outer tube having an upper portion of substantially constant diameter down to a point near jet orifice level, an intermediate portion of diminishing diameter at least down to a point struck by the vapor jet along a cone with angle 15 degrees from the pumping direction, and a lower portion of substantially constant diameter down to the outlet, the length of the vapor jet measured along the said cone from the jet orifice to the tube not exceeding 2.6 times the width of the annular space at jet orifice level.

3. A vapor vacuum pump according to claim 1, characterised by means for adjusting the height of the jet relatively to the outer tube, whereby the length of vapor jet measured along a cone with angle 15 degrees from the pumping direction is varied.

4. A vapor vacuum pump according to claim 2, characterised by means for adjusting the height of the jet relatively to the outer tube, whereby the length of vapor jet measured along a cone with angle 15 degrees from the pumping direction is varied.

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